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OSCILLOSCOPE

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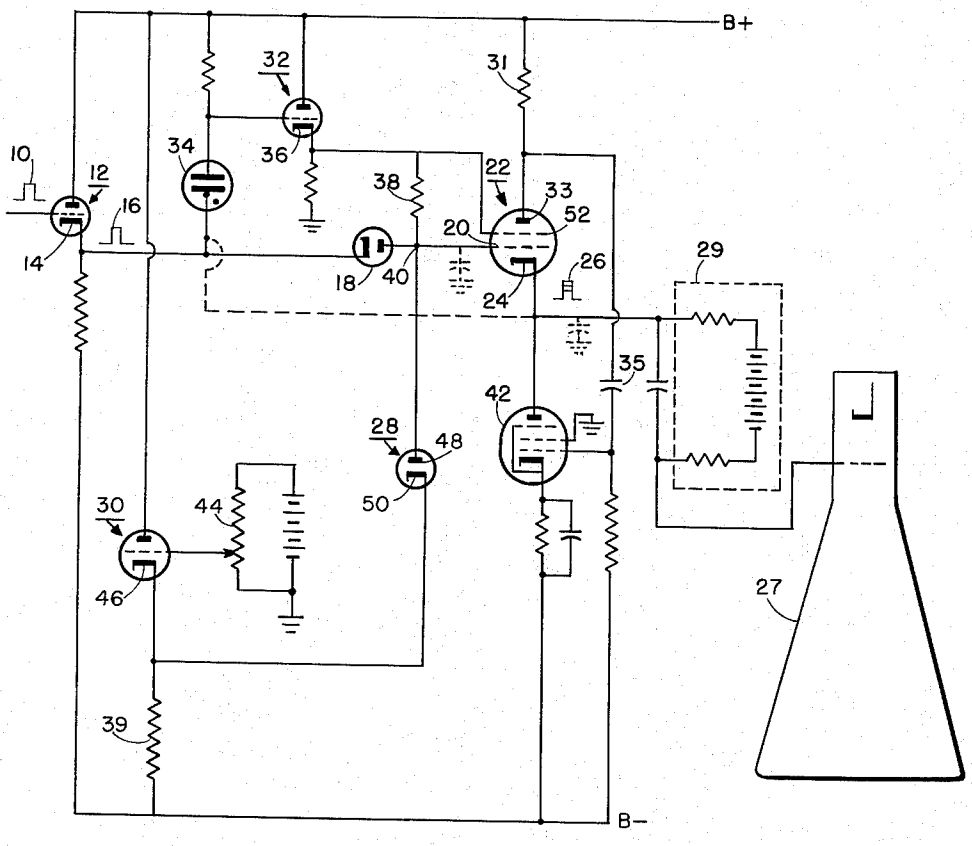

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This invention relates to an oscilloscope, and more particularly to a brightening circuit therefor.

In an oscilloscope, electrical input signals are converted to a visible display, the display itself being produced by a cathode ray tube whose screen glows where impinged upon by a beam of electrons. The point of impingement moves when the beam is deflected, and the resultant fluorescent spot of light therefore also moves. In this way the moving light spot is said to "write," thus producing the display. The display itself may be bright or dim, depending upon the number of impinging electrons. Since various conditions (ambient light, contrast requirements, etc.) change from time to time the brightness is preferably adjustable.

Sequential displays are produced by repositioning the electron beam to its original starting point, an operation known as "retrace." If, however, the electron beam were permitted to write during the retrace interval, the resultant visible line could cause confusion. To prevent this, the electron beam is "cut off," so that the retrace is "blanked out," or invisible.

In order to control the display brightness, its duration, retrace blanking, synchronization of the display with incoming signals, etc., a so-called "brightening pulse" is used to control the electron beam. The pulse's amplitude determines the brightness of the display, while its shape, frequency, etc., control the other features.

The application of this brightening pulse to the control grid of the cathode ray tube introduces problems, since in modern day oscilloscopes the cathode ray tubes use high voltages, often several thousand volts. The deflection plates of the tube are preferably at ground potential, so the potential at the cathode is placed thousands of volts below ground. Since most of the other oscilloscope circuitry is at substantially ground potential, it becomes difficult to couple the brightening pulse which is near ground potential, to the control grid of the cathode ray tube which is several thousand volts below ground. Many brightening pulse coupling systems have been suggested, but most of them are complex, expensive, cumbersome, or have poor high or low frequency response.

When the brightness was varied by most prior art circuitry, a phenomenon known as "loss of base line" was introduced. This deleted the early portions of the display, a result which was highly objectionable. Copending application Serial No. 678,217 by Samuel Solow, now Patent No. 2,884,562, issued April 28, 1959, entitled Brightness Control Circuit, discloses one way of controlling brightness without loss of base line.

It is therefore the principal object of my invention to provide an improved variable pulse amplitude control system.

It is another object of my invention to provide an improved brightening circuit for an oscilloscope.

The attainment of these objects and others will be realized from the following specification, taken in conjunction with the single figure of the drawing which is a schematic diagram of the circuit of my invention.

The operation of my circuit may be understood from the drawing and the following explanation.

In this description, "upvolting" means raising the potential without signifying that the potential is positive, negative or undergoes any changes in sign; "downvolting" means lowering the potential; and "cathode follower

action" means that the cathode potential follows the potential changes applied to the grid.

Basically, my circuit operates as follows. Fixed amplitude control pulse **10** is applied to input tube **12** which, by cathode follower action, produces at its cathode **14** a "brightening gate" **16**. This is applied through decoupling tube **18** to control grid **20** of output tube **22**, which in turn produces at its cathode **24** a brightening pulse **26**. This pulse is applied to the grid of the cathode ray tube **27** to control the brightness thereof. The amplitude of brightening pulse **26** is controlled by a clamping diode **28** working in conjunction with brightness control tube **30**.

The following detailed explanation will provide an even better understanding of my invention. A control signal **10** is obtained from an ancillary circuitry in a manner well known in the art. Control signal **10**, of course, has the requisite amplitude, repetition rate, shape, and characteristics. It also has a fixed base level. When control pulse **10** is applied to input tube **12**, connected as a cathode follower, cathode **14** produces brightening gate **16**. This is applied through a "bootstrapping" arrangement, such as a voltage regulator tube **34**, to "assist" tube **32**, also connected as a cathode follower. Its output electrode, cathode **36**, is thus upvolted at substantially the same rate, and to the same extent as cathode **14**. This means that resistance **38** and decoupling diode **18** are connected in series across the substantially constant voltage between cathodes **14** and **36**. Proper selection of the value of resistance **38** leaves enough voltage across decoupling diode **18** to keep it conductive. Since decoupling diode **18** has only a small voltage drop thereacross when it is conductive, point **40** is therefore upvolted and downvolted correspondingly with cathode **14** and gate **16**. Thus point **40** applies to control grid **20** a waveform which is substantially identical with gate **16**. Cathode follower action of output tube **22** causes cathode **24** to produce brightening pulse **26**. Tube **22** may use a resistance as its cathode load, but I prefer to use tube **42** as a constant current device to improve cathode follower action. The action of tube **42** will be discussed later. My circuit, as thus far described, will produce a brightening pulse **26**.

In order to control the brightness of the cathode ray tube, the amplitude of brightening pulse **26** must be adjustable. If a low brightness is desired, potentiometer **44** is set at a low potential. Cathode follower action of "brightness control" tube **30** establishes its cathode **46** at substantially the same potential. Cathode **50** of clamping diode **28** is therefore also at substantially the same potential.

Gate **16**, acting through elements **34**, **32**, **38**, and **18** as previously described, upvolts point **40**, grid **20** and anode **48** of clamping diode **28**. When the potential at anode **48** exceeds the potential at cathode **50**, which is fixed by potentiometer **44** and tube **30**, diode **28** becomes conductive. It therefore clamps the potential at point **40** to the value established by potentiometer **44**, thus preventing point **40** from any further upvolting. Control grid **20** is therefore clamped and, by cathode follower action, brightening pulse **26** has imposed thereon an upper limit, that in turn limits the brightness at the cathode ray tube.

Since control signal **10** has a fixed amplitude, which has not yet been reached, it continues to upvolt cathode **14** and the cathode of decoupling diode **18**. Since the anode thereof is clamped, upvolting its cathode causes it to become non-conductive, thus decoupling control signal **10** from brightening pulse **26**.

To achieve higher brightness, potentiometer **44** is set for progressively higher potentials. The operation of my circuit is the same as above.

When maximum brightness is desired, potentiometer

44 is set at its highest value. With this setting, cathode 50 of the clamping diode 28 is at such a high value that it is never exceeded by the potential at point 40 and anode 48. Tube 28 remains non-conductive. Clamping is therefore not achieved, and the brightness rises to its maximum. Potentiometer 44 thus acts as the brightness control.

It was shown that assist tube 32 supplied the operating potential for decoupling diode 18. Tube 32 also improves the operation of output tube 22 because its cathode 36 is connected to screen grid 52 of tube 22. While in output tube 22 the control grid 20 is upvolted directly by gate 16, the screen grid 52 is upvolted by gate 16 acting through voltage regulator tube 34 and assist tube 32. The result, as far as output tube 22 is concerned, is to simultaneously upvolt its screen grid and its control grid, thus reducing the effects of stray capacitance at the control grid and providing a better brightening pulse 26.

The connection to screen grid 52 has the following disadvantage. When control grid 20 is clamped, the continued upvolitng action of gate 16 operating through tube 32, causes the signal applied to screen grid 52 continue to rise. This means that the output, brightening pulse 26, is not completely clamped but tends to increase slightly. Its top would therefore slope upwards. To overcome this condition, voltage regulator tube 34 may be disconnected from cathode 14 and instead connected to cathode 24 of output tube 22 as shown by the dotted lines. In this way, when the output is clamped, the signal applied to screen grid 52 is also clamped. Tube 32 operates in the same manner as previously described except that, instead of being energized by cathode 14, it is now energized by the potential at cathode 24.

There is also another disadvantage in connecting tube 32 to cathode 14. After decoupling diode 18 is rendered non-conductive, and point 40 is supposedly clamped through tube 28, cathode 36 is still being upvolted. This causes a current flow through resistance 38, diode 28, and cathode load resistance 39. The current flow tends to slightly upvolt point 40 and brightening pulse 26, which are supposedly clamped. Disconnecting tube 34 from cathode 14, and connecting it to cathode 24, as suggested, overcomes this shortcoming also. Now when output pulse 26 at cathode 24 is clamped, so is tube 32. This suggested modification therefore eliminates two types of brightening pulse degradation.

Brightening pulse 26, which is near ground potential, must now be applied to the cathode ray tube's control grid which is several thousand volts below ground. I use a floating potential source 29 which, with its stray capacitance decoupling resistances, assures proper potential relationships so that in the absence of brightening pulse 26, the cathode ray tube is dark but is brightened as soon as brightening pulse 26 is applied through its coupling capacitance.

Since input signal 10 has a fixed base level, brightening pulse 26 also has a fixed base level. In this way, adjustment of the amplitude of brightening pulse 26 changes the brightness at cathode ray tube 27, but does not introduce any loss of base line.

It is known that stray capacitance exists between the various wires and other elements of a circuit. At high frequencies, stray capacitance becomes more effective and introduces appreciable deterioration of the various signals. If assist tube 32 were not in the circuit, the stray capacitance between ground and control grid 20 would have to be charged up by gate 16. This would degrade the signal at control grid 20, and therefore brightening pulse 26. Due to the action of tube 32, stray capacitance is charged by the current flowing through resistance 38. In this way, the input to tube 22 and its output are not deteriorated by stray capacitance.

Since cathode 24 of output tube 22 is also being upvolted and downvolted, the problem of stray capacitance also exists at that point. I overcome this problem by use of tube 42. This tube primarily acts as a constant current device for cathode follower 22, and therefore improves its action. Tube 42 also minimizes the effect of stray capacitance at cathode 24 in the following manner. At higher frequencies, such as are present in the rapid rise of the brightening pulse 26, more current tends to flow through the stray capacitance. This additional current flows from B+ through resistance 31, and therefore downvolts anode 33 of output tube 22. The downvolting is coupled through capacitance 35 to the control grid of tube 42. There it tends to decrease the current flow therethrough to compensate for the current that charges up the stray capacitance. These same stray capacities are discharged through tube 42 when the pulse falls, since anode 33 upvolts and increases current in tube 42. In this way, constant current conditions are maintained at output tube 22, despite stray capacitance.

While I have described preferred forms of my invention it will be understood that other modifications may be devised without departing from the inventive concept, I wish therefore not to be limited by the foregoing description but, on the contrary, to be limited solely by the claims granted to me.

What is claimed is:

1. A brightening circuit comprising an output tube operating as a cathode follower, and having a control grid and an output electrode; input means producing a brightening gate; means applying said brightening gate to said control grid, said means comprising a unidirectional conducting decoupling tube having input and output electrodes connected in series between said gate producing means and said control grid; and means controlling the amplitude of said brightening gate, said means comprising a source of adjustable potential and a clamping tube, said clamping tube having a first electrode connected directly to said source and a second electrode connected directly to said control grid.

2. A circuit for producing a brightening pulse comprising an output tube operating as a cathode follower, and having a control grid and an output electrode; input means applying a brightening gate to said control grid, said means comprising a unidirectional conducting decoupling tube having a cathode and anode connected in series with said control grid, whereby said brightness gate may be decoupled from said pulse; means controlling the amplitude of said gate, said means comprising a source of adjustable potential and a clamping tube, said clamping tube being connected directly between said control grid and said course, and means controlling the point at which said clamping tube becomes operative, said controlling means comprising an assist tube energized by said gate and having an input and an output electrode and an impedance directly coupling output from said assist tube output electrode to said control grid.

3. A brightening circuit comprising an output tube operating as a cathode follower, and having a control grid, a screen grid and a cathode; input means applying a brightening gate to said output tube, said means comprising a decoupling tube having anode and cathode electrodes, one of said electrodes being connected to said control grid, and the other electrode adapted to receive said brightening gate; means controlling the amplitude of said gate, said means comprising a unidirectional conducting clamping tube having one of its electrodes directly connected to said control grid and having another of its electrodes directly connected to a source of adjustable potential; an assist tube connected to supply output from a cathode electrode; means whereby said assist tube is energized by said gate; and an impedance directly coupling said output from said cathode of said assist tube to said control grid of said output tube and a connection between said assist tube cathode and said screen grid.

4. A brightening pulse producing circuit comprising an output tube operating as a cathode follower, and having a control grid and a cathode where said brightening

pulse appears; input means applying a brightening gate to said output tube, said means comprising a unidirectional conducting decoupling tube having cathode and anode electrodes, one said electrode being connected to said control grid, and the other said electrode adapted to receive said brightening gate; means controlling the amplitude of said gate, said means comprising a unidirectional conducting clamping tube having cathode and anode electrodes, one of said electrodes being connected directly to said control grid and the other said electrode being connected directly to a source of adjustable potential; an assist tube connected to supply output from a cathode electrode; means whereby said assist tube is energized by said brightening pulse from said cathode of said output tube; and an impedance directly coupling said output from said cathode of said assist tube to said control grid of said output tube.

5. A brightening circuit comprising an output tube operating as a cathode follower, and having a control grid, a screen grid, and a cathode; input means producing a brightening gate; means applying said brightening gate to said output tube, said means comprising a decoupling diode having its anode connected to said control grid and having its cathode connected to said gate producing means; means controlling the amplitude of said gate, said means comprising a clamping diode having its anode connected to said control grid, and having its cathode connected to a source of adjustable potential; an assist tube operating as a cathode follower, having a control grid and a cathode; a connection between said control grid of said assist tube and said cathode of said output tube; an impedance connected between said cathode of said assist tube and said control grid of said output tube; and a connection between said cathode of said assist tube and said screen grid, whereby a brightening pulse of adjustable amplitude is produced at said cathode of said output tube.

6. The combination of claim 5 including means for applying said brightening pulse to a cathode ray tube whose brightness is to be controlled.

7. A brightening circuit comprising an output tube operating as a cathode follower, and having a control grid, a screen grid, an anode, and a cathode; a load impedance connected to said anode; a constant current device including a control grid, connected as the cathode load of said output tube; a coupling between said anode of said output tube and said control grid of said constant current device; input means producing a brightening gate; means applying said brightening gate to said output tube, said means comprising a decoupling diode having its anode connected to said control grid of said output tube and having its cathode connected to said gate producing means; means controlling the amplitude of said gate, said means comprising a clamping diode having its anode connected to said control grid of said output tube and having its cathode connected to a source of adjustable potential; an assist tube operating as a cathode follower, said assist tube having a control grid and a cathode; a connection between said control grid of said assist tube and said cathode of said output tube; an impedance connected between said cathode of said assist tube and said control grid of said output tube; a connection between said cathode of said assist tube and said screen grid, whereby a brightening pulse of adjustable amplitude is produced at said cathode of said output tube; and means applying said brightening pulse at said cathode of said output tube to a cathode ray tube whose brightness is to be controlled.

8. A brightening circuit comprising an output tube operating as a cathode follower, and having a control grid, a screen grid, an anode, and a cathode; a load impedance connected to said anode; a constant current device, having a control grid, connected as the cathode load of said output tube; a capacitive coupling connected between said anode of said output tube and said control grid of said constant current device; input means producing a brightening gate, including a cathode follower stage; means applying said brightening gate to said output tube, said means comprising a decoupling diode having its anode connected to said control grid of said output tube and having its cathode connected to said gate producing means; a source of adjustable potential; a brightness control tube connected as a cathode follower, and having a control grid and a cathode; a connection between said control grid of said brightness control tube and said source of adjustable potential; a clamping diode having its anode connected to said control grid of said output tube, and having its cathode connected to said cathode of said brightness tube, whereby the amplitude of said gate is controlled; an assist tube operating as a cathode follower, said assist tube having a control grid and a cathode; a bootstrapping connection between said control grid of said assist tube and said cathode of said output tube; an impedance connected between said cathode of said assist tube and said control grid of said output tube; a connection between said cathode of said assist tube and said screen grid of said output tube, whereby a brightening pulse of adjustable amplitude is produced at said cathode of said output tube; and means applying said brightening pulse from said cathode of said output tube to the control grid of a cathode ray tube whose brightness is to be controlled, said last means including a floating potential source and coupling circuit.

9. The combination comprising input means providing a source of gating pulse; an output stage providing an output brightening pulse, said stage having first and second control electrodes, a common electrode and an output electrode; means applying said gating pulse to said first control electrode; bootstrapping means applying said gating pulse to said second control electrode; and clamping means connected to said first control electrode providing an adjustable potential level at said first electrode to control the amplitude of said brightening pulse at said output electrode.

10. The device of claim 9 including unidirectional conducting decoupling means connected in series between said source of gating pulse and said first control electrode to prevent the application of said pulse above a preselected clamping potential level.

11. The device of claim 9 wherein said clamping means includes a unidirectional conducting diode connected to a source of adjustable potential.

12. The device of claim 9 wherein said output stage is operated as a cathode follower having an anode connected as said common electrode and a constant current device connected as a cathode load.

13. The device of claim 12 including a connection between said anode electrode of said output stage and a control electrode of said constant current device.

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