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E. BRÜCHE ET AL

2,185,172

ELECTRON MULTIPLIER

Filed March 26, 1937

Fig. 1

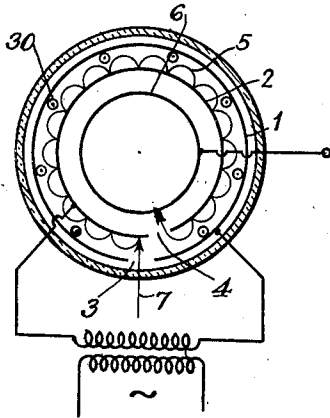


Fig. 2

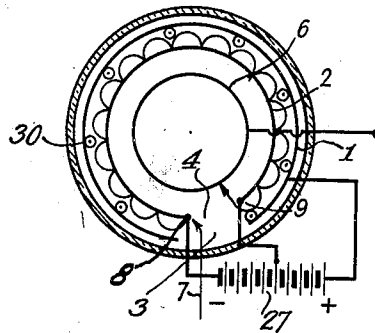


Fig. 4

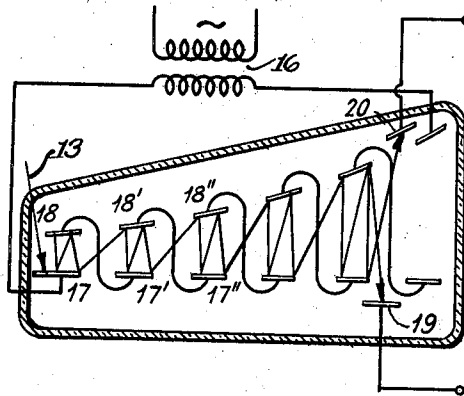


Fig. 3

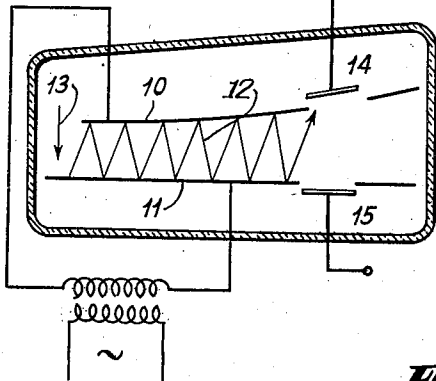
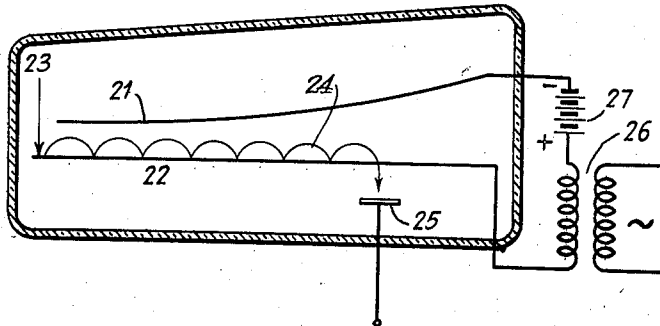


Fig. 5



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ELECTRON MULTIPLIER

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6 Claims. (Cl. 250—27)

It is known to multiply secondary electrons by providing between two plates an alternating voltage which transfers the electrons and their secondary electrons alternately from one plate to the other plate. There are, however, difficulties encountered as regards the removal of the electrons. If no separate means are provided for this purpose, the electrons are removed from the space between the plates only when the electronic space charge has become large enough, the electrons being then also removed from the multiplying process. Another possibility is to let the electrons fall upon plates arranged behind one another in one plane and being successively connected to a higher potential. A magnet-field arranged perpendicularly with respect to said plates prevents the electrons from falling upon the oppositely located anodes and serves at the same time to focus the electrons coming from any one of the said plates upon the next plate. Especially when multiplying in many steps an arrangement of the just mentioned kind presents the drawback that a slight change in the intensity of the magnet-field impairs the focussing upon the next plate whereby the amplifying factor is diminished in an undesired measure.

The drawbacks stated in the preceding paragraph are obviated in the present invention by providing a particular electrode arrangement not directly requisite for the liberation of the secondary electrons, but having the effect that the previously liberated electrons are directed upon a collector without any disturbing reactions upon the subsequently liberated electrons and without any straying.

The invention is illustrated diagrammatically and by way of example by the accompanying drawing wherein Figures 1 through 5 each shows several constructional forms of such arrangements and combinations of parts as constitute our invention.

Referring to Fig. 1, 1 and 2 denote two cylinders which are arranged concentrically with respect to one another and have recesses or apertures 3 and 4. Both cylinders are connected to an alternating voltage, and parallel to them is provided a magnet-field 30 produced, for instance, by a permanent magnet which may be located wholly or partly in the inner cylinder. Through the recess 3 a beam or ray of light 7 impinges upon the cylinder 2 which liberates on this cylinder photo-electrons which when the alternating voltage amplitude and the magnet-field are suitably chosen do not impinge upon the outer cylinder 1, but fall back upon the cylinder 2 where secondary

electrons are liberated by them. The magnet-field and the amplitude and the frequency of the alternating voltage are so chosen that the electrons liberated from the cylinder at the zero-phase of the voltage return after one period so that the action is repeated and the primary electrons, as well as the secondary ones, describe about such a path as is indicated by the line 5 until finally they fall through the recess 4 upon a collector 6.

As can be comprehended by theoretical considerations there take part in the multiplying action, with the arrangement in question, not only the electrons liberated in the zero-phase, but also the electrons liberated somewhat later. Therefore, the constancy of the magnet-field is, with the present invention, not of particular importance, the less, as there are no individual plates with spaces therebetween.

A modification of Fig. 1 is shown in Fig. 2 in which the cylinder 2 does not consist of metal, but of a semi-conductor. In this case the end 8 of the cylinder 2 upon which the light 7 impinges is connected up to the negative pole of a source 27 of continuous voltage. The outer cylinder 1 is connected to the positive terminal of said source of voltage, and the other end of the cylinder 2 is connected to about the middle portion of the said source. A magnet-field placed thereover makes the electrons describe paths similar to those shown in Fig. 1.

A particular advantage presented by the arrangements shown in Figs. 1 and 2 is that the collector 6 is protected from the action of the secondary electron cylinder 2, whereby the protective grids which may, perhaps, become necessary can nevertheless be dispensed with.

In another constructional form of the invention a continual transport of the electrons can be obtained without an additional field by a suitable arrangement of the electrodes. If, namely, the plates are arranged not parallel to one another, as is the usual arrangement, but obliquely with respect to one another, as in Fig. 3, then, if the thus arranged plates are connected to an alternating voltage, the force does not only exert its action from the one plate to the next, but simultaneously therewith from the end where the two plates are nearest to one another to the end where they are farthest remote from one another, in consequence whereof the electrons describe such a path as indicated by the line 12, if the time elapsed when the electrons pass from the one plate (10 or 11) to the other corresponds to the semi-period of the alternating voltage.

In Fig. 3, 13 denotes the incident light, and 14 and 15 are collector plates. The paths which the electrons must cover become continually longer, it is true, but as the arrangement is considerably insensible to mistunings, the position of the plates, the amplitude, and the frequency of the alternating voltage can be so adjusted that the electrons remain in phase during the entire length of their path and take part in the multiplying.

Another modification which renders multiplying possible in very many cases is illustrated in Fig. 4. The alternating voltage generated by a transformer 16 is subdivided by capacitive voltage subdivision, in that several pairs of plates 17 and 18 are connected in series with one another, the increase of the alternating voltage from one pair of plates to the next pair of plates, as brought about by the subdivision of the voltage compensates the increase of the distance between the plates in such a manner that the time of oscillation is equal to the transit time of the electrons in the pair of plates. Besides, the collector plates 19 and 20 are so arranged that their potential does not disturb the potential of the plates.

Finally, also such a constructional form as that shown in Fig. 5 is possible in which the two secondary emission plates are dispensed with. There are employed in this constructional form two plates 21 and 22, upon the one of which impinges a ray of light 23. The plate 21 is charged negatively, relatively to the plate 22, with a voltage which is smaller than the otherwise existing alternating voltage. In every period of the alternating voltage each of the electrons describes, when the voltages and the distances have been suitably chosen, a bow of the path 24. A collector 25 intercepts finally the electrons. The alternating voltage is generated by a transformer 26 and the continuous voltage is produced by a battery 27.

We claim:

1. An electronic amplifier tube comprising a pair of electrodes, said electrodes being oppositely arranged and at an acute angle with respect to each other, at least one of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for impressing an alternating current potential upon said electrodes to produce successive stages of electron multiplication, the angle of the electrodes with respect to each other causing a migration of the electrons in the direction of divergence of the electrodes, and a collector anode for receiving the secondary electrons.

2. An electronic amplifier tube comprising a pair of electrodes, said electrodes being oppositely arranged and at an acute angle with respect to each other, at least one of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for producing a magnetic field parallel to said electrodes, means for impressing an alternating current potential upon said electrodes to produce successive stages of electron multiplication, and a collector anode positioned adjacent one of the electrodes in the region of their point of greatest spacing for receiving the secondary electrons.

3. An electronic amplifier tube comprising a pair of rectangular electrodes, said electrodes being oppositely arranged and at least one of said electrodes being curved so that the distance between the electrodes increases in a predetermined manner, at least one of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for impressing an alternating current potential upon said electrodes to produce successive stages of electron multiplication, the angle of the electrodes with respect to each other resulting in a migration of the electrons in the direction of divergence of the electrodes, and a collector anode for receiving the secondary electrons.

4. An electronic amplifier tube comprising a pair of rectangular electrodes, said electrodes being oppositely arranged and at least one of said electrodes being curved so that the distance between the electrodes increases in a predetermined manner, at least one of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for producing a magnetic field parallel to said electrodes, means for impressing an alternating current potential upon said electrodes to produce successive stages of electron multiplication, and a collector anode positioned adjacent at least one of the electrodes in the region of their point of greatest spacing for receiving the secondary electrons.

5. An electronic amplifier tube comprising a pair of spaced apart sets of discrete electrodes, the electrodes of one set being paired with the electrodes of the other set, the electrodes of one set being supported at increasing distances from and at an acute angle to the corresponding electrodes of the other set, at least one set of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for producing an alternating electrostatic field between corresponding pairs of electrodes, to produce successive stages of electron multiplication, the angle of the electrodes with respect to each other causing a movement of the electrons in the direction of divergence of the electrodes, and a collector electrode for receiving the secondary electrons.

6. An electronic amplifier tube comprising a pair of spaced apart sets of discrete electrodes, the electrodes of one set being paired with the electrodes of the other set, the electrodes of one set being supported at increasing distances from and at an acute angle to the corresponding electrodes of the other set, at least one set of said electrodes being capable of producing secondary electrons upon electronic bombardment, a source of primary electrons, means for producing a magnetic field parallel to said electrodes, means for producing an alternating electrostatic field between corresponding pairs of electrodes, to produce successive stages of electron multiplication, and a collector electrode positioned adjacent the pair of electrodes having the greatest spacing for receiving the secondary electrons.

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