Sept. 20, 1927.

1,642,777

W. C. JONES

RECEIVER

Filed Oct. 30, 1924

Fig. 1.

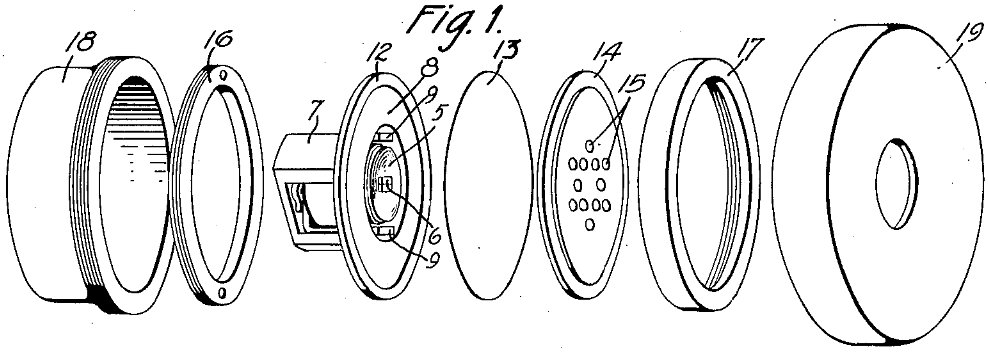


Fig. 3.

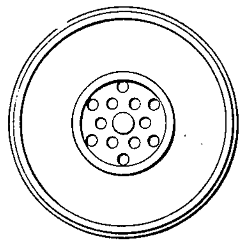
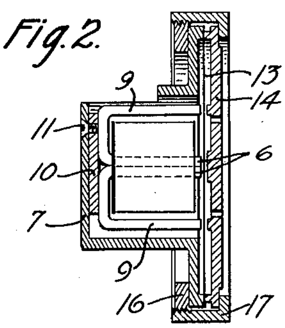


Fig. 2.



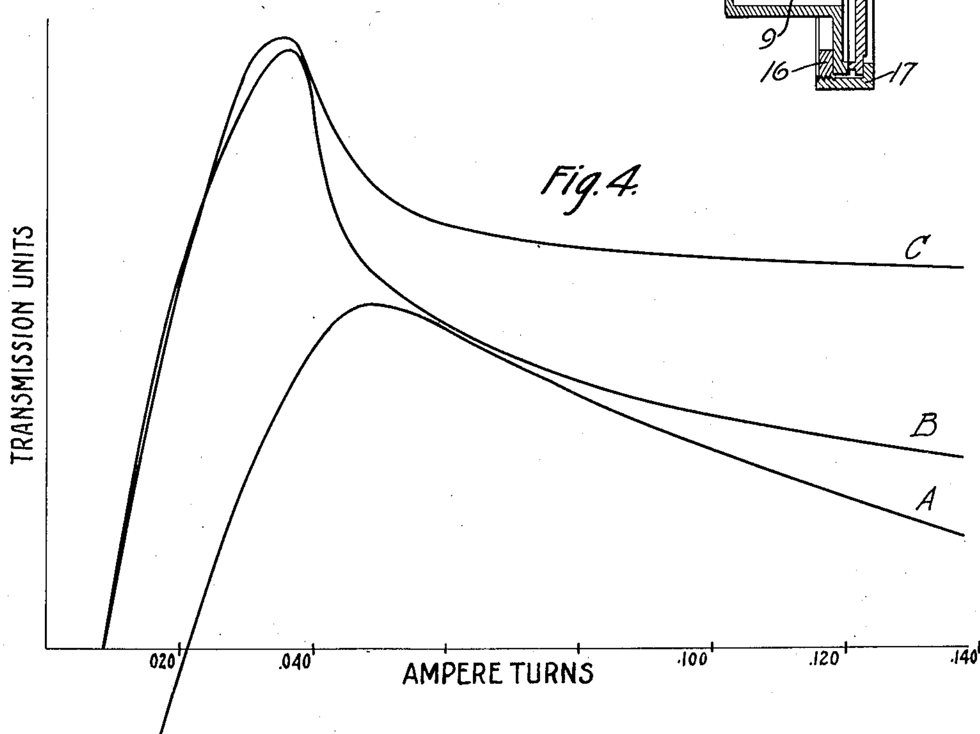


Fig. 4.

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Patented Sept. 20, 1927. **1,642,777**

UNITED STATES PATENT OFFICE.

WARREN C. JONES, OF FLUSHING, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

RECEIVER.

Application filed October 30, 1924. Serial No. 746,791.

This invention relates to telephone receivers, and its object is a telephone receiver of improved efficiency and moreover one that is stable in its operating characteristics under severe service conditions.

The invention is particularly applicable to subscriber station receivers of the electromagnetic type, although it is not limited to this type. The requirements for a receiver of this type are of such a nature that it is not only necessary that the receiver be an efficient transducer for converting the electrical energy of the speech currents into sound energy, but it should preferably reach its maximum efficiency at a low magnetizing current such as would be present on long subscriber loops where the attenuation is a maximum. Furthermore, the construction of the receiver should be such that its efficiency of operation is not materially altered when the instrument is subjected to wide temperature variations such as might be experienced in extreme cases.

In a receiver of this type, there are two forces which play an important part in determining its characteristics; namely, a variable force resulting from the combined action of the polarizing and variable fluxes and a steady force due to the polarizing flux alone. The former constitutes the useful driving force, and the latter owing to the control which it exerts over the reluctance of the air-gap, influences not only the efficiency at small magnetizing currents but is instrumental in determining the magnetizing current at which maximum efficiency occurs. The magnitude of the steady force resulting from the polarizing flux at high magnetizing currents also has an important bearing on the stability of the receiver, since it is influential in determining the minimum separation which may be employed between the diaphragm and the pole pieces. There is also a third force which acts upon the diaphragm; namely, a variable force which is proportional to the square of the variable flux and which is an octave higher in frequency than the voice current. However, in a well designed receiver the magnitude of the polarizing flux is sufficient to render the influence of this variable force negligible and to remove any distorting effect due to the double frequency.

On long subscriber loops where the magnetizing current is small and the flux density in the diaphragm and the pole pieces is low, the length of the air-gap determines the magnitude of the polarizing flux and since a given polarizing flux is required to bring the magnetic circuit up to its maximum efficiency, it follows that the length of air-gap thus fixes the minimum magnetizing force or ampere turns necessary to bring the magnetic circuit to maximum efficiency. Therefore, so far as the iron portion of the magnetic circuit is concerned the effective permeability of the material becomes the most important factor in determining the useful driving force. Since for a given receiver the magnetizing current is determined by the resistance external to the receiver, the magnetizing force necessary for establishing the polarizing flux is dependent upon the number of turns in the winding, a fact which obviously reacts upon the electrical impedance of the receiver. This impedance, if maximum operating efficiency is to be obtained, is fixed by the electrical impedance of the apparatus at the subscriber station and by the acoustic impedance of the ear, since under these conditions the impedance looking into the receiver must be the same as the impedance looking towards the line. In the case of the present subscriber sets this impedance does not permit winding the receiver with a sufficient number of turns to provide the magnetizing force necessary to bring the circuit up to maximum efficiency. It therefore follows that in order to meet the impedance requirement and still have the receiver reach its maximum efficiency under severe conditions such as exist on long loops, it is necessary to sacrifice magnetic efficiency and arrange the circuit in such a manner that one member, either the pole structure or the diaphragm, approaches saturation at a magnetizing current equal to that obtainable on long loops. This condition is best met by employing a diaphragm of low mass and of a material and thickness such that it approaches saturation at low current values since as a result of the low mass the unbalance in the acoustic impedance between the receiver and the ear load is to a certain extent corrected.

In accordance with a feature of the invention, the diaphragm and pole pieces are so dimensioned and spaced with respect to each other that the receiver reaches its maximum efficiency at much lower magnetizing forces than has been possible heretofore.

In accordance with another feature of the invention, by the addition of a plate which serves as a magnetic shunt and becomes effective only at the higher magnetizing forces, the efficiency of the instrument for short loops is increased.

Still another feature consists in constructing the magnetic portion of the receiver so that changes in temperature will not cause marked variation in the operating air-gap which will be reflected in the efficiency of the receiver.

These and other features of the invention may be more clearly understood by reference to the accompanying drawing, in which

Fig. 1 is an exploded view in perspective of a preferred form of electromagnetic receiver embodying the features of the invention;

Fig. 2 is a view partly in section of the assembled receiver shown in Fig. 1;

Fig. 3 is a view of the magnetic shunt employed in this construction; and

In Fig. 4 are curves showing the improved efficiency obtained by following this construction.

Referring more particularly to Figs. 1 and 2, the operating coil 5 assembled on the center leg 6 of an E-shaped pole piece, is mounted within a cup-shaped member 7 having a flanged portion 8. The pole piece consists of two U-shaped members 9, 9 positioned as shown to provide the common central leg 6 and are welded or otherwise intimately secured to the plate 10, which in turn is secured to the bottom of cup-shaped member 7 by means of screws 11. The flanged portion 8 is provided with a peripheral ring 12 adapted to serve as a seat for the diaphragm 13. A plate member 14 provided with a series of perforations 15, 15 is adapted to be mounted adjacent the diaphragm and serve as a magnetic shunt therefor in the manner to be explained hereinafter. The flanged portion 8, diaphragm 13 and plate 14 are assembled as a unit and are clamped together by means of an inner clamping ring 16 threading into an outer clamping ring 17. This assembled unit is adapted to be mounted in a standard form of receiver cup 18 which may be either of metal or of an insulating material such as hard rubber and on which is threaded a receiver cap 19 which also serves as an ear piece.

The pole pieces 9, 9, diaphragm 13 and preferably the plate 14 are composed of a magnetic material having an effective permeability at low magnetizing forces very much higher than that of iron, a lower hysteresis factor, and a resistivity of the order of 45 microhms per centimeter cube. To obtain this material, iron and nickel are fused together in an induction furnace preferably in the proportion of about 55% iron and 45% nickel, good commercial grades of these materials being suitable for this purpose. The molten composition is then poured into a mold and cooled either in the form in which it is to be later employed or in a convenient form to be worked over for this purpose. While 55% iron and 45% nickel have been mentioned as being the proportion of the ingredients of nickel and iron preferably to be employed in making up this material, it should be understood that this proportion may deviate from these figures and, under certain conditions, it may even be desirable to add a third element. Thus, for example, if the composition consists of 21½% iron and 78½% nickel, a material having an even higher permeability than that of the 55% iron, 45% nickel composition is obtained, but this latter composition has a considerably lower resistivity. By the addition of approximately 1% chromium to the 21½% iron, 78½% nickel the resistivity is increased to approximately that obtained with the 55% iron, 45% nickel composition.

To develop the utmost permeability of the magnetic material, the finished parts are subjected to a heat treatment which, for particular cases, varies somewhat as regards the tempertures employed and the duration of the heating and cooling periods. The optimum values of these variables may readily be determined for a specific case by experiment. In the case of the preferred composition, consisting of 55% iron and 45% nickel, a suitable heat treatment has been found to be to heat the material to a temperature of 1100° C. and then to cool at the rate of approximately 4° C. per minute. This rate of cooling is not critical but can be varied over wide limits. The magnetic material obtained in this manner has an extremely high effective permeability at low magnetizing forces and saturates at a point considerably below that of magnetic iron. The effective permeability of this material to small alternating currents with various values of direct current superimposed is shown graphically in a copending application of George W. Elmen Serial No. 747,718 filed Nov. 4, 1924.

After the heat treatment, the material, to maintain a high constant value of permeability must be guarded against any considerable strains, and therefore this treatment is preferably applied to the material in its finished form.

In Fig. 4 are curves showing the improvement in operating efficiency resulting from embodying the various features of the invention in the magnetic circuit of a receiver. Curve A shows the improvement in transmission units or miles gained in transmission with an electromagnetic receiver employing the improved alloy for pole pieces but with a standard ferro type diaphragm, as compared with a standard type of subscriber's station receiver. Curve B shows the additional improvement resulting from replacing the ferro type diaphragm with a diaphragm of the proper thickness composed of the improved alloy. Curve C shows the gain in efficiency at high magnetizing currents when employing a magnetic shunt for the diaphragm.

Referring to curve A, it will be noted that with the use of the nickel-iron alloy containing 45% nickel and properly heat treated in the pole pieces of the receiver, there results a maximum gain in efficiency equivalent to four transmission units while a gain of two transmission units or better is obtained over the entire working range. The winding of this receiver consisted of 1,200 turns, and since the maximum gain was attained at a magnetizing current of 50 milliamperes, the maximum efficiency was obtained with an energizing force of 60 ampere turns. By replacing the ferro type diaphragm with a diaphragm of the proper thickness composed of the nickel-iron alloy containing 45% nickel, there results, as shown on curve B, a maximum gain in efficiency equivalent to nine transmission units, but what is even more important this maximum gain is obtained with a smaller magnetizing current, approximately 35 milliamperes, which corresponds to an energizing force of 42 ampere turns. It will be seen that curve B drops off rapidly slightly beyond its maximum point and approaches curve A. This rapid drop in efficiency is due to the early saturation of the diaphragm and it was to overcome this rapid decrease in efficiency that the plate 14 of Fig. 1 was positioned adjacent to the diaphragm to serve as a magnetic shunt therefor by carrying a portion of the flux after the diaphragm has become saturated. The improvement gained by the use of this plate is shown strikingly in curve C, from which it will be seen that, by its use, there results a slight gain in maximum efficiency and this gain decreases slowly so that with a magnetizing current of 90 milliamperes, which corresponds to a short subscriber's loop, the efficiency is still approximately six transmission units better than that of the standard type of substation receiver. The improvement that can be effected by a magnetic shunt is determined largely by the minimum separation necessary to insure stable operation, since the shunt plate in relieving the saturated condition of the diaphragm increases the deflection of the diaphragm for a given magnetizing current, and causes the diaphragm to be drawn into contact with the pole pieces when operating at the larger magnetizing forces. Under normal service conditions this separation should be approximately fifteen thousandths of an inch and in no case less than ten thousandths of an inch.

In order to obtain the maximum efficiency of the receiver, it is necessary to reduce the separation between the diaphragm and the pole pieces to the minimum value consistent with stable operation, and in this connection it is necessary to eliminate, so far as possible, all variation due to changes in temperature. An analysis of the causes underlying the fluctuation in efficiency which accompanies a change in temperature has shown that these changes are due to a change in actual separation between the diaphragm and pole pieces, arising from unequal radial expansion of the diaphragm and its clamping surfaces, and unequal linear expansion of the magnetic unit and its supporting structure, the former being much the more important factor. To minimize these effects, the material composing the clamping surfaces should have the same linear temperature coefficient of expansion as the diaphragm, and a similar relation should exist between the unit and its supporting structure. In accordance with the present invention, the changes in efficiency due to changes in temperature have been reduced to a minimum by providing a material having the same temperature coefficient for the diaphragm, pole pieces, and clamping members. An electromagnetic receiver embodying the features of this invention was tested for transmission efficiency, then subjected to a temperature of 20° below zero F., after which it was raised to a temperature of 160° F. and then allowed to cool to room temperature, whereupon it was tested and found to have shown no appreciable change in efficiency. Furthermore, in this construction arrangements are made for clamping the various portions of the magnetic structure together, thus obtaining the advantages of unit construction.

What is claimed is:

1. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm approaching saturation at low magnetizing forces, and means for relieving the saturated condition of the diaphragm.

2. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm approaching saturation at low magnetizing forces, and a magnetic shunt for said diaphragm.

3. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm approaching saturation at low magnetizing forces, and a magnetic member mounted adjacent the diaphragm to relieve the saturated condition thereof.

4. In a telephone receiver, an energizing

winding, a magnetic circuit therefor including a vibrating diaphragm approaching saturation at low magnetizing forces, and a magnetic shunt for said diaphragm operable only upon large magnetizing currents traversing said winding to relieve the saturated condition of the diaphragm.

5. In a telephone receiver, an energizing winding, a magnetic circuit therefor including pole pieces and a vibrating diaphragm saturated at low magnetizing forces and a magnetic plate mounted adjacent to but separated from the diaphragm at portions in alignment with the pole pieces by an air gap of not less than .010 of an inch.

6. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm saturated at low magnetizing forces and a magnetic shunt composed of a material having a higher permeability than iron at low magnetizing forces and a lower saturation point.

7. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm saturated at low magnetizing forces, and a magnetic shunt composed of an alloy containing substantially 45% nickel and 55% iron.

8. In a telephone receiver, an energizing winding, pole pieces therefor, a thin vibrating diaphragm capable of being saturated at low magnetizing forces, and means for relieving the saturated condition of the diaphragm when operating at high magnetizing forces.

9. In an electromagnetic receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm, said magnetic circuit being so proportioned that the receiver attains its maximum efficiency with an energizing force of less than 50 ampere turns.

10. In an electromagnetic receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm, said magnetic circuit being so proportioned that the receiver attains its maximum efficiency with an energizing force of approximately 42 amperes turns.

11. In an electromagnetic receiver, an energizing winding, a magnetic circuit therefor composed of a material having a permeability higher than that of iron at low magnetizing forces and a saturation point below that of iron, said magnetic circuit being so proportioned that the receiver reaches its maximum efficiency at an energizing force of less than 50 ampere turns.

12. In an electromagnetic receiver, an energizing winding, a magnetic circuit therefor composed of an alloy containing approximately 45% nickel and 55% iron, said magnetic circuit being so proportioned that the receiver reaches its maximum efficiency at an energizing force of less than 50 ampere turns.

13. In an electromagnetic receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm, said diaphragm being composed of an alloy containing approximately 45% nickel and 55% iron, and having a thickness of approximately .006″, said diaphragm being separated from the pole pieces by an air gap of approximately .008″.

14. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm, a magnetic shunt for said diaphragm, and means for locking said parts in position to provide a unitary structure.

15. In a telephone receiver, an energizing winding, a magnetic circuit therefor including a vibrating diaphragm, a magnetic shunt for said diaphragm, and a pair of clamping rings cooperating to lock said parts in position to provide a unitary structure.

In witness whereof, I hereunto subscribe my name this 28th day of October A. D., 1924.

WARREN C. JONES.