ELEMENTARY CORRESPONDENCE COURSE

LESSON XIII

ANTI-SIDETONE EQUIPMENT

THE BELL TELEPHONE COMPANY OF PENNSYLVANIA

THE DIAMOND STATE TELEPHONE COMPANY

IGNORANCE IS MORE EXPENSIVE THAN EDUCATION

March, 1949
Revised, April, 1952

The greatest thing a human soul ever does in this world is to SEE something, and tell what it SAW in a plain way. Hundreds of people can talk for one who can think, but thousands can think for one who can see. To see clearly is poetry, prophecy, and religion, all in one.

JOHN RUSKIN

• LESSON XIII •

ANTI-SIDETONE EQUIPMENT

Furnishing telephone service consists of providing complete facilities for carrying on a conversation, by electrical means, between two points. To a subscriber, the most important link in the chain of facilities comprising a built-up connection is the instrument installed on his premises. He is usually unfamiliar with the complex apparatus and plant facilities which make up a complete circuit, and he is unaware of the many research and design problems which had to be solved in order to provide equipment capable of transmitting his voice over almost unlimited distances rapidly and without noticeable distortion. Although the instrument is but one of the factors necessary to provide talking facilities, its mechanical and electrical design can and does play an important role in fixing the volume and quality of the speech reproduced at the distant end of a telephone connection.

EFFECTS OF SIDETONE

When two persons are carrying on a direct face-to-face conversation the surroundings are usually the same for both the talker and the listener. The talker is accustomed to regulating his talking volume by what he himself hears under the existing noise conditions, by the ease with which he can hear the other person, and by the ease with which the listener appears to hear him. Experience has shown that, under normal conditions, the factor which becomes the controlling one on speaking volume is the loudness with which the speaker hears himself.

These same factors also tend to regulate the talking volume in telephone conversations, although the relations between them differ somewhat from the conditions of a face-to-face conversation. For quite a large variation in volume, in the customary talking range, the speaker is not conscious of this adjustment in the loudness of his speech. The telephone user's speech sounds reach his own ears through both the air and the receiver. When the path through the receiver produces a volume louder than that heard through the air this electrical path tends to control the loudness of the speaker's voice. We speak of this sound as SIDETONE and describe the electrical circuit as the SIDETONE PATH.

Sidetone, in telephony, is the reproduction in a telephone receiver of the sounds entering the telephone transmitter of the same set. The relative amount of sidetone produced depends upon the design of the set, the efficiencies of the instruments and the electrical characteristics of the circuit to which the set is connected. It does not consist entirely of the talker's speech but consists also of the room noise present at the location of the telephone set.

The volume of the voice sidetone heard in the telephone set usually causes the speaker to believe that he is talking louder than he actually is. Then too, there is frequently a wide difference in the room noise level at the two ends of a telephone connection. Variables such as these make it more difficult for a person to judge how well he is being heard when talking on the telephone than when he is carrying on a face-to-face conversation.

Because the transmitter itself has the characteristic of causing power variations in the electrical circuit greater than those of the sound waves activating its diaphragm the transmitter is, in effect, an amplifier. Thus the speaker hearing his own voice more loudly than normal as sidetone involuntarily lowers it, and in doing so he impairs reception at the distant end of the connection. Similarly, room noise picked up and amplified by the transmitter, and heard as sidetone, tends to obscure incoming speech and further impairs reception.

Room noise present at the location of a telephone does not reach the ear through the local receiver only. It also travels the air path and reaches the ear because of leakage under the receiver cap. The room noise reaching the ear by these two paths masks the incoming speech in a manner similar to the interference resulting from induced, and other line noises, and so has a definite adverse effect upon the receiving performance of the set.

The total amount of room noise heard in the listening ear depends, of course, upon the amount of noise present, the overall efficiency of the sidetone path and instruments, and the tightness with which the receiver is held to the ear. Subscribers using the telephone in noisy locations often learn that the effect of room noise may be reduced by holding the receiver tightly to the ear and covering the mouthpiece of the transmitter when listening.

Although methods for the control of sidetone were known for many years, its importance was not fully appreciated and little was done about it either in circuit design or in the physical design of the transmitter and receiver. An analysis of its effects on conversation requires a study of volume, noise, and quality, and it was not until means were developed for measuring all three of these factors that steps were taken to eliminate or control the amount of sidetone in telephone circuits.

SIDETONE REDUCTION CIRCUIT

For many years a modified arrangement of the standard sidetone circuit, known as the sidetone reduction connection, was used at certain locations where room noise conditions were excessively bad. It involved merely a simple interchange of connections. Although it did reduce sidetone and so improve the receiving efficiency of the circuit, the condenser, 3-4 winding of the induction coil, and the receiver were no longer connected across the transmitter terminals and consequently the booster effect of this circuit was lost. The result was a noticeable decrease in transmitting efficiency. *(Note:—The booster action in this circuit was described in Lesson XII.)*

The sidetone reduction connection was usually made at stations where the loop resistance to the central office was less than 150 ohms. On longer loops it was made only when a survey indicated that the loss in transmitting efficiency was more than offset by the reduction in the room noise picked up by the transmitter.

ANTI-SIDETONE CIRCUITS

An ANTI-SIDETONE substation circuit is one in which, under ideal conditions, no current flows in the local receiver when the local transmitter varies the line current. The number of possible forms of anti-sidetone circuits is almost unlimited, depending upon what restrictions are placed on the number of terminals to the various elements making up the circuit. Dr. G. A. Campbell, of the Bell Telephone Laboratories, who developed the anti-sidetone substation circuit using a single induction coil, has shown that with certain assumptions there are over one-half million such circuits.

A practical anti-sidetone circuit must reduce the diversion of energy into the sidetone path between the transmitter and receiver without materially affecting the electrical efficiency of the set in transmitting or receiving. This means that sounds, either noise or speech, which are picked up by the transmitter will be reproduced in the receiver of the same set at a much lower level than in a comparable sidetone instrument.

Considerable development work was necessary to secure an arrangement which provided the desired transmission improvements, and which at the same time could be economically incorporated into new or existing telephone apparatus. The circuit finally adopted met these conditions and required, besides

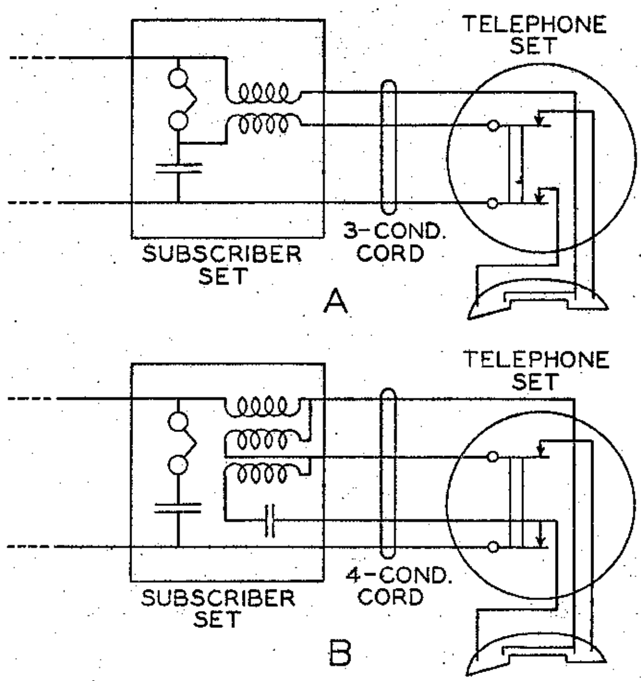

Figure 1 — Wiring arrangement of (A) sidetone subscriber's telephone set and (B) anti-sidetone subscriber's telephone set.

the equipment in the sidetone subscriber sets, a second capacitor and a third winding on the induction coil. Where the combined station set was not used one extra conductor is required in the cord to the telephone set. The circuit arrangements for the two types of subscriber equipment, using separate subsets and instruments, are shown in Figure 1.

Instruments incorporating the fundamental operating principles of the anti-sidetone circuit are now in almost universal use in the Bell System. An understanding of its operation therefore becomes essential in the study of modern subscriber sets.

The conventional sidetone circuit and anti-sidetone circuit in general use are shown in the upper schematic diagrams of Figure 2. Inasmuch as their effect upon the features to be discussed is negligible the ringer branches have been omitted. In analyzing these circuits, it is convenient to rearrange the circuit elements and this can be done without making any electrical changes in the process. Since, in the sidetone set, the receiver and the B winding of the induction coil are in series, they can be interchanged without affecting the operation of the circuit, and a similar rearrangement can be made in the anti-sidetone circuit by interchanging the position of winding B and the receiver, together with the equipment bridged around it. The middle schematic diagrams, S-2 and A-2, show these circuit rearrangements. The lower diagrams, S-3 and A-3, show the circuits rearranged in a mesh form more suited to analysis.

An examination of drawings S-3 and A-3 indicates that the anti-sidetone circuit differs from the sidetone set only by the addition of a balancing branch, consisting of a third induction coil winding C and a network N, bridged across the receiver to form a third path. Actually the network N is not a separate physical item of equipment but represents a combination of electrical characteristics obtained by the proper selection of the resistance component and the total self-impedance in the design of winding C.

The windings A, B and C of the induction coil are contained on a single laminated soft iron core and are thus inductively coupled to each other. They are so wound and connected that if a current were passed through all three in series the magnetic fields of A and B would be aiding and that of winding C would be opposing both A and B.

TRANSMITTING CONDITION

In most cases the talking current is furnished from the central office battery. However, it is only the variations in this current, resulting from changes in the transmitter resistance as its diaphragm vibrates, which results in speech or other sounds being transmitted over a circuit. These changes in resistance and current, following Ohm's Law expressed as E = IR, produce corresponding variations in the potential, or circuit (Figure 3—upper) under talking conditions, at a given instant of time, a voltage E_T across the transmitter causes current to flow from point 1 to point 2. At this point the current divides, with the part marked I_L passing out over the line. The remain-

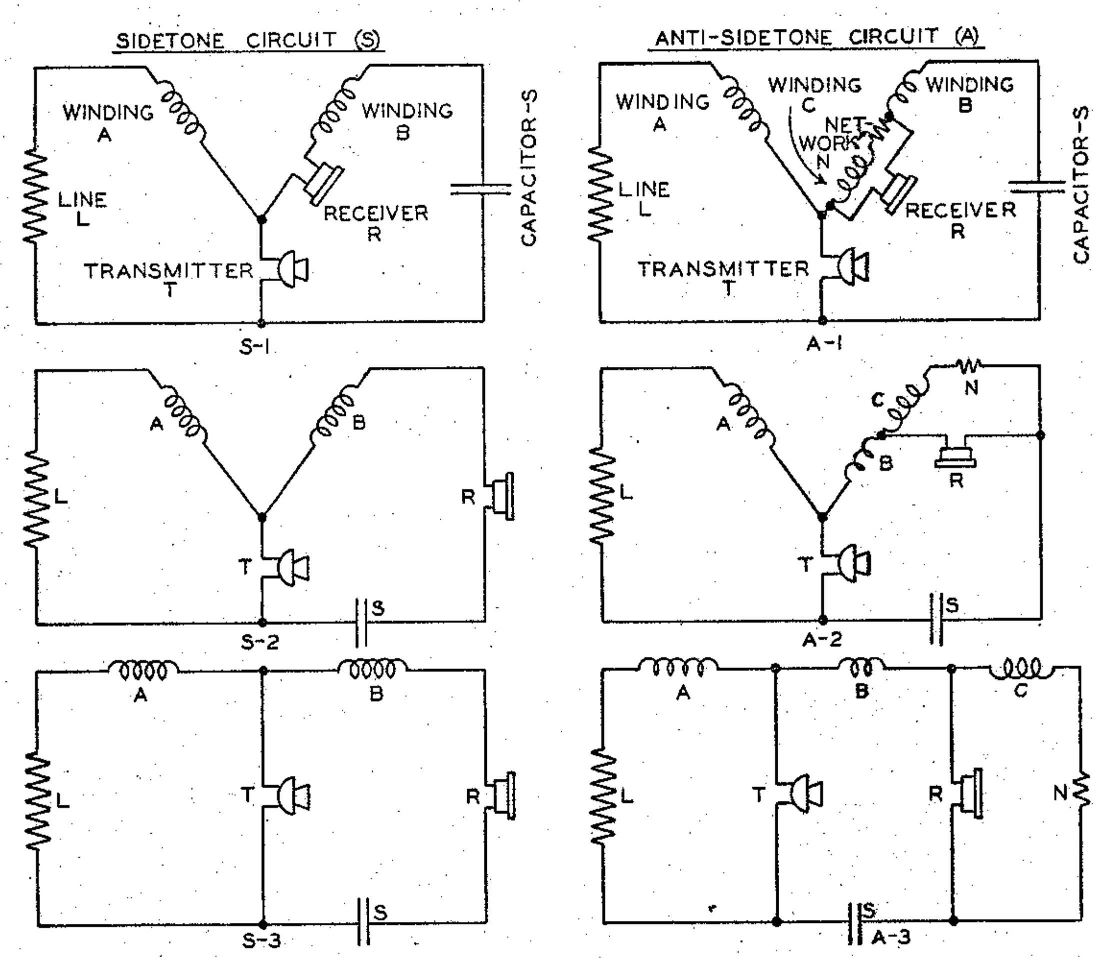

Figure 2 — Conventional schematic drawings of the sidetone and anti-sidetone subscriber's telephone circuits with ringer branch omitted. Center and lower drawings show circuit components rearranged for purposes of explanation.

voltage, existing across the terminals of the transmitter. For the purpose of examining what happens in an anti-sidetone circuit we may therefore look upon the transmitter as a source of emf which fluctuates in response to the diaphragm movement.

Consider now the action which takes place in the sidetone and the anti-sidetone subset circuits when someone speaks into the transmitters. In the sidetone der of the current, I_S, passes around the internal circuit composed of the B winding, receiver, and the capacitor and causes sidetone. A complete description of how the sidetone set operates has been given in Lesson XII.

In the anti-sidetone circuit (Figure 3—lower) a similar action takes place. In this case, however, the current I_S tends to divide further at point 4, with a portion of it passing down through the receiver and the remainder, I_N, flowing through the winding C and the balancing network N. If, in some way, the third circuit element, consisting of winding C and the network N, can be made to produce an electrical condition whereby all of the current I_S will be by-passed through it, with none passing down through

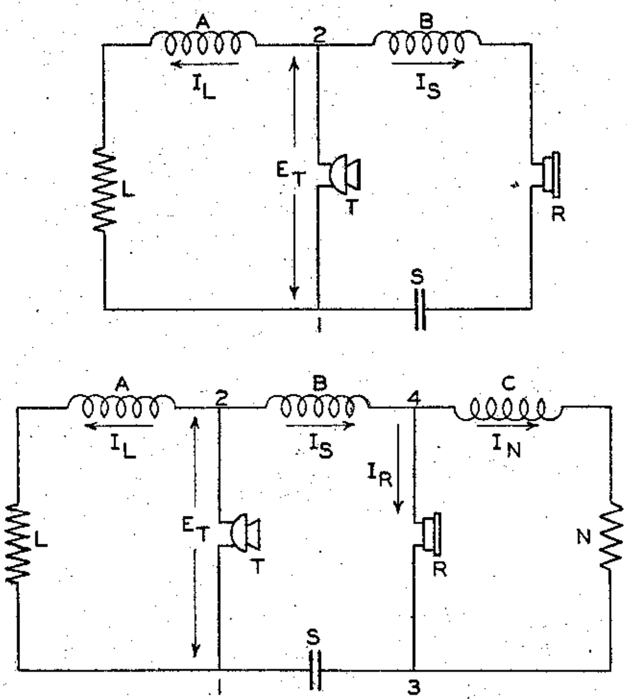

Figure 3 — Relative directions of current flow in (upper) sidetone and (lower) anti-sidetone circuits under transmitting conditions.

the receiver, there will be no sidetone. This is exactly what the third circuit element is designed to do. The action accomplished by the third branch is not dependent entirely upon the electrical characteristics of winding C and the network but also upon the proper design of windings A and B in relation to the impedances of the transmitter, receiver, and the line. The calculations involved in the design of the circuit and the relationships which must exist to accomplish the anti-sidetone effect are somewhat complex, but the fundamental behavior of the circuit is not difficult to undestand.

As described above, the current I_S, flowing through the winding B tends to divide at 4 with a part I_R, attempting to pass downward through the receiver, and the remainder, I_N, flowing through winding C and the balancing network N, in the directions indicated. Due to the magnetic coupling which exists between the windings of the induction coil, the variations in line current I_L, and in sidetone current, I_S, when the transmitter is spoken into, cause an emf to be induced in winding C.

This induced emf causes a second current to flow in winding C and in the same direction as that of I_N. The electrical characteristics of the circuit are such that, under ideal conditions, this second current is just equal in value to I_R. Thus, the total current flowing in the third winding is equal to I_N plus I_R, or I_S. At point 3 there is again a tendency for the current to divide with a portion equal to I_R attempting to pass upward through the receiver. The movement of this current is opposed by the I_R of equal value attempting to pass downward from point 4. The resultant current through the receiver is zero and no sidetone is heard.

This circuit arrangement does not sacrifice the beneficial effects of the booster circuit in order to obtain its anti-sidetone effect. Since the resultant of the two currents flowing in the third branch of the circuit is equal to the current I_S flowing in winding B it is obvious that the full value of this current acts in conjunction with winding B and the capacitor S to produce the same booster action which is obtained in the sidetone circuit. A 2 mf capacitor is provided in the talking circuit of the anti-sidetone set causing an appreciable transmission gain over that obtained with the 1 mf unit used jointly in the ringer and talking circuit of the sidetone subset. The use of a separate ringing capacitor also materially improves the induced noise condition on party lines employing grounded ringing.

RECEIVING CONDITION

In receiving, the line current I_L flows through winding A of the sidetone circuit in the direction indicated (Figure 4—upper) and, for all practical purposes, may be considered to follow the low impedance path through the transmitter and back to the line. Due to the magnetic coupling the current flowing in winding A induces an emf in winding B and the resulting current, I_S, flows in a path from the winding, between points 2-1 through the transmitter, capacitor and from point 3 to point 4 through the receiver and back

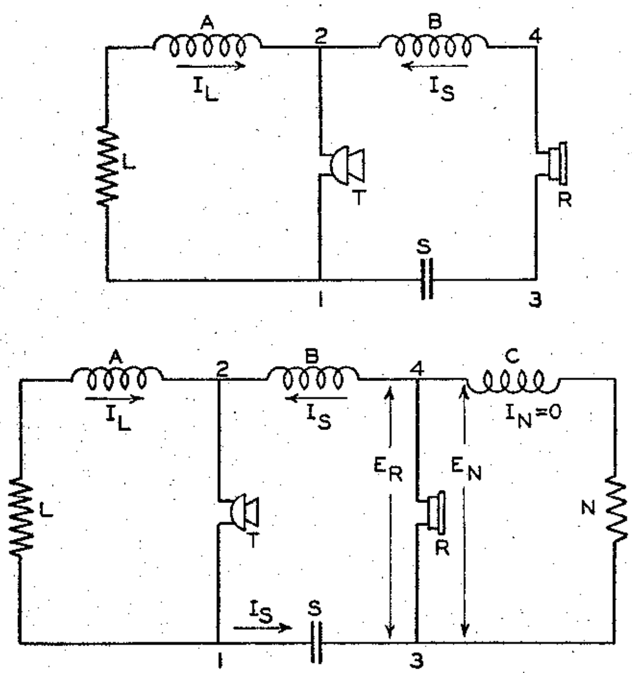

Figure 4—Relative directions of current flow in (upper) sidetone and (lower) anti-sidetone circuits under receiving conditions.

to winding B. It is this current which actuates the receiver and reproduces the sounds spoken into a distant instrument. In the anti-sidetone circuit, (Figure 4—lower) the currents flowing in windings A and B each cause an emf to be induced in the third winding C, but the two induced voltages are of opposite polarities. That induced by the current in winding A is the greater. The electrical constants of the circuit are adjusted so that the net sum of these two opposing voltages induced in winding C is just equal in value but opposite in polarity to the voltage drop existing across the receiver between points 3 and 4, as the current I_S flows through it. As a result no current is diverted from the receiver because of the third circuit branch and, therefore, the balancing network causes no loss in receiving efficiency.

The above analysis is based on assumed instantaneous directions of current flow. A similar analysis can be made when the direction of current flow is reversed.

The balancing network can be designed to function ideally for only a given set of line conditions and at a single frequency. In commercial usage instruments are connected to lines whose impedances vary widely and the frequencies of the sounds transmitted over them cover a range of several thousand cycles. Therefore, in actual practice the performance of the balancing network is not perfect, but the sidetone is greatly reduced.

Equipment employing the anti-sidetone circuit in subscriber stations was made available in 1931. In addition to incorporating the anti-sidetone feature in all new equipment a systematic conversion program was set up. In new sets the 101 type closed core induction coil was used. Converted sets continued, for some time, to employ the No. 46 open core type of induction coil, with a third winding added. The modified coil was known as the 146 type. A similar system of adding 100 to the code number of any piece of sidetone equipment was used to designate items converted for anti-sidetone use. Thus, 534 type sidetone subscriber sets became 634 anti-sidetone instruments, 50 type desk stands became 150 type, etc.

It had become a general practice up to this time to connect one or more extension telephones to a common battery subscriber set. With the introduction of the anti-sidetone set this method of connection could no longer be used for the reason that the transmitters of all stations would be permanently bridged to each other. For extensions, therefore, it became necessary to use a separate subscriber set at each extension station, or a modified instrument equipped with an extra set of switch-hook contacts, and a four conductor cord between the bell box and the instrument.

Most conversions required facilities available only in Western Electric Company shops. However, to simplify the operation, an Apparatus Unit consisting of an assembly containing an anti-sidetone induction coil, two capacitors, and a connecting block was developed for making the conversion. This operation could be performed without removing the set from the wall. Installation was made by removing all parts from the existing sidetone subscriber set except the ringer and its associated parts. Space was then available for installing the equipped mounting plate and attaching it through the holes that had been previously used to mount the induction coil.

MODERN SUBSCRIBER INSTRUMENTS

The tendency is to make subscriber instruments smaller, lighter, and in types best suited to the locations at which they are to be used. This trend is well illustrated in the 302 type combined telephone set equipped with the "F" type handset. It was designed to be used generally under the same conditions as the hand telephone instrument with a separate subset. The new mounting contains all of the apparatus formerly included in the subscriber set and thus permits a telephone installation to be made without the need of attaching to walls or furniture any telephone apparatus other than a relatively inconspicuous connecting block. The set presents a pleasing appearance, as well as providing improvements in convenience of use, service performance, and maintenance. It has a more pleasing ringing tone than had earlier instruments and has less tendency to slip when dialing.

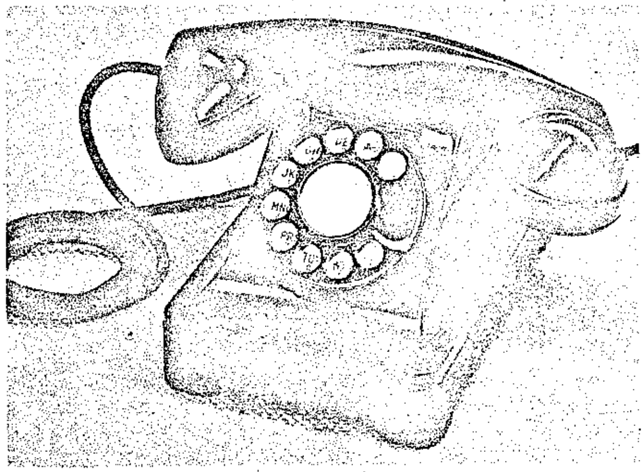

Figure 5—302 type combined telephone set equipped with an "F" type handset.

The housing of the 302 type set consists of an upper case and a base plate. The upper part, containing the switchhook, and having a circular opening in front for a dial was originally a zinc-alloy die-casting. More recent models are of a molded plastic which is both lighter and more durable.

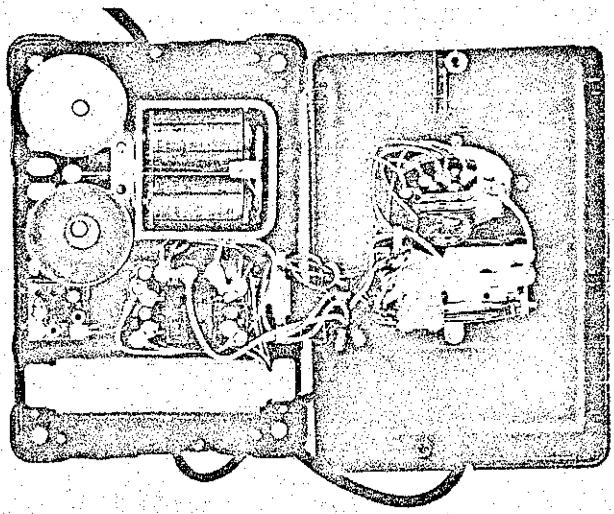

Figure 6—Interior of 302 type combined telephone set showing the arrangement of equipment.

The baseplate is formed of sheet steel and contains a terminal block for facilitating any necessary rearrangements of the cording, and leads for the various connections required, together with the mounting arrangements for the ringer, induction coil and capacitors.

It was the reduced size of the 101 type closed core induction coil and the design of a new and smaller type ringer which made possible the construction of the combined set at its present dimensions. The gongs of the new B type ringer are mounted eccentrically to permit adjustment. A means is also provided for changing the tension on the biasing spring in order to secure proper operation.

Another type of instrument much in demand is the hang-up type of handset mounting which is used in conjunction with a separate bell box. Originally designed to be suspended from the side of a desk it found much popularity in other types of installations such as kitchens and halls of homes. A typical example of this instrument is shown in Figure 7.

Another recent development is the 354 type combined wall set. This instrument, (Figure 8) equipped with an F1A handset, has a plastic housing containing

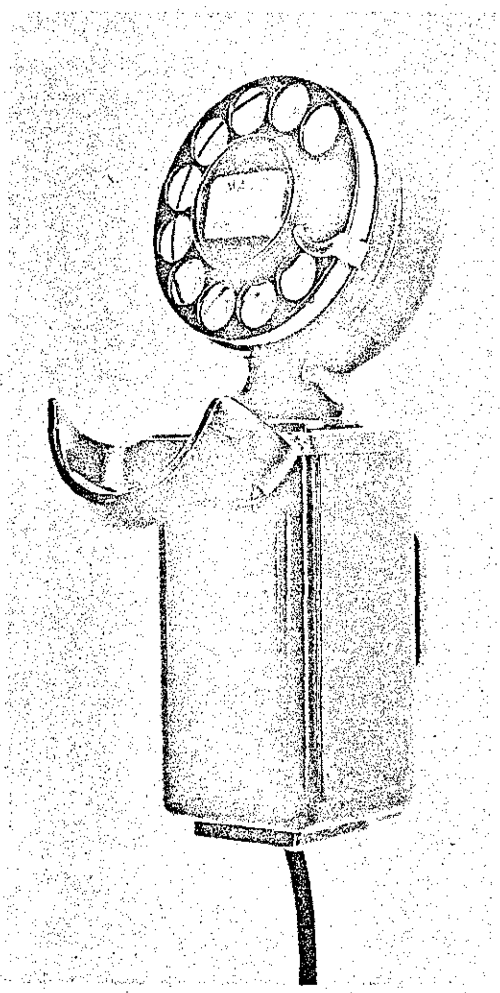

Figure 7 — No. 211B hand telephone set equipped with a G1 handset mounting, and a 41A dial mounting with 4HB dial.

a handset-supporting hook, switch contact springs and a metal base on which are mounted a B2A ringer, a 101B induction coil, a 195A capacitor and a terminal strip. It may be used for tip-party dial message rate and automatic ticketing stations as well as for types of services using non-polarized types of ringing. The set is finding an extensive field of use in residences where hang-up types had heretofore been in demand.

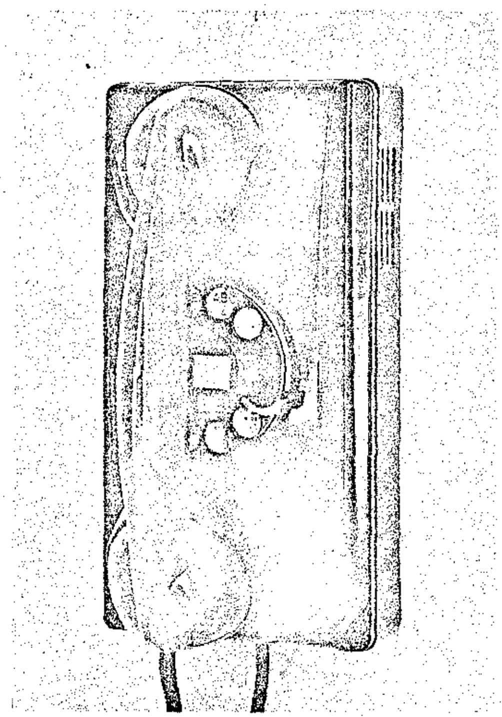

Figure 8 — 354 type combined wall set.

These sets are not the ultimate in design, and research is being carried on continuously at the Bell Telephone Laboratories to develop new and better telephone instruments.

The latest addition to the hand telephone set family is the 500 type. This set affords a considerable gain in transmission over existing ones, especially when used on stations most distant from a central office. Its other principal new features include:

a. Neoprene jacketed mounting and handset cords.

b. Limited manual adjustment of ringer volume under control of the subscriber.

c. Dial number plate of lucite with characters printed under the surface and appearing outside the finger wheel. This reduces marring of the designations from wear.

d. New type dial with better speed regulation, and better protection for moving parts from dirt.

e. Built-in dial induction suppression filter.

f. Self-healing capacitors and sealed capacitors and coil mounting.

g. Easily removable housing with no attached wires.

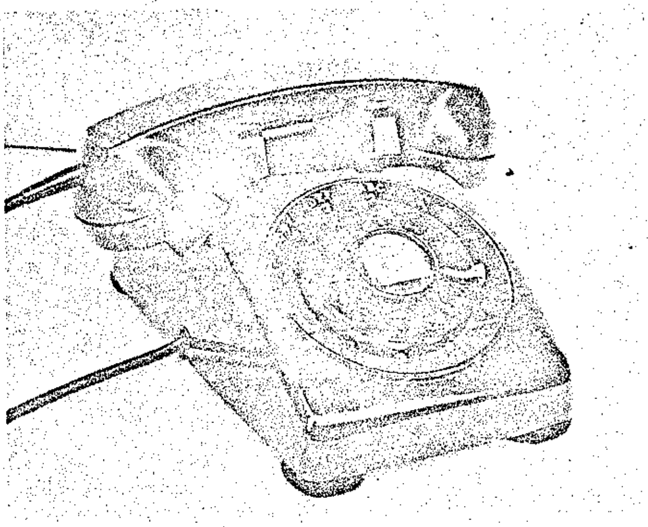

Figure 9 — 500 type combined telephone set.

The handset weighs 12 ounces, which is 4 ounces less than the "F" type handset. The transmitter is somewhat similar to the F-1 type but differs in many respects. Its maximum frequency response is at about 3000 cycles rather than at 1800 cycles as is the case of the F-1 transmitter. It is smaller and lighter, and its diaphragm is clamped at the outer edge, with the damping and acoustic controls being obtained by acoustic resistance elements in the case.

The receiver is completely new in design. It has a higher efficiency than the HA1 receiver unit and the upper range of its frequency response has been extended from 2700 to about 3500 cycles.

All apparatus aside from the handset is chassis-mounted and is wired on the base plate with means provided for attaching and terminating the cords, ringer, and dial leads. The plastic cover has no wiring or apparatus attached to it other than the switch plungers.

The ringer also is of entirely new design. It uses a single coil with a laminated silicon steel core instead of two coils as on the conventional ringers. It has, however, two windings to permit its use on 2-party message rate service as well as on general service.

The pitch of the sound output is lower than that of the older ringers resulting in a more pleasing tone. This lower tone is also advantageous to the many people who suffer a hearing loss in the higher frequencies.

This instrument was designed with the objective of providing improvements in technical performance and appearance, additional convenience to the subscriber, and simplification of installation and maintenance.

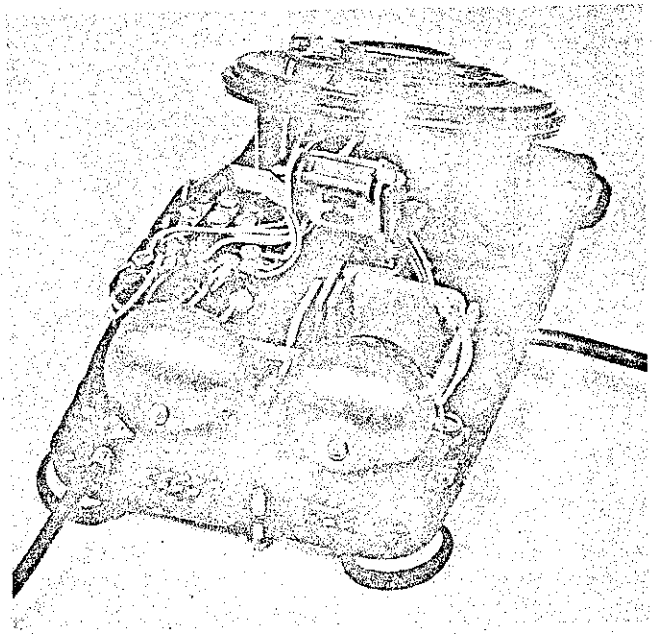

Figure 10 — Interior view of 500 D type combined set showing the arrangement and mounting of components on base.

THE 500 TYPE ANTI-SIDETONE CIRCUIT

The corrective action of an anti-sidetone circuit is not wholly dependent upon the electrical characteristics of the balancing network contained in the telephone set. The subscriber loop is a part of the overall circuit and its impedance has an important effect on the degree of sidetone reduction obtained when connected to a particular station circuit. In the 300 type telephone set the balancing network contained a fixed resistance, and no provision was made to compensate for variations in loop lengths. A maximum of sidetone reduction could therefore be obtained at only one frequency.

lengths of the subscriber loops were shortened. In the later models, types 500 C and D, the resistance lamp and thermistor elements have been discontinued. The equalizing effect is obtained by the use of the two silicon-carbide varistors, (V1) and (V2), shown in the circuit of the 500 type set in Figure 11. The resistance of this type of varistor, at any instant, is a function of the magnitude of the voltage being applied to its terminals.

One varistor is bridged across the set in series with 200 ohms. Variations in loop current may cause this bridge to vary in resistance from 600 ohms to 4000 ohms. The second varistor is bridged across the

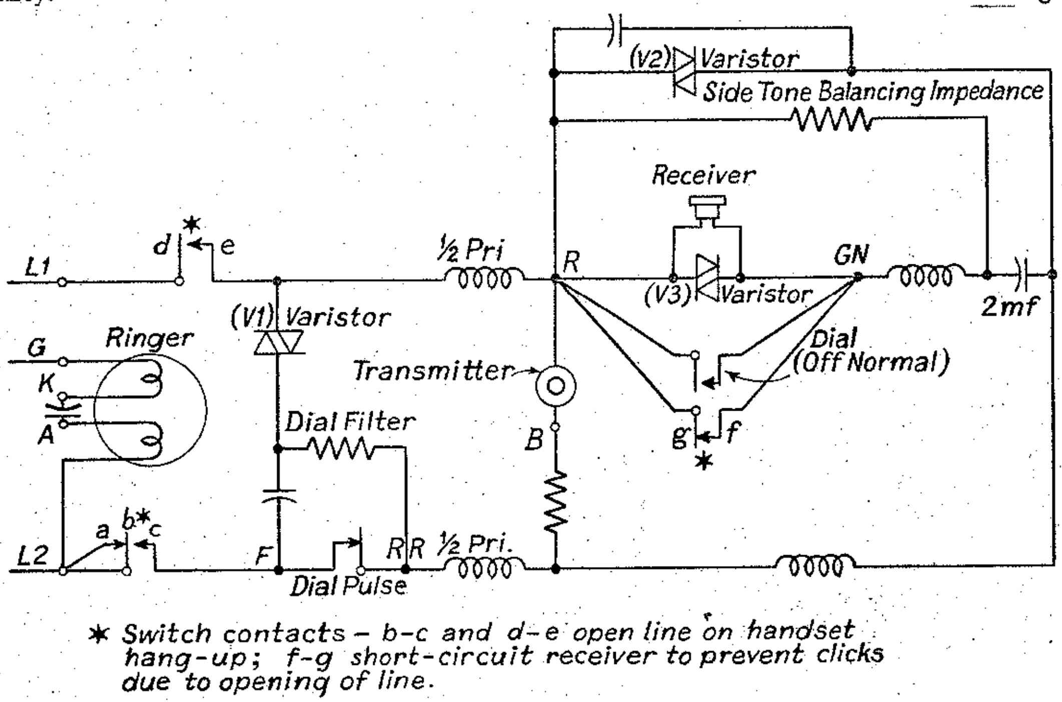

Figure 11 — Circuit diagram of 500 D type telephone set.

receiver, one winding of the induction coil and the 2 mf capacitor.

In order to maintain a sidetone level in the new and more efficient instruments which did not exceed the level existing in the 300 type sets it was necessary to provide a means for obtaining a balanced value of impedance and to limit the talking current, under varying conditions of loop length.

The early models of the 500 type set contained an equalizing feature consisting of a resistance lamp and a thermistor. This unit was designed to control sidetone by reducing the instrument efficiencies as the

With this type of equalizer both the line and network impedances are correspondingly changed, and the degree of sidetone balance is directly maintained under varying conditions of loop length without any change in the instrument efficiencies.

The anti-sidetone circuit in the 500 type set may be examined in a manner similar to that used to study this action in the 300 type set and other earlier anti-sidetone circuits. The actions of the varistors need not be considered for the purpose of explaining the anti-sidetone action of the circuit. Figure 12 is a simplified circuit of the 500 type set showing the transmission paths only. As in the previous analysis the circuit

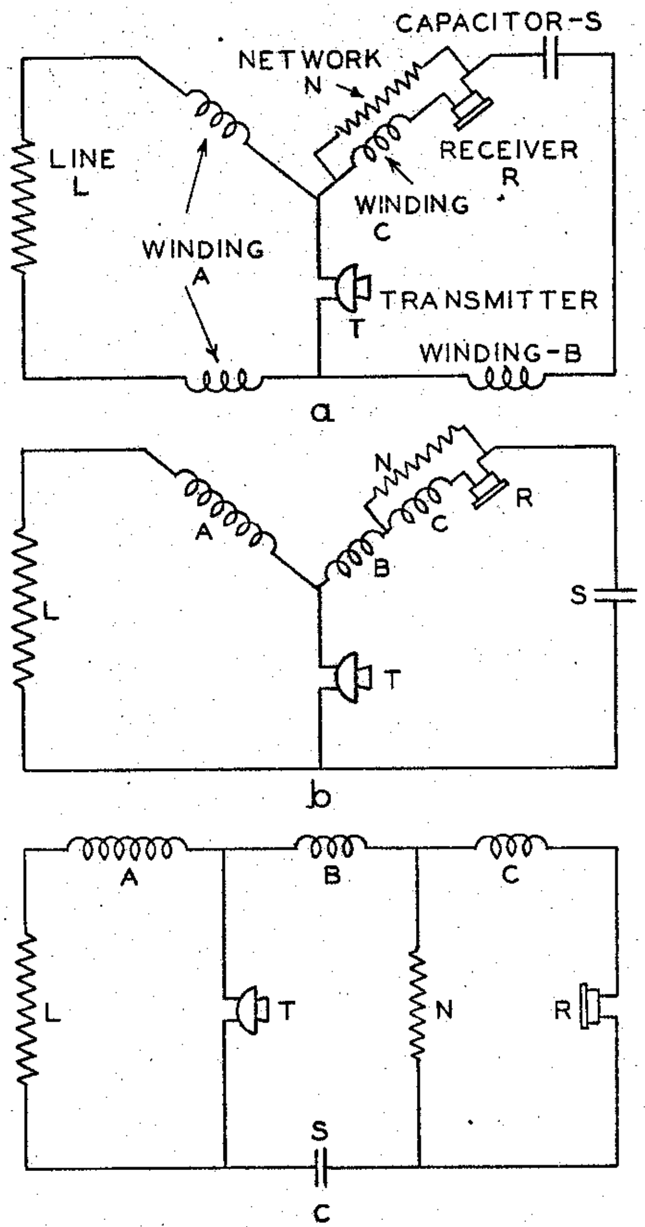

Figure 12 — Schematic drawings of the 500 C and D telephone showing the transmission paths only. Center and lower drawings show circuit components rearranged for purposes of explanation.

elements have been rearranged, but from an electrical standpoint they are identical. The winding A, B and C of the induction coil are inductively-coupled, and are so wound and connected that if a current were passed through all three in series the magnetic fields produced by them would all be of the same relative polarity. This is in contrast to the older type anti-sidetone circuit, such as that employed in the 300 type combined set, where, under such a condition the fields produced by windings A and B are aiding and that produced by C is opposing.

In the transmitting condition shown in Figure 13, at a given instant of time a voltage E_T across the transmitter will cause a current to flow from point 1

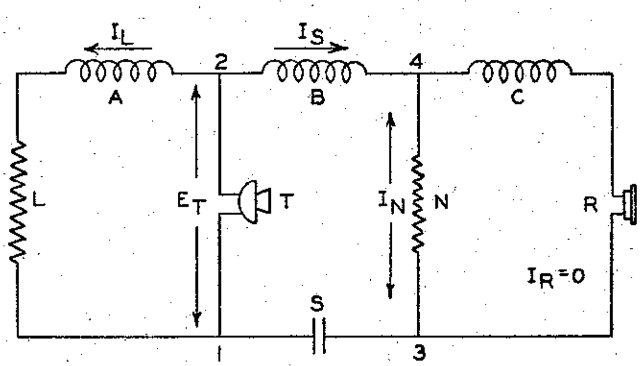

Figure 13 — Relative directions of current flow in 500 type circuit under transmitting condition.

to point 2. At this point the current divides, with the part marked I_L passing out over the line. The remainder of the current, I_S, flows through the B winding and at point 4 it again divides, with part of the current tending to flow through the network N to point 3, and the remainder flowing through the circuit composed of winding C and the receiver. However, the circuit elements are so designed that the emf's induced in winding C as a result of the currents flowing in windings A and B cause a current to flow in C which is equal in value and opposite in direction from that tending to flow through coil C from point 4. Thus, the resultant current flow through the receiver is zero.

In the receiving condition shown in Figure 14, the line current I_L flows through winding A as indicated, and for all practical purposes, may be considered to follow the low impedance path through the transmitter and back to the line. Due to the magnetic coupling the current flowing in winding A induces an emf in winding C, and the resultant current I_R flows in the path from the winding through the network and the receiver and back to winding C. It is this current which actuates the receiver and reproduces the sounds spoken into the distant transmitter.

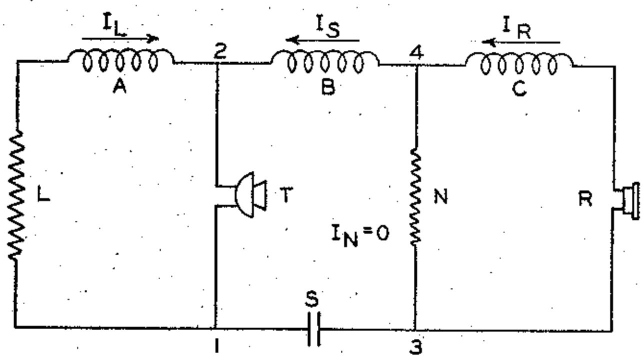

Figure 14—Relative direction of current flow in 500 type circuit under receiving condition.

The currents flowing in windings A and C each cause an emf to be induced in winding B. However the two voltages are of opposite polarity, and the one induced by current in winding A is the greater. The electrical constants of the circuits are so designed that the net current flowing in the B coil mesh is equal in value to that flowing in the C coil mesh. Since the currents are in opposite directions as they attempt to pass through the network branch N, which is common to both meshes, the resulting current in the network is zero. Hence no power is dissipated in the network and there is no loss in receiving efficiency.

REVIEW QUESTIONS

1. What three factors act to regulate the volume of a talker's speech in a face-to-face conversation?

2. Define sidetone.

3. Explain the effect of room noise on reception at a sidetone telephone instrument.

4. (a) What condition is produced in an anti-sidetone substation circuit under ideal conditions?

   (b) What are requirements for a practical anti-sidetone circuit?

5. Explain, by reference to the drawing in Figure 3, how the third winding on the induction coil reduces or eliminates sidetone in the local receiver when the transmitter is spoken into.

6. Explain, by reference to the drawing in Figue 4, why in the ideal condition, the third winding bridged across the receiver, causes no transmission loss when an anti-sidetone set is functioning in the receiving condition.

7. (a) Describe the improved features of the 302 type combined set by which it differed from the previous model having a separate subset and hand telephone instrument.

   (b) Name two factors which made possible the design of the 302 type combined telephone set.

8. (a) What is the weight of the handset used with the 500 type instrument?

   (b) At what frequency does its transmitter have its maximum response?

   (c) How high does the frequency range of its receiver extend?

   (d) How does the ringer of the new set differ from conventional types?

   (e.) Name five other new features of this set.

9. Is there any fundamental difference in the magnetic relationship between the three windings of the induction coil of 300 and 500 type sets? Explain.

10. Draw a diagram and explain the anti-sidetone action in the 500 type set under the transmitting condition.

7.6 Our two present "standard" telephone sets are the <u>300 type</u> which has an F-1 **transmitter and an HA-1 receiver,** and the <u>500 type</u> which has a T-1 transmitter a **a U-1 receiver.** See Figures 19 and 20.

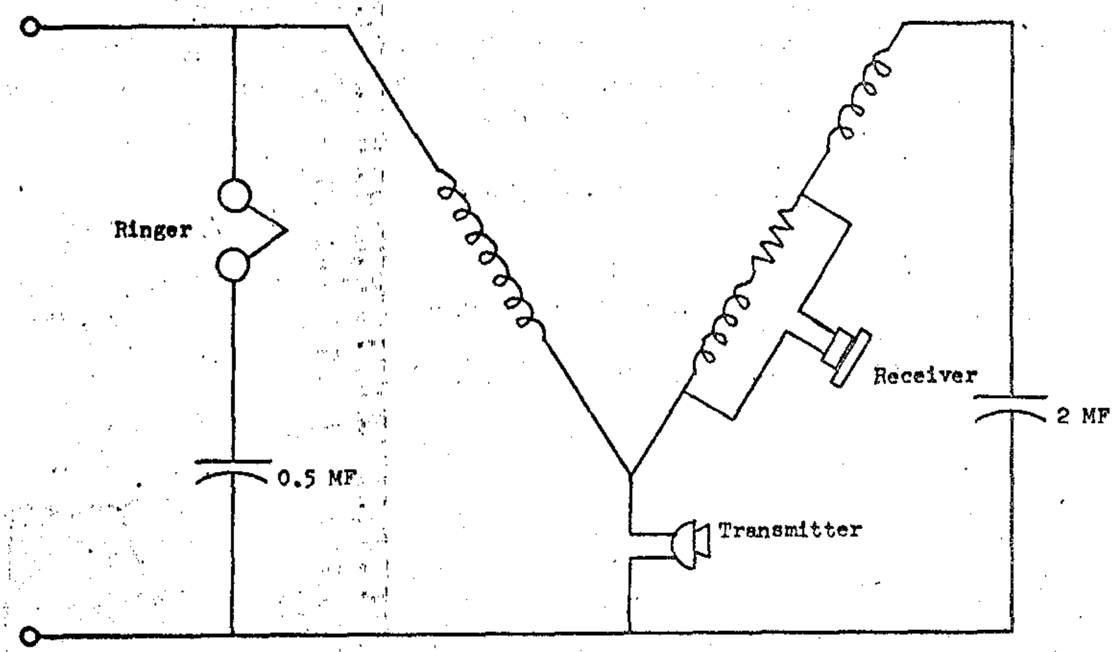

Figure 19 - 300-Type Telephone Set

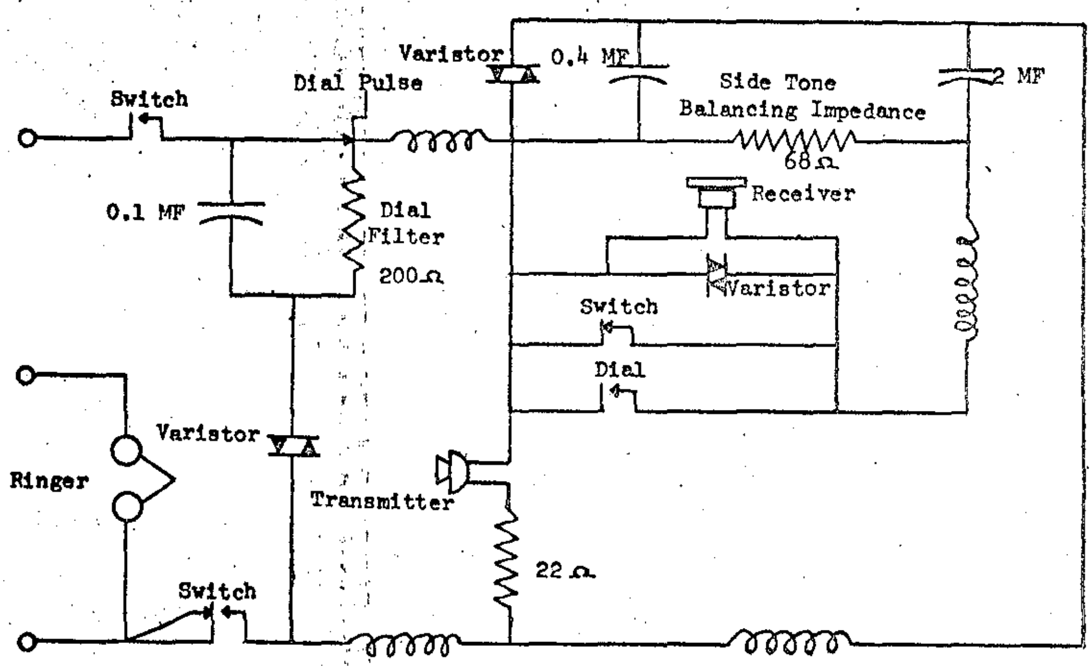

Figure 20. 500-Type Telephone Set