Nov. 29, 1966 S. E. TOWNSEND 3,289,195

DELAY LINE WAVE SHAPE GENERATOR

Filed Nov. 9, 1962 2 Sheets-Sheet 1

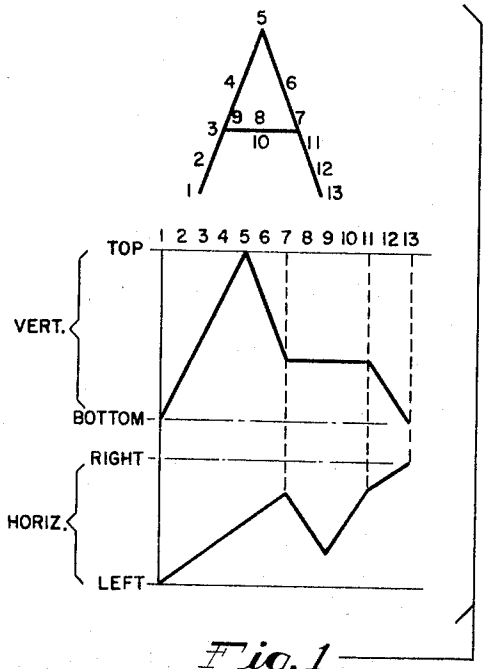


Fig. 1

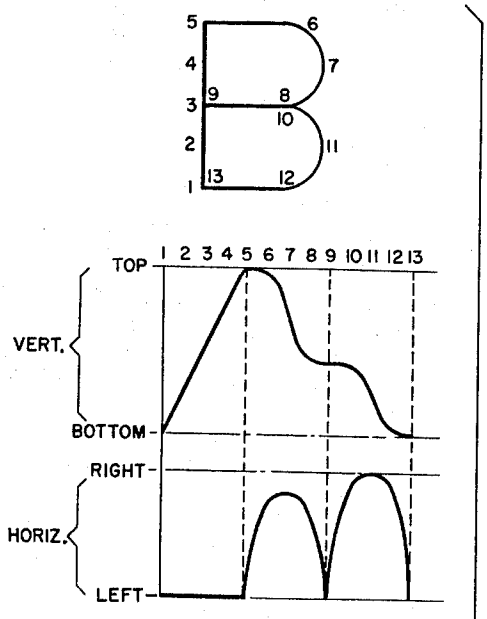


Fig. 2

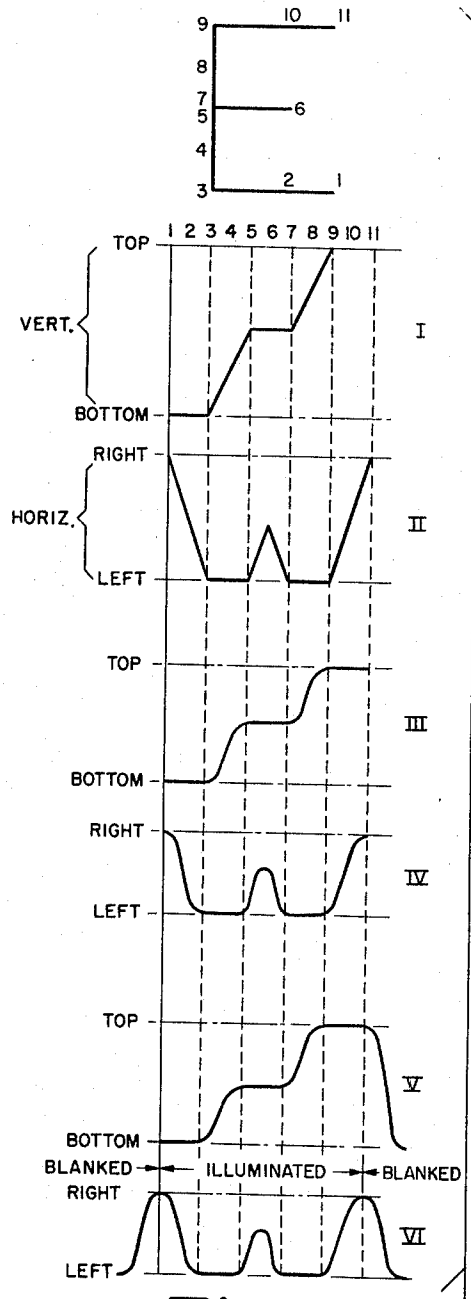


Fig. 3

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Nov. 29, 1966 S. E. TOWNSEND 3,289,195

DELAY LINE WAVE SHAPE GENERATOR

Filed Nov. 9, 1962 2 Sheets-Sheet 2

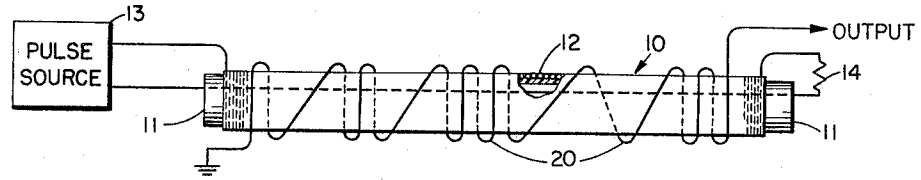


Fig. 4

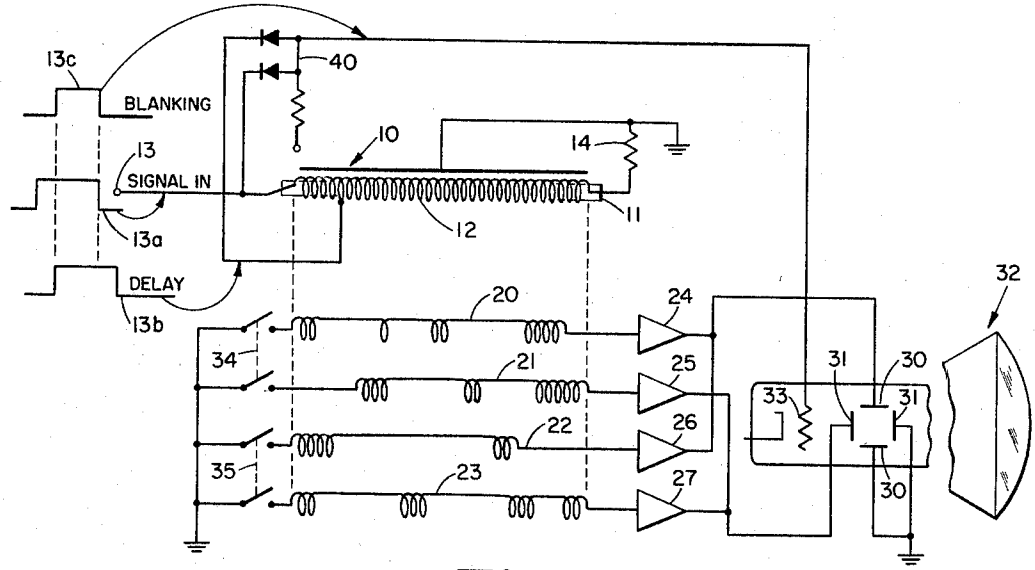


Fig. 5

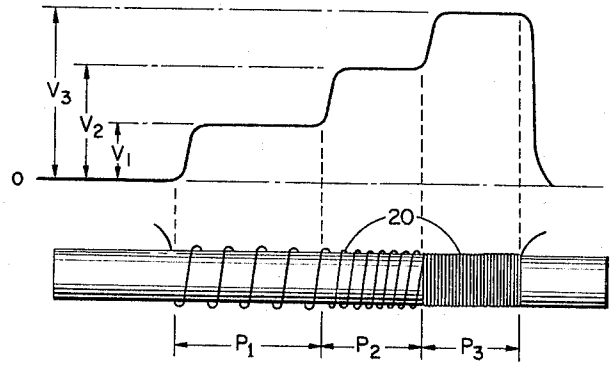


Fig. 6

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3,289,195

DELAY LINE WAVE SHAPE GENERATOR

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This invention relates to means for generating voltages of unique wave shape. The voltage wave shapes contemplated here are of the type which, for example, when applied to the orthogonal deflecting electrodes of a cathode-ray tube will produce a trace of any desired character on the screen of the tube.

An object of this invention is to provide a simple unitary structure of passive electronic components for generating unique wave shapes.

The objects of this invention are attained in a delay or artificial transmission line of the type having uniformly distributed series inductances and parallel capacitances. An elongated ferrite core wound with fine wire is typical of such a line. A voltage step or voltage pulse applied to the one end of the delay line travels along the line, the velocity of propagation, determined by the parameters of the core and winding, being considerably reduced compared to the velocity of propagation along an open line. Upon the delay line is wound an elongated secondary winding of nonuniform pitch. As the wave front moves along the line, voltages are induced in different portions of this secondary winding, the induced voltage being variable and a function of the pitch of the winding. Where, for example, turns of the secondary winding are more closely spaced, higher voltages will be induced. Accordingly, by altering the winding pitch, voltages of predetermined waveform can be produced. The waveforms may conveniently be selected to match the desired waveforms for application to the deflection circuits of a cathode ray tube for tracing characters on the screen of the tube. Since two deflecting voltages must simultaneously be applied to the vertical and horizontal deflection circuits, two secondary coils are wound on the delay line for each character to be displayed.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the specific embodiment described in the following specification and shown in the accompanying drawings, in which:

FIGS. 1, 2 and 3 show alphabetic characters for display on a cathode-ray tube with the accompanying vertical and horizontal deflection voltages for tracing those characters;

FIG. 4 shows an elementary delay line with one shaped output secondary winding, according to this invention;

FIG. 5 shows schematically one waveform generator, with exploded view of secondary windings, and associated utilization means, according to this invention; and,

FIG. 6 shows one waveform and the winding distribution on a delay line for producing that waveform.

In FIG. 1 is shown the elementary character A and the orthogonal deflection voltages necessary to a cathode-ray tube for displaying the character on the tube screen. It is assumed here that the starting point of the scan is in the lower left-hand corner of the pattern, and that during thirteen time intervals the beam is deflected vertically and horizontally successively to the thirteen positions indicated. In the example shown the beam is deflected diagonally upward from position 1 to position 5 and then downwardly to position 7 where the vertical deflection is arrested while the beam is deflected horizontally to the left and then to the right to complete the horizontal bar of the A; whereupon, the final leg of the

A is completed during time intervals 11 and 12, terminating at position 13. The cathode-ray beam must then be cut-off or blanked during return to position 1 or to the position for starting the next character.

FIGS. 2 and 3 show, respectively, the vertical and horizontal deflection wave shapes which may be employed for inscribing, respectively, the letters B and E. The movement of the beam vertically and horizontally during the scanning intervals is shown on the time scales for the waveforms. It will be noted that the trace of the letter B includes both straight and curved lines.

For practical reasons, it is not feasible to generate the abrupt corners on the wave shapes as idealized in lines I and II of FIG. 3. Because of certain integrating characteristics of practical circuits, the wave shapes actually generated are smoothed and rounded, as suggested in lines III and IV of FIG. 3. Fortunately, in generating such letters as E, the important parts of the waveform are the horizontal portions representing the straight line of the character. Since the other portions are not critical in shape, but only in amplitude, the forms of lines III and IV may be used. Where the start and finish of the scan is not in the lower left-hand corner, the undesired portions of the scan are blanked out, as shown on lines V and VI in FIG. 3 by applying the necessary cut-off bias to the control grid of the tube.

The delay line **10** shown in FIG. 4 comprises an elongated rod or tube **11**, either straight or curved, upon which is wound closely-spaced turns **12** of fine wire. The input end of the coil **12** is connected to the pulse source **13** and the opposite end is connected to the terminating resistance **14** which, preferably, is of a value equal to the characteristic impedance of the line. The distributed series inductance and shunt capacity of the coil reduces the velocity of propagation to the desired low value.

Velocities of one inch per microsecond are not uncommon in commercial delay lines. The core should be of material which has low losses at high frequencies, such as ferrite. The core form may be a solid rod or a hollow tube and may be elongated and straight, as shown, or curved. One commercially obtainable delay line comprises a ferrite core about one centimeter in diameter and five inches long and wound with fine copper varnished wire one layer deep and with minimum winding pitch, the delay in five inches of line is about five microseconds.

According to the invention, the winding **20** is wound on top of the primary winding **12**, and the pitch of the winding is varied widely to provide induced voltages in the winding **20** of various values as the wave front in the line travels from one end of the line to the other. If a pulse of the duration and shape of the voltage shown in FIG. 6 is desired, where there are three voltages V_1, V_2 and V_3, the coil **20** is wound with three different pitches, P_1, P_2 and P_3. For a constant velocity of propagation of the wave front along the line, the voltages induced successively in the three winding portions are measured by the pitch of those portions. The widely spaced turns of pitch P_1 will produce relatively low voltage V_1 at the terminals of the winding, while the relatively higher voltages V_2 or V_3 will be produced by more closely wound portions P_2 and P_3. That is, terminal voltage is inversely proportional to pitch. The secondary winding may be divided into many sections and the pitch changed upwardly or downwardly in each sections to provide the various waveforms suggested in FIGS. 1, 2 and 3.

Where two closely coordinated voltages are required, as for the vertical and horizontal deflection circuits of a display tube, two secondary windings should be wound, one upon the other upon one delay line. Each winding may, conveniently, be applied to the core by a variable pitch coil winding machine having a programmed lead-

screw feed. In practical embodiments of the five-inch delay line, mentioned above, it was found that the rise time of the secondary voltage to maximum value was less than .5 microsecond. This, then, is an approximation of the resolution of the generator.

According to an important feature of this invention, one or more pairs of secondary windings are wound upon the delay line, as shown in FIG. 5. For purposes of illustration, the secondary windings at **20**, **21**, **22** and **23** are shown in exploded plan. Winding **20** is wound directly on the delay line and then winding **21** is wound over winding **20**. Windings **22** and **23** and additional windings are likewise successively applied. The wire of the windings is suitably insulated, as by varnish coating. The windings at the output ends are each connected into voltage amplifiers. Amplifiers in FIG. 5 are shown at **24**, **25**, **26** and **27**. The amplifiers are divided into two groups and their outputs are connected, respectively, to the vertical deflection electrodes **30** and horizontal deflection electrodes **31** of the cathode-ray tube **32**. The control grid for turning the electron beam on and off is shown at **33**. The opposite ends of the secondary windings are each connected to switches. Switches **34** and **35** selectively open and close the circuits of pairs of windings of each character to be displayed. Conveniently, the switches may comprise diodes for remote or programmed switch operation. That is, the diodes would be normally reverse biased to prevent conduction and would be forwardly biased to permit conduction by coded binary information.

Blanking voltages are applied to the control grid from the AND gate **40** which has two input terminals connected, respectively, to the input terminal **13** and to a tap on the primary delay line winding **12** a measured distance from the input end. This distance is proportional to the time of delay desired before the cathode-ray tube is unblanked. The duration of the overlap of the input pulse **13***a* and the delayed pulse **13***b* determines the duration, **13***c*, of the period of unblanking. The pulse duration contemplated here is longer than the time of travel of the wave front of pulse **13***a* through the line inasmuch as the voltages of reverse polarity, caused by the trailing edge of the energizing pulse at **13**, is normally not employed in the display of the characters of FIGS. 1, 2 or 3.

Many modifications may be made in circuit details and component parameters of the wave shape generator of this invention without departing from the scope of the invention.

What is claimed is:

1. In combination with a cathode-ray tube and associated deflection circuitry, an elongated transmission line, source means connected to one end of said line for propagating a wave front at a predetermined velocity along said line, a winding associated with said line to inductively receive an induced voltage from the travelling wave front, said winding being connected to and adapted to transmit said induced voltage to said deflection circuit of said cathode-ray display tube, the pitch of the turns of said winding being nonuniform and being a function of the desired deflection voltage.

2. The combination in a character display system comprising a cathode-ray tube with orthogonal deflection circuits, a delay line, means connected to one end of said line for propagating a wave front toward the other end of said line, a pair of windings disposed on said delay line and inductively coupled to primary current flowing in said delay line, said windings being connected, respectively, to said deflection circuits, the pitch of said windings being nonuniform and being a function, respectively, of the instantaneous orthogonal deflection voltages required in said deflection circuits for displaying a predetermined character.

3. In a character display system the combination comprising a cathode-ray tube having a control electrode and beam deflection means, deflection circuitry coupled to said beam deflection means, said circuitry comprising a delay line wave shape generator, an elongated transmission line with distributed constants, means connected to one end of said line to propagate a wave front toward the other end of said line, a first winding of irregular pitch inductively coupled to said delay line to generate a voltage wave of unique irregular shape in response to said propagating wave front, control means coupling said winding to said deflection means for deflecting the beam of said cathode-ray tube in accordance with said irregular voltage.

4. The invention defined in claim **3** further comprising a blanking means adapted to control the output of said cathode-ray tube, said blanking means including an AND gate with two input circuits and an output circuit, said input circuits being connected, respectively, to spaced points on said delay line and said output circuit being connected to said control electrode of said cathode-ray tube.

5. The invention as defined in claim **3** including a second winding of irregular pitch electrically coupled to said delay line and being adapted to generate a unique irregular voltage wave in response to said propagating wave front and provides it as an input to said control means.

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