

LOCAL SUBSCRIBER LOOP SIGNALS AND SIGNALING SYSTEMS USED IN MESSAGE TELEPHONE SERVICE

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1. GENERAL

1.01 In providing facilities and equipment for telephone service, it is necessary to consider, not only the technical requirements for the transmission of speech as well as the volume and routing of traffic, but also the limits set by signaling considerations. This practice describes the signals and signaling systems normally encountered in the design and operation of subscriber loop telephone plant. Special emphasis has been placed on signaling nomenclature and on the operating principles of the various signaling systems.

1.02 For application purposes signaling ranges should be obtained from the appropriate Bell System Practices, Key Sheets, Range Charts, Standard Drawings or other approved sources.

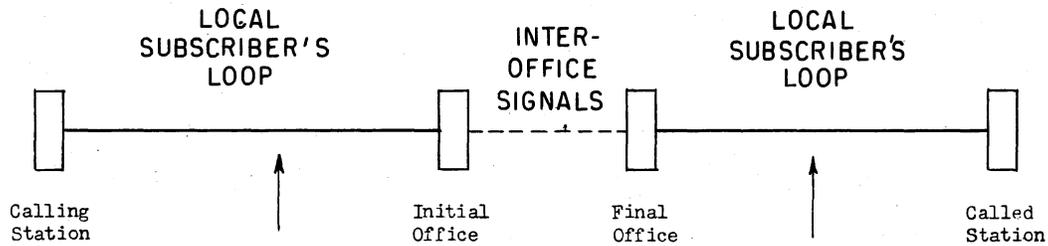
1.03 These practices will be limited in their scope to practical signals, and methods for the transmission thereof, in existing telephone systems or in those under current development. The theoretical aspects of signaling will not be discussed.

1.04 Signaling, as used in telephone systems, embraces both the codes and also the physical means by which certain types of messages are transmitted. The signal codes may consist of pulse groups, either simple or complex. In a typical telephone connection, signals are needed in both the calling and called subscribers' loops and in trunks between the switching centers through which the call may be routed. The electrical signaling power is usually supplied in one of the following forms:

- (1) direct current
- (2) single frequency tone or
- (3) multiple frequency tone.

Signaling may be required in both directions of transmission, sometimes sequentially and sometimes simultaneously. For some purposes, precise signal element timing is necessary, or definite

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Direction	→	←		→	←
Information Signals	Party Identification	Audible Ring			Coin Deposited Signal
	Coin Deposited Signal	Line Busy (Busyback)			Coin Denomination Tones
	Coin Denomination Tones	Paths Busy	<p align="center"><u>Note</u></p> <p align="center">Interoffice signals are covered in Section 987.100.02</p>		Recorder Warning Tone
	Class of Service Tones or Indication	Vacant Code (Vacant Level Tone)			
	Number Checking Tone	No-Such-Number Tone			
	Recorder Warning Tone	Reverting Tone			
		Post Pay Coin Deposit Coin Tone			
		Permanent Signal Tone			
		Machine Announcement			
		Howler			
		Dial Test Tone			
		Transmission Test Tone			
Supervisory Signals	Off Hook	Connection or Hold		Ringling	On Hook
	On Hook	Disconnect		Disconnect	Off Hook
	Flashing (Man or Toll Ser. Only)	Recall			Flashing
Control Signals	Digits (Verbal Request)	Dial Tone ("Number Please")		Collect or return coins	
		Collect or Return Coins			

Fig. 1 — Signals in Local Subscribers' Loops

limits must be met for pulse length, pulse magnitude or pulse form. Signals may be transmitted either within the channel and frequency range used for voice, or by other means.

1.05 In this practice the general features of the three classes of signals — supervisory, control and information — and their application to signaling in customers' loops are discussed.

2. LOCAL SUBSCRIBER LOOP SIGNALS

(A) Types of Signals Transmitted Over Customer Loops

2.01 Fig. 1 is a chart covering the signals normally transmitted and received over customers' loops. There are three classes of local signals:

- (1) Supervisory signals.
- (2) Control signals.
- (3) Information signals.

2.02 *Supervisory signals* are the means by which a customer initiates a request for service, holds or releases a connection or recalls an operator or the equivalent.

2.03 *Control signals* are means for passing information for use in establishing a connection.

2.04 *Information signals* are just what the name implies, that is, they give a telephone user some information. In Fig. 1 and in the following discussion these signals are listed and discussed before the others.

(B) Information Signals in Subscriber Loops

2.05 *Information Tones*: Several types of tone are used to inform customers of the progress of their calls. Familiar examples of such tones are dial tone, line busy and audible ring. In Fig. 1 these tones are listed by direction of transmission in the calling and called subscribers' loops. Although dial tone is shown as a control signal, since it indicates that the equipment is ready to receive dial pulses, it may also be considered to be an information signal. Since information must be conveyed when the receiver is off-hook, voice-frequency signals are used. During off-hook, the bell or other alerting device at the station can not ordinarily be used, since it is in parallel with the transmitter-receiver combina-

tion. A ring in the ear would be objectionable. The information tones (except recording warning tones) are not used on completed connections and do not interfere with the conversation.

(C) Supervisory Signals in Subscriber Loops

(1) General

2.06 The customer must notify the central office that he wants to make a call. To release his line and the central office equipment, it is necessary to notify the central office that the call is completed.

2.07 *Magneto Supervision*: A simple way to perform these supervisory functions is to use a magneto generator at the customer's premises. Cranking the magneto generates 16 to 20 cycles which actuates a "drop" before the operator. When the operator answers, the customer verbally passes the wanted number. After the conversation, he rings again and tells the operator he is through. This simple operating scheme is still used on a few rural lines. The magneto generator develops ample output to provide a long signaling range.

2.08 *Common Battery Supervision*: Today, the local switching systems supervise by the use of dc current over the loop. This is called common battery signaling since the primary source of power is a storage battery located in the central office and common to all lines.

2.09 The number of available leads is a basic restriction upon supervisory schemes. Only two wires are needed for the talking path and, for economic reasons, they are also used for signaling. Effectively, a third conductor can be obtained by using grounded arrangements, however, "earth potentials" and alternating current induction must be considered. Their effect is equivalent to a generator in series with the ground connection. Since the earth potential may have unpredictable variations in magnitude and polarity, grounded circuit arrangements must either have adequate margins to work under adverse conditions or some method must be used to balance out the effects of the earth potential.

2.10 Finally, the design of both metallic and grounded supervisory circuits must consider the effects of leakage resistance between the conductors and from them to ground.

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2.11 At any particular time, the customer's instrument is either on-hook or off-hook. In supervision of the loop, there are four possible situations of interest: (1) resting, (2) calling, (3) talking, and (4) release.

2.12 *Resting* is indicated by the combination of an on-hook signal and the absence in the office of any connection between the line and a talking path.

2.13 *Calling* is indicated by an off-hook signal and absence of connection to a talking path.

2.14 *Talking* is indicated by an off-hook signal and a connection to a talking path.

2.15 *Release* is indicated by an on-hook signal (other than momentary) and connection to a talking path.

2.16 The supervisory signals occur *before* or *after* the conversation.

2.17 To keep the supervisory signals from interfering with the talking currents, it is necessary either to transmit no power over the loop during conversation or else to supply power at a frequency outside of the voice band. Both alternatives are in use in the telephone plant. Voice-frequency signaling arrangements are carefully designed not to interfere with conversation and also so that the talking currents do not cause false signal operation. Also, when low or intermediate frequencies are used for signaling, precautions are taken so that harmonics will not cause intolerable interference during conversation. In the subscriber's loop, the direct current is used for supervision as well as to supply transmitter power.

2.18 When the receiver is lifted, the switch-hook contacts close the loop. This initial closure on tip and ring is a "request for service." In almost all systems, the closure operates a line relay. The operation of the line relay in manual systems alerts an operator who first connects a cord circuit and her telephone set to the line, then announces her readiness to receive the called number. In dial systems the calling line is selected by a line finder or equivalent circuit and connected to either:

- (1) the first of a series of direct controlled selectors in step-by-step systems or

- (2) a sender or register in common control system such as panel or crossbar.

The line relay is disconnected by the operation of a cutoff relay (or by contacts on the line switch in a crossbar office). In the dial system "Dial Tone" is transmitted to advise the calling party that the called telephone number may be dialed. Dial tone is obtained from "low tone" (600 cycles per second modulated with 120 cycles per second) which may be modified in quality by the equipment that couples it to the line. In all cases the direct flow, without interruptions beyond a critical length, maintains the necessary circuit connections.

2.19 When a connection is established, supervision is advanced to another circuit in the connection, such as a cord circuit in manual offices, a selector in panel systems, a connector or repeater in step-by-step systems or a register, junctor, or trunk in crossbar.

2.20 The supervisory relay remains operated while the connection is set up and as long as the call continues. After the connection is established, momentary opens are ignored.

2.21 Replacing the receiver at the end of conversation or abandonment of a call being set up opens the loop, releases the supervisory relay and restores all circuits to normal. Key telephone systems, such as the 1A or 1A1, are arranged so that the control office can release a hold condition if, for example, the customer goes away and leaves a trunk connected after conversation is over. For the hold circuit, such key telephone systems use a direct current bridge path through the winding of a relay in series with a make contact on the relay. When the central office operator or equipment interrupts the battery supply momentarily, the hold releases. In some cases, such as in permanent signal holding trunks, the battery source is intermittently grounded to obtain this type of release. Key equipments, such as the 101A or 101B, have the retard coil type of hold and can not be released in this manner.

(2) Line Relay Requirements

2.22 Because of its function in the over-all signaling picture the line relay has many requirements that must be considered in its design. These requirements cover such things as operate time, impedance and impedance balance, reliability and physical size.

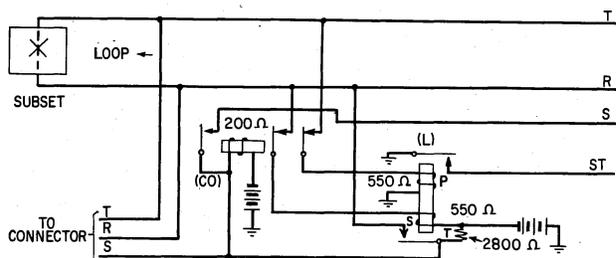


Fig. 2 — Line Circuit in Step-by-Step Office

2.23 Fig. 2 shows a typical line circuit in a step-by-step office. When the circuit is closed through, or on an incoming call, the (CO) relay operates over the sleeve lead and disconnects the (L) relay.

2.24 The crossbar arrangement is somewhat similar except that the cut-off contacts are on the vertical of the line switch, hence, the (CO) relay is not needed.

2.25 Fig. 3 shows a method for the supervision of a connection which has been set up between two customers. Reverse battery supervision is used in the trunk loop. Only the supervisory relays are shown. The features controlled by these relays differ among the classes and types of trunks.

2.26 A path is set up to the called line and held under control of the calling line. When the called line answers, it too is given supervisory control. When either party hangs up, the con-

nection is partially released. Time delays in trunks prevent immediate disconnection of the switching linkages serving the customer hanging up last. These delays eliminate “false starts” (false functioning as though a new call were being originated). The (S1) relay of Fig. 3 is a slow release relay so that short flashes or inadvertent dialing do not release the connection.

(3) Polarities (Idle Line)

2.27 All of the present standard switching systems connect the line relay to supply battery on the ring side of the line. The tip side is usually grounded except for PBX and prepay coin lines.

(4) Types of Talking Battery Supply

2.28 At the central office, two arrangements are commonly used to supply talking battery to the loop:

(1) Fig. 4 shows the bridged impedance arrangement. Battery is supplied to the loop through an (S) relay which in current practice is usually sandwich wound or parallel wound for impedance balance reasons and has high inductance to minimize transmission loss at voice frequencies. The various types of relay winding systems are discussed in Sections AB63.241 and AB63.246.11.

(2) Fig. 5 shows the repeating coil battery supply arrangement. The resistance lamp is used with 48-volt battery supply to protect

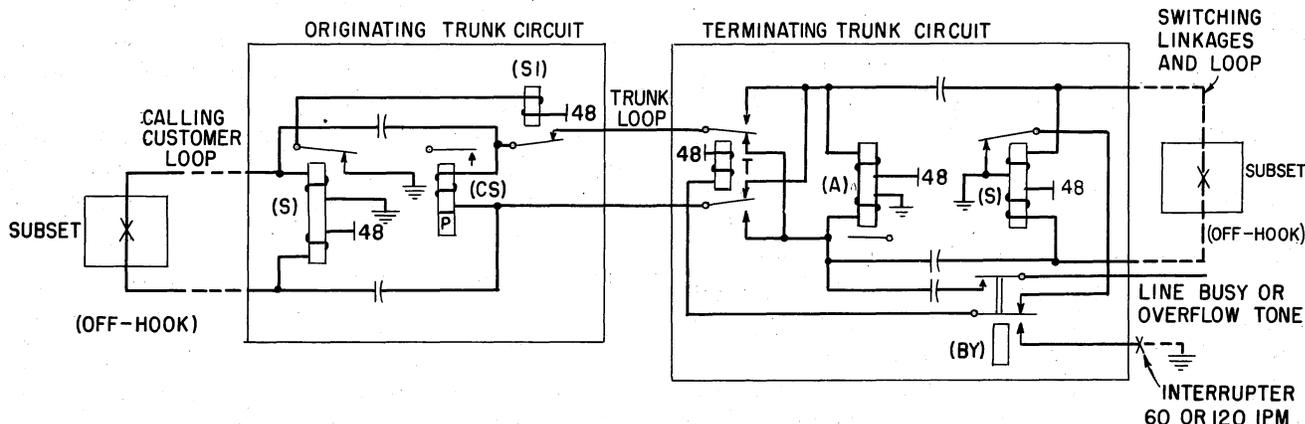


Fig. 3 — Supervision on a Completed Call

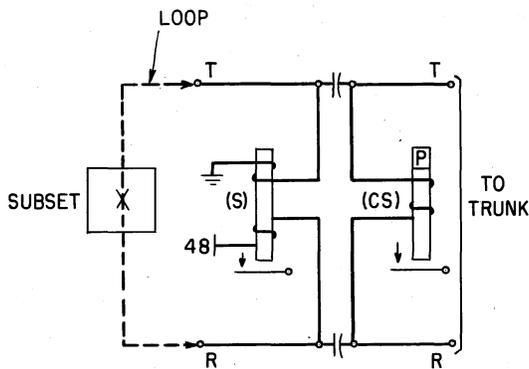


Fig. 4 — Bridged Impedance Battery Supply

the repeating coil from excessive current and saturation on short loops. This arrangement permits unequal ratio impedance matching by the proper selection of coil ratio. Sometimes, by the use of tapped windings, more than one ratio may be obtained with one type of coil.

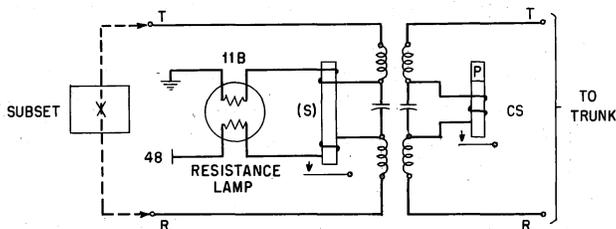


Fig. 5 — Repeating Coil Battery Supply

(5) Polarities (Supervision)

2.29 All systems connect the line supervisory relay to battery on the ring side of the line. The positive side of the talking battery is grounded.

(6) Flashing

2.30 In manual systems, slow opens and closures of the switchhook are used to flash a lamp before the operator to recall her to the connection. Attempts to flash on an outgoing call to a dial central office may cause an unwanted disconnection since, on calls, an open loop for more than the release time of a single slow-release relay will cause disconnection.

(7) Alerting (Ringing)

2.31 When a wanted connection is being established, the called line must be notified that there is an incoming call. This notification, called ringing, is given by an audible or sometimes by a visual signal. Ringing starts when the connection is made to the called line and continues until the called line answers or until the calling line hangs up and releases the connection.

2.32 Types of ringing service are individual, 2- and 4-party full selective, 4- and 8-party semiselective, bridged and divided harmonic ringing, multiparty code ringing, signaling of PBXs, mobile radio signaling and various special arrangements such as those used in railroad dispatch signaling.

(a) Some Requirements for a Ringing System

2.33 Some of the requirements for a ringing system are listed below:

- (1) The alerting device must cause enough "annoyance" to demand attention but not enough to be irritating. The first automatic ringing system invented rang a bell continuously, however, this was found to be too annoying and interrupted machine ringing was substituted and is still used. Interrupted ringing also has the advantage that it saves signaling power.
- (2) When an audible ringing device is used, the important acoustic frequencies are found to be in the 1000- to 2500-cycle band. Many people with impaired hearing do not hear frequencies above 3000 cycles very well. Frequencies lower than about 800 cycles tend to be masked by low-frequency room noise.
- (3) The sound level required depends upon the frequency and time distribution of the energy. The general sound level is not the whole story. A weaker, concentrated, energy peak may override room noise better than more energy spread over a broader band and a longer time interval.

2.34 Since ringing takes place before conversation begins, the ringing power sent over the loop may be either in or out of the voice band.

2.35 Ringing must be possible over all loops. Selective ringing of any one of four parties on the same loop must be possible without alerting any other party.

2.36 When the called party answers, there must be a quick and reliable transfer of circuit arrangements from the ringing to the talking condition. This change is accomplished by a "tripping" circuit of the type which will be described further on.

2.37 The ringing system must not interfere with the transmission of talking currents, dial pulsing signals and supervisory signals. Conversely, the ringing system must tolerate interference from the other signaling systems sharing the loop. For example, on party lines, the ringer must be insensitive to dialing by another party. Cross ring must not occur on multiparty lines.

2.38 Finally, the system must be reliable. Visits to customer premises to service a ringer are expensive and must be held to a minimum. Simple circuits and rugged components are musts. Customer operated ringer-volume controls, available with C-type ringers, are a step in the direction of reduced maintenance.

(b) Terms Used in Ringing Systems

2.39 The following is a list of common terms used in connection with ringing systems:

(1) *Individual Line*: A subscriber line serving only one main station, although additional stations may be connected to the line as extensions. An individual line is not arranged for selective ringing for the extensions on the line.

(2) *Extension*: An additional telephone set bridged across the customer's line which may have the same type of equipment and in general provides the same service as the main station.

(3) *Party Line*: A subscriber line serving more than one main station. Provision is made for selective ringing for the parties on the line.

(4) *Multiparty Line*: A party line arranged to serve more than four main stations. Although 2- and 4-party lines might be considered as multiparty lines, they are arbitrarily excluded from this classification.

(5) *PBX (Private Branch Exchange)*: A switching center located on a subscriber's premises with facilities for connecting together the telephone stations which it serves and for connecting these stations to trunks to a cen-

tral office or, in some cases, for connecting these stations to tie trunks to another PBX.

(6) *Individual Ringing*: The type of ringing ordinarily employed to alert stations on single party lines or PBX operators or PBX stations.

(7) *Selective Ringing (Two or More Parties)*: A party-line ringing system which rings only the bell, or bells of the desired party.

(8) *Semiselective Ringing (Four or More Parties)*: A party-line ringing system which rings the bells of two parties simultaneously. Party differentiation is by means of a one-ring, 2-ring code.

(9) *Multiparty Ringing*: Any ringing system which can ring more than four parties. Two- and 4-party ringing are arbitrarily excluded from this classification.

(10) *Terminal per Station*: A party system in which there appears in the central office a separate set of terminals for each station on the party line. The tip and ring conductors are reversed for part of the terminals to pick the correct side of the line for ringing. Separate directory numbers are assigned for each party. This arrangement offers advantages over the terminal-per-line system in the efficient use of central office name codes and aids also in the provision of full intercepting service.

(11) *Terminal per Line*: A party system in which there appears, at the central office, only one set of terminals for each party line. A final digit or letter of the directory number identifies each party on the line.

(12) *Bridged Ringing*: A term applied to any ringing system in which all the ringers on a line are connected across the line. A capacitor is connected in series with each ringer to avoid shunting dc current.

(13) *Ground Return Ringing (Divided Ringing)*: A ringing system in which ringers may be connected between either or both sides of the line and ground, with a capacitor in series with each ringer.

(14) *Code Ringing*: A ringing system in which the number or duration of rings, or both, indicate which party is being called. Although semiselective ringing is a form of code ringing,

it is excluded from this classification to make the terms distinctive.

(15) *Harmonic, Decimonic, and Anharmonic Ringing*: Ringing systems which obtain selectivity by using a ringer at each station which responds only to a particular frequency.

(16) *Ac-Dc Ringing*: A ringing system utilizing a combination of alternating current and negative direct current, the direct current being provided to facilitate tripping. The alternating current and direct current potentials are nominally 86 volts rms and -48 volts, respectively.

(17) *Superimposed Ringing*: A ringing system utilizing a combination of alternating current and direct current where both positive and negative direct current components are provided, primarily to obtain selectivity. The direct current is reduced to 37 to 40 volts to prevent pretripping with tube sets. (Pretripping means operating the tripping relay before the called party answers.)

(18) *Pulsating Current*: Current of such a wave shape as would appear at the output of a half-wave rectifier operating on a 20 cycles-per-second sine-wave input. It may be either positive or negative and is used for selective ringing of relay sets. Since this current is less suited for ringing individual lines, a sine-wave current with a frequency of 20 cycles per second is used for this purpose. Pulsating current is now used only in older manual offices.

(19) *Tripping Relay*: A relay which is connected in series with the ringing supply and which operates when the called customer answers. It must not operate when the normal ringing voltage is applied to the line plus bridged ringer capacitance but must operate on the direct current which flows when the called party answers.

(20) *Pretrip*: False operation of the tripping relay before the called party answers is called "pretrip."

(21) *Revertive Ringing*: Ringing another party on the same party line as the calling party. Selective or code-type ringing is employed along with other features described in this section.

(22) *Biased Ringer*: A polarized ringer with its armature held against one of the magnetic cores by a biasing spring so that it will respond to pulsating or superimposed current only if of the correct polarity. Current of the opposite polarity will pull in the same direction as the spring, thus keeping the armature at rest against a stop. The purpose of the biasing spring in cases where the ringer receives the full alternating current wave is to prevent bell tapping during dialing.

(23) *Relay-Type Subscriber Set (Relay Set)*: A type of subscriber set employing a relay in the ringing circuit to obtain 4-party selective or 8-party semiselective ringing.

(24) *Tube-Type Subscriber Set (Tube Set)*: A type of subscriber set employing a cold cathode electron tube in the ringing circuit to obtain 4-party selective or 8-party semiselective ringing. Normally used for inductive coordination situations.

(25) *Vibrating Reed Selector*: A switch containing one (as in voice-frequency controlled ringing) or more (four in new mobile radio signaling) contacts in series, each of which is operated by a tuned reed. The reeds are actuated simultaneously by currents of one frequency for each reed which flow through a common coil.

(c) Operation of Ringing Systems

2.40 The calling device is a polarized bell rung by alternating current of nominal 20 cycles (actually about $19\frac{1}{3}$ cycles). The system has a very long range because of the high power which can be used with little interference into other loops which may be carrying conversations.

(1) Individual Lines

2.41 On individual lines, the ringer is bridged across the line in series with a capacitor.

2.42 Fig. 6 shows a schematic of the 500D telephone set with a bridged ringer. The inductance of the ringer is high so the shunt transmission loss is small in the voice-frequency band. The series capacitor prevents flow of direct current through the ringer coils. The capacitor value is chosen to resonate with the ringer inductance at about the ringing frequency. The

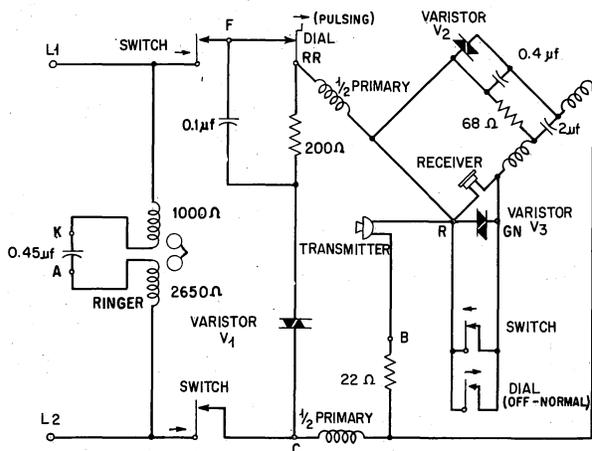


Fig. 6 — Schematic of 500D Telephone Set

resonance increases the ac current through the ringer coils and improves the ringing efficiency.

(2) Party and Multiparty Lines

2.43 Bridged Ringers (Metallic Connection):

The arrangement shown in Fig. 7 may be used on multiparty lines to provide code ringing or for simultaneous ringing on private lines.

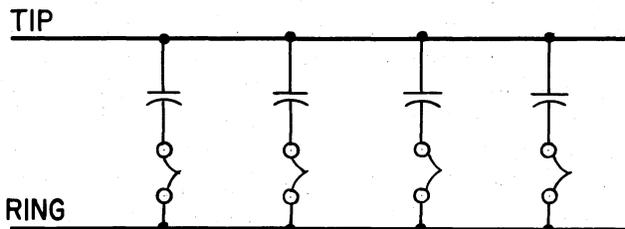


Fig. 7 — Bridged Ringers

2.44 Grounded Ringers: With grounded ringers some of the ringers are connected between tip and ground and some between ring and ground. Alternating current is applied between one side of the line and ground to obtain 2-party selectivity. For 4-party semiselectivity, as shown in Fig. 8, a one-ring, 2-ring code is used. Multiparty divided code ringing is accomplished by the use of codes also.

2.45 Four-Party Selective Ringing: The first commercial selective ringing system for 4-party magneto lines employed two oppositely

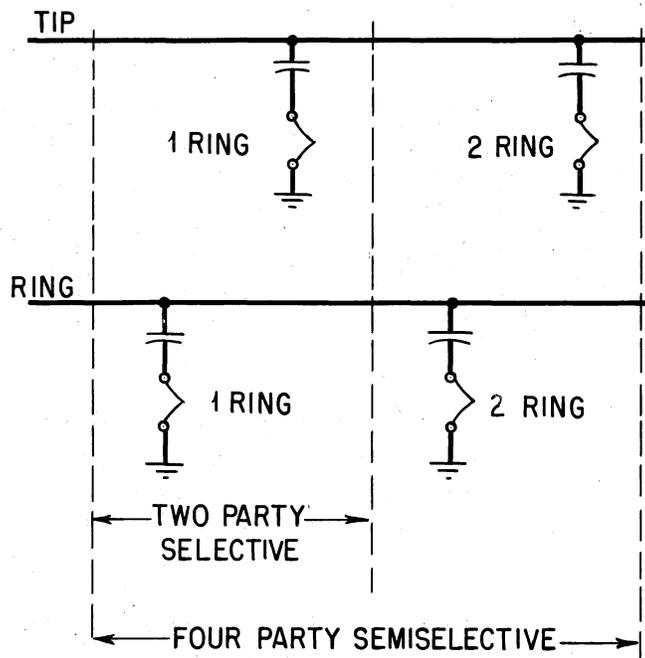


Fig. 8 — Grounded Ringers

biased ringers connected directly from each side of the line to ground without a series capacitor. Ringing bias was obtained by spring tension on the ringer armatures. Ringing was accomplished by applying the correct polarity pulsating current between one side of the line and ground. When used on common battery lines, a resistance of perhaps 48,000 ohms was placed across a capacitor in series with each ringer to permit polarized ringing but to prevent operation of the line relay.

2.46 Four-Party Selective and 8-Party Semiselective Ringing with Relay Sets: This system operates without a direct current path between each side of the line and ground. The system employs a relay, a capacitor and a biased ringer at each station as shown in Fig. 9. When four additional subscriber sets, connected like the first four, are added to a 4-party selective line and a 2-code ringing signal is used, 8-party semiselective ringing results. It is necessary, however, to use high impedance ringers and relays to satisfy the tripping relay requirements.

2.47 Pulsating ringing current of the proper polarity is applied across the line with one side grounded. All four relays operate and connect their respective ringers to ground. The two ringers on the grounded side of the line re-

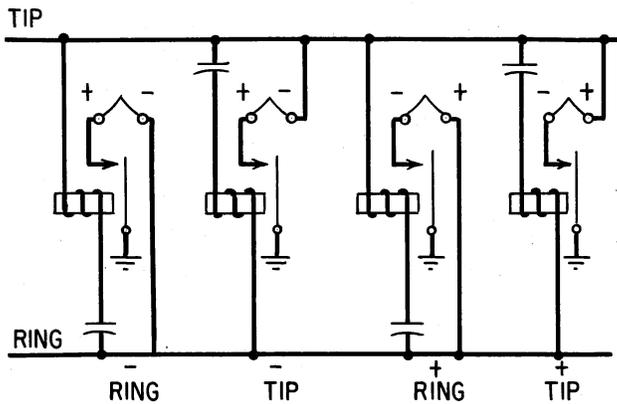


Fig. 9 — Four-Party Selective Ringing With Relay Sets

ceive little, if any, ringing current. The other two ringers accept ringing current, but only one of the two receives current of the proper polarity to ring it.

2.48 Superimposed Ringing: Superimposed ringing uses both alternating current and direct current components and may be used for both individual and 4-party selective sets. This current combination replaced the use of pulsating current for party lines. In individual and 2-party service, a series capacitor blocked the direct current. With superimposed current, the ringers have greater bias margins than with pulsating current. For party lines where high direct current ground potential is experienced, an inverted circuit is used, as shown in Fig. 10.

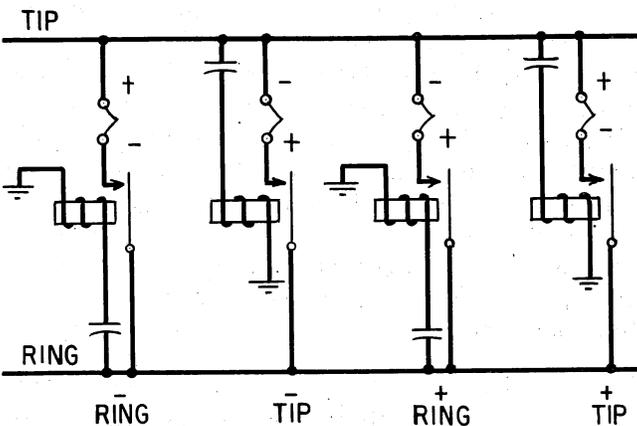


Fig. 10 — Inverted Four-Party Selective Ringing With Relay Sets

2.49 Three-Element Tube Sets for 4-Party Selective and 8-Party Semiselective Ringing:

A later and improved method of obtaining 4-party selective and 8-party semiselective ringing with lower maintenance and first cost uses cold cathode gas triodes as shown in Fig. 11.

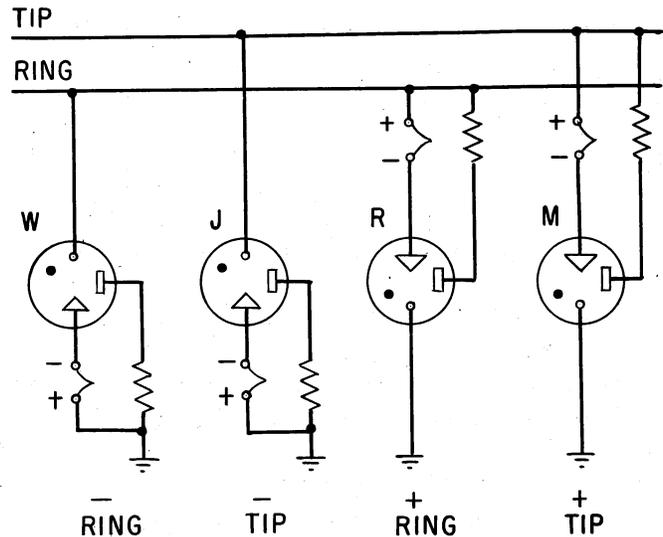


Fig. 11 — Four-Party Selective Ringing With Three-Element Tube Sets

2.50 Application: Three-element tube sets may be used on the same lines as relay sets and operate with the same ringing supply. They are not adaptable on a standard basis to 2-party dial stations because of the tip party identification feature. Their application, from an inductive coordination point of view, is covered in Section AB63.238. The ringing range limitations for various conditions are covered in Section AA460.100.

2.51 Four-Element Tube Sets: Where such high induced voltages are present that they might break down the starter gaps in 3-element tubes during conversation and cause sputtering, 4-element tubes are used. These tubes will not fire with less than about 200 volts between the line and ground. The starter gap is connected across tip and ring through resistors as shown in Fig. 12 rather than from line to ground.

2.52 In some cases, inductive interference on magneto and divided code ringing lines has been reduced by the use of 2-element tubes, such as the Vincent Rare Gas Relay, without providing a superimposed ringing current supply.

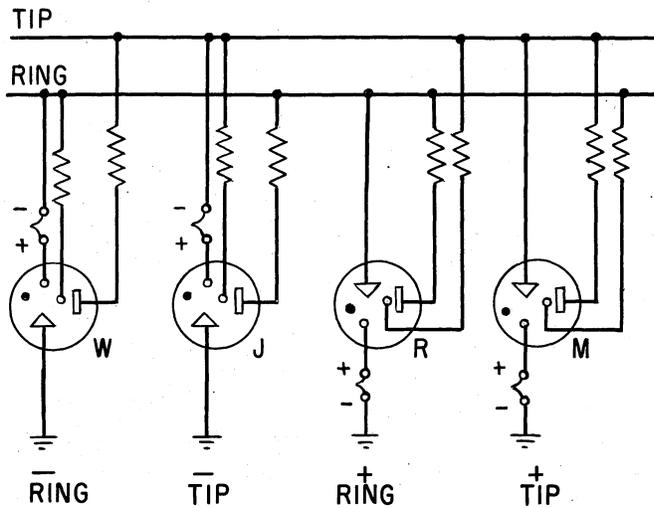


Fig. 12 — Four-Party Selective Ringing With Four-Element Tube Sets

2.53 Harmonic Ringing: Selective service may be obtained by the use of mechanically tuned ringers, each responding to a different frequency. However, this system has several disadvantages. The station sets are not interchangeable

and the generators are complicated as well as costly. The ringing frequency limits are rather narrow and, since current flows through all the ringers (in the bridged connection), the ringing current is high. This system is not generally used by the Bell System. Harmonic ringers, however, are manufactured by the Western Electric Company and sold to independents and sometimes to Associated Companies.

2.54 Tone Ringer: A ringer using frequencies in the voice range has been tried out experimentally and may be used in the future.

(3) PBX and Secretarial Board Ringing

2.55 Many subscriber loops are used as trunks between central offices and PBXs or special operators' positions at which visual signals are used. On an incoming call, a lamp is lighted from the local battery supply when interrupted ringing current is received from the central office. Fig. 13 illustrates one type of PBX signaling system.

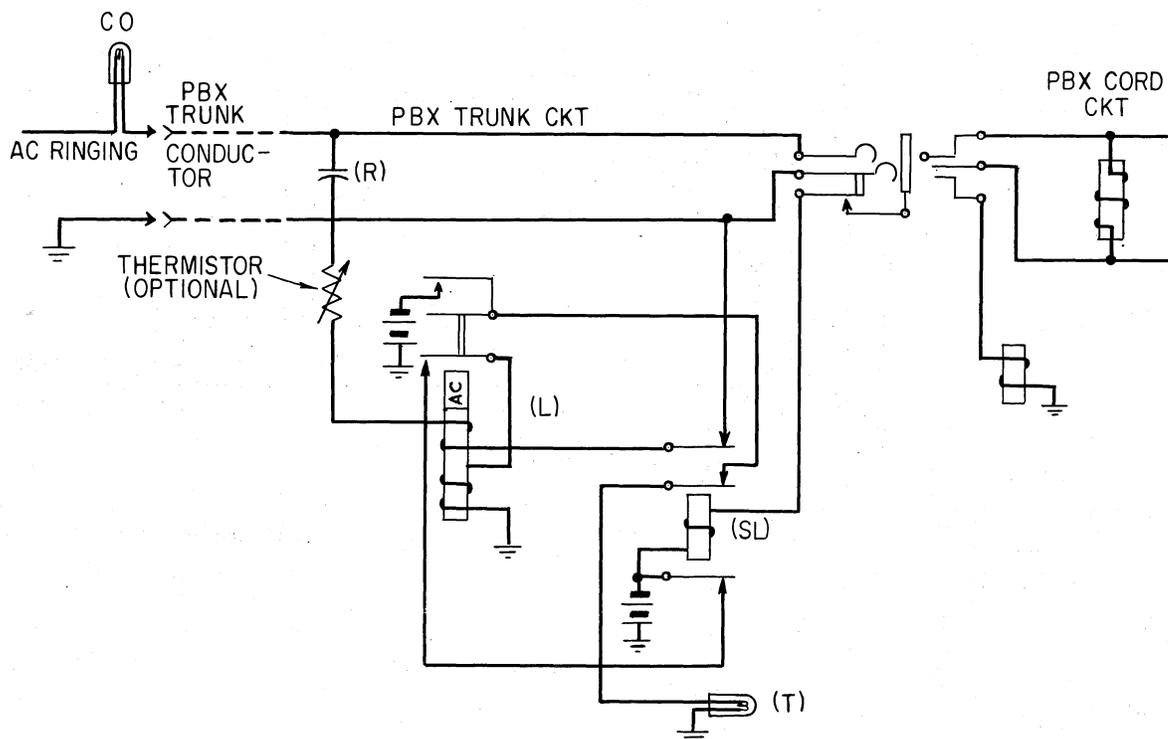


Fig. 13 — PBX Trunk Signaling

(d) Ringing Current Generation, Connection and Tripping

2.56 Ringing Machine: Fig. 14 is a simplified schematic of a ringing machine with ringing and tripping circuits applied to an individual line in a step-by-step office. For other types of offices the details vary but the operation is basically the same.

2.57 The commutator ring on the ringing machine which supplies ringing current to the line is divided into two segments which correspond, respectively, to a ringing interval of about 2 seconds, followed by a silent interval of 4 seconds. During both ringing and silent intervals, direct current is supplied from the battery, while alternating current is also supplied during the ringing interval. For semiselective and code ringing systems, interrupters of various types are provided to give the codes.

2.58 Ringing is accomplished by operation of relay (K) in a connector circuit which takes place after the final digit of the desired number has been dialed. Alternating current then

flows from the interrupter, through the P winding of the tripping relay (F) through one set of contacts to the ring side of the line, through the station ringer and back to ground over the tip. It should be noted that, in the newer step-by-step offices, the tripping relay is being located in the ground return side of the line and the ringing current is supplied through either a 13D resistance lamp or a 220-ohm resistor.

2.59 Audible Ringing: The small capacitor across the contacts of the tripping relay allows the audible components of the ringing current to flow back to the calling subscriber during ringing, thus indicating to him that ringing is taking place.

2.60 Tripping: When the called party answers the ringing must be stopped and the circuit arranged for talking. A "tripping" relay, the (F) relay of Fig. 14, does this. As ordinarily used, the tripping relay is in series with the interrupted ringing supply to the loop. When the switchhook contacts are closed upon answering, dc current flows through the P winding and operates the make-first contact which closes a tripping

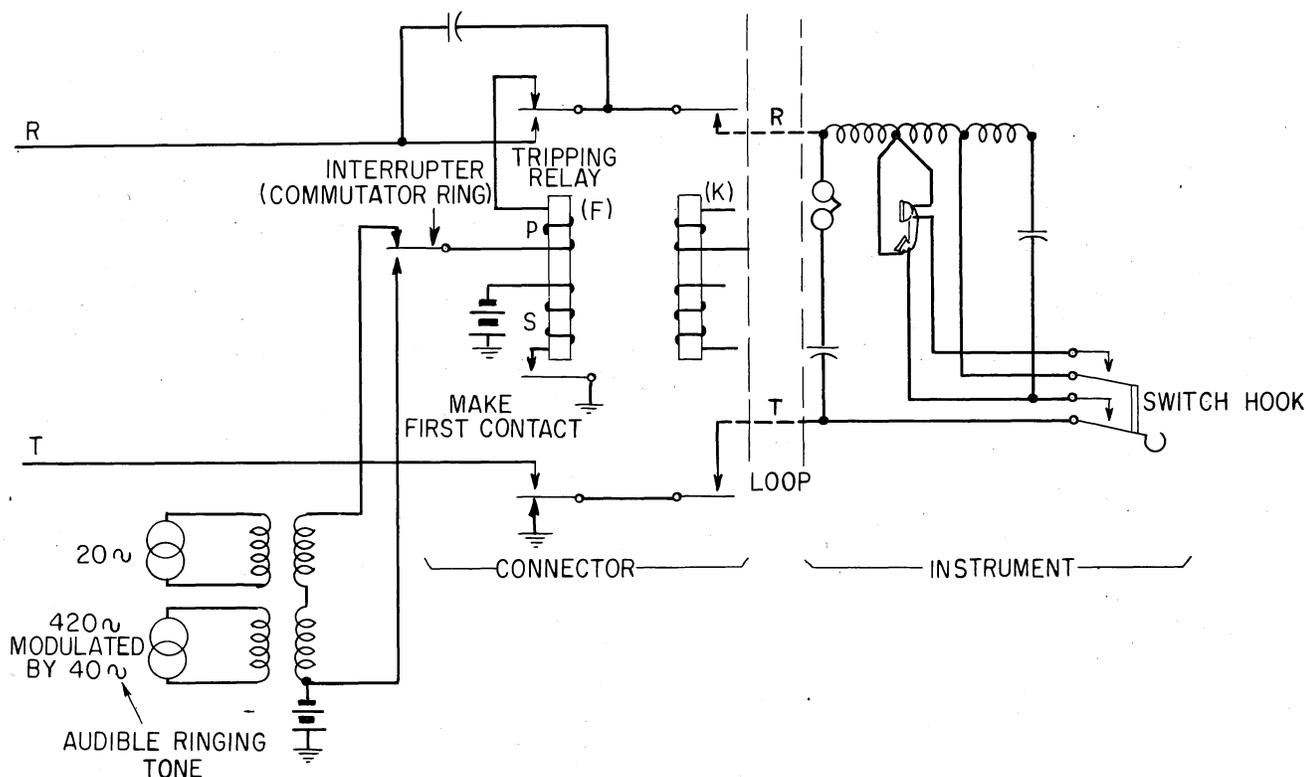


Fig. 14 — Ringing in a Step-by-Step Office

lockup circuit through the S winding and battery. A copper sleeve is used to make the tripping relay quite insensitive to alternating current and also slow operate. The remaining two contacts of the (F) relay are used to place the line in the talking condition. The hold and release features of the connector circuit are not shown in Fig. 14.

2.61 In most cases, ac ringing current is applied for 2 seconds and direct current for 4 seconds, so that tripping occurs even if the called party answers during the silent interval. When the direct current component is 48 volts (ac-dc ringing), the margins for operating the tripping relays are greater during the ringing interval than during the silent interval.

(e) Generation of Ringing Codes

2.62 At each central office, equipment is provided to generate the various codes needed both for signaling and for automatic operation of office equipment. The ringing generator either drives a shaft with interrupters on it, which provide all the needed codes, or else it drives a shaft with a single interrupter, which supplies 120 interruptions per minute. The 120 interruptions per minute are used to step relay interrupter circuits, which provide the codes. Although some types of offices can provide additional types of ringing service, all can provide individual, 2-party selective and 4-party semiselective.

2.63 *Ringling in the No. 5 Crossbar Telephone System:* In a No. 5 crossbar office, for example, 10-party divided code ringing is available in addition to the individual and party-line types. The ringing codes and their applications are shown in Fig. 15. As indicated, a number of signals other than those for ringing are produced for control purposes.

2.46 The ringing signals are 20 cycles per second alternating current (84 to 88 volts) superimposed on positive or negative direct current (37 to 40 volts or sometimes 45 to 50 volts in offices where no 4-party full selective or 8-party semiselective service is provided). Since code 1 generator is the one most frequently used, three separate brushes provide it at different times of the ringing cycle to distribute the load on the ringing machine. Approximately one-third of the circuits requiring this code are assigned to each brush.

2.65 For revertive ringing in 2-party selective, 4-party semiselective or 10-party divided code ringing, where there is no polarity distinction, the customer dials the directory number, obtains a busy tone from a reverting call trunk and hangs up. If the called party is on the *same side* of the line as the calling party, the ringers on the calling and called side will ring with the called party code and the ringers on the other side of the line will receive the reverting ring (RR). If the called party is on the *opposite side* of the line, the called side ringers ring with the called code and the reverting ring rings the calling side. In both cases the called customer answers his code and the calling party picks up his receiver when ringing ceases.

2.66 For 4-party selective or 8-party semiselective revertive ringing, where there is polarity distinction, the calling customer, (1) dials the directory number, (2) gets a steady high tone, (3) dials a station digit which identifies himself, (4) receives a busy tone, and (5) hangs up. If both stations are on the *same side* of the line with the *same polarity*, code 1 ground or code 2 ground is used to operate relays which transmit the correct polarity ringing current of the called station code to both parties. If the two parties are on the *same side* of the line but of *opposite polarity*, code 1 ground or code 2 ground operates relays which transfer ringing current of the called customer's polarity and code to the two stations of that polarity on that side of the line for the first 3 seconds. Code A ground then switches the ringing supply to the calling station ringing condition and code B ground or code C ground will operate relays to transfer current of the calling customer's polarity and code to the two stations of that polarity on his side of the line. When code A is removed, the circuit will return to the called station ringing condition. If the two parties are on *opposite sides* of the line, current of the called station's polarity and code is sent over his side of the line by code 1 ground or 2 ground and operates the two ringers of that polarity for the first 3 seconds of the ringing cycle. The A code will switch the conditions to the calling subscriber and the two stations of the correct polarity on his side of the line will receive the calling customer's ring from code B ground or C ground. In all the above cases, the called customer

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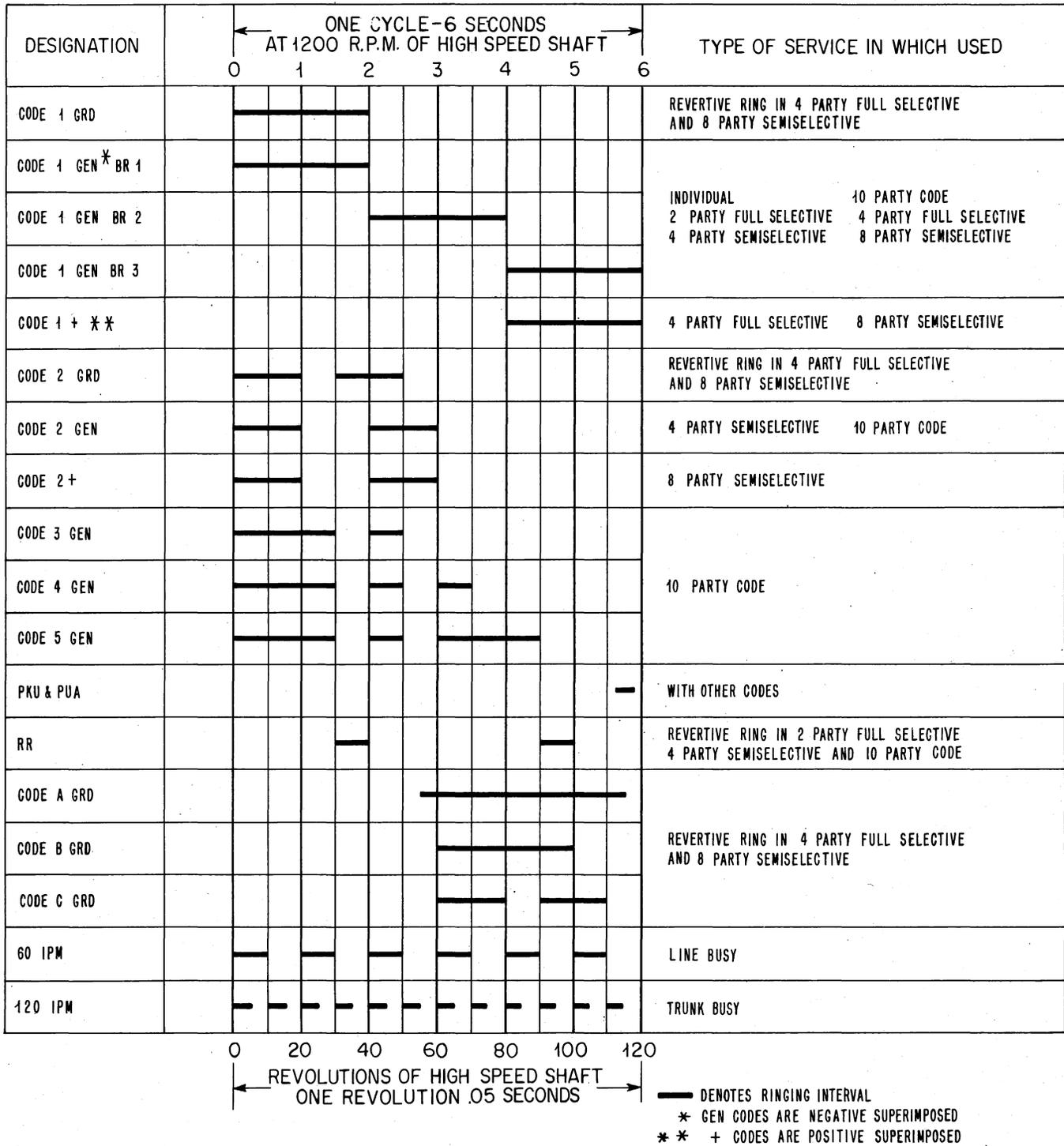


Fig. 15 — Ringing in No. 5 Crossbar

answers his code and the calling customer removes his receiver from the hook when ringing ceases.

2.67 The PKU (pickup) code is provided to insure that codes sent over the lines will start at the beginning of the ringing cycle to avoid confusion with other codes.

2.68 *Party Ringing in Panel and No. 1 Crossbar:* In panel and No. 1 crossbar offices 10-party divided code ringing and more recently 8-party semiselective or 4-party selective ringing may also be provided. Connection of the proper ringing code is accomplished by means of auxiliary line circuits and a common ringing interrupter circuit which converts available pulses into the code 1 and code 2 ringing signals. Revertive calls are made by dialing special reverting telephone numbers which divert the call to special reverting call trunks and also identify the party designation of both the calling and called party.

(D) Control Signals in Subscriber Loops

(1) Means for Passing the Wanted Number

2.69 The calling customer must have a means by which to transmit the wanted telephone number to the switching system. This information is passed before conversation starts and so there need be no conflict with the talking currents. It is necessary to identify any one of more than 50,000,000 stations. At least eight decimal digits and actually ten or more are required when practical routing codes are used.

2.70 A customer served by a *manual central office* requests the wanted number verbally. The information is transmitted over the loop to the central office by voice. Each digit is expressed by a different word and the office name (if needed) and the called number digits are spoken sequentially.

2.71 For a *dial central office* combinations using multiple leads, frequency coding or time sequence are possible for communicating the wanted number, however, only a few are economically practicable.

2.72 In the scheme now used, the pulsing contacts on a dial opens the loop and interrupts the flow of direct current supplied from the central office. The number of interruptions cor-

responds to the number dialed: once for one, twice for two, etc, up to ten times for zero. Between digits, the loop is closed for a somewhat longer period than the momentary closures between the pulses of a train. The longer interdigital interval enables the central office equipment to recognize the end of a digit. Although office names are expressed as letters in the directory listing, the familiar dial finger hole markings translate the dialed letters to the equivalent digits.

(2) Multiple Use of Dc Signals

2.73 Note the multiple use of direct current signals over the loop. The initial closure is a "request for service" supervisory signal. Subsequent short opens (dial pulses) are control signals. Closure following a pulse train is a control signal for the switching equipment. A long open at any time releases the connection. In addition, voice transmission is obtained by means of amplitude modulation of the dc current.

2.74 The subset information generating equipment and the central office equipment are parts of a unified whole. Today, dials are universally used as the pulse generators. Such equipment as extension ringers, PBXs, etc, and the cable pair or other loop facilities may distort the dial pulses in different ways.

2.75 At the central office, the simplest switching scheme uses the dial pulse information from the subset directly to control the devices that set up the wanted switching paths. The widely used step-by-step system uses directly controlled switches. To do this, a number of requirements must be met: If there is any discrepancy between needs of the devices in the switching network and the supplied information, the latter must be corrected. Correction usually takes added equipment.

2.76 In common control switching systems, such as panel and crossbar, the information from the subset does not control the switches directly. Instead, as the information is generated, it is received at the central office and stored temporarily. The stored information is then used to set up a suitable talking path. Perhaps it is changed in form before it is used. Much greater flexibility in central office design and interoffice trunking is gained at the expense of added equipment.

SECTION 987.100.01

(3) Dial Speeds and Per Cent Break

2.77 Trains of dial pulses are described for switching purposes in terms of pulse repetition rate and per cent break. Per cent break is the ratio of the duration of a single open loop interval to the sum of an open and a closed interval.

2.78 Nominal values for the 5-type dial in the older 302-type sets are 8 to 11 pulses per second and 59.5 to 67.5 per cent break. Individual pulse variation increases the range of the effective instantaneous speed to 7.5 to 12 pulses per second. In the 302-type set an off-normal contact shunts all the transmission elements during dialing.

2.79 The 500-type sets use an improved 7-type dial and the 6-type dial replaces the 5 type. The average speed is 10 pulses per second with limits of 9 and 11. During dialing, the transmitter, induction coil and a current equalizer are in series with the pulsing contact; in 500-type sets (all vintages) an off-normal contact shunts the receiver but not other transmission elements. Some earlier sets omit the equalizer. The standard per cent break is 60 to 64 per cent but the limits for the earlier sets were 58 to 62 per cent.

2.80 Step-by-step imposes more stringent pulsing requirements on the dial than either panel or crossbar. Certain functions such as end-of-digit recognition, terminal hunting, and cut through, which require up to about 0.6 second, must be performed within the interdigital time. The speed of operation of the switches used in this system is limited to a maximum of 12 pulses per second with limits of 44 to 72 per cent break.

(4) Station and Line Conditions

2.81 In general the conductor resistance of loops may normally vary from short to long loops with wide resistance range (including 200 ohms for the subset), the leak resistance from 10,000 ohm upward, and the ringing bridge from virtually 0-to-2 microfarad capacitance. The virtually 0 capacitance effect occurs when a bridge is connected from tip to ground on a 2-party selective line with the ring party not installed. Fig. 16 represents both the 302-type set conditions, with the transmitters and induction coil shorted when the dial is off normal, and the 500-type set conditions, with only the receiver

shorted and the remaining transmission apparatus in the circuit during pulsing.

2.82 Fig. 17 shows the conditions presented by a line with both main and extension station served by a manual PBX. The maximum total ringing bridge capacitance may not exceed one microfarad but, when the line is connected to the PBX trunk for dialing through to the central office, the PBX cord circuit puts an added 2 microfarad ringing bridge (rering signal) on the line. The maximum bridged capacitance is greater than for direct loops.

2.83 Fig. 18 shows a typical dialing arrangement normally furnished for PBX attendants. In panel and crossbar areas, the pulsing rate may be either 10 or 20 pulses per second. When the dial is normal, an inductive holding bridge is connected across the loop. To minimize the shunt transmission loss, this bridge is high impedance. When the dial is moved off normal, the holding bridge and the operator's telephone circuit are short-circuited. When the dial returns to normal, the short circuit is removed and a substantial transient is generated by the insertion of the inductor in the direct current path. Central office equipment is designed to prevent this transient from causing incorrect interpretation of the dialed digits. During dialing, there is no ringing bridge on the PBX operator's dial circuit or trunk. Specific information on PBX loop ranges will be found in such sources as the appropriate Key Sheets and Range Charts.

2.84 *Dial Pulsing Characteristics:* The conventional dial signal is the result of an impedance change, first an open, then a closure of the dial contacts. When the contacts open, the ringing bridge capacitors charge up, and a current transient results with a path which includes the central office battery. Leak resistance adds a direct current component to accentuate the effect. When the contacts close, the ringing bridge capacitors discharge through the dial contacts. Since the charging and discharging transients traverse different paths, the make and break components of a pulse are not symmetrical when they reach the central office. To compensate as nearly as possible for the dissymmetry, the dial signal is biased by making the per cent break greater than 50 per cent.

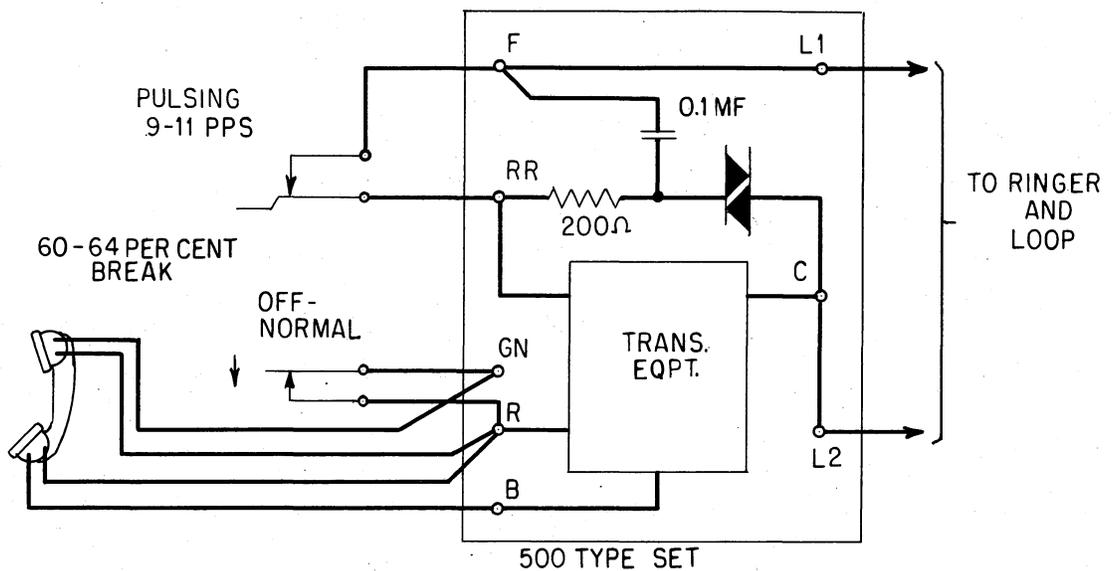
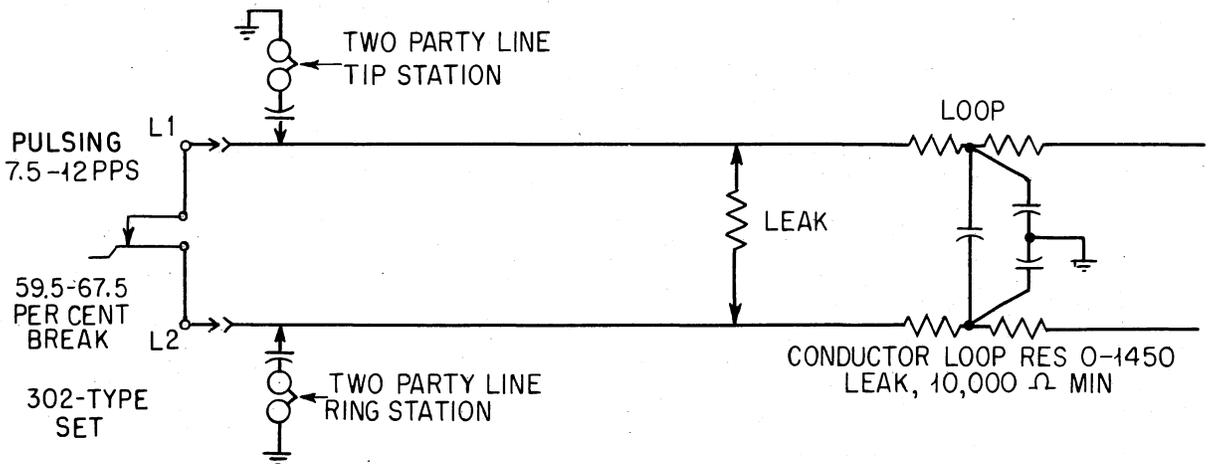
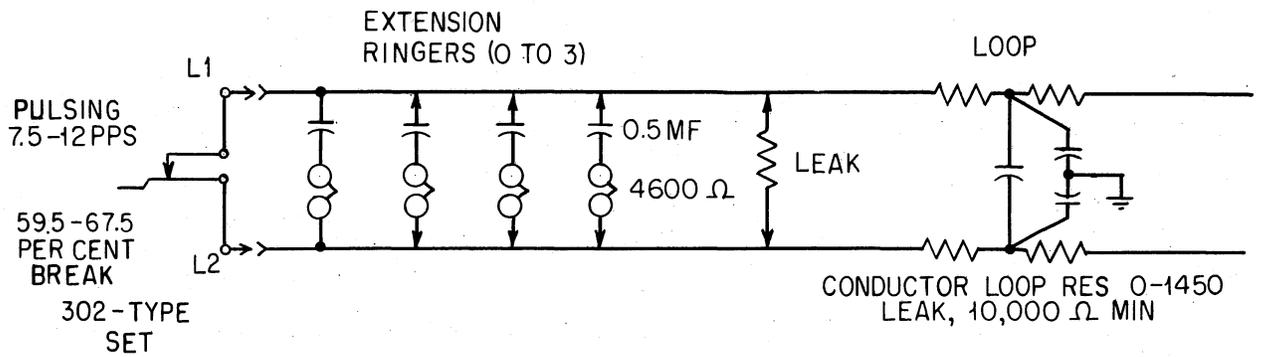


Fig. 16 — Loop Dialing Conditions — 302- and 500-Type Sets

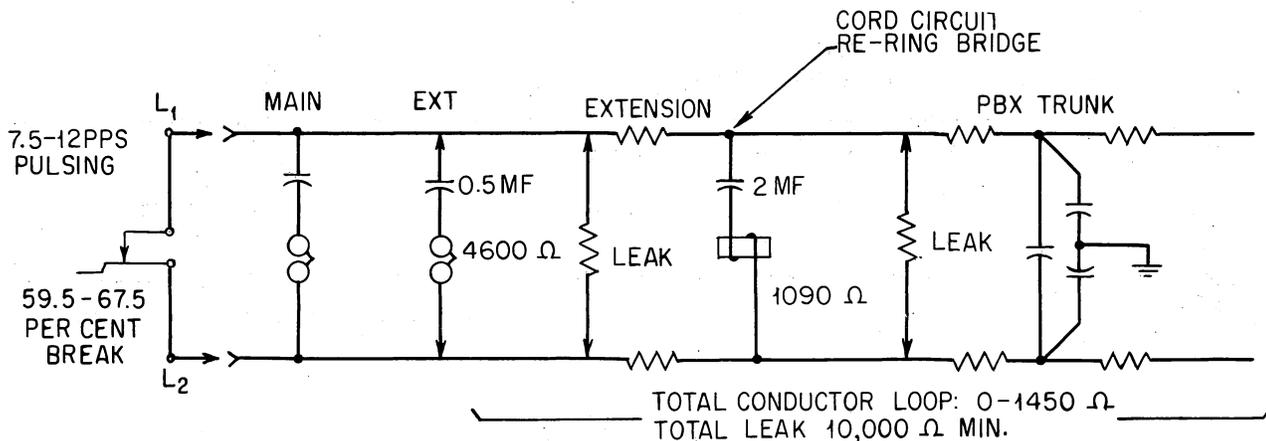


Fig. 17 — Loop Dialing Conditions — PBX Extension

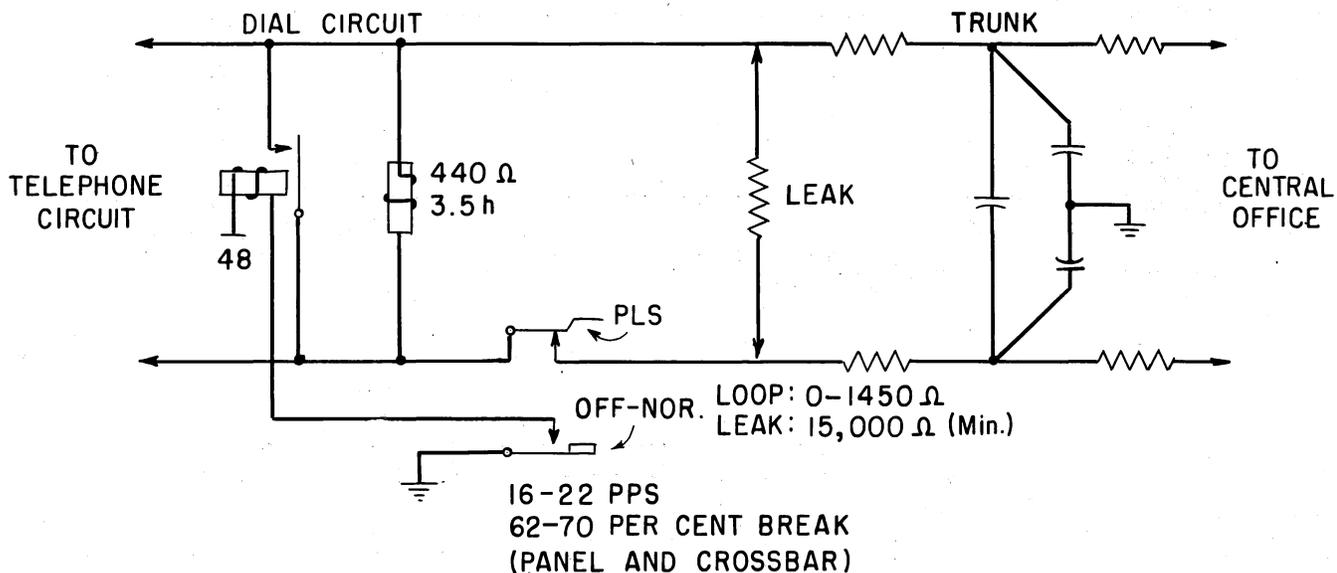


Fig. 18 — Loop Dialing Conditions — PBX Attendant

2.85 Pulsing Limits: The limiting station and line conditions which the central office equipment must meet are:

- (1) Minimum loop, maximum leak, maximum bridged capacitance, usually called the leak condition. The break transient at the beginning of a pulse effectively shortens the open period of the dial pulse, thus reducing the per cent break.
- (2) Maximum loop, zero leakage and minimum bridged capacitance, usually called the loop condition. This combination tends to shorten the make period after the dial pulse, thus increasing the per cent break.

(5) Central Office Conditions: Step-by-Step

2.86 Fig. 19 illustrates how dialing operates a step-by-step switch. The (A) relay operates over the loop through the dial contacts. The slow release (B) relay operates from the make contact of the (A) relay and remains operated while (A) relay releases momentarily during each pulse. During a pulse, when the back contacts of the (A) relay close, the slow release (C) relay operates in series with the switch's vertical magnet (VM). The (C) relay holds over the interval between pulses and releases during the longer interval between digits to allow the switch to cut through to the next switch of the train. The ver-

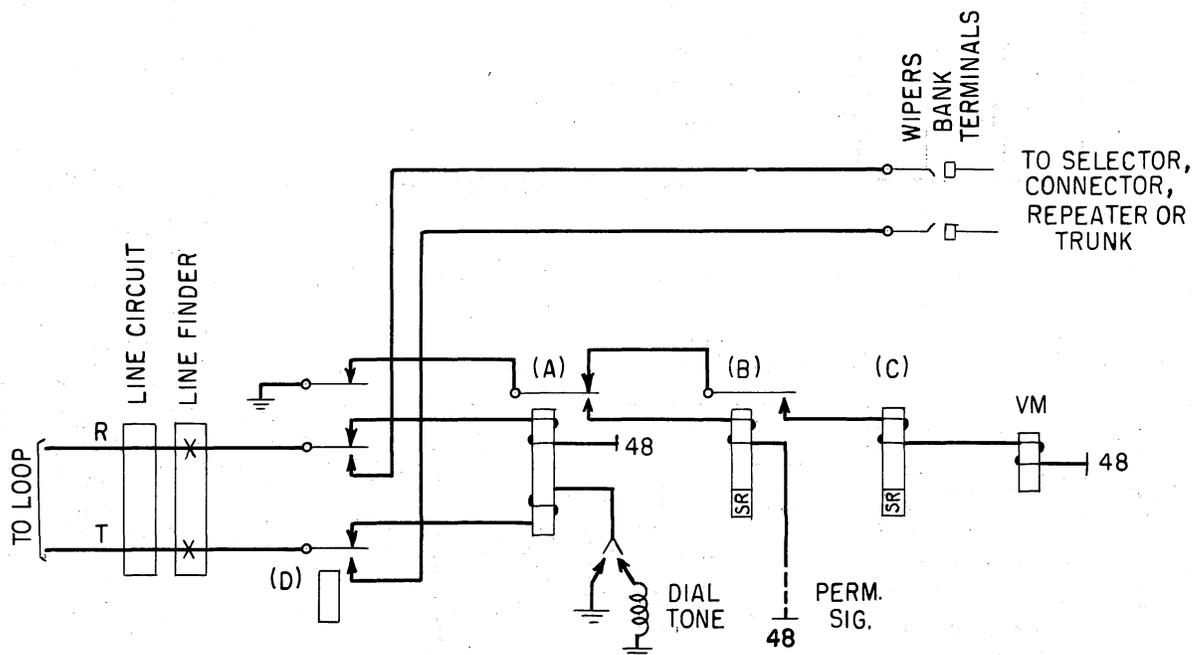


Fig. 19 — Part of Selector Circuit — Step-by-Step Office

tical magnet (VM) operates in series with (C) relay each time the (A) relay releases. This magnet raises the switch mechanism vertically and must remain operated long enough to latch for each pulse.

2.87 More time is required for the operations during the dial break than for those during make. Also, as previously mentioned, the break transient on the limiting leak condition causes a delay in the release of (A) relay. A high per cent break, in excess of 50 per cent, permits the switch to follow a faster dial than would be possible without this bias.

(6) Central Office Conditions: Panel and Crossbar

2.88 Fig. 20 is a simplified schematic of the dialing circuit used in crossbar and later panel offices.

2.89 The (L) relay responds to the dial pulses and converts the open intervals into ground pulses. It must: (1) Repeat the dial pulses with as little distortion as possible and (2) not unbalance the line so much that noise or crosstalk become objectionable.

2.90 Loop balance is achieved by making approximately equal the alternating current impedance to ground of both sides of the impedance terminating the loop. This is complicated by the fact that dial tone must be connected to the loop when the circuit is prepared to receive pulses. Five methods are illustrated in Fig. 21. The single line winding arrangement simplifies the handling of coin and 2-party message rate calls.

2.91 (L) Relay Operation: Because of: (1) Pulse distortion by the loop, and (2) variations in the operate and release times of the (L) relay, the pulse length and the intervals between pulses delivered by the (L) relay have a wider range than the original dial pulses. To maintain (L) relay pulse limits within satisfactory margins for correct circuit operation puts close requirements upon the dial pulsing rate and per cent break.

2.92 As indicated in Fig. 20 a 3-winding polar (L) relay is used in No. 5 crossbar to meet the divergent conditions. Current through a bias winding causes release. A good release-operate current ratio results. Its low inductance gives a fast response. Also, it can be adjusted to operate

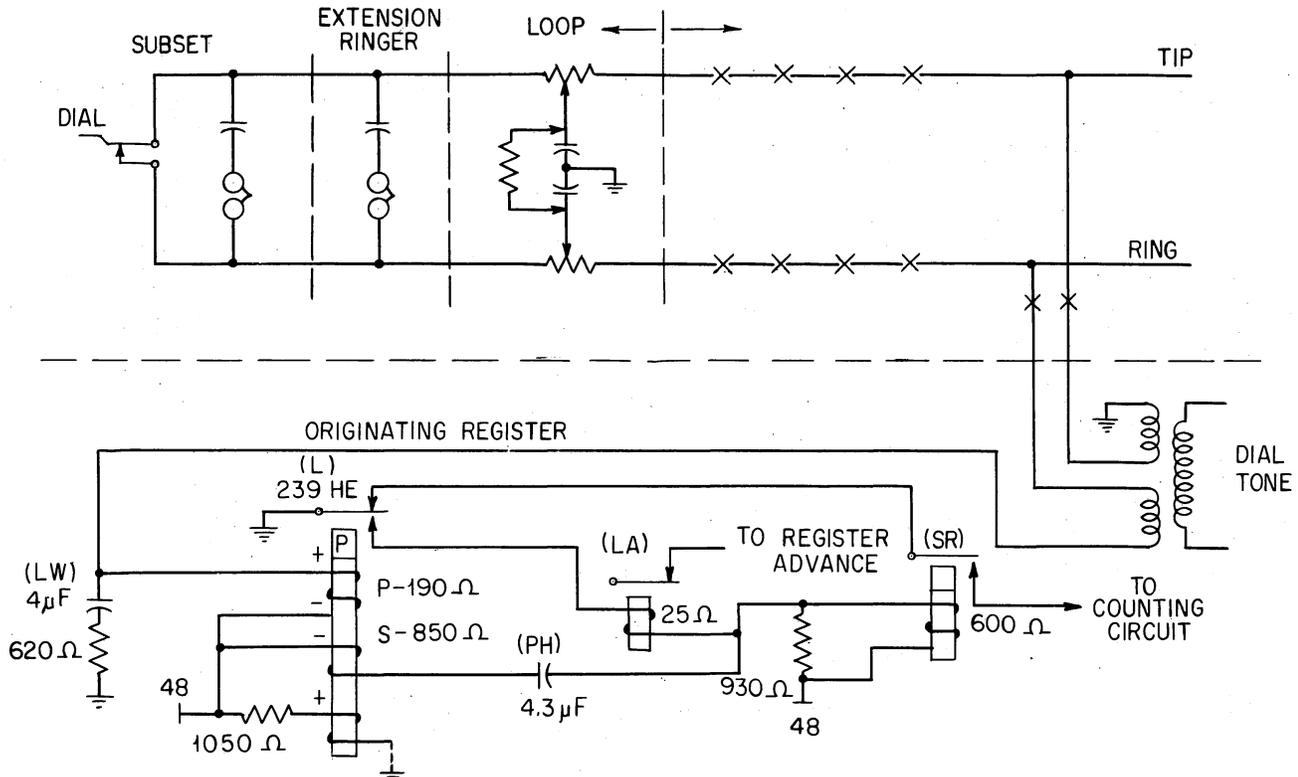


Fig. 20 — Dial Pulsing — Crossbar and Panel

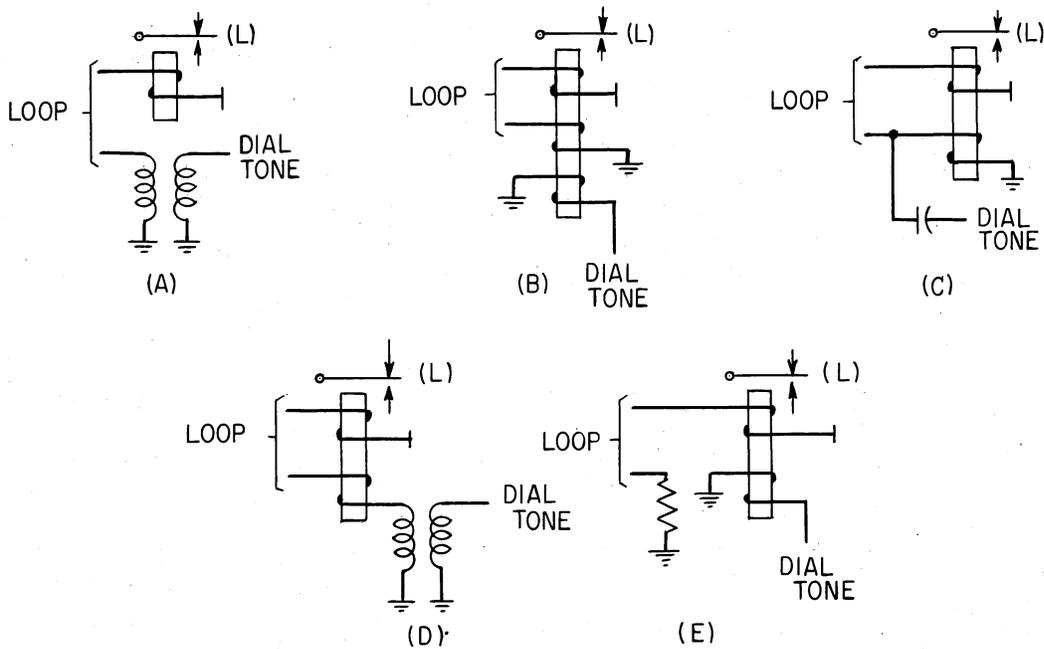


Fig. 21 — Various (L) Relay Arrangements

in either direction on very few ampere turns. There is also some self-compensation against battery voltage variation since the same battery is connected to both the operating and bias windings.

(7) Coin Collection and Return

2.93 Tone signals from a coin box inform the operator of the denomination of the coins deposited and a confirming signal shows the presence of coins. The familiar 5-, 10- and 25-cent tinkles and bongs are sent in the voice band. The operator hears them and thereby checks the amount deposited.

2.94 The coin-deposited signal, in prepay service, is a ground on one side of the loop. It is removed when the coins are collected or returned.

2.95 Prior to the No. 5 crossbar system, all coin boxes except SXS requested service by a "ground-start" signal. A coin in the box grounded one side of the loop as a seizure signal. This arrangement was used to get a simple coin control. The line relay served as a check that a coin has been deposited and the ground permitted the use of the conductors in parallel under some conditions for collection and return.

2.96 In the SXS System and the No. 5 crossbar, "loop start" was initially adopted so that a universal line relay would serve for coin and non-

coin lines. The originating register made a coin test. The introduction of a 10-cent charge for local calls required either a coin detecting circuit in every trunk or the use of the ground start. The latter was adopted.

2.97 Fig. 22 shows an arrangement for manual coin collection and return.

2.98 The present-day coin box requires considerable power to collect and return coins. The signals must be sent from the central office and must not conflict with the direct current talking power. To operate the coin box, direct current voltage to ground is used, one polarity for collect and the other for return. To maintain the loop balance to ground sufficiently to avoid intolerable crosstalk and foreign voltage interference, the coin box magnet must be high impedance.

2.99 To clear coins from the hopper, the control voltage must be on for at least one-half second, otherwise a heavy deposit of many coins may not be collected or refunded properly.

2.100 Coins may need to be disposed of while the customer is on the line. Precautions are taken so that high voltage transients will not cause discomfort to the listener.

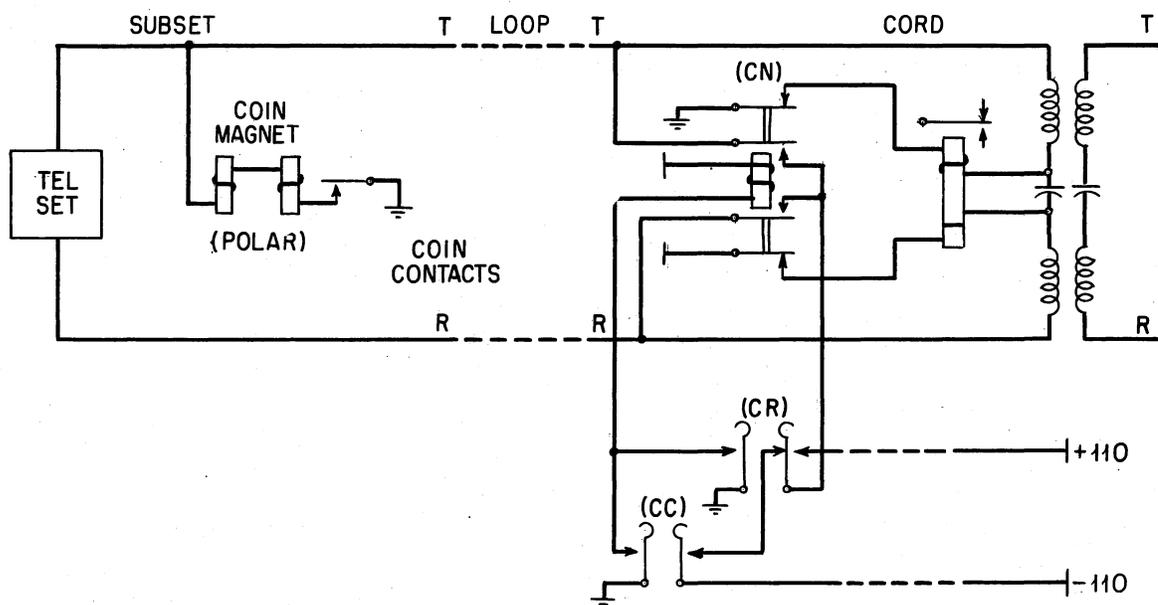


Fig. 22 — Coin Collection and Return

2.101 Where conditions require a sensitive, low-resistance relay is provided in series with the coin magnet which, when it operates, multiplies the tip and ring conductors and thus reduces the total resistance in the control path, especially when collection or return is made after the customer hangs up and the loop would otherwise be open at the switchboard contacts.

(E) Ranges and Working Limits in Subscriber Loop Signaling

2.102 Published ranges and working limits must be based on a very low probability of failure after taking into account the expected ranges of variation in equipment and its adjustment, battery voltages, earth potential differences, power induction and types of customer usage.

2.103 Because the ranges vary with the different types of offices the proper limits should be obtained from the practices and key sheets.

(F) Signaling with Subscriber Line Carrier

2.104 The P1 subscriber carrier system provides up to four carrier channels on a single pair of open wire leads in addition to the voice-frequency channel. On each of the carrier channels, ringing is obtained by means of modulated voice-frequency tones. For 4-party selective and 8-party semiselective ringing, three tones of 2500, 1750, and 1150 cycles per second are used. For divided code ringing only the 2500- and 1750-cycle tones are used. Private line or code ringing requires only the 2500-cycle tone which is the

Ringing in P1 Carrier System							
Called Party	C.O. Ringing Signal				P1 Carrier Signal		
	Tip		Ring		2500 cps 20 pps Spurts	1750 cps	1150 cps
	85V AC	DC Bias	85V AC	DC Bias			
Note 1							
T+	20cps	+40V			X	X	X
T-	20cps	-40V			X	X	
R+			20cps	+40V	X		X
R-			20cps	-40V	X		
T	20cps	-48V*			X	X	
R			20cps	-48V*	X		
All			20cps	-48V*	X		
* Tripping Battery							
Note 1: For 8-party semi-selective or divided code service, either Code 1 or Code 2 ringing is used.							

Fig. 23

basic ringing signal and is applied in spurts at a rate of 20 pulses per second. The encoding scheme is indicated in Fig. 23.

2.105 At the central office end the signaling tones are generated at each carrier terminal by transistor-type oscillators, are coded in accordance with the applied ringing signal and the selected type of network, and are then applied to the carrier system channel.

2.106 At the remote terminal of each carrier channel the tones are decoded, amplified and detected. The direct current output is converted to conventional ringing current by a network in which mercury-type relays are used to modulate a 22.5-volt direct current power supply.

2.107 In the opposite direction, supervision and dial pulsing are obtained by interruption of the channel carrier. During on-hook intervals the power to the oscillator-modulator at the remote terminal is cut off by means of a suitable network.

2.108 Additional information on the P1 subscriber carrier system will be found in Section AB25.250.0.

(G) Mobile Radio Signaling

2.109 The system used for mobile radio signaling sends 600- and 1500-cycle pulses alternately when the operator dials. Each time the tone frequency changes, a code wheel in the mobile station steps one position. Five trains of pulses are transmitted with a total of 23 to 26 pulses. If the proper number of pulses is received in each train, the code wheel steps to the final position and the bell rings. If the wrong number of pulses is received in any train, the code wheel drops back to its starting position and the final position is never reached. Before a ringing code is transmitted, a single pulse is sent which resets all selectors to their starting position. A few other applications of this type of system are in private telephone networks, as well as coastal harbor and plant order wires for maintenance purposes.

2.110 The system provides 7800 codes and the mobile equipment is fairly expensive and physically large.