Oct. 23, 1962 W. J. SHANAHAN 3,060,419

NUMBER OR SYMBOL GENERATOR

Filed Dec. 16, 1958 4 Sheets-Sheet 1

FIG. 1.

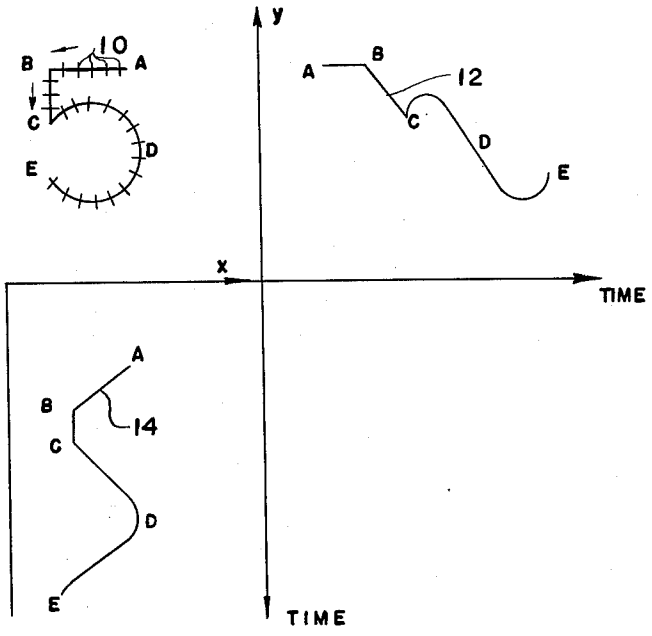

FIG. 2.

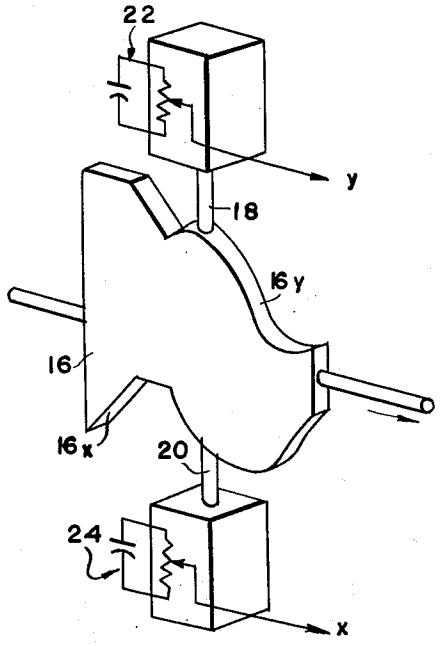

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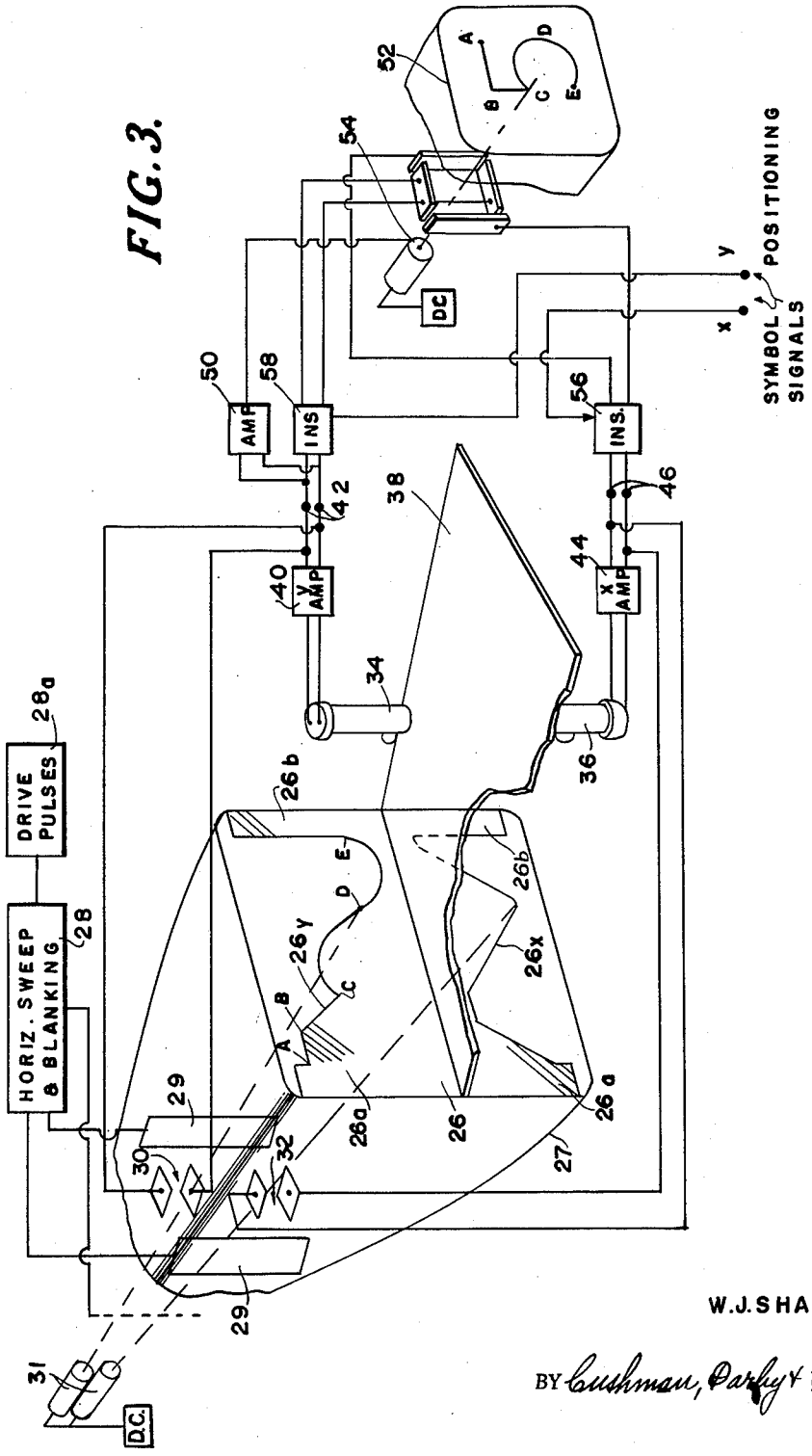
FIG. 3.



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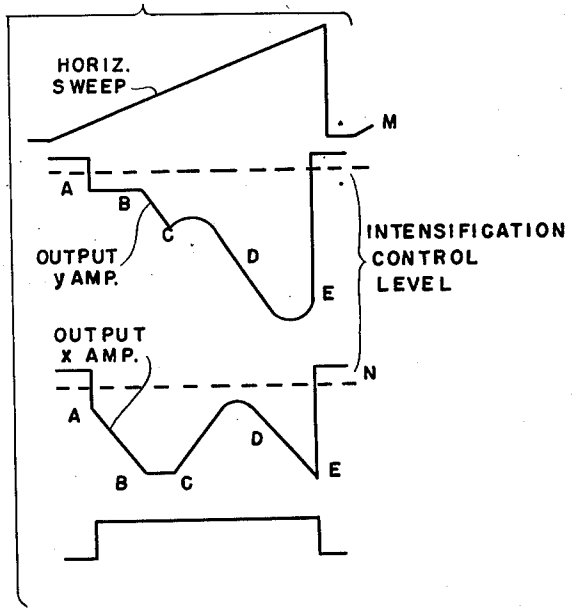
Filed Dec. 16, 1958 4 Sheets-Sheet 3

FIG. 4.



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Filed Dec. 16, 1958 4 Sheets-Sheet 4

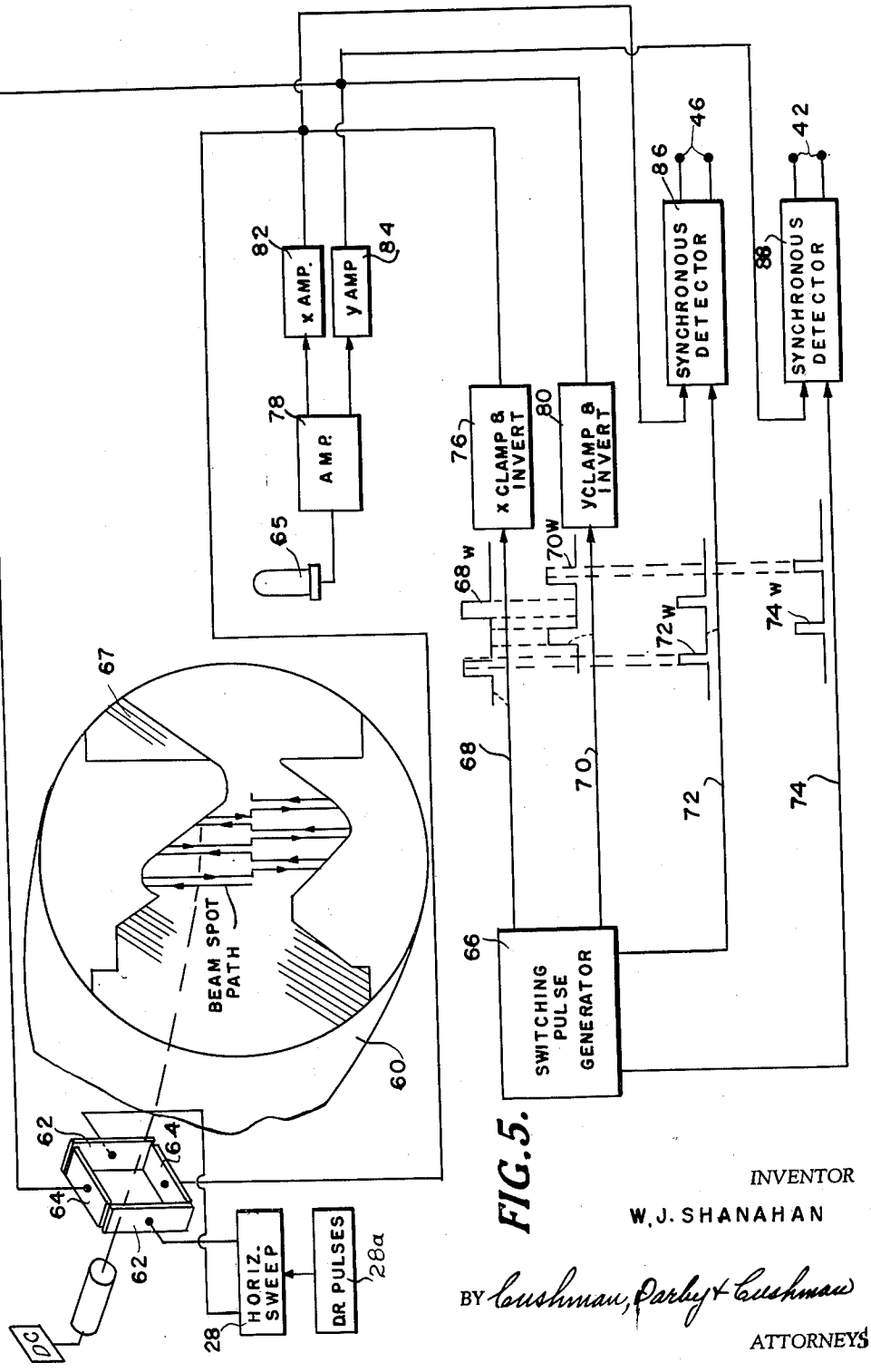

FIG. 5.

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United States Patent Office

3,060,419

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NUMBER OR SYMBOL GENERATOR

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2 Claims. (Cl. 340—324)

This invention pertains to apparatus for generating symbols such as numbers, letters and the like for display or other purposes.

In accordance with the present invention symbols can be generated and displayed or recorded by electronically or otherwise following the contours of complementary profiles for establishing suitable coordinate points for defining each elemental portion of the symbol. By use of the various embodiments of the invention it is possible to create or record symbols such as numbers and letters in a manner not heretofore possible.

Accordingly, the primary object of this invention is to provide improved means for generating and displaying symbols such as numbers and letters.

The many subordinate objects of the invention and the entire scope of the invention will become further understood with reference to the following detailed description of exemplary embodiments.

The exemplary embodiments can be best understood with reference to the accompanying drawings, wherein:

FIGURE 1 shows an exemplary symbol developed by the invention, and time versus intensity plots pertinent thereto.

FIGURE 2 shows a mechanical arrangement for producing complementary deflection potentials according to an embodiment of the invention.

FIGURE 3 shows a first electronic embodiment of the invention.

FIGURE 4 shows plots of voltages versus time pertinent to FIGURE 3.

FIGURE 5 shows a second electronic embodiment of the invention which is a modification of part of the apparatus of FIGURE 1.

The characters or symbols according to this invention are generated or "written" by moving a record making means along the contour of the symbol as shown in FIGURE 1. A number 5 as an example of a character or symbol is shown in the process of being written. The record making means, for example, an electron beam, or inking pen, starts at A, proceeds through B and C, to D and E. In order to produce this type of deflection utilizing a Cartesian device such as a cathode ray tube, it is necessary to split up the beam motion into an x and a y component.

A further requirement is that the writing rate of an electron beam or pen at any instant must be constant in order to permit the intensity of the number to be everywhere constant. If there were any writing rate modulation of the beam during its traverse of the number, a corresponding variation in written intensity will normally result.

The technique of sweeping a record making means such as an electron beam along the character being made has many advantages over other proposed number display devices such as monoscope TV scanning devices and magnetic core or other devices producing an array of dots. For a given writing time it will be recognized that the character in the present invention may be intensified for the entire interval, whereas if it were attempted to display the same symbol by television or other raster or quasi-raster scanning schemes, it would be necessary to keep the beam blanked or unintensified for upwards of 90% of the writing time if the characters were not to be made to appear coarse. A second advantage is that for

a given resolution display tube it is possible to obtain a considerably more readable and higher resolution symbol than is possible using line scanning techniques.

The technique of symbol generation by continuous writing has been demonstrated previously by the so-called "Lissajou pattern" technique. In this technique, which has previously been employed, the symbols to be produced are composed of a series of straight lines, ellipses and sine waves suitably joined together to produce patterns which may be made to resemble commonly accepted numerical symbols. A technique has also been described for performing a similar operation using straight line segments joined together to form crude approximations to commonly utilized numbers and letters.

The present invention overcomes the limitation of the above known scheme by employing two arbitrary function generators and a means for preparing these arbitrary functions for any characters whatever.

To write the number 5 in accordance with the present invention, it is necessary to produce the corresponding x and y deflection waveforms. For this reason two functions must be generated such that any combination of values taken at a given instant must define a point on the curve. In addition the functions must be such that

$$\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2$$

is a constant, representing the velocity of the spot along the curve to be scanned.

In order to understand how these criteria may be met simultaneously, reference is made to FIGURE 1. Assume that the number 5 is to be traced or generated in the direction shown. A series of equal spaces **10** representing equal time intervals are marked off along the curve representing 5. These time intervals correspond to fractional parts of the character writing period. There are then laid off as a function of time, the vertical or y component **12** and horizontal or x component **14** of the number as taken from the curve. This is shown in FIGURE 1 and the corresponding points of the x and y waveforms are labeled so as to indicate the correspondence with the points on the numerical symbol. By assuming equal time intervals the x and y waveforms are automatically drawn so that the sum of the squares of the x and y rates automatically will be as a constant.

It is necessary to produce two such waveforms **12** and **14** as are shown in FIGURE 1 as a function of time. These waveforms must be generated simultaneously and in correct phase. Several techniques have been discovered. If the number is to be written slowly, as for a mechanical plotter, the x and y waveforms may be cut into the shape of cams. This is shown schematically in FIGURE 2. A cam **16** is cut to the form of the y waveform on one surface **16**y, and to the form of the x waveform on its opposite surface **16**x. The cam is shown schematically as having a horizontal linear motion, provided by any suitable means (not shown). Cam followers or plungers **18** and **20** ride along the upper and lower edges, respectively, of cam **16** to move potentiometers **22** and **24** connected to appropriate sources of voltage and producing therefore corresponding outputs as functions of time. If the outputs of these potentiometers were set to the horizontal and vertical inputs of a graphic servo-driven plotting pen recording board, for example, the number would be accurately reproduced by the pen.

For many applications in which such symbol is to be produced the waveforms much be produced at a much higher rate. For this reason an electronic curve follower is required. Such an electronic curve follower may be constructed to produce an electrical output corresponding to a mask cut in the desired shape. Reference is now made to FIGURE 3. In this diagram a mask **26**, the

upper edge **26***y* of which corresponds to the *y* waveform, and the lower edge **26***x* of which corresponds to the *x* waveform, is shown in place on the face of a dual beam cathode ray tube **27**. The dual beam tube has a single horizontal deflection or sweep circuit **28** driven by pulse circuit **28***a* and working into deflecting plates **29**, but employs two separate vertical deflection circuits working into an upper set **30** and lower set **32** of deflecting plates. Two guns **31** are provided, and a grid **33** for conventional blanking of the spot during horizontal retrace.

Two photocells are positioned in front of the mask: one is **34** suitably masked off from the other, designated designated **36** by barrier **38** so that each is able to see only its corresponding beam spot.

The rest position of the upper beam is at the upper edge of the tube, and the rest position of the lower beam is at the lower edge of the tube. This may be accomplished by applying a suitable D.C. potential across the deflection plates **30** and **32** of the double beam cathode ray tube.

An amplifier **40** connected to the photocell **34** is provided which, however, tends to drive the upper beam toward the center of the cathode ray tube if any light from the beam spot arrives at the cell **34** so as to provide an output therefrom. This amplifier is of sufficient gain to be capable of full-scale deflection of the beam spot with an input corresponding to a small fraction of the total possible light output from the beam spot.

For this reason the beam does not remain at its rest position, but is driven downward by the output of the amplifier until it lies partially behind the upper edge of the mask. As the beam begins to disappear behind the mask the photocell sees less and less of the beam until finally an equilibrium position is arrived at such that the amount of light reaching the photocell is just barely able to sustain the downward deflection. The spot will then hub the upper edge of the mask. A *y* output signal is also available from amplifier **40**, as at terminals **42**. A corresponding wave, the output from photocell **36**, is fed to amplifier **44** which is connected to plates **32** to drive the lower beam upward toward the center of the tube. The lower beam is therefore made to follow the lower edge of the mask. The *x* output is available at terminals **46**.

In order to produce the *y* waveform from this device, a sweep or sawtooth waveform is applied to the horizontal deflection plates **29** of the cathode ray tube. This causes the horizontal position of both spots to move continuously from left to right. The spots continuously hug the edges of the mask and therefore the corresponding outputs from the outputs of the amplifiers must therefore represent the *x* and *y* voltage waveforms corresponding to the horizontal and vertical components of the symbol.

It will be noted that suitable design of the amplifier is desirable to prevent the spot from hunting. Hunting will normally occur if extensive phase shifts are produced in the amplifier or in the phosphor of the cathode ray tube itself. Those of ordinary skill in the art will understand the solution of this problem.

Continuing with FIGURE 3, it will be noted that while the typical *x* and *y* waveforms corresponding to the number 5 have been shown on the mask, the left and right sides of this mask have been prolonged vertically as at **26***a* and **26***b* to produce elevated pedestals to the left and to the right of the waveform generating portions of the mask. The resulting waveforms for the *y* and *x* portions of the signal are as shown in FIGURE 4, Parts *a* and *b*, respectively, in each case prior to sweeping across the portion of the mask between points A and E. The beam spot lies behind the elevated pedestals, producing a corresponding pedestal in the resultant waveform. One or both of these waveforms may then be amplified by conventional circuits such as **50** above levels M or N, as is shown in FIGURE 4, and the output employed as the intensification waveform shown. Reshaping of this waveform may be desirable in an attempt to still further limit the width of the number.

In producing a number using this technique, it is necessary to have a sweep waveform on the face of the cathode ray tube **27** which is sufficiently large to deflect horizontally well into both pedestal areas on the left and right side of the cathode ray tube. It is also desirable to blank the retrace of the cathode ray tube **27** in order to prevent the same number from being generated in reverse during the reverse traverse of the spot. Both of these specifications may be met by simple standard circuitry. Circuit **50** may automatically decrease the intensity of the beam of display device **52**, by acting upon a control electrode **54**. The positioning of the sweep and its size are not critical so long as the sweep is at least large enough to scan across the face of the tube **27**. If the sweep is displaced slightly in a horizontal direction, the only result is to cause the number to be generated a little earlier or later in time, but no change or distortion in the number will result. In addition, since the blanking waveform is generated from the *x* and *y* waveforms directly, it is automatically timed to coincide with the beginning and end of the number regardless of the positioning of the sweep waveform.

The display cathode ray tube **52** may be a Skiatron dark trace tube or any other type of electrostatically or magnetically deflected tube. The techniques described herein are also suitable for the generation of symbolic characters to be displayed upon any type of *x*, *y* recorder if the generation of the symbols is accomplished at an acceptable speed.

In practice, tube **52** may be large and a symbol intended to be only a part of a total display, and the system intended to be capable of selective placement of the symbol in various areas of the tube face. For this purpose D.C. insertion circuits **56** and **58** may be employed to orient the symbol "rest" or reference position of the spot according to *x* and *y* coordinate points, respectively.

It will be recognized that in lieu of a single dual beam cathode ray tube that two separate cathode ray tubes might also be employed, one carrying each mask. If this is the case, however, the deflection sensitivity must be equal or provision must be made for adjusting the horizontal sweep waveform so that corresponding *x* and *y* points are traced out at the same instant.

A further embodiment of the invention utilizes a single beam cathode ray tube to scan both masks. In this technique a single beam is switched back and forth between the upper and lower edges of the mask, thus producing two output waveforms which may be separately rectified and used for the generation of number waveforms. A block diagram of the dual reflection technique is shown in FIGURE 5. In this diagram a single beam cathode ray tube **60** is shown. There are two sets of deflection plates, one set **62** for horizontal and one set **64** for vertical. The mask **67** is substantially the same as that shown in FIGURE 3, with the *y* waveform cut into the top of the mask and the *x* waveform into the bottom. A single photocell **65** watches the face of tube **60**.

In order to produce the correct deflection waveform, electronic switching pulses must be provided. These are generated in circuit **66**. The output of the high PRF pulse generator consists of the following signals:

An *x* sample on line **68**
A *y* sample on line **70**
An *x* detect on line **72**
A *y* detect on line **74**

The *x* sample and *y* sample waveforms are pulses chosen to interleave in time so that at no time do they occur together. These may be produced by conventional multivibrators and delay circuits or may be taken from successive outputs of a ring counter. While in theory the *x* and *y* sampling waveforms might consist merely of

the outputs from the opposite plates of a single multivibrator, it is desirable because of the finite decay time of the phosphor to provide some separation between the *x* and *y* sample waveforms, as is shown by the vertical alignment of the waveforms **68***w*, **70***w*, **72***w* and **74***w*. The *x* and *y* detect waveforms are narrower pulses than the *x* and *y* sample waveforms and are chosen to fall near the end of their respective periods.

The *x* sample waveform is applied to a clamping circuit **76**, which includes an inverter. This produces a waveform which is "clamped" to an arbitrary D.C. level which may be ground. During the unclamping time the voltage at the output of the clamp tube will normally rise to B+ except in the presence of a suitable signal from the amplification circuit **78** of photocell **65** which is connected as through a diode or parallel connected triode to prevent the waveform from completely rising to B+. If no output from the photocell occurs, therefore, the output from the *x* clamp will swing between the clamp level and B+ during the *x* sampling period. The output from the *x* clamp is connected to one of the vertical deflection plates. The other vertical plate is connected to circuit **80** in *y* sample line **70** and therefore said other plate is clamped to the reference level during the entire time of occurrence of the *x* sampling pulse. Therefore, the *x* sampling pulse is solely effective in producing the beam vertical deflection during the *x* sampling period. As the deflection voltage rises, however, the beam reaches a point where the phosphor light spot may be "seen" by the photoelectric cell, producing an output. This output is amplified by circuit **78** and applied to an *x* amplifier **82** connected in parallel with the output of the *x* clamp. This is to limit the deflection waveform applied to the deflection plates to prevent the beam from rising appreciably above the top of the mask. In this respect the entire system constitutes a negative feedback loop and is similar to the system described in FIGURE 3. Due to the phosphor response time as well as other time delays in the circuits, there may be some overshoot of the beam past the edge of the mask which is damped to zero during the sampling interval. For this reason the sampling interval should be chosen to be sufficiently long compared to the phosphor decay time. Compensating networks of either the lead or lag type may be employed as in conventional feedback amplifiers to stabilize the system to prevent excessive hunting.

At the end of the *x* sample period, the lower deflection plate is again clamped to the reference level and the *y* clamp **80** then operates, attempting to pull the upper deflection plate to B+. This would normally cause the beam to be deflected to or beyond the upper limit of the tube face, or by feedback from the photocell to the *y* amplifier **84**, prevent it from going beyond the edge of the mask. The amplifier is designed to load down the *y* clamp with a sufficiently large signal of negative polarity to prevent the beam from moving above the edge of the mask.

The beam is, therefore, caused to travel in the path shown in the diagram in FIGURE 5, following alternately the upper and lower edges of the mask. It should be recognized, of course, that the time scale is grossly exaggerated in the figure to show details. Normally the sampling frequency is at least 60 to 100 times the horizontal scanning rate, so that a large number of samples are taken during a single scan. The outputs of the *x* and *y* clamp circuits, therefore, represent square wave carriers, amplitude modulated on one side by the *x* and *y* masks, respectively.

In order to recover the mask waveforms it is necessary to detect these signals. This may be accomplished by conventional diode detectors, but is preferably done in a synchronous detector to permit the output to follow rapid changes in the waveforms on the mask. The use of a single diode detector would be limited by all of the factors which conventionally prevent such detectors from following variations in the modulation which are at a high rate compared to the carrier frequency.

While the *x* and *y* deflection waveforms may be combined in a push-pull deflection circuit so as to maintain more uniform focus across the face of the electrostatically deflected tube, the *x* and *y* waveforms would not be as easily separable as in the illustration given here. The waveforms in this case are available on separate wires and may therefore be easily rectified without crosstalk.

Synchronous detectors **86** (*x* channel) and **88** (*y* channel) of conventional design are shown in FIGURE 5. These constitute a bi-directional switch which is open for a time interval equal to the *x* and *y* detection pulse periods. An output condenser in each (not shown) holds the sampled waveform until the next pulse arrives. The *y* output is on terminals **42**, and *x* on terminals **46**. The remainder of the system of FIGURE 3 applies.

The final waveforms have a slight staircase waveform on the rising and falling fronts, but these may be easily removed by the addition of low pass filters without causing unnecessary integration of the waveform. The detection pulse is timed to occur near the end of the sampling period in order that any transients which may be introduced by overshoot in the feedback amplifier, etc., may have subsided before sampling takes place. The output waveforms are then substantially the same as those obtained in the scheme of FIGURE 3. These waveforms will contain blanking pedestals which may be treated as explained in connection with FIGURE 3, to produce a blanking waveform which is suitable for intensifying the cathode ray tube **52** on which the numbers are to be displayed.

A number of minor detailed features may be employed to make the intensification waveform less critical. The simplest of these consists of slightly integrating and thus delaying the leading edge of the blanking and slightly integrating or otherwise delaying the sudden return of the *x* and *y* waveforms to the rest position at the end of the number. This prevents "tails" from appearing at the leading and trailing edges of the number by assuring that despite any delays in the system the beam is intensified only during the actual time the number is to be written, and when the number writing beam is in the correct position.

The foregoing detailed description of illustrative embodiments is only given to provide a clear understanding of the invention and the true scope of the invention is to be determined from the appended claims.

What is claimed is:

1. Apparatus for generating symbols comprising a dual beam cathode ray tube having a face layer adapted to radiate energy momentarily in areas impinged upon by the beam, barrier means for dividing the field of view to said face layer into two parts, a fully opaque mask having upper and lower differently contoured varying edges respectively representing coordinate developing profiles and respectively disposed stationarily adjacent said parts of said face layer, two radiation sensitive devices for watching the respective parts of the face layer separated by said barrier with said mask being between said devices and said face layer, means for horizontally deflecting the dual beams in unison across the face of said tube, and means including two sets of vertical deflection means respectively for said beams and respectively coupled thereto two feedback circuits responsive to said radiation sensitive devices respectively for causing said beams to follow the said profile edges respectively during said unison deflecting.

2. Apparatus for generating symbols comprising a single beam cathode ray tube having a face layer adapted to radiate energy at least momentarily from areas impinged upon by said beam, a single radiation sensitive device watching said face layer, a fully opaque mask having upper and lower differently contoured varying pro-

file edges stationarily positioned between the radiation sensitive means and said face layer to intercept radiation from certain areas of the face layer, means for horizontally sweeping the beam over said face layer, means for fully sweeping said beam over said face layer up and down a multiplicity of times for each horizontal sweep thereof including means for effectively delaying the start of each up sweep from the finish of the preceding down sweep and vice versa, and means responsive to the radiation sensitive device for limiting each up sweep of said beam substantially to the instant level of said upper profile edge and for limiting each down sweep

of said beam substantially to the instant level of said lower profile edge.

References Cited in the file of this patent

UNITED STATES PATENTS

2,455,532	Sunstein	Dec. 7, 1948
2,528,020	Sunstein	Oct. 31, 1950
2,844,759	Bryan	July 22, 1958
2,872,669	Johnson	Feb. 3, 1959
2,907,018	Haining	Sept. 29, 1959