United States Patent

Nielsen

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[54] CHARACTER GENERATOR EMPLOYING PULSED BEAM INTERROGATION OF MATRIX

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[52] **U.S. Cl.** .....**340/324 A**, 178/6.6 R, 178/15

[51] **Int. Cl.** **G06f 3/14**

[58] **Field of Search** .....340/324 A, 146.3; 178/6.6 R, 178/15

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Assistant Examiner—Marshall M. Curtis
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[57] **ABSTRACT**

A cathode ray tube character generator suitable for computer output microfilming employs pulsed beam interrogation of a selected sector of a character matrix according to a predetermined pattern. There is shown a tube having a phosphor plate producing stationary light spots for effectively dissecting a character on a matrix transparency that is external of the tube. The pattern of stationary light pulses is produced with high speed phosphor and digitally implemented deflection system, with each stationary light spot being judged on a digital on or off basis. High quality character generation at suitable rates results. The system provides improved signal to noise ratio for the signal produced from the character matrix; e.g. with a cathode ray tube light source, the system decreases noise which is realized to be related to microscopic variations in the phosphor surface.

An implementation of the control system is shown as essentially a logic network, with transistor switching of various resistors in and out of the deflection coil circuit according to predetermined progression, with the light spot pattern being developed e.g., on a left to right, down, right to left down basis. Incremental shift of the deflection system from one setting to the next occurs with the beam blanked, and no change in setting occurs when the beam is unblanked.

A cathode ray tube system identical to the character generator is used as the display tube for the microfilm camera, both controlled by a master clock, with delay of the pulses to the display tube. In both systems the beam unblank pulses are correlated with the clock pulses, and the falling edge of the clock pulses controls the next incremented setting of the deflection network.

7 Claims, 4 Drawing Figures

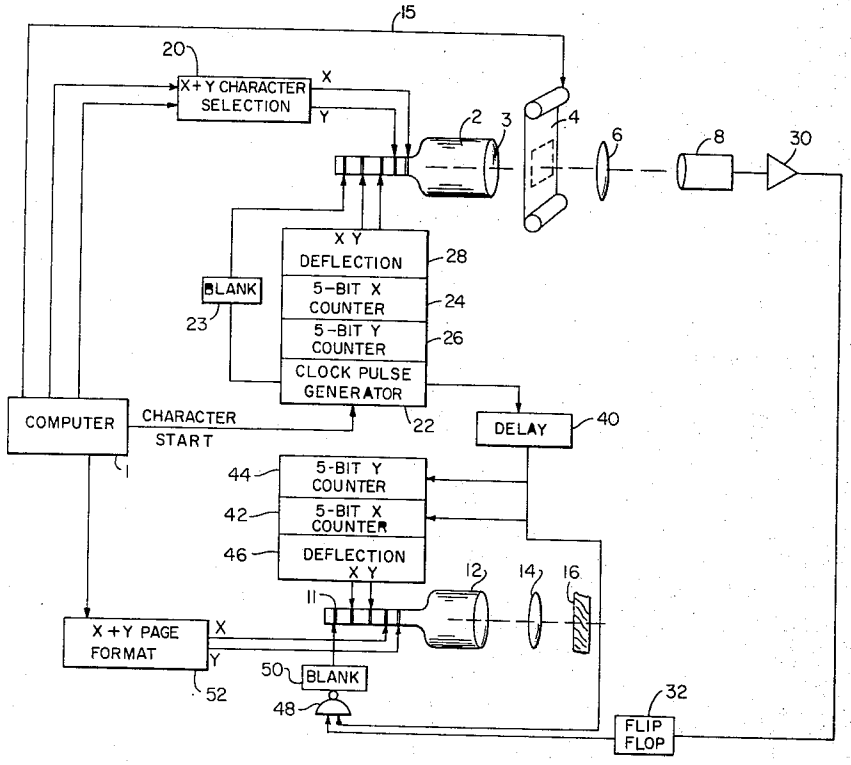
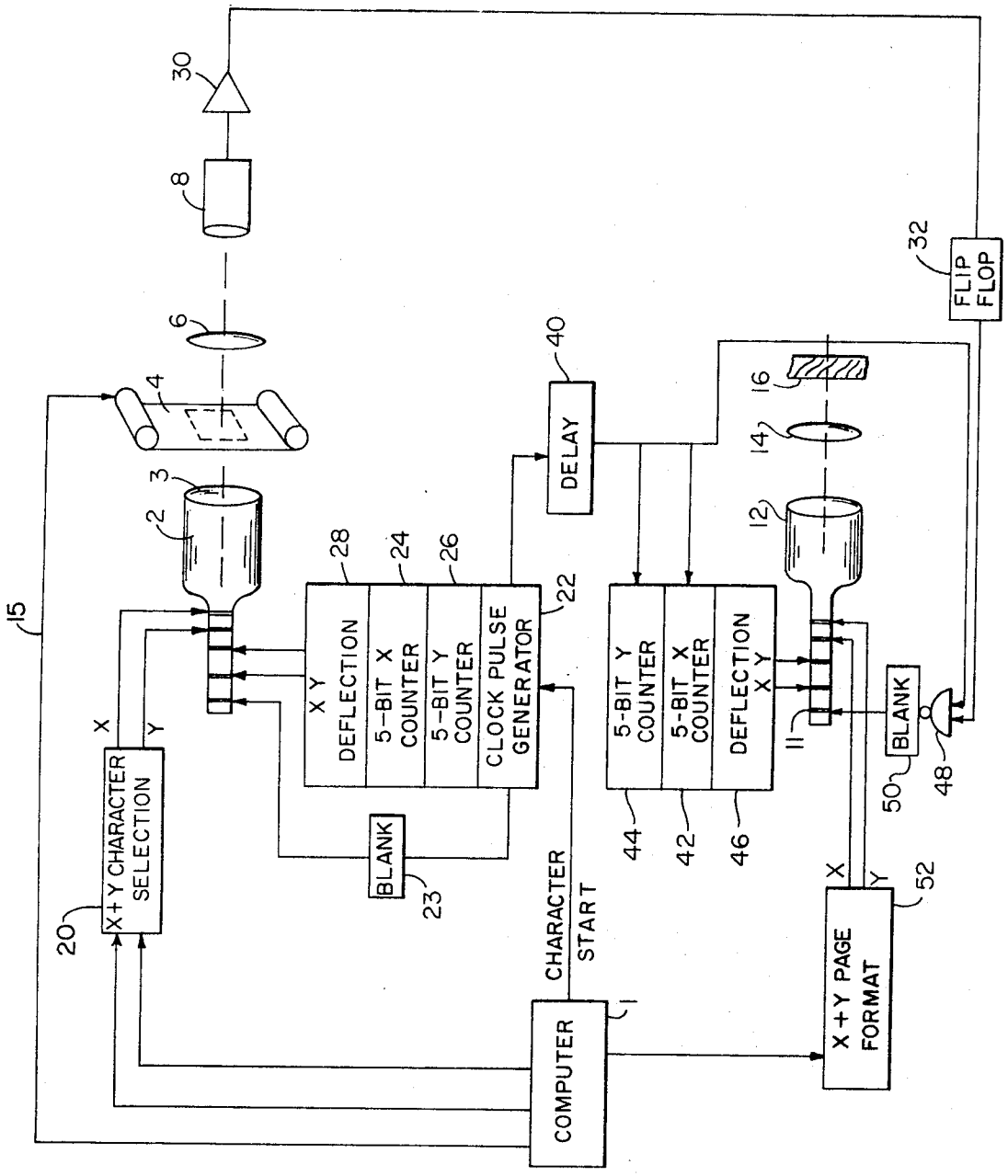


FIG 1


30
8
6
4
3
2
15
X
Y
X+Y CHARACTER SELECTION
20
28
24
26
22
X Y DEFLECTION
5-BIT X COUNTER
5-BIT Y COUNTER
CLOCK PULSE GENERATOR
BLANK
23
DELAY
40
32
FLIP FLOP
16
14
12
5-BIT Y COUNTER
5-BIT X COUNTER
DEFLECTION X Y
44
42
46
11
BLANK
50
48
CHARACTER START
COMPUTER
1
X
Y
X+Y PAGE FORMAT
52

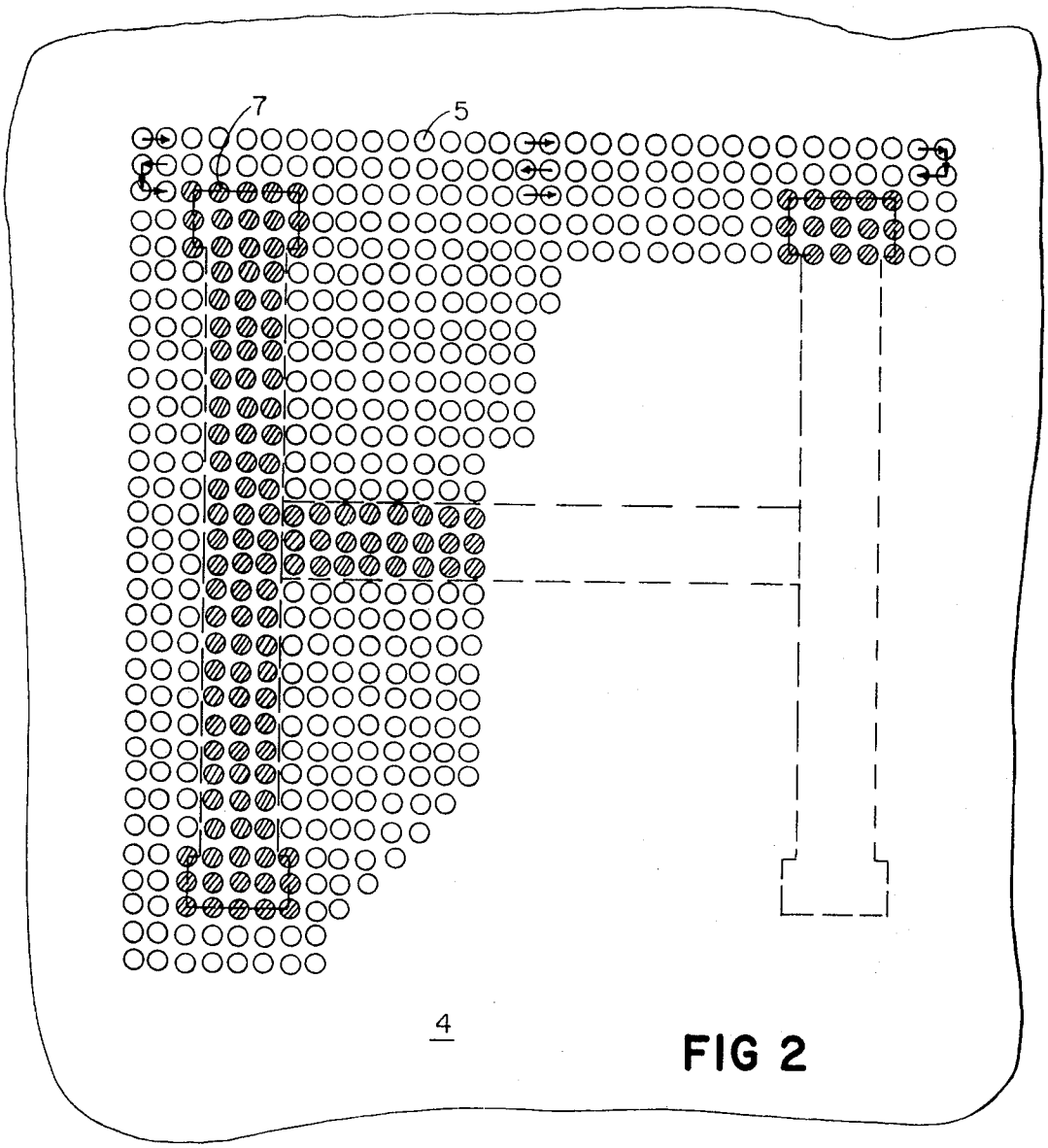


FIG 2

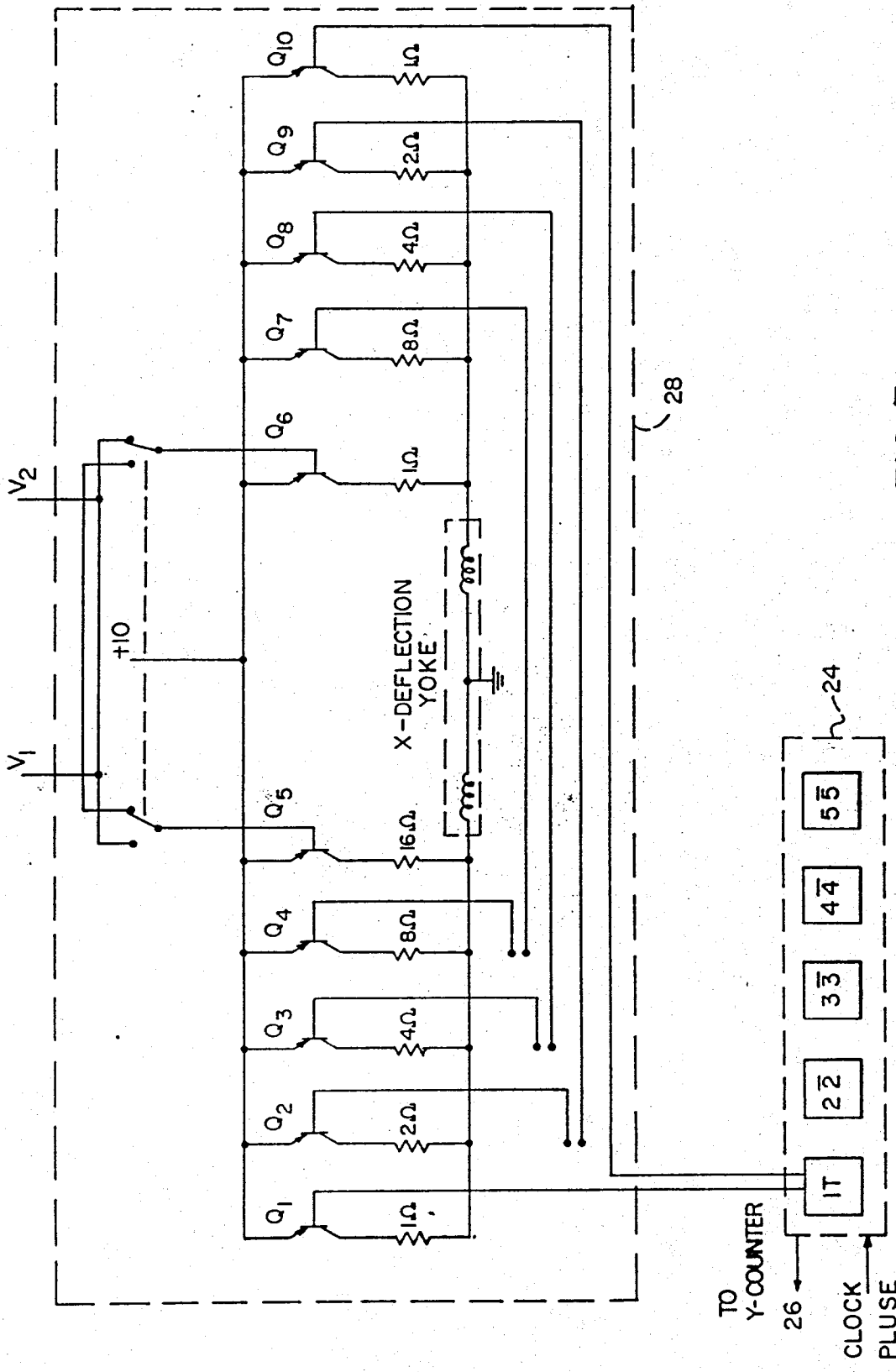

Q10
1Ω
Q9
2Ω
Q8
4Ω
Q7
8Ω
Q6
1Ω
Q5
16Ω
Q4
8Ω
Q3
4Ω
Q2
2Ω
Q1
1Ω
28
V2
V1
+10
X-DEFLECTION YOKE
24
5 5̄
4 4̄
3 3̄
2 2̄
1T
TO Y-COUNTER
26
CLOCK PLUSE

FIG 3

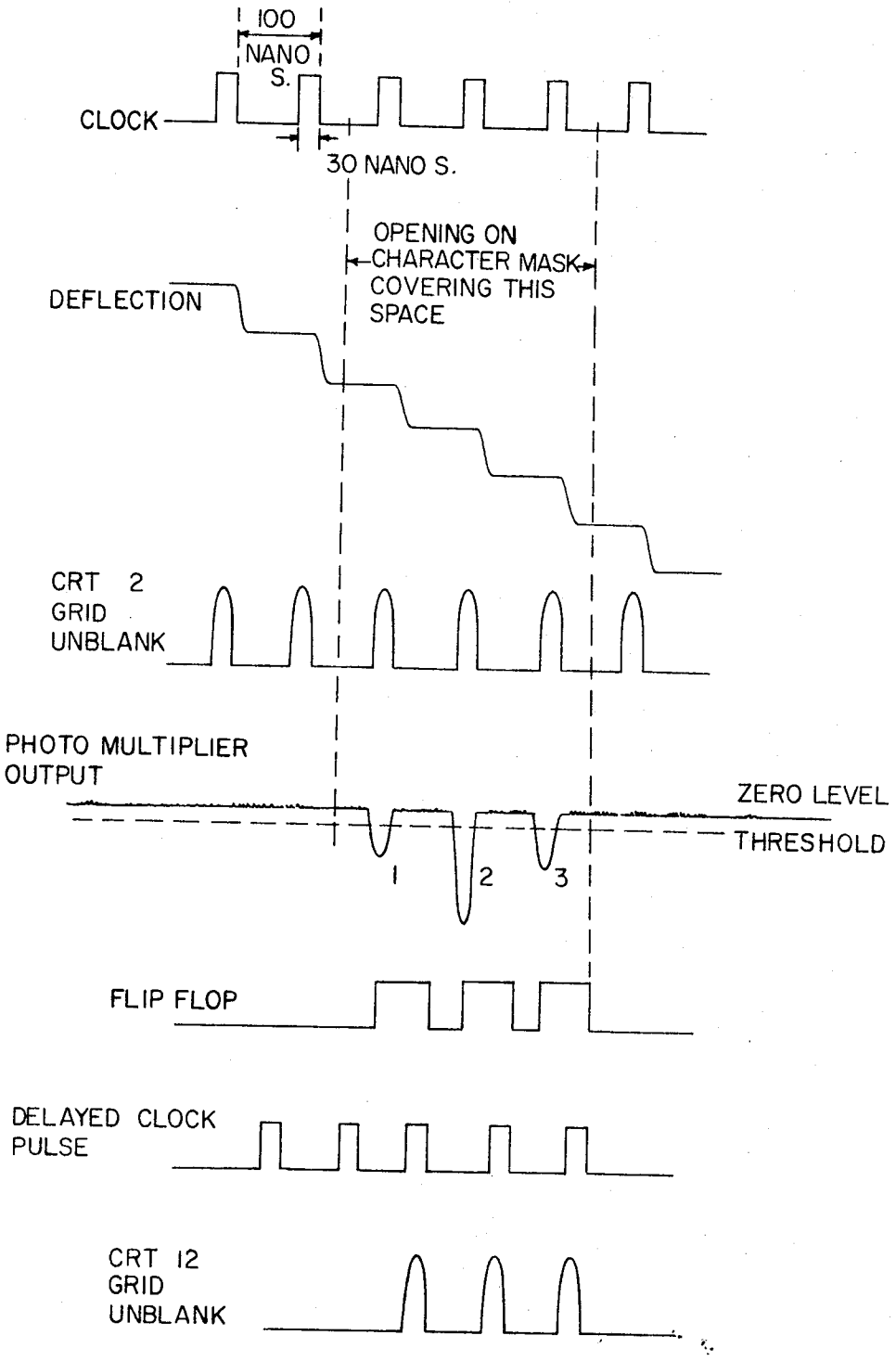

100
NANO
S.
CLOCK
30 NANO S.
OPENING ON
CHARACTER MASK
COVERING THIS
SPACE
DEFLECTION
CRT 2
GRID
UNBLANK
PHOTO MULTIPLIER
OUTPUT
ZERO LEVEL
THRESHOLD
1
2
3
FLIP FLOP
DELAYED CLOCK
PULSE
CRT 12
GRID
UNBLANK

FIG 4

CHARACTER GENERATOR EMPLOYING PULSED BEAM INTERROGATION OF MATRIX

Objects of this invention are to provide an alphanumeric cathode ray tube character generator useful with computer output microfilm recorders and the like with special emphasis on character quality, and flexibility as far as choice of character font, resolution and speed is concerned and with very short replacement time of a character matrix. Another object of the invention is to accomplish this with a very simple system and at a very reasonable cost.

An aspect of my invention is the combined realization that although an external character matrix such as has long been known in flying spot scanners would solve the need for flexibility and rapidity of change of character matrices for character operators, still scanning (while having many desirable features) is not practical in this context, and that the difficulties can be overcome by use of pulsed interrogation of a matrix using a predetermined pattern of stationary dots generated sequentially at high speed. With this principle, while employing a high speed phosphor to generate a light source and a digitally implemented deflection system, character speeds on the order of 20,000 characters per second with high resolution can be obtained, and are suitable for on-line computer output microfilm recording.

In this context I realized that phosphor noise was a limiting factor and I realized that stationary light pulses and appropriate digital "on-off" detection afforded a means of greatly reducing the noise problem.

According to this pulsed interrogation principle the invention features a control system for the cathode ray tube which includes means for incrementally changing the value of the deflection system to provide a series of predetermined deflection settings for each character, sufficient in number, e.g. 1,000, to dissect the character and permit its reproduction. The control system includes means for maintaining the electron beam blanked during change in the setting of the deflection system from one value to the next and means for holding the setting of the deflection system constant while the beam is unblanked. With this system each tiny portion of the beam-receiving surface or phosphor that corresponds to a setting of the deflection system is exposed to only a stationary beam of constant electron intensity which forms an emission pulse for detection by the emission-responsive element. The responsive element is then set to have a detection threshold to enable detection over the range of variations in the emission that may occur.

Between pulses the light output of the high speed phosphor can go completely to zero, thus making it possible to employ a detection threshold that can tolerate considerable variation in the intensity of one emitted light pulse relative to the next.

The system overcomes a noise problem which I have realized originates because of the particulate nature of the phosphor, it decreases the "on" portion of the tube duty cycle, thus enabling use of higher beam energies, and it leads to decrease in noise from other components of the system. In total result it enables character generation in a more favorable economic context than has heretofore been known.

I have realized the importance in this context of the fact that phosphor noise arises because phosphor is produced as a fine powder, containing particles of different size and different chemical compositions. When these different particles are bombarded with electrons they emit very different amounts of light. Therefore at one tiny location on the phosphor one can obtain a light output that is several times brighter than at other tiny areas although the electron beam current is the same in both cases. In a system utilizing such a phosphor with very high noise output and a character matrix where the body of the character is transparent while the surroundings are opaque and a photomultiplier tube as the light sensor, the high noise generated by a phosphor will result in great difficulties in distinguishing the off-on type signal that the photosensor will see from the very high variation in light intensity produced by the phosphor. Thus in a scanning system a signal to noise ratio, e.g. of one to four, may be obtained, which would be entirely useless. However, according to the present invention, by pulsing on and off and being careful not to move the beam while it is pulsed, then the phosphor noise will show up as higher or lower amplitude of the pulse, but there is never any doubt about whether a pulse does exist or not. In any electronic system there will always be a certain amount of noise, of course. But in the pulsed system of the present invention the noise level can be brought to less than one-tenth of the weakest signal and it therefore becomes very easy to set a threshold above which one calls the output "light" and below which one calls the output "dark". The pulses generated in this manner may be introduced into a differential amplifier and the output of the amplifier becomes a very distinct logic signal that is either fully turned on or fully turned off.

A preferred embodiment of the invention features a deflection system for X- or Y-coils in the form of a logic network with an array of resistors supplying current to the respective coil when switched on. The network, under the control of a master clock switches the resistor on in accordance with a predetermined progression to alter the current in an incremental manner. Preferably each coil is divided into two halves and is operated in push pull fashion, with pairs of resistors adding and subtracting equal current from the two coils, thus maintaining a constant current from condition for the power supply.

Preferably the display device for the characters comprises a cathode ray tube with a similar network, and the two are controlled in a timed relation, using the same source of clock pulses to time the unblank pulses and the incremented setting of the deflection system.

Although the two cathode ray tubes are operated with identical circuits, I realize that the time it takes for a pulse to get from one location to another, sometimes through only some few feet of wire, is sufficiently long to be a source of trouble. For this purpose a clock pulse generator is common to the two systems but the clock pulse that is sent to the display tube is delayed by an amount that is adjustable so that each arrival at the display tube coincides with the arrival of the corresponding "light" or "dark" pulse originating at the photomultiplier tube.

In the preferred embodiment now to be described the deflection system for each of the two tubes both contains a 10-bit counter. The counter is started on an impulse from the computer which designates a certain character. The counter goes through one complete cycle after which it resets, becomes stationary and is ready for the next start pulse. The first five stages of the counter comprise a so called reversible synchronous counter. It is provided to give the fastest possible switching time from position to position with the least amount of delay. This five-bit counter is used to generate 32 positions that can be thought of as lying on a horizontal line. The second five-bit counter counts the number of lines that are to be produced and with five bits will also result in 32 lines. In this manner the character area or sector is divided into 1,024 individual positions. The deflection system for the display tube contains exactly the same circuits as that for the character generator tube, but the clock pulse that is used for the display tube deflection is delayed a certain amount from that of the character generator tube.

Referring now to the drawings, in FIG. 1 a computer 1 controls the deflection of an electron beam in character generator cathode ray tube 2. Light generated on the phosphor 3 of cathode ray tube 2 passes through a character matrix 4 and is focused by lens 6 onto a photomultiplier tube 8. The output of the photomultiplier tube controls the control grid 11 in a second cathode ray tube 12 and the light output of tube 12 is focused through lens 14 on a film strip 16. In more detail the system functions as follows: A start pulse from computer 1 causes a clock pulse generator 22 to emit clock pulses at a very high rate. A counter 24 consisting of five bits normally referred to as a synchronous counter counts 32 clock pulses. At the end of the count of 32 rather than reset to 0 as is ordinarily done in a counter, this particular counter switches to

count in the opposite direction and counts by 32 counts down to 0 again. At the same time as it switches direction it advances another counter **26** also consisting of five bits. The clock pulses from clock pulse generator **22** are taken through blank control circuits **23** to the control grid of cathode ray tube **2**. Every time a clock pulse is generated the cathode ray tube **2** is unblanked for a very short time causing light to be generated at a particular location on the phosphor. Previous to beginning the count the computer **1** has also caused *x* and *y* character selection circuits **20** to position the beam in a sector opposite one particular character on the character matrix. When the output of the two five-bit counters **24** and **26** are converted to *x* and *y* deflection signals in deflection control circuits **28**, the deflection system is caused to step across the character area in 32 discrete steps, and after each step the control grid activates or unblanks the beam, and then deactivates or blanks the beam, thus completing the unblank pulse before the next step. Thus a succession of stationary, short duration light spots is produced. This is illustrated in more detail on FIG. **2** where it can be seen that at the end of a horizontal row of dots, the deflection system is stepped one vertical step and from there it steps back to its left-most dot position. In FIG. **2** the character, here the letter "H", may be transparent and its background opaque, for purposes of illustration. At certain locations light spots **5** appear behind the opaque area of the matrix and no light reaches photomultiplier tube **8**. At other locations on the cathode ray tube **2** the light spots **7** have appeared behind the transparent character that is being interrogated. In that case light from the phosphor on the cathode ray tube **2** passes through the matrix **4** and is focused by lens **6** onto the light sensitive surface of photomultiplier tube **8**. The output of photomultiplier tube is amplified in a differential amplifier **30** and the output of the amplifier **30** is used to control the setting of flip-flop **32**. The output of flip-flop **32** again is used to enable input gate **48** to the blank circuit **50** for the output cathode ray tube **12**. The clock pulses that were generated by clock pulse generator **22** are also taken through a delay circuit **40** to counters **42** and **44** that in construction are identical to the counters **24** and **26**. These two counters also control a deflection system **46** which is identical to the deflection system **28** associated with cathode ray tube **2**. The delay circuit **40** which causes a delay of the clock pulses send the clock pulses to the other input of the unblank enabling gate **48**. The system therefore functions in the following way. When light is sensed by the photomultiplier **8** flip-flop **32** is set thus enabling one input of gate **48**. Thereafter, when the delayed clock pulse arrives from delay circuit **40** the blank circuit **50** takes control of cathode ray tube **12**. This ensures that the unblank of cathode ray tube **12** is made in true synchronism with the output of counters **42** and **44** to ensure that the electron beam in CRT **12** is at its proper location and is stationary before the tube is unblanked. This prevents smear of the character and results in very well defined character edges. The character displayed on the face of cathode ray tube **12** is focused through lens **14** on a film strip **16**. Each time, after a character has been generated, the computer **1** controls the location of the next character through *x* and *y* page format circuitry **52**. In this way it is possible to compose a full page of characters.

The character matrix **4** consists of a photo negative on for example, a 35-millimeter film strip. The size of the matrix on the film strip is approximately three-quarters inch square. This makes the character on the order of fifty-thousandths of an inch square and the beam that is used to interrogate the character areas is in the order of one-thousandths to one and a half thousandths of an inch diameter, assuming a beam of one and a half thousandths of an inch, 32 beam locations will just about exactly cover the fifty-thousandths of an inch wide character area.

The character matrix is a photograph as mentioned before on 35-millimeter film strip. This makes it possible to have several matrices on the same film strip and a connection is from the computer **1** to the drive mechanism for the film strip containing the matrix **4** will make it possible for the computer to select any one of a large number of matrices representing different character forms or different alphabets, all with little time elapse.

One preferred embodiment of the *x* and *y* delfection circuits labelled **28** and also **46** on FIG. **1** is shown in greater detail on FIG. **3**. Only one axis is shown, in this case the *x* deflection system. A magnetic deflection field is created in the yoke by controlling the current flowing through the yoke. This is done by turning transistors on and off in pairs so that Q_1 and Q_{10} define one pair, Q_2 and Q_9 a second pair and so on. Both Q_1 and Q_{10} control a current from a plus 10 volt source through a 1-ohm resistor. Basically, this would result in a current of 10 amps if we can disregard the saturation voltage of the transistor. The system functions in the following manner. Let us say that Q_1 is turned on by the output stage of one of the five-bit counters. At the same time, the other side of the flip-flop in the counter causes Q_{10} to be turned off. There is, therefore, a current flowing through Q_1 and its 1-ohm resistor into one-half of the deflection yoke. When that particular bit is switched Q_1 is turned off and Q_{10} is turned on. We now get a current of equal magnitude to flow through Q_{10} and its 1-ohm resistor at the right hand half of the deflection yoke. So we have changed the magnetic field through the yoke by reducing the current in one side and at the same time increasing the current in the opposite side of the yoke.

The other transistor pairs function is exactly the same way. The main advantage of handling current switching in this way is that the drain from the power supply remains practically constant whether the current flows from 10 volts through Q_1 and the left side of the yoke or from 10 volts through Q_{10} and the right side of the yoke—the current flowing out of the power supply is still the same which avoids certain problems.

The resistors connected to the various transistor pairs are selected such that they perform in a binary progression, Q_1's resistor is 1 ohm, Q_2's 2 ohms, Q_3's 4 ohms, and so on. Therefore, the currents that are switched in and out become half of the foregoing stage moving from Q_1 to Q_2 through to Q_5.

(An alternate embodiment, not shown is to employ 32 resistors (or resistor pairs) representing the 32 binary positions, each resistor having the same resistance value, the counter switches, one pair at each count. The added member of resistors in this system is offset by the uniform effects upon the power supply over the full set of switching steps needed to produce the desired pattern.)

The individual transistor pairs in the deflection system are controlled by flip-flops in the five-bit *x*-counter **24** on FIG. **1**. This is shown in FIG. **3** and each flip-flop is connected to two transistors—its one "1" output to Q_1 and its not one "$\overline{1}$" output to Q_{10}. A similar connection is made from the second flip-flop to Q_2 and Q_9 and so on. Suitable transistors for the above operation are lamp driven circuits available from Texas Instruments, TI SN 75–45ON.

The pulse diagram on FIG. **4** illustrates the relationship between the various pulses and deflection signals that are generated in this system. The first trace illustrates the clock pulse as it is generated in clock pulse generator **22**. In a typical system the pulse width of each clock pulse is in the order of 30 nanoseconds (30×10^{-9} secs.), while the pulse distance from falling edge to falling edge is in the order of 100 nanoseconds. At the time the clock pulse falls to its zero level, the counter stage **24** and the deflection system **28** cause the current through the deflection yoke to change to the next level. This is illustrated in the second trace where some few steps are shown. In a practical system the transition from one step to another takes a certain length of time. In a typical system where 30 nanosecond clock pulses can be utilized, this transition takes place in about 25 to 30 nanoseconds. The actual movement from one step to the next is equivalent to the dot diameter and is therefore approximately equal to one and one-half thousandths of an inch.

The clock pulse generated in clock pulse generator **22** controls the blank circuit **23** and the third trace on FIG. **4** labelled

"CRT No.2 Grid Unblank" illustrates the timing of the unblank pulses. With this arrangement the clock pulse passes through only one single circuit with a very short delay in the order of 6 nanoseconds, and for all practical purposes the clock pulses cause the unblank pulse to occur simultaneously with itself being reblanked at its end. A comparison made between the grid unblank pulses and the deflection steps indicate that towards the end of each step after the circuits have had an opportunity to come to equilibrium, the grid is unblanked and the result is that a discrete stationary light spot is created at each location. In the time between the clock pulses the tube is completely blanked, resulting in no light output for a duration of approximately 70 nanoseconds. During that time the deflection circuits are set up for the next step and when the beam is unblanked again a stationary light spot will occur at a new location. The response time of the phosphor that is used in cathode ray tube **2** is of importance where high speed operation is desired. In the preferred embodiment, a cathode ray tube of the 5CEP type manufactured by several tube manufacturers have been utilized, equipped with a high speed phosphor referred to as SW, supplied by Sylvania Electric. Its response time is in the order of some few nanoseconds—considerably faster than is required even for this high speed operation.

On FIG. **4** two vertical dashed lines indicate the steps that correspond to positions where the character matrix has a transparent opening. We can therefore expect that the light generated by the three unblanked pulses within that boundary will result in light being picked up by the photomultiplier tube **8**.

The fourth trace on FIG. **4** illustrates the pulses as generated by photomultiplier **8**. The pulses are labelled **1**, **2**, and **3**. They are shown having different amplitudes. This pertains to the noise problems that has been discussed earlier. The phosphor noise resulting from different efficiency of the phosphor at different locations, results in pulses of quite different height. Ratios as high as 1:8 or 1:10 have been observed. But it is of importance to notice that the output of the photomultiplier tube **8** between pulses reaches a reference zero level as indicated on FIG. **4**. As with all electronic circuits even at the zero level three is a certain amount of noise originating at many different points in the circuits. However, there is a very large difference between such noise level, which is constant under practically all operating conditions, and the noise level which is generated by the phosphor. It is possible to select a certain threshold level above which the output of the photomultiplier is taken as an indication of light and below which it is assumed that no light has been sensed. In the cases of the three pulses, labelled **1**, **2** and **3**, in FIG. **4**, even the lowest is still higher than the noise level and the threshold level by a reasonable amount. Each light pulse, although differing from its neighbors, is substantially constant over its own duration because the constant stream of electrons is striking the same phosphor particles over that time. This facilitates detection by the photomultiplier circuit.

The duration of the light pulses due to the very fast operation of both the phosphor and the photomultiplier tube are of the same duration as the initial clock pulses, approximately 30 nanoseconds at the base. Each clock pulse when amplified in amplifier **30** causes flip-flop **32** to be set and the fifth trace on FIG. **4** indicates the setting of the flip-flop. Every time the flip-flop has been set it remains set until reset by the delayed clock pulse, which is shown as trace No. **6**. The delayed clock pulse (delayed in circuit **40** on FIG. **1**) is adjusted to a very particular delay to cause the unblank pulse at cathode ray tube **12** to be generated preceding the time the deflection system is caused to move to the next step. Therefore, the system performance around cathode ray tube **12** will be identical to that around cathode ray tube **2**. In other words, the timing of unblanking of cathode ray tube **12** does not depend on the light pulse sensed by photomultiplier **8** but rather by the clock pulse generated in the delay circuit **40**. The light pulse from photomultiplier **8** merely causes an enable signal to be generated by flip-flop **32** enabling gate **48**, but the actual timing is controlled by delay circuit **40**.

The character rate that can be achieved with this system depends to a very high degree on the desired character resolution. In an existing construction of the preferred embodiment it is possible to generate 20,000 characters per second with a resolution of 1,024 points each, producing in very readable resolution for microfilm. It is obvious that if one would reduce the horizontal and vertical counters to four bits each for a count of 16 by 16 and a total of 256 points of resolution, the character rate could be increased by a factor of 4 without being penalized from any performance limitations from any other portions of the system. Going in the opposite direction it would be possible to increase the character resolution to say, for example, 64 by 64 by accepting a reduction in character speed by a factor of 4. Also it is possible to choose any performance in between. This should be understood such that it will be practical to operate with 24 by 24 dots rather than 32 by 32 and gain an increase of speed of approximately 2.

It is to be noted that, alterations in the beam intensity, and variations in the pattern of dots can lead to various intensities of microfilmed characters or symbols, and production of gray scale.

What is claimed is:

1. In a character generator comprising a cathode ray tube having an electron beam source, a character selection deflection system for directing the beam generally toward a selected one of a set of sectors of a beam receiving surface, said surface adapted to produce emissions, a character generating deflection system for directing the beam over the area of said selected sector, a character matrix having character forms positioned for exposure to emissions from corresponding sectors of said beam receiving surface, an emission-responsive element including circuitry for detecting the emissions from said surface as modified by the selected character form of said matrix, and a recording device operable in timed relation with said character generating deflection system and controlled by said responsive element to record the character, the improvement comprising a control system associated with said character generating deflection system for causing pulsed interrogation of the selected character form on said matrix, said control system including means operative after a sector has been selected for incrementally changing the input signal to said character generating deflection system to provide a series of predetermined deflection positions in number and spacing sufficient, together, to effectively cover the area of said sector, means for maintaining said electron beam blanked during change in said character generating deflection system from one position to the next in said series, and means for maintaining constant the position of said character generating deflection system while said beam is unblanked, said control system thereby adapted to cause each position on said sector to be exposed only to a stationary beam that forms an emission pulse for detection by said responsive device.

2. The character generator of claim **1** wherein said beam-receiving surface is a phosphor plate located at the end of said cathode ray tube, adapted to emit a spot of light when struck by said beam, said character matrix comprises a transparency located outside of said tube in a position to be illuminated by said light emissions at said various positions, and said responsive element is positioned on the side of said transparency opposite to that of said cathode ray tube and arranged to receive said light emission as modified by the character form selected by said beam, the cathode ray tube having characteristic variations in light spot intensity depending upon the position of said beam, and said responsive element having a detection threshold to enable detection of the light spot over the range of its characteristic variations in intensity.

3. The character generator of claim **1** wherein said deflection system comprises an X-deflection coil and circuit and a Y-character generating deflection coil and circuit, said control system comprises, for each deflection coil, an array of resistors, and a series of electronic switches arranged to insert

and remove said resistors from supplying current to the respective deflection coil in accordance with a predetermined progression thereby to alter the current in the respective coil in a stepwise manner.

4. The character generator of claim 1 in which said character generating deflection system comprises a first deflection coil having a predetermined first number of settings and a second coil having a predetermined second number of settings, said control system including means for holding the setting for said first coil constant while causing the setting for the second coil to proceed through its full series of values, means thereupon to increase by one position the setting for said first coil, and means thereupon to cause the setting for the second coil to proceed in reverse order through its full series, thereby to effectively produce a series of left to right, down, right to left, down cycles of incremental progressions for covering the character form of the character matrix.

5. The character generator of claim 3 wherein said resistances and switches of each circuit define a deflection network capable of being switched into said circuit in accordance with a binary progression, a pulse generator and a binary counter arranged to count generated pulses and control said network in accordance with the count.

6. The character generator of claim 1 wherein said recorder comprises a cathode ray display tube having a character generating deflection system and a control system having a series of settings for pulsed operation of a stationary beam, a master clock controlling the timing of the advancing of the settings of the character generating deflection systems of both said tubes, means delaying the clock pulses applied to said display tube, an enable switch connected to be enabled by signals from said emission responsive element and said delayed clock pulses arranged to produce an unblank pulse on said display tube whenever said enable switch is activated by said responsive element, with said unblank pulse timed to occur prior to change in said character generating deflection settings.

7. The character generator of claim 1 in combination with a microfilm recorder, said character generator and recorder including means adapted to be controlled by signals representing the output of a computer to enable computer output microfilm recording.

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