Aug. 18, 1953 P. GLASS 2,649,542

FUNCTION GENERATOR

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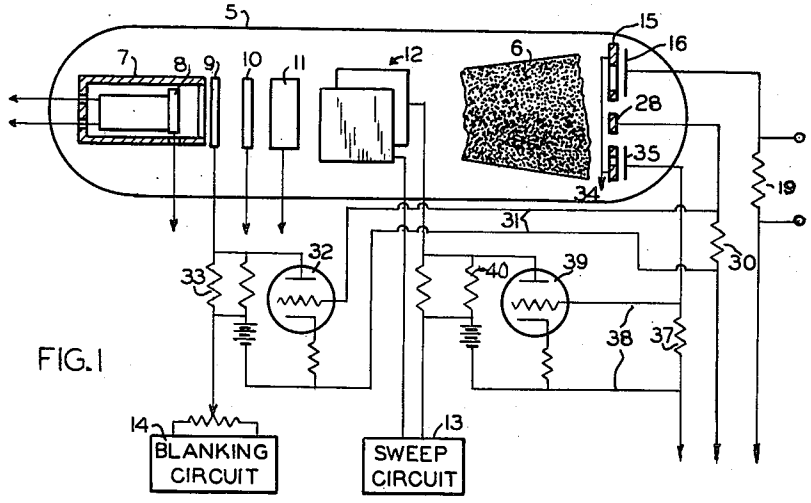


FIG. 1

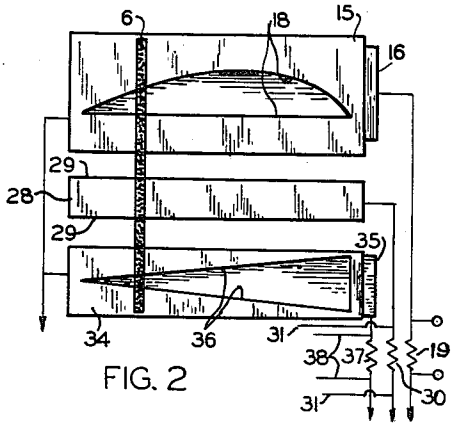


FIG. 2

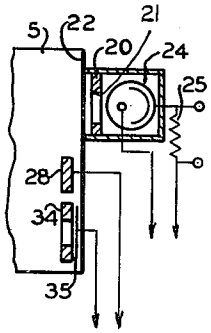


FIG. 3

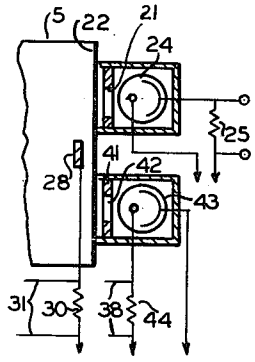


FIG. 4

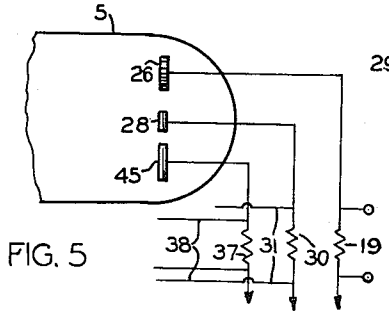


FIG. 5

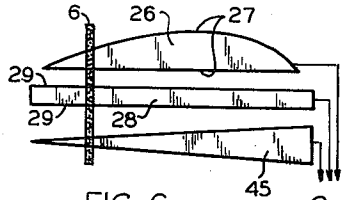


FIG. 6

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FUNCTION GENERATOR

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7 Claims. (Cl. 250—27)

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This invention relates to method and means for producing, by means of a cathode ray tube, an electrical output, such as a current or voltage, the magnitude of which is so controlled as to be varied with respect to time in accordance with a predetermined function which may be of non-linear character.

Heretofore, beam type cathode ray tubes have been used with satisfactory results for producing outputs that vary in respect to time in proportion to linear functions, and efforts have been made to adopt such systems to permit output variation in accordance with predetermined non-linear functions. In the latter case, due to inherent characteristics of beam type cathode ray tubes, adequate stabilization to produce highly accurate operation has been impractical. The present invention, by making use of a somewhat unconventional cathode ray tube, makes possible adequate stabilization of either or both ray density and sweep travel.

In general, in devices of this kind the output magnitude depends on magnitude of current conducted to an anode by the flow of electrons in the cathode ray, and the non-linear functional variation of the output is imposed by means of a mask having an edge extending in the general direction of the ray sweep and profiled to correspond to a graph of the intended functional variation, with the positive abscissa or X-axis extending in the sweep direction and the positive ordinate or Y-axis extending perpendicular to the sweep direction. Such mask may be interposed in the path of the ray ahead of an anode, or between a fluorescent screen and a light-sensitive cell. Variation in accordance with the function represented by the profiled mask edge may be accomplished by varying the beam-conducted anode current during the sweep, by a scan type sweep wherein the beam is caused to perform a series of vertical or Y sweeps on successive tracks along the X-axis or primary sweep direction, or the beam may be forced to follow the mask edge contour during its sweep by means of a feed-back circuit controlled by the anode current or voltage, and arranged to maintain the magnitude of beam-conducted anode current at a constant value, and the anode current or voltage serving to control the feedback circuit constitutes the tube output.

In any such system it is obvious that a variation in electron density of the beam will result in a variation of magnitude of current conducted to the anode by the beam other than that imposed by the profiled mask edge; or in the case of the fluorescent screen and light sensitive cell, in a similar variation in the intensity of light actuating the cell. Such variations, of course, produce departure of output variation from the predetermined functional one. Similarly, variations from theoretical constant and predetermined rate of sweep of the beam in the positive direction of the X-axis serve to distort the abscissa scale and also result in departure of output variation from the intended functional character.

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Usual stabilization practice by means of negative feedback controlled by variation of the beam-transmitted energy, either anode current or beam-excited light from a fluorescent screen cannot be followed in these cathode ray beam tube arrangements, due to the inherent requirement that these systems be capable of non-linear variation as imposed by the mask edge. Obviously a negative feedback stabilization circuit would be equally effective to interfere with intended output magnitude variation imposed by the mask edge as it would to correct an unintended variation in beam density or in sweep speed.

An object of the present invention is the novel arrangement of a function-generating system controlled by a cathode ray tube to provide for adequate stabilization of either or both ray density and sweep rate, by negative feedback means, and without impairment of the intended operation of the system to produce, by variation of the effective beam energy, a predetermined function that may be non-linear.

Another object is the provision of a novel combination of an unconventional cathode ray tube with beam-energy masking means, permitting great flexibility of selection of details of system arrangement.

Another object is the provision of a novel arrangement for generating an electrical output that varies in accordance with a predetermined function that may be non-linear.

In the accompanying drawings:

Fig. 1 is a diagrammatic representation of a function-generating system arranged according to the invention.

Fig. 2 is an enlarged elevation of one arrangement of certain types of elements that may be used to control the tube output and negative feedback stabilizing circuits.

Figs. 3, 4 and 5 are fragmentary diagrams corresponding to part of Fig. 1, disclosing other arrangements of control elements.

Fig. 6 is an elevation similar to Fig. 2, showing the arrangement of the control elements of Fig. 5.

Describing the drawings in detail and first referring to Figs. 1 and 2, a cathode ray tube 5 has at one end an electron gun and control electrodes arranged to produce and direct toward the other end of the tube a cathode ray in the form of a vertically wide, thin and plane sheet of electrons, designated 6 and a short section of which is shown in Fig. 1. Production and direction of this sheet may be accomplished by

an electron gun 7 having an emitter 8 that may be elongated in the directions of the plane of the electron sheet, a control grid 9 for regulating the electron density of the sheet, an accelerating electrode assembly 10, and a ray-shaping electrode arrangement 11. An arrangement of deflecting plates 12 is arranged to move the sheet laterally, perpendicular to its plane, or in the directions of the X-axis of the tube, in accordance with their relative potential, and these plates are energized by a saw-tooth generator sweep circuit 13. The control arrangement 14 of the grid 9 may include blanking means acting with the sweep circuit to prevent a return trace, and also may include a manual ray density control.

In operation of the tube 5, as the sheet 6 of electrons sweeps parallel to the X-axis in the positive direction, a portion of its energy is received and translated to an electrical output varying in respect to time in accordance with the function to be generated. Variation of such output is accomplished by varying the width of the portion of the beam that is so received and translated. Variation of this width as the sweep progresses, and in accordance with the function to be represented by the output variation, may be made by means of a body having an edge extending in the general direction of the sweep, so that the plane of the electron sheet extends across such edge substantially transversely, and travels along it during the sweep. This edge is profiled, with relation to the sweep rate as an abscissa scale, and the function variable as an ordinate scale, to represent the predetermined function in accordance with which the output is to vary. Thus the edge corresponds to a graphical representation of the predetermined function.

The output-controlling body may be a collector electrode or anode of the cathode ray tube, with either or both edges that extend in the direction of sweep profiled continuously to proportion the current conducted to it by the electron sheet to the variation of the predetermined function as the sweep progresses. It may be a mask arranged in front of a collector electrode or anode to partially mask the latter from the ray, and having a profiled edge arranged to vary the anode current in the indicated way. The output control body also may be a mask interposed between a fluorescent screen arranged at the receiver end of the tube in usual fashion, and a light sensitive cell located to receive light from the screen in intensities that are varied during the sweep by the profile of the mask. In any of these arrangements, the electrical output of the arrangement is determined by the effective width of the beam, that is to say the width of the part of the electron sheet the energy of which is received by the output-controlling element of the system, and translated into an electrical output. The magnitude of such output is determined by the width of this effective position of the electron sheet.

In Figs. 1 and 2 the output magnitude-controlling element is in the form of a mask 15, suitably connected in the tube supply circuit to drain current of ray portions that strike it, and arranged in front of an anode plate 16. From Fig. 2, it will be seen that the mask has an edge 18 extending in the general direction of the X-axis and sweep, and profiled to represent the function in accordance with which the output is to vary, a typical non-linear function-representing profile being illustrated. As shown, this edge may comprise one edge of an opening, through which a corresponding area of the anode 16 is exposed to impingement by the electron sheet 6, and that thus controls the effective width of the sheet during progress of the sweep, and the current conducted to the anode. An output voltage may be developed across a resistance 19 connected in the anode supply.

In the arrangement of Figs. 3 and 4 the output controlling element comprises an opaque mask 20 having a function-representing profiled edge 21, and located between a fluorescent screen 22 arranged in usual fashion at the receiver end of the tube 5, and a light sensitive cell 24, arranged to receive light from the screen 22 as the latter is excited by the electron sheet, and of varying intensity during sweep, as controlled by the profile of the mask 20. Output of the cell 24 may be a voltage developed across a resistance 25 in the cell supply, which voltage varies in accordance with the magnitude of energy of the sheet translated to current by the cell 25. The magnitude of energy so translated, as in Fig. 1, depends on the effective width of the electron sheet, and such width is determined and varied during sweep by the profile of the mask 20.

Figs. 5 and 6 disclose another variation of the invention. In this arrangement, the output control element comprises an anode plate 26, the profile of which, as determined by the configuration of the edges 27 that extend in the direction of sweep, is such as to vary the effective width of the electron ray, the current received by the anode, and consequently the tube output.

The use of a sweeping sheet-like ray of electrons with an edge profiled in the direction of sweep to represent a function, and the profile of which continuously during sweep determines the width of the ray that is effective in producing the output, in addition to affording a simple but highly effective function-generating device, provides a means of effecting stabilizing negative feedback control of the two conditions that are subject to error-producing variation. Referring to Figs. 2 and 6, it will be seen that the maximum sheet width required for cooperation with the output controlling element 15, 22 or 26, is much less than the full sheet width. The portion of the ray that falls outside the output-controlling portion may be utilized for stabilization purposes without interfering in any way with the intended functioning of the output-controlling arrangement.

In each of the figures a ray density-control arrangement comprises an anode 28 arranged outside the area of the output control arrangement to receive a portion of the ray other than that serving to control the function-representing output. The anode 28, as shown is rectangular, with parallel sides 29 extending parallel to the sweep direction or X-axis. An output voltage may be developed from the current received by the anode 28, by a resistance 30 connected in its supply, and the voltage so developed may be used as input control voltage to a negative feedback ray density-control circuit. In the arrangement disclosed by the drawings, such voltage is applied by lines 31 to the control grid of a voltage control tube 32, the output of which appears as a negative feedback voltage across a resistance 33 connected in the voltage line to the density control grid 9.

Still another, or third part of the sheet like

cathode ray 6 may be used to stabilize the sweep of the sheet. To accomplish such sweep stabilization, a portion of the energy of the sheet, increasing during progress of the sheet in proportion to the intended sweep rate, is used to control a negative feedback circuit. A convenient mode of accomplishing such control and feedback comprises translation of the energy of this portion of the beam to a proportionally varying voltage serving as control input voltage to a negative feedback voltage circuit. In Figs. 1 to 3, a mask 34 is arranged in front of an anode 35 and in the sweep path of the third portion of the ray 6. The mask 34 is profiled to pass to the anode 35 a portion of the beam that increases during the progress of the sweep in linear proportion to the intended sweep rate. As shown the mast 34 has an opening bounded by straight sides 36 inclined at equal angles away from each other in the sweep direction. A feedback control voltage may be developed across a resistance 37 connected in the supply to anode 35, and applied by lines 38 as control input voltage to a voltage control 39 the output of which appears as a negative feedback voltage across a resistance 40 connected in the sweep voltage supply to the deflector system 12.

In Fig. 4, a variation of the sweep-stabilizing control element is shown. Similar to the function-representing output arrangement of Figs. 3 and 4, the sweep-stabilizing control voltage generator comprises an opaque mask 41, mounted external of the tube 5 and having an opening 42 linearly increasing in width in the sweep direction. A light sensitive cell 43 is arranged to receive light emitted by the ray-excited fluorescent screen 22 and passing through the mask opening 42. A voltage output of cell 43 may be developed across a resistance 44, and applied to the input lines 38 of a feedback voltage control circuit arranged as in Fig. 1.

In Figs. 5 and 6, the sweep stabilizing feedback control voltage element, similar to the anode 26, comprises an anode 45, linearly increasing in width in the sweep direction to increase during progress of the sweep the width of the portion of the ray that is effective for sweep stabilization. The stabilization circuit inputs of Figs. 5 and 6 correspond to those of Fig. 1.

From the foregoing, it is evident that the invention according to one aspect, involving the cooperative effect of a laterally sweeping sheet-like cathode ray and an intercepting body having a profiled edge for intercepting portions of the ray that vary in width during progress of the sweep, presents a very simple but highly effective mode of generating electrical outputs variable in proportion to functions that may be non-linear. It is further evident that, according to another aspect of the invention, the employment of a wide sheet-like cathode ray permits employment of one or more parts of the ray for stabilization purposes without interference in any manner with the function-generating operation of the system.

The disclosed forms of the invention indicate the great flexibility of the invention and the possibilities of selection of specific arrangements to suit particular types of service. In general it may be noted that the external masking and energy converting devices, of the kind disclosed at 20, 24 in Figs. 3 and 4, and at 41, 43 in Fig. 4, are suitable for service of the kind where different functions are to be generated by a single device, since they permit substitution of masks having different profiles. Internally arranged masks, or shaped anodes are suitable where a single function only is to be generated by the tube. Since the density feedback circuit can be used in conjunction with a manual density control, its control electrode normally is enclosed in the tube, as shown, though an external arrangement can be readily made should a given situation make it desirable.

Since variations from the disclosed detailed arrangements are possible without departing from the concept of the invention, it is to be understood that the scope of protection to be afforded the invention is to be determined by the appended claims rather than by the specific disclosures.

I claim:

1. A cathode ray tube function generator comprising: a cathode ray tube having means for producing and directing a thin plane cathode ray, a ray density control circuit, a sweep-producing deflecting system arranged to sweep such ray repeatedly in a direction extending perpendicular to its plane, means for receiving energy of a portion of the ray of predetermined maximum width and for translating energy so received into an electrical output of magnitude proportional to magnitude of energy so received, and means for varying during sweep the width of the portion of the ray from which energy is so received; a ray density stabilizing arrangement comprising second means arranged for receiving energy from a second portion of the ray of constant width during sweep, and a negative feedback circuit having an input arranged to be controlled by the energy received by said second receiving means and an output arranged to stabilize said ray density control circuit; and a sweep stabilizing arrangement comprising third means aranged for receiving energy from a third portion of the ray of linearly increasing width during the sweep, and a second negative feedback circuit having an input arranged to be controlled by the energy received by said third receiving means and an output arranged to stabilize said deflecting system.

2. A cathode ray tube function generator according to claim 1, wherein each of said energy receiving means includes an edge extending in the general direction of sweep, said edge included by the first receiving means being profiled in accordance with the function to be represented to vary during sweep the width of the ray portion from which energy is so received; said edge included by the second receiving means is parallel to the sweep direction to maintain constant during sweep the width of the ray portion from which energy is so received; said edge included by the third receiving means is straight and inclined away from the sweep direction to linearly increase during sweep the width of the ray portion from which energy is so received.

3. A cathode ray tube function generator according to claim 1, wherein at least one of said energy receiving means comprises an energy receiving surface and an energy intercepting mask interposed in the path of ray energy to said surface, said mask having an edge extending in the general direction of sweep and profiled to control the width of the ray portion from which said surface receives energy.

4. A cathode ray tube function generator according to claim 1, wherein at least one said energy receiving means comprises an anode arranged in the path of an individual portion of

the cathode ray and a cathode ray intercepting mask arranged in the path of the ray portion to the anode, said mask having an edge extending in the general direction of sweep, and profiled to control during sweep the width of the cathode ray portion reaching said anode.

5. In a cathode ray function generator that comprises a cathode ray tube provided with a cathode ray projector arranged to project a plane, sheet-like cathode ray in a given direction, a sweep device for deflecting said cathode ray laterally, in a direction transverse to said ray-projection direction and periodically in response to periodic variation in the electric output of a sweep circuit, and a second device for varying intensity of said cathode ray in response to variation in the electrical output of a beam intensity control circuit; the combination of means for translating energy of the ray into electrical energy varying in accordance with a preselected function during progress of each sweep, comprising a receiver disposed to receive energy from a preselected portion of said ray that is of variable width but of preselected maximum width less than the full width of said ray, and means including an energy-intercepting edge profiled in the direction of sweep in accordance with said preselected function and located relative to the path of said energy to vary the width of said ray portion from which said energy is received by said receiver during progress of each sweep, a second receiver disposed to receive energy from a second portion of said ray, means including a second energy-intercepting edge profiled in said sweep direction and located in the path of the energy of said second ray portion to provide at each instant during each sweep receipt by said second receiver of energy from a preselected width of said second ray portion, means for translating energy received by said second receiver into an electrical output of magnitude varying inversely with magnitude of energy received by said second receiver and of the same character as the electrical output applied to one of said devices, and circuit means connecting said translating means to said device for application of the electrical output of the former to the latter as a stabilizing negative feedback control condition.

6. In a cathode ray function generator that comprises a cathode ray tube provided with a cathode ray projector arranged to project a plane, sheet-like cathode ray in a given direction, a sweep device for deflecting said cathode ray laterally progressively, in one of the directions extended transverse to said ray-projection direction and periodically in response to periodic variation in the electrical output of a sweep circuit; the combination of means for translating energy of the ray into electrical energy varying in accordance with a preselected function during progress of each sweep, comprising a receiver disposed to receive energy from a preselected portion of said ray that is of variable but preselected maximum width less than the full width of said ray, means including an intercepting edge profiled in said direction of sweep in accordance with said preselected function and located relative to the path of said energy to vary the width of said ray portion from which energy is received by said receiver during progress of each sweep, and sweep-stabilizing means comprising a second receiver disposed to receive energy from a second portion of said beam and means including a second intercepting edge profiled in said sweep direction to increase the energy received by said second receiver progressively during each sweep and in linear inverse proportion to said variation in said sweep circuit output, means for translating energy received by said second receiver into an electrical output similar in character to said sweep circuit output and varying inversely with magnitude of energy received by said second receiver, and circuit means connecting said translating means with said sweep device for application of the electrical output of the former to the latter as a stabilizing negative feedback control condition.

7. In a cathode ray function generator that comprises a cathode ray tube provided with a cathode ray projector arranged to project a plane, sheet-like cathode ray in a given direction, a sweep device for deflecting said cathode ray laterally in a direction extended transverse to said ray-projection direction and periodically in response to periodic variation in the electrical output of a sweep circuit, and a ray intensity control device for varying intensity of said cathode ray in response to variation in the electrical output of a beam intensity control circuit; the combination of means for translating energy of the ray into electrical energy varying in accordance with a preselected function during progress of each sweep, comprising a receiver disposed to receive energy from a preselected portion of said ray that is of variable but preselected maximum width less than the full width of said ray, and means including an intercepting edge profiled in said direction of sweep in accordance with said preselected function and located relative to the path of said ray portion from which energy is received by said receiver, means for stabilizing intensity of said ray comprising a second receiver device disposed and arranged to receive energy from a second portion of said ray of uniform width throughout progress of each sweep, whereby magnitude of such energy varies with intensity of said beam, and means for translating energy received by the latter to an electrical output of the same character as the condition applied to said ray intensity control device of magnitude varying in inverse proportion to magnitude of the latter energy, and circuit means connecting said translating device to said ray intensity control device for applying the output of the former to the latter as a negative feedback control condition.

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