Ringing Schemes 945-804

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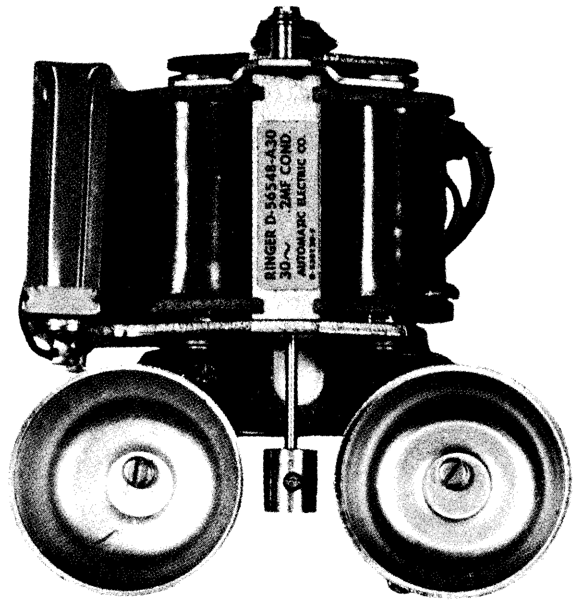


Bulletin **945-804**

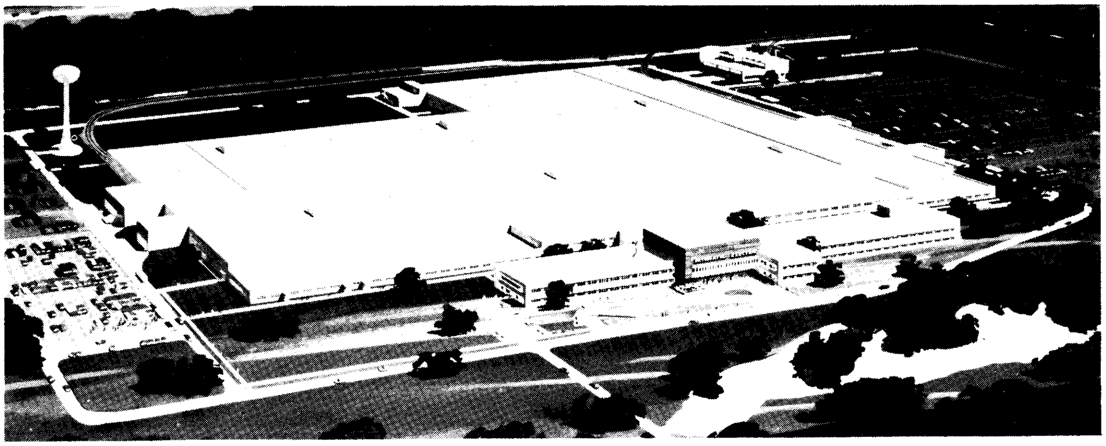
AUTOMATIC ELECTRIC TRAINING SERIES

AUTOMATIC ELECTRIC

GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS



Factory, development laboratories, and general office at Northlake, Illinois, U.S.A.

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FOREWORD

"Ringing Scheme", as used herein, means a technique used to audibly signal a customer. It includes exchange equipment and subscriber-station apparatus and connections necessary to produce and extend an audible signal to a selected customer. The selection of an appropriate Ringing Scheme is dependent upon the type of exchange equipment, Terminal per line or Terminal per station, type of ringing (single-frequency, multi-frequency, coded, etc.), and the customer's class of service (individual line, or party line).

This publication is directed to readers who already have a basic understanding of exchange equipment and customer station apparatus. Its intent is to supplement this basic understanding with detailed information relating to the construction, flexibility – in some cases the limitations – of the various types and applications of Ringing Schemes.

RINGING SCHEMES

1. INTRODUCTION

In its broadest sense, a ringing scheme is simply a technique used to audibly signal the customer wanted in a telephone connection. The need for reliable and efficient signaling was recognized early in telephone history, and to meet that need the ringer was developed, and concurrently the hand-operated magneto generator for operating the ringer. At that time a telephone system consisted merely of a number of telephone stations, each equipped with a ringer and a magneto, interconnected by a common line. A particular station magneto, when cranked by its user, actuated the ringers of all stations connected. It was also necessary to distinguish the desired party from the several rung, and for this purpose a signaling code based on the number of rings was devised.

With the introduction of modern automatic switching systems, the job of signaling a customer was transferred to the central office equipment which could select a called station in response to incoming dialed digits. Various ringing arrangements were used; some to afford compatibility with the existing customer apparatus of the older manual and magneto systems, others to provide reliable and inexpensive signaling methods for use in the newly developed installations. The wide variety of schemes available today all can be described by various characteristics of the ringing circuit between the central office and the called subscriber; the nature of the ringing current – or more accurately, the ringing voltage, the connector apparatus used in the central office, the extent to which distributing frames are used, the ringer apparatus and its connection to the line, and the ringer capacity of the line.

This bulletin describes various ringing schemes currently used with Strowger automatic telephone systems, related exchange equipment, and classes of service. The equipment for a particular scheme will be discussed only in regard to its ringing functions.

2. THE RINGING CIRCUIT

The ringing circuit in any scheme is a closed electric path including four elements:

a. Ringing generator and interrupter. The ringing generator and interrupter supply the periodic current necessary to operate the ringer (bell) at the customer station.

b. Connector. The connector, the last switch in the Strowger switchtrain, is positioned onto the called party's line in response to the last digits dialed by the calling party. After the connector has been so positioned, it tests whether the called line is busy or idle, supplies busy or ringback tone to the calling party, and, if the line is idle, extends ringing current to the desired station over one of the line conductors (- or +) used for voice transmission.

c. Connecting wires and cables. The connection between the connector bank terminals and the customer's station extends physically over the "line" conductors in the customer's line circuit, over a series of connecting wires and cables. These include: jumper wires on the various distributing frames within the central office; and, in the outside plant, the customer line proper, that is, an open wire line or aerial or underground cables, and drop wires and house cables at the station.

d. Customer's station. The customer's station contains the actual ringing apparatus, which ordinarily consists of a two-gong polarized ringer.

3. CLASS OF SERVICE

All ringing schemes belong to one of two classes of service, individual line or party line, on the basis of the privacy they afford in conversation. In planning a telephone exchange, the first and most important decision to be made in regard to ringing schemes is the choice of a class of service for a particular locale. This choice represents somewhat of a compromise between service and economy, and is chiefly dictated by customer preferences, expected call traffic, and the expense of line equipment.

3.1 Individual-line Service

As this term suggests, each set of bank terminals (+, -, and C) of the central office connectors has access to one and only one customer. Consequently, the customer has complete privacy as to ringing and conversation (although, within the station location there may be several extension telephones).

A special type of "individual-line" service, exists in the case of Private Branch Exchanges

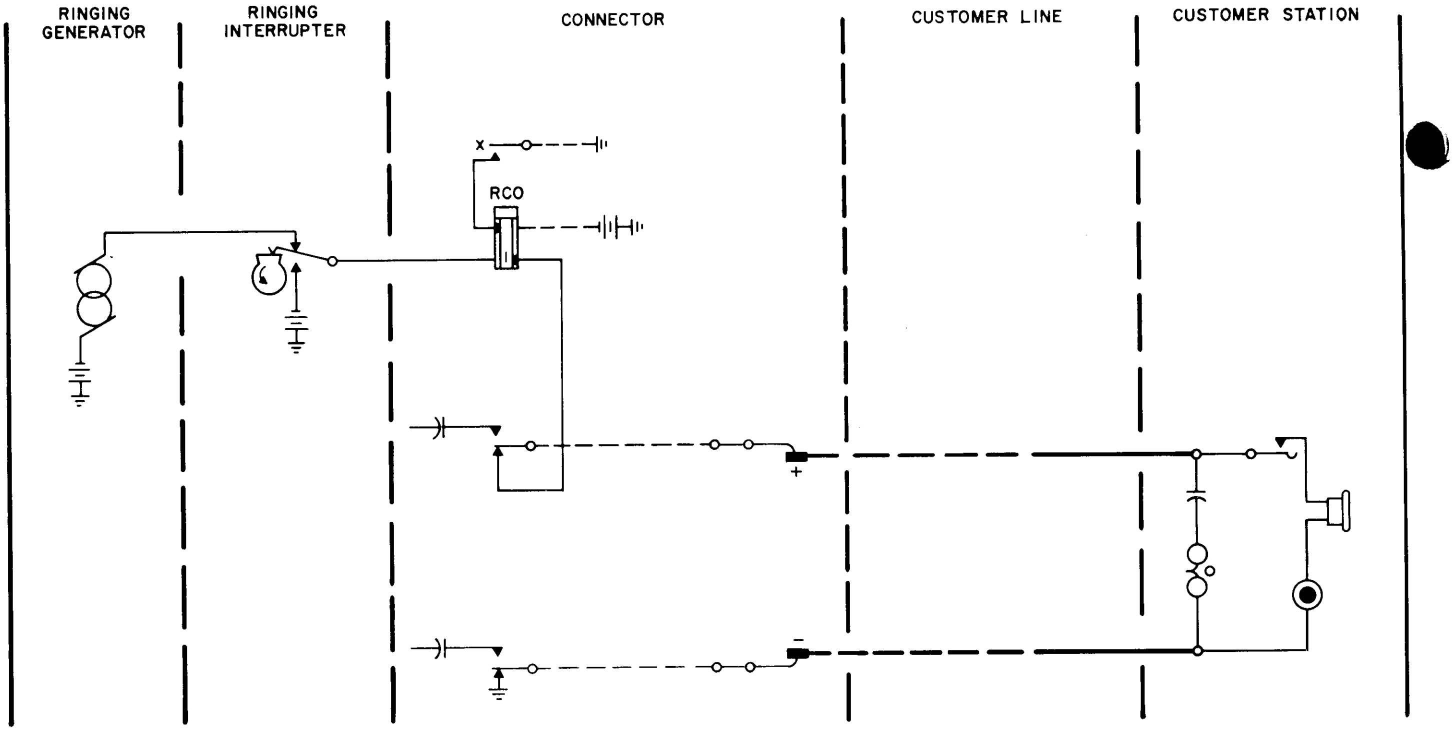

Figure 1. Individual line ringing circuit.

(P-B-X's). The trunks interconnecting the P-B-X with the (public) central office afford privacy in conversation and ringing and therefore, are rung as individual lines.

3.2 Party-line Service

Party-line service, meaning multi-party line service, is an economical method of serving a number of telephones with a single line (+ and - leads). The service is typically used in localities where lines are long and each customer's traffic is light, so that a common conversation circuit can be shared by all connected parties. Party-line service differs from the service provided by extension telephones in that it features distinctive signaling of called parties on incoming calls, and each instrument serves a different customer or family.

For such signaling, three kinds of party-line ringing are used: fully-selective schemes, in which only a single party's, namely the desired party's, ringer is operated; semi-selective schemes, a combination of selective ringing and code ringing, in which the ringers of some but not all parties operate simultaneously; and non-selective schemes, that is, mere code ringing schemes. Anywhere from two to ten stations may be served by these schemes; more than ten parties are rarely used, if only because of the increased possibility of interference between parties during conversation.

At the central office, corresponding types of connectors, ringing generators, and interrupters, and shelf arrangements are required --- depending on the particular scheme involved. Central office equipment will be described later.

4. INDIVIDUAL-LINE RINGING SCHEME

Individual-line ringing is the simplest scheme for signaling a called party, and consequently serves as a foundation upon which the other ringing schemes are built. It is the type of scheme most commonly referred to in the other bulletins of the Training Series, and is reviewed here to illustrate the operation of a basic ringing circuit.

4.1 Individual-Line Ringing Circuit

A simplified, individual-line ringing circuit is shown in figure 1. The diagram indicates only the significant elements in the path of the ringing current. Pictured is a basic 2-digit connector, whose wipers have just been positioned on the bank terminals of the called line. The connector has already found the line to be idle and is prepared to extend ringing current.

The telephone of the called party is "on-hook"; i.e., its hookswitch is depressed by the handset resting in its cradle. The ringer is connected in series with a capacitor across the line, and the transmission circuit is open. Ringing current will find a closed a-c circuit, shown by the heavy line in the diagram.

The ringing potential consists of the combination of a periodic a-c component, supplied by the ringing generator, and a d-c component, supplied by the central office battery. The resultant waveform, shown in figure 2, is a sine wave with its axis of symmetry shifted 48 volts from zero. During ringing, the d-c component is blocked by the capacitor in the customer's phone, while the a-c component is admitted. The resulting a-c (figure 3) passes through the ring cut-off (or "ring-trip") relay in the connector, but fails to operate it, because the relay is slow to operate. However, when the called party lifts his handset, a d-c path is completed. Direct current then flows through the ring cut-off relay to ground, causing it to operate and lock via its "X" contacts. The remaining contacts of the relay transfer the called line from the ringing generator to the calling party, thus terminating the ringing.

4.2 The Ringing Generator

In automatic telephony, regardless of the scheme used, the ringing potential is always a composite of a-c and d-c components. The a-c component, which actuates the ringer, can be supplied by a variety of devices; the principal types being rotary generators, static magnetic (sub-cycle) generators, electronic (tube or transistor) generators, and vibrating-reed generators.

The frequency and power-capacity of the output, and also the size, cost, and efficiency of each type, determine its application to a particular exchange.

4.3 The Ringing Interrupter

Output from any generator is continuous, and must be interrupted to produce pauses in the ringing cycle. For this purpose, the ringing generator usually has a mechanical interrupter consisting of motor driven rotating cams which actuate spring pileups, and in turn, interrupter relays. The timing of the ringing can be controlled in such a system by varying the peripheral length of the lobes on the cams.

The standard interrupter ringing cycle is 6 seconds, and consists of a 1.2-second ring, followed by a 4.8-second silent interval. It would seem that this interruption could be provided by a single cam and relay combination. Although such an arrangement is possible, the generator would be heavily loaded for 1.2 seconds and unused for 4.8 seconds – this would be inefficient. Instead, the connectors served by a generator in the exchange are divided equally into five "Ringing Groups", with each group connected in sequence to the generator, for 1.2 seconds, by a separate cam and relay combination. In this manner, the generator load is equalized, a smaller generator can be used, and its full power output can be utilized.

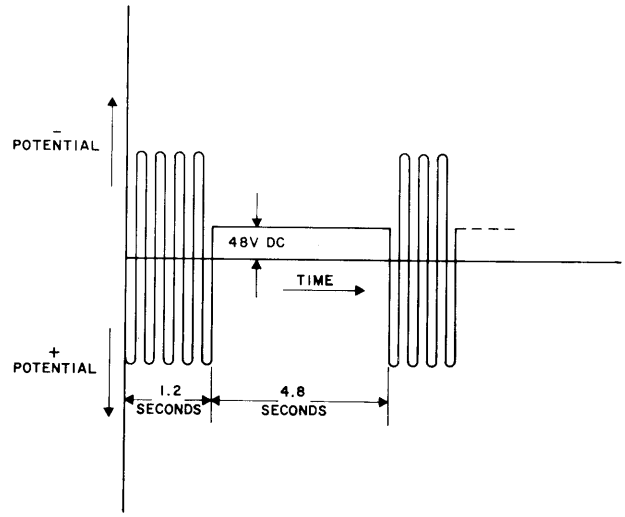

Figure 2. Ringing potential for individual line service.

The relays A through E shown in figure 4 operate one at a time for 1.2 seconds of each 6-second ringing cycle. The battery shown at the contacts of these relays provides a d-c voltage to operate the ring cut-off relay in the connector when the called party answers the call in the 4.8-second silent period.

4.4 Generator Connections

The central office battery, which supplies the d-c component of ringing potential, can be connected into the ringing circuit by one of two methods. If, as in figure 1, the battery is placed between the generator and ground, the configuration is known as battery-connected generator.

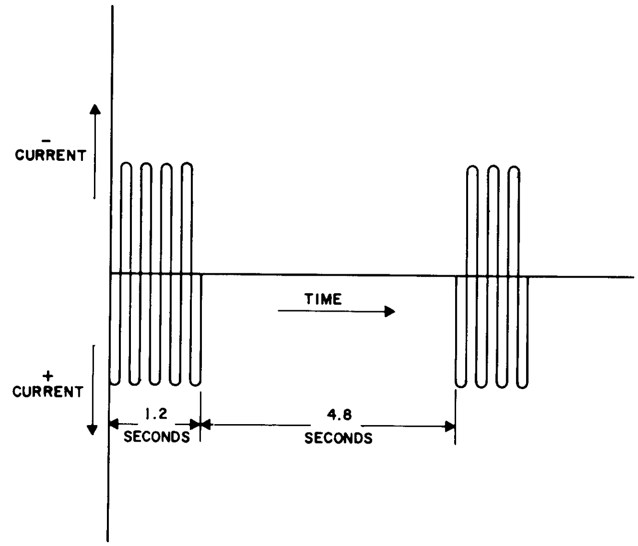

Figure 3. Ringing current for individual line service.

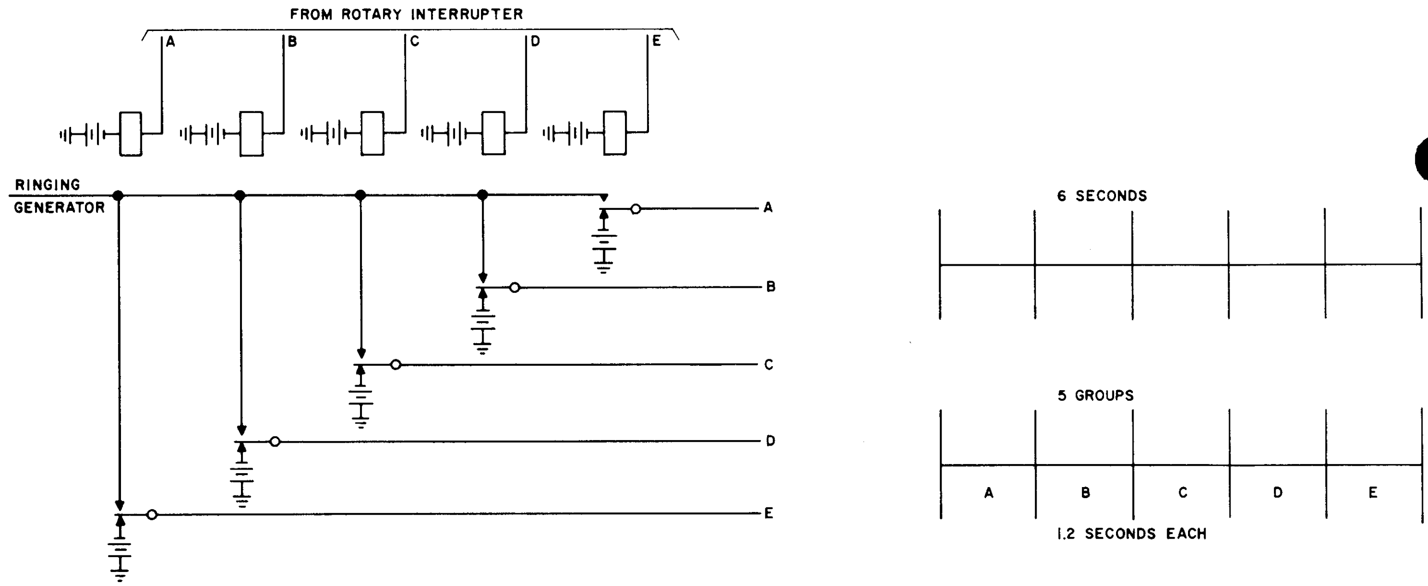

Figure 4. Ringing groups, interrupter relays.

The alternate method of connecting the generator to the line, ground-connected generator (figure 5), places battery between the ring cut-off relay and ground, and grounds one ringing-generator terminal. The ground-connected generator plan, however, could result in generator overload, should a line-to-ground fault occur on the other side of the line. To prevent this, a 250Ω current-limiting resistor is placed in series with the generator.

4.5 The Straight-Line Ringer

The actual station signaling apparatus in an individual-line circuit is the straight-line ringer (figure 6). This ringer is responsive to a relatively wide range of a-c frequencies – approximately 16-2/3 to 33-1/3 cps – and consequently can be used in any scheme where ringing potential is supplied at a single frequency of this range. Two types of straight-line ringers have been employed in Automatic Electric Company telephones, high-impedance and low-impedance, the high-impedance ringer being the modern improved type.

Working parts of both types usually include a two-coil, series connected electromagnet with a magnetically polarized yoke, a pivoted armature supporting a bell clapper, a bias spring, and two gongs. The clapper is held against one of the gongs by tension on the

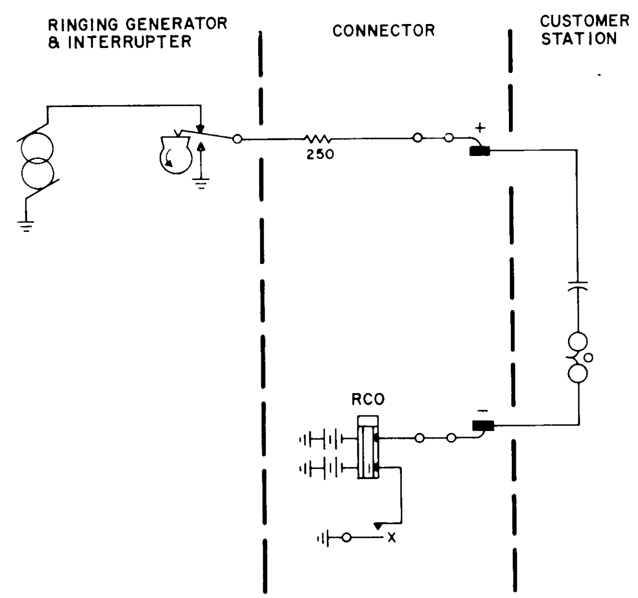

Figure 5. The ground connected generator circuit.

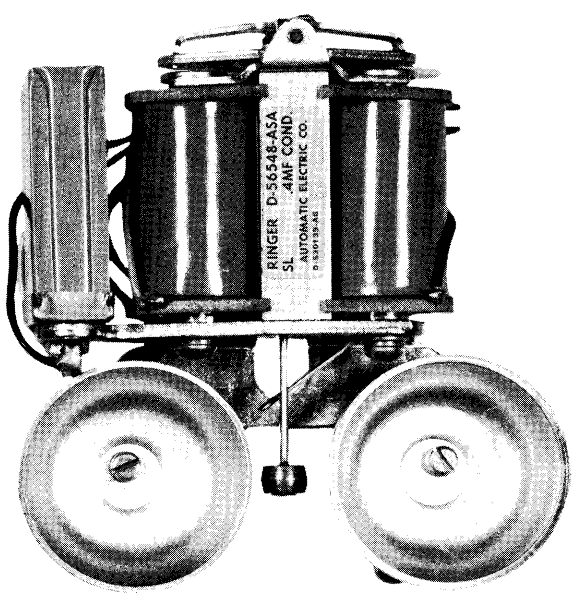

Figure 6. Straight-line ringer.

biasing spring. When a-c is applied across the coils, one polarity of current causes the clapper to strike one gong, in opposition to the bias spring; the reverse polarity aids the bias spring in returning the clapper, to strike the other gong. Spring bias tension is necessary to prevent the clapper from actuating the gongs on stray potentials and accidental jarring.

5. RINGER CONNECTIONS

The line connection to the telephone of figure 1, in which the ringer is connected across both sides of the line, is appropriately called bridged ringing. In the simplified circuit illustrated, the line serves only one telephone; more telephones could be similarly bridged across the line, but during ringing all parties would be signaled when only one party was desired. The parties' rings would have to be coded (longs and shorts, etc.).

One means to selectively ring two parties on a line is "divided" ringing. In this system, the ringing circuit is via one line-wire (+ or -) with earth return, while the voice transmission circuit extends over both line wires (figure 7). The desired station is selected by connection of the ringing generator lead to the appropriate line wire.

The one-party bridged ringing and two-party divided ringing systems just described are simple ringing schemes. Generally, these line connections are used with other line-conserving techniques described in the following sections, to enable several telephones to be served by a single line. In any scheme where an option exists in the choice of line connections, the number of stations, which can be served by the divided ringing configuration, is just twice that for bridged ringing.

6. PARTY-LINE STATION EQUIPMENT

It is possible to provide party line service to more than two telephones by utilizing various properties of the ringing potential for station discrimination: the frequency of the a-c component; the timing or coding of ringing pulses; and the polarity of the d-c component. Accordingly, three party-line ringing schemes have been developed and used: multi-frequency ringing; coded ringing; and superimposed ringing.

6.1 Multi-frequency Ringing

The multi-frequency ringing system (sometimes referred to as the harmonic ringing system) uses a variety of ringing frequencies to obtain fully-selective signaling of called stations on a party line. The system uses a special type of station ringer, known as a harmonic ringer, (figure 8), whose clapper assembly is designed to mechanically resonate at a particular frequency. When the applied ringing potential is of the corresponding frequency, the clapper vibrates enough to strike the signaling gongs.

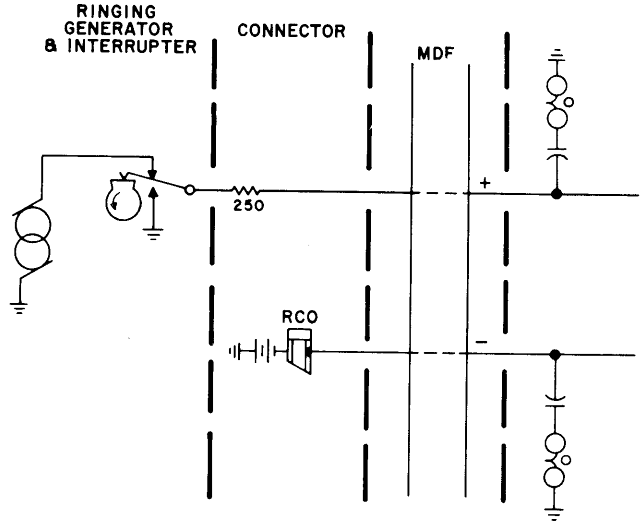

Figure 7. Simplified divided ringing circuit.

Five frequencies are generally employed in this system, to serve five stations with a bridged ringer connection, or ten stations with a divided ringer connection. These frequencies conform to one of three ordered sets: "multiple" frequencies (16-2/3, 25, 33-1/3, 50, and 66-2/3 cps) which are multiples (harmonics) of 8-1/3 cps, "Decimonic" frequencies (20, 30, 40, 50, and 60 cps) which are multiples of 10 cps, and non-multiple "synchromonic" frequencies (16 or 20, 30, 42, 54, and 66 cps).

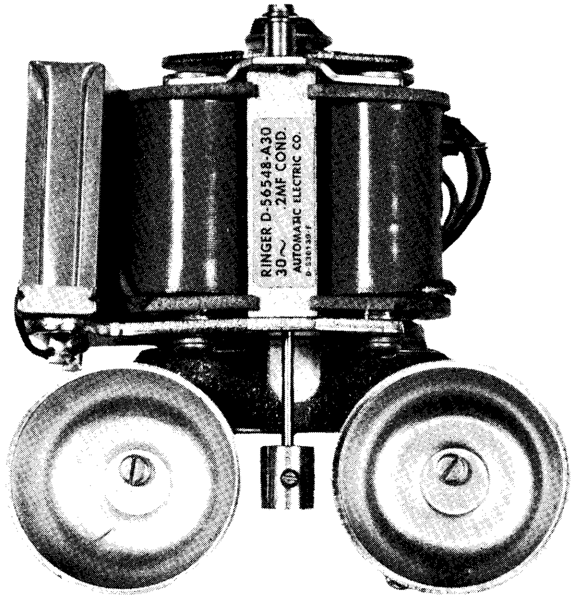

Figure 8. Harmonic ringer.

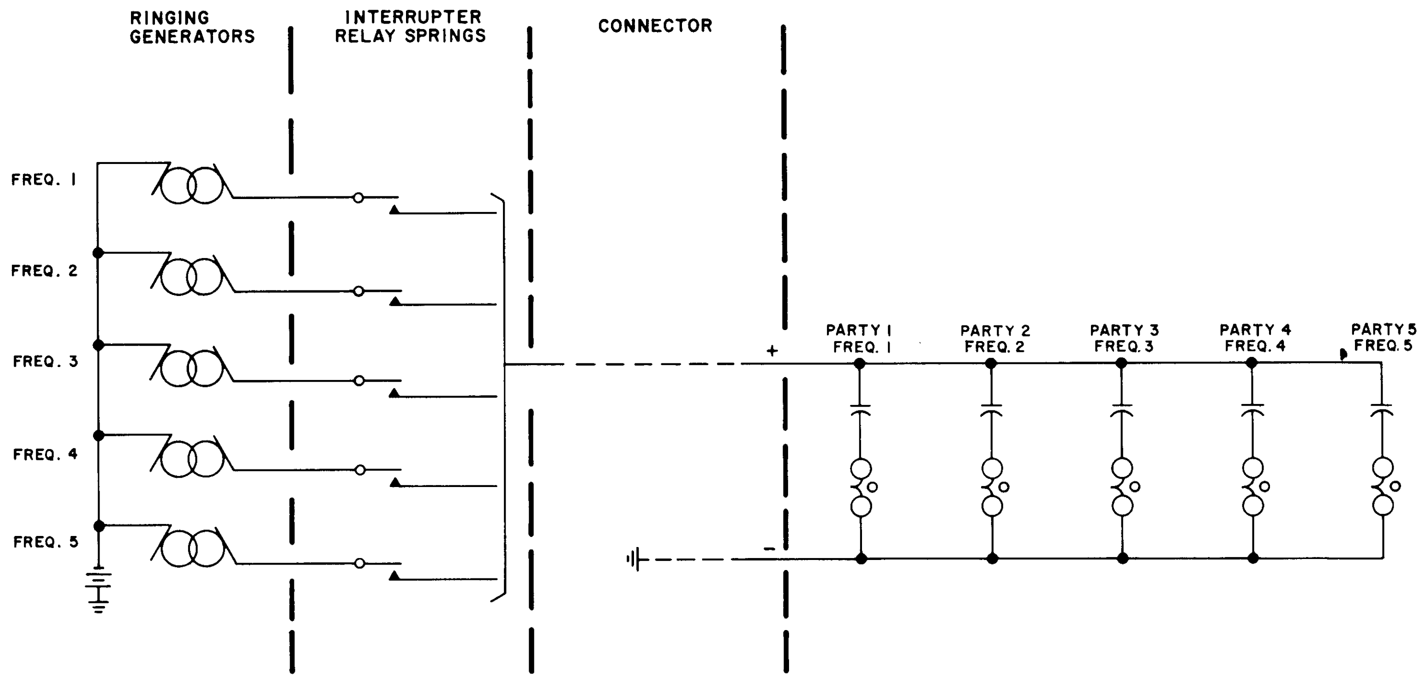

Figure 9. Multi-frequency, bridged ringing scheme for five parties.

Because the "multiple" and "Decimonic" frequencies are based on harmonic relationships, they originally lent themselves to economical production of commercial rotary and magnetic ringing generators, with all generators on one, single speed rotating shaft.

It was found, however, that there was an occasional tendency in this frequency series for non-selected ringers to "tinkle" when ringing potential was applied to the line. Such false ringing was eliminated by the adoption of the nonmultiple frequencies. Presently, with the use of modern, flexible electronic ringing generators, reliable service can be obtained with any frequency system, and the choice is somewhat arbitrary.

Figure 9 shows a simplified multi-frequency ringing circuit for five parties with bridged ringer connections. Ringing current flows through all ringers on the line but only the clapper responsive to the frequency of the connected generator vibrates enough to strike the gongs, thereby signaling the called party. Different values of series capacitance are used with the ringers of the various frequencies.

6.2 Coded Ringing

In coded ringing, all phones on a party line are rung simultaneously, and stations are distinguished by a signaling code based on the length and number of pulses in the ringing cycle. Five codes have been adopted in general practice and these consist of various combinations of long and short rings. Coded ringing can service five parties with a bridged-line ringer connection, or ten parties with a divided-line ringer connection.

Coded ringing requires only a single frequency of ringing potential (usually 20 cps), for use with ordinary straight line ringers. The ringing

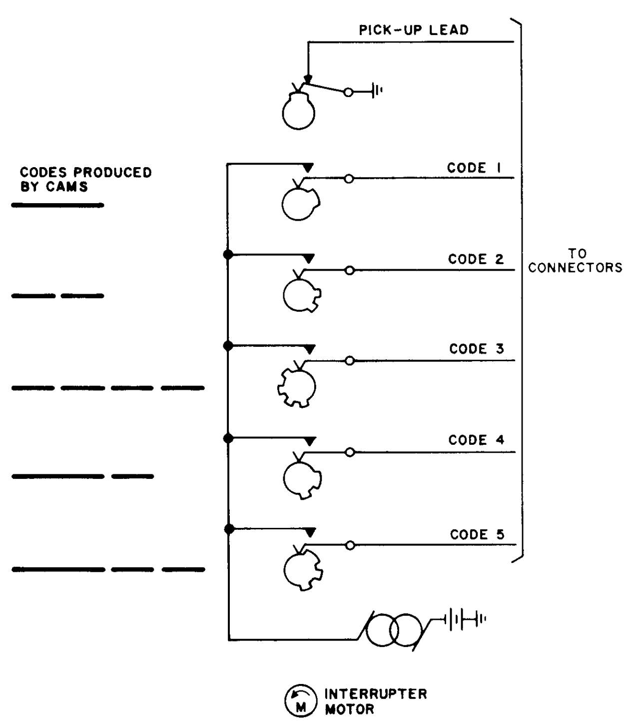

Figure 10. Simplified ringing interrupter arrangement for coded ringing.

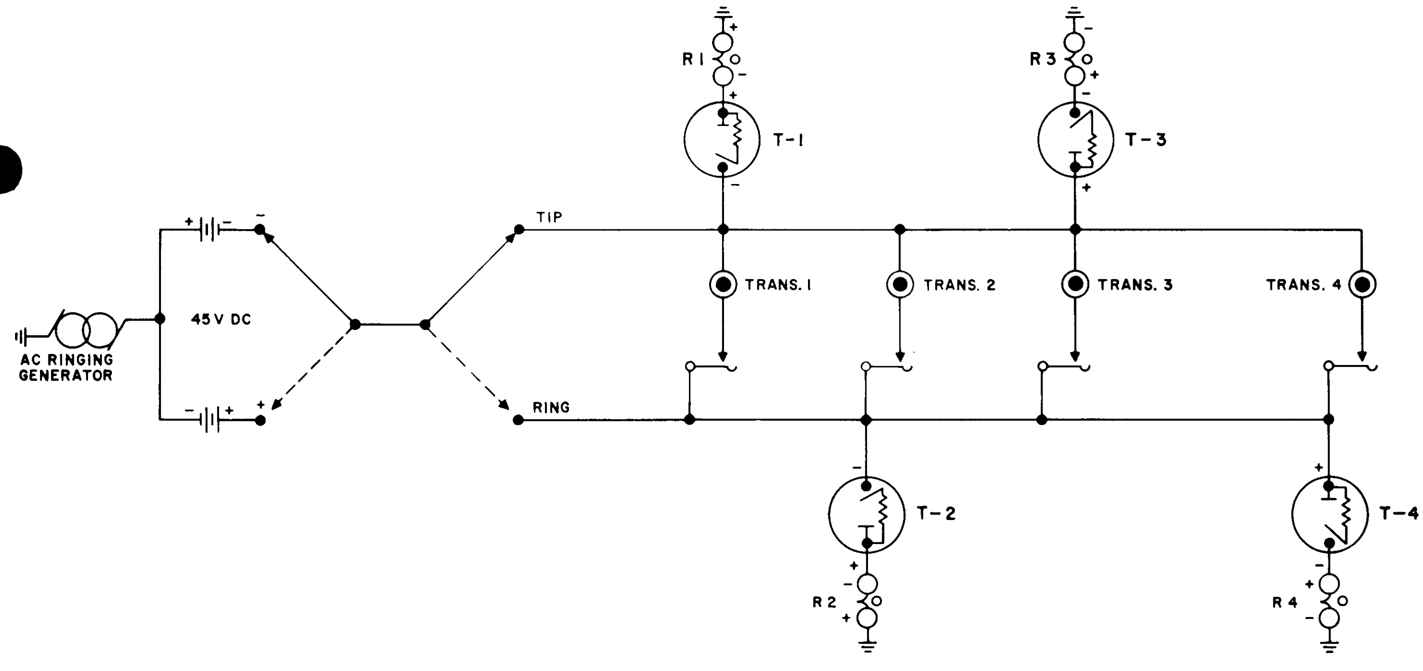

Figure 11. Superimposed ringing for four parties.

interrupter, however, requires six cams. Five cams produce the actual coded ring pulses. At the start of each complete ringing cycle, the sixth cam closes a circuit to a pick-up relay in the connector. The pick-up relay must be operated before ringing current can be sent out over the line. Since this relay is only energized at the beginning of the complete ringing cycle, partial or erroneous codes are prevented from being sent out on the line.

Figure 10 shows the interrupter cams and their associated codes. The codes, indicated by dots and dashes, are individually selected and placed across the line by the central office switching equipment.

6.3 Superimposed Ringing

It will be recalled that in automatic telephony a d-c office battery potential always is "superimposed" upon the a-c ringer-actuating potential, to supply operating current to the ring cut-off relay when the called party answers; and ordinarily this d-c component has no effect in selecting a customer. However, in the so-called "superimposed ringing" system, two sets of d-c battery of opposite polarities are connected into the ringing circuit, for the added purpose of station selection on a party line. Telephones associated with this system are equipped with a rectifier making them responsive to only one of the two polarities of ringing potential. In this manner, superimposed ringing can provide fully-selective ringing to two or four parties, using respectively, bridged or divided ringers. Although theoretically either type could be used, divided ringing is generally used with this system.

Since polarity is the means used for party selection, only a single frequency of ringing current (usually 20 cycles) is needed. The telephone ringers on the line are all similar (straight-line ringers) but are connected to the line in series with a cold-cathode gas-filled rectifier tube, instead of with the usual capacitor. In a divided line ringer connection, two ringers are connected to each line, with their rectifier tubes polarized and their ringers biased in opposite directions. In this configuration, current flows through only one ringer, when a particular polarity of ringing potential is placed across the line and ground.

The rectifier tube used for current control has three electrodes – two anodes and a cathode – in an inert-gas-filled glass envelope. The gas in the tube is ordinarily an insulator and conducts, by "ionization", only when the voltage impressed across the anodes and cathode exceeds a certain value. The anodes, interconnected by a 120,000-ohm resistor, are of two types; a control anode, which initially ionizes the gas in the tube, and a main anode, which conducts the ringing current. Through the use of different design and different materials for the electrodes, the "breakdown" voltage is made considerably less for current flowing from the cathode to the main anode, than for current flowing in the reverse direction; this characteristic makes the tube a rectifier.

Figure 11 is a schematic of a four-party, divided-line superimposed ringing circuit,

TABLE I: Ringing Schemes in General Use

Type of Ringing	Ringer Connection	Maximum Stations/Line	Ringing Selectivity	Ringers
Single Frequency	Bridged	1	Individual line	Untuned
Single Frequency	Divided	2	Fully-selective	Untuned
Multi-frequency	Bridged	5	Fully-selective	Tuned
Multi-frequency	Divided	10	Fully-selective	Tuned
Coded	Bridged	5	Non-selective	Untuned
Coded	Divided	10	Semi-selective	Untuned
Superimposed	Divided	4	Fully-selective	Untuned, with tube
One & two ring multi-frequency	Bridged	10	Semi-selective	Tuned
One, two & three ring superimposed	Divided	10	Semi-selective	Untuned, with tube

showing the associated a-c generator, batteries, rectifier tube and station ringers. The central office switching equipment is arranged so that either positive or negative superimposed ringing potential can be connected to either side of the line. For each polarity of ringing potential, a superimposing battery of 35 to 40 volts is employed. The superimposing battery is connected in series with the a-c generator and supplies the d-c component of potential during ringing. Because of the nature of the rectifier tube's operation, the ringing potential is critical; the combined a-c and d-c potentials must be great enough to ignite and sustain tube ionization in the desired telephone, at the same time the d-c component must be small – to prevent direct current through the tube as that could cause the ringing cutoff relay to accidentally operate.

When the switching equipment closes ringing potential to one side of the line, the "control gap" (the gap between the cathode and the control anode) ignites in the tubes of both connected parties. Because of the tube rectifier, only the tube of the called party conducts the ringing current through its main anode. Current through the control gap of the other party is kept to a negligible value – insufficient to operate a ringer – by the resistor in series with the control anode.

Multi-frequency and superimposed ringing schemes can be used alone, or either can be combined with coded ringing, to cover more parties. When such combinations are used it is theoretically possible to serve up to 50 parties with a single line; however, considerations of subscriber-call privacy and traffic usually limit the maximum to 10 parties, and consequently, two codes.

Table I lists all party-line and individual-line ringing schemes in general use. Included in the table is information on the ringing type, ringer connection, station capacity, and signaling selectivity for each scheme.

7. CENTRAL OFFICE EQUIPMENT FOR VARIOUS PARTY-LINE SCHEMES

Each ringing scheme previously described can be used with any of several switching equipment plans in the central office. The exchange plans are generally classified as terminal-per-line (T/L) or terminal-per-station (T/S), on the basis of whether the terminals of connectors represent lines or particular customer stations. The terminal-per-station exchanges are of two specific types, frequency-per-shelf (also referred to as frequency per group) and frequency-per-terminal, differing in the manner the ringing potential is routed to the connector bank terminals.

7.1 Terminal-per-line Exchange (T/L)

The T/L exchange provides only one connector bank assignment for each telephone line, hence,

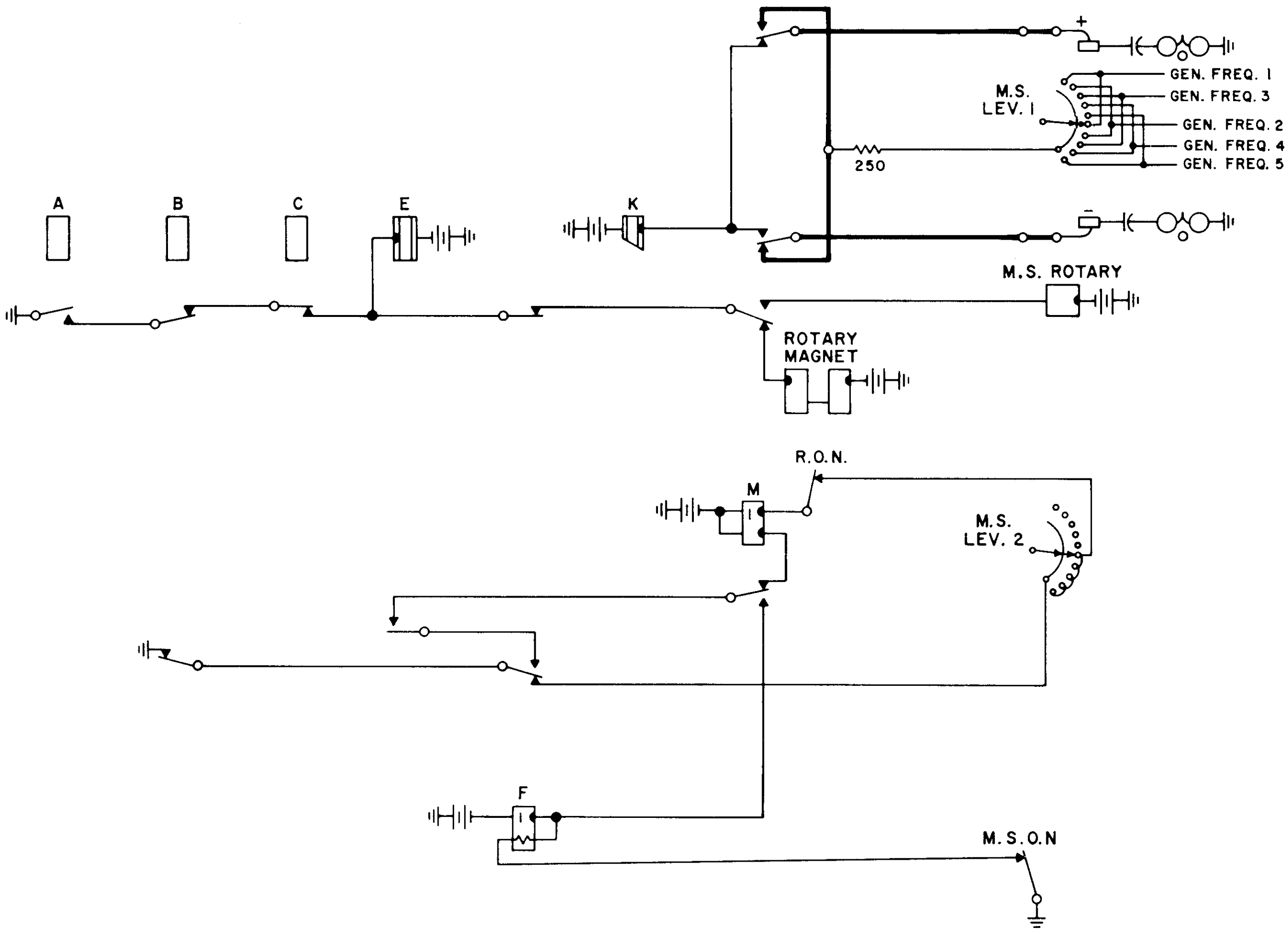

Figure 12. Ringing circuit of a T/L connector equipped for a divided, multi-frequency ringing scheme.

all the stations served by that line. The exchange must use 3-digit connectors containing a minor switch, which responds to the last dialed (or first) digit depending on the type of connector. The connector accesses the called line by means of the first two, or second two incoming digits – in the manner of the familiar basic 2-digit connector. The third (or first) digit operates the minor switch, selects the frequency code, polarity or combination of ringing potential to be sent, on the line, and the side of the line to be rung. In this system, consequently, directory numbers except for the last (or 3rd from last) digit are the same for all parties on the line.

The extra digit makes the party-line connector somewhat more complex (extra components: two relays and a minor switch) than the basic 2-digit connector, although circuitry for the first two incoming digits is very similar. The minor switch is equipped with two levels; one level is used to select the frequency, superimposed polarity, code, or combination of frequency or polarity and code to be applied on the line; the other level is employed – if divided ringing is used – to mark the side of the line to be rung.

Each code, frequency, or combination of code and frequency required is supplied to the connector by a separate lead from the ringing generator. When codes are employed, these generator leads must be accompanied (figure 10) by a pick-up control lead to mark the start of the ringing cycle. Thus when one-and two-ring multi-frequency ringing is employed in an exchange, up to 11 leads must be provided. All the connectors on a shelf are used in conjunction with the same ringing scheme, so that one set of leads will serve the whole shelf.

Figure 12 is a partial schematic diagram for a party-line connector serving 10 parties with divided, multi-frequency ringing. The circuit shows the minor switch and associated relays ready to ring a called customer after his party-line was tested and found idle. Ringing current finds a path as indicated by the heavy line.

The minor switch has been stepped to the 6th bank contact (corresponding to a dialed digit of six) by ground pulses from pulsing relay A. Ringing potential of correct frequency, in this example frequency 1, is supplied by the terminals of minor switch level 1 through the wiper, a 250-ohm resistor and the contacts of relay M, to the "-" line-wire. (Recall, the resistor is always used in the ground-connected generator configuration.)

Relay M controls the side of the line to be rung. If a circuit is closed to relay M through contacts of level 2 of the minor switch, then relay M operates and closes ringing potential to the "-" side. Conversely, an open circuit on these contacts will result in ringing on the "+" side. With the strapping on level 2 as shown, ringing potential is applied to the "+" side of the line for digits 1 through 5 and on the "-" side for digits 6 through 0.

A 3-digit connector used to access party-lines can also serve individual lines. In the latter instance, the connector bank terminals representing a line, also represent a station (consequently, the connector is at the same time a terminal-per-line and a terminal-per-station connector). Three digits are used, as with party-lines, to connect the called party, and the third digit is so chosen that the minor switch selects 1-ring ringing potential of straight-line frequency. If the connector is arranged for divided ringing, either side of the line may be accessed, since individual lines employ bridged ringing.

7.2 Terminal-per-station, (T/S) Frequency-per-shelf Exchange (F/S)

This type of an exchange employs basic 2-digit local connectors equipped with three sets of bank contacts, +, -, and C. These connectors are grouped in shelves, and each shelf is fed ringing potential of a particular frequency, polarity, code. Accordingly with bridged ringing each station on a party-line is represented on the bank terminals of a different shelf. A particular station on a party-line is then selected by accessing the line from a shelf with the appropriate ringing potential.

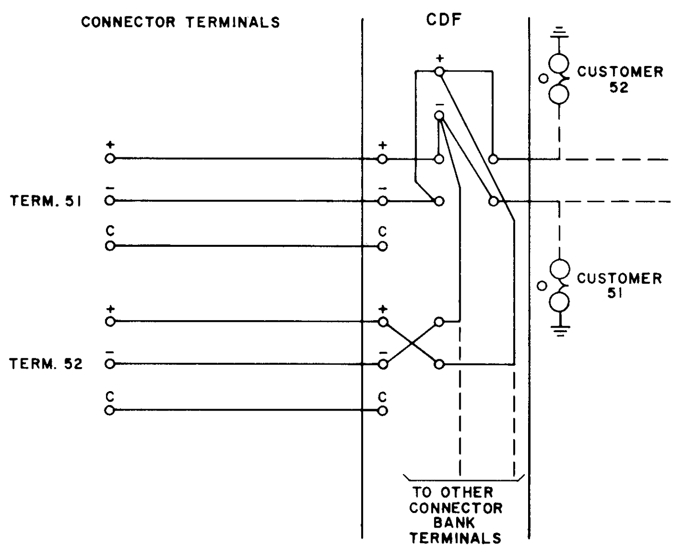

Figure 13. Bunching block connections for divided ringing in a frequency-per-shelf exchange.

The bank terminals of all stations sharing a party-line are connected in common to the line by means of party-line bunching blocks on the LIDF (Line Intermediate Distributing Frame) or CDF (Combined Distributing Frame), whichever is used in the exchange. These bunching blocks additionally serve, in the case of divided ringing, to route ringing potential to the appropriate line-wire (+ or -).

Figure 13 shows how this is accomplished. The "-" bank contact of each set can provide "hot" (live) ringing potential, and is strapped to a different one of the line-wires at the bunching block. When either of the two terminations is accessed the connector supplies ringing current to the line-wire strapped to its "-" bank contact. Central office battery (battery connected generator) or ground (ground connected generator) as received on the "+" bank contact, is always strapped to the line-wires not rung; this short circuits the unwanted ringers on the other line-wire thereby preventing their accidental operation on stray potentials.

The F/S method of party selection imposes a limitation in the formation of party lines. The limitation is; any terminal number is inherently rung with only one set frequency, if the customer moves to another part of town, and the only cable pair passing his house and not already filled, has on it already a party rung with the frequency our just-moved customer had at his old location, then our just-moved customer cannot keep his old telephone number, but must accept a new (changed) number.

Figure 14 illustrates the T/S, F/S scheme applied to 10 parties on a divided multi-frequency ringing party line. Illustrated are the station ringers and their corresponding digits (only the significant final three digits), station bank contacts, and connections between the bank contacts and the line on the LIDF bunching block.

Frequency-per-shelf exchanges can, of course, be used to serve individual lines. In such an instance, all individual-lines are grouped on shelves supplied by ringing potential of straight-line frequency and of the standard interruption rate.

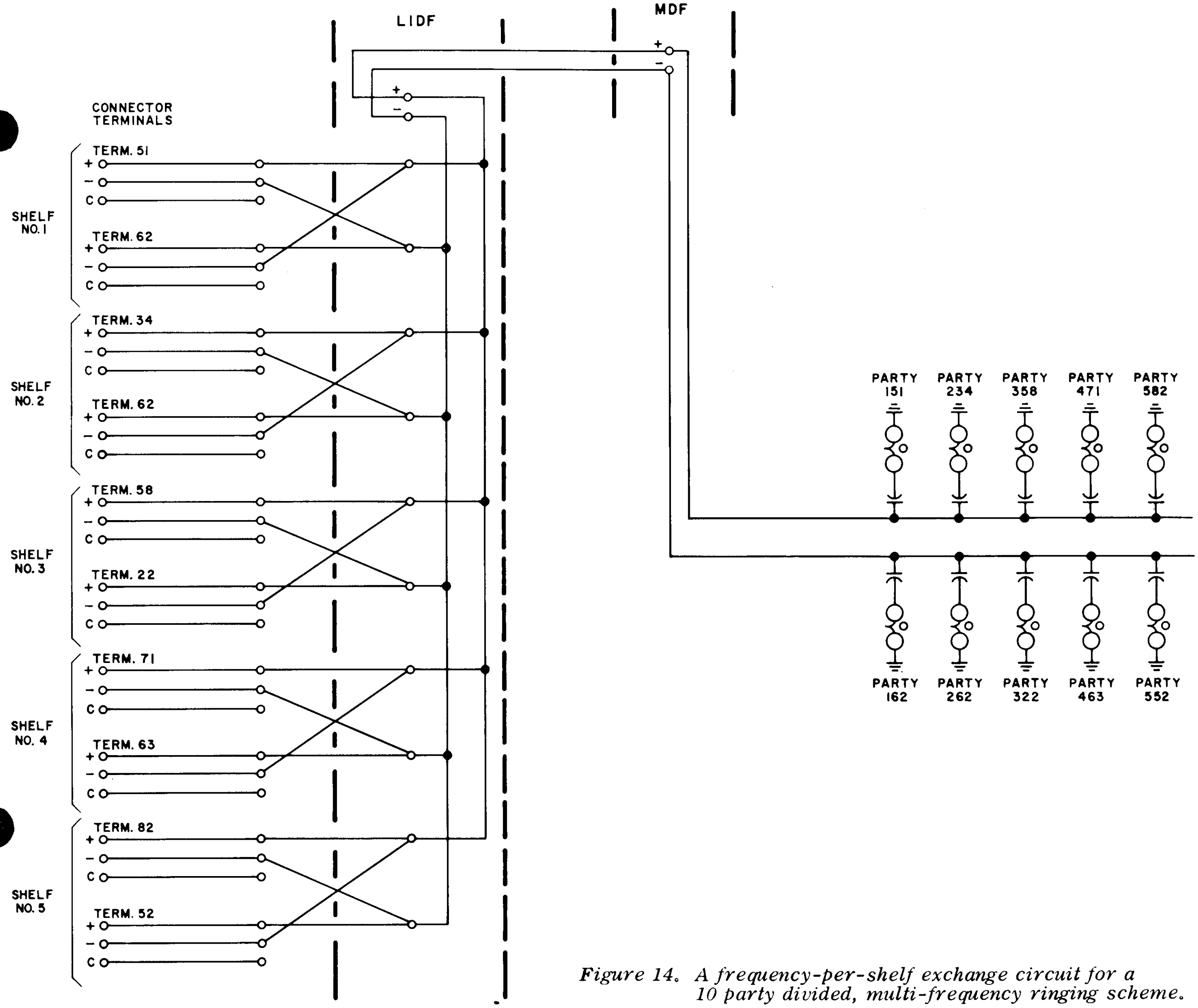

Figure 14. A frequency-per-shelf exchange circuit for a 10 party divided, multi-frequency ringing scheme.

7.3 Terminal-per-station, Frequency-per-terminal Exchange

The frequency-per-terminal and frequency-per-shelf types of T/S exchanges have the common provision of a separate connector bank termination for each customer station available for calling. The difference between the types is basically one of flexibility in the assignment of ringing potentials to called stations on a party-line. In a 3-wire, F/S office, each shelf of connectors receives a separate ringing potential of a particular frequency, polarity, code, or combination, and the type of potential a station receives is dependent on the shelf location of connectors assigned to it. Thus a direct correlation exists in the frequency-per-shelf system between a customer's number and the potential assigned him. The frequency-per-terminal system employs connectors which can individually supply any one of the various party-line ringing potentials to the stations on their banks, and thereby eliminates the shelf arrangements and directory number limitations necessary in the frequency-per-shelf system.

The F/T exchange requires four connector-bank terminations for each customer station. Three terminals (+, -, and C) serve the same functions as they do in the 2-digit connectors of the 3-wire plan; the fourth terminal, designated the EC (extra control) bank contact, determines which of several discriminatory ringing potentials available to the connector is placed on the line. Depending upon which ringing scheme is used in the exchange, all frequencies, polarities, or codes of ringing potential are supplied in sequence to each

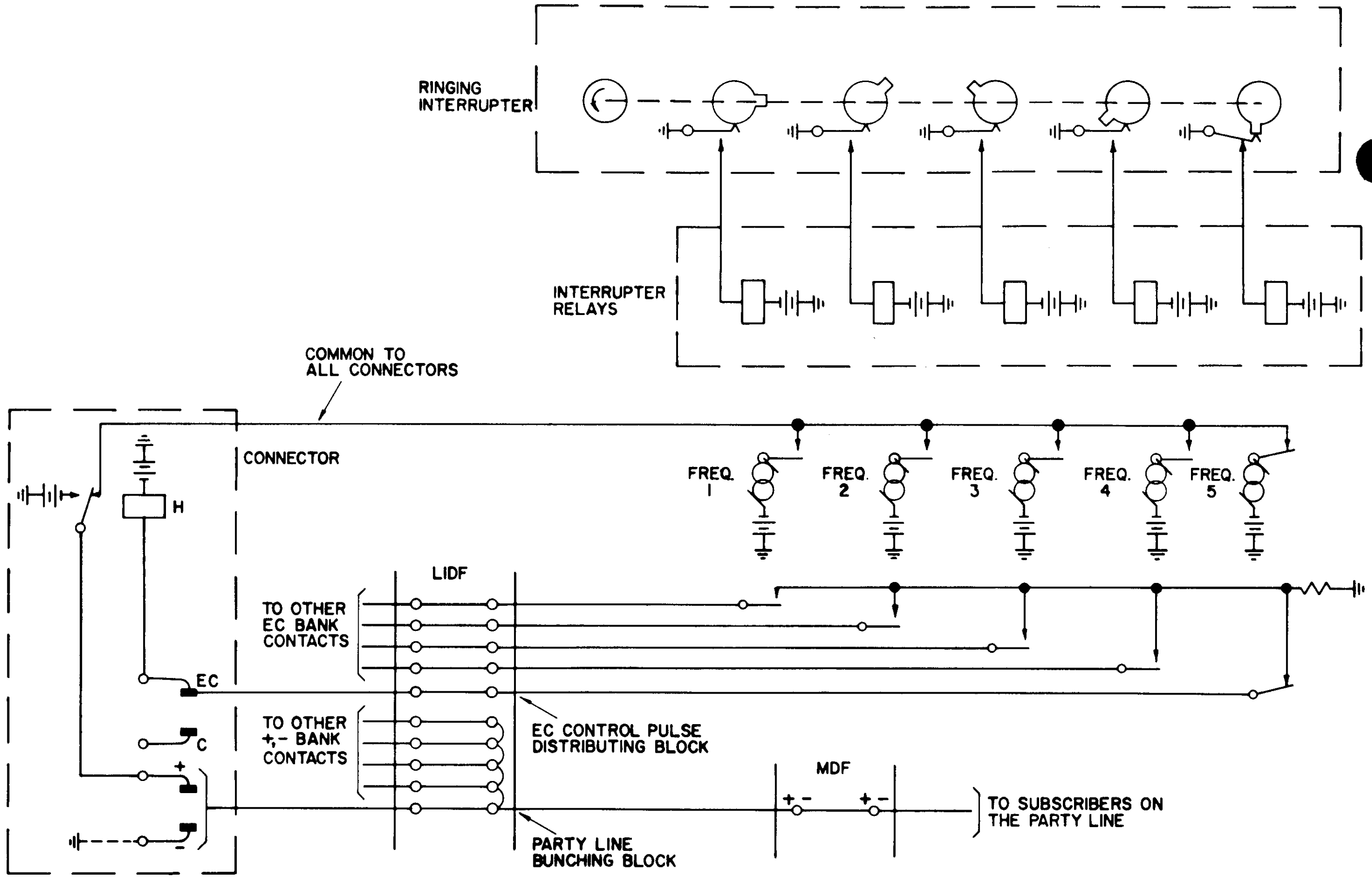

Figure 15. Frequency-per-terminal exchange circuitry for a five party, bridged multi-frequency ringing scheme.

connector over a single lead from the ringing generators. The EC contact of a particular station receives ground pulses from a ringing interrupter relay during the interval in which the desired ringing potential is applied to the generator lead. These pulses are used to operate a ringing control relay in the connector, which ''gates'' only one of the several possible potentials to the called station.

The exact manner in which the EC contacts and generator lead are used is different for each type of discriminatory ringing potential, and these will therefore be discussed separately.

a. Multi-frequency ringing: Each of the five frequencies is placed in sequence on the generator lead for a period of 1.2 seconds. The resultant six-second interval is repeated cyclically, so that for any frequency, there appear 1.2-second pulses separated by 4.8 seconds – the standard ringing cycle. The EC bank contact of a particular station receives a continuous 1.2-second pulse during the time slot corresponding to that of the station's frequency on the generator lead.

b. Superimposed ringing: The two polarities of ringing are placed alternately on the generator lead, each for a period of 2 seconds. The EC contact of a particular station receives a 2-second ground pulse simultaneous with the application of the station's ringing polarity on the generator lead.

c. Coded ringing: One frequency stays always on the generator lead. A ground appears on the EC contact during each ring of the called station's code to operate a relay and extend the code to the line.

d. One- and two-ring multi-frequency ringing: As in the ordinary multi-frequency ringing, each of the five frequencies is placed in sequence on the generator lead. However, the EC contact of a particular station, instead of containing a continuous ground marking during the desired frequency interval provides either one or two ground pulses to the ringing control relay. In this way, the ringing control relay, in addition to ''gating'' the desired frequency to the line, pulses out the station code.

e. 3-code superimposed ringing: The generator lead, as in ordinary superimposed ringing, supplies alternately both polarities of ringing potential to the connector, in periods of 2 seconds. The EC contact is supplied with ground impulses corresponding to one of the three possible codes, and the pulses occur during the time slot associated with called station ringer polarity.

All stations sharing a party-line (these may or may not be located on connectors of the same shelf) have their common connection to the line by means of party-line bunching blocks on the CDF or LIDF employed by the exchange. When divided ringing is employed on a line, the division of ringing current to the "+" and "-" sides of the line is governed by the strapping of jumper leads on these bunching blocks to the individual stations.

Consider a 5 party, bridged multi-frequency ringing scheme in an F/T exchange. Figure 15 shows the ringing circuit at the central-office end of such an installation, picturing a F/T connector, ringing generators of five frequencies, associated interrupters and interrupter relays, and distributing frame connections to the line and the bank terminals. The connector has been stepped to a set of terminals representing one of the party-line stations, and connections are shown for the significant EC, +, and - contacts. Each of the interrupter relays will operate once and in sequence during a complete cycle of the interrupter cams. When one of the relays operates, it simultaneously places resistance ground on one of the EC contacts, and ringing potential of a particular frequency on the generator lead.

In this example frequency 5 is applied to the + lead.

While up to now only party-lines have been discussed, individual lines can also be served by 4-wire connectors and, in fact, by the same connectors which serve party-lines. For this purpose, individual-line stations have their EC bank contacts marked so as to select 1-ring ringing potential of straight-line frequency.

7.3.1 Advantages of the frequency-per-terminal, terminal-per-station plan.

The F/T T/S plan offers the previously mentioned feature of complete flexibility in the assignment of directory number. Furthermore, the plan shares important advantages common to both types of terminal-per-station exchanges, in number changing and intercepting practices.

a. Number changing: With T/S as against T/L operation, practically all number changing of party-line stations is eliminated on line regrouping, or upgrading, and in subscriber moves within the exchange area. This permits more efficient utilization of outside plant facilities, equalization of originating traffic loads on the subscriber lines, and greater ease in changing class of service.

b. Intercepting: When a call is made to a vacant or changed number, or a line out of order, an operator or a recorder announcer must be provided to "intercept" the call and inform the calling party of the status of his call. With a T/S exchange, it is simple to place a station on intercept, merely jumper the station's bank terminals to an operator or a recorder announcer. In a T/L exchange, where one set of bank terminals represents all stations on a party line, the equipment for intercepting calls to a particular station is much more involved.

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