Jan. 2, 1962 G. WOLF 3,015,753

CIRCUIT FOR CONTROLLING THE SWEEP OF A CATHODE-RAY OSCILLOSCOPE

Filed Jan. 22, 1958 2 Sheets-Sheet 1

FIG. 1

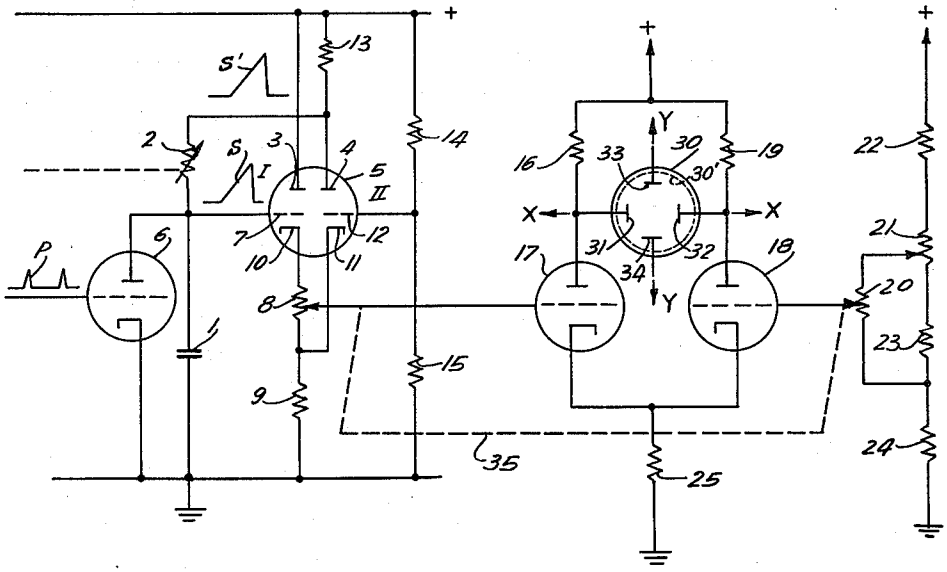
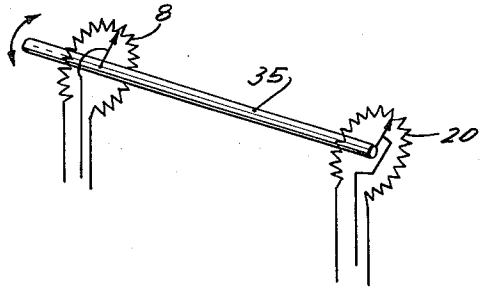


FIG. 3



INVENTOR.
Gerhard Wolf
BY Michael S. Striker
ATTORNEY

Jan. 2, 1962 G. WOLF 3,015,753

CIRCUIT FOR CONTROLLING THE SWEEP OF A CATHODE-RAY OSCILLOSCOPE

Filed Jan. 22, 1958 2 Sheets-Sheet 2

FIG. 2

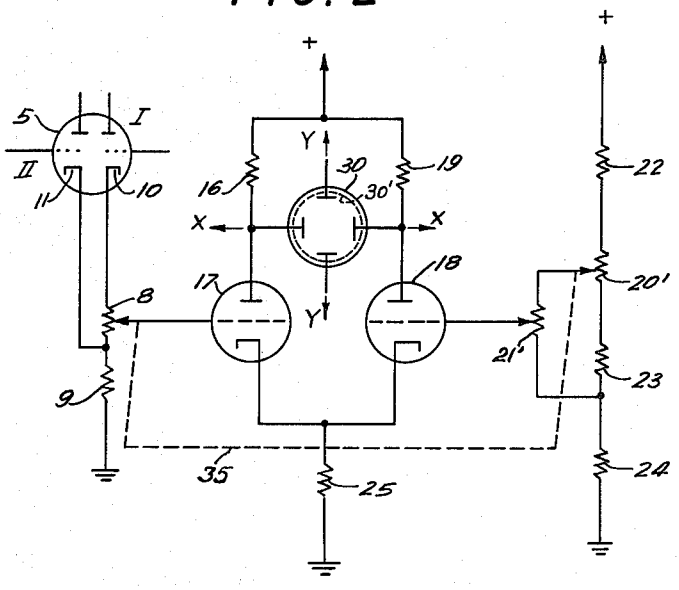
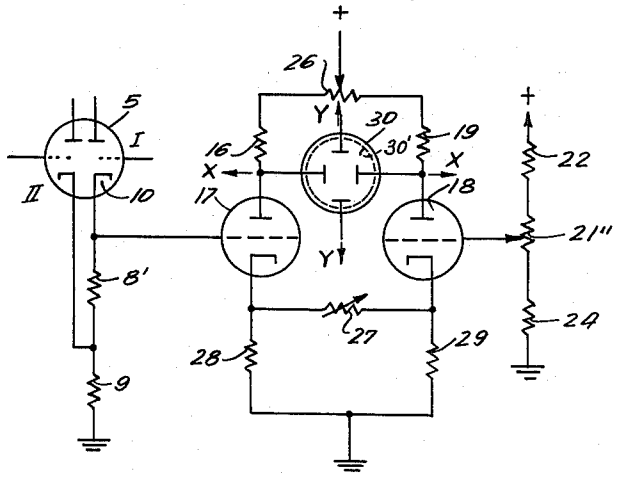


FIG. 4



INVENTOR.
Gerhard Wolf
BY
Michael S. Striker
ATTORNEY

United States Patent Office 3,015,753 Patented Jan. 2, 1962

3,015,753

CIRCUIT FOR CONTROLLING THE SWEEP OF A CATHODE-RAY OSCILLOSCOPE

Gerhard Wolf, 5 Chopin Strasse, Munich, Pasing, Germany

Filed Jan. 22, 1958, Ser. No. 710,550
Claims priority, application Germany Jan. 23, 1957
9 Claims. (Cl. 315—26)

My present invention relates to cathode-ray oscilloscopes, especially those of the broad-band type, in which linearity of sweep is of paramount importance.

Generally, the sweep voltages of cathode-ray tubes used as oscilloscopes or the like are derived from a storage condenser which is periodically charged at a relatively slow rate and discharged at a relatively rapid rate in the rhythm of the desired sawtooth pattern. The discharge of the condenser may be brought about by an extraneous control signal or by the attainment of a critical voltage level at which an associated electron-discharge device is triggered into conductivity to establish a path across the condenser terminal. If the charging current is supplied through a resistor from a source of constant voltage, the condenser voltage varies along an exponential curve which can only in its initial portion be regarded as approximating a straight line; better linearity is obtainable if the resistor is replaced by a constant-current device, such as a pentode tube. In general, known circuit arrangements designed to insure the desired linearity are of considerable complexity and require the selection and maintenance of a multiplicity of critical operating potentials.

An important object of my present invention is to provide an improved circuit arrangement for the purpose described which is of simple design and adapted to produce a succession of virtually perfect sawtooth pulses of widely variable amplitude.

Another object of this invention is to provide an improved sweep circuit for oscilloscopic and other uses enabling the performance of switching operations (e.g. to vary its output amplitude) without giving rise to objectionable transient phenomena such as occur in reactance-coupled circuits.

A further object, allied with the preceding one, is to provide a purely resistance-coupled sweep circuit having means for adjusting the amplitude of its sweep voltage without superimposing an undesired direct-current component upon this voltage.

Still another object of the invention is to provide, in a cathode-ray oscilloscope, simple means for magnifying selected portions of the sweep and for varying the degree of magnification while maintaining a selected point of the sweep axis fixed on the viewing screen.

The invention in one of its aspects is based on the realization that the non-linearity of the voltage of the condenser charged through a fixed resistor is due to the progressive reduction of the voltage drop across the resistor as the condenser is charged. The invention eliminates this reduction in voltage drop through the provision of an amplifier having a voltage-amplification factor of unity (+1), the amplifier output serving as the source of charging current while its input is connected across the condenser. In this manner, the potential of the charging source is caused to rise at the same rate as the condenser voltage whereby a constant voltage difference is maintained across the charging resistor.

According to a more specific feature of the invention, the amplifier comprises a double triode connected in push-pull via a common cathode resistor, the first triode having its grid-cathode circuit connected across the condenser whereas the second triode has its plate connected to the high-voltage terminal of the charging resistor. One

of the triodes of the charging amplifier is advantageously connected as a cathode follower and works into a control amplifier, which may be of the single-stage push-pull type, serving to apply the produced sawtooth voltage to the deflecting elements of a cathode-ray tube.

A more particular feature of my invention resides in the provision of variable resistance means so connected to the control amplifier that a change in the amplitude of its output will be accompanied by a shift in the operating point of the amplifier, one of the inputs of the latter being further connected to a source of variable potential enabling the selection of a portion of the sweep axis which is to remain in view as the amplifier is overdriven by operation of the variable resistance means.

The above and other objects, features and advantages of my invention will become more fully apparent from the following detailed description of certain embodiments, reference being made to the accompanying drawing in which:

FIG. 1 is a circuit diagram of a sweep-voltage generator embodying the invention;

FIG. 2 is a circuit diagram of part of a modified sweep-voltage generator similar to that of FIG. 1;

FIG. 3 illustrates a potentiometer coupling adapted to be used in the systems of FIGS. 1 and 2; and

FIG. 4 is a fragmentary circuit diagram similar to FIG. 2, showing a further modification.

Like reference numerals have been used throughout the drawing to designate corresponding elements.

In FIG. 1 there is shown a sweep-voltage generator comprising, as a first stage, an amplifier in the form of two triode sections I, II within a single envelope **5**. A condenser **1** has its lower terminal connected to the negative pole (ground) of a source of direct current, not shown, and has its upper terminal connected to the grid **7** of triode section I as well as to the plate of a three-element discharge tube **6** whose cathode is grounded. The plate **4** of triode section II is connected through an anode resistor **13** to the positive pole (+) of the direct-current source and also through an adjustable resistor **2** to the ungrounded terminal of condenser **1**. Control pulses P are periodically applied to the grid of tube **6**, which may be of either the gas-filled or the high-vacuum type, to discharge the condenser **1**.

The cathodes **10** and **11** of sections I and II are grounded through a common resistor **9**, a potentiometer **8** being inserted between resistor **9** and cathode **10**. Plate **3** of section I is connected directly to positive battery (+) while grid **12** of section II is connected to a point of fixed potential on a voltage divider **14**, **15** which is bridged across the D.-C. source.

The final stage of the system shown in FIG. 1 comprises a push-pull control amplifier whose individual triodes **17**, **18** share a common cathode resistor **25**. The plates of tubes **17**, **18** are connected to positive potential through respective resistors **16** and **19**. These plates are also connected to respective scanning elements here shown as the horizontal beam-deflecting electrodes **31**, **32** of a cathode-ray tube **30** having a screen **30'** and whose vertical deflecting electrodes **33**, **34** are connected to a source of signal not shown. The directions of the X-axis and of the Y-axis are indicated by arrows X—X and Y—Y, respectively. The slider of potentiometer **8**, connected to the grid of tube **17**, is ganged with the slider of a potentiometer **20** connected to the grid of tube **18**; the connection between the two sliders has been indicated schematically at **35** and, as illustrated in FIG. 3, may comprise a rotatable shaft on which the two sliders are mounted for displacement in unison with respect to the associated resistance elements. Another voltage divider comprises, serially connected between positive potential and ground, a resistor **22**, another potentiometer **21**, a

resistor 23 and a further resistor 24. Potentiometer 20 is connected between the junction of resistors 23, 24 and the slider of potentiometer 21, being thus effectively in cascade with the latter.

The operation of my improved sweep-voltage generator will now be described.

The parameters of charging amplifier 5 are so selected that the voltage on plate 4 will vary in the same sense and to the same extent as the voltage or grid 7, i.e. that the amplifier has a dynamic voltage-amplification factor of unity so far as the output of section II is concerned. Under these circumstances, the voltage drop across charging resistor 2 will remain constant and the condenser 1 will charge linearly, between pulses P, to produce a sawtooth voltage S on grid 7 accompanied by a similar sawtooth voltage S' on plate 4. Because of the cathode-follower action, a similar sawtooth voltage is developed across the potentiometer 8 and is applied to the grid of tube 17 with an amplitude determined by the setting of this potentiometer. Advantageously, the operating potentials and circuit constants are so chosen that triode section I will not conduct when the condenser 1 is fully discharged, i.e. when the generator output has reached the foot of the sawtooth S, so that the position of the baseline of the sawtooth pattern will be unaffected by the setting of potentiometer 8. This is so because at the beginning of a charging step the two terminals of the potentiometer will be at the same potential so that any displacement of its slider will not alter the driving voltage applied to the left-hand tube 17 of the control amplifier. This voltage will, with the higher potentiometer settings, overdrive the control amplifier so that the beam of oscilloscope tube 30 will be deflected off the viewing screen during part of its sweep. The position of the beam, however, is co-determined by the input voltage applied to the grid of right-hand tube 18 under the control of potentiometer 20 and 21. A compensating adjustment of potentiometer 20, effected by the mechanical coupling 35, will therefore result in a displacement of the sawtooth pattern on the sweep axis X—X (here defined by the horizontal deflecting electrodes 31 and 32) in such sense that a selected part of the pattern will always remain in view, no matter what the degree of magnification. The selection of a reference point on the sweep axis X—X is made with the aid of potentiometer 21 which serves to maintain a predetermined D.-C. voltage difference (e.g. zero) on the electrodes 31, 32 on the occurrence of a selected portion of each sweep cycle S.

Suppose that it be desired to magnify a portion of the sweep at the foot of the leading edge of the sawtooth S. In this case the compensating voltage increment supplied to the grid of tube 18 should be a small fraction of the amplitude increment produced by the adjustment of potentiometer 8. Thus, the slider of potentiometer 21 should be positioned near its lower end so that the maximum voltage excursion derivable from potentiometer 20 will be small. If, however, a portion of the sweep near the top of the sawtooth is to be magnified, the voltage increments from bothe potentiometers 8 and 20 should be of substantially the same magnitude; for this purpose the slider of potentiometer 21 is moved to a position near the upper end of the potentiometer. If magnification of an intermediate sweep portion is desired, the voltage swing on potentiometer 20 should be about half the amplitude swing on potentiometer 8 so that the slider of potentiometer 21 should occupy a middle position. It will thus be seen that I have provided extremely simple means for selecting a reference point on the sweep axis and insuring that the magnified portion of the projected image will not be deflected off the screen when normal scanning is resumed. It will also be seen that the position of such reference point can be readily coordinated with the setting of the potentiometer and that an identification of the chosen sweep portion by luminous markers or the like becomes unnecessary.

It will be apparent that the two-stage cathode-follower device I, II shown in FIG. 1 has the advantage of producing both a high-potential output voltage of magnification factor +1 for the charging of a condenser (at plate 4) and a low-potential adjustable output for the driving of a control amplifier coupled thereto via an ohmic connection. In addition, it enables the adjustment of the output amplitude between equipotential points so as to prevent the superposition of a D.-C. component upon the sawtooth voltage S. It may be mentioned, however, that the flow of a small current through potentiometer 8 in the discharged condition of condenser 1 is not objectionable since it would only result in a slight displacement of the operating range of potentiometer 21 which may readily be compensated by a change in the calibration of the latter.

In the modified circuit of FIG. 2, the independently adjustable potentiometer 21' has been connected directly to the grid of tube 18 while the compensating potentiometer 20', ganged via link 35 with amplitude-control potentiometer 8, has been serially included in the voltage divider 22—24. Thus, the positions of the two cascaded potentiometers have been interchanged with respect to FIG. 1 yet the mode of operation remains essentially the same. The extent of the voltage swing on potentiometer 20' is limited by the setting of potentiometer 21', with the maximum voltage swing again corresponding to the amplitude swing on potentiometer 8; as in the preceding embodiment, the voltage excursions on the two ganged potentiometers will be proportional for any setting of the third potentiometer.

In the systems heretofore described, proper operation depends on precise synchronization of the potentiometers 8 and 20 (or 20') by means of the mechanical linkage 35. Since such synchronization is not always fully realizable, I have shown in FIG. 4 a modified system dispensing with all mechanical couplings and substituting a single variable resistance for the two ganged potentiometers of the preceding embodiments. The voltage divider for the right-hand tube 18 of the control amplifier has been simplified and consists of two fixed resistors 22, 24 in series with a single potentiometer 21'' inserted therebetween. A rheostat 27 is bridged across the cathodes of tubes 17 and 18 which have been provided with individual cathode resistors 28, 29 in lieu of the common cathode resistor 25. The grid of left-hand triode 17 is connected to a fixed point on the cathode lead of amplifier section I, e.g. directly to the cathode 10 thereof, and the potentiometer 8 in that lead has been replaced by a fixed resistor 8'. A further potentiometer 26 is bridged across the plate resistors 16 and 19 of the control amplifier and has its slider connected to positive potential. The D.-C. operating point of the system of FIG. 4, depending on the ratio of the input voltages applied to the grids of tubes 17 and 18, is selected through an adjustment of potentiometer 21''. The setting of rheostat 27 is a degeneratively connected feedback resistance which determines the gain of the push-pull amplifier 17, 18 to vary the amplification of the sweep voltage on cathode 10 while at the same time effecting the necessary compensating displacement of the operating point. As in the previous instances, therefore, adjustment of a single control element 27 is effective to change the magnification of a selected portion of the sweep centered on a reference point which, having been preselected through adjustment of potentiometer 21'', remains substantially fixed on the viewing screen 30' at all rates of magnification. The auxiliary potentiometer 26 may be used for the accurate centering of this reference point on the viewing screen.

It is to be understood that the system herein disclosed may be employed with integrating circuits other than sweep-voltage generators and that various modifications and adaptations thereof, which will be readily apparent to persons skilled in the art, are embraced in the scope of the invention as defined in the appended claims.

I claim:

1. In a cathode-ray oscilloscope, in combination, a screen; means for causing a reciprocating sweep of an electron beam in X-axis direction across said screen about a zero position in which the center of said sweep is located at a predetermined point along the X-axis of said screen, and including push-pull amplifier means for amplifying and controlling a first voltage determining said zero position as well as for controlling a first voltage determining said sweep, and linear sawtooth generator means directly coupled with said amplifier means for producing said second voltage under control of said amplifier means; adjusting means for shifting the electron beam in the direction of the X-axis into a shifted position in which the shifted center of the sweep is located a predetermined shifting distance from said predetermined point of said screen, and including means for regulating said first voltage; first control means for varying the total length of said sweep of said electron beam, whenever required, by regulating said second voltage; and second control means coupled with said first control means for simultaneous actuation, for further varying said predetermined shifting distance by further regulating said first voltage in equal proportion with a simultaneous regulation of said second voltage, whereby a selected point along the path of the electron beam across the screen in X-axis direction remains at a fixed distance from an Y-axis line through said predetermined point, irrespective of variations of said length of said sweep.

2. The combination according to claim 1 wherein said sawtooth voltage generator includes a charging capacitor, a charging resistor and a discharge tube, means for causing a linear rise of the sawtooth voltage and means for keeping the capacitor charging current at a substantially constant level, means for keeping the voltage drop across said charging resistor substantially constant and comprising a direct-current amplifier stage having an amplification factor + 1 and having a fixed potential difference between its input and output, said input being connected with said charging capacitor, and said output being connected with said charging resistor for furnishing current flowing therethrough.

3. The combination according to claim 1, wherein said first control means comprise a first potentiometer, and wherein said second control means comprise a second potentiometer, the sliding taps of said first and second potentiometers being mechanically coupled, a common control member being provided for joint adjustment of said coupled potentiometers.

4. The combination according to claim 3, said adjusting means including a third potentiometer connected in cascade with said first potentiometer.

5. The combination according to claim 4, wherein said third potentiometer is adjustable to a position in which the range of voltage adjustment of said second potentiometer substantially equals that of said first potentiometer.

6. The combination according to claim 1, wherein said first and second control means are combined into a single variable resistance means comprising a variable cathode feedback resistor for variable negative feedback and degeneratively connected between the cathode electrode means of said push-pull amplifier means for equally influencing said sweep determining second voltage and said zero-position determining first voltage.

7. The combination according to claim 2, wherein said sawtooth generator comprises a double triode amplifier, a coupling resistor as a direct current coupling means connected between the cathodes of said double triode for maintaining an amplification factor substantially constant at + 1 by means of negative feedback, and tap means provided on said coupling resistor and connected with said push-pull amplifier means for controlling the amplitude of the saw-tooth voltage of said generator applied to said push-pull amplifier means.

8. The combination according to claim 7, including resistance means connected with the grid of one section of said double triode for adjusting the grid potential thereof in such a manner that the potentials at the cathodes of said double triode equal each other when said discharge tube is in conductive condition, said discharge tube being arranged to be substantially non-conductive when said charging condenser is in discharged condition.

9. In a cathode-ray oscilloscope arrangement, in combination, a screen; means for causing a reciprocating sweep of an electron beam across said screen about a zero position in which the center of the sweep is located at a predetermined point of said screen; adjusting means for shifting the electron beam in direction of the sweep into a shifted position in which the shifted center of the sweep is located a predetermined shifting distance from said predetermined point of said screen; first control means for varying the total length of the sweep of said electron beam, whenever required; and second control means, actuated simultaneously with said first control means, for varying said predetermined shifting distance in equal proportion with the variation of said length of the sweep, whereby a selected point along the path of the electron beam across the screen remains in a fixed position relative to said predetermined point, irrespective of variations of said length of the sweep.

References Cited in the file of this patent

UNITED STATES PATENTS

2,264,197	Hadfield	Nov. 25, 1941
2,310,671	Batchelor	Feb. 9, 1943
2,411,030	Ryder	Nov. 12, 1946
2,487,602	Schoenfeld	Nov. 8, 1949
2,619,613	Sanger	Nov. 25, 1952
2,660,691	Bertram	Nov. 24, 1953
2,695,516	Petroff	Nov. 30, 1954
2,695,974	Skellet	Nov. 30, 1954
2,766,401	Slater	Oct. 9, 1956
2,836,763	Currie	May 27, 1958