500 SERIES COMBINED TELEPHONE SETS
TRANSMISSION PERFORMANCE
A, B, J, AND K SERIES

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1. GENERAL

1.01 This section describes the electrical characteristics and transmission performance of the 500 and 501 A, B, J, and K series of combined telephone sets. It includes discussion of crosstalk and sidetone considerations and of the effects of longitudinal noise and set unbalances.

1.02 The 500 and 501 A and B series sets contain the 311A equalizer which for service and economy reasons was omitted from the J and K series sets. The omission of the equalizer alters the transmission characteristics of the sets and imposes certain limitations upon their fields of use. These effects are discussed in this section.

2. FIELD OF USE

2.01 The 500 series sets were designed to provide substantial volume improvement on long loops and at the same time to be applicable on very short loops without introducing crosstalk and sidetone problems. With proper loop loading they will provide satisfactory transmission out to the loop resistance limit of all common battery signaling offices. The use of long line equipment will permit extension of the loop to a resistance at which the particular type of equipment will provide a minimum loop current of 23 mA. With commonly used types, this may be as much as 1800 ohms. Beyond these limits local battery talking sets are required. Development of long line equipment with higher voltage battery supply than the present 48 volts may eventually permit universal use of 500 series sets on all common battery signaling loops.

2.02 In the J and K series sets the lack of equalizers permits full transmitter and receiver gains regardless of loop resistance, except that on short loops there is some reduction due to direct current saturation of the induction coil primary. By limiting the field of use of these sets to loops with a resistance of 400 ohms or more, the introduction of crosstalk and excessive sidetone problems is minimized. The choice of 400 ohms as the minimum loop resistance was suggested by the reasons that (1) it represents the value, with 48-volt toll grade battery supply, at which the transmitting output of the unequalized 500-type set is approximately equal to that of a 302 set on a very short loop, and (2) it offers a reasonable compromise between excessive sidetone and a field of use too restricted for practical application.

3. CIRCUIT DESCRIPTION

3.01 Figure 1 shows the circuit schematic of the 500B set which includes dial and equalizer. The manual set, designated 500A, is equipped with an apparatus blank in place of the dial. The J and K sets, otherwise identical to the A and B sets, respectively, have a terminal block in place of the equalizer. These sets are adaptable for all individual, 2-party, and divided code ringing services by changes in the set connections, thus eliminating the requirement for separate types with additional codes. Details of 500 series set connections for the different classes of service are to be found in the 502 Division of the Plant Series.

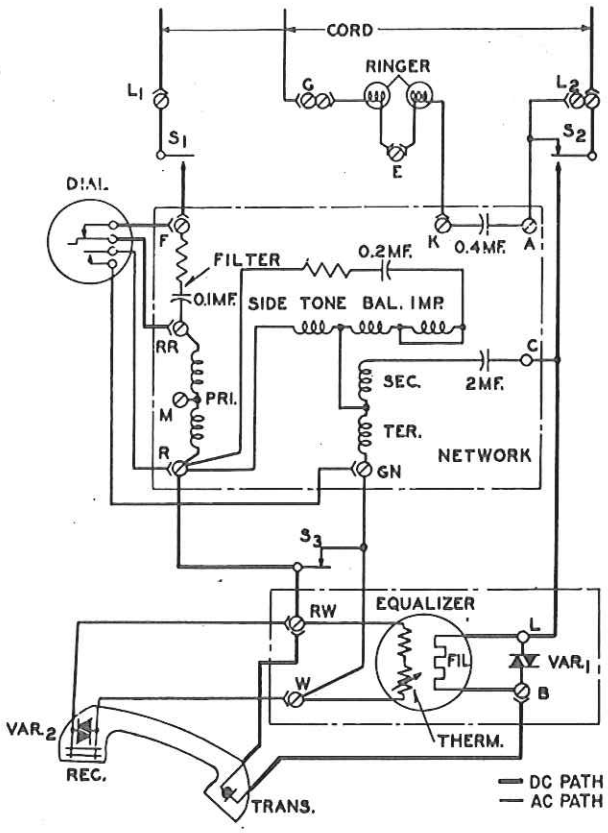

Fig. 1—Circuit Schematic of 500B Set

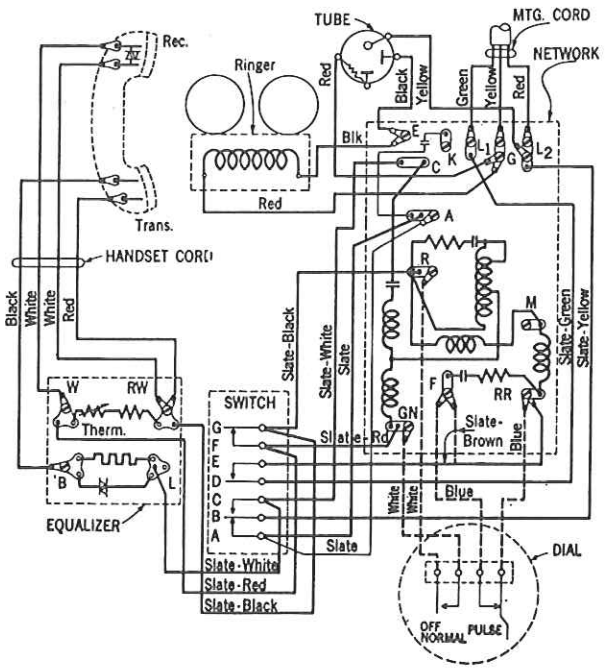

Fig. 2—Circuit Diagram of 501B Set

3.02 The 501 series sets were designed for 4-party full selective and 8-party semiselective ringing lines. With the exception of the ringer, which is coded C3A, and the addition of a 426A cold cathode vacuum tube, the 501 series are identical to the 500 series sets. Figure 2 is the circuit diagram of the 501B set. As described in the AB63 Series of practices, the 501 series sets may be used at 2-party flat rate and divided code ringing stations to provide mitigation in cases of high inductive noise.

3.03 The transmission network in the 500 and 501 A, B, J, and K series sets is coded the 425A network and is illustrated in Fig. 3. It includes an induction coil, a 2-μF talking capacitor, a 3-element sidetone balancing network, a 0.4-μF ringing capacitor, and a dial filter consisting of a 0.1-μF capacitor and a 50-ohm resistor. The sidetone balancing network contains an autotransformer which provides inductance and, through the use of a short-circuited winding, resistance in the balancing circuit. The autotransformer also serves to couple the other two elements, a resistor and a capacitor, to this circuit at the correct impedance level. Provision of a split primary winding in the induction coil and the arrangement of the switch contacts permit conversion in the field for individual service and for the various party-line services by simple changes of the ringer connections. The dial filter serves the dual purpose of providing dial contact protection as well as suppression of radio frequency induction.

3.04 The 311A equalizer, illustrated in Fig. 4, consists of a tungsten filament with a thermistor bead in proximity, both enclosed in a glass envelope, and a silicon carbide varistor bridged across the filament to protect it from excessive current. These components are mounted on a molded plastic terminal strip which serves as the cover of a protective can permanently mounted on the base of the set. As shown in Fig. 1, the filament is in series with the transmitter, and the thermistor bead in series with a loss limiting resistor shunts the receiver. The loss characteristic of the equalizer is controlled entirely by the dc line current through the set. The tungsten filament has a rising resistance-current characteristic and inserts a combined battery supply and ac transmitting loss which is small at 27 mA or less and rises to about 5 dB at 75 mA or more. The thermistor bead is

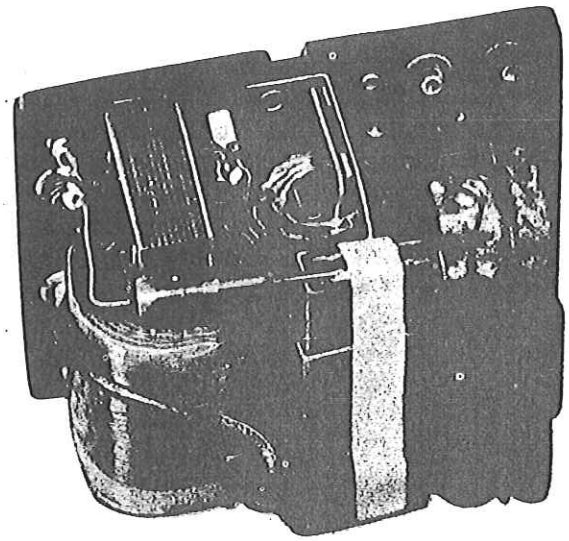

Fig. 3—425A Network with Cover Removed

heated by the filament and because of its inverse temperature characteristic introduces a corresponding receiving loss that tracks closely with the transmitting loss.

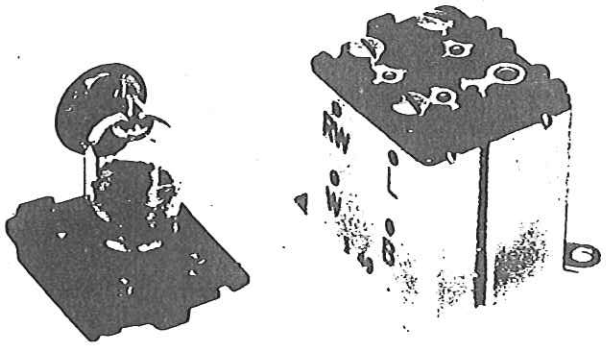

Fig. 4—311A Equalizer

4. TRANSMISSION PERFORMANCE

4.01 The transmission performance of the 500 series sets has been rated with reference to the 302 set (F1A-AST) rather than by direct comparison with the working reference system. The transmission comparisons of the two sets are based on speech volume alone. The reason for comparing them solely on a volume basis is related to the transmission rating of the 302 set. When the transmission performance of the 302 set was determined by comparison with its predecessors, large improvements in quality were exchanged for lower received speech volume. The wider frequency response of the 500 set does afford some improvement in quality, but any further reduction in the volume of received speech in exchange for quality does not appear to be warranted.

4.02 Figure 5 shows the overall frequency response of the 500-type A and B series sets compared with the 302 set. Measurements were made on the basis of acoustic pressure, "mouth to ear," with both transmitters at modal distance. Thus, the curves show the T plus R gain of the 500 set over the 302 set through the frequency range. The pair of curves for the short loops shows the effect of the equalizer. In this case, the differences between the two curves are due primarily to the difference in the response characteristics of the respective transmitters and receivers of the two sets. The 500 set short-loop curve does not apply to the J and K sets since these sets are not equipped with equalizers. On long loops the equalizer effect is small, and the solid curve may be applied to J and K sets as well as to the A and B sets. In general, these curves show that the response of the 500 sets is much more uniform throughout the frequency range and without the rather sharp peaks of the 302 set.

4.03 Effective loop loss data for 500-type sets may be found in the AB43 Series of practices. Strictly speaking, the loop loss curves do not apply to J and K series sets on short and medium length loops because the losses for these sets are less than those shown by the curves. However, this may be disregarded since loop design is based on the gains obtainable with equalizer equipped sets.

4.04 Figures 6 and 7 show the impedance characteristics of 500A and B sets and of 500J and K sets, respectively, for various values of loop current. For comparison purposes, the impedance of the 302 set at 60 mA is included in Fig. 6.

5. CROSSTALK

5.01 The transmitting volume of 500A, B, J, and K sets is about 5 dB higher on long loops than 300 series common battery talking sets. However, it is less than 1 dB higher than local battery talking sets with two dry cells, and about

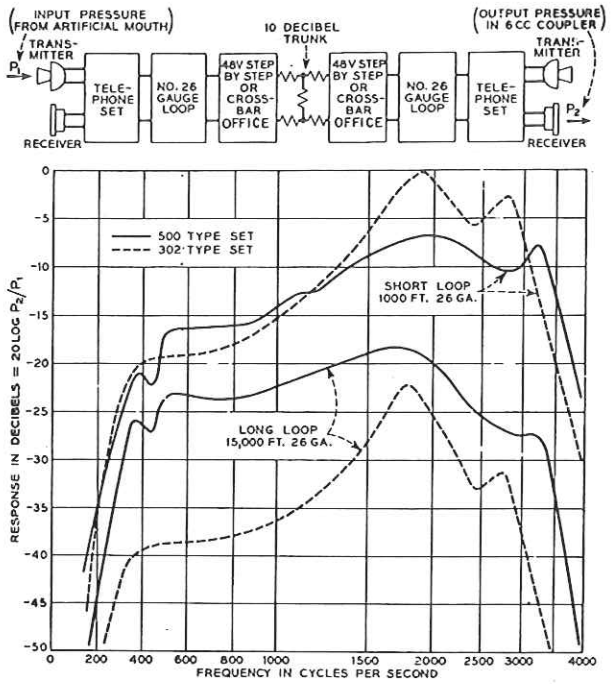

Fig. 5—Overall Frequency Response

2 dB lower than LBT sets with three cells. In the A and B sets, the transmitting volumn is never higher on any length loop than the volume of a 300 series CBT set on a very short loop, which was the design objective.

5.02 The receiving volume on long loops is 5 to 6 dB higher than that of the HA1 receiver in either CBT or LBT sets, but only 1 dB higher than the HC5 receiver.

5.03 From the foregoing it appears that, except where crosstalk couplings are marginal and an unsatisfactory condition may exist with LBT-HC5 sets, the 500A and B sets will not aggravate the crosstalk problem.

5.04 On loops with a resistance below about 900 ohms, the use of 500J and K sets may result in some unsatisfactory crosstalk performance due to the lack of equalization. Replacement of J and K sets with equalizer-equipped sets may provide sufficient relief in such cases.

5.05 Further discussion of the crosstalk aspects of station sets may be found in the AB61 Series of practices.

6. SIDETONE

6.01 On long loops the 3-element balancing network in 500 and 501 A, B, J, and K series sets provides about 10-dB better sidetone balance than the single element network of the 300 series common battery talking sets. As the resistance of the loop decreases, this improvement in sidetone balance diminishes until, on very short loops, the balance is about equal to that of the 302 set. However, the equalizer reduces the transmitter and receiver efficiencies as the loop shortens and results in an acoustic volume of sidetone in the 500A and B sets about equal to that of the 302 set for all loop lengths. In the case of J and K series sets, which are not equipped with equalizers, the sidetone volume increases as the loop resistance decreases, but does not become excessive if minimum loop resistance for these sets is held to 400 ohms. Figure 8 shows the comparative sidetone levels of the equalizer equipped 500 and 501 A and B series sets and the 302 set.

7. NOISE

7.01 On short and medium length loops, the susceptiveness of 500A and B sets to longitudinal noise compares favorably with the 300 series for most set, loop, and central office conditions. On long loops, for reasons pointed out in Part 5 of Section 852-220-100, 500A and B sets on party-line flat rate services are as much as 5-dB more susceptive than 300 series sets over parts of the frequency range above 250 Hz. For the 500J and K sets, from which the equalizer was omitted, the higher susceptiveness applies generally to all loops.

7.02 On 2-party message rate dial tip stations, the 500B and K sets have a susceptiveness as much as 7 dB higher than the 304 set over most of the frequency range above 300 Hz. Where an excessive noise condition is encountered, considerable improvement in the overall susceptiveness of the 500B and K sets may be realized by moving the ringer lead from the R terminal on the network to the M terminal. However, even with this connection the susceptiveness in the 500- to 1200-Hz range is still as much as 5 dB higher than the 304 set. Under this condition the susceptiveness of the 500K set is a little less than that of the equalizer-equipped 500B set. Where 500 sets are required for transmission reasons, there is no advantage from a noise standpoint to be realized by substituting F1A-LBT sets because the

signal-to-noise ratio remains about the same. Furthermore, if an HC5 receiver is used in the LBT set, its higher response at low frequencies may aggravate the condition even more than the 500 set and produce a higher overall susceptiveness.

7.03 If longitudinal noise voltages are high enough to cause transmission impairment on J and K sets on party-line services (other than message rate dial tip stations) with loops between 400 and about 900 ohms, some mitigation may be provided by changing to equalizer-equipped sets. On longer loops set changes will probably not provide much improvement, and such impairment may require that measures be taken in outside plant to improve the noise condition. Detailed information on the susceptiveness of these sets under various set, loop, and battery supply conditions will be found in the AB63 Series of practices.

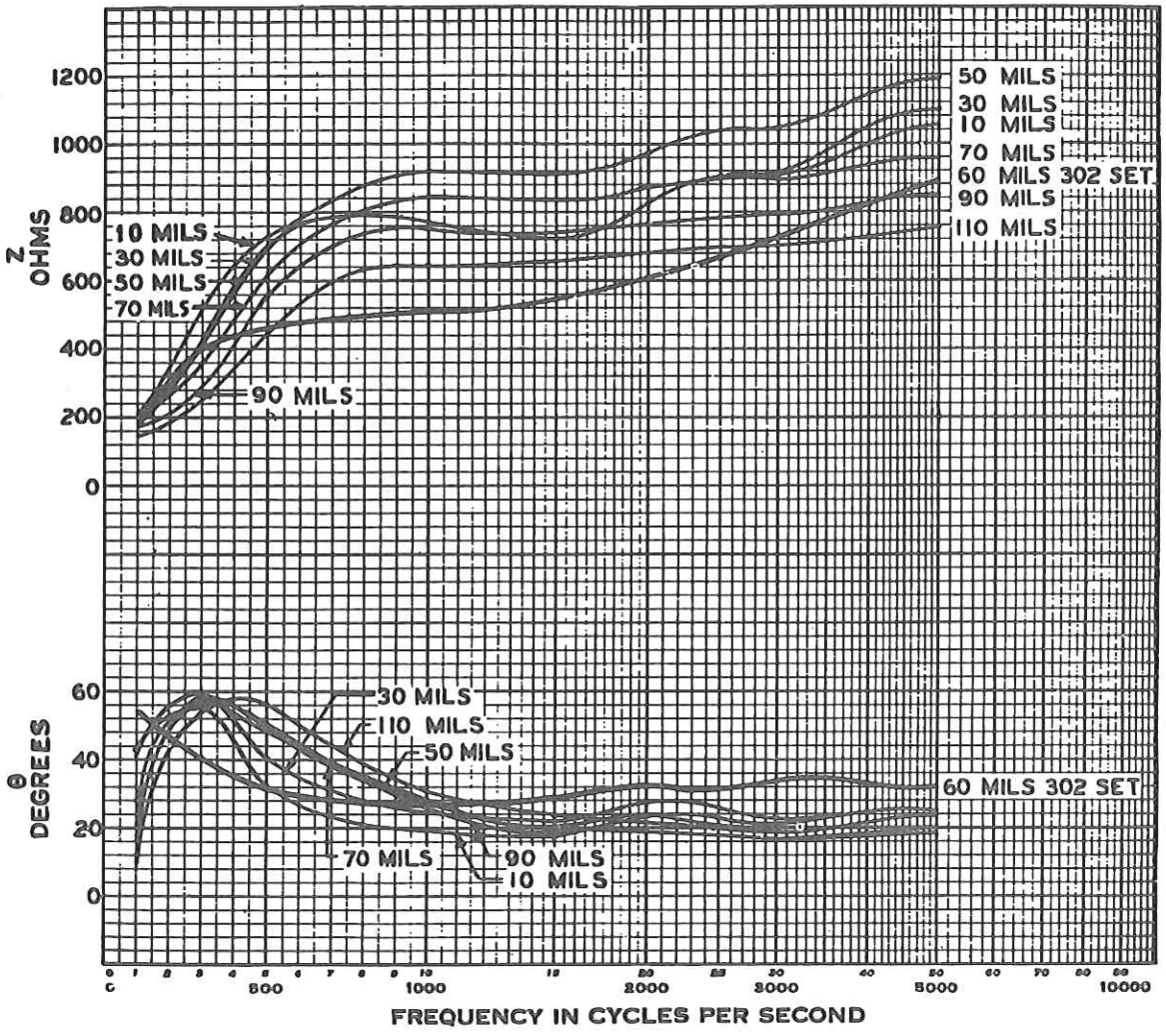

Fig. 6—Impedance Characteristics of 500A and B Sets with Various Values of Loop Current

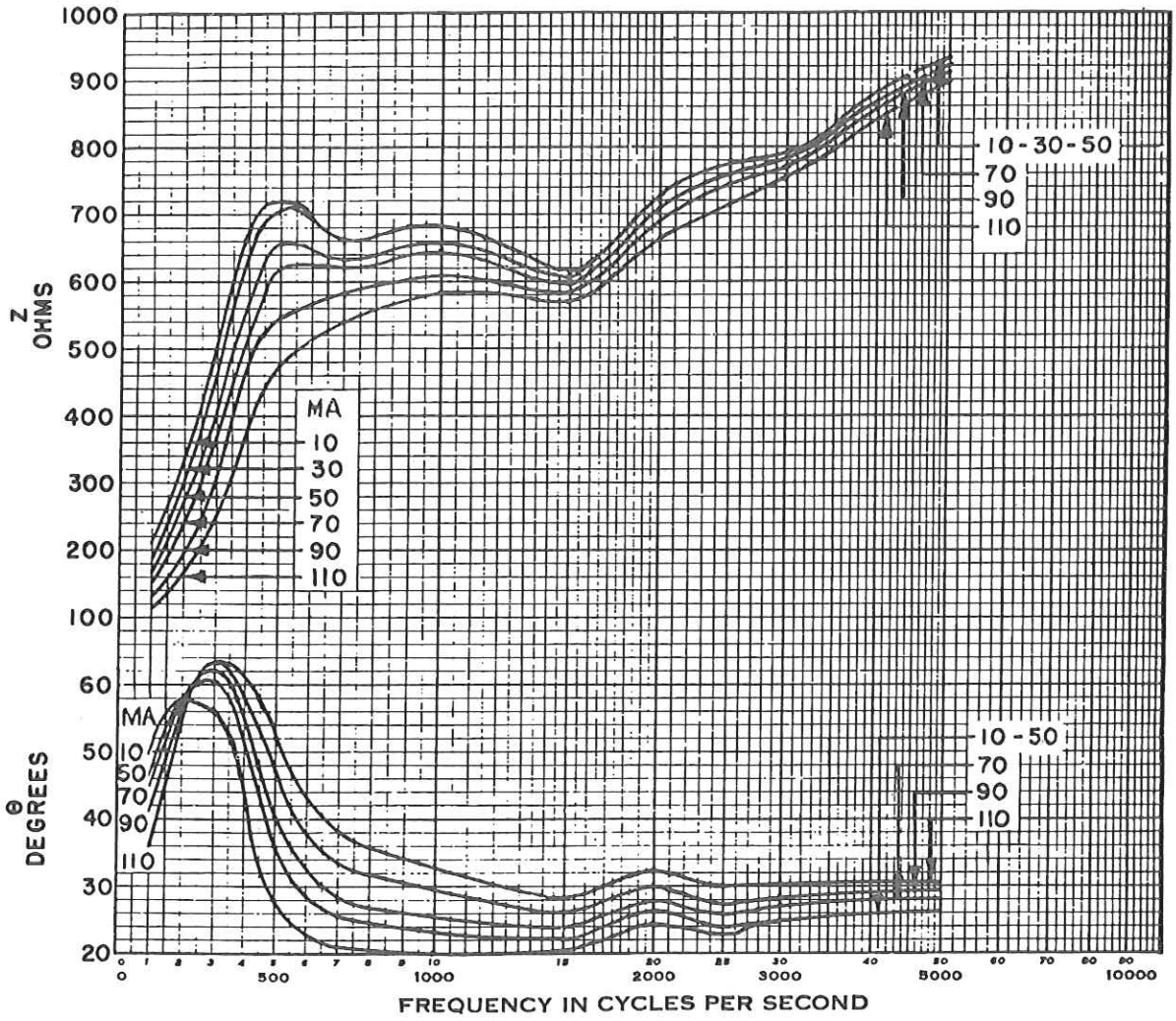

Fig. 7—Impedance Characteristic of 500J and K Sets with Various Values of Loop Current

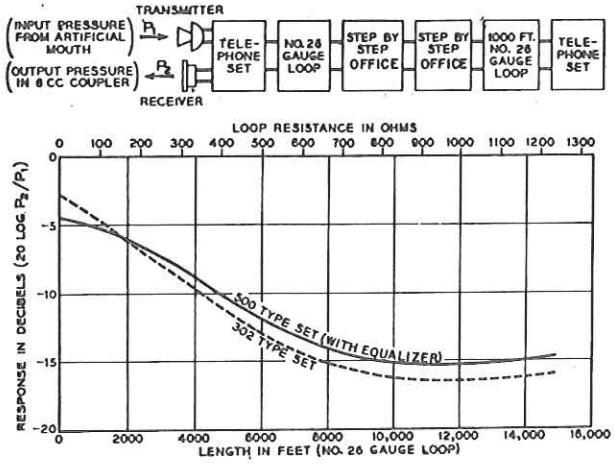

Fig. 8—Comparative Sidetone Levels