TELEPHONE RECEIVERS NOS. 2P AND 10A

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This article describes the No. 2P Telephone Receiver. This receiver is an improvement on the No. 1L type which is in service on handset telephones. A similar receiver No. 10A for use on telephonists' headsets is referred to also.

General: In Bell's original telephone a device consisting of a permanent magnet, a coil to produce flux variation in accordance with current variation, and an iron diaphragm to change electrical energy into acoustical energy was used both as receiver and transmitter.

It is remarkable that this device has been used ever since as a telephone receiver, no fundamental changes in design having taken place until quite recently. The improvement in receiving efficiency which has been achieved particularly with the modern receiver type 1L used on handset telephones has resulted mainly from the greatly improved quality of the magnetic materials used.

The essential parts of a telephone receiver (see Fig. 1) are the magnet N.S., a coil C, and an iron diaphragm D. The diaphragm is clamped rigidly round its outer edge between the receiver case and the earpiece, but is free to vibrate in the air space S1 between the diaphragm and the case and the air space S2 between the diaphragm and the earpiece. The function of the receiver diaphragm is to transform electrical energy into mechanical energy and then to radiate acoustical energy. It has a natural period of vibration which is governed by its mechanical properties of mass and stiffness and by the load in the air spaces on each side.

For **good quality reception,** if the resonant frequencies of the diaphragm fall within the audio band, the damping effect of the air in the air spaces on each side of the diaphragm must be large.

On the other hand, for **maximum volume efficiency** the fundamental resonant frequency should fall in the middle of the audible band or the resonances should be spaced at intervals within the band. The older types of receiver have two pronounced diaphragm resonances. In receiver 1L used on handset telephones the fundamental resonance occurs at 1000 to 1100 cycles per second with another resonance at about 3500 to 3800 cycles. The latter is too high to be of value on telephone circuits with a cut-off frequency at about 3000 cycles.

The damping effect of the air in a confined air space on a telephone receiver can readily be observed. When a receiver is held closely to the ear, a larger acoustic load is impressed on the diaphragm and the damping effect is far greater than for a receiver in free air, with the result that the quality of reception is improved. When the receiver is lying on a table its output is considerably distorted when compared to a receiver held against the ear, due to the absence of the damping effect of the air in the space between the earpiece and the ear.

Magnetic Materials Used in Earlier Receivers, including Type 1L: The earliest type of watch-case receiver used in Commonwealth and Swedish Ericsson Magneto telephones was provided with a circular carbon steel permanent magnet, soft iron pole pieces and a tinned iron diaphragm. The permanent magnet consisted of a number of flat steel rings each magnetised across a diameter, the rings being placed one above the other with like poles together.

The well-known Bell receiver in use for so many years on magneto, C.B. and automatic wooden-cased wall sets and pedestal type table sets was provided with a tungsten steel U-shaped magnet, soft iron pole pieces and a "Stalloy" diaphragm, varnished black on both faces. Stalloy is an alloy of iron, silicon and aluminium containing 3.5 per cent.-4 per cent. silicon, and 0.1 per cent.-0.2 per cent. aluminium.

The 1L receiver in use on moulded handsets is provided with a cobalt steel bar magnet, cobalt iron pole piece and a stalloy diaphragm varnished black on both sides. The thickness of the diaphragm over the varnish is 10 to 11 mils.

Telephone Receiver No. 2P

General: The new type of telephone receiver (see Fig. 1) is designed to give a more uniform frequency response than the former types without loss in volume efficiency, thus providing better quality reception. Briefly, this is achieved by three resonances which are spaced at intervals and damped by acoustic networks. The

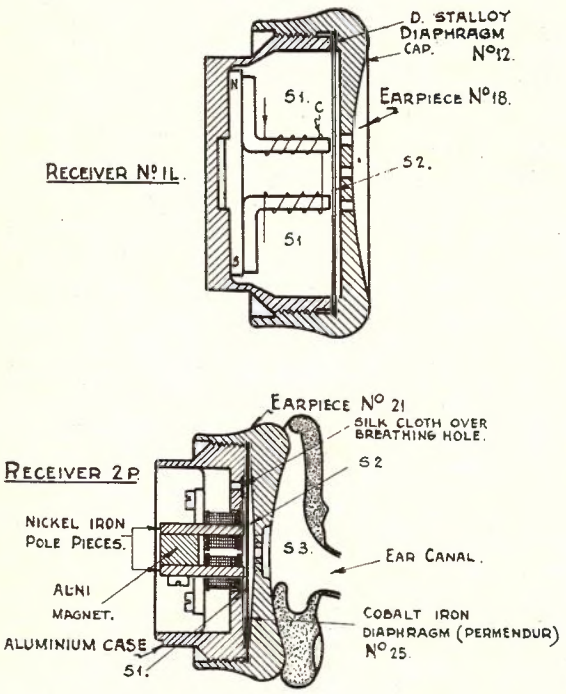

FIG. 1. RECEIVERS 1L & 2P.

acoustic pad behind the diaphragm consists of a shallow chamber (space S1) directly behind the diaphragm and connected with a larger chamber at the back by a small hole which is covered with a silk diaphragm of very fine mesh. The acoustic pad in front of the diaphragm consists of a shallow chamber between the diaphragm and the earpiece, connected by four small holes in the centre of the earpiece to the air space S3 between the earpiece and the ear. The loss in volume which results from damping the diaphragm is compensated for by the use of much better quality magnetic materials and improvements in the design of the magnetic circuit.

Construction: The 2P receiver is similar in construction to the 1L type. The receiver fits into the moulded handset to which it is secured by two fixing screws which also make the electrical connections. The die-cast aluminium case on which the pole pieces and magnet assembly are mounted incorporates the shallow chamber (S1) behind the diaphragm. The small silk diaphragm or cover is held in position by a small metal washer which is secured by staking the metal of the frame in three places. The magnet assembly is secured by fixing screws to the aluminium case, the pole pieces projecting through slots in a moulded plate insulator which is sealed to the aluminium frame and to the pole tips to make an air-tight joint.

Receiver 2P is provided also with a new moulded earpiece which will be known as Earpiece No. 21. The external dimensions are practically the same as those of the earpiece used on Receiver 1L, but slight changes in design have been made to assist in determining the earcap resonance. An important difference in the outside shape of the new receiver earpiece is that the four holes in its centre are arranged in the bottom of a small recess $\frac{1}{2}$ inch in diameter and 1/10th inch deep in the front of the earcap, as it is essential that none of the holes is obscured by the cartilage of the ear when the receiver is in use.

The inside surface of the new earpiece is conical instead of flat to provide air flow to the centre holes and a more uniform cross-section of air in the air space when the receiver is in use.

Magnetic Materials: The 2P Receiver is provided with a short "Alni" bar magnet, the approximate composition of the alloy being nickel 25 per cent., aluminium 10 per cent., copper 5

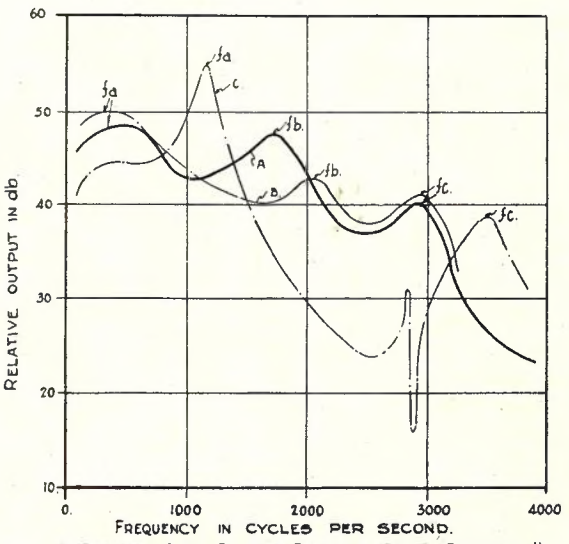

FIG 2. FREQUENCY RESPONSE CHARACTERISTIC CURVES.

per cent., the remainder iron. This alloy gives a high flux density per unit of volume and the specific gravity of the alloy is lower than tungsten or cobalt steel, thus giving some further reduction in weight.

The soft iron pole pieces are of nickel iron containing approximately 36 per cent. nickel. This alloy has been chosen on account of its high permeability and high specific resistance, the latter reducing eddy current losses.

The new receiver diaphragm, which will be known as Diaphragm No. 25, is of "Permendur" and is varnished black on one face only, the side nearest to the ear when in use. Permendur is an iron, cobalt, vanadium alloy containing approximately 50 per cent. cobalt and 7 per cent. vanadium. Permendur has high permeability at high values of flux density, an essential requirement, as, in order to obtain as small a diaphragm mass as practicable it is necessary to use the thinnest possible diaphragm. The use of vanadium in the alloy is necessary to enable the material to be rolled into very thin sheets and considerably increases the specific resistance which otherwise is rather low, thus reducing eddy current loss. The thickness of the diaphragm over the varnish is about 10 mils.

It is claimed that the cross-sectional area of the pole pieces is the maximum practicable and

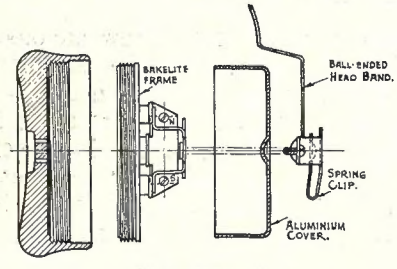

FIG. 3. RECEIVER 10A.

the separation between the pole pieces and diaphragm is the minimum consistent with security against pulling in the diaphragm against the pole pieces.

The D.C. resistance of receiver 2P is about 55 ohms and its impedance at 1000 cycles when fitted with a dummy ear is about 455 $\angle 65°$ ohms. Receiver 10A has a D.C. resistance of about 60 ohms and an impedance at 1000 cycles with a dummy ear of 225 $\angle 57°$ ohms. Its weight is $6\frac{1}{4}$ ozs. with the headband.

Improvement in Performance: The frequency response characteristic of receivers 2P, the handset type, and 10A, the headset type, when compared with receiver 1L, which is typical of the older type receiver, is shown in the curves (Fig. 2). Curves A and B are flatter than C and the output between the frequencies from 1500 to 3000 cycles per second has been raised about 10 db. above that of receiver 1L. This increased efficiency over the upper part of the voice frequency range is one factor which is responsible for the improved performance of the new receivers. Another advantage is that the absence of defined resonance peaks reduces the masking effect, which may be pronounced with the older receivers when the frequencies around the diaphragm resonance tend to mask other frequencies which are produced relatively weakly, resulting in loss of intelligibility.

Research Laboratory tests (Test Reports Nos. 943 and 944) indicates that the volume efficiency of the new receivers is about 2 db. above the 1L type (voice ear tests), and that the articulation efficiency is about 9 per cent. better than the 1L type. After an accelerated life test no marked loss in efficiency occurred.

A further advantage which is claimed for the new receivers is that the effect of surges or abrupt interfering noise on the ear is considerably reduced due to the fact that the new receiver has no very pronounced resonance. This should result in an overall gain in transmission efficiency, as the user will hold the receiver more closely to the ear, thus improving reception.

Applications: Apart from general use, the new receiver will be particularly suitable for use on telephones in noisy situations and by persons with defective hearing and also on telephones associated with amplifiers. It should also be of particular use to telephonists who usually work under rather noisy and trying conditions.

Method of Obtaining Improved Frequency Response (Figs. 1 and 2): As mentioned earlier, in the older receivers such as the 1L type the fundamental resonance occurs at about 1100 cycles per second (fa) due to the mass and stiffness of the diaphragm and the damping effect of the air in the space S1 between the diaphragm and the case. A second resonance called the "earcap resonance" occurs at about 3500 cycles (fc) due to the damping effect of the air in the space S2 between the diaphragm and the earcap, the air in the earcap holes and the air in the air space S3 between the earcap and the ear. This resonance is too high to be of value in telephone circuits having a cut-off frequency at, say, 3000 cycles per second.

In the new receivers, types 2P and 10A, the combined effects of the mass and stiffness of the diaphragm, and the damping due to the air in the shallow chamber S1 and the air in the leak hole, give rise to two resonant frequencies at about 300 (fa) and 1700 (fb) cycles per second for receiver 2P and 300 (fa) and 2000 (fb) cycles per second for receiver 10A. The fine silk covering over the leak hole serves to flatten out the peaks and the troughs, thus producing a flatter curve.

The effect of the acoustic chamber S2 between the diaphragm and the earcap, the air in the four earcap holes and the air in the air space S3 between the earcap and the ear is to produce a moderately sharp resonance in the region of 2900 cycles per second (fc), i.e., within the audio frequency band.

The change in earcap resonance (fc) for the new receivers, when compared with the earlier types such as 1L, is due to the altered shape of the inside of the earpiece, the reduction in the number and size of the holes in the earpiece, and the concentration of the holes at the centre.

Telephonist's Head Receiver No. 10A

The new telephonist's head receiver has the same magnet and pole pieces as the 2P type, but the weight is still further reduced by the substitution of a bakelite frame for the die-cast aluminium case. A pressed sheet aluminium cover is fixed to the back of the receiver by two screws, which also serve to attach the spring clip which holds the ball-ended headband (see Fig. 3).

Conclusion

The improvement in reception with the new receiver is primarily one of quality, and this has been achieved without loss in volume efficiency. The receivers were developed by Messrs. Standard Telephones and Cables, in conjunction with the B.P.O. Research Department.

References

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