Jan. 6, 1925. 1,522,070

T. H. NAKKEN

MEANS FOR TRANSFORMING LIGHT IMPULSES INTO ELECTRIC CURRENT IMPULSES

Filed Nov. 3, 1920

Fig. 1.

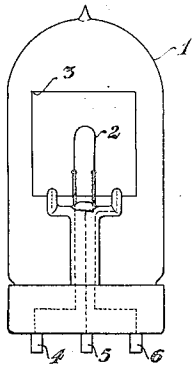
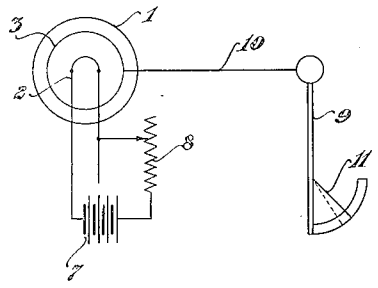


Fig. 2.



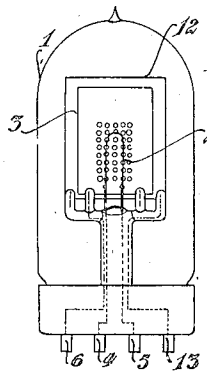


Fig. 3.

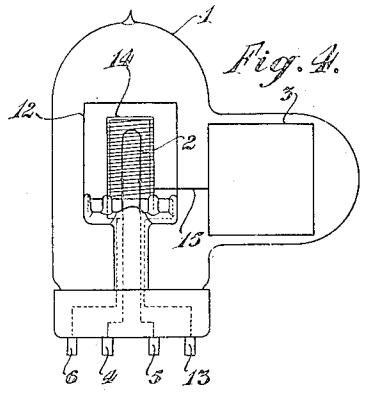


Fig. 4.

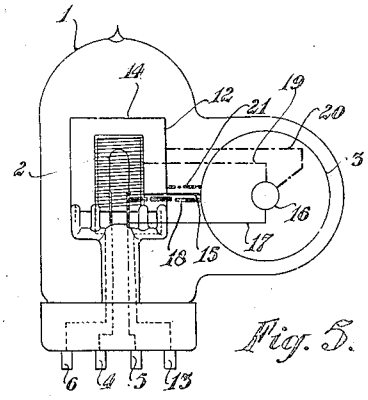


Fig. 5.

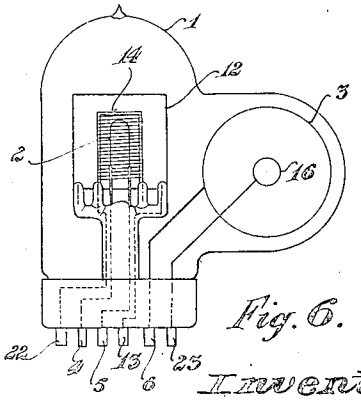


Fig. 6.

Inventor
T. H. Nakken,
By H. R. Kerslake.
Attorney

Patented Jan. 6, 1925. 1,522,070

UNITED STATES PATENT OFFICE.

THEODORUS H. NAKKEN, OF ROTTERDAM, NETHERLANDS, ASSIGNOR TO NAAMLOOZE VENNOOTSCHAP NEDERLANDSCHE LUMINOTRON MAATSCHAPPIJ, OF ROTTERDAM, NETHERLANDS, A COMPANY OF NETHERLANDS.

MEANS FOR TRANSFORMING LIGHT IMPULSES INTO ELECTRIC-CURRENT IMPULSES.

Application filed November 3, 1920. Serial No. 421,549. REISSUED

To all whom it may concern:

Be it known that I, THEODORUS HENDRIK NAKKEN, a citizen of the United States of America, residing at Rotterdam, Netherlands, have invented certain new and useful Improvements in Means for Transforming Light Impulses Into Electric-Current Impulses, of which the following is a specification.

Up till now the selenium cell has practically been the only means for transforming light impulses into electric current impulses. It is well known in the art, however, that the selenium cell has some very inconvenient features, inter alia its sluggishness or inertia, its inconstancy and the impossibility of being adjusted once it has been completed. With a view to these disadvantages the selenium cell can only be used in those cases wherein the influence of said inconveniences may be neglected, but as a matter of fact it is of no value for the solution of quite a number of highly important problems such as the talking film, the rapid action telephotography, the telephote, etc.

My present invention is based upon the fact well-known to those skilled in the art that a good many metals emit electrons when exposed to light, especially to ultra-violet rays. This so-called photo-electric or Hallwach-effect is very strong with the alkaline metals, especially with their amalgams. The emission of electrons is absolutely instantaneous. The number of electrons emitted per unit of time depends upon the intensity of the light, the area of the exposed surface and the temperature of the metal. The said effect is strongest with negatively charged bodies owing to the negative character of the emitted electrons and to the fact that the emission is, as a matter of course, furthered by a negative charge. It may also be safely assumed that photo-electric bodies when exposed to light have no tendency to take up new electrons.

The photo-electric effect may be used for the transformation of light impulses into electric current impulses. Means such as the so-called gas cells have already been suggested for generating electric currents along the lines stated, but the currents thus generated are exceedingly weak. Moreover, said gas cells are of no pratical use as they are dependent for their proper operation upon a high voltage which must be maintained at a given critical value depending, inter alia, upon the temperature.

According to my present invention practical means for the purpose stated may be obtained by the provision of one or a plurality of photo-electric bodies inside a transparent or translucid glass or other bulb which is either completely exhausted, or filled with rarefied neutral gas such as helium, argon, etc., said bulb enclosing a filament for the emission of electrons and, but not necessarily, one or more other elements.

The annexed diagrammatic drawing shows apparatus constructed in accordance with my new principles in which—

Figure 1 is a diagrammatical side view of an apparatus constructed in accordance with the invention;

Fig. 2 is a similar view in top plan, showing the actino-electric plate connected with an electro-scope; and

Figs. 3, 4, 5 and 6 are elevations similar to Fig. 1, illustrating various forms of the apparatus.

The invention may best be explained with reference to Figs. 1 and 2.

In all figures:

1 is the glass or other bulb which may be fully exhausted or filled with neutral gas under low pressure,

2 is the filament,

3 a photo-electric plate, for instance of rubidium, hereinafter to be termed "body,"

4 and 5 are the contact pins of the filament,

6 is the contact pin of the body.

When the filament 2 (see Fig. 2) is brought to incandescence owing to its connection with battery 7 and regulating resistance 8, the filament at once emits electrons part of which reach the body. The

latter will hereby be negatively charged until a maximum is attained and an equilibrium established, when the filament will absorb as many electrons per unit of time as it emits. The charge can be read on a calibrated electroscope 9 connected through a wire 10 with the body 3. The leaf 11 of the electroscope will deflect and remain stationary in a given position. If now the body 3 is exposed to light same will instantaneously emit a given number of electrons per unit of time, the potential drops and the leaf 11 moves back by gravity through a certain distance. When the light source is removed the original conditions are instantaneously restored.

Owing to the presence of free electrons in the bulb the body cannot suffer from so-called "fatigue," such as is the case with the selenium cell. That is to say, said body is always in condition for instantaneously emitting electrons.

Figs. 3–6 illustrate apparatus embodying the invention and adapted to transform the potential variations of the body into electric current impulses which, in their turn, may be transformed in an arbitrary manner into other forms of energy.

In Fig. 3 the body 3 is perforated, a plate 12 being provided within the bulb 1 and connected with a contact pin 13. Intermediate between filament 2 and plate 12 is the body 3.

If now the + pole of a battery of say 40–100 volts is connected with contact 13, that is to say with plate 12, its — pole being connected with contact 4 or 5 of the filament, then the latter when lit to incandescence by a separate battery (not shown) will cause a current to pass. The amount of this so-called plate current depends upon the potential of body 3, and slight variations of this potential will entail comparatively great variations of the plate current. This phenomena need not be explained in detail, but reference is had to the vacuum valve or electron relay in which slight variations of the potential of the grid have a similar effect on the plate current. It should be well understood, however, that in an electron relay the potential of the grid is affected by electric impulses, whereas in my new apparatus the potential of the body is controlled by light impulses in the manner explained.

The same effect is realized when the body is not placed between filament and plate, provided always that its distance to the filament is smaller than that between the filament and the plate, and that it does not prevent the passage of electrons between these two elements. When these conditions are fulfilled the exact form of the body is arbitrary.

The potential of the body may attain such a high value as to render it advisable to provide for a leakage resistance, or to charge the body positively, for which the contact pin 6 may be used.

If the distance from filament to body is too small, the latter may be damaged by the heat of the first, and in order to obviate this inconvenience I may use the construction shown in Figs. 4–6. The body here is placed at a considerable distance from the filament and as near to the wall of the bulb as possible, so that it may be cooled, if necessary, by means of a suitable fan which is impossible with the apparatus shown in Fig. 3. In order that the increase in distance between filament and body may not interfere with the proper effect, I connect said body through a wire 15 with a metallic member 14. It will be understood that this apparatus functions in quite the same manner as that illustrated in Fig. 3, but it has the great advantage that said member may now be made of metal having a high fusing point. In analogy with the nomenclature used in connection with electron relays said member 14 will hereinafter be termed "grid."

Another embodiment of the invention is shown in Fig. 5. The photo-electric body 3 here is made in the shape of a concave mirror in the focus of which is placed a small metal plate 16, hereinafter called "electrode." The provision of this electrode allows of quite a number of different connections, some of which will now be described more in detail.

(*a*) Assuming the body to be connected through wire 15 with the grid, and the electrode through wire 17 with the filament, it will be understood that electrons emitted by the said body will reach the electrode and that the following circuit, partly metallic and partly electronic, will be established: filament, grid, wire 15, body, electrode, wire 17, filament. The strength of this current is determined by the emission of electrons by the body, i. e. by the intensity of the light to which the body is exposed, said strength in its turn determining the potential of the grid and, consequently, the amount of plate current.

(*b*) The circuit described sub *a* may be reversed by connecting the body through a wire 18 with the filament, and the electrode through a wire 19 with the grid. As a matter of course the opposite effect will now be obtained.

(*c*) If the body is connected through wire 15 with the grid and the electrode through wire 20 with the plate, then owing to emission of electrons the following will take place:

1°. the potential of the grid will be reduced and the strength of the plate current increased, i. e. a greater number of electrons reach the plate directly,

2°. electrons emitted by the body reach

the plate, i. e. the emission of electrons tends to increase the strength of the plate current.

(*d*) The circuit described sub *c* may be reversed by connecting the body through wire 21 with the plate, and the electrode through wire 19 with the grid, and the opposite effect will then of course be realized.

(*e*) Assuming the body not to be connected with any of the other elements, and the electrode to be connected through wire 19 with the grid, then the electrons emitted by the body will flow from the electrode to the grid the charge of which will thus be increased whereby the plate current is weakened. In this case the action upon the plate current is entirely electronic.

In order that the above and still other connections may be effected without having to change the construction of the apparatus proper, I preferably use apparatus as shewn in Fig. 6. The body, the filament, the plate, the grid and the electrode here are connected with exterior contact pins, all interior connections being dispensed with. That is to say, in addition to the contact pins shown in the previous figures the apparatus has contacts 22 and 23 connected with the grid 14 and with the electrode 16 respectively. The desired connections can now be made simply by connecting one contact pin with another. This construction has further the advantage that, for instance, one of the elements may be grounded.

It is pertinent here to state that the apparatus described may be varied in many respects without departing from the scope and the spirit of my invention. For instance, the plate 12 may be provided outside the bulb, or form part of the bulb wall, and the bulb may contain, in addition to a plurality of photo-electric bodies, one or more spare filaments whereby the life of the apparatus is increased.

It will be clear to anyone skilled in the art that my novel means may be employed for quite a number of widely different purposes. I may still add that said means may be used, inter alia, as a generator of radio frequency alternating currents the strength of which is governed by light impulses.

What I claim as my invention and desire to secure by Letters Patent is:—

1. A method of transforming light variations into electric current variations, which consists in submitting a photo-electric body enclosed by a bulb which is exhausted of air, to the influence of a stream of electrons flowing from a source of electrons, subjecting said body to the action of a variable exterior souce of light, and associating such body with an electric circuit so that the strength of the current of such circuit will be varied in accordance with the variations of the source of light.

2. A method of transforming light variations into electric current variations, as claimed in claim 1 in which the stream of electrons flowing from said source of electrons is submitted to the governing influence of a body provided in the path of the said electrons.

3. A method of transforming light variations into electric current variations, which consists in submitting a photo-electric body enclosed by a bulb which is filled with rarefied neutral gas to the influence of a stream of electrons flowing from a source of electrons, subjecting said body to the action of a variable exterior source of light, and associating such body with an electric circuit, so that the strength of the current of such circuit will be varied in accordance with the variations of the source of light.

4. Means for transforming light impulses into electric current impulses including a bulb, electron emitting means arranged in said bulb and a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light.

5. Means for transforming light impulses into electric current impulses including a bulb, an electron emitting means arranged in said bulb, a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emittitng means, such photo-electric body being adapted to be submitted to the action of a variable source of light, and a plate member also arranged in said bulb.

6. Means for transforming light impulses into electric current impulses including a bulb, an electron emitting means arranged in said bulb, a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light, a metal plate arranged in said bulb, and a grid also arranged in said bulb.

7. Means for transforming light impulses into electric current impulses including a bulb, an electron emitting means arranged in said bulb, a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light and individual contacts for the electron emitting means and photo-electric body arranged externally of said bulb.

8. Means for transforming light impulses

into electric current impulses including a bulb, an electron emitting means arranged in said bulb, a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light, a plate member also arranged in said bulb, and individual contacts for the electron emitting means, photo-electric body and plate arranged externally of said bulb.

9. Means for transforming light impulses into electric current impulses including a bulb, an electron emitting means arranged in said bulb, a photo-electric body spaced apart from but associated with said electron emitting means so as to be influenced by the stream of electrons emitted from said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light, a metal plate arranged in said bulb, and a grid also arranged in said bulb and individual contacts for the electron emitting means, photo-electric body, plate and grid, arranged externally of said bulb.

10. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb and a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light.

11. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb, a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light, and a plate member also arranged in said bulb.

12. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb, a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light, a metal plate arranged in said bulb, and a grid also arranged in said bulb.

13. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb, a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light and individual contacts for the filament and photo-electric body arranged externally of said bulb.

14. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb, a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light, a plate member also arranged in said bulb, and individual contacts for the filament, photo-electric body and plate arranged externally of said bulb.

15. Means for transforming light impulses into electric current impulses including a bulb, a filament arranged in said bulb, a photo-electric body spaced apart from but associated with said filament so as to be influenced by the stream of electrons emitted from said filament, such photo-electric body being adapted to be submitted to the action of a variable source of light, a metal plate arranged in said bulb, a grid also arranged in said bulb, and individual contacts for the filament, photo-electric body, plate and grid, arranged externally of said bulb.

16. Means for transforming light impulses into electric current impulses including a bulb, electron emitting means arranged in said bulb, and a photo-electric body spaced apart from said electron emitting means but exposed to the electrons emitted by said electron emitting means, such photo-electric body being adapted to be submitted to the action of a variable source of light.

17. Means for transforming light impulses into electric current impulses including a bulb, electron emitting means arranged in said bulb, a photo-electric body associated with said electron emitting means so as to be influenced by the stream of electrons emitted therefrom, said photo-electric body being in the form of a concave mirror, and an electrode in the focus of said mirror.

18. Means for transforming light impulses into electric current impulses including a bulb, electron emitting means arranged in said bulb, a photo-electric body associated with said electron emitting means so as to be influenced by the stream of electrons emitted therefrom, said photo-electric body being in the form of a concave mirror, a metal plate within said bulb and a grid also within said bulb, an electrode in the focus of said mirror said photo-electric body having a metallic connection with the grid and the electrode having a metallic connection with the electrode emitting means.

19. Means for transforming light impulses into electric current impulses comprising a bulb, electron emitting means, arranged in

said bulb, a photo-electric body exposed to the electrons emitted by said electron emitting means so as to have a static potential imparted thereto by said electrons, said photo-electric body being adapted to be submitted to a varying source of light so that the potential thereof imparted thereto by said electrons may be caused to vary in accordance with the variations in the strength of such light, and means whereby such variations in the static potential of said photo-electric body may cause corresponding variations in the electric current in one or more circuits.

In testimony whereof I affix my signature.

THEODORUS H. NAKKEN.