ELECTRON RINGING TUBES APPLICATION

1. GENERAL

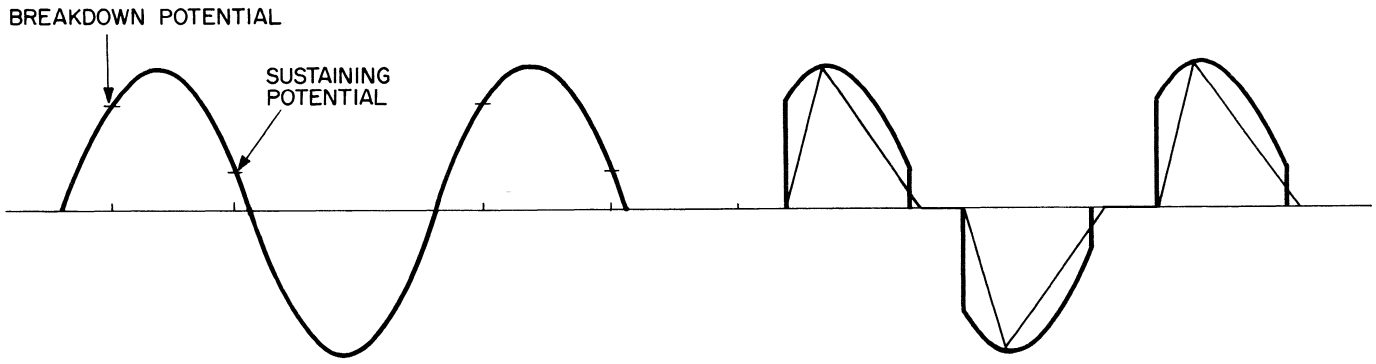
1.01 This section provides information concerning the application of cold cathode gas-filled electron tubes at customer stations in conjunction with telephone set ringers.

2. INDUCED NOISE REDUCTION

2.01 Despite careful construction with proper open wire transpositions, cable sheath continuity and maintenance of specified clearances, telephone plant will often be subject to undesired longitudinal alternating current, due either to inductive or electrostatic coupling with paralleling high-potential electric transmission or distribution lines or to an alternating current flowing in the earth sufficient to generate an a-c potential difference between the locations of the customer station and the central office. A portion of the longitudinal potential thus caused is converted to audible metallic noise (hum) by small imbalances in the central office equipment, in the loop facility, and by the type and location of grounded ringers at party-line stations in divided-ringing exchanges. The insertion of a ringer isolation device such as a cold-cathode gas diode in series with the ringer at every station on such a line will greatly increase the impedance to ground provided by the ringer path, so long as the longitudinal line-to-ground potential remains below the value required to ionize the gas across the gap between the electrodes in the tube. Thus a very high impedance is maintained in each of the ringer paths during conversation and idle-line periods, so that the total longitudinal current in the line is reduced. The a-c potential appearing between the two line conductors is thereby minimized, with resultant freedom from supply-frequency noise or hum.

2.02 When ringing potential is applied from the central office between one line conductor and ground, the gas in each tube connected to that conductor ionizes as soon as its breakdown potential is reached, resulting in a visible glow which appears around whichever electrode is more negative at that moment. As a result of the ionization, the tube conducts and offers only a very low impedance in series with the ringer, the armature of which is actuated by the current flow. After the peak of the wave has been reached, the tube continues to conduct until its sustaining potential is passed, at which point the glow disappears and the electrode gap again introduces a high impedance into the circuit, halting current to the ringer. As the breakdown potential is reached for the opposite polarity, the tube again conducts, the glow this time appearing around the other electrode, and current flows through the ringer in the reverse direction. When the applied potential falls below the sustaining value, the tube again cuts off.

2.03 Since the series tube conducts only during the period in each half-cycle between its breakdown value (as the applied potential is rising) and the somewhat lower sustaining value (as it is falling), the waveform of the current flowing through the ringer coil exhibits a sawtooth pattern even when the generator waveform is sinusoidal (see Figure 1). The smaller amount of energy imparted to the



1a. Sinusoidal Generator Waveform

1b. Irregular (Sawtooth) Waveform at Ringer.

Figure 1. Change in Waveform of Ringer Current Caused by Gas Diode in Series With Ringer.

ringer armature during these shorter pulses, and the potential drop across the tube, cause a reduction in ringer performance, particularly in the case of frequency ringers, where a large mass with low compliance must be set in motion. For this reason, series tubes should be used only with straight-line ringers. Where power induction is experienced on lines with frequency ringers, use a ringer isolation relay.

2.04 If the interfering a-c line-to-ground potential is greater than the sustaining potential of the tube, ionization of the gas will be maintained indefinitely, once it has been started by a ring on the line. If the foreign potential is greater than the breakdown potential, the gas will ionize immediately upon connection. Ringing tubes must therefore not be used if the value of the foreign potential is expected to approach that of the sustaining potential. Drainage devices may be helpful in such cases (see the 605-202 series of General System Practices).

2.05 It should be noted that if a gas tube is installed in series with the ringer at one station on a line, a tube must also be installed at every other station on that line in order to secure any reduction in induced noise, and in order to avoid ringing difficulties due to a mixture of high and low impedance ringer paths. If installation of series tubes is found necessary on an open-wire line served by one pair of a given lead, it is probable that the lines served by the other pairs in the exposed spans of the lead will also benefit from a similar installation. However, if longitudinal imbalance is inherent in the construction of the lead (incorrect transposition or excessive conductor-to-ground conductance, for example), ringing tubes will not correct the condition.

3. SELECTIVE RINGING

3.01 To provide a system of four-party full-selective ringing without the use of tuned ringers or multiple generators, arrangements known generically as polarized ringing have been developed. By the use of a two-code interrupter, they may be expanded to eight-party service on a semi-selective basis. A three-code interrupter provides a capacity of twelve parties and is sometimes used on ten-party rural lines. In the system most commonly used, called superimposed ringing, the single-frequency generator output is stepped up slightly through an autotransformer and connected to the interrupter busses in series with two batteries of bias cells, with one bus wired for positive bias and the other for negative. The output of the ringing interrupter is therefore an alternating potential of about 135 volts superimposed on a direct bias potential of 45 or sometimes 67½ volts.

3.02 At the party-line stations, each ringer is connected in series with a cold-cathode gas electron tube on a divided-ringing basis. The use of biased straight-line ringers allows four combinations of ringer polarity and line conductor. If the tubes used are simple diodes, as in Part 2, the approximately equal area of the two electrodes will permit approximately equal current flow in either direction. In such cases the selective response of the ringers is due entirely to the mechanical action of their bias springs, which exert enough force on the armature to prevent gong tap on the relatively low potential supplied to the ringer when the party of the opposite polarity on the same line conductor is being called.

3.03 On such a call, the armature of the selected ringer is drawn back, overcoming the force of its bias spring, during the half-cycle when the bias potential and the alternating component are additive. At this time, the oppositely-poled ringer is also heavily energized, but the generated flux merely helps the bias spring to hold the armature in place against the pole piece. During the remaining half-cycle, when the reverse a-c peak is reduced by the bias value, the armature of the selected ringer is aided somewhat in its return to the rest position, and the flux generated in the oppositely-poled ringer is insufficient to overcome the force of the bias spring.

3.04 While such an arrangement is sometimes used, unduly stiff settings of the ringer bias springs are necessary, and have an adverse effect on ringer output quality. A more common use of two-element gas tubes for selective ringing is in the system known as pulsating ringing, in which the output of the central office generator is connected to the interrupter busses in series with half-wave rectifiers, rather than bias batteries. In this case the output of the ringing interrupter is a pulsating direct potential of the selected polarity, and there is no tendency to gong tap at the oppositely-poled station. This permits more normal values of bias spring tension.

3.05 A series of three-element tubes has been developed for superimposed ringing in which two elements of substantially different surface area (see Figure 2) are separated by a greater gap than

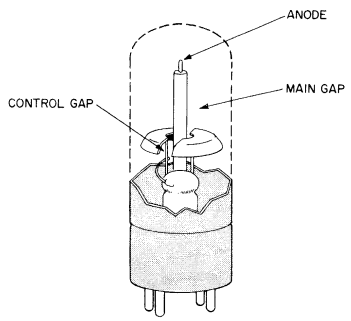


Figure 2. Electrode Arrangement, Three-Element Tube (313C Shown).

would be practical with the diodes previously mentioned. The element with the greater area, provided with a coating from which electrons can more readily be released, is the cathode, and a thin wire element serves as the anode. If only this main gap were connected in series with the ringer, a potential of approximately 180 volts would be required to ionize the gas for conduction. The addition of a third element, called the control anode, separated from the common cathode by a smaller control gap and protected against excessive current flow by a series resistance, provides the means for initial ionization of the gas in the tube at lower potentials of approximately 65 to 90 volts. The control gap and its series resistance should be connected in parallel with the series combination of the main gap and the ringer, as shown in Figure 3. Because of the very small transfer current (only a few hundred microamperes flowing in the control gap will cause ionization to transfer to the main gap), the potential drop in the series resistance is fairly low despite its high value (120,000Ω). The control gap is therefore maintained at nearly the full conductor-to-ground potential, and exercises control over the deionization of the tube, as well as its ionization.

3.06 The difference in surface area of the two main electrodes causes the main gap of the

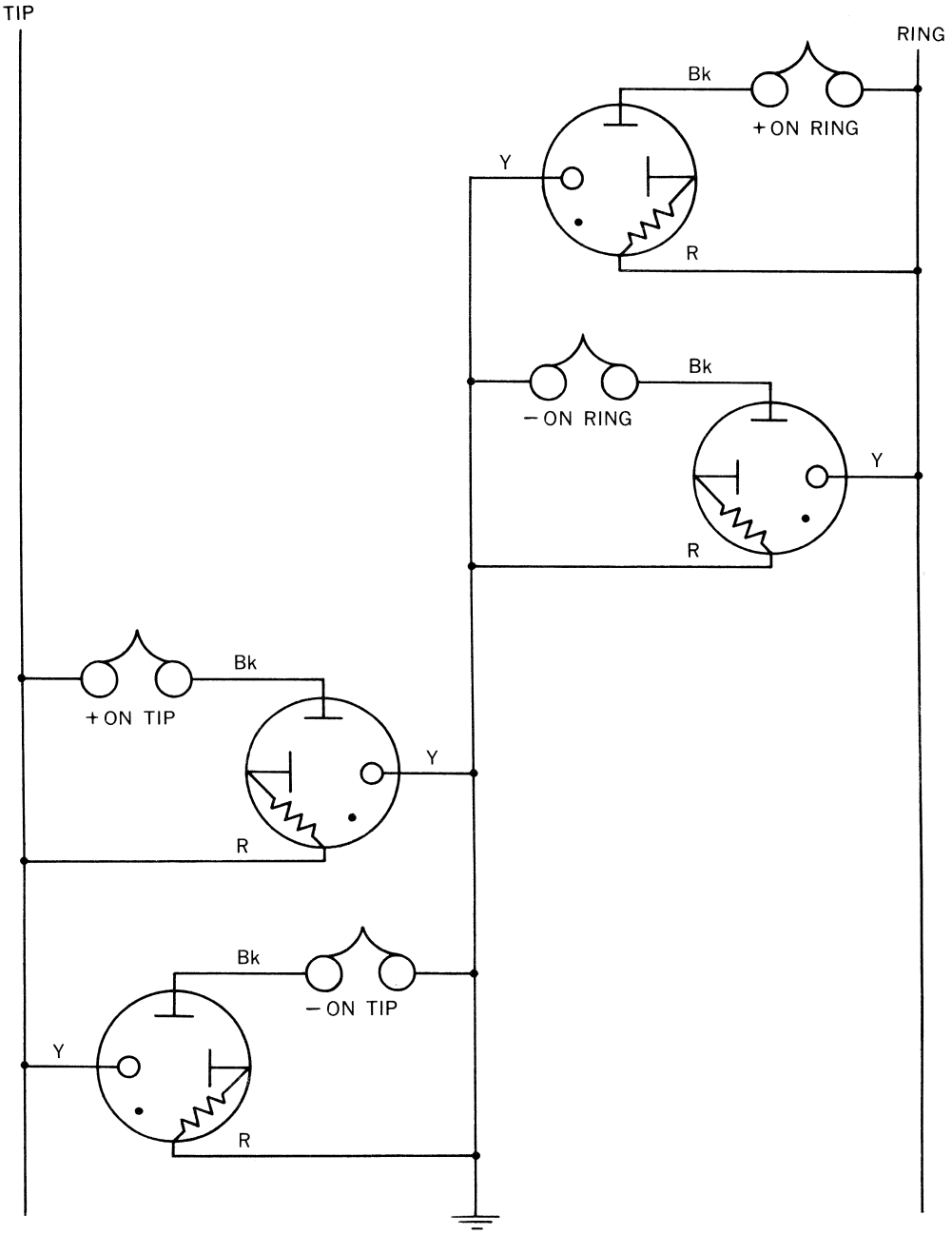


Figure 3. Superimposed Ringing Connections for Four-Party Selective Service

three-element type of tube to exert a rectifying action, passing only about 1/10 as much current in the reverse direction as when properly poled. Accordingly, it is not necessary to provide as stiff an adjustment of ringer bias springs as when two-element tubes are used.

3.07 When a line served by open wire in an exchange arranged for superimposed ringing is exposed to induction from parallel electric distribution lines, the induced potential may exceed the sustaining value of the control gap. For this situation a series of four-element tubes has been developed, in which the starter anode is separated from the main cathode and is positioned near a separate starter cathode which is also protected by a series resistance. The main gap is connected in series with the ringer between the line conductor and ground, just as with any other ringing tube, but the control gap is connected between the two line conductors, so that it is unaffected by induced conductor-to-ground potentials.

4. TUBE SELECTION

4.01 Two-element ringing tubes which have been used for noise reduction or selective ringing include the G.E.Co. NE-32 neon lamp (see Figure 4) and the Brach RTC-series tubes. The Leich 014226 ringing tube was an NE-32 glow indicator lamp modified by the addition of spade-tipped leads and coated with opaque black paint to stabilize the operating characteristics. Leich 600-, 900-, 700- and 100-series telephone sets were arranged for interior mounting of this tube by means of an accessory clip. Although the basic lamp is still manufactured, preparation of the modified assembly has been discontinued by A.E.Co. For connections, see the appropriate section in the 473 series covering the desired series of Leich sets.

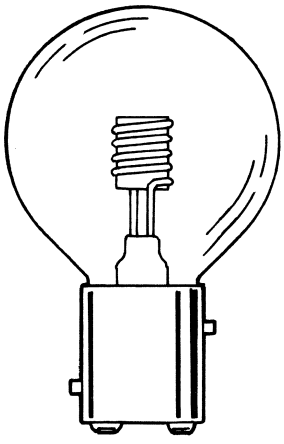


Figure 4. G.E. Co. NE-32 Neon Lamp.

4.02 The Brach RTC-2 ringing tube and its predecessor, the RTC-1, are cylindrical assemblies consisting of a half-inch diameter argon bulb, about 1½ inches long, mounted inside a 2½-inch length of black phenolic tubing of about 15/16 inch outside diameter, with its leads connected to metal caps inserted and pinned in the ends of the tube. An angle bracket secured to each cap by two eyelets and fitted with a washer-head screw provides a means of connecting the device into the ringer circuit (see Figure 5). Leich 600-series telephone sets were arranged for interior mounting and connection of the Brach tube directly by its terminals. Leich 900 sets can be fitted with accessory lugs to provide the same mounting and termination, while the 700- and 100-series sets can be fitted with a clamp, pad and leads for the same purpose. For connections, see the appropriate section in the 473 series covering installation of the desired series of Leich instruments.

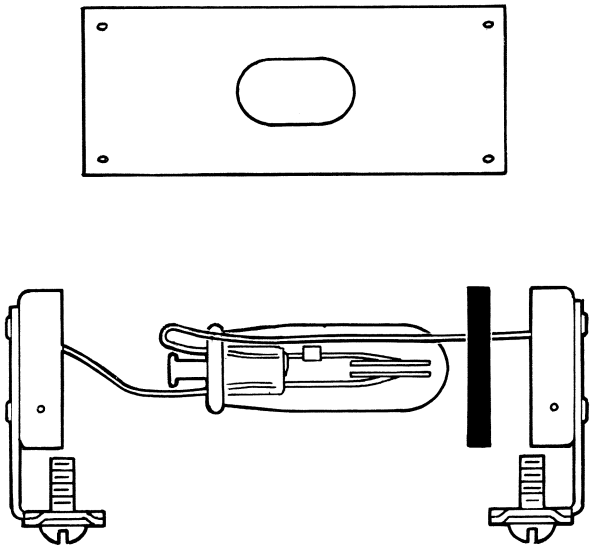


Figure 5. Brach RTC-2 Ringing Tube (shown disassembled).

4.03 Where desk telephone sets of the non-combined type are in use, the Brach tube may be mounted in the subset, adjacent to the coil, capacitor and ringer. Most combined sets, however, lack space for such mounting. If the station protector is located indoors or in a protected outdoor position, or if a fused-type protector is used, the tube may be mounted in or adjacent to the protector housing. For mounting purposes a 3/4-inch fuse clip is provided with each tube, as well as a 10-32 x ½" machine screw, nut and split lockwasher.

4.04 If lack of mounting space inside the telephone instrument would require that the tube be mounted at the protector, but the protector is of the compact fuseless type, mounted outdoors in an

exposed location, do not attempt to mount the tube adjacent to the protector. In such a case, or if a frequency ringer is involved, use a ringer isolation relay instead of a tube (see Section 471-151-200).

NOTE: The Brach RTC-2 ringing tube is sold under its inventor's original trade name, the Vincent Rare Gas "Relay", which was applied because of the analogy between its function and that performed by electromechanical relays previously used. To avoid confusion with the improved form of ringer isolation relay now in use, which employs a sealed reed capsule and a series gas tube, the use of the term "relay" in referring to the Brach tube has been avoided in this section.

4.05 When the Brach tube is installed at the protector, it should be connected between the ground conductor of the station wire and the ground terminal of the protector (see Figure 6). In this way, the direct ground connection to the protector units is maintained, and the ground connection in series with the tube is extended only to the ringers of the telephone sets connected to the station wiring. Where more than one set is served by the same protector, the ringing tube should be mounted at the protector, even if the instruments are of a type which will accommodate a tube within its housing, in order to minimize the number of tubes required.

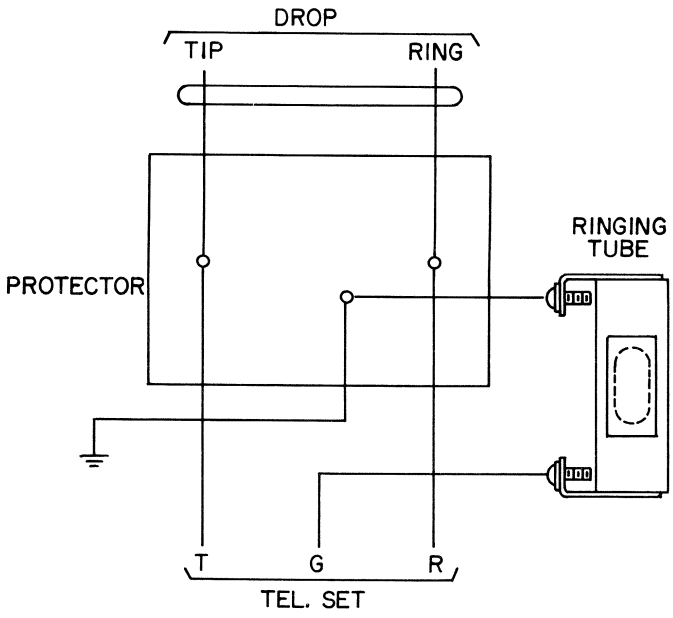


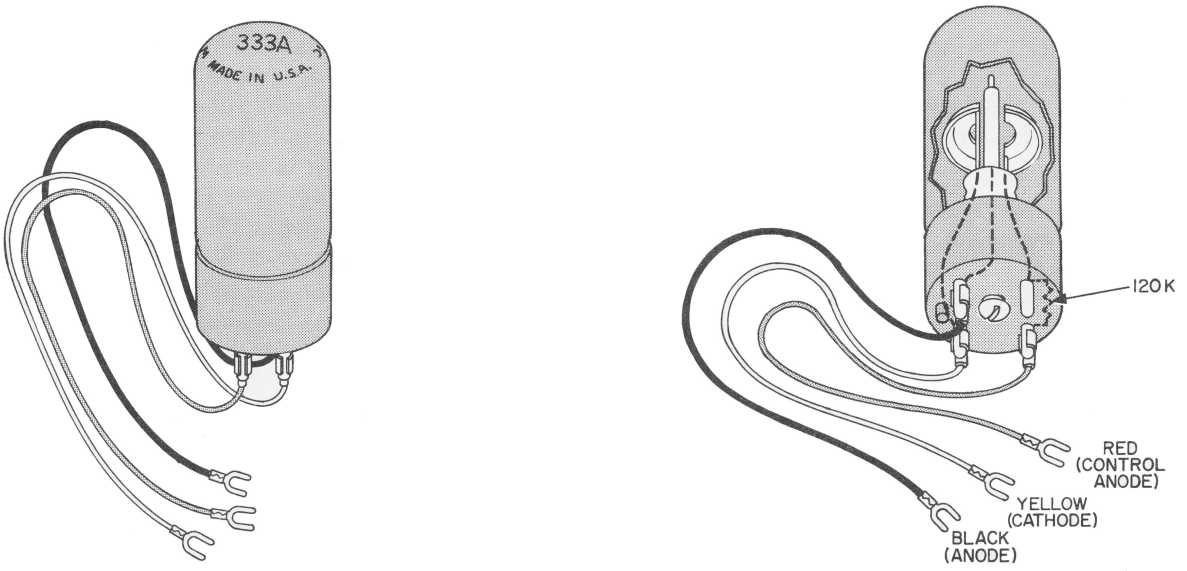
Figure 6. Brach RTC-2 Ringing Tube Connections at Protector.

NOTE: The phenol fibre tube surrounding the device has an aperture cut into it to permit checking the gas tube for a visible glow during operation. Since the breakdown potential of the tube is reduced by the effect of incident light, the aperture should be covered with black tape if the tube must be mounted outside the protector housing.

4.06 Three-electrode gas tubes which have been used for superimposed selective ringing inculde the W.E.Co. Numbers 313C, 333A, 359A, 372A, 405A and 426A. All but the last-named are similar in characteristics and basic construction, differing only in the terminating arrangements (see Figure 7). The electrodes are enclosed in a T-9 envelope covered with opaque paint to exclude light, with the control anode resistor housed within the tube base. The Number 313C tube has a four-pin standard electron tube base, the Number 333A has a base arranged for mounting with a single machine screw in the center, and has 12-inch spade-tipped leads soldered to the pins. The Numbers 359A, 372A and 405A are similar except for variations in lead length to suit particular applications. Mounting brackets or straps were manufactured to permit installing these lead-equipped tubes in Leich telephone sets and in the A.E.Co. Type 40 instrument. For connections, see the appropriate section in the 473 series covering installation of the desired set.

4.07 The W.E.Co. Number 426A electron tube assembly consists of a W.E.Co. 443A (6388) tube secured to a black styrene angle mounting bracket, and fitted with spade-tipped leads. An equivalent assembly is manufactured by the Chatham division of Tung-Sol. The 6388 tube is a three-electrode type enclosed in a T-6½ envelope with a miniature nine-pin base. The pins protrude through holes in the angle bracket and are welded to the control anode resistor leads and to terminals on the flexible wire leads (see Figure 8). The bracket is supplied with a #6 self-tapping screw which permits direct mounting of the unit in most telephone sets, ringer boxes or subsets. For connections, see the appropriate section in the 473 series covering installation of the desired equipment.

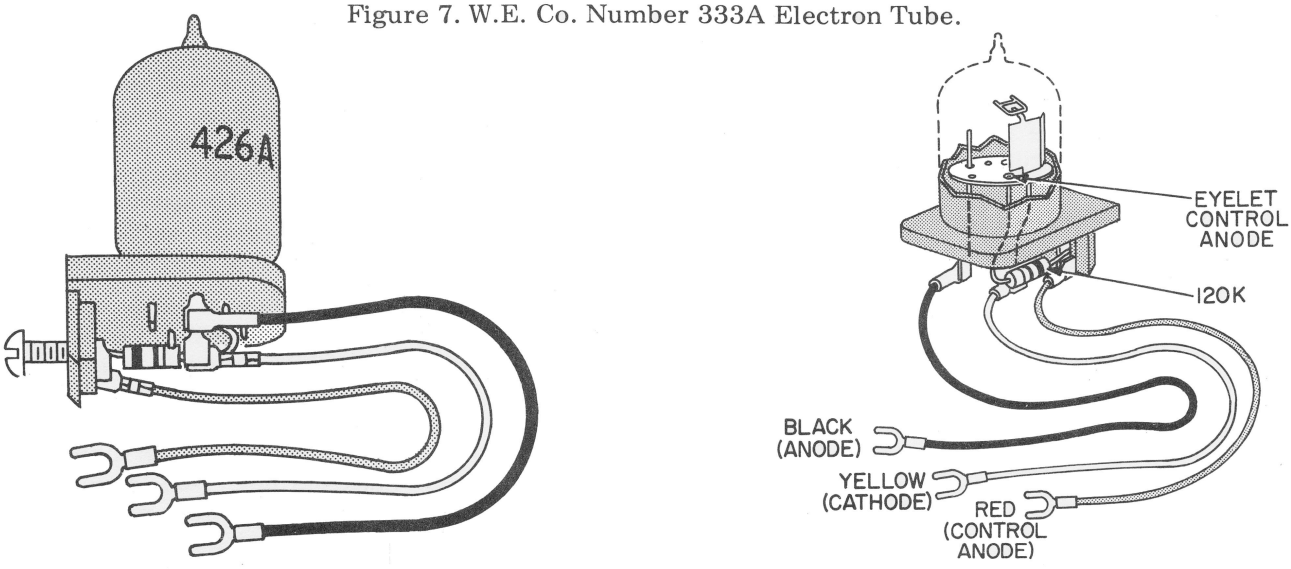
4.08 Four-electrode gas tubes which have been used for superimposed ringing include the W.E.Co. Numbers 411A and 425A. The Number 411A electron tube is mechanically similar to the Number 372A, but has a separate starter cathode and a fourth lead. The Number 425A tube bears a corresponding relationship to the Number 426A (see Figure 9). Intended primarily for field application, the Number 425A tube has been provided as a factory-wired option only in the Leich 100-series telephone sets. For its connections in that application, see Section 473-211-200.



7a. Exterior View

7b. Electrode Connections.

Figure 7. W.E. Co. Number 333A Electron Tube.



8a. Exterior View.

8b. Electrode Connections.

Figure 8. W.E. Co. Number 426A Electron Tube Assembly.

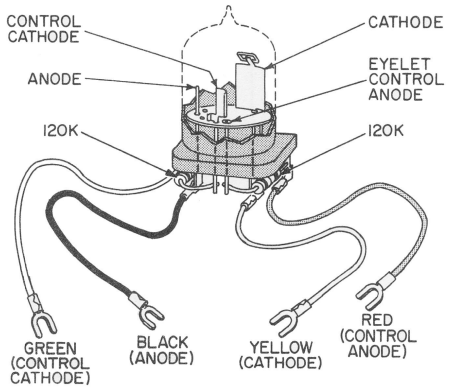


Figure 9. Electrode Connections, W.E. Co. 425A Electron Tube.