SECTION 975-115-100
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AT&TCo Standard

SIGNALS AND SIGNALING SYSTEMS BETWEEN OFFICES — USED IN MESSAGE TELEPHONE SERVICE GENERAL DESCRIPTIVE INFORMATION

CONTENTS PAGE

1. GENERAL

1.01 In providing signaling facilities and equipment for telephone service it is necessary to consider signaling from the trunking standpoint as well as that of the loop. This practice describes the signals and signaling systems normally encountered in the design and operation of telephone trunking plant.

1.02 Also included is a section on Audible Tones and Visual Signals which give a definite type of information to the telephone user, operator, or repairman.

2. SUPERVISORY SIGNALS AND DIAL PULSING BETWEEN OFFICES

(A) General Features of Supervisory Signals

2.01 Supervisory signals are used to convey information regarding a state or condition existing at either end of a trunk or connection. In telephone terminology the two conditions of most importance may be broadly described as on-hook and off-hook. These terms, of course, originated from the action of the "switchhook," from which the receiver of an early type telephone was lifted during the off-hook period.

2.02 Typical supervisory signals and some closely related functions of information signals are described below under headings for the two directions of transmission.

(1) Signals from Calling to Called End

(a) *Connect (Seizure) Signal:* This signal is the means by which the calling end initiates a request for service. It begins with the transition from the normal on-hook or idle state to the busy or off-hook state and tells the far end of the seizure. The actual line signal depends on the type of supervisory system; for example, in a single-frequency signaling system, a connect signal is the change from tone to no tone transmitted from the calling to the called end of the system.

(b) *Disconnect (Release) Signal:* This signal is the means by which the calling end notifies the called end that the established connection is no longer needed and should be released. If either end of the connection can control the release, this signal may be thought of as passing in either direction. Physically, the signal is indicated by the return from the busy or off-hook state to the idle or on-hook state.

(c) *Ring Forward (Rering) Signal:* In manual operation this signal is used by an operator at the calling end to recall an operator at the called end on an established connection. It is used principally on intertoll trunks and, in addition, on some local trunks with operators at both ends. It is originated by means of a ringing key in the cord circuit. On trunks arranged for use with E and M lead signaling systems, relays in the outgoing trunk convert the spurt of ringing current to a single disconnect pulse for each pull of the ringing key. The pulse length is determined by the slow releasing characteristics of certain relays so that the transmitted signal may be in the range of 100 $\pm$ 30 milliseconds long. On 2-wire intertoll trunks the voice path is cut and terminated during rering. To prevent rering from causing false disconnections trunk circuits are designed not to release on signals of less than 140 milliseconds. Relays in the incoming trunk circuit respond to the signal and flash the operator's cord supervisory lamp at a 120 interruptions per minute rate (flashing recall) on some switchboards, such as the No. 3, while on others, such as the No. 1, a 2-second timed lighting of the cord lamp is provided. On some of the older ringdown trunks, the rering is merely a short spurt of ringing current resulting from a pull of the ringing key.

(d) *Flashing:* This signal consists of rapid changes from connect to disconnect which flash a lamp at a manual board. It is used to recall an operator.

(e) *Start Ringing Signal (Controlled Ringing Start Signal):* This signal is used to start the ringing of a subscriber's line. When a (TX) operator is ready to complete a delayed outward call for a local party, she dials the calling party, but does not ring on his line. She then attempts to reach the called party and, when successful, rings on the connection to the calling party. The start ringing signal does not pass over the toll line but only from the terminal toll switchboard to the local manual or dial office.

(2) Signals from Called to Calling End

(a) *On-Hook Signal:* This signal is indicative of the idle condition at the called end. It informs the calling end that the receiver is on the switchhook at the called end or that an equivalent circuit condition exists at the called end. This signal is transmitted on the change from the busy to the idle state. Except for direction of transmission, it is analogous to the *disconnect* signal.

(b) *Off-Hook Signal:* This signal is indicative of the busy condition at the called end. It informs the calling end that the receiver is off the switchhook at the called end or that an equivalent circuit condition exists at the called end. Except for the direction of transmission, it is analogous to the *connect* signal.

(c) *Ringback Signal:* This signal is used by an operator at the called end of an established connection to recall the originating operator or calling subscriber. It is used only on those intertoll trunks and on some local trunks which involve operators at both ends. The signal is a spurt of ringing current or an on-hook pulse, depending on the supervisory system, and continues for the period of operation of the ringing key.

(d) *Flashing Supervisory Signals:* These signals, which include the *line busy, paths busy, reorder,* and *no circuit* signals are described in Part 4 under Audible Tones and Visual Signals since they more nearly fall into that category, despite the word "supervisory" in the name.

(B) Fields of Usage of Supervisory Signals

2.03 Supervisory signals fall into two groups:

(1) Those which are used between a subscriber and the central office and

(2) Those which are used between offices.

Local loop signals are discussed in Section 975-110-100. Supervisory signals between offices were formerly of two general types:

(1) Those used within local exchange areas and

(2) Those used for ringdown supervision on intertoll trunks.

The trend toward dial operation and other factors have made necessary the merging of exchange supervisory methods with intertoll systems to cover the full length of all dialed connections. This development has been accomplished either

(1) by the use of signals between offices based on just two terminal conditions for the transmission of both supervisory functions and dial pulsing or

(2) by the use of a separate multifrequency signaling system, in addition to the supervisory system, for the transmission of digits.

(C) Basic Line Signals between Offices

2.04 Most of the supervisory line conditions can be described in terms of:

(1) The idle or on-hook and

(2) the busy or off-hook state.

The two basic line signal changes are: (a) from the idle to the busy state and (b) from the busy to the idle state. The table in Fig. 1 outlines the signals produced by these changes.

2.05 Multiple use of the available line signaling conditions is possible by making use of different times and sequences. The time sequence diagram in Fig. 2 represents a possible exchange of signals between two switching centers connected by dial pulsing trunks with sender operation. In the diagram signaling in the two directions is shown in coordinated time sequence.

	Line Signals	
Signal Condition Transition	Sent from Calling to Called End	Sent from Called to Calling End
(a)	Connect	Off-hook Stop pulsing
(b)	Disconnect	On-hook Start pulsing
(b) followed by (a) one or more times	Dial pulses Rering	Delay dial wink Flashing supervision Ringback
Signals involving neither (a) nor (b) (used with MF pulsing)	KP, ST	Sender lamp Assignment signal

Fig. 1

(D) Arrangements for Passing Supervisory Signals between Offices

2.06 The following table in Fig. 3 lists some of the general types of systems used for supervisory signaling and the normal fields of application.

2.07 The means by which supervisory (and some control) signals are passed between telephone systems are described below. Only the unique signaling arrangements are described although, in practice, there are many combinations of the elementary systems.

(1) Single Lead Signaling

2.08 Single lead signaling is seldom used between offices.

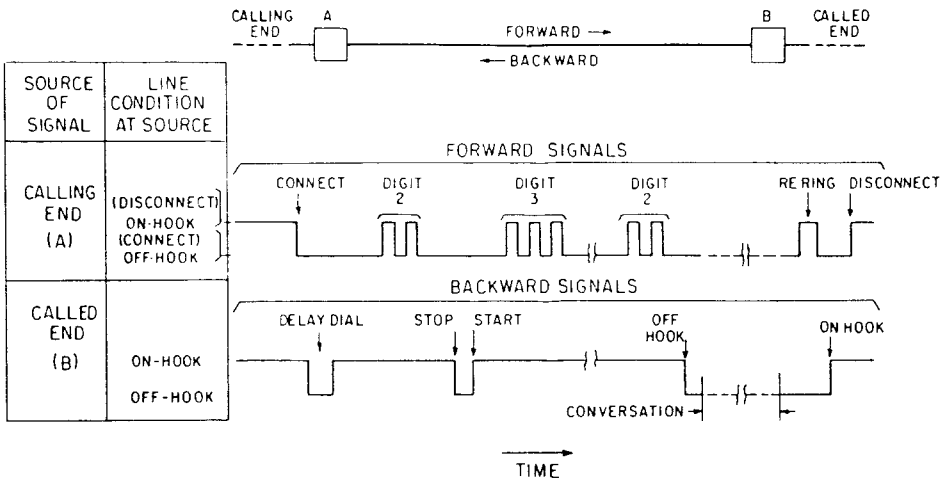


Fig. 2 — Typical Time Sequence of Trunk Signals for Dial Pulsing Between Offices

(2) Simplex Signaling

2.09 The principle of operation used in simplex signaling systems is illustrated in Fig. 4. Simplex operation has the advantage that the effective line conductor resistance is only one-fourth of that for loop signaling. On the other hand, the range of operation for the simple arrangement shown in Fig. 4 is seriously limited by the presence of earth potentials. The simplex (SX) signaling systems with E and M lead operation and full duplex transmission are provided with earth potential compensating arrangements. Simplex signaling is sometimes used to obtain an additional circuit function by use of a simplex signaling channel on trunks which already have loop signaling. One application is in certain local intercepting trunks.

(3) Loop Signaling (Short Range Dc Methods)

2.10 Loop signaling employs both the tip and ring conductors to form the "loop." The short range loop signaling methods are not arranged to transmit signals in both directions independently, as are the E and M lead signaling systems which are described later. As a result these methods are not used on intertoll trunks or on 2-way dialing trunks; however, they are extensively used on exchange, toll connecting and some shorter one-way dialing toll trunks. They are usually an integral part of the trunk circuit rather than a separate assembly of equipment. Various types of loop signaling methods are described in Items (1) to (6) :

(1) *Wet-Dry:* A trunk is "wet" when battery and ground are connected to it at the called end. It is "dry" when battery and ground are removed. In this system a trunk is "dry" during off-hook (busy) and "wet" during on-hook (idle). At the calling end a connect signal is indicated by placing a direct current bridge across the trunk and a disconnect signal by an open trunk. A disadvantage for trunk usage is "joint control" of release; that is, both calling and called parties must hang up before a connection is released. For toll dialing, release of the established connection up to the toll switching trunk is under control of the calling party only, and the switching trunk tests busy until the called party disconnects.

(2) *High-Low:* At the calling end a connect signal is provided by connecting battery and ground to the trunk through a marginal supervisory relay. At the called end the on-hook (high resistance) signal is changed to low resistance for off-hook. A disconnect is indicated by an open trunk at the calling end. The basic high-low scheme, long used in straightforward local manual trunks from "A" to "B" boards, is shown in Fig. 5. The marginal cord circuit supervisory relay (C) has a noninductive winding, in addition to the operating winding, to reduce the unbalanced impedance in the voice path. This relay is adjusted to operate when the high resistance winding of the (L) relay is shorted out by the (S) relay, even on a maximum resistance trunk. It is also adjusted not to operate and to release, if operated, on the

	Field of Application				
	Local Within Office	Voice Frequency Trunks			Carrier Frequency Trunks
		2-Wire	4-Wire	Phantom	
Single Lead Signaling					
Tip or Ring	X				
Sleeve	X				
Simplex Signaling	X				
Loop Signaling					
High-Low		X			
Wet-Dry		X			
Reverse Batt.		X			
Batt.-Grd.		X			
E and M Lead Signaling Systems					
Duplex (DX)		X			
Simplex (SX)		X			
Composite (CX)		X	X	X	
Single Freq. (SF)					
2600 or 1600 CPS			X*		X*
2400/2600 or 1600/2000		X	(X)*		(X)**
3700 CPS					X

* SF systems using different frequencies in the two directions are normally used only in 2-wire trunks or in trunks using a combination of 2-wire with 4-wire or carrier facilities.

** Applications of the 3700 CPS out-of-band systems are limited to the carrier systems with this feature built in.

Fig. 3 — Arrangements for Transmitting On-Hook and Off-Hook Signals

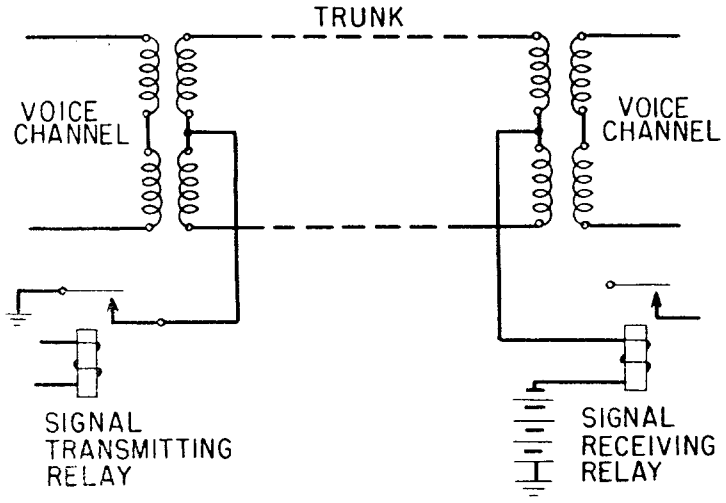


Fig. 4 — Principle of Simplex Signaling

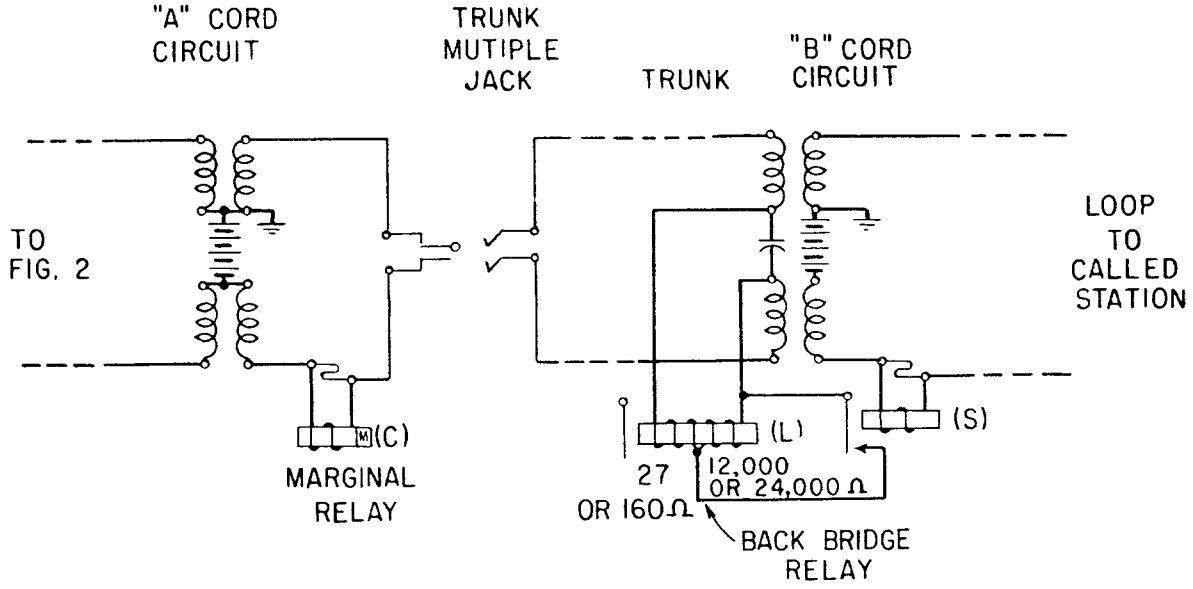


Fig. 5 — High-Low Signaling

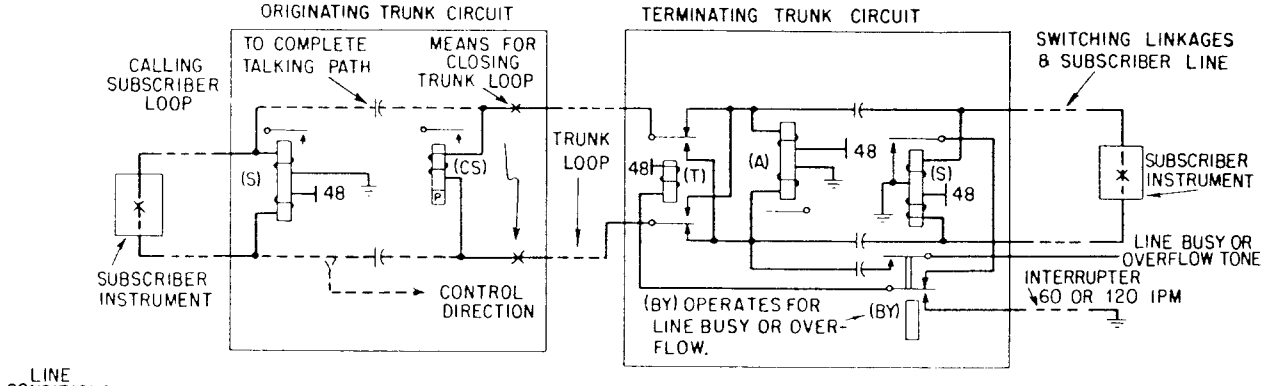
current which results when the high resistance winding of the (L) relay is not shorted, even on a minimum length trunk. Numerous auxiliary circuits and variations in relay types have been used to extend the range of conductor resistance over which signaling may be secured with adequate reliability.

(3) *Low-High:* This is a seldom used variation of the high-low scheme of supervision and is the same except that on-hook (low resistance) is changed to high resistance for off-hook.

(4) *Reverse Battery:* At the calling end a connect signal is indicated by line closure through a polar relay. At the called end battery and ground are reversed on the tip and ring for the change from on-hook to off-hook. A disconnect signal is indicated by an open trunk at the calling end. Operation of the polar relay indicates an off-hook signal from the called end. This is the method most used for supervision within and between modern local switching systems. All systems except manual employ this method which is the present standard for loop signaling. Fig. 6 shows the general supervisory plan for No. 5 crossbar on the call between two offices of this type. Calls between stations associated with the same office are completed by the use of a single intraoffice trunk circuit.

(5) *Reverse High-Low:* This is a combination system used, for example, between a CDO and an operator office. The operator office responds to reversed battery and the CDO to high-low supervision. Trunk battery is supplied and reversed by the CDO, and the operator office bridge is high for on-hook and low for off-hook. A disconnect is indicated by a return to normal polarity at the CDO, followed by an open when the on-hook signal is received. If an on-hook signal is received before disconnect, removal of the reversed battery connect signal awaits the disconnect by the suscriber at the CDO.

(6) *Battery and Ground Signaling:* This is a variation of loop signaling in which increased range is obtained by supplying battery



LINE CONDITIONS SEE NOTES								
(1)	OFF HOOK	S OPERATED	CS NORMAL	LOOP CLOSED	LOOP NORMAL	A OPERATED	S NORMAL	ON HOOK
(2)	OFF HOOK	S OPERATED	CS OPERATED	LOOP CLOSED	LOOP REVERSED	A OPERATED	S OPERATED	OFF HOOK
(3)	ON HOOK	S RELEASED	CS RELEASED	LOOP OPEN	LOOP REVERSED	A RELEASED	S OPERATED	OFF HOOK
	ON HOOK	S RELEASED	CS RELEASED	LOOP OPEN	LOOP NORMAL	A RELEASED	S RELEASED	ON HOOK
(3A)	OFF HOOK	S OPERATED	CS RELEASED	LOOP CLOSED	LOOP NORMAL	A OPERATED	S RELEASED	ON HOOK
	ON HOOK	S RELEASED	CS RELEASED	LOOP OPEN	LOOP NORMAL	A RELEASED	S RELEASED	ON HOOK

NOTES: (1) BEFORE CALLED SUBSCRIBER ANSWERS
(2) CALLED SUBSCRIBER ANSWERS
(3) CALLING SUBSCRIBER HANGS UP FIRST
OR
(3A) CALLED SUBSCRIBER HANGS UP FIRST

* THE (CS) RELAY IS POLAR IN OPERATION BUT ALSO HAS MECHANICAL BIAS TO CAUSE RELEASE ON OPEN CIRCUIT.

Fig. 6 — Reverse Battery Signaling

and ground at both ends of the loop but with opposite polarities at the two ends. This nearly doubles the current available and provides compensation for earth potential differences. At the calling end, a connect signal is indicated by closure of both leads. At the called end, an off-hook signal is indicated by polarity reversal. This must bring about a reversal at the calling end to hold the connection. This system is used along with battery and ground *pulsing* for trunks.

2.11 *Polarities in Local Trunks:* The table in Fig. 7 shows the most commonly used trunk polarity conditions. There are many exceptions. For reverse battery supervision these are the on-hook signals and are reversed with respect to the off-hook signals. These potentials are normally provided through the trunk supervisory relays to the trunk tip (T) and ring (R) conductors.

Normal On-Hook Trunk Polarities		
System	T	R
Manual	G	Battery
Step-by-step	G	Battery
Panel	Battery	G
No. 1 crossbar	Battery	G
No. 5 crossbar	G	Battery

Fig. 7

2.12 The table in Fig. 8 is a summary of the usual supervisory signals used on local trunks.

(4) E and M Lead Signaling Systems

2.13 The E and M lead signaling systems derive their name from certain historical designations of the signaling leads on the circuit drawings covering these systems. All communication between a trunk circuit and a separate signaling system is done over two leads, an *M* lead which trans*M*its battery or ground signals to the signaling system and an *E* lead which rec*E*ives open or ground signals from the trunk. The near end condition is reflected by the M lead and far end condition by the E lead. This relationship is illustrated in Fig. 9.

2.14 There are a number of different types of systems which employ E and M lead signaling. The direct current arrangements, duplex (DX), composite (CX) and simplex (SX), are described first, then the alternating current single-frequency systems, i.e., the carrier systems with built-in 3700 cycles per second signaling and the newer 2600 cycle; inband external signaling units. More detailed descriptions are given in Section AB23.370.9. The E and M lead signaling equipment is usually separate from the trunk equipment and, functionally, is normally located between the trunk circuit and the line. By segregating certain functions in the trunk circuits and others in the signaling system, the particular kind of trunk circuit necessary at each end and the particular type of E and M signaling system required may be selected independently, with assurance that they will work together.

2.15 *Duplex (DX), Composite (CX) and Simplex (SX) Signaling:* These signaling systems were developed to provide means for direct current signaling and dial pulsing beyond the range of loop signaling methods and up to about 300 miles. For direct current signaling on quadded cable which is phantomed, CX signaling is used since the number of leads is not sufficient for loop signaling. DX signaling is used on paired cable facilities.

2.16 *Signal Lead Extension between Trunk and Signaling Equipment:* Sometimes it is necessary to extend the E and M leads over cable pairs between buildings. For this purpose, signal lead extension circuits are used to secure adequate range and independence of battery supplies. At the trunk circuit a unit of the type shown on Drawing SD-95487-01, as used in (DX) signaling, which is described later, is used and, at the signaling equipment, a signal lead extension circuit of the type shown on Drawing SD-95488-01 is used. These units are designated (EMX1) and (EMX2) for layout purposes as shown in Fig. 10.

2.17 *Back-to-Back Operation of Signaling Systems:* The requirement for back-to-back operation of signaling units occurs frequently when trunks are made up by patching between two systems at one location. In such cases pulse

Type of Supervisory Signaling	Calling End		Called End		Battery Supply
	Seizure Signal	Disconnect Signal	On-Hook	Off-Hook	
High-low	Closure C	Open C	High	Low	C
Wet-dry	Closure C	(1)	Wet	Dry	T
Reverse battery	Closure C	Open C (2)	Normal	Reverse	T
Low-high	Closure C	Open C	Low	High	C
Reverse high-low	Battery C then Reverse	Normal C then Open	High	Low	C

C = Calling (originating) end.

T = Called (terminating) end.

Note 1: Trunk release occurs after the originating end disconnects, but also awaits an on-hook signal from the terminating end.

Note 2: In some cases release, after the originating end disconnects, awaits on-hook from the terminating end.

LOOP SIGNALING SYSTEMS

Fig. 8

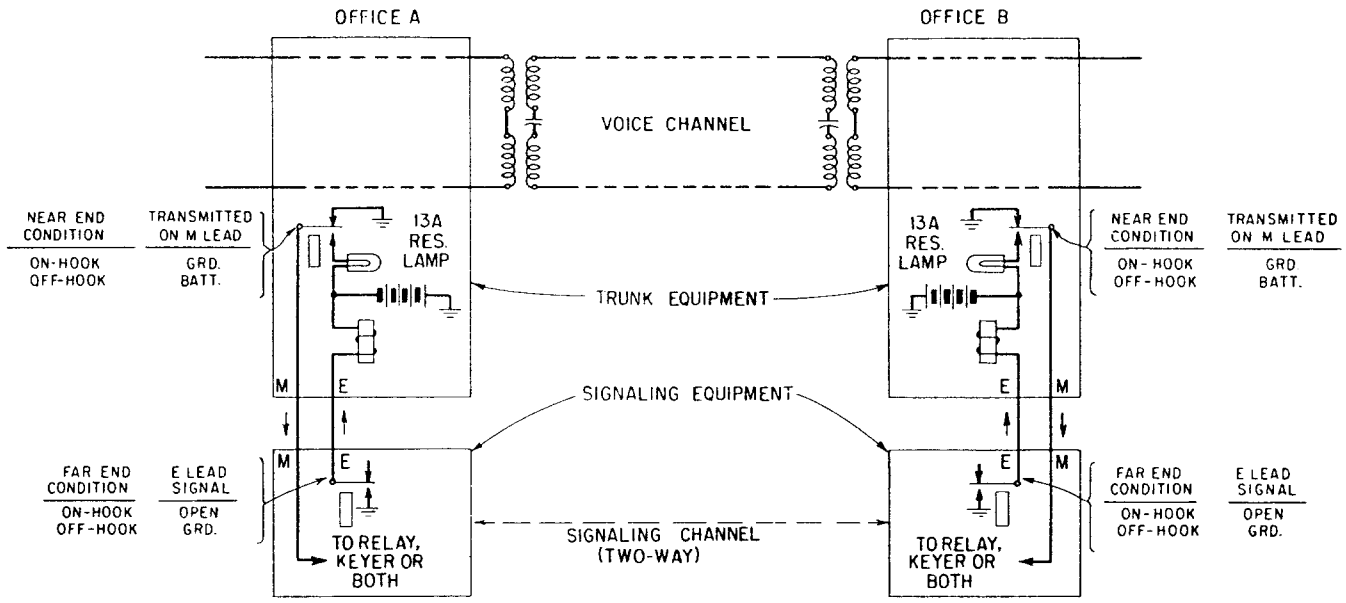
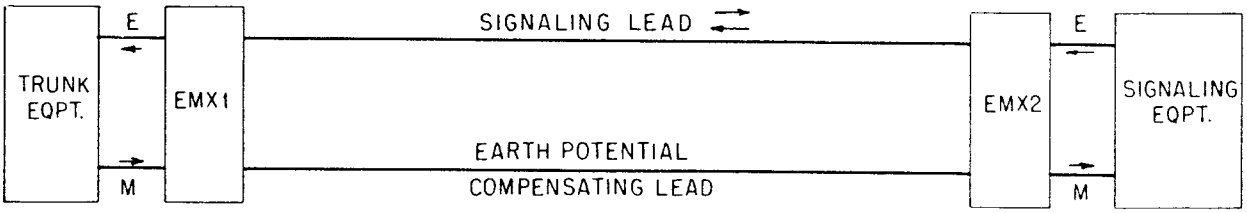


Fig. 9 — Signals Between Trunk and Signaling Equipment in E and M Lead Signaling Systems



LINE CONDITION		APPLIED AND RECEIVED ON M LEAD	APPLIED AND RECEIVED ON E LEAD
TRUNK EQPT.	SIGNALING EQPT.		
ON-HOOK		GROUND	
OFF-HOOK		BATTERY	
	ON-HOOK		OPEN
	OFF-HOOK		GROUND

Fig. 10 — Signal Lead Extension Between Trunk and Signaling Equipment with Pulse Link

link circuits may be used as indicated in Fig. 11 to obtain the necessary signal conversion. Two general types are used:

(1) The relay type per SD-95095-01 and

(2) the nonrelay type per SD-95043-01.

Of the two, the relay type gives better performance in repeating dial pulses.

2.18 *Signal Lead Extension between Signaling Systems:* When extended range operation is required between two signaling units in different buildings with separate battery supplies, two signal lead extension circuits per Drawing SD-95488-01 (EMX2) may be used. This usage is shown in Fig. 12.

2.19 Arrangements are also available to permit connections between loop signaling or ringdown signaling and E and M lead systems. For more information regarding the various types of loop converters, reference may be made to Section AB23.370.9.

(a) DX Signaling

2.20 In the DX signaling system, one wire of a pair is used for full duplex signaling on a ground return basis. The other wire provides compensation for differences in earth potential and to some extent in battery voltages. A typical application between two trunk units arranged for E and M lead signaling is shown in Fig. 13. The over-all signal conversion is the same as that previously described for other E and M lead signaling systems.

2.21 The DX signaling system may be used on both 10 and 20 pps dial pulse trunks as well as on MF and automatic trunks. With proper balancing network adjustment, DX signaling cir-

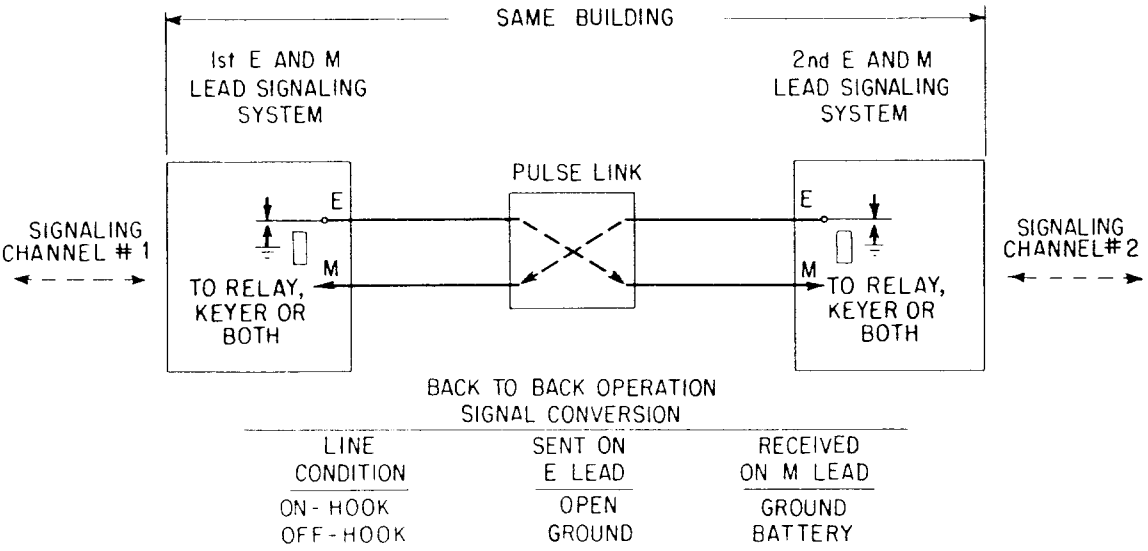


Fig. 11 — Back-To-Back Operation of E and M Lead Signaling Systems

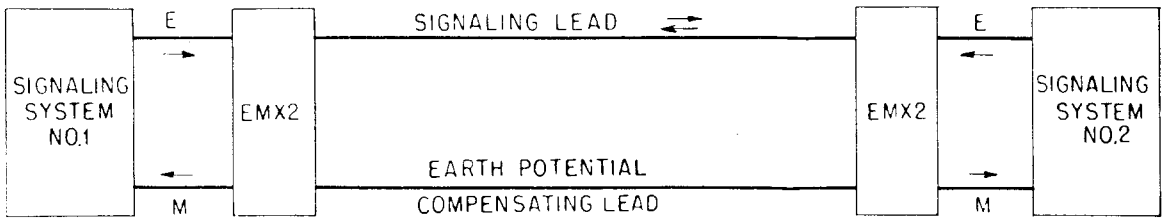


Fig. 12 — Signal Lead Extension Between Signaling Systems

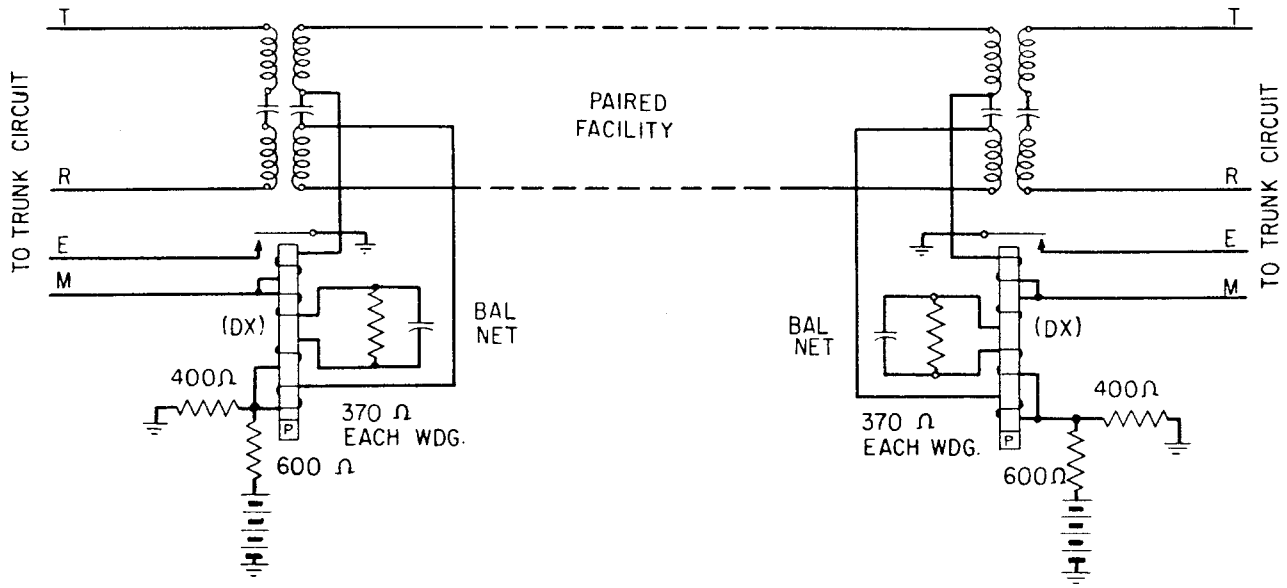


Fig. 13 — DX Signaling Systems Between Two Trunk Circuits

cuits will repeat 12 pulses per second of 58 per cent break with a distortion not exceeding plus or minus 4 per cent break. This includes an allowance, on a probability basis (not by arithmetical addition), of 2 per cent error in measurement. This performance is better than most loop signaling arrangements and is equal to that of intertoll CX signaling arrangements. DX signaling is particularly adapted to intertoll, toll connecting and exchange trunks in paired cable facilities. Either E- or V-type voice repeaters may be used, the latter with bypass equipment.

(b) Composite Signaling

2.22 Composite (CX) signaling legs are derived from the line by means of a CX set, which separates the low-frequency signaling currents from the voice. The crossover frequency is about 100 cycles. Two CX legs can be derived from one pair of wires and four from a phantom group. The four can be used independently, each with a ground return path, but more generally they are used to provide the required three signaling channels per quad in addition to an earth potential compensating channel. The signaling channels need not necessarily follow the talking channels. A typical arrangement is shown in Fig. 14.

2.23 CX, as well as DX and SX, signaling is full duplex in operation, that is, they all provide simultaneous 2-way signaling and dialing paths in the two directions. The circuit techniques are those used in full duplex telegraph operation. A 3-winding polar relay at each end of the line receives signals from the distant end. Balancing networks are provided which are adjusted for each layout according to the signaling frequency impedance of the line. The sending current divides between line and network windings with equal and opposite effects on the (CX), (DX), or (SX) relay, so as not to interfere with its operation or release on incoming signals.

2.24 At an intermediate voice repeater, such as one of the V-type, either two sets of CX equipment and a pulse link may be provided, or bypass equipment must be used to provide signaling around the repeater.

2.25 Earth potential compensation, which is optional, is usually necessary for proper performance and should be used in all cases on trunks used for intertoll dialing. Under some conditions, filters may be required to overcome the effect of longitudinal alternating current induced voltages. More information on this subject will be found in Section AB23.370.5.

2.26 Three general types of CX sets, designated C, D, and E are used in signaling as described in Section E42.010.

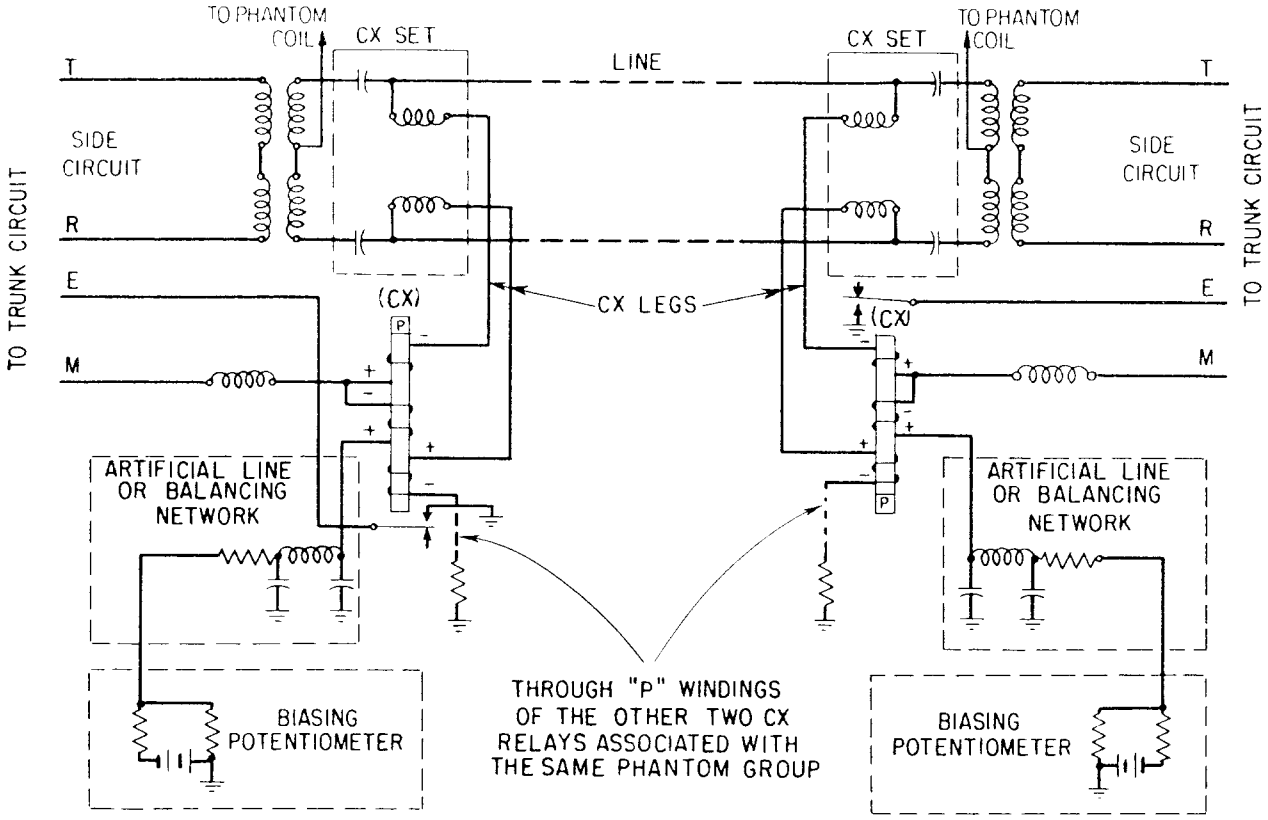


Fig. 14 — Composite Signaling Circuit for One Voice Channel

2.27 The exact ranges depend upon the type of CX set, the signaling battery voltage limits, presence or absence of voice repeaters in the circuit and the sensitivity of the relays (i.e., the specific type of relay) in the signaling equipment itself. For more information on the circuit drawings involved and on the interpretation of the published signaling ranges, reference may be made to Section AB23.370.5. Although the ranges are largely controlled by the effect on dial pulsing, which is classified as control signaling rather than supervisory, they are briefly discussed here to unify the treatment.

(c) Simplex Signaling (With E and M Lead Operation)

2.28 Simplex signaling systems of this type provide full duplex operation as indicated in Fig. 15 by the use of equipment similar to that used for composite signaling.

2.29 A simplex signaling system is shown in Fig. 15. The signaling currents in the line conductors induce no voltage in the metallic voice path and, conversely, voice currents cause no current flow in the simplex leg. Since SX signaling is not adaptable to phantom quadded facilities SX's are not used on long trunks. Simplex signaling has been largely superseded, for new work, by the DX signaling system which has also been described.

(d) Other Trunk Signaling Systems

2.30 All signaling systems in telephone service that use frequencies within the transmitted voice band (approximately 250-3000 CPS) are known as inband signaling systems. Systems using frequencies well outside this band, such as the built-in 3700 CPS unit in "N" carrier and the low-frequency systems (20 CPS, 135 CPS), are called out-of-band signaling systems.

2.31 In inband signaling both the voice and signaling paths are the same so that special equipment is not required to keep the two coordinated. When two or more carrier systems using inband signaling are operated in tandem, the application of signaling equipment is required only

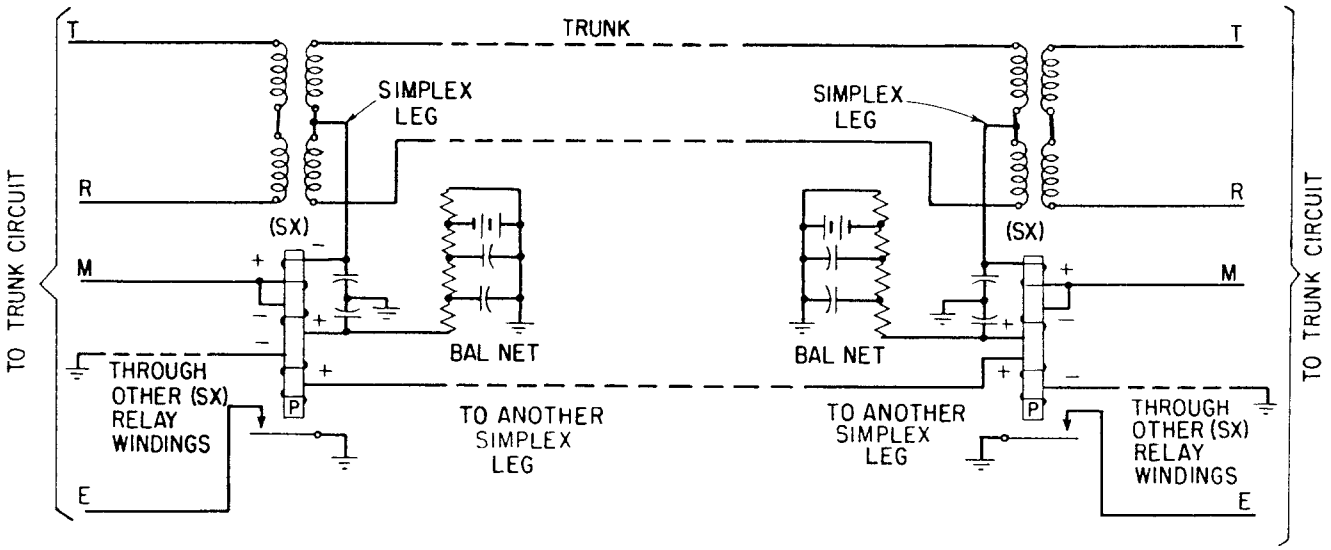


Fig. 15 — Simplex Signaling System

at the end terminals. Also, such a system does not necessitate any increase in bandwidth.

2.32 Contrasted to inband signaling the main advantage of out-of-band signaling is its freedom from talk-off problems which is discussed in more detail elsewhere in this section.

(e) 2600-Cycle Single-Frequency Signaling (SF)

2.33 The single-frequency signaling systems are designed to transmit supervisory and dialing signals over the same channel as that used for speech. When multifrequency pulsing is used to transmit digital information, the single-frequency system is still needed for supervisory purposes.

2.34 A signaling frequency of 2600-cycles is used in both directions for 4-wire lines, whereas, for 2-wire lines 2400-cycles is used in one direction and 2600-cycles in the other. A simple block diagram of 2600-cycle single-frequency system, as used at one terminal of a 4-wire voice channel, is shown in Fig. 16.

2.35 This system transforms idle, or on-hook, and busy, or off-hook, signals, received on the M lead, into periods of tone and no tone, respectively, applied to the transmitting voice channel. It also independently responds to the presence or absence of incoming signaling frequency tone on the receiving voice channel and applies on the E lead corresponding periods, with some pulse length correction, of on-hook and off-hook signals.

2.36 The 2600-cycle system replaces the earlier 1600-cycle system. Because of the signaling frequency the 2600-cycle system cannot be used on narrow band facilities, such as with EB channel banks or on H-172 and other low cut-off loaded lines. It can be used on 4-wire broadband carrier such as the J, K and L systems, and TD-2 radio systems and 4-wire H-88 or lighter loaded cable facilities. It can also be used on similar types of 2-wire facilities if not more than one intermediate repeater is used, in which case a 2400-cycle frequency for the reverse direction is used.

2.37 During the transmission of outgoing pulses on the M lead the line is momentarily cut and terminated to avoid interference from dial normal transmission or other noise sources. During pulsing, the level of tone applied to the line is increased by 12 db to improve signaling reliability. Received signaling tone is cut off from the local equipment before the length of the pulse which is passed is great enough to actuate the receiving equipment of other systems which may be connected in tandem. A blocking amplifier is provided in the receiving branch to isolate the receiving equipment from noise coming from the local equipment direction.

2.38 Signal and guard detectors are used, the first operating on single-frequency tone and the second on other speech frequencies. The outputs of the two detectors oppose each other and provide additional margin against false operation during speech.

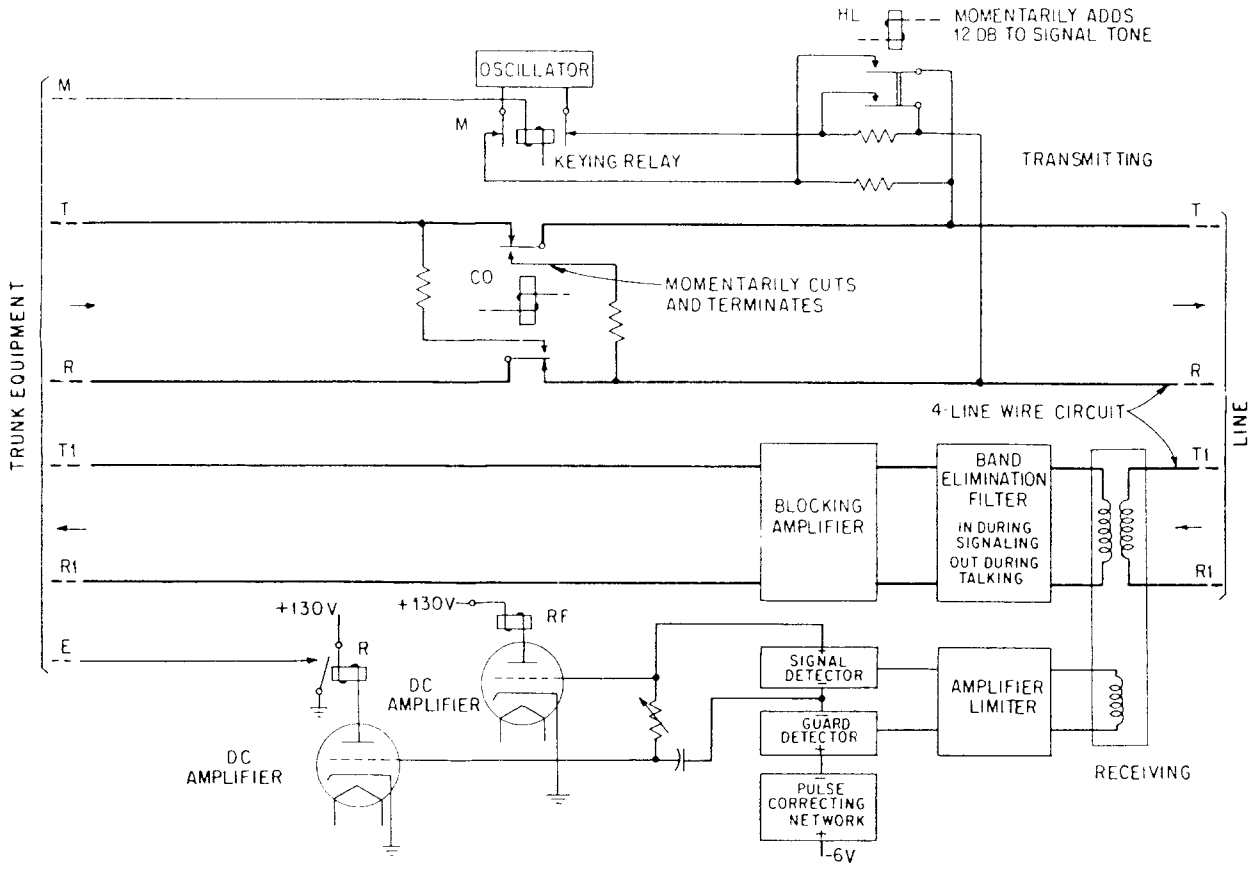


Fig. 16 — 2600-Cycle Single-Frequency Signaling Circuit

2.39 Arrangements are available for converting existing 1600-cycle signaling units to the 2600-cycle type of operation when operating conditions or equipment warrants.

2.40 *Tone Appliers:* The use of single-frequency signaling systems, particularly in tandem, interferes with the transmission of audible tones associated with flashing. For customer dialing, the audible signals are required, hence, tone appliers are used to reapply audible tone near the originating end of a connection. As an example, tone appliers, such as covered by Drawing SD-27034-01, may be associated with trunks incoming from a local office to a CAMA equipped tandem office. In other cases, as at a No. 5 crossbar office with AMA, tone appliers may be associated with outgoing trunk circuits.

(f) Carrier Systems with Built-In Signaling

2.41 All of the Bell System carrier systems with built-in signaling use 3700-cycles, which is just above the voice band. The resulting useful voice band is somewhat narrower than that obtained with the so-called broadband systems. The use of an out-of-band tone for signaling, however, avoids impairment of the compandor system and permits use of relatively high signaling tone levels.

2.42 *N Carrier:* N carrier may or may not have built-in signaling. A built-in E and M lead 3700-cycle signaling system is shown in Fig. 17. Tone is transmitted during the idle or on-hook condition and no tone during off-hook. A varistor-type keyer under control of the M lead applies tone in the transmitting 4-wire branch beyond the compressor and ahead of the channel modulator. At the receiving end, the tone is picked off the receiving branch by means of a 3700-cycle filter at the demodulator output ahead of the voice-frequency low-pass filter.

2.43 An arrangement has been made available whereby two N signaling systems may be operated back-to-back without using a separate pulse-link circuit or the equivalent.

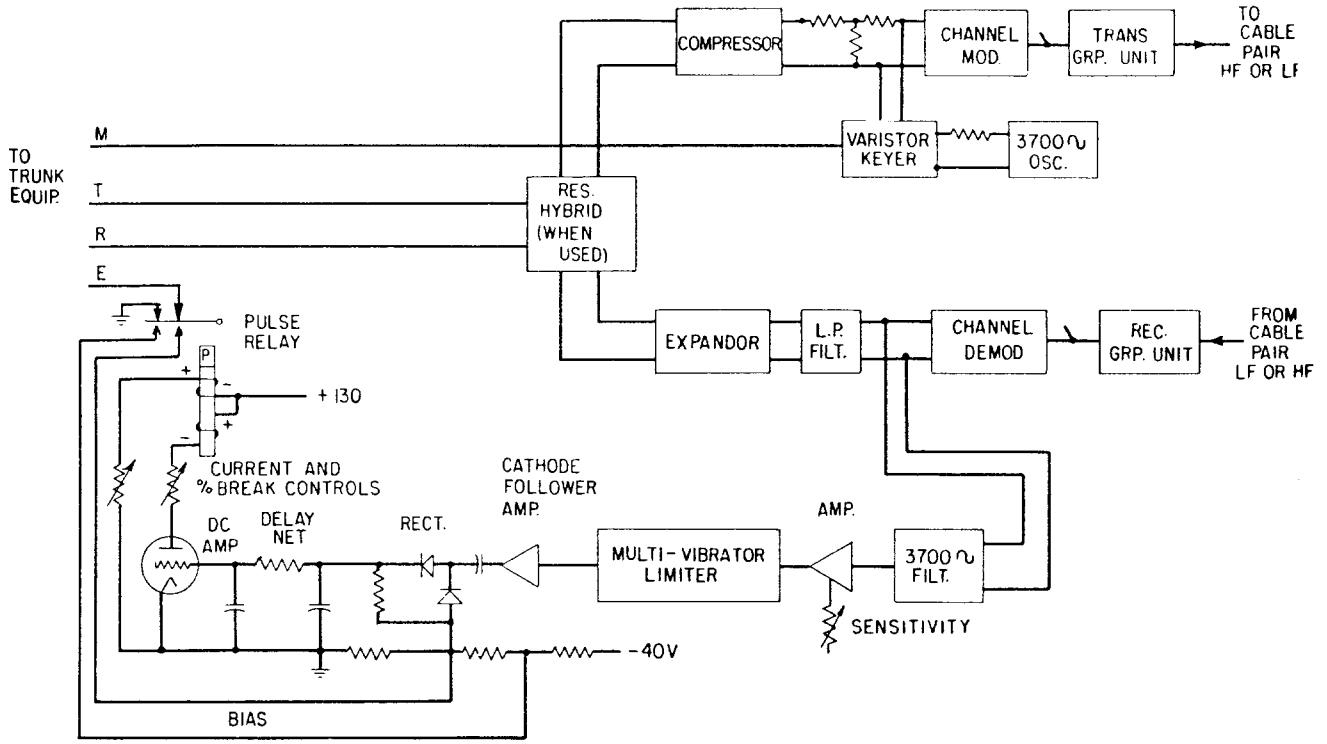


Fig. 17 — N-1 Carrier Signaling System

2.44 *O and ON Carrier:* From a signaling standpoint the O and ON arrangements are the same as for N carrier.

(5) E-Type Repeaters

2.45 The effect of E-type repeaters upon (CX), (DX) and (SX) trunk signaling is almost negligible. Composite (CX), (DX), and simplex (SX) signaling circuits for dial system trunks have polar transmission and comparatively long range. For these circuits, as for dc loop signaling, battery voltage, loop resistance, and insulation leak to ground are the principal range limiting factors. Polar transmission, unlike the neutral transmission of dc loop pulsing circuits, is not impaired by change in line impedance as long as the latter remains within normal limits. This feature and their range limits enable polar signaling circuits to operate equally well with and without E-type repeaters.

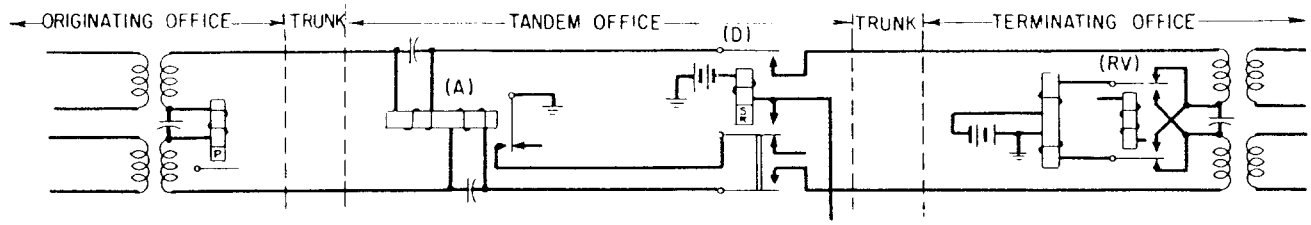
2.46 The small dc effect E-type repeaters have upon CX, DX, and SX signaling is the same for supervision and dial pulsing. Each E-1 and E-2 involved requires a slight subtraction from the maximum conductor loop resistance shown in the circuit drawings. No additional reduction in loop resistance is needed for E-3 repeaters.

(E) Repeated Supervision at an Intermediate Office

2.47 An example of repeated supervision at an intermediate office is the crossbar tandem office which employs the following types of supervision:

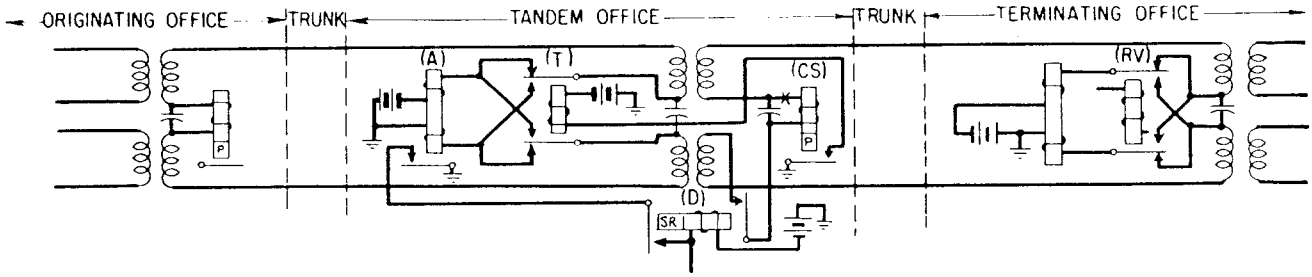
(1) *Through Supervision:* Supervisory signals are transmitted directly between the terminating and originating offices through the tandem office as shown in Fig. 18 (a). For holding purposes the incoming tandem trunk also recognizes the signals by means of the (A) relay. The loop for holding the connection during talking includes the in- and out-trunk conductors and the equipment at the originating, intermediate and terminating points. Range may be limited by the originating, tandem or terminating office equipment.

(2) *Repeated Supervision:* Supervisory signals, transmitted in either direction, are recognized by the incoming tandem trunk, regenerated and retransmitted as shown in Fig. 18 (b). The holding circuit is independent



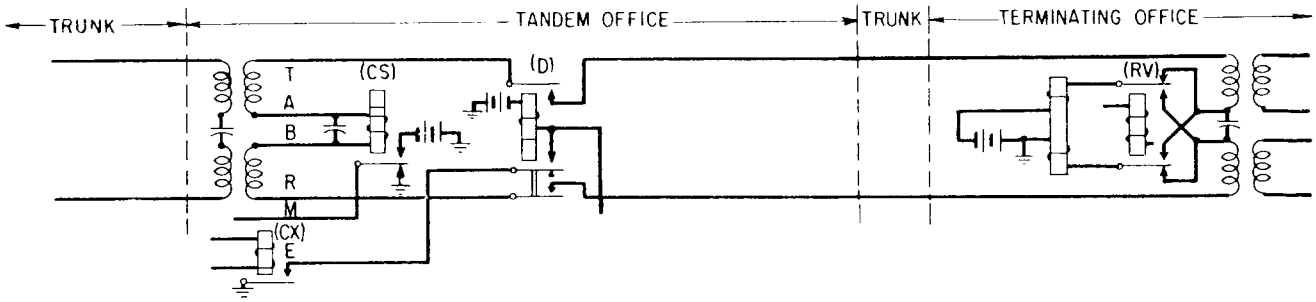
(D) RELAY IS OPERATED FROM SENDER AND LOCKED TO (A)

(a) THROUGH SUPERVISION



(D) RELAY IS OPERATED FROM SENDER AND LOCKED TO (A)

(b) REPEATED SUPERVISION



(D) RELAY IS OPERATED FROM SENDER AND LOCKED TO E LEAD FROM CX RELAY

(c) COMPOSITE, SIMPLEX OR OTHER E AND M LEAD SIGNALING AT A TANDEM OFFICE.

Fig. 18 — Tandem Office Supervision

of the completing trunk. This independence permits greater range and insures greater freedom from false disconnects. In repeated supervision trunks, a conversion may be made at the tandem office from reverse battery to high-low supervision, or vice versa.

(3) *E and M Signaling:* E and M lead supervision, and dial pulsing when required, is received and retransmitted on a reversed battery basis to a local terminating office. Supervisory signals from the terminating office are converted to E and M lead signaling. This arrangement is used when toll lines or trunks from distant offices terminate in a tandem office. A typical arrangement is shown in Fig. 18 (c).

(F) Use of Telegraph Channels for Signaling

2.48 Occasionally, the use of telegraph channels for signaling is desirable. The conversion from E and M signaling to full duplex telegraph operation is made by means of a telegraph pulse link as described in Section AB23.370.9. The telegraph channels are normally provided by means of one of the voice-frequency systems, such as the 43A1 which is described in Section E44.263.

(G) Trunk Alerting Systems

2.49 Supervision for alerting purposes between switchboards (either local or toll or a combination of the two) may be either straightforward or ringdown.

(1) Ringdown Signaling

2.50 In ringdown operation, the operator operates a key in a cord circuit to ring on a trunk. Ringdown signaling on intertoll trunks uses suitable types of "ringers" to transmit and receive the signals. Supervision on ringdown trunks is limited to originating operator-controlled signals to summon the distant operator, recall her or to indicate a ring-off on a built-up call. Ringdom trunks are not suitable for intertoll dialing, although connection of dial to ringdown trunk may be provided with operator intertoll dialing. Various types of ringdown signals as described in Section AB23.370.9 are as follows:

(a) Magneto
(b) 20-cycle signaling
(c) 135-cycle signaling
(d) 1000-cycle signaling

(2) Straightforward Signaling (SFD) (Automatic Supervision)

2.51 Straightforward supervision, by comparison with ringdown, requires no specific signaling actions by the originating operator. Insertion of a cord in a trunk jack automatically lights a lamp at the distant switchboard as a connect signal and removal of the cord gives the disconnect signal. Similar operation between a dial switching center and a terminating manual office is called *automatic* supervision.

2.52 Straightforward supervision is faster than ringdown since the originating operator is kept informed of the progress of the call by visual indication of the called party answer and hangup.

3. DIGITAL SIGNALS

3.01 Digital signals are used chiefly to carry the information which directs the establishment of a particular desired connection. This consists chiefly of the called office code and telephone number as well as auxiliary information.

3.02 In some applications, digital signals simply carry information, such as the wanted number, to a circuit, such as a sender or register, which in turn takes the proper action to complete the call. In other cases, the signal pulses actuate the switching mechanisms directly.

3.03 Besides the digital information, auxiliary signals are necessary to tell when the digits are to be sent. Typical examples are:

(1) Delay dialing or pulsing signals which occur before any digits are sent.
(2) Stop pulsing signals which occur after some digits are sent.
(3) Start pulsing signals which occur before additional digits are sent. These auxiliary signals are discussed further in Part 3 (C).

3.04 By an extension of the definition, the signals used for coin control, message register operation and transmission pad control fall into the digital signal category.

(A) Types of Digital Signals

(1) Verbal Signals

3.05 Verbal signals were the means first used for passing digits and will continue to be necessary in some situations, such as for placing

person-to-person toll calls. Verbal signals, mechanically produced, are used in the call announcer system which is described in (6).

(2) Dial Pulsing (DP)

3.06 Dial pulsing is a means for transmitting digital information from a subscriber's dial to the central office equipment. In step-by-step systems the dial pulses are used to actuate directly the switching equipment in the local office. On trunked step-by-step calls the dial pulses for the distant selections are relayed forward by an outgoing dial pulse repeater. At the terminating office the relayed pulses may either operate the switching equipment directly or may be again relayed by an incoming dial pulse repeater. Dial pulsing is also used into and out of step-by-step tandem offices. Senders which accept dial pulses from trunks are available for No. 1 and No. 5 crossbar and crossbar tandem as well as at crossbar toll systems. Outgoing dial pulsing may be transmitted by senders at No. 5 crossbar, crossbar tandem, panel sender tandem, and crossbar toll systems. Dial pulsing is also used on some outward trunks at manual, DSA and toll switchboards.

3.07 With dial pulsing the numerical value of each digit is indicated by the number of pulses in a train. Pulses from a subscriber's dial are momentary openings of the loop which are followed at the switching equipment by a fast acting relay. A slow release relay, which ignores the pulses but releases between pulse trains, is used to advance the equipment for the next digit.

3.08 Dial pulse repeaters and outpulsing senders may transmit signals either by *loop pulsing* or by *battery and ground pulsing*. Loop pulsing is similar to that from a dial with the battery and ground being generally supplied at the terminating end, except in the case of certain *wet-pulsing* circuits. With battery and ground pulsing, one winding of the receiving relay is energized by battery from the terminating office and the other from the originating end. This arrangement permits an increased range of trunk resistance if adequate balance between the two relay windings is maintained. The two pulsing methods are illustrated in Fig. 19. *Supervision* may also be obtained on either a *loop* or on a *battery and ground* basis. The method used is not necessarily the same, in any case, as that used for pulsing.

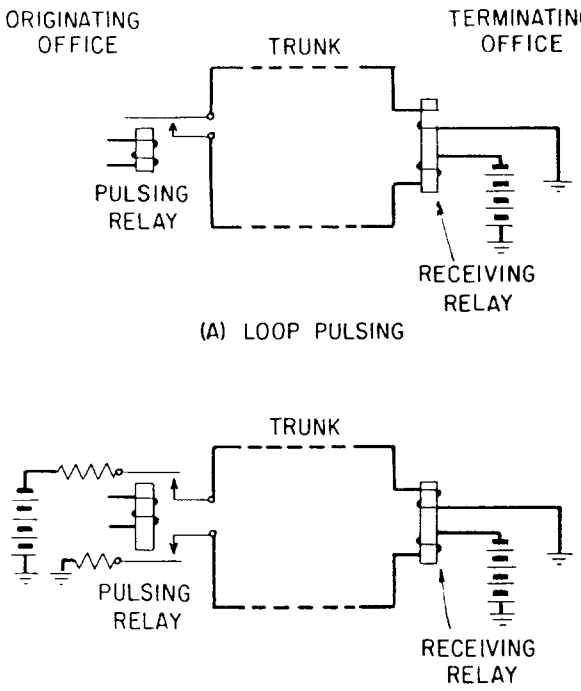


Fig. 19 — Pulsing Methods

3.09 Senders usually pulse with 0.6 seconds interdigital time. The minimum interdigital time should be as near to 0.6 seconds as possible to allow time for trunk hunting in the terminating office. For customer dialing and operator keying or dialing to a sender, the interdigital time is under human control.

3.10 The newer subscriber type dials have an improved speed controlling governor which combines the effects of the driving and centrifugal forces. Better speed regulation and resistance to dial forcing is obtained.

3.11 Dial pulse repeaters are either of the *nonpulse-correcting* or the *pulse-correcting* type. The latter type is designed to be capable of receiving distorted loop pulsing signals and yet to transmit pulses with essentially the optimum pulse form. To prevent the distortion from becoming too great in extended dialing areas, not more than two nonpulse-correcting repeaters are normally operated in tandem before being followed by a repeater of the pulse-correcting type.

3.12 Dial pulsing may be transmitted over duplex (DX), composite (CX), simplex (SX), single-frequency (SF), and other E and M lead signaling systems. Suitable loop converter circuits are required at both ends of such systems.

3.13 A discussion of the factors which determine the ranges for interoffice trunks in step-by-step systems is given in Section AA400.801. Subscriber loop ranges are affected by the type of pulse repeaters used as well as by the types of dial in use.

(3) Multifrequency Pulsing (MF)

3.14 MF is another means now available for passing digits over a talking path. The voice channels must transmit the necessary frequency band with some requirements for uniformity of transmission in this band.

3.15 Multifrequency pulses are transmitted either by senders or by operators. With a keyset roughly two digits per second can be sent, whereas senders transmit about seven digits per second.

3.16 Fig. 20 shows an arrangement in which a switchboard equipped with multifrequency keypulsing is connected, by a direct multifrequency trunk, to a crossbar office.

3.17 The table in Fig. 21 shows how the digits to be transmitted are each indicated by a combination of two audio frequencies on the basis of an additive code.

3.18 The pulses consist of different combinations of six audio frequencies which are transmitted two at a time for each digit. Fifteen combinations are possible, ten of which are used for the digits 0 to 9, inclusive, and one each for signals indicating the beginning (KP) and end (ST) of pulsing. The remaining three combinations are available for future requirements.

3.19 The multifrequency signal receiver is connected to a trunk as part of a sender or register as indicated in Fig. 20. A block diagram of the receiver is shown in Fig. 22.

3.20 A check circuit in the receiver verifies that two and only two relays operate after each digit. Any error, such as pressing two keys simul-

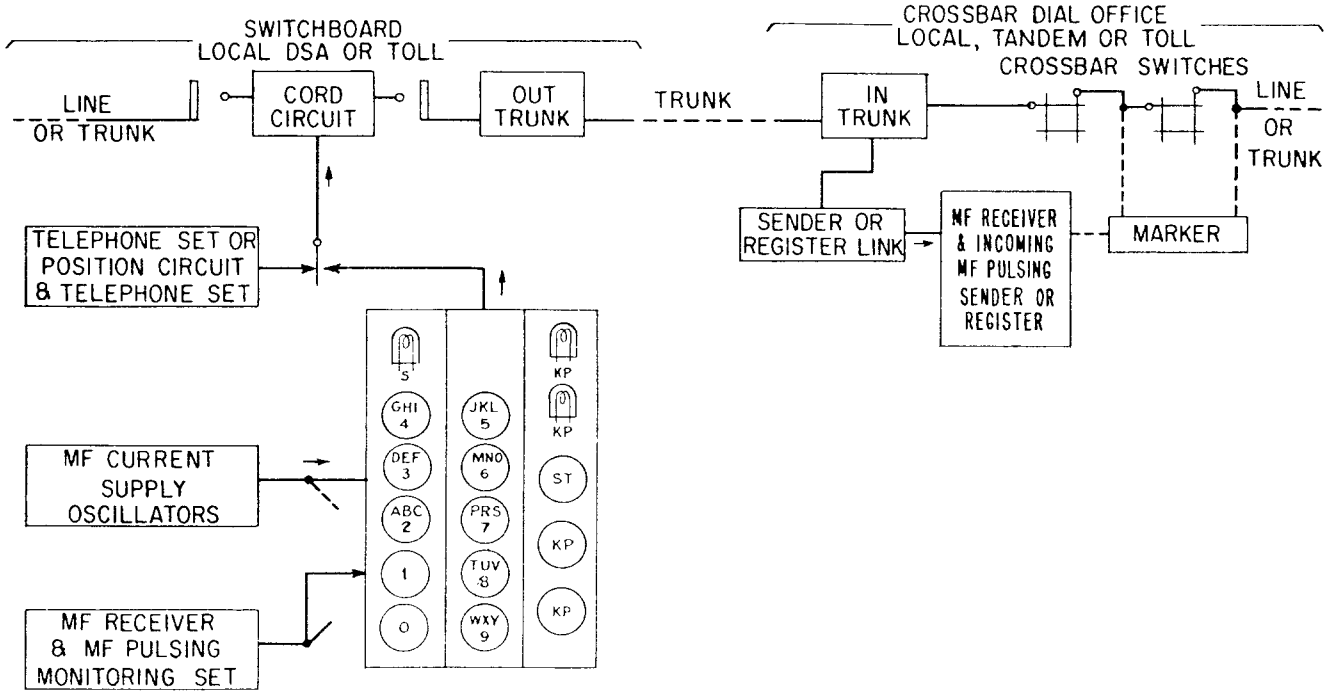


Fig. 20 — MF Pulsing from a Switchboard to Dial Office

Multi Frequency Code					
Digit	Frequencies Cycles per Second	Additive Code Designation	Digit	Frequencies Cycles per Second	Additive Code Designation
1	700 + 900	0 + 1 = 1	7	700 + 1500	0 + 7 = 7
2	700 + 1100	0 + 2 = 2	8	900 + 1500	1 + 7 = 8
3	900 + 1100	1 + 2 = 3	9	1100 + 1500	2 + 7 = 9
4	700 + 1300	0 + 4 = 4	0	1300 + 1500	4 + 7 = 11
5	900 + 1300	1 + 4 = 5	KP	1100 + 1700	2 +10 = 12
6	1100 + 1300	2 + 4 = 6	ST	1500 + 1700	7 +10 = 17

Fig. 21

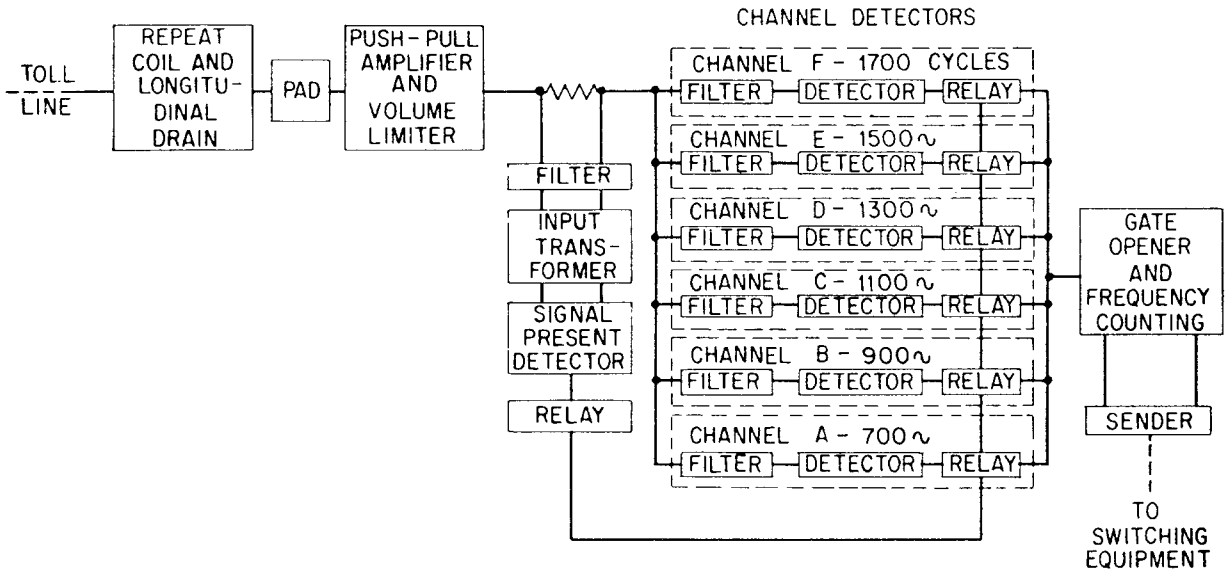


Fig. 22 — Receiving Circuit for MF System

taneously, is detected and a reorder signal is returned to the sending end to flash the cord lamp. The operator must then release and start over.

3.21 The multifrequency system transmits only digital information; hence, other circuits such as CX, SF or loop arrangements must be provided for supervision.

3.22 Since (MF) pulsing is quite fast and occurs only during the period while a connection is being established, relatively small number of senders or registers which include multifrequency receivers can be used as common equipment for a large number of trunks.

(4) Panel Call Indicator (PCI)

3.23 The panel call indicator system was originally developed to transmit digits from a panel office to a manual "B" operator. This pulsing system is also used from local or toll crossbar offices to manual offices, and from panel and crossbar offices to PCI senders at crossbar tandem or panel sender tandem. PCI pulsing is also used locally in panel sender tandem offices between operator keyset positions and the senders. Panel call indicator pulsing will also be used within panel and No. 1 crossbar offices, between the regular senders and groups of auxiliary senders, which will provide multifrequency outpulsing, when needed, particularly for toll calls to foreign

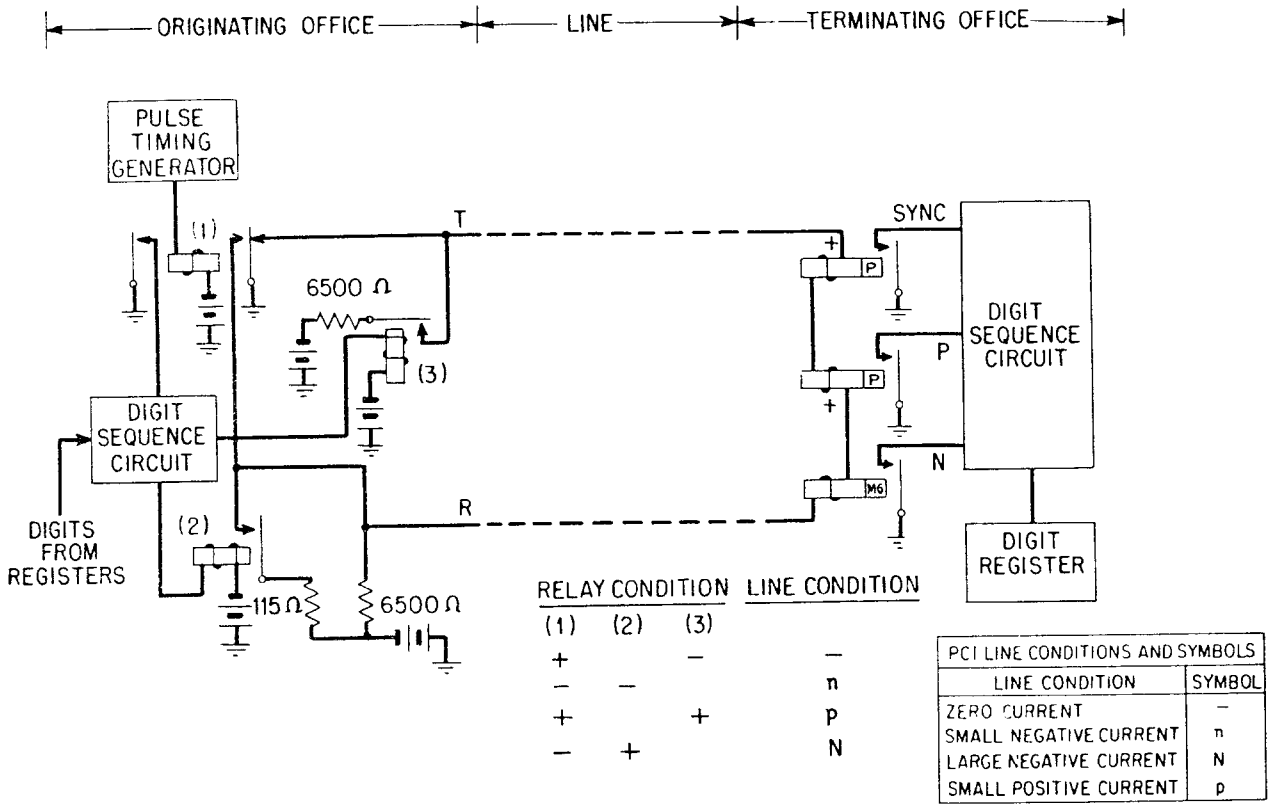


Fig. 23 — Basic PCI Pulsing System

numbering plan areas. In the PCI signaling system, the digits are represented by a time division sequence of pulses which are received and registered on relays or switches and, in manual offices, are then displayed on a lamp field before the operator. The tip and ring conductors are temporarily switched from the normal supervisory equipment to equipment which transmits the panel call indicator signals.

3.24 A combined marginal and polar transmission scheme is used over a metallic circuit as shown in Fig. 23. Closure of the trunk to the relays of the PCI control circuit indicates to the originating sender that the digits are to be transmitted.

3.25 In pulsing, the system uses four conditions of direct current on the line for which the symbols used in this discussion are shown in Fig. 23.

3.26 The polarities indicated in Fig. 23 are those of the ring conductor with respect to the tip. Another condition, heavy positive current, is reserved as a final *end of pulsing* signal which is sometimes required.

3.27 Each code is divided into four time divisions or quadrants designated as A, B, C and D in the tables in Figs. 24 and 25. Each quadrant A, B, C or D may be considered to have a normal and a modified line condition or mark as indicated in Fig. 24.

PCI Line Conditions				
	Panel Call Indicator Cycle for One Digit			
Time Intervals	A	B	C	D
Line Condition				
Normal	−	n	−	n
Modified (Mark)	p	N	p	N

Legend:
− = Open loop
p = Light positive current
n = Light negative current
N = Heavy negative current

Fig. 24

3.28 In the absence of a 10,000 digit (0 or 1) or a party letter (W, R, J or M), pulses for a 0 are sent after the last digit. The digits are transmitted by one or the other of two codes as indicated in the table in Fig. 25.

Digits, Letters or Party Code Letters	Panel Call Indicator Codes							
	Hundreds, Tens, Units, Ten-thousands (0,1) and Tandem Office Codes				Thousands			
	A (1)	B (2)	C (4)	D (5)	A (2)	B (4)	C (8)	D (1)
0	-	n	-	n	-	n	-	n
1	p	n	-	n	-	n	-	N
2(W)	-	N	-	n	p	n	-	n
3(R)	p	N	-	n	p	n	-	N
4(J)	-	n	p	n	-	N	-	n
5(M)	-	n	-	N	-	N	-	N
6	p	n	-	N	p	N	-	n
7	-	N	-	N	P	N	-	N
8	p	N	-	N	-	n	p	n
9	-	n	p	N	-	n	p	N

Fig. 25

3.29 As indicated in the table in Fig. 25 the code for the thousands digit differs from that used for the other three.

3.30 It will be seen from the mark signal values in parentheses at the column headings of the table in Fig. 25 that the modified signals used for each digit are in each case based on an additive code, for example, 9 is indicated by (C = p and D = N) or (4 + 5) for a hundreds, tens or units digit and also by (C = p and D = N) meaning (8 + 1) for a thousands digit.

3.31 The B and D negative intervals, n or N, in addition to the digital information also control, by their negative polarity, the synchronization of sending and receiving circuits and advance the receiving circuit to register successive digits.

3.32 The time sequence of four intervals for one digit is sent in approximately 0.275 second. Signals for a 4-digit number are sent without pause between digits in slightly more than one second. Panel call indicator transmits digits faster than dial pulsing and cheaper than multifrequency within its range of operation.

3.33 *Step-by-Step Call Indicator:* In some cases, dial pulsed digits incoming to manual offices in step-by-step areas are received and registered on relays or switches and displayed on a lamp field before the operator. Such an arrangement is called step-by-step call indicator.

(5) Revertive Pulsing (RP)

3.34 In revertive pulsing, the originating office controls the setting of switches in a terminating office by ground pulses which "revert" back over the trunk from the terminating office. The originating office initiates only start and stop signals. The stop signal is transmitted when the desired number of revertive pulses has been received for each selection at the terminating office.

3.35 A schematic of the "fundamental circuit" between two panel offices is shown in Fig. 26. When the sender, located in the calling subscriber's central office, has recorded the number dialed, and a test for the proper trunk condition has been made, the relay designated (FO3) in Fig. 26 closes the "fundamental" circuit as a start signal. The stepping (STP) relay in the originating office and the (L) relay in the selector circuit at the terminating office then operate in series, the latter operating the clutch magnet, which forces the rack against the cork roll and thereby raising the elevator.

3.36 As the elevator rises, the commutator brush comes in contact with the metal segments of the commutator, alternately grounding and opening the tip side of the line. When the tip side is grounded, the stepping (STP) relay is short circuited, causing it to release. The alternate operation and release of the stepping (STP) relay, under pulse control, "counts down" the pulse counting circuit. When the predetermined number of pulses, corresponding to the incoming brush selection needed to reach the called subscriber's telephone number, have been received the back contact (BO) relay, controlled by the pulse counting circuit, operates and opens the pulsing loop. This open is a signal which causes the release of the distant (L) relay, after ground is also broken by the upward brush movement at the commutator. This stops further upward motion of the elevator. This entire process of trunk loop closure, pulse counting and loop opening is repeated for the remaining selections required at the incoming and final frames at the terminating office. A reversed battery "incoming advance" pulse is sent after the final digits selection. This causes a polar (OF) relay in the fundamental circuit at the originating sender to operate and start a chain of events leading to trunk closure and release of the sender.

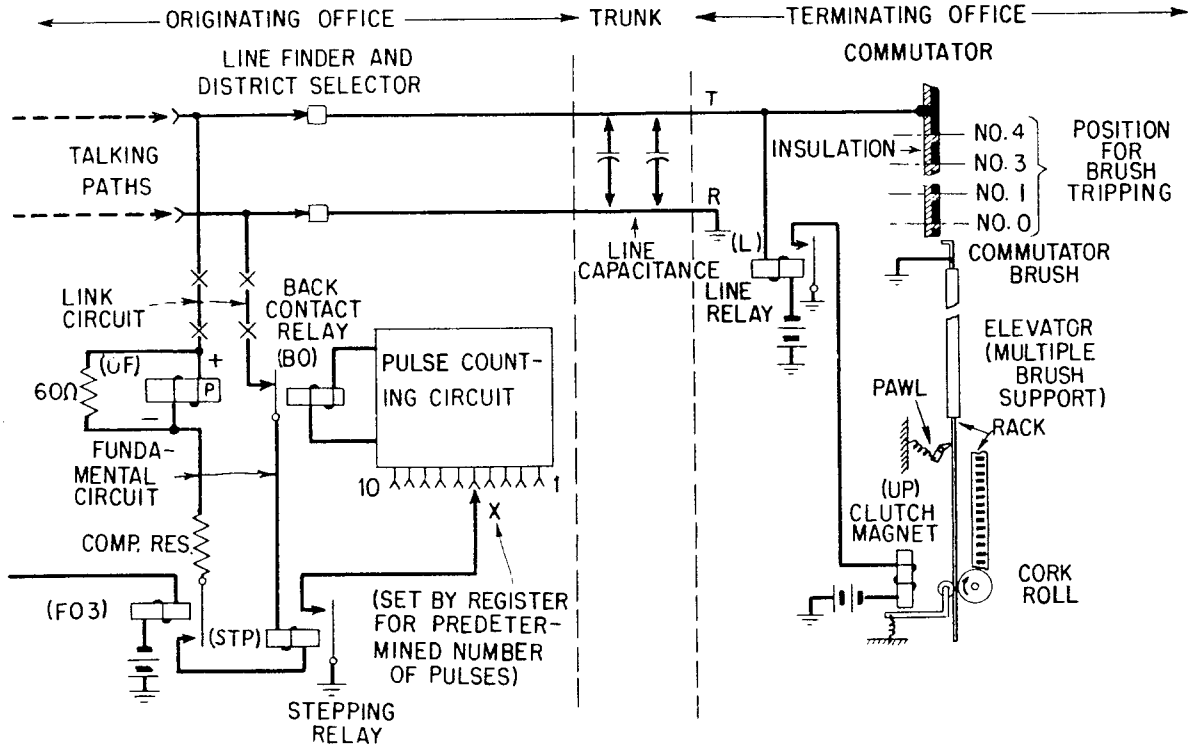


Fig. 26 — Revertive Pulsing Between Panel Offices

3.37 The compensating resistance is used to pad out short trunks so that the fundamental circuit resistances of long and short trunks are reasonably uniform during pulsing in order to secure reliable operation.

3.38 *Revertive Pulsing Code:* Revertive pulsing came into being because, in making selections, the panel equipment moves at its own natural speed and hence cannot be directly controlled at the direction of the sending office. The 100 point switch "banks" mounted on 5 bank frames in panel offices led to the use of a non-decimal code. To control the selections, the decimal code dialed by subscribers is registered and then translated into the code shown in Fig. 27, which forms the normal pattern for communication between panel offices.

3.39 In the panel switching systems the district brush and district group selections occur within the originating panel office. The office brush and office group selections occur either in the originating office, or sometimes at a distant office selector tandem office. The remaining selections are made at the terminating office.

3.40 Revertive pulsing is also used with an incoming register or other relay equipment at a tandem or terminating office, for example, at No. 1 or No. 5 crossbar or at crossbar tandem offices. In such cases, a self-interrupting relay train produces ground pulses while other relays record the number of pulses. The code may be modified by the use of either "low five" or "high five" incoming group selections so as to direct calls to the "A" or "B" office of paired units using common incoming trunk groups. At crossbar tandem and at No. 5 crossbar offices, office brush and group selections are sometimes used to form a routing code.

3.41 Revertive pulsing is faster than dial pulsing, about 27 pulses per second. The interdigital time is shorter than in dial pulsing.

3.42 In the early "ground cutoff" type panel offices, the release time of the (L) relay at the incoming or final frame is a controlling limitation on pulsing range. This is true since, with the line opened at the (BO) relay and also with ground removed at the commutator, the release time of the (L) relay is controlled by the charging transient of the line capacitance. *Repeating*

Revertive Pulsing Code		
Selection	Number of Positions	Designation
1. District brush	5	0 to 4
2. District group	10	0 to 9
3. Office brush	5*	0 to 4
4. Office group	10	0 to 9
5. Incoming brush	5	0 to 4**
6. Incoming group	4	0 to 3
7. Final brush	5	0 to 4
8. Final tens	10	0 to 9
9. Final units	10	0 to 9

* For calls routed on a revertive pulsing basis via Crossbar Tandem or No. 5 Crossbar an additional 5 pulses may sometimes be used. The combination of office brush and office group selections then forms a code with 100 choices available.

** As an alternative "high five", count 5 to 9, is sometimes used to select one of two paired units at No. 1 or No. 5 Crossbar.

Fig. 27

incoming selector circuits were later developed to improve the pulsing range to a degree by the use of a polar (L) relay, such as the 280DC by improved circuitry at the incoming frame and by repeating the pulsing from the final frame. The improved circuit separates to some extent, by the use of additional relays, the reception of the stop pulsing signal and the commutator break, which jointly control the release of the final selector up drive.

3.43 In the later "battery cutoff" type panel offices, a single (L) relay is used to control both incoming and final selections. For maximum range a relay of improved characteristics is used, rather than special circuitry, to improve the pulsing range over that obtainable with an ordinary flat type relay.

(6) Call Announcer (CA)

3.44 This is a method which has been used for the completion of calls from a panel sender tandem office to a manual "B" operator. It will function satisfactorily over any channel suitable for talking, irrespective of length.

3.45 With call announcer, the sender equipment records the called number and then cuts through certain leads to mechanical speech transmitting equipment so that a terminating operator receives the number verbally.

3.46 The call announcer equipment uses a motor-driven shaft on which are mounted eight drums, each of which carries two strips of photographic film. A beam of light from a lamp is focused through a series of lenses and a slot upon a sound track on each film. As the drum revolves, the sound track shading varies the amount of light reaching a photoelectric cell mounted behind each film. The current in the cell is proportional to the light reaching it through the sound track. The resulting voice current is amplified to bring it up to the required speech level.

3.47 A separate channel is provided for each of the numerals 0 to 9, party letters, W, R, J and M and two spares.

3.48 On call announcer trunks, the terminating circuit reverses battery to the sender as a start signal to indicate that an operator is ready at the B board. The sender then actuates the speech channels in the proper sequence to give the recorded number. The pronouncement is made at normal voice level and speed with a pause between the hundreds and tens digits.

(7) DC Keypulsing (DCKP)

3.49 This system permits operators in the same building with automatic switching equipment to pass digits to the control circuits more rapidly than by dialing. A 10-button keyset is used. A digit is sent by depressing the appropriate key momentarily.

3.50 Four leads with either high or low resistance and battery or ground are used, operating over the tip and ring with a ground return as shown in Fig. 28. The receiver has sensitive, polar and marginal relays in each lead. Contacts in the keyset apply battery or ground through resistors to the two leads to indicate each digit. Each digit is recorded on a set of register relays.

3.51 The table in Fig. 29 shows the T and R lead conditions, relay operations and DCKP code.

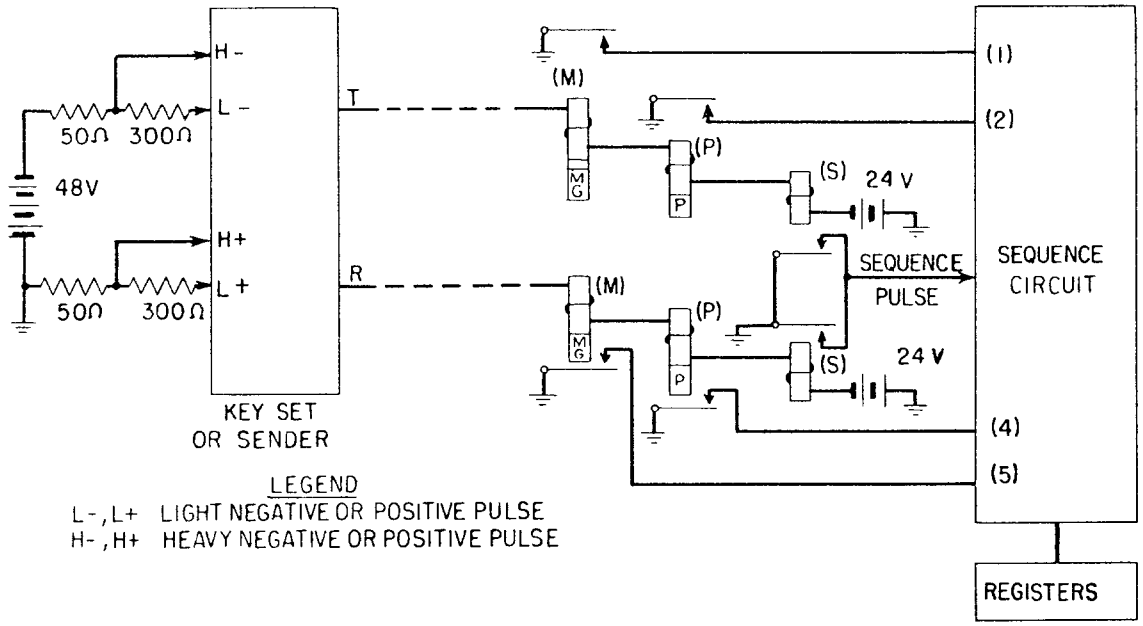


Fig. 28 — 2 Wire DC Keypulsing

Signal Conditions and DC Keypulsing Code					
	Pulses		Receiver Relays Operated		Additive
Digit	Tip	Ring	Tip	Ring	Code
1	H+		S,M		1
2	L-		S,P		2
3	H-		S,M,P		1+2
4	L+	L-	S	S,P	4
5	L+	H+	S	S,M	5
6	H+	H+	S,M,	S,M	1+5
7	L-	H+	S,P	S,M	2+5
8	H-	H+	S,M,P	S,M	1+2+5
9	L+	H-	S	S,M,P	4+5
0	L+		S		None
Start	H+	L-	S,M,	S,P	1+4

Legend:

L+ (Light Pos.) Indicates high resistance ground
H+ (Heavy Pos.) " low " "
L- (Light Neg.) " high " battery
H- (Heavy Neg.) " low " "

Fig. 29

(B) Auxiliary Signals Used When Passing Digits

3.52 Auxiliary signals are needed for coordination of pulsing control between the originating and terminating offices. In (1) and (2) below they are grouped by direction of transmission.

(1) Signals from Called to Calling End

(a) *Dial Tone:* Low tone (600 cycles per second modulated with 120 cycles per second) is sent to a subscriber or operator in response to a connect signal to indicate that the receiving end is ready to receive dial pulses. It is used in all types of dial offices when dial pulses are produced by customer's or operator's dials. Normally dial tone means that the entire wanted number may be dialed, but there are some cases where the calling party must await a second dial tone or where an operator, after dialing an initial group of digits, must wait for a second dial tone before the rest of the number can be dialed. Some dialing switchboards are arranged to permit listening for dial tone between certain digits. *See Dial-Normal Transmission Signal* below.

(b) *Dial Jack Tone:* Low tone is used as a start dial signal to tell a DSA operator that the connection reached through a dial jack is ready to receive dialing.

(c) *Order Tones (Zip Tones) (Trunk Assignment Tones):* High tones, sent over interposition, local interoffice or toll trunks indicate:

(1) to the originating operator that the order should be passed and,

(2) to the receiving operator that an order is about to be passed. For call announcer (CA) and automatic display call indicator (ADCI) the tone serves function (2) only.

(d) *Single Order Tone:* This is a relatively long (about one-half second) signal which means that the originating operator should pass the office name and number.

(e) *Double Order Tone:* This signal is two short spurts in quick succession and means that the operator should pass only the desired number.

(f) *Triple Order Tone:* This signal is three short spurts in quick succession and means that the operator should pass the office name only and wait for another order tone.

(g) *Quadruple Order Tone:* This signal is four short spurts in quick succession and means that the operator should pass the city name only and wait for another challenge. It is used in manual toll tandem.

(h) *Dial-Normal Transmission Signal:* In effect, this is a second dial tone returned to an operator between digits indicating that she may dial the rest of the number. For example, when an operator reaches a link-type CDO via a step-by-step office after dialing a routing code, she must pause until an idle link at the CDO returns dial tone. This method of operation is an alternative to the newer method employing the *Delay Dialing* and *Stop-Go* signals described below.

(i) *Delay Dialing (Delay Pulsing) Signal:* This is an off-hook signal returned in response to a connect (seizure) signal indicating that the receiving end is not ready for pulsing. When ready the signal changes to on-hook.

(j) *Wink Start Pulsing Signal (Wink):* This signal is a momentary off-hook pulse nominally 1/5 sec. long and 1/7 sec. minimum, transmitted when the receiving end is ready to receive pulsing. Unlike the delay dialing signal, the maximum duration of the wink is well below the minimum off-hook period which could result in premature charging on the call.

(k) *Start Dialing (Start Pulsing) Signal:* This is an on-hook signal which is transmitted when the receiving end is ready to receive pulsing. Originating senders may require either that:

(1) a Delay Dialing or a Wink precedes this signal, or

(2) sufficient time has elapsed after the connect signal to permit detection of a delay dialing signal if it is to be sent.

(l) *Stop Signal:* This is an off-hook signal, which may occur between digits, indicating that the receiving end is not ready to receive further digits.

(m) *Go Signal:* This is an on-hook signal received after a *Stop Signal* to indicate that the received end is prepared to resume pulsing.

(n) *Assignment Signal:* Either momentary line closure without battery and ground or an open is used with panel call indicator or call announcer to indicate that the called end is

ready to receive the digits. When a calling sender seizes a trunk to a manual office using key display call indicator (KDCI), a B operator at that office depresses her assignment key to indicate that she is ready. In all other uses of the assignment signal, such as at manual offices using automatic display call indicator (ADCI), at call announcer positions, at panel sender tandem and at crossbar tandem (CAMA), the signal is sent automatically.

(2) Signals from Calling to Called End

(a) *Keypulsing Signal (KP):* In multifrequency and direct current keypulsing, this is the signal which primes the receiver for the pulsing to follow. In multifrequency pulsing, the keypulsing pulse consists of 1100 and 1700 cycles per second with equal amplitudes. In direct current keypulsing the keypulsing signal is a combination of polarities and current values over two leads to the local sender.

(b) *ST Signal:* In multifrequency pulsing, the combination of 1500 and 1700 cycles tells the distant receiver that all the digits have been sent. In direct current keypulsing, the ST signal tells the local sender that all digits have been sent.

(c) *End of Pulsing Signal:* This signal in panel call indicator pulsing tells the distant end that all the digits have been sent. The signal is a final "heavy positive pulse" of current and is required when (PCI) traffic is completed through a crossbar tandem, a panel sender tandem or a panel office selector tandem. The signal is not necessary for direct trunking but manual offices must be equipped to handle it when there is an office selector tandem in the area.

3.53 *Signaling Polarities:* In loop signaling, the off-hook and on-hook polarities vary among the several systems, and for some situations wiring reversals of tip and ring may be required in the outgoing trunk, in the incoming trunk or at distributing frames.

(C) Control Signaling between Unlike Offices and in Tandem Systems

3.54 In multioffice exchange areas, trunks are frequently required between offices with different types of switching equipment. It is not unusual for step-by-step, panel, No. 1 crossbar and No. 5 crossbar offices to be located within the area of direct or tandem trunking in metropolitan areas. For many situations, operators will be required at the larger dial offices to handle some types of calls, and signaling arrangements must be provided accordingly.

3.55 Considering only the direct trunking problem, the possible ways of transmitting digital information between the different types of offices are illustrated by Fig. 30. This chart is of a general character only, since equipment is not provided at all offices to handle some of the types of signaling indicated, depending on the over-all economies of the situation. Furthermore, no attempt has been made to depict many of the variations and exceptions arising from the numerous types and vintages of equipment.

3.56 *Office Selector Tandem:* The Distant Office Frame or Office Selector Tandem (OST) was an early development for increasing trunking efficiency from panel to manual and panel offices. The system may also be used with crossbar offices since they coordinate fully with the panel system. Selections at the OST were made over the incoming trunk by revertive pulsing. Digital information to the called offices was transmitted over the combination of incoming and outgoing trunk by PCI pulsing and a final heavy positive pulse was used to place the OST equipment in the talking condition with through supervision as indicated in Fig. 31.

3.57 *Panel Sender Tandem:* A later and more elaborate panel tandem system was known as Full Selector Tandem or Panel Sender Tandem which is shown in Fig. 32. Incoming trunks could be either manual straightforward (SF) or tandem-type panel call indicator (TPCI), using seven or eight digits. Outgoing completing trunks could be either revertive pulsing (RP), dial pulsing (DP), panel call indicator trunks (PCI) or call announcer (CA). In all cases, repeated pulsing and supervision were used with resulting increases in signaling ranges.

3.58 *Crossbar Tandem:* The first crossbar tandem system was developed later for tandem switching, primarily in panel — crossbar and step-by-step areas. In the original design shown

ORIGINATING OFFICE	TERMINATING OFFICE				
	STEP BY STEP	PANEL	#1 CROSSBAR	#5 CROSSBAR	MANUAL
STEP-BY-STEP	DP	V DP*	DP	DP	V DP**
PANEL	X	RP	RP	RP (MF*)	PCI
#1 CROSSBAR	X	RP	RP	RP (MF*)	PCI
#5 CROSSBAR	DP	RP	RP MF	MF RP DP	PCI
MANUAL	DP	V	MF DP V	MF DP V	V

LEGEND

DP—DIAL PULSING
DP* — " " - TERMINATING SENDER REQUIRED
DP** — STEP-BY-STEP CALL INDICATOR
RP — REVERTIVE PULSING
MF — MULTI-FREQUENCY PULSING
(MF*) — MF WHEN AUXILIARY SENDERS ARE MADE AVAILABLE AT ORIGINATING OFFICE
PCI — PANEL CALL INDICATOR PULSING
V — VERBAL
X — DP FROM DSA OPERATOR

Fig. 30 — Methods for Transmitting Digital Information Between Offices

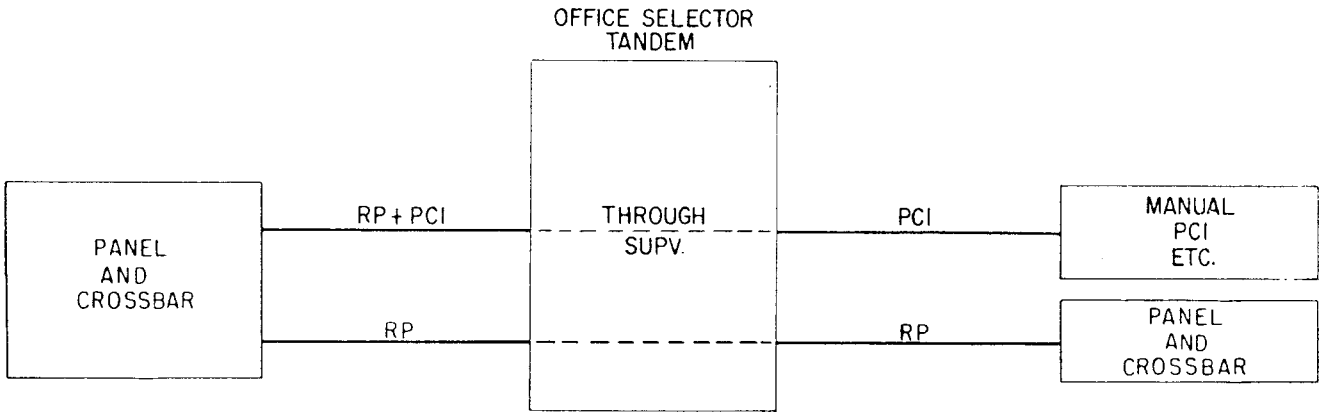


Fig. 31 — Office Selector Tandem

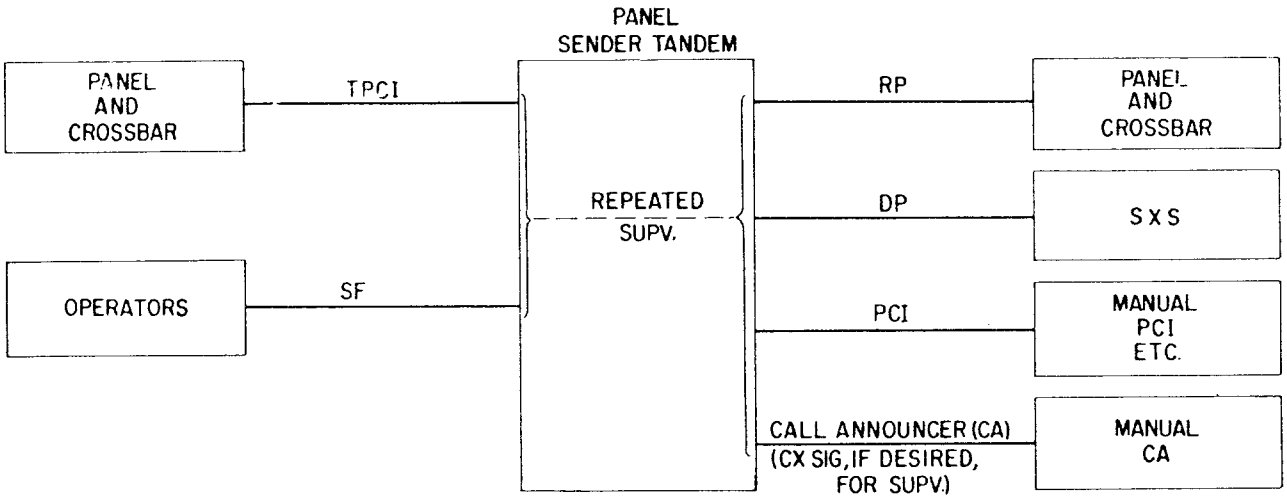


Fig. 32 — Panel Sender Tandem

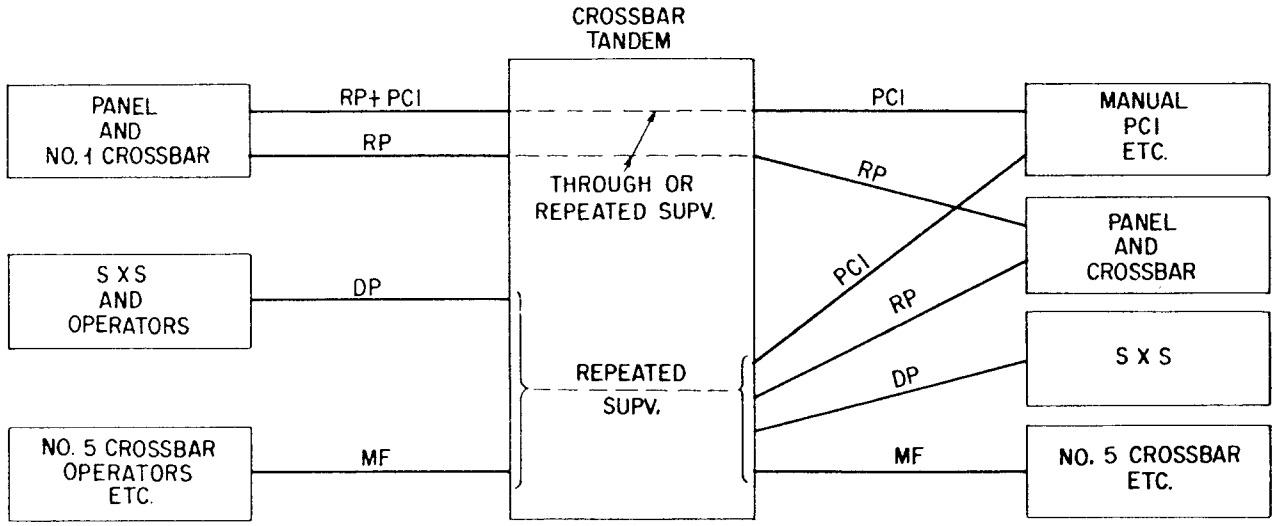


Fig. 33 — Crossbar Tandem

in Fig. 33, senders were available to operate with incoming trunks having revertive (RP) pulsing. They were followed by dial pulsing (DP) senders and later by multifrequency pulsing (MF) senders. Calls incoming from revertive trunks and completed to panel call indicator (PCI) trunks are switched at the tandem office under revertive pulsing office brush and office group control. They are completed at the called office by through PCI pulsing of either the local or tandem type. A final "heavy positive" pulse is used to place the tandem equipment in the talking condition. Calls from (RP) to (RP) trunks are completed with repeated pulsing. Either through or repeated supervision type incoming (RP) trunks may be used for either type of connection. Calls from (DP) or (MF) pulsing trunks and from incoming toll lines are completed to (RP), (PCI), (DP), or (MF) trunks with repeated pulsing and supervision.

3.59 *Zone Registration:* With zone registration in panel or No. 1 crossbar offices, multiunit calls may be billed on a bulk basis. *Remote control zone registration,* illustrated in Fig. 37, is similar except that the timing equipment is located at a crossbar tandem office rather than at each originating office. The use of remote control zone reg-

istration on trunks incoming to a tandem office does not require changes in the type pulsing and supervision previously discussed.

3.60 *Automatic ticketing* is sometimes used at step-by-step offices to record information for either bulk or detailed billing.

3.61 *Automatic Message Accounting (AMA):* This system is installed at crossbar offices and automatically perforates in code on paper tapes information for billing of customer dialed calls. In No. 5 crossbar, the automatic routing and billing may be extended to any number of foreign numbering plan areas.

3.62 *Centralized Automatic Message Accounting (CAMA):* This system provides means for recording billing data from as many as 200 central offices for which the originating traffic at each office does not justify AMA. The equipment is installed at strategically located offices, such as crossbar tandem, each of which serves a large number of central offices as indicated in Fig. 34. The tandem sender, whether associated with (DP), (MF) or (PCI) incoming trunks, sets up a temporary connection, when required for billing purposes, to an operator who verbally requests the number of the calling subscriber and keys it into the sender. A recapture register and translation network is used to convert the digital information to the (MF), (DP), (PCI) or (RP) pulsing code required by the called office. The sender does not complete the forward pulsing until the initial billing information is recorded. By modifying the senders in panel and No. 1 crossbar offices to accept a toll directing code such as 1-1, calls may be dialed into a CAMA equipped crossbar tandem office serving an adjoining numbering plan area.

3.63 *CAMA:* The early CAMA system is suitable for the handling of only a maximum of seven or eight dialed digits. In order to adapt the system to customer and operator dialing on a nationwide scale, an additional three digits must be received from the originating office for foreign area calls. At panel and No. 1 crossbar offices, auxiliary senders with (MF) outpulsing will be used to handle such calls. At CAMA equipped offices, not only crossbar tandem, but also No. 5 crossbar and 4A toll crossbar step-by-step intertoll and (MF) senders or registers will be used to handle up to 11 digits. Outgoing pulsing may be either DP or MF and may vary as successive alternate routes are selected. The transmitted code may have none, three or six digits deleted and none, one, two or three added as well as code conversion when required. The crossbar toll systems, which are equipped with home area and foreign area card translators, provide a somewhat greater degree of routing flexibility than the others.

(D) Signals Used in Charging for Calls

3.64 *Field of Use:* Although signals of this class are primarily used in local loops, they are included in this list of control signals for completeness.

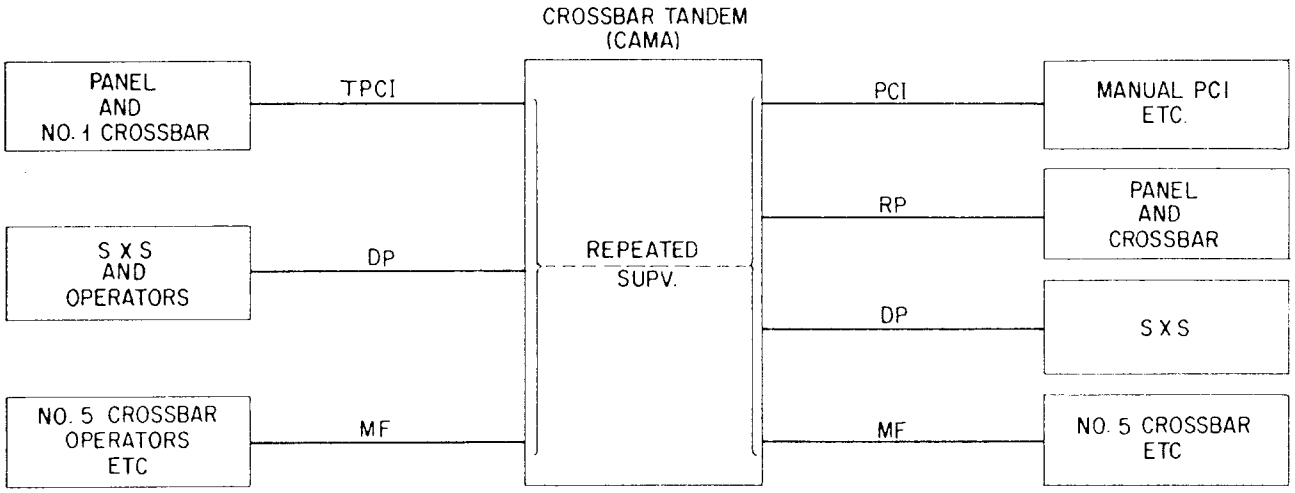


Fig. 34 - Crossbar Tandem (CAMA)

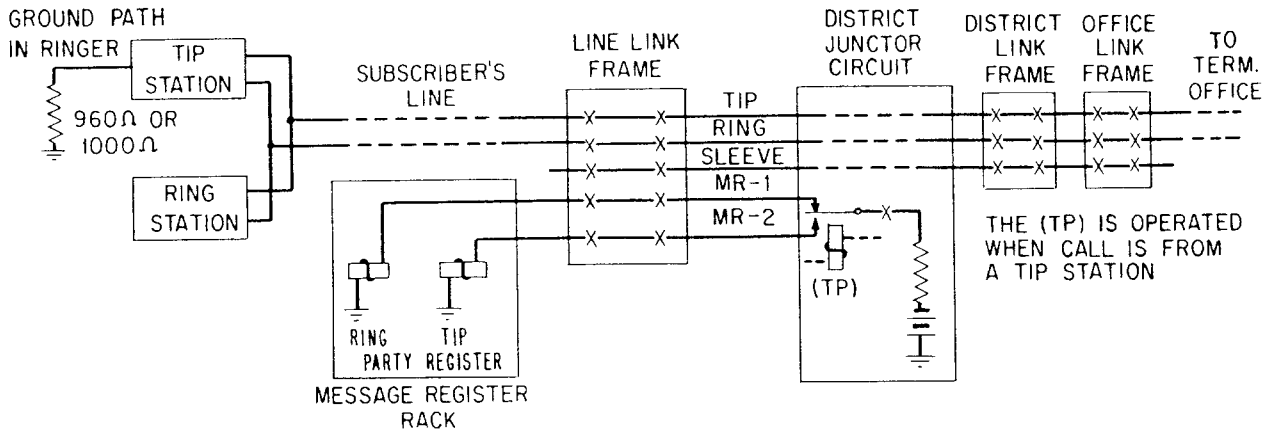


Fig. 35 — Message Register Operation in No. 1 Crossbar System

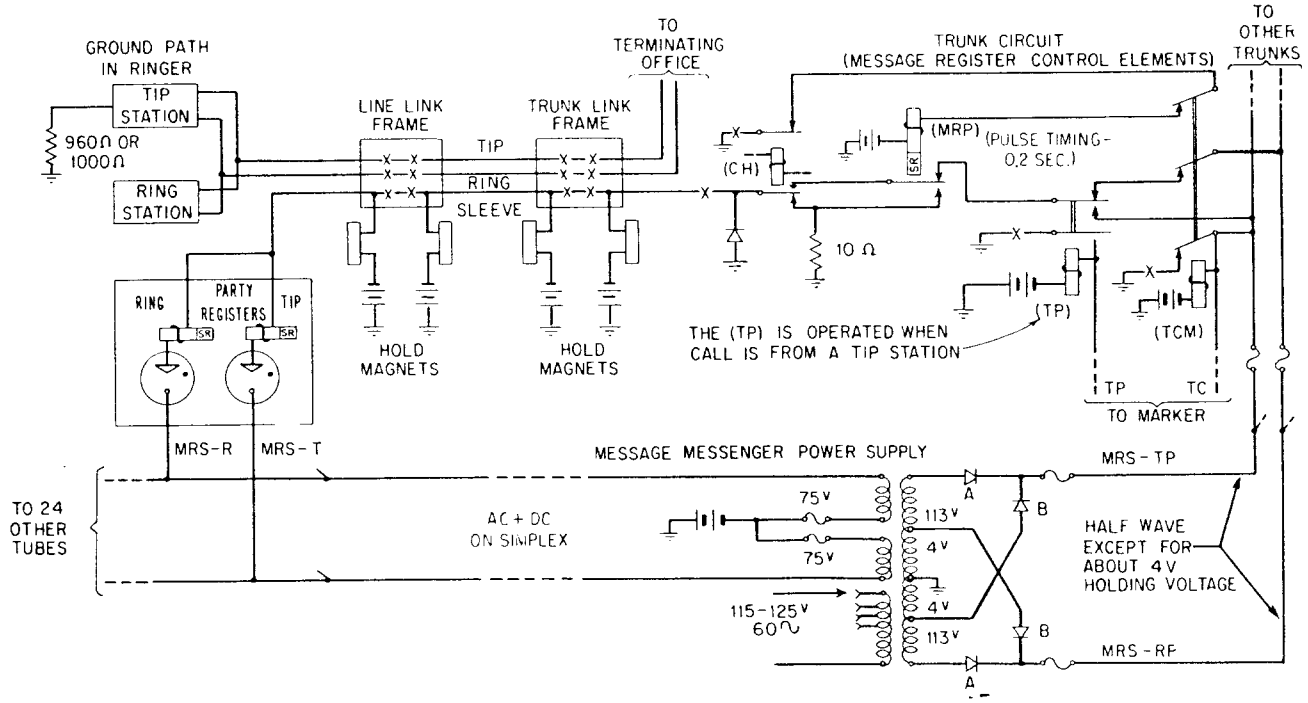


Fig. 36 — Message Register Operating Circuit in the No. 5 Crossbar System

3.65 *Message Register Operation:* Simplified schematics of the arrangements used in No. 1 and No. 5 crossbar for operating message registers on 2-party lines are shown in Figs. 35 and 36, respectively.

3.66 In both systems, a call placed by the tip party of a 2-party line is indicated to the central office equipment by a 960- or 1000-ohm path to ground. In the No. 1 crossbar system, the (TP) relay will then be operated, thus causing the tip register to be operated over the MR-2 lead when the charge is made. For a call from the ring party, the ring register is operated over the MR-1 lead. In the No. 5 crossbar system, either the tip or ring register is operated over the sleeve lead.

3.67 *Remote Control Zone Registration:* Zone registration is a method of making a record for charging purposes of multiunit short haul traffic. The subscriber's message register is operated more than once for the initial time period and once or more for each overtime period. Tim-

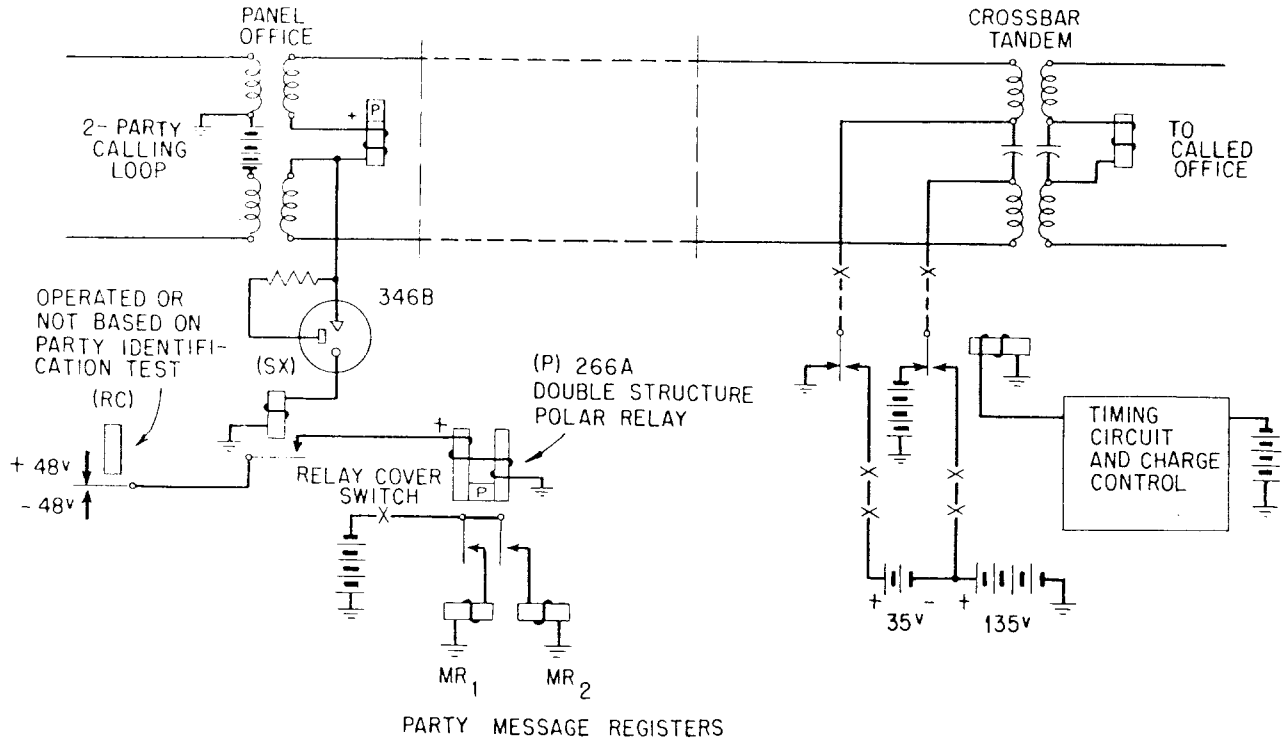


Fig. 37 — Remote Control Zone Registration at a Panel Office

ing is automatic. No arrangements have been made available and none are contemplated for step-by-step or No. 5 crossbar. Fig. 37 shows the arrangement for remote control zone registration at a panel office for a call routed through a crossbar tandem office equipped with the timing circuit. The charging signals are transmitted by simplex operation over the tandem trunk pair which is already carrying an off-hook signal to the calling office.

4. AUDIBLE TONES AND VISUAL SIGNALS

(A) General Features of Information Signals

4.01 Signals in the category of information signals give information regarding the progress or disposition of telephone calls, to either operators or subscribers, hence all signals are either audible or visible. Visual signals such as no circuit, paths busy and line busy signals are sometimes used for operator handled calls. The audible signals must, of course, be easy to interpret and must conform to the transmission system design requirements for signal levels and freedom from interference effects with respect to (1) voice currents, (2) circuit noise or (3) other signaling systems. The transmission of the flashing control signals, whether associated with audible tones or not, is generally a function of the system used for conveying other on-hook and off-hook information. When single-frequency signaling systems are used, additional circuits called tone appliers are needed to resupply the audible portion of the combined signals.

(B) Signal Elements and Their Generation

4.02 The following three basic signal elements are used singly or in combination to produce many information signals:

(1) *High tone* is a current of approximately 500-cycles per second (cps) when obtained from a tone alternator or about 400 cps when supplied by an interrupter.

(2) *Low tone* is a current of about 600 cps modulated by 120 cps when supplied by a tone alternator or by 133 cps when supplied by an interrupter. The modulation frequency gives this tone its low pitched quality from which the name is derived.

(3) *Battery, ground* or *both* may be supplied by the central office signal battery. These signal elements are also supplied with interruptions at standard rates of 30, 60 or 120 per minute (IPM) and sometimes at other interruption rates. To obtain even more unique information signals, different per cent breaks or a series of uneven interruptions are also used or have been in earlier practice.

(C) Typical Information Signals Used in Telephone Service

4.03 The following signals usually have the indicated composition and significance:

(1) *Audible Ringing:* This is a ringing indication, largely 420 cps modulated with 40 cps, which is interpreted by the calling party to mean that the called line has been reached and that ringing has started. It is also used on calls to operators (special service, long distance, intercepting, etc.) during the "awaiting-operator-answer" interval.

(2) *Line Busy:* Low tone interrupted at 60 IPM, 50 per cent break, indicates that the called subscriber's line has been reached, but that it is busy. A customer receives the interrupted tone only, whereas for an operator both tone and flash are provided. When a line busy signal is applied by an operator it is sometimes called a *busy-back tone.*

(3) *Reorder, Paths Busy (All Trunks Busy) (Overflow Tone):* Low tone interrupted at 120 IPM, in all types of offices, indicates that the local switching paths to the office or equipment serving the called subscriber are busy. This signal may indicate a condition such as a timed out sender or unassigned code dialed. It is interpreted by either a subscriber or an operator as a reorder signal. The present standard for nationwide dialing is 60 IPM for line busy (above) and 120 IPM for paths busy, the latter with 0.3 second off-hook (with audible low tone), and 0.2 second on-hook. These interval values are reversed in toll practice. In some older offices, 120 IPM is being used for line busy and 60 IPM for paths busy and in some offices 60 IPM is now used for both signals.

(4) *No Circuit (NC):* For customer dialed calls, 30 IPM interrupted low tone with flashing is being standardized for a no circuit or all toll lines busy signal. The flashing intervals are 0.3 second off-hook and 1.7 second on-hook. Although audible tone may be supplied at the office with the (NC) condition, it may also be reapplied at or near the outgoing office or toll switching center. When the 5A announcement system is used for a verbal report of a no circuit condition on customer dialed calls a flashing signal is not provided. In nationwide dialing the no circuit signal has the same flashing rate as the former overflow signal.

(5) *Permanent Signal Tone:* A customer's line, not in use, which exhibits a steady off-hook condition is routed to a permanent signal trunk. High tone, superimposed on battery, is supplied through a resistance lamp to the ring of the trunk. The tone is used to inform an operator or other employee making a verification test that the line is temporarily out of service. An intermittent ground may also be applied to the ring of the permanent signal trunk to cause the release of key telephone systems left in the hold condition. Typical reasons for the line condition are:

(a) No dialing within the allowed waiting interval,

(b) a handset is off-hook,

(c) low insulation resistance or other line trouble.

In some offices, if three or more digits are dialed, but not a complete telephone number or code, the call is released and dial tone is returned.

(6) *Partial Dial Tone:* High tone is used to notify the calling party that he has not completed dialing within a preallotted time, measured after receipt of dial tone, or that he has not dialed enough digits. This is a signal to hang up and try again. This signal is supplied by tone trunks in No. 5 crossbar offices.

(7) *No-Such-Number Tone:* This signal tells the calling party to hang up, check the called number, and dial again. Two types are used: (1) Low tone, frequency modulated 1 cps, and interrupted every 6 seconds for ½ second. (2) Low tone interrupted every third second. Calls to unassigned or discontinued numbers may also be routed to intercepting operators or preferably to a machine announcement system, such as the 6A or 7A, which verbally supplies the required message.

(8) *Vacant Code Tone:* Low tone interrupted at 60 IPM, 50 per cent break, with each third tone pulse omitted is used in panel and crossbar to indicate that the dialed office code is unassigned. In step-by-step areas, this signal is called *vacant level tone.* Recorded verbal announcements may also be used for this service. For operator originated calls, the verbal announcement is preceded by two flashes. When all the announcement trunks are busy at tandem offices calls are routed to the so-called "cry-baby" tone which is produced by switching the constants of an oscillator circuit.

(9) *Reverting Tone:* The same type of signal as line busy tone is used for reverting tone in all systems. In No. 5 crossbar, a second dial tone is sometimes also used when a calling party identification digit is required. The reverting signal informs the calling subscriber that the called party is on the same line, and that he should hang up while the line is being rung.

(10) *Recorder Warning Tone:* When recording equipment is used a "beep" of 1400 cps tone is connected to the line every 15 seconds for a 0.1 second interval to inform the distant party that the conversation is being recorded. The tone source is located within the recording equipment and cannot be controlled by the party applying the recorder to the line. This tone is required by law, and is recorded along with the speech.

(11) *Deposit Coin Tone:* Low tone, sent from a community dial office (CDO) to a post-pay coin telephone, informs the calling party that the called party has answered and that the coin should be deposited.

(12) *Group Busy Tone:* This audible signal is indicated by low tone on the sleeve of trunk jacks at cord switchboards. Absence of the tone tells operator that there is at least one idle trunk in a group.

(13) *Order Tones (Zip Tones) (Trunk Assignment Tones):* These signals consist of spurts of high tone which are returned to the calling operator over interposition, local, or toll trunks. They are more fully described in Part 3 in connection with auxiliary control signals.

(14) *Coin Denomination Tones and Signal:* At multislot coin telephones, these tones are produced by two gongs as nickels, dimes, and quarters are deposited. They are picked up by a special transmitter in the coin collector and enable the operator to check the amount deposited.

(15) *Coin Return (Test) Tone:* High tone is used to tell an operator in a dial central office that a testman has completed a call to her position over a coin trunk.

(16) *Coin Collect Tone:* Low tone over a coin recording completing trunk, informs the originating toll operator that the local operator or coin control circuit has collected the charge.

(17) *Coin Return Tone:* High tone over a coin recording completing trunk informs the originating toll operator that the local operator or coin control circuit has returned the charge when the connection is not completed.

(18) *Number Checking Tone:* High tone is sometimes used at DSA switchboards in panel, No. 1 crossbar, and some step-by-step areas to verify the verbal identification of the calling line.

(19) *Class-of-Service Tones:* These signals are used at a toll board operating as an "A" board to identify the class of service of the calling subscriber. The indication may be high, low or no tone.

(20) *Intercepting Loop Back Tone:* High tone sent from an intercept operator to the "A" board operator in manual offices indicates that the intercept operator has completed the call and that the "A" operator should disconnect from the circuit. The completion of intercepted calls in this manner is no longer standard practice.

(21) *Vacant Position Tone:* Low tone is applied to all straightforward trunks terminating in a vacated position in manual offices.

(22) *Dial Off-Normal Tone (Dial Key Off Normal):* Low tone is returned to an operator after she has completed a call into a step-by-step office, and after the called party has answered to remind her to restore the dial key.

(23) *Trouble Tone (Plugging-Up Cord Tone):* Low tone applied by an operator or testman at a B position in a manual office to the jack sleeve of a line or trunk in the calling multiple tells other operators the line or trunk is in trouble.

(24) *Warning Tone:* High tone warns an operator that the circuit she is connected to is not in condition for normal operation. Examples: (1) An operator at an automatic display call indicator (ADCI) position plugs into the wrong jack. (2) An operator at a sender monitor position plugs into a sender supervisory jack while the sender is under test.

(25) *Overflow Signal (All Toll Lines Busy):* The use of this signal and the overflow method of operation have been abandoned in favor of the no circuit signal. It was used in manual operation to produce 30 IPM flashes of a calling cord lamp (1.7 sec. lighted, 0.3 sec. dark) to indicate that the desired intertoll group was busy. The operator could then either disconnect or hold. With overflow operation, if a trunk becomes available while holding the signal changes to reorder.

(26) *Master Busy Signal:* The use of this signal has been abandoned in favor of the no circuit signal. When it was used uneven or irregular 60 IPM flashes of a calling cord lamp (1.3 sec. lighted, 0.2 sec. dark, 0.3 sec. lighted, 0.2 sec. dark, repeat) indicated that all trunks and associated overflow trunks in the intertoll group were busy. The operator would then disconnect immediately and try again after a short wait as determined by operating practices.

(27) *Howler Tone:* A tone of 480 cps, graduated in 1/10 sec. steps with successive levels from 0 to 120 dba, is used to inform a subscriber that his receiver is off-hook.

(D) Plant Department Information Signals

4.04 The following information signals are primarily used by telephone employees in connection with construction, installation and maintenance work:

(1) *Dial Test Signal:* These signals are sent from a central office dial test circuit to a testman checking a subscriber's dial speed. The sequence for one circuit design is as follows: A suitable code is dialed and low tone is then returned when the dial test circuit is seized. The testman then dials "0". If the pulsing speed is too fast, low tone with 120 IPM is returned, and if the dial is too slow, low tone with 60 IPM. If the pulsing speed is OK audible ringing is returned.

(2) *Cable Tones:* These are signals of various types which include cable splicers tone (buzzer tone), cable trouble locating tone, and others. They are used in construction and maintenance work and are not ordinarily heard on working lines.

(3) *Transmission Test Tone:* This tone, usually supplied from a 1 milliwatt, 0 dbm, source at 1000 cps is used for transmission testing purposes. Information regarding the transmission losses caused by facilities and equipment is obtained by the use of measuring equipment calibrated in decibels (db), at the receiving point. For other testing purposes, tones of other frequencies and levels and various composite tones including random or white noise are also used.

(E) Information Signals Used for Alarm Purposes

4.05 The typical alarm signals shown in Fig. 38, which are transmitted over a regular talking path, are returned on a call to an alarm checking terminal at a CDO. The no-tone condition is used for a major alarm since it would be effective in case of failure of the tone generating equipment.

Trouble Alarm Condition	Alarm Signal Transmitted After Delay of	Type of Signal
No trouble signal	-	2-ring code
Minor Alarms		
Individual fuses	0 min.	Busy tone
Ringing transfer	1-4 min.	Busy tone
Release magnet	1-4 min.	Busy tone
Permanent signals less than excess number	20-60 min.	1-ring code
Major Alarms		
Main and common fuses	0 min.	No tone
Excessive permanent signals	0 min.	Dial tone
Ringing failure	1-4 min.	No tone
Low or high voltage	1-4 min.	No tone
End cell control	1-4 min.	No tone
Master charge control relays	1-4 min.	No tone
Line finder control blocked	1-4 min.	No tone
Line finder start lead grounded	1-4 min.	No tone

TYPICAL ALARM SIGNALS

Fig. 38