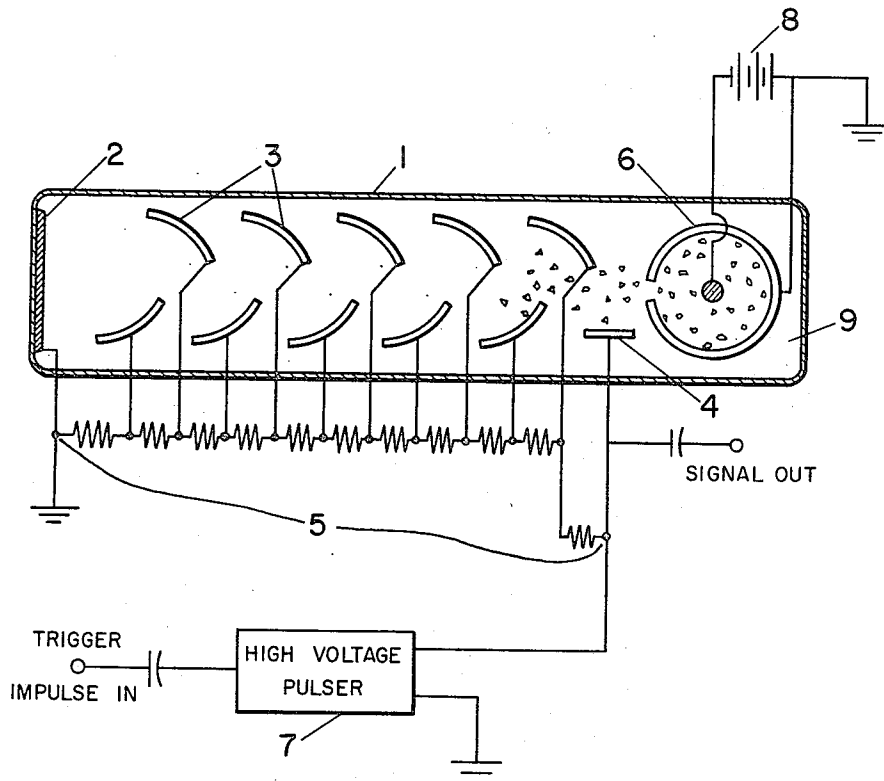


Jan. 6, 1959

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SECONDARY ELECTRON MULTIPLIERS

2,867,729

Filed July 19, 1955



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SECONDARY ELECTRON MULTIPLIERS

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Application July 19, 1955, Serial No. 523,133

6 Claims. (Cl. 250—207)

This invention relates to a secondary emission multiplier having exceptionally high output signal current.

The output signal current of present electron multipliers is limited by the space charge surrounding the electrodes within the multipliers to a value of a few milliamperes even though very high voltages per stage may be employed. This space charge effect might be neutralized by introducing gas into the multiplier; however, heretofore it has been found impractical to do so since positive ions would be accelerated back to the early stages of the multiplier and produce so many secondaries that total breakdown would ensue.

Because of this inherent limitation of the amplification available in electron multiplier tubes it is necessary to amplify the output of such tubes to raise the output to a readily useful level. This requires expensive, as well as, extensive amplifier circuits.

One attempt to overcome this problem is represented by the patent to L. F. Wouters, No. 2,594,703. In this invention the patentee has designed a circuit which permits a photomultiplier tube to be operated at voltages many times normal operating voltages by virtue of pulsed operation, as opposed to continuous operation, which prevents deleterious overloading of the photomultiplier tube.

In accordance with the present invention it has been found that positive ions necessary to neutralize the space charge effect may be introduced into an electron multiplier tube and the deleterious effects previously encountered, as discussed above, overcome by switching on the dynode voltage intermittently for periods of time so brief that the ions do not move perceptibly.

It is therefore an object of the present invention to provide a new and improved electron multiplier tube.

Another object of the invention is to provide an electron multiplier having exceptionally high output signal current, thus eliminating the need for costly, bulky, and delicate amplifiers subsequent to the multiplier.

Still another object of the invention is to provide an electron multiplier tube containing ionized gas therein to increase the amplification through such tube by neutralizing the space charge effect.

A further object of the invention is to provide an electron multiplier tube having intermittent operation for periods so brief as to eliminate perceptible movement of the ionized gas within the tube.

Still further objects and advantages of the invention will be apparent from the following description and claims considered together with the accompanying drawing.

Referring to the drawing in detail there is provided a photomultiplier tube 1 containing conventional elements including; photo cathode 2, dynodes 3, collector plate or anode 4, and a voltage divider 5 comprised of a plurality of similar resistors tapped so as to provide increasing potentials to the dynodes in a conventional arrangement. Of course it will be readily apparent that other types of photomultiplier tubes or straight electron multiplying

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tubes may be substituted for the above components. In addition to these components of standard multiplying tubes a source of ions 6 is disposed in region 9 remote from the cathode and inside the envelope of the multiplier, said source consisting either of an electron beam directed so as to ionize a gas occupying the space between the multiplier dynodes or an auxiliary cathode and perforated anode situated so that positive ions are formed between anode and cathode and released through the perforations to bathe the dynode space with ions. The potential for operating the auxiliary ion source is provided by battery 8. External means 7 are provided for pulsing the dynode potentials from zero to operating voltage for brief intervals.

A particular application of this invention is the counting of particles which are produced in short bursts by a synchrotron. The time of arrival of each burst can be accurately predicted and the dynode voltage of the multiplier tube may be switched on by triggering the high voltage pulse generator with an input pulse a brief instant before the synchrotron burst. The charged particles emitted from the synchrotron can then be permitted to impinge upon a suitable crystal which will produce light scintillations to activate the photo cathode 2 of photomultiplier tube 1. The photomultiplier tube operates in a conventional manner with the exception that its output current is greatly increased because of the presence of the ion cloud which is produced by the auxiliary ion source 6. This source bathes the dynode space with ions at a steady fixed rate since its operating potential is derived from battery 8. However, since the tube is only operated during the brief time interval that a pulse is emitted from high voltage pulser 7, the ions do not move perceptibly and consequently do not have the opportunity to be accelerated back to the early stages of the multiplier tube and produce so many secondaries that total breakdown would ensue. The length of the high voltage pulse from pulser 7 is designed to be as short as practical to insure the complete response of the photo multiplier to the synchrotron burst. Thus the deleterious effects of introducing ionized gas as encountered by the prior art are overcome while the benefit of the increased output current due to these ions is retained.

The present invention may also be employed as a duty-cycle counter for the measurement of amounts of continuous radiation. This can be accomplished by supplying pulses to the high voltage pulser 7 at regular brief intervals for a specified period of time. The total number of particles counted during the specified time interval by the photomultiplier 1 used in conjunction with a scintillation crystal may be divided by the magnitude of the duty cycle to obtain a measure of the total radiation received during the specified time interval.

While the salient features of this invention have been described with reference to the preferred embodiment, it will be understood that this invention is not limited to the particular details described above as many equivalents will suggest themselves to those skilled in the art.

What is claimed is:

1. In an electron multiplier tube circuit, the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, means adjacent said anode but remote from said cathode for ionizing said gas within said envelope, and means for providing operating potentials to the said dynodes and anode intermittently for brief periods.

2. In a multiplier tube circuit, the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, an auxiliary ion source located within said envelope adjacent said anode but remote from said cathode for ionizing said gas within said envelope, and means for

providing operating potentials to the said dynodes and anode intermittently for brief periods.

3. In a multiplier tube circuit, the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, an auxiliary ion source located within said envelope adjacent said anode but remote from said cathode including an electron beam directed so as to ionize said gas in said envelope, and means for providing operating potentials to the said dynodes and anode intermittently for brief periods.

4. In a multiplier tube circuit, the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, an auxiliary ion source located within said envelope adjacent said anode but remote from said cathode including an auxiliary cathode and a perforated anode situated so that positive ions are formed between the perforated anode and auxiliary cathode and released through the perforations of said anode to bathe the dynode space with ions, means for impressing a suitable potential on the aforesaid auxiliary cathode and perforated anode, and means for providing operating potentials to the said dynodes and anode intermittently for brief periods.

5. In a multiplier tube circuit, the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, means adjacent said anode but remote from said

cathode for ionizing said gas within said envelope, a voltage divider having a plurality of equal resistors connected to the said dynodes and anode, and a high voltage pulser which impresses an operating potential across said voltage divider intermittently for brief periods.

6. In a multiplier tube circuit the combination comprising a cathode, a plurality of dynodes, an anode, an envelope enclosing said components, gas within said envelope, an auxiliary ion source located within said envelope at a point remote from said cathode consisting of an auxiliary cathode and perforated anode situated so that positive ions are formed between the perforated anode and auxiliary cathode and released through the perforations of said anode to bathe the dynode space with ions which neutralize the space charge surrounding said dynodes, a voltage divider having a plurality of equal resistors connected to the said dynodes and anode, and a high voltage pulser which impresses an operating potential across said voltage divider intermittently for brief periods.

References Cited in the file of this patent

UNITED STATES PATENTS

2,457,530	Coggeshall et al.	Dec. 28, 1948
2,499,320	Loevinger	Feb. 28, 1950
2,594,703	Wouters	Apr. 29, 1952
2,784,317	Robinson	Mar. 5, 1957