B & M # 718B

SAGE DATA TRANSMISSION SYSTEMS — PRIVATE SERVICE SYSTEMS
AIR-GROUND VOICE COMMUNICATION SYSTEM
DESCRIPTION — DUAL FACILITY TRUNK EQUIPMENT

CONTENTS

1. GENERAL

A. Introduction

1.01 This section describes the dual facility (DF) trunk circuit which has been designed and developed for use in the SAGE system for the control of air-ground (A/G) voice communications.

1.02 This circuit provides for talking, signaling, and supervision over long distances, usually between a direction center (DC) and a radio site, on either one of two 4-wire voice circuits. One voice circuit is known as the "regular" and the other as the "alternate." The physical route that the regular trunk follows between the DC and the radio site is not the same as that taken by the alternate trunk.

B. Principal Features

1.03 The principal features of the DF trunk circuit are:

(a) To recognize and transmit a push-to-talk signal from an operating console.

(b) To cause a remote radio transmitter to radiate carrier in response to a push-to-talk signal by the use of a remote keying unit.

(c) To mute the associated radio receiver when the push-to-talk signal is received in the keying unit.

(d) To provide a visual lamp indication to the operator that the transmitter is on the air.

(e) To enable a radio receiver to activate the circuit and provide a visual signal (CODAN lamp) to the operator indicating an incoming transmission.

(f) To provide a means to transfer the voice and signaling leads from the regular side of the DF trunk to the alternate side when there is a line failure or a desired transfer.

(g) To provide a continuous monitoring tone on the trunks.

(h) To actuate certain visual and audible alarms for maintenance purposes.

C. General Operation

1.04 The DF trunk circuit provides A/G voice circuits and transmits signals between a direction center and a radio site. By operating a push-to-talk switch at a console in a direction center, the operator is able to key a radio transmitter and

mute the associated radio receiver. When the transmitter has reached proper signal strength an acknowledgement signal is returned to the operator. On an incoming call a codan signal is sent from the site indicating to the console operator that carrier is being received by the radio receiver. Fig. 1 and 2 indicate the position of the DF equipment in the A/G voice communications system.

1.05 Dual 4-wire circuits are used with each trunk circuit with continuous monitoring tone applied on the trunks at all times. Should one of the routes fail or the monitoring tone be interrupted, an automatic transfer to the alternate route will take place. Should a trunk prove to be noisy or otherwise unusable, the operator by operating a transfer key can initiate a transfer to the other trunk.

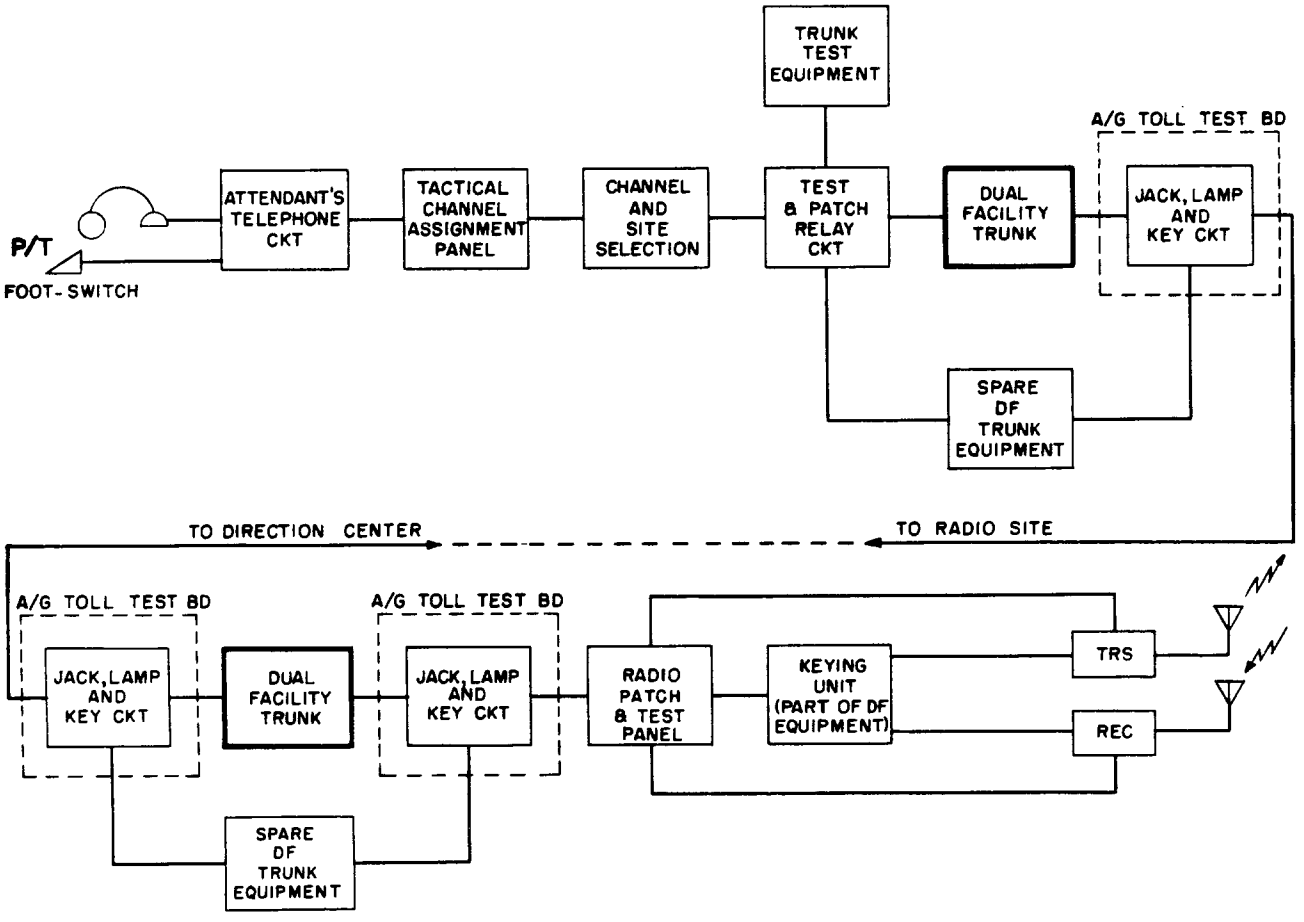

Fig. 1 - Direction Center and Radio Site

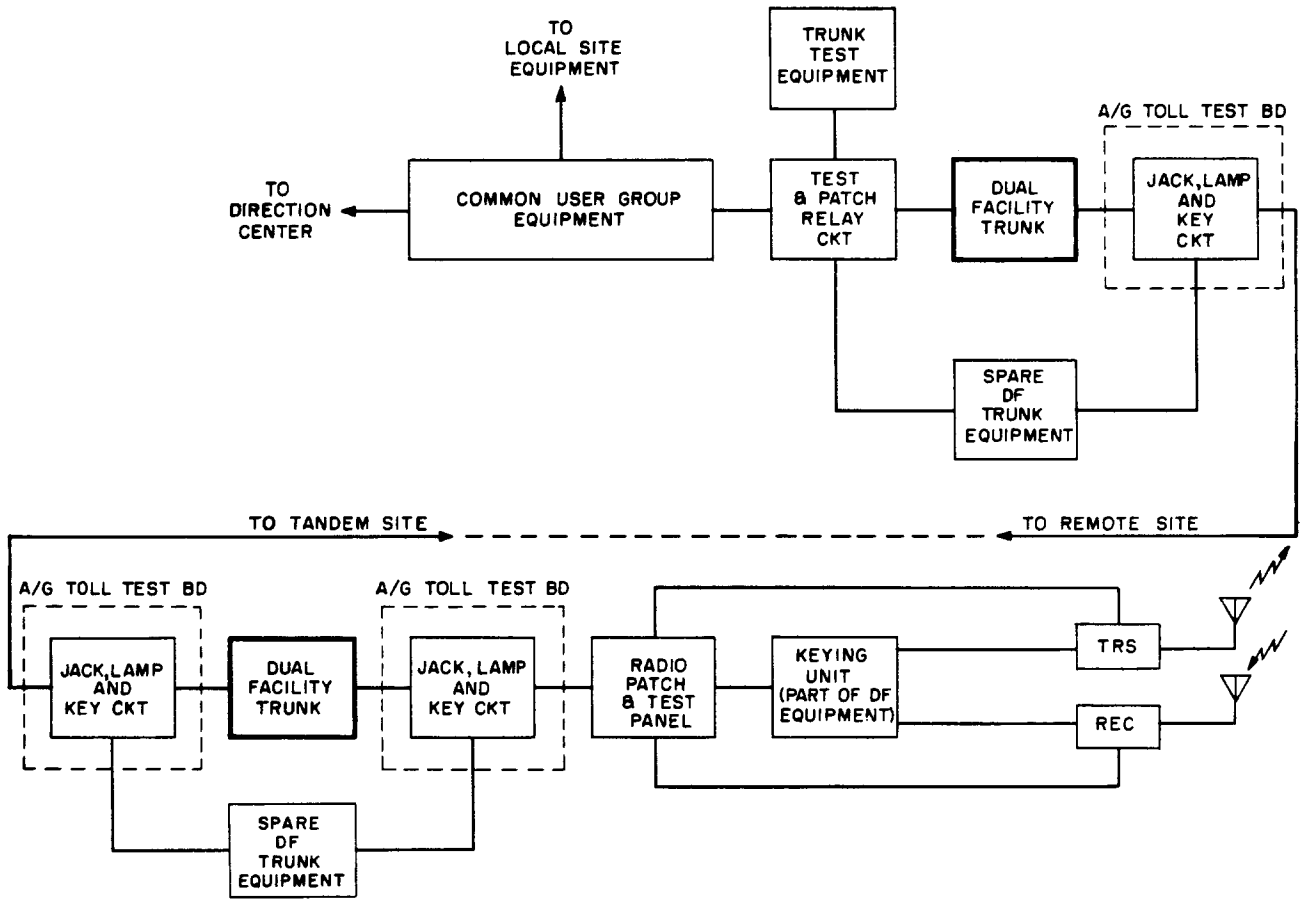

Fig. 2 - Tandem Site and Remote Site

2. SIGNALING

A. Principles and Application

2.01 Dual facility 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 regular talking path and 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 the primary functioning part of the circuit. Therefore, it is important to cite its main features and application.

2.02 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. Channels 13 and 14 are used in the DF circuit centered on midband frequencies of 2465 cycles and 2635 cycles, respectively. Channel 13, the lower of the two, is used for transmitting from the radio site to the direction center, and channel 14 from the direction center to the radio site. Signaling is accomplished by a frequency shift on the lower band between 2500 cycles and 2430 cycles and on the higher band between 2670 cycles and 2600 cycles.

2.03 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 receivin (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 the signaling frequency band. The purpose of these filters in DF is to prevent the voice frequencies in the signaling range from interfering with the signals being received by the 43A1 terminals and to prevent the signaling frequencies in the speech spectrum from entering the trunk circuits. It can be seen that speech frequencies in the signaling range will not enter the trunks and signaling tones are confined to the trunks. Thus, it is possible to provide signaling on a regular talking circuit with only small impairment to voice transmission due to filter action.

2.04 Fig. 4 indicates in outline form the manner of application of the 43A1 terminals to two 4-wire circuits to permit the switching from one to another in the event a failure occurs on either circuit. This is done in such a way as to prevent any noticeable service interruption. The transfer from one circuit to the other is accomplished by the action of the relay

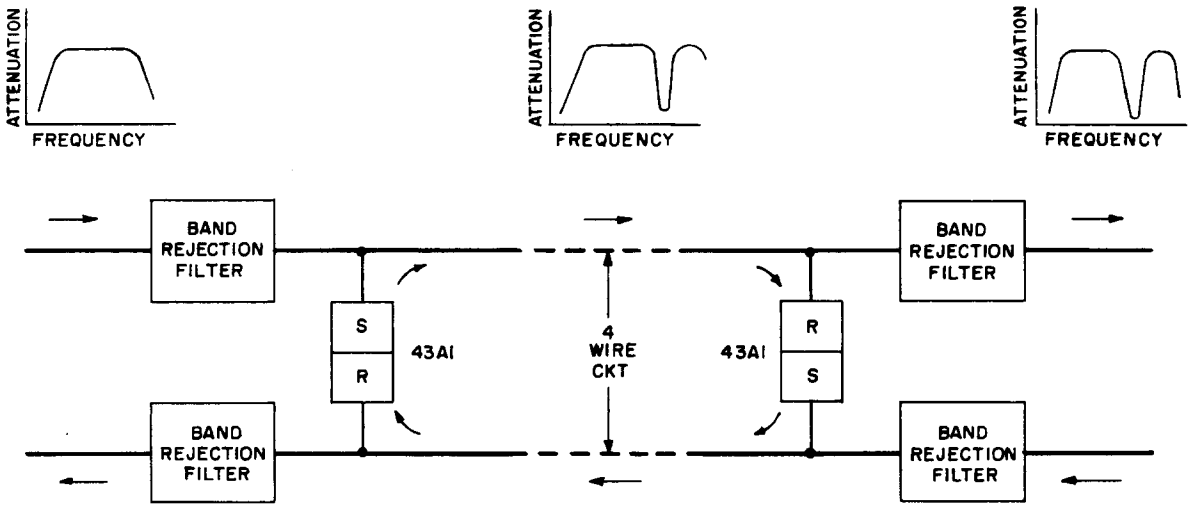

Fig. 3 - Use of 43A1 Terminals With One 4-wire Circuit

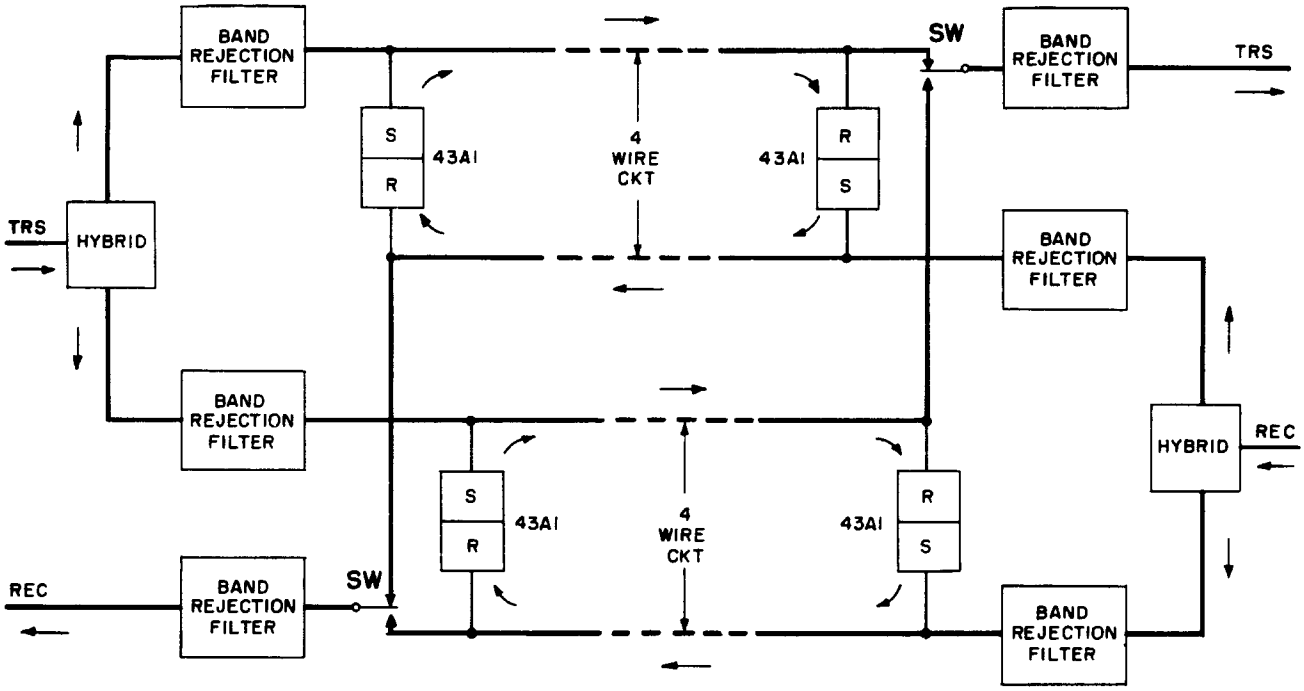

Fig. 4 - Use of 43A1 Terminals With Two 4-wire Circuits

contacts designated SW. The action of the band rejection filters is the same as outlined above. The hybrid coils permit parallel sending between DC and radio site without interference between regular and alternate trunks.

B. Monitoring and Transfer

2.05 A single 43A1 terminal is a 3-state device with one condition for each of the two signaling frequencies and one for the off or no-tone condition. Since one of the two frequencies is normally on the line at all times, it is possible to obtain pilot tone monitoring. By connecting the signaling equipment on the drop side of the regular trunk carrier equipment, the means is provided to monitor the over-all speech path.

2.06 The interruption of the signaling tones will cause an immediate transfer whether the interruption is caused by a manual signal or a trunk failure. A timing feature in the circuit distinguishes between the two conditions and causes an alarm in either the U. S. Air Force or telephone company maintenance section. For example, an interruption of less than approximately 1 second will provide a signal to Air Force personnel signifying a manual transfer. An interruption in excess of 2 seconds, which in all probability would be a trunk failure, will provide a signal to telephone maintenance personnel. This timing feature, however, does not in any way delay the trunk transfer action.

3. TRANSMISSION

A. General

3.01 The DF 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 over-all loss of about 2 db in the transmission path. Fig. 5 presents typical frequency response curves for the filters.

3.02 The location of the signaling band with respect to 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 midband frequency of the rejection band is increased, assuming that the noise is negligible or has about the same frequency spectrum as the speech.

B. Line Loss Objectives

3.03 The transmission levels for use in the 1000-cycle line-up of the circuits, in the case of remote operation of the radio equipment, are for an over-all line loss objective of 14 db in the outward direction from DC to radio site and 18 db for the inward direction from radio site to DC. For local operation, or when the radio site is relatively close to the direction center, such as "on base," the over-all line loss objective in the outward direction is 14 db and, for the inward direction, a maximum 24 db. These figures are based on a maximum allowable local cable loss of 8 db at 1000 cycles between DC and radio site.

4. EQUIPMENT ELEMENTS

A. Trunks

4.01 The DF trunk requires the use of two 4-wire circuits and provides for transfer or throw over from one to the other to guard against service interruptions. This throw over takes place automatically in the event of tone failure from the 43A1 terminals or manually through the use of the line transfer button. As stated previously, one set of the 4-wire circuits is known as the "regular" and the other as the "alternate."

B. 43A1 Carrier Telegraph Terminals

4.02 43A1 Carrier Telegraph Terminals are bridged across each 4-wire circuit at the terminating and originating ends making a total of two terminals at each end. Each terminal has associated with it two plug-in type networks, one for sending signals and the other for receiving signals.

4.03 Some adjustments and limitations of the 43A1 terminals applicable to the DF circuits are as follows:

(a) The SEND switch on the terminals at the DC is set in the high-frequency

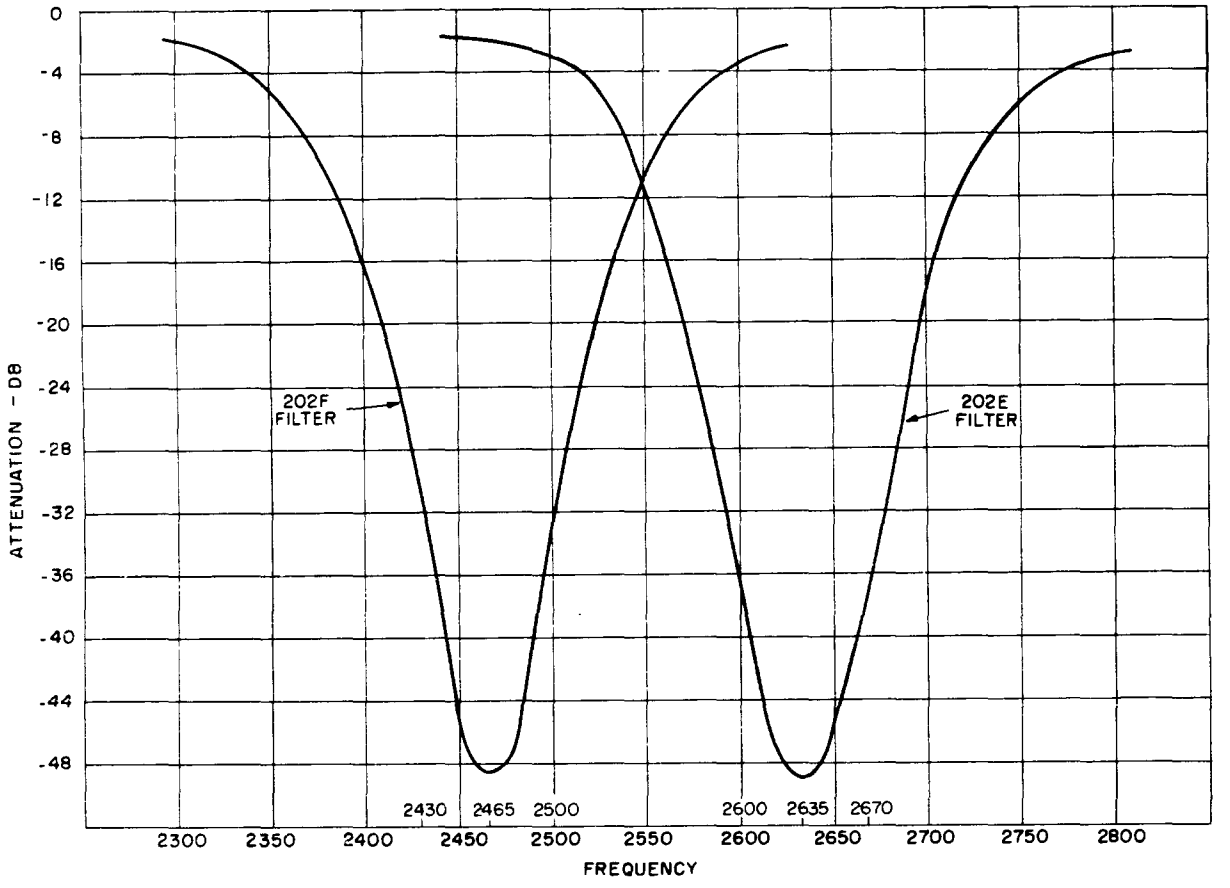

Fig. 5 - Characteristics of Filters

mark position or "HM" and at the site end in the low-frequency mark position or "LM."

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

(c) The SEND LEV potentiometer is adjustable for setting the transmitting level from the 600-ohm sending network to a maximum of +6 dbm.

(d) Noise conditions permitting, transmission and supervision will function at a minimum receive level of about -40 dbm at the input to the terminal receiving network. This figure is greater than the minimum specified for the terminal but it is a recommended limit for this circuit. The receive gain is adjustable by the use of the REC GAIN control.

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

4.04 A separately fused 130-volt battery source is provided for each 43A1 carrier telegraph terminal. This is done to prevent a complete circuit failure due to the loss of 130-volt battery supply by a fuse operating. Also, in the event a fuse does operate, an automatic transfer to the other circuit will occur.

4.05 Supervisory relays are wired directly to the 43A1 terminals. These relays respond to the "tone off" and "tone on" conditions caused by either line failures or a transfer condition activated by an operator at the direction center.

4.06 To prevent interference between speech and signaling, the frequency components of speech in the signaling range are removed or blocked by the band filters. Type 202 filters are used for this purpose. The transmitting pairs use a 202E filter with a rejection band from about 2500 to 2800 cps, and the receiving pairs a 202F filter

with a rejection band from about 2300 to 2600 cps. The discrimination at the signaling frequencies is approximately 35 db.

4.07 Other relays and lamps are associated with the circuit. These are controlled by manual means, by the action of the supervisory relays, or by the action of the transmitter or receiver. A timing feature is used in the circuit to distinguish between an actual line failure or a momentary delay of operation.

C. Trunk Terminations

4.08 The talking path from the control point or operator position to the DF equipment is a 2-wire circuit. By the action of the PT relay (Fig. 6) these leads are connected either to the transmitting or receiving pairs. At the DC end, a hybrid coil enables the transmitting pair to be provided two routes to the site. At the site end, a hybrid coil enables the receiving pair to be provided two routes to the DC (Fig. 4).

4.09 Resistance terminations are placed on idle trunks. At the DC, a 600ω resistance is bridged across the input side of the hybrid coil providing for proper balance of the coil in the receiving or idle condition. When the push-to-talk switch is operated this resistance is transferred to the receiving pairs. At the site a 1000ω resistance is bridged across the receiving (from DC) side of the alternate trunk. This resistance is transferred to the regular trunk by the action of the switching relay.

D. Keying Circuit

4.10 A portion of the circuit at the site end is referred to as the keying unit. Although schematically a part of the DF circuit, it is physically separated from it and will be located normally in the U. S. Air Force Transmitter Building with the radio equipment rather than with the telephone equipment. As shown in Fig. 1 and 2, it is located between the Radio Patch and Test Panel and the radio equipment.

4.11 The purpose of the keying unit, in response to signals transmitted via the DF trunks, is to control a radio transmitter by turning carrier on or off, 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 trunk equipment. It also provides a means to light lamp signals at the radio patch and test panel to indicate whether outgoing or incoming transmissions are taking place. The keying unit may be used with either common user group equipment or DF 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 equipment (transmitter and receiver).

E. Equipment Mounting

4.12 All of the trunk equipment is mounted on 23-inch mounting plates on standard relay racks with the following limitations:

(a) On 11-foot 6-inch relay racks there will be eight dual facility trunk equipment per bay.

(b) On 9-foot relay racks there will be six dual facility trunk equipments per bay.

(c) When 7-foot cabinets are used, which may be at on-base sites, five dual facility trunk equipments are mounted in each cabinet.

5. METHOD OF OPERATION

A. Direction Center to Radio Site

5.01 Fig. 6 shows a functional schematic of the DF trunk. As shown, each of the 4-wire circuits has wired to it a 43A1 carrier telegraph terminal at the direction center (DC) end and at the site end. In the normal condition the DC sends a 2670-cycle tone to the radio site and receives from the radio site a 2500-cycle tone. These tones are the signaling and monitoring tones.

5.02 When a console operator at the DC operates his push-to-talk foot switch, a push-to-talk signal results causing both 43A1 terminals at the DC to shift frequency from 2670 to 2600 cycles. This shift is recognized at the radio site by the 43A1 terminal of the trunk in use which relays the push-to-talk signal to the keying circuit. The keying circuit, being connected directly to a transmitter, turns on the transmitter causing it to radiate carrier. This sequence of operations takes place in about 0.1 seconds. When it is recognized that carrier is being emitted, an acknowlegment signal (carrier on) is sent back from the transmitter to the site 43A1 terminals through the keying circuit causing a frequency shift from 2500 to 2430 cycles. This shift is recognized by the 43A1 terminals at the DC and a visual lamp signal is provided to the operator indicating that actual voice transmission may begin. The over-all period of time from operation of the push-to-talk switch to the lighting

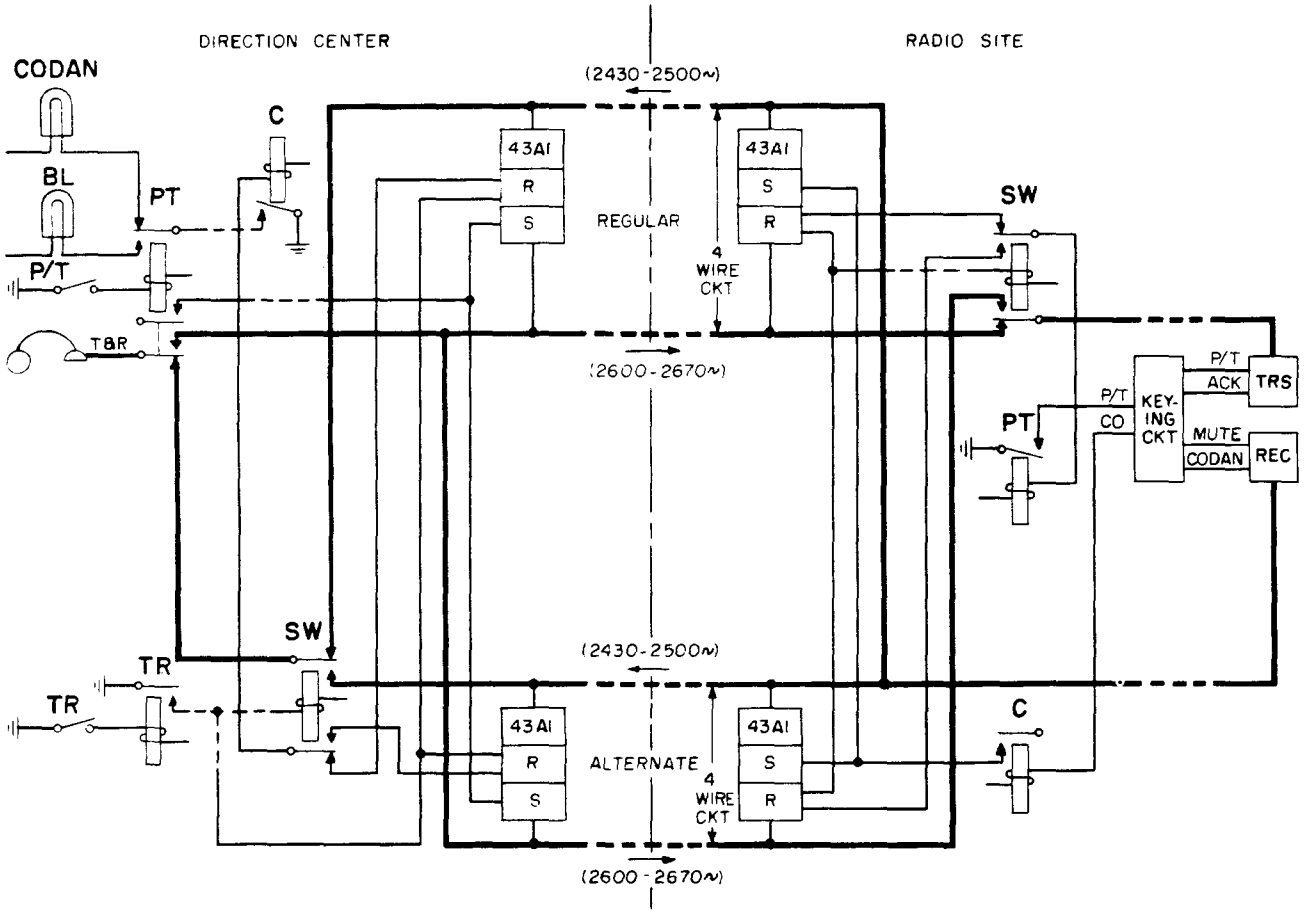

Fig. 6 - Functional Schematic of Dual Facility Trunk

of the TAC lamp is approximately 0.6 seconds. This assumes about 0.4 second for operation of the carrier-on relay associated with the radio transmitter.

B. Radio Site to Direction Center

5.03 In the normal condition both ends of the circuit are in the receive position. When a radio receiver set for a particular frequency picks up a radio signal from an aircraft operating on the same frequency, a codan relay associated with the receiver assigned to that channel is operated providing a signal to the DF equipment through the keying circuit. This causes a frequency shift at the site 43A1 terminals from 2500 to 2430 cycles which in turn is recognized by the DC terminals. A codan lamp is then lighted at the console through the action of a trunk relay advising the operator of an incoming transmission. This series of operations takes approximately 75 milliseconds.

C. Alarm Indications

5.04 Audible alarms or lamp signals, or both, are located at various points to indicate trunk failures, line transfers, and "in-use" conditions. At the telephone company toll testboard in the DC, lamp signals are provided to indicate whether the regular or alternate trunk is in use. Should either trunk fail, the "in-use" lamp (R or A) is changed accordingly and an audible alarm is given, as well as a lamp signal (STA or STB), to indicate which trunk failed. When a manual transfer takes place, a visual and audible alarm is indicated at the U. S. Air Force Radio Supervisory Panel, indicating which trunk has been transferred to the other route. The "in-use" lamp also changes at this time at the testboard. The Radio Supervisory Panel is provided and maintained by the telephone company.

5.05 At the radio site at the toll testboard, similar trunk failure (STA and STB) and "in-use" (R and A) lamp signals are provided but with no audible alarms. When a manual transfer takes place audible and visual alarms are provided at the Radio Patch and Test Panel indicating the trunk which has transferred. When a trunk failure occurs, the failure is indicated at both the DC and site on the toll testboards.

6. CONNECTING EQUIPMENT

A. Direction Center

6.01 Dual facility trunks are connected on the line and drop sides to other pieces of equipment, as shown in Fig. 1 and 2. At a DC or tandem point the trunks are connected on the line side to jacks of the Jack, Lamp, and Key Circuit on the toll testboard. Here they may be patched to any of the outgoing toll trunks or opened and the spare trunk equipment be substituted. On the drop side at the DC or at a tandem point the trunks are connected to the test and patch relay circuit. Each bay of DF equipment will have mounted at the top of the bay the test and patch relay equipment associated with the DF trunks mounted in that bay. The purpose of the test and patch relay circuit is to transfer the leads on the drop side of a DF circuit to a spare DF circuit and to provide test access to any trunk.

6.02 When it is desired to substitute the spare trunk equipment for any regular trunk equipment, the transfer on the line side is made by connecting a patching cord from the regular trunk line jacks to the spare trunk equipment jacks. The transfer on the drop side of the trunk equipment is made by inserting a short-circuiting plug in the toll test PTCH jack for the particular trunk being removed from service. This operates a relay which transfers the leads to the Radio Channel and Site Selection circuit from the regular trunk to the spare trunk.

6.03 A test relay is provided for each trunk equipment, including the spare, to disconnect the leads on the drop side of the trunk from the regular key equipment or CUG channel circuit and to connect them to the trunk operational test circuit. To do this, the plug of a test cord at the toll testboard is inserted in the TST jack of the particular trunk to be tested and a key is operated. This connects all the trunk leads, except the T and R, to multiple to the trunk operational test circuit. It is not necessary to connect the T and R since they appear on the TST jack.

B. Radio Site

6.04 At the site or terminating end, the DF trunk equipment is connected both on the line and drop sides to the Jack, Lamp, and Key Circuit which provides access for testing, patching, and monitoring on the circuits.

6.05 There are instances where the DF trunk will be connected at a tandem point to common user group equipment (Fig. 2). In cases such as this, the Channel and Site Selection circuit and Tactical Channel Assignment Panel are not directly associated with the DF trunk equipment