Dec. 15, 1931. W. H. EDWARDS 1,836,109

IMPEDANCE MODIFYING DEVICE

Filed May 14, 1929 2 Sheets-Sheet 1

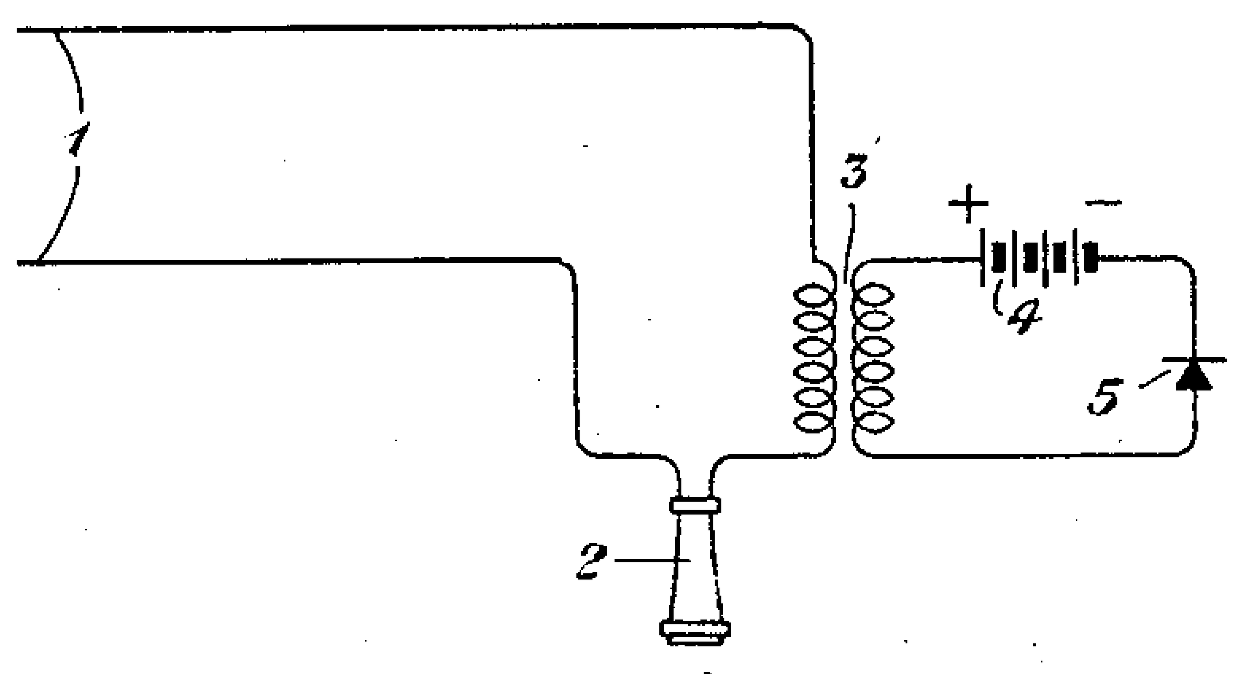

Fig. 1

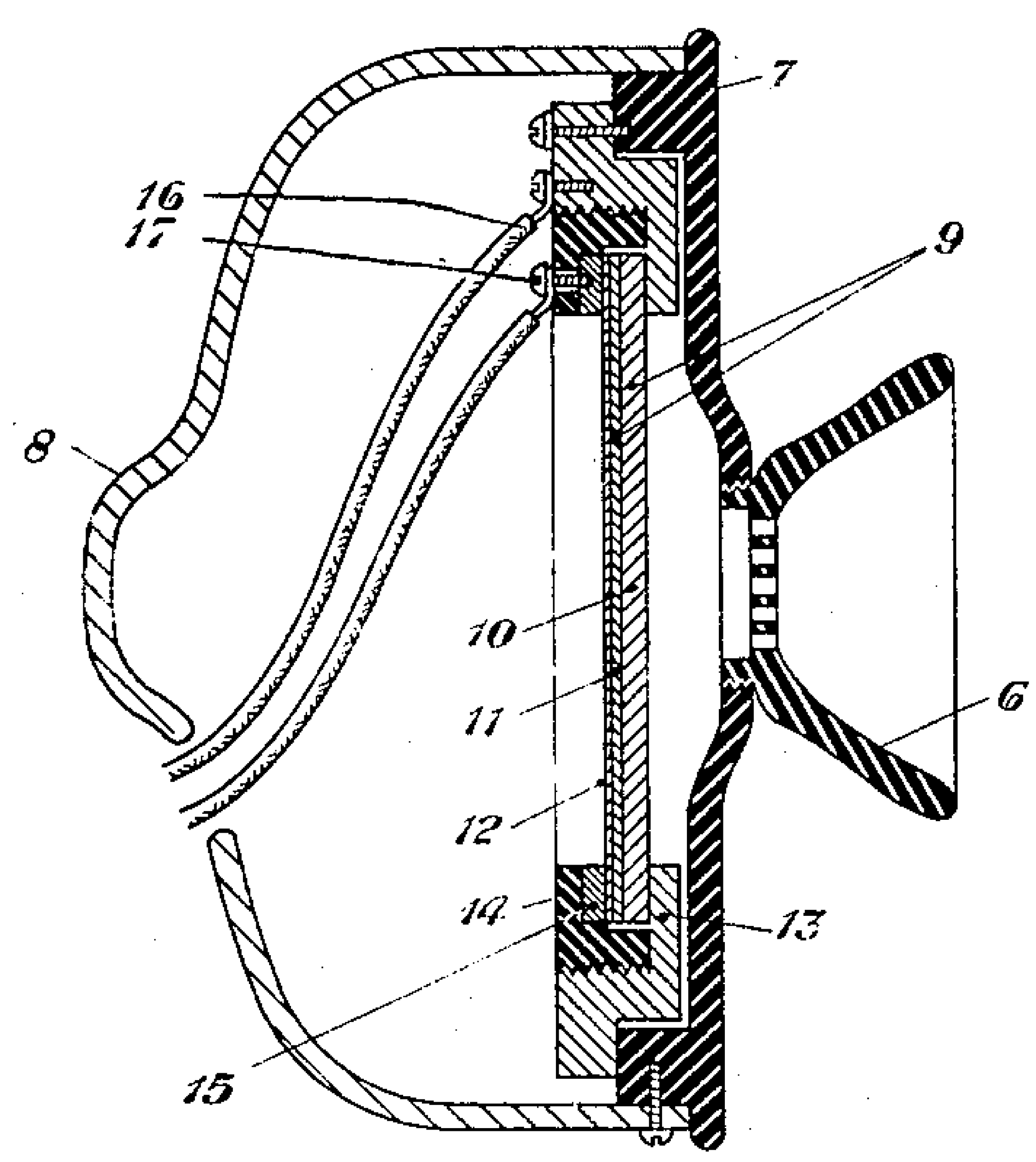

Fig. 2

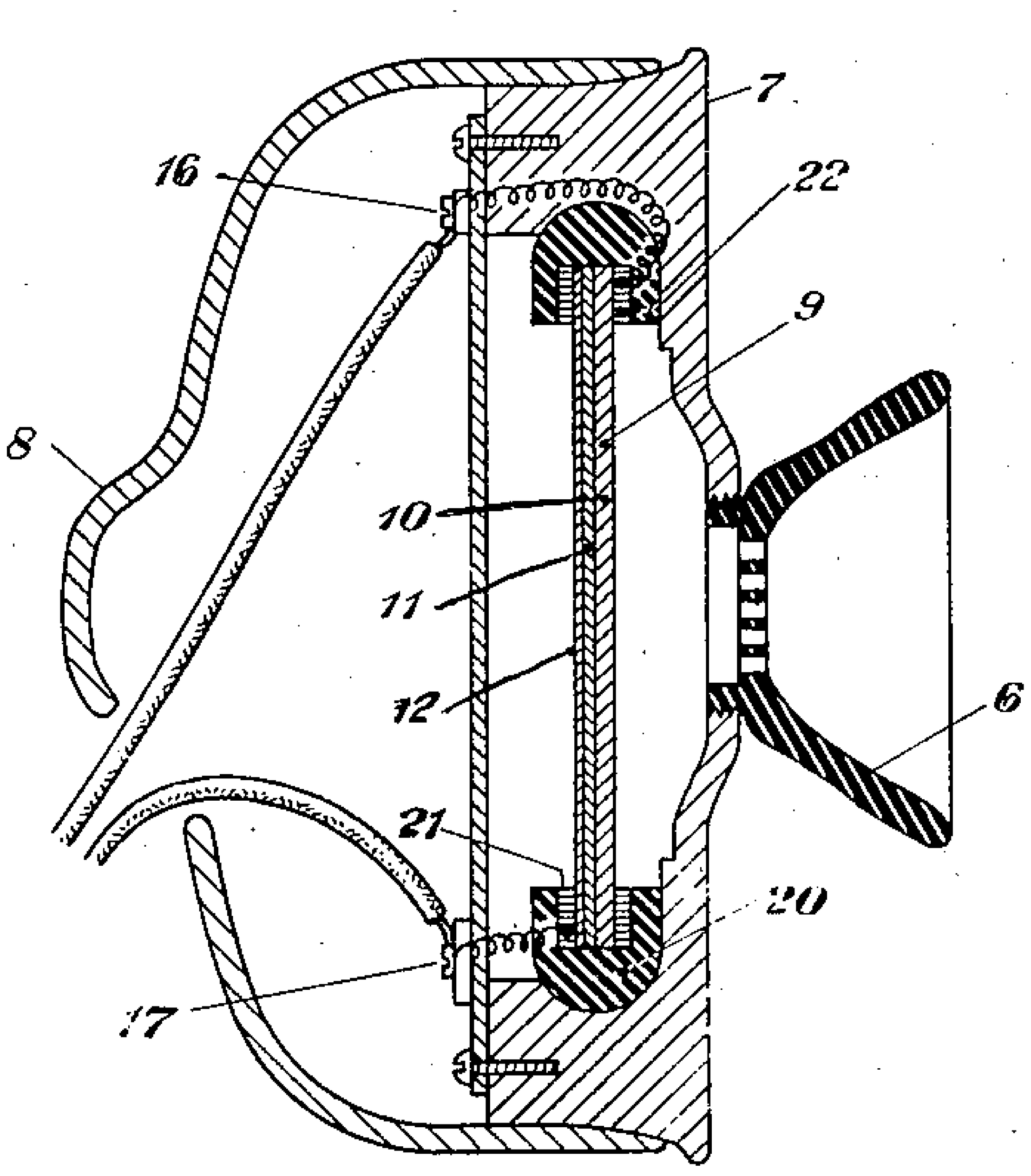

Fig. 3

INVENTOR
W. H. Edwards
BY
[signature]
ATTORNEY

Dec. 15, 1931. W. H. EDWARDS 1,836,109

IMPEDANCE MODIFYING DEVICE

Filed May 14, 1929 2 Sheets-Sheet 2

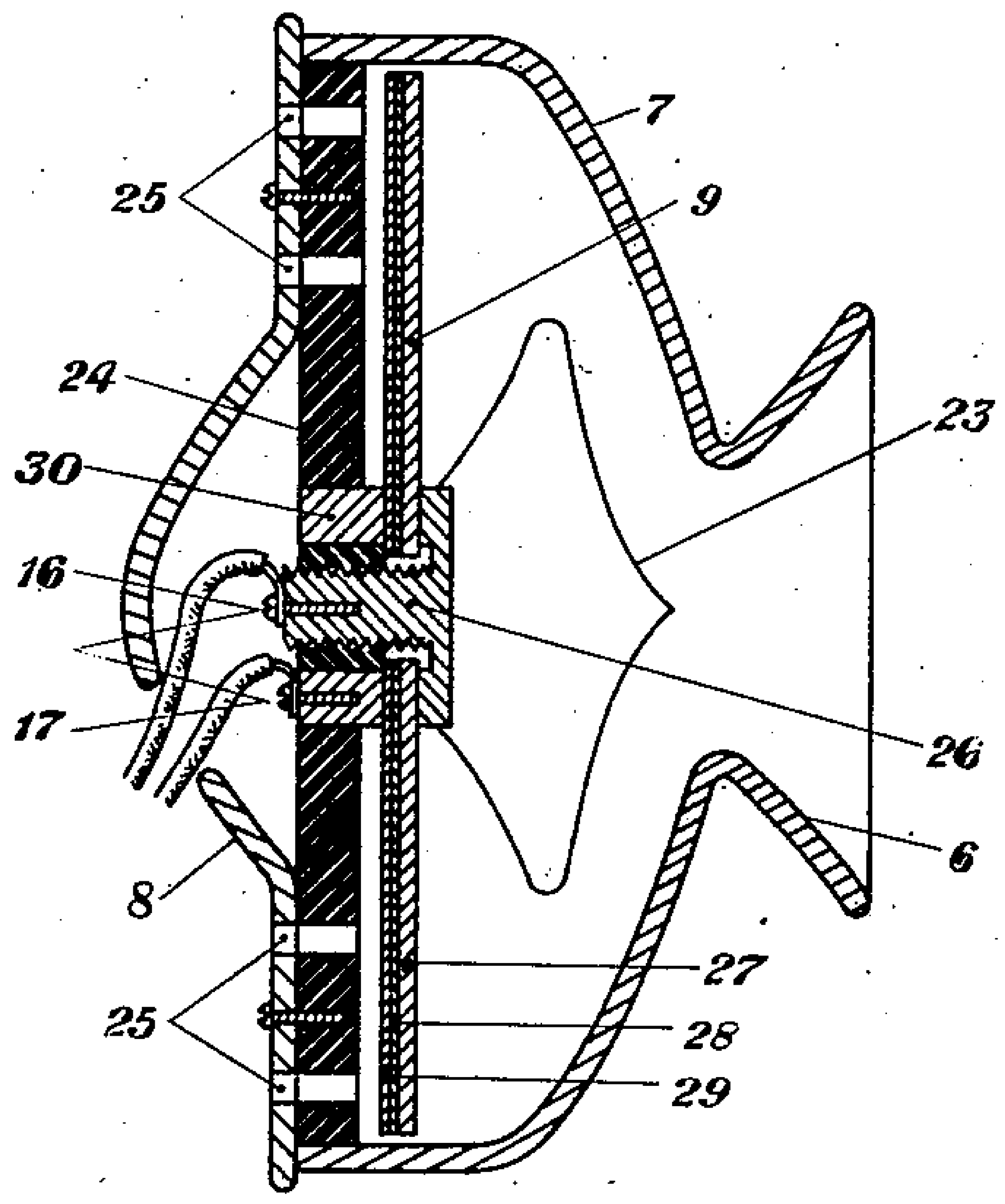

Fig. 4

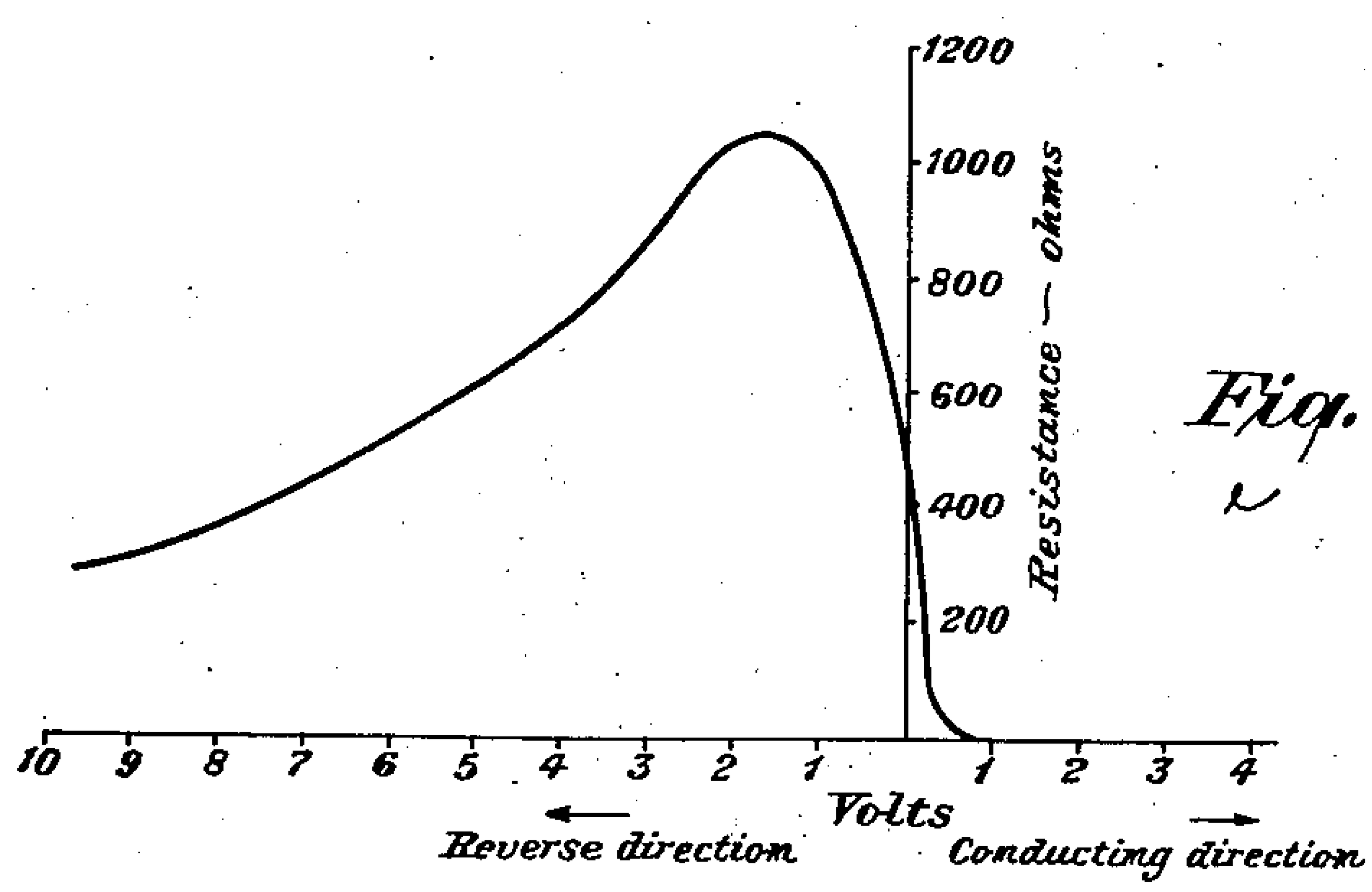

Fig. 5

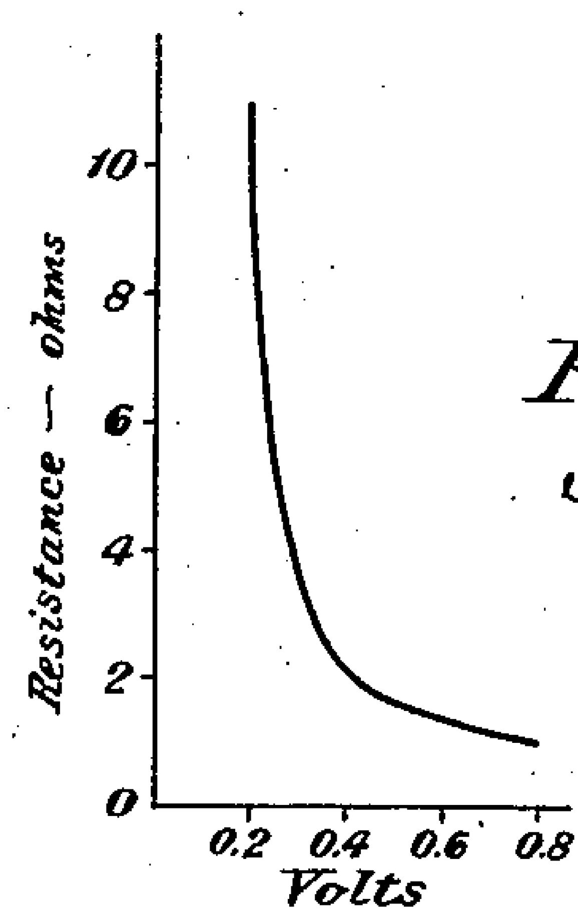

Fig. 6

INVENTOR
W. H. Edwards
BY
[signature]
ATTORNEY

Patented Dec. 15, 1931 | 1,836,109

UNITED STATES PATENT OFFICE

WILLIAM H. EDWARDS, OF GREAT NECK, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

IMPEDANCE MODIFYING DEVICE

Application filed May 14, 1929. Serial No. 363,084.

This invention relates to a method of and means for varying the impedance of an element, and more particularly to the utilization of such principles and apparatus for the transmission of sound energy.

In the operation of the arrangements of the invention, a device such as a thin film rectifier, for example, a disc of copper and cuprous oxide, is included in a circuit and is subjected to external stress. It has been found that subjecting a device of this character to stress will vary its impedance in the circuit. In accordance with the arrangements of this invention, the stress to which the device is subjected is caused by the pressure of sound waves. Under such conditions, the arrangements may operate as a means for the transmission of sounds, such for example, as a telephone transmitter. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

For purposes of illustration, it will be assumed that the element whose impedance is to be varied by the method of this invention is a rectifier of the well known copper oxide type. However, other types of thin film or contact rectifiers of the electronic type may be utilized. Also, rectifiers of the electrolytic type may be employed provided the film is rigidly connected to a thin disc, so that the stress in the rectifying medium may be changed as the disc is flexed. One of the suitable methods of forming the copper oxide rectifier element might consist in heating a copper sheet about .005″ thick to over 1000° C. until a thin closely adherent layer of cuprous oxide about one or two thousandths of an inch is formed. A heat treatment is then administered at lower temperatures. The outer surface of the oxide may then be reduced to metallic copper by electrolysis or by suitable deoxidizing agents in order to reduce the surface contact resistance. This resistance may also be reduced by removing the outer high resistance oxide by chemical or mechanical means, in which case the copper flash may be omitted. The impedance element in the circuit might be formed of one or more such units.

At the junction of the bulk of the cuprous oxide and the mother copper, there is believed to be a transition layer, wherein the copper oxide crystals match perfectly the copper crystals which they adjoin. This transition layer is of high resistivity but in formation is made to match on to the copper in such a way (probably with considerable stress in the transition layer) as to reduce to a low value the work function of escape into it of electrons from the copper. However, it matches on to the adjoining cuprous oxide in such a way as to make a large work function. There is no such effect between the thin metallic copper when used on the outer surface of the oxide as between the mother copper and the oxide, due to the different manner in which it is formed. Based on the theory of a transition layer depending upon initial stresses or on substantially perfectly matched crystals, it is proposed in accordance with the principles of this invention, to vary the stresses in this transition layer or the manner in which the crystals are matched and thus vary the work functions. Inasmuch as the oxide and the surface coating of copper are very thin, the transition layer is near the surface of the rectifier plate and is subject to approximately the maximum fibre stresses existing in the plate when it is flexed. Furthermore, when a portion of the plate bends in one direction, the transition layer has tension stresses superimposed on the initial stresses, and when bent the other way, has compression stresses added to it. It has been found by experiment that bending a plate so that the oxide is placed in tension instantly increases the resistance in the reverse direction and that when placed in compression, the opposite occurs. It has also been found that variations in pressure cause variations in resistance in the conducting direction. Also, if kept within proper limits, it appears that this flexure can be continued indefinitely without deterioration of the discs.

Inasmuch as diaphragms are commonly used to respond to changes in pressures of air and other media, it is proposed in accordance with the arrangements of this invention to utilize rectifier plates or discs of the above type as a diaphragm for a telephone transmitter. These plates or discs would be supported in a suitable manner and provided with convenient electrical connecting means in order to obtain impedances varying with the changes in pressure.

The invention may be more fully understood from the following description, together with the accompanying drawings, in the Figures 1, 2, 3, 4, 5, and 6 of which the invention is illustrated. Fig. 1 is a circuit diagram embodying the invention. Fig. 2 is a sectional view of the construction of the telephone transmitter of the invention. Figs. 3 and 4 are modifications of Fig. 2. In Fig. 5 is shown a resistance-voltage characteristic curve illustrating certain properties of the variable impedance device of the invention. Fig. 6 is an enlargement of a portion of Fig. 5. Similar reference characters have been utilized to denote like parts in all of the figures.

In the circuit diagram of Fig. 1 there is shown a local battery circuit consisting of a telephone line 1 connected to a receiver 2 and including the winding of a transformer 3. The other winding of transformer 3 would be connected in circuit with a source of current, such as battery 4, and the variable impedance element 5.

The variable impedance element comprises a rectifier plate or disc of the thin film or contact variety utilized as a diaphragm for a telephone transmitter and is shown more fully in Fig. 2. The transmitter mouthpiece 6 is attached to a suitable housing comprising the members 7 and 8. The rectifier disc serves as a diaphragm 9 and may be composed of a portion 10 of copper, an oxide film 11, and a surface flash of copper 12. This diaphragm may be clamped firmly at its periphery by the brass clamping surface 13 in contact with the copper of the diaphragm and the brass insert 15 in contact with the other side of the diaphragm. The brass clamping surface 13 and the brass insert 15 will be insulated from each other by the material 14 and will each be connected to the terminals 16 and 17, and thence in circuit with the battery 4, as shown in Fig. 1. It is pointed out that the thickness of the diaphragm has been exaggerated in Fig. 2 for purposes of illustration.

The variable pressure of the voice waves will set up certain stresses in the diaphragm or rectifier disc 9 of Fig. 2. The stresses set up in the extreme fibres are a maximum near the clamping surface. However, stresses of opposite sign are existent in the extreme fibres on the same side but at the center of the diaphragm. As has been pointed out, the summation of all the changes in stress determines the resultant resistance of the rectifier in each direction. Accordingly, the variable pressure of the voice waves by setting up a variable stress in the rectifier element will cause its impedance to vary in accordance with the variations of the voice waves and the device will operate in the manner of a telephone transmitter.

In Fig. 3 is shown a modification of the transmitter of Fig. 2. The transmitter comprises two housing members 7 and 8 into which is fitted the mouthpiece 6. The diaphragm disc 9 comprises the copper portion 10, the oxide film 11, and the surface flash of copper 12. The diaphragm is mounted in the cushion 20 of soft rubber or other suitable material pressed into a depression in the support member 7. Contact rings 21 and 22 are inserted between the rubber and opposite sides of the disc, with which they make contact, and are affixed to leads to terminals 16 and 17. It is pointed out that with an arrangement of this type all stresses superimposed by pressure of the voice waves on the oxide film at any instant are in the same direction, i. e., all either compression or tension.

In Fig. 4 is shown a further modification of the transmitter construction. The transmitter comprises two housing members 7 and 8. A portion 6 of member 7 serves as the mouthpiece. The diaphragm 9 is similar to those heretofore described in its construction and comprises the copper element 27, the oxide film 28 and the surface flash of copper 29. An insulating bridge support member 24 is provided affixed to housing member 8. A brass insert member 26 screws into the bridge support member and makes contact with one side of the diaphragm. Terminal 16 is connected to the brass insert member. Terminal 17 is connected to an insulated contact ring 30 which makes contact with the other side of the diaphragm. An insulating throat member 23 is affixed to member 26 to direct the air waves so that they strike the diaphragm near the periphery where the greatest deflection will be produced. Vent holes, such as 25, are provided to prevent excessive damping of the diaphragm. With this arrangement, it is pointed out that all stresses superimposed on the oxide film at any instant are in the same direction, i. e., all either compression or tension.

In Fig. 5 and in Fig. 6, which is an enlargement of a portion of Fig. 5, is shown a curve illustrating the resistance-voltage characteristics of certain rectifier plates or discs of the copper oxide variety It is pointed out that the most efficient portion of the curve on which to operate the device as a transmitter in accordance with the arrangements of the invention, is between the point of zero voltage, where the resistance is comparatively high, and the knee of the curve in the conducting direction, where the resistance is comparatively low. With this declining resistance-voltage characteristic, the effective internal resistance of the device to the alternating current component of the transmitter current generated in the transmitter would be considerably lower than the normal direct current resistance, as is the case with carbon transmitters. Operation on the downward slope of the curve in the reverse direction would also have a similar effect.

A telephone transmitter constructed in accordance with the arrangements of this invention, would have the advantage of extreme simplicity and, on that account, might lend itself to designs having good quality of transmission to a greater degree than a more complicated type. Furthermore, due to the absence of loose contacting parts, packing, burning, and positional effects would be non-existent. Due to the simplicity, low first and maintenance costs could be expected.

From the above it will be seen that one of the desirable uses to which the variable impedance device might be put in accordance with this invention is that of a telephone transmitter. However, it is pointed out that this use thereof has been shown and described in detail for purposes of illustration and that the device is capable of many other uses. Accordingly, while the arrangements of the invention have been shown as embodied in certain specific arrangements, it is pointed out that they are capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claim.

What is claimed is:

A microphone whose translating medium is composed of a diaphragm of metal having a thin film of the oxide of said metal over substantially its entire surface, the impedance of said translating medium being changeable by internal stresses set up therein by its flexure in response to external forces.

In testimony whereof, I have signed my name to this specification this 11th day of May, 1929.

WILLIAM H. EDWARDS.