Oct. 9, 1928. 1,687,211

W. C. JONES

TELEPHONE RECEIVER

Filed Dec. 31, 1926 3 Sheets-Sheet 1

Fig. 1.

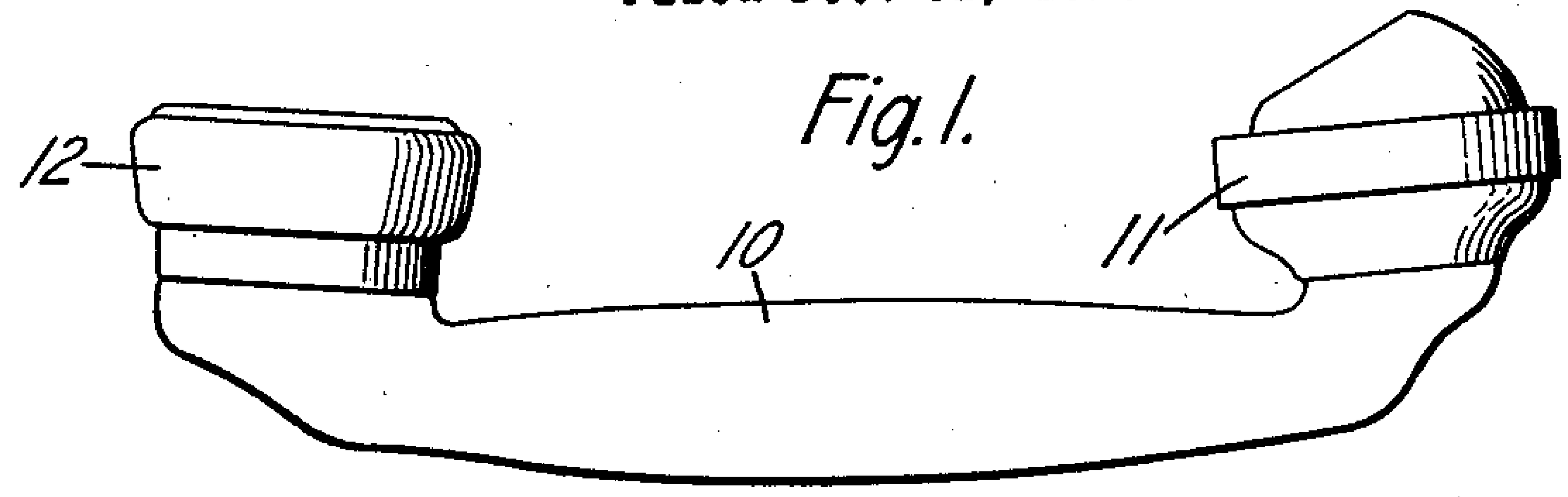
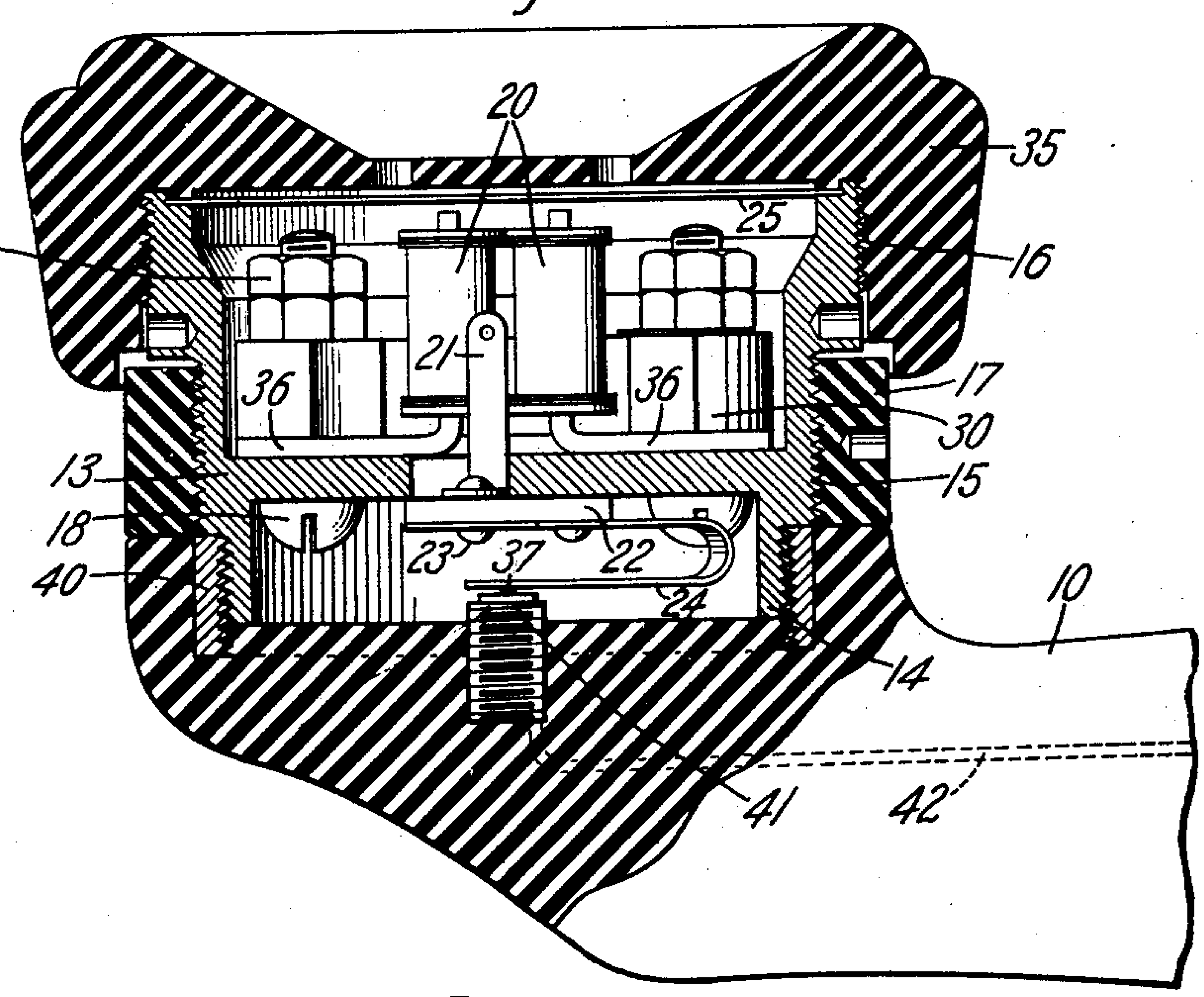


Fig. 2.



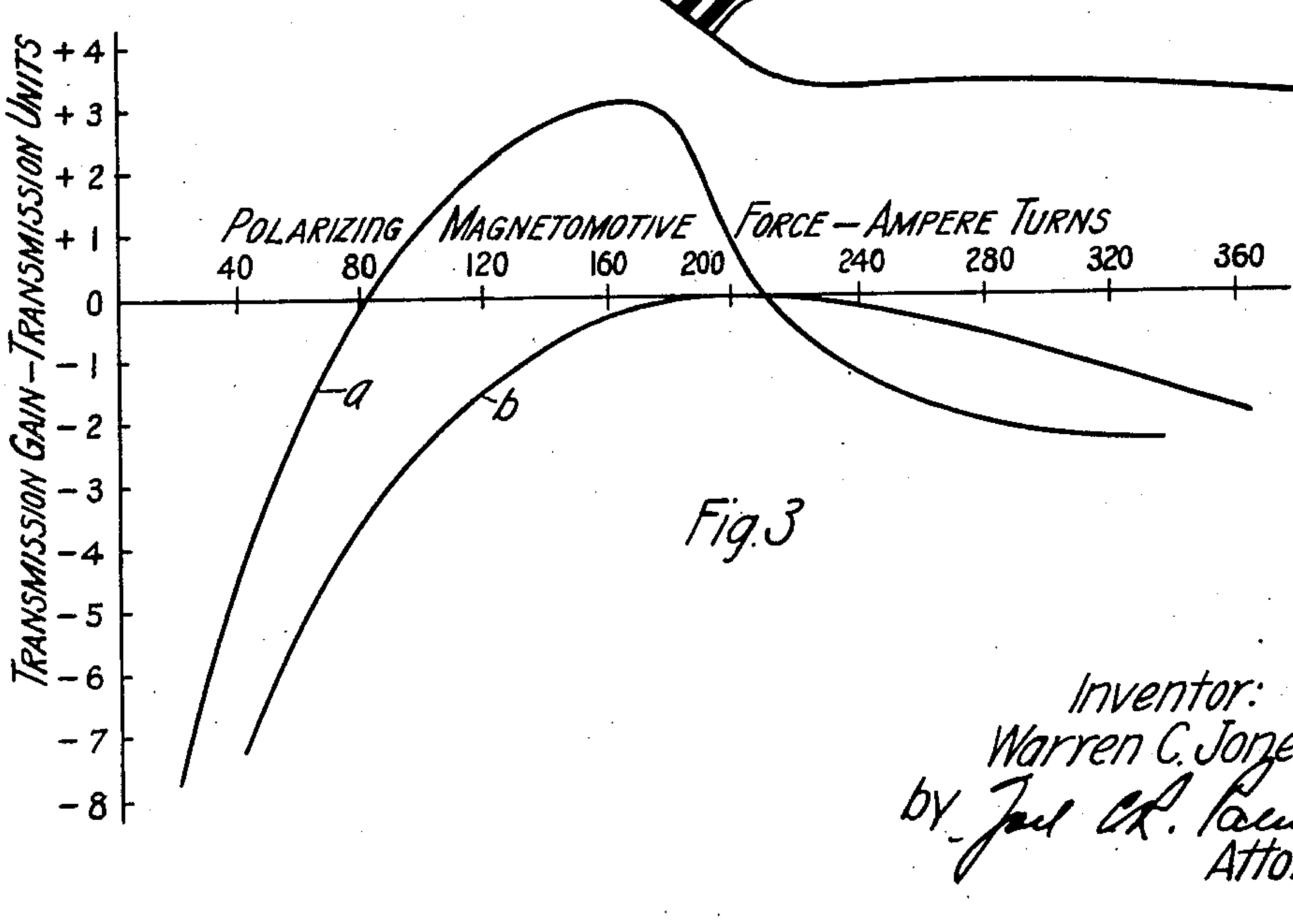


Fig. 3

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Fig. 4.

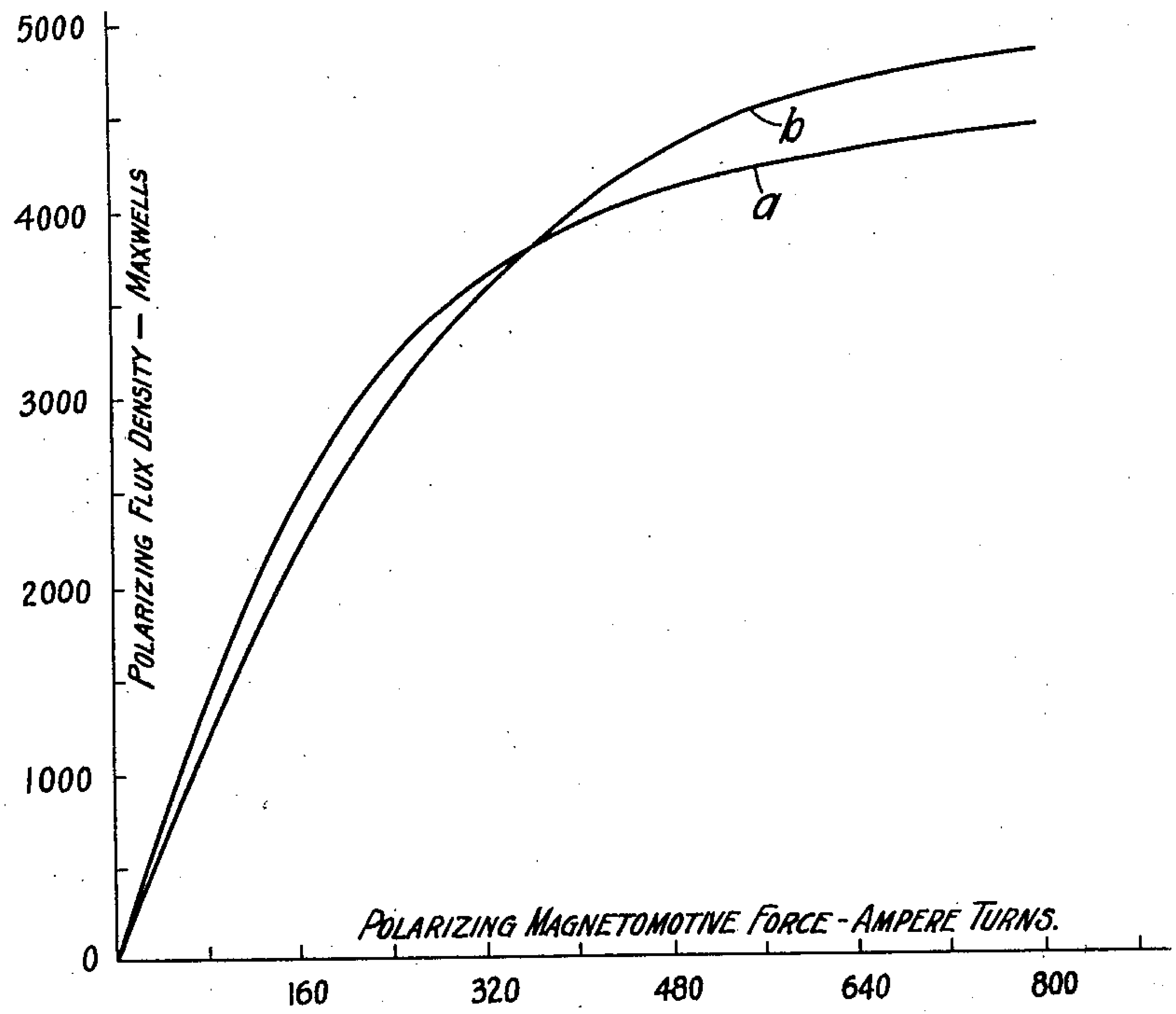

Fig. 5.

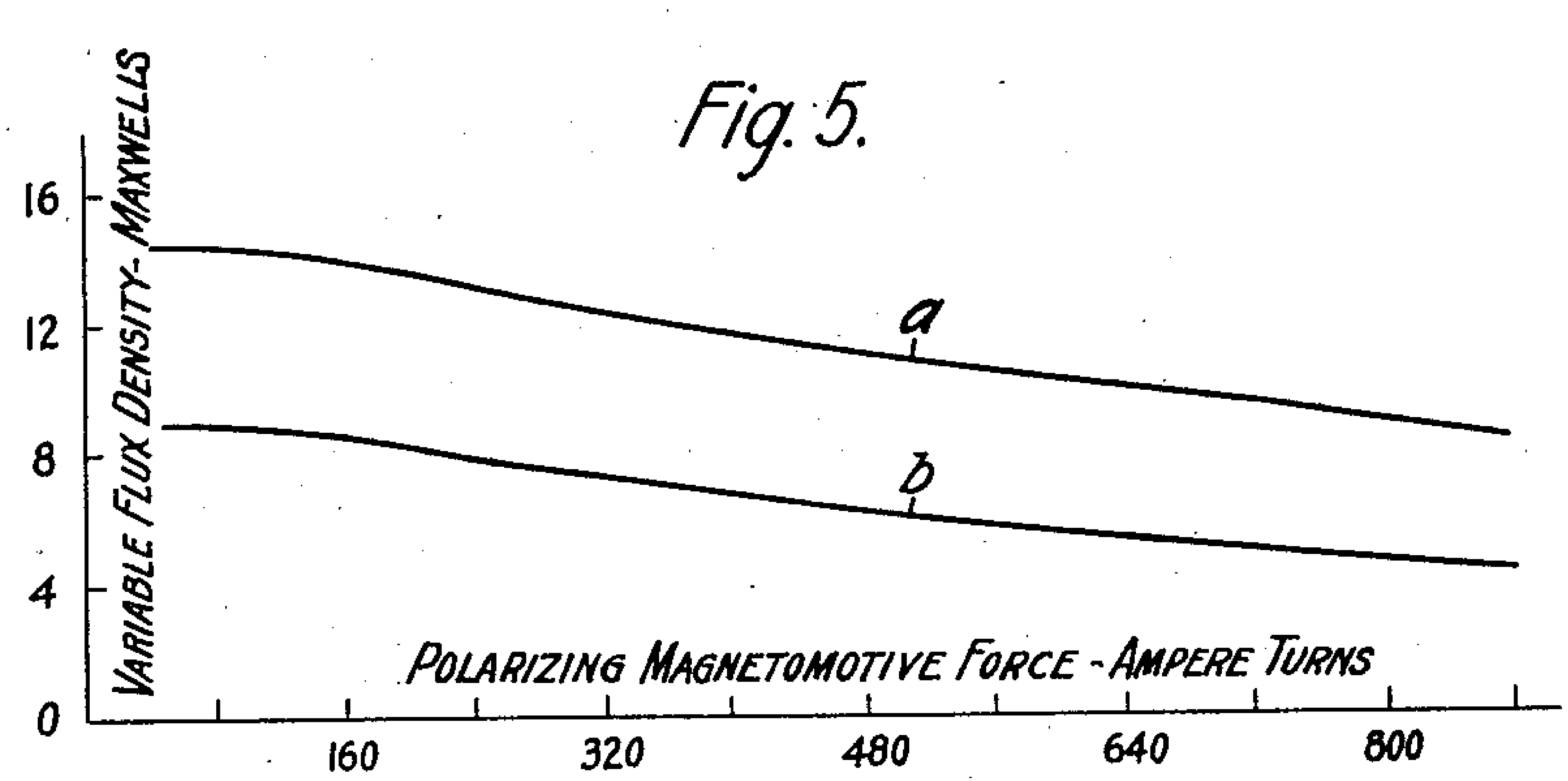

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Fig. 6.

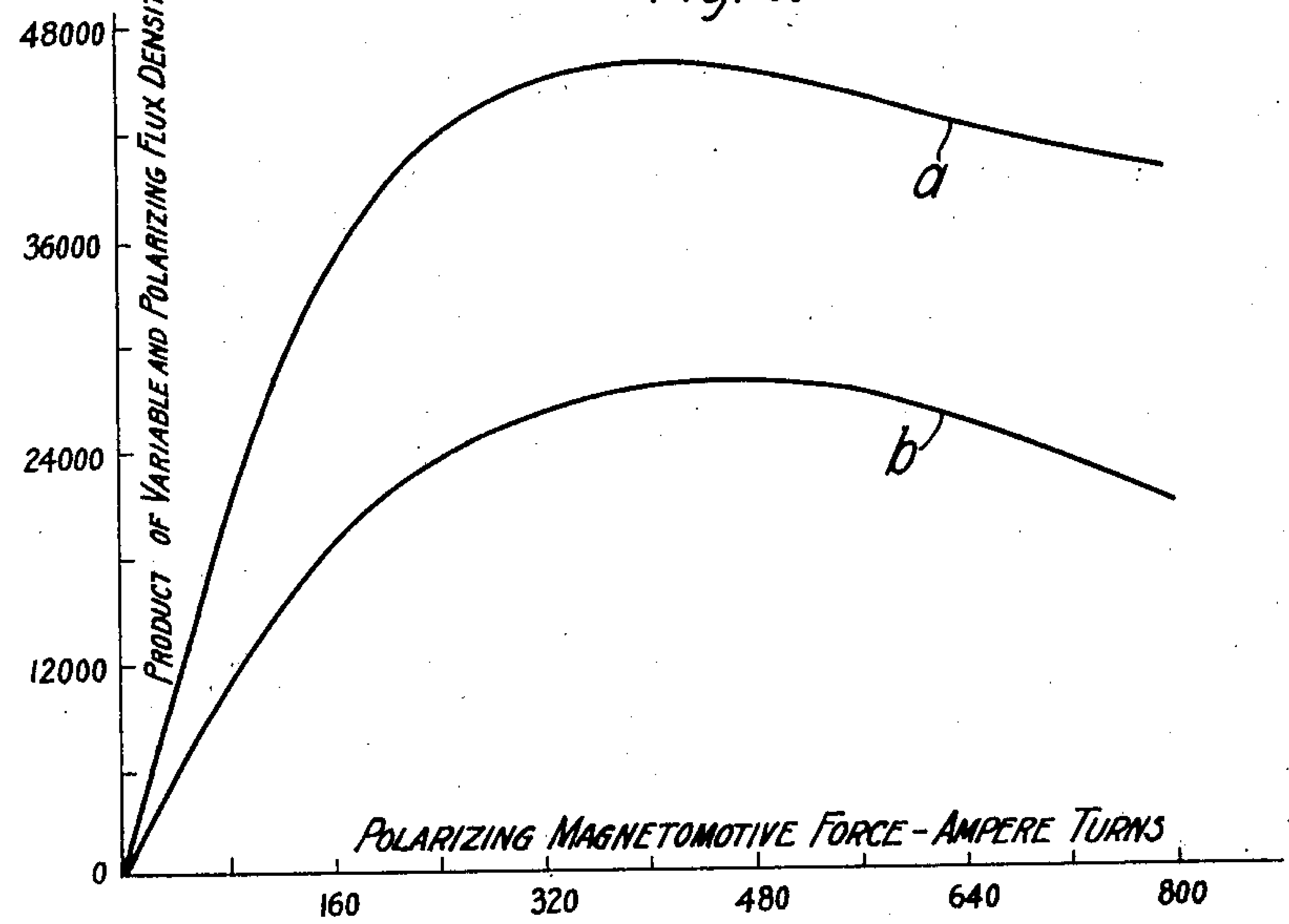
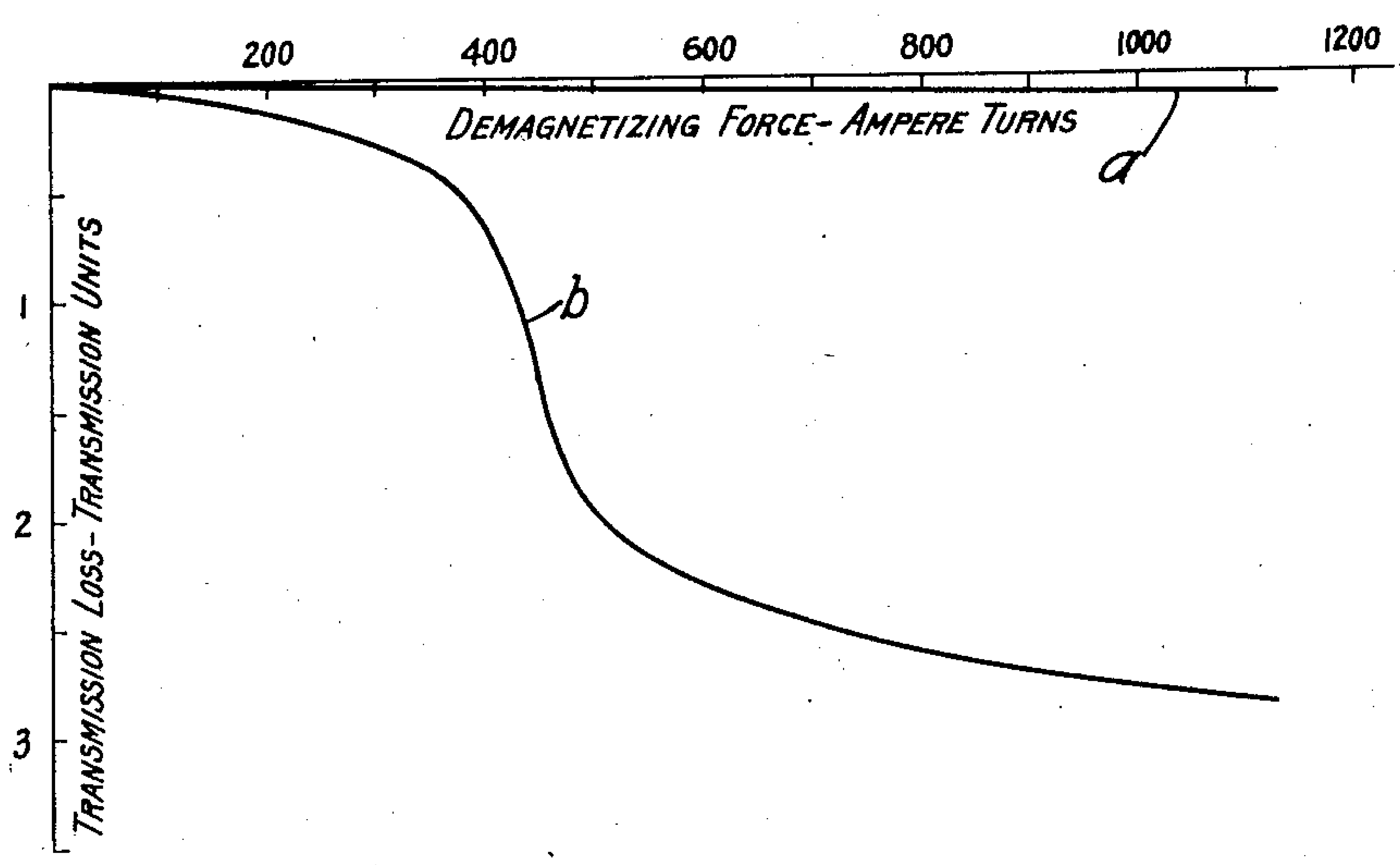


Fig. 7.



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Patented Oct. 9, 1928. 1,687,211

UNITED STATES PATENT OFFICE.

WARREN C. JONES, OF FLUSHING, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE RECEIVER.

Application filed December 31, 1926. Serial No. 158,186.

This invention relates to receivers and particularly to receivers which employ a permanent magnet for supplying polarizing flux.

An object of this invention is to obtain increased and substantially constant efficiency in a telephone receiver.

In a telephone receiver for use in subscriber's sets, increased efficiency is of great importance in that each transmission unit gain in receiver efficiency makes possible an increase of approximately one mile in the length of the subscriber's loop which can be employed. It is of advantage, moreover, that the maximum efficiency of the receiver should occur at as low a value of polarizing flux as is consistent with quality, since this makes possible a reduction in the size of the permanent magnet used.

In accordance with this invention, the efficiency of a permanent magnet receiver is increased by employing a high permeability material in its magnetic circuit. This increased efficiency is realized, moreover, at a low value of polarizing flux, thus making possible a decrease in the size of the permanent magnet employed. The efficiency of this receiver is maintained at its maximum value by constructing the permanent magnet of a material possessing high coercivity.

In one aspect, this invention may be considered as an improvement on the receiver disclosed in Patent #1,551,143 of August 25, 1925, to H. A. Frederick.

The invention may be better understood by referring to the following description and the accompanying drawing in which:—

Fig. 1 shows a telephone handset in which a receiver, in accordance with the present invention, may be employed;

Fig. 2 is an enlarged sectional view taken through the center of the receiver portion of the handset shown in Fig. 1;

Fig. 3 shows, by means of curves, the relative efficiency of a receiver constructed in accordance with this invention and of a similar type of receiver employed heretofore;

Fig. 4 shows the relation existing between polarizing magnetomotive force and polarizing flux density in the air gaps of the magnetic circuit of the receivers whose efficiency curves are shown in Fig. 3;

Fig. 5 shows the relation between polarizing magnetomotive force and variable flux density, in the air gaps of these receivers, resulting from alternating current flowing in the receiver winding;

Fig. 6 shows the relation between polarizing magnetomotive force and the product of the polarizing and variable flux densities plotted in the curves of Figs. 4 and 5; and

Fig. 7 shows the relation between demagnetizing force and transmission loss for receivers employing different materials in their respective permanent magnets.

Referring now to the drawing, Fig. 1 shows a telephone handset, comprising a handle 10, a transmitter 11, and a receiver 12 constructed in accordance with this invention.

Fig. 2 is a cross-sectional view showing the receiver 12 and a portion of the handle 10 in detail. The receiver consists of a casing, preferably of aluminum, having a base portion 13 for supporting the magnetic structure of the receiver. This casing is provided with externally threaded portions 14, 15 and 16 of different diameters, respectively. The portion 14 is adapted to be threaded into an internally threaded ring 40 embedded in the handle 10, the receiver cap or ear piece 35 is fitted onto the threaded portion 16, and a lock nut 17, in the form of a ring preferably of phenol-plastic composition, engages the threaded portion 15 and is adapted to be screwed against a bearing portion of the handle for holding the unit securely in position. The permanent magnet 30 and the core pieces 36 are secured to the base portion 13 by the screws 18 and nuts 19. The coils 20 are mounted on the cores 36, and one end of the coil winding is connected to the metallic strip 21 secured to the insulating member 22, this member being secured to the base portion 13 by the screws 23. The other end of the metallic strip is connected electrically to the spring 24, secured to the insulating member 22. A boss 37 on the lower portion of spring 24 is adapted to make a firm contact with a contact member 41 secured within the handle 10 and connected electrically to a conductor 42 in the handle of the handset structure. The other end of the coil winding is grounded to the metallic casing 13. A diaphragm 25 of magnetic material is clamped between the upper portion of the aluminum casing and the receiver cap 35. In some cases, it may be preferable, however, to employ a diaphragm of non-magnetic material having a piece of magnetic material attached thereto. The magnetic material employed in the diaphragm 25 and the pole pieces 36 is preferably one having an effective permeability, at low magnetizing forces, very much higher than that of silicon steel, a lower hysteresis loss and a resistivity of the order of 45 microhms per centimeter cube. An alloy composed of 45% nickel and 55% iron has such properties when suitably heat treated. To obtain this material, iron and nickel are fused together, preferably in the proportions of 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 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 proportions 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 per cent iron and 78½ nickel, a material having 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 composition, the resistivity is increased to approximately that obtained with the 55% iron-45% nickel composition. For a detailed description of various compositions of nickel and iron and other elements which may be used reference is made to patent to G. W. Elmen #1,586,884, June 1, 1926.

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 temperatures employed and the duration of the heating and cooling periods. The optimum values of these periods can readily be determined for a specific case by experiment. In the case of the preferred composition consisting of 55% iron-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 lower than the saturation point of silicon steel.

The permanent magnet 30 is preferably constructed of cobalt steel which has a considerably higher coercive force than tungsten steel, although other materials having high coercive force may be employed. One suitable form of cobalt steel alloy consists of 20% cobalt, 8.5% tungsten, 1.6% chromium, 0.66% carbon and the rest iron. Other suitable cobalt alloys are disclosed in United States patents to Honda, 1,338,132 and 1,338,133, April 27, 1920.

Fig. 3 shows efficiency curves for a receiver constructed in accordance with the present invention (curve *a*) and for a similarly constructed receiver employing a ferro-type diaphragm, silicon steel cores and a permanent magnet of tungsten steel (curve *b*). In obtaining these curves, a direct current was caused to flow in the receiver winding, in either direction so as to add to or subtract from the polarizing flux generated by the permanent magnet. The polarizing magnetomotive force is plotted in ampere turns above an arbitrary zero value and the transmission gain is plotted in transmission units above or below the maximum efficiency indicated in curve *b*. The curves show that when the permanent magnet is designed to provide the polarizing flux necessary for maximum efficiency, a receiver constructed in accordance with this invention, affords a transmission gain of about three transmission units over the one employing a ferro-type diaphragm and silicon steel cores. It is shown, moreover, that the polarizing flux necessary for maximum efficiency is less for the receiver of this invention, which fact makes possible the use of a smaller permanent magnet.

The curves of Figs. 4, 5 and 6 are useful in analyzing the causes for this improved efficiency. The curves of these figures relating to the receiver constructed in accordance with this invention are designated by the letter *a* while the curves for the other receiver referred to above, namely one employing a ferro-type diaphragm, and silicon steel cores, are designated by the letter *b*. In obtaining these curves the core pieces were attached to the poles of an electromagnet and the polarizing flux and variable flux were measured over a range of polarizing magnetomotive forces by means of search coils introduced in the magnetic circuit at the pole tips. The curves of Fig. 4 indicate the relation between polarizing magnetomotive force and polarizing flux density in the magnetic circuits of these receivers, and the curves of Fig. 5 show the relation between polarizing magnetomotive force and variable flux density. The useful force exerted on the diaphragm of a receiver is a function of the product of the polarizing and variable flux densities plotted in Fig. 6. The curves of Fig. 6 show the relation between polarizing magnetomotive force and the product of the polarizing and variable flux densities plotted in Figs. 4 and 5, respectively. As shown in this figure the maximum value of the product, for the receiver employing nickle-iron alloy in its magnetic circuit is approximately 65% higher than the maximum value for the receiver employing the ferro-type diaphragm and the silicon steel cores. This improvement in the force exerted on the diaphragm is mainly responsible for the increased efficiency of the receiver of this invention as shown in Fig. 3.

The curves of Fig. 7 show the transmission loss due to demagnetization of the permanent magnets of two receivers; the receiver to which curve *a* relates employs a permanent magnet of cobalt steel while the one to which curve *b* relates, employs a permanent magnet of tungsten steel. It is apparent from these curves that not only is greater stability obtained in the receiver employing the cobalt steel magnet but also that the losses in efficiency resulting from demagnetization in the case of the tungsten steel magnet may entirely offset the improvement obtained by the use of the nickel-iron alloy in the magnetic circuit of the receiver in accordance with this invention. In order to maintain the receiver at its maximum efficiency, therefore, it is necessary to employ a permanent magnet having a high coercive force.

What is claimed is:

1. A telephone receiver comprising a permanent magnet of cobalt steel and pole pieces for said magnet composed of an alloy consisting chiefly of nickel and iron.

2. A telephone receiver according to the preceding claim in which the nickel component is less than 50% of the whole.

3. A receiver comprising a winding and a magentic circuit therefor including a diaphragm and a permanent magnet, said diaphragm being formed of a material comprising nickel and iron, having a permeability greater than that of silicon steel at low magnetizing forces and said magnet being formed of a cobalt steel alloy having a coercive force greater than that of tungsten steel.

4. A receiver comprising a permanent magnet of cobalt steel, pole pieces for said magnet composed of nickel-iron alloy, and a diaphragm of nickel-iron alloy mounted in operative relation to said pole pieces.

5. A receiver comprising a winding and a magnetic circuit therefor including a diaphragm and a permanent magnet, said diaphragm being formed of an alloy of approximately 45% nickel and 55% iron and said magnet being formed of an alloy of approximately 20% cobalt, 9% tungsten, a small amount of chromium and carbon, and the rest iron.

6. In a receiver, a magnetic circuit including a diaphragm, a permanent magnet forming a part of said magnetic circuit for supplying polarizing flux therethrough, pole pieces for said permanent magnet and an energizing winding associated with said pole pieces, said diaphragm and pole pieces being composed of a material comprising nickel and iron having a permeability higher than that of silicon steel at low magnetizing forces and a saturation point below that of silicon steel.

In witness whereof, I hereunto subscribe my name this 29th day of December A. D. 1926.

WARREN C. JONES.