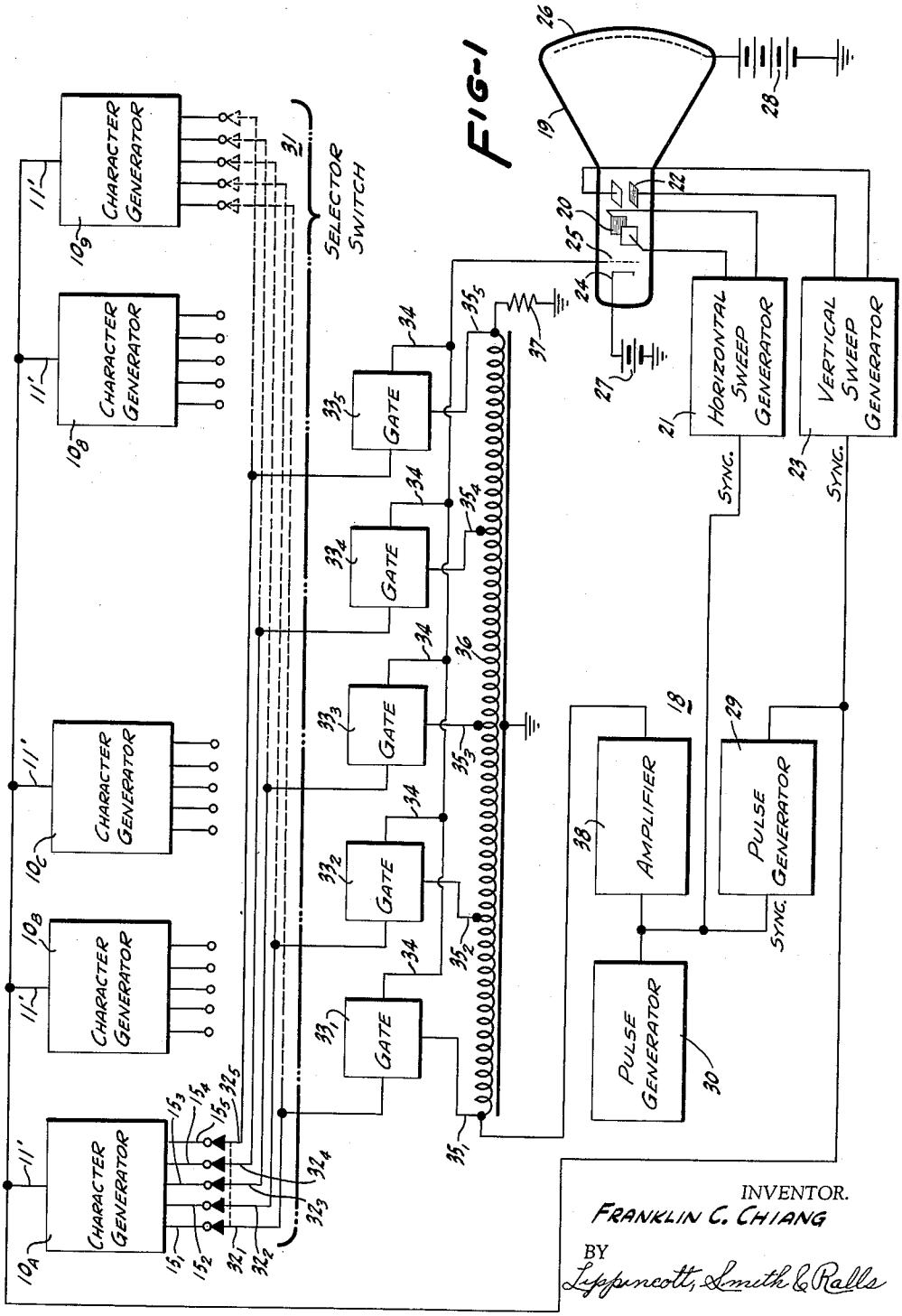
Sept. 10, 1963 FRANKLIN C. CHIANG 3,103,658

CHARACTER GENERATION SYSTEM

Filed Jan. 13, 1958 4 Sheets-Sheet 1

FIG-1



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CHARACTER GENERATION SYSTEM

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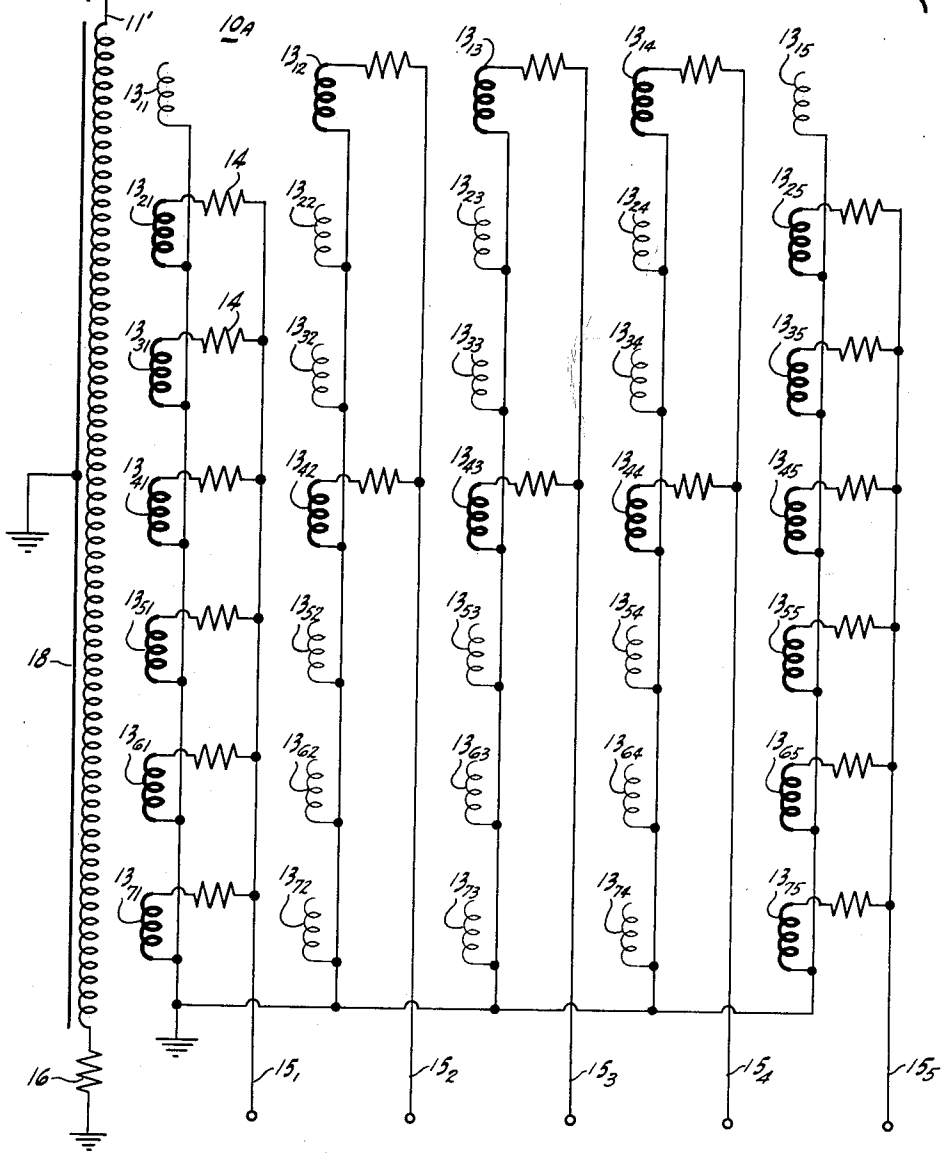
FIG-2



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CHARACTER GENERATION SYSTEM

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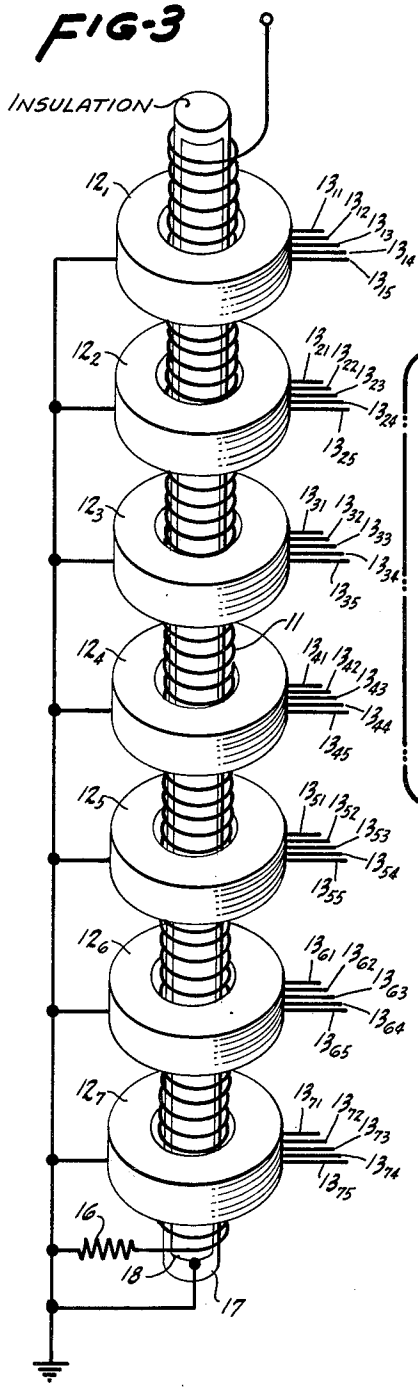
FIG-3



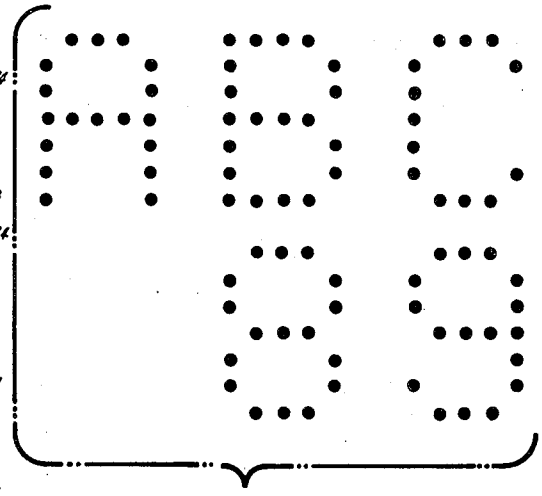


FIG-4

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CHARACTER GENERATION SYSTEM

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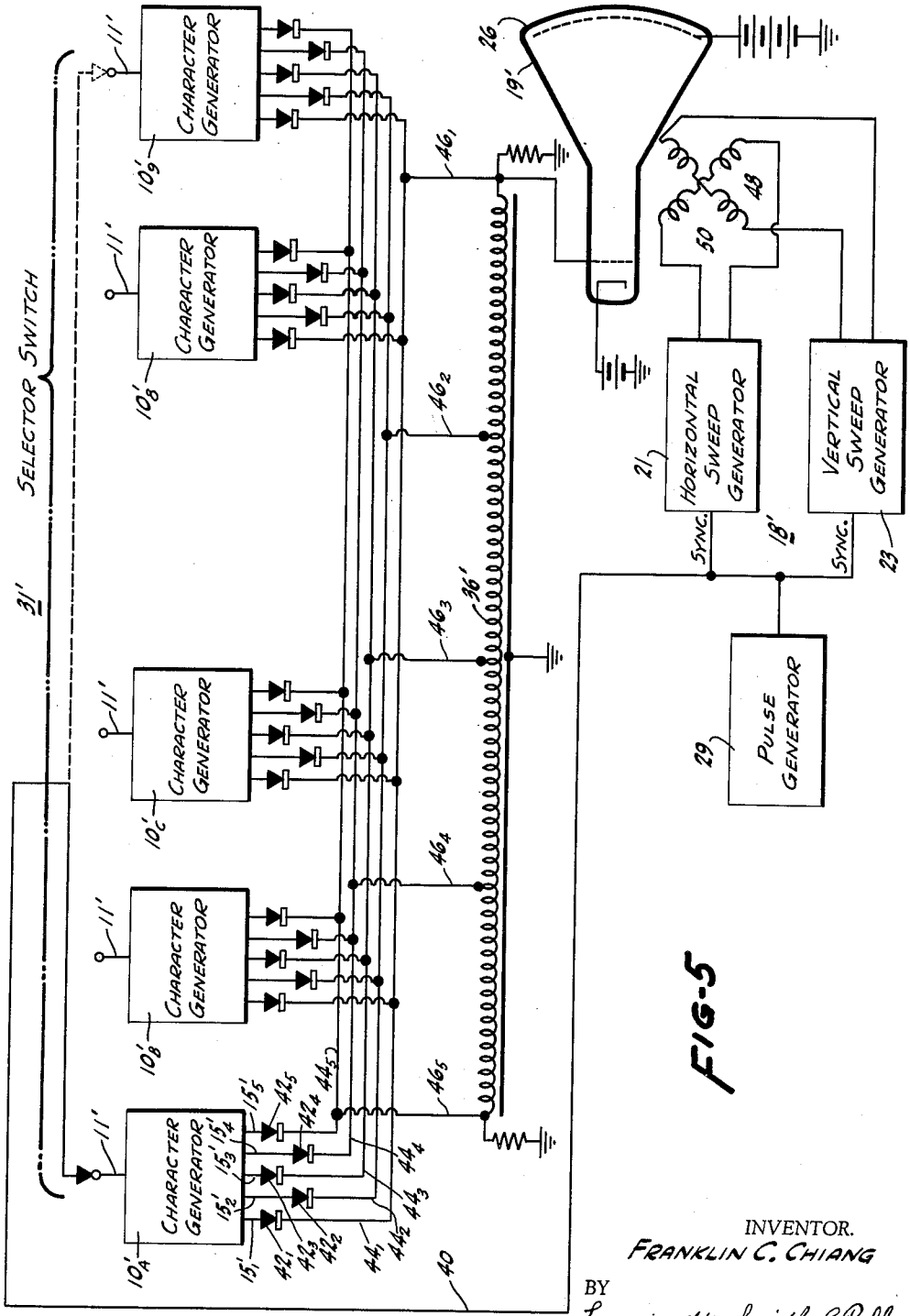

FIG-5

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3,103,658

CHARACTER GENERATION SYSTEM

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2 Claims. (Cl. 340—324)

This invention relates to electrical signalling, and more particularly to a system of character generation for graphically reproducing and displaying selected characters responsive to electric signals representing said characters.

The principal object of this invention is to provide a system for generation and displaying selected characters in a signal-responsive device such as a cathode-ray tube from a remote point by transmitting a relatively small number of electric pulses.

It is a further object of this invention to provide a plurality of character-identification generators such that each generator permanently identifies a particular character and only a single signal is required to trigger the generation of a selected character to be graphically reproduced. Also, depending upon the individual requirements of the character reproductions, each character can be generated for a time interval as short as 25 microseconds, or as long as many seconds, and can be repeated as many times as desired to aid visual perception.

Another object of this invention is to provide a system of character generation wherein, in the case of long distance transmission, only one identification code is required for each character.

The above and other objects may be attained by employing this invention which provides among its features a system in which a selected character is reproduced graphically upon the repetitively scanned screen of a cathode-ray tube by means of a pulse train generated in time relation with the raster of the cathode-ray tube. Different pulse trains for reproducing the different characters are generated by means of a plurality of character-generators—a separate character generator being provided for each character that is to be graphically reproduced. The system also includes means for selecting any desired one of the character generators, and means for connecting the selected character-generator to the cathode-ray tube.

Other objects and advantages will become apparent from a consideration of the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic circuit diagram of an exemplary embodiment of this invention, a plurality of character-generators being shown therein represented by blocks 10_A through 10_9;

FIG. 2 is a schematic circuit diagram of a typical character-generator 10_A;

FIG. 3 is a schematic view showing the construction of a delay line employed in character-generator 10_A;

FIG. 4 is a representation of several of the characters which may be reproduced and displayed; and

FIG. 5 is a schematic circuit diagram of another exemplary embodiment.

The embodiment illustrated in FIG. 1 comprises a plurality of character-generators 10_A through 10_9 connected in parallel with each generator identifying a particular character, such as a letter of the alphabet or a numeral. The subscript identifies the character which that generator will reproduce. As is best shown in FIGS. 2 and 3, each character-generator (10_A for example) includes a delay line **11** and a plurality of pick-up units 12_1 through 12_7 in axially spaced relation to each other along the delay line. Each of the pick-up units is provided with five separate windings, and thus a matrix of thirty five windings is provided, as is best illustrated in FIG. 2. The five windings of unit 12_1 are identified by reference numerals 13_{11} through 13_{15}; the five windings of unit 12_2 by reference numerals 13_{21} through 13_{25}; etc. Selected windings of each unit are connected in parallel with corresponding windings of other units and to respective output lines 15_1 through 15_5 to provide a pulse train which will generate a selected character, as hereinafter explained. In the generator 10_A shown in FIG. 2, the windings are interconnected so as to define a matrix coded to generate the character A. Isolation resistors **14** are connected in series with the respective windings to prevent undesirable interactions therebetween.

In the specific embodiments herein illustrated and described, deflection circuits of the cathode-ray tubes **19** and **19'** are arranged to provide a scanning raster composed of five approximately vertical scanning lines. In other words, horizontal sweep generator **21** operates with a period five times as long as that of the vertical sweep generator **23**. Each of delay lines **11** has a delay time equal to the scanning time of one vertical line of the raster of the cathode-ray tube. Approximately at the beginning of each vertical scanning line an electric pulse is supplied by a pulse generator **29** through lines **11'** to the input end of each delay line **11** of the character generators. As each such pulse travels down a delay line **11**, voltage pulses are induced first in the five windings of pick-up unit 12_1, then in the five windings of pick-up unit 12_2, etc., so that seven sets of five pulses each are successively produced within each character-generator during each vertical scanning line. In a manner hereinafter explained, each of the five output lines 15_1 through 15_5 of a selected character-generator is connected in succession to the cathode-ray tube **19** during each scanning frame of five lines, so that pulses from thirty five windings may be transmitted to the cathode-ray tube at the thirty five different points in the scanning cycle, respectively. The delay line **11** is terminated with a resistor **16** equal to the characteristic impedance of the line to prevent reflections from the lower end of the line.

As will be noticed in FIG. 3, the seven pick-up units 12_1 through 12_7 are annular and extend around delay line **11**. Each pick-up unit may be adjusted in position along the length of line **11** to adjust the timing of the pulses induced in its windings. The delay line proper may be of conventional construction; a helix or the like of insulated wires wound about an insulating form **17** and one or more metal foil grounding strips **18**. This construction provides a fairly large distributed inductance or capacitance, whereby appreciable time delays (e.g., up to several hundred microseconds) are readily obtained.

The thirty five windings 13_{11} through 13_{75} are arranged as shown in FIG. 2, to define a rectangular matrix in which corresponding windings of the seven units represent seven horizontal rows of the matrix and the five windings of each unit represent five vertical columns of the matrix. Each intersection of a matrix row with a matrix column represents a point on the screen of the cathode-ray tube. If the coil at such an intersection is connected into a circuit, a visible spot will be generated at the corresponding point on the screen, by means hereinafter described. Hence, to obtain a coded interconnection of the windings to identify a specific character, selected windings in each vertical matrix column are connected in parallel, so that when successive electric pulses are transmitted down the delay line **11**, and the five columns of the matrix are connected in succession to the cathode-ray tube, a pulse train is supplied to the control electrode of the cathode-ray tube in timed relation with

the scanning raster to cause a graphic reproduction of the character defined by the coded matrix of the selected character generator.

The conventional cathode-ray tube **19** has an electron gun at the base of the neck, including a cathode **24** and a control electrode **25**, to produce a beam of electrons which is acted upon by horizontal and vertical deflection means **20** and **22** to produce a scanning raster upon the screen **26**. A raster may be defined as a predetermined pattern of scanning lines which provide substantial uniform coverage of an area. An electrical circuit **18** includes horizontal and vertical sweep generators **21** and **23** which are connected to the deflection means **20** and **22** respectively of the cathode-ray tube **19**. Each of the two sweep generators produces a sawtooth waveform scanning signal for deflecting the electron beam of the cathode-ray tube repetitively back and forth and up and down the screen **26**. The period of the horizontal sweep generator is five times as long as the period of vertical sweep generator **23**, so that, in this case, the scanning lines are approximately vertical and there are five vertical lines in each scanning frame.

Electric circuit **18** also includes a pulse generator **29**. Pulse generator **29** and vertical sweep generator **23** are synchronized by any suitable means (for example, by using the pulses generated by generator **29** as synchronizing pulses for generator **23**) so that generator **29** supplies a pulse to each input line **11'** of the character generators approximately at the beginning of each vertical scanning line. Horizontal sweep generator **21** is synchronized with another pulse generator **30** which supplies a pulse substantially concurrently with each fifth pulse supplied by generator **29**.

The cathode-ray tube **19** is biased to cut-off by any suitable means, such as the positive voltage supply **27** connected to the cathode **24**. Therefore, no light appears at the screen **26** except at points in the scanning cycle when pulses are supplied to the control grid **25**. Thus, each pulse supplied to grid **25** produces a visible spot on screen **26**, at a point in the screen that depends upon the timing of the pulse relative to the scanning cycle. It is evident that any desired character can be displayed on the screen **26** by supplying a properly timed train of pulses to grid **25** during each scanning cycle. Accelerating voltage for the electron beam of the cathode-ray tube is provided by a voltage supply **28**.

Means are provided for selectively connecting one of the character generators to the cathode-ray tube and in this instance comprises a selector switch **31** having a plurality of input leads 32_1 through 32_5 adapted to be connected to the output leads 15_1 through 15_5 of a selected character generator. Switch **31** may be manually or automatically operated, and in practice may be a high-speed electronic or electromagnetic switching network responsive to coded signals received from an electrical communications system, or the like. However, the specific construction of the switch is of no concern to this invention. For present purposes, switch **31** can be considered to be a simple, manually operated, mechanical contact, electrical switch.

Assume that the input leads 32_1 to 32_5 have been connected to the output leads 15_1 through 15_5 respectively of the character generator 10_A, which has been coded to have a matrix identifying the character A. It will be observed that leads 32_1 through 32_5 are connected to respective ones of the five normally-closed or non-conductive gates 33_1 through 33_5. Thus, each pulse appears at one of the output leads 15_1 through 15_5 for the selected character generator and passes through switch **31** to a respective one of the gates 33_1 through 33_5.

Each of the gates is connected by an output lead **34** into the control electrode **25** of the cathode-ray tube **19**. These gates are well-known circuits that transmit electric pulses from an input lead to an output lead only when the gate is opened, or made conductive, by voltages supplied to another input lead.

In this case, the gates 33_1 through 33_5 have their second or control input leads connected to respective taps 35_1 through 35_5 of a master delay line **36**. Thus, an electric pulse traveling from left to right along delay line **36** will open each of the gates 33_1 through 33_5 in succession. Delay line **36** is terminated by resistor **37** equal to the characteristic impedance of the line, to prevent undesirable reflections from the right end of the delay line.

Pulse generator **30** provides a pulse approximately at the beginning of each scanning frame. These pulses are amplified by an amplifier **38**, and are supplied to the left end of the master delay line **36**. The duration of each pulse so supplied to line **36** is made approximately equal to the duration of one vertical scanning line, which is one-fifth of the duration of the scanning frame. Therefore, gate 33_1 is open during the scanning time of the first vertical line of each frame. It is closed during the scanning of the other four lines of each frame.

Delay line **36** is constructed to provide between each of its taps and the next tap a time delay approximately equal to the time interval between vertical scanning lines. Thus, gate 33_2 is open during the second vertical scanning line of each frame, gate 33_3 is open during the third vertical line of each frame, etc.

Considering the period of the pulses provided by the generator **29** to be T_n, then the second pulse generator **30** and the circuit **18** is arranged so as to provide to the master delay line **36** pulses having a period of $5T_n$, and a duration of T_n. Thus, as each of the pulses supplied to the master delay line **36** travels from one end to the other end thereof, each of the gates 33_1 through 33_5 in succession is opened for a time interval T_n. Since the total delay of lines **11** in the character generator is T_n, the complete train of pulses appears in each of the lines 15_1 through 15_5 during each interval T_n. Therefore, each gate in succession transmits a complete train of pulses from one output line of the selected character generator to control grid **25** of the cathode-ray tube. This permits a complete sequence of the pulses received from the selected character generator output leads 15_1 through 15_5 to pass sequentially into the leads **34**. In turn, the control electrode **25** of the cathode-ray tube gun is driven more positive by each pulse allowing the electron beam to pass through the deflection means **20**, **22** and produce upon the cathode-ray tube **19** a pattern of dots thus forming the character selected for display. Thus, the matrix connections of the selected character generator are displayed on a screen **26**, to provide a graphical display of the selected character. When switch **31** is connected to generator 10_A, a pattern of dots forms the character A on screen **26**.

Considering once again the character generator 10_A representative of the character A (FIG. 2), it will be seen that the matrix is so arranged that if the generator **29** drives the delay line **11** by imparting a train of pulses thereto, one such pulse is supplied to the upper end of line **11** approximately at the beginning of each vertical scanning line. During the first scanning line of the frame, line 15_1 is connected to cathode-ray tube **19** through open gate 33_1, while the remaining lines 15_2 through 15_5 lead to closed gates. Hence, considering only the first matrix, from the first scanning line at a time T_1, the windings 13_{71} and 13_{75} of the first pick-up unit 12_1 will receive a pulse which is transmitted through switch **31** and gate 33_1 to the control electrode **25** of the cathode-ray tube. Similarly, at time T_2 the windings 13_{61} and 13_{65} of the unit 12_2 receive a pulse; at time T_3 the windings 13_{51} and 13_{55} of the unit 12_3 receive a pulse; at time T_4 the windings 13_{41} through 13_{45} of the units 12_4 each receive a pulse; while at a time T_5 and T_6 windings 13_{32} through 13_{34} and 13_{22} through 13_{24} respectively each receive a pulse; and at a time T_7 windings 13_{12} and 13_{13} and 13_{14} each receive a pulse. All of the pulses are sequentially transmitted through output leads 15_1 through 15_5 as a pulse train and then through respective gates 33_1 through

33_5 to the control electrode **25** by action of the delay line **36**.

In the manner hereinbefore indicated, these pulses will be transmitted through switch **31** to respective ones of the gates 33_1 through 33_5 which will be actuated sequentially to produce these pulses in the same sequence upon the control electrode **25** of the cathode-ray tube to reflect the sequence prearranged and coded into the matrix of the selected character generator. At the same time, since the vertical and horizontal sweep generators are synchronized with the pulses supplied to the control electrode **25**, the matrix of the selected character generator 10_A–10_9 will be constantly repeated in timed relation with the vertical and horizontal sweep generator so that the character will be graphically portrayed on the screen **26** of the cathode-ray tube **19** until such time as another one of the character generators is selected.

In the embodiment shown in FIG. 5, the general arrangement and function is similar to the embodiment of FIGS. 1–4, except for the arrangement of the means whereby the train of pulses from a selected character generator $10'_A$ through $10'_9$ is selectively switched into connection with the electric circuit **18'** and the cathode-ray tube **19'**. The selector switch **31'**, similar to the selector switch **31**, is now connected into lead **40** from pulse generator **29** so that a selected character generator can be connected through its input line **11'**. On each of the output lines $15'_1$ through $15'_5$ of each character generator, there is provided diodes 42_1 through 42_5 respectively to prevent feedback through character generators other than the one selectively connected into switch **31'**.

Corresponding output lines of each character generator 10_A through 10_9 are connected into respective common lines 44_1 through 44_5, which are in turn connected to delay line **36**, through respective leads 46_1 through 46_5, at spaced locations therealong. Thus, for instance, line 44_1 connects all of the output leads $15'_1$ of character generators $10'_A$–$10'_9$ to the right end of master delay line **36'** (as viewed in FIG. 5). Corresponding leads $15'_2$, $15'_3$ and $15'_4$ of the other generators are connected into delay line **36'** at selected points intermediate its ends while all of the output leads, corresponding to $15'_5$ of character generator $10'_A$, connect into delay line **36'** at its left end as viewed in FIG. 5 . Delay line **36** acts to sequentially store the pulses transmitted thereto by the output leads $15'_1$ through $15'_5$ and deliver these pulses sequentially at its right end, as viewed in FIG. 5. The train of pulses appearing at the right end of delay line **36'** will be supplied to the grid **25'** of cathode-ray tube **19'** to function in the same manner as described in connection with the embodiment of FIGS. 1–4. The horizontal and vertical sweep generators **21** and **23** are, in the form of the invention of FIG. 5, connected into electromagnetic deflection means **48** and **50** (in place of the electrostatic deflection means **20**, **22** of FIGS. 1–4) respectively acting upon the electron beam of the cathode-ray tube **19'** to produce a scanning raster on the screen **26'** of the tube.

Sweep generators **21** and **23** are synchronized, by suitable means, with the pulses delivered by generator **29** to the character generators $10'_A$ through $10'_9$. As previously indicated, horizontal sweep generator **21** operates with a period five times as long as that of the vertical sweep generator. Therefore, the pulse train of a selected character generator, such as $10'_A$, will be fed into the master delay line **36'** in sequence, stored in the delay line by being sequentially transmitted thereto, and appear sequentially at the control electrode **25'** of the cathode-ray tube from the end of master delay line **36'**, thus the character represented by the selected pulse train will be graphically reproduced on the screen of the cathode-ray tube in the same manner as explained in connection with the embodiment of FIGS. 1–4.

Essentially then, the modification of FIG. 5 eliminates (1) the need for a switch for each one of the output leads

on each character generator, (2) the requirement for a plurality of gates in connection with the means for selectively connecting a character generator to the cathode-ray tube, and (3) the necessity for a separate pulse generator and a gating amplifier in its electrical circuit **18'** connecting the character generators to the sweep generators of the cathode-ray tube, when compared to the embodiment of the character generation system of FIGS. 1–4.

From the foregoing, it will be seen that a desired character defined by a character generator may be selectively switched into the system and be graphically portrayed by actuation from an external source, which source may be remote from the system, by employing in each character generator a plurality of pick-up units having separate windings which are interconnected in a prearranged manner defining a matrix, and said coils being excited by a delay line to produce a pulse or signal train corresponding to the matrix selectively switched by means **31** or **31'** into connection, through a master delay line, in timed relation with the raster of a cathode-ray tube upon the screen of which the character defined by the matrix will be visually displayed, the horizontal and vertical sweep generators being synchronized with the pulse or signal train generated in a selected character generator.

Although the present illustration shows the coils arranged in rows in the matrix and the corresponding windings of the coils connected to represent columns of the matrix, this relationship of rows and columns can be reversed without departing from the concept of the invention by employing conventional techniques well known to those skilled in the art. Also the delay lines **11** employed in the character generators may be provided with taps in place of the inductively coupled pick-up units and as such would be similar in construction to delay lines **36** and **36'**.

It will be understood that this invention is not limited to specific embodiments herein illustrated and described, and that the following claims are intended to cover all changes and modifications which fall within the true spirit and scope of the invention.

What is claimed is:

1. A system of character generation, comprising in combination, a cathode-ray tube and deflection means therefor producing a scanning raster, a plurality of character generators, each of said generators including a delay line and a plurality of coils spaced axially along said delay line, each of said coils having a plurality of separate windings thereon, said windings being interconnected to define a matrix representing a selected character with certain corresponding windings of said coils being connected in parallel representing alinement of the matrix in a first direction and the windings on each coil itself representing alinement of the matrix in a second direction, an output lead for each of said corresponding windings so that when said delay line is excited a sequential signal train can be applied to the cathode-ray tube in timed relation with the raster thereof, an electric circuit synchronously connected to said cathode-ray tube deflection means for driving the deflection means and connected to said plurality of character generators to drive said delay line in timed relation to said raster, and means for selectively connecting one of said character generators to said circuit and to said cathode-ray tube in response to a received signal from an external actuation source, said means being connected to the control electrode of said cathode-ray tube and synchronized with said electrical circuit whereby said sequential signal train will allow a beam of electrons to strike the screen of the cathode-ray tube under the control of said deflection means and produce a raster in timed relation with said circuit whereby the character determined by the matrix of the selected character generator will be visually reproduced.

2. The combination according to claim 1 wherein said means comprises a switch selectively connectable to said output leads, a plurality of gates arranged in sequence and connected to said switch and to the control electrode of the cathode-ray tube to be thus connected sequentially to said output leads, and a master delay line synchronously connected to said circuit and to said gates to have the gates function sequentially in response to the sequential signal train transmitted from the matrix of the selected character generator through said output leads and said gate, whereby the control electrode of said cathode-ray tube will be driven in response to said signal train.

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