April 10, 1928. 1,665,571

F. N. WATERMAN

ELECTRICAL TRANSLATING APPARATUS

Original Filed June 29. 1923

Fig.1.

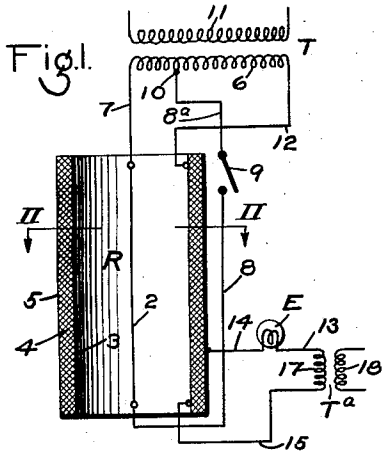


Fig.2.

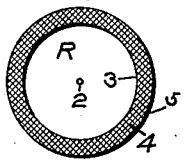


Fig.3.

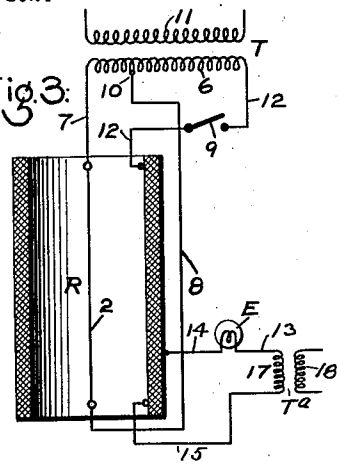


Fig.6.

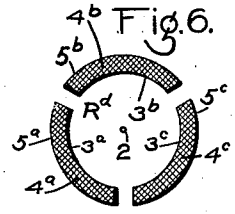


Fig.4.

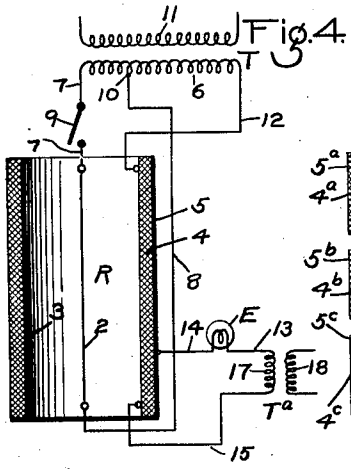


Fig.5.

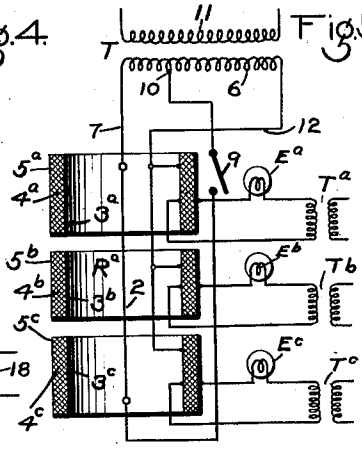


Fig.7.

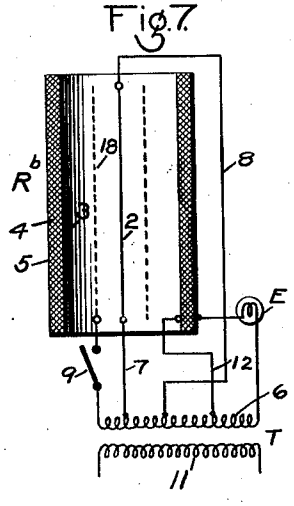


Fig.8.

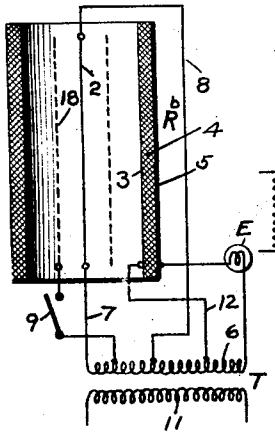


Fig.9.

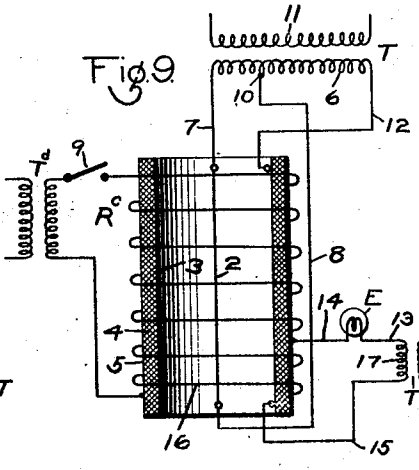
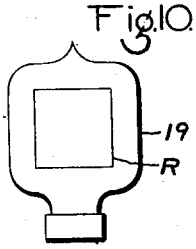


Fig.10.



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His ATTORNEY

Patented Apr. 10, 1928. 1,665,571

UNITED STATES PATENT OFFICE.

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ELECTRICAL TRANSLATING APPARATUS.

Continuation of application Serial No. 648,447, filed June 29, 1923. This application filed October 19, 1923. Serial No. 669,578.

My invention relates to electrical translating apparatus.

The present application is a continuation of my co-pending application filed on the 29th day of June, 1923, Serial No. 648,447, for electrical translating apparatus.

I will describe several forms of apparatus embodying my invention, and will then point out the novel features thereof in claims.

In the accompanying drawing, Fig. 1 is a view, partly diagrammatic and partly in cross section, showing one form of apparatus embodying my invention. Fig. 2 is a sectional view of the translating device R on the line II—II in Fig. 1. Figs. 3 and 4 are views showing modifications of the controlling circuits shown in Fig. 1 and likewise embodying my invention. Fig. 5 is a view similar to Fig. 1 but showing a modification of the translating device to permit the control of a plurality of secondary circuits. Fig. 6 is a view showing another modification of the translating device to likewise permit the control of a plurality of secondary circuits. Fig. 7 is a view similar to Fig. 1 but showing a modified form of apparatus embodying my invention, and Fig. 8 is a view showing a modification of the apparatus shown in Fig. 7. Fig. 9 is a view showing still another form of apparatus embodying my invention. Fig. 10 is a view showing a translating device of my invention enclosed in a bulb.

Similar reference characters refer to similar parts in each of the several views.

Referring first to Figs. 1 and 2, the apparatus includes a translating device, shown here as functioning as a relay, and designated as a whole by the reference character R. This device comprises an electron emitting member 2 which as here shown is a filament adapted to be heated by the flow of electric current. The device also comprises a plate 3 surrounding said filament either in whole or in part and arranged to be heated by the bombardment thereagainst due to the emission of electrons from the filament, and a thermo-sensitive substance 4 so located as to be exposed to changes in the temperature of the plate 3. By thermo-sensitive substance I mean a substance having the characteristic of varying in electrical resistance in response to variations in temperature. This substance preferably has a high negative co-efficient, so that its electrical resistance decreases as its temperature increases, and rises again upon cooling to substantially its initial value. For example, this substance may be cupric oxide.

As here shown the plate 3 is tubular in shape, the thermo-sensitive substance 4 is in the form of an envelope surrounding the plate, and the thermo-sensitive substance is held in place by a second tubular member 5 of metal which also serves as an electrode for a secondary circuit as will appear hereinafter.

The filament 2 is included in a primary circuit which comprises a source of current and means for controlling or modifying the flow of current in the filament. As here shown, the primary circuit passes from the left hand terminal of secondary 6 of transformer T, through wire 7, filament 2, wire 8, contact 9, and wire 8^a to an intermediate point 10 in the secondary 6. The primary 11 of transformer T is supplied with alternating current from a source not shown in the drawing.

The device R is also provided with a plate circuit for imparting high velocity to electrons emanating from the filament, which plate circuit passes from the left hand terminal of secondary 6, through wire 7, filament 2, thence through the intervening space between this filament and the plate 3, and from the plate 3 through wire 12 to the right hand terminal of the secondary of transformer T.

The secondary circuit of the apparatus passes from the secondary 17 of a transformer T^a, through wire 13, an electro-responsive device E, wire 14, electrode 5, thermo-sensitive substance 4, plate 3, and wire 15 to the other terminal of transformer secondary 17. As here shown, the electro-responsive device E is an electric lamp. The primary 18 of transformer T^a is constantly supplied with alternating current from a source which is not shown in the drawing.

The device R will usually be enclosed in a tube or bulb from which the air is exhausted or which contains a nonoxidizing gas, and will necessarily be so enclosed when the filament 2 is of an oxidizable material. This is illustrated in Fig. 10, wherein the translating device R is enclosed in a bulb 19.

Another reason for enclosure in a bulb is

that the amount of gas which can be tolerated in the device is exceedingly small, especially when the difference of potential between the filament and plate is considerable. When the amount of gas is small, the bombardment against the plate is predominatingly by electrons which are emitted by the filament. However, if there is any appreciable amount of gas present, a few of the electrons in their passage from the filament to the plate will strike atoms of gas, and some of these collisions will result in ionization. This ionization will consist in the breaking off of an electron from the atom, and so after the collision there will be two electrons moving toward the plate instead of one. The remainder of the atom will constitute a positively charged ion and so it will move toward the filament. These positive ions will tend to disintegrate the filament, and this is the reason why the amount of gas in the bulb should be small.

The plate is, therefore, in the general case, bombarded by electrons of two kinds, viz, those that are emitted by the filament and which may be called primary electrons, and those which are produced by impact of primary electrons against atoms or molecules of gas and which may be called secondary electrons or ions. The bombardment may therefore in some cases be partly, and possibly largely, ionic, although at the present time I believe that in practical applications of my invention the bombardment will be almost entirely by primary electrons. In any event the bombardment may be said to be due to the emission of electrons from the filament.

The operation of the apparatus shown in Fig. 1 is as follows: When the contact 9 is open, as shown in the drawing, the supply of current to the filament 2 is discontinued, so that there is no bombardment of the plate 3 in spite of the fact that a difference of potential between these two elements is constantly maintained by the plate circuit. Under this condition the thermo-sensitive substance 4 is comparatively cool and its resistance is then so high that the current, if any, which flows in the secondary circuit of transformer T^a is not sufficient to light the lamp E. When, however, contact 9 is closed, so that current is supplied to the filament 2, electrons are emitted from this filament and flow to the plate 3, because of the difference of potential maintained between these two elements by the plate circuit. Due to the consequent bombardment against the plate 3, the temperature of this plate rises, thereby causing the thermo-sensitive substance 4 to be heated. The resistance of this substance is then reduced to such value that the current flowing in the secondary circuit from transformer T^a is of sufficient magnitude to light the lamp E. When switch 9 is again opened, the electron stream ceases, so that the plate and the thermo-sensitive substance again become cool with the result that the lamp E becomes extinguished. It will be seen, therefore, that when contact 9 is closed, lamp E is lighted, and when contact 9 is opened, lamp E is extinguished.

Referring now to Fig. 3, the apparatus is the same as that shown in Fig. 1, except that the contact 9 is placed in the plate circuit instead of in the circuit for energizing the filament 2. In Fig. 3, then, the filament 2 is constantly heated, but there will be no appreciable bombardment of the plate, except when the contact 9 is closed. When the contact is closed, the plate will be heated as before by bombardment, and so lamp E will be supplied with sufficient current to cause it to become lighted.

In Fig. 4 the contact 9 is included in wire 7, so that it simultaneously controls both the filament and the plate circuits. That is to say, when this contact is open the filament is cool and the plate circuit is de-energized, but when the contact is closed the filament is heated and the plate circuit is energized, whereupon the bombardment against the plate causes the thermo-sensitive substance 4 to be heated, as in Fig. 1.

Referring now to Fig. 5, the apparatus is the same as that shown in Fig. 1, except that the translating device, which is here designated R^a, comprises a plurality of thermo-sensitive units 4^a, 4^b and 4^c, each in the form of a ring or band, and each provided with an individual plate 3^a, 3^b or 3^c, and with an individual sleeve or electrode 5^a, 5^b or 5^c. Each unit of thermo-sensitive substance is provided with an individual secondary circuit comprising a secondary of transformer T^a, T^b or T^c, and an electro-responsive device designated by the reference character E with a suitable exponent. When either the filament circuit or the plate circuit is de-energized, all of the thermo-sensitive units are cool, so that all of the lamps E are extinguished. When both the filament circuit and the plate circuit are energized, however, all of the thermo-sensitive units are heated so that all of the lamps E become lighted. It will be seen, therefore, that the apparatus shown in Fig. 5 is suitable for the control of a plurality of secondary circuits by a single primary circuit and a single translating device R^a.

Fig. 6 shows a modification of the translating device of Fig. 5. This device R^d comprises a plurality of segmental units 4^a, 4^b and 4^c of thermo-sensitive substance, each unit being provided with an individual segmental plate 3^a, 3^b or 3^c, and with an individual segmental outer electrode 5^a, 5^b or 5^c. Each thermo-sensitive unit may be employed to control an individual secondary circuit as in Fig. 5, and the circuits associated with

the device may be the same as those shown in Fig. 5.

Referring now to Fig. 7, the apparatus shown in this view is substantially the same as that shown in Fig. 1, except that the translating device, which is here designated R^b, includes a grid 18 which is interposed between the filament 2 and the plate 3, this grid preferably being tubular in shape, as indicated in the drawing. The filament and plate circuits are substantially the same as the corresponding circuits shown in Fig. 1. The apparatus is further provided with a grid circuit which passes from the left hand terminal of transformer secondary 6, through contact 9, grid 18, filament 2, and wire 7 to an intermediate point in transformer secondary 6. In the arrangement of apparatus shown in Fig. 7 the secondary circuit including the lamp E is also supplied with current from the secondary 6 of transformer T. With the connections shown in Fig. 7, the grid is negative with respect to the filament at the same instant that the plate is positive with respect to the filament, that is, the grid and plate currents are out of phase, so that when the grid circuit is energized the grid opposes the flow of electrons from filament to plate. The apparatus is so proportioned that when the grid is de-energized the electron stream is such as to heat the plate by bombardment so that the thermo-sensitive substance is heated and lamp E is lighted, but that when the grid is energized the bombardment against the plate is reduced to such extent that the thermo-sensitive substance becomes cool and the lamp E is extinguished.

In Fig. 8 the apparatus is the same as in Fig. 7, except that the circuits are so arranged that the grid is positive with respect to the filament at the same instant that the plate is positive with respect to the filament. In other words the grid and plate currents are in phase with each other. The apparatus is so proportioned that when the grid is de-energized the bombardment against the plate is not sufficient to heat the plate and thermo-sensitive substance to the degree required to light the lamp E, but that when the grid is energized the bombardment is intensified and the plate and thermo-sensitive substance are then heated to such degree that the lamp E becomes lighted.

It will be seen that the translating device R^b in Fig. 7 functions as a back contact of a relay, in that the lamp is lighted when the controlling (grid) circuit is open, and extinguished when the controlling circuit is closed, whereas in Fig. 8 the translating device functions as a front contact of a relay in that the lamp is lighted when the controlling circuit is closed and extinguished when the controlling circuit is opened. The advantage of the apparatus shown in Fig. 8 over that shown in Fig. 1 is that the grid circuit consumes only a small amount of power, so that the control of the secondary circuit can be accomplished with less power by the apparatus shown in Fig. 8 than by the apparatus shown in Fig. 1.

Referring now to Fig. 9, the apparatus is the same as that shown in Fig. 1, with the addition of means for creating a magnetic field which is substantially perpendicular to the electron stream. The translating device, which is here designated R^c, is provided with a coil 16 surrounding the sleeve 5 and included in circuit with the secondary of a transformer T^d, the primary of which is constantly supplied with alternating current. The circuit for coil 16, which will be obvious from the drawing, includes a contact 9. When contact 9 is closed, the magnetic field reduces the bombardment against the plate 3, and so prevents effective heating of the thermo-sensitive substance 4 by bombardment. Under this condition lamp E will, of course, be extinguished. When contact 9 is open, however, the electron stream is not interrupted, the thermo-sensitive substance 4 is heated by bombardment, and lamp E is lighted. It will be seen, therefore, that with the apparatus shown in Fig. 7, the supply of energy to the translating device R^c prevents the lighting of lamp E, and so the device R^c functions as the back contact of a relay.

Each translating device R^a, R^b, R^c and R^d will preferably be enclosed in a bulb 19 as shown in Fig. 10, for the reasons set forth in connection with the device shown in Fig. 1.

Although I have herein shown and described only a few forms of apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a filament, a primary circuit including a source of current for heating said filament, a plate, a plate circuit including said filament and said plate and a source of current for imparting high velocity to electrons emitted by said filament when the latter is heated by the primary circuit, a thermo-sensitive substance in contact with said plate and arranged to be heated by bombardment due to electrons flowing from said filament to the plate said substance having the characteristic of varying in electrical resistance in response to variations in its temperature, and a secondary circuit including said thermo-sensitive substance and a source of current whereby the amount of current flowing in the secondary circuit varies in response to the temperature of said substance and so in response to the intensity

of bombardment due to electrons flowing from said filament to said plate.

2. In combination, a filament, a primary circuit including a source of current for heating said filament, a plate, a plate circuit including said filament and said plate and a source of current for imparting high velocity to electrons emitted by said filament when the latter is heated by the primary circuit, a grid interposed between said filament and said plate, a grid circuit including said filament and said grid and a source of current for controlling the electron stream flowing from said filament to said plate, a thermo-sensitive substance in contact with said plate and arranged to be heated by bombardment due to electrons flowing from said filament to the plate said substance having the characteristic of varying in electrical resistance in response to variations in its temperature, and a secondary circuit including said thermo-sensitive substance and a source of current whereby the amount of current flowing in the secondary circuit varies in response to the temperature of said substance and so in response to the intensity of bombardment due to electrons flowing from said filament to said plate.

In testimony whereof I affix my signature.

FRANK N. WATERMAN.