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R. COLBERG ET AL
DYNAMIC MULTIPLIER
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FIG. 1

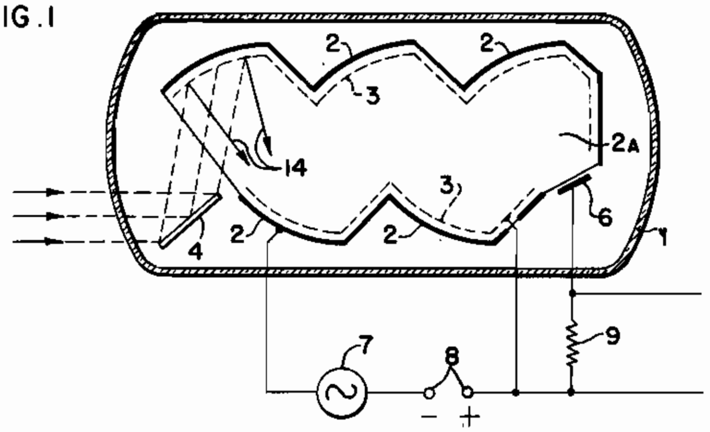


FIG. 2

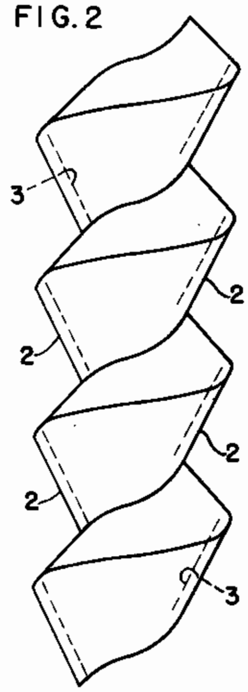
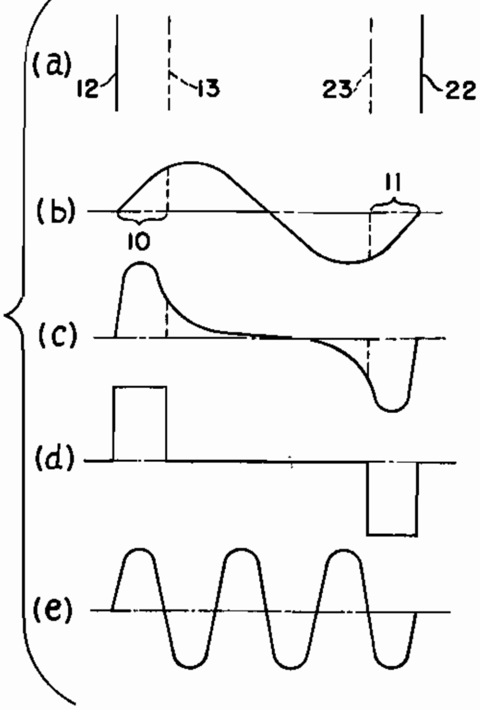


FIG. 3



INVENTORS
ROLF COLBERG
FRIEDRICH MICHELS

BY [signature]
ATTORNEY

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ALIEN PROPERTY CUSTODIAN

DYNAMIC MULTIPLIER

Rolf Colberg, Berlin-Lichterfelde, and Friedrich Michels, Berlin-Zehlendorf, Germany; vested in the Alien Property Custodian

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The invention relates to secondary emission multipliers. There exist two groups of secondary emission multipliers. The so called "static" multipliers are provided with a plurality of secondary emission electrodes having each a constant potential increasing with the distance from the cathode. Each electron is multiplied only once at each electrode of the multiplier. The "dynamic" multipliers on the other hand contain usually only one or two secondary emission electrodes. They are operated with an alternating potential in such a manner that one and the same electrode is impacted several times by secondary electrons emitted by the same or another electrode. Each of the electrodes has the same potential along its surface in each instant.

The invention relates to a type of multiplier including features of both above mentioned classes of multipliers. The arrangement may be called a dynamic multiplier because it operates with only one or two secondary emission electrodes having an alternating potential. It has however in common with the known static multipliers that the electrons are guided after each impact in a new direction so that they move along a predetermined path through the arrangement.

In the dynamic multipliers as hitherto used, the electrons move in groups but they fill practically the whole discharge space between the electrodes and are not confined to prescribed electrons paths. In the arrangement according to the invention however they move along well defined paths. This has the advantage that the maximal current intensity is dependent only upon the number of electrons impacting upon the last secondary emission electrode because the electrons are not mixed with those electrons coming from an earlier secondary emission stage. In consequence thereof the difficulties existing in usual dynamic multipliers as for instance the production of undesired oscillations are overcome. It has been impossible furthermore to obtain a concentrated output-stream of electrons directed towards relatively small anodes. The output electron-stream may be directed towards a diaphragm and used in any appropriate manner.

It has been suggested to produce the repeated impact of electrons upon a single secondary emission electrode by a suitable choice of the variable potential applied to the electrode. These so called multipactors operate with an alternating potential having a "long period." The period of the alternating potential is long in comparison to the transit-time of an electron on its flight through the discharge space. The multiplication is obtained during the increasing portion of the alternating potential period by making use of the fact that the electrode has acquired a higher potential after each transit-time of the electron so that the electrons impact upon the same electrode but each time with a higher velocity, so that new secondary electrons are liberated. During the descending portion of the alternating potential no multiplication takes place.

The multiplier of the invention has two series of electrode-elements arranged opposite to one another and all elements of each series have one and the same potential. According to the invention the electrode-elements are connected with one another in each series. In front of each secondary emission electrode there is arranged an accelerating electrode including in its interior a space free from electrical fields.

Other aspects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing Fig. 1 shows a longitudinal section through the tube according to the invention, Fig. 2 shows a view of the secondary emission electrode confining the discharge space and Fig. 3 shows a number of diagrams for explaining one mode of operation of the tube.

The tube 1 of Fig. 1 contains two secondary emission electrodes 2, having each a number of concavely curved portions connected by substantially flat portions. The electrodes 2 are arranged opposite to one another so that the curved portions form two series of impacting surfaces having a uniform potential. Preferably the two oppositely arranged electrodes 2 are connected by metallic walls enclosing the discharge space on both sides of the device. The electrode formed by these parts has therefore the shape of a closed chamber or cell having an input-opening for the light or for electrons and an output-opening at the other end of the chamber. An accelerating grid 3 is arranged parallel to the electrodes 2. A similar grid may also be arranged in front of the lateral side-walls of the chamber and has for instance the form of a wide mesh wire-screen consisting of wires of 0.1 mm and one mesh per mm. The screen may also be replaced by a number of parallel wires lying parallel to the plane of the section of Fig. 1. A mirror is built into the tube so that light falling in the direction of the dotted arrows upon the mirror is reflected upon the first portion of the secondary emission electrode as indicated by broken lines. An output-electrode or anode 6 is arranged at the opposite end of the multiplier and connected by way of the resistance 8 to the positive pole of a source of D. C. potential, the negative pole of which is connected by way of a source of A. C. potential 7 to the electrode 2.

The potentials are chosen in such a manner that the period of the alternating potential is large in comparison to the time of flight of an electron through the discharge space from one curved portion of the secondary emission electrodes **2** towards the opposite curved portion. The potential of the source **8** is larger than the amplitude of the A. C. potential so that the accelerating electrode **3** is always positive against electrode **2**. The anode **8** and the accelerating electrode are separately brought out of the tube. They have however the same D. C. potential. These two electrodes may be connected within the tube and in this case a larger output-current is obtained. The output-capacity is at the same time increased so that it may be preferable to use a separate output-connection.

In the operation of the tube the photo-electrons emitted by the upper left portion of electrode **2** are accelerated by the positive potential of electrode **3** in the direction of the lower left portion of electrode **2**. In consequence of the concave curvature of the photo-electrode the electrons are bundled so that they impact upon the opposite portion of electrode **2** at a relatively small area. The paths of the electrons in this first stage are indicated by arrows **14**. During the ascending portion of the alternating potential the electrode **2** becomes more positive during the transit-time of the photo-electrons, so that the electrons impact upon this electrode with a velocity sufficient to liberate a number of secondary electrons. This operation is repeated in the direction of the next curved portion of the oppositely arranged electrode and so on until the electrons are drawn away from the right upper element in the direction of the anode **8** having an area of 1 cm^2 or less. It is a special advantage of the arrangement that the electrons impact upon the electrodes under a small angle, so that a particularly large number of secondary electrons is emitted. It may be preferable to arrange the accelerating electrodes at a somewhat larger distance in front of the secondary emission electrode, so that the accelerating field is effective during a longer portion of the time of flight of the electrons. In the space between the grids **3** no acceleration takes place.

The arrangement of Fig. 1 can be replaced by an arrangement represented in Fig. 2. In this case the secondary emission electrode has the form of a screw-surface. The form of the electrode is produced by rotating and at the same time moving an elementary section of electrode **2** in axial direction. The accelerating grid **3** may be inserted into this chamber by screwing a preformed grid into the device and by fastening it in an appropriate manner. Also in this case the surface impacted by electrons may be curved concavely against the discharge space in order to produce a concentrating effect upon the electrodes.

As the electrode is nearly completely closed towards the outside, it may be preferable to employ the electrode as a portion of the wall of the high vacuum-tube. The tube is then a metal tube having substantially the form of Fig. 2 provided at the ends with insulating portions carrying the connecting leads and the window for the entrance of light.

The operation of the tube has been described in accordance with the method used in multipactors. It is however possible to operate the tube with an alternating potential the period of which is equal to the time of flight of an electron through the discharge space or to an integral fraction of this time. Fig. 3*a* shows in a diagram two portions of electrode **2** lying opposite to one another and designated with reference numerals **12** and **22**. These electrodes have the same potential. The accelerating grid is designated with **13** and **23**. Figs. 3*b* to 3*e* shows the potential of electrode **12** and **22** as a function of the location of an electron moving from electrode **12** to electrode **22**. While the electron travels from electrode **12** towards electrode **22**, the potential of these electrodes changes in accordance with the values represented in the curves. If now the tube is operated with a sinus potential the period of which is equal to the transit-time of the electrons, the electrons are accelerated between the electrodes **12** and **13**, if the point of zero-potential is taken as starting point. The section **10** only of the sinus potential is used, because after that time the electrons enter the space between grids **13** and **23** free from accelerating fields. Behind the screen **23** the second acceleration in the portion **11** takes place because in the meantime the alternating potential has reversed its direction and the potential of secondary emission electrode **22** is against on its ascending portion. This operation can be considered as a special case of the method of the long period.

The operation can be improved by employing in accordance with Fig. 3*c*, an A. C. potential having none-sinusoidal form in which the extreme values of the potential are situated more towards the beginning and the end of the period. This form is best represented by Fig. 3*d* in which two impulses of opposite direction are employed.

Another manner of operation is that with an alternating sinus potential of Fig. 3*e* in which the time of flight of the electrons is an integral multiple of the period of the alternating potential. From the foregoing description it can be seen that the positive half-wave at the beginning of the oscillation and the negative half-wave at the end of the train of oscillations is made use of while the intermediate half-waves are ineffective, because the electron starting with the beginning of the first half-wave is moving through the space between grids **13** and **23** during these intermediate half-waves. This is however only true for electrons beginning their flight at the beginning of the first period. It is however clear that after one full period the same conditions are present for new electrons so that now a new group of electrons is accelerated and enters the space between the grids. This is again repeated during the third half-period so that n groups of electrons are moving in the space between two electrodes **12** and **22**, if the period of the alternating potential is equal to $1/n$ of the time of flight. The efficiency of this device will therefore be high particularly if always one half-wave corresponds to the time of flight within the accelerating space. It is also possible to make the arrangement in such a manner that the time of flight between electrodes **12** and **13** is smaller or larger than a half-wave and that it corresponds for instance to a quarter-wave, in which case the portion of the time of flight corresponding to positive portions of the wave must be larger than the portion corresponding to negative half-waves, so that an acceleration is obtained.

FRIEDRICH MICHELS.
ROLF COLBERG.