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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Electrical Amplifiers and other Control Arrangements and Devices

I, OSKAR HEIL, German citizen, of 21 Jagowstrasse, Berlin-Grunewald, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to electrical amplifiers and the like and provides novel apparatus adapted to effect alternating current amplification and to perform other functions e.g. general control functions such as have usually been performed hitherto by thermionic valves. In general terms the present invention—which, as will be seen later, embodies a principle which is believed to be new and is based upon a discovery believed to be new—may be stated to provide a substitute for thermionic valves.

The discovery upon which this invention is based is that if a semi-conductor be arranged as to form part of a condenser which is subjected to a varying voltage charge the resistance thereof will vary as a function of said varying voltage and according to this invention this phenomenon or effect is utilised for amplifying or other control purposes.

It has been discovered that a thin layer of semi-conductor will fluctuate within wide limits in its resistance to an electric current if the said layer be arranged to act as an electrode of a condenser which is charged to a varying voltage.

The invention is illustrated in and further explained in connection with the accompanying diagrammatic drawings.

Referring to fig. 1 which serves to illustrate the essential principle of the invention 1 and 2 are metal electrodes between which is a thin layer 3 of a semi-conductor. A battery 4 sends a current through the thin layer of semi-conductor and this current is measured by the ammeter 5. If, now, an electrode 6 in electro-static association with the layer 3 is charged positively or negatively in relation to the said layer 3, the electrical resistance of this layer is found to vary and the current strength as measured by the ammeter 5 also to vary. Thus it is possible by the application of an alternating voltage of any wave form to the terminals 7 to produce a corresponding variation in the current through 5. This principle may be utilised to provide amplifiers which act in a way analogous to thermionic valve amplifiers. It is advantageous to make the distance between the electrode 6 and the semi-conductor 3 as small as possible, e.g. by providing a thin layer of insulation—preferably one having a high dielectric constant—between them.

Control electrodes playing a function like that of electrode 6 of fig. 1 can be provided on both sides of the layer 3. Again a plurality of control electrodes may be arranged next each other or one behind the other on one or both sides of the layer 3 and these electrodes may be operated separately, e.g. for the purpose of effecting simultaneous control by a plurality of alternating voltages.

Amplifier devices in accordance with the present invention can be made in various ways a preferred way being by applying the layers of semi-conductor, all the required electrodes and the insulating layers in succession to insulating plates the metal members being applied either by vaporizing metal or by depositing metal by cathode dispersion. The best thickness of semi-conductor layer to be used in any case depends on the conductivity of the semi-conductor employed and should be first ascertained by experiment for each semi-conductor material. In general, the greater the conductivity of the semi-conductor the more thin must be the layer thereof for best results.

One arrangement in accordance with this invention is shown in figure 2, the separate points embodied in figure 2 being shown assembled at *a* and enlarged and in exploded perspective view at *b*. In figure 2, 3 is a layer of semi-conductor which is connected to two metallic electrodes 1 and 2 via which the current to be controlled is passed through the layer 3. 6 are the control electrodes and these are separated from the construction 1 3 2 by layers 8 of insulating material. One controlling potential may be applied between the terminal 7′ and the terminal

of the battery 4 connected to the electrode 2 to control the current from the battery 4 through the semi-conducting layer 3 while a second controlling potential may be applied between the terminal 7″ and the other terminal of the battery 4 or alternatively (as shown dotted) to the same terminal of the battery 4. In place of insulating material air or vacuum insulation may be used, i.e. the parts 6 may be spaced from the construction 1 3 2 by air or, by using an evacuated enclosing envelope, by vacuum.

The term semi-conductor is used in the present specification in its present day well understood sense to include such substances as tellurium, iodine, cuprous oxide, vanadium pentoxide in which conduction is effected by a displacement of electrons as in the case of metals and does not include substances wherein conduction depends upon ionisation or electrolytic action in which case conduction takes place by a transfer of atoms or molecules.

As regards elements which are semi-conductors, these fall in the periodic system on the border line between metals and metalloids and these materials generally exist in at least one form which possesses a metallic character. As regards other materials which are semi-conductors, these possess a similarity to metals either in respect of a metallic sheen or in respect of their high absorption of light.

The term semi-conductor is also used in the present specification to include what may be termed "gap" conductors, i.e. conductors which exhibit an inverted Hall effect. As is known, if a flat plate-like conductor is traversed longitudinally by an electric current and is subjected to a magnetic field whose lines of force are perpendicular to the plane of the conductor, there is set up in the conductor a potential difference transverse to the direction of current flow. This is known as the Hall effect and normally the potential difference is of a sense corresponding to a negative Hall coefficient. Most metals possess such a negative Hall coefficient but there exist certain materials which possess a positive Hall coefficient, the potential difference set up being of the opposite sense. These materials may be said therefore to exhibit an inverted Hall effect. A general characteristic of semi-conductors is a negative temperature coefficient of resistance.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to performed I declare that what I claim is:—

1. An electrical amplifier or other control arrangement or device wherein one or more thin layers of semi-conductor traversed by current is or are varied in resistance in accordance with control voltage applied to one or more control electrodes arranged close to and insulated from said semi-conductor layer or layers so as to be in electrostatic association therewith.

2. An arrangement or device in accordance with claim 1 and comprising at least one narrow strip-shaped thin layer of semi-conductor provided on its two longer edges with electrodes which serve to lead electric current into and from said layer, there being at least one control electrode arranged close to a face of the semi-conductor layer and insulated therefrom.

3. An arrangement or device in accordance with any of claim 1 or 2 and comprising at least one thin semi-conductive layer and at least one control electrode in electro-static association therewith said layer and electrode being insulated from one another by insulation of high dielectric constant.

4. An arrangement or device in accordance with any of claim 1 or 2 and comprising at least one thin semi-conductive layer and at least one control electrode in electro-static association therewith said layer and electrode being insulated from one another by air insulation.

5. An arrangement or device in accordance with any of claim 1 or 2 and comprising at least one thin semi-conductive layer and at least one control electrode in electro-static association therewith said layer and electrode being insulated from one another by vacuum insulation.

6. An arrangement or device in accordance with any of the preceding claims and comprising a thin layer of semi-conductor, electrodes on opposite edges thereof, an output circuit including a source of potential said electrodes and said layer in series, a control electrode adjacent one face of said layer and insulated therefrom, and means for applying control potentials between said control electrode and one of said other electrodes.

7. An arrangement or device in accordance with any of claims 1 to 5 and comprising a thin layer of semi-conductor. electrodes on opposite edges thereof, an output circuit including a source of potential said electrodes and said layer in series, a control electrode adjacent one face of said layer and insulated therefrom, a second control electrode adjacent the opposite face of said layer and insulated therefrom, said layer being thus sandwiched between said control electrodes, and means for applying control

potentials between said control electrodes.

8. An arrangement or device in accordance with claim 6 or 7 and wherein the control electrode or electrodes (as the case may be) is or are spaced from the adjacent layer face or faces by an interposed sheet or sheets of solid dielectric.

9. An arrangement or device in accordance with any of claims 6 to 8 mounted in an evacuated envelope.

10. An arrangement or device in accordance with any of the preceding claims and wherein the semi-conductor is tellurium, iodine, cuprous oxide, vanadium pentoxide or a so-called "gap" conductor.

11. An electrical amplifier or other control arrangement or device utilising the phenomenon of varying semi-conductor resistance substantially as herein described with referance to the accompanying drawings.

Dated this 4th day of March, 1935.

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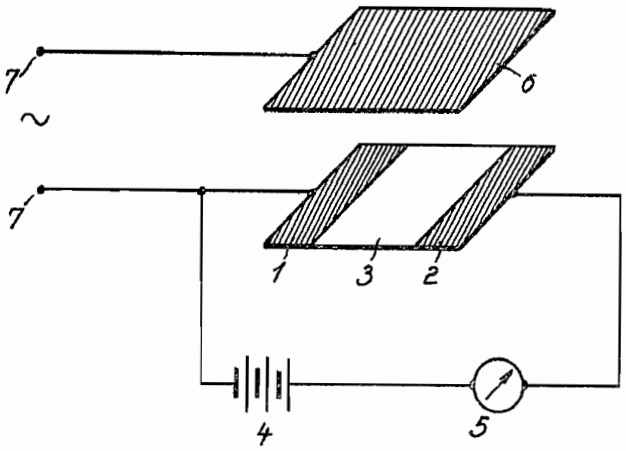
[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1



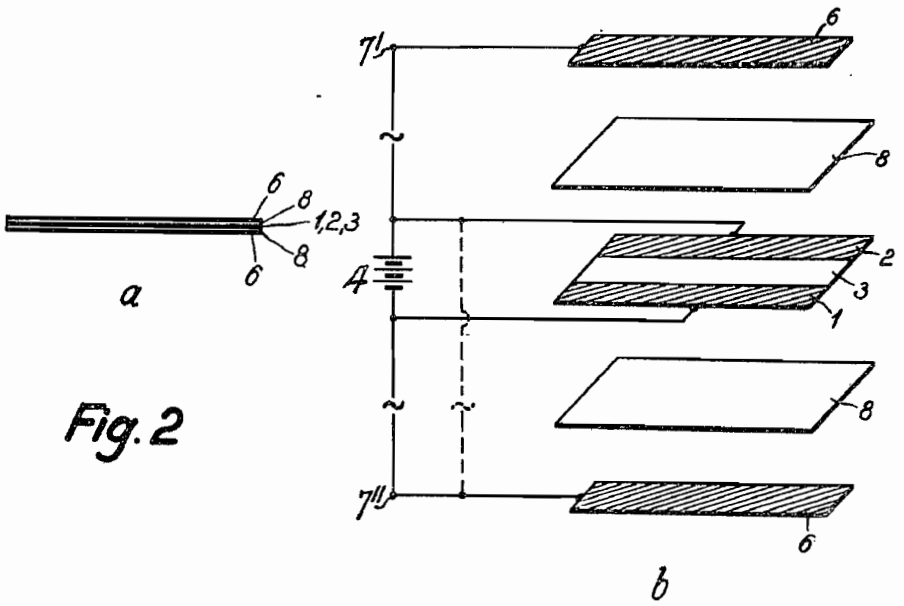


Fig. 2

Malby & Sons, Photo-Lith.