

N<sup>o</sup> 24,850



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PROVISIONAL SPECIFICATION.

**Improvements in Instruments for Detecting and Measuring  
Alternating Electric Currents.**

I JOHN AMBROSE FLEMING of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention to be as follows:—

It is well known that alternating electric currents can only be detected and measured by the use of some instrument, the indications of which do not depend upon the direction of the current. Hence an instrument of which the indication is dependent upon the heating of a wire by the current commonly known as a hot wire instrument is suitable for the above purpose. Also one depending upon the attraction or repulsion of electric current, commonly known as an electro-dynamometer, because in both these cases the indication or reading of the instrument is the same even if the current direction is reversed.

On the other hand, an ordinary galvanometer of the movable needle or movable coil type cannot by itself be used for detecting or measuring alternating currents because it only gives an indication with a unidirectional current and is therefore unaffected by an alternating current.

The object of my invention is to provide a means by which an ordinary galvanometer can be used to detect and measure alternating electric currents and especially high frequency alternating currents commonly known as electric oscillations.

The means I employ for this purpose consists in the insertion in the circuit of the alternating current of an appliance which permits only the passage of electric current in one direction and constitutes therefore an electrical valve.

I construct it as follows:—

In a glass bulb, I seal two or more carbon filaments such as are used for the manufacture of electric lamps. These filaments each have their own separate terminals. One or more of these carbon filaments may be replaced by loops of platinum wire, provided at least one carbon filament is used. A high vacuum must be made in the bulb. Two such bulbs are employed and for the sake of simplicity, I may describe the mode of use when a double carbon filament in each bulb is used. The two bulbs are each associated with a small insulated primary or secondary battery of sufficient voltage to bring one of the filaments to bright incandescence of greater intrinsic brilliancy than if used as an incandescent lamp. The bulbs are connected in parallel with each other and inserted in the alternating current circuit, but so that an incandescent filament and a dark or cold filament in each bulb form the electrode or connection for the current to be measured to enter and leave the bulb.

In series with one of the bulbs is placed an ordinary galvanometer. In the two branch circuits formed of the two bulbs, one in series with a galvanometer the local insulated batteries are arranged to ignite carbon filaments at opposite ends. That is to say, the carbon filament nearest to one common terminal is the ignited filament in one bulb and that farthest from the same common terminal in the other bulb.

[Price 8d.]



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These bulbs have the property that inside the bulb, negative electricity can move from the hot to the cold carbon filament even under a very low electromotive force but it cannot move in the opposite direction. Hence, owing to the arrangement of the bulbs, the alternating current arriving at the common terminal splits and all the positive alternations pass through one bulb and all the negative  
5 through the other bulb. The galvanometer is therefore affected solely by currents flowing in one direction. The bulbs serve the purpose of separating out the two constituents of the alternating current.

In place of two bulbs, one only may be used in series with a galvanometer and then the bulb only allows currents to pass in one direction and the galvanometer  
10 gives an indication.

The device is especially applicable to the detection and measurement by an ordinary galvanometer of high frequency electric currents or oscillations, where any form of mechanical or electrolytic rectifier is useless.

I construct the bulbs with two or more sets of carbon filaments. 15

One set when rendered incandescent forming one electrode of the valve and the other set kept cold, the other electrode.

In place of carbon filament for the cold electrodes I use sometimes, loops of platinum wire or platinum wires with plates on the end.

In making the connections of the bulb to the alternating current circuit it is  
20 essential to join one end of the galvanometer wire to that terminal of the hot carbon filament to which the negative end of the local or heating battery is applied.

The other end of the galvanometer and the two ends or all the ends of the cold filaments taken together constitute the terminal of the indicating appliance. 25

The carbon filament may also be heated by part of the alternating current which is being rectified or measured.

Any other method of heating one or more of the carbon filaments may be employed.

The above described multiple carbon filament bulb and a galvanometer may be  
30 used as a receiving instrument in wireless telegraphy.

For this case, the aerial receiving wire has the primary circuit of an oscillation transformer inserted in it and one of the above described electrical valves and a galvanometer are inserted in the secondary circuit.

The feeble alternating currents excited in the aerial by electric waves, then  
35 make themselves evident by indications in the galvanometer.

Dated this 16th day of November 1904.

J. A. FLEMING.

## COMPLETE SPECIFICATION.

**“Improvements in Instruments for Detecting and Measuring  
40 Alternating Electric Currents.”**

I, JOHN AMBROSE FLEMING, of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and  
45 ascertained in and by the following statement:—

This invention relates to certain new and useful devices for converting alternating electric currents and especially high frequency alternating electric currents or electric oscillations into continuous electric currents for the purpose of making them detectable by, and measurable with, ordinary direct current instruments such as a “mirror galvanometer” of the usual type or any ordinary direct  
50 current ammeter.

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Such instruments as the latter are not affected by alternating electric currents either of high or low frequency which can only be measured and detected by instruments called alternating current instruments of special design. It is, however, of great practical importance to be able to detect feeble electric oscillations, such as are employed in Hertzian wave telegraphy by an ordinary movable coil or movable needle mirror galvanometer. This can be done if the alternating current can be "rectified", that is either suppressing all the constituent electric currents in one direction and preserving the others, or else by changing the direction of one of the sets of currents which compose the alternating current so that the whole movement of electricity is in one direction. Many means have been devised and are in use for rectifying low frequency alternating currents, such as are used in electric lighting. There are well known forms of mechanical rectifier, also there is a well known form of electro-chemical rectifier depending on the fact that when a plate of carbon and aluminium is placed in any electrolyte which yields oxygen on electrolysis, an electric current can only pass through this cell in one direction if below a certain voltage.

Both these forms of rectifier are however inapplicable for high frequency currents. I have found that the aluminium-carbon cell will not act with high frequency currents.

I have discovered that if two conductors are enclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor but not in the reverse direction.

As the hot conductor should be heated to a very high temperature say near to the melting point of platinum (1700° C.), it should be of carbon preferably in the form of a filament such as is used in any ordinary incandescent electric lamp. The cold conductor may be of many materials, but I prefer a bright metal such as platinum or aluminium or else carbon.

The two conductors are enclosed in a glass bulb similar to that of an incandescent lamp, and I generally heat the carbon filament to a high state of incandescence by a continuous electric current, the electrical connection to the filament and the cold conductor being made by platinum wires, sealed air tight through the glass.

Figure 1 is a full size sectional elevation of an instrument constructed according to this invention, the electrical connections being shown diagrammatically. This figure illustrates the application of the invention to wireless telegraphy.

Figures 2 and 3 show modifications to smaller scales.

In Figure 1 *a* is a glass bulb, and *b* is a carbon filament like the carbon filament of an incandescent lamp, suitable say for taking a current of 6 to 8 volts and 2 to 4 amperes. *c* is a cylinder of aluminium open at the top and bottom which surrounds but does not touch the filament. The cylinder *c* is suspended and steadied by platinum wires *d*, and the ends of the filament *b* are connected to platinum wires connected to the leads *e* and *f*. The platinum wires are sealed through the glass in the ordinary manner.

As a very high vacuum should be obtained in the bulb *a* and as a considerable quantity of air is occluded in the conductors these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it whilst the cylinder *c* can be heated by surrounding the bulb *a* with a resistance coil through which a current is passed the whole being enclosed in a box lined with asbestos or the like. When as hereinafter described the cylinder *c* is replaced by any form of conductor which can be heated by passing a current through it this method is usually more convenient than that just described.

The carbon filament is made highly incandescent in the usual way by a continuous electric current produced by the battery *h* the negative pole of which is connected to the wire *e* and the positive to the wire *f*. The wires *d* and *e* are

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connected together by a wire  $j$  which completes the circuit through the secondary winding  $k$  of an induction coil (such as is ordinarily used in wireless telegraphy) and a galvanometer  $l$ .  $m$  is the primary winding of the induction coil having one end connected as is usual to an aerial wire  $n$  and the other to earth  $o$ . The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon  $b$  to the metal cylinder  $c$  but not in the reverse direction so that the alternations induced in the coil  $k$  by the Hertzian waves received by the aerial wire  $n$  are rectified or transformed into a more or less continuous current capable of actuating the galvanometer  $l$  by which the signals can be read. 5 10

Although Figure 7 shows the application of the instrument to wireless telegraphy it will be understood that the aerial wire  $n$  may be replaced by any circuit in which there is an alternating electromotive force, whether of low frequency or of high frequency.

I may increase the effect in the following manner:—I employ two bulbs arranged as shown in Figure 2 each being similar to that shown in Figure 1.  $p$   $p$  are the two coils of a differential galvanometer connected to the bulbs in such fashion that currents flowing in opposite directions through the two bulbs, flow in the same direction round the two coils of the galvanometer as regards the needle  $q$  of the galvanometer itself. For this purpose the hot conductor of each bulb is connected to the cold conductor of the other, hence, one bulb permits negative electricity to flow only in one direction and the other bulb permits only negative electricity to flow in the opposite direction through it. The common terminal of the two galvanometer coils  $p$  is connected to the coil  $k$  or any source of alternating electromotive force or of electrical oscillations, the other terminal of the said source being connected to the bulbs as shown. Each bulb has its own separate insulated battery  $h$  for heating its hot filament. 15 20 25

Under these circumstances, alternating electric currents are split into two continuous currents passing through the two bulbs in opposite and, in the two coils of the galvanometer, in the same directions. 30

By thus using a differential galvanometer I make use of the whole of the energy of the alternating current instead of discarding half of it. In this manner very feeble electrical oscillations can make themselves apparent by the indication which they give on a sensitive mirror galvanometer.

A number of these valves may be associated together in parallel as shown in Figure 3 so that alternating currents rectified by them separately may produce continuous currents which are added together. 35

In place of using a metal cylinder surrounding a carbon loop filament, I sometimes use a number of carbon filaments. Some of these are heated by means of an electric current, and become the hot conductor of the oscillation valve and the others remain cold and form the cold conductor. Or the metal cylinder may be replaced by a cylinder of meerschaum or the like having wound helically upon it a narrow ribbon of metallic foil. 40

The galvanometer  $l$  may be replaced by any other instrument for detecting the oscillations or by a relay for actuating a detecting or recording instrument. 45

In those cases in which a larger alternating current has to be dealt with, the hot conductor may be a rod of soft graphitic carbon held in suitable supports.

I find it possible by means of the device described above to rectify an alternating current without the use of any auxiliary continuous heating current. Thus, if I pass through the carbon filament an alternating current to bring it to bright incandescence, I find if I connect either terminal of the filament by a circuit outside the bulb with the terminal of the embracing cylinder or other cold conductor, then in this circuit a continuous current flows. Hence, the device may be used for rectifying either high frequency or low frequency alternating currents of electrical oscillations, provided these are of sufficient strength to render a carbon filament brilliantly incandescent. 50 55

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

- 5 1. A vacuous vessel having in it two conductors adjacent to but not touching each other, one of them being heated, these conductors being connected by a circuit outside the vessel, such circuit being exposed to some influence tending to produce an alternating current in it and which contains a galvanometer or other instrument for detecting a continuous current substantially as described.
- 10 2. In instruments such as are covered by Claim 1, heating the conductor by means of a continuous electric current passed through it substantially as described.
3. The application of the instruments covered by Claims 1 and 2 to wireless telegraphy substantially as described.
- 15 4. Duplicating the instruments covered by Claims 1, 2 and 3, by connecting the two coils of a differential galvanometer respectively to the heated conductor in one vessel and the unheated conductor in the other, the connection between the two coils being connected to the other pair of conductors substantially as described.
- 20 5. Instruments for converting alternating electric currents into unilateral currents substantially as described.

Dated this 1st day of August 1905.

J. A. FLEMING.

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

Fig. 1.

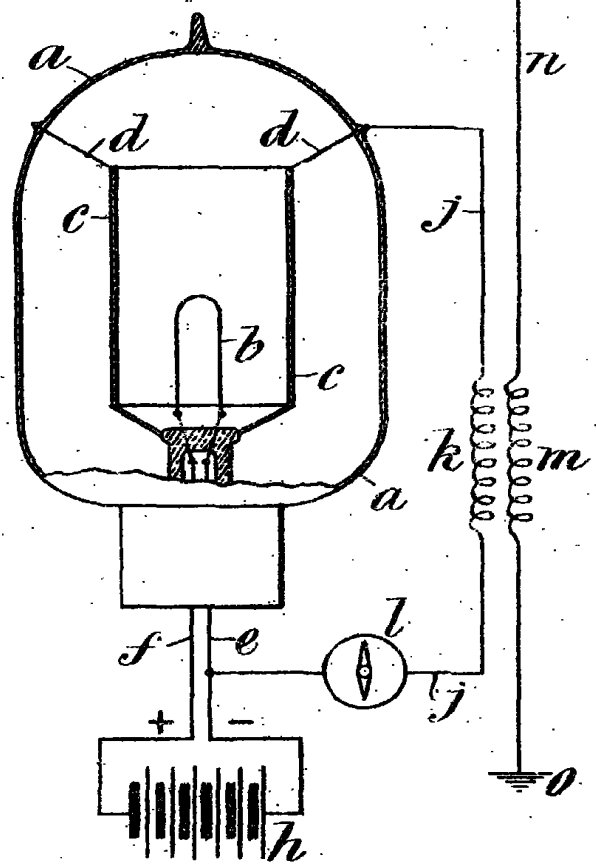


Fig. 2.

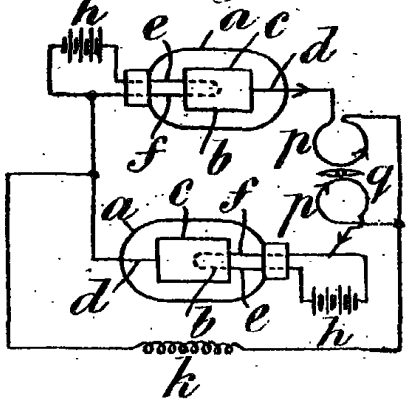
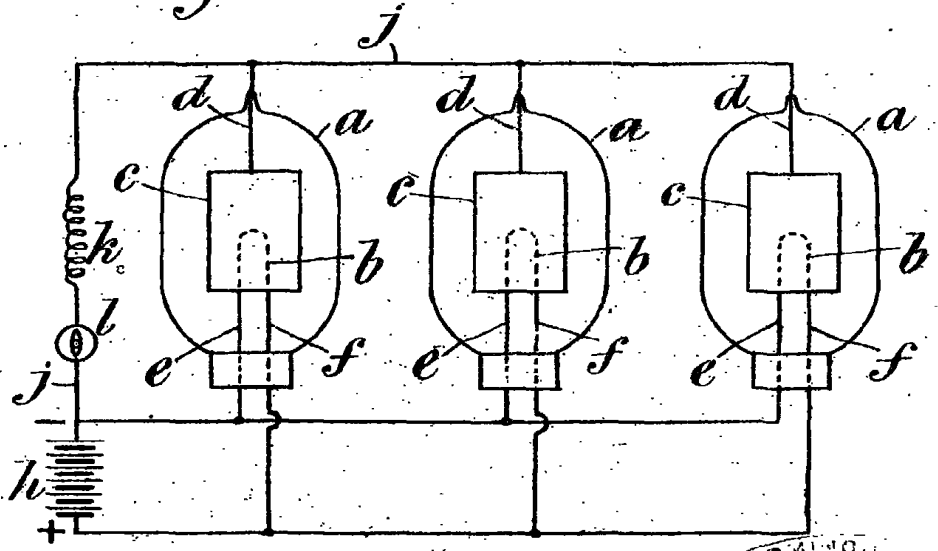


Fig. 3.



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