Sept. 22, 1931. W. H. EDWARDS 1,823,933

REPEATER APPARATUS

Filed May 14, 1929

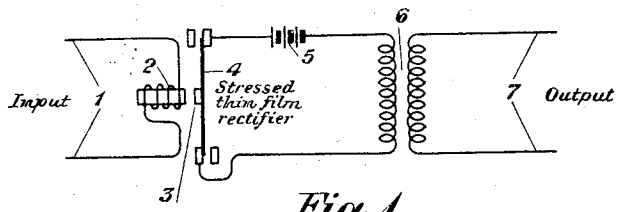


Fig. 1

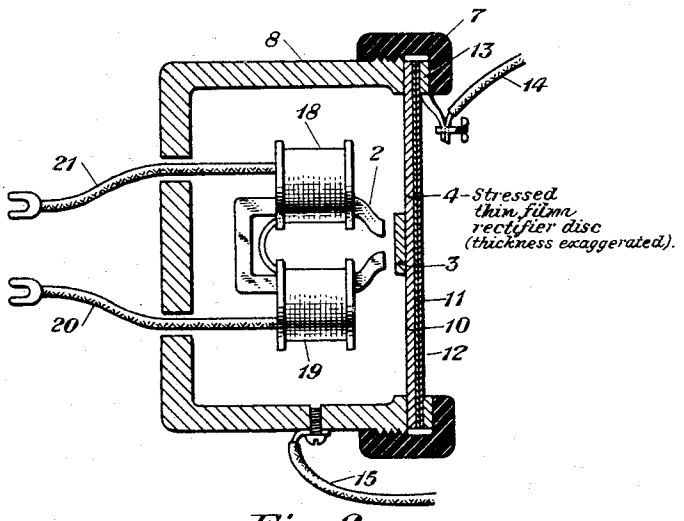


Fig. 2

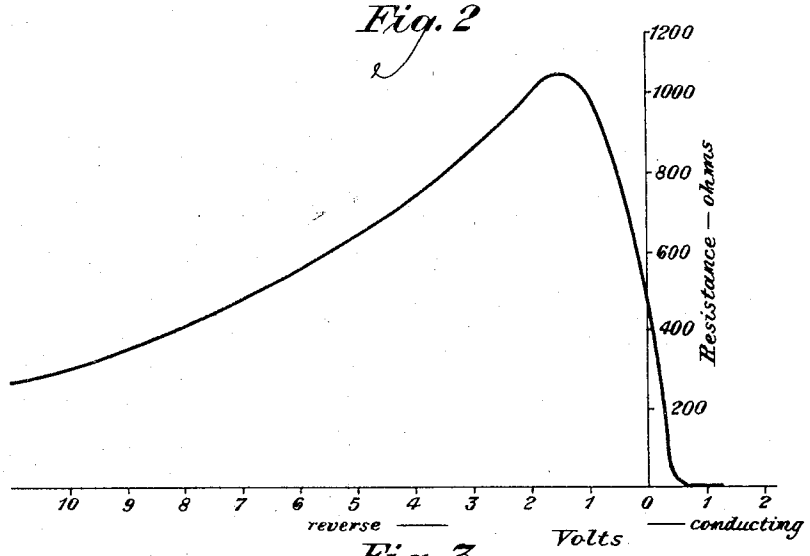


Fig. 3

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UNITED STATES PATENT OFFICE

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REPEATER APPARATUS

Application filed May 14, 1929. Serial No. 363,085.

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 and repetition of sound energy.

In the operation of the arrangements of the invention, a device such as a thin film rectifier, for example, a disk of copper and cuprous oxide, is included in a circuit and 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 utilizing the device as an armature for an electromagnet in another circuit over which voice waves are being transmitted. Under such conditions, the device may operate as a telephone repeater. 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, may be a rectifier of the well known copper oxide type. However, other types of thin film or contact rectifiers may be utilized. One of the suitable methods of forming the 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. The impedance element in the circuit might be formed of one or more of 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 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 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 fixed. 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 disks.

The characteristics of the thin film rectifier disk would adapt it for use as a telephone repeater in accordance with the arrangements of this invention. The weak alternating currents coming in over the line would be utilized to energize the coils of an electromagnet to cause it to attract or repel an armature attached to the rectifier disk. This would vary the stress to which the device was subject and vary its impedance in the secondary circuit in which it was connected. In this secondary circuit, there would be a source of energy. This action would cause a modulation of the comparatively large amount of direct current flowing in the secondary cir-

cuit in accordance with the incoming currents. By separating the alternating current component therefrom by use of a transformer, the amplified output current is available.

The invention may be more fully understood from the following detailed description together with the accompanying drawings in the Figures 1, 2 and 3 of which the invention is illustrated. Fig. 1 is a circuit diagram illustrating an embodiment of the invention. Fig. 2 is a sectional showing of the repeater element of the invention. In Fig. 3 is shown a curve illustrating the resistance-voltage characteristics of the rectifier disk utilized in the invention.

In Fig. 1 is shown a portion of a circuit 1 over which sound waves are being transmitted. Included in this circuit is the winding of an electromagnet 2. Adjacent to the pole piece of magnet 2, is an armature 3 of magnetic material mounted on the stressed thin film rectifier disk 4, which may be of copper and copper oxide. This disk would be connected in a circuit with the battery 5 and the winding of transformer 6. An output circuit would in turn be connected to transformer 6. The weak alternating currents coming in over line 1 will energize magnet 2 and cause it to attract or repel the armature 3. This will bend disk 4 and subject it to stresses, thus varying its impedance in the secondary circuit. In other words, this action modulates the comparatively large amount of direct current from battery 5 in accordance with the incoming currents in circuit 1. By use of the transformer 6, the alternating current component may be separated therefrom and is available in amplified form in circuit 7, and the arrangements may be operated as a means for repeating in amplified form energy coming in over line 1.

In Fig. 2 is shown a sectional view of the repeater apparatus. Similar reference characters have been utilized to denote like parts with respect to Fig. 1. The leads 20 and 21 would be connected to the sides of circuit 1 and would be connected to the windings 18 and 19 of the electromagnet 2. Adjacent to the pole pieces of magnet 2 is the armature 3 of magnetic material which may be repelled or attracted by the energization of coils 18 and 19. The armature 3 is affixed to the stressed thin film rectifier disk 4. This disk has had its thickness shown as exaggerated for purposes of illustration, and may be composed of a copper section 10, an oxide film 11, and a surface flash of copper 12. It is pointed out that other metals than copper might be utilized in the make-up of the disk. The disk may be held in position by an insulated clamping member 7 and a casing 8. The casing 8 may be in contact with one side of the disk and will be connected to terminal 15. A contact ring 13 will be provided in contact with the other side of the disk. To this may be connected the terminal 14. Terminals 14 and 15 will be connected to the secondary circuit including the battery 5 and the winding of transformer 6.

In Fig. 3 there is shown a curve illustrating the resistance-voltage characteristics of certain types of thin film rectifiers, such as those of the copper oxide type. It is pointed out that the most efficient portion of the curve on which to operate the device as a repeater-amplifier 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. Operation on the downward slope of the curve in the reverse direction would also have a somewhat similar effect.

While the invention has been disclosed as embodied in certain specific arrangements which are deemed desirable, it is understood that it is capable of embodiment in many other and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a transmission system comprising a circuit including a source of current and a disk having a stressed transition layer between two substances, the method of repeating sound energy which comprises causing sound waves coming in over an adjacent circuit to vary the impedance in its circuit of said transition layer by superimposing stresses on the layer by flexing said disk.

2. In a transmission system comprising a circuit including a source of current and a disk having a stressed transition layer between two substances, the method of repeating sound energy which comprises causing sound waves coming in over an adjacent circuit to vary the impedance in its circuit of said transition layer by superimposing stresses on the layer by flexing said disk and thereby varying its impedance in its circuit proportionally to said incoming sound waves and selecting the alternating current component from the current in said first mentioned circuit.

3. A transmission system comprising an incoming line section, a magnet included therein, an intermediate line section including a source of energy and a thin film rectifier disk, said disk including a stressed transition layer between two substances and being so positioned as to bend under the magnetic control of said magnet thereby varying the stresses and impedance on the transition layer, and an output circuit inductively connected to said intermediate circuit.

4. In a transmission system comprising a source of current and a disk having a stressed transition layer between two substances, the

method of amplifying sound energy which comprises causing sound waves coming over an adjacent circuit to vary the impedance in its circuit of said transition layer by superimposing stresses on the layer by flexing said disk.

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

WILLIAM H. EDWARDS.