

GENERAL DESCRIPTION

1600- OR 2000-CYCLE SINGLE FREQUENCY SIGNALING SYSTEM

EQUIPPED WITH SIGNALING CIRCUIT SD-56202-01

TOLL SYSTEMS

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1. INTRODUCTION

1.01 The SF signaling system was developed to extend the range of pulse operation over intertoll trunks. It is an a-c system in the voice range, and therefore dial pulses and supervisory signals can be transmitted over the same distance as the voice. It will be used where the lengths of trunks are beyond the range of simplex or composite signaling, or where the number of available d-c channels is not adequate for all the voice channels, as is usual on carrier routes.

1.02 This signaling system is essential for the extension of dial operation of intertoll trunks to meet nationwide operator toll dialing requirements.

1.03 Under the nationwide system, the originating toll operator has control of the entire connection, both its completion and release, and receives switchhook supervision from the called station as well as from the calling station. Signals must be sent in both directions to enable the operator to establish the connection, to charge for it, and to release it.

1.04 Efficient nationwide dial operation requires that all intertoll trunks provide for rapid 2-way transmission of the necessary supervisory signals in addition to meeting the requirements of speech transmission and pulsing. For efficient dial operation the supervisory signals required are:

From the Originating End to the Terminating End

- (1) A seizure signal which causes the connection of digit receiving equipment at the terminating end.
- (2) A disconnect signal which causes the release of the circuits at the terminating end and beyond.
- (3) A ring forward signal which brings in a distant operator or causes the ringing of the called subscriber.

From the Terminating End to the Originating End

- (1) A start pulsing signal which indicates that the digit receiving equipment is ready.
- (2) A stop pulsing signal where it is desired to interrupt the progress of the digit transmission.
- (3) A called party answer signal.

(4) A called party disconnect signal.

(5) A ring back signal which recalls the originating operator.

(6) A line busy signal which flashes the supervisory lamp of the originating operator in a distinctive fashion.

(7) Paths busy, overflow and master busy signals which flash the originating operator's supervisory lamp at distinctive rates.

1.05 These signals can be transmitted by d-c signaling methods. However, d-c signaling (composite signaling) is not practical or economical on trunks more than 300 miles long. Furthermore, composite signaling is not adequate when carrier facilities are employed for dial intertoll trunks because the number of voice channels over a carrier system usually exceeds the number of available composite signaling channels. It is therefore necessary to use additional cable pairs to obtain sufficient d-c signaling channels.

1.06 The extension of dial operation of intertoll trunks to a nationwide scale and the increasing use of carrier facilities require a new approach to meet the above signaling requirements.

1.07 The SF signaling system provides for 2-way transmission of supervisory signals over the same channel as voice and for the same distance. It does this by using signal tones of one or two distinct frequencies (1600 or 2000 cycles) in the voice band. Briefly, the principle used is as follows. At each end of the trunk a single frequency signal tone source is provided. This tone is applied or removed from the trunk under control of the intertoll trunk relay circuit. At the opposite end of the trunk a vacuum tube receiver responds to the application or removal of the signal tone, and then passes d-c signals to its associated trunk relay circuit.

1.08 All the supervisory signals required for dial pulsing and multifrequency pulsing intertoll trunks can be transmitted by this method. In addition, like composite signaling, the SF system can be used on dial pulsing trunks to transmit the digit pulses which route the call to the called station.

1.09 The signaling frequencies are on the trunks while they are idle, but not during the talking period. This arrangement differs from the usual practice followed in the design of trunk signaling circuits, which is to use no current for the trunk idle condition. However, the objectives in this case: namely, (a) a minimum interference to voice by signal frequency, and (b) the need for a continuous and positive signaling system are important enough to change the practice in this case. The on and off intervals of the signal frequency

tones are of the same length as the d-c signals applied to the system by the inter-toll trunks. For example, an on-hook signal is indicated by a steady tone on the line and this signal indication exists until tone is removed, while an off-hook signal is indicated by removal of tone and this signal indication exists until tone is applied. This method is classified as continuous signaling and on account of its continuity is superior to so called spurt signaling methods (such as ringdown). Ringdown operation applies a spurt of tone for signaling. At all other times no signal is on the trunk.

1.10 The main components of the SF system are a tone supply, a signal transmitter, and a signal receiver at each trunk terminal. Like composite signaling, the SF system uses E and M leads to pass the signals to and from the trunk relay circuit. The transmitter, under control of d-c signals obtained via the M lead, alternately applies and removes tone from the trunk. The receiver at the distant terminal changes the tone signals to d-c signals and sends them via the E lead to the associated trunk relay circuit at that end.

1.11 The transmitters and receivers are connected at all times, and therefore safeguards are used which provide for non-interference between speech and signals.

1.12 The SF system was designed especially for 4-wire facilities and when so applied, signal tones of 1600 cycles are transmitted in both directions (see Fig. 1). Two-wire facilities can be used by providing 4-wire terminating sets. In this case

signal tone of 1600 cycles is transmitted in one direction and 2000 cycles in the opposite direction (see Fig. 2). A different frequency is required in each direction because of echoes around intermediate hybrid coils. This is explained in Part 2 - FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS.

1.13 The SF signaling system can be connected in tandem with another single frequency system or with a composite signaling system by means of a pulse link circuit. The pulse link circuit transmits the signals received over the E and M leads from one circuit to the M and E leads of the next circuit.

1.14 Converter circuits permit the application of SF signaling to ringdown trunks. The converters change the d-c or low frequency a-c signals received from the ringdown trunk circuit to those accepted by the SF circuit and vice versa. SF signaling is used for ringdown operation primarily when one or both terminals of the system are soon to be converted to dial operation.

1.15 The spurt signaling method is maintained when SF signaling is used over ringdown trunks between toll offices. In this case spurts of SF tones are used to signal, and no tone is on the line during the idle condition. In this manner, SF ringdown operation differs from SF dial operation where tone is present on idle lines.

1.16 To sum up, the function of the SF signaling system is to exchange ringing, pulsing, and supervisory signals between two toll offices. The signals are

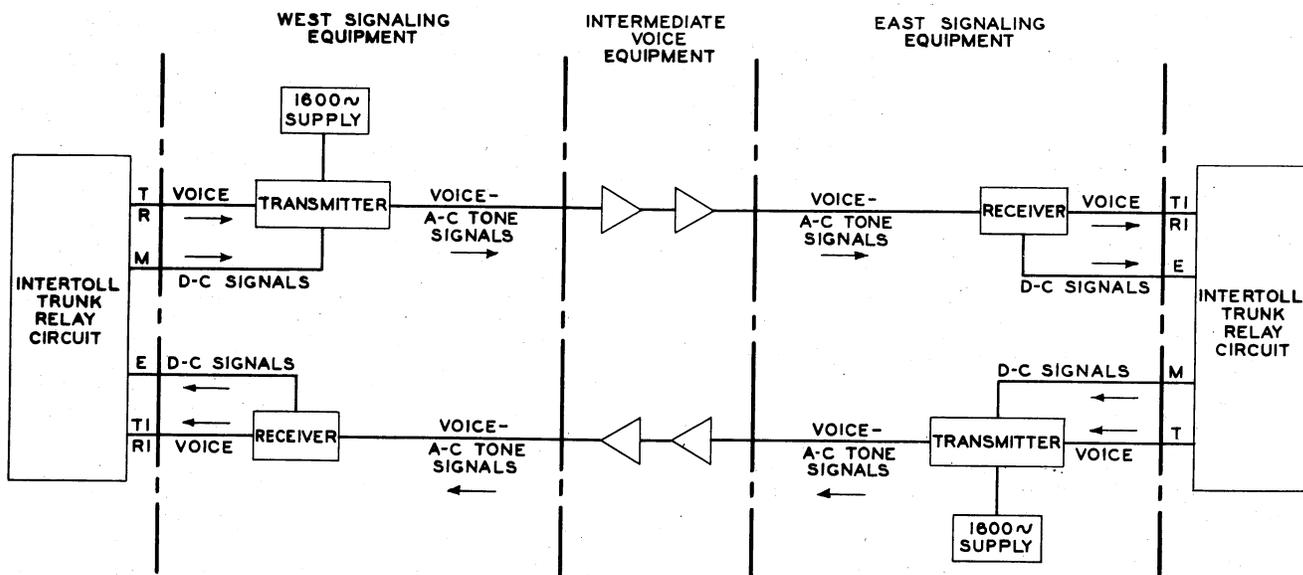


FIG.1-SINGLE FREQUENCY SIGNALING APPLIED TO 4-WIRE LINE FACILITIES

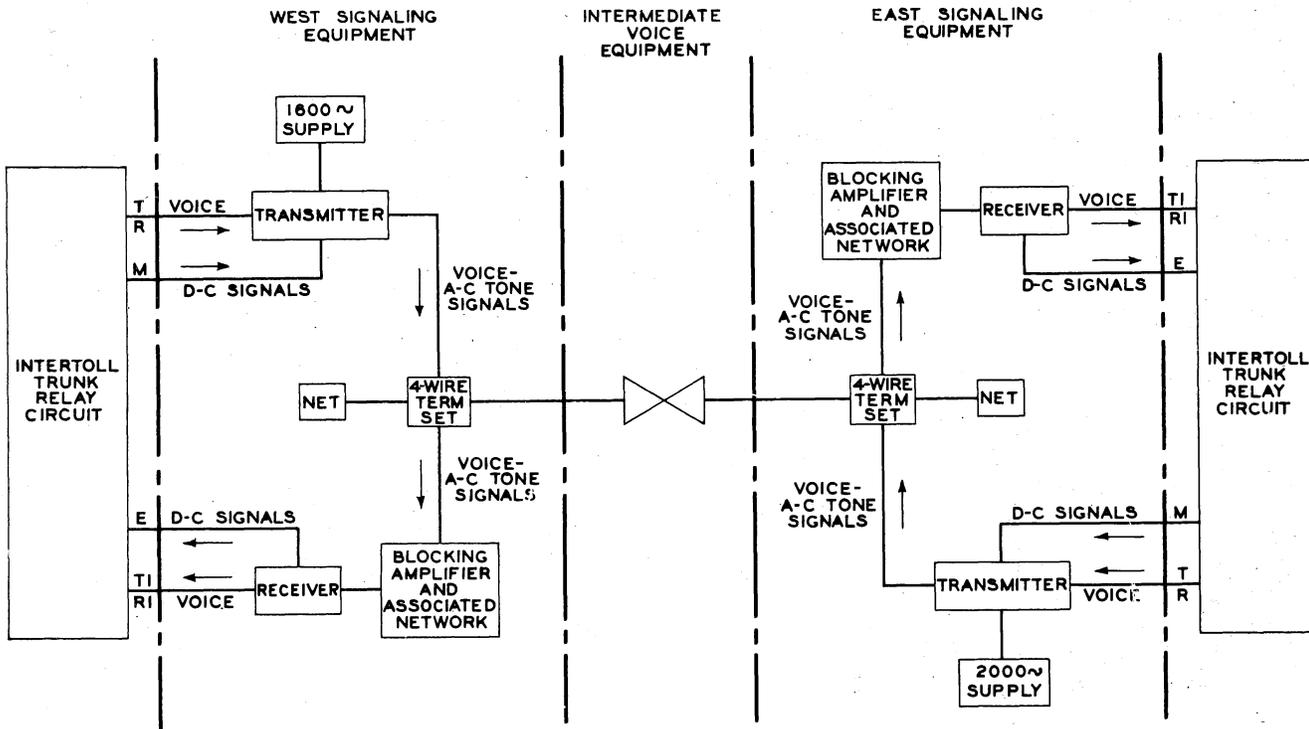


FIG.2-SINGLE FREQUENCY SIGNALING APPLIED TO 2-WIRE LINE FACILITIES

exchanged by the application, removal, or interruption of distinctive tones. Two levels of tone are used, low level and high level. Low level tone is used during the idle condition, that is, prior to seizure. High level tone is used after the circuit has been engaged, for example, for pulsing and for the disconnect signal. Because these tones are within the voice band and the signaling circuit is bridged across the voice channel, safeguards are provided to prevent false operation of the signaling circuit by signaling frequencies present in voice, music, or any extraneous noise. Conversely, safeguards are provided which prevent signaling tones from interfering with voice reception in those cases where the tones are present during a talking condition, as for example, on intercept calls.

2. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS

(A) General

2.01 This part describes the basic circuit functions of the equipment elements used in the SF signaling system. These elements are:

- (a) 1600- or 2000-cycle supply circuit.
- (b) 1600- or 2000-cycle signaling circuit.

(c) Pulse link circuit.

(d) Converter circuit.

(B) 1600- or 2000-Cycle Supply Units

2.02 A vacuum tube oscillator at each terminal of the system furnishes the a-c tone used for signaling. These oscillators are adjusted to 1600 cycles when 4-wire facilities are used between signaling terminals. When 2-wire, or combinations of 2-wire and 4-wire facilities are used, the oscillator at one terminal is adjusted to 1600 cycles and that at the other to 2000 cycles.

2.03 The frequency of the signal tone is maintained to ± 3 cycles. By holding the frequency within these close limits it was possible to make the band width of the discriminating network (which passes the signaling tone) narrow. This lessens the possibility of false operation of the receiver by voice energy during the talking period.

2.04 The output of an oscillator is set at either of two levels, -6.6 or -9.6 dbm (0 dbm = 1 milliwatt), depending upon the voice level point at which the signaling system is connected to the voice channel, as will be explained in (C).

2.05 The tone supply unit used in large installations has two oscillators which share the load for a maximum of 104 signaling systems. Failure of one oscillator causes the automatic transfer of its load to the other oscillator, at the same time sounding an alarm.

2.06 Front and rear views of this unit are shown in Fig. 3. Two sensitrol relays, one for each oscillator, monitor the output of the oscillators and operate the transfer relays and the alarms when the output is outside of limits.

2.07 The tone supply unit used in small installations has a single oscillator which furnishes signaling tone for a maximum of two signaling systems. Failure of this oscillator causes an alarm to be sounded, which the maintenance forces must answer immediately since there is no mate oscillator.

2.08 Front and rear views of this unit are shown in Fig. 4. The output of the oscillator is monitored by a normally operated relay instead of a sensitrol relay.

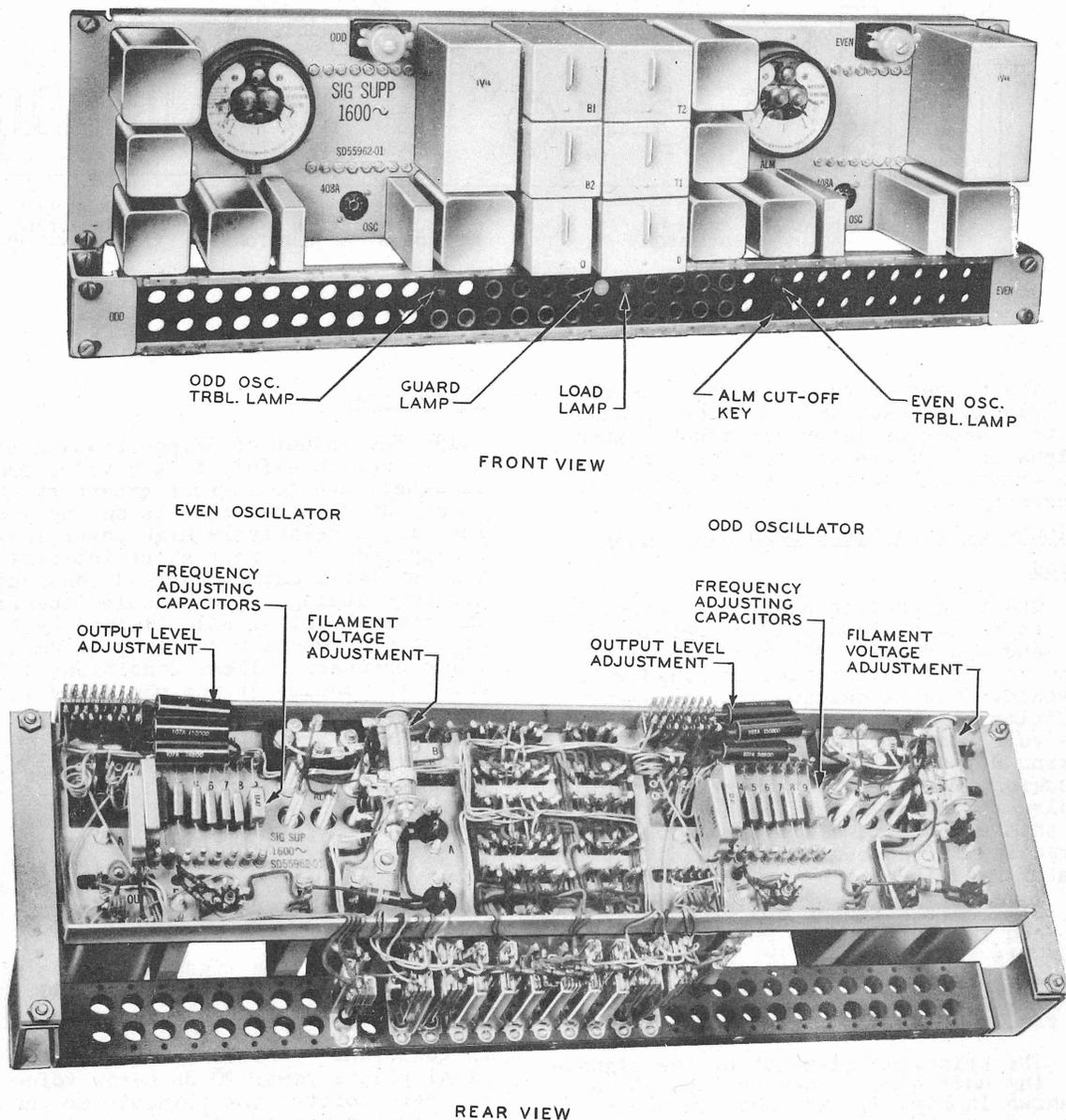


FIG. 3 - SINGLE FREQUENCY SUPPLY UNIT FOR LARGE INSTALLATIONS

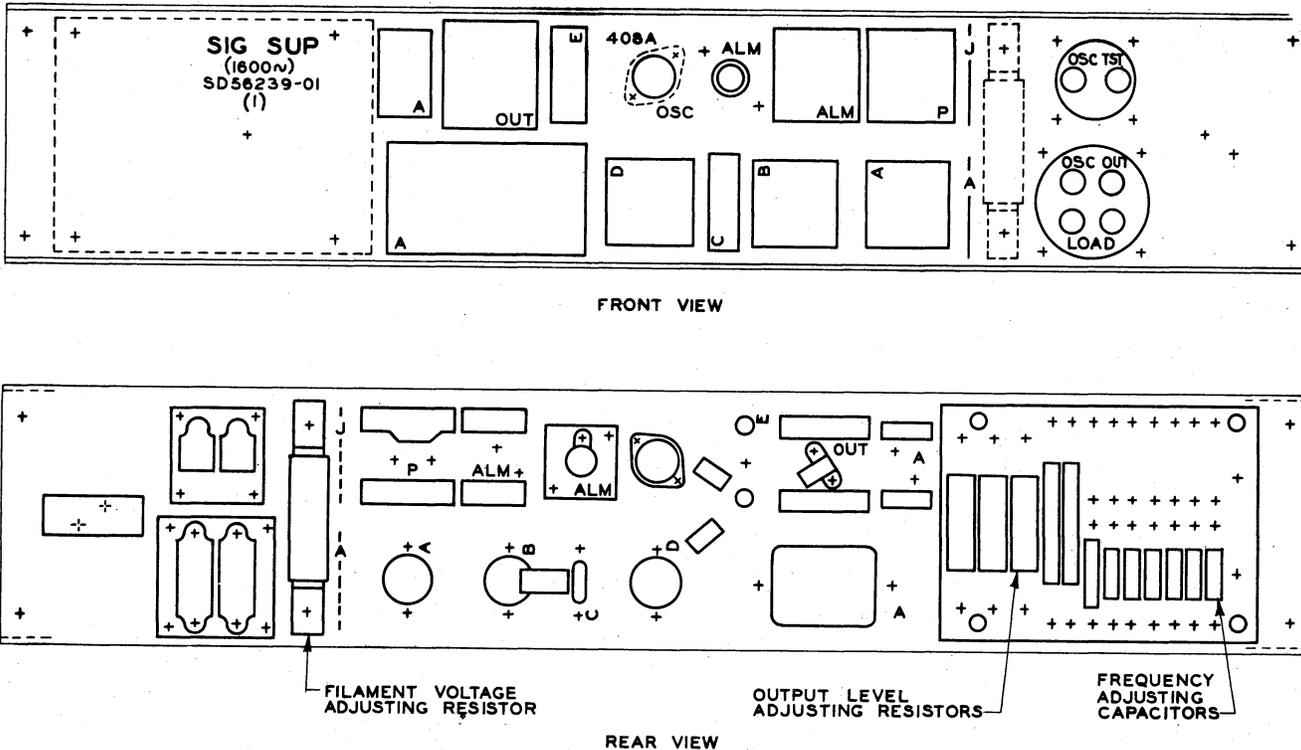


FIG.4-SINGLE FREQUENCY SUPPLY UNIT
FOR SMALL INSTALLATIONS

2.09 The number of each type of tone supply units used in an office depends upon the number of intertoll trunks using SF signaling. There are various arrangements which will be described in (F), Bay Arrangements.

(C) 1600- or 2000-Cycle Signaling Units

General

2.10 The SF signaling units are connected to the oscillators described in (B). They send and receive all the signals required for dial, automatic, or ringdown operation. The signaling unit for 4-wire facilities has a transmitter, a receiver, and a voice amplifier with its associated blocking network. For 2-wire facilities a blocking amplifier and a blocking network are also required as mentioned in Part 1. With this exception, all elements operate in practically the same manner with both types of facilities.

2.11 Fig. 5 is a photograph of the front and rear of the equipment unit for 2- and 4-wire facilities. Fig. 6 shows front and rear views of the equipment unit with the additional apparatus required for 2-wire facilities.

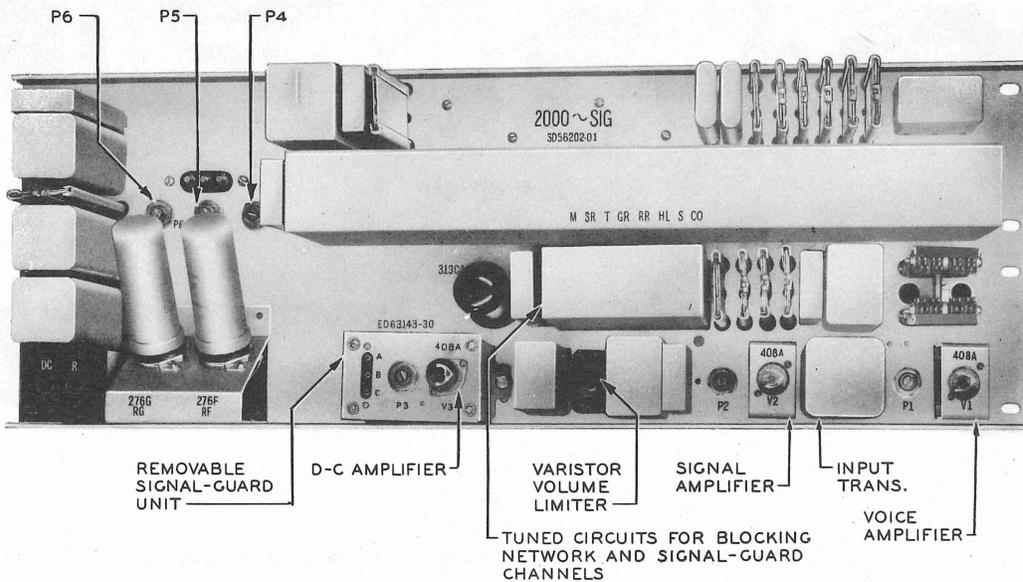
2.12 The principal elements of the signaling unit used on 4-wire facilities are shown in Fig. 7, attached, in block diagram form. The functions of these elements will now be described.

Transmitter

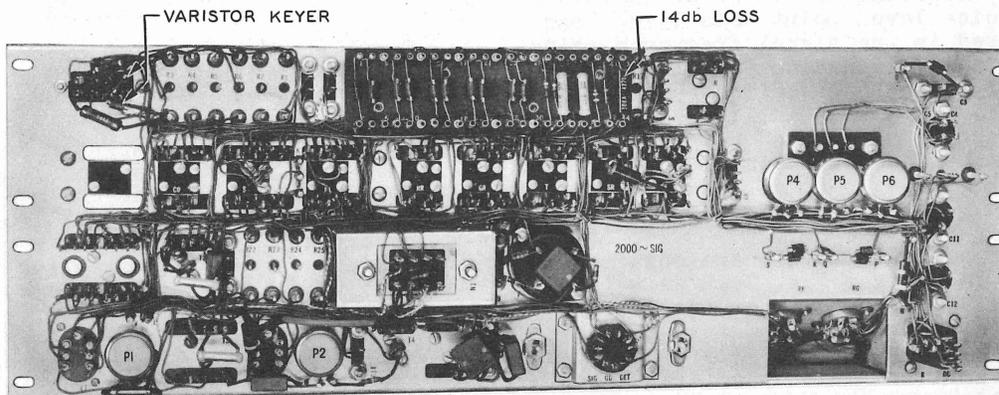
2.13 The amount of SF power which can be applied safely to any voice channel is determined to a great extent by the length of time the tone is on the line. That is, a relatively high power level may be applied for a very short interval while a lower level may be applied continuously without causing objectionable interference. The power level is also limited by the amount of crosstalk coupling to adjacent voice channels. These conditions influenced the choice of the power levels used in the SF transmitter.

2.14 A signal power 20 db below voice level is satisfactory for steady application of 1600 or 2000 cps signal frequency (low level). A 14 db higher power (high level) is satisfactory for short intervals. At the switchboard voice is at the zero transmission level (0 dbm).

2.15 However, the signal power is not applied to the line at the switchboard, but at the -13 db or -16 db voice level point, whichever is available in the office in question. Therefore, to keep the low level signal power 20 db below voice level at these points, the transmitter furnishes low level power of -33 dbm in -13 db offices, and -36 dbm in -16 db offices.



FRONT VIEW



REAR VIEW

FIG. 5 - SINGLE FREQUENCY SIGNALING UNIT

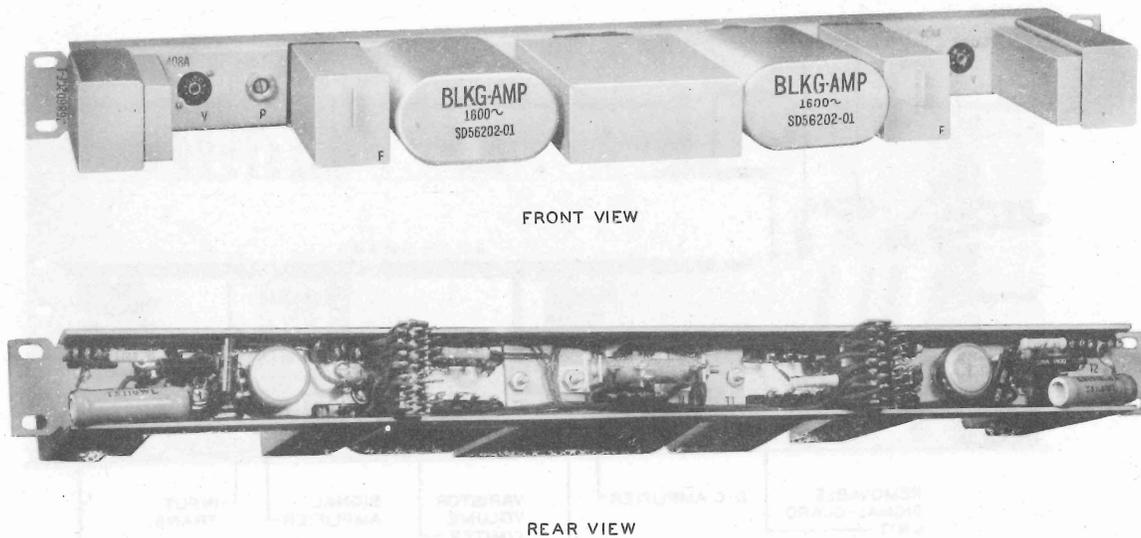


FIG. 6 - BLOCKING AMPLIFIER AND BLOCKING NETWORK UNIT

2.16 High level power of -19 dbm is furnished in -13 db offices and -22 dbm in -16 db offices.

2.17 By applying the power at the -13 db voice level point this 13 db loss is insured in the signal frequency going back to the originating end of the line. Similarly, in -16 db offices a 16 db loss is insured. This is an important safeguard in case a fault should occur which greatly increased the signal power.

2.18 These power levels are obtained as follows (see Fig. 7). As pointed out in (B), the oscillator provides two levels of power, -6.6 dbm and -9.6 dbm; the former being used in -13 db offices and the latter in -16 db offices. For low level power the transmitter introduces a loss of 26.4 db, and therefore when connected to the -6.6 dbm oscillator output, low level power of -33 dbm is obtained. For high level power, the transmitter introduces a loss of 12.4 db (by short-circuiting 14 db of the 26.4 db), and thus a high level power of -19 dbm is obtained. When connected to the -9.6 dbm oscillator output (-16 db offices), the power levels are of course 3 db lower.

2.19 Table A shows the transmitting levels for -13 db and -16 db offices.

TABLE A

Transmitting Levels

	<u>-13 db Office</u>	<u>-16 db Office</u>
Oscillator	-6.6 dbm	-9.6 dbm
Low level signal	-33 dbm	-36 dbm
High level signal	-19 dbm	-22 dbm

2.20 A germanium varistor keyer (see Fig. 7) applies and removes signal tone under control of the d-c signals received from the intertoll trunk relay circuit via the M lead. The varistors are low impedance (130 ohms) for the tone-on condition and high impedance (1 megohm) for the tone-off condition. This change in impedance is caused by either a ground or a battery signal from the trunk circuit. Ground on the M lead produces a potential across the varistors which makes them low impedance; battery on the M lead reverses this potential and makes the varistors high impedance. This method of changing from tone-on to tone-off is used instead of opening the signal path because it is faster.

2.21 During the interval between the change from tone-on to tone-off, and vice versa, the transmitter momentarily splits the drop side from the line side of the outward transmission path by means of a cut-off relay, and terminates each side in 600 ohms. This prevents interference with the proper operation of

the signaling circuit by any disturbance originating in the drop side.

Receiver

2.22 The receiver changes the a-c signals received from the distant transmitter to d-c signals which it transmits to the associated intertoll trunk relay circuit over the E lead.

2.23 The receiver, like the transmitter, is bridged on the voice transmission path at either of two transmission level points, in this case +4 db or +7 db, depending upon which level is available in the office involved. Where the transmitter is connected at the -13 db voice level point and the distant receiver is connected at the +4 db voice level, it is apparent that the voice level is increased by 17 db. Since the signal level is increased by the same amount, the low level signal of -33 dbm is also increased by 17 db to -16 dbm.

2.24 On the other hand, with the transmitter connected to the -13 db voice level point, if the distant receiver is connected to the +7 db voice level point the voice level is increased by 20 db, and therefore the low level signal of -33 dbm is increased by the same amount to -13 dbm. In each case the signal level is maintained 20 db below the voice level. The same relationship exists for the other combinations of voice levels and signal levels so that there is always a nominal increase in low level signal to -16 dbm in +4 db voice level receiving offices, and to -13 dbm in +7 db offices. This relationship is shown in Table B.

2.25 These signal levels at the receiving end are computed and do not take into consideration slight variations in the voice level points (which are measured at 1000 cycles), variations in the power levels produced by the oscillator, and variations in the signal frequency. These variations may cause the actual signal level to be lower than the nominal or computed figures. In addition, the receiver sensitivity may vary. Therefore, the just operate sensitivity of the receiver is not set at the nominal values of -16 or -13 dbm. Instead it is set 8 db lower than these figures (-24 or -21 dbm) to compensate for the losses which may occur due to these variations.

2.26 There is a corresponding nominal increase in high level signal power from -19 or -22 dbm to -2 or +1 dbm when the associated receivers are connected to the +4 db or +7 db voice levels. The receiver sensitivity remains at -24 or -21 dbm for high level signals.

2.27 Table B shows in condensed form the various levels at the output of the transmitter and the input of the receiver, together with the sensitivity of the receiver.

2.28 As shown in Fig. 7, an input transformer in the receiver circuit divides the inward transmission branch into a signal path and a voice path. It does this by means of a separate secondary winding for each path.

2.29 The voice path contains a voice amplifier and a blocking network. The blocking network is inserted only during the idle and signaling periods, during which time it applies approximately 35 db

TABLE B

(a) -13 db Transmitting Office

<u>Signal Level Transmitted</u>	<u>Signal Level Received at</u>		<u>Receiver Sensitivity</u>
	<u>+4 db Office</u>	<u>+7 db Office</u>	
-33 dbm (low)	-16 dbm (-33+17)	-	-24 dbm (-16-8)
-33 dbm (low)	-	-13 dbm (-33+20)	-21 dbm (-13-8)
-19 dbm (high)	-2 dbm (-19+17)	-	-24 dbm
-19 dbm (high)	-	+1 dbm (-19+20)	-21 dbm

(b) -16 db Transmitting Office

<u>Signal Level Transmitted</u>	<u>Signal Level Received at</u>		<u>Receiver Sensitivity</u>
	<u>+4 db Office</u>	<u>+7 db Office</u>	
-36 dbm (low)	-16 dbm (-36+20)	-	-24 dbm (-16-8)
-36 dbm (low)	-	-13 dbm (-36+23)	-21 dbm (-13-8)
-22 dbm (high)	-2 dbm (-22+20)	-	-24 dbm
-22 dbm (high)	-	+1 dbm (-22+23)	-21 dbm

loss to signal frequency, thus effectively confining the signal frequency to the signal path. The functions of the blocking network and voice amplifier are covered in more detail later under Voice Amplifier and Blocking Network.

2.30 The signal path contains a signal amplifier which is used to adjust the sensitivity of the receiver by controlling the gain.

2.31 As previously discussed, signal and voice ordinarily are not on the line at the same time. However, since the receiver is connected at all times, false operation might occur due to voice or other sounds in the signal frequency range if proper safeguards were not provided. Several features have been designed into the equipment to provide these safeguards.

2.32 A varistor volume limiter (see Fig.7) in the signal path prevents false operation of the receiver on high levels of voice or other tones. Harmonics generated in the volume limiter or in the signal amplifier are eliminated at this point by a low-pass filter.

2.33 The frequencies which are not blocked are prevented from falsely operating the receiver by a guard circuit. Briefly, this guard operates as follows.

2.34 A discriminating network in the signal path (see Fig. 7) divides the incoming energy into two channels, one for the signal frequency range and the other for all other frequencies. This latter channel is called the guard channel.

2.35 The signal frequency channel is connected to the grid of a vacuum tube in the amplifier circuit. Signal frequency energy develops voltage across an anti-resonant circuit. When this voltage is rectified by a varistor, it tends to make the grid positive and cause increased current to flow. An increase in current would operate the relays which transmit the signal to the trunk over the E lead.

2.36 However, the energy of frequencies other than signal frequency in the guard channel is also connected to the same grid and it develops a guard voltage, which tends to keep the grid negative and oppose an increase in current. When an appreciable amount of guard energy is present, as is the case during the talking period, the ratio of guard voltage to signal voltage is high, and therefore insufficient current flows in the amplifier circuit to falsely operate the signal relays. This is called the high-guard condition and is the condition that obtains during the talking period.

2.37 During the idle condition, the guard channel is short-circuited, and

therefore all the voltage developed by the incoming signal is effective in making the grid positive, with the result that considerable current flows in the amplifier circuit and the signal relays are held operated. This is the no-guard condition.

2.38 During the signaling periods, that is, during the seizure, disconnect, pulsing, and ringing periods, the guard channel is effective, but not as effective as during the talking period or high-guard condition. The guard channel is made less effective by connecting a resistance shunt across the guard channel. This is the low-guard condition.

2.39 The low guard is used during the signaling periods because during dial pulsing the trailing spurts of mixed frequencies which follow the dial pulses enter the guard channel and perform a useful function in speeding up the release of the receiver between pulses. High guard is not used for this purpose because it would slow down the operate time of the receiver too much.

2.40 During the talking condition the receiver is made less sensitive by 12 db as a further protection against false operation due to loud talking. That is, the operate sensitivity is changed from -24 dbm to -12 dbm (or -21 dbm to -9 dbm).

2.41 In addition to operate sensitivity, volume limiting, and guard action, the receiver uses mechanical and electrical delay features which further prevent its false operation or release. The mechanical delay is obtained by making certain relays slow in releasing or slow in operating. Thus, if long spurts of almost pure signal tone occurring in voice currents are received, the mechanical delay prevents the signal imposed upon the E lead from being changed. The electrical delay is introduced by the time necessary to charge a capacitor before the voltage developed across the voltage dividing network can affect the grid of the d-c amplifier.

Voice Amplifier and Blocking Network

2.42 A voice amplifier and a blocking network which is inserted when required (see Fig. 7) are connected in the drop side of the receiving branch. The voice amplifier is a one-stage vacuum tube amplifier which has a flat frequency response over a wide range of voice frequencies. The gain of the amplifier is adjusted to compensate for the loss due to the bridged signal receiver.

2.43 Since an amplifier is a one-way device, this amplifier acts as a blocking device which prevents false operation or interference with receiver operation due to noise originating on the drop side (see Fig. 8, attached).

2.44 As previously explained, the blocking network is inserted in the voice path, under relay control, whenever signal tone is being transmitted from either terminal (during the idle and signaling periods). It is a band elimination filter tuned to the frequency of the signal tone transmitted from the distant terminal and attenuates the signal by approximately 35 db when the network is inserted. This loss, in addition to lowering the level of signal tone to a point where it is inoffensive to operators and subscribers, and aiding in controlling echoes, also eliminates interference with another a-c signaling system which may be connected in tandem.

2.45 Fig. 8 also illustrates the use of the blocking network associated with the voice amplifier to suppress echoes of signal tone. If the call has advanced to the stage where tone is not being sent in either direction, the blocking networks at both terminals are removed, permitting all frequencies to reach the drop sides without attenuation. Assume that at this time a start pulsing signal (high level tone) is sent from the terminating end (east terminal), which notifies the operator or equipment at the originating end (west terminal) that the terminating end is ready to receive dial pulses. The receiver at the originating end, upon receiving this signal, quickly reinserts the blocking network which blocks the passage of signal tone to the drop side (voice path).

2.46 If the blocking network were not inserted, the signal tone would not only be transmitted to the originating operator or subscriber but, due to trans-hybrid transmission, the echo would go back to the terminating end over the outward transmission path where it might operate the receiver and change the condition on the E lead. It takes about 20 milliseconds to insert the blocking network, and during this interval the echo of the signal tone gets back to the terminating receiver. However, this interval is too short to fully operate the receiver, and no damage is done.

2.47 The blocking network performs a similar function where the call is routed to an intercepting operator after the routing digits have been forwarded. In this case, after all the digits have been transmitted, low level tone toward the intercepting operator is removed. Low level tone is still sent to the originating end of the connection, because if it were removed an "answer" condition would be sent to the originating end and the call would be charged. To prevent the calling subscriber from hearing the tone the blocking network is left in. Therefore, as a result, the intercepting operator's voice transmission is slightly

impaired because the voice tones in the signal tone range are attenuated by the blocking network along with the low level tone.

2.48 The blocking network also eliminates interference with another SF signaling system which may be connected in tandem. Consider that two intertoll trunks are connected by an intertoll step-by-step selector and that both trunks are using SF signaling. Dial pulses in the form of SF signal tones are received at the step-by-step office, changed to d-c, and repeated to the next SF signaling system. Talking path continuity is established between the trunks by the step-by-step selector before all the digits are received, and if the blocking network in the first SF system were not inserted the SF tone pulses in the first system would interfere with the tone pulses in the next system.

Blocking Amplifier and Blocking Network

2.49 As discussed in Part 1, when SF signaling is used on 2-wire facilities, 2000 cps signals are transmitted in one direction and 1600 cps in the other. Referring to Fig. 9, attached, assume that the west terminal transmits at 1600 cps, in which case the west receiver is tuned to receive 2000 cps. Due to trans-hybrid leakage at the west terminal and echoes returning from the 2-wire repeater points and the east terminal, the 1600 cps signal would enter the west receiver if no safeguards were provided, where it would look like guard energy and interfere with the reception of 2000 cps signals from the east terminal transmitter.

2.50 To prevent this an amplifier and blocking network are connected in the line side of each receiving branch. Each unit is tuned to the frequency of the associated transmitter and introduces a 35 db loss to that frequency, thus effectively blocking the leakage and echo signals. These networks are inserted immediately after tone is applied by their associated transmitters and remain connected until the tone is removed.

2.51 When the voice terminal is provided with an echo suppressor, blocking amplifiers are connected to the drop sides of the transmitting branches in both 2- and 4-wire facilities (see Fig. 9). This safeguard is required in connection with intercepting calls for the following reason. As previously discussed, on these calls, the signal tone from the terminating (or intercepting) end is not removed during conversation. The amplifier is so connected that it prevents this signal tone from getting to the drop side and operating the echo suppressor. If the echo suppressor were allowed to operate at this

time, it would cut off voice transmission to the intercepting operator.

2.52 Blocking amplifiers with associated blocking networks are provided on the drop sides of the transmission branches of 2- and 4-wire facilities where operator trunks designed for dial normal transmission are used. (These trunks maintain talking path continuity while the dial is normal, opening the path only when the dial is in rotation, whereas other operator trunks keep the talking path open during the entire dialing period.) With the dial normal type of trunks, the signal tone components of voice frequencies, originating on the drop side of the transmission branch, if not blocked, would travel from the originating office to the terminating office where they might falsely operate the receiver and cause wrong numbers. However, the blocking amplifier and network combination, which is inserted during the dialing period, is tuned to introduce approximately 35 db loss to the particular frequency used to transmit dial pulses and thus prevents this trouble.

2.53 Although the amplifier is called a blocking amplifier, it actually performs blocking action only when used in connection with an echo suppressor. For the other two uses described, it does not perform any blocking function, but its use in conjunction with the blocking network makes possible a simple network design.

Control Relays

2.54 The control relay circuit (see Fig. 7) contains the relays which perform various functions associated with the operation of the transmitter and receiver. For example, the control relays determine when a high level signal tone is to be transmitted and when the insertion of a blocking network is required in the outward transmission path. They also control the sensitivity of the receiver and the type of guard used. The mechanical delay features and the insertion of the blocking network in the inward transmission path are also made under control of these relays.

(D) Signal Converter Circuits

2.55 SF signaling can be used on ringdown trunks, in which case signal converters are used to change the signals from the trunk circuit to those accepted by the SF system, and vice versa.

2.56 One type of converter circuit is used on ringdown operation of No. 1 and similar switchboards; another is used on No. 3 and similar switchboards. These converters change the signals received on a ringdown basis from the switchboards to d-c signals suitable for application to the M leads associated with the SF circuit. These signals are then transmitted on an

SF basis to the terminating office, where another converter receives them over the E lead and changes them back to a form suitable for ringdown operation.

2.57 Still another converter is used at times of changeover from manual to dial operation, when it is usually desirable as an interim measure to operate the switchboard ringdown trunk equipment by use of spare dial signaling equipment. Generally this need occurs at an outlying manual office (which is not being arranged for intertoll dialing) that connects with an office which is being changed to intertoll dialing.

2.58 The ringdown trunk circuit at the manual office is connected by means of a converter circuit to the SF circuit. The trunk can then be used as a one-way trunk operated on an automatic basis incoming to the manual office only.

2.59 Signals transmitted by ringdown operation are spurt signals and are sent only when it is desired to connect, disconnect, rering, or ring back. Tone is not present on the toll line except when signals are sent. Therefore ringdown operation differs from dial operation using SF signaling where tone is present on idle lines.

(E) Pulse Link Circuit

2.60 SF signaling systems can be connected to each other or to CX systems by means of a relay type pulse link circuit which changes the E and M leads on one side of the link to M and E leads on the other side.

2.61 Where an SF system is connected to a CX system, a pulse link circuit is required as shown in Fig. 10A.

2.62 Normally 1600 and 2000 cps are used on both the 4-wire and 2-wire facilities when these two types are connected to each other. In such cases, pulse link circuits are not required (see Fig. 10B).

2.63 However, in those locations where it is desirable to use 1600 cps in both directions for the 4-wire section, and 1600 and 2000 cps for the 2-wire section, a pulse link circuit and additional transmitters and receivers are required at the junction of the facilities as shown on Fig. 10C.

2.64 Where an echo suppressor or a compandor is inserted at the junction of two single frequency circuits, a pulse link circuit and additional transmitters and receivers are required at the junction to repeat the SF signals around this equipment (see Fig. 10D).

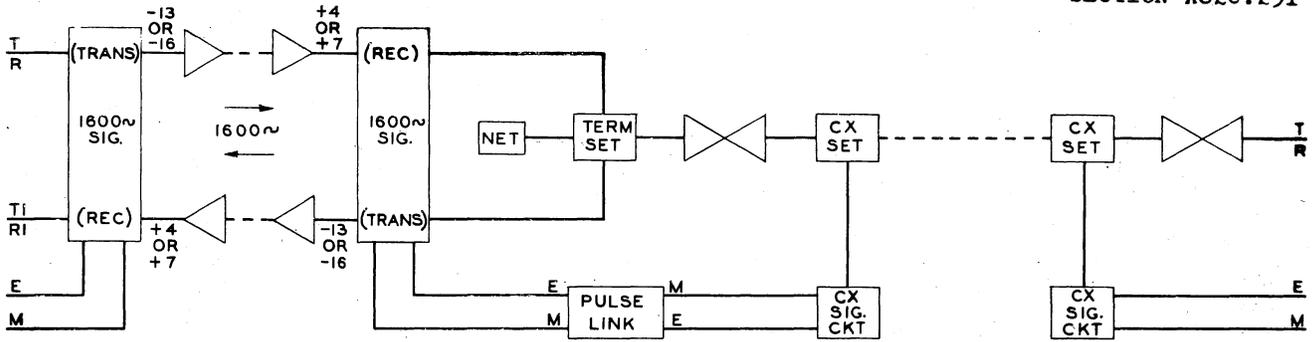


FIG.10A—SINGLE FREQUENCY SYSTEM CONNECTED TO CX SYSTEM

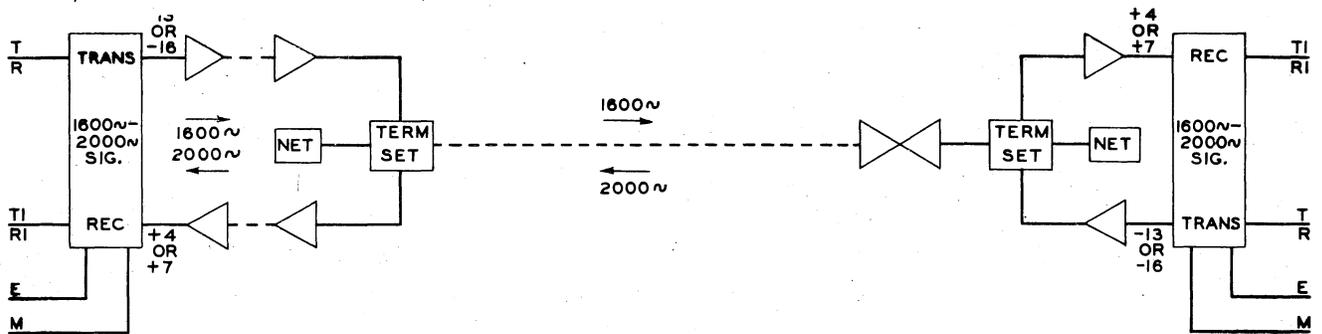


FIG.10B—4-WIRE FACILITY CONNECTED TO 2-WIRE FACILITY 1600~ - 2000~ SIGNALING (NO PULSE LINK)

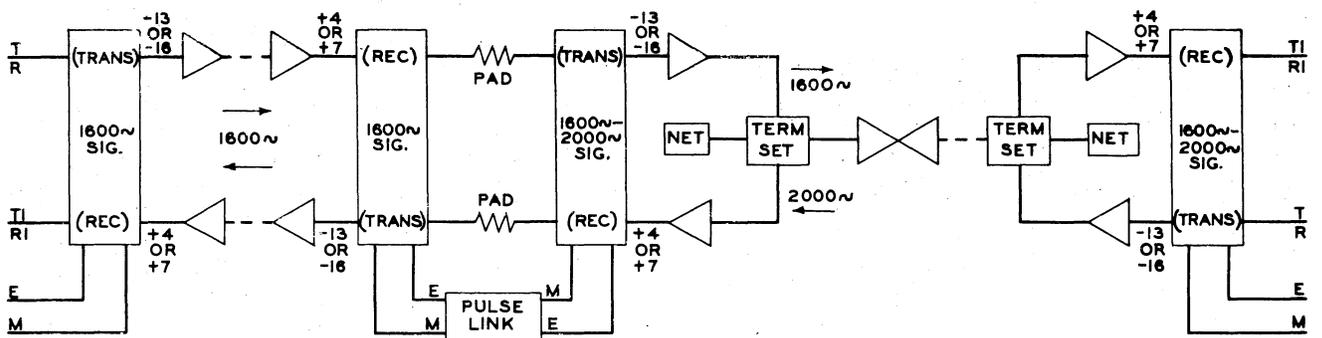


FIG.10C—4-WIRE FACILITY CONNECTED TO 2-WIRE FACILITY 1600~ AND 1600~ - 2000~ SIGNALING (WITH PULSE LINK)

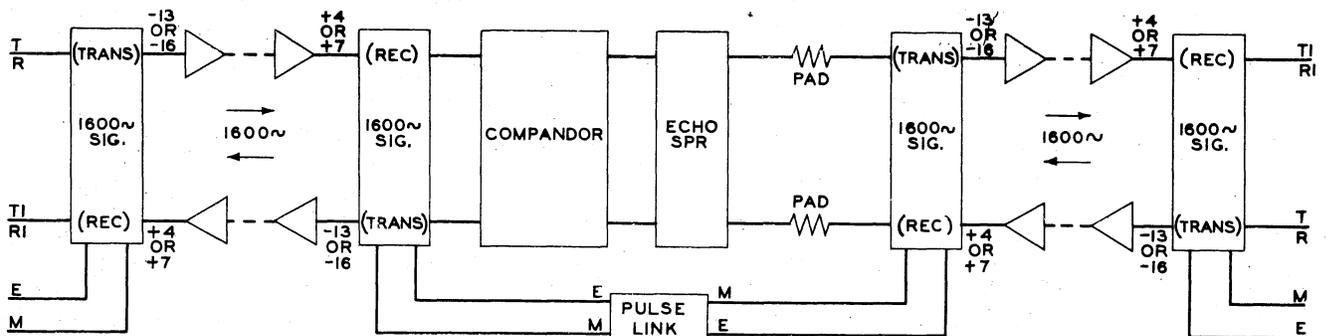


FIG.10D—COMBINATION 4-WIRE WITH SIGNAL BY-PASS AROUND COMPANDOR AND ECHO SUPPRESSOR AT INTERMEDIATE POINT 1600~ SIGNALING

(F) Bay Arrangements

2.65 All equipment for the SF signaling system is furnished in small units, assembled, wired, and tested in the shop. The units mount on relay rack frames, usually 11' 6" high, arranged for 23-inch mounting plates. There are several relay rack bay arrangements depending upon the number of SF signaling circuits in a particular office. All the bay arrangements have a fixed test assembly which provides maintenance facilities at a convenient, central test point.

2.66 There are three basic arrangements of the equipment units. One is for large installations and the other two are for small installations. The arrangement used in large installations is shown in Fig. 11, attached. A maximum of 104 signaling circuits are used in this arrangement. An arrangement for installations where the maximum number of signaling circuits is ten is shown in Fig. 12A. For still smaller installations, four or less signaling circuits, the arrangement shown in Fig. 12B is used.

3. METHOD OF OPERATION ON A TYPICAL CALL(A) General

3.01 This part describes the operation of the SF signaling system on a typical call. It starts with the trunk idle condition, goes through the steps performed in setting up the connection between two offices, and returns to the trunk idle condition. Fig. 13, attached, includes a block diagram of the signaling circuits in both offices and a table showing the sequence of the signaling operations.

3.02 In service the terminals of the SF system between two toll offices, west and east, could be any of the following:

- (a) Originating and terminating.
- (b) Originating and intermediate.
- (c) Intermediate and terminating.
- (d) Both intermediate.

3.03 Because the SF system works in the same manner, no matter in which section of the over-all connection it is used, one office can always be considered as the originating office and the other as the terminating office. Therefore only case (a) will be described.

3.04 For this particular call certain other conditions are assumed. These are:

- (a) Two-wire facilities are used between the toll offices.
- (b) 1600 cycles is the frequency of the west to east tone.
- (c) 2000 cycles is the frequency of the east to west tone.
- (d) Both the east and west offices transmit tone at the -13 db voice-transmission level, and both receive tone at the +4 db voice level.
- (e) The called office has senders (or registers).
- (f) The trunk is a dial pulse inter-toll trunk.

(B) Idle Condition of the Trunk

3.05 While the trunk is idle, low level (-33 dbm) signal tone is transmitted in both directions, causing the receivers to remain operated and to send idle signals to their associated trunk relay circuits over their E leads. The level of this received signal tone is -16 dbm, and each receiver is in the high-operate sensitivity condition (-24 dbm).

3.06 During the idle condition all energy entering the receivers is used to keep them operated. No guard action is required because the receivers are already operated; therefore, the guard channel is short-circuited.

3.07 All blocking networks are inserted in their respective circuit branches during the idle condition.

(C) Seizure Signal

3.08 When a call originates at the west terminal, the 1600-cycle tone (west to east) is removed, causing the east receiver to release and send a seizure signal to its associated trunk relay circuit.

3.09 At the east terminal the receiver changes to a low-guard condition by removing the short circuit and substituting a low impedance shunt across the guard channel. This low-guard condition gives some protection against false operation of the receiver, but its main function is to cause the receiver to release quickly during any subsequent reception of dial pulses.

3.10 The east blocking network, tuned to 1600 cycles, is removed because the west to east signal tone of this frequency is no longer on the trunk.

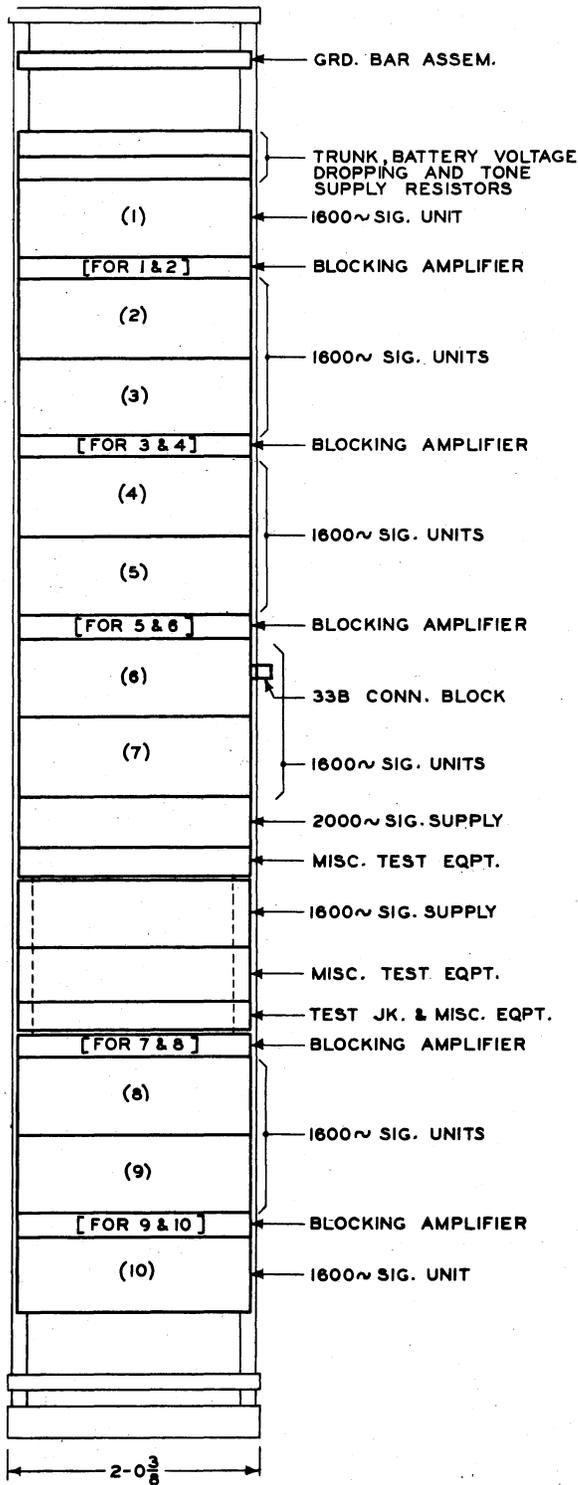


FIG. 12A - BAY ARRANGEMENT FOR 10 SIGNALING CIRCUITS

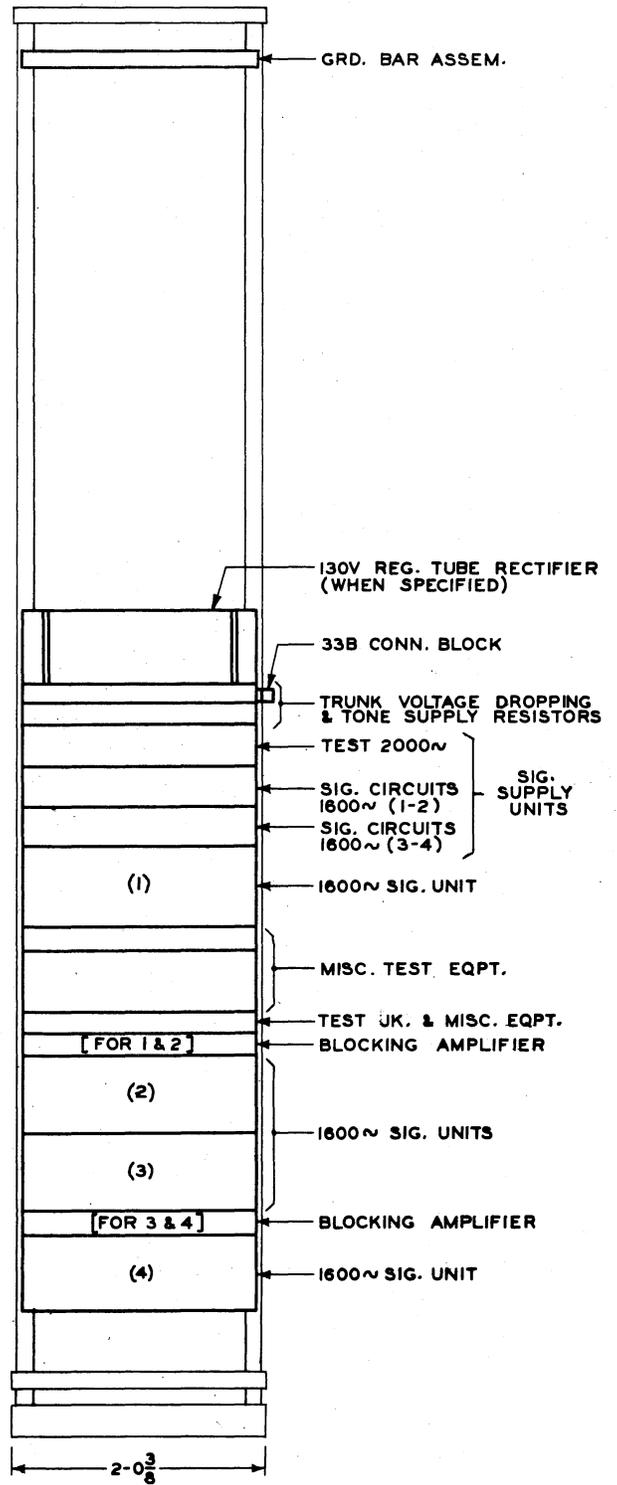


FIG. 12B - BAY ARRANGEMENT FOR 4 SIGNALING CIRCUITS

(D) Stop Pulsing Signal

3.11 On calls to step-by-step offices the west terminal would send dial pulses immediately after sending a seizure signal to the east terminal. However, this is a call to an office with senders (or registers), and therefore time must be allowed after the seizure signal is received for the east office to find and connect a sender. Therefore the east office sends a stop pulsing signal to the west terminal until a sender is ready to receive dial pulses.

3.12 The stop pulsing signal is sent by removing the east to west 2000-cycle signal tone. At the west terminal the receiver releases and passes the stop pulsing signal on to its associated trunk relay circuit.

3.13 At this stage, while waiting for a start pulsing signal from the east terminal, there is no tone on the trunk in either direction of transmission. The condition at this stage is the same as the talking condition and, since the receivers cannot distinguish this stage from the talking stage, they react in the same manner. That is, they change to high guard, low-operate sensitivity and incorporate the mechanical delay features which would prevent their operation by the talker's voice energy if it were the talking stage.

3.14 Because the east transmitter has removed the 2000-cycle tone, the blocking network tuned to this frequency is no longer needed and it is removed from the line side of the east receiver.

3.15 At the calling end (west terminal) the 1600- and 2000-cycle networks are removed as soon as the receiver releases in response to the stop pulsing signal. The 2000-cycle network was kept in until this time because tone was still being received, whereas the other network tuned to 1600 cycles was kept in on the possibility that dial pulses were to be transmitted immediately. This latter condition occurs on trunks to non-sender offices (such as step-by-step) where pulses are forwarded immediately after trunk seizure.

3.16 The networks at both terminals will be inserted and removed again before the actual talking condition is established, but it should be remembered that they are removed at this time because the absence of tone in both directions looks like a talking condition to the receivers.

(E) Start Pulsing Signal

3.17 When the east terminal has connected a sender to the incoming trunk relay circuit and is ready to receive pulses, a start pulsing signal is sent to the west terminal. This signal is sent by applying high level tone (-19 dbm). High level tone is necessary because the receivers are in their least sensitive and high-guard conditions at this stage. The high level tone is sent long enough to operate the receiver (approximately 250 milliseconds), followed by low level tone.

3.18 As soon as the east terminal starts sending tone for the start pulsing signal, the east receiver realizes that it, in turn, is going to receive tone (dial pulses) from the west terminal. Therefore, this receiver returns to normal sensitivity and low-guard conditions, and removes the mechanical delay.

3.19 Also, because the east terminal is again transmitting tone, the 2000-cycle network at that terminal is inserted to block any trans-hybrid leakage into the receiver.

3.20 At the west terminal the high level tone causes the receiver to operate and pass the start pulsing signal on to the trunk relay circuit. After receiving the start pulsing signal, the receiver no longer needs protection against false operation so it returns to normal sensitivity, no guard, and removes the mechanical delay. The receiver knows that it is receiving 2000-cycle tone from the east terminal and that its associated transmitter is going to send 1600-cycle tone to the east receiver for dial pulses. It therefore reinserts the blocking networks.

(F) Dial Pulses.

3.21 The west terminal now transmits all the digits needed to route the call to the called station. It does this by interrupting high level (-19 dbm) tone, in response to dial pulses received over the M lead, until all the digits have been forwarded. Then it removes the tone.

3.22 West to east tone is not sent again until after the talking period when the connection is to be released. Low level signal tone is still being received from the east and remains on until the called subscriber answers.

(G) Off-Hook Signal (Start of Talking Period)

3.23 When the called party removes the receiver from the switchhook and the charge delay interval has elapsed, a signal is sent back to the originating operator informing her that the talking period is

established and that she should start timing the call. This signal is sent between the toll offices by removing the east to west signal tone.

3.24 At both terminals the receivers return to high guard, low sensitivity, and incorporate their mechanical delay features, to prevent operation by voice energy (talk-off). All blocking networks are removed because tone has been removed in both directions, and if the networks were left in there would be a slight impairment of voice transmission.

(H) On-Hook Signal (End of Talking Period)

3.25 At the end of the talking period when the called subscriber returns the receiver to the switchhook, an on-hook signal is transmitted to the originating operator. This signal informs her that she should note the time, for charging purposes, and then proceed to release the connection.

3.26 The on-hook signal is transmitted from the east to west terminal by high level tone (250 milliseconds), followed by continuously sent low level tone. The high level tone is used to operate the west receiver, and the low level tone remains on the trunk as an idle signal. These are the last east to west signals.

3.27 At both terminals the receivers again remove the mechanical delay, return to normal sensitivity and low-guard conditions and, in addition, reinsert the 2000-cycle blocking networks.

(I) Disconnect Signal

3.28 Upon receipt of the on-hook signal the originating operator releases the connection. After the equipment at the originating end returns to normal, a disconnect signal is sent to the terminating end which notifies the equipment there that the connection is released. The equipment at the terminating end then restores to normal.

3.29 This signal is also sent by high level tone and is followed by continuously sent low level tone which remains on the line as an idle signal. These are the last west to east signals.

3.30 At both terminals the 1600-cycle networks are reinserted.

3.31 Thus at the end of the 250-millisecond period of the disconnect signal the SF signaling circuit is in the same condition that it was prior to the start of the call; that is, low level signal tone is being transmitted in both directions, the receivers are in their no-guard, normal sensitivity conditions and do not have the mechanical delay feature, and the blocking networks are inserted.

4. TESTING AND MAINTENANCE

(A) General

4.01 The maintenance of the single frequency type of signaling system presents some new problems not encountered in d-c or spurt (ringdown) systems. For example, continuity and freedom from shunts on the voice channel are necessary for proper operation of the signals during the idle condition as well as during the busy condition. This is necessary because tone is used to indicate the idle condition; and therefore any opens or appreciable shunts on the voice channel when the trunk is idle will result in false connect signals to the incoming trunk relay equipment, which in turn will call for the connection of a sender. A succession of these opens or shunts (hits) might result in a considerable increase in the load on dial office equipment. In sender type offices (panel or crossbar), sender and link usage would be increased. In step-by-step offices the selector equipment would be falsely used and, in some cases, the hits might look like dial pulses and cause numbers to be rung.

4.02 On the other hand, an open in the voice channel of a busy trunk will prevent disconnection of the incoming trunk relay equipment and the called subscriber line.

4.03 These conditions, peculiar to SF signaling, make it particularly important that the maintenance force avoid operations which might destroy the continuity or cause hits on toll circuits, without first taking the circuits out of service.

4.04 This part briefly describes the test equipment used and the principal features of the SF signaling system that require testing and adjustment. It also covers the general testing procedure and describes some typical tests. Procedures for testing and maintenance are covered in the other sections (directive) in the A series.

(B) Test Equipment

General

4.05 Fixed and portable test units are used in various combinations to maintain the SF signaling system. The test units and the signaling circuit units are equipped with jacks, and many of the connections between the various test units and the signaling circuit units are made with patching cords. Several of the typical patched test connections are shown in figures which will be referred to later in this part.

4.06 Tests of the SF signaling equipment units are made by patching from test

access jacks associated with each unit to jacks on the miscellaneous test equipment unit (described below) and jacks on the various test sets. These access jacks permit testing a complete SF signaling system from office to office, a complete transmitting or receiving unit, functional portions of a unit, and individual apparatus elements of a unit.

4.07 The test access jacks for the double oscillator supply unit are mounted on a jack strip directly beneath the unit, and the jacks associated with the single oscillator unit are mounted on the oscillator panel. Some of the test jacks for the

signaling unit are mounted on the unit itself, and others on a common jack strip which contains similar jacks for all the signaling units within a bay. These same common strips contain the test jacks for the blocking amplifiers when these amplifiers are mounted in the bay along with the signaling equipment. When the blocking amplifiers are located in a separate bay, the test jacks are mounted on a common strip in that bay.

4.08 Figs. 14 to 16 show typical test access jacks associated with the SF signaling equipment. Fig. 17 shows the test jacks on the miscellaneous test equipment unit.

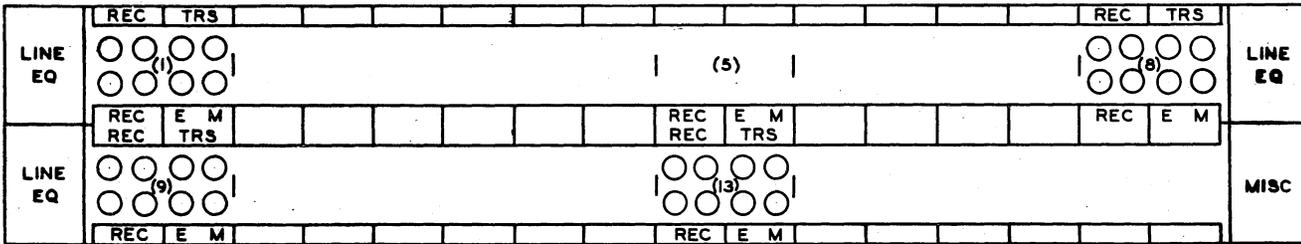


FIG. 14 - SF TEST ACCESS JACKS
13 SIGNALING CKTS. PER BAY

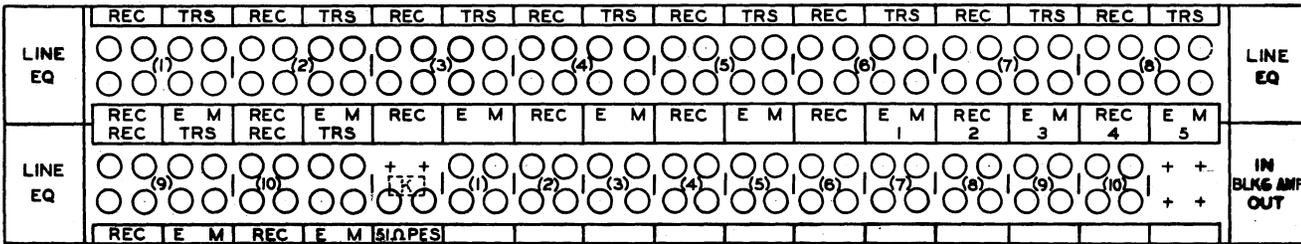


FIG. 15 - SF TEST ACCESS JACKS
10 SIGNALING CKTS. PER BAY

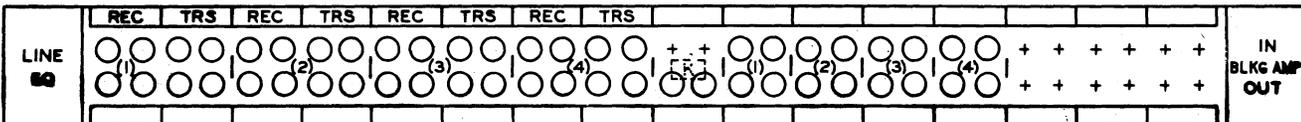


FIG. 16 - SF TEST ACCESS JACKS
4 SIGNALING CKTS. PER BAY

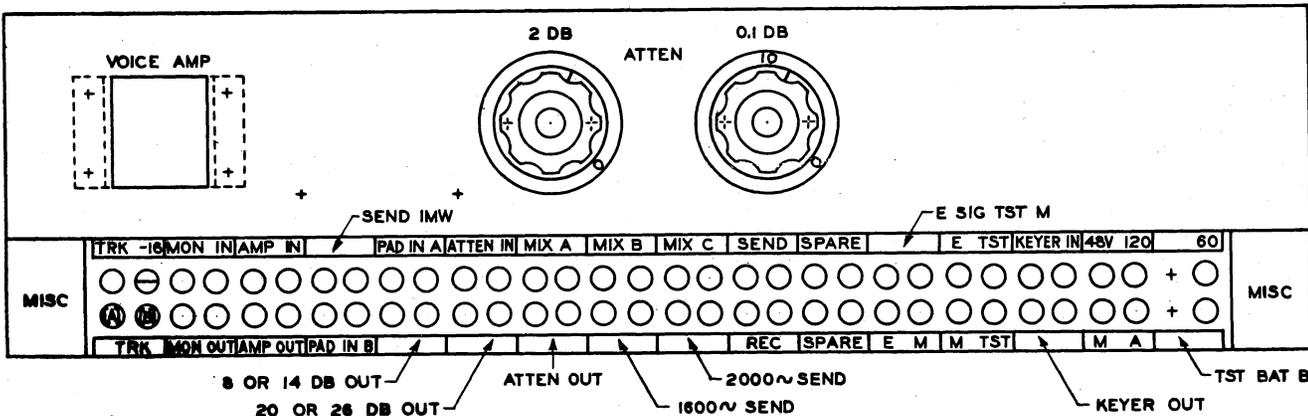


FIG. 17 - MISCELLANEOUS TEST EQUIPMENT

Miscellaneous Test Equipment Unit

4.09 This unit is specifically designed for testing the SF signaling system and is mounted on the signaling circuit equipment bays (see Fig. 17). It has built-in jack-ended testing facilities and miscellaneous jack-ended connecting circuits.

4.10 The jack-ended test facilities are used to supplement the test facilities in the portable test sets and other test equipment. They are never used alone because there is no indicating equipment - the meters and lamps are located on the other test equipment. The miscellaneous jack-ended connecting circuits are wired to the IDF, toll test board, etc. and are used for several purposes. They connect the built-in test facilities to the other test equipment, provide talking connections between the circuits under test and the test equipment, etc.

4.11 Some typical uses of the test facilities and connecting circuits are listed below.

Built-in Test Facilities

These are used for:

- (a) Checking the frequency of the tone supply circuit.

- (b) Monitoring on the voice paths of the signaling circuit.
- (c) Checking the general performance of the transmitter and receiver.
- (d) Testing the performance of the voice and blocking amplifier.
- (e) Checking the insertion loss of the blocking network.
- (f) Checking relay response times.
- (g) Supplying battery to the portable test sets.

Miscellaneous Connecting Circuits

These include:

- (a) Spare line circuit to IDF.
- (b) Talking trunk to toll test board.
- (c) Patching trunk circuit for extending E and M leads of the signaling circuit to the toll test board.
- (d) Patching trunk circuit for extending sending and receiving circuits to the toll test board or to the transmission measuring bay for testing.

4.12 Fig. 18 illustrates the use of test facilities in this unit and Fig. 19, the use of a connecting circuit.

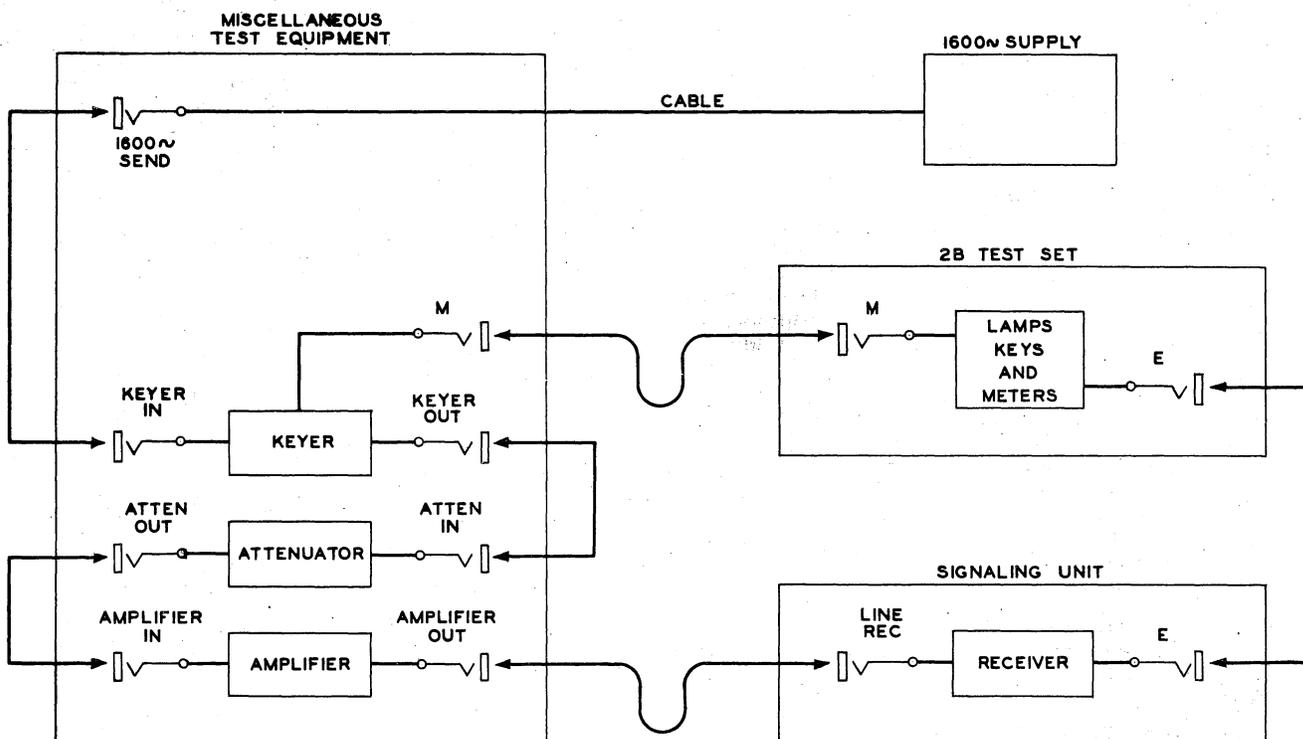


FIG. 18-TYPICAL USE OF TEST FACILITIES OF THE MISCELLANEOUS TEST EQUIPMENT UNIT

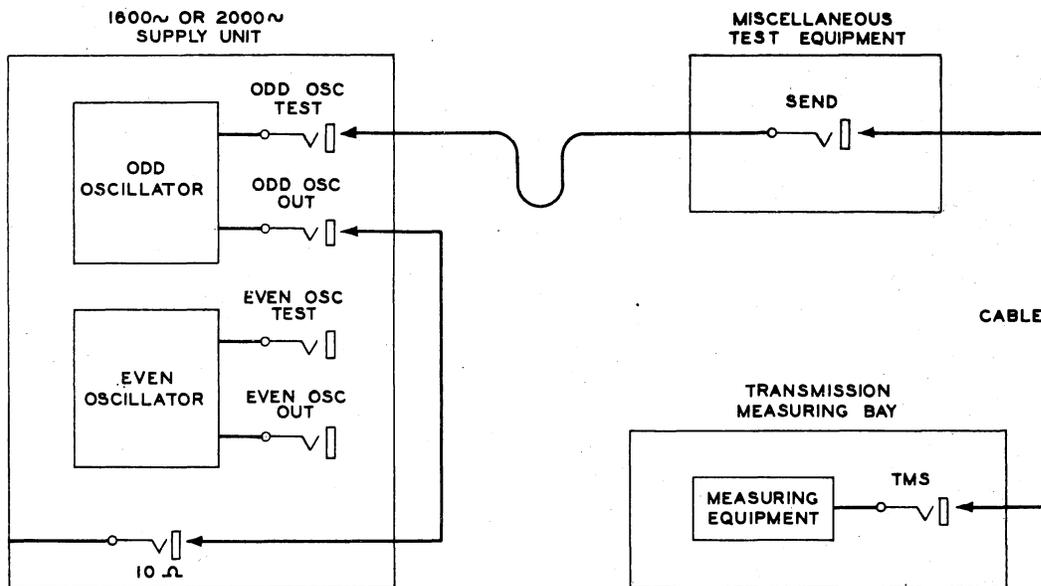


FIG.19—TYPICAL USE OF A CONNECTING CIRCUIT ON THE MISCELLANEOUS TEST EQUIPMENT UNIT

4.13 The miscellaneous test equipment unit is located on one of the signaling equipment bays. To keep the lengths of the patching cords at a reasonable length, one of these units is provided for not more than five adjacent signaling bays and is mounted in the central bay of this group. One test unit never serves bays on both sides of a building column, so that in certain cases a test unit may serve only one bay of signaling equipment.

Portable Test Equipment

No. 2B Signaling Test Set

4.14 This test set is used to check the over-all signaling features of the SF signaling circuits. It does this on an E and M lead basis. When it is connected to the M lead, keys can be operated which provide the same type of d-c pulsing and supervisory signals that are transmitted by the intertoll relay circuit in service. When it is connected to the E lead, it indicates on lamps and meters the response of the receiver to the a-c pulsing and supervisory signals provided by the transmitter. (The No. 2A signaling test set which is similar to the No. 2B is used in some offices.)

4.15 Certain individual relays are also tested, such as the RR and CO relays in the transmitter and the T relay in the receiver.

4.16 The set includes a vacuum tube generator which can produce accurate pulses at rates of from 2-1/2 to 18 per

second. A meter is provided for indicating the number of pulses produced by this generator. The per cent break of the pulses can readily be adjusted over a wide range. A second meter is provided for checking this. This meter is also used to indicate the per cent break of pulses received from a signaling circuit under test. Control keys are provided for furnishing on-hook and off-hook supervisory signals on the M lead, and lamps are provided for indicating these signals as they are received over the E lead.

Miscellaneous Test Sets

4.17 The following additional test sets are required for maintenance and testing:

- (a) A No. 13A transmission measuring set or office transmission measuring equipment such as the No. 40B system.
- (b) A 35-type relay test set.
- (c) An M9B volt-ohmmeter.
- (d) A cold-cathode tube test set (J24754).
- (e) A mercury relay test set (J94725A).
- (f) A DuMont No. 208 oscilloscope.

(C) Typical Tests

General

4.18 No attempt is made here to describe all the tests, or to give all the details of those tests which are described.

The purpose is to give a general picture of several typical tests and the general procedures followed. As mentioned earlier, the detailed procedures are covered in other sections in the A series.

4.19 As previously mentioned, over-all tests of the SF signaling circuits are made on an E and M lead basis using the No. 2B (or 2A) signaling test set. When such tests pick up faulty operation under dial pulsing or supervisory conditions, a simple series of tests of individual features is made using the No. 2B (or 2A) signaling test set and other test equipment (such as the 35-type relay test set, the M9B volt-ohmmeter, etc.). When these tests of individual features have been completed, the over-all tests are again made using the No. 2B (or 2A) signaling test set. In some cases these over-all tests are followed by an over-all test from office to office using the toll test board.

Tests of SF Supply Units

4.20 The over-all performance of the supply unit is automatically checked when over-all tests are made on the signaling circuits using the No. 2B (or 2A) signaling test set.

4.21 Individual tests of the supply units include the following.

4.22 The outputs of both oscillators of a supply unit are constantly monitored for level. This is done with sensitrol relays of the voltmeter type, one for each oscillator. If the output of an oscillator varies by more than ± 1 dbm this relay operates, causing a visual and audible alarm. At the same time the load is transferred from the oscillator in trouble to the mate oscillator.

4.23 Operation of an alarm cut-off key silences the alarm and lights a guard lamp. When the trouble is cleared and the sensitrol relay is reset, the alarm lamp is extinguished and the load is automatically transferred back to its home oscillator. The guard lamp is extinguished when the load has been transferred.

4.24 Failure of both oscillators results in a major alarm. This alarm cannot be silenced until the trouble is cleared.

4.25 Routine tests of these alarm and transfer features are made by manually operating the sensitrol relays.

4.26 The output level under load and no-load conditions is checked using the 13A transmission measuring set or the 40B transmission measuring system. The load condition is simulated by putting a 10-ohm shunt across the oscillator output. Under

this condition, the level should not change more than 0.5 dbm. Test connections for this test are shown in Fig. 19.

4.27 Output frequency is maintained at ± 3 cps. Routine tests of this requirement are made by comparing the oscillator output with a reference frequency such as the office 4-kc standard, a previously calibrated oscillator, or a tone from another office. The DuMont No. 208 oscilloscope is used in making this test.

4.28 A trouble condition on any of the signaling circuits or tone distribution circuits (the load circuit), connected to a supply circuit which reduces the output by more than 1 dbm, causes a load alarm lamp to light and the sounding of a major alarm. There is no output transfer in this case because the trouble is in the load circuit and a transfer would put the other oscillator out. The alarm can be silenced only by clearing the trouble.

4.29 Tests of the load alarm feature are not made on a routine basis because the test consists of momentarily opening the circuit between the oscillator and the load and this causes trouble on both idle and busy trunks.

4.30 The test access jacks on the double oscillator supply unit for making the above tests are mounted on a jack strip on the supply unit (see Fig. 3, Part 2). The corresponding jacks in the single oscillator supply unit are mounted on the same mounting plate as the other elements of the oscillator (see Fig. 4, Part 2).

4.31 Output level, frequency, and filament voltage adjustments of both the units are made at the rear of each unit.

4.32 Initial output level adjustment is made at the shop or by the installer by selection of optional taps on the output transformers, the selection of the taps depending upon the voice level at the point where the signaling circuit is connected. Fine adjustment of output level is obtained by strapping the 107-type resistors.

4.33 Frequency adjustment is made by strapping capacitors in the plate circuit of the oscillator.

4.34 Slide wire resistors are adjusted to obtain the correct filament voltage.

Tests of Signaling Unit

4.35 Tests of the signaling units are of three general types:

- (a) Over-all tests of the complete signaling units made from a transmitter in one office to its associated

receiving equipment in a distant office.

(b) Tests of individual functional elements, such as the transmitter, the receiver, voice and blocking amplifier, etc.

(c) Tests of individual apparatus.

Over-all Tests of Signaling Unit

4.36 These tests check the over-all performance of the signaling system - the supply units, the transmitter, the receiving equipment, and the interoffice trunk connecting them. All types of pulsing and supervisory signals used in service are tested using two No. 2B (or 2A) signaling test sets, one in the home office and one in the associated distant office.

4.37 The test sets in the home and distant offices are both connected to the E and M signaling leads. With this setup signaling in both directions can be tested.

4.38 Use of the interoffice trunk on these tests picks up trouble in the trunk which might react on the signaling system.

Tests of Individual Functional Elements

4.39 The transmitters are tested to check their ability to send out high and low level tone, and to remove tone from the line. In these tests the No. 2B (or 2A) test set is connected to the M lead of the transmitter. The test man operates keys in the test set which sends d-c signals to the transmitter causing it to transmit high and low level tones, and to remove tone in response to these signals. For checking low level tone and removal of tone, the output of the transmitter is patched to the 13A transmission measuring set or the office transmission measuring system through a connecting circuit on the miscellaneous test equipment unit. For high level tone checks, the test man monitors the output of the transmitter with a headset.

4.40 The receivers are checked for their ability to respond to high level tone, low level tone, and no tone. They are also checked for their response to dial pulses (per cent break of pulses). Fig. 18 is a schematic of the connections for these tests. The M lead from the 2B (or 2A) test set is patched to a varistor-keyer on the miscellaneous test equipment unit. A source of steady tone is patched to the varistor-keyer and the output of the keyer is patched through an attenuator and amplifier to a jack, which in turn is patched to the receiver. The E lead of

the receiver is connected to the E lead of the No. 2B (or 2A) test set. Lamps on the test set indicate the response of the receiver to supervisory signals, and a meter shows the per cent break of the pulses. With this setup the test man can duplicate all of the transmitter functions by transmitting on-hook and off-hook signals as well as dial pulses.

4.41 It will be recalled that the voltage discriminating network in the receiver divides all incoming energy into either signal or guard energy. Signal energy is used to operate the receiver, and guard energy (all energy other than signal) is used to prevent its operation. As explained earlier, there are three guard conditions during the progress of a call: namely, no-guard during the idle period, low-guard during the signaling period, and high-guard during the talking period.

4.42 Tests are made to check that the receiver establishes these guard conditions. For these tests 1000-cycle testing tone is used to represent all guard energy. Various levels of guard tone (1000 cycles), signal tone (1600 or 2000 cycles), and combinations of guard and signal tone are patched from the miscellaneous test equipment to the receiver under test. A patch is also made from the E lead of the receiver to the No. 2B (or 2A) test set. Lamp indications on the test set tell whether the voltage discriminating network is performing properly.

4.43 The blocking networks are tested in the same manner as the voice and blocking amplifiers except that signal tone of 1600 cps (or 2000 cps) is used, and in this case the test is made to insure that the blocking network introduces a loss of 35 db.

4.44 The voice and blocking amplifiers are checked for their gain on voice frequency using 1000 cps testing tone. The input of an amplifier is patched to the source of 1000 cps testing tone on the miscellaneous test equipment and the output is patched to the transmission measuring equipment at the toll test board. A gain control potentiometer is provided to adjust the gain to the required limits.

Tests of Individual Apparatus

4.45 Timing tests are made on certain relays when the failure of such relays to operate or release in a definite time might cause service reactions such as wrong numbers or false disconnects. The RR relay in the receiver, which controls the duration of the rering signal to a distant receiver, is such a relay. (If the rering is too long a false disconnect is given, if it is too short the rering signal will be ineffective.)

4.46 This relay is tested by connecting the M lead of the transmitter to the No. 2B (or 2A) test set and sending pulses of a definite duration over this lead. The contacts of the relay which control the duration of these pulses are connected to a jack in the signaling unit. This jack is patched to the test set which has a meter to indicate the length of the pulses.

4.47 Other relays with critical operate and release times, such as the CO and T, are tested in a similar manner.

4.48 Mercury relays such as the RG relay in the receiver are not

individually checked on a routine basis. In general, failure of these relays will be apparent from circuit tests. When such failures are detected, the mercury relays are tested using mercury relay test set (J94725A). These relays are mounted like vacuum tubes and so can be readily removed for testing.

4.49 When receiver or transmitter tests indicate troubles due to failure of the germanium varistors, these varistors are tested using the M9B ohmmeter which measures their forward and reverse resistance.

Bell Telephone Laboratories, Inc.

5 Attachments: Figs. 7,8,9,11 and 13

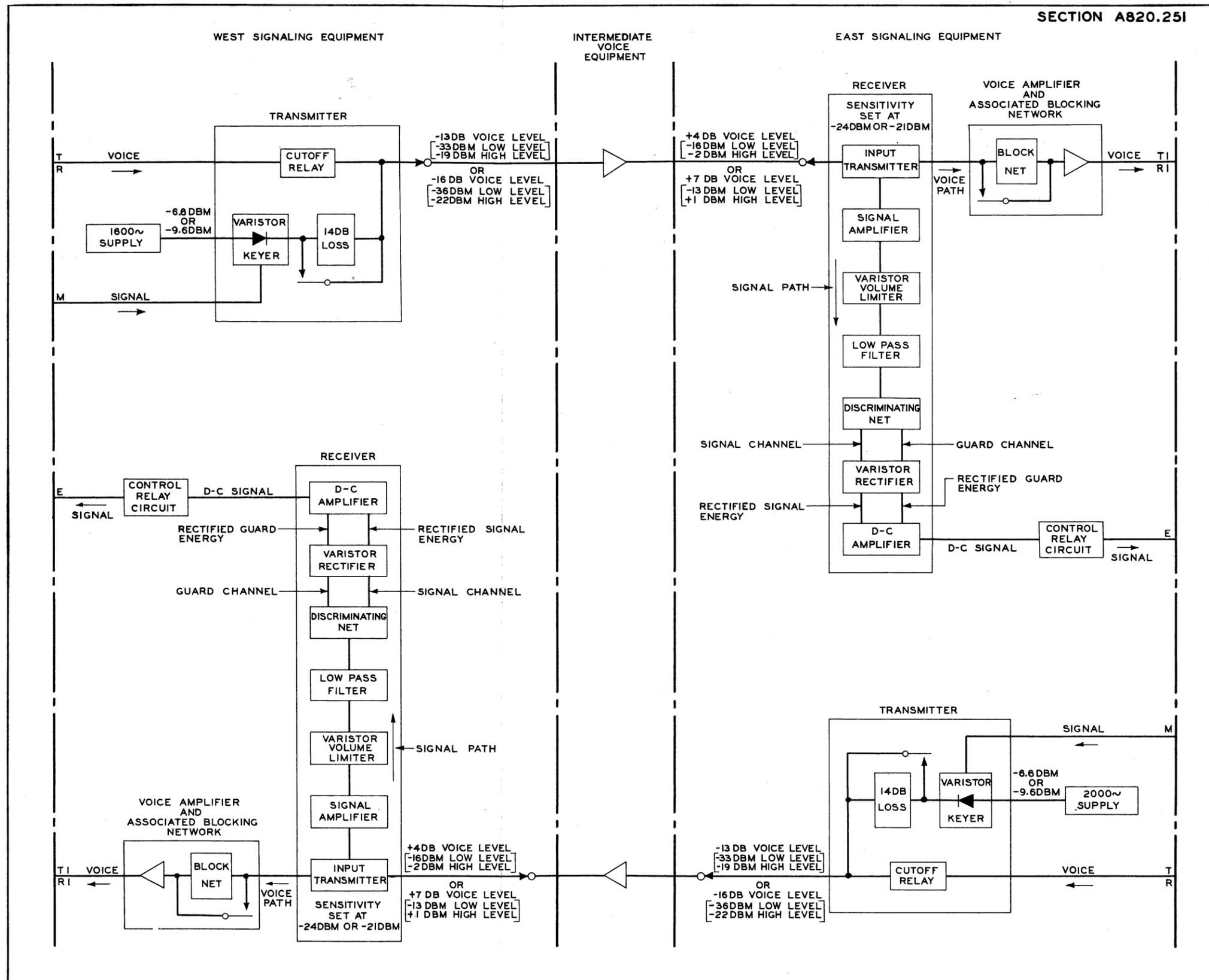


FIG. 7
PRINCIPAL ELEMENTS OF THE SINGLE
FREQUENCY SIGNALING SYSTEM

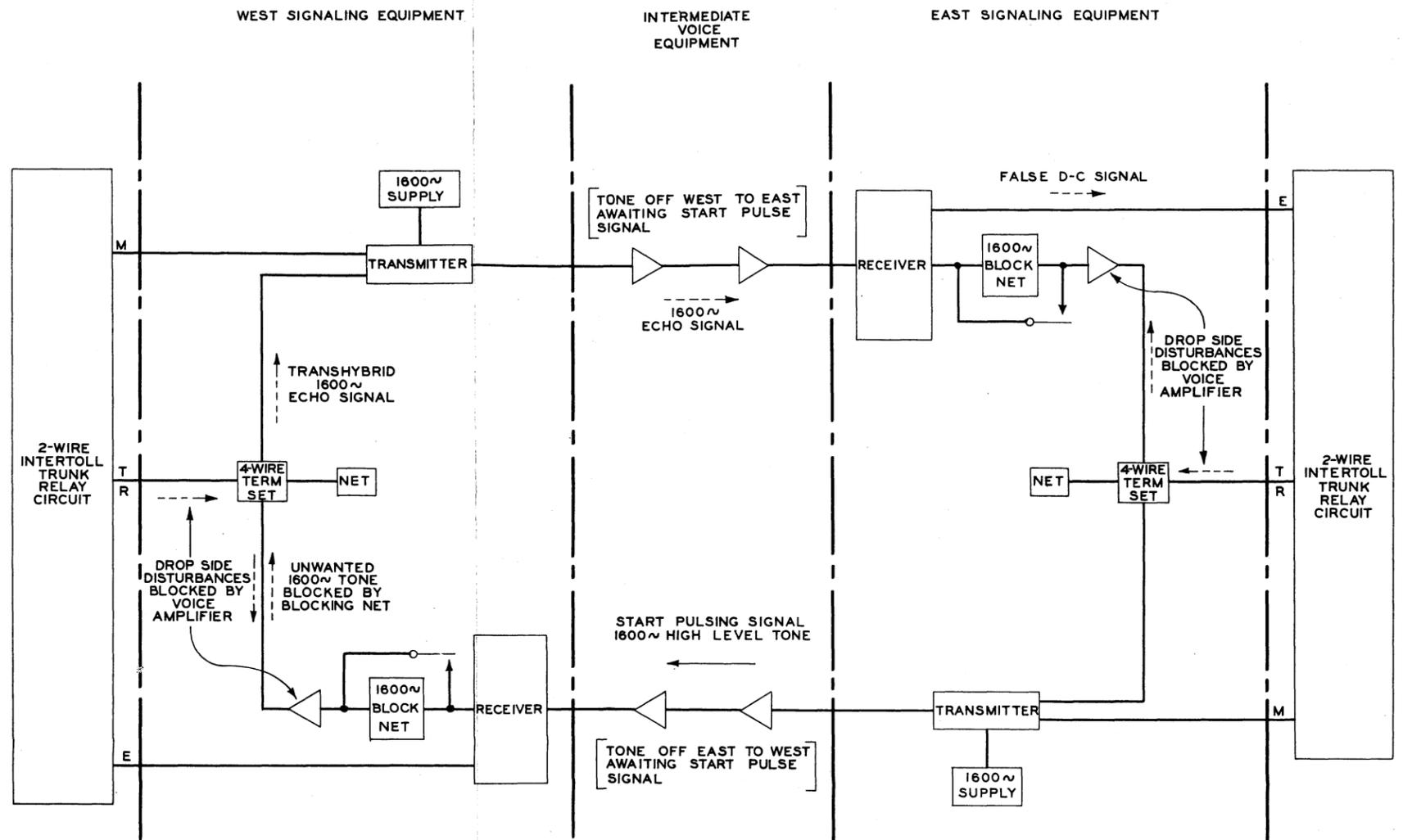


FIG. 8
USE OF VOICE AMPLIFIER AND
ASSOCIATED BLOCKING NETWORK

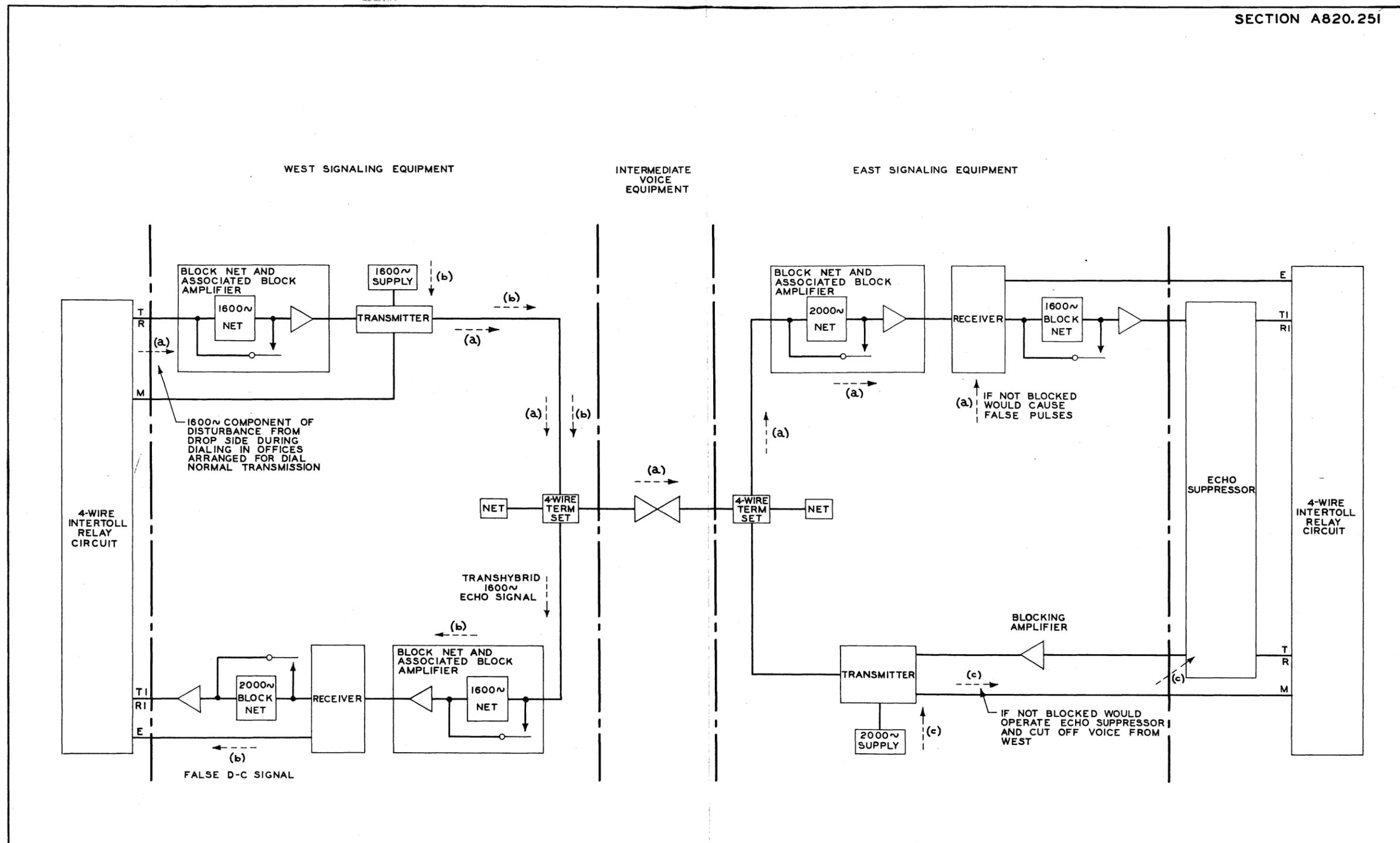
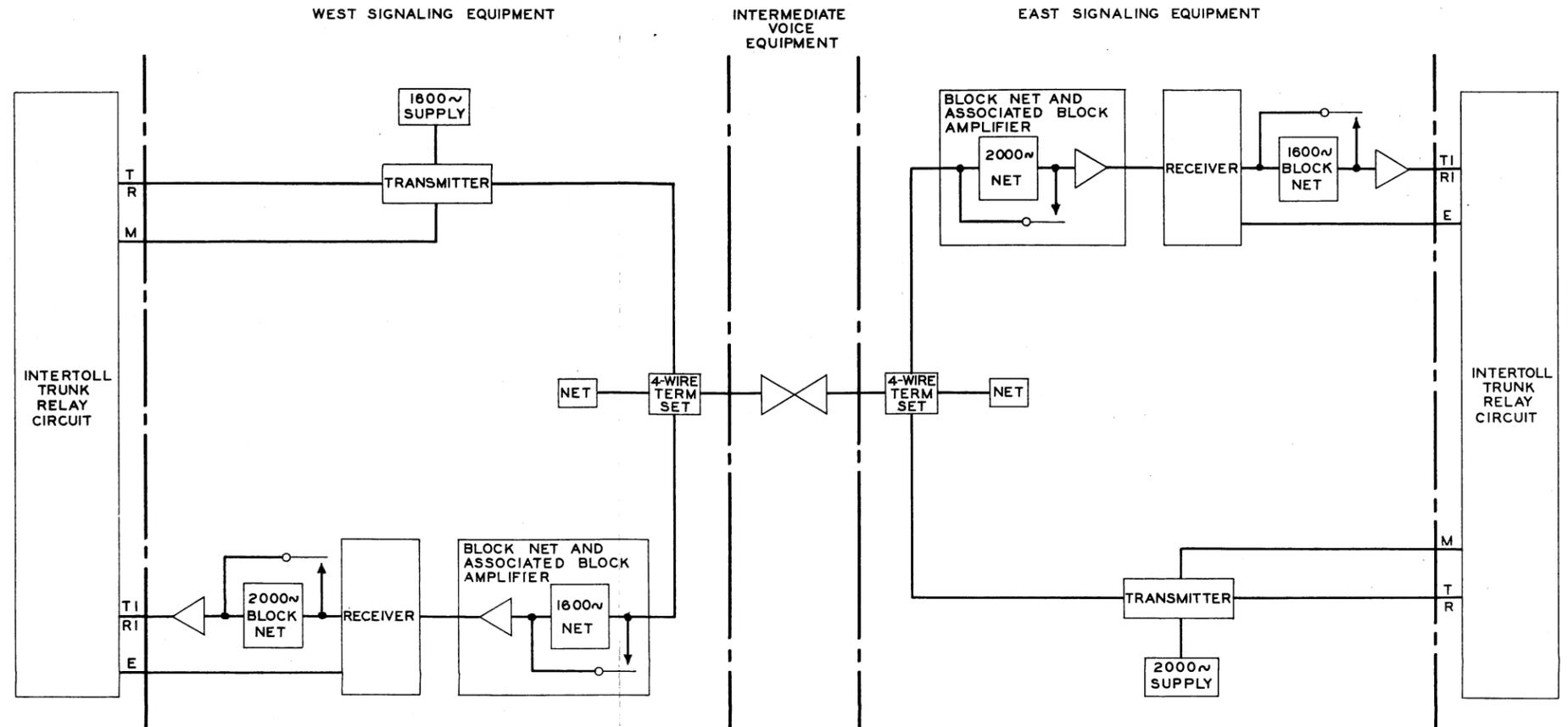


FIG. 9
 USE OF BLOCKING AMPLIFIER, AND BLOCKING NETWORK
 AND ASSOCIATED BLOCKING AMPLIFIER



FIG. 11
BAY ARRANGEMENT FOR
104 SIGNALING CIRCUITS



SIGNAL	WEST TERMINAL							TONE CONDITION ON LINE	EAST TERMINAL							
	TRANSMITTED LEVEL	RECEIVED LEVEL	RECEIVER SENSITIVITY	GUARD	MECHANICAL DELAY	NET			NET		MECHANICAL DELAY	GUARD	RECEIVER SENSITIVITY	RECEIVED LEVEL	TRANSMITTED LEVEL	SIGNAL
						1600w	2000w		2000w	1600w						
IDLE → ←	-33	-16	-24	NONE	OUT	IN	IN	LOW LEVEL → ←	IN	IN	NONE	NONE	-24	-16	-33	IDLE → ←
SEIZURE →	NONE	-16	-24	NONE	OUT	IN	IN	NO TONE → ←	IN	OUT	LOW	LOW	-24	NONE	-33	SEIZURE →
STOP PULSING ←	NONE	NONE	-21	HIGH	IN	OUT	OUT	NO TONE → ←	OUT	OUT	HIGH	HIGH	-12	NONE	NONE	STOP PULSING ←
START PULSING ←	NONE	-2 -16	-24	NONE	OUT	IN	IN	NO TONE → ←	IN	OUT	LOW	LOW	-24	NONE	-19 -33	START PULSING ←
DIAL PULSES →	-19 NONE	-16	-24	NONE	OUT	IN	IN	HIGH THEN NONE → ←	IN	OUT	LOW	LOW	-24	-2 NONE	-33	DIAL PULSES →
OFF-HOOK ←	NONE	NONE	-12	HIGH	IN	OUT	OUT	NO TONE → ←	OUT	OUT	HIGH	HIGH	-12	NONE	NONE	OFF-HOOK ←
ON-HOOK ←	NONE	-2 -16	-24	NONE	OUT	OUT	IN	NO TONE → ←	IN	OUT	LOW	LOW	-24	NONE	-19 -33	ON-HOOK ←
DISCONNECT →	-19 -33	-16	-24	NONE	OUT	IN	IN	HIGH THEN LOW → ←	IN	IN	NONE	NONE	-24	-2 -16	-33	DISCONNECT →

NOTE: ALL LEVELS ARE IN dbm

FIG. 13
TABLE AND BLOCK DIAGRAM ILLUSTRATING THE RELATIONSHIP
BETWEEN SF SIGNALING OPERATIONS AND THE SIGNALS
PASSED DURING A TYPICAL CALL