

**SAGE DATA TRANSMISSION SYSTEMS — PRIVATE SERVICE SYSTEMS**  
**AIR-GROUND VOICE COMMUNICATIONS SYSTEM**  
**DESCRIPTION — COMMON USER GROUP EQUIPMENT**

CONTENTS	PAGE	CONTENTS	PAGE
1. GENERAL . . . . .	1	8. MAINTENANCE . . . . .	15
A. Introduction . . . . .	1	A. Emergency Patching —	
B. General Operation . . . . .	2	Trunk and Channel . . . . .	15
C. Application . . . . .	2	B. Spare Channel Patching . . . . .	15
D. Principal Features . . . . .	4	C. Alarms . . . . .	15
2. THE AIR-GROUND SYSTEM . . . . .	4	9. EQUIPMENT ARRANGEMENTS . . . . .	15
A. At the Direction Center . . . . .	4	A. General . . . . .	15
B. At the Radio Site . . . . .	5	B. Description . . . . .	15
3. SIGNALING . . . . .	6	<b>FIGURES</b>	
A. Principles and Application . . . . .	6	1 — CUG Equipment and Connecting Circuits . . . . .	3
B. Monitoring and Transfer . . . . .	7	2 — Tandem Site and Remote Site . . . . .	5
C. Code Signaling . . . . .	8	3 — Use of 43A1 Terminal with a	
4. TRANSMISSION . . . . .	8	4-wire Circuit . . . . .	6
A. General . . . . .	8	4 — Pulse Length Codes . . . . .	7
B. Objectives . . . . .	9	5 — Typical Channel Codes . . . . .	8
5. EQUIPMENT ELEMENTS . . . . .	9	6 — Functional Schematic of CUG Operation . . . . .	12
A. 43A1 Carrier Telegraph Terminals . . . . .	9	1. GENERAL	
B. Channel Circuit . . . . .	9	A. Introduction	
C. Code Sender . . . . .	9	1.01 This section describes the Common User	
D. Trunk Circuit . . . . .	9	Group (CUG) system which has been de-	
E. Code Receiver . . . . .	10	veloped for use in the SAGE air-ground voice	
F. Link and Controller . . . . .	10	communications system for establishing connec-	
G. Trouble Indicator . . . . .	10	tions between Intercept Directors (IND) at a	
H. Automatic Test Circuit . . . . .	10	Direction Center (DC) and their assigned radios	
I. Keying Circuit . . . . .	11	at a radio site. The term air-ground (A/G)	
6. METHOD OF OPERATION . . . . .	11	means communications in both directions, i.e.,	
A. Direction Center to Radio Site . . . . .	11	air-to-ground and ground-to-air. This section is	
B. Radio Site to Direction Center . . . . .	13	reissued to include information on air-ground	
7. OTHER FEATURES . . . . .	13	operation via the AUTOVON Switched Net-	
A. Transfer — Automatic and Manual . . . . .	13	work. Since this reissue covers a general re-	
B. All Trunks Busy . . . . .	14	vision, arrows ordinarily used to indicate	
C. Glare . . . . .	14	changes have been omitted.	
D. Leering . . . . .	14	1.02 A CUG system consists of a number of	
		component parts such as channel circuits	
		with associated code senders, a link and con-	
		troller, a trouble indicator, an automatic test	

circuit, trunk circuits with associated code receivers, and other miscellaneous circuits. Each radio site served by a Direction Center, with the exception of a remote site served from a tandem site, requires its own CUG equipment at the Direction Center. In other words, four radio sites require four CUG systems. Only one trouble indicator and one automatic test circuit are required to serve all CUG systems in one Direction Center building. Fig. 1 indicates the various units of CUG equipment and their position in an overall A/G system.

**1.03** The facilities interconnecting common user group terminals are divided into two general categories:

- (a) Point-to-point — These are two point circuits interconnecting CUG 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.

**1.04** 4-wire subscriber lines and some point-to-point common user group circuits may route via a Dial Restoration Panel (DRP) at SAGE locations. The DRP is essentially a manual 4-wire patching arrangement which has the ability to establish and restore data and air-ground communications using the AUTOVON Switched Network. Transmission aspects of air-ground circuits are covered in Section 314-553-105.

**1.05** Point-to-point and switched common user group circuits which route via a DRP may be restored via the AUTOVON Network using PBX access lines should the need arise.

**1.06** Certain SAGE locations may not have a sufficient quantity of circuits to justify a DRP. In these cases, for access to the AUTOVON Network, a multiline keypulsing telephone instrument with associated line and transfer circuits will be provided. This arrangement has essentially the same features as a DRP, i.e., Dialing, Supervision, and Transfer.

## **B. General Operation**

**1.07** In operating a CUG system under normal traffic conditions, an operator (IND) at a console operates a site button to select a radio

site and a common control part of the system puts in a bid for an idle trunk to the site. When the trunk is connected, the code corresponding to the radio channel previously assigned to the IND is automatically transmitted. Reception of this code by the receiving trunk circuit at the radio site initiates the establishment of a connection of the trunk circuit to the particular radio channel. With the connection established, the IND may communicate with an airplane by means of the normal control signals. This connection is normally held until the IND selects another site. Calls initiated from an airplane through a site where the connection has not been previously established by an IND are set up just as calls originated from the Direction Center (DC). In this case, the received carrier frequency initiates the call. However, connections originated by an airplane are held only as long as the carrier is being received from the airplane. The connection is then automatically released. It is always possible for each IND to reach a radio channel at the site, even though there are considerably fewer trunks than there are INDs or radio channels.

**1.08** When a group of interceptor airplanes is ordered into the air, they operate on a previously assigned radio channel and an IND at the DC is assigned to control their operations. His console position is patched so that he has access to that particular radio channel at all sites. The radio set to which he is connected employs the same frequency for receiving and transmitting, one direction at a time. Thus, when the IND wishes to talk, he must transmit a push-to-talk (P/T) signal to key the remote radio, thus switching it into the transmitting condition from its normal receiving condition. In the interest of rapid trouble detection, all trunks connecting Direction Centers to radio sites are continuously monitored using pilot tone to detect circuit failures. Should one of the lines associated with a trunk become open or should the signaling on it fail, switching takes place automatically within the CUG equipment to provide another trunk connection.

## **C. Application**

**1.09** In both the dual facility (DF) and the CUG systems, the signals interchanged between the IND position and the radio site are

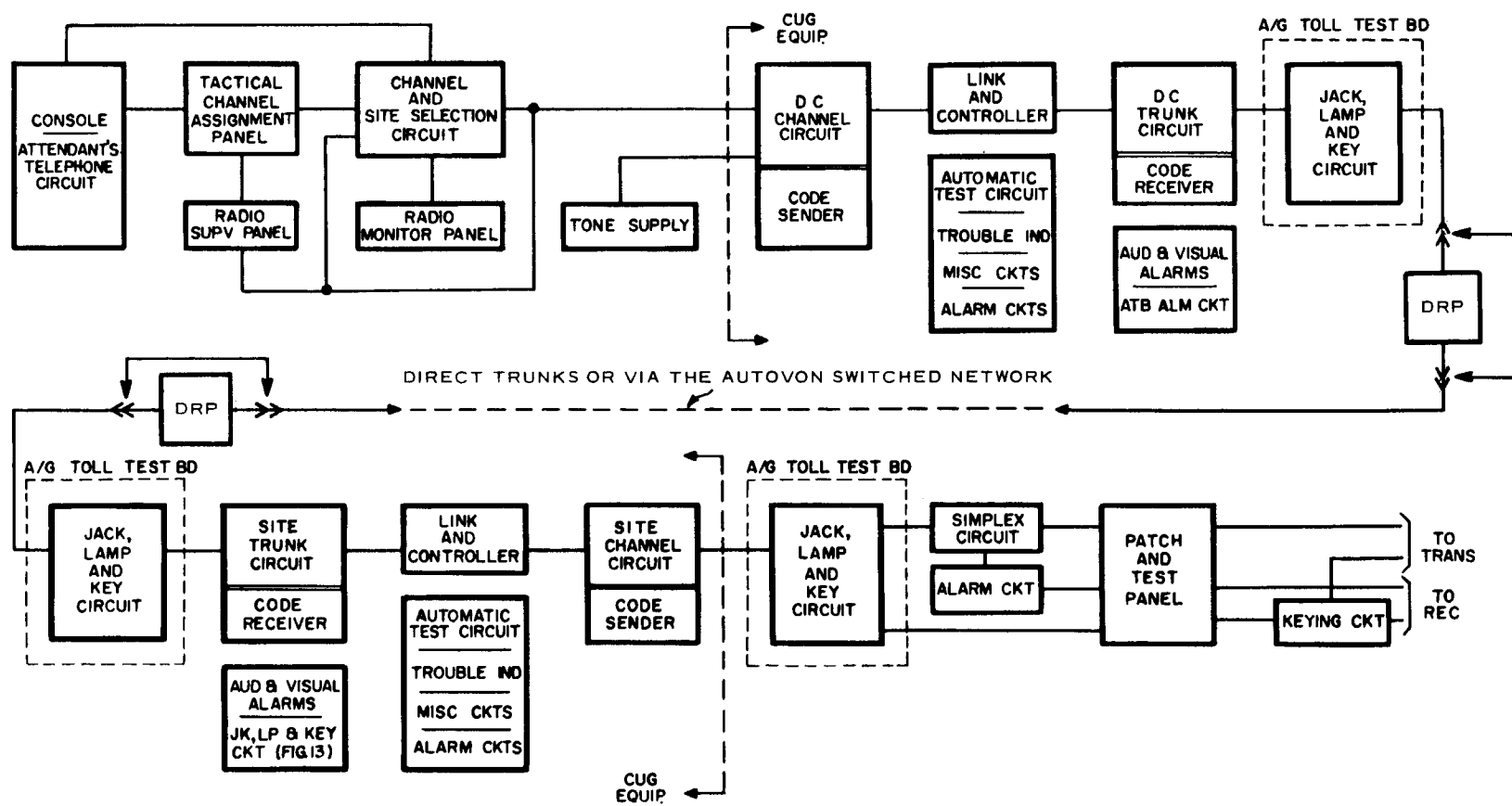


Fig. 1 - CUG Equipment and Connecting Circuits

the same; only the manner of establishing the connection is different. Consequently, CUG may be used as a replacement for, or in conjunction with, DF equipment. There are advantages to such a change.

- (a) The total number of trunks required between a DC and a radio site can be reduced without impairing the operational abilities of the voice communications system.
- (b) The number of trunks provided between a DC and a radio site may be furnished in accordance with local traffic requirements.
- (c) Full access is provided to *any* idle trunk, even though there are fewer trunks than radios or console operators.

#### D. Principal Features

**1.10** CUG provides for the placing of all trunks between a DC and a radio site in a common pool, regardless of physical routing, and makes these trunks available to all operating consoles at the DC or to radio receivers at the site. The functions of this system include the following:

- (a) To recognize a site selection signal from an operating console for a particular site.
- (b) To test for and select an idle trunk to the site.
- (c) To pulse a code over the trunk to the site to indicate the desired channel.
- (d) To recognize the transmitted code at the site and select the proper channel.
- (e) To close through a talking and signaling connection from the operating console to a remote keying unit, in order to key the radio transmitter.
- (f) To recognize a push-to-talk signal from the console.
- (g) To cause a remote radio transmitter to radiate carrier by the use of an associated keying unit.
- (h) To provide a visual lamp signal to the operator, indicating that the radio transmitter is on the air.
- (i) To recognize a codan signal (incoming transmission) from a radio receiver.

- (j) To test for and select an idle trunk to the DC.
- (k) To pulse a code over the trunk to the DC to indicate the desired channel.
- (l) To close through a talking and signaling connection from the radio receiver to the operating console.
- (m) To recognize an all-trunks-busy condition and establish certain circuit conditions as a relief measure when this occurs.
- (n) To provide a "don't talk" tone to an operator during an all-trunks-busy condition if the operator is temporarily delayed in obtaining a trunk.
- (o) To actuate audible and visual signals and alarms in connecting circuits and equipment.

## 2. THE AIR-GROUND SYSTEM

### A. At the Direction Center

**2.01** The block diagram shown in Fig. 1 indicates the units of an air-ground voice communications system using CUG equipment. The following paragraphs outline briefly the functional part of each connecting unit in the system.

**2.02** *The tactical channel assignment panel (TCAP)* provides for the assignment of one of 20 channels to each of 20 operating consoles. Two other channels are common to all consoles.

**2.03** *The channel and site selection circuit* permits the console operator to select any site and to use a previously assigned channel for A/G voice communications to and from that site.

**2.04** *The radio supervisory panel* provides a means of monitoring and testing on lines to A/G radio units in order to supervise the maintenance and trouble reporting on these lines.

**2.05** *The radio monitor panel*, by the use of loudspeakers, is used for constant monitoring on the two common channels associated with all the consoles and all the sites. It also enables the panel attendant to talk on these channels.

2.06 *The tone supply* provides a tone, under the control of the channel circuit, to the console operator during the interval when the push-to-talk switch is operated until the connection is established at the site during an all-trunks-busy condition.

**B. At the Radio Site**

2.07 *The jack, lamp, and key circuits*, which are located on the toll testboard at both the DC and the radio site, provide for the testing of trunks and for patching to the various trunk circuits. That portion of the jack, lamp, and key circuit connected to the site channel circuit consists of a number of jacks to patch the channel circuits to the radio equipment. When a radio site is used as a tandem point between a DC and another radio site and DF equipment is used between the tandem site and the other radio site, the test and patch relay circuit of the DF

equipment is connected to the site channel circuit instead of to the jack, lamp, and key circuit. (See Fig. 2.)

2.08 *The simplex circuit* is merely a simplex lead from CUG to the radio patch and test panel to provide an alarm indication that a console originated trunk transfer action has taken place.

2.09 *The radio patch and test panel*, sometimes referred to as the PTA, is the patching and testing point for the radio equipment. It indicates the available status of radio equipment, receives the line transfer indication, permits release of alarm signals when trouble is cleared, provides for monitoring on 2-way conversations on channels in use, and provides for emergency patching between transmitter and receiver buildings.

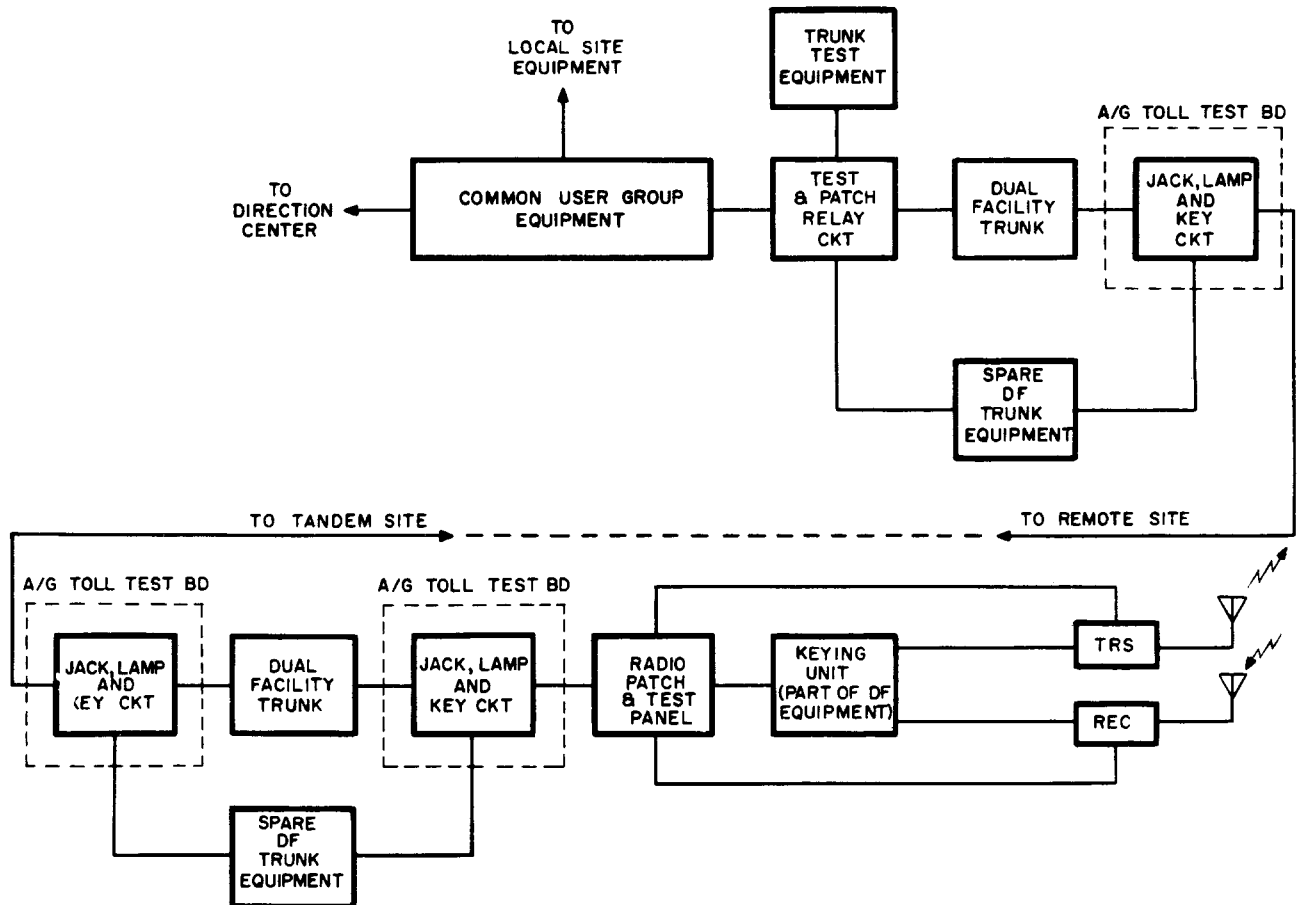


Fig. 2 - Tandem Site and Remote Site

3. SIGNALING

A. Principles and Application

3.01 The signaling arrangements employed in CUG trunk circuits make use of a technique referred to as "slot signaling." The term "slot signaling" is applied to the method whereby a predetermined frequency bandwidth is removed from the normal voice channel in the voice-frequency spectrum (200 to 3000 cps) and is used for signaling purposes. Signaling is accomplished by use of the 43A1 carrier telegraph terminal. This terminal is an important functioning part of the system.

3.02 The 43A1 terminal operates on a frequency shift basis and is regularly used in carrier telegraph systems. It is constructed so that plug-in type frequency determining units or networks can be connected to the terminal, and the selected frequencies utilized for sending and receiving signals. Each frequency selected is assigned a channel number according to current Bell System Practices. The frequency selected is considered as the nominal midband frequency, whereas the actual operating frequencies for signaling purposes are 35 cycles above and below this amount.

3.03 Initially, CUG equipment was entirely on a point-to-point basis employing channels 13 and 14 centered on midband frequencies of

2465 and 2635 cycles, respectively. Channel 13, the lower of the two, is used for transmitting from the radio site to the DC, and channel 14 from the DC to the radio site. Signaling is accomplished by a frequency shift on the lower band between 2500 and 2430 cycles, and on the higher band between 2670 and 2600 cycles.

3.04 For operation over the AUTOVON Switched Network, the frequencies of the 43A1 carrier must be changed. This is necessary to disable echo suppressors and to permit full duplex operation. In the DC to radio site direction, the frequency shift from 2260 to 2330 cycles (channel 12 in the 43A1) turns on the radio site transmitter. In the radio site to DC direction, the frequency shift from 2090 to 2160 cycles (channel 11 in the 43A1) provides an indication of receiver CODAN operation or a transmitter "carrier on" indication.

3.05 Fig. 3 shows in diagram form the use of the 43A1 in a 4-wire telephone circuit with the terminals bridged across the tip and ring of each pair at each end of the circuit. (For the purpose of description, only the sending (S) and receiving (R) filter portions of the 43A1 are designated.) Band rejection filters, shown in the line on the drop side of the terminal equipment, present a high loss to a particular frequency band. The purpose of these filters is to prevent

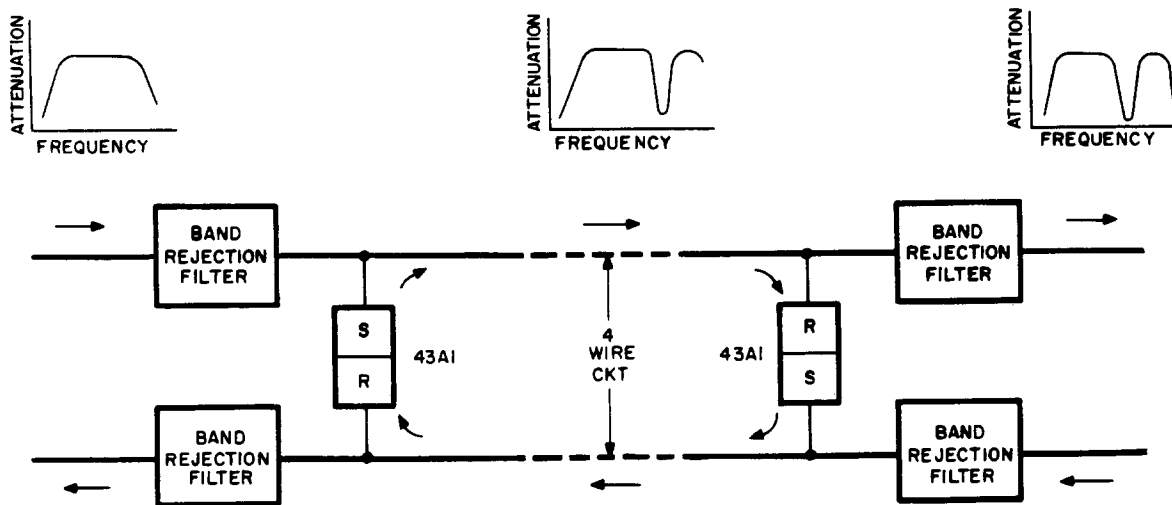


Fig. 3 - Use of 43A1 Terminal with a 4-wire Circuit

the voice frequencies in the signaling range from modulating the 43A1 terminals, as well as to prevent the signaling frequencies in the speech spectrum from entering the trunk circuits. It can be seen, then, that speech frequencies in the signaling range will not enter the trunk and that signaling tones are confined to the trunks. Thus, it is possible to provide signaling on a regular talking circuit with only negligible interference with voice transmission due to filter action.

### B. Monitoring and Transfer

**3.06** A single 43A1 terminal is a 3-state system, with one condition for each of the two signaling frequencies and one for the off or no-tone condition. Since one of the two signaling frequencies is on the line at all times, it is possible to obtain pilot tone monitoring. By con-

necting the signaling equipment on the drop side of the regular trunk terminating equipment, the means is provided to monitor the overall speech path.

**3.07** An interruption of the monitoring tone will cause a trunk transfer, whether the interruption is caused by a manual signal or by a line failure. A timing feature in the trunk circuits determines the condition and causes an alarm in either the U.S. Air Force or Telephone Company maintenance section. For example, an interruption of approximately one second will provide a signal to Air Force personnel signifying a manual transfer. An interruption in excess of 2.5 seconds, which in all probability would be a trunk failure, will provide a signal to Telephone Company maintenance personnel.

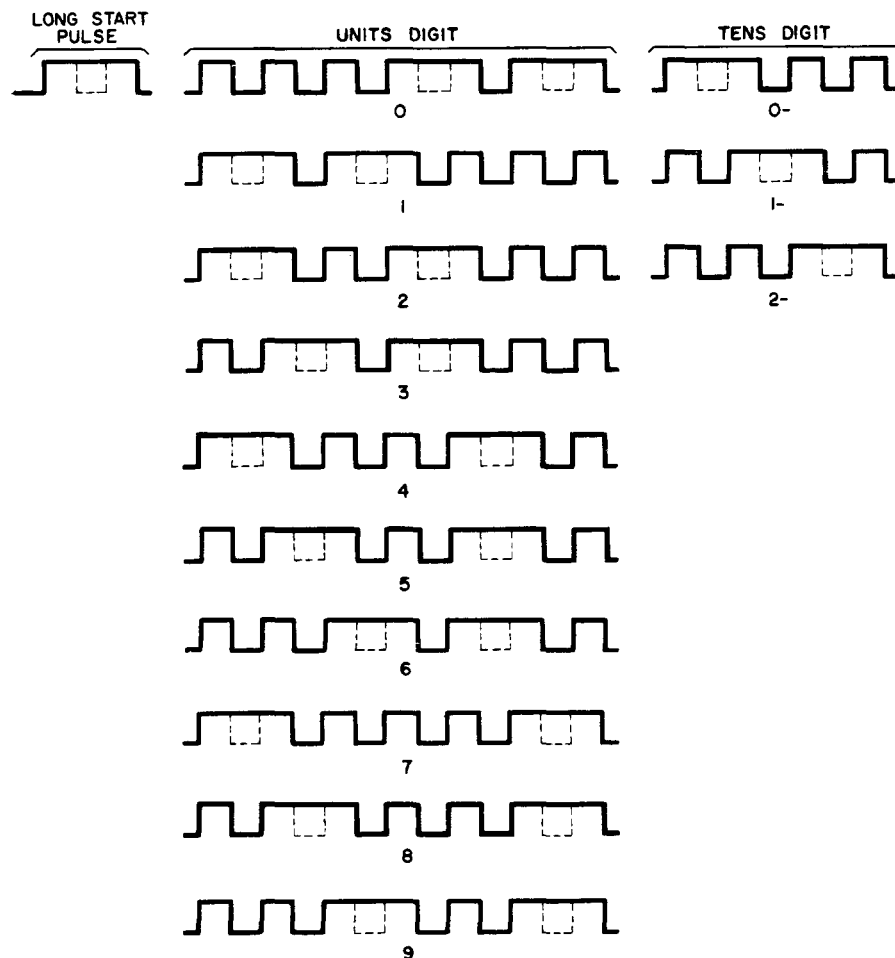


Fig. 4 - Pulse Length Codes

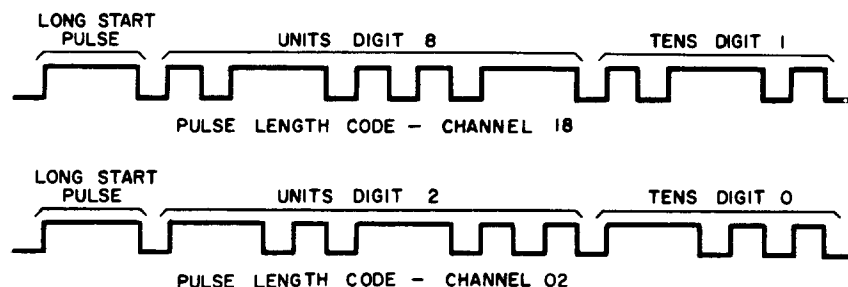


Fig. 5 - Typical Channel Codes

### C. Code Signaling

**3.08** Pulse length code signals are used between the DC and the radio site in order to establish correct channel connections. Two-digit codes are used. A 2/5 code is used for the units digit and a 1/3 code for the tens digit. In simpler terms, the units digit consists of two long pulses and three short, and the tens digit of one long and two short. By varying the combination of pulses in each digit, it is possible to obtain 30 different code combinations which are used to indicate channels 00 through 29.

**3.09** The code pulses originate in the code sender by the action of a pulse generator which provides uniformly spaced pulses at the rate of 25 pulses per second. At this rate, a single pulse uses approximately 20 milliseconds of pulsing time. A long pulse, which consists of two short pulses bridged together, is approximately 60 milliseconds.

**3.10** Fig. 4 shows the pulse code used in the system, with dotted lines indicating the pulses which are bridged. A prepare pulse, called the long start pulse, precedes each code and is always transmitted. Any code combination of digit pulses, plus the long start pulse, requires 13 pulses, four of which are long pulses.

**3.11** Fig. 5 shows typical codes for two channel circuits. It will be noted that the units digit is transmitted before the tens digit and that there is no delay between digits. The code to be transmitted is determined by prewired cross-connections on each code sender's terminal block.

**3.12** Pulses are accepted and terminated in a code receiver which registers the code and enables the link and controller to select the de-

sired channel. A parity check in the code receiver ensures that the correct number of pulses is received in the proper sequence or no operation takes place. In such instances, the associated trunk circuit times out and another trunk is selected.

## 4. TRANSMISSION

### A. General

**4.01** The trunk circuits employ the slot signaling technique in which a portion of the normal speech band is used for signaling purposes. This means that in transmitting and receiving speech, speech frequencies in the band blocked by the rejection filters do not reach the receiving unit. Under normal noise and operating conditions, this results in some impairment in intelligibility equivalent to the insertion of an overall loss of about 2 db in the transmission path.

**4.02** The location of the signaling band, with respect to the frequency, required that consideration be given to the impairment penalty imposed by the band elimination. For this reason, the upper end of the speech band was used since theory indicates that the extraction from the voice channel of a band of frequencies of fixed width has a diminishing effect on the articulation impairment as the frequency of the band is increased, assuming that the noise is negligible or has about the same frequency spectrum as the speech.

**4.03** To prevent interference between speech and signaling, the frequency components of speech in the signaling range are removed or blocked by the band filters. Nonswitched operation uses a 202E filter in the DC to radio site



direction, and a 202F filter in the radio site to DC direction. Switched operation employs 733A filters in the DC to radio site direction, and 733B filters in the radio site to DC direction. The discrimination at the signaling frequencies is approximately 35 db.

## B. Objectives

**4.04** The transmission levels for use in the 1000-cycle line-up of the circuits are given in Section 314-553-105. The losses between the DC telephone transmitter at the IND's console to the radio transmitter is the same for both switched and point-to-point operation.

## 5. EQUIPMENT ELEMENTS

### A. 43A1 Carrier Telegraph Terminals

**5.01** A 43A1 carrier telegraph terminal is used in each DC and radio site trunk circuit. Each terminal which is bridged across the 4-wire terminations on the trunk circuit (Fig. 3) has associated with it two plug-in type networks, one for sending signals and the other for receiving signals.

**5.02** Adjustments of the 43A1 terminals applicable to the CUG circuits are as follows:

(a) The SEND switch on the terminals is set in the low-frequency mark position, or "LM," at the DC and at the radio site.

(b) The REC switch on the terminals is set in the high-frequency receive position, or "H+," at the DC and at the radio site.

(c) The SEND level of the terminal is adjusted to -28 dbm by means of the SEND level control.

(d) Under severe noise conditions, supervision will function at a minimum signaling receive level of -32 dbm at the input to the terminal receiving network. This level is much higher than the minimum receive gain level of -46 dbm specified for the terminal, to permit a "just operate" adjustment of the supervisory relay by means of the REC GAIN control. The received gain level of -46 dbm is the same as for the 43A1 terminals used in the DF trunk circuits.

(e) A FIL ADJ control for each terminal circuit provides a means of adjusting the filament voltage from -24 volt supply to the -20 volt requirement.

(f) Maintenance information is included in Section 314-553-300.

**5.03** A separately fused 130-volt battery source is provided for each 43A1 carrier telegraph terminal. In the event a fuse operates while a trunk is in use, an automatic transfer to another trunk circuit takes place.

**5.04** Supervisory relays are wired directly to the 43A1 terminals. These relays respond to the "tone off" and "tone on" conditions caused by either a release signal, a transfer condition activated by an operator at the Direction Center, or a line failure.

### B. Channel Circuit

**5.05** At the DC and at the radio site, for each common user group, there are normally 20 channel circuits for regular use, two emergency channels which are common to all operating consoles, and one spare channel which may be substituted for any one of the others.

**5.06** The channel circuit at the DC, in conjunction with the operation of the radio channel and site selection circuit and the link and controller, provides the connecting link between the operating IND position and the trunk circuit. The channel circuit at the radio site, in conjunction with the link and controller and a keying unit or a dual facility trunk circuit, provides for connecting the site radio equipment to a trunk. Operationally, all the channel circuits, whether at the DC or at the radio site, perform the same functions.

### C. Code Sender

**5.07** Associated with each channel circuit is a code sender. The purpose of the code sender is to transmit a series of coded pulses which are determined by prewired cross-connections on a terminal block associated with the sender. (See 3.08). A sender is capable of transmitting a single code identifying itself with a particular radio channel or console position, depending on the direction of the call. The sender functions only when trunk and channel connections are being established.

### D. Trunk Circuit

**5.08** The trunk circuit is the connecting circuit between the 4-wire toll terminal equipment and the CUG equipment. The purpose of

the trunk circuit is to enable voice communications, transmitter control, and supervisory signals to be passed between any one of the channels at the DC and the corresponding channel at a radio site.

**5.09** The functions and purposes of all trunk circuits are the same. In the event a simultaneous seizure of a trunk occurs (that is, seizure of the same trunk at both the DC and the radio site), arrangements are made to release the connections and establish new ones. This condition is called "glare" and is discussed in 7.08.

**5.10** A trunk circuit becomes connected to a channel circuit through link and controller action. When trunks and channels are connected at the DC and at the radio site, through connections are established from operating console to the radio equipment. The function of the trunk now, in addition to providing a talking path, is to pass push-to-talk signals, codan signals, transfer and release indications, and alarm signals. This is accomplished by 43A1 telegraph terminal units. Because of their importance in the signaling portion of the CUG system, the 43A1 units have been explained in detail in Part 5(A).

#### **E. Code Receiver**

**5.11** A code receiver is associated with each trunk circuit. While a code sender is capable of sending only one code, code receivers are capable of receiving all codes; therefore, all code receivers are alike.

**5.12** The purposes of the code receivers are to receive the code pulses sent sequentially from a distant point by a code sender, to distinguish between long and short pulses, to register the code received, and to transmit this information to the controller so that the proper channel circuit will be selected. It is a self-checking device which makes a parity check for the proper number of pulses. If an incorrect code is received, the call is not completed, causing a trunk time-out and reselection of another trunk at the originating end.

#### **F. Link and Controller**

**5.13** The link and controller consists of crossbar switches and relays which serve as the connecting equipment between channel and

trunk circuits. The controller provides for the selection of idle trunks, recognizes busy trunk conditions, and has the ability to interpret codes registered in the code receiver and to use this information to ensure a correct trunk and channel connection. The crossbar switches make up the link portion of the equipment. They are used to establish the connections between the trunk circuits which are terminated on the verticals and the channel circuits which are on the horizontal.

**5.14** In each link and controller equipment unit there are two controller units designated A and B, and a group of common relays to serve both. The purpose in using two controllers is to enable either one to be selected for service and to permit one to be removed from service when maintenance is required, without preventing the operation of the system. They are normally used alternately in serving traffic.

#### **G. Trouble Indicator**

**5.15** When the link and controller fails to complete its functions within a timed interval, depending upon how far the call has progressed, the trouble indicator is automatically connected to it. The trouble indicator, by means of a lamp display, registers the progress of a call through the link and controller, should the call fail to be completed, and causes an alarm to be sounded.

**5.16** All CUG equipments at a DC are served by one trouble indicator which is on the test and alarm frame. At the radio site, a trouble indicator is similarly located. Only one trouble may be displayed at one time on the indicator. Each attempt to connect the indicator is counted on message registers, however, whether the indicator is available or not. These registers count the number of times each controller requires a connection to the indicator.

#### **H. Automatic Test Circuit**

**5.17** The automatic test circuit has direct access to each trunk circuit, channel circuit, and link and controller in the same building. It permits the testing of these circuits on either a manual or an automatic basis. Only one circuit of a particular type may be connected at a time, but any combination of circuits may be used for a given test. For example, a trunk circuit may be

tested with all channel circuits, a channel circuit with all trunk circuits, or all trunk circuits may be tested with all channel circuits. Tests of the circuits are not made while the circuits are in service.

**5.18** At DCs, or at tandem sites, more than one CUG system will be available. By manual selection, the test circuit can be connected to any one of these. When this is done, all further tests, whether manual or automatic, will be confined to that system until another is selected and the initial one is released. The selection of trunks or channels in the system is accomplished by the use of keys and dial-type switches on the test frame.

**5.19** A test channel, with a code sender capable of sending all codes, is part of the test equipment. This test channel may be used to originate calls to trunks or to terminate calls from trunks, thereby eliminating the need for the regular service channels in testing trunks. When automatic tests are made of all channel circuits, the test channel is not included in such tests but may be tested with regular manual or automatic tests with the trunk circuits.

**5.20** As has been indicated, two types of tests are permissible: a manual test which allows setting the test circuit on any one channel or trunk and testing with any other trunk or channel, and an automatic test. Under automatic testing, any particular channel may be tested with all trunks, a particular trunk may be tested with all channels, or all channels may be tested with all trunks. A repeat key permits the test circuit to repeat its test when operating on a manual basis.

**5.21** The test circuit is arranged to recognize various busy conditions of either trunk or channel by the operation of a pass-busy key. Busy tests are made during automatic testing, to determine if a channel is service busy. When a channel tests busy, the test circuit is automatically advanced. Should there be a demand for a service channel while it is being tested, testing will be suspended and the channel released. A trunk plugged busy is always passed on automatic tests, but may be selected and tested if on a manual test.

**5.22** The test frame at a DC can initiate an overall test to a radio site. When this is done, the test call is terminated on the test channel at the site and operational sequences can be checked or transmission measurements made. If the test frame at the site is manned, an overall test can be made between service channel circuits. All overall tests must be made on a manual basis.

### **I. Keying Circuit**

**5.23** An important unit used with the CUG system, although not an integral part of it, is the keying circuit. This circuit is part of the radio site dual facility trunk equipment. It is normally located in the U.S. Air Force transmitter building with the radio equipment, rather than with the telephone equipment. Circuit-wise, it is between the radio patch and test panel and the radio equipment.

**5.24** The purpose of the keying circuit is to control a radio transmitter in response to signals transmitted from the site channel circuit, to mute the associated radio receiver when the transmitter is being used, and to act as a relay point for signals from the transmitter and receiver to the CUG equipment. It also provides a means to light lamp signals at other points to indicate whether outgoing or incoming transmissions are taking place. The keying unit is used with either CUG equipment or dual facility equipment without the use of any optional wiring or change in lead designation. In all instances, there is one keying unit associated with each radio channel.

## **6. METHOD OF OPERATION**

### **A. Direction Center to Radio Site**

**6.01** The console operator at a DC is able to transmit through any site on his assigned channel by the operation of the channel and site selection keys. The operation of the site key will set the CUG equipment in operation if it is assumed the channel key is operated. When the site key is operated, the channel circuit is activated, causing it to put in a bid for a trunk through the link and controller (Fig. 6). The link and controller will test for an idle trunk and seize it. The trunk circuit at the DC then makes itself busy to other selections and, at the

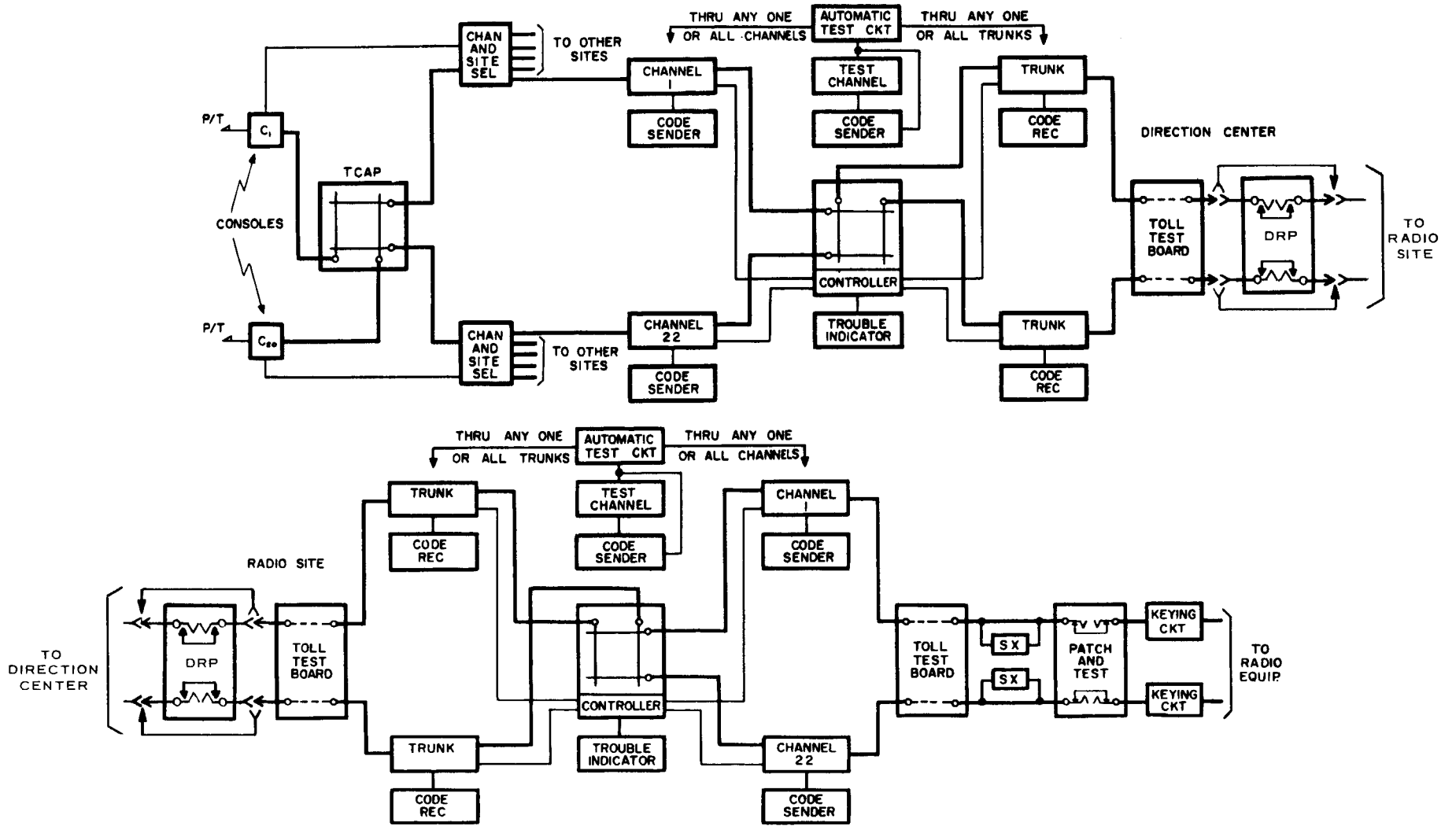


Fig. 6 - Functional Schematic of CUG Operation

same time, causes the corresponding radio site trunk circuit to do the same. Signaling between trunk circuits is accomplished by the frequency shift action of the 43A1 carrier telegraph terminals. The code receiver attached to the site trunk is now prepared to receive code pulses.

**6.02** The code sender associated with the channel circuit pulses out its particular code as soon as the above circuitry is established. Pulses from the code sender are repeated by the 43A1 terminals in the DC trunk circuit to the 43A1 terminal in the site trunk circuit to the code receiver. After the code receiver has registered the code, the site link and controller is called in to "read" the code and to select the channel that corresponds to the originating one. The channel will then be connected, the code receiver released, and a through connection will be established from the operating console to the radio equipment. Signaling and code pulsing between trunk circuits are done through the frequency shift action of the 43A1 telegraph terminals and the slot signaling technique.

**6.03** While a link and controller is functioning at the DC or at the radio site, the associated trouble indicator is prepared to display, by means of progress lamps, any failure of the call through the link and controller equipment. Should the trouble indicator be used to register a trouble, the controller is released as soon as registration is completed and is available again for service use. Failures in the channel and trunk circuits prior to their connection to the link and controller and after their connection to each other are recorded on lamps at the test and alarm frame.

**6.04** The console operator, to talk to an aircraft after connections are established, operates the push-to-talk (P/T) foot switch. This signal is relayed through the channel and trunk circuits to the keying circuit. The keying circuit, upon receiving the push-to-talk signal, keys the transmitter and mutes the receiver. This action, along with relay action in the transmitter, causes a signal to be sent back to the console lighting the "BL" lamp which notifies the operator that talking may begin. The keying action takes about one second from the time of operation of the P/T switch to the lighting of the lamp.

## **B. Radio Site to Direction Center**

**6.05** Normally, the console operator (IND) will use his TAC (channel) button and ALL SITES button when in a standby condition. Should he initiate a call to an aircraft, he will have used the TAC button and a particular site button. In either case, the incoming reply will light the CODAN lamp which is beside the site button.

**6.06** Assuming the latter case, where an aircraft has been called by the IND and a connection between the DC and the radio site is established, the following action takes place. When the IND finishes his call to the aircraft, he releases the P/T switch. This releases the keying circuit at the site, closing through the radio receiver to the talking leads. The aircraft pilot's reply is detected by the receiver which causes the keying circuit to send a signal back to the console through the channel and trunk circuits. The signal is indicated by the lighting of the CODAN lamp at the console, and the IND can hear the reply to his transmission.

**6.07** When an IND is in the standby condition (that is, when he is using the ALL SITES button), a connection from the radio site to the DC must be established. Receipt of a codan signal by a radio receiver activates the appropriate site channel circuit through the keying circuit. The CUG action is the same now as described for the DC to radio site call, resulting at the DC with the lighting of a CODAN lamp for that site on the proper console. The IND may hold the connection by operating the correct site button. The circuit functions now as though the call has originated from the console. Any incoming call connection that is not selected by an IND is released by the equipment as soon as the codan signal is removed by the radio receiver.

## **7. OTHER FEATURES**

### **A. Transfer — Automatic and Manual**

**7.01** Provisions are made in the CUG equipment for both automatic and manual transfers. Automatic transfers take place because of either tone failure or equipment failure. Manual transfers are initiated by an operator at either an operating console or the radio supervisory panel.

**7.02** When an operator determines that transmission on an established connection is unsatisfactory, he may operate the transfer key. This causes a release action in the trunk circuit. Both DC and site trunk circuits then release their channel connections, but the trunk is held busy for a short guarded interval to prevent reselection. The channel circuit at the DC, immediately on being released from the trunk, puts in a bid to the controller for another trunk. New connections are then made as for the initial call. When such a transfer is made, an alarm is sounded at the radio patch and test panel in the transmitter building and a lamp is lit to indicate which channel was unsatisfactory.

**7.03** Should a tone or equipment failure occur while a trunk is in use, the trunk is released of its connections after a time-out period of about 2.5 seconds (to distinguish the failure from a manual transfer). After the time-out period, the channel circuit bids for a new connection. In this case, the trouble alarm indications are at the toll testboard and the automatic test frame.

#### **B. All Trunks Busy**

**7.04** In the CUG system there are usually enough trunks to handle the traffic. Under emergency conditions, however, there may be more channels assigned than there are trunks available. This would lead to an all-trunks-busy (ATB) period under heavy traffic or outage conditions. To help overcome such conditions, the system is arranged to recognize an ATB period and to provide trunking facilities for all users with only a minimum of delay. A better understanding of this requires an explanation of push-to-talk seizure and site selection seizure.

**7.05** Under normal operating conditions, an IND can seize and hold a trunk to a radio site simply by operating the site selection key. This establishes a connection to a site from the DC and is known as site selection seizure. Should an IND do this and remain in a standby condition without talking and all trunks become busy, the selected trunk may be released from its connection. The IND now is still connected to the channel circuit, but does not have a trunk connection. If the operator desires to talk out through the site, operating the P/T switch will reestablish the connection. This is push-to-talk

seizure. If there is a delay in getting the trunk, a distinctive tone is provided in the IND's headset to notify him he is not connected.

**7.06** The channel circuits are broken up into two groups for releasing their trunks during an ATB period and are in the site selection seizure condition until the last available trunk has been seized. When this happens, a release circuit, which is part of a trunk and channel alarm circuit, will test one of the groups for nontalkers; that is, neither a P/T switch has been operated nor a codan signal received during the past second. The release circuit places the nontalkers in the group on push-to-talk seizure and releases the associated trunks, making them available for other DC or site originated calls. Should all trunks in a group be busy talking, the other group is tested in a like manner.

**7.07** INDs that are placed on push-to-talk seizure do not remain in this condition indefinitely but periodically are permitted to attempt to reestablish the connection, and thus may be reconnected automatically when other trunks are released or restored to service. When the ATB period has passed, all INDs on P/T seizure are reconnected and conditions are back to normal.

#### **C. Glare**

**7.08** Glare is the simultaneous seizure of the same trunk at the DC and at the radio site. This can happen if an IND and an aircraft pilot try to establish connections at the same instant and seize the same trunk. The trunk circuits are arranged to recognize such a seizure.

**7.09** In a glare condition, the channel circuits are released from their trunk connection. The link and controller will then reselect another trunk. This action takes place at both the DC and at the radio site.

#### **D. Leering**

**7.10** Leering is the simultaneous seizure of two trunks, one at the DC and the other at the radio site, to establish connections using the same channel. When this occurs, the DC controller identifies the condition by finding a connection already established to the channel when it attempts to complete the trunk connection for the site originated call. In this condition, the DC

originated call is completed and the site originated trunk will be released. Trunk operation at the DC is the same as for any outgoing call once the leering condition is removed.

## 8. MAINTENANCE

### A. Emergency Patching — Trunk and Channel

**8.01** In regular operating conditions, the channel circuits and trunk circuits are connected through the link and controller. There may, however, be some occasion where it is necessary to remove the link and controller from service temporarily. Patching jacks are provided to ensure that connections between consoles at the DC and radio equipment at the site may still be obtained on such occasions.

**8.02** All trunk and channel circuits have patching jacks which enable these circuits to be patched to one another bypassing the link cross-bar switches. These patching jacks are designated PA and PB in both trunk and channel circuits. Care must be exercised when patching is necessary, to ensure that corresponding channels are patched to corresponding trunks.

### B. Spare Channel Patching

**8.03** A spare channel circuit is provided which may be substituted for any service channel. To accomplish this, plug and jack arrangements using pin-type connectors are provided, permitting a substitution to be made.

**8.04** The code sender associated with the spare channel is not prewired to transmit a specific code. When the spare channel is used in place of a service channel, internal wiring of the plugs associated with the service channels permits transmittal of the code that corresponds to that of the service channel.

**8.05** A spare idle and spare in-use lamp indicate the status of the spare channel circuit. These lamps are located beside each other with the spare channel equipment. One of these lamps should be lighted at all times.

### C. Alarms

**8.06** Audible alarms or lamp signals, or both, are provided at the DC and at the radio site to indicate equipment failures, line trans-

fers, and tone failures. The alarm appearances are determined by the maintenance responsibility.

**8.07** Equipment failures in the channel and trunk circuits and in the link and controller are activated by time-out features in the circuits. If a channel or trunk circuit fails to function properly when a connection is being established through the controller, the trouble indicator is called in and an alarm is sounded. The progress lamps on the trouble indicator will show how far the call has progressed.

**8.08** Equipment failures in the link and controller can cause either major or minor alarms. In the common relays portion of the controller, there are three chain circuits. Should one of these remain open for a short-timed interval, a major alarm is sounded and the trouble indicator is called in. If either the A or B controller unit fails to function properly, the call is switched to the other unit and a minor alarm is sounded if the call progresses. If both of the controllers fail, a major alarm is sounded. In both cases, the trouble indicator registers the controller in trouble. A major alarm is also sounded if there is a grounded start lead in the controller and both the A and B units have been tried. All start leads have individual keys which can open the lead if it becomes grounded and temporarily ties up the controller.

**8.09** Tone failures cause a trunk transfer and a minor alarm and lamp signal at the toll testboard. Manual transfers bring in lamp signals at the radio patch and test panel.

## 9. EQUIPMENT ARRANGEMENTS

### A. General

**9.01** Each common user group system is arranged and equipped for 22 channels and a maximum of 40 trunks, which are to be equipped as specified. The associated test and alarm frame at DCs is arranged to care for a maximum of eight common user group systems. At radio sites, this frame is arranged to care for one or two common user group systems.

### B. Description

**9.02** At DCs, the CUG equipment is mounted on 11-foot 6-inch frames arranged for 23-inch mounting plates. At radio sites, the same frames

are ordinarily used but 9-foot 0-inch frames are available for use where ceiling heights do not permit the use of 11-foot 6-inch frames. At DCs and at radio sites using 11-foot 6-inch frames, three types of frames are used. The channel frame is a double frame and mounts the channels, the relay part of the link and controller, and the trunk jacks. The trunk frame is also a double frame and mounts ten trunks and the crossbar switches of the link and controller associated with them. Two-, three-, or four-trunk frames may be used, depending on the number of trunks furnished. The test and alarm frame for DCs is a double frame and will serve a maximum of eight common user group systems. The test and alarm frame for radio sites is a single frame

and will serve one or two common user group systems.

**9.03** At radio sites using 9-foot frames, five types of frames are used. The channel frame is a double frame and mounts the channels, the keys, and the lamps of the link and controller, and the trunk jacks. The controller frame is a single frame and mounts the relays of the link and controller only. The trunk frame is a double frame and mounts eight trunks and the crossbar switches of the link and controller associated with them. A supplementary trunk frame mounts four trunks. The test and alarm frame is a double frame and will serve one or two common user group systems.