A Universal Telephone Ringer

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As part of the constant Bell System objective of standardization and simplification, a new and more efficient ringer, or bell, has been developed for the 500-type telephone set. Because this single, standard ringer can be used for all classes of telephone service, two important savings will be realized. Manufacturing costs will be reduced by eliminating the necessity for different types of ringers, and service costs will also be reduced, since there will be no need for substituting a new ringer when a customer wishes to change his grade of telephone service.

The bell that summons you to the telephone has been classified, by the communication engineer, as a ringer. This bell must ring when you are being called regardless of the miles between your telephone and the central office from which the calling signal is generated. But the central office generates other signals as well. It is of equal importance that this bell refuse to ring for all extraneously induced voltages and all signaling voltages not intended for your particular telephone set. It is this combination of a carefully controlled "ring" requirement and an additional carefully controlled "no ring" requirement that marks the ringer as a highly specialized bell and as an important component of telephone apparatus.

Telephone ringers have been regarded so specially in the past, that in 1952 the Western Electric Company found it necessary to manufacture twenty different ringers to satisfy the Bell System demand for ringers in new and repaired telephone sets. Most of these were adopted prior to the tremendous expansion of telephone plant that has occurred in the last twenty-five years. As the size of the plant increased, the need for strict standardization of apparatus became a necessity.

The new and much improved 500-type telephone set* was introduced to the public in the latter part of 1949, and about four million have since been produced. While this set was being developed, serious consideration was given to the possibility of designing a single ringer that would meet the ringing requirements for all major classes of Bell System service.

Since no practical means was then at hand to realize this objective, two new ringers were developed and introduced.† One of these, the C2A, was to be used in all individual, two-party, four-party semiselective, and some multi-party coded ringing

Above — The author placing a telephone ringer in automatic adjusting machine used to balance magnetic and mechanical forces.

* Record, *September*, 1951, *page* 414.
† Record, *October* 1951, *page* 473.

installations. The other, the C3A, was to be used in all four-party full-selective and eight-party semi-selective installations.* To obtain this selective ringing, the latter ringer was always used in conjunction with a cold cathode tube.

Thus, only two ringer codes were needed to supply all of the ringing requirements of the new telephone set. This was a noteworthy improvement over previously introduced telephone sets with their multiplicity of ringer codes.

Since many advantages would be gained by the use of a single ringer, however, further work was undertaken with the objective of developing a design suitable for use with all classes of service. If this could be done, only one coded ringer would need to be manufactured for all of the various types of new telephone sets. This would in turn simplify field operations, since any change in grade of service could be taken care of without changing the ringer in the regraded set.

In attempting to use the individual line ringer in four-party service, there were limitations that made this application impracticable. Its sensitivity, adjusted by the shop to meet the requirements of a single-party line service, was insufficient to guarantee operation in all multi-party services. In addition, the ringer impedance was considerably higher than that desired for the efficient use of the power available in four-party selective telephone service.

Perhaps the most serious limitation of the single-party ringer, however, was one of fundamental design. An automobile engine designed to run on gasoline will not run as well on any other fuel. Similarly, this ringer, designed to operate on a symmetrical full-wave current, behaved badly and occasionally became non-operative when used with the unidirectional pulsating current of four-party telephone service.

The four-party selective ringing circuit used by the Bell System is shown in Figure 1. The activating voltage used in selective ringing consists of a twenty-cycle alternating voltage on which a direct-current biasing voltage has been superimposed. In four-party selective ringing, two parties are connected between each side of the line and ground, and signaling is accomplished by impressing this combined ringing voltage across one side of the line and ground. The direction of the dc bias on the impressed voltage determines which of the C3A ringers connected to that side of the line will ring. Selection is obtained by connecting the cold cathode tube and the ringer coil in each of the telephone sets so that one is activated with a negatively biased signaling voltage and the other with a positively biased signaling voltage.

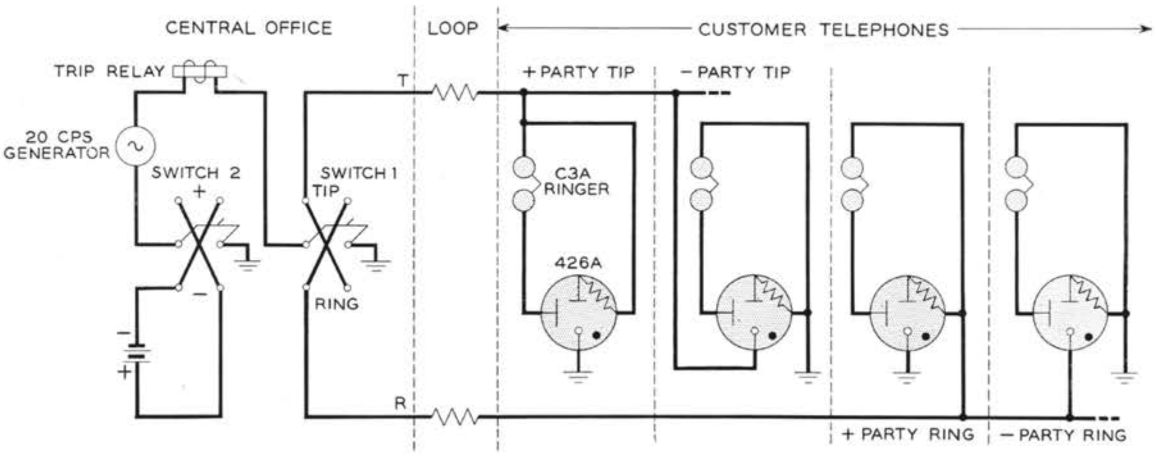

Fig. 1 — Circuitry involved in selecting one ringer from the four telephones on a four-party line.

To illustrate, assume in Figure 1 that the plus party on the tip side of the line is being called. At the central office a connection is established between the ringing generator and the tip side of the telephone line (switch 1). The other side of the generator in turn is connected to the positive terminal of a grounded central office battery (switch 2). The ring side of the line is also grounded to insure against false operation of party telephones on that side of the line. This positively biased twenty-cycle ringing

* With full-selective ringing, the customer hears only one ring – his own; with semiselective and coded ringing, he hears in addition one or more other ringing combinations.

voltage, which is being impressed between the tip side of the line and ground, alternates between a rather large positive value and a relatively small negative value because of the dc bias. The cold cathode tube in the plus party tip telephone, being connected to pass those positive voltages that exceed the breakdown voltage of the tube, will allow a considerable portion of each cyclic positive pulse to pass through the ringer to ground. These pulses activate the ringer and summon the customer.

Now let us see what happens when this voltage is impressed across the ringer circuit of the non-called party on the tip side of the line. The cold cathode tube is so connected that it will not pass the positive voltages. The magnitude of the voltage during the negative portion of the cycle is low, and

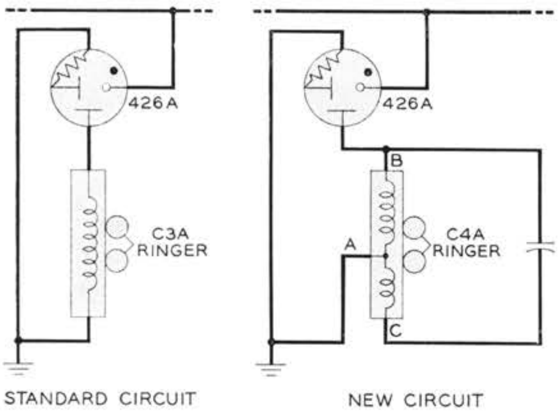

Fig. 2 — Left: standard ringing circuit for multi-party lines; right: the newly developed circuit that has made possible the use of C-4 telephone ringers in multi-party lines.

even if it exceeds the breakdown voltage of the tube, it is insufficient to activate the ringer. Since little or no current will flow under these circumstances, the ringer will not ring and needlessly disturb the non-called customer.

Thus four families can be provided telephone service through the cooperative use of a single pair of wires, and any one of them can be summoned to the telephone without disturbing the other three.

It has been shown that the current flowing through the ringer in four-party selective service is unidirectional and pulsating. Therefore each ringer must be properly poled on installation so that it will be activated by the ringer current intended for it. When thus poled, the initial ringing pulse will cause the armature to operate, allowing the clapper ball to strike the furthest gong. During the time interval between pulses, the armature must restore to the nonoperate position, allow the clapper ball to strike the other gong, and be available for reactivation by the next pulse of current. This ringer must therefore be adjusted with a sufficiently high mechanical restoring force to assure that the armature returns to its original position between ringing pulses.

Should the armature stick magnetically in the operate position, the ringer would be incapable of responding to succeeding signaling impulses. The customer's telephone would then be out of service to all incoming calls and could only be restored to service through a visit by a telephone repairman.

The best ringing tone is realized when the mechanical restoring force is held to a minimum. The single-party ringer is therefore purposely adjusted to have a minimum restoring force, and there is a real danger that a ringer so adjusted will stick and thus become inoperative if used in four-party selective service.

A new ringer circuit has now been developed which overcomes the major difficulties of operating, in four-party selective service, a ringer designed for individual party service. Figure 2 shows the newly developed circuit as well as the standard circuit previously used for multi-party operation.

The single coil of the individual party ringer is composed of two separate windings: an inner low impedance winding and an outer winding of considerably higher impedance. In single-party service the two windings are connected series-aiding and act as a single winding. In two-party message rate service the low impedance winding is connected, for all tip-party dial message-rate installations, as a one thousand ohm bridge between the tip side of the line and ground for purposes of tip-party identification. Since this bridge to ground is not present in the ring-party installations, identification can be established between parties on the basis of line impedance to ground. In the new circuit the double winding is used to advantage by connecting the ringer as an auto transformer. The low impedance winding in series with a 0.4-mf condenser is bridged across the second ringer winding. This resonant circuit is also connected in series with the main gap of the three-element cold cathode tube.

In the interest of over-all economy, only one network was coded for all 500-type sets. Since the ringing capacitor is contained within the network, it is available for four-party selective and eight-party semi-selective service, even though the previous multi-party connections had not called for its use in the telephone circuit. By taking advantage of the

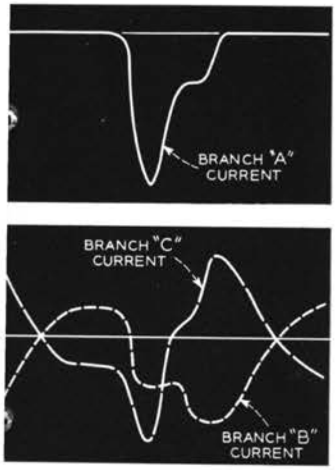

Fig. 3 — Above: *current in Branch A of Figure 2;* below: *currents in Branches B and C of Figure 2.*

double ringer winding and by making use of an available component of the telephone set, a major step was thus taken toward the use of a single ringer code for all 500-type telephone sets.

With these connections, the ringer impedance is considerably reduced. This increases the signaling efficiency since it enables more power to be delivered to the ringer.

In addition, the unidirectional pulsating activating current normal to four-party service is converted to approximately a symmetrical full-wave current within the ringer windings through the use of this resonant circuit connection. Thus the single-party ringer, designed to operate on full-wave current, can now also be used for full-selective four-party service. Sticking of the armature is no longer to be feared since the reverse half cycle of activating current is now present to drive the armature back to its normal position. In addition, there is a marked improvement in the character of the ringing tone due to this full-wave operation.

The upper half of Figure 3 shows the pulsating current wave in the main (A) branch of the ringer circuit marked on the schematic of Figure 2. This is the characteristic current curve that in the past has made it necessary to design special ringers to insure proper operation in four-party selective service. In contrast, the lower curves show the full-wave characteristic of the currents flowing in the branches (B and C) of the new resonant circuit.

To further clarify how ringer performance is improved, an additional set of curves is shown as Figure 4. The curve, Figure 4(a), marked ampere turns in high impedance coil, represents the current curve of branch B of Figure 3 multiplied by the number of turns in the ringer winding through which that current is passing. The curve marked ampere turns in low impedance coil represents the current curve of branch C of Figure 3 multiplied by the number of turns in that ringer winding. In addition, however, this curve is inverted with respect to Figure 3 to indicate that the winding connections have been reversed. This has been done to phase the currents in the two ringer windings.

Having connected the ringer windings for optimum operating efficiency, the two curves of ampere turns can be added to give the curve shown in Figure 4(b). This curve represents the total effective ampere turns through the entire ringer coil.

The force acting on the armature of the ringer is proportional to the ampere turns present in the ringer. The curve therefore clearly indicates the approximately symmetrical full-wave character of the forces generated during a ringing interval. Because of the greatly improved character of the generated driving forces, ringer efficiency was improved, ringing tone was made steady and clear, and the restrictions previously imposed by the pulsating voltage source no longer applied.

Although these circuit changes made it possible to use the individual line ringer in four-party selective and eight-party semiselective service, further work was required to determine the capabilities of the then standard individual line ringer to meet the sensitivity requirements of four-party and eight-party services under adverse circuit conditions. A detailed study was therefore made of ringer capabilities, and this in turn led to a statistical evaluation of the single-party ringer when this was util-

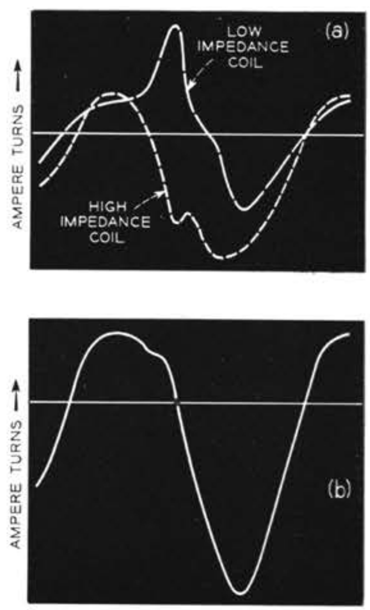

Fig. 4 — Curves illustrating the full-wave characteristics of the new C4A ringer when connected for four-party selective service.

ized as proposed in multi-party service. On the basis of this study it was concluded that the ringer then standard would be satisfactory except for a very small percentage of installations. An attempt was then made to evolve a satisfactory installation procedure for the Operating Telephone Companies. It became apparent that any procedure that involved tailoring telephone installations in the field would be unduly complicated and difficult to administer properly. A better solution was to increase the efficiency and thereby the sensitivity of the individual line ringer so that it would meet all of the ringing requirements of multi-party service.

Evaluation studies on the C-type ringer had progressed sufficiently in the years since it was first introduced to indicate ways in which its efficiency could be improved without altering the fundamental design. Since the ringer is a large production item with the usual associated high tool costs and specialized assembly procedures, it was important that any changes be of such character that they could be incorporated into the design with a minimum of inconvenience to the manufacturing department. It was equally important that both old and new design ringers could be treated substantially alike when returned from the field for repair.

An increase in efficiency was realized by a redesign of the armature and clapper assembly. Since this assembly was the only major component altered in the ringer design, it could be incorporated into the assembly procedure with a minimum disruption of shop effort. By restricting the change to this one component, repair procedures could be maintained as before, and old ringers returned for repair could be converted to the new, more efficient ringer design by the replacement of the armature assembly and a simple alteration in the bias spring bracket. With this increase in efficiency it became possible to increase the sensitivity of the ringer in shop adjustment by an amount sufficient to guarantee effective ringer operation in all four-party selective and eight-party semiselective service.

Fig. 5 — R. T. Jenkins checking the performance of a telephone ringer.

This new ringer has been coded the C4A ringer and replaces both the C2A and C3A ringers which have been classified "manufacture discontinued."

A design objective long sought has been realized. A single code of ringer is now being used in all 500-type telephone sets regardless of the class of service these sets are intended for. This new ringer is more efficient than any of its predecessors, being capable of operating effectively in individual line service on telephone lines that are somewhat longer than those previously used. In addition, the new ringer can be used in all four-party selective and eight-party semiselective services now offered by the Bell System.

THE AUTHOR

Walter Kalin started his Laboratories career in 1924, working on the development of loud speakers for motion picture sound systems. He was next concerned with the problems related to a new telephone handset. In 1938 he turned to the development of hearing aids, temporarily interrupting this work during World War II to help develop a military headset for use under the battle helmet. Since 1948 he has been concerned with problems associated with ringers used in new telephone sets. He is currently in charge of the ringer development group. Mr. Kalin received the B.S. degree from Cooper Union in 1929.