Aug. 25, 1925.

1,551,143

H. A. FREDERICK

TELEPHONE RECEIVER

Filed Nov. 17, 1922

Fig. 1.

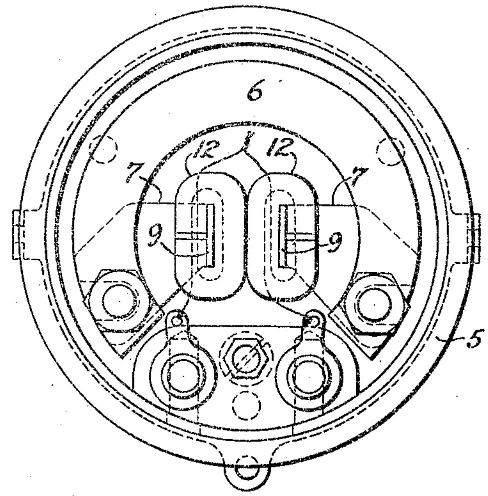
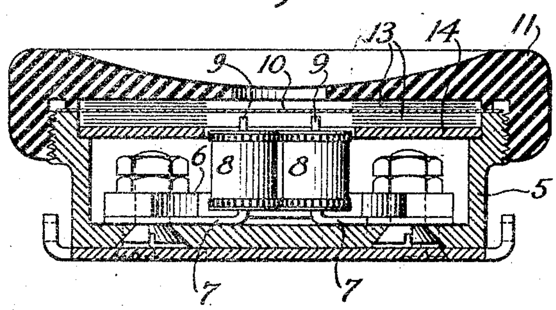


Fig. 2.



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Patented Aug. 25, 1925. **1,551,143**

UNITED STATES PATENT OFFICE.

HALSEY A. FREDERICK, OF UPPER MONTCLAIR, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE RECEIVER.

Application filed November 17, 1922. Serial No. 601,483.

To all whom it may concern:

Be it known that I, Halsey A. Frederick, a citizen of the United States, residing at Upper Montclair, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Telephone Receivers, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone receivers and particularly to magnetic systems for receivers of the watch-case type.

An object of the invention is to overcome deterioration of the magnet of receivers under service conditions without decreasing the efficiency or quality of the acoustic production.

Another object is to provide a receiver which is much more constant in its behavior under service conditions than those now in use without decreasing the efficiency or quality of acoustic production or increasing the weight or size of the instrument.

The advantages of this invention may be realized in a telephone receiver of the watch-case type and accordingly the practice of the invention in a receiver of that type is described specifically by way of example in the following specification.

Receivers of the watch-case type have been made in large quantities in accordance with the principles set forth in the United States patent to H. A. Frederick, 1,273,351, July 23, 1918. They are used for telephone operators' and radio operators' head receivers and receivers for the deaf. It has been for some time recognized that receivers of this type deteriorate under service conditions due to the demagnetizing effect of abnormal currents in the receiver coils. For example, in telephone operators' head sets the demagnetization frequently amounts to 25% of the total flux of the magnet. By this invention the per cent of demagnetization is very greatly decreased.

The principle upon which the invention is based can be better understood after a description of this type of instrument is given. Reference is made, therefore, to the following specification and the accompanying drawing in which Fig. 1 is a plan view of a watch-case type of receiver embodying this invention with the ear cap, diaphragm and other elements removed to show the magnetic system; and Fig. 2 is an elevational view partly in section of the receiver shown in Fig. 1.

A receiver case 5, which as shown is of metal but may be of insulating material, forms a housing for the permanent magnet 6, the poles of which are secured to the pole pieces 7—7 carrying windings 8—8 and having their pole faces 9—9 located adjacent the diaphragm 10, which is clamped to the casing 5 by means of a cap or ear piece 11. The cores are shown as provided with slotted metal spool heads 12—12 at their tips.

The diaphragm 10 should, of course, be of good magnetic material, preferably soft iron, and should have a natural frequency of between 800 and 1200 pulsations per second, which is approximately the range of maximum sensitivity of the human ear.

In certain cases high mechanical damping is purposely introduced to insure a high quality of reproduction. Such damping is shown in the drawing and consists of layers of paper 13, annular in form, inserted above and below the diaphragm and held in place by the cap 11 and the ring 14. This form of damping is more completely described in the United States application of Charles R. Moore, Serial No. 505,059 filed October 3, 1921.

It is essential also to provide a magnetic system of such materials and so proportioned that the steady flux density at the tips of the cores of the electromagnet, due to the permanent magnetizing force, and with the normal air-gap separation of the cores and the diaphragm, will be slightly beyond the point of maximum permeability and such that the permeability will decrease rapidly upon a decrease of the air-gap, and such that at the tips of the cores, the product of the polarizing flux density and the effective permeability for small oscillations of a frequency of approximately the maximum sensitivity of the human ear, will be a maximum. This result is attained by choosing for the cores a material having a permeability which has a sharply defined maximum value and which decreases rapidly beyond its point of maximum permeability, and applying to these cores a permanent magnetizing force which will maintain a flux density in them, at normal air-gap separation, of a value which is beyond the point of maximum permeability of the cores and at such value that with the size and material used for cores, the product at their tips of this polarizing flux density and the effective permeability for small oscillations at a frequency of approximately the maximum sensitivity of the average human ear, is a maximum. Silicon steel has been found to embody the necessary magnetic characteristics to render it suitable for the core material, although other materials having such characteristics as to produce the desired result may be used.

By the use of such a magnetic material, polarized to such a density that the product of the polarizing flux density and the effective permeability is a miximum, the magnetic system is made such as to operate at the maximum possible efficiency. In addition, by the use of such a magnetic material having a sharply defined permeability curve polarized to a flux density above that required for maximum permeability, it is possible to decrease the actual air-gap without danger of the diaphragm being drawn in and adhering to the poles. This feature is fully described in the above mentioned patent.

Cores of this type of instrument are ordinarily **L**-shaped and may be of variable cross-sectional area, as described in the Frederick patent. The portions between the coils and the magnet are larger than the portion within the coils and the ends adjacent the diaphragm. According to usual design each of the cores has a pole face area of between .010 and .013 of a square inch and a ratio of breadth to thickness of between five to one and six to one, the cross-sectional area of the pole pieces below the coils being about eight-fifths of that of the upper portion. The air gap separation between the pole faces and the plane of the diaphragm seat is about .010 or .012 of an inch.

The magnet 6 has heretofore been made of tungsten steel and with a cross-sectional area about equivalent to the area of a square 1/4 inch on each side and the flux density at the pole faces of the cores is approximately 8,000 gausses.

When, as stated above, a reduction in strength of the magnet occurs as a result of demagnetization in service, the magnitude of the flux threading the air-gap is diminished not only by the reduced strength of the magnet, but also by the added reluctance of the larger gap resulting from the decreased force exerted on the diaphragm. Such a reduction in total flux materially alters the density at the pole faces adjacent to the gap and hence the conditions for maximum efficiency described in the above patent. As a result of this change, a marked reduction in the efficiency of the receiver occurs. This demagnetizing action is largely due to the passage of current through the windings of the receiver in such a direction as to set up in the magnetic circuit of the receiver a magneto motive force opposed to that of the magnet. Such currents may arise from accidental short-circuits in the system in which the receiver is used, currents induced from power lines, or lightning discharges, etc. In the case of radio receivers the currents introduced by static discharges may also gradually reduce the strength of the magnet.

The portion of demagnetizing magneto motive force set up by the current in the coils which is effective in producing reduction in the strength of the magnet is a function of the effective reluctance of the permanent magnet, cores, diaphragm, leakage paths and air-gap. Inasmuch as the reluctance in the magnetic circuit external to the magnet is the controlling factor in determining the effective magneto motive force, the demagnetization can be decreased by an increase either in the length of the magnet or in its cross-section. From the standpoint of the magnet, minimum demagnetization can therefore be secured by the choice of a material of high coercive force or by making the magnet large in cross-section and length. It would, however, be necessary to make the magnet very large to secure the necessary permanence were it not for the control which can be exerted over the maximum demagnetizing force by the design of the cores. It is a well known fact that the reluctance of steel is a function not only of the dimensions, that is, length and cross-section, but also of the permeability. The latter factor being a function of flux density, it is evident that the reluctance of the cores will decrease with increasing demagnetizing magneto motive force reaching a minimum at the point of maximum permeability. Above the density required for maximum permeability, the reluctance will increase with added demagnetizing current, becoming very high when the core material approaches saturation. Under these conditions, it is evident that a definite maximum is set to the magneto motive force which can be impressed upon the magnet, and that this maximum is a function of the cross-section of the core within the coil and the flux density at which the core material saturates. Denoting the average cross-sectional areas of the core within the coil and that of the magnet by S_c and S_m respectively, the flux density at which the core material saturates by B_s, the length of the magnet by L_m, and the coercive force of the magnet by H_c, it has been found that

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the demagnetizing effect of the current on the winding of the receiver is negligible if the ratio of

$$\frac{S_c B_s}{S_m L_m H_c}$$

expressed in c. g. s. units, is less than 5.5. If this ratio is less than 5.5 the receivers are satisfactory from the standpoint of demagnetization but in order to meet other conditions such, for example, as that of maximum efficiency referred to above and also to make economical use of materials, it is necessary that the ratio be maintained above a certain limit. Considering the various design features such as operating efficiency, costs and weight of materials used and the demagnetizing effect due to current in the receiver coils, it has been found that the most satisfactory results are obtained if this ratio is maintained between 2.5 and 5.5 and in no case should the lower limit be less than 1.5. The requirements for magnetic efficiency stated in the patent previously mentioned are the principal factors in determining the material employed in the cores and fix within rather narrow limits the flux density at saturation (B_s). The reduction which can be effected in the cross-sectional area S_c for purposes of decreasing demagnetization is also dependent upon meeting the flux requirements for maximum efficiency as well as being limited by the necessity of maintaining mechanical ruggedness. If a tungsten iron (or other) alloy (having a coercive force of approximately 60 c. g. s. units) is employed, it is necessary in order to keep the demagnetization within limits to increase the size of the magnet to such an extent that it is the principal factor in determining the size and weight of the receiver. A receiver of this sort may, under certain conditions, such as in the case of telephone operators and deaf persons who use the instrument for long periods, cause severe nervous strain and grave discomfort. According to this invention, this situation is met by the use of an iron cobalt alloy having a coercive force (200 to 250 c. g. s. units) much higher than has previously been known. With this steel as a magnet material, it is possible to reduce the size and weight of the receiver without sacrificing other characteristics and to provide a more nearly balanced structure in which the magnet weighs approximately the same as the cores and winding combined. Thus without any sacrifice in the highest obtainable efficiency it is possible to secure a structure not only exceedingly permanent in its characteristics, but markedly reduced in weight and size. There has for some time been upon the market cobalt steel alloys having very high values of coercive force which are available under the trade names of KS steel and permanite. It at first seemed doubtful whether the advantage of this material as a substitute for tungsten steel would offset the disadvantages of the higher price of the material and the added cost of working it due to extreme hardness. Similar alloys are much used as tool steels and are so hard and brittle that the cost of shaping them into circular magnets of small diameter is very much greater than in the case of tungsten steel.

One suitable form of the cobalt steel alloy contains 20% of cobalt, 8½% of tungsten, 1.6% of chromium, .66% of carbon and the rest iron. Other suitable cobalt alloys are disclosed in United States Patents to K. Honda 1,338,132 and 1,338,133, April 27, 1920.

What is claimed is:

1. A telephone receiver comprising a permanent magnet, pole pieces attached thereto, and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by the coil and the flux density of said pole pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being less than 5.5.

2. A telephone receiver of the watch-case type comprising a circularly shaped permanent magnet, L-shaped pole pieces attached thereto, and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by the coil and the flux density of said pole pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being between 1.5 and 5.5.

3. A telephone receiver of the watch-case type comprising a circularly shaped permanent magnet, L-shaped pole pieces attached thereto, and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by the coil and the flux density of said pole pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being between 2.5 and 5.5

4. A telephone receiver of the watch-case type comprising a circularly shaped permanent magnet, L-shaped pole pieces for said magnet of a material having a sharply defined permeability peak, the flux density produced by said magnet at the core ends remote therefrom being of a value to bring the permeability to or slightly beyond the peak value and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by said coil and the flux density of said pole

pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being less than 5.5.

5. A telephone receiver of the watch-case type comprising a circularly shaped permanent magnet of an iron-cobalt alloy containing from 5 to 60% of cobalt and having a coercive force of from 150 to 250 c. g. s. units, L-shaped pole pieces for said magnet, and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by said coil and the flux density of said pole pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being less than 5.5.

6. A telephone receiver of the watch-case type comprising a circularly shaped permanent magnet of an alloy comprising 20 to 30% of cobalt, 1 to 10% of tungsten, .5 to 10% of chronium, .5 to 2% of carbon and the rest of iron, L-shaped pole pieces attached thereto, and coils mounted upon said pole pieces, the ratio of the product of the average cross-sectional area of each of said pole pieces throughout the portion covered by the coil and the flux density of said pole pieces at saturation to the product of the length, the cross-sectional area and coercive force of said magnet being less than 5.5.

7. A telephone receiver comprising a permanent magnet of iron Cobalt alloy having a coercive force greater than 150 c. g. s. units, pole pieces connected thereto, coils mounted on said pole pieces, and a diaphragm in operative relation to said pole pieces, said coercive force, the saturation flux density of the pole pieces and the dimensions of the magnet and pole pieces being so related that the receiver has high efficiency for normal currents in said coils and there will be no substantial demagnetizing effect on said magnet due to abnormally large currents in said coil.

In witness whereof, I hereunto subscribe my name this 11th day of November A. D. 1922.

HALSEY A. FREDERICK.