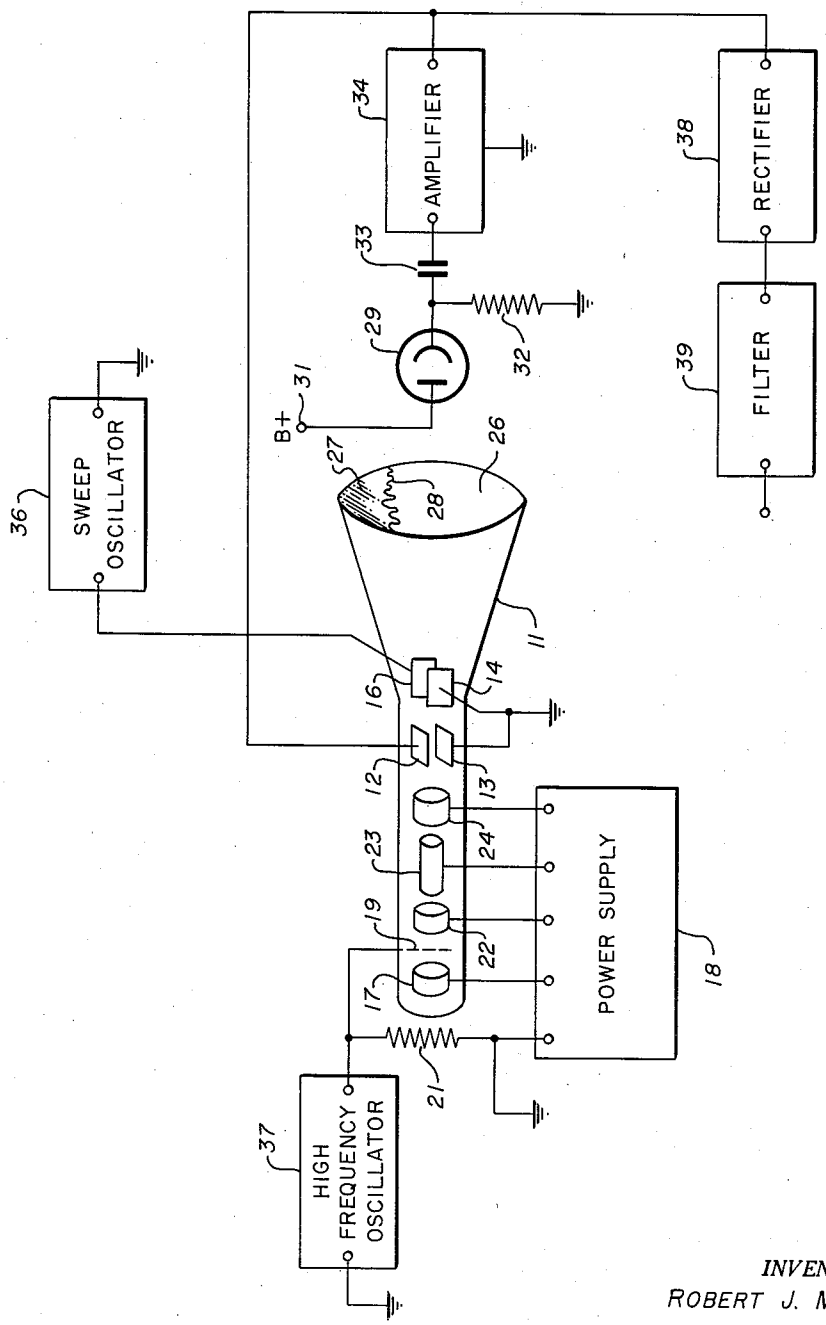
Jan. 24, 1961 R. J. MORRIS 2,969,466

DYNAMIC CURVE TRACER

Filed Oct. 29, 1957



INVENTOR.
ROBERT J. MORRIS

United States Patent Office

2,969,466

Patented Jan. 24, 1961

2,969,466

DYNAMIC CURVE TRACER

Robert J. Morris, 2157½ Vine St., Berkeley 9, Calif.

Filed Oct. 29, 1957, Ser. No. 693,173

6 Claims. (Cl. 250—217)

The present invention relates to an electronic signal generator circuit and more particularly to a circuit for obtaining an electrical voltage analog for the outline of a physical body.

When working with audio or other low frequency apparatus it is frequently necessary to obtain a particular voltage signal varying with time in some irregular manner not easily obtained by charging or discharging simple combinations of resistance, capacitance and inductance. If a graphical representation of a desired waveform is produced, there are various curve tracers which can translate such a waveform into a time varying voltage by usage of the familiar phototube-selsyn motor system wherein a phototube scans along the edge of a graphical curve while position correction information is applied to a selsyn motor. A linkage from the motor to a variable resistor or the like will vary the amplitude of a voltage to recreate the curve. Such phototube-selsyn combinations are satisfactory in situations where slow tracing rates may be satisfactorily utilized and where the slope of the curve to be traced is not excessive.

The present invention in contrast provides a means for rapidly translating a graphical representation of a voltage curve into a time varying voltage output signal and can repetitively produce such an output signal at rates of several thousand times per second. If desired, the time base for a particular graphical curve may be electronically altered without necessitating replotting of the graph.

The curve tracing properties of the invention may be further utilized for tracing the outline of opaque objects to obtain an output signal dependent upon the shape thereof. Such opaque objects may further contain a motional component, thereby modulating the output signal.

It is an object of the present invention to provide a means for translating the outline of an opaque mask into a time varying voltage.

It is another object to provide a means for eliminating signals from a phototube output created by slowly varying light impulses due to the persistence effect of light emitting phosphors in a cathode-ray tube screen.

It is a further object to provide a convenient means for altering the time base of a graphically plotted curve.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in conjunction with the accompanying drawing which is a block circuit diagram of the invention.

Referring now to the drawing, there is shown a conventional cathode-ray tube 11 having upper and lower vertical deflection plates 12 and 13 and having first and second horizontal deflection plates 14 and 16. Electrons are emitted from a cathode 17 which is connected to a positive potential in a power supply 18. A control electrode 19 provides a means for controlling the intensity of the electron beam emitted from the cathode 17 while

a control electrode resistor 21 couples the control electrode 19 to a ground potential point. An accelerating electrode 22, a first anode 23, and a second anode 24 are connected respectively to progressively higher positive potential points on the power supply 18. Means for adjusting the various potentials from the power supply 18 to the cathode-ray tube 11 may be included although not shown here.

A phosphor coated screen 26 is the target end of the cathode-ray tube 11. An opaque mask 27 covers a portion of the screen 26, such mask having an edge 28 graphically defining a curve of which an electrical representation is to be obtained. Such a mask may be prepared by plotting some desired waveform on opaque graph paper and cutting the paper along such waveform curve to secure edge 28. An opaque curve drawn on a transparent sheet will also suffice if the curve line is sufficiently thick. The mask 27 is disposed in a position such that with no potentials applied to the vertical deflection plates 12 and 13, the electron beam of the cathode-ray tube strikes the phosphor screen 26 in an area not covered by the mask 27. For illustrative purposes, the mask 27 is shown covering the upper portion of the screen 26 with "X" time axis or abscissa of the curve 28 being disposed parallel to and above the horizontal axis of the cathode-ray tube 11. There is nothing inherent to be implied by such placement of the mask 27, since other arrangements and mask positions are equally practicable.

A phototube 29 is disposed proximal to the screen 26 so that light produced thereon, except in the screen area covered by the mask 27, is viewed by the light sensitive cathode of the phototube 29. A lens system may be included to focus light onto the phototube 29. The anode of the phototube 29 is connected to a B-plus voltage terminal 31 while the cathode is coupled through a cathode resistor 32 to ground potential. A coupling capacitor 33 is connected from the cathode of the phototube 29 to the input terminal of a conventional alternating voltage amplifier 34. The amplified output signals from the amplifier 34 are coupled to the upper vertical deflection plate 12 while the lower vertical deflection plate 13 is connected to ground potential. The amplifier 34 output signals applied to the upper vertical deflection plate must deflect the electron beam upward toward the mask 27 with increasing light intensity incident on the phototube 29.

A sweep oscillator 36 is connected to the second horizontal deflection plate 16 while the first deflection plate 14 is connected to a ground potential point. It is, of course, obvious that the push-pull type of deflection plate circuitry might be readily substituted for the single-ended type shown. It is further obvious that a magnetic deflection system might be utilized.

A high frequency oscillator 37 has an output signal coupled to the control grid 19 whereby the intensity of the electron beam is controlled. A rectifier circuit 38 receives the output signals from the amplifier 34 followed by a filter 39 which discriminates against signals having the frequency produced by the high frequency oscillator 37.

Considering now the operation of the invention, assume that operating potentials are applied and that a suitable mask 27 has been prepared and secured to the screen 26. A spot of light, produced on the screen 26 by the cathode-ray tube electron beam, is detected by the phototube 29 and the resultant signal amplified in the amplifier 34. The amplifier 34 output signal is applied to the upper vertical deflection plate 12, deflecting the electron beam upward until the spot produced thereby is partially shielded from the phototube 29 by the mask 27. The light incident on the phototube 29 is

thus reduced, thereby reducing the amplitude of the potential applied to the upper deflection plate 12 so that the electron beam vertical position stabilizes, striking the screen 26 at the edge 28 of mask 27. If the sweep oscillator 36 has an output potential linearly deflecting the electron beam horizontally along the X axis of the curve 28, the vertical deflection signal is adjusted by the above process so that the electron beam always impinges on the screen 26 along the edge 28 of the mask 27.

It is apparent that the time duration of the above process is severely limited by the time constant of the capacitor 33 and alternating voltage amplifier 34 in the vertical deflection signal circuit. However, the substitution of a direct voltage amplifier therefor would not be satisfactory except where slow scanning rates are contemplated and with a screen 26 using very short-persistence phosphors. With the usual type of operation considered, the persistence of the phosphors in the screen 26 causes an exponentially decreasing light radiation after cessation of excitation by the electron beam. The persistence effect creates a delay error in the deflecting signal from the phototube 29 since a portion of the light reaching the phototube 29 is the result of phosphor excitation for previous events and is not purely a function of excitation of the concurrently produced electron beam.

To eliminate such effect, the high frequency oscillator 37 is utilized to modulate the electron beam so that pulsating light is created in the screen 26. The light due to the persistence effect is relatively slowly decaying. There are then two signals produced by the phototube 29; one is a slowly varying persistence effect signal while the other is a high frequency signal equal to the electron beam modulation frequency. The capacitor 33 and the alternating voltage amplifier 34 effectively filter out the slowly varying signals, leaving only the high frequency signal.

Considering now the operation of the invention with the modulated electron beam, during the intervals when the electron beam is "on," a vertical deflection signal is produced raising the electron beam to the edge 28 of the mask 27. During the beam "off" intervals, the capacitor 33 discharges through the cathode resistor 32 so that a downward deflection signal is produced and the electron beam is deflected downward away from the mask a distance proportional to the preceeding upward deflection. The resultant is an amplitude modulated high frequency signal having an envelope matching the outline of the mask 27. A portion of the vertical deflection signal is coupled to the rectifier 38 and thence to a filter 39 for removing the modulation frequency component in the output signal. The rectifier 38 and filter 39 together are equivalent to a conventional amplitude modulation radio detector. The output from the filter 39 is then a voltage varying in accordance with the curve in the mask 27. Such voltage curve will have a repetition equal to the frequency of the sweep oscillator 36. A further advantage obtained from beam modulation is the relative insensitivity of the system to ambient room light, reducing the light shielding requirements.

Without altering the mask 27 it is possible to change the time base of the output voltage curve by utilizing non-linear horizontal deflection signals, i.e. exponential, cosine, or even signals produced in a second curve tracer. In such a manner the invention may be used for combining various plotted curves.

Other uses for the invention include the production of audio tones by coupling a loudspeaker to the output of the filter 39. The tones so produced may be readily modulated by motion of, for instance, an operator's hand between the screen 26 and the photocell 29.

In another embodiment of the invention, it is possible to eliminate the high frequency oscillator 37 by placing an additional mask across the face of the screen, such mask being comprised of parallel, narrow, regularly spaced opaque strips disposed so that the electron beam sweeps transversely across the strips. The consequent modulation of the light as the beam progresses across the screen produces a high frequency signal in the phototube 29. Such a slit system may be less satisfactory than the electron beam modulation system when a non-linear sweep oscillator signal is utilized since the modulation frequency will vary as the beam motion transversely across the slits varies.

While the invention has been disclosed with respect to a single preferred embodiment, it will be apparent to those skilled in the art that numerous variations and modifications may be made within the spirit and scope of the invention and thus it is not intended to limit the invention except as defined in the following claims.

What is claimed is:

1. In electronic apparatus, the combination comprising a cathode-ray tube having a beam deflection system and a fluorescent screen, a photosensitive device disposed proximal to said screen, a high frequency pass filter coupling said photosensitive device to said deflection system, high frequency modulation means periodically interrupting the beam in said cathode-ray tube, and a mask covering a portion of said screen.

2. In electronic apparatus, the combination comprising a cathode-ray tube having a beam intensity control electrode and a beam deflection system and a fluorescent screen, a phototube disposed proximal to said screen, a high frequency pass filter coupling said phototube to said deflection system, a high frequency signal coupled to said control electrode, and a mask covering a portion of said screen.

3. In electronic apparatus, the combination comprising a cathode-ray tube having a screen and a deflection system, a phototube receiving light produced on said screen, a high frequency pass filter having an input coupled to said phototube and having an output coupled to said deflection system, high frequency modulation means periodically interrupting the emission of additional light from said screen, and a mask partially covering said screen.

4. In an electronic instrument, the combination comprising a first cathode-ray tube having an ordinate deflection system and an abscissa deflection system and having a fluorescent screen, a first phototube receiving light from the screen of said first cathode-ray tube, a first high frequency pass filter coupling said first phototube to the ordinate deflection system in said first cathode-ray tube, first modulation means periodically varying the intensity of light received by said phototube, a first mask partially covering the screen of said first cathode-ray tube, a second cathode-ray tube having an ordinate deflection system and a fluorescent screen, a second phototube receiving light from the screen of said second cathode-ray tube, a second high frequency pass filter coupling said first phototube to the ordinate deflection system of said second cathode-ray tube, second modulation means periodically varying the intensity of light received by said second phototube, a second mask partially covering the screen of said second cathode-ray tube, and a rectifier having an input coupled to said second high pass filter and having an output coupled to said abscissa deflection system of said first cathode-ray tube.

5. In an electronic instrument for translating a graphical representation of a curve into a time varying voltage, the combination comprising a cathode-ray tube having an ordinate deflection system and an abscissa deflection system and having a fluorescent screen and having a control electrode, an opaque mask covering a portion of said screen such mask having an edge shaped to conform to said graphical representation, a phototube receiving light emitted from said screen, a filter passing only high frequencies coupling said phototube to said ordinate deflection system, a sweep voltage source coupled to said

abscissa deflection system, and a source of high frequency voltage coupled to said control electrode.

6. In electronic apparatus, the combination comprising a cathode-ray tube having a fluorescent screen and having mutually transverse first and second deflection systems, a phototube receiving light from said screen, a low frequency rejection filter connected between said phototube and said first deflection system, a plurality of narrow parallel opaque strips disposed on said screen perpendicular to the deflection of said second deflection system, and a mask shielding said phototube from a portion of said screen.

References Cited in the file of this patent

UNITED STATES PATENTS

2,461,667	Sunstein	Feb. 15, 1949
2,528,020	Sunstein	Oct. 31, 1950
2,654,027	Baum	Sept. 29, 1953
2,656,101	Haviland	Oct. 20, 1953
2,702,158	Winter	Feb. 15, 1955