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RUGGEDIZED PHOTODIODE TUBE WITH SEMICYLINDRICAL CATHODE AND ANODE OF ELONGATED CROSS-SECTION

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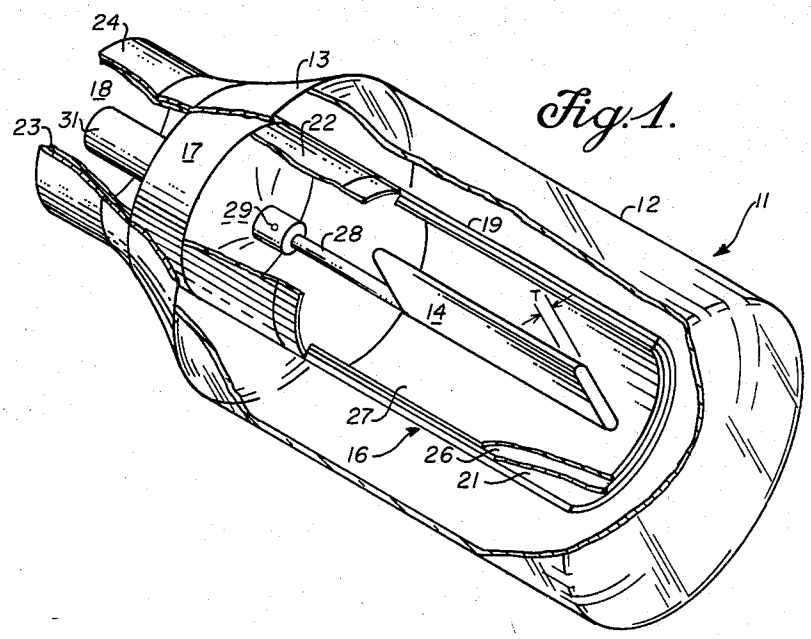
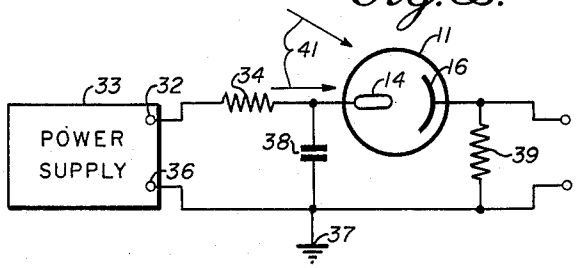


Fig. 1.

Fig. 2.



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RUGGEDIZED PHOTODIODE TUBE WITH SEMI-CYLINDRICAL CATHODE AND ANODE OF ELONGATED CROSS-SECTION

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5 Claims. (Cl. 313—94)

The present invention relates in general to phototubes and, more particularly, to a ruggedly constructed coaxial photodiode tube having an improved anode-cathode arrangement.

The demands of many of today's scientific programs necessitate the use of instrumentation and their associated electronic components that must meet stringent requirements. Thus, it has come to be that photodiode tubes as known in the art are inadequate for purposes of optimum flexibility and performance.

Photo diode tubes generally employ anodes of cylindrical geometry. However, because of the geometry of the anode, the spiral effect, common in these tubes, results in a difference in transit time required by the emitted electrons to go from the cathode to the anode. As the electrons are emitted by the cathode, the path lengths vary because some of the electrons miss the anode initially and spiral around the anode a number of times before reaching it. This difference in transit time results in the production of a signal that is spread in time over a longer duration than the duration of incidence of the original electromagnetic radiation on the photosensitive cathode surface. Transit-time spread imposes a limitation on the response of photodiode tubes.

Also, under high-peak current operating conditions, that is, when a great many electrons are emitted by the cathode, the transit-time spread adversely affects the response of photodiode tubes, to a greater degree than in the case of lower peak current, operating conditions. This is because many more electrons are freed from the cathode resulting in many more electrons spiraling around the anode before being collected.

Most prior-art photodiode tubes employ wire-supported mounts in sustaining the anode and cathode elements. This has resulted in tubes whose anode and cathode elements become misaligned when exposed to hard mechanical use. Since the operating characteristics depend upon the alignment of the elements, it is disadvantageous to have a change in alignment.

To reduce the current leakage between the anode and cathode elements to a minimum, the elements are terminated at opposite ends of the photodiode tube's envelope. Tubes constructed in this manner have a characteristic impedance of an order of magnitude of 10^6 ohms.

The present invention provides an apparatus which overcomes the limitations of prior art photodiode tubes. More particularly, the present invention is a ruggedly constructed photodiode tube which includes a cathode element adapted to emit electrons when subjected to electromagnetic raditaion. Of primary importance to the ends of the invention, the photodiode further includes an anode of elongated cross section rigidly held in spatial opposition to the cathode element, and positioned in a manner to effect the least possible amount of interference with the radiation incident upon the cathode surface.

The anode and cathode elements are terminated coaxially.

It is, therefore, an object of this invention to provide a photodiode which has improved transient response characteristics.

Further, it is an object of this invention to provide a photodiode with improved resolving time.

Another object of this invention is to provide a mechanically rugged photodiode of coaxial configuration.

Yet another object of this invention is to provide a photodiode with a relatively low characteristic impedance which can be accurately controlled during construction.

Still another object of this invention is to provide a photodiode that has the capability of handling large output currents.

The manner of achieving these and other objects and advantages will be more apparent to those skilled in the art from the following detailed description of a preferred embodiment of the invention taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of the photodiode tube with portions broken away to show its internal construction; and

FIGURE 2 is a schematic of a circuit exemplifying the use of the present invention.

With reference to FIGURE 1, coaxial photodiode tube **11** comprises a generally cylindrical envelope **12**, preferably of glass, open at one end. The open end of the envelope **12** is sealed to the enlarged end of an electrically conductive cylinder **13**, of Kovar alloy or equivalent material. Within the envelope **12** is an anode **14** of elongated cross section, preferably rectangular, rigidly mounted to have a common plane of symmetry with a concave surface of a cathode **16**. An electrical insulating seal **17**, providing the means of rigidly mounting anode **14** in spacial relation to cathode **16**, is hermetically secured at the end of cathode **16** adjacent to the enlarged end of cylinder **13**. The anode **14** and cathode **16** assembly, in turn, is supported as by welding the cathode **16** coaxially to the inside surface of the reduced end of cylinder **13**. The anode **14** and cathode **16** terminate in a coaxial terminal **18**.

Cathode structure **16** preferably comprises a cathode support **19** fashioned from a tubular conducting material, such as Kovar alloy. A section of the tubing is removed part of the way along the longitudinal axis exposing a semi-cylindrical cathode support surface **21**. The remainder of the Kovar tubing forms a fully cylindrical end portion **22**. The cylindrical portion **22** of the cathode support **19** connects cathode structure **16** to the electrically conductive cylinder **13** at a weld **23**, and forms the outer conductor **24** of the coaxial terminal **18**. The exposed semi-cylindrical cathode surface **21** has a substrate **26** of nickel or the like spot welded to its inner surface. Preferably, antimony is evaporated on the nickel surface and a cesium activating agent **27**, which is sensitive to electromagnetic radiation, is deposited on the cathode surface. The process of activating the cathode is a well-established art.

Anode **14** of elongated cross section, preferably rectangular, lies in a plane that is perpendicular to the facing surface of cathode **16** at its midpoint. The narrow edge surface of elongated anode **14** adjacent to cathode **16** is curved and is centered with respect to an axis extending along the center of curvature of the semi-cylindrical cathode **16** in a manner such that the curved edge of anode **14** is coaxial with semi-cylindrical cathode **16**. An ex-

tension 28 of elongated anode 14 is preferably secured by a set screw 29 to inner conductor 31 of coaxial terminal 18. Inner conductor 31 hermetically passes through glass seal 17. Anode 14 is held in spacial relation to the facing surface of cathode 16 by glass seal 17.

The elongated portion of anode 14 extends the surface area of anode 14. Moreover, anode 14 as disposed in the manner previously described facilitates interception of the electrons emitted by cathode 16 that miss the surface of the anode 14 that is adjacent to the cathode surface 27. Thus, the spiral effect common in photodiodes employing cylindrical anodes is eliminated. As a result of the improved anode-cathode arrangement, the electrons that are emited by cathode 16 and travel to anode 14 have similar path lengths and, hence, substantially common transit times. This also results in a photodiode tube having a higher degree of resolution.

In addition to the before-mentioned advantage of the previously described photodiode tube, it is to be noted that additonal features exist. Particular attention may, however, be directed to certain features. The sturdy manner in which the anode and cathode elements are mounted and supported results in a device that is able to withstand considerable hard mechanical use. As a result of the improved anode-cathode arrangement, the time required from the termination of a pulse of incident radiation on the cathode surface to the instant a succeeding pulse of discernible strength can be detected has been reduced to 10^{-10} sec. Existing photodiode tubes require 10^{-8} sec. because of the spiral effects. Also, the elongated anode cross-sectional configuration resulting in a photodiode tube having improved transit-time characteristics provides the photodiode tube with the capability of handling approximately 50 times the output current of existing photodiode tubes of comparable size.

As a further important feature of the photodiode it should be noted that the coaxial terminal 18 comprises an inner conductor 31 whose center coincides with the axis of outer conductor 24. Inner conductor 31 is connected to anode element 14, and outer conductor 24 is connected to cathode element 16. Thus, the anode-cathode arrangement approximates a concentric cylindrical capacitor whose characteristic impedance is relatively low when compared to photodiode tube known in the art. The characteristic impedance of photodiode tube 11 can be controlled by controlling the thickness T of anode 14 and the perpendicular distance from the midpoint of the cathode facing surface to the surface of the narrow edge of elongated anode 14.

In a typical functional arrangement, the photodiode tube 11 is connected as shown in FIGURE 2. A positive terminal 32 of a power supply 33 is connected to anode 14 of the photodiode tube 11 through a resistor 34. The negative terminal 36 of power supply 33 is connected to chassis ground 37. A capacitor 38 is connected between anode 14 of photodiode tube 11 and ground 37. Electromagnetic-sensitive cathode 16 of the photodiode tube 11 is connected to ground 37 (or the negative terminal 36 of the power supply 33) through a resistor 39. This results in the establishment of a potential difference between the anode 14 and cathode 16 of the photodiode tube 11.

With photodiode tube 11 connected in the circuit just described, light 41 is impinged on radiation-sensitive cathode surface 27. The action of light 41 on cathode surface 27 results in electrons being freed from the cathode surface 27. The potential difference between anode 14 and cathode 16 causes the freed electrons to form a current that is directed from the cathode 16 to the anode 14. The photodiode tube 11 operates in a manner such that the number of electrons leaving cathode surface 27 and arriving at the anode 14 is directly proportional to the intensity of the impinging radiation 41. The various improved characteristics of the tube noted hereinbefore of course attend its operation.

While the present invention has been hereinbefore described with respect to a single embodiment, it will be apparent that numerous modifications in the construction of the photodiode tube are possible. In particular, the cathode element of the photodiode tube may be of other geometrical configurations than semi-cylindrical. For example, the cathode element can take the form of a spherical segment or parabolic configuration. Also, the anode can have a biconvex cross section. Thus, it is not intended to limit the invention except by the terms of the following claims.

What is claimed is:

1. A photodiode tube comprising a hermetically sealed envelope, a semicylindrical cathode disposed within said envelope, said cathode having a surface responsive to electromagnetic radiation by the emission of electrons, an anode of elongated cross section disposed within said envelope, the narrow edge of said elongated cross section being convexly curved, said curved edge of said anode being coaxial with the facing surface of said semicylindrical cathode, and an electrical connector means connected to said anode and cathode hermetically penetrating said envelope to the exterior thereof.

2. A photodiode tube as claimed in claim 1, further defined by said curved edge of said anode being of a semicylindrical cross section.

3. A photodiode tube as claimed in claim 1, further defined by said electrical connector being a coaxial connector, said coaxial connector having an outer cylindrical conductor in coaxial extension with said cathode, and said coaxial connector having an inner conductor in electrical connection with said anode.

4. A photodiode tube comprising an envelope having an open end, an electrically conductive cylinder having an enlarged end portion, said open end of said envelope hermetically sealed to the enlarged end portion of said cylinder, a semicylindrical cathode disposed within said envelope, said cathode having a surface responsive to electromagnetic radiation by the emission of electrons, said cathode having a cylindrical extension hermetically secured coaxially to the inside surface of the reduced end portion of said electrically conductive cylinder, an electrical insulating seal means hermetically secured coaxially to the inside surface of the cylindrical extension of said cathode, and an anode of elongated cross section positioned within said envelope the narrow edge of said elongated cross section being convexly curved, said curved edge of said anode being coaxial with the facing surface of said semicylindrical cathode, said anode having a cylindrical extension rigidly secured to and hermetically transpiercing said insulating seal means, said extension of said anode disposed in coaxial relation with the extension of said cylindrical cathode extension while being in coaxial extension with the curved edge of said anode.

5. A ruggedized photodiode tube comprising a generally cylindrical glass envelope, said envelope having an open end, a first electrically conductive cylinder having an enlarged end portion, said open end of said envelope hermetically sealed to the enlarged end portion of said first cylinder, a semicylindrical cathode disposed within said envelope, said cathode having a surface responsive to electromagnetic radiation by the emission of electrons, said cathode having a cylindrical extension hermetically secured coaxially to the inside surface of the reduced end portion of said first cylinder, an electrical insulating seal means hermetically secured to the inner surface of the extension of said cathode, an anode disposed within said envelope, said anode having a substantially rectangular cross section, said anode having a convexly curved edge adjacent to the facing surface of said cathode, said curved edge of said anode of semicylindrical cross section and disposed coaxial with said semicylindrical cathode, said anode having a cylindrical extension in coaxial extension with said curved edge, and a second electrically conductive cylinder coaxially disposed within said first electrically

conductive cylinder, said second cylinder rigidly secured to and hermetically transpiercing said insulating seal means and rigidly secured to the cylindrical extension of said anode.

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