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[54] **ELECTRON MULTIPLIER FORMED BY TWISTING FINGERS IN PARALLEL PLATES**

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[52] **U.S. Cl.** **313/95,** 313/105

[51] **Int. Cl.** **H01j 43/20,** H01j 39/04

[58] **Field of Search** 313/105, 104, 95; 313/103

[56] **References Cited**

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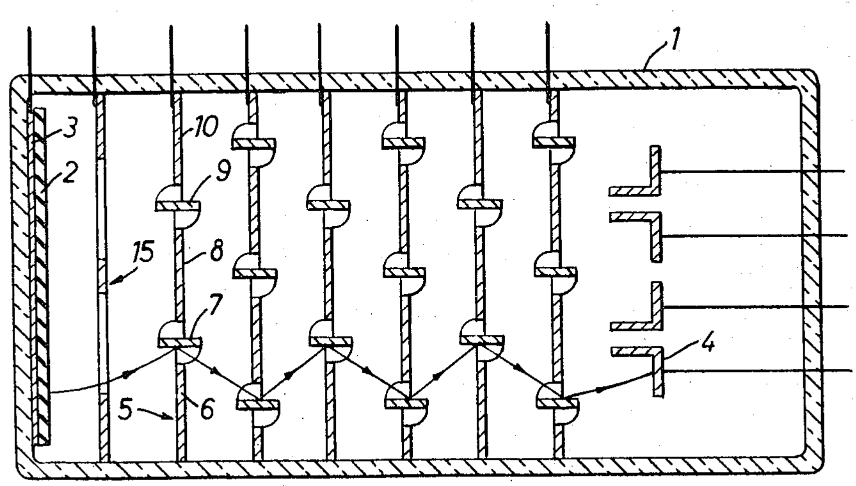
[57] **ABSTRACT**

A multichannel electron multiplier has a plurality of multiplying stages. Each stage is formed from a flat plate of secondary electron emissive material slit into a plurality of fingers. Alternate fingers are twisted out of the plane of the plate at right angles thereto. The twisted fingers in successive stages are staggered to provide a plurality of zigzag electron multiplying channels. The source of electrons to be multiplied in a photo-electron emissive cathode and light is focused or collimated onto the photocathode at positions corresponding to the multiplying channels. In a second embodiment, the faceplate of a multiplier tube is a fibre optics plate and light is directed onto it by fibre optics light guides to positions corresponding to the multiplying channels. A focusing electrode is disposed between the photocathode and the first multiplying stage and serves to focus electrons onto the twisted fingers. The non-twisted fingers also help to focus electrons onto the twisted fingers in successive multiplying stages along the multiplying channels.

5 Claims, 3 Drawing Figures



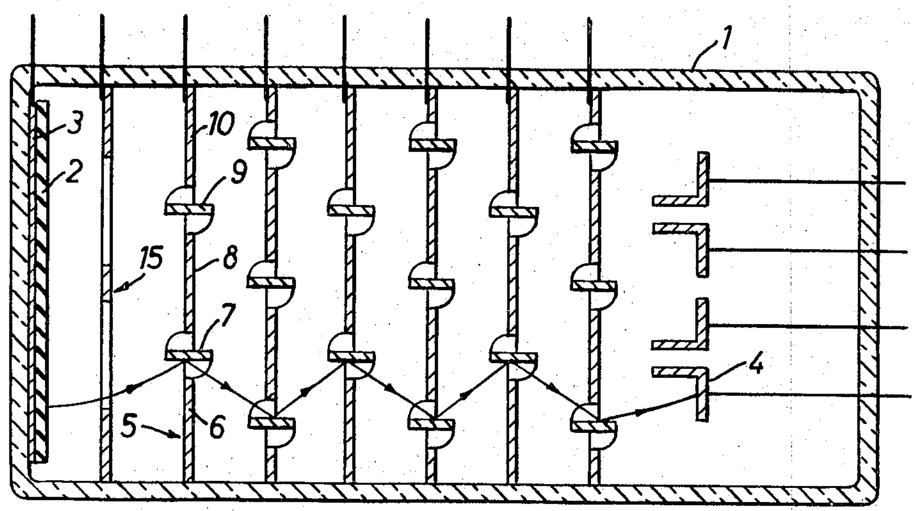


FIG.1

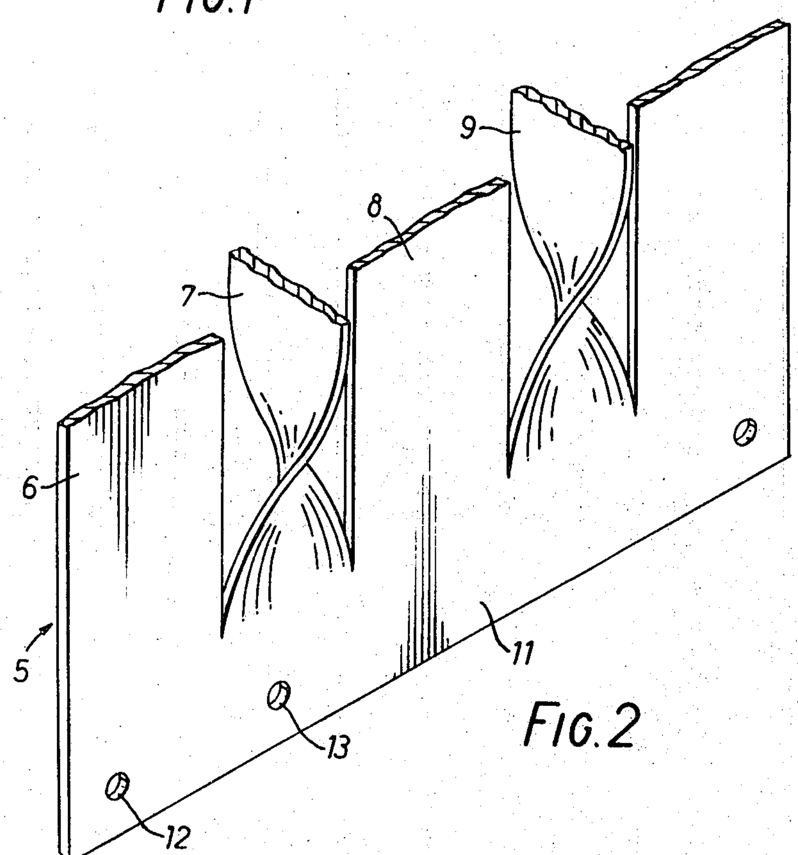


FIG.2

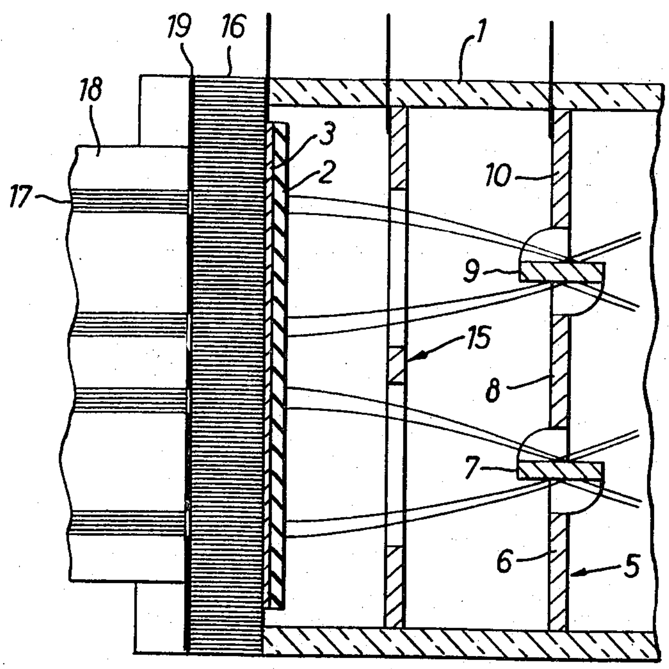


FIG. 3

ELECTRON MULTIPLIER FORMED BY TWISTING FINGERS IN PARALLEL PLATES

The present invention relates to electron multiplying arrangements, and it relates especially to such arrangements as may be utilised in multi-channel electron multiplier tubes.

The majority of multi-channel electron multipliers known to the applicants employ continuous dynodes, rather than the more complicated discrete dynodes found in single-channel electron multipliers, in the interest of conservation of space. Electron multipliers incorporating continuous dynodes exhibit various disadvantages in dependence upon their design. Such tubes may exhibit, for example, non-linearity, long transit time, transit time spread, low output or low efficiency.

It is an object of the present invention to provide a multi-channel electron multiplier in which the above disadvantages are substantially reduced or eliminated.

According to the invention there is provided an electron multiplier having a plurality of electron multiplying stages comprising a plurality of parallel plates slit to form parallel fingers of which alternate fingers are twisted out of the plane of the plates perpendicular thereto, the twisted fingers in successive plates being staggered to form separate zigzag electron multiplying channels.

In order that the invention may be clearly understood and readily carried into effect, one embodiment thereof will now be described (by way of example only) with reference to the accompanying drawings of which:

FIG. 1 represents a longitudinal, sectional view of a photomultiplier tube in accordance with one example of the invention,

FIG. 2 shows, on an enlarged scale, part of one of the transverse plate members, and

FIG. 3 represents a longitudinal sectional view of part of a second example of an electron multiplier in accordance with the invention.

Referring now to FIG. 1, there is represented a photomultiplier tube in accordance with one example of the invention. The tube comprises a tubular envelope 1 provided in known manner with a photocathode 2 on a substantially transparent electrode 3 at one end thereof. The photocathode 2 emits electrons in response to light falling thereon and so constitutes a source of electrons. In the specific tube shown in FIG. 1, there are four channels and six stages of multiplication (or gain as it is commonly called). A respective electron collecting electrode (such as 4) is provided to collect the electrons emerging from each of the four channels. The channels and the stages of gain are constituted by means of six similar members such as 5 disposed transversely to the axis of the tube and spaced apart along said axis. The members such as 5 are formed from plates of electrically conductive, secondary electron emissive material, and all the members are mutually electrically insulated. A member 5 is shown on an enlarged scale in FIG. 2, and it can be seen that said member is formed in a one-piece construction, from a sheet of suitable material such as beryllium copper or silver-magnesium alloys. The sheet is slit parallel to one of its edges to define a plurality of finger portions 6, 7, 8, 9 and 10 which are interconnected by a common lower web 11. A common upper web (not shown) interconnects the upper ends of the finger portions. Alternate ones of the finger portions, 7 and 9 in this example, are twisted as shown so as to be orientated at right angles to the other finger portions. Thus when the member 5 is in position in the envelope 1, as shown in FIG. 1, the twisted portions such as 7 and 9 lie substantially parallel to the longitudinal axis of the envelope and they are arranged to constitute the first multiplication stages of each of the four channels.

The other transverse members are similarly formed, but when positioned in the envelope 1, alternate members are staggered as shown in FIG. 1. The lower web 11 is formed with holes as indicated at 12, 13 and 14 in FIG. 2, through which longitudinal extensive, electrically insulating support/spacer pillars (not shown) can be inserted. The pillars are inserted through the holes in the webs of all six transverse members and are suitably secured to the envelope at either end so as to provide location and support for said members. The upper web (not shown) is also formed with holes through which similar pillars can be inserted.

It will be appreciated from the foregoing that a discrete dynode system of simple design is employed. Moreover, the secondary electrons are focussed at each stage, the total transit time exhibited is small and transit time spread is reduced compared with the spread exhibited by multi-channel photomultipliers incorporating a continuous dynode structure.

The electron focussing is so arranged that electrons strike all secondary emissive surfaces at large angles of incidence, thus ensuring optimum gain. Moreover, the focussing electrodes are designed so that light and ion feedback to the cathode is negligible.

It will be observed that in the example shown in FIG. 1, each of the transverse members such as 5 includes five finger portions. In such circumstances, the six members can conveniently be formed from a single sheet of suitable material which is first slit as described earlier to provide thirty similar finger portions supported between upper and lower webs. The slit sheet is then processed so that alternate finger portions are twisted at right angles to the plane of the sheet and so that holes are formed in the upper and lower webs opposite the first, fifth, sixth, tenth, eleventh etc., finger portions to provide for the insertion of supporting and locating pillars. The sheet, after such treatment, is then cut through the upper and lower webs at the outside edge of every fifth finger portion so that banks of five finger portions are cut off. Consecutive banks of five then have, automatically, the correct form with respect to one another, to constitute adjacent transverse members of the photomultiplier. The above technique is suitable for any case in which an odd number of finger portions are required for each transverse member.

As shown in FIG. 1, a first focussing electrode 15 is provided between the photocathode 2 and the first transverse member 5. The focussing electrode 15 can conveniently be formed in a one-piece construction, with thin finger portions extending between upper and lower webs and the regions between said portions being stamped or cut out. Typical voltages to be applied in operation of such a photomultiplier are:- OV to the photocathode, 5 to 15V to the first focussing electrode 15, and 100V, 200V, 300V, 400V, 500V, and 600V, respectively to the six transverse plate members, the voltages applied to said members increasing with distance from the photocathode 2.

Typical dimensions for the widths of finger portions such as 7 and 8 are 2.2mm and 1.8mm respectively.

In operation of the above described multiplier, light is collimated or focussed onto the photocathode **2** at positions corresponding to the four channels. In the example shown in FIG. **3**, the window or faceplate comprises a fibre optic block **16** formed in known manner. Light is conducted to the photocathode **2** by means of bundles, such as **17**, of fibre optics elements from light generated by a source such as an X-ray machine. The bundles **17** are carried by suitable support means **18** and an apertured mask **19** is interposed between the faceplate **16** and the support means **18**. The apertures in the mask correspond to the multiplying channels. The multiplier operates as previously described.

Although the embodiments described above relate to photomultipliers, the device may be used for multiplying electrons generated by sources other than photoemitters.

What we claim is:

1. An electron multiplier having a hermetically sealed envelope, a plurality of secondary electron emissive multiplying electrodes in said envelope, said electrodes comprising a plurality of parallel conductive plates arranged one behind the other and slit to form fingers in the planes of said plates with alternate fingers being twisted out of the planes of the plates perpendicular thereto, the twisted fingers in successive plates being staggered to form separate zigzag electron multiplying channels.

2. An electron multiplier according to claim **1** including a photocathode as a source of electrons to be multiplied.

3. An electron multiplier according to claim **1** including focussing means disposed between a source of electrons and a first of said plates to direct electrons into respective channels.

4. An electron multiplier according to claim **1** in which the envelope of the multiplier is provided with a fibre optics faceplate.

5. An electron multiplier according to claim **1**, including collecting electrodes for collecting electrons having traversed said multiplying channels.

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