June 10, 1969 B. J. STALP 3,449,619

APPARATUS FOR CONTROLLING THE VOLTAGE ON AN ELECTRON TUBE ELEMENT

Filed April 21, 1967

FIG. 1

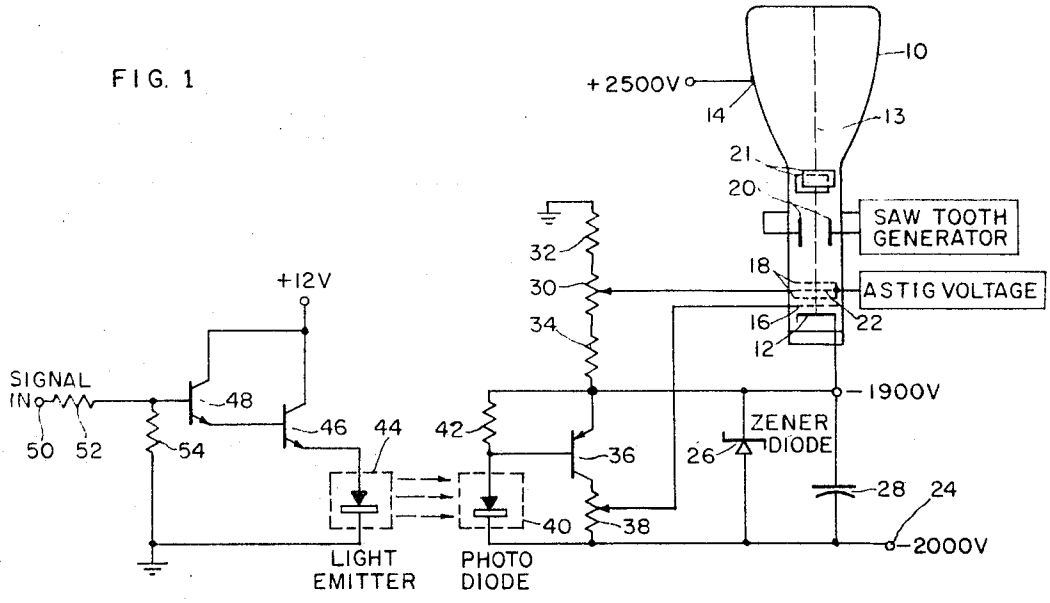
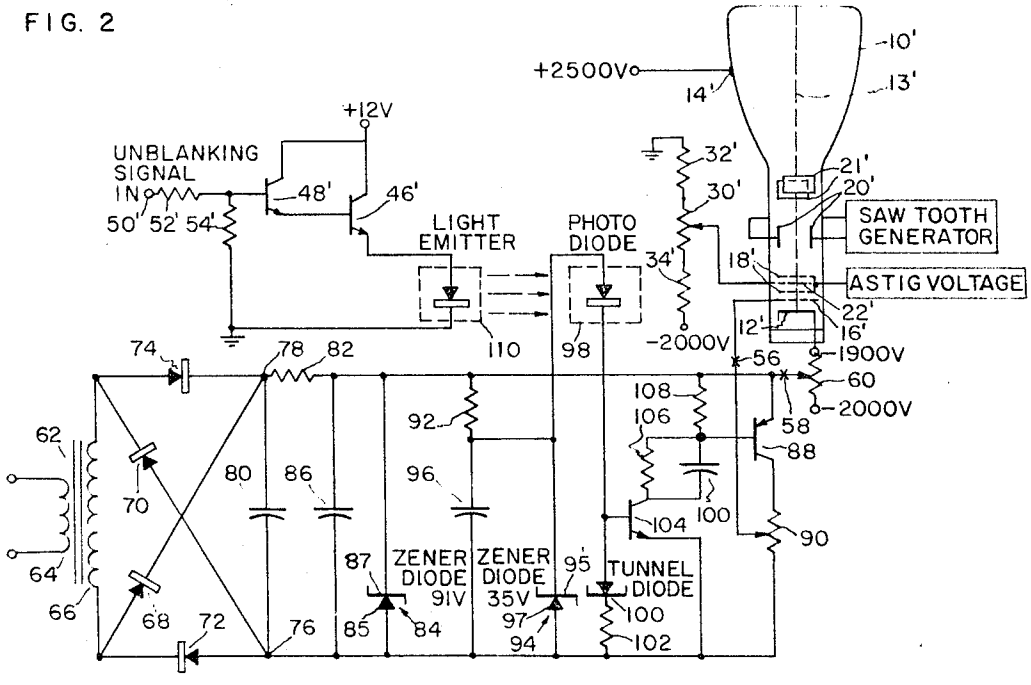


FIG. 2



BERNARD J. STALP
INVENTOR

BY
BUCKHORN, BLORE, KLARQUIST & SPARKMAN
ATTORNEYS

United States Patent Office 3,449,619
Patented June 10, 1969

3,449,619

APPARATUS FOR CONTROLLING THE VOLTAGE ON AN ELECTRON TUBE ELEMENT

Bernard J. Stalp, Hillsboro, Oreg., assignor to Tektronix, Inc., Beaverton, Oreg., a corporation of Oregon

Filed Apr. 21, 1967, Ser. No. 632,706
Int. Cl. H01j 31/26
U.S. Cl. 315—10 10 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for applying a modulating control signal at a low voltage level to an element of an electron tube connected to a higher voltage supply. A modulating signal operates a light source for illuminating light-sensitive means connected in a circuit at the higher voltage level of the electron tube element. A DC voltage differential or bias applied to such tube element is altered in accordance with the modulation.

Background of the invention

The present invention relates to an apparatus for controlling the voltage on an electron tube element and more particularly to improved apparatus for modulating a high potential electron tube terminal with a low voltage level signal.

Electron tubes, such as cathode-ray tubes, traveling wave tubes and the like, include elements which must be maintained at extremely high voltages, e.g., on the order of several thousand volts, for proper operation of the tube. One example is the control grid of a cathode-ray tube which may be operated at a negative voltage of several thousand volts with respect to ground. It is frequently desired to apply modulation to such control grid for varying the intensity of the electron beam in the cathode-ray tube, or for shutting the beam off and then turning it on during blanking and unblanking periods. The modulating or unblanking signal is conventionally generated in circuitry at a much lower voltage level with respect to ground. For example, low voltage level circuitry may produce unblanking pulses having a voltage near ground level and timed with respect to the sweep voltages applied to horizontal deflection means in the cathode-ray tube. Capacitive coupling or the like is frequently not suitable for providing the proper signal to the control grid, particularly in the case of an unblanking pulse which is to be applied for the duration of a horizontal cathode-ray tube sweep. DC coupling means is normally more desirable.

A successful unblanking circuit heretofore employed includes a high-voltage negative power supply means for the control grid which is somewhat separate from the high-voltage negative power supply means connected to the cathode element of the cathode-ray tube. The additional high-voltage negative power supply means is in this case referenced to a low-voltage level unblanking signal. Although effective, this system involves the expense and added complexity of extra high-voltage power supply circuitry.

Summary of the invention

According to the present invention, an element of an electron tube, such as the cathode-ray tube, is maintained at a high-voltage derived from a high-voltage supply, and

a DC voltage differential or bias is provided to such element at the high level. The differential voltage or bias is in turn controlled by an amplifier receiving its input from a light-sensitive cell. The modulating signal is then applied, at a much lower voltage level, to operate a light source for illuminating the light-sensitive cell and controlling the same. Since the low voltage and high voltage circuits are completely separated or isolated except for a light path, the low voltage modulating signal is effective to modulate the tube element voltage without being elevated to a high-voltage level by an additional high-voltage power supply circuit or the like.

It is accordingly an object of the present invention to provide an improved apparatus for modulating a high-voltage element of an electron tube.

It is another object of the present invention to provide improved means for effectively unblanking the control grid of a cathode-ray tube without requiring high-voltage power supply circuitry for elevating the voltage level of the unblanking signal to the voltage level of the control grid.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention, however, both as to organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

Drawings

FIG. 1 is a schematic diagram of a first circuit comprising a first embodiment of the present invention; and

FIG. 2 is a schematic diagram of a circuit comprising a second embodiment of the present invention.

Detailed description

Referring to FIG. 1, an electron tube **10**, here comprising a cathode-ray tube, includes a cathode **12** for emitting an electron beam **13**, a post-accelerating anode **14** suitably connected to a high positive voltage, a control grid **16**, astigmatism anode elements **18**, horizontal deflection plates **20**, vertical deflection plates **21**, and a focusing element **22**. Cathode **12** is connected to a terminal **24**, which is maintained at a high negative voltage, e.g., approximately —2000 volts, through a constant voltage dropping Zener diode **26**. The voltage drop across diode **26** is taken to be approximately 100 volts; therefore approximately —1900 volts appears at cathode **12**. The voltage drop across the Zener diode provides a regulated low DC differential voltage or bias for application to the control grid **16** of tube **10**, as will hereinafter become more apparent. Zener diode **26** is shunted by capacitor **28** used to aid in suppressing currents across the diode during switching transients and the like so that the Zener diode may hold a constant voltage. Focusing element **22** is connected to the movable tap of a potentiometer **30**, included in a voltage divider additionally comprising resistors **32** and **34** located on either side of the potentiometer **30** and connected respectively to ground and the —1900 volt point.

Also connected across the Zener diode is an amplifier including a PNP transistor **36** having its emitter connected to the —1900 volt point and having its collector coupled to the —2000 volt terminal **24** through potentiometer

38, the movable tap of which is connected to control grid 16. A light-sensitive means 40, suitably in the form of a photodiode, has its emitter connected to terminal 24, and its collector coupled to the base of transistor 36. Likewise, the collector of means 40 is coupled through dropping resistor 42 to −1900 volts.

Light-sensitive means 40 is positioned to receive light from a light source or light emitter 44, the latter desirably taking the form of a light-emitting diode. The cathode of light emitter 44 is suitably grounded while the anode thereof is connected to the emitter of NPN transistor 46. The base of transistor 46 is in turn connected to the emitter of NPN transistor 48 and the base of the latter transistor is coupled to input terminal 50 through input coupling resistor 52. Input resistor 54 is interposed between the base of transistor 48 and ground while the collectors of both transistors 46 and 48 are connected to a low positive voltage. Transistors 46 and 48 comprise an amplifier.

In operation of the circuit of FIG. 1, a single input, which may be either a pulse signal as in the case of an unblanking signal, or alternatively a variable modulating signal, is provided as the input at terminal 50. Such signal input is amplified in the amplifier comprising transistors 48 and 46 to provide current gain, both such transistors being connected in an emitter follower configuration. Thus, variations in signal input produce changes in current which are provided to light emitter 44 whereby to produce a variable amount of light therefrom directed toward light-sensitive means 40.

Light-sensitive means 40 is supplied current through resistor 42, and as varying illumination is received from light emitter 44, the resistance of means 40 changes so that a variable voltage corresponding thereto is supplied to the base of transistor 36. Transistor 36 in turn draws a corresponding amount of current through potentiometer 38 causing the voltage to vary at the movable tap thereof. This voltage is directly connected to modulate the control grid 16. When little or no current passes through transistor 36, the control grid 16 will reside near -2000 volts, suitably biasing the grid to cut off whereby the electron beam in tube 10 is in effect shut off or blanked. However, as a variable amount of current flows through potentiometer 38 corresponding to the signal input at terminal 50, the voltage at control grid 16 will vary in a less negative voltage range to modulate the electron beam in tube 10, depending, of course, on the setting of the movable tap of potentiometer 38.

The signal applied at input terminal 50 is suitably an unblanking pulse for rendering visible the trace of the electron beam 13 in tube 10, as at times when the beam is deflected in a given direction by deflection plates 20. Such unblanking pulse is referenced to ground and moreover such signal will comprise a fairly low voltage pulse having an amplitude of a few volts or at the most a few hundred volts. This unblanking pulse is thus applied through the medium of light for controlling or varying the low DC voltage differential or bias on the control grid in the desired manner, even though the control grid is maintained at a much higher voltage level with respect to ground. No extra high voltage grid power supply circuitry is required. Other signals besides an unblanking signal can be similarly applied to input terminal 50 so as to modulate the control grid 16 and thereby continuously provided "Z-axis" modulation of electron beam 13. Such a signal should have a level for maintaining the grid above the blanking level.

When the term "light" is used in the present application, it is meant to include similar radiation, e.g., in or near the visible region, for example in the infrared region. In the latter case, light emitter 44 may comprise a gallium-arsenide diode. Such a diode, when employed with a suitable light-sensitive means 40 receptive to radiation in the infrared region, is suitable for high operating speeds. Light emitter 44 and light-sensitive means 40 may together comprise a commercially available optically coupled isolator or light path means provided with electric-to-light conversion input and output elements. The light emitter may alternatively comprise a more conventional electrically energized light source and the light-sensitive means 40 may comprise a photocell appropriately connected to provide an input for transistor 36.

FIG. 2 illustrates a second embodiment of the present invention which may be conveniently connected for unblanking purposes and the like in a cathode-ray tube system which is already in use, with a minimum of disturbance of other circuitry. Primed reference numerals in the FIG. 2 circuit refer to elements corresponding to similarly numbered elements described in connection with the circuit of FIG. 1. The circuit has the additional advantage of being less susceptible to damage in case of failure or excessive current in the cathode-ray tube. The circuit illustrated in FIG. 2 may be connected in the control grid lead of an existing circuit between points 56 and 58, theretofore connected together for coupling control grid 16′ to the movable tap of voltage dropping or bias potentiometer 60 also called an intensity control potentiometer.

In the FIG. 2 circuit, a floating low voltage power supply is employed having an AC power input transformer 62 provided with a primary winding 64, appropriately connected to a source of line voltage. Transformer 62 has a secondary winding 66 for supplying at least part of an appropriate voltage differential used for normally biasing the grid 16′ of the cathode-ray tube 10′ at a voltage such that electron beam 13′ is prevented from reaching the face of cathode-ray tube. A bridge rectifier, comprising diodes 68, 70, 72 and 74 connected in a conventional manner, provides a DC output voltage at power supply terminals 76 and 78. A filter, including capacitor 80 shunted across the power supply terminals, a series dropping resistor 82, and a shunt capacitor 86, separates terminals 76 and 78 from Zener diode 84. The regulated voltage available across the Zener diode, here 91 volts, is applied to an output amplifier comprising PNP transistor 88, the emitter-collector path of which is connected in series with potentiometer 90 across Zener diode 84. The control grid 16′ is connected to the movable tap of potentiometer 90, and in the absence of conduction through transistor 88, control grid 16′ will be maintained by the Zener diode at approximately 91 volts negative with respect to the movable tap of potentiometer 60. Zener diode 84 as a part of the floating power supply together with potentiometer 90 here functions to provide voltage dropping means for providing a low DC differential.

A circuit including voltage dropping resistor 92 in series with Zener diode 94 is connected across Zener diode 84. Zener diode 84 drops approximately 35 volts and is shunted by low AC impedance capacitor 96 used to provide current across the diode and to prevent transients from affecting its regulated voltage. Zener diode 94 provides voltage for the circuit including light-sensitive means 98 in series with tunnel diode 100 and resistor 102 connected in that order from cathode terminal 95 to anode terminal 97 of the diode. The junction between light-sensitive means 98 and tunnel diode 100 is coupled to the base of an NPN transistor 104 having its emitter connected to anode terminal 85 of Zener diode 84 and its collector connected to the opposite or cathode terminal 87 of Zener diode 84 through a voltage divider comprising resistors 106 and 108. The collector of transistor 104 is also coupled to the base of transistor 88 since the latter is connected to the midpoint between resistors 106 and 108. In addition, a speed-up capacitor 110 is interposed between the collector of transistor 104 and the base of transistor 88 to enhance coupling.

Light-sensitive means 98, suitably comprising a photodiode or the like similar to light-sensitive means 40 in the previous embodiment, is illuminated by a light source or emitter 110, which may comprise a light-emitting diode as

in the previous embodiment. Light emitter **110** is driven by an amplifier comprising transistors **48'** and **46'** supplying current therefor, operating in a manner similar to similarly numbered elements of the FIG. 1 embodiment.

In operation, it is desired that electron beam **13'** strike the face of cathode-ray tube **10'** only when the beam is being deflected in a given direction thereacross by horizontal deflection plates **20'**. To this end, an unblanking signal is provided at input terminal **50'** substantially coincident with the horizontal deflection signal. The unblanking signal may, for example, be derived from the sawtooth generator connected to the horizontal deflection plates **20'**.

When a positive unblanking pulse, for example, is provided at input terminal **50'**, transistors **48'** and **46'** conduct, causing conduction in light emitter **110** and emission of light therefrom. Light falling upon light-sensitive means **98** provides an increase in current passing from the regulated source including Zener diode **94** through tunnel diode **100**. This increase in current is sufficient to switch tunnel diode **100** very rapidly from its low voltage state to its high voltage state, thereby providing a positive pulse at the base of transistor **104**. This input at the base of transistor **104** causes conduction between the collector and emitter of transistor **104** and the application of a negative going pulse at the base of transistor **88**. Resultant conduction in the latter transistor raises the voltage at the variable tap on potentiometer **90** so as to provide a positive going pulse at the control grid **16'** of cathode-ray tube **10'**. The extent of this voltage increase at grid **16'** will be determined by the setting of the variable tap of potentiometer **90**. Potentiometer **90** is desirably adjusted so that the electron beam **13'** appears only in the presence of an unblanking signal at terminal **50'**. The intensity potentiometer **60** is set at a value for adjusting the desired trace intensity produced by electron beam **13'** when it is not blanked, i.e., when the unblanking signal is presented.

In oscilloscope circuits and the like, the use of the apparatus according to the present invention for unblanking the cathode-ray tube of the oscilloscope reduces the number of component parts and simplifies the unblanking circuits. Although the circuit has been illustrated primarily in connecton with the control of a cathode-ray tube, it is understood that other types of electron tubes having elements normally maintained at a high voltage level may be similarly controlled or modulated according to the present invention using a signal referred to a low voltage reference, or a signal referred to a reference at a substantially different voltage level, as an input thereof. For example, the circuit according to the present invention is advantageously used for modulation of traveling wave tubes.

While I have shown and described several embodiments of my invention, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from my invention in its broader aspects. I therefore intend the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

I claim:

1. In a circuit employing an electron tube having an element maintained near a high voltage level, means for applying modulation to said element from a modulating signal referenced to a substantially different voltage level comprising:

means for receiving said modulating signal including a light source operative in response to said modulating signal for providing a variation in light intensity according to said modulating signal,

means for providing a low DC voltage differential at said element which low DC voltage differential is referenced to said high voltage level,

and means for varying said low DC voltage differential as applied to said element, said last-mentioned means including light sensitive means for receiving light from said light source and producing an electrical variation corresponding thereto, and further including means direct coupling said electrical variation for altering said low DC voltage differential in accordance with light received.

2. The apparatus according to claim **1** wherein said electron tube is a cathode-ray tube and wherein said element is the control grid thereof, said control grid receiving modulation proportional to said modulating signal over a wide frequency range because of said direct coupling.

3. The apparatus according to claim **1** wherein said light sensitive means comprises a photosensitive diode.

4. The apparatus according to claim **1** wherein said light source comprises a light-emitting diode.

5. The apparatus according to claim **1** where said means for providing a low DC voltage differential includes voltage dropping means for coupling said element to a source of high voltage, said electron tube having a second element coupled directly to such high voltage.

6. The apparatus according to claim **1** wherein said means for providing a low DC voltage differential includes a floating low voltage power supply coupled to said element.

7. The apparatus according to claim **1** wherein said means direct coupling said electrical variation for altering said low DC voltage differential includes a tunnel diode responsive to said electrical variation, the voltage across said tunnel diode abruptly changing in response to a predetermined change in electrical value.

8. The apparatus according to claim **1** wherein said means direct coupling said electrical variation for altering said low DC voltage differential includes amplifying means for amplifying said electrical signal, the output of said amplifying means being directly connected to alter said low DC voltage differential.

9. A circuit for operating a cathode-ray tube including a control grid and cathode, said circuit comprising:

means for providing a high negative voltage to said cathode,

a voltage dropping means connected between said last-mentioned means and said cathode,

amplifying means having power supplying terminals disposed across said voltage dropping means and including a direct coupled amplifier device and an impedance forming an output,

means for said amplifier device serially connected between said terminals,

a light-sensitive means connected to provide an input for said amplifying means,

light emitter means for selectively providing light illumination to said light-sensitive means,

amplifier means for operating said light emitter means in response to an input signal,

and means for adjustably direct coupling said control grid to said impedance in said amplifying means.

10. A circuit for operating a cathode-ray tube including a cathode and a control grid, said circuit comprising:

means for providing a high negative potential,

voltage dropping means for coupling said cathode to said high negative potential,

a floating, low voltage DC power supply, one output terminal of which is adjustably connected to said voltage dropping means,

a light sensitive means and a tunnel diode direct coupled in series across terminals of said floating power supply,

a direct coupled amplifier also coupled across said floating power supply and deriving its input from said tunnel diode, said amplifier including an amplifying element and an output impedance means therefor coupled across terminals of said floating power supply,

means for direct coupling said control grid adjustably to said output impedance means,

a light emitter means for providing illumination to said light sensitive means,

and an amplifier for receiving a cathode-ray tube unblanking signal for operating said light emitter means

to cause illumination of said light emitter means in response to said unblanking signal.

References Cited

UNITED STATES PATENTS

2,506,672	5/1950	Kell et al.	178—6
2,815,487	12/1957	Kaufman	332—3
3,215,853	11/1965	Corradetti	307—311 X
3,283,237	11/1966	Williams et al.	307—311 X
3,293,483	12/1966	Engel	315—10

RODNEY D. BENNETT, JR., *Primary Examiner.*

R. E. BERGER, *Assistant Examiner.*

U.S. Cl. X.R.

250—206; 315—30, 158; 332—3

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,449,619 Dated June 10, 1969

Inventor(s) BERNARD J. STALP

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 50, after "DC", insert -voltage--.

Column 5, lines 40 through 45, should be deleted, beginning with "amplifying means" and ending with "said terminals", and rewritten as a single paragraph, as follows:

--amplifying means having power supplying terminals disposed across said voltage dropping means and including a direct coupled amplifier device and an impedance forming an output means for said amplifier device serially connected between said terminals,--

SIGNED AND
SEALED
MAR 24 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents