Jan. 20, 1925. 1,523,540

H. HECHT

ELECTROMAGNETIC VIBRATOR

Filed Nov. 1, 1921

Fig. 1.

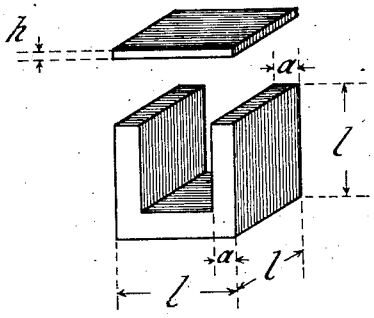
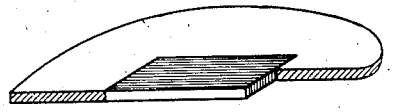


Fig. 2.



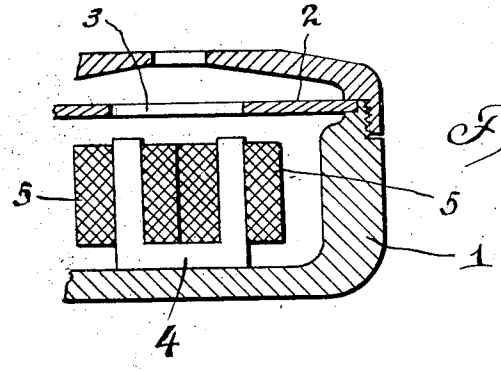


Fig. 3.

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UNITED STATES PATENT OFFICE.

HEINRICH HECHT, OF KIEL, GERMANY, ASSIGNOR TO SIGNAL, GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, OF KIEL, GERMANY.

ELECTROMAGNETIC VIBRATOR.

Application filed November 1, 1921. Serial No. 512,077.

To all whom it may concern:

Be it known that I, HEINRICH HECHT, citizen of the German Republic, and residing at Kiel, county of Schleswig-Holstein, State of Prussia, Germany, have invented certain new and useful Improvements in Electromagnetic Vibrators, of which the following is a specification.

The invention relates in general to telephones and more particularly to telephone receivers. The object of the invention is to produce a novel type of telephone receivers of a greatly improved eletromagnetic efficiency. The improvement is, of course, applicable to all other kinds of eletromagnetic vibrators whose construction is similar to that of a telephone receiver. The invention is based on the fundamental idea that, to improve the efficiency of the telephone receiver, it is not sufficient to reduce only one of the kinds of losses, or a certain group of the losses, that occur in this instrument, as has been done hitherto. In distinction herefrom the present invention contemplates the simultaneous reduction of all the various kinds of losses that occur in a telephone and especially of all the electrical and magnetic losses.

The invention effects a reduction in (*a*) the iron losses, (*b*) the vibrating masses of the armature and the receiver diaphragm, and (*c*) the copper losses.

The efficiency of a telephone receiver or any similar electromagnetic vibrator depends upon a constant *c* that is determined by the equation

$$c = \frac{1}{mk}\frac{B^2}{e}$$

in which *m* denotes the vibrating mass (armature with its elastic support), B the magnetic lines of force, *k* another constant, and *e* the losses occurring in the iron. The smaller *m* and *e* become and the greater the value of B, the greater will be the value of *c* and the greater the electromagnetic efficiency of the apparatus. The above-mentioned improvements (*a*) and (*b*) operate in this direction.

But in accordance with the recognized fact underlying the present invention, the greatest possible efficiency of a telephone receiver can only be attained if the copper losses also are reduced, and the best compromise will be obtained when the iron losses are made approximately equal to the copper losses. Therefore in order to obtain a really appreciable improvement it was found necessary to also reduce the copper losses to the same amount as the iron losses.

Regarding firstly the reduction of the iron losses the train of thought pursued with respect to known forms of telephone receivers is as follows:

The well known and almost universally adopted receiver has two different paths for the magnetic flux of the permanent field and the induced alternating magnetic flux produced by the receiver coils, the path for the former usually consisting of a ring-shaped or U-shaped magnet, and the path for the latter comprising pole pieces attached to the said magnet. With this arrangement it is not possible to prevent a large part of the permanent flux from passing straight from one pole piece to the other so that an undesired by-path for the lines of force is provided.

In distinction therefrom the receiver according to the invention has only a single path for the permanent (or continuous) and alternating fluxes.

The invention is illustrated in the drawing in which—

Fig. 1 is a perspective view of the iron path provided for the magnetic fluxes,

Fig. 2 is a perspective view, partly in section, of a vibrating receiver diaphragm with an inserted laminated armature, and

Fig. 3 is a vertical transverse section, partly broken away, of a conventional telephone receiver casing in which the improved form of receiver is mounted.

As shown in Fig. 1 the metallic path, which is identical for the continuous and alternating magnetic fluxes, consists of a U-shaped, paramagnetic, laminated body. For permanent magnets the laminæ are made of magnetizable steel, and for receivers in which the continuous field is produced by an electromagnet, the laminæ consist of soft sheet iron. A laminated armature as shown in Fig. 1 is preferably employed in conjunction with the laminated magnet. By these measures the value B is increased and *e* is considerably reduced in comparsion with the corresponding values in known types of receivers.

A reduction of the vibrating mass *m* can be obtained by inserting the laminated arma-

ture in the receiver diaphragm (preferably in a perforation in the same) as shown in Fig. 2. A number of satisfactory methods of fixing a laminated armature in a diaphragm in the manner illustrated have been evolved, but these methods do not form a part of this invention. It has also been found that the armature may be made very thin without giving rise to an impermissible increase of its magnetic reluctance.

Of course there will have to be a compromise here between the smallest possible mass and the smallest possible magnetic saturation of the armature dependent on the shape and size of the entire magnet, i. e. on the magnet proper together with its armature. Calculations and experiments have shown that on the basis of the relative measurements of the magnet with its armature as shown in Fig. 1 the thickness of an armature giving satisfactory results is approximately defined by the equation

$$h = \frac{1}{5}a$$

in which h denotes the height of the laminæ of the armature and a the thickness of the shanks of the magnet.

The desired reduction of the copper losses has been accomplished by giving the magnet a certain shape and size. It will be obvious that, as a result of the dimensions of the iron and of the proportions described above, a definite quantity of copper will be required to diminish the copper losses just as much as the iron losses. If the correct size of magnet is chosen certain most favorable shapes exist in which the magnet may be made. It has been ascertained by experiment that the approximately most favorable shape of the magnet is the form of a cube each edge of which is equal to 1. The thickness a of the shank of the magnet should be $\frac{1}{4}$. If, with the magnet of this shape, the interior space between the shanks is filled with copper windings, the above requirement as to the equality of the iron and copper losses will be sufficiently satisfied. It has been found that the most favorable size for the said cube is obtained when the length of each of its edges 1 is made equal to 1–2 cms.

In Fig. 3, 1 denotes the telephone case, 2 the diaphragm having the laminated armature 3 mounted in its center. At 4 is shown the laminated U-shaped magnet, on the shanks of which the copper coils 5, 5 are placed, these coils being of such size that the entire space between the shanks is filled with windings.

By the collateral aplication of the above-described measures the entire electromagnetic efficiency (including reduction of copper losses) as compared with known types of telephone receivers, and on the assumption that the damping constants in both types are equal, is increased more than tenfold.

In addition to telephone receivers the present invention is of course important for other electromagnetic vibrators such as talking current amplifiers which consist of a vibrating electromagnet associated with a co-operating microphone or the like. It is possible for instance to construct a talking current amplifying relay or repeater in accordance with the invention which, with a sufficiently large damping (damping=0.2 or more), still gives a good amplifying effect. This is rendered possible because of the high efficiency of the electromagnetic part (greater than 75%) obtained by the invention as distinguished from the known types of repeaters consisting of a telephone receiver and a microphone which has either an unsatisfactory amplifying effect or a damping, much too small for practical use in telephony.

I claim:—

1. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a vibratory armature cooperating therewith, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature having both the same path, said winding filling the space between the shank of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

2. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a vibrating diaphragm having an armature mounted on it cooperating with said magnet, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

3. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a vibrating diaphragm having an armature mounted on it cooperating with said magnet, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature, having both the same path,

said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses, the thickness of said armature being suitably chosen to retain the armature below the magnetic saturation point for a given flux in the field magnet.

4. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a laminated vibrating armature cooperating therewith, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

5. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a vibrating diaphragm having an armature constituting the central portion thereof and cooperating with said magnet, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

6. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a vibrating diaphragm having an armature constituting the central portion thereof and cooperating with said magnet, a winding on said magnet adapted to carry the alternating current produced by the vibrations of said armature, the continuous magnetic flux and the alternating flux, induced during the vibrations of the armature, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses, the thickness of said armature being suitably chosen to retain the armature below the magnetic saturation point for a given flux in the field magnet.

7. A magnetic telephone receiver having a U-shaped laminated continuous field magnet, a diaphragm carrying in its central portion a laminated armature, a winding on the shanks of the field magnet and filling the space between the shanks and adapted to carry the alternating current produced by the vibrations of said armature, the continuous and the alternating magnetic fluxes having both the same path, the contour of said field magnet constituting substantially a cube, the thickness of each shank being equal to one-quarter length of the cube edge, the armature thickness being equal to one-fifth of the shank thickness, to render the losses of energy in the windings equal to the magnetic energy losses.

8. An electromagnetic vibrator comprising a laminated U-shaped field magnet suitably constructed to carry a continuous magnetic flux, and a vibratory armature cooperating therewith, said field magnet also adapted to carry an alternating flux following the same path as the continuous flux, a winding on said magnet adapted to carry alternating current in correlation with said alternating flux, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

9. An electromagnetic vibrator comprising a laminated U-shaped field magnet suitably constructed to carry a continuous magnetic flux, and a vibratory armature cooperating therewith, said field magnet also adapted to carry an alternating flux following the same path as the continuous flux, a winding on said magnet adapted to carry alternating current in correlation with said alternating flux, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses, the thickness of said armature being suitably chosen to retain the armature below the magnetic saturation point for a given flux in the field magnet.

10. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a laminated vibrating armature cooperating therewith, a winding on said magnet adapted to carry alternating current, the continuous magnetic flux and the alternating flux produced by the alternating current in said winding, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses.

11. An electromagnetic vibrator comprising a laminated U-shaped continuous field magnet and a laminated vibrating armature cooperating therewith, a winding on said

magnet adapted to carry alternating current, the continuous magnetic flux and the alternating flux produced by the alternating current in said winding, having both the same path, said winding filling the space between the shanks of the U, said field magnet being suitably dimensioned to receive a sufficient amount of winding to render the losses of energy in the windings equal to the magnetic energy losses, the thickness of said armature being suitably chosen to retain the armature below the magnetic saturation point for a given flux in said field magnet.

In testimony whereof I affix my signature.

HEINRICH HECHT.