A New High Performance from Subscribers' Telephones

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Research, investigation, design, and testing are now complete, and a new range of G.E.C. telephones is in production. The telephones incorporate new components, which have been designed and matched to each other to give a level of performance not excelled by any telephone available today.

In comparison with their predecessors, the new telephones have a considerably better volume output and a marked improvement in articulation. The net result is an improvement in performance of 4-6db on receiving and 6db on sending. In consequence, local distribution networks may include longer lines, or smaller wires, or give a better performance with existing lines.

For a standard of performance stipulated as an acceptable minimum, the new telephone will operate over a local line loop of 1120 ohms of 6216 cable (.5mm conductor). Alternatively, 3.2 miles o f 1016 cable (.6mm) could be extended to 5.3 miles for a similar performance, or be replaced by 416 cable (.4mm).

These figures indicate a saving of capital cost or a better usage of existing investment that are of great importance to Telephone Administrations.

The new components, and the improvements they give, are described in this present article. They are included in a new instrument-the "G.E.C. 1000" Telephonewhich is described elsewhere in this issue, and in the Gecophone "K", the Muraphone "K" and the Switching Telephones.

Handset

A notable feature is the new handset. Its curved shape (Fig. 1) has not only an aesthetic significance-it has a highly-important technical basis. It tilts the transmitter into a more-sensitive position during normal use, thereby resulting in an improvement of about 2db in sending performance, whilst the shape and size of the mouthpiece give an improved frequency response.

Transmitter

The transmitter inset is the immersed-electrode carbon-granule type that has been so effective in G.E.C. telephones for some years. The resistance of this type of transmitter is partially dependent on the value of the current passing through it ; the relationship between current and resistance is shown in Fig. 2. The frequency response is shown in Fig. 3.
Non-linear and amplitude distortion are inherent in practical carbon-granule transmitters. The distortion

Fig. 1. - New telephone handset showing receiver and transmitter capsules.

can be reduced by restricting granule agitation in the direction of current flow, but increased restriction results in decreased output from the transmitter. The inset establishes an appropriate balance and thereby gives a very high output consistent with an acceptable frequency response; together with a satisfactory signalling resistance.

Some years ago, the G.E.C. conducted tests in highhumidity areas, where some transmitters had been found to deteriorate in service. The tests indicated that, particularly on short lines, minute sparking occurred between adjacent granules. To protect them, a resistor was included for simple connexion across the transmitter. This p ractice is repeated in the new telephones. When specified on orders, the resistor will be included in the internal wiring of the telephone.

Receiver

The receiver is of the inset type. It employs a rocking armature, which drives a light diaphragm. A very-high electro-acoustic conversion ratio is combined with an improved frequency response. Fig. 4 indicates the order of improvement compared with the former receiver, and shows the greater output at the higher frequencies, which is so important for good articulation.

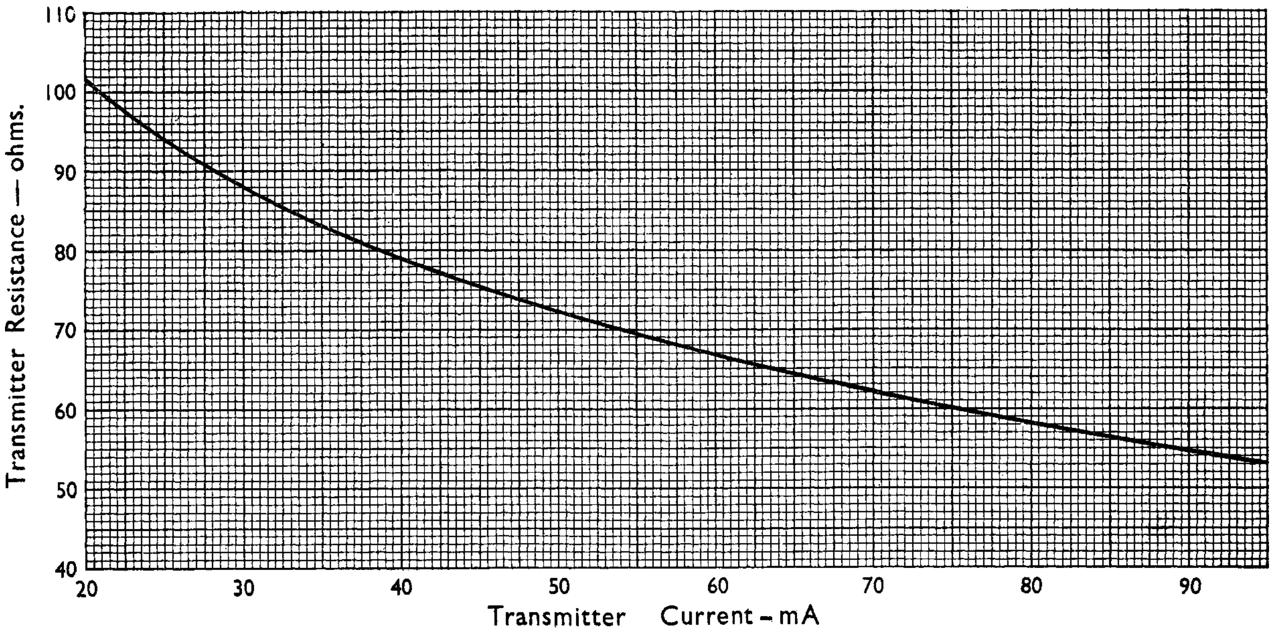


Fig. 2.-Variation of transmitter resistance with current flowing.

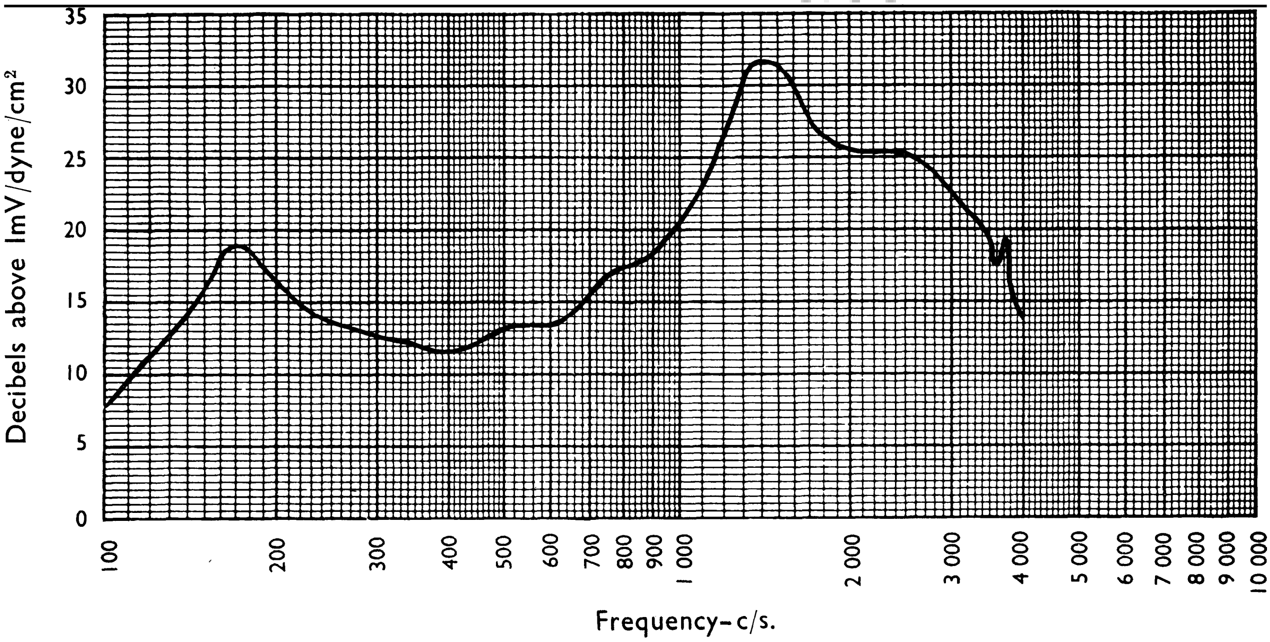


Fig. 3.-Transmitter frequency response.

The armature, rocking on a central support, drives the diaphragm via a small rod. The diaphragm, which in previous receivers consisted of a flat plate of magnetic material, is now a very-thin dished disc of light alloy. The use of the light alloy results in a large increase in the ratio of effective area to effective mass. The magnetic circuit of the rocking-armature receiver is analagous to that of the ordinary ringer, where a central permanent magnet polarises an armature, which is alternately attracted and repelled by the electro magnets on each side. The similarity ends there, however, for the magnetic and mechanical parameters of the receiver unit have been critically proportioned to produce the correct mass-to-compliance ratio and mechanical impedance to suit an ear-damped unit.

The high efficacy of the receiver is obtained by the use of a very small air-gap, ingeniously controlled, a high-permeability magnetic system, and a high stiffnessto-massratio. After acoustic equalisation, the resulting frequency-response characteristic is substantially flat, as shown by the curve in Fig. 4. The small central magnet is anisotropic and works on a recoil loop of its demagnetisation curve.

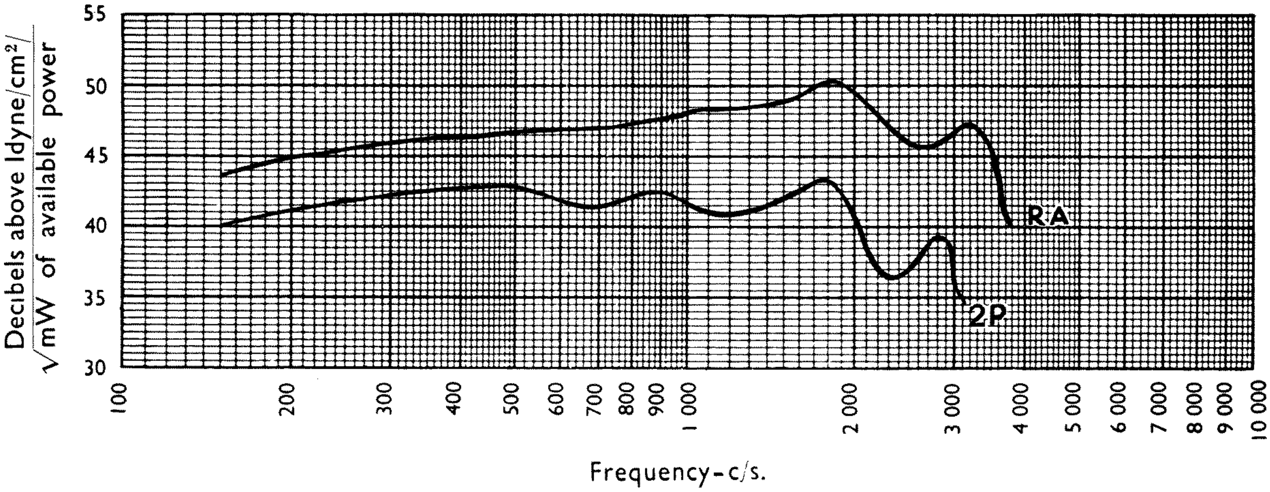


Fig. 4.-Receiver frequency response.

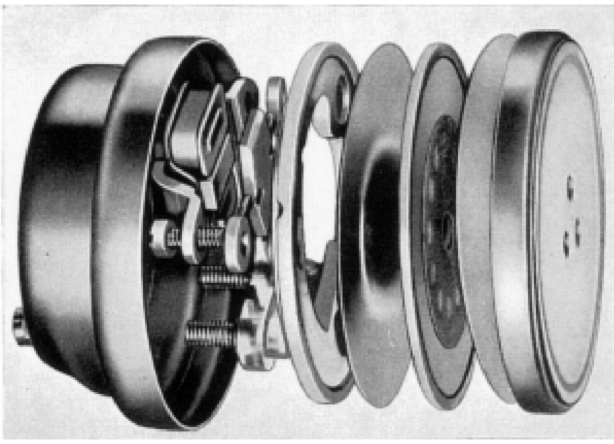


Fig. 5.-Exploded view of rocking-armature receiver.

After saturation the receiver is subjected to a demagnetising process, which stabilises the magnet, and adjusts the strength to an optimum value. The impedance of the receiver, when loaded with an artificial ear of 3cc capacity, is 150 ohms.

Induction Coil

The induction coil is a most important component in a telephone. The extent to which its design governs performance has been used in the new instruments to take some of the improvement given by the new receiver and transfer it to the sending side. Without this transfer the overall performance would not have reached the high level that distinguishes the new telephones.

In redesigning the coil, a closed-iron magnetic circuit was chosen in preference to an open-iron circuit for economy in space. By using a design having two long and two short limbs advantage could be taken of the new grain-orientated silicon iron for the laminated core. This results in a smaller coil (only half the cross section of iron) than would result if normal isotropic silicon iron were used, (Fig. 6).

Circuit

The new circuit is shown in Fig. 7. The ratio of turns of the three windings of the induction coils, the impedance provided by each, and the value of the two capacitors, have been chosen so that, notwithstanding the improvements in sending and receiving efficacies, the degree of sidetone suppression remains very high, particularly on the longer reactive lines.

Operation of the dial off-normal springs provides a short-circuit across the receiver, creates a clean impulsing loop, and an efficient spark-quenching path consisting of a low impedance network in series with capacitor C2.

The circuit is redrawn in Fig. 8 in hybrid-transformer form. This illustrates more clearly that with turns ratio for optimum conditions of send and receive, the sidetone balance has been obtained by correct selection of values for C1, C2, R1, and R2.

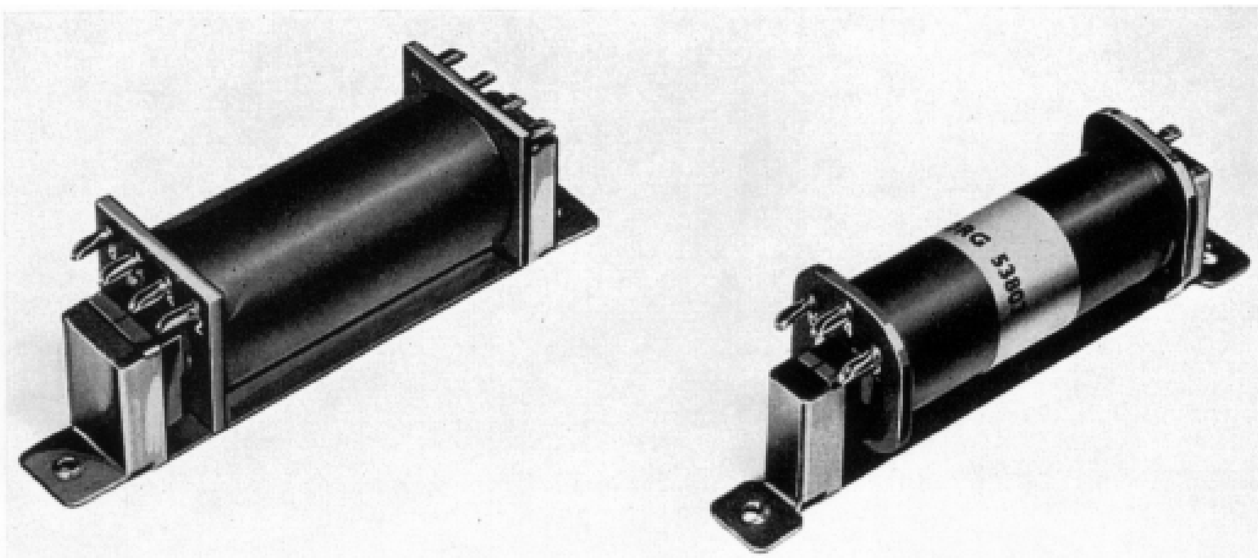
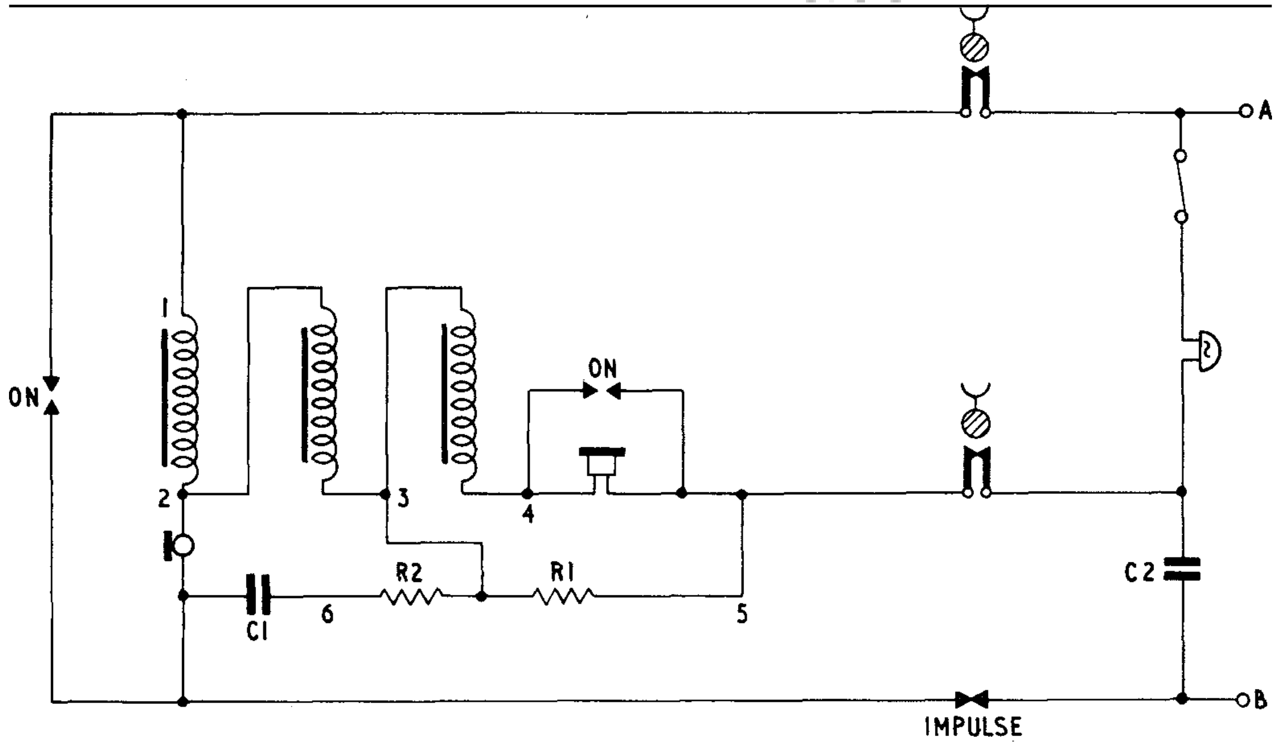


Fig. 6.-Comparison of new (right) and former induction coils.



Resistance

The talking resistance offered to the line by the complete telephone varies with the steady current drawn over the line. The mean value of talking resistance for a given line loop is shown in Fig. 9, from which maximum current consumption per line may be deduced.

The maximum resistance occurs when the handset, off the cradle switch, is in the horizontal face-down position. This is of the order of :

165 ohms at 20 milliamps of line current. 120 ohms at 55 milliamps of line current. Impedance

The following table gives the approximate impedance looking into the line terminals of the telephone with the handset removed from the cradle. Readings were taken with 50-milliamps direct current flowing in the line, one-volt AC input, and a dummy transmitter of 60 ohms.

Frequency c/s	300	500	800	1000	2000	3000
Impedance	578	476	460	463	498	510

Transmission

The transmission performance of a telephone and its associated battery feed circuit is normally measured against the performance given by some standard arrangement. Measurement can be by volume alone or can include the effects of articulation, sidetone, and room noise. The subject is covered in the appendix.

The efficacy of the telephone itself may be assessed in terms of the maximum length of local line over which it will work satisfactorily. Alternatively, the telephone, together with its standard local line, may be compared with the COIF international reference levels, S.F.E.R.T. for volume, and A.R.A.E.N. for articulation.

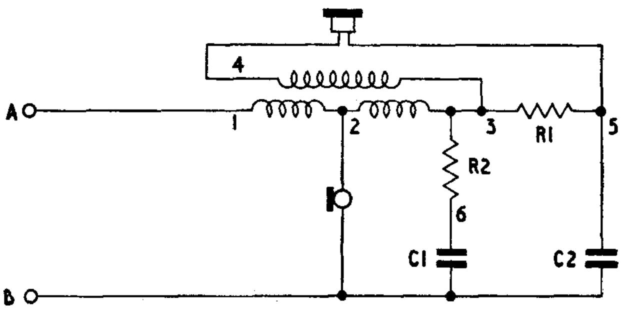


Fig. 8.-Circuit of "G.E.C. 1000" Telephone drawn in hybrid form.

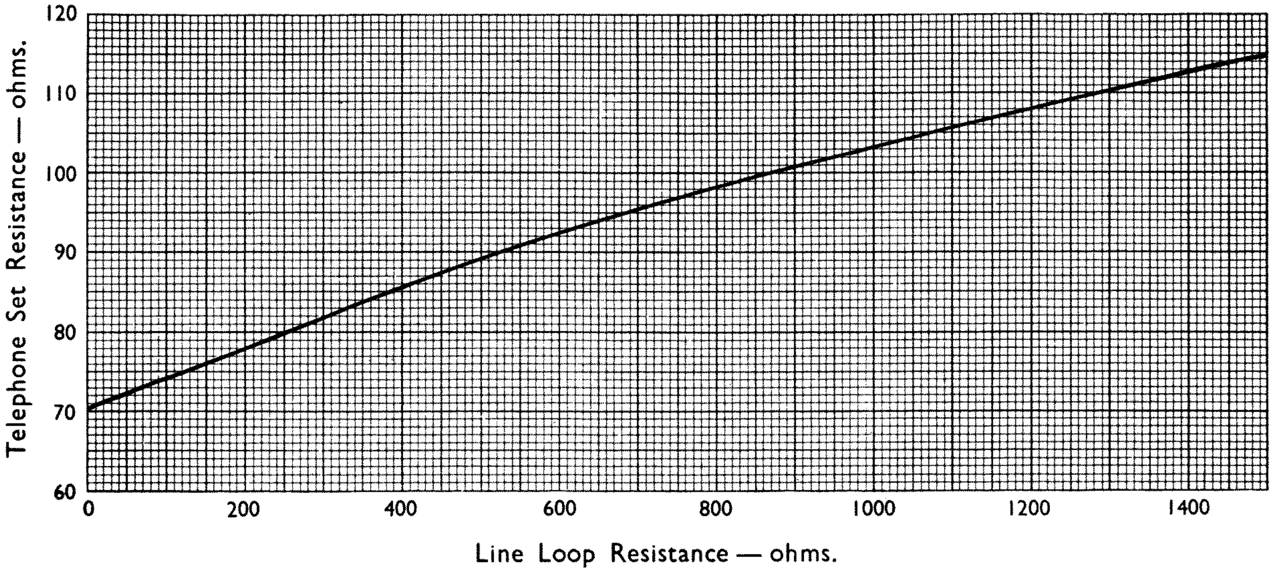


Fig. 9-Variation of talking resistance with length of line.

Limiting Transmission Level

The maximum length of local line is that which gives the minimum transmission level satisfactory for national and international working. These limiting volume or transmission levels are shown on the curves in Figs. 10, 11, 12 and 13. From these the maximum lengths of the various types of cable, and the international ratings for the local circuit are readily obtainable. Volume Rating

The curves in Figs. 10 and 11 show the sending and receiving levels on a volume basis for the new telephone on various local lines. Similar ratings for the earlier Gecophone and the present B.P.O. standard telephone No. 332 are shown in broken lines. The gain in volume for sending in the new telephones is seen to be of the order of 6db. These loudness ratings do not include the full effect of the improvement in frequency response.

Articulation Rating

A more realistic evaluation of the efficacy of the telephone is obtained when the effects of articulation and room noise are taken into account. The curves in Figs. 12 and 13 show the sending and receiving levels compared with the limiting transmission level. The effect of sidetone is included in the receiving perform ance, but not in the sending performance. The levels shown can therefore be referred directly to A.R.A.E.N. because the sidetone conditions are identical to those used by the CCIF laboratory in assessing the international ratings.

Sidetone

In spite of the increase in both sending and receiving volumes in the new telephones, the sidetone has been suppressed on the longer lines to a level similar to that of the former Gecophone and the B.P.O. No. 332 telephones. As the sidetone effect is similar except for the very short lines, the difference between the full and dotted curves (Fig. 12) represents a true comparison between the efficacies of the new and earlier telephones. It is seen that the maximum improvement in receiving efficacy occurs on lines longer than 200 ohms. On shorter lines the receiving efficacy falls off towards that of the earlier telephones. This is an advantage, since the increased reception of the telephone is not required on short lines, where the performance of former telephones was satisfactory.

Comparison between the curves in Figs. 11 and 13 show the effect of sidetone on reception in the presence of room noise. The level of sidetone depends upon the impedance presented to the terminals of the telephone. The variation of the sidetone level with line length for various types of line is shown in Fig. 14.

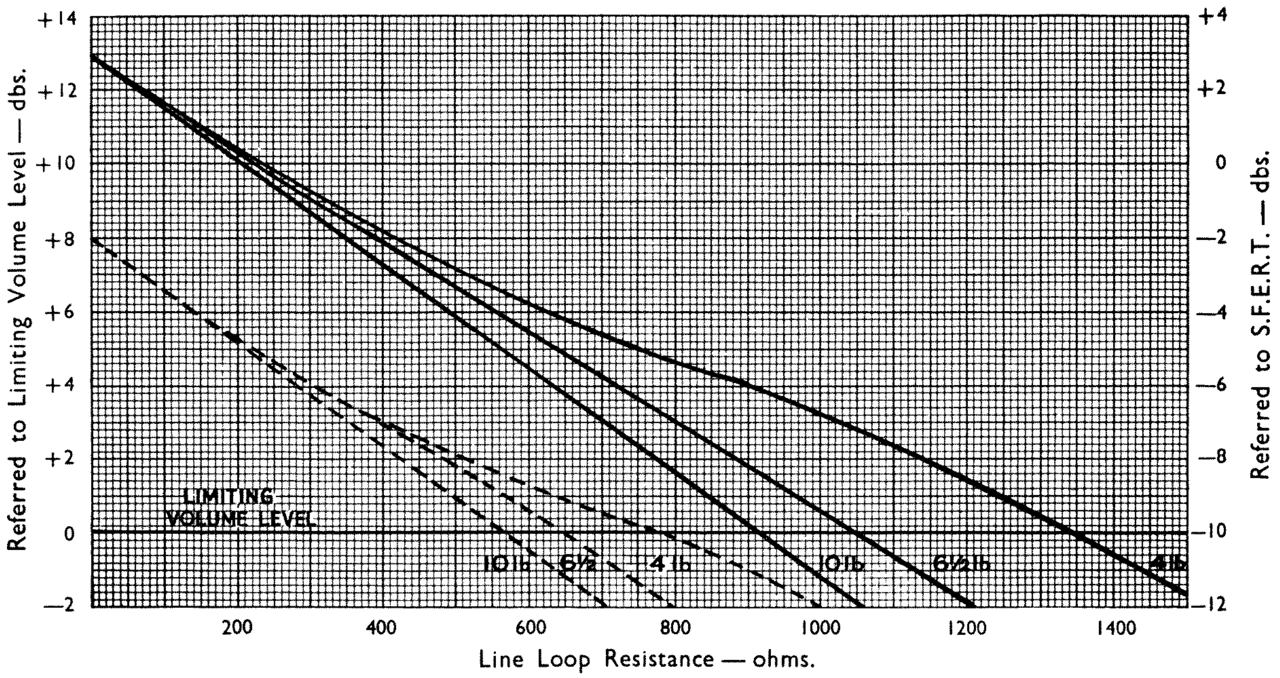


Fig. 10.-Volume ratings for the telephone-sending.

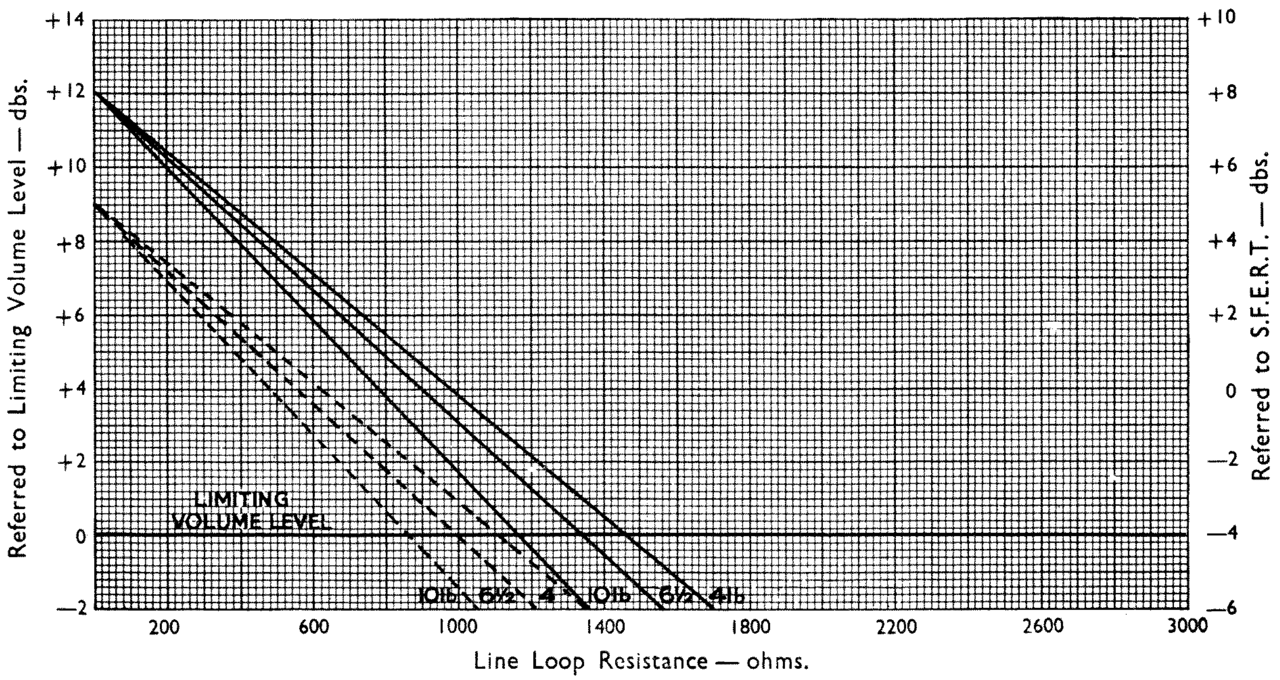


Fig. 11.-Volume ratings for the telephone-receiving.

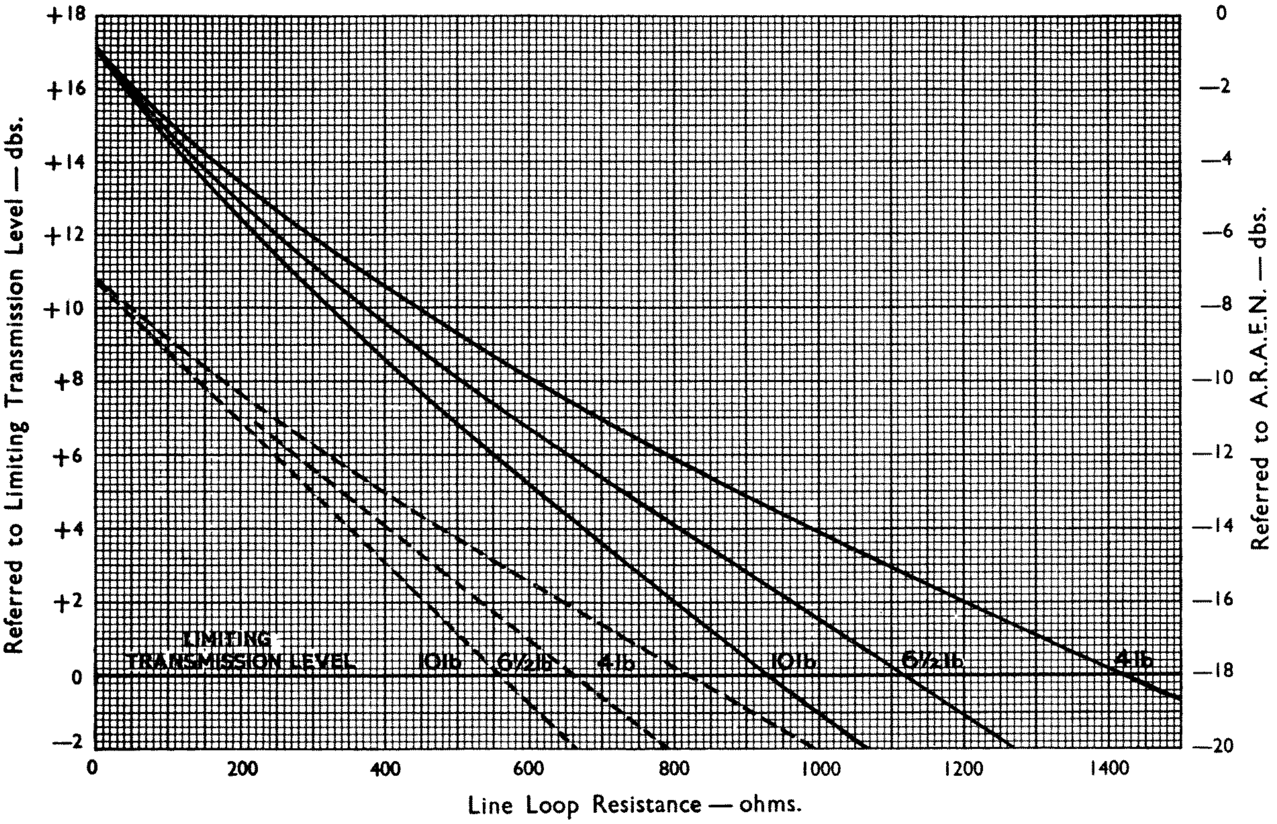


Fig. 12.-Articulation ratings for the telephone-sending.

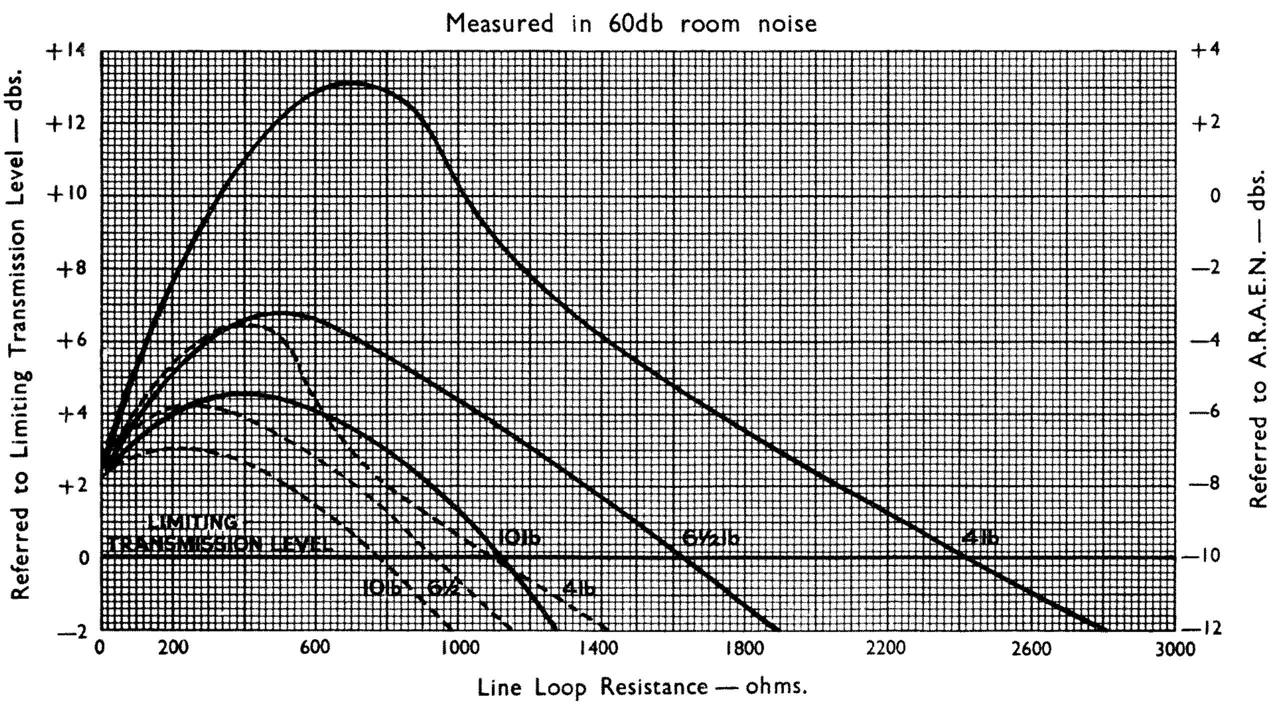


Fig. 13.-Articulation ratings for the telephone-receiving.

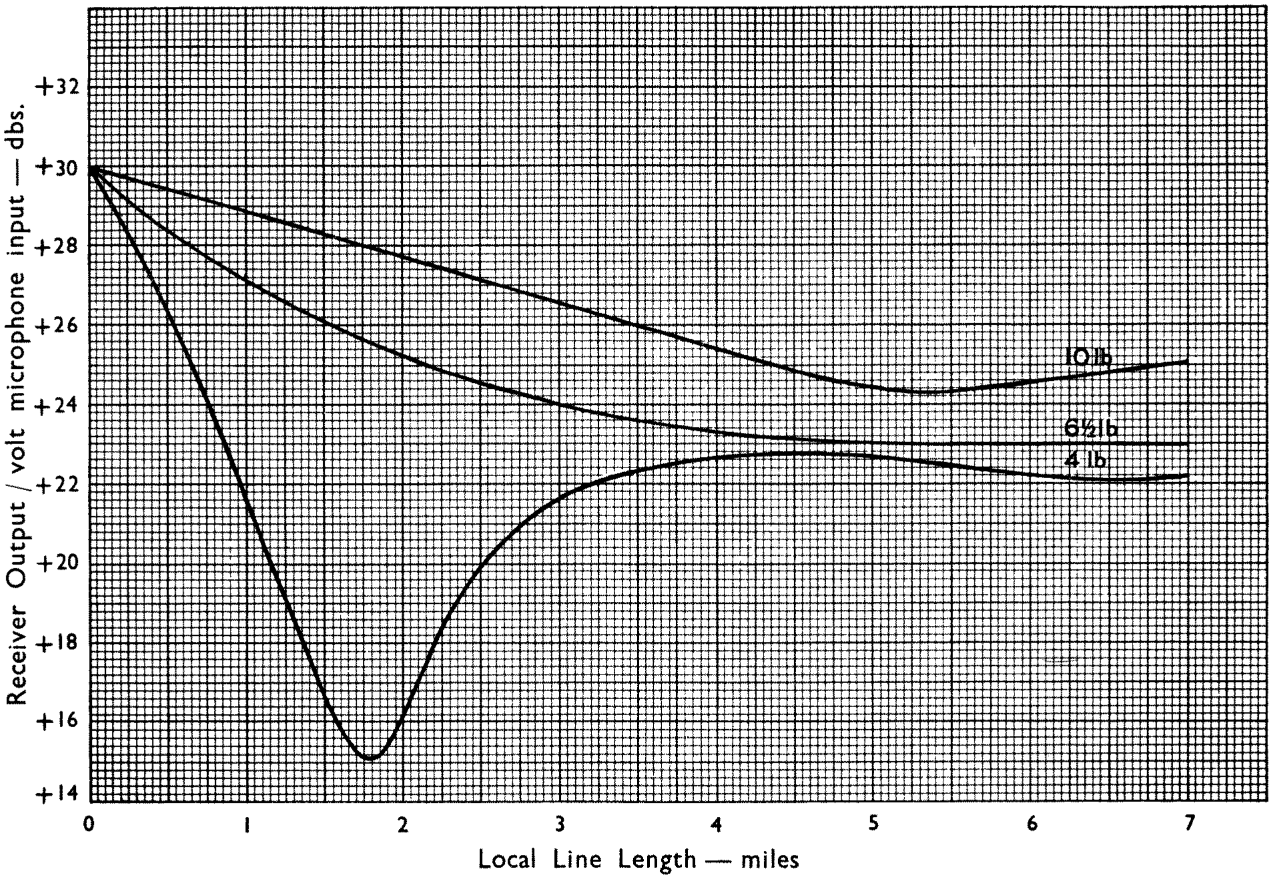


Fig. 14.-Sidetone levels for the telephone.

Long Lines

The curves of Figs. 12 and 13, show that in comparison with the minimum reference level for national and international working the receive rating for the existing G.E.C. Table Telephone was already higher than the send rating (broken lines). This is why part of the increased performance due to the new receiver is transferred to the sending side in the new telephones. Even with this transfer, it is still the sending side that determines the maximum length of local line permissible.

Comparison between the full and broken lines in Fig. 12 shows an improvement of the order of 5 to 6db for sending performance on long lines, which, expressed in terms of line plant, means that maximum line length may be increased, or a lighter gauge of cable used.

Short Lines

The increase in transmission performance is maintained over very-short lines. On such lines, if warranted by exceptional circumstances, reduction of the transmission performance may be obtained by introducing a resistor into the line connexions.

Effect of Transmitter Shunt

Where a shunt is fitted across the transmitter, a sending loss of approximately 2db occurs on long local line; the effect on reception is negligible.

Acknowledgments

The author gratefully acknowledges permission from the British Post Office to publish the transmission performance data in this article.

The General Electric Company Limited of England
August 1956