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[54] DISPLAY SYSTEM TO GENERATE SYMBOLS FORMED OF CONIC SECTIONS

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[52] **U.S. Cl.** **315/23,** 315/24
[51] **Int. Cl.** **H01j 29/70**
[58] **Field of Search** 235/197; 315/22–24, 27

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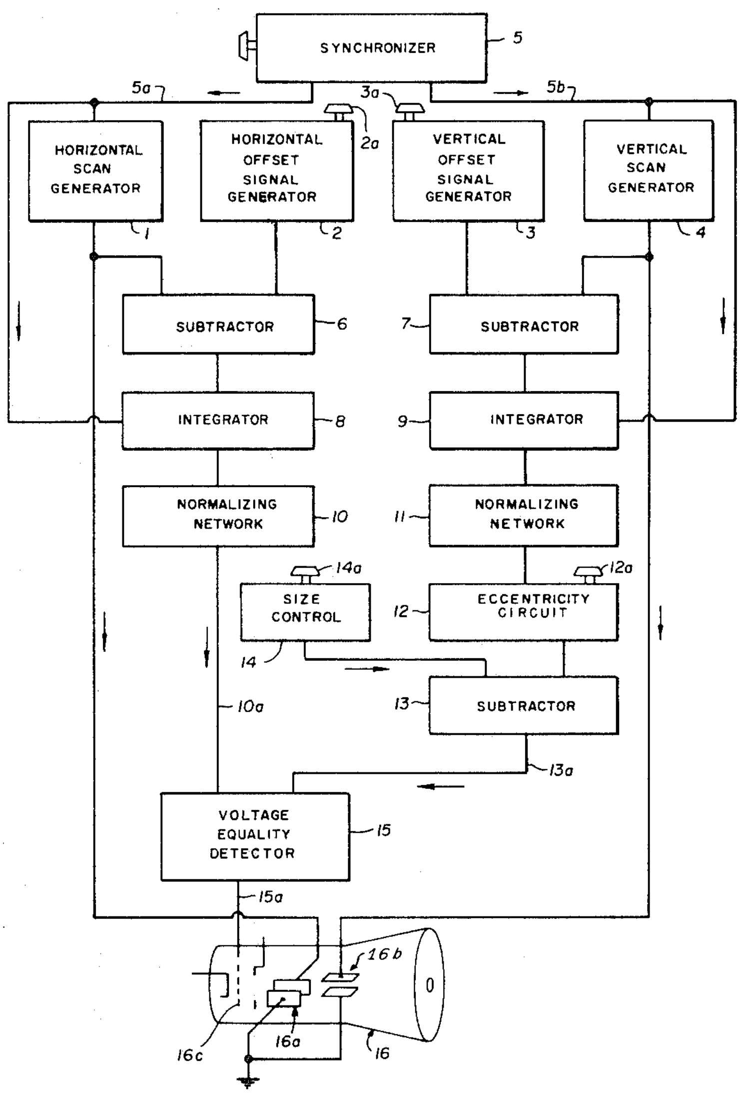
[57] **ABSTRACT**

Apparatus for generation of symbols on the screen of a cathode ray tube is disclosed featuring integration of the electron beam scanning potentials, signal normalization, and voltage equality detection of the integrated signals to generate, according to the adjustment of biasing controls, symbols formed of conic sections locatable in any position on the screen for navigation, identification, or other purposes.

11 Claims, 10 Drawing Figures



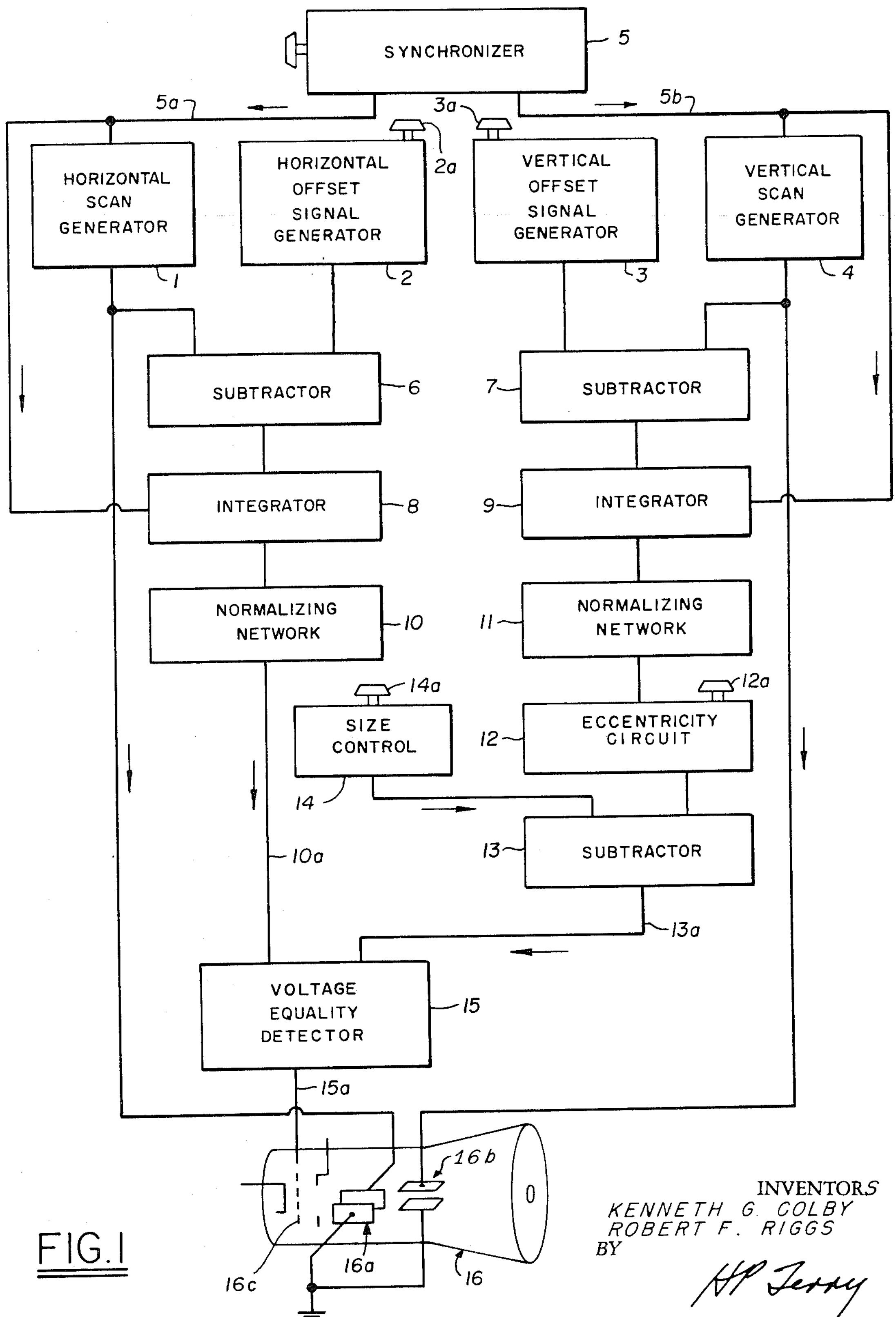


FIG. I

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FIG. 2

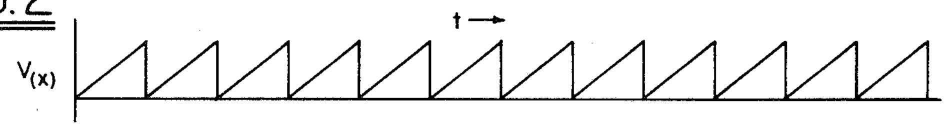

FIG. 3

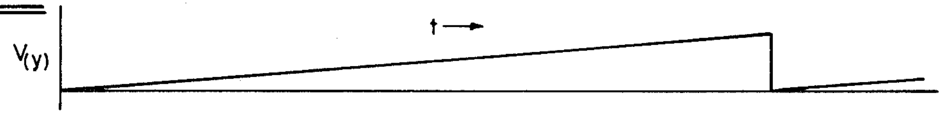

FIG. 4

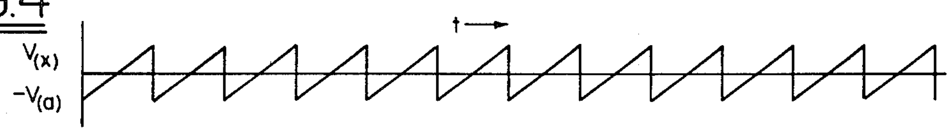

FIG. 5

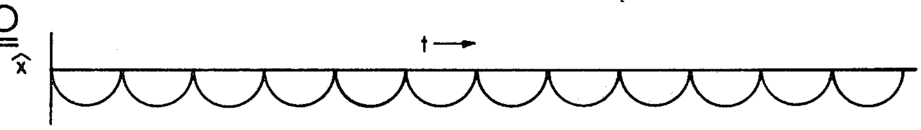

FIG. 6

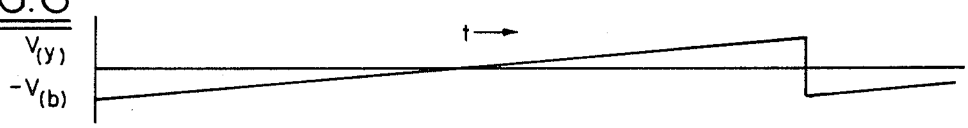

FIG. 7

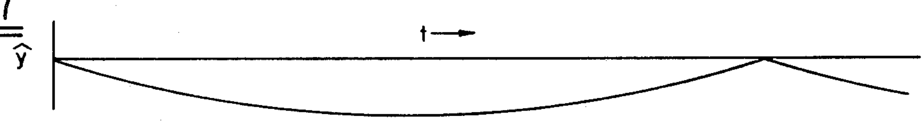

FIG. 8

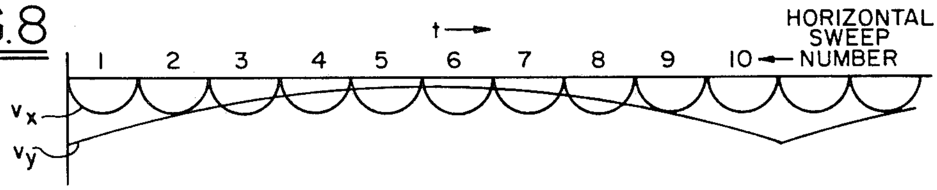

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FIG. 10

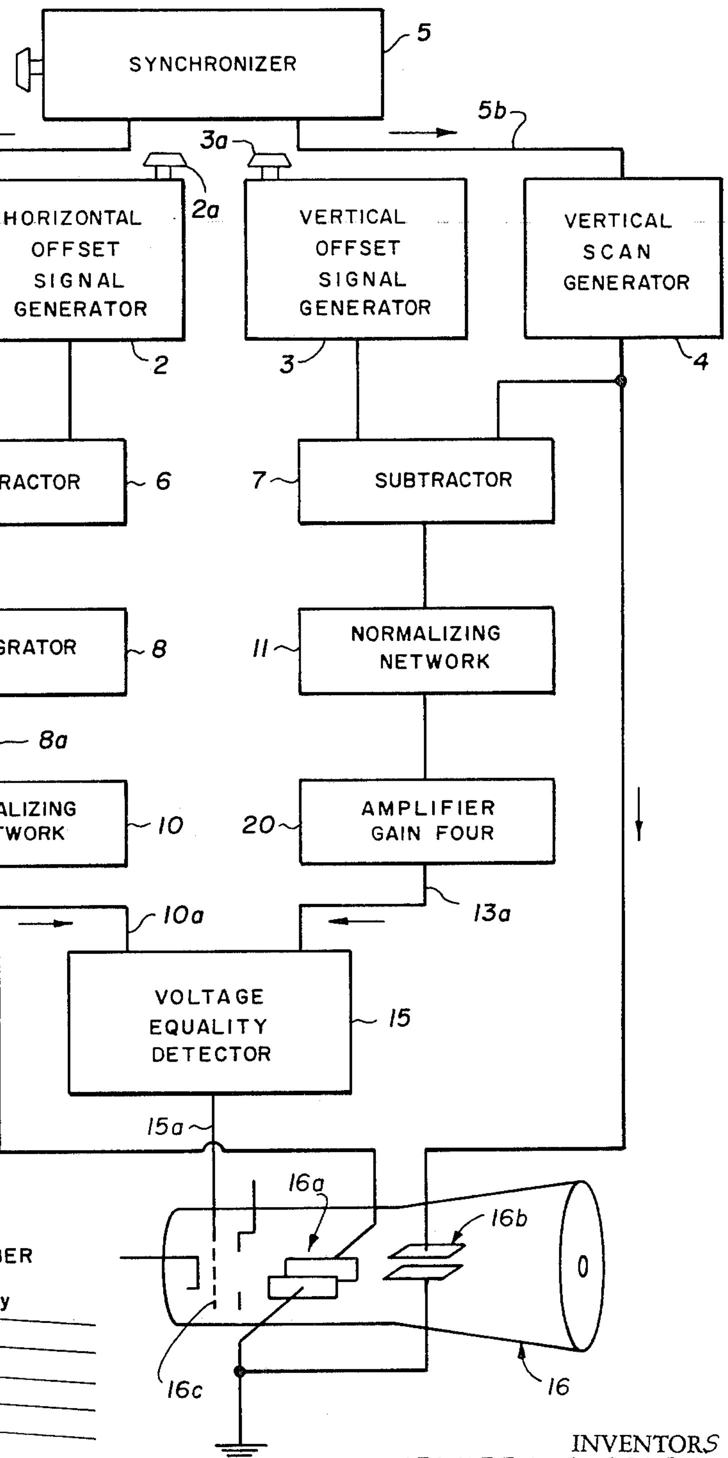
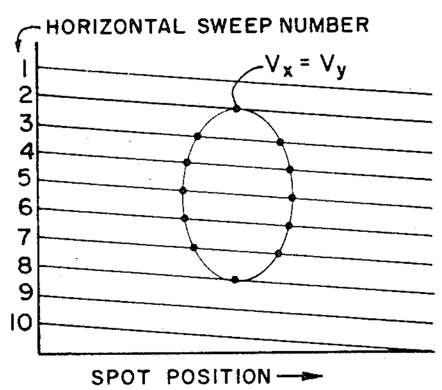


FIG. 9



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DISPLAY SYSTEM TO GENERATE SYMBOLS FORMED OF CONIC SECTIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains to the art of symbol generation employing display devices such as cathode ray tubes and more particularly concerns generation of navigation, identification, or warning symbols for navigation, collision warning, or other displays, where such symbols are generally presented simultaneously with topographic or mapping displays such as are generated from radar data.

2. Description of the Prior Art

The prior art includes systems for generating a wide range of types of symbols on the screens of cathode ray tubes used, for example, to display teletype messages or the outputs of digital processing apparatus. Such arrangements provide only the display of symbols and are therefore relatively easily accomplished. Such arrangements often generate the symbols by successive connected strokes of the intensified cathode ray beam and depend upon stored analog or digital programming of the required deflection and beam intensification events. An ellipse, for example, may be approximated by a hexagon; i.e., by six straight line segments. The resulting approximations are not aesthetically pleasing and are generally difficult and time-consuming to generate.

The difficulty greatly increases when the indicator is to display radar or mapping data requiring repetitive scansions of the indicator face by the electron beam for its presentation. Symbols or parts of symbols may be generated during the otherwise unused retrace intervals, for example, of a raster scanned electron beam. Whether the symbols are provided from digital storage or are selected from a monoscope storage tube or other analog source, construction of the symbol during retrace is complex and expensive, and requires considerable equipment. Furthermore, smoothly curved symbols such as circles or ellipses serve certain purposes as identification or proximity warning symbols in navigation systems and more particularly in marine collision warning systems where a symbol formed by a concatenation of straight line segments may not be an acceptable substitute for a smooth circle, ellipse, or the like.

SUMMARY OF THE INVENTION

The present invention relates to apparatus for the generation on the screen of a cathode ray indicator tube of symbols adaptable for use in many types of displays, but particularly suited to employment as identification or proximity warning symbols in navigation or collision warning displays of radar data. According to the invention, circles, ellipses, straight lines or other conic sections are constructed by novel use of the same deflection voltages as scan the electron beam in a raster pattern for presenting, for example, radar data. The vertical and horizontal scan voltages may both or individually be subjected to biasing, integration, and normalization and the resultant wave forms are supplied to the inputs of a voltage equality detector circuit. At each successive equality event, the electron beam is successively intensified for generation of an element of the desired symbol. The complexity of methods using the sweep retrace time is eliminated and the apparatus is further simplified since voltage squaring is accomplished according to the invention in simple, inexpensive integrators, rather than in wide band squaring circuits.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a preferred embodiment of the invention.

FIGS. **2** to **8** are graphs of wave forms useful in explaining operation of the invention.

FIG. **9** is a representation of a symbol formed according to the invention.

FIG. **10** is an alternative form of the apparatus of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** represents apparatus for drawing symbols such as circles or ellipses under manual or other control on the face of a typical display, such as a cathode ray indicator tube **16** of the type employed in navigation systems or in other applications. Synchronizer **5**, as will be seen, exercises control over timing of elements of the system, in particular for the raster scansion of the electron beam of cathode ray tube **16** over its face. In general, synchronizer **5** is a conventional device generating trigger pulses that appear on output leads **5***a* and **5***b*. As is often the case in prior art cathode ray tube displays, the rate of vertical scan of the cathode ray beam differs from the rate of horizontal scan; for example, there may be 600 horizontal scansions of the electron beam for one vertical scan. For such an example, there will be 600 trigger pulses on lead **5***a* for each single pulse on lead **5***b*, these pulse trains normally being in synchronized relation.

Horizontal scan generator **1** is a conventional saw tooth sweep generator which is synchronized by the control pulses appearing on lead **5***a*. Its output is coupled to a first input of subtractor circuit **6**. Horizontal off-set signal generator **2** supplies a unidirectional offset or bias signal to a second input of subtractor **6**. Offset signal generator **2** may be a simple potentiometer connected across a unidirectional voltage source, the variable position tap of the potentiometer being adjustable by use of control **2***a*. On the other hand, generator **2** may represent a source of unidirectional signal commonly found in an associated device, such as in navigation radar, computer, or plotter systems.

The difference signal generated by subtractor **6** is supplied to an integrator **8** of conventional nature, a device which integrates the difference signal until reset by a pulse of the pulse train found on lead **5***a*. The integration process thus produces a repetitive wave with each cycle of the wave started by a pulse of the pulse wave train on lead **5***a*.

The novel indicator system may include one or more normalizing networks, such as the normalizing network **10** fed by the output lead **8***a* of integrator **8**. Circuit **10** is a conventional network which may take any of several forms, including that of a simple potentiometer or divider resistance network of two series resistors connected between lead **8***a* and ground, and with a common or an adjustable point between the two resistors coupled via lead **10***a* to a first input of voltage equality detector circuit **15**. It is seen that voltage equality detector **15** is thus supplied from the first channel of the invention with a normalized repetitive wave of a first frequency.

The second channel, that coupled to the synchronizer output lead *5b*, is somewhat similar to that coupled to lead *5a*, with the addition of certain novel adjustment elements. Vertical scan generator **4** is again a conventional saw tooth sweep wave generator. It is synchronized by the pulses appearing on lead *5b* and its output is coupled to a first input of a subtractor circuit **7** which, like subtractor circuit **6**, may be a conventional analog circuit commonly used for voltage subtraction. Vertical off-set signal generator **3** supplies a unidirectional off-set voltage or bias signal to a second input of subtractor **7**. Off-set generator **3** may be similar in structure to generator **2**. Further, off-set generator **3** may be located as would be a signal source of the type commonly present in elements of navigation or other systems with which the invention may be associated.

The difference signal generated by subtractor **7** is supplied to an integrator **9** similar to integrator **8** for integration of the difference signal until integrator **9** is reset by a pulse of the pulse train appearing on lead *5b*. The integration process produces a repetitive wave with each cycle started by a pulse of the wave on lead *5b*. The second channel may include a normalizing network **11** similar to network **10** of the first channel.

The output of normalizing network **11** is coupled to eccentricity circuit **12**, a circuit whose gain may be manually changed by adjustment of knob **12***a*. On the other hand, the gain of eccentricity circuit **12** may be electrically adjusted according to a command furnished by other equipment such as a navigation computer or other apparatus. Evidently, eccentricity circuit **12** may be an amplifier whose gain may be manually or electrically adjusted, or both. An output of eccentricity circuit **12** is coupled to a first input of subtractor **13**, a circuit which may be similar to subtractors **6** or **7**.

A second input is supplied to subtractor **13** from adjustable size-control **14**, whose effect may be changed by manipulation of control knob **14***a*. The size control circuit **14** may constitute a simple potentiometer connected across a unidirectional voltage source, the variable position tap of the potentiometer being adjusted by use of a control knob **14***a*. On the other hand, size control **14***a* may represent a source of unidirectional signals, such as a source commonly found in navigation radio computer or plotter systems.

It is seen that the subtractor circuit **13** supplies via lead **13***a* a second input to voltage equality detector circuit **15**, an input which is a normalized and otherwise adjusted repetitive wave of a second frequency. The frequency of the repetitive wave on lead **10***a* will generally be much greater than the frequency of the repetitive wave on lead **13***a*, though these conditions may be reversed. Equality detector **15** may be any of several kinds of circuits available in the prior art which spontaneously generate a sharp trigger pulse when two wave forms such as those on input leads **10***a* and **13***a*, are of substantially equal amplitude. The well known Schmidt trigger circuit is one example of such circuits. The trigger pulses output of detector **15** are coupled via lead **15***a* to the intensifier grid of cathode ray indicator **16**. The electron beam, when intensified, is swept across the face of the indicator by the horizontal scan voltage from generator **1**, which is applied to horizontal deflection plates **16***a* of indicator **16**. Vertical scansion of the electron beam is provided by coupling the output of vertical scan generator **4** to the vertical deflection plates **16***b* of indicator **16**.

In operation, the horizontal and vertical scan signals respectively produced by generators **1** and **4** are lineal ramp or saw tooth waves. It may be assumed for instance, that they are both positive waves, based with respect to ground as shown in FIGS. **2** and **3**. These wave trains are then respectively offset, according to the invention, by unidirectional signals V(a) and V(b), signals arising respectively in generators **2** and **3**, as shown in FIGS. **4** and **6**. It will be seen that the off-set biases correspond to the desired off-set of the center of the circle (or ellipse) to be formed on the screen of cathode ray tube **16**. In the figures, the general case is illustrated in which an ellipse is to be drawn, but with its center exactly centered on the screen of indicator tube **16**.

The offset wave trains V(x)–V(a) and V(y)–V(b) are respectively integrated with respect to time by integrators **8** and **9**. The integrated repetitive wave trains $\hat{x}$ and $\hat{y}$ are composed of inverted sections of parabolas, as is seen in FIGS. **5** and **7**. The integrators **8** and **9** are respectively reset to zero at the commencement of each cycle of the respective waves V(x) and V(y). Thus the quantities $\hat{x}$ and $\hat{y}$ are always respectively brought to zero at the start of each cycle of waves V(x) and V(y). It will be observed that FIGS. **1** to **7** have been drawn as if wave V(x) has only 10 cycles for each cycle of V(y), rather than 600 or several hundred cycles, as is normally used. It will be understood that such has been done purely for convenience in simplifying the nature of the drawings; as noted previously, as many as 600 or more cycles of horizontal sweeping will often occur during only one vertical sweep.

Referring now to FIG. **8**, the integrated wave forms $\hat{x}$ and $\hat{y}$ have been normalized by factors that remain to be further discussed. The vertical sweep signal is subtracted from a unidirectional signal V(D) in subtractor **13** so as to regulate the size of the ellipse to be drawn. The consequent appearance of the voltages v_x and v_y that enter voltage equality detector **15** is seen in FIG. **8**. Progressing from zero along the time scale of FIG. **8**, the voltages v_x and v_y become instantaneously equal at certain times, causing the equality detector circuit **15** to emit an output pulse for each quality event. The pattern of equality events is seen to be symmetric about the voltage zero lying between the horizontal sweeps numbered **5** and **6**. There is one event for each of sweeps number **2** and **9**, two slightly separated events for each of sweeps number **3** and **8**, two more greatly separated events for each of sweeps number **4** and **7**, and two most separated events appear each of sweeps number **5** and **6**. Upon reflection that intensifications caused by the equality events are occuring as the scan pattern grows upward on the screen of indicator **16**, it will be understood that an ellipse such as that of FIG. **9** is outlined by a series of corresponding intensified spots on the screen of indicator **16**. Further, it may be demonstrated analytically that the generated figure is precisely elliptic or circular in shape when moved from the center of the display as well as at that center.

For that purpose, consider that the actual horizontal and vertical deflections of the electron beam are related to time in such a way that for any particular instantaneous sweep situation:

$$x = k_x t \quad (1)$$

$$y = k_y t \quad (2)$$

where x is the instantaneous distance to the horizontally swept position from the vertical zero reference and y is the instantaneous distance from the vertically swept position from the horizontal zero reference (k_x and k_y are constants).

There are then developed signals instantaneously proportional to x and y:

$$V(x) = C_x x \quad (3)$$

$$V(y) = C_y y \quad (4)$$

where C_x and C_y are also constants. Similarly, there are developed off-set voltages $V(a)$ and $V(b)$ in generators 2 and 3:

$$V(a) = C_x a \quad (5)$$

$$V(b) = C_y b \quad (6)$$

where a and b are respective distances to the off-set position with respect to zero references. The outputs of integrators **8** and **9** are respectively:

$$\hat{x} = \int_0^t [V(x) - V(a)]dt \quad (7)$$

$$\hat{y} = \int_0^t [V(y) - V(b)]dt \quad (8)$$

Using the relations expressed in equations 1 to 6, equations 7 and 8 may be rewritten as:

$$\hat{x} = \frac{1}{2} C_x k_x t^2 - C_x a t = \frac{x^2 - 2ax}{2k_x/C_x} \quad (9)$$

$$\hat{y} = \frac{1}{2} C_y k_y t^2 - C_y b t = \frac{y^2 - 2by}{2k_y/C_y} \quad (10)$$

The outputs of integrators **8** and **9** are recognized as parabolic waves and the normalizing factors are seen to be represented by the terms $C_y/2ky$ and $C_x/2kx$.

Consider that the well known analytical equation for an ellipse:

$$(x-a)^2/(h^2) + (y-b)^2/(l^2) = \text{one} \quad (11)$$

may be rewritten in the form:

$$[x^2 - 2ax] = h^2 - (h^2/l\,[y^2 - 2by] - (h^2/l\,[b^2 - a^2] \quad (12)$$

The terms in the brackets are readily recognized as corresponding to the parabolic waves output from the respective normalizer networks **10** and **11**. The equality expressed in equation 12 represents the condition for simultanuity between the left and right sides of the equation when x and y are each functions of time. For example, in FIG. **1**, the eccentricity network **12** is used to multiply the deflection signal in the second channel by the term $(h/l)^2$. The size control **14** has an output signal V(D) that is recognized as:

$$V(D) = h^2 - (h/l)^2\, b^2 - a^2 \quad (13)$$

For generating only true circles:

$$h = l \quad (14)$$

and the eccentricity circuit **12** may be eliminated.

Other conic sections such as parabolas or hyperbolas may be drawn by modifications of the invention. For example, the circuit of FIG. **1** may be modified in a very simple manner to produce hyperbolic traces instead of circles or ellipses. For this purpose, a conventional adder circuit is substituted for subtractor **13**, so that the output of eccentricity circuit **12** is added to the dimension signal emanating from size control **14**, and the sum is supplied via lead **13***a* to voltage equality indicator **15**. Now:

$$V(D) = (h^2/l^2)\, b^2 - a^2 + h^2 \quad (15)$$

where the quantities a, b, h, and l are identified in the usual general analytical expression defining a hyperbola by:

$$(x-a)^2/(h^2) - (y-b)^2/l^2 = \text{one} \quad (16)$$

Parabolas may be generated by the embodiment shown in FIG. **10**. In FIG. **10**, elements common to those in FIG. **1** are identified by the same reference numerals and need not be discussed in further detail herein. Such elements include elements **1** to **11** and **15** and **16**.

In FIG. **10**, it is seen that a substitution has been made in the second channel for the formerly employed eccentricity circuit **12**, the size control **14**, and the subtractor **13**. The new element introduced is an amplifier **20** having a gain of four; that is, its output amplitude is calibrated to be four times as great as its input amplitude. Accordingly, any circuit which will multiply signal amplitude by four will be useful as circuit element **20**. Accordingly, the second channel is now modified to generate the quantity:

$$v_y = 4m\,(y-b) - a^2 \quad (17)$$

where m is readily identified from the general analytical expression for a parabola:

$$(x-a)^2 = 4m(y-b) \quad (18)$$

In this case, the normalizer network **11** in the second channel multiplies the quantity $[V(y) - V(b)]$ by l/C_y. The axes of the conic sections may be reversed simply by switching the deflection roles of the first and second channels.

It will be recognized by those skilled in the art that the novel symbol generator may be operated to produce elements required for the assembly of various alpha-numeric symbols. Merely by appropriate manual programming or by conventional programming of a universal digital computer, AND or OR gates may evidently be operated so that portions of the circle, ellipse, or other conic section may be drawn while other portions are blanked out by appropriate control of the intensifier grid of indicator **16**. Further, by appropriate manual or other control of eccentricity circuit **12**, circles, ellipses of various major-to-minor axis ratios, and straight lines may readily be generated. It is apparent that many symbols in addition to purely alphanumeric symbols may also be constructed employing the invention. By manual or other adjustment of the outputs of the horizontal off-set signal generators **2** and **3**, those symbols may be placed at any desired position of the face of cathode ray tube **16**.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than of limitation and that changes within the purview of the appended claims may be made without departure from the true scope and spirit of the invention in its broader aspects.

We claim:

1. Apparatus for generating display symbols comprising:
indicator means having first and second electron beam deflection means,
means for supplying first and second wave trains of respective first and second frequencies to said respective first and second electron beam deflection means,
means for integrating said first wave train for producing a first output wave train,
means for integrating said second wave train for producing a second output wave train,
amplitude equality detection means responsive to said first and second output wave trains for providing a third output signal upon substantial equality of said first and second output wave trains,
means for applying said third output signal to intensify said electron beam for forming a symbol.

2. Apparatus as described in claim 1 further comprising bias circuit means for off-setting said first wave train.

3. Apparatus as described in claim 2 further comprising means for normalizing said first output wave train.

4. Apparatus as described in claim 1 further comprising bias circuit means for off-setting said second output wave train.

5. Apparatus as described in claim 4 further comprising means for normalizing said second output wave train.

6. Apparatus as described in claim 4 further comprising adjustable subtractor circuit means for diminishing the amplitude of said second output wave train.

7. Apparatus as described in claim 4 further comprising adjustable adder circuit means for increasing the amplitude of said second output wave train.

8. Apparatus for generating display symbols comprising:
indicator means having first and second electron beam deflection means,
means for supplying first and second wave trains of respective first and second frequencies to said respective first and second electron beam deflection means,
means for integrating said first wave train for producing a first output wave train,
means for amplifying said second wave train for producing a second output wave train,
voltage equality detection means responsive to said first and second output wave trains for providing a third output signal,
means for applying said third output signal to intensify said electron beam for forming a symbol.

9. Apparatus as described in claim 8 wherein said means for amplifying said second wave train comprises means for amplifying the amplitude of said second wave train substantially by the quantity four.

10. Apparatus for generating display symbols comprising:
indicator means having first and second electron beam deflection means,
means for supplying first and second wave trains of respective first and second frequencies to said respective first and second electron beam deflection means,
first and second means for integrating said respective first and second wave trains for producing first and second output wave trains,
first and second means adapted for normalizing said first and second output wave trains for producing respective normalized first and second wave trains,
amplitude equality detection means,
means for supplying said normalized first and second wave trains to said amplitude equality detection means, and
means for applying signals generated by said amplitude equality detection means representing amplitude equality events to intensify said electron beam for forming a symbol.

11. Apparatus as described in claim 10 further comprising first and second bias circuit means for off-setting said respective first and second wave trains.

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