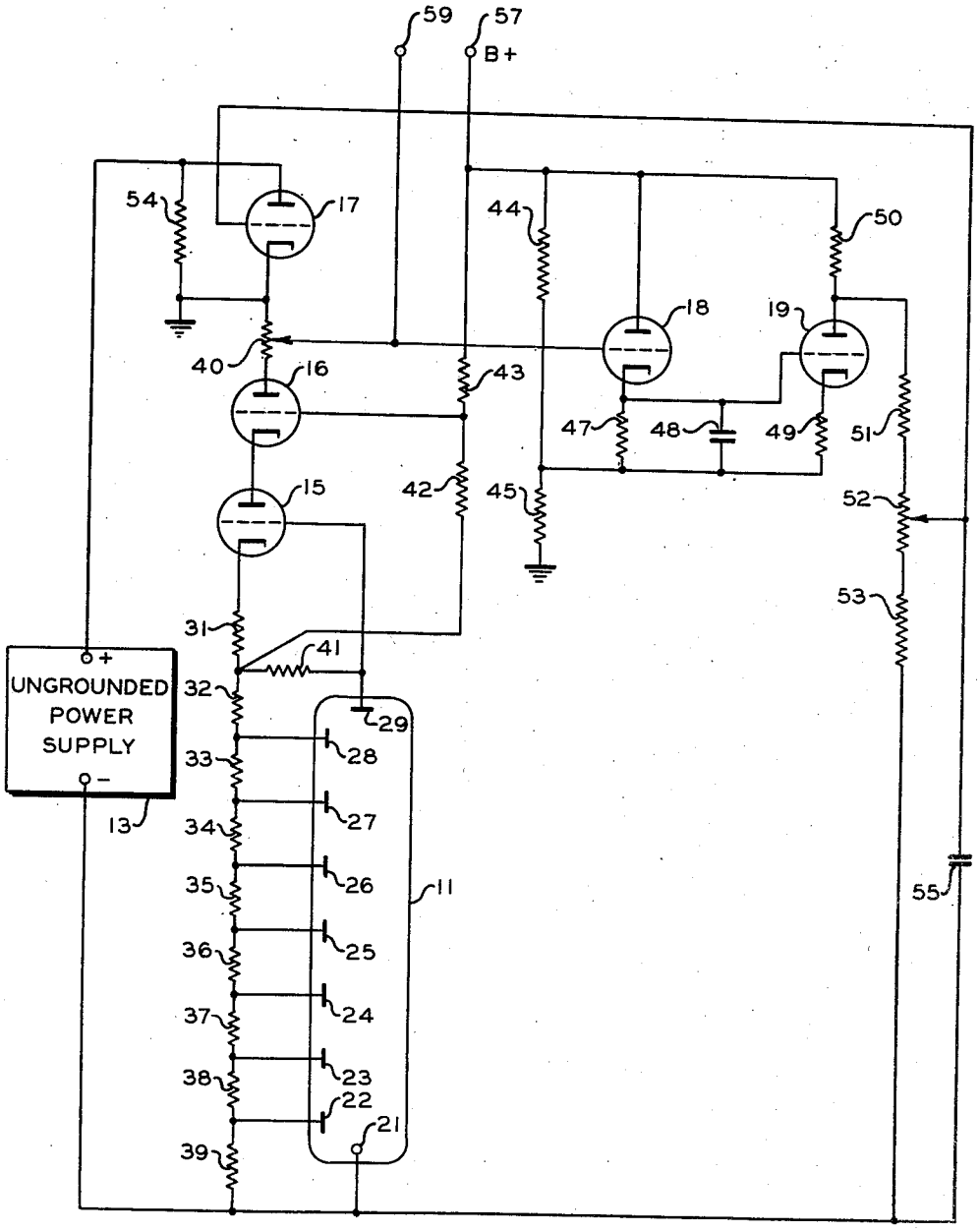
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AUTOMATIC GAIN CONTROL CIRCUIT FOR ELECTRON MULTIPLIER PHOTOTUBES

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AUTOMATIC GAIN CONTROL CIRCUIT FOR ELECTRON MULTIPLIER PHOTOTUBES

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This invention applies to electronic control systems and more particularly to automatic gain control systems for electron multiplier phototubes.

Heretofore the operation of electron multiplier phototubes has been erratic such that in some instances the final stages of electron multiplication within the phototube saturated so that the output of the phototube no longer distinguished between different light levels at the input.

The general object of the present invention is to overcome the foregoing difficulties.

Another object of the present invention is to provide an automatic gain control system for electron multiplier phototubes so as to prevent saturation of any of the stages of the phototube.

These and other objects will be apparent from the following specification when taken with the drawing, the single figure of which is a schematic diagram of one form of the invention.

Referring to the drawing, an automatic gain control system for electron multiplier phototube 11 is shown having an ungrounded source of voltage 13 and a variable resistance electron tube 17 connected in series with voltage source 13 and phototube 11. Electron tubes 18 and 19 are energized by the signal output of the phototube appearing at terminal 59. Tube 18 has in its cathode output circuit a comparatively long time constant circuit comprising resistor 47 and condenser 48 in parallel. The output from tube 19 is coupled back to the grid of tube 17 to control its grid bias. This, in turn, controls the voltages applied to the phototube 11 and thus the gain thereof. Electron tubes 15 and 16 in series form a cascade amplifier to amplify the signal output of phototube 11 before it appears at output terminal 59.

Electron multiplier phototube 11 has as its electrodes a light sensitive cathode 21, a final anode or collector 29, and intermediate anodes or secondary emitters 22, 23, 24, 25, 26, 27, and 28. It is to be understood that phototube 11 need not be limited to the number of electrodes or to the particular multiplier structure as shown in the drawing. A bleeder comprising resistors 31, 32, 33, 34, 35, 36, 37, 38, and 39 in series is used to apply successively more positive voltages from voltage source 13 to successive electrodes of phototube 11, photoelectric cathode 21 being the most negative, anode 22 being more positive, and so on with final anode 29 being most positive.

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In electron multiplier phototube 11 the current at the final anode 29 is

$$i = i_0 g^n$$

where

i_0 is the current emitted by cathode 21,
g is the ratio of secondary to primary electrons at each intermediate anode, 22 through 28, and
n is the number of such intermediate anodes.

Also g is proportional to the voltage between intermediate electrodes which in turn is dependent on the voltage applied across the bleeder made up of resistors 31 through 39. In the present invention, apparatus is provided to automatically control this voltage and thus the gain of phototube 11. It is obvious that large changes of gain can be obtained with small changes of voltage.

As an example of the application of this invention in a radar training device the input to the phototube 11 is a modulated light source. It is necessary that the output voltage at terminal 59 be a faithful reproduction of the modulated light source input. If the final stages of phototube 11 should saturate all or part of the input modulation would be lost at the output.

To prevent any saturation of the final stages of phototube 11 bleeder resistors 31 through 39 are energized from an ungrounded power supply 13 through electron tubes 15, 16, and 17 in series. The junction of resistors 31 and 32 are also connected to a positive potential applied at terminal 57 through resistors 42 and 43 in series. If the grid bias of electron tube 17 is increased its plate resistance will increase and therefore the voltage across bleeder resistors 31 through 39 will decrease reducing the gain of phototube 11. A resistor 54 is connected in parallel with tube 17 to provide a shunt path in the event that tube 17 should become non-conducting. Likewise resistors 42 and 43 provide a shunt path about tubes 15 and 16. Resistors 42 and 43 also serve as a voltage divider, their junction being connected to the grid of tube 16 to determine its fixed bias and thus the operating points of tubes 15 and 16.

Final anode 29 is connected to the junction of resistors 31 and 32 through resistor 41 which acts as the load resistor for phototube 11. As the current at final anode 29 increases due to an increased light input at cathode 21 the voltage at anode 29 becomes more negative. Since anode 29 is directly connected to the grid of tube 15

its plate potential goes in a positive direction. The plate of tube 15 is directly connected to the cathode of tube 16 whose grid is at a fixed potential. Therefore, due to the above conditions, the plate of tube 16 and the voltage at output terminal 59 goes in a positive direction. Likewise, if the light input had decreased the output voltage at terminal 59 would go in a negative direction.

Resistors 44 and 45, connected in series to ground from a positive potential applied at terminal 57, comprises a voltage divider to determine the fixed cathode bias of tube 18. The grid of tube 18 is connected to the output voltage appearing at potentiometer 40 which is so set that tube 18 will be non-conducting with a very low level or zero light input to phototube 11. Tube 18 has its cathode connected to the grid of tube 19 and to a comparatively long time constant circuit comprising the parallel combination of resistor 47 and condenser 48. As the light input to phototube 11 increases tube 18 begins to conduct charging condenser 48 rapidly and raising the grid potential of tube 19. Thus the plate of tube 19 rapidly drops in potential. A voltage divider, comprising the series combination of resistors 50, 51 and 53 and potentiometer 52, is connected from a positive potential at terminal 57 to the negative terminal of power supply 13. The plate of tube 19 is connected to the junction of resistors 50 and 51. The output of this circuit at the variable arm of potentiometer 52 is coupled back to the grid of tube 17 to control its bias. The resistors 50, 51, and 53 are chosen and potentiometer 52 set so that with a low level light input to the phototube 11 the grid of tube 17 will be at essentially ground potential and tube 17 will have a low plate resistance. Larger light inputs will cause tube 17 to increase its plate resistance.

In the above electron tube circuit, tube 18 with resistor 47 and condenser 48 is essentially a peak detector when a modulated light input is used. It, with the other circuits, automatically controls the gain of phototube 11 on the basis of the strongest light input so that no stages of phototube 11 saturate. Tube 18 also serves the purpose of isolating output terminal 59 from the long time constant circuit of resistor 47 and condenser 48. Tube 19 is an amplifier and is self-biased by its cathode resistor 49. Condenser 55 is connected from the variable arm of potentiometer 52 to the negative terminal of power supply 13 and prevents any rapid fluctuations in the gain of phototube 11.

The invention described in the foregoing specification need not be limited to the details shown, which are considered to be illustrative of one form the invention may take. It is to be understood that the cascade amplifier of tubes 15 and 16 may be eliminated or replaced by any other amplifier giving the desired gain. It is also to be understood that the electron tube circuit (tubes 18 and 19) may readily be replaced by any other combination of electron tubes and a comparatively long time constant circuit.

What is claimed is:

1. An automatic gain control system for an electron multiplier phototube comprising, a source of voltage for the electrodes of said phototube, means for connecting a variable resistance element in series with said voltage source and said electrodes, and means coupled between the output circuit of said electron multiplier phototube and said variable resistance and responsive to the output signal amplitude of said phototube for controlling the resistance of said variable resistance element to control the voltages applied to said electrodes thereby controlling the gain of said electron multiplier phototube.

2. An automatic gain control circuit for an electron multiplier phototube having as its electrodes a light sensitive cathode, a final anode, and a plurality of intermediate anodes, said gain control circuit comprising, a source of potential having the negative terminal thereof connected to said cathode, a potential divider including a plurality of terminals having successively more positive voltages when said divider is coupled to the positive terminal of said potential source, means connecting said terminals to said cathode and to said plurality of intermediate anodes so that successive intermediate anodes are connected to terminals successively more positive than the preceding intermediate anode and more positive than said cathode, an output circuit coupled to said electron multiplier phototube, an electron tube having a variable plate resistance controlled by the grid bias applied to said tube, said tube being connected in series with said source of potential and said potential divider, and means coupled between said output circuit and the grid circuit of said electron tube for controlling the grid bias of said variable resistance electron tube in accordance with the amplitude of the output signal from said phototube, thereby to control the voltages applied to said electrodes and the gain of said electron multiplier phototube.

3. The apparatus of claim 2 wherein the means for controlling the grid bias of said variable resistance electron tube comprises an electron tube circuit energized by the signal output of said phototube, said circuit comprising a second electron tube and a comparatively long time constant circuit, the output of said second electron tube being coupled back to the grid circuit of said first mentioned electron tube to control the gain of said electron multiplier phototube on the greater signal outputs thereof.

4. An automatic gain control circuit for an electron multiplier phototube having a cathode, a final anode, and a plurality of intermediate anodes, said control circuit comprising, a voltage dividing network connecting said cathode, said intermediate anodes and said final anode, an output circuit coupled to said final anode, a voltage source, variable impedance means coupling said voltage source to said voltage dividing network, and means coupled to said variable impedance means and said output circuit for altering the impedance of said variable impedance means in accordance with the maximum amplitude of the output signal from said phototube.

5. An automatic gain control circuit for an electron multiplier phototube having a cathode, a final anode, and a plurality of intermediate anodes, said control circuit comprising a load impedance coupled to said final anode, a voltage dividing network connecting said cathode, said intermediate anodes and said load impedance, a voltage source, variable impedance means coupling said voltage source to said dividing network, peak detecting means coupled to said load impedance, said peak detecting means having the output thereof coupled to said variable impedance means to control the impedance thereof.

6. An automatic gain control circuit for an electron multiplier phototube having a cathode, a final anode, and a plurality of intermediate

anodes, said control circuit comprising a load impedance coupled to said final anode, a voltage dividing network connecting said cathode, said intermediate anodes and said load impedance, a voltage source, an electron tube having a variable anode-cathode resistance controlled by the grid bias applied to said tube, said electron tube coupling said voltage source to said divider through said anode-cathode resistance, a peak detecting means coupled to signals appearing across said load impedance, said peak detecting means having the output thereof coupled to said electron tube to control the bias thereof.

7. An automatic gain control circuit for an electron multiplier phototube having a cathode, a final anode and a plurality of intermediate anodes, said control circuit comprising, a load impedance coupled to said final anode, a voltage dividing network connecting said cathode, said intermediate anodes and said load impedance, a voltage source, an electron tube having a variable anode-cathode resistance controlled by the grid bias applied to said tube, said electron tube coupling said voltage source to said divider through said anode-cathode resistance, an amplifier coupled to said load impedance, a peak detecting means coupled to said amplifier and having the output thereof coupled to said electron tube to control the bias thereof whereby the gain of said phototube is determined by the peak amplitude of signals in the output thereof.

8. Apparatus as in claim 7 wherein said peak-detecting means includes an output circuit having a time constant that is long compared to the duration of individual fluctuations in signals in the output of said phototube multiplier.

9. A gain control circuit as in claim 7 wherein the output of said peak detecting means is coupled to said electron tube through a second voltage dividing means, said second voltage dividing means including a means for preventing rapid variations in the bias of said electron tube.

10. An electron multiplier phototube amplifier stage with automatic gain control, said amplifier stage comprising, an electron multiplier phototube having a cathode, a final anode and a plurality of intermediate anodes, a voltage dividing network connecting said cathode, said intermediate anodes and said final anode, a voltage source, variable impedance means coupling said voltage source to said voltage dividing network, and means coupled between the output of said amplifier stage and said variable impedance means for altering the impedance of said variable impedance means in a direct relationship to the alteration of the maximum amplitude of the output signal from said amplifier stage occurring within a preselected time interval.

11. An automatic gain control circuit for an electron multiplier phototube having a cathode, a final anode, and a plurality of intermediate anodes, said control circuit comprising, a load impedance coupled to said final anode, a voltage dividing network connecting said cathode, said intermediate anodes and said load impedance, a voltage source, variable impedance means coupling said voltage source to said dividing network, detecting means including a triode electron tube and resistance-capacitance circuit connected in the anode-cathode circuit of said triode electron tube, means coupling the grid circuit of said triode electron tube to said load impedance and means coupling said detecting means to said variable impedance means to control the impedance thereof in direct relationship to the alteration of the maximum amplitude of the output signal from said phototube occurring within a preselected time interval.

12. An electron multiplier phototube amplifier stage with automatic gain control, said amplifier stage comprising, an electron multiplier phototube having a cathode, a final anode and a plurality of intermediate anodes, the signal to be amplified being applied to said cathode of said phototube, a load impedance coupled to said final anode, a voltage dividing network connecting said cathode, said intermediate anodes and said load impedance, a voltage source, variable impedance means coupling said voltage source to said dividing network, detecting means coupled to said load impedance, said detecting means being adapted to produce an output signal proportional in amplitude to the amplitude of the amplified input signal, said detecting means having the output thereof coupled to said variable impedance means to control the impedance thereof in accordance with the amplitude of the output signal from said amplifier stage.

13. An electron multiplier phototube amplifier stage with automatic gain control, said amplifier stage comprising an electron multiplier phototube having a cathode, a final anode, and a plurality of intermediate anodes, the signal to be amplified being applied to said cathode of said phototube, a load impedance coupled to said final anode, a source of bias voltages coupled to said cathode, said intermediate anodes and said load impedance, detecting means coupled to said load impedance, said detecting means having the output thereof coupled to said source of bias voltages to control the amplitude of said bias voltages in direct relationship with the changes in amplitude of the output signal from said amplifier stage.

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