Oct. 9, 1956 E. H. SHEFTELMAN 2,766,444

ELECTRONIC CHARACTER DISPLAYING APPARATUS

Filed Sept. 1, 1953 4 Sheets-Sheet 1

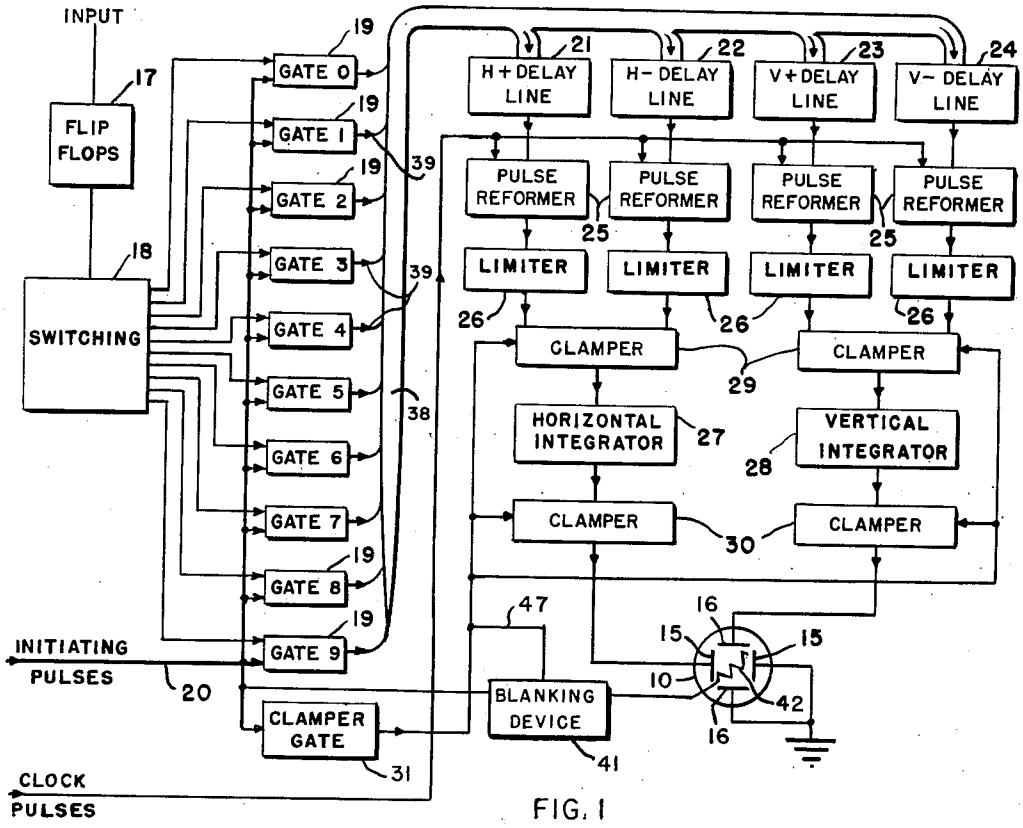

FIG. 1

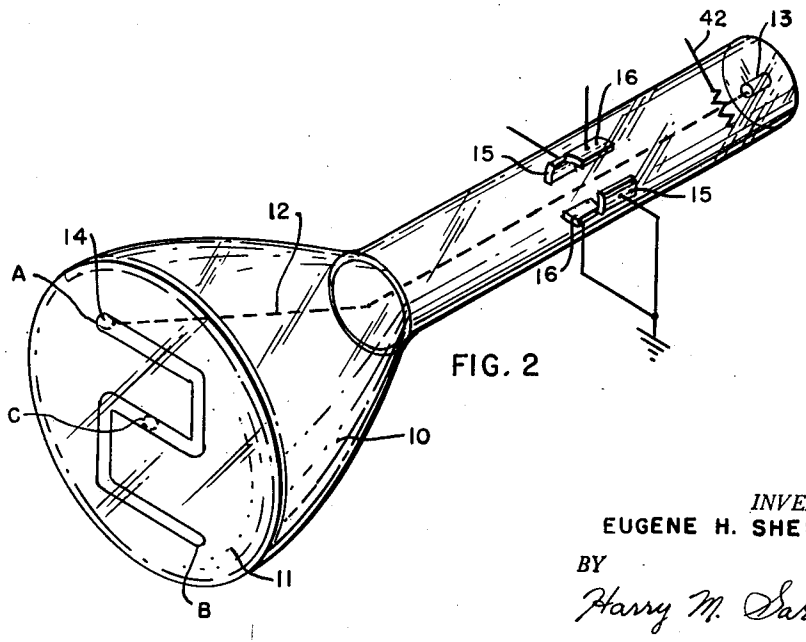

FIG. 2

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ELECTRONIC CHARACTER DISPLAYING APPARATUS

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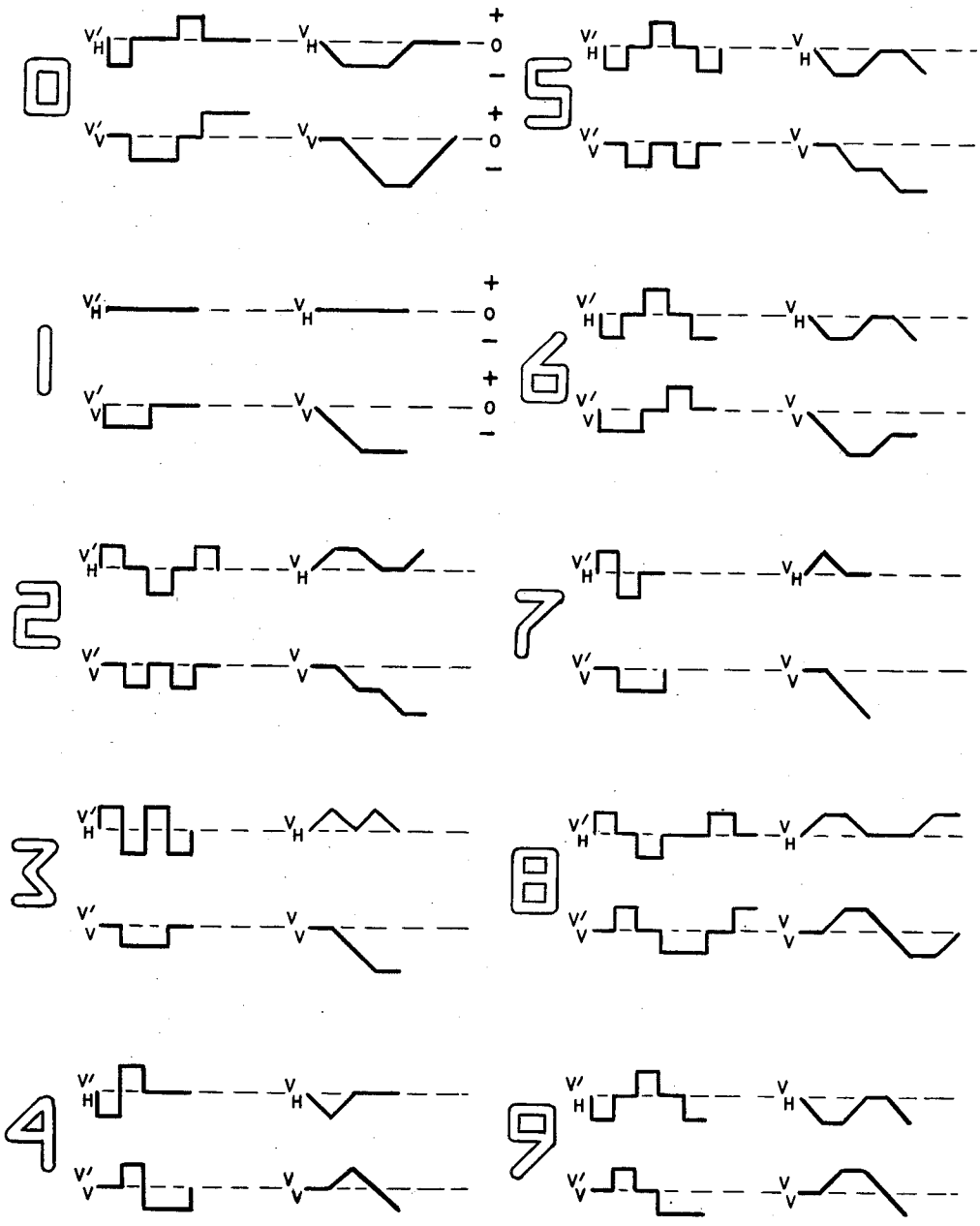

FIG.3

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ELECTRONIC CHARACTER DISPLAYING APPARATUS

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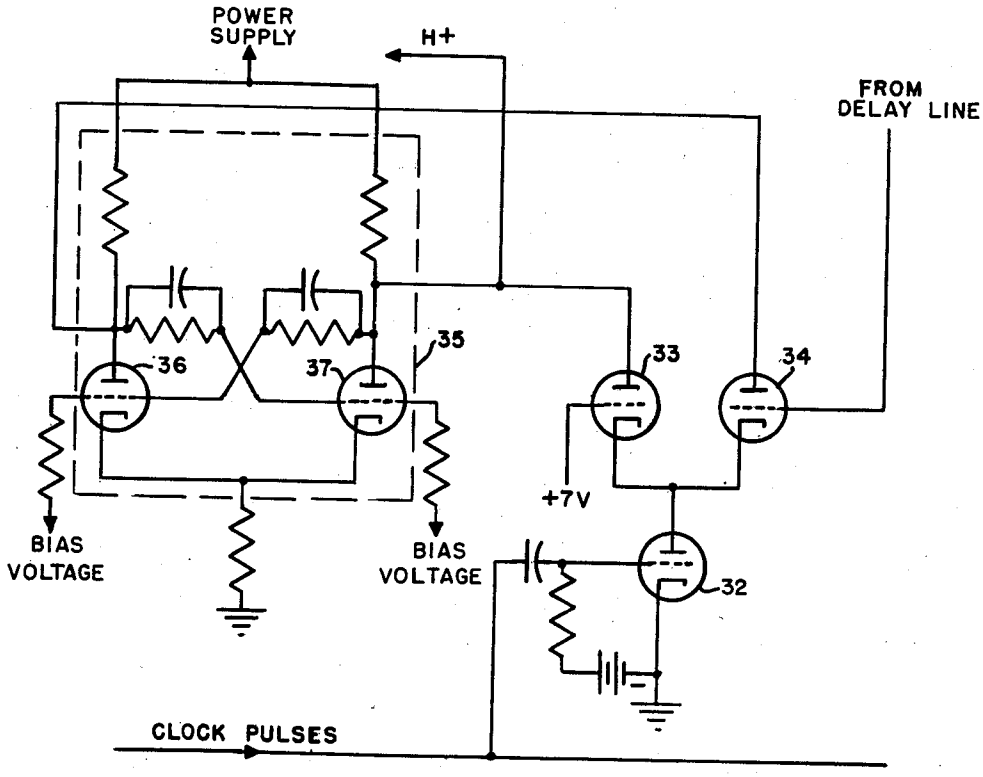

FIG. 4

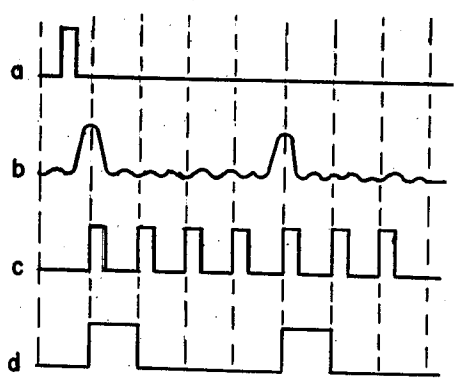

FIG. 5

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ELECTRONIC CHARACTER DISPLAYING APPARATUS

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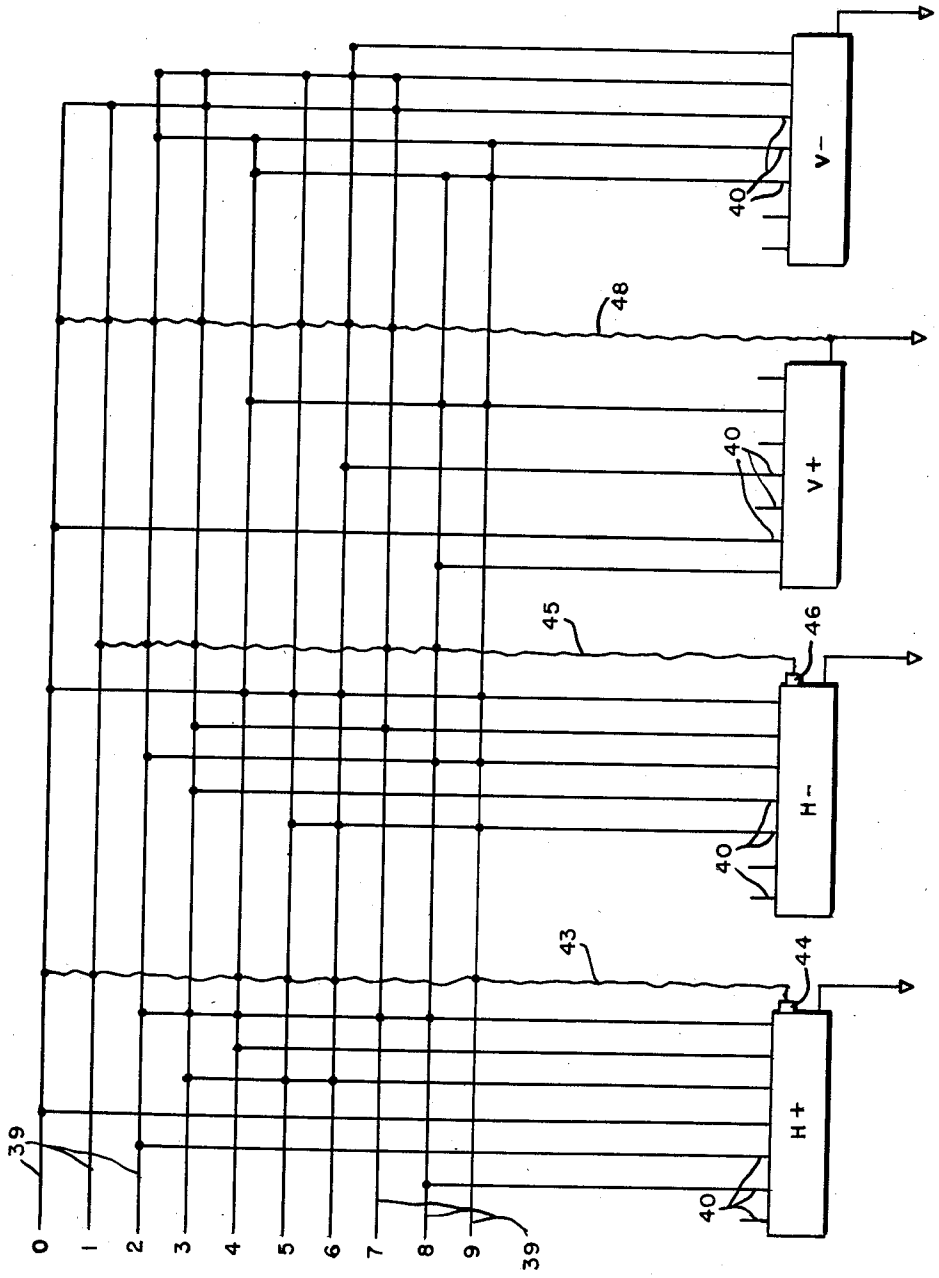

FIG. 6

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ELECTRONIC CHARACTER DISPLAYING APPARATUS

Eugene H. Sheftelman, Jamaica, N. Y., assignor to the United States of America as represented by the Secretary of the Army

Application September 1, 1953, Serial No. 377,989

6 Claims. (Cl. 340—318)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to an electronic apparatus for tracing a desired form or character upon the face of a cathode ray tube by direct control of the electron beam of the tube along the path delineating the character or form.

The invention is particularly useful where it is desired to quickly display a form or character with maximum brilliancy. In the present invention this desirable result is achieved without employing the complexity of circuits necessary to a scanning operation.

The invention may be briefly described as follows:

A controlled series of sloping voltage wave forms are applied to the deflector plates of a cathode ray tube. The sloping voltage wave forms are given appropriate amplitudes and polarity to draw and display a selected character upon the face of the cathode ray tube.

A group of characters, for example, the Arabic numerals from 0 thru 9 may be painted upon the tube face by manipulation of its electron beam. To do this each character is divided into a convenient number of increments and a selected numeral is created by putting together in succession the correct increments in proper sequence to create the desired numeral.

In operation each of the character increments is drawn on the tube face by sloping wave forms of measured duration. To draw a complete character automatic selection of the correct sequence of pulses is made and the resulting pulse train is applied to the deflecting elements of the tube. Proper sequence of the pulses is obtained thru the action of the electronic delay lines which may be of conventional construction with their values designed for the particular function required.

It is a primary object of the invention to provide means for selectively and instantly displaying electronically one or more characters or forms in brightly visible form.

A further object of the invention is to provide means for displaying characters which are indicative of results obtained during the process of solving a problem, for example, in an electronic calculating device.

A further object of the invention is to utilize the brightness of a direct trace of the electron beam upon the face of a cathode ray tube for drawing a selected character.

A still further object of the invention is to provide automatic electronic means for creating the desired character upon the face of a cathode ray tube without a conventional scanning operation.

Other objects and features of the invention will more fully appear from the following description and will be particularly pointed out in the claims. To present a better understanding of the invention a particular embodiment thereof will be described and illustrated in the accompanying drawings in which:

Fig. 1 is a schematic drawing illustrating the elements of the apparatus in block diagram.

Fig. 2 is a diagrammatic illustration of the manner in which a character is drawn upon the cathode ray tube.

Fig. 3 illustrates the form of the numerals 0 to 9 inclusive together with graphical illustration of the activating pulse trains and sloping wave forms to draw each numeral.

Fig. 4 is a circuit diagram illustrating the elements for accurately timing and shaping the character drawing pulses.

Fig. 5 is a diagrammatic illustration of the resulting values of the output circuit of Fig. 4 for a selected input pulse train coming from a particular delay line.

Fig. 6 is a circuit diagram of the pulse train forming portion of the apparatus.

The invention has many applications and the number of characters available for display can be extended as desired. In the specific embodiment to be described herein the Arabic numerals 0 thru 9 are to be made available for display.

Among the many uses of the apparatus is the instantaneous display of solutions or partial solutions of problems in computing devices or the invention may be used to display selected characters upon announcement or call boards. In such applications the energizing of a selected circuit or the pressing of a button will automatically display the desired number, form or group of numbers.

The medium chosen for displaying characters is one or more cathode ray tubes **10** capable of tracing characters upon their face **11**. The characters are drawn by controlling the electron beam **12** issuing from the gun **13** in a manner to cause the spot **14** where the beam strikes the tube face to follow the path necessary to delineate the desired character such as the numeral **2** shown on the face of the tube **10**. The control of the beam **12** may be accomplished in any suitable manner such as by means of the two pairs of electrostatic plates **15** and **16** which are energized in a manner to be described.

Before describing the circuits and circuit elements necessary for accomplishing the desired end it may be desirable to first describe the manner in which the characters are constructed upon the tube face by a succession of deflecting voltage wave forms integrated from a succession of pulses. Each pulse causes the beam **12** to trace upon the tube face a certain portion of each character and by selecting the correct succession of pulses a desired character is painted upon the tube face.

To illustrate the above method more clearly reference may be made to Fig. 3 where the graphic representation is shown of the values and arrangement of the pulses which control the form of each numeral and the integrated pulses which deflect the beam.

Fig. 2 shows the path traced by the beam in constructing Arabic numeral 2. The beam starts from A and stops at B. In Fig. 3 are shown the two sets of pulse trains Vh' and Vv' which control the form of each numeral, 0 thru 9, and also the wave forms Vh and Vv which are produced by integrating Vh' and Vv' with respect to time. Vh and Vv are the sloping wave forms which are actually applied to the horizontal and vertical deflecting plates. Taking numeral 2 as a specific example, the beam is constrained to move from A to B as follows: Starting from rest at A, the Vv wave form remains 0 while Vh rises linearly positive. This causes the beam to move horizontally across the top bar of the numeral. After this the Vh wave form holds fixed at a positive value while the Vv wave form drops linearly negative. This causes the beam to move vertically downward. Next the Vv wave form holds fixed at a negative value while the Vh wave form drops linearly negative, coming to rest at 0. This causes the beam to move horizontally in the reverse direction, forming the middle bar. Next the Vh wave form holds fixed at 0 while the Vv wave form drops linearly to its maximum negative excursion, causing the beam to move

vertically downward to the foot of the numeral. Finally the Vv wave form holds fixed at its maximum negative value while the Vh wave form rises linearly once more. This causes the beam to move horizontally to point B on Fig. 2, and the character has been completed. Whenever the deflecting wave form slopes, the slopes are always the same except for sign, and therefore, it should be noted that the speed of the beam across the face of the tube has been everywhere constant, since this is one of the features of the invention. The speed of the beam is proportional to the square root of the sum of the squares of the derivatives of Vh and Vv at that instant. The derivatives of Vh and Vv are Vh' and Vv'.

It should also be noted that in the formation of certain characters such as the numeral 4 a diagonal trace must be made. This is accomplished by applying simultaneously positive or negative going voltages respectively to the pairs of deflecting electrodes **15** and **16**. This causes the beam **12** to follow a diagonal vector representing the resultant of the two voltages.

Since the slopes of the deflecting voltages are everywhere the same except for sign, it will be evident that when both Vv and Vh slope at the same time the speed of the beam will be 1.414 times the speed when not making a diagonal. The maximum variation in speed of the beam when making any character will therefore be in the ratio 1:414:1. It is highly desirable to hold the variation in beam speed to as low a value as possible in order to keep all parts of characters uniformly illuminated. In scanning operations, the nature of the operation is such that the character cannot be illuminated as uniformly as is done by this invention. The principles of the invention may be applied to the display of a wide variety of forms and characters.

While the invention is useful in many applications a specific use thereof will be presented herein in connection with computing operations wherein information fed to the computer may have a plurality of classifications and it is desired to have visual identification of its class.

The invention provides an efficient apparatus for instantaneously displaying a number which identifies its class and thereby indicates into which one of a group of storing facilities the information is to be placed. The visual information displayed by the apparatus is useful in many ways as will be obvious to those skilled in the art.

In the specific form of the invention presented herein the input innformation is received in a unit **17** shown in Fig. 1 and containing a plurality of conventional flip-flop circuits the outputs of which are connected to a binary-to-decimal diode matrix selector **18** wherein the information is classified into a plurality of categories which in the present example are ten in number. The original input information in passing thru the flip-flop circuits and the matrix selector **18** raises the potential of one of the ten lead wires up to ground potential while the remaining wires are resting at negative potential. The particular wire which is now at ground potential determines which one of a group of numerals from 0 thru 9 is to be displayed by the apparatus. The Arabic numerals to be displayed are chosen as one example of a group of characters of any nature or configuration which can be displayed by the apparatus. It will be evident to those trained in the art that the act of grounding one of the ten switching leads to select the proper numeral can be performed by numerous types of electronic circuits and equipment, depending on the manner in which the information as to which numeral is desired is made available. For instance, if the information arrived in the form of a sequence of pulses indicating the numeral in binary form, the sequence could be stored in an electronic register as it arrived. If the stages of the register were connected to the switching leads thru a binary-to-decimal diode matrix, then when the incoming pulse train was fully stored in the register, only one of the switching leads would be grounded.

Each of the ten wires are connected respectively to ten gating circuits **19**. The wire which has ground potential will condition its respective gating circuit to pass a pulse applied to circuit **20**. The pulse then travels to a group of electronic delay lines **21**, **22**, **23** and **24**. The pulse which is fed to the said delay lines reaches one or more of the lines at one or more selected taps thereon desirably thru an isolating diode. It will thus be seen that by a proper selection of connections to the various taps on the respective delay lines a predetermined pattern is created as a result of which these delay lines will create a chain of pulses having an arrangement which will produce a successive chain of events. The successive chain of events applied to the specific example described herein will cause the beam of a cathode ray tube to trace out a desired character.

Referring again to the delay lines the line **21** is designed to produce a train of positive pulses which create the horizontal increments of the numeral, the delay line **22** produces a negative pulse chain for creating horizontal increments of the numeral which have to be drawn in the opposite direction, the delay line **23** is designed to create a train of positive pulses for creating vertical character increments and the delay line **24** creates a chain of negative pulses for creating vertical increments which have to be drawn in the opposite direction. Thus thru the medium of the delay lines pulse trains are formed having the proper sequence and polarity to form various numerals upon the face of the tube **10** an outline of which has been described above.

The pulses as they issue from the delay lines desirably are reformed in the square wave reformer circuits **25** to be described in detail hereinafter. The pulse trains issuing from the circuits **25** are then fed to limiter circuits **26** where they are given uniform amplitude and wherein certain of the pulses are given negative polarity.

From the limiter circuits the horizontal pulse trains are fed to a horizontal integrator **27** where the final horizontal deflecting voltages are created and fed to the deflector plates **15** of the tube **10**. The vertical pulse trains are fed to a vertical integrator **28** the output of which is fed to the plates **16** of the tube **10**.

To start spot **14** from a chosen point on the tube face **11** each integrator is clamped to a fixed potential before the numeral is traced. This function is performed by clamp circuits **29** and **30** connected to integrators **27** and **28**. These clamp circuits are energized before and after each tracing operation by a voltage derived from the clamping gate circuit **31**. This function will be amplified hereinafter.

Referring to Fig. 4 of the drawing a pulse reformer circuit is shown such as that used in the pulse reformers **25** of Fig. 1.

An accurately timed series of clock pulses is employed as a time trimming means to correct the timing of the raw pulses coming from the delay lines. The clock pulses are fed to the grid of a tube **32** in relatively rapid succession. The tube **32** is biased to cutoff so that it is not conducting between clock pulses but each clock pulse shifts the tube into its conducting state. The plate output of the tube **32** feeds power to the cathode of a pair of tubes **33** and **34** the outputs of which become divided into two components the values of which are a function of the respective grid potentials of the tubes **33** and **34**.

When a clock pulse alone is applied to the grid of the tube **32** the tube **33** conducts a relatively heavy current since its grid is normally biased to conduct while the grid of the tube **34** which is connected to the output of its delay line is at this time at a low potential such as ground potential. Since the tube **33** is conducting heavily the potential of the output line H-plus is at a low value.

The square wave forming portion of the circuit consists of a bi-stable flip-flop circuit **35** containing tubes **36** and **37**. The current flowing in the plate circuit of tube **33** energizes the tube **37** which in turn causes this tube

to establish a stable condition of the flip-flop. Thus the voltage of the output of the H plus line is held uniformly low or at ground potential and no pulse occurs in the output since at this time it is assumed that no plate is coming from the delay line.

As shown in Fig. 5 (*c*) an accurate succession of clock pulses is being fed into the system which acts as the master timing control. In this connection it should be added that the delay lines are so designed that pulses passing therethru will have the same timing as the clock pulses. It is apparent therefore that when a pulse arrives from the delay line **38** to bias the grid of the tube **34** a clock pulse will also be acting to cause the tube **32** to conduct and consequently the tubes **33** and **34**. Thus since the pulse from the delay line has a relatively high voltage, for example plus 15 volts, as against the plus 7 volts applied to the grid of the tube **33**, the high bias of the tube **34** will cause it to conduct heavily relative to the tube **33**. Thus the voltage on the plate of the tube **33** will be increased sharply and thus the H plus output voltage is raised.

At this same instant current in the plate circuit of tube **34** causes the tube **36** of the flip-flop circuit to establish a stable condition at the higher voltage. Thus a square pulse is created. If upon the next clock pulse a pulse from the delay line is also received the pulse length is increased to the duration of two clock pulses and may be prolonged until the flip-flop is caused to shift its condition to the lower voltage by failure of a delay line pulse to arrive at the same time as a clock pulse. It is obvious that depending upon the order in which delay line pulses are received an accurately timed square wave pulse chain is created.

A graphical representation of the above method of pulse formation is shown in Fig. 5 wherein the H plus chain of pulses is illustrated in connection with the delineation of the number 2. In line (*a*) an initiating pulse is shown. In line (*b*) a graph of the pulse chain as received from the delay line is shown. In line (*c*) clock pulses are illustrated in relation to delay line pulses and in line (*d*) the final square pulse chain is shown.

Thus far the description of the invention has not been concerned with the accurate placement of the characters upon the center of the tube face **11**. Obviously the ability of the device for accomplishing this function as a valuable refinement to the broad concept of the invention. The broad invention, however, is not to be restricted to the use of character positioning means.

Character positioning means will be described and shown in connection with Fig. 6 of the drawings. In this figure also are shown the connections between the outputs of all gating circuits **19** to the various taps upon the four delay lines **21**, **22**, **23** and **24**. Thus Fig. 6 illustrates the circuit contained in the cable **38** shown in Fig. 1. Fig. 6 shows the points of connection between each of the lines **39** and the taps **40** upon the delay lines to which they are connected. The distance between each of the taps **40** represents a unit of time delay.

The manner in which the spot **14** is placed in correct position to draw a centralized character upon the tube face may be accomplished in various ways. The objective of such a means must be capable of placing the spot at a suitable starting position for each character. A preferred means for accomplishing this result will now be described.

A fixed period of time is allowed for positioning the spot during which time the tube face must be blanked out. To do this a blanking device **41** is provided and placed in a line connected at one end to the initiating pulse line **20** and extending to the control grid **42** of the tube **10**. The potential of the grid **42** is controlled by the blanking device **41** to cut off the electron beam during the time interval between the occurrence of the initiating pulse and the instant of actually starting to draw the character and includes the time consumed for positioning the spot.

To position the spot it is moved from an arbitrary resting position. Any suitable resting position may be chosen. In the example to be described herein this position is shown at (*c*) in Fig. 2 of the drawings and is the geometrical center of the rectangle embracing all of the characters. The rectangle is two time units high and one time unit wide.

For characters where the drawing thereof is started in one corner of the reectangle the spot must be moved to right or left half of a time unit and at the same time upwardly or downwardly a full time unit to the right or left corner.

Other characters require only that the spot be moved horizontally to the right or left for half a time unit or upwardly or downwardly for a full time unit. By reference to Fig. 6 the connections to form the various types of characters are shown.

In Fig. 6 a special wire **43** is connected to a tap **44** on the H+ delay line. This tap is designed to cause a delay of half of a unit time period. Another wire **45** is connected to a half unit time delay tap **46** on the H— delay line.

It will be seen by reference to Fig. 6 that as the pulse is routed to one of the ten wires **39**, for instance, the wire for drawing the numeral 2, a positive pulse of unit duration is applied directly to the plate **16** of the tube **11** thru the wire **48** and to the H— half unit time delay tap **46**. The combination of the resulting voltages when applied to the tube move the spot into the upper left corner of the rectangle. At this instant the blanking device turns on the beam **12** and the various increments of the numeral 2 are assembled on the screen **11** in the manner hereinbefore described in connection with the formation of the numeral 2. It should be pointed out that the pulses composing the pulse trains for drawing the characters after leaving the delay lines are integrated and applied as sloping voltages to the deflector plates of the cathode ray tube **10**.

The clamper gate **31** measures a time interval equal to the maximum time required to form a character. At the end of this time period the clamper acts to terminate the cycle and return the spot to its resting position (*c*). A connection **47** from the clamper gate to the blanking device **40** provides the means which act at this time to blank out the electron beam thru the medium of the grid **41** at the end of the character drawing cycle. By following the chain of events as shown for each character in Fig. 3 and noting the connections to the taps on the delay lines as shown in Fig. 6 it is possible to follow the formation of each character.

What is claimed is:

1. An electron beam controlling apparatus comprising a cathode ray tube, a plurality of input lines representing a group of characters or forms to be drawn upon the screen of said tube, a pulse forming selective switching means for initiating a pulse in a selected one of said input lines, a plurality of tapped electronic delay lines, a gating circuit interconnecting each input channel to selected taps on said delay lines whereby chains of pulses are created by said input pulse applied to a selected input channel and wherein said pulses have a time sequence and polarity of character forming significance and means to integrate said chains of pulses from said delay lines to obtain a series of voltages whose value change with time along a sloping curve and means to apply the voltages to the beam deflecting elements of said tube.

2. An electron beam controlling apparatus having the elements defined in claim 1 together with square wave forming, amplitude limiting and integrating means acting to derive beam deflecting voltages from the said pulse trains.

3. An electron beam controlling apparatus comprising

a cathode ray tube having rectangular coordinate beam deflecting means, a plurality of input wires each wire being adapted when energized to produce a different beam control program, a group of tapped electronic delay lines connected to said input wires each wire being connected to a selected group of taps on said delay lines, square wave pulse forming means connected to the output of each delay line and adapted to form equal measured pulses, polarizing means to change the polarity of the output of at least some of said square wave devices thereby assembling chains of pulses constituting a character drawing program, separate channels interconnecting said pulse forming means respectively to the horizontal and vertical beam deffecting means of said cathode ray tube and integrating means in each of said channels for deriving beam deflecting voltages from said pulses which act to draw character increments in end to end relation on the face of the said cathode ray tube.

4. An electron beam controlling apparatus comprising an electronic selecting device responsive to an input signal and having a plurality of output lines, a plurality of tapped electronic delay lines interconnected with each of said output lines, each output line being connected to selected taps on said delay lines thereby to form predetermined pulse programs, square wave pulse shaping and polarizing means connected to the output of each delay line the outputs of which are fed to two independent channels, electron beam indicating means having rectangular coordinate deflecting means connected to said channels whereby an input signal fed by said selector to one of said input lines is transformed into trains of electronic pulses arranged in predetermined time sequence and polarity according to said pulse program, integrating means for said pulse trains and means to subject said electron beam to an electric field varying in intensity according to the program set up by said integrated pulse trains to move said electron beam in response to said program whereby straight character increments are drawn in end to end relation by said beam to form a character.

5. A character displaying apparatus comprising a cathode ray tube having rectangular coordinate beam control members, a plurality of input lines each line representing one of a group of characters or forms to be displayed each character being composed of a plurality of straight

graphic structural increments, a plurality of tapped electronic delay lines, gating circuits interconnecting each of said input lines with selected taps on said delay lines, the taps selected for interconnection being so chosen that an initiating pulse applied thru one of said lines will develop chains of pulses at the outputs of said delay lines having a predetermined timed character forming sequence, square wave pulse shaping means connected to each delay line, at least two of said delay lines acting to time pulse trains for creating straight horizontal character increments and at least two delay lines being provided for creating straight vertical character increments, means to shift the polarity of at least some of the pulses issuing from the delay lines whereby a predetermined program may be created for drawing a selected character increment in end to end relation by increment, integrating means to derive beam deflecting voltages from said pulses and connections from the outputs of the delay lines controlling the horizontal increments to the horizontal deflecting plates of said cathode ray tube and connections from the delay lines controlling the vertical increments to the vertical deflecting plates of said tube.

6. A character displaying apparatus having the elements defined in claim 5 together with means for applying a series of accurately timed and spaced timing pulses to the pulse forming circuits at a frequency the same as and occurring in synchronism with the rate of display of the increments of the characters or at some multiple of such frequency.

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