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SENSITIVE ELECTRON DISCHARGE TUBE

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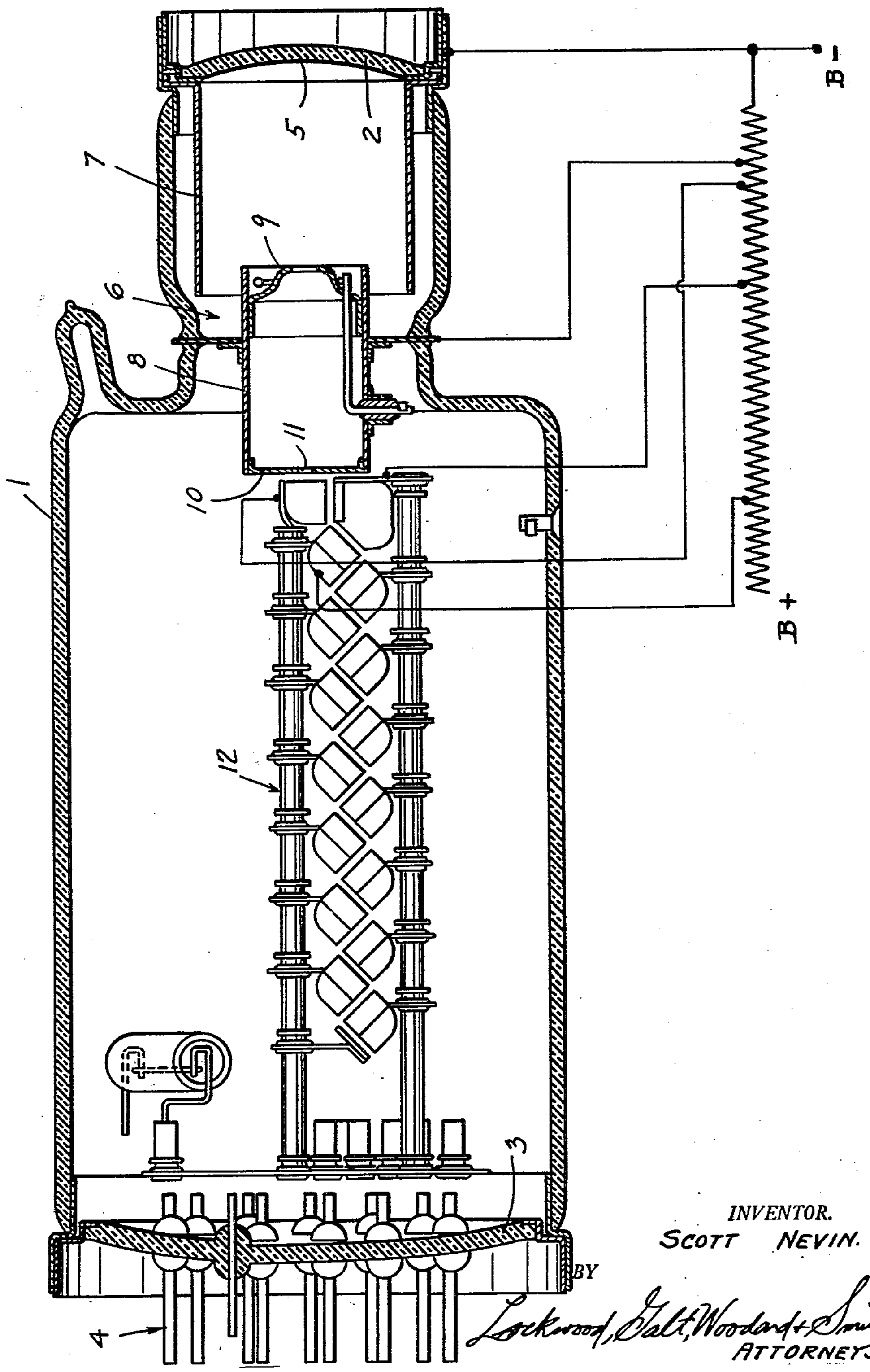

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SENSITIVE ELECTRON DISCHARGE TUBE

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The present invention relates to a sensitive electron discharge tube and more particularly to a photoelectric device in which the signal-to-noise ratio is improved.

In photoelectric devices which are sensitive to radiant energy projected thereon, it has been found that the cathodes of such devices are both thermionically and photoelectrically emissive. The emission produced by thermal effects is undesired in some cases since it produces a space current in the tube which interferes with tube-operating sensitivity. In such tubes wherein thermal emissivity is present, the usual signal is comprised of combined thermal and photoelectric emission. Since the primary purpose of almost all photoelectric tubes is the detection of radiant energy, it logically follows that any emission from a cathode not due primarily to such radiant energy, constitutes "noise" and impairs sensitivity.

In photoelectric devices wherein the "noise" factor is desired to be kept at a minimum, thereby maintaining the tube sensitivity to radiant energy at a maximum, the utilization of only a minute portion of the tube cathode has been found to provide such maximum sensitivity.

It is, therefore, an object of this invention to provide an electron discharge tube of the type mentioned in the foregoing, in which only a small area of the overall cathode area is utilized for producing a usable signal.

It is a further object of this invention to provide a method for producing a signal in response to radiant energy, such signal having a maximum "signal-to-noise" ratio.

It is a still further object of this invention to provide a method and structure for intercepting the major portion of thermally emitted electrons from a photoelectric surface for minimizing the deleterious effects produced thereby in detecting a radiant energy signal.

In accordance with the present invention, there is provided a photoelectric tube comprising a photoelectric cathode, a masking electrode provided with a tiny aperture and spaced a predetermined distance from said cathode, and electron lens means interposed between said cathode and said masking electrode for focusing the electrons emitted by said cathode in an electron image plane which includes said aperture, a part of said electron lens means being conductively connected to said masking electrode. By means of this arrangement, only a relatively small area of the cathode is utilized for producing a usable signal, such small area producing a signal of maximum "signal-to-noise" ratio.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawing, the scope of the invention being pointed out in the appended claims.

In the accompanying drawing, the figure is an axial cross section of one embodiment of this invention, showing the manner of connecting operating potentials thereto.

According to the drawing, an evacuated, cylindrical envelope 1 is provided on its right-end with a conventional, transparent face plate 2 and on its left end with a base 3 in which is supported suitable terminal pins 4. A photoelectric material, indicated by the reference numeral 5, is coated on the internal face of the transparent end plate 2, this material constituting any of the well known photoelectric compositions such as silver-oxide-caesium. This cathode arrangement is conventional and serves to emit electrons in response to a radiant energy image focused on the right-hand surface thereof through the transparent face plate 2.

An electron lens indicated generally by the reference numeral 6, is supported within the envelope 1 in cooperative relation with the cathode 5. This lens comprises a cathode sleeve 7 conductively connected at its right-hand end to the cathode and an anode sleeve 8 which coaxially extends a short distance inside the cathode sleeve 7. An apertured member 9 is fitted into the right end of the anode sleeve 8, and a masking disc or electrode 10 which is provided with a central aperture 11, is provided in the opposite end. The sizes of the sleeves 7 and 8, and the positions thereof, are somewhat critical and can be determined by conventional experimental or mathematical techniques to meet given design requirements. For the purposes of this invention, it is only necessary to state that the structure of electron lens 6 is made such as will focus an electron image emitted by the cathode 5 onto an image plane coincident with the masking electrode 10. In achieving this focus condition, the paths of all the electrons emitted by the cathode 5 are caused to cross one another coaxially of and in the plane of the aperture in the member 9 and thereafter to diverge until an image composed of electrons exists in the plane of the electrode 10. The method and structure for obtaining an electron image in this so-called "image plane" are well known and need not be further elaborated here.

A multi-stage electron multiplier, indicated by the reference numeral 12, is mounted adjacent the masking electrode 10 opposite the masking aperture 11. Any electrons passing through this aperture 11 will thereupon impinge on the first stage of the multiplier which emits secondary electrons at a rate greater than unity, these electrons being multiplied by succeeding stages in a manner well known to the art. This multiplier structure is conventional and serves the purpose of increasing the magnitude of the electron-signal passed through the masking aperture 11.

Operating potentials may be connected to the various electrodes just described in such a manner as to apply B— or ground potential to the cathode 5 and sleeve 7, and a potential which is positive with respect thereto to the anode sleeve 8. A positive potential is connected to the first stage of the multiplier 12, and successively higher potentials are applied to the succeeding stages in accordance with conventional practice.

In operation, an optical image cast on the entire surface of the face plate 2, will serve to excite the cathode 5. Electrons will be emitted over the entire surface of the cathode, which are focused through the apertured member 9 and into the plane of the masking electrode 10. Only those electrons which fall within the area of the masking aperture 11 will be utilized since they pass through onto the first stage of the multiplier 12. By this means, it is seen that only a small-elemental area of the cathode 5 is effective in producing the signal utilized by the multiplier 12. All of the remaining cathode surface is made ineffective by interception of the electrons, which are both thermionically and photoelectrically emitted, by the masking electrode 10.

As a corollary, an optical image may be cast on only that elemental area of cathode 5 which is in registry with the mask aperture so that the only emission by the remainder of the cathode is thermal. Since this thermal emission is intercepted by the masking electrode, it cannot interfere with the operating sensitivity of the tube.

Thermal electron emission from the cathode 5 is directly proportional to the magnitude of cathode area. Therefore, by reducing the effective cathode area to a minimum, thermal emision or "noise" is kept at a minimum. The arrangement just described provides a practical and effective means for utilizing a most efficient size of cathode area.

While it is recognized that a small cathode area conduces to maximum signal-to-noise ratio, no practical successful method has been proposed for fabricating such a small area which will produce consistent results. Much is known about fabricating relatively large cathode surfaces for producing under mass production techniques, cathodes which will provide predictable results. Therefore, in the present invention, well known, proven prior art methods are followed in fabricating the cathode. However, in order to achieve the ultimate in operating sensitivity, means are used in conjunction with this cathode for utilizing only a small segment of this area in order to achieve maximum signal-to-noise ratio.

What is claimed is:

1. The method of obtaining high signal-to-noise ratio in a radiant energy electron discharge device comprising the steps of providing electron emission from a cathode of relatively large area which is sensitive over its entire area to radiant energy projected therein, focusing the electrons emitted by said cathode in a plane spaced from said cathode, masking out all but a tiny area of electrons in said plane, and utilizing only those electrons emitted from a correspondingly tiny area of said cathode.

2. The method of obtaining high signal-to-noise ratio in a radiant energy electron discharge device comprising the steps of providing electron emission from a cathode of relatively large area which is sensitive over its entire area to radiant energy projected thereon, withdrawing electrons emitted by said cathode and focusing them into an image plane spaced from said cathode, collecting all of the electrons projected into said image plane with the exception of a few electrons which are emitted by a portion of said cathode of predetermined size, and utilizing only those electrons which are not collected for producing an electrical signal.

3. The method of producing a photosensitive cathode of relatively high signal-to-noise ratio comprising the steps of providing electron emission from a photoelectric cathode surface which is many times too large in area, and utilizing only a small elemental area of said cathode for producing a usable signal by projecting all of the electrons emitted by the cathode into an image plane spaced from said cathode, and masking out all of the electrons in such image plane with the exception of those emitted by said elemental area.

4. A sensitive photoelectric device comprising a photoelectric cathode capable of emitting electrons in response to radiant energy projected thereon, a masking electrode provided with a tiny aperture and spaced a predetermined distance from said cathode, and an electron lens means interposed between said cathode and said masking electrode for focusing the electrons emitted by said cathode in an electron image plane which includes said aperture, a part of said electron lens means being conductively connected to said masking electrode.

5. A sensitive photoelectric device comprising a photoelectric cathode capable of emitting electrons in response to radiant energy projected thereon, a masking electrode provided with a tiny aperture and spaced a predetermined distance from said cathode, and an electron lens including a first conducting sleeve conductively connected to one end to said cathode and extending toward said masking electrode, and a second conducting sleeve smaller than the first and being supported coaxially with respect thereto, said masking electrode being conductively supported internally of said second sleeve.

6. A sensitive photoelectric device comprising a photoelectric cathode capable of emitting electrons in response to radiant energy projected thereon, a masking electrode provided with a tiny aperture and spaced a predetermined distance from said cathode, an electron lens including a first conducting sleeve conductively connected at one end to said cathode an extending toward said masking electrode, and a second conducting sleeve smaller than the first and being supported coaxially with respect thereto, said masking electrode being conductively supported internally of said second sleeve, said first and second sleeves including means causing the paths of all electrons emitted by said cathode to cross-over at a point intermediate said cathode and said masking electrode.

7. A sensitive photoelectric device comprising a photoelectric cathode capable of emitting electrons in response to radiant energy projected thereon, a masking electrode provided with a tiny aperture and spaced a predetermined distance from said cathode, an electron lens including a first conducting sleeve conductively connected at one end to said cathode and extending toward said masking electrode, and a second conducting sleeve smaller than the first and being supported coaxially with respect thereto, said masking electrode being conductively supported internally of said second sleeve, and electrode means supported adjacent said aperture on the side opposite from the cathode for utilizing the electrons passed by said aperture, all other electrons which are emitted by said cathode being intercepted by said masking electrode.

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