1600- OR 2000-CYCLE SINGLE FREQUENCY SIGNALING SYSTEM
EQUIPPED WITH SIGNALING CIRCUIT SD-56202-01
DETAILED CIRCUIT OPERATION

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1. INTRODUCTION

1.01 This system is an a-c signaling system used to extend the range of pulse operation over intertoll trunks. It uses frequencies within the voice band (1600 or 2000 cycles) to pass dial pulses and supervisory signals over the same distance as voice. The 1600-cycle frequency is used to signal in both directions over 4-wire facilities. Both frequencies, one in each direction, are used to signal over 2-wire facilities. These tones are applied to the voice channels and are transmitted over them between terminals of the SF signaling system.

1.02 A tone supply circuit and a signaling circuit (composed of a transmitter and a receiver) are located at each end of a trunk. Like composite signaling the SF system uses E and M leads to pass signals to and from a trunk relay circuit. The transmitter, under control of d-c signals obtained via the M lead, applies, removes or interrupts the signal tone transmitted to the distant terminal. At the distant terminal a vacuum tube receiver tuned to the incoming signal tone responds to these various conditions and sends d-c signals to the trunk relay circuit at that end.

1.03 A general description of the SF signaling system is given in Section 179-201-101. In that section the functions of the various equipment units, their physical appearances and typical bay arrangements are described. In addition, a typical call between two offices is described and the sequence of signals and major circuit operations are explained as the call progresses.

1.04 This section describes the detailed circuit operation and makes reference to operational sketches and sequence charts. The sketches and charts referred to in the description are listed in a separate index.

2. 1600- OR 2000-CYCLE SUPPLY CIRCUIT

2.01 The tone used by the SF signaling system is furnished by a bridge type vacuum tube oscillator. The oscillator circuit is basically the same for both the double oscillator supply unit and the single oscillator supply unit.

2.02 OS 101-1 is a simplified schematic of the double oscillator circuit. Frequency and amplitude of an oscillator are controlled by the bridge circuit in which two arms are formed by the primary windings of the output (OUT) transformer; the third arm is formed by the resistors E, F, and G; and the fourth arm by the resonant circuit consisting of retard coil A and the F1 to F9 capacitors.

2.03 The No. 408A vacuum tubes are of the miniature type and are connected to operate as high gain pentodes. The 20 volts required for filament operation are supplied by either the 24- or 48-volt central office battery. A 130-volt supply furnishes the plate and screen voltages which are 119 and 96 volts respectively.

2.04 Both oscillators are adjusted to the desired frequency (1600 or 2000 cycles) by strapping selected capacitors from the two groups of F1 to F9 capacitors. Output levels are adjusted by selection of taps on the A retardation coils and combinations of resistors E, F, and G. The taps allow fine adjustment and the resistors coarse adjustment.

2.05 Signal tone of the desired frequency and level is furnished from the secondary winding of the OUT transformers to all the associated signaling circuits. The ODD oscillator supplies tone to all

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odd-numbered signaling circuits and the EVEN oscillator to the even-numbered signaling circuits.

2.06 A signaling circuit transmits tone at either of two levels for the idle condition of the trunk. Tone is transmitted at -33 dbm when a signaling circuit is connected at the -13 db voice level point, and at -36 dbm when a signaling circuit is connected at the -16 db voice level point. Optional wiring and apparatus in the output of the supply circuits are used to obtain the correct tone level needed by the various signaling circuits within an office.

2.07 If all the signaling circuits within an office are connected at the -16 db voice level point, B-wiring is used on the OUT transformers. This wiring uses only a portion of the secondary windings of the OUT transformers. If all the signaling circuits are connected at the -13 db voice level point, A-wiring is used. This wiring uses the full secondary windings to obtain the additional 3 db.

2.08 In large installations some signaling circuits may be connected at the -13 db voice level and others at the -16 db voice level. For this condition A-wiring is used because it supplies the higher of the two levels necessary for those circuits connected at the -13 db voice level point. For those circuits connected at the -16 db voice level point, shunt resistors (J) are connected between the output transformer and the signaling circuits. These shunt resistors reduce the signal tone level (supplied by A-wiring) 3 db so that it is correct for the signaling circuits connected at the -16 db voice level point.

2.09 All these adjustments for frequency and output level are made at the time of installation.

2.10 As stated previously, the two oscillators supply tone to different groups of signaling circuits; the ODD oscillator to odd-numbered signaling circuits and the EVEN oscillator to even-numbered signaling circuits. A maximum load of 104 signaling circuits can be supplied with the load divided between the oscillators. Each oscillator supplies signal tone to the signaling circuits within its associated group by a multiple arrangement of resistors in the tip and ring conductors between the oscillator and the signaling circuits.

2.11 Between each oscillator and its distribution circuit is an automatic alarm and transfer circuit. This circuit transfers all the signaling circuits within a group from one oscillator to the other whenever the output of the first oscillator changes by more than ±1 dbm. This magnitude of change causes sufficient current to flow in the winding of the sensitrol relay (ALM) and move its armature to the number 4 or 5 contact. The B and T relays operate, and the signaling circuits associated with the oscillator in trouble are transferred to the other oscillator.

2.12 As this takes place an identifying lamp (ODD OSC or EVEN OSC) is lighted and a minor alarm is sounded. The maintenance man silences this alarm when he operates an alarm cut-off key on the supply unit. A guard lamp also lights when he does this. When he clears the trouble (which may be due to such things as low supply voltage, a defective vacuum tube, etc.), the identifying lamp goes out. The guard lamp, however, remains lighted until the automatic transfer circuit has done its job of returning the load of signaling circuits to the repaired oscillator.

2.13 The automatic alarm and transfer feature also operates when the output of both oscillators changes more than ±1 dbm. In this case both oscillators attempt to transfer their load and fail. They fail because when both transfer relays are operated another relay (D) operates and causes the release of both transfer relays. That is, there is no advantage in transferring the load circuits when both oscillators are in trouble. When this occurs a major alarm is sounded because all the signaling circuits served by the supply unit are out of service. This alarm cannot be silenced until the trouble is cleared.

2.14 As shown on OS 101-1, the automatic alarm and transfer circuit also operates whenever there is trouble in either load circuit which causes the output level of the associated oscillator to be changed by ±1 dbm. The transfer takes place because the sensitrol relay cannot differentiate between oscillator trouble and load trouble. However, once the load circuit is transferred to the second oscillator the trouble is transferred with it. This causes the second transfer relay to operate and, as above, whenever both transfer relays are operated they are made to release. Therefore, for this trouble, a major alarm sounds because one-half the signaling circuits served by the supply unit are out of service.

2.15 The jacks shown on OS 101-1 are used when testing a supply unit or its associated load circuit. Such checks as measurements of output level and output frequency are made by patching a particular set of jacks to the proper measuring equipment.

2.16 OS 102-1 shows the supply circuit used in small installations. This single oscillator circuit is the same type as the double oscillator just described and uses the same means of frequency and output level adjustment.

2.17 However, this oscillator supplies a maximum of two signaling circuits and both circuits must be connected at the same voice level point. This is usually the case in small installations, and for this reason no shunting resistors are provided.

2.18 A single relay (P) is normally operated by the cathode current through the vacuum tube. When the oscillator is in trouble and the cathode current decreases, the P relay releases and a major alarm is sounded.

2.19 This circuit also has jacks for measuring output frequency and output level, and for connection to a signaling circuit under test.

3. 1600- OR 2000-CYCLE SIGNALING CIRCUIT

(A) General

3.01 This part describes the operation of the signaling circuit on a relay to relay basis. Relay operations in the signaling circuit in one office affect relay operations in the signaling circuit in another office. For this reason the typical call method is used to discuss the operations in the sequence they occur during service. Because the sequence of relay operations in the SF signaling circuit differs with the type of trunk used, five typical calls are described.

3.02 The first call described is over a dial pulse trunk to an office equipped with dial pulse registering equipment (crossbar). This type of call uses a majority of all the signals which can be sent and received by the SF system. This type of call requires the called office to transmit both a stop and start pulsing signal. For this reason and because it is the first call described, considerable circuit detail is given during the progress of the call.

3.03 The second call described is over a dial pulse trunk to an office that does not have dial pulse registering equipment (step-by-step) and therefore does not return the stop and start pulsing signals. Many of the signaling operations are the same as during the first call. Consequently, the description of the step-by-step call is relatively short and relies upon comparison of the sequence charts for both types of calls.

3.04 The third and fourth calls are over ringdown trunks. Here the sequence of operations differs from both the preceding calls because SF signaling is used as spurt signaling. That is, spurts of SF tone are used to establish and release a connection and SF tone is not present on idle trunks.

3.05 The final call is over an incoming automatic trunk. This call combines some of the features of the dial pulse call and the ringdown calls. SF tone is on the trunk during the idle condition (similar to dial pulse) and the call is to a switchboard (similar to ringdown).

3.06 In addition to the signals discussed during the typical calls, other paragraphs of this part are devoted to a discussion of signals not encountered during the progress of the typical calls. These include such signals as rering and flashback.

3.07 In describing the various operations reference is made to OS 103-1 which shows a simplified schematic of an SF signaling circuit in an east and west office.

3.08 For all the calls and miscellaneous operations discussed in the following paragraphs certain assumptions are made. These assumptions are:

(a) Two-wire facilities are used between the toll offices.

(b) 1600 cycles is the west to east signal tone.

(c) 2000 cycles is the east to west signal tone.

(d) The west office is the originating office.

(e) The east office is the terminating office.

(f) In both offices the transmitters are connected at the -13 db voice level point and the receivers are connected at the +4 db voice level point.

(B) Typical Call to a Crossbar Office

Idle Condition of the Trunk

3.09 During an idle condition the associated outgoing trunk circuit at the west terminal (see OS 103-1) has ground connected to one end of the M lead, the other end of which is connected to the midpoint of resistor R3. A resistance path to ground is thus furnished from the number 1 terminals of varistors VR1 and VR2. The number 2 terminals of these varistors have a negative potential to ground of approximately -13 volts obtained from the potentiometer-resistor R6.

3.10 The potential across VR1 and VR2 (number 1 terminal positive with respect to the number 2 terminal) is sufficient to permit a current flow through each varistor, thus causing their internal resistance to become approximately 130 ohms. Signal tone supplied by the oscillator is transmitted through capacitors C1 and C2, varistors VR1 and VR2, to the T1 repeat coil and thence to the outward transmission path. (See SC 101-1.) The level of tone transmitted is -33 dbm (20 db below that of voice level at the point where the signaling circuit is connected).

3.11 The 1600-cycle tone is transmitted over the voice path of the 2-wire line facilities to the east terminal where it is normally received at -16 dbm. It passes through the blocking amplifier and the associated blocking network. The T1 repeat coil of the amplifier takes the signal tone from the toll line and passes it through the blocking network to the grid of vacuum tube V. Because the incoming signal to the east terminal is 1600 cycles and the blocking network is tuned to 2000 cycles, the signal passes without attenuation.

3.12 The blocking amplifier is a flat gain amplifier adjusted to provide zero gain and zero loss between the IN and OUT jacks when the blocking network is out of the circuit. Potentiometer P in the grid circuit of vacuum tube V is used to adjust the gain of the amplifier.

3.13 After passing through the amplifier, the incoming tone is directed to the input transformer T3 where the inward transmission path divides into a voice and a signal path. Part of the signal tone enters the voice path where a small amount gets through until the 35 db attenuation is inserted by the blocking network. This network is tuned to the incoming 1600 cycles so that signal tone is restricted to the toll facilities and the signal path in the receiver.

3.14 The remainder of the tone is directed to the signal path and the grid of vacuum tube V2. Potentiometer P2 controls the level of signal tone fed to the grid of vacuum tube V2. The potentiometer is set so that when R-wiring (for +4 db circuit) on T3 is used an input signal of -24 dbm causes the cathode current in vacuum tube V3 to be 7 milliamperes. When Q-wiring (for +7 db circuit) is used, an input signal of -21 dbm establishes the same current value with the potentiometer at the same position. This happens because Q-wiring uses taps on the secondary of T3, which cause a 3 db reduction of gain.

3.15 Amplified by the action of vacuum tube V2, the tone is delivered through the T4 output transformer to a load composed of volume limiter VR19, a low-pass filter composed of retard coil L1 and capacitors C15 and C16, and a voltage dividing network N1. To appreciate the action of the volume limiter and the low-pass filter requires understanding of the action of the voltage dividing network under conditions of signal tone alone, signal tone and voice, or voice alone being received. A description of the action of the network under these conditions follows before proceeding with the call.

3.16 The voltage dividing network consists of two resonant circuits, one parallel and one series, tuned to the incoming signal frequency (in this case, 1600 cycles). (These networks are tuned in the shop and are coded 200F for circuits receiving 1600 cycles and 200E for circuits receiving 2000 cycles. The resonant circuits for the voltage dividing network and the blocking network are in the same can.) Each tuned circuit is shunted by a half-wave rectifying arrangement composed of two germanium varistors in series with a storage capacitor. A-c voltage develops across each tuned section, and as a result of the rectifying characteristic of the varistors, d-c voltage appears across capacitors C18 and C19.

3.17 If the incoming energy is mainly pure signal tone, a relatively large a-c voltage appears across the parallel resonant network because this section is high impedance to signal frequency. Therefore, the C19 storage capacitor is charged by relatively high d-c voltage. Capacitor C18, on the other hand, shunts the low impedance series resonant section and because relatively little a-c voltage is developed across this section it is charged by a smaller d-c voltage.

3.18 If the incoming energy is mainly voice and has a negligible signal frequency component, the reverse is true. The parallel resonant section is a low impedance to all voice frequencies, and because of this a relatively small a-c voltage appears across the section. Capacitor C19 thus receives a small d-c charge. On the other hand, the series resonant section has a large a-c voltage across it due to its high impedance to voice frequencies. Therefore, capacitor C18 is more highly charged for this condition.

3.19 If the incoming energy contains both types of frequencies, each tuned section produces voltages in accordance with the relative power and frequency of the various components.

3.20 Regardless of the component frequencies of incoming energy, capacitors C19 and C18 become oppositely charged; C19 positively, C18 negatively with respect to their junction point. These two voltages are combined in a special proportion (by means of resistors R46 and R47) which affects the grid voltage of vacuum tube V3. This can be seen more clearly if the grid-cathode circuit of tube V3 is traced.

3.21 Starting at the grid of vacuum tube V3 a grid-cathode path can be traced through resistors R48 and R46, varistors VR25 and VR24, the inductance coil of the parallel resonant section of N1, resistor R26, to the potentiometer composed of R25 and R26, and lastly from ground through the P1 winding of the R relay to the cathode terminal of V3.

3.22 The potentiometer arrangement of R25 and R24 produces a voltage of -8 volts to ground which is the fixed grid to cathode bias voltage. A grid to cathode bias of -8 volts is close to the cut-off point of the V3 tube. The action of the charged capacitors is to change the bias on the grid of V3; the amount and the direction of change are dependent upon the level of signal tone with respect to voice or other extraneous energy. The charge on capacitor C19 tends to make the grid more positive, thus permitting more plate-cathode current flow; the charge on capacitor C18 tends to make the grid more negative, thus driving the grid below cut-off and reducing plate-cathode current flow.

3.23 This action is more easily seen if a charge and discharge cycle of these storage capacitors is described.

3.24 During the first positive half-cycle of incoming signal tone, when the voltage across the parallel network is rectified, practically all of the current flows into capacitor C19 because it is discharged. During the negative half-cycle no current flows through the circuit because the varistors cannot pass current in the reverse direction. However, the potential still exists across C19 from the charge of the positive half-cycle and it starts to discharge through R46, R47, VR20, VR21, and R15 to the other side of C19.

3.25 The high resistance in this path allows only a small current to flow and consequently only a small portion of the charge is removed. During the next positive half-cycle C19 again charges to the peak voltage developed across the circuit. The low resistance in the charging path allows C19 to charge very quickly, but the high resistance in the discharge path forces it to discharge slowly. Therefore, after one or more cycles, the full voltage across C19 is maintained as long as signal tone is received.

3.26 The voltage drop across R46 due to the discharge current is in the same direction as the -8 volts bias produced by the potentiometer of R24 and R25. When pure signal tone is received the algebraic sum of the -8 volts fixed bias, the positive voltage across C19, and the negative voltage due to the drop across R46 is such that the grid bias voltage is sufficiently positive to permit a relatively large plate to cathode current in tube V3. The charge across C18, under the condition of pure signal tone, is negligible and need not be considered in computing the algebraic sum.

3.27 However, if the incoming signal is not pure but contains other frequencies in addition to the signal frequency, capacitor C18 receives a relatively higher charge. Its discharge path is through N1, VR24, VR25, R46 and R47. The voltage drop across R46 is in the same direction as that caused by the discharge of the other storage capacitor C19. If the voltage drop across R46 due to the combined discharging currents of C18 and C19 exceeds the potential across C19, the net effect is to make the grid of V3 more negative and drive the grid below cut-off.

3.28 The parallel resonant circuit, the associated varistors VR24 and VR25, and capacitor C19 form the signal channel of the receiver. The signal channel alone produces voltage which tends to operate the receiver by permitting a high plate-cathode current in tube V3. The series resonant circuit, the associated varistors VR20 and VR21, and capacitor C18 form the guard channel. The guard channel produces voltage which tends to prevent operation of the receiver by reducing the cathode current in V3.

3.29 It was stated previously that the output of vacuum tube V2 was directed to a volume limiter (VR19) and a low-pass filter. The volume limiter supplements the guard action of the receiver. Its function is to restrict the level of any voice energy entering the signal path especially when signal tone is present in the voice energy. Thus, if there is a large signal frequency component in the voice energy of a loud talker, the volume limiter restricts the amount of signal component which would get through and operate the receiver.

3.30 The volume limiter and vacuum tube V2 generate unwanted harmonics even when pure signal tone is received. The low-pass filter (coil L1 and capacitors C15 and C16) is used to prevent these harmonics from reaching the voltage dividing network where they would develop unwanted guard voltage.

3.31 One other feature which is used to prevent false receiver operation should be noted before proceeding with the call under consideration. As already described, the discharging path of capacitor

C19 contains resistors R46 and R47. At the instant the discharging current starts to flow, R47 is effectively short-circuited by the low resistance of varistors VR22 and VR23 in series with capacitor C17. As C17 becomes charged the impedance of this series combination slowly reaches the value of resistor R47 and no longer short-circuits it. The instant, therefore, that the C19 discharging current begins to flow, its discharge circuit resistance is low and the discharging current through R46 consequently high because of the effective removal of R47.

3.32 The net effect of C19 discharging and the high current through R46 is at first a smaller positive voltage on the grid of V3 than is obtained when the signal gets to a steady state condition. This action, in conjunction with the discharging action of C18 in increasing the voltage across R46, tends to delay considerably the build-up of a positive voltage of sufficient magnitude to drive the grid of V3 above cut-off. This delay prevents receiver operation on very short spurts of almost pure signal tone that might be in any received voice energy.

3.33 Some of the features of the receiver have been discussed; others are discussed as the call under consideration progresses. Prior to the description of the action of the signal and guard channels, signal tone was being received and amplified by vacuum tube V2. The operations described in the following paragraphs start at that point.

3.34 When signal tone is received and the charge on C19 is maintained, the bias on the grid of V3 is such that a relatively large plate-cathode current flows. The RF (remove filter) and R (receiving) relays which are in the plate and cathode circuits respectively operate when the current in tube V3 increases. The RF relay quickly inserts the blocking network in the voice path where it blocks the incoming signal tone. The R relay is slow operating due to the secondary winding and varistor VR3 which tend to restrict the build-up of flux in the P1 winding. This slow operation of the R relay is further protection against talk-off or operation of the receiver on short spurts of signal frequency which may be present in any voice energy.

3.35 When the R relay operates ground is connected through varistor VR18 to the primary winding of the RG (regeneration) relay, causing it to operate and remove the ground from the E lead. The removal of the ground establishes an idle condition for the trunk.

3.36 The GR (guard remove) relay also operates, shorting out the series resonant section of the voltage dividing network. The result of this action is to remove the guard channel and make all incoming energy (signal tone and noise) active in keeping the receiver operated. This is the no-guard condition of the receiver which also at this time has normal sensitivity (operates at -24 dbm).

3.37 The conditions described above (from the origination of an idle signal through receiver operation to the removal of ground from the E lead) are similar for transmission of the same type signal from the east terminal to the west terminal. However, the tone sent toward the west is 2000 cycles, the blocking network in the line receive branch of that terminal is tuned to 1600 cycles, the blocking network in the voice amplifier path is tuned to 2000 cycles, and both the parallel and series sections of the voltage dividing network are tuned to 2000 cycles. The action of each of these networks and tuned sections is similar to those in the east terminal, and thus the receivers in both terminals are operated and are in their no-guard and normal sensitivity conditions.

Seizure Signal

3.38 When the trunk circuit is seized at the west terminal, a trunk circuit relay operates and connects -48 volt battery to the M lead. Battery on the M lead creates a greater negative potential at the number 1 terminals of VR1 and VR2 than that created at the number 2 terminals by the potentiometer R6. As a result of this new potential condition VR1 and VR2 have high internal resistance (in the order of one megohm), and thus effectively block signal tone from reaching the outward transmission path. Tone is not completely removed from the transmission path but the level is reduced in the order of 80 db which, as far as the receiver at the east terminal is concerned, is as effective as complete absence of tone.

3.39 Battery on the M lead also causes the M (out signal) relay to operate which completes one of the operating paths of the CO (cut-off) relay. The outward transmission path is split and terminated by the operation of the CO relay. This is done whenever there is a transition from tone-on to tone-off or vice versa. By opening the transmission path just long enough when signal tone is being connected or disconnected, noise from the drop side does not interfere with the action of the receiver at the distant terminal. The length of time that the transmission path is split and terminated is dependent upon the length of time the CO relay (which may be operated over several paths) remains operated. A minimum period of operation and the resulting split transmission path is assured by the slow release of the CO relay. The slow release of approximately 100 milliseconds is accomplished by varistors VR6 and VR7. They shunt the relay winding permitting current to flow in the direction which tends to keep the relay operated after the operating path is opened.

3.40 Although west to east signal tone is removed at this time for the transmission of the seizure signal, the transmitter prepares to continue signaling operations. It conditions itself to transmit tone at a 14 db higher level when the HL (high level) relay operates and shorts out resistor R16 in the output circuit of the varistor keyer.

3.41 The T relay operates and also shorts out R16. This is done to permit transmission of high level tone for a relatively long period of time during the disconnect signal. The T relay also connects capacitor C21 in parallel with C19, thereby increasing the storage capacity for voltage which keeps the receiver operated. This type of aid is necessary to produce distortionless report signals. As it is assumed for the call under consideration that a disconnect signal does not take place at this time and that report signals are not to be received, the description of these features is postponed until later. It may be said, however, that the effect of C21 is to keep the receiver operated about 20 milliseconds longer than it would be without C21.

3.42 When the west to east signal tone is removed, the receiver at the east end quickly releases. The RF, R, GR, and RG relays release. Ground is connected to the E lead by the released RG relay approximately 30 milliseconds after cessation of tone. This ground is a seizure signal to the east trunk relay circuit.

3.43 During the idle period the east receiver had been in a no-guard condition and all energy entering the receiver was used to keep the receiver operated. At this time, with the incoming signal removed and the receiver in a released condition, the receiver is exposed to any voice or noise on the trunk. It therefore becomes selective to incoming frequency by establishing a low-guard condition. This is done when the released GR relay removes the short across the series resonant section of the voltage dividing network. Now the receiver is less likely to operate if false signal energy is received.

3.44 Under the low-guard condition if a short spurt of signal tone frequency is received as a component of voice or noise, the a-c voltage developed across the series resonant section due to the other components is rectified and charges capacitor C18. The charge on capacitor C18, as explained, is used to keep the receiver released. It should be pointed out that R15 shunts the series resonant section restricting the impedance across this section to approximately 5000 ohms. Later, this resistor shunt is removed, permitting a higher impedance and therefore high-guard action.

Stop Pulsing Signal

3.45 When the incoming seizure signal is received in the east office, equipment designed to register the expected dial pulses is not immediately available. A stop pulsing signal is therefore transmitted from the east end to indicate that such equipment is as yet unavailable, and consequently the transmission of the dial pulses should be delayed. Transmission of the stop pulsing signal is ordered by the incoming trunk circuit at the east end when it replaces ground on the M lead by battery.

3.46 Battery on the M lead, as has already been shown, results in the immediate removal of transmitted tone followed by the operation of the M, CO, and HL relays, with the CO relay slowly releasing. After this signal is sent, the east end receiver is in the same condition as when an off-hook or subscriber answer signal is sent. This is readily seen by referring to SC 101-1. An off-hook condition with conversation following would further expose the receiver to false operation. The receiver cannot differentiate between the signals and prepares to increase the protection against false operation by changing its operate sensitivity, increasing the guard, and providing a mechanical delay.

3.47 The operate sensitivity of the receiver is made -12 dbm when the S (sensitivity) relay operates and changes taps on input transformer T3, thereby reducing the portion of secondary winding used as receiver input. This makes it more difficult for average voice energy to operate the receiver. The unused portion of the secondary winding is shunted by resistor R14 (0.91 megohm). This action maintains a high resistance load across the unused portion of the secondary winding, thus keeping a more constant low bridging loss to incoming voice transmission.

3.48 The signal-to-guard efficiency is changed to high-guard by the removal of the R15 shunt across the series resonant section. The impedance across the series resonant section, with R15 removed, rises to high values for frequencies further and further away from resonance (in this case 1600 cycles). Consequently higher a-c voltages are developed by any voice energy received, and when these voltages are rectified capacitor C18 receives a higher charge.

3.49 The mechanical delay is introduced when the S relay opens the operating path of the RG relay. Thus, the RG relay (which formerly operated immediately after the R relay) cannot operate until the S relay releases.

3.50 All of these features (lowered sensitivity, higher guard efficiency, and mechanical delay) are incorporated in the receiver to prevent its operation by spurts of almost pure signal tone which might be in the transmitted voice energy.

3.51 The east terminal is further conditioned for voice transmission when the S relay removes the blocking network (tuned to 1600 cycles) in the voice amplifier path by shorting out terminals 9 and 10. In addition, the blocking network (tuned to 2000 cycles) in the line receive side is removed when the F relay operates.

3.52 At the west end the discontinuance of incoming tone (as a result of the transmission of the stop pulsing signal) results in the release of the RF, R, RG and GR relays, and the operation of the SR relay. Ground connected to the E lead by the RG relay is interpreted as a stop pulsing signal by the west trunk relay circuit.

3.53 It should be pointed out that the west receiver was in a no-guard condition and that capacitor C21 was in the circuit (GR and T relays were operated) before incoming tone ceased. Both of these conditions keep the receiver operated longer, and consequently the time from cessation of tone to the application of ground by the E lead is approximately 60 milliseconds.

3.54 As soon as the GR relay releases and removes the short across the series resonant section at this terminal, this receiver becomes selective to incoming frequencies by establishing a low-guard condition.

3.55 The action of the west receiver now varies depending upon whether the stop pulsing signal is removed in less than a second (it may be if equipment is immediately available in the east office) or whether it lasts longer than one second.

3.56 If the stop pulsing signal is of less than one second duration, the west receiver takes no action. However, if the stop pulsing signal is maintained for more than one second, the west receiver also assumes that the talking condition has been established because signal tone is not being sent in either direction. It then proceeds to increase the protection against false operation by lowering its sensitivity, changing to high-guard and incorporating the mechanical delay feature.

3.57 The S relay performs these functions after a timed interval. The S relay cannot operate until the T relay releases; the latter cannot release until the T cold-cathode vacuum tube fires, which in turn depends upon the charging of capacitor C9.

3.58 Capacitor C9 starts to charge when the GR relay releases and removes the ground shunting the capacitor. When the stop pulsing signal is maintained for a minimum of one second, capacitor C9 accumulates a charge of approximately 72 volts. Terminal 1 (control anode) of the T vacuum tube receives this same potential when capacitor C9 is charged. This potential is sufficient for a breakdown of the control gap across terminals 1 and 4. The resulting ionization reduces the breakdown voltage of the main gap (across terminals 2 and 4) and the tube fires. Current flows from the 130-volt battery to the main anode (2), to cathode (4), and through the secondary winding of the T relay. The T relay is wound differentially and the current through the secondary winding causes its quick release. The T vacuum tube ceases to fire when the T relay releases and removes the source of voltage.

3.59 In addition to operating the S relay and obtaining the resulting protection against voice currents, the west receiver removes the blocking network in the line receive path and the blocking network in the voice amplifier path.

3.60 The condition of the signaling circuits at both terminals is such that ideal conditions for the talking period have been established. That is, both receivers are in their low sensitivity condition, have high-guard action, and have incorporated the mechanical delay.

Start Pulsing Signal

3.61 When the equipment at the east office is ready to receive dial pulses, the associated incoming trunk circuit at that end removes battery and replaces it by ground on the M lead. Signal tone (2000 cycles) is again transmitted from the east end, this time at a 14 db higher level. The M and F relays quickly release, inserting the line side blocking network tuned to 2000 cycles.

3.62 The east receiver prepares to receive incoming tone and realizing that the talking period is not yet established where mechanical delay, high-guard and low sensitivity are needed, proceeds to establish a condition best suited for the reception of dial pulses. The release of the S relay increases the sensitivity, removes the mechanical delay, and restores the receiver to a low-guard condition.

3.63 The release of the S relay permits the slow releasing RR (rering) relay to release. The RR relay releases slowly because of the action of varistors VR15 and VR16 and potentiometer P5. As soon as the M relay releases and until the RR relay releases, a supplementary ground is applied to the M lead for approximately 175 milliseconds. This action is beneficial during the sending of any rering signal, as is explained later, but has no value at this moment since the trunk circuit maintains a steady ground on the M lead. At this time high level tone (-19 dbm) is sent for approximately 275 milliseconds (100 milliseconds additional due to the slow releasing HL relay) followed by continuously sent low level tone (-33 dbm).

3.64 At the west end the reception of this high level signal tone causes the receiver, even though it may at this moment be in its low sensitivity condition, to operate the RF and R relays and to release the slow releasing SR relay. The RF relay quickly inserts the blocking network tuned to the received signal frequency (2000 cycles) into the inward transmission path.

3.65 It should be noted that the time interval between reception of incoming tone and the grounding of the E lead depends upon whether or not the S relay has been operated. If the S relay is operated with all the resulting talk-off protection the time is approximately 150 milliseconds, whereas if the S relay has not been operated the time is approximately 60 milliseconds. In either case, after the receiver operates, it has no-guard action, normal sensitivity (-24 dbm) and both blocking networks are back in the circuit.

Dial Pulses

3.66 The transmission of information relative to the called subscriber number now takes place so that the call can be routed through the next switching office. SC 101-1 illustrates the transmission of the first (digit 2) and last digits (digit 1) of a typical call. The associated trunk circuit at the originating end passes the dial pulses to the SF signaling circuit by changing the condition on the M lead from battery to ground for the break period of each pulse. Removal of battery causes the immediate transmission of high level (-19 dbm) signal tone and the release of the M relay followed by the operation of the CO relay. The CO relay, as always, cuts the outward transmission path.

3.67 During the train of pulses representing a given digit or letter the M relay follows the pulses, whereas the CO and HL relays remain operated due to their slow releasing characteristics. However, during interdigital time the CO relay releases while the M and HL remain operated because of battery on the M lead.

3.68 At the called end the arrival of these tone pulses causes the operation of the R relay, and in turn the RG relay, which repeats the pulses to the trunk circuit by removing ground from the E lead. The SR relay holds up over the operated period of the R relay and thus causes the CO relay to operate and hold over the train of pulses, releasing however during the interdigital time.

3.69 These pulses never arrive at the called end in the form they were transmitted. They vary in received power, are altered by frequency shift (if over a carrier system), and are usually accompanied by a variety of trailing echoes. The action of the guard channel and the slow operating characteristics of the R relay considerably chop off the front end of these tone pulses. The d-c pulses are therefore considerably shorter than the tone pulses. The R relay, however, repeats these pulses to the regenerating relay RG which (under control of its secondary winding) increases the shortest pulse to one of specified minimum duration.

3.70 The sole function of the secondary winding of the RG relay and its associated arrangement of varistors, capacitors, and resistors is to guarantee a minimum operated period of the RG relay once it has operated. The action can best be described as follows. When the RG relay is normal capacitors C3, C4 and C5 are charged from ground through contacts 4 and 5, varistor VR12 and the 1100-ohm section of R19 to 48-volt battery. The moment the back contact of the RG relay is opened, the energy stored in these capacitors discharges through potentiometer P6, resistor R19, and the secondary winding of the RG relay. The flow of current through the secondary winding keeps the relay operated independently of its operating path.

3.71 The minimum operated period of the RG relay is set by adjusting potentiometer P6. When the circuit is properly adjusted it produces pulses of 60 per cent break at 10 pps.

3.72 At the end of the dial pulsing period the circuits at both ends of the system return to the same conditions in which they were before dial pulsing actually started. That is, no signal tone is being transmitted in the west to east direction and low level tone is being transmitted in the east to west direction. The circuit remains in this condition until the called subscriber answers.

Off-Hook Signal

3.73 After the east terminal switching equipment routes the call to the called subscriber and he answers, the trunk relay circuit at the east terminal replaces ground on the M lead by battery, causing the removal of east to west signal tone. The sequence of operations that result is identical to those previously described for transmission of the stop pulsing signal where the stop pulsing signal was maintained for at least one second. At both ends of the system the receivers are in their low sensitivity and high guard conditions, and have the mechanical delay feature incorporated. These all give each receiver its maximum talk-off protection now that the talking condition has been established.

On-Hook Signal

3.74 When conversation is finished and either the calling or called subscriber hangs up, the originating operator receives an on-hook supervisory signal informing her that the call is completed. The on-hook signal from the two parties can originate simultaneously or one could be sent prior to the other. The signal from the calling subscriber is received via the circuit from the calling subscriber's local office; the signal from the called office is received from the distant toll office via the SF signaling system. In either case the operator takes down her cords and automatically a disconnect signal is sent from the calling end to the called end. The disconnect signal releases the switching equipment used in setting up the call and restores the trunk to the idle condition.

3.75 The following description assumes that the on-hook signal from the called subscriber is received first.

3.76 When conversation is finished and the called subscriber hangs up, an on-hook signal is transmitted by the SF signaling system back to the originating operator, informing her that the call is completed. The on-hook signal is transmitted toward the west end by high level (-19 dbm) tone for approximately 250 milliseconds followed by continuously sent low level (-33 dbm) tone. This type of signal, the sequence of operations, and the condition of the receiver at both ends of the system are identical to those described in conjunction with the start pulsing signal. The receiver at the east end changes to a low-guard, normal sensitivity condition; the receiver at the west end, since tone is being received, changes to a no-guard, normal sensitivity condition.

Disconnect Signal

3.77 The originating operator recognizes the steady on-hook signal and proceeds to disconnect. When she removes her cords the trunk relay circuit connects ground to the M lead and high level tone is transmitted toward the east end. This is the disconnect signal sent so that equipment in the distant office used in setting up the call may be released.

3.78 The M relay releases followed by the operation of the HL and the release of the CO. Ground is removed from the C9 capacitor by the HL relay, permitting the cold-cathode timing tube to time out and release the T relay. The signal tone level sent to the east end remains high until the T relay releases, and it is then followed by low tone. The low level tone remains on the trunk as an idle signal.

3.79 At the east end ground is removed from the E lead and a disconnect signal is transmitted to the associated trunk relay circuit, allowing the switching equipment to return to normal.

3.80 The CO relay operates because the SR relay is still operated although it is in the process of releasing. The SR relay releases in approximately 250 milliseconds, allowing the GR relay to operate and the CO relay to release.

3.81 Actually the signaling circuit at the east end has returned to normal but the one at the west end has not. The T relay at that end is still operated. As soon as the T relay releases the circuit is restored to normal with both transmitters sending out low level tone, both receivers in a no-guard and normal sensitivity condition, and with the mechanical delay feature removed.

(C) Typical Call to a Step-by-Step Office

3.82 A call may be established through an office (step-by-step) which does not use dial pulse registering equipment. The switching through this type of office is under direct control of the incoming dial pulses. Because it is not necessary to attach dial pulse registering equipment, no stop and start pulsing signals are required. For this type of call dial pulses are sent immediately after the seizure signal.

3.83 SC 102-1 shows the sequence of operations of the SF signaling system during such a call. Most of the operations are identical to those already described and consequently are not described here.

3.84 The operations for the idle circuit condition and for the seizure signal are performed in an identical manner. Dial pulses follow immediately after the seizure signal without the intervening stop and start pulsing signals. Therefore, east to west signal tone is not removed until the called subscriber answers. Because tone is not removed in both directions of transmission until that time, the receivers do not go through the extra step of providing all the protection against false operation until it is actually needed.

3.85 One other difference should be noted. The east office (assumed to be step-by-step) uses P-wiring on the blocking network in the voice receive path. This wiring puts the network under control of both the RF and S relays. The network is not removed until the talking period (when the S relay is operated). By keeping the network in the circuit none of the signal tone dial pulses can get through the voice path to another SF signaling system connected in tandem with this one.

3.86 Once the network is removed from the circuit it is not necessary to wait for the S relay to release before it is reinserted. The RF relay will operate and reinsert the network as soon as signal tone is received. However, if signal tone is not received first but is transmitted first (as shown on SC 102-1 for the on-hook condition), the S relay releases and reinserts the network.

3.87 The other operations (off-hook, on-hook, and disconnect signals) are identical as shown on the sequence chart.

(D) Typical Calls to Manual Offices via Ringdown Trunks

3.88 The sequence of operations of the SF signaling system when used on ringdown trunks is unlike those previously described for dial trunks. Whereas presence of signal tone during the idle condition is normal for dial trunks, the absence of signal tone for the idle condition is normal for ringdown trunks. Tone is transmitted on ringdown trunks only when it is desired to signal the distant operator.

3.89 Converter circuits are used to change the signals sent by the trunk circuit to those accepted by the SF system and vice versa. OS 104-1 shows three typical converter circuits; two of the converters are used for ringdown trunks and one for incoming automatic trunks. The last named is discussed later in connection with incoming automatic trunk operation.

3.90 The first converter (SD-56159-01) shown is used for connecting an SF signaling circuit to No. 3 type switchboards. As shown on OS 104-1, the switchboard may exchange signals over an ST and a G lead or over an SG lead. The following description discusses signaling over the SG lead (both methods are shown on the sequence chart of OS 104-1.)

3.91 During the idle period negative 48-volt battery is connected through a break contact of the M relay of the converter circuit to the M lead of the SF signaling system. Battery applied to the M lead keeps tone from the line and the receiver at the distant end released. Ground connected to the E lead by the released receiver causes the operation of the SP relay in the converter circuit. The operated SP relay connects the SG lead, over which signals are sent to and from the trunk relay circuit, to the M relay. This single lead takes the place of both the M and E leads between the converter circuit and the trunk circuit.

3.92 Thus during the idle condition, battery is connected to the M leads, ground to the E leads, tone is not being transmitted in either direction, and the receivers are released.

3.93 Each step in establishing the idle condition has not been explained, for the method of operation of the various relays in the single frequency circuit has been discussed previously. It should be noted, however, that the S relay, as OS 104-1 shows, is operated at both terminals during the idle condition. Thus the receivers at both terminals have high-guard, low sensitivity, and mechanical delay. At both terminals the HL relay is operated which means that when tone is transmitted it will be at high level.

3.94 To signal the operator at the distant end the originating operator at the west terminal operates a ringing key which causes battery to be applied to the SG lead. The operation of the M relay in the converter circuit removes battery and supplies ground to the M lead of the SF signaling circuit. Application of this ground permits high level signal tone to be transmitted toward the distant end where it causes the east receiver to operate and change the condition of the E lead to an open. The released SP relay in the east converter circuit connects battery to the SG lead of the associated trunk circuit, causing a signal to be brought in at the switchboard.

3.95 During the ringing period both receivers change to normal sensitivity and remove the mechanical delay. The receiver at the east end removes all guard action; the receiver at the west end changes from high-guard to low-guard.

3.96 At the conclusion of the ringing period battery is disconnected from the SG lead at the east end when the ringing key is restored. The M relay in the converter circuit releases, ground is again connected to the M lead, and tone is removed. The circuits restore with only those relays operated which were operated during the idle period. Thus the talking period condition of a ringdown trunk is the same as the idle period.

3.97 When the talking period is over and the calling subscriber on-hook signal is received by the originating operator, she rings toward the east end as a disconnect signal. The operations are identical to those in establishing the connection. At the end of the ringing period the SF signaling circuit restores to the same condition as when idle.

3.98 The second converter (SD-56163-01) shown on OS 104-1 is one which changes 20-cycle ringing signals from No.1 type switchboards to d-c signals required for operation of the SF signaling circuit. Conversely, the converter changes the d-c signals from the SF signaling circuit to 20-cycle ringing for the switchboard. Ringing to and from the switchboard side is done over the tip and ring conductors.

3.99 The sequence chart on OS 104-1 shows that during the idle period battery is kept on the M lead and ground on the E lead. The SF signaling circuit is in the same condition as that described for the other converter - that is, tone is not being transmitted from either the east or west office.

3.100 When an originating operator (west office) rings, the 20-cycle current is rectified by the A varistor and relay A operates. This causes the M lead to be grounded and high level tone to be sent toward the distant end. The operations of the SF signaling circuit are the same as those described for the first converter and are not described here. Reference should be made to the sequence charts.

3.101 When the east converter receives the incoming signal (E lead open), the R relay in the converter releases and passes 20-cycle ringing current to the switchboard.

3.102 At the end of the ringing period, the SF tone is removed and the SF signaling circuit restores to normal.

(E) Typical Call to a Manual Office via an Incoming Automatic Trunk

3.103 Operation of the SF signaling system on an incoming automatic trunk is similar to operation on a dial pulse trunk. In both cases SF tone is present on an idle trunk and must be removed in both directions before the start of the talking period.

3.104 The third converter (SD-56131-01), shown on OS 104-1, is used on incoming automatic trunks to No. 3 type switchboards. This converter also uses either the SG lead or the ST and G signaling leads to the switchboard. However, this converter differs from the first converter described.

3.105 The first converter (SD-56159-01) received a signal over the E lead at the start and end of the ringing period. The duration of the signal was controlled by the duration of the ringing signal from the originating operator. However, this last converter (SD-56131-01) receives only one signal over the E lead. This signal is received when tone is removed. Like dial operation it does not receive another signal until additional information is passed (rering or disconnect in this case).

3.106 This converter sends a 2-second signal toward the switchboard as a ringing signal to the called operator.

3.107 The operation of the SF signaling and converter circuits is as follows. During the idle condition low level tone is being sent in both directions. The SF signaling circuit is in the same condition as that described for a dial pulse trunk. (See SC 101-1.) Both receivers are operated and are in their no-guard and normal sensitivity conditions.

3.108 When the west terminal puts battery on the M lead, the low level west to east tone is removed. The SF operations that result are identical to those previously described.

3.109 At the east terminal the R relay sends a signal to the switchboard. This signal is maintained until the A tube fires and the B relay operates (for approximately 2 seconds).

3.110 While this signal is being sent to the switchboard the converter circuit removes the east to west SF tone. This is done when the A relay operates and applies battery to the M lead.

(F) Other Operations

Rering Signal

3.111 The first two calls described were completed by mechanical switching systems and only one operator, the originating operator, was needed to establish the connection. If the call had been extended from the east terminal of the SF signaling system through the east terminal switching equipment to a manual toll office, a second operator would have been in on the connection. When there is another operator on the connection, it is often necessary to send a rering signal to obtain her attention after the connection has been established.

3.112 A rering signal must be restricted in duration so that it is not accepted as a disconnect signal which would release the established connection. Trunk relay circuits are arranged so that rering signals are transmitted for periods of from 50 to 100 milliseconds. This signal duration is satisfactory for other types of signaling but not for SF signaling. A signal of such short duration is not even recognized by the distant receiver because at the time the signal is sent the receiver has incorporated its mechanical delay feature as protection against talk-off. This difficulty is overcome by having the SF signaling system increase the duration of the tone rering signal to the point where it is recognized by the distant receiver as a rering signal, and then decrease the duration of the signal when it leaves the distant receiver as a d-c rering signal.

3.113 The rering signal is transmitted after the talking condition has been established and therefore the M, HL, S, SR, and RR relays are operated at both ends of the SF signaling system. The action of the SF signaling system (see OS 103-1 and SC 103-1) is as follows.

3.114 Assume that the west operator desires to rering the east operator. The west trunk relay circuit passes the rering signal on to the SF signaling system by connecting ground to the M lead. High level signal tone is immediately sent to the east terminal, the transmission path is cut and terminated, and the east receiver changes to normal sensitivity and low-guard.

3.115 The ground on the M lead supplied by the west trunk relay circuit may be removed in as little as 50 milliseconds but a supplementary ground is maintained on the M lead. This supplementary ground is supplied by the SF signaling circuit through contacts of the operated RR relay. This action (sometimes called rering augmentation) permits the SF signaling circuit to continue to send tone until the RR relay releases.

3.116 Actually in the lineup tests of the circuit the interval between the start of tone transmission and the release of the RR relay is adjusted to 175 +5 -10 milliseconds. Therefore, during the rering operation in service, the signaling circuit produces this same pulse duration.

3.117 When the RR relay releases, the supplementary ground is removed. The transmission of tone ceases and the M relay reoperates. The CO relay subsequently releases and reestablishes the outward transmission path.

3.118 At the east terminal the reception of the 175-millisecond tone pulse is followed by the operation of the R, GR, and T relays, and in turn the slow release of the S relay. It takes approximately 150 milliseconds for the receiver to operate and change the condition of the E lead from ground to open when the mechanical delay feature is in operation. Therefore, the interval between the time the RG relay operates and the end of the tone rering pulse is approximately 25 milliseconds. It takes another 60 milliseconds before the receiver releases after the tone rering pulse is removed. (Sixty milliseconds because the east receiver has changed to no-guard and has the effect of capacitor C21. Both these conditions increase the time necessary to release the receiver.) The total interval that the RG relay remains operated and keeps the E lead open is 85 milliseconds (25 plus 60). This interval is long enough to register a rering signal but not sufficiently long enough to register a disconnect signal.

3.119 As shown on SC 103-1, at the end of the rering tone pulse, the T tube fires and releases the T relay. The S relay reoperates, and the circuit at the east terminal is in the same condition it was prior to the transmission of the rering signal.

<u>Report Signals</u>

3.120 The dial pulse calls described previously were assumed to go through without meeting any delays. If a call meets a delay, as it might, for example, if the intertoll trunks out of the next toll office are busy or if the trunks to the called local office are busy, report signals are returned to the originating operator. These signals, which appear as distinctive lamp flashes at her switchboard, tell the operator that she has encountered a delay. From the type of signal she knows how to proceed (reorder or disconnect).

3.121 These signals are sometimes called flashing signals because they are similar to a subscriber flashing the switchhook at his station. However, whereas flashing by a subscriber is usually at an irregular rate, these flashing report signals are at distinctive controlled rates (30, 60, or 120 IPM). They are sent to the SF signaling system by the trunk relay circuit at the called end as periods of off-hook and on-hook d-c signals. The SF system transmits tone for the on-hook periods and removes it for the off-hook periods.

3.122 The operation of the SF signaling system when required to carry these signals is as follows. (See OS 103-1 and SC 103-1.)

3.123 Report signals are returned after the dial pulsing period when the digit information necessary to route the call has been transmitted to the called end of the SF signaling system. The SF signaling system is therefore in the await-subscriber-answer condition. That is, no tone is being sent from the originating end and low level tone is being sent from the called end. (This low level tone is normally removed when the called subscriber answers. (See SC 101-1 and 102-1.) At the calling end the following relays are operated: M, HL, GR, T, R, and RG. At the called end only the SR relay is operated.

3.124 At the called end (east terminal), battery is applied to the M lead for the off-hook period. (See SC 103-1.) This period may be for as little as 200 milliseconds or as much as 500 milliseconds, depending upon the particular report signal being transmitted.

3.125 The battery on the M lead causes the removal of the east to west signal tone and the operation of the M, CO, and HL relays. As before, the CO relay during its operation cuts the outward transmission path. When the HL relay operates it causes the operation of the S relay, and in turn the RR relay.

3.126 At the end of the off-hook period, ground is again connected to the M lead, causing signal tone to be transmitted to the west terminal. This time the tone is of high level because the HL relay is operated. The M, S, and RR relays release in approximately 175 milliseconds (as explained in connection with the rering signal description). The HL relay releases in another 100 milliseconds. Therefore, high level tone is transmitted for approximately 275 milliseconds followed by low level tone for the remainder of the on-hook period. The minimum on-hook period is 300 milliseconds; the maximum is 500 milliseconds.

3.127 The CO relay cannot release until the HL relay releases; therefore, it can remain operated for a maximum of 375 milliseconds.

3.128 When signal tone is removed at the called end at the start of the off-hook period, the receiver at the originating end (west terminal) has normal sensitivity and is in a no-guard condition. Thus, because the GR and T relays are operated it takes approximately 60 milliseconds before the off-hook signal is passed on to the west trunk relay circuit via the E lead.

3.129 The release of the GR relay causes the west receiver to establish a low-guard condition. In addition, the released GR relay removes the 1000-ohm ground shunt from capacitor C9 and it starts to charge through resistor R29.

3.130 The elements of the T vacuum tube timing circuit are such that the C9 capacitor does not charge to the required striking voltage for a minimum of one second. As just pointed out, the maximum off-hook period of any flash does not exceed 500 milliseconds. Consequently, the C9 capacitor does not reach the necessary striking voltage and the T relay remains locked.

3.131 This means that capacitor C21 (which increases the storage capacity for voltage that tends to keep the receiver operated) is not removed from the circuit. If capacitor C21 were removed from the circuit, the operate and release time of the receiver would differ in some cases by as much as 20 milliseconds in such a manner as to cause shortening of the off-hook signal. Naturally, if these report signals were required to be transmitted through four or five switching points with each office contributing to the shortening of the pulse, the length of pulse which would finally reach the originating end would be too short to give the proper flashing signal.

3.132 Upon conclusion of the off-hook period, high level signal tone is received for the start of the on-hook period. The rearrival of tone causes the RF, R, and RG relays to operate. The RG relay operates about 50 milliseconds after the arrival of the high level tone and removes ground from the E lead for the duration of the on-hook signal.

3.133 The GR relay operates and again the west receiver returns to a no-guard condition. The GR relay also restores the ground shunt across capacitor C9, and thus prevents it from reaching the striking voltage required for tube R.

3.134 These flashing report signals are repeated (off-hook, on-hook, off-hook, on-hook, etc.) until the originating operator recognizes the signal and disconnects. When she removes her cords, the disconnect signal sent toward the east terminal releases the switching equipment at that terminal and the SF signaling system returns to the idle condition.

3.135 It should be pointed out that the preceding description assumed that audible tone was not returned along with the flashing signals. If audible tone had been transmitted without any flashes, the M lead at the called end would not have changed from ground to battery and back again. The audible tone would have been transmitted over the voice path of the SF system just as any voice transmission without any operations on the part of the SF signaling circuit.

3.136 However, if audible tone and flashing signals are returned simultaneously, the audible tone has some effect on the operation of the SF signaling circuit. For example, if audible tone is received at the time the off-hook signal is received (removal of SF signal tone), the audible tone slightly delays the release of the west receiver. This is because the receiver is in its no-guard condition and all energy entering the receiver tends to keep it operated. Consequently, when the east to west signal tone is removed, the west receiver remains operated by the audible tone accompanying the off-hook signal. The release of the receiver is delayed until the CO relay at the east terminal operates and cuts the outward transmission path at that terminal. With the outward transmission path cut, audible tone cannot get through and the west receiver releases.

3.137 The CO relay may remain operated for a maximum of 375 milliseconds after which it again releases and allows audible tone to get through. But by this time the west receiver is released and the audible tone now tends to keep the receiver released. This is because the receiver is in a low guard condition and the audible tone develops guard voltage. Therefore, when high level tone is transmitted for the on-hook period of the flashing report signal, the operation of the west receiver is delayed (by the guard voltage developed by the audible tone) until the CO relay reoperates at the east terminal.

3.138 Many terminating circuits return audible tone and flashing report signals simultaneously. As shown above there is some distortion introduced in the flashing signals by the delay caused by the presence of audible tone. Actually, even though there may be four or five switching points in the established connection, the phase relationship of the audible and flashing signal changes and the delay effect of audible tone is not too accumulative.

Intercepting Operator Condition

3.139 Some calls are routed to an intercepting operator after the dial pulsing period. These positions do not return an off-hook signal because the originating operator would assume that it was the called subscriber off-hook signal and she would begin timing the call.

3.140 Therefore, while the intercepting operator is talking to the calling subscriber, low level signal tone is still being sent toward the originating end. This signal tone is blocked by the network in the voice path of the receiver at the originating end. Actually all blocking networks are in their respective branches and the voice transmission in both directions is slightly impaired.

3.141 The condition of the SF signaling circuit at this time is the same as the await subscriber answer or just prior to the transmission of report signals. That is, at the calling end the M, HL, GR, T, R, and RG relays are operated. At the called end only the SR relay is operated. Therefore the originating receiver (west receiver) is in a no-guard condition and all energy (low level signal tone and intercepting operator voice) tends to keep the receiver operated.

3.142 There may be occasions, however, when the superimposed voice energy could cause the originating receiver to release even though signal tone is still being received. It is prevented from releasing by the action of capacitor C21 which shunts capacitor C19, and thereby increases the storage capacity for voltage used to keep the receiver operated. To see how this is done assume that the frequency of the superimposed voice energy is low and the level comparatively high. When this occurs, limiting takes place (by the volume limiter), and consequently the level of signal tone used to charge capacitor C19 is also reduced. Capacitor C19 can become discharged during the negative half-cycle of signal tone and no longer keep the receiver operated. Capacitor C21 which parallels capacitor C19 provides additional storage space for voltage during the positive half-cycle, and therefore does not become discharged during the negative half-cycle.

Operations on an MF Trunk

3.143 The SF signaling system operates in a manner similar to the operations described in connection with a dial pulse call when it is associated with a trunk over which multifrequency pulses are transmitted. The only difference between a call over this type of trunk and a dial pulse trunk is that the signaling circuit is not required to perform any operations relative to passing digit information.

3.144 The signaling circuit passes the seizure, the stop, and start pulsing signals in the same manner; and then stands by. Routing information is passed from the calling end to the called end by multifrequency pulses. These pulses consist of combinations of tones (700, 900, 1100, 1300, 1500, and 1700 cycles) obtained from a multifrequency supply circuit. These tones are within the voice band and consequently are passed along the voice transmission branches of the SF signaling system just like any voice transmission.

3.145 After all the multifrequency pulses are passed, the SF signaling circuit waits for the removal of SF signal tone by the called end. As before, the removal may be the off-hook signal from the called subscriber or the start of a report signal. In either case the SF signaling circuit performs as described previously.

4. REFERENCE LIST OF BSP's, CD's, SD's and ED's

Sections

179-205-301 - Supply Circuit SD-55962-01 - Alarm Routine, Manual Transfer, and Trouble Clearing Procedures
179-205-501 - Supply Circuit SD-55962-01
179-217-501 - Single Frequency Signaling Circuit SD-56202-01
179-217-701 - Single Frequency Signaling Circuit SD-56202-01

Circuit Descriptions

CD-55962-01 - 1600- or 2000-Cycle Supply Circuit
CD-56202-01 - 1600- or 2000-Cycle Single Frequency Signaling Circuit
CD-56239-01 - 1600- or 2000-Cycle Supply Circuit - For Small Installations

Schematic Drawings

SD-55962-01 - 1600- or 2000-Cycle Supply Circuit
SD-56202-01 - 1600- or 2000-Cycle Single Frequency Signaling Circuit
SD-56239-01 - 1600- or 2000-Cycle Supply Circuit - For Small Installations

Equipment Drawings

ED-63032-01 - 1600- or 2000-Cycle Signaling Supply Equipment

ED-63075-01 - Blocking Amplifier Panel Equipment and Typical Arrangements (J68602CF)

ED-63142-01 - 1600- or 2000-Cycle Single Frequency Signaling Unit Equipment

ED-63157-01 - 1600- or 2000-Cycle Signaling Bay Equipment (Maximum 104 Signaling Units)

ED-63800-01 - 1600- or 2000-Cycle Signaling Bay Equipment - Maximum 10 Signaling Units

ED-63801-01 - 1600- or 2000-Cycle Signaling Bay Equipment - Maximum 4 Signaling Units

ED-63827-01 - 1600- or 2000-Cycle Signaling Supply Equipment - For Small Installations

ED-63851-01 - Blocking Amplifier Panel Equipment and Typical Arrangements (J68602CJ)