2400- OR 2600-CYCLE SINGLE-FREQUENCY SIGNALING SYSTEM GENERAL DESCRIPTIVE INFORMATION TOLL SYSTEMS

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FIGURES

1. GENERAL

A. Features

1.01 The 2400- or 2600-cycle single-frequency signaling system is designed to pass the signals of telephone trunks over voice-frequency transmission line facilities without impairing the normal use of these facilities in trunks for speech. Terminals of this system supplement trunk relay circuits and are joined to the latter for signaling with only two leads. This system accepts and delivers signals in dc form on the equipment or office side and transforms them to or from ac form on the line side. It employs only a single distinctive frequency in the voice band for one direction of signaling. The same frequency, 2600 cycles, is employed in both directions on 4-wire line facilities, which have separate transmission paths between terminals. On 2-wire line facilities, 2400 cycles are used one way and 2600 cycles the other way. One signal frequency is applied or removed at each end of a line facility to operate or release a relay at the

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far end. In this way, two alternate signal conditions are provided in both directions of transmission. Normally, speech and signal frequency are not on the line facility at the same time.

1.02 This section is reissued to include a network for use with MF outpulsing on 2-wire lines. Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 This system enables signaling to share in the benefits of the amplification provided in carrier systems and voice-frequency repeaters and to have comparable operational range with that of voice transmission. It uses a signal transmitter and a signal receiver at each terminal of every trunk served. These signaling circuits are designed for insertion in series with separate transmitting and receiving branches, that is, 4-wire transmission at the terminals of line facilities. In this location, the transmitting branch is opened momentarily for critical signaling conditions and the receiving branch is provided with continuous, one-way transmission. These features protect the signaling circuits from noise and tones originating on the office side of each terminal.

1.04 Normal signal power applied to the line facility is −20 dbm at a zero transmission level, although it is 12 db higher (−8 dbm at zero transmission level) for about the first 0.2 second of application. The transmitter is arranged for office transmission levels of either −16 or −13; the receiver, for either +7 or +4. Nominal gain required in the line facility is 23 to 17 db, depending on the office levels. For 4-wire facilities, the over-all loss allowance for signal power between terminals is 9 db; on 2-wire facilities, 12 db. In both cases, these figures include 3 db for variations within the signaling equipment and 6 db for maximum loss in signal power within the line facility. For 2-wire facilities, 3 db more is allowed to compensate for less favorable line conditions and for the 2-wire network added to the receiver.

1.05 Relatively high signal power of short duration is used for effective operation in the presence of greater than normal line noise. The guard channel principle is employed to avoid false operation by signal frequency present in speech or music to which the receiver is exposed because of its continuous association with the line. The guard channel uses frequencies outside the signal frequency band to oppose the operating effect of signal frequency. In addition, this system inserts narrow band-elimination networks centered on the signal frequency in the voice path to limit the effect of signal power when this is present on the line. These networks are switched out at all other times.

B. Application

1.06 The 2400- or 2600-cycle SF signaling system is applicable to most carrier and repeatered wire line facilities. It is not suited to narrow voice-band facilities such as EB channels and H172 loaded cable nor to intermediate-band facilities such as early C carrier channels. This system is the second in-band SF system; the earlier 1600- or 2000-cycle SF system is described in Section A820.251. The plan of operation and basic functions of the two systems are very similar. However, the 2400- or 2600-cycle system is simpler and less expensive mainly because the design problems relating to protection against false signals are more easily solved with higher signal frequencies.

1.07 This system, like all separate signaling systems, has E and M leads on the drop or office side. These leads are one-way dc paths: the E lead takes signals from the signal circuit, the M lead, to the signaling circuit. The E and M leads go directly to trunk relay circuits or to other signaling circuits. The E and M lead signals for the "idle" and "busy" conditions of a trunk are shown in Fig. 1. Fig. 2 and 3 show the relation of the principal parts of this system to the other components of typical 2-wire and 4-wire intermediate dial trunks.

2. SIGNALING CONDITIONS

A. Trunk Signals

2.01 The signals required in telephone trunks are determined by the terminal switching systems and method of operation for the trunks. The two forms of operation for intermediate trunks are ringdown and dial. Ringdown operation is suited only to trunks terminating in manual switchboards and needs only one signal, used for ringing, in each direction between the two terminals of a trunk. Dial operation is needed for trunks terminating in dial switching offices. It requires two different and alternate signal conditions in each direction between terminals. Two alternate signals are adequate for

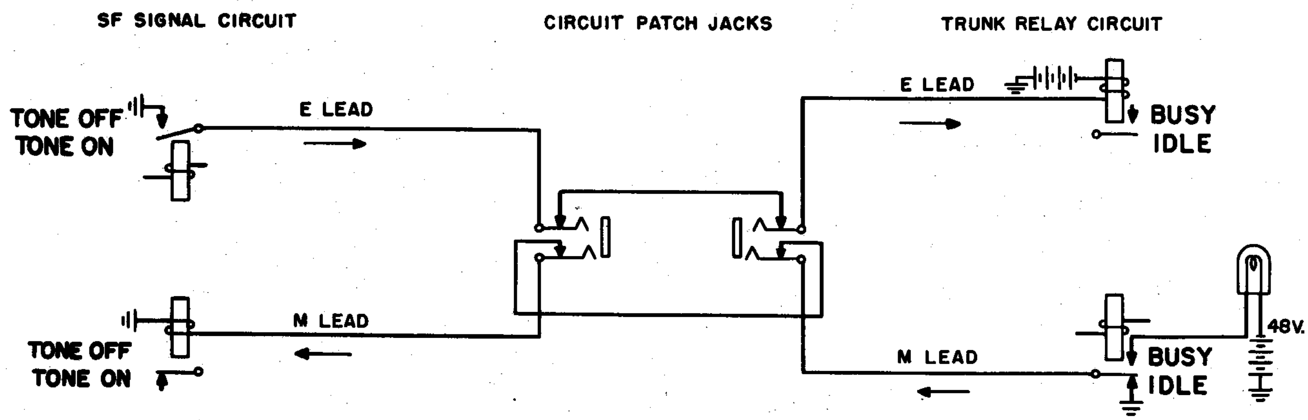

Fig. 1 – E and M Lead Signaling Conditions

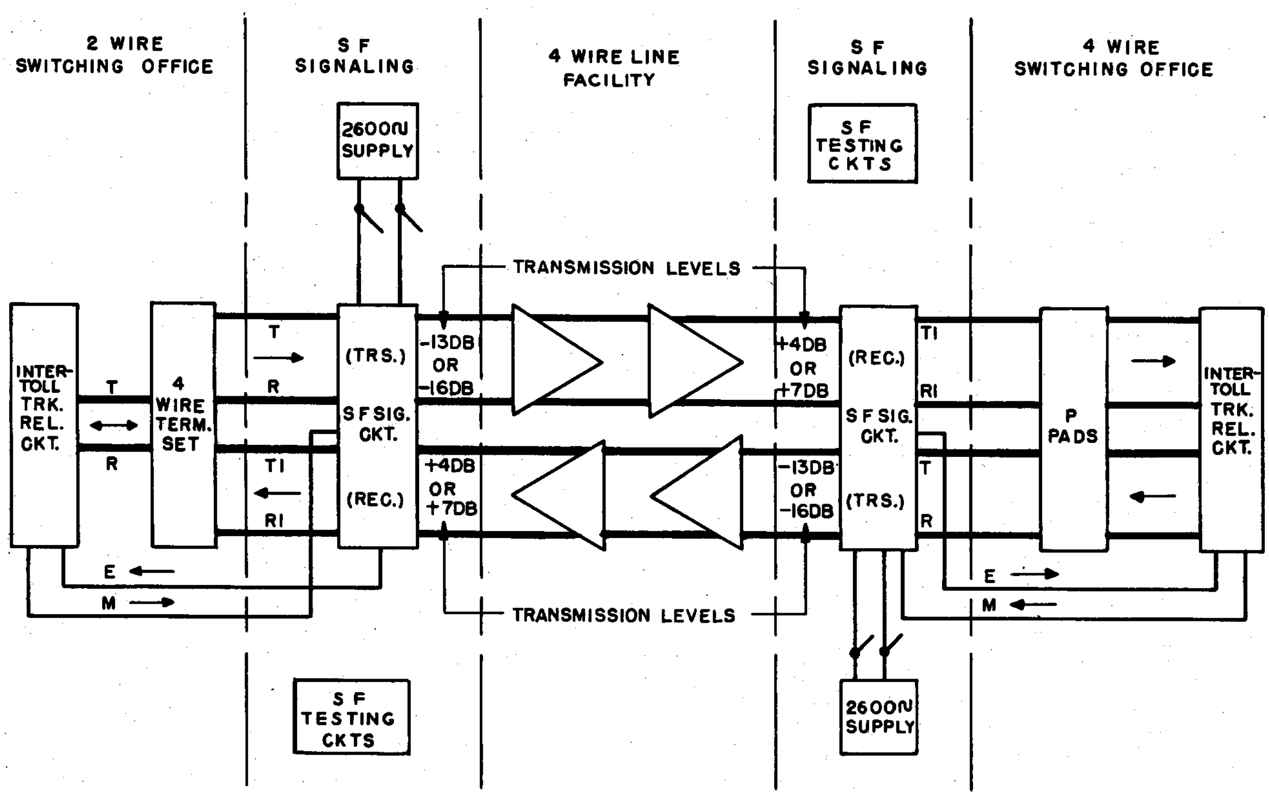

Fig. 2 – Single-frequency Signaling on 4-wire Line Facilities

supervision, that is, the indication at each terminal in a trunk of the basic service conditions, idle or in use, existing at the distant terminal. By timing in the trunk relay circuits, the same two signals used for supervision are also used for ringing, dial pulsing, and start-stop control of dial or MF pulsing. The direction in which connections involving a trunk are established also determines the use made of the signals. For example, the two supervision signals in the forward direction of an intertoll trunk connection serve as connect and disconnect signals and in the reverse direction serve as subscriber's set off-hook and on-hook signals.

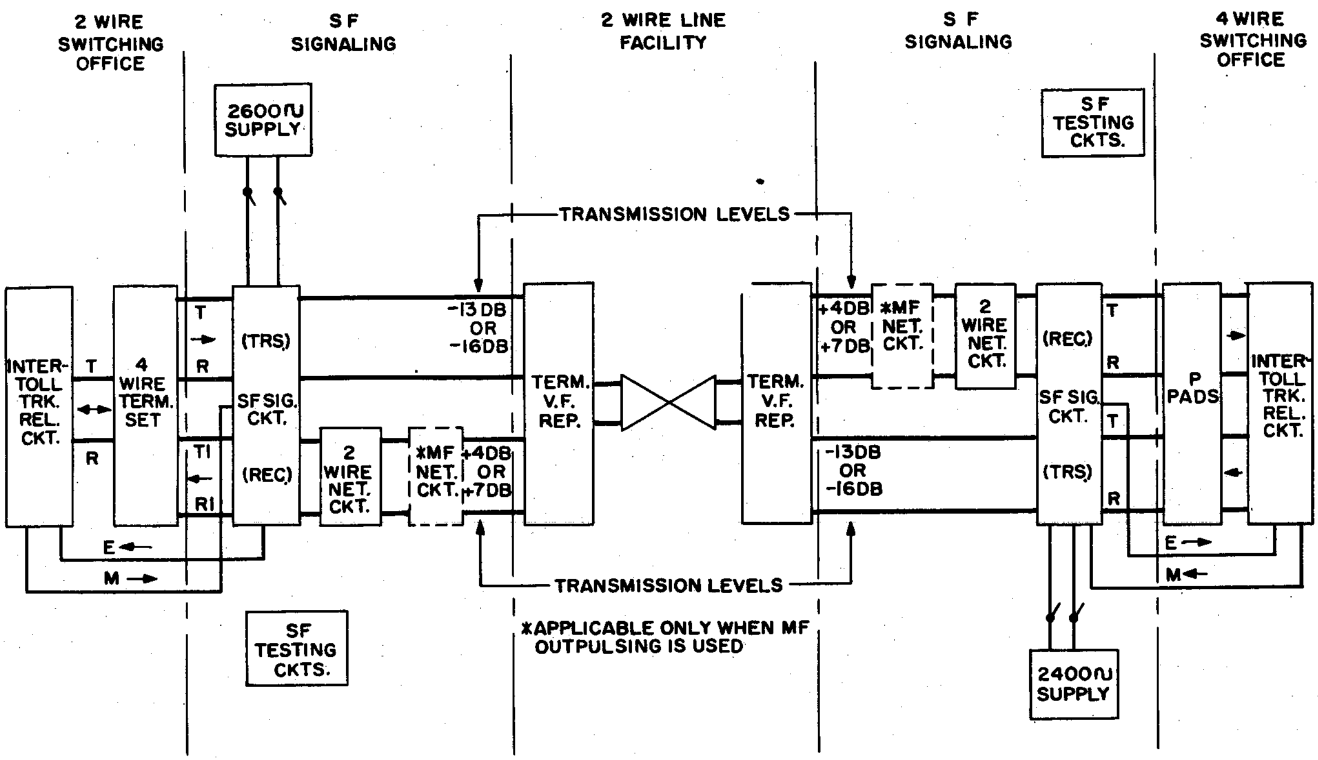

Fig. 3 – Single-frequency Signaling on 2-wire Line Facilities

2.02 Typical dial trunk signals and their uses are as follows:

CALLING TO CALLED END

SIGNAL	USE
(1) Connect	Seizure, make busy, and hold for each connection.
(2) Dial Pulsing	Transfer of called number to set up wanted connection.

(Multifrequency pulsing is an alternate and faster method involving additional and separate common equipment for this purpose.)

SIGNAL	USE
(3) Ring Forward	Call in operator on connection to toll switchboard.
(4) Disconnect	Release of connection and associated busy condition.

CALLED TO CALLING END

SIGNAL	USE
(1) Stop Pulsing	Delay sending of digits until called end is ready to receive them.
(2) Start Pulsing	Assurance digits can be accepted.
(3) Flashing	Combination of on- and off-hook signals at various rates of change to indicate the condition of a connection (a) Subscriber line busy 60 IPM* (b) Trunks busy — reorder 120 IPM (c) Trunks busy — no circuit condition 30 IPM (d) Recall by subscriber Not over 120 IPM
(4) Off-hook	Indicate answer
(5) Ring Back	Recall calling operator
(6) On-hook	Indicate hangup

*Interruptions per minute

2.03 The foregoing signals with SF signaling are

SIGNAL FREQUENCY	CALLING TO CALLED END	CALLED TO CALLING END
Off	Connect	Off-hook and stop pulsing
On	Disconnect, dial pulse (break interval), and ring forward	On-hook, start pulsing, and ringback

B. Signal Interference

2.04 A distinguishing feature of SF signaling is the alternate presence or absence of signal tone in the line. This permits effectively continuous signaling. Use of voice paths for this type of signaling is obtained only by compromise of a number of conflicting conditions. For example, there are advantages in the use of no line current for the normal idle trunk condition. This, however, conflicts with other objectives considered to be more important, namely, use of a voice frequency for signaling and a minimum of interference to speech by the signal frequency. Therefore, the signal frequency is applied during the trunk idle condition and is removed for the connect and off-hook signals. This arrangement allows alternate usage of the voice channel for signal and voice transmission, in most cases; normally the two are not on the line simultaneously.

2.05 The signal power that can be used on a voice channel is dependent, in inverse relation, upon its frequency and duration time because of crosstalk effects and its addition to multichannel amplifier loads. For these reasons, it is desirable to use the lowest signal power which is practicable. The normal signal power used in SF signaling is just above the low quarter of the average voice power range.

2.06 The frequency spectrum of voice channels is not affected by in-band SF signaling in ordinary usage. However, signal frequency band-elimination networks are provided in SF receivers to hold the signal power within the line facility. These networks are inserted in the line only when signal tone is present; they are switched out when signal tone is absent (that is, during the normal talking condition). Since intercept positions do not return off-hook supervision (tone-off) to intermediate trunks, the band-elimination network at the calling end is not switched out on this type of connection. The network attenuates signal frequencies present in speech along with the signal itself. Under these conditions, some slight impairment occurs in voice transmission from the intercept position.

C. Protection Against Voice Interference

2.07 As the SF receiver is connected permanently in the voice path, precautions are necessary to prevent its false operation by any occurrence of signal frequency in speech, music, tones, noise, and other energies in the line. The frequency band width accepted for operation of the receiver is made narrow, since this reduces the effective operating power of voice and noise frequencies. However, reduction in band width is limited as there must be sufficient allowance for frequency variation in the signal supply, for frequency shift in carrier channels, for variations in elements of the tuned circuit in the receiver, and for the proper relation of the minimum signal time duration and the time required by the tuned circuit to reach a steady-state condition.

2.08 The primary protection is secured by guard action and by volume-limiting in the signal path of the receiver. Guard action is the use of all frequencies outside the narrow signal band to oppose operating effect of signal frequency. This increases the power and duration time of signal frequency needed to operate the receiver in the presence of other frequencies. The action of volume-limiting augments the effect of guard action. The amount of guard and range of volume-limiting are determined by the signal-to-noise ratio when operation of the receiver is wanted. Additional protection is secured by an increase in guard action and in operate time of the receiver when the usual talking condition is established which, of course, is the time of greatest exposure to voice energies.

D. Noise Action

2.09 The use of guard action and volume-limiting to prevent false operation of the receiver introduces the liability that voice or noise may prevent the operation of the receiver by signal frequency or may cause it to release falsely after it is operated. By design, these effects are confined to the operate time of the receiver. After it is operated, the guard action is disabled and all voice frequencies tend to hold the receiver operated. However, this change is delayed for a short time in order to avoid increasing the hazards of false operation and does not occur during dial pulsing.

3. EQUIPMENT UNITS

A. General

3.01 The individual components of the 2400- or 2600-cycle SF signaling system consist of nine different equipment units and two factory-wired relay rack bay frames. All units are arranged for mounting on relay rack bays and all except the basic signaling unit (transmitter-receiver) are fixed in position. The basic signaling unit is arranged for plug and socket mounting and is secured to the mounting bars with quarter-turn, anchored screw fasteners to facilitate removal for maintenance. The two relay rack bays have the same framework but different local cables. One, intended for the first bay in each group of four SF bays, has provision for common equipment units in addition to signaling units. The other bay accommodates signaling units only. The separate components within the SF system are as follows:

SIGNAL FREQUENCY SUPPLY

(1) 2400- or 2600-cycle oscillator
(2) Load transfer and alarm
(3) Resistances (32 pairs per mounting plate)

SIGNALING CIRCUIT

(4) Transmitter-receiver
(5) Line network for 2-wire line facility
(6) Line network for MF outpulsing on 2-wire line facility

MAINTENANCE

(7) Monitoring unit
(8) Testing unit
(9) Battery supply

MOUNTING BAYS

(10) First of 4-bay group
(11) Other bays in group

B. Signal Frequency Supply

3.02 The supply of 2400 cycles for 2-wire line facility applications and of 2600 cycles in every application is a part of each installation of this system. These supplies are intended only to serve the circuits of this system. There are three different equipment units for the generation, protection, and distribution of these two distinctive single frequencies. As listed above, these comprise (1) a single vacuum tube oscillator circuit that serves as the source of either 2400 or 2600 cycles, (2) a load transfer and alarm circuit to guard the output of two oscillators of the same frequency and permit their use for the supply of a maximum of 120 SF signaling circuits, and (3) a mounting plate for 32 pairs of resistances for the supply leads to the circuits in one relay rack bay. These resistances are wired in the signal frequency supply distributing leads. One resistance is furnished for each lead of a supply pair to every SF signaling and maintenance circuit. The resistances provide protective separation of the individual circuit supply leads and assist in the provision of the correct power in the frequency supply to each circuit served.

3.03 A front view of the usual combination of two oscillator units and one load transfer and alarm unit is shown in Fig. 4. Each unit is contained in one 2-inch by 23-inch mounting plate. The oscillator circuit uses a Wheatstone-Wien bridge with a high-gain pentode vacuum tube. Two arms of the bridge are formed by windings of the output transformer, the third arm is composed of resistance including an output volume potentiometer, and the fourth arm establishes the output frequency with a parallel resonant combination of inductance and capacity. Optional wiring of inductance and capacity components permits coarse adjustments of output volume and frequency. Fine adjustments are obtained by means of the volume potentiometer and a variable air condenser. A potentiometer and pin-type test jacks are provided for adjustment of heater voltage. Two pin jacks are furnished for measurement of plate current, also two oscillator output test jacks. Both oscillators normally operate all the time.

3.04 The frequency supply of the oscillator unit normally varies no more than ±3 cycles. Accuracy and stability of the signal frequency supply directly increase the reliability of the SF signaling system. Taps on the output transformer provide either of two output levels as measured at the oscillator test jacks with a 600-ohm load, namely, −9.6 dbm for −16 office transmission levels and −6.6 dbm for −13 office transmission levels. The output level is designed to hold within ±0.25 db of normal with ordinary variations in tube characteristics, office temperature, supply voltage, and load. Where a trans-

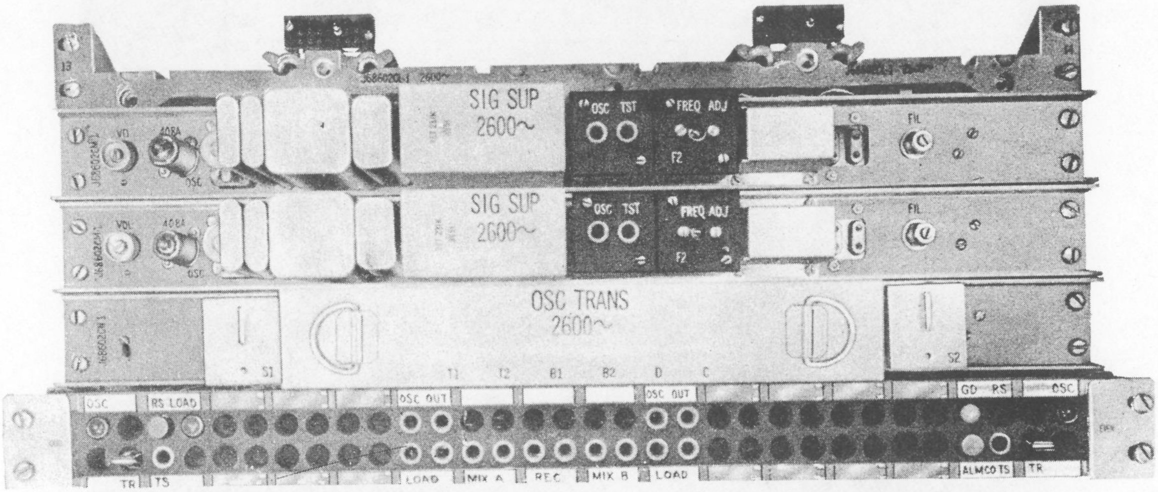

Fig. 4 – 2400- or 2600-cycle Supply Oscillators, Load Transfer, and Alarm Assembly

fer and alarm unit is not provided, a single oscillator is limited to supplying no more than two signaling circuits in addition to testing circuits in order to protect continuity of service.

3.05 The supply load transfer and alarm unit is designed for use in installations where more than four SF signaling circuits are provided. The service protection it gives permits the use of a pair of oscillators to supply up to 120 signaling circuits. The transfer and alarm unit is used with two oscillators of the same frequency and provides individually for (1) oscillator output and load cutoff jacks, (2) a minor alarm in case of one oscillator tube failure, (3) automatic transfer of the load from one oscillator in trouble to the other, (4) restore keys and indicating lamps for these trouble conditions, and (5) a locking load transfer key. In addition, it provides (6) a frequency checking test circuit, (7) a minor alarm cutoff key and locking circuit which automatically is restored when the trouble condition is cleared, and (8) a major alarm in case of failure of both oscillators and also when a plug is inserted in a load jack.

3.06 The third unit in the supply group consists of a 2-inch by 23-inch mounting plate for 19-type resistances, two cable well terminal strips and supply resistances as needed for the SF signaling and testing circuits in one relay rack bay. Optional straps on the terminal strips permit changing the frequency of the signal supply to signaling circuits without modification of the bay wiring. As the resistance in each signal circuit supply lead consists of one half of a 19 type and has one terminal in common with another odd- or even-numbered circuit, it is most practical to assign the same signal frequency to circuits in successive number groups of four. The signal frequency supply to individual signal circuits can be reduced 3 db by the addition of a third optional supply resistance in shunt with the two regular supply resistances.

C. Signaling Circuit

3.07 This is the principal component of the system. One is required for each trunk terminal or end of signaling section served. It consists of the SF transmitter and SF receiver for 2- and 4-wire line facilities, and the 2-wire line and MF networks as required. The transmitter and receiver are contained in one equipment unit and the 2-wire line and MF networks are each furnished as individual units.

3.08 The 2400- or 2600-cycle SF transmitter and receiver unit is 8 inches high, 11 inches wide, and 7 inches deep. A front view of this unit is shown in Fig. 5. This unit has only two options, one to receive 2400 cycles and the other to receive 2600 cycles. It is removable from its relay rack mounting for maintenance purposes.

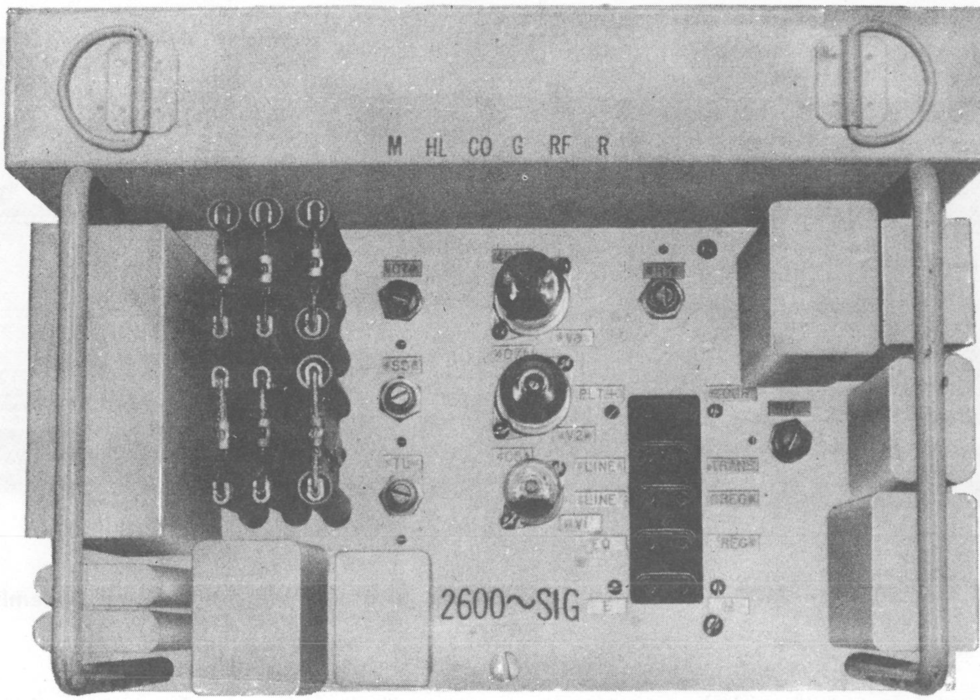

Fig. 5 — 2400- or 2600-cycle Signaling Unit

3.09 The leads associating this unit with trunk and line circuits go to the intermediate distributing frame for cross connections. Two dc signaling leads, called E and M, join the signaling unit to a trunk circuit and eight leads are used for its insertion in a line facility. The latter leads are equally divided between the line and equipment sides of the unit. The four leads on each side are T and R, for the transmitting branch, and T1 and R1, for the receiving branch of the line circuit. The principal elements of the signaling circuit are shown in block form in Fig. 6. The transmitter is at the top and the receiver in the lower left part of this figure. The 2-wire line and MF networks, are at the right of the receiver.

3.10 The transmitter changes dc signals accepted by the M lead into signal frequency in the T and R leads. As shown in Fig. 6, it has three relays, M, CO, and HL, a 12-db pad for signal frequency, and a retard coil. Signal frequency is continuously furnished from a common supply. The M lead goes directly to the M relay and potentiometer. The latter, not shown, permits screwdriver adjustments to equalize the operate and release times of the M relay. This relay when nonoperated applies, and when operated, removes signal frequency in the T and R leads. Each time the M relay operates or releases, the CO relay is momentarily operated. The release time of the CO is long enough to ensure that it stays operated during dial pulsing. The CO relay splits and terminates the T and R leads to avoid interference from noise occurring on the equipment side. The HL relay is operated by the M relay after the CO relay has operated and holds up until the M relay releases. The HL relay is slow releasing, and when operated, raises the level of signal frequency applied to the line. This ensures a high level of signal frequency when it is first applied and during dial pulsing. The retard coil is bridged on T and R with a midpoint ground. The function of the grounded bridge is to drain off longitudinal currents arising in the equipment that might interfere with the signaling operation. The transmission loss in the T and R leads of the transmitter portion of the signaling circuit is negligible (less than 0.1 db).

3.11 The receiver portion of the SF signaling circuit transfers signals received by signal frequency in the T1 and R1 leads to dc signals in the E lead. It has input and output transformers in the one-way path for the voice

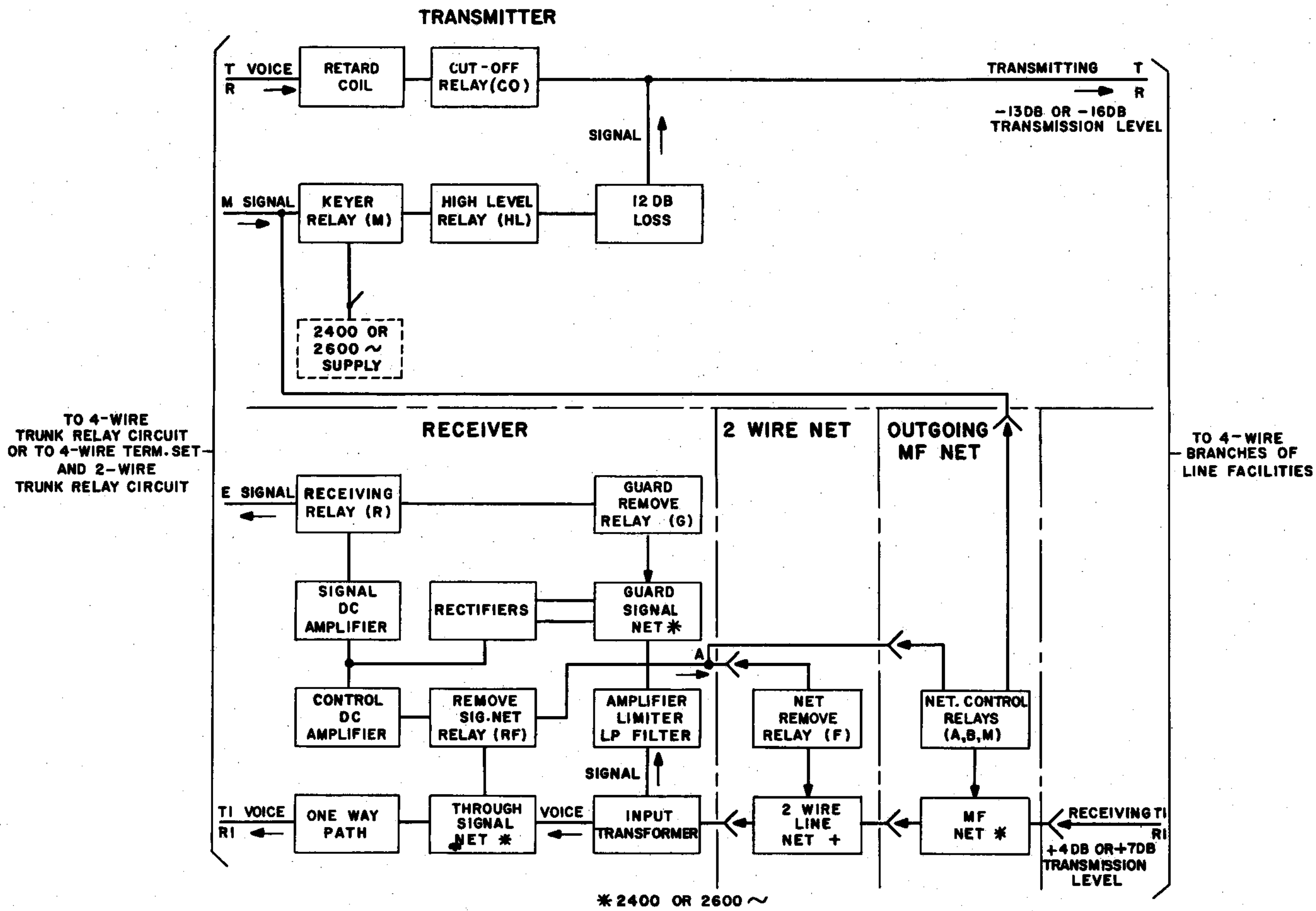

Fig. 6 – Principal Elements of 2400- or 2600-cycle Signaling Circuit

channel; five vacuum tube circuits comprising (1) one-way voice path, (2) signal amplifier, (3) guard rectifier, (4) signal dc, and (5) control dc amplifiers; three relays, R, RF, and G; two tuned networks, one for the voice path and one for signal-guard discrimination; and four varistors, two of which serve as signal rectifiers. The one-way path blocks noise on the office side of the trunk from interfering with the signaling paths. The signal band elimination filter is inserted in this path, when signal frequency is in the receiving branch, to reduce the level of this frequency going past the signaling circuit.

3.12 The signal path starts in a third winding of the input transformer. This path has considerable low-frequency attenuation to protect the receiver against line noise and includes a potentiometer, not shown, used to adjust operate sensitivity. It leads to the signal amplifier and limiter tube. The retardation coil used as the output transformer in this stage is tuned by a condenser to act as a low-pass filter and sharply attenuates harmonics of the signal frequency that may be introduced by limiting action in the tube. The output voltages of this stage are applied to the signal-guard network and separated into signal and guard components. These are separately rectified, the signal by varistors and the guard by a vacuum tube, combined in opposition and fed to the grids of the signal and control dc amplifiers. The RF relay in the plate of the control tube and the R relay in the plate of the signal tube are operated by the positive rectified voltage developed by the signal frequency. The RF relay is fast in operation and release. When operated, it inserts the through signal net in the T1 and R1 leads. Positive battery, through make contacts on this relay and voltage changes in its winding,

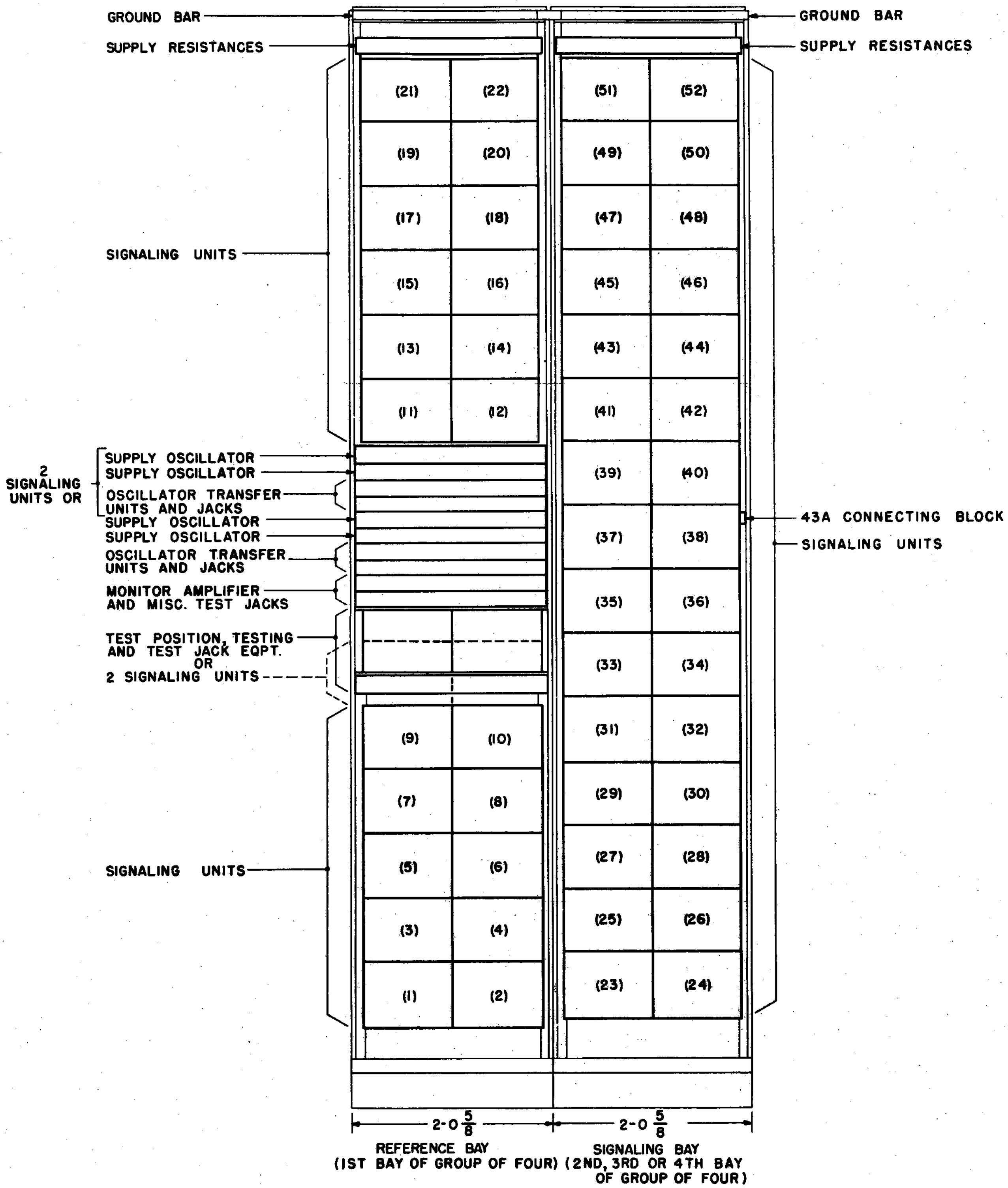

Fig. 7 — 2400- or 2600-cycle Signaling System Bay Arrangements

are used to correct the operate and release times of the R relay for dial pulsing. These times are adjusted by the OT and RT potentiometers. The operate time of the R relay is normally made slow to secure protection against false signals. Compensation for this factor, and to a limited extent for low and high values of per cent break in dial pulsing, is incorporated in the circuit. The R relay delivers dc signals to the E lead. The G relay is controlled by the R relay and is released when the R is operated. When released, it disables the guard channel action. When the G relay is operated, operation of the M relay in the transmitter circuit increases the guard channel action. Also, when the M relay is operated and RF relay is released, ground is connected on the A lead to the 2-wire line network circuit to remove this network from the voice path.

D. Mounting Bays

3.13 Two factory-wired relay rack bay assemblies provide for mounting all equipment units of this system with the exception of the 2-wire line network unit and the maintenance battery supply unit. The two bay assemblies use the same bulb-angle-type framework. This is 11 feet 6 inches in height and spaced for 2-inch by 23-inch mounting plates. The layout of units on the two bay assemblies is shown in Fig. 7. The left-hand bay assembly is suited for the starting bay of this system in each office and for the first bay in each group of four bays in line. It accommodates the common equipment units in addition to 22 to 26 signaling units. The right-hand bay assembly provides for 30 signaling units and supply resistances and is intended for the second, third, and fourth bays in each group of four SF bays.

E. Two-wire Line Network

3.14 The 2-wire line network portion of the signaling circuit, since it is required only for application to 2-wire line facilities, is furnished with its own equipment unit which has capacity for three networks. This unit is 2 inches high and 23 inches wide; a front view is shown in Fig. 8. Because the need for this unit is variable, it is best located in miscellaneous relay rack space. Unlike the SF transmitter-receiver, it is not arranged for plug and socket mounting. This circuit is required to prevent interference in the SF receiver from echoes of the signal frequency applied to the line facilities by the SF transmitter in the same signaling circuit. As shown in Fig. 6, it is inserted in the receiving branch on the line side of the main signaling circuit. There are four leads, T1 and R1 on both the line and equipment sides, and a fifth lead A on the latter side. These leads are cross-connected. It has a network, relay, and resistance. The relay designated F is operated in series with the resistance over the A lead from the associated main SF circuit. When operated, it switches the network out of the voice path.

F. Network for MF Outpulsing on 2-wire Lines

3.15 The use of sender MF outpulsing with trunks having 2-wire line facilities requires another network in addition to that mentioned in 3.14. This circuit is needed to prevent false release of the outgoing end SF receiver by echoes of MF tones applied to the line. Stop-start pulsing signals from the incoming end are required before the MF outpulsing can begin. The start pulsing signal will cause the guard channel of the outgoing end receiver to be disabled approximately 0.2 second after receipt of the signal. Some senders, however, are capable of MF outpulsing so quickly after receiving a start-pulse indication that 2-wire line echoes feed back into the SF receiver (which is still in a guard condition) and force its release. False release of the receiver prevents completion of the attempted call. This network inserts a filter which passes only the received SF tone and protects the receiver until its guard is disabled, at which time the filter is removed. The 0.2-second delay cannot be eliminated from the receiver itself since it is needed for operation with dial pulsing which may go through the same trunk and SF signaling circuits in the opposite direction.

3.16 An equipment unit (Fig. 9) having capacity for two networks is contained on a 2- by 23-inch mounting plate. It will normally be located on a miscellaneous relay rack bay and its six leads will appear at an intermediate distributing frame for cross connection. The network circuitry consists of three relays and a bandpass filter. Four leads are used to insert the MF network in the receive leg on the line side of the 2-wire line network, described in 3.14. Two additional control leads connect the network to the associated SF unit. Fig. 6 shows the application of the network when required.

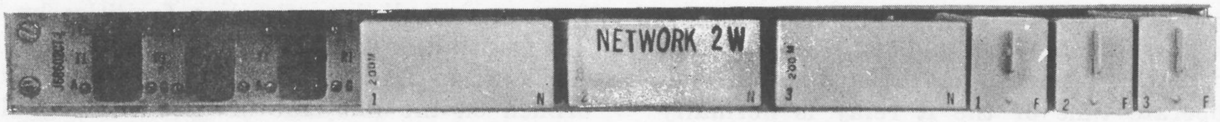

Fig. 8 — 2400- or 2600-cycle Network for 2-wire Line

4. METHOD OF OPERATION

A. General

4.01 As the usual application of SF signaling is in dial intertoll trunks, its operation is described in this section for a typical call on a trunk that links two toll dial switching systems. In order to cover all features of the 2400- or 2600-cycle SF signaling circuits, a trunk with 2-wire line facilities, as shown in Fig. 2 and with trunk circuits arranged for dial pulsing that terminate in offices using senders or registers, is used in this call. The operation starts with the trunk idle, goes through the steps performed in setting up and releasing a connection, and returns to the trunk idle condition.

B. Trunk Idle

4.02 When the trunk is idle, that is, has no connection at either end, the trunk circuits have ground on the M leads and the SF transmitters apply the signal frequency to the line facility at each terminal. Presence of signal frequency on the line facility causes the SF receivers to hold operated and to keep their respective E leads open. The normal signal power at −16 office transmission levels is −36 dbm, at +7 levels, −13 dbm. On 4-wire line facilities, the normal operate sensitivity of the SF receiver at +7 levels is −22 dbm. This provides an operating margin of 9 db for loss variations in the sending power, in the transmission characteristics of the line, and in operate sensitivity of the receiver. On 2-wire line facilities, the receiver operate sensitivity at +7 levels is −25 dbm to allow for loss in the 2-wire network and less favorable line conditions. At this time, since each SF receiver is operated, guard channels are disabled and all energy entering the receivers tends to hold them operated. While signal frequency is on the line, the through signal and 2-wire networks are in both east and west receiving branches.

C. Connect

4.03 When a call originates, say at the west terminal, the trunk circuit there changes from ground to battery on its M lead and its SF transmitter removes 2600 cycles and momentarily opens and terminates the transmitting branch to shut out noise on the office side from the line. Absence of 2600 cycles in the east receiving branch releases the SF receiver there and this puts ground on its E lead. This is the connect signal to the east trunk circuit. The east SF receiver, after releasing, restores its guard channel with low guard to signal ratio. The through signal and 2-wire networks remain in both the east and west receiving branches since 2400 cycles are still on the line.

D. Stop Pulsing

4.04 On receipt of the connect signal, the east trunk circuit substitutes battery for ground on its M lead to originate a stop-pulsing condition since in this office, time must be allowed for the association with the trunk of an incoming sender or register. The east SF transmitter then removes 2400 cycles from the line and momentarily opens and terminates the transmitting branch to block office noise. Absence of 2400 cycles in the west receiving branch releases the SF receiver there and this puts ground on its E lead. This gives the stop-pulsing signal to the west trunk circuit. With signaling frequency off the line, the two SF receivers have higher guard ratios and the through signal and 2-wire networks are taken out of both east and west receiving branches.

E. Start Pulsing

4.05 The association of an incoming sender with the east trunk circuit causes the latter to change from battery to ground on its M lead for removal of the stop-pulsing condition. The east SF transmitter applies 2400 cycles (−24 dbm at −16 transmission level) for a short interval; it then drops the tone to normal power and momentarily opens and terminates the transmitting branch. This open interval prevents office noise from interfering with the operation of the west receiver. The short interval of higher power signal frequency speeds west receiver operation and provides additional margin against line noise.

4.06 Presence of 2400 cycles in the west terminal operates its SF receiver. Ground is removed from the E lead and the guard channel is disabled. The removal of ground from the receiver lead at this time is interpreted as a start-pulsing indication by the west trunk circuit. Operation of the receiver also causes its through and 2-wire networks to be reinserted. The guard channel in the east SF receiver drops back to its low ratio.

F. Dial Pulsing

4.07 In this call, the information needed to set up the desired connection in the east office is sent from the west office over the trunk by dial pulsing. This pulsing originates in a switchboard operator dial or a sender. Each break interval of dial pulsing changes the signal on the M lead from battery to ground. In the west office, the SF transmitter applies 2600 cycles to the line for each interval of ground on the M lead using −24 dbm at −16 transmission level and opens and terminates the transmitting branch for the duration of pulsing for each digit. Presence of 2600 cycles in the east terminal operates its SF receiver and it removes ground from the E lead for the duration of each operation. Its guard channel is not disabled during pulsing as the slow-release relay controlling this feature holds over the break intervals. The open intervals on the E lead to the east trunk circuit and associated sender are the dial pulsing signals. After registering the digits, the sender sets up the desired connection and releases itself from the trunk.

G. Off Hook

4.08 On answer of the called party, the east trunk circuit changes from ground to battery on its M lead, the east SF transmitter removes 2400 cycles from the line and momentarily opens and terminates the transmitting branch, and the west SF receiver releases and puts ground on its E lead. This is the off-hook signal to the west trunk circuit. With no signaling frequency on the line, the SF receivers have the high guard ratios and all networks are taken out. This is the normal condition when speech goes over the line facility.

H. On Hook

4.09 When the called party hangs up, the opposite conditions to those produced by the off-hook signal are established. The east trunk circuit goes from battery to ground on the M lead, the east SF transmitter applies 2400 cycles to the line and momentarily opens and terminates the transmitting branch, the west SF receiver operates and removes ground from the E lead, and the west trunk circuit receives the on-hook signal. The through signal and 2-wire networks at both ends are reinserted in the line and the east SF receiver has low guard.

I. Disconnect

4.10 The call is terminated by release of the trunk at the west end. The trunk circuit there changes from battery to ground on the M lead, the west SF transmitter applies 2600 cycles to the line and momentarily opens and terminates the transmitting branch. At the east end, the SF receiver operates and removes ground from the E lead. This is the disconnect signal and the connection at this end falls down. Each SF transmitter is sending signal tone and each SF receiver is operated and its guard channel disabled. This is the normal trunk idle condition.

5. MAINTENANCE

A. General

5.01 The plug and jack mounting of the individual 2400- and 2600-cycle signaling equipment units permits their removal for replacement or for detailed testing and adjustment in a test panel location. While certain "in-service" adjustments or checks may be made while the unit is in place in the signaling bay, the majority of the more detailed adjustments are intended to be made with the signaling unit plugged into the relatively more convenient test panel location. Two principal test facilities are provided; (1) a monitoring circuit (Fig. 10) by means of which certain limited observations or checks of performance can be made while the

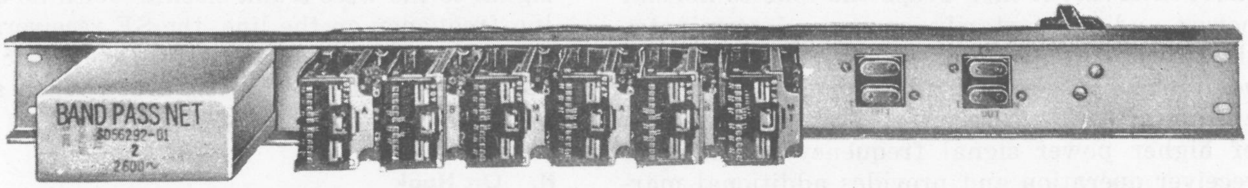

Fig. 9 — Network for MF Outpulsing on 2-wire Lines

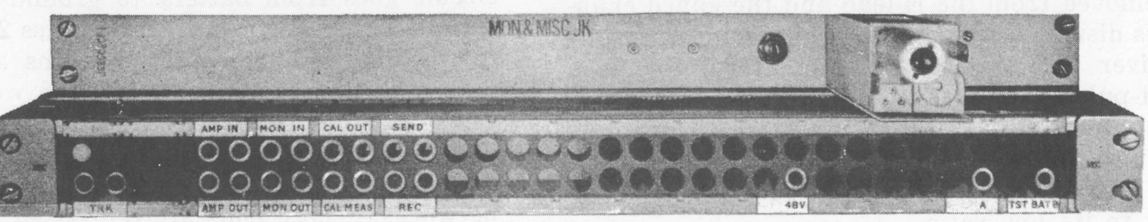

Fig. 10 — 2400- or 2600-cycle Signal Monitoring Unit

signaling units are in place on the relay rack bays, and (2) a test position and associated test unit (Fig. 10) into which a signaling unit can be plugged for complete performance testing and for accurate adjustment.

5.02 Ten pin-type jacks on each signaling unit, as shown in Fig. 5, provide means for bridging connections to the LINE TRANSMIT, LINE RECEIVE, EQUIPMENT RECEIVE, E and M, and PLATE CURRENT leads when the unit is in the signaling bay. When removed from the signaling bay and placed in the test position, direct access via the test circuit is afforded to all significant input and output leads of the signaling unit.

5.03 The use of a 2-type signaling test set, a 13A or equivalent transmission measuring set, and an operator telephone set is required in conjunction with both the monitoring circuit and the test position for either "in-service" or "out-of-service" maintenance of the signaling units.

5.04 The 2400- or 2600-cycle oscillator circuit is provided with pin-type test jacks for bridging connection to the heater and the cathode circuits for the measurement of potential incident to the adjustment of the heater current and the checking of the oscillator tube cathode current. Bridging jacks are provided for the measurement and the patching of the oscillator output and cutoff-type jacks afford means for patching connection to the load circuits served by the oscillators. A beat frequency checking circuit is provided for audible comparison of output frequencies.

5.05 When more than two signaling circuits are served by a signaling supply circuit, a pair of oscillators is employed. When there are more than four signaling circuits, a transfer and alarm unit is associated with the pair of oscillators to assure continuity of service. (See 3.05.) In addition to automatic transfer, this unit permits manual transfer of load from either oscillator to the other for testing.

5.06 The signal supply oscillators, oscillator transfer circuit, and the jacks, keys, and alarm lamps associated with these circuits and with the beat-frequency test circuit, are shown in Fig. 4.

B. Monitoring

5.07 The monitoring unit consists essentially of a V3-type amplifier with associated input and output jack circuits as shown in Fig. 10. One of these units is provided for each four bays of signaling equipments. Included in this monitoring unit assembly are battery supply jacks for a 2-type signaling test set and for general testing, a jack and lamp appearance of the

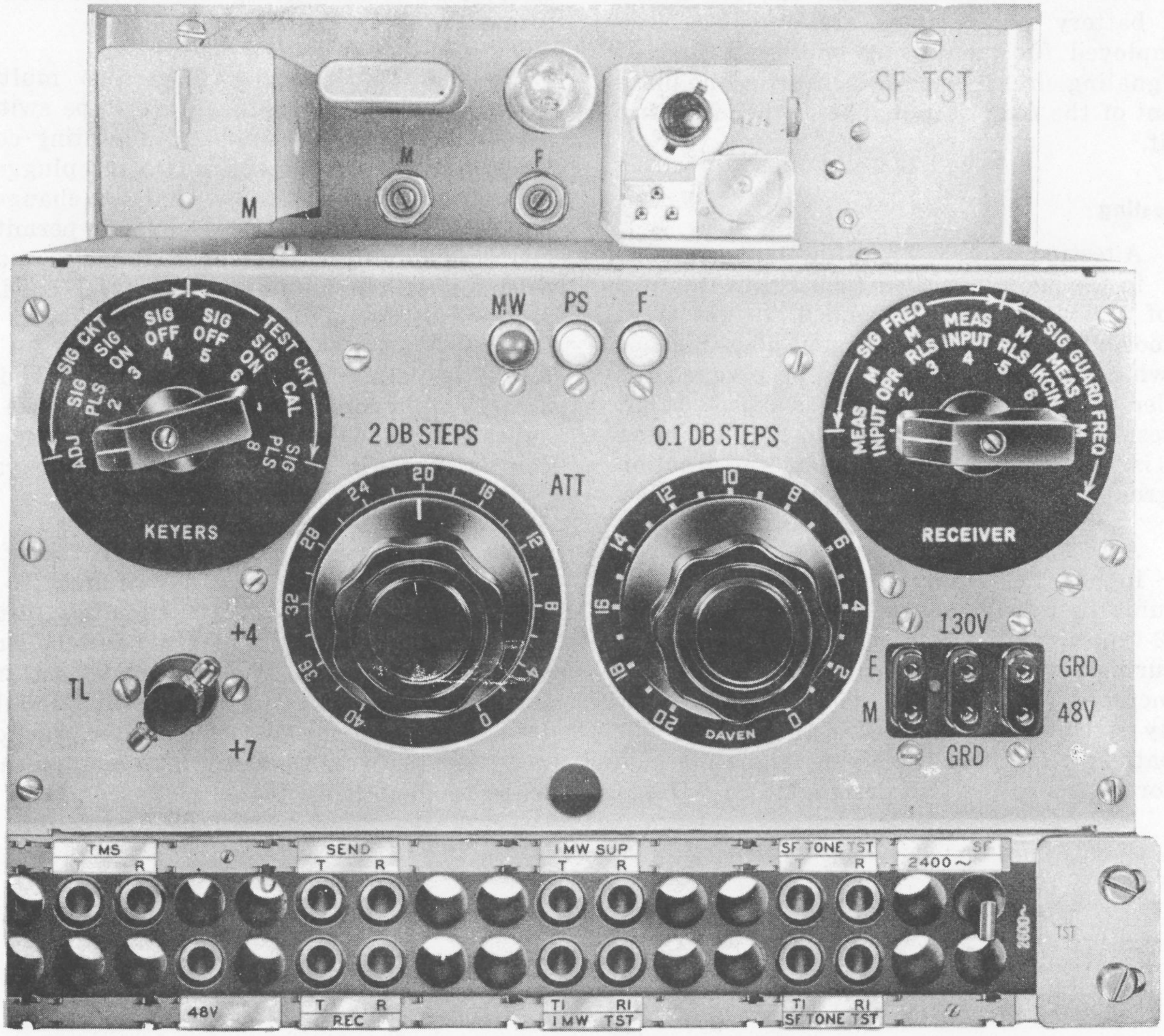

Fig. 11 – 2400- or 2600-cycle Signal Testing Unit

office intercommunication trunk circuit, and two pairs of jacks, designated SEND and REC which extend to the distributing frame for interconnection as required.

5.08 Two input circuits provide access to the monitoring amplifier, one circuit connects directly to the 600-ohm input on the AMP IN jacks; the other is a high-impedance input of approximately 20,000 ohms on the MON IN jacks. This latter connection causes a bridging loss of only about 0.2 db when connected to a signaling circuit input or output. It introduces a series loss of approximately 30 db which is compensated for by adjusting the gain of the monitoring amplifier. The output of the monitoring amplifier appears on the tips of the AMP OUT jacks for patching connection to tip-ring circuits. The output also is present on the sleeves of the MON OUT jacks to permit monitoring with an operator telephone set.

5.09 The calibrating circuit which appears on the CAL OUT and CAL MEAS jacks provides means for adjusting the gain of the amplifier so that accurate direct reading level measurements can be made of signaling tones appearing on the signaling unit pin-type test jacks, through the use of a transmission measuring set.

5.10 The 2-type signaling test set, for which battery supply jacks are provided, may be employed for monitoring on the E lead of the signaling circuit and for measuring the plate current of the final output tube of the signaling circuit.

C. Testing

5.11 A testing unit shown in Fig. 11 is provided in the signaling bays (usually in the first bay of a line-up) at a convenient height from the floor adjacent to an associated plug-in space into which a signaling unit may be plugged for detailed test and adjustment. It is expected that one test position for each 500 to 600 signaling units is adequate, depending upon the location and grouping of the signaling units in the office.

5.12 A jack strip, a portion of which is shown in Fig. 11, is provided directly below the test unit to provide means for the association of a 2-type signaling test set and a transmission measuring set with the test circuit. Jacks also are included for access to the 1000-cycle, 1-mw supply circuit associated with the test circuit for battery supply to the 2-type signaling test set, for trunks to the IDF designated SEND and REC, etc. A monitoring unit is provided immediately above the test unit.

5.13 The test panel employs two multiple-section multiposition wafer-type switches by which the various test and adjusting conditions required can be applied to the plugged-in signaling unit without the need for changes in patching connections. Selecting keys permit the connection of either 2400 or 2600 cycles and the selection of the required input level condition required in the particular office.

5.14 The attenuator circuit and certain signal output conditions are available on the jack appearances for external connection by test cords to units in place on the signaling bays for abbreviated check test purposes.

5.15 A battery supply unit consisting of one mounting plate provides filtered 24- and 130-volt power for the 2-type signaling test set. One such supply unit is required for the supply jacks associated with each test panel and monitoring panel. This battery supply unit should be located as near the test panel as is practicable in order to avoid induced interference in the leads to the supply jacks.