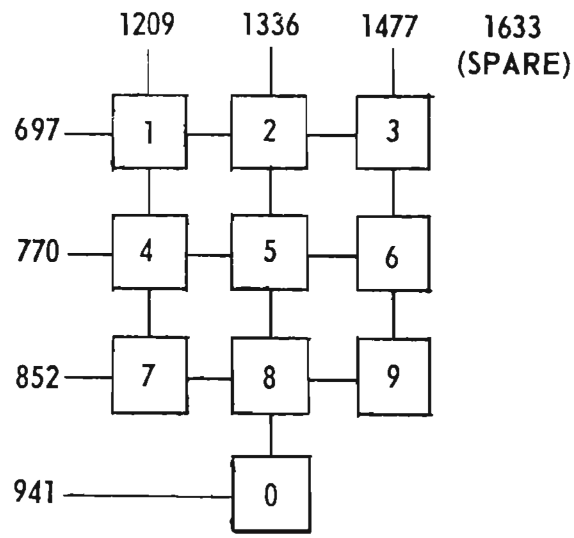

Figure 2-15 TOUCH-TONE Dialing Freq Combinations

The two frequencies generated will indicate a digit from 0 to 9 and two special service tones as shown in Figure 2-15. The combination of one low group frequency and one high group frequency gives 16 possible signal combinations. The extra four signals are for use with the special 16 push-button phones.

Depressing any pushbutton also operates the "Common Switch" which reduces sidetone to the receiver, opens the transmitter path and applies bias voltage to the transistorized oscillator.

2.10 RINGERS

The telephone ringer or "bell" is used to indicate the presence of an incoming call. Three types of ringers are in use today; the unbiased ringer, the biased ringer, and the harmonic ringer.

Unbiased ringers are intended for use on alternating current only. When alternating current passes thru the electromagnets, the magnetism set up by the permanent magnet is strengthened in one coil and diminished or overcome in the other on the first half cycle. The armature now tilts toward the core having the strongest magnetism and the clapper ball strikes one gong. As the current is reversed on the half cycle, the other coil has the greater attraction and the clapper ball strikes the other gong.

The biased ringer is used in all cases where superimposed current (direct current superimposed on alternating current) is used for ringing. The biased ringer is constructed like the unbiased ringer except that it is equipped with a biasing spring to hold one end of the armature against the respective magnet core. See Figure 2-16. A pulse of the proper polarity will overcome the pull of the spring and pull the armature against the other core, ringing first one gong and then the other as the armature is released and returned to the biased side by the biasing spring. Pulses of the opposite polarity would, of course, have no effect on the ringer. This makes it possible to ring either of two ringers on one wire by choosing the polarity of pulses to be sent out over the line.

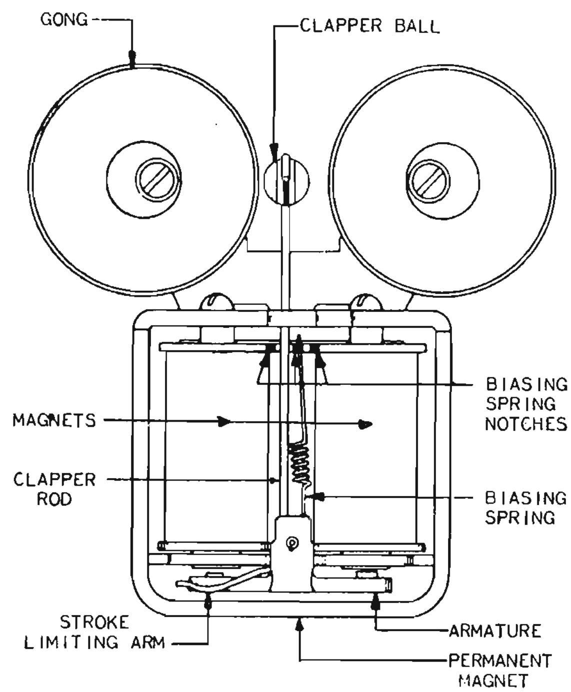

Figure 2-16 Biased Ringer

The harmonic ringer resembles the unbiased ringer in general construction. However, the armature of the harmonic ringer is secured to a stiff steel spring rigidly mounted between the two halves of the core yoke, instead of being pivoted by trunion screws. Thus, the armature and tapper are held normally in a median position. Each ringer is mechanically tuned so that it responds only to ac ringing of one frequency. The natural period of vibration is determined by the strength of the spring and the weight of the gong tapper. The four ringing current frequencies are: 16-2/3, 33-1/3, 50 and 66-2/3 cycles per second.

2.11 RINGING MULTIPLE-PARTY LINES

A. 2-Party Selective Ringing

In 2-party selective ringing, the ringers of the two parties are connected one from each side of the line to ground, instead of across the line as in individual lines. This is shown schematically in Figure 2-17, in which the subscriber stations, other than just the ringer portions, do not appear. Likewise, the tripping circuit is not shown, and the ringing circuit is shown only symbolically. Actually, the ringer is essentially the same as already indicated, but with a means for applying the ringing

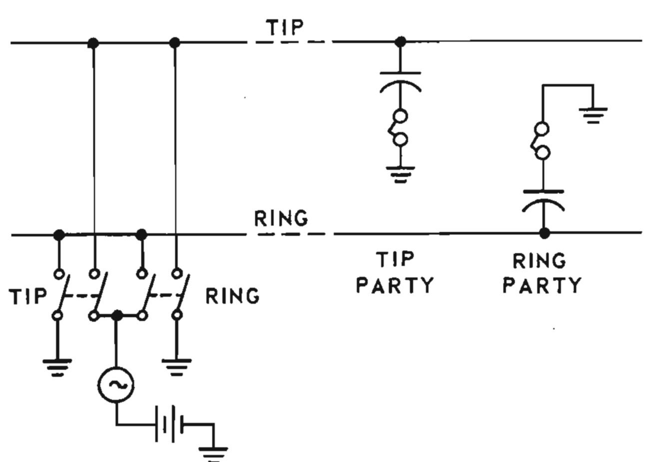

Figure 2-17 2-Party Selective Ringing

voltage to either side of the line at will, ground being applied to the opposite side in either case. If ringing voltage is applied to the tip side of the line, only the tip-party ringer will operate, as the ring-party ringer is then grounded on both sides. When ringing voltage is applied to the ring side of the line, the opposite occurs.

B. 4-Party Full Selective Relay System

The first successful 4-party full-selective ringing was accomplished by having a relay in series with a capacitor bridged across the line at each party's station. Operation of the relay applied ground to the ringer, as shown in Figure 2-18. In this diagram, two degrees of selection in the ringing are obtained, first by applying the ringing voltage to either tip or ring wire, as in the case of 2-party ringing, and further by changing the polarity of the battery current which is superimposed on the alternating current from the ringing machine. Thus four selective combinations are obtained, positive or negative direct current with alternating current on the tip wire, and positive or negative direct current with alternating current on the ring wire.

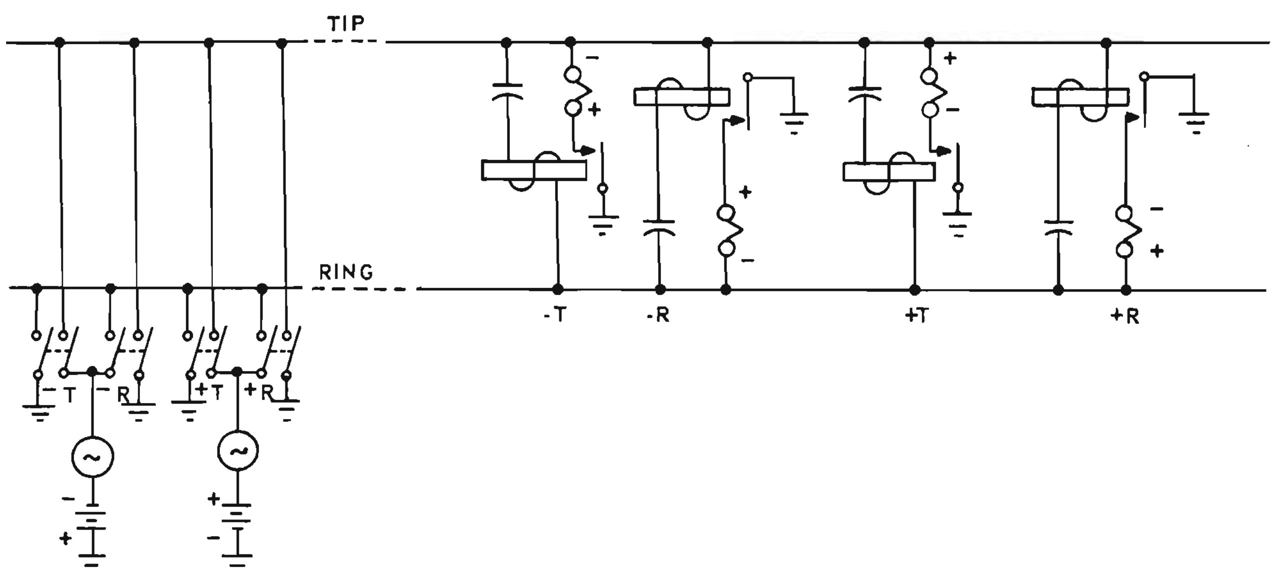

Figure 2-18 4-Party Full Selective Ringing Using Relays

When any one of the four combinations is applied (by throwing any one of the four switches in the diagram) all four of the relays operate, as there is no directional or polarity sense in the operation of the relays. Ground is thus applied to all four ringers, but only two of these are connected to the side of the line corresponding to the one switch thrown, thus eliminating the other two ringers. Which one of the two possible ringers operates, is determined by the polarity of the direct current and the bias of the ringer. The bias is obtained mechanically by means of a spring which pulls one end of the armature of the ringer to a stop position where it is nearly in contact with one of the cores of the ringer winding. Of the two ringers connected to the tip wire, one is biased to the side which requires positive direct current to overcome the pull of the spring (negative direct current only holds the armature more firmly against the core), and the other to the side which requires negative direct current. The two ringers connected to the ring wire are similarly biased for positive and negative operation. Thus only one ringer can operate when one of the switches shown in the diagram of Figure 2-18 is closed.

C. <u>8-Party Semiselective Coded Ringing</u>

<u>8-party semiselective ringing</u> is obtained by doubling up on a 4-party full-selective arrangement. Two ringers operate for each of the four combinations of ringing. The final step in selection is achieved by code, for instance, one ring for one of the two selected ringers and two rings for the other.

D. <u>Inverted Relay Biased Bell System</u>

In order to overcome the difficulties experienced with ground potentials which seriously interfered with the operation of Relays in the Central Office, as well as causing substation "Cross-Ringing" or failure to ring, the position of the ringer and the relay was reversed to obtain the Inverted Relay Biased Bell System as shown in Figure 2-19.

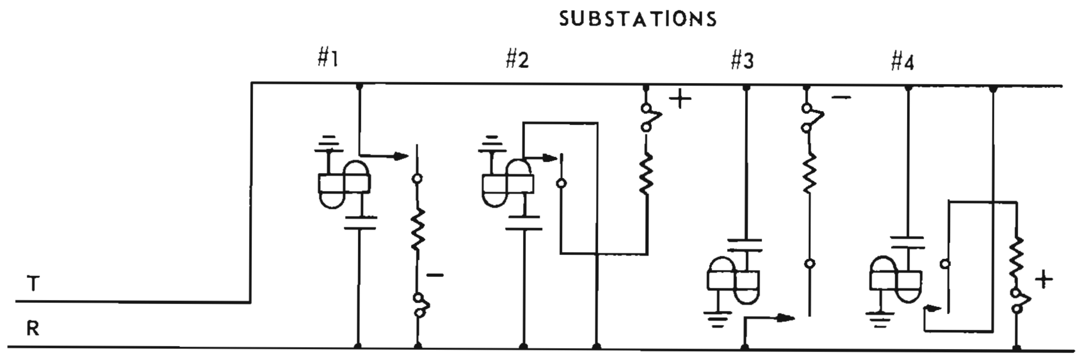

Figure 2-19 Inverted Relay Biased Bell System

Two (2) substation relay windings are connected from each side of the customer line to ground, each relay in series with a capacitor. When pulsating ringing current is applied to the called customer line, one side of the line is grounded. As a result, only two(2) substation relays operate - those two having their windings connected to the ungrounded side of the line. One of the two substation ringers, bridged across the customer line by operation of the two substation relays, is selected by applying pulsating ringing current of the proper polarity to the line.

When positive ringing pulses are applied to the tip conductor of the called customer line and ringing ground to the ring conductor, Substation #3 and #4 relays operate, bridging their respective ringers across the subscriber line. Only Substation #4 ringer operates as it is biased for positive ringing pulses.

E. <u>4-Party Full Selective Ringing Using Harmonic Ringers</u>

In <u>4-party full selective harmonic ringing</u>, each substation ringer is bridged across the customer's line, in series with a capacitor. A particular substation is signaled by the selection of one out of four ac ringing current frequencies: 16-2/3, 33-1/3, 50 or 66-2/3 cycles per second applied to the called customer's line. Only the ringer tuned to the frequency selected will operate.

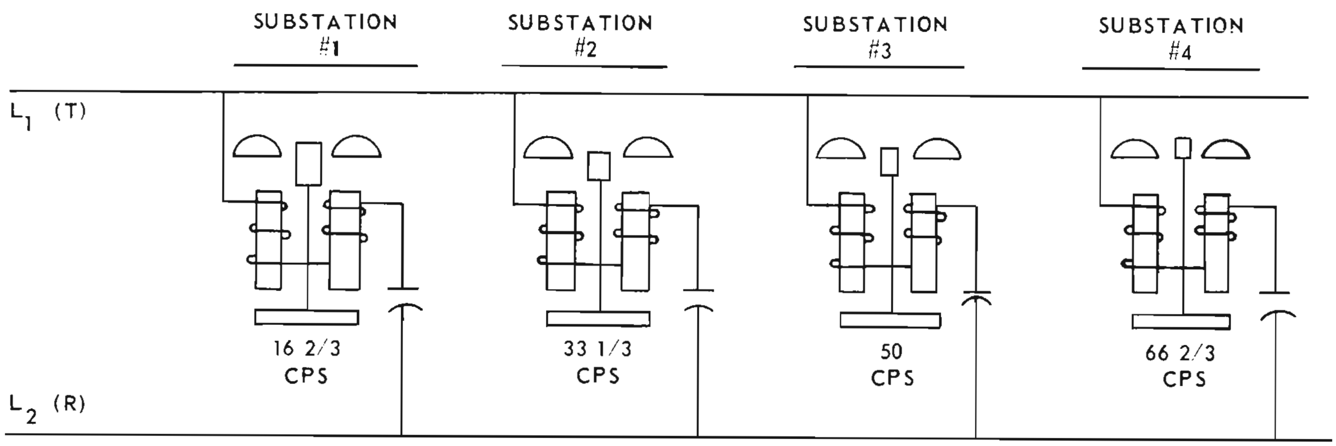

Figure 2-20 4-Party Full Selective Ringing Using Harmonic Ringers

8-Party full selective ringing is then possible with the use of harmonic ringers. Four substation ringers are connected from one side of the line, and the remaining four ringers from the other side of the line, each to ground and each through a capacitor. Any one of the eight substations may be signaled, with the exclustion of all others, by applying ac ringing current of the correct frequency to the side of the customers line, tip or ring, to which that substation ringer is connected, utilizing ground return.

The harmonic ringer is not used too frequently in the Bell System. It is inconvenient to manufacture four different types of the harmonic ringers. It is simpler to manufacture a ringer with the biasing spring that can be positioned to operate on positive superimposed ringing, negative superimposed ringing or ac ringing current alone, by neutralizing the biasing spring.

F. 4-Party Full Selective Ringing Using 3-Element Cold-Cathode Tubes

The present standard method of 4-party full selective ringing is one which employs 3-element cold-cathode tubes instead of the relay and capacitor. These are arranged as indicated in Figure 2-22. The tubes have a control anode and cathode which form a "control gap." This breaks down, or ionizes, when a potential of

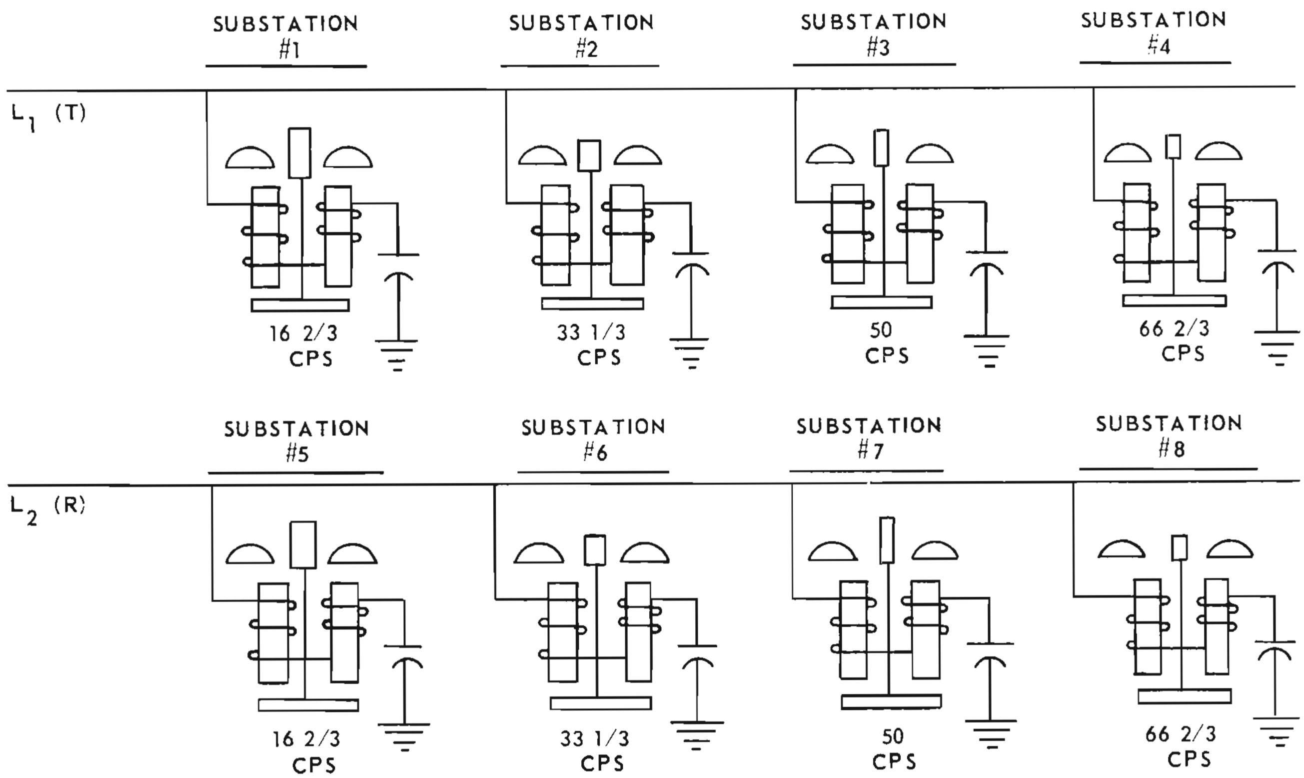

Figure 2-21 8-Party Full Selective Ringing Using Harmonic Ringers

about 70 volts (of either polarity) is applied across it. Ionization of the gas in the tube permits current conduction to occur in the main gap, provided the third element, the main anode, is positive with respect to the cathode. Current in the control gap is limited by a series resistor to about one microampere, but the main gap can handle currents as high as 30 milliamperes. Referring to Figure 2-22, it will be noted that when any one of the four switches is thrown, the control gaps of two of the tubes will breakdown. The other two control gaps cannot breakdown because both sides of the gaps are at ground potential. For instance, if the -T switch is thrown, the control gaps of the tubes for the -T and +T parties will breakdown. The superimposed direct current has the correct

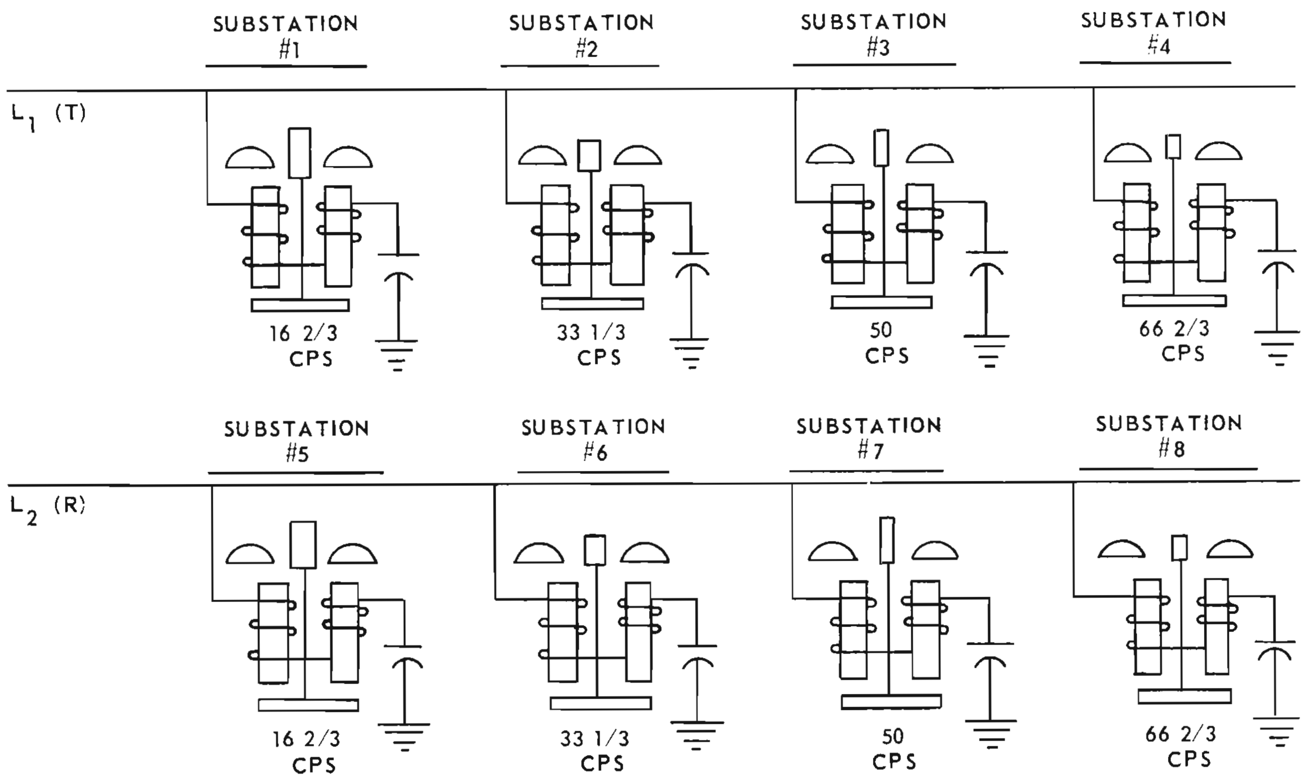

Figure 2-21 8-Party Full Selective Ringing Using Harmonic Ringers

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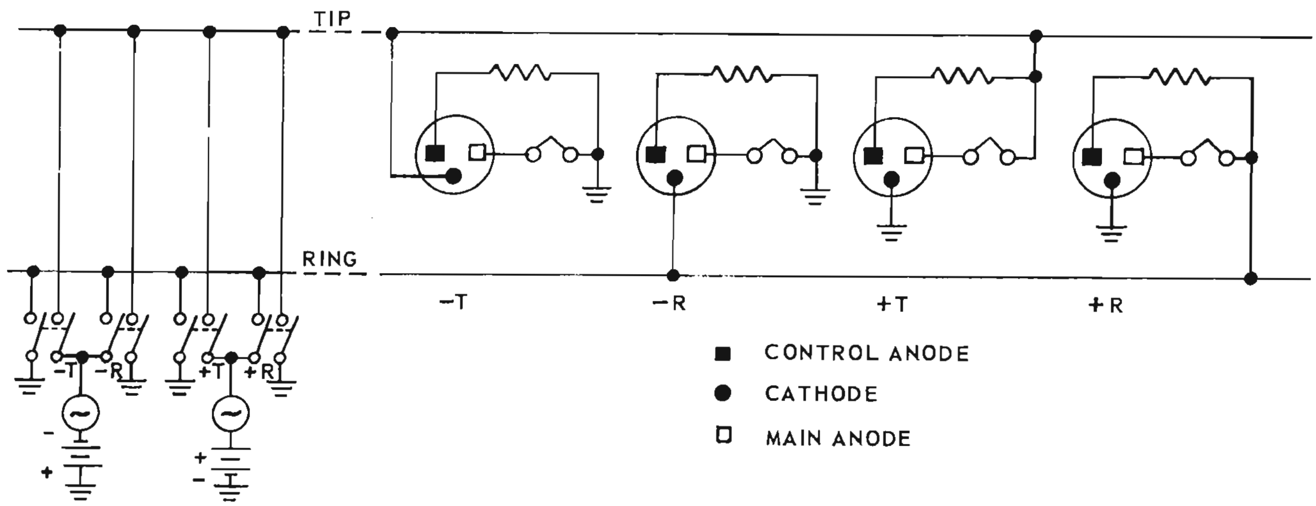

Figure 2-22 4-Party Selective Ringing Using 3-Element Cold-Cathode Tubes

polarity to cause conduction of ringing current in the main gap of the -T party, but the wrong polarity for that of the +T party. Hence the ringer of the -T party is the only one of the four which operates. In the same way, throwing any one of the other three switches operates only the one corresponding ringer.

The tube subset has several advantages over the relay type. With the relay type subset, ringing current flows through 2 ringers and 4 relays. In the case of the inverted relay biased system, ringing current flows through 2 relays and 1 ringer. However, ringing current flows through only 1 ringer in the tube-type subset since the electron tube will pass current in only one direction. This arrangement reduced the voltage drop due to line resistance, and permits an extended ringing range for 4-Party Service.

The electron tube also eliminates bell tapping and false ringing sometimes caused by dialing or switching operations.

In addition, the tube may be mounted in any position, while the relay must be mounted vertically to insure proper operation. Adjustment of the relay is also required to insure proper functioning of the relay type subset.

2.12 RINGING AND TRIPPING CIRCUITS

A simplified schematic of a ringing machine appears in Figure 2-23, which shows ringing and tripping circuits applied to an individual line, that is, to a subscriber line to which only one station is connected. It will be noticed that the commutator which supplies ringing current to the line is divided into two segments which correspond, respectively, to a ringing interval of about two seconds, followed by a silent interval of four seconds. During both ringing and silent intervals, direct current from a 45-volt battery is supplied. Alternating current is supplied only during the ringing interval.

Ringing is accomplished by closure of switch contacts, or, in dial offices, relay contacts as shown at the point marked C in the diagram. This causes the relay marked A to operate and relay B remaining unoperated since its winding is short-circuited. Operation of relay A applies ground to one side of the customer loop and the ringing commutator to the other side. Alternating current flows through the ringer at the customer station set during the ringing interval, and to ground back at the central office, thereby ringing the bell. As long as the customer does not lift the handset from its mounting, there is no dc path in the customer circuit.

The purpose of the tripping relay is to insure that the called subscriber cannot be "rung in the ear," whether he answers the call during the ringing interval or the silent interval. In other words, operation of the tripping relay is an indication that the customer has removed the handset from its mounting, and is presumably ready for conversation. The tripping relay is so designed that it cannot operate on alternating current alone, that is, as long as the direct current path is open. Removal of the handset closes the direct current path through the switch-hook, transmitter, and one induction coil winding at the subscriber station. The relay will operate firmly on direct current alone if the call is answered during the silent interval. If the call is answered during the

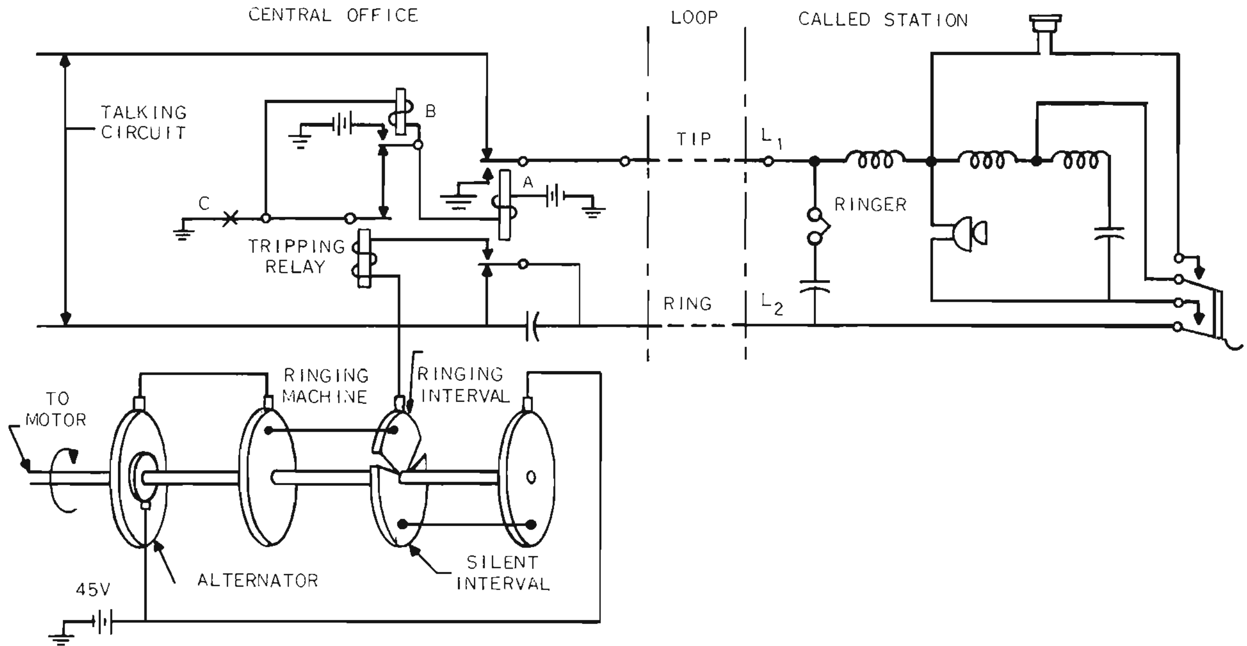

Figure 2-23 Superimposed Ringing and Tripping Circuits

ringing interval when both alternating and direct currents flow through the winding of the tripping relay, the latter will tend to operate intermittently. However, at the first operation of the tripping relay, the short-circuit is removed from the winding of relay B, which operates and locks up to battery through its contacts, thereby shunting down relay A. This, in turn, restores the line to the talking condition before the called customer can raise the handset to his ear.

A condenser is shown in Figure 2-23 near the contacts of relay A. When the circuit is in the talking condition, with relay A nonoperated, the capacitor is short-circuited. In the ringing condition, relay A removes the short-circuit from the capacitor, which allows a small amount of ringing current to flow back to the calling customer, thus permitting him to hear the so-called "audible ring."