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Wyess

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[54] **BRIGHTNESS LIMITER FOR IMAGE INTENSIFIERS**

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[51] **Int. Cl.** **E04g 17/06**

[58] **Field of Search** 250/213, 200, 83.3, 83.6; 330/59

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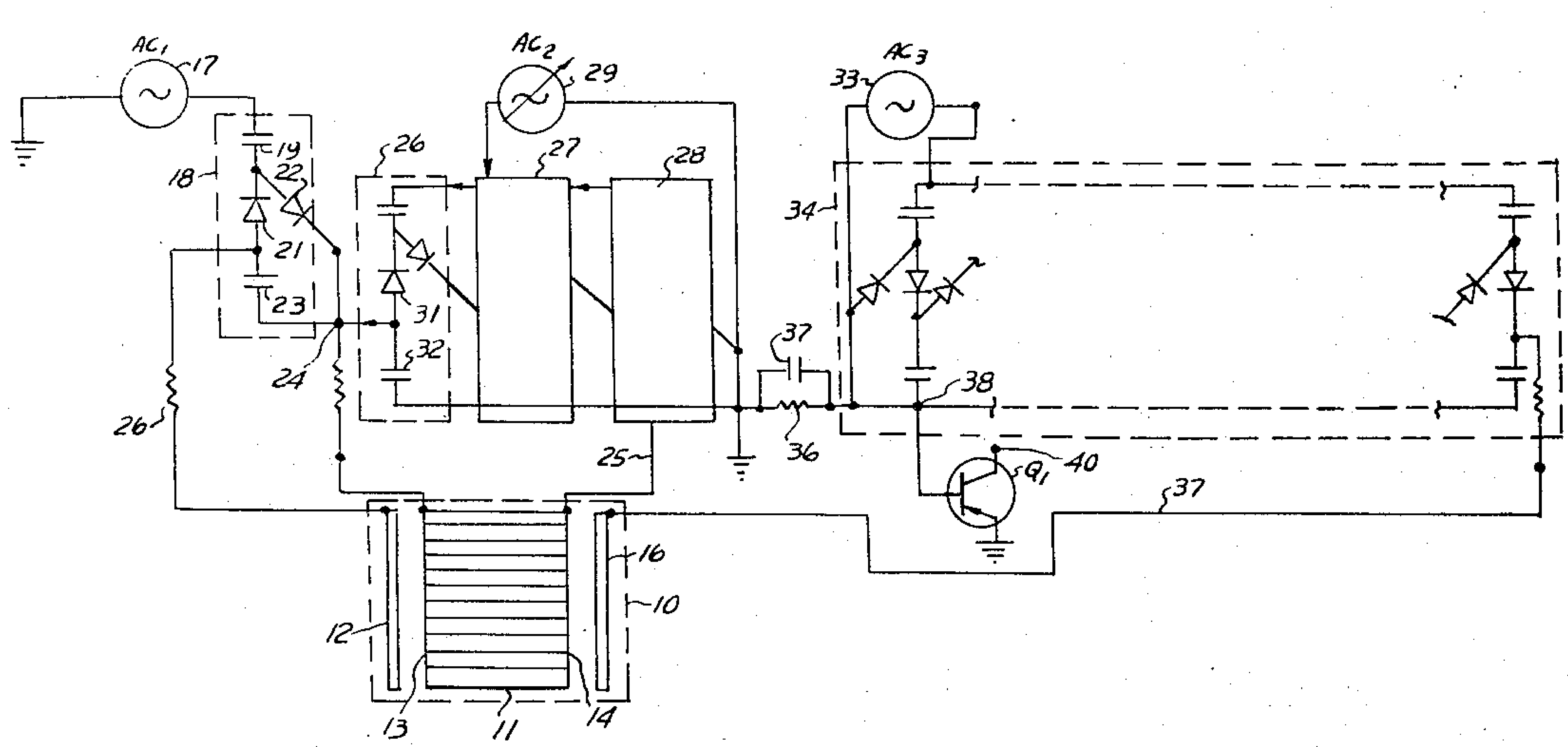
[57] **ABSTRACT**

The invention is directed to a system for automatically limiting the output brightness of an image intensifier having a microchannel plate (MCP). The intensifier includes a radiation-sensitive surface which is located in the proximity of the input surface of the MCP. An output screen is located in the proximity of the output surface of the MCP. The two surfaces of the MCP are maintained at different voltages which accelerate electrons through the MCP to cause the multiplication of electrons therein. The output brightness of the intensifier is directly proportional to the current supplied to the output screen. This current is dependent upon the voltage supplied across the microchannel input and output surfaces. Therefore, the system senses the output screen current and changes the voltage applied across the MCP to limit the sensed current and the output brightness to some desired level.

7 Claims, 2 Drawing Figures



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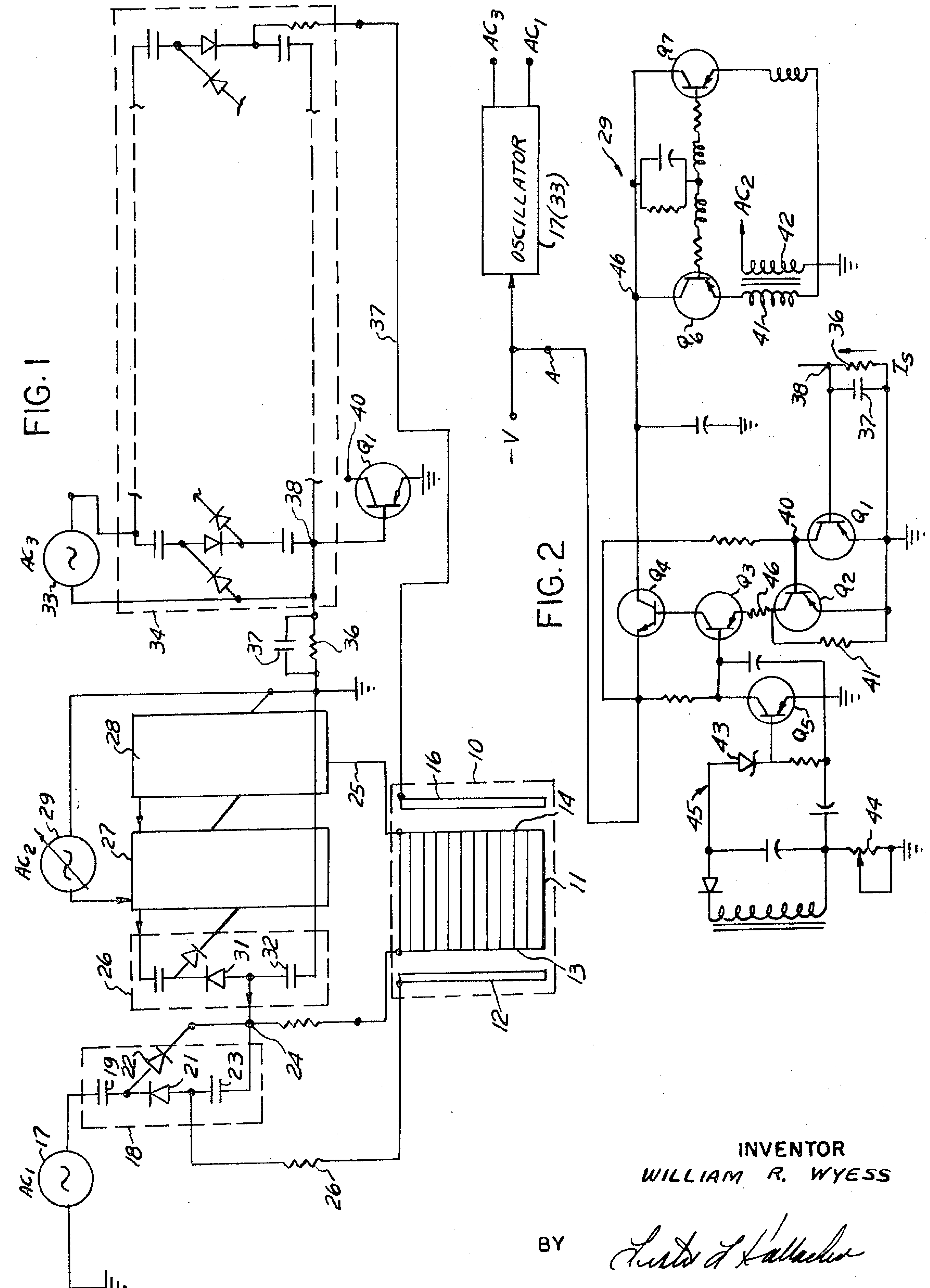

FIG. 1

FIG. 2

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BRIGHTNESS LIMITER FOR IMAGE INTENSIFIERS

BACKGROUND OF THE INVENTION

Image intensifiers utilizing microchannel plates (MCP) are well known in the art. In such intensifiers a microchannel plate is placed between a radiation-sensitive input screen and an output screen which yields a visible output. The output screen therefore is frequently a phosphorous screen. Radiation, such as photons or charged particles, incident on the input screen cause the release of electrons from the input surface. The electrons pass to the MCP where they are multiplied by several orders of magnitude because of secondary emission effects in the MCP. The multiplied electrons emanate from the MCP and impact with the output screen so that each electron causes the screen to fluoresce. Because of the structure of the MCP, any image information carried by the radiation impinging on the input surface is preserved and reproduced on the output surface as a highly intensified image.

Intensification of the input image is highly desirable and is the primary purpose of the MCP. However, overintensification can be detrimental. If the brightness of the output image is excessive, contrast and image sharpness are lost, resulting in a reduction of the usefulness of the output image. Moreover, the life of the image intensifier could be impaired.

SUMMARY OF THE INVENTION

The invention is directed to a system for limiting the brightness of an image intensifier of the type described hereinabove. Some of the disadvantages of such intensifiers are therefore overcome by the inventive system.

The output brightness of an image intensifier is directly proportional to the current supplied to the output screen of the intensifier tube. This current is caused by the flow of electrons from the MCP to the output screen and, for a given incident radiation on the input screen, is dependent upon the biasing voltage supplied across the MCP. Accordingly, the invention is directed to a system which limits the current in the output screen.

Current limiting is achieved by utilizing a current-sensitive biasing source to supply a voltage across the MCP. The output screen current is sensed and used to control the output of the biasing source and thus limit the brightness of the intensifier.

The input and output surfaces of the MCP are respectively located in the proximity of a radiation-sensitive input screen and an output screen capable of sustaining a visual output image. The input and output screen are maintained at different constant voltages so that electrons travel from the input screen to the output screen. A current-sensitive voltage means, such as a current controlled oscillator, biases the output surface of the MCP. Accordingly, the intensity of the output image is limited to a level insuring a high contrast and sharp image.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a preferred embodiment of the inventive system.

Figure 2 is a preferred embodiment of a current-sensitive biasing source which can be used in the inventive system.

DETAILED DESCRIPTION

Figure 1 shows a Wafer Image Intensifier 10 which is used to recieve and intensify a radiation image. The Image Intensifier 10 includes three active elements: Microchannel Plate (MCP) 11; Photocathode 12, which is the radiation-sensitive input screen; and Phosphor Screen 16, which is the output screen of the intensifier tube. Photocathode 12 is placed in the close proximity of the Input Surface 13 of MCP 11, and Phosphor Output Screen 16 is placed in the close proximity of Output Surface 14 of MCP 11. Input Screen 12 and Output Screen 16 are placed near the Input and Output Surfaces 13 and 14, respectively, of MCP 11 so that a current flow is created by electron exchange between the surfaces and the MCP 11. However, the screens are positioned with respect to the Input and Output Surfaces such that they will support different biasing potentials with respect to the potentials of the MCP surfaces.

In operation, a radiation image impinging upon input screen or Photocathode 12 causes the emission of electrons by Photocathode 12. Any image information contained within the impinging radiation is reproduced in the form of a corresponding electron image because of photoemission by the Photocathode 12. The electrons, and therefore the electron image, are attracted to Input Surface 13 of MCP 11. This is so because Input Surface 13 of MCP 11 is maintained at a higher positive potential than Photocathode Screen 12. Accordingly, electrons emanating from Photocathode 12 are attracted to the Input Surface 13 of MCP 11.

Microchannel Plate 11 consists of a bundle of discrete hollow glass tubes, or channels, which are capable of amplifying an electron image by many orders of magnitude. Each electron impinging upon Input Surface 13 of MCP 11 results in the emission of a number of secondary electrons within the MCP 11. The secondary electrons then cause the emission of more secondary electrons so that the number of electrons emanating from Output Surface 14 of MCP 11 is substantially higher, by the order of many magnitudes, than the number of electrons impinging on Input Surface 13. The electron gain or multiplication within the MCP is controlled primarily by the potential difference applied across the Input and Output Surfaces 13 and 14, respectively, of the MCP. Because of the electron multiplication which occurs within the MCP, the radiation impinging upon Photocathode 12 results in the emanation of a quantity of electrons from Output Surface 13 which greatly exceeds the quantity initially produced by the radiation. Image information is preserved by the close proximity of Screen 12 to the surface 13 of the MCP and by the high density of discrete hollow channels of which the MCP is comprised. And also because the electron multiplication occasioned by a single electron occurs in only one channel. Accordingly, the point-to-point variations of the image of the impacting radiation are preserved. The input image information is therefore reproduced in a highly intensified form at Output Surface 14 of MCP 11. The electrons emanating from MCP 11 and containing the input radiation image information impinge with Phosphorous Output Screen 16, causing the screen to fluoresce and reproduce the input image. The close proximity of Screen 16 to Output Surface 14 also is instrumental in preserving the image information.

Because electrons are always attracted through the image intensifier tube from Photocathode 13 to Phosphorous Output Screen 16, the voltages applied to the various surfaces and screens become more positive in the direction of electron flow.

A potential is applied to Photocathode 12 by a constant voltage AC Source 17 through a Multiplier-Rectifier 18. Multiplier-Rectifier 18 rectifies the AC signal so that a constant DC potential is applied to Photocathode 12. If desired, this can be applied through a Current Limiting Resistor 26. Multiplier-Rectifier 18 includes a Capacitor 19 which is connected to the oppositely poled Diodes 21 and 22. The anode of Diode 21 is connected to the cathode of Diode 22 through a Capacitor 23 at Junction 24. This circuit operates in known manner to double the zero to peak input voltage and also to rectify the voltage so that a constant DC voltage is obtained at the output thereof. Diodes 21 and 22 conduct on alternate half cycles of AC Source 17 according to their polarity. Capacitor 23 is thereby charged so that the voltage output of Multiplier 18 with reference to ground is equivalent to the peak AC input voltage of AC Source 17 plus the voltage present at Junction 24. AC Source 17 can be an output of a regulated oscillator so that the DC potential applied to Photocathode 12 is constant.

The biasing voltage across Input Surface 13 and Output Surface 14 of MCP 11 is applied from a Variable Voltage Oscillator 29 through three Multiplying Sections 26, 27 and 28 which are constructed and operate in the same manner as Multiplier-

Rectifier 18 described hereinabove. Each of the Multiplying Sections 26, 27 and 28 multiply the zero to peak AC input voltage by a factor of 2. The respective Multiplying Section output voltages are additive so that the DC voltage developed across Capacitor 32 is 6 times the zero to peak AC input voltage. The DC voltage across Capacitor 32 is applied across Surfaces 13 and 14 of MCP 11. Obviously, if desired, more or less sections can be used to increase or decrease the potential across MCP 11.

It will be noted that Multiplier-Rectifier 18 is referenced to the voltage applied to Surface 13 of MCP 11 at Junction 24. Accordingly, the biasing voltage applied to Photocathode 12 varies by the same amount as the voltage applied to Input Surface 13. This is done in order to maintain a constant voltage differential between Photocathode 12 and MCP Input Surface 13.

Phosphorous Output Screen 16 is biased by an AC Source 33 which is rectified and multiplied through Multiplying Section 34. Multiplying Section 34 will contain the desired number of multiplying sections so that the DC output voltage is substantially multiplied from the peak AC input voltage supplied by AC Source 33, as shown by the partial sectioning of the multiplying section.

The path of Screen Current I_s is defined by the electron flow between Output Surface 14 and Phosphorous Screen 16, Lead 25, Current Sensing Resistor 36, Multiplying Section 34, and Line 37, which connects the multiplier section to Phosphorous Screen 16. The output intensity of the intensifier, as evidenced by the visual image on Phosphorous Screen 16, is dependent upon the DC voltage applied across MCP 11 from AC Source 29. Current I_s is dependent upon this voltage, and accordingly the output image intensity can be limited by sensing the Current I_s and using this current to control the voltage amplitude of Oscillator 29. Screen Current Sensing Resistor 36, which is bypassed by a smoothing Capacitor 37, is used to sense the screen current and control the voltage of Oscillator 29.

The manner in which Current I_s controls Oscillator 29 is illustrated with reference to FIG. 2, which shows an exemplary embodiment of an oscillator which can be used to control the biasing voltage applied across MCP 11. FIG. 2 also shows another Oscillator 17 which can be used to supply the constant AC voltages, AC_1 and AC_3, to Photocathode 12 and Phosphorous Screen 16.

As shown in FIG. 2, Oscillator 29 includes a regulator section comprised of Transistors Q_1 through Q_5 and an oscillator section comprised of Transistors Q_6 and Q_7. As shown in FIGS. 1 and 2, Junction 38 of Resistor 36 and Capacitor 37 is connected to the base of Transistor Q_1. When the current through Current Sensing Resistor 36 is below the level at which limiting is to occur, Transistor Q_1 is cutoff. For this condition, Q_2 is saturated and the regulator-oscillator circuit operates in a voltage regulation mode to provide a constant voltage to MCP 11. This is accomplished by maintaining a constant transformer feedback voltage at Junction 45. The voltage at Junction 45 is compared to the reference voltage developed by Zener Diode 43 and the base to emitter potential of Q_5. If a potential difference occurs, the error signal is amplified by Transistors Q_5, Q_3 and Q_4 and applied as a DC level change to the input of Oscillator Q_6 and Q_7 at Junction 46. Accordingly, the feedback voltage at Junction 45 is automatically readjusted to reduce the error signal to a near-zero level. The output of the oscillator is thus maintained at a near constant level. The biasing voltage AC 2, which sets the amplitude of the DC voltage supplied across MCP 11, is taken off the Secondary 42 of Transformer 41. When Oscillator 29 is operated in a voltage regulation mode, its output amplitude can be manually controlled through Potentiometer 44.

When the current through Current Sensing Resistor 36 rises to its prescribed limiting level, the voltage across Resistor 36 rises above the threshold conduction level of Q_1. For this condition, Oscillator 29 switches over to a current regulator mode to provide a constant screen current characteristic. When Q_1 conducts as a result of the screen current reaching its prescribed limiting level, the conduction of Q_2 is reduced. This, in turn, reduces the conduction level of Q_4 thereby lowering the input voltage of Oscillator Q_6 and Q_7 at Junction 46. As a result, the amplitude of the output of Oscillator 29 is reduced proportionally and the biasing potential applied across MCP 11 is lowered to maintain the sensed screen current at its prescribed limiting level. Attendently the intensity or brightness of the output image present on Phosphorous Screen 16 is limited also.

Oscillator 17, shown in FIG. 2, can be of any of several known types. As an example, if Transistors Q_1, Q_2, and Resistor 41 of regulated Oscillator 29 are eliminated so that the emitter of Transistor Q_3 is grounded through Resistor 46, this oscillator can be used as Oscillator 17.

What is claimed is:

1. A system for limiting the intensity of the output image of a microchannel plate intensifier comprising:
   a microchannel plate having an input surface and an output surface; a radiation sensitive input screen in the proximity of said input surface, and an output screen capable of sustaining an output image in the proximity of said output surface so that image information present in input radiation impinging upon said input screen is intensified and discernable on said output screen;
   means for maintaining said input screen at a first constant voltage;
   means for maintaining said output screen at a second constant voltage;
   current sensitive voltage means for applying a varying voltage across said microchannel plate, said current sensitive voltage means including a voltage controlled oscillator and means for changing the voltage amplitude of the output of said oscillator
   resistive means in series with said output screen for sensing current flow to said output screen, said current sensitive voltage means being responsive to said means for sensing to change said variable voltage in response to said output screen current.

2. The system of claim 1 wherein said means for changing includes electron control means responsive to said output screen current.

3. The system of claim 2 wherein said electron control means is a transistor, the control electrode of said transistor being coupled to said resistor.

4. The system of claim 3 wherein said transistor decreases said oscillator output voltage when said screen current is sufficient to render said transistor conductive.

5. The system of claim 4 further including first multiplier-rectifier means interposed between said oscillator and said input surface so that a varying DC voltage is applied across said microchannel plate.

6. The system of claim 5 wherein said means for maintaining said input screen includes a second multiplier-rectifier interposed between said input screen and an AC supply;
   and said means for maintaining said output screen includes a third multiplier-rectified interposed between said output screen and an AC supply;
   said constant voltages being DC voltages having a level at least as high as the peak voltages of the respective AC supply.

7. The system of claim 3 wherein said transistor is a field effect transistor.

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