United States Patent [19]

Ibaugh

[11] **3,849,644**

[45] **Nov. 19, 1974**

[54] **ELECTRON DISCHARGE DEVICE HAVING ELLIPSOID-SHAPED ELECTRODE SURFACES**

[75] Inventor: **James Louis Ibaugh,** Landisville, Pa.

[73] Assignee: **RCA Corporation,** New York, N.Y.

[22] Filed: **Mar. 28, 1973**

[21] Appl. No.: **345,666**

[52] **U.S. Cl.** **250/207,** 313/105

[51] **Int. Cl.** **H01j 39/12**

[58] **Field of Search** 250/207; 313/103, 104, 313/105, 56

[56] **References Cited**

UNITED STATES PATENTS

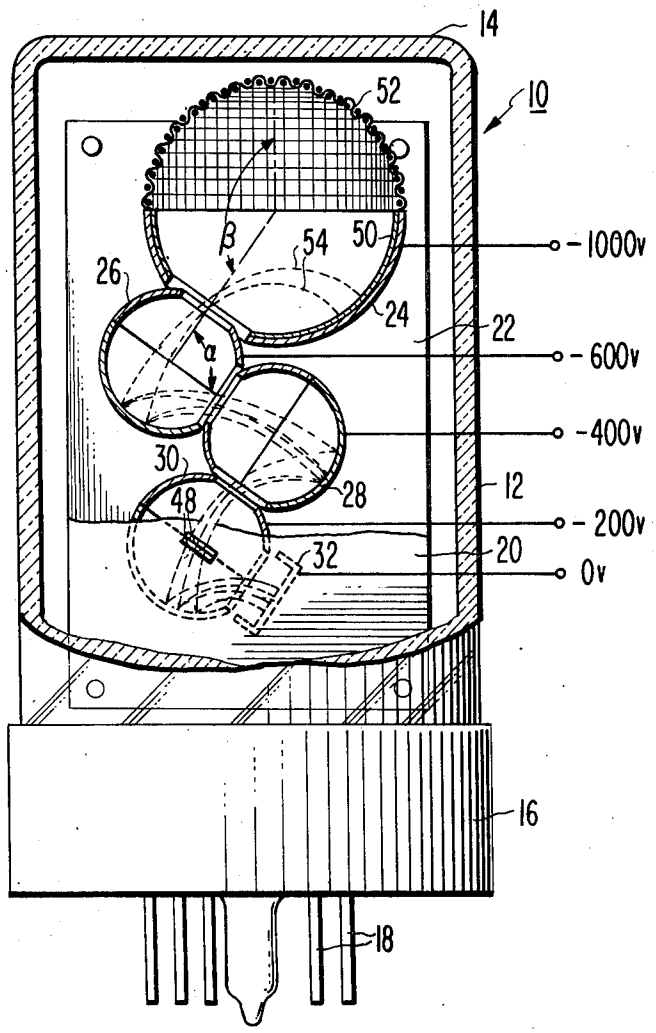
2,176,221	10/1939	McGee	313/105
2,204,479	6/1940	Farnsworth	313/105
2,245,614	6/1941	Shockley	313/105
3,183,390	5/1965	Grader	250/207
3,349,273	10/1967	Gregg	250/207
3,684,910	8/1972	Stutzman	313/105

Primary Examiner—James W. Lawrence
Assistant Examiner—D. C. Nelms
Attorney, Agent, or Firm—Gleen H. Bruestle; Robert J. Boivin

[57] **ABSTRACT**

An electron discharge device with a series of electrodes, one or more having an interior ellipsoid-shaped cavity wall surface, a portion of which is formed of, or coated with, electron emissive material. Electron communication from or to a preceding or succeeding electrode, respectively, is provided through an input aperture and an output aperture, respectively, in each of the interior ellipsoid-shaped cavity wall surfaces. Various means of accelerating electrons, emitted from each ellipsoid shaped cavity wall surface, through the output aperture thereon, to the succeeding electrode are provided.

14 Claims, 2 Drawing Figures



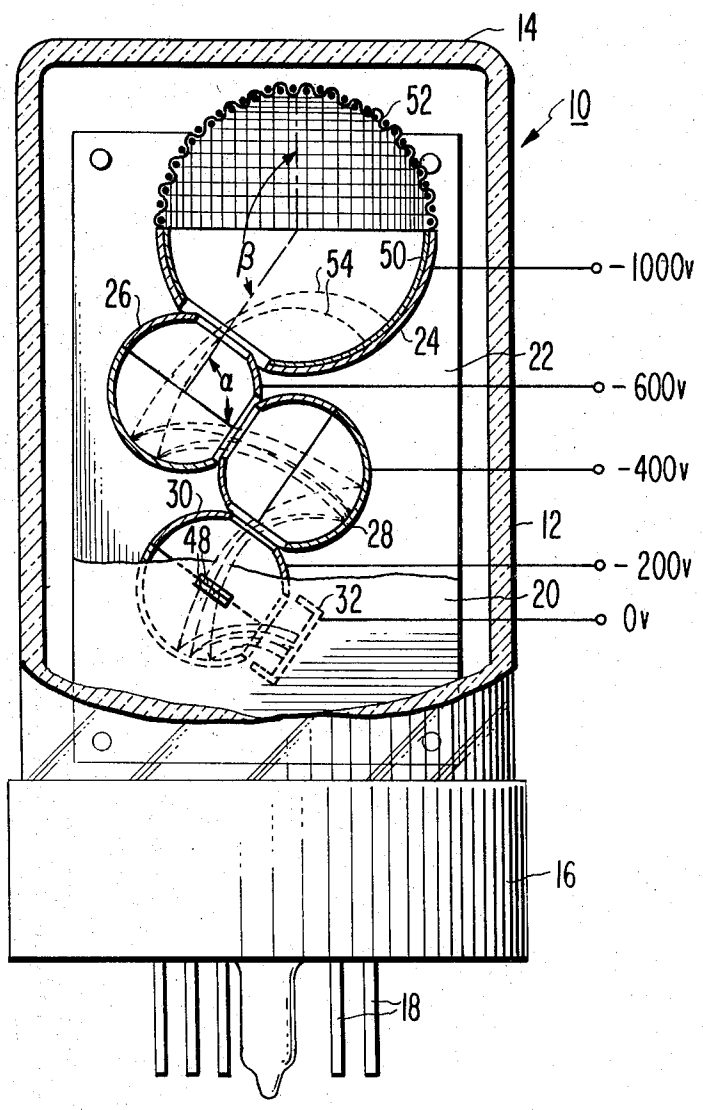

14
10
52
β
54
50
-1000v
26
24
22
α
-600v
-400v
30
28
12
48
-200v
32
20
0v
16
18

FIG. 1

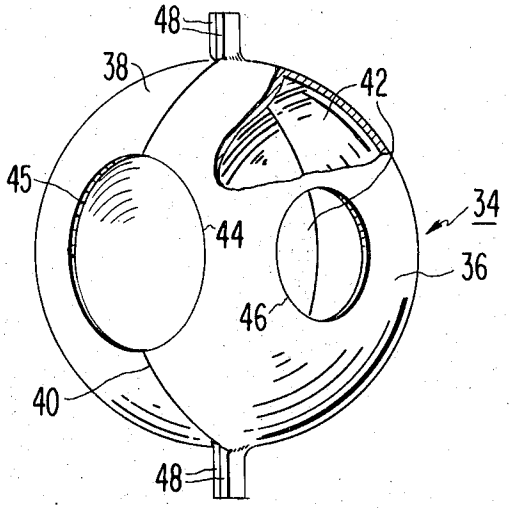

48
38
42
45
34
44
36
46
40
48

FIG. 2

ELECTRON DISCHARGE DEVICE HAVING ELLIPSOID-SHAPED ELECTRODE SURFACES

BACKGROUND OF THE INVENTION

The present invention relates to electron discharge devices and more particularly to electron multipliers, and photomultiplier tubes.

Electron multipliers are used, for instance, as internal amplifiers in camera tubes and photomultiplier tubes. An electron multiplier is a device utilizing secondary electron emission to amplify or multiply electron current from an electron source, such as the photocathode of a photomultiplier or a thermionic cathode. The usual electron multiplier comprises a staggered series, or chain, of secondary emitting dynodes, interposed between an electron source and an output collector of multiplied electrons. The dynodes are formed of or coated with secondary emissive material and impressed with progressively increasing potentials.

Electrons emitted from the electron source are directed upon the first dynode, releasing therefrom several secondary electrons for each impinging electron. These emitted electrons are thereupon accelerated onto the secondary emissive surface of the next dynode, whereupon each produces more secondary electrons. This process is repeated at each succeeding dynode or "stage" of the multiplier. Thus, electrons entering the low potential input end of the electron multiplier chain are successively multiplied by secondary emission at each dynode along the dynode chain. An electric field accelerates the secondary electrons from one dynode to the next successive dynode. The electrons from the last dynode are collected by an anode or collector of electrons.

Electron multipliers are particularly useful for amplifying electron current produced by weak signals, such as light, nuclear radiation, or radiation in the electromagnetic spectrum. Photomultipliers are particularly useful for converting weak light signals into electron currents which are thereafter amplified by an electron multiplier within the photomultiplier. However, electron multipliers and photomultipliers have generally been limited in their ability to amplify only the information-significant component of their input. These limitations are caused by certain occurrances within the electron multiplier itself, resulting, for example, from poor collection efficiency at various stages of the device, and from sources of noise that are not associated directly with the process of conversion of the input signal or its subsequent electron multiplication. For example, in photomultipliers, electron interstage skipping may produce undesirable fractional-photoelectron pulses in the output. Poor collection efficiency at the first electrode of a photomultiplier or of an electron multiplier may destroy the information-significant component of the input signal. Also, sources of extraneous light within electron multipliers, such as, for example, electrode glow, electroluminescence, and ionization of residual gases have been found to limit the application of photomultipliers for applications requiring the detection of weak signals, as described in H. R. Krall, "Extraneous Light Emission From Photomultipliers," IEEE Transactions on Nuclear Science, February, 1967. Generally, it has been found that such extraneous light sources result in "dark current noise" because of the generation of undesired electron or electrical currents

within the tube which reach the anode. For example, extraneous light sources in the electron multiplier portion of a photomultiplier have been found to be coupled or "piped" back to the electron source or photocathode, thereby producing an undesirable after-pulse in the output signal current.

One approach to reducing electron interstage skipping or the effects of extraneous light has been to utilize a box-and-grid dynode structure as described, for example, in U.S. Pat. No. 2,245,614, issued to W. Shockley on June 17, 1941 (U.S. Cl. 250-175).

This approach and others seeking to accomplish a similar result have been found inadequate, as further described in the above-referred to article by H. R. Krall, or subject to further deficiencies, such as, for example: increased complexity of manufacture; increased cost of manufacture; possibility of interstage electron skipping; or increased subjectivity to environmental stresses, such as, vibration or shock.

SUMMARY OF THE INVENTION

The novel electron discharge device comprises a series of electrodes, at least one of which has an interior ellipsoid-shaped cavity wall surface, formed of, or coated with, an electron emissive material. Electron communication from or to a preceding or succeeding electrode, respectively, is provided through an input aperture and an output aperture, respectively, in each of the ellipsoid-shaped cavity wall surfaces. Electron multiplication occurs at each succeeding electron emissive surface in chain-like fashion Electrons, emitted from a preceding electron emissive surface, are accelerated through the input aperture of the ellipsoid-shaped cavity wall surface with trajectories impinging upon that dynode's electron emissive surface. Various means of accelerating electrons, emitted from each ellipsoid-shaped cavity wall surface, through the output aperture thereon, to the succeeding electron emissive surface are provided.

By providing electrodes having interior ellipsoid-shaped electron emissive cavity wall surfaces, collection efficiency at those stages is improved. The effects of undesirable noise sources are minimized and the ability of the electron discharge device to detect weak input signals is thereby improved. The manufacture of dynodes is made easier and less costly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a photomultiplier tube utilizing electrodes in accordance with the invention; and

FIG. **2** is an enlarged, perspective view of a composite electrode illustrating the common structure of the electrodes of the tube in FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the novel tube is a photomultiplier tube **10,** shown in FIG. **1** of the drawings. Referring now to FIG. **1,** the tube **10** has an elongated evacuated envelope **12** with a transparent faceplate **14** at one end and a stem portion **16** having a number of electrical lead pins **18** at the other end. Two ceramic insulating spacers **20** and **22,** mounted internally of the tube **10,** rigidly mount a staggered series of electrodes: photocathode **24,** dynodes **26, 28,** and **30.** Similarly, a collector of electrons or anode **32** is rigidly mounted between the two ceramic insulating spacers **20** and **22**

at the terminal end of the staggered dynode series or electron multiplier chain. Lead pins **18** are electrically connected to electrodes **24, 26, 28, 30** and anode **32** internal of the tube **10** (connections not shown) to provide for the impression of potentials required for the proper operation of the photomultiplier depicted in FIG. **1.**

A common structure for the electrodes **24, 26, 28,** and **30** is shown in greater detail in FIG. **2.** Referring now to FIG. **2,** the composite electrode **34** is spherically shaped and is composed of two mating submembers **36** and **38,** each having partial internally disposed spherically shaped surfaces, joined together at their peripheral mating surfaces **40** to describe a single cavity within its interior substantially surrounded and enclosed by a spherically shaped wall surface **42** of the composite electrode **34.** Each submember **36** and **38** includes an annular cut-out region **44** and **45** which together join to define an output aperture on the composite electrode **34.** Submember **36** additionally includes an annular cut-out region **46** which defines an output aperture on the composite electrode **34.**

Submembers **36** and **38** also matingly join to define external mating tabular extensions **48** which join to provide a means of rigidly mounting the composite electrode **34** between ceramic insulating spacers.

In the preferred embodiment, as shown in FIG. **1,** electrodes **24, 26, 28** and **30** are composed in similar manner; as herein described for the composite electrode **34** and as depicted in FIG. **2;** each having analogous parts and descriptions, with minor variations as hereinafter described. Thus, for example, electrodes **24, 26, 28** and **30** each have mating tabular extensions **48** which rigidly mount each electrode between ceramic insulating spacers **20** and **22,** in a staggered series, as shown in FIG. **1,** such that the focal points of the interior spherically shaped surfaces which substantially surround each electrode cavity, of these electrodes lie on a single plane corresponding to the cross-sectional plane of FIG. **1.**

Referring now to FIG. **1,** electrodes **26, 28,** and **30,** together defining the electron multiplier chain of tube **10,** each comprise a pair of hemispherical mating submembers analogous to submembers **36** and **38** of the composite electrode **34,** depicted in FIG. **2,** which may be easily formed of certain extrudable materials, such as, for example, materials having a copper berylium, nickel, or molybdenum composition. In the preferred embodiment, electrodes **26, 28,** and **30** are formed of a copper berylium material, of .005 to .010 inch thickness, the oxidized form of which has secondary emissive characteristics, thereby directy forming an interior cavity wall having a spherically shaped electron emissive surface, analogous to the spherically-shaped surface **42,** depicted in FIG. **2.**

Similarly, electrode **24,** comprising the photocathode or source of electrons in the photomultiplier, shown in FIG. **1,** defines a pair of hemispherical mating submembers analogous to submembers **36** and **38** of the composite electrode **34,** depicted in FIG. **2,** which may be easily formed of certain extrudable materials such as, for example, materials having a nickel, silver, or molybdenum composition. In the preferred embodiment, electrode **24** is formed of a nickel material having a thickness of 0.10 inch. In an analogous manner to that previously shown for composite electrode **34** depicted in FIG. **2,** an interior cavity wall having a spherically shaped surface is formed internal of electrode **24.** On the spherically-shaped surface, a photoemissive surface **50,** along its inner periphery, is provided for emitting electrons in response to light directed to impinge upon its surface. The photoemissive surface may be formed of any of the known photoemissive materials, such as, for example: manganese-antimony-oxygen-cesium, or a multialkali photoemissive film.

Referring to FIG. **1,** electrodes **24, 26, 28,** and **30** are physically arranged intimately adjacent in a staggered but insulated series whereby the focal points of successive pairs of spherically-shaped cavity wall surfaces along the electron multiplier chain may be visualized to lie on two separate parallel planes perpendicular to insulating spacers **20** and **22.** Electrodes **26, 28,** and **30** each have a 1 inch diameter spherically shaped electron emissive surface, an annular input aperture having a .4 inch diameter, and an annular output aperture having a .50 inch diameter. Electrode **24** is formed to have a 2.0 inch diameter spherically-shaped surface, an annular input aperture having a 2.0 inch diameter, for permitting light to impinge upon its photoemissive surface **50,** and an annular output aperture having a .65 inch diameter. Electrode **24** additionally includes a light permeable electrostatic grid or wire mesh **52** disposed across its input aperture which is in electrical contact with the electrode **24** so as to comprise a relatively complete hemispherically-shaped electrostatic surface over that input aperture, thereby preventing the escape of photoelectrons from that electrode through its input aperture. Electrodes **24, 26, 28** and **30** are arranged such that a preceding electrode's output aperture is aligned with the input aperture of the next succeeding electrode along the electron multiplier chain to provide a means of electron communication between successive electron emissive surfaces. In the preferred embodiment, the respective input or output apertures of each of the electrodes **26, 28,** and **30** are angularly staggered relative to each other so that the respective focal points of each aperture (located along the cross-sectional plane depicted in FIG. **1**), describes a 90° angle α as viewed from the focal point of each respective internally disposed spherically-shaped surface of each electrode, as shown in FIG. **1** at electrode **26.** In a similar manner, the focal points of the input and output aperture of electrode **24** describe a 135° angle β when viewed from the focal point of that electrode's internally disposed spherically-shaped surface.

In operation of tube **10,** light is focused through the input aperture of electrode **24** and its associated light permeable electrostatic grid **52** so as to impinge upon the spherically-shaped photoemissive surface **50.** Upon striking the photoemissive surface **50,** photoelectrons are emitted which tend to travel or migrate toward the focal point of the spherically shaped photoemissive surface. An electric accelerating field, which is created by the dimensionally smaller opening which forms the input aperture of electrode **26,** as compared with the adjacently aligned output aperture of electrode **24,** extends into the interior cavity of the preceding electrode **24** and accelerates emitted electrons through both the output aperture of electrode **24** and the adjacently aligned, but dimensionally smaller, input aperture of electrode **26.** Referring to FIG. **1,** a portion of the electrode surrounding the input aperture of electrode **26** "internests" within the larger output aperture of electrode **24,** is intimately adjacent thereto, and is insulated

therefrom. The photoelectrons are thereafter accelerated by the field of the spherically shaped surface of electrode **26,** to impinge upon that electrode's interior cavity wall surface, formed of, or coated with electron emissive material. Upon striking the spherically shaped electron emissive surface of electrode **26,** secondary electrons are emitted which are similarly accelerated, by means of an electric accelerating field created by the dimensionally smaller and internesting input aperture of electrode **28,** through the output aperture of electrode **26** and the adjacently aligned, but dimensionally smaller, input aperture of electrode **28,** so as to impinge upon the spherically shaped interior cavity wall surface, formed of, or coated with electron emissive material within electrode **28.** There, they are again multiplied and accelerated through the output aperture of electrode **28** and the adjacently aligned, but dimensionally smaller, internesting input aperture of electrode **30,** and so on, generally along the trajectories shown by the dashed lines **54,** until they are finally collected by anode **32.** Typical voltages maintained on the various components of the tube **10** for operation are shown in FIG. **1.**

The novel electron discharge device has an improved performance due to high electron transmission through successively aligned output and input apertures of the electrodes of the device. The improved electron transmission is accomplished by the use of adjacently aligned, enclosed, ellipsoid-shaped electrode cavity wall surfaces, whereby electron trajectories within the device are particularly restricted from impinging upon undesirable regions of the device. The transmission between successive electron emissive surfaces of the device is nearly 100 per cent, a substantial improvement in transmission over that obtained by conventional electron multiplier structures. Also, because of the staggered arrangement of the respective input and output apertures of successive electrodes of the device, and because of the enclosed nature of the electrode surfaces themselves, feedback of extraneous light or residual gas ions to preceding electron emissive surfaces is greatly reduced and, consequently, a significant reduction in "dark current noise" is accomplished.

The assembled electron discharge device is particularly rugged. Also, because individual electrode submembers may be manufactured with a minimum of extrusion, the electrodes of the novel tube are considerably less costly to manufacture than prior electron discharge structures.

GENERAL CONSIDERATIONS

The term "electrode" is intended to refer to either the source of electrons or one of the dynodes succeeding that source of electrons. The electrodes are arranged in a staggered series having a succesion of electrodes disposed between the input end of the tube and the anode, such that intermediate electrodes have the requisite electron communciation to a preceding or a succeeding electrode or both.

While the electrodes of the preferred embodiment dislcose an interior spherically-shaped cavity wall surface having an electron emissive peripheral portion thereon, the invention is intended to encompass other electrode structures having interior ellipsoid-shaped cavity wall surfaces, including aspherical surfaces accomplishing a similar result, whereby electrons are similarly directed from an enclosed electrode surface to a central region internal of that electrode. The electron optics within the structure of the preferred embodiment is greatly simplified by the use of interior spherically shaped cavity wall surfaces; however, the inventive concept could be applied to other interior ellipsoid-shaped cavity wall surfaces, or aspherical variations thereof, by persons skilled in the art. Also, not all the periphery of the cavity wall surfaces need be electron emissive. Only the portion of that peripheral surface upon which a required number of electrons impinge is required to be electron emissive.

In general, the size, shape, and arrangement of individual electrodes or their mating submembers may be varied substantially without significantly affecting the operation of the disclosed device. Likewise, while individual electrodes are most advantageously located intimately adjacent but in electrical isolation from a preceding or succeeding electrode, or both, the separation may be increased, so long as the requisite collection efficiency between electrodes is accomplished.

In the preferred embodiment, the input and output apertures, which provide a means of electron communication between successive electrodes, are annular in shape; however, the size, shape, placement, and relative angular displacement α or β of each individual aperture i.e., the degree which they are angularly "staggered" may be varied substantially so long as the collection efficiency and the consequent "dark current noise" associated with the tube's operation is adequate for the application. For example, the intermediate region between the input and output apertures, located on the periphery of each electrode, might be removed thereby creating a single aperture having a similar function to that accomplished by the respective input and output apertures herein described.

While the electrodes depicted in FIG. **1** have been positioned so as to have a common central plane intersecting the focal points of all interior cavity wall surfaces and their respective input or output aperture focal points, three-dimensional modifications may be incorporated whereby electrodes are helically arranged in a staggered series or other three-dimensional arrangement without deviating from the inventive concept described herein. Thus, for example, an electrode similar to electrode **24,** depicted in FIG. **1,** might be centrally located within an electrode arrangement of another embodiment, such that a series of electrodes are disposed in a chain-like fashion around its periphery, along a first plane (corresponding to the cross-sectional plane depicted in FIG. **1**). In this additional embodiment, the focal point of the annular input aperture of the central electrode could be relocated on the central electrode and displaced relative to the first plane to permit either light or electrons to be directed perpendicular (or at an angle) to that first plane so as to impinge upon the central electrode's interior ellipsoid-shaped cavity wall surface. An appropriate means of collecting multiplied electrons would, of course, be disposed proximate to the output aperture of the final electrode of the electron multiplier chain similar to anode **32,** depicted in FIG. **1.** Such an embodiment would have the additional benefit of being more compact as to vertical height than conventional electron multiplier structures.

The means for accelerating emitted electrons out of, between, or into, successive electrodes may comprise various structures or combination of structures, such

as, for example: a wire grid, wire mesh, electrostatic post, or a dimensionally smaller input aperture extending over or internesting with, the output aperture of a preceding electrode, such as disclosed in the preferred embodiment. By providing an electron permeable mesh (not shown) over the successive input apertures of the electron multiplier chain depicted in FIG. 1, greater penetration of a preceding electrode's interior ellipsoid-shaped cavity area by the accelerating field created by the succeeding electrode might be accomplished thereby improving electron acceleration to the succeeding electrode or anode. The means of accelerating electrons may be in electrical contact with or electrically isolated from individual electrodes along the electron multiplier chain.

In the manufacture of electrodes, a material having poor electron emissive characteristics may be utilized to form any of the interior spherically shaped cavity wall surfaces, such as, for example, nickel material, and later sensitized to be an acceptable electron emitter by depositing materials which react with or coat that internal surface to be either an accpetable photoemitter or secondary emitter. Similarly, a material such as ceramic which is not an acceptable electron emissive material for such applications, and yet easily molded to provide the required ellipsoid-shaped cavity wall surfaces for individual or several electrodes simultaneously, may be utilized as a substrate upon which the requisite electron emissive surfaces are deposited.

What is claimed is:

1. An electron discharge device comprising:

a. a staggered series of electrically disconnected electrodes, each of said electrodes including:

i. a cavity within its interior substantially surrounded and enclosed by an ellipsoid-shaped electrode wall surface with an electron emissive peripheral portion thereon,

ii. an input aperture through which an input energy source may be focused to impinge upon the electron emissive peripheral portion of said ellipsoid-shaped electrode wall surface,

iii. an output aperture through which electrons emitted from said electron emissive peripheral portion may be accelerated for egression out of said electrode, said input and output apertures being arranged in staggered angular relation to each other, and

b. means for restrictingly accelerating electrons emitted from immediately preceeding electrodes to succeeding electrodes of said series, in sequence, said means comprising an electron permeable electrostatic electron accelerating member internesting within the output aperture of an immediately preceeding electrode and positioned intimately adjacent thereto.

2. An electron discharge device as recited in claim **1**, wherein said ellipsoid-shaped electrode wall surface comprises:

a spherically shaped electrode wall surface.

3. An electron multiplier of the type having at least one dynode stage for multiplying electrons, and an anode for collecting multiplied electrons,

the improvement therein comprising that said dynode stage comprises:

a. a dynode electrode having:

i. a cavity within its interior substantially surrounded and enclosed by a spherically shaped electrode wall surface with an electron emissive peripheral portion thereon,

ii. an input aperture in said dynode through which electrons may be accelerated to impinge upon said electron emissive peripheral portion thereby causing the emission of electrons therefrom,

iii. an output aperture in said dynode through which electrons emitted from said electron emissive peripheral portion may be accelerated for egression out of said dynode, said input and output apertures being arranged in staggered angular relation to each other, and

b. means for accelerating emitted electrons to a succeeding electrode along the electron multiplier chain, disposed adjacent said output aperture.

4. An electron multiplier as recited in claim **3**, wherein said dynode electrode further comprises:

a plurality of mating submembers with partial aligned cavities together defining said interior cavity.

5. An electron multiplier as recited in claim **4**, wherein at least one of said mating submembers additionally comprises:

a means for mounting said dynode internal of said electron multiplier.

6. An electron multiplier as recited in claim **3**, wherein:

said spherically shaped electrode wall surface has a copper-berylium composition, and

said electron emissive peripheral portion comprises an oxidized form of copper-berylium.

7. An electron multiplier as recited in claim **3**, including a plurality of dynode stages, wherein the means for accelerating emitted electrons in sequence between succeeding dynode electrodes along the electron multiplier chain comprises:

the input aperture of a succeeding dynode electrode having a dimensionally smaller opening than the output aperture of the preceeding dynode electrode, and wherein said apertures are adjacently aligned to permit electron acceleration therethrough.

8. An electron multiplier as recited in claim **3**, wherein said means for accelerating emitted electrons comprises:

an electron permeable grid.

9. An electron tube comprising an electron multiplier of the type having a plurality of electrodes including a source of electrons, a collector of multiplied electrons, and a staggered series of electrically disconnected dynodes, for successively multiplying electrons, disposed intermediate said source of electrons and said collector of electrons,

the improvement therein comprising:

a. at least one of said dynodes having:

1. a cavity within its interior substantially surrounded and enclosed by an ellipsoid-shaped electrode wall surface;

2. an electron emissive surface on a portion of said ellipsoid-shaped electrode wall surface,

b. a restricted means of successive electron communication in sequence between: said source of electrons, successive ones of said electron emissive surfaces of said dynodes, and said collector of electrons.

10. A tube defined in claim **9**, wherein said ellipsoid-shaped electrode wall surface comprises:

a spherically shaped surface.

11. A tube defined in claim 9, wherein said restricted means of successive electron communciation comprises:

a. an output aperture in each of said dynodes through which electrons may be accelerated for egression out of said dynode, and

b. an input aperture in each of said dynodes, at least one of said input apertures having a dimensionally smaller opening than the output aperture of the preceding electrode and positioned in aligned internesting relation thereto whereby electrons may be accelerated through said input aperture, from a preceeding electron emissive surface, to impinge upon its electron emissive surface, said input and output apertures being arranged in staggered angular relation to each other.

12. A tube defined in claim 9, wherein said restricted means of electron communication comprises:

a. an output aperture in each of said dynodes through which electrons may be accelerated for egression out of said dynode,

b. an input aperture in each of said dynodes through which electrons may be accelerated, from a preceding electron emissive surface, to impinge upon its electron emissive surface, said input and output apertures being arranged in staggered angular relation to each other, and

c. an electron permeable grid disposed adjaent said input aperture.

13. A tube defined in claim 9, wherein each of said dynodes further comprises:

a plurality of mating submembers with aligned partial cavities together defining said interior cavity.

14. A photomultiplier tube of the type having a source of photoelectrons; a collector of multiplied electrons; and a staggered series of electrically disconnected dynodes, for successively multiplying electrons, disposed intermediate said source of photoelectrons and said collector of electrons,

the improvement therein comprising:

a. said source of photoelectrons having:

1. a cavity within its interior substantially surrounded and enclosed by a spherically shaped electrode wall surface,

2. a photoemissive surface on a portion of said spherically shaped electrode wall surface,

3. an input aperture in said spherically shaped electrode wall surface thereby light may be directed upon said photoemissive surface on a portion of said internally disposed spherically shaped surface,

b. a restricted means of communicating said photoelectrons to a succeeding dynode comprising:

1. an angularly staggered output aperture, relative to said input aperture, in said spherically shaped electrode wall surface through which electrons may be accelerated for egression out of said source of electrons, and

2. a light permeable electrostatic grid disposed adjacent and across said input aperture, whereby photoelectrons, are restricted in their egression out through said input aperture.

* * * * *