

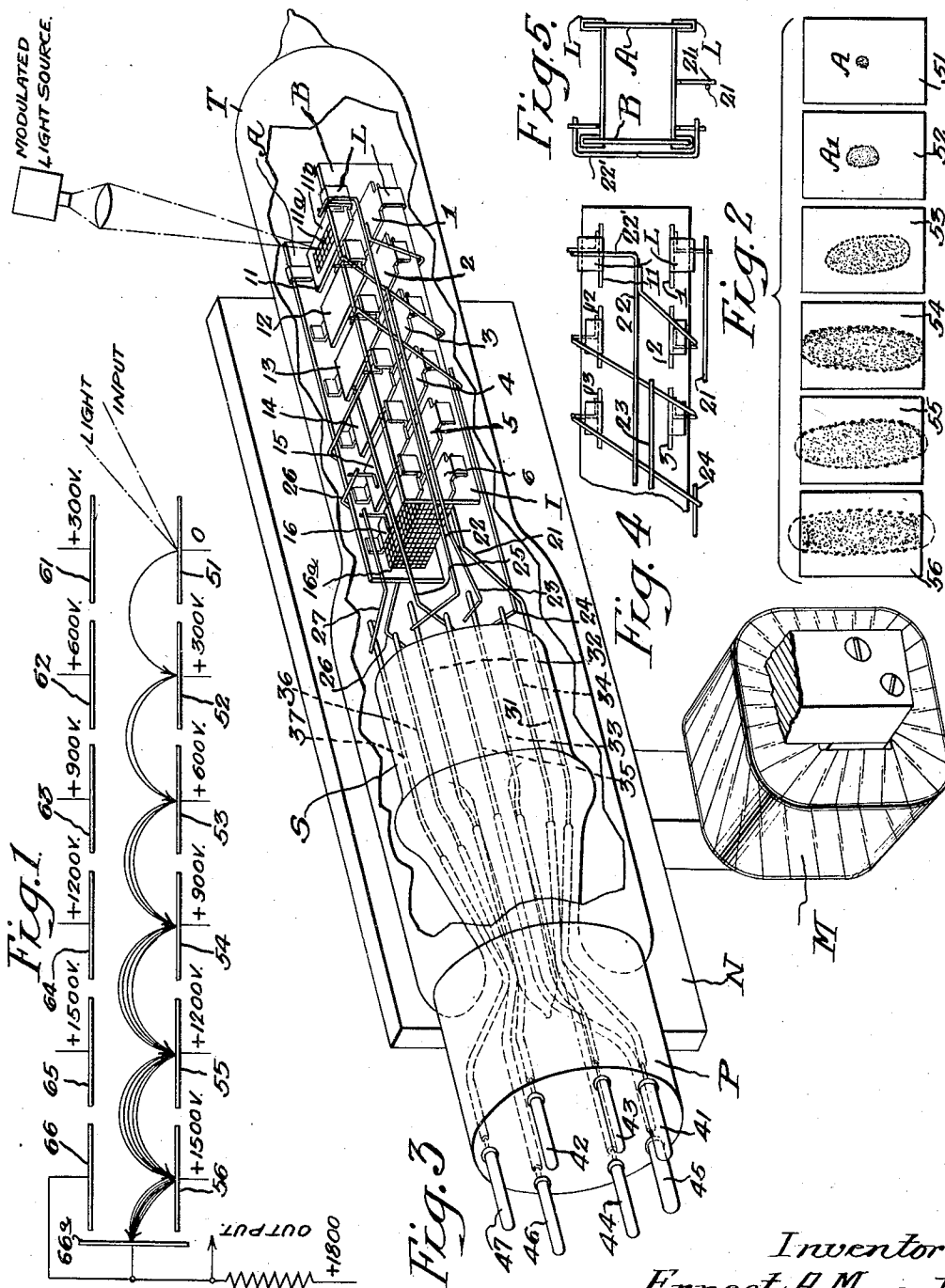
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ELECTRON MULTIPLIER

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ELECTRON MULTIPLIER

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4 Claims. (Cl. 250—27.5)

This invention relates to electric discharge devices, particularly electron multipliers, and has special reference to improvements in construction of multi-electrode tubes of the type disclosed in copending application Serial No. 4,049 to Louis Malter, filed January 30, 1935. Discharge devices of this type are adapted to be used as amplifiers, oscillators, modulators and frequency doublers. They are especially useful as direct current amplifiers, radio frequency power amplifiers and as self contained, photo-actuated amplifiers.

The novel features characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, will be best understood by reference to the accompanying drawing wherein:

Figure 1 is a diagrammatic representation of a multi-electrode photo-sensitive electron multiplier, one of several disclosed in the above-mentioned Malter application.

Fig. 2 is a plan view of the "lower" electrodes of Fig. 1 showing the tendency of the electrons to "spill-over" the edges of the surfaces of the multiplying electrodes, a condition which the present invention is designed to obviate.

Fig. 3 is a perspective view of a multi-electrode photo-sensitive electron multiplier showing a unitary electrode and insulating assembly within the tube, with a portion of the tube envelope and of the external magnet broken away to show the elements more clearly.

Fig. 4 is an enlarged side elevation of a portion of the electrode assembly of Fig. 3 showing in detail the combined potential distributing and electrode supporting leads.

Fig. 5 is an end elevation of Fig. 4.

If electrons moving with considerable velocity strike an electrode surface, secondary electrons are emitted. The number depending upon the velocity of impact, the nature of the surface material and the field available to draw the secondary electrons away, there may for instance, be ten times as many secondary electrons as primary ones. If the newly-liberated electrons are accelerated and thrown against another electrode the number may once more be increased by the same or similar factor, again and again until the gain is, in fact, enormous.

While a wide variety of arrangements of electrodes is possible the general arrangement illustrated in Fig. 1 and described in detail in the above mentioned pending case has so far proven the most successful. Light entering the device and striking a photo-sensitive electrode 51 re-

leases primary electrons which are drawn upward by the electrostatic field, provided by the upper or accelerating electrode 61 but are deflected by a constant magnetic field perpendicular to the plane of the paper. When the voltages and field are properly adjusted the adjacent plate 52 is struck in the center by the group or bundle of primary electrons. As indicated in both Figs. 1 and 2 the secondary electrons from the point of impact encounter electrical conditions substantially identical to those met by the original electrons. The secondary electrons, however, become increasingly more numerous and spread laterally over a greater area of the electrode surfaces 52—56. After several such steps the output is taken from the collector plate 56a at the opposite end of the tube.

As previously set forth the gain per stage depends upon several factors.

(1) Upon the material of which the electrodes are made. Farnsworth once said that he has gotten an increase of 10 times with a surface of caesium on oxidized nickel. Malter has obtained 8.5 with rubidium on oxidized silver, 7 is a good figure for caesium on oxidized silver.

(2) Upon the voltages applied to the accelerating and to the multiplying electrodes.

(3) The gain per stage also depends upon the ability to focus or otherwise confine all of the secondary electrons from one electrode to the next succeeding one. This factor is determined to a large extent upon the adjustment of the magnetic field; it has been observed, however, that, even with an optimum adjustment of the field, by the time the last plate has been reached the electrons are so numerous and so spread that many of them fail to strike it and are lost.

The present invention contemplates and its construction provides an electron-multiplier device wherein, by reason of a novel insulating means, the electrons are confined within a predetermined path or area circumscribed by the several electrode surfaces.

The invention further resides in the provision of an extremely rigid unitary assemblage of the several electrodes and the path defining insulating means whereby the efficiency of the device generally is increased and its manufacture is simplified.

Another and important feature of the invention is the provision of an electrode assembly, including a translucent accelerating electrode designed, positioned and arranged to ensure optimum performance of electron multipliers of the photo-sensitive type.

Referring now to Fig. 3 of the drawing: The improved electrode assembly of the invention may conveniently be contained in an elongated evacuated tube T having a preferably annular or cylindrical stem S around and through which the stem wires 31—37 are sealed. It is to the internally projecting terminals of the stem wires that the electrode leads 21—27 are respectively joined, as by welding. The stem wires are shown as terminating externally in the prongs 41—47 of a seven plug socket P of conventional design.

In the particular embodiment illustrated there are twelve electrodes; six accelerating or "upper" electrodes and six "lower" electrodes, five of which are multiplying electrodes and the other (the outermost) the primary electron emitter. The set of accelerating electrodes, numbered 11—16, are arranged in spaced relation in a single plane. The electrodes 1—6 of the lower set are paired with those of the upper set, i. e., they are similarly arranged in a second, parallel plane. The upper electrode 16 (nearest the stem S) is the anode or output electrode, it has an extension 16a, which may conveniently be of wire cloth, bent downwardly towards but not touching the innermost lower electrode 6. This extension 16a to the plate 16 is designed to intercept electrons which, if it were not present, might pass through the open end of the assembly without being utilized. This bi-part electrode 16, 16a is connected to a single lead wire 27.

In accordance with the earlier Malter disclosure and as indicated in Fig. 1 of the instant case each of the lower electrodes, with the exception of the primary emitter 1 may be operated at a potential corresponding to that of the next preceding upper electrode. When so operated each electrode lead, with the exception of lead 27 to the anode 16 and lead 21 to the primary emitter 1 supplies the operating voltages for two electrodes. Thus lead 22 supplies electrodes 2 and 11; lead 23, electrodes 3 and 12; lead 24, electrodes 4 and 13; lead 25, electrodes 5 and 14; and lead 26, electrodes 6 and 15. As shown in detail in Figs. 4 and 5 the connections between electrodes of similar potential and their common lead may conveniently be made by short terminal rods 21', 22', etc., anchored, as by welding to the back or outer surface of each electrode.

The electron-confining and electrode-supporting assembly comprises a pair of outwardly extending, oppositely located, parallel arranged strips A—B of mica or other insulating material. These insulating strips are preferably prefabricated and suitably orificed to accommodate the oppositely located bent-over lugs L of the several electrodes. Increased rigidity may be ensured by bending these lugs L over the edges of the insulating strips as indicated in Fig. 5. As clearly shown in Fig. 5 the insulating strips, together with the respective upper and lower sets of electrodes form a conduit for the electrons constituted by a series of box-like containers. The electron confining effect of this conduit is due not alone to the mechanical presence of the insulating side strips A—B but may be accounted for in part at least by the fact that the inner walls become negatively charged during operation of the device and, being so charged, serve to exert an electrically repellent or space charge effect upon the electrons, directing them inwardly away from the side walls and towards the center of the electrodes.

A photo-sensitive surface permits of a more compact and small electrode assembly than that

practical with the usual thermionic type primary emitter though either may be employed depending to some extent upon the use to which the tube is to be put. One drawback encountered in the operation of photo-sensitive electron multipliers is the difficulty in focusing light from the external modulated light source upon the photo-sensitive surface. Up to now it has been common practice to direct the light rays at an acute angle towards the tube so that they will not be blocked by the accelerating electrode. (See Fig. 1). In so doing, however, the beam will usually fall upon the glass at such an angle as to diffuse it so that the rays will impinge upon the photo-sensitive surface with an intensity less than may be desired—inhibiting optimum performance of the device.

The above and other disadvantages inherent in existing photo-tubes are obviated, in accordance with the present invention, by the provision of a translucent accelerating electrode 11, Fig. 3. Since this electrode 11 is electrically charged, it is preferably made of metal, suitably orificed as at 11a to permit passage of the light rays. To ensure the desired rigidity and potential distribution its foraminous surface is provided with a surrounding frame work 11b. With such a construction the light rays may now obviously be so directed as to fall directly and at a desired angle upon the photo-sensitive primary electron emitter 1.

In operation a single magnetic field is preferably employed for concentrating and directing all of the electron streams to the proper target or multiplying electrodes 2—6, whereby the major portion of each secondary electron stream is utilized and the primary electrons are prevented from being drawn past the targets to impinge directly upon the output electrode. Any convenient means may be utilized for establishing a magnetic field parallel to the electrode surfaces, such for example, as the device partially shown in perspective in Fig. 3. Preferably this device is constituted by a U-shape element of magnetically permeable material on which is mounted an energizing coil M and to each upstanding portion of which is affixed a plate N also of permeable material. The tube T is disposed between these plates in such position that a substantially uniform magnetic field is set up parallel to the opposed surfaces of the sets of electrodes. Obviously, a permanent magnet may be substituted for the electro-magnet shown, or the tube may be disposed within a coil of wire carrying an electric current.

The single embodiment of the invention which has been illustrated for purposes of explaining the inventive concept is susceptible of various modifications which will be apparent to others skilled in the art.

What is claimed is:—

1. An electron multiplier device comprising a sealed container, a plurality of separate electrodes mounted within said container and spaced from the walls thereof, said electrodes having surfaces adapted to liberate electrons by secondary emission, and insulating means for confining said electrons within a predetermined path defined by the boundaries of said surfaces, said insulating means constituting a support for said electrodes.

2. A multi-electrode electron multiplier device comprising an elongated container, a pair of insulating strips mounted in parallel relation on opposite sides of the long axis of said container,

a plurality of sets of electrodes supported by said insulating strips, the electrodes of each set being spaced from each other to form a conduit for electrons from all said electrodes, the side walls
5 of said conduit being constituted by the inner surfaces of said insulating strips and said electrodes.

3. The invention as set forth in claim 2 and wherein an electron collecting electrode is provided, said electrode being supported by said insulating strips substantially completely closing a
10 terminal of said conduit.

4. A multi-electrode electron multiplier device

comprising an elongated container, a pair of insulating strips mounted in parallel relation on opposite sides of the long axis of said container, a plurality of sets of electrodes supported by said insulating strips, the electrodes of one set being
5 paired with the electrodes of another set, one electrode of one pair being electrically connected to another electrode of another pair, and a plurality of current carrying support wires for said electrode assembly.

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10