

# The Anti-Sidetone Station Circuit

By J. W. FOLEY

*Transmission Standards Department*

THE subscriber telephone set is used to provide a connection between the line and both the transmitter and receiver. A function of the two-winding transformer, which has been widely used in this set, is to improve the efficiency of these connections. With such an arrangement, the subscriber hears not only the speech coming over the line from the distant end, but also his own speech, since the voltages generated in the transmitter by his voice affect his own receiver. The sound picked up by a transmitter and heard through its associated receiver is called "sidetone." It is possible, however, to design the circuit of a two-way telephone set so that under ideal conditions the sound picked up by the transmitter is not heard through the associated receiver. Such an arrangement, known as an anti-sidetone circuit, involves some complications over the two-winding transformer circuit. In recent years an anti-sidetone subscriber set employing a three-winding transformer has come into wide use in the Bell System.

Sidetone has several detrimental effects on telephone transmission. A person naturally regulates the volume of his speech by the apparent loudness of his own voice in his ear. The presence of sidetone increases the apparent loudness, and there is a tendency to decrease his talking volume, which reduces the level of the outgoing voice signals. Sidetone also interferes with incoming trans-

mission, because it allows room noise, picked up by the transmitter, to mingle with and partially mask the incoming speech.

The first anti-sidetone circuit in commercial use was invented by C. E. Scribner in 1893, and was used for some of the operator telephone sets. In 1906, G. A. Campbell showed that there were a large number of possible anti-sidetone circuits employing a single transformer and a single balancing network. To be practicable for general use, the circuit must be applicable to existing conditions and apparatus, and should require a minimum of additional expense. 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 in new or existing telephone apparatus. The circuit adopted meets these various requirements and necessitates—besides the equipment of the sidetone subscriber sets—an additional condenser, an additional winding on the transformer, and, where the combined station set is not used, one extra conductor in the cord to the telephone set.

The circuit for the standard sidetone subscriber set is shown in the upper diagram of Figure 1. The condenser serves two purposes. It prevents the bell from placing a d-c path across the line when the set is not in use, and it confines all the direct

current to the path through the transmitter when the set is in use. Omitting the bell and the switchhook, which play no essential part under talking conditions, this circuit can be arranged schematically as shown in

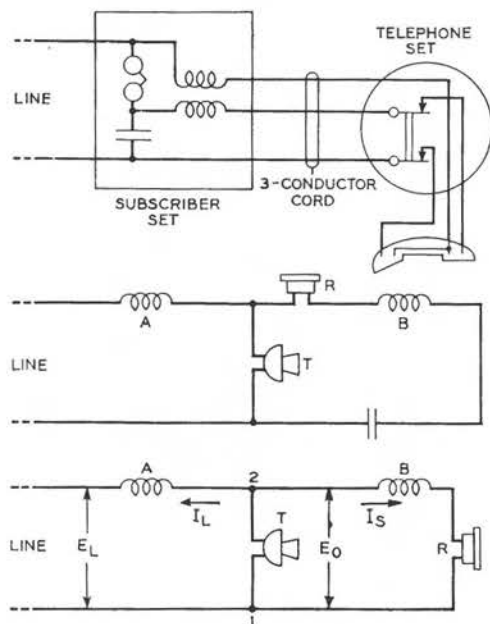


Fig. 1—Wiring arrangement of sidetone subscriber set, above; equivalent diagram, center; and ideal diagram, below

the middle sketch. Since the receiver and the B winding of the induction coil are in series, they can be interchanged in position without affecting the operation of the circuit; and since the condenser, under ideal conditions, would be of infinite capacitance, it would have no effect on the talking circuit and may thus be omitted in this explanation of the operation of the circuit. With these two changes the circuit would be as shown in the lower sketch.

Under talking conditions, a voltage—marked  $E_0$  on the diagram—is generated across the transmitter. Current flows through the transmitter from 1 to 2, where it divides—part,

marked  $I_L$ , passing out over the line; and part, marked  $I_S$ , passing around the circuit including the receiver. It is the latter current that causes the sidetone. Received speech current also will pass through both the transmitter and the receiver.

For many years a modified arrangement of this circuit, known as the sidetone-reduction connection and involving only a simple interchange of connections, was frequently used on the shorter station loops to obtain a reduction of sidetone, although it is not strictly what is termed an anti-sidetone circuit. The arrangement is shown in Figure 2. It gives a reduction in sidetone of about 7 db, and a gain in receiving efficiency of about 1 db, but it causes a loss of about 5 db in transmitting efficiency.

In the anti-sidetone set now being employed, the sidetone circuit is modified by shunting another path around the receiver, as shown in Figure 3. In this anti-sidetone circuit also, under transmitting conditions shown in the lower diagram, the current from the transmitter divides—part going over the line and part around the local circuit. If the additional circuit element, consisting of winding c of the transformer and the network N, can be made to carry all of  $I_S$ , however, there will be none left to pass through the receiver, and there will thus be no sidetone. This is exactly what this additional circuit element is designed to do; and al-

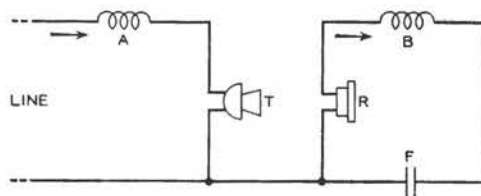


Fig. 2—Schematic of sidetone reduction circuit used for short station loops

though under commercial conditions the action is not perfect, the sidetone is greatly reduced.

This condition, and the further condition that there shall be no current in the network during receiving, is brought about by a proper design of the windings A, B, and C and the network N in relation to the impedances of the receiver, transmitter, and line. The calculations, and the relationships that must exist, are somewhat complicated, but the qualitative behavior of the circuit is not difficult to see.

In the lower diagram of Figure 3, which shows the transmitting condition, arrows indicate the relative directions of current flow at an arbitrary instant. The windings are so poled—A and B in the same sense and B in the opposite sense—that the voltage  $E_c$  tends to make current flow through the network to an amount just equal to the current  $I_s$  flowing through winding B. Hence no current flows to or from the junction (4) in the branch which contains the receiver. Another way to visualize the situation is to consider that the circuit is designed so that the voltage drop from point 2 to point 4 is just equal to the drop from point 2 to points 1 or 3. As a result there is no voltage drop from point 4 to point 3 and no current flows through the receiver. As already pointed out, these ideal conditions are not completely met, but the sidetone current that passes through the receiver is greatly reduced.

For received speech, the relative directions of the currents in the circuit are shown by the arrows in the central diagram. The currents in windings A and B, as in the transmitting case, induce opposing voltages in winding c, the voltage from winding A being the greater. The net

voltage in winding c is just sufficient to counteract the tendency of the voltage drop across the receiver, due to the current  $I_s$ , to send a current through the network. As a result there is no current in the network during receiving, a condition which must be fulfilled if the circuit is to be ideally efficient.

In the actual set, the network N is a simple resistance, and is incorporated in the winding c, so that there

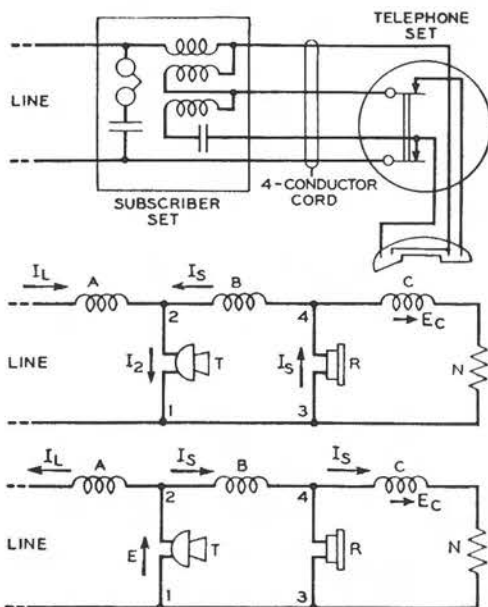


Fig. 3—Schematic circuit of anti-sidetone subset, with currents indicated for receiving conditions, center; and for transmitting conditions, below

is no separate physical element in the circuit corresponding to N. The actual circuit is shown in the upper diagram. Instead of using the same condenser for both ringing and talking, as is done with the sidetone set, two condensers are used—one of small capacitance in series with the ringer and one of larger capacitance for the talking circuit. This gives better transmission,

dialing, and ringing performance, and permits fewer switch-hook contacts.

The new anti-sidetone set is slightly lower in transmitting and receiving volume efficiency than is the sidetone set, since the ideal requirements can only be partially fulfilled; but its large reduction in sidetone, amounting to some 10 db, results in an effective overall gain in transmission of

about 6 db. The reduction in sidetone also makes it possible to get greater benefit from the improvements afforded by modern transmitters and receivers. The anti-sidetone set described above is that used for common battery systems, but a set has also been developed for local-battery systems, so that this equipment is now available for all kinds of service.



### FIRST TRANSCONTINENTAL LINE PLACED IN OPERATION TWENTY-FIVE YEARS AGO

*When, on July 29, 1914, Theodore N. Vail, then President of the American Telephone and Telegraph Company, took his telephone receiver from its hook in New York and spoke to G. E. McFarland, President of The Pacific Telephone and Telegraph Company, at San Francisco, another epoch-making achievement in telephone communication became a fact.*

*Previous to 1911, by using as large wires as were economically practicable, the telephone would talk reasonably well over a distance about as long as New York to Chicago. With the development and practical application of loading coils this distance was doubled in 1911 and New York and Denver were interconnected. The desirability, however, of a transcontinental telephone system had long been apparent. It was accomplished in 1914 through extensive research work under the direction of F. B. Jewett. There was extensive research on transmission lines, on repeater circuits and on amplifiers for repeaters, all of which culminated in a transcontinental system.*

*In the early days of the New York-San Francisco line three types of repeaters were successfully demonstrated: a mechanical repeater, a mercury arc repeater and the vacuum tube repeater. The latter proved to be one of the most powerful and flexible tools in the communication art; and in succeeding years it has been vital in carrier current transmission, transatlantic radio telephony, radio broadcasting and sound pictures.*