United States Patent

[11] 3,621,320

[72] Inventor **Haruo Maeda**
Osaka, Japan
[21] Appl. No. **828,277**
[22] Filed **May 27, 1969**
[45] Patented **Nov. 16, 1971**
[73] Assignee **Matsushita Electric Industrial Co. Ltd.**
Osaka, Japan
[32] Priority **May 31, 1968**
[33] **Japan**
[31] **43/37665**

[54] **SECONDARY ELECTRON MULTIPLIER CONSISTING OF SINGLE SAWTOOTH MULTIPLYING SURFACE**
5 claims, 4 Drawing Figs.

[52] **U.S. Cl.** **313/105,** 328/243
[51] **Int. Cl.** **H01j 43/04,** H01j 43/18, H01j 43/20
[50] **Field of Search** 313/103, 104, 105

[56] **References Cited**

UNITED STATES PATENTS

3,197,662	7/1965	Schneeberger	313/104
3,244,922	4/1966	Wolfgang	313/103 X
3,349,273	10/1967	Gregg	313/105 X

Primary Examiner—Robert Segal
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: A secondary electron multiplier comprising a supporting plate having two kinds of inclined surfaces, one of which has a coating of low-resistance material and on which coating a secondary emissive layer is formed, the other of which has a coating of high-resistance material, the low-resistance and high-resistance coatings forming a series circuit across which a voltage source is connected so that a repeller electric field which serves to accelerate secondary electrons is built up around the surfaces of said secondary emissive layers.

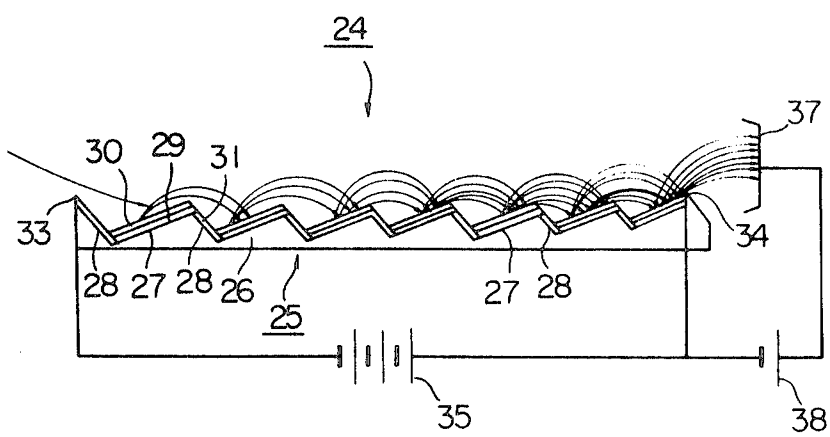


Fig. 1

PRIOR ART

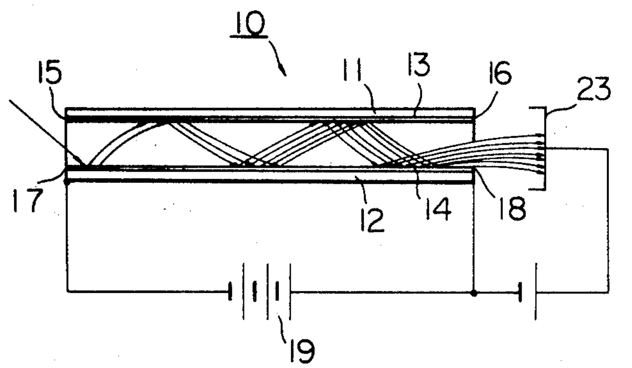
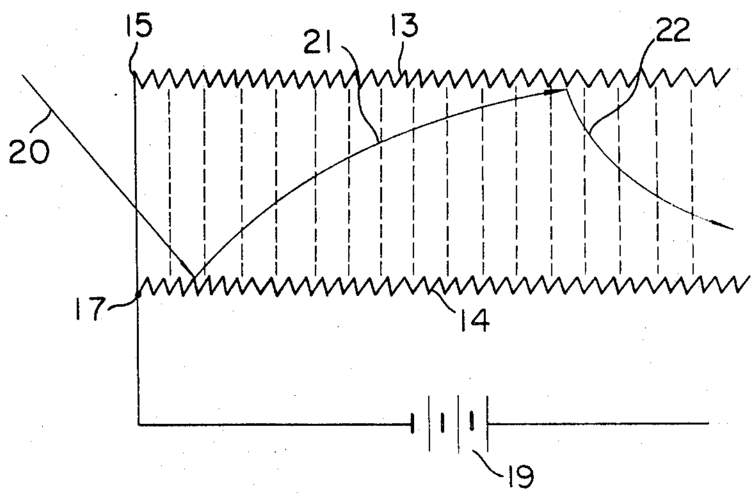


Fig. 2



HARUO MAEDA

INVENTOR

BY STEVENS, DAVIS, MILLER & MOSHER

ATTORNEYS

Fig. 3

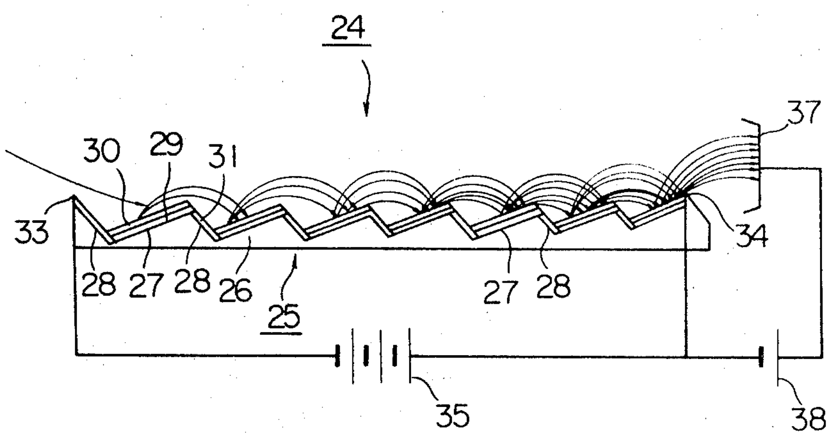
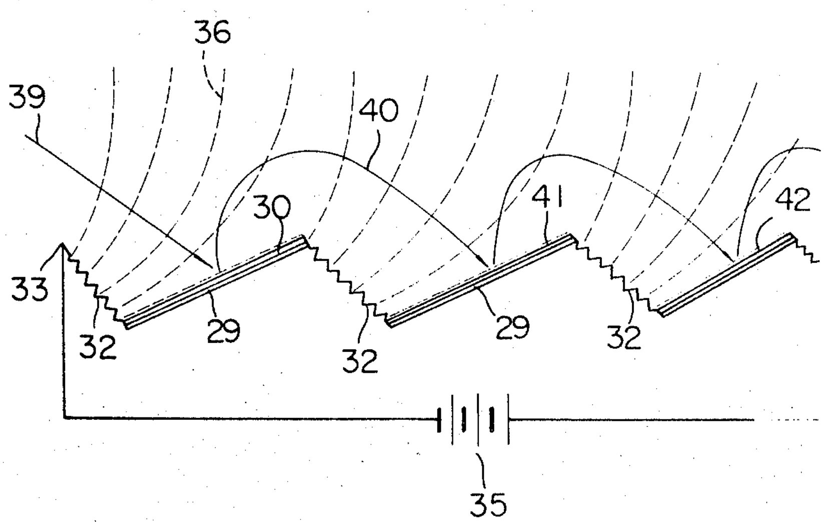

24
37
30
29
31
33
34
28
27
28
26
27
28
25
35
38

Fig. 4


36
39
40
30
41
42
33
32
29
32
29
32
35

SECONDARY ELECTRON MULTIPLIER CONSISTING OF SINGLE SAWTOOTH MULTIPLYING SURFACE

This invention relates to improvements in channel-type secondary electron multiplier.

It is an object of this invention to provide an improved secondary electron multiplier having an increased multiplication factor.

It is another object of this invention to provide an improved secondary electron multiplier having a supporting plate which has two kinds of inclined surfaces, one for depositing thereon a secondary emissive material and the other for depositing a highly resistive material.

These and other objects will be effected by this invention as will be apparent from the following description taken in accordance with the accompanying drawings, throughout which like references indicate like parts in which:

FIG. 1 is a schematic view of a conventional secondary electron multiplier of channel type.

FIG. 2 is an explanatory view of the electrons emitted in the secondary electron multiplier of FIG. 1.

FIG. 3 is a schematic view of a secondary electron multiplier of this invention.

FIG. 4 is an explanatory view of the electrons emitted in the secondary electron multiplier of FIG. 3.

Referring to FIG. 1, a conventional channel-type secondary electron multiplier **10** generally comprises parallel disposed plates **11** and **12** which are coated on their interior surfaces with secondary emissive material to form secondary emissive layers **13** and **14**, respectively. These layers **13** and **14** have external terminals **15**, **16**, **17** and **18** at their ends, of which the terminals **15** and **17** are connected to the negative terminal of a voltage source **19** and the terminals **16** and **18** to the positive terminal of the voltage source **19**. Thus, equipotential planes are built up normal to the secondary emissive layers **13** and **14**, as indicated by the dotted lines of FIG. **2**. Normal to these equipotential planes an electric field is established between the plates **11** and **12**, which electric field serves to accelerate secondary electrons emitted from the secondary emissive layers **13** and **14** in the axial direction. The operation of the secondary electron multiplier is as follows: primary electrons **20** (FIG. **2**) supplied from a source of primary electrons (not shown) are caused to impinge on the secondary emissive layer **14** near the external terminal **17**, releasing a greater number of secondary electrons than that of the incident primary electrons. The released electrons trace parabolic trajectories, as generally indicated at **21**, under the influence of the axial electric field, impinging on the surface of opposite secondary emissive layer **13**. Upon impingement of the secondary electrons on the secondary emissive layer **13**, a greater number of another secondary electrons than that of the secondary electrons are liberated from the layer **13**, tracing similar parabolic trajectories **22** to strike on the secondary emissive layer **14**. This process repeats until multiplied secondary electrons are captured by a collector electrode **23** positioned in the neighborhood of the output end of the secondary electron multiplier **10**. In the secondary electron multiplier of this type, the frequency at which electrons are caused to impinge on the secondary emissive layers **13** and **14** and accordingly the factor by which electrons are multiplied is proportional to the length of the secondary emissive layers **13** and **14** and is inversely proportional to the gap therebetween. Thus, in order to have available an increased multiplication factor, it is necessary that the secondary emissive layers **13** and **14** be rendered longer and the gap therebetween smaller. Furthermore, equipotential planes normal to the electric field established between the two secondary emissive layers **13** and **14** should be uniformly normal to the secondary emissive layers. However, the increase in the length of the secondary emissive layers would only impair the compactness of the secondary electron multiplier.

Such a difficulty is eliminated in the secondary electron multiplier of this invention. Referring in detail to FIG. 3, a secondary electron multiplier **24** of the invention largely comprises a secondary electron emitting plate **25**. The secondary electron emitting plate **25** comprises a supporting member **26** of generally sawtooth section having two kinds of inclined surfaces **27** and **28**. The supporting member **26** has on each of the long inclined surfaces **27** a coating **29** of low-resistance material such as metal, and on the surface of the coating **29** there is formed a secondary emissive layer **30**. The secondary emissive layer **30** may be of any suitable material such as magnesium oxide or potassium chloride which has a high ratio of secondary emission and a high resistance. The supporting member **26** may be made of glass or ceramic. On each of the short inclined surfaces **28** of the supporting member **26** of a coating **31** of highly resistive material is deposited. And these low-resistive coatings **29** and high-resistance coatings **31** are electrically connected in series with each other.

In FIG. 4, the resistances **32** represent resistances given by the highly resistive layer **31**.

External terminals **33** and **34** are connected to the series-connected low-resistance and high-resistance coatings **29** and **31** at the opposite ends thereof for applying thereto an accelerating voltage. A voltage source **35** is connected across the external terminals **33** and **34**. Since each of the secondary emissive layers **30** forms a substantially equipotential plane due to the presence of the low-resistance coatings **29** underlying the secondary emissive layers **30**, equipotential planes are built up as indicated by the dotted lines **36** (FIG. 4).

An electrode **37** for collecting multiplied secondary electrons is positioned near the output end of the secondary electron emitting plate **25**. Between the electrode **37** and the external terminal **34** is connected a voltage source **38** for maintaining the electrode **37** at a positive potential with respect to the external terminal **34**, so that the secondary electrons leaving the secondary electron emitting plate **25** may be substantially totally captured by the electrode **37**.

In the operation of the electron and multiplier shown in FIG. 3, electrons **39** from a source of primary electrons (not shown) are caused to impinge upon the secondary emissive layer **30** nearest to the external terminal **33** by suitable means, releasing a greater number of secondary electrons than that of the incident primary electrons **39**. These emitted secondary electrons trace parabolic trajectories as generally indicated at **40** under the influence of the electric field normal to the equipotential planes **36** and impinge upon the following secondary emissive layer **41**, liberating other secondary electrons which are then caused to impinge upon the next secondary emissive layer **42**. This process repeats until the secondary emissive layer nearest to the external terminal **34** is excited by the secondary electrons emitted from the preceding secondary emissive layer to release secondary electrons which are captured by a collector electrode **37**.

In this embodiment, it is important that the secondary electron emitting plate **25** be of such a configuration as to give the highest possible ratio of secondary emission. It should be noted that a higher multiplication factor than those obtained with the conventional channel-type electron multiplier can be attained since, as best understood from the inspection of the equipotential planes **36** near the secondary emissive layers **30**, **41** and **42**, the layers face the incident electrons approximately normally thereto.

The layers **29**, **30** and **31** can be applied to the supporting member **26** firstly by evaporating a low-resistance material such as metal and secondly by a secondary emissive material on each of the long inclined surfaces **27** from one side. A highly resistive material is then applied to each of the short inclined surfaces **28** from the other side.

What is claimed is:

1. An electron multiplier consisting of a single sawtooth multiplying surface comprising:
   - a. a source of primary electrons;
   - b. an insulating supporting plate having first and second kinds of inclined flat surfaces alternately and regularly positioned along its length, said plate having an upper surface portion shaped in a sawtooth form;
   - c. a low-resistance material coating on said first kind of inclined surface;

d. a secondary emissive layer on and in electrical contact with said low-resistance material coating;

e. a high-resistance material coating on said second kind of inclined surface, said low-resistance and high-resistance coating being connected to each other forming a series circuit to yield secondary electron multiplication, the inclined surfaces for depositing said secondary emissive layer being longer than the inclined surfaces for depositing said high-resistance coating;

f. a voltage source connected across said series circuit to establish electron-accelerating electric fields around the surfaces of said secondary emissive layers, the secondary electrons emitted from the respective emissive surfaces due to incoming primary electrons accelerating toward and impinging upon the following emissive surfaces at a high potential; and

g. a collector electrode kept at a positive potential with respect to said secondary emissive layers.

2. An electron multiplier as set forth in claim 1, in which said secondary emissive layer is composed of magnesium oxide.

3. An electron multiplier as set forth in claim 1, in which said secondary emissive layer is composed of potassium chloride.

4. An electron multiplier as set forth in claim 1, in which said supporting plate is composed of glass.

5. An electron multiplier as set forth in claim 1, in which said supporting plate is composed of ceramic.