

March 23, 1965

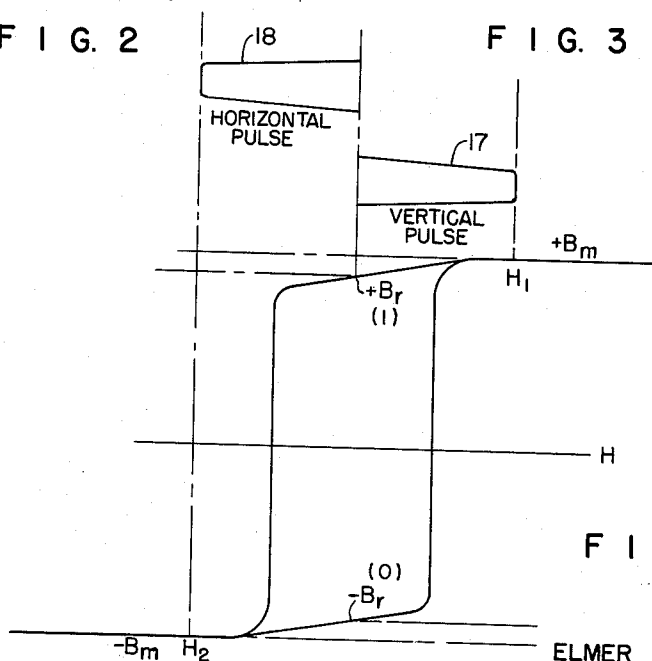
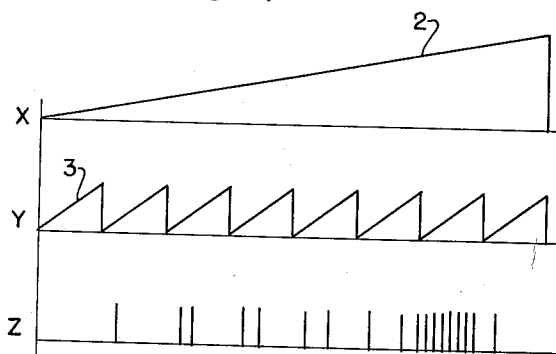
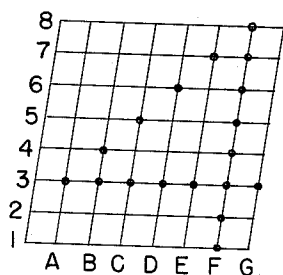
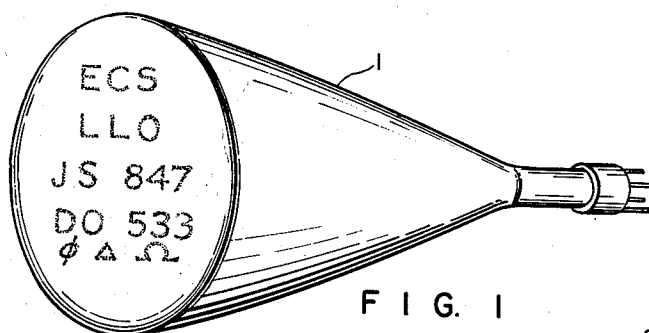
E. C. SIMMONS

3,175,208

CATHODE RAY TUBE SYMBOL GENERATOR HAVING
FORWARD AND REVERSE WOUND CORES

Filed April 29, 1960

3 Sheets-Sheet 1



INVENTOR.

ELMER C. SIMMONS

BY

Joseph Weintraub
ATTORNEY

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E. C. SIMMONS
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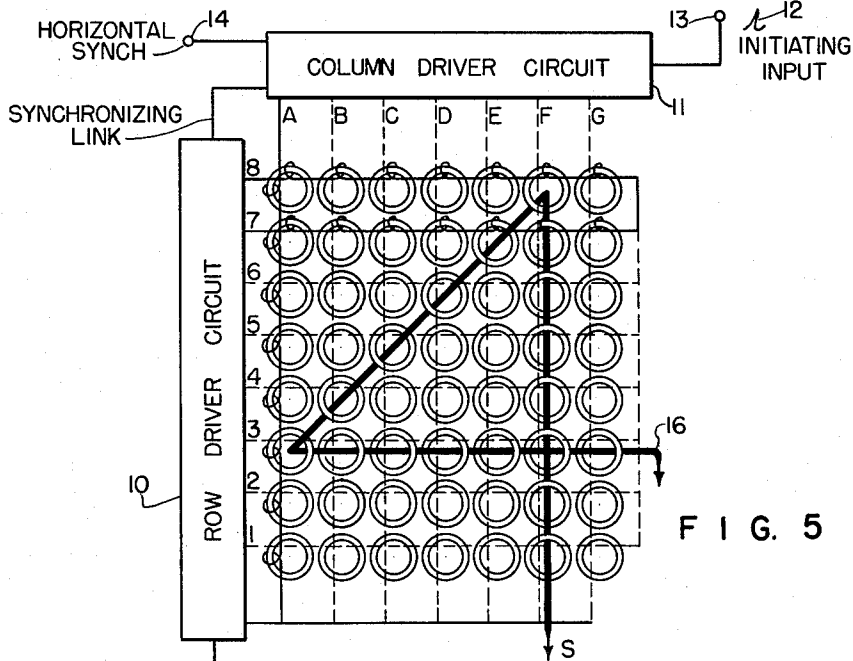


FIG. 5

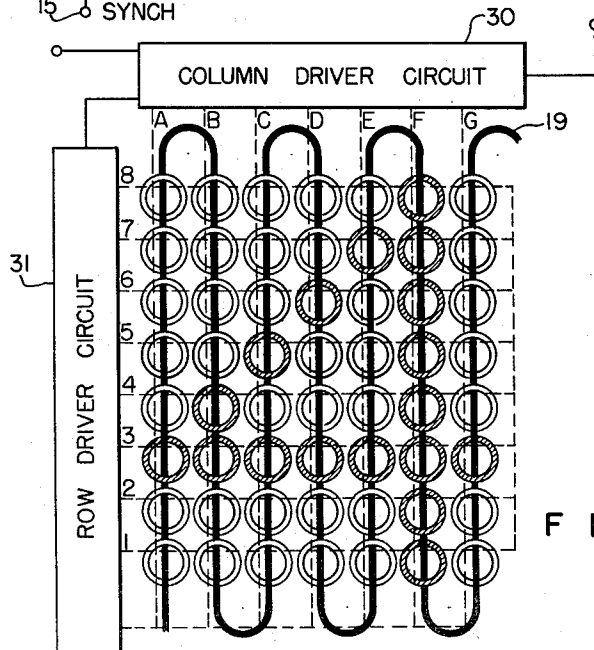


FIG. 6

INVENTOR.
ELMER C. SIMMONS

BY
Joseph Weingarten
ATTORNEY

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E. C. SIMMONS
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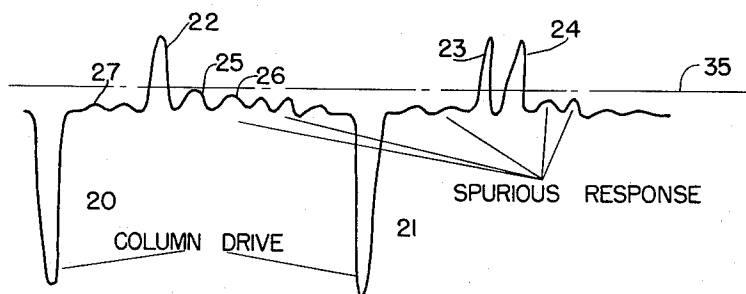


FIG. 7

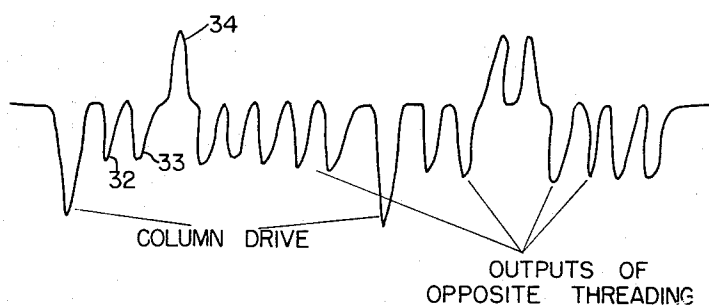


FIG. 8

INVENTOR.
ELMER C. SIMMONS
BY
Joseph Weingarten
ATTORNEY

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**CATHODE RAY TUBE SYMBOL GENERATOR
HAVING FORWARD AND REVERSE WOUND
CORES****Elmer C. Simmons, Whitman, Mass., assignor to Laboratory for Electronics, Inc., Boston, Mass., a corporation of Delaware**

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4 Claims. (Cl. 340—324)

The present invention relates in general to improved memory devices of the magnetic core matrix type which serve as basic components in electronic display systems utilizing cathode ray tubes to produce characters on a luminescent screen.

The use of a magnetic core memory matrix for generating characters to be selectively presented in a character display system is well known and the construction of a feasible magnetic core matrix has been described in a monograph entitled "High Speed Number Generator Uses Magnetic Memory Matrices" by An Wang in the May 1953 issue of Electronics. Essentially, the magnetic core memory matrix described in that monograph consists of a rectangular array of bistable magnetic cores arranged so that the cores are aligned in rows in one direction and are aligned in columns in the orthogonal direction. The magnetic memory matrix was used in a system for displaying characters, such as numerals, on the fluorescent screen of a cathode ray tube, the system being arranged to cause the entire field to be scanned while intensifying the trace at appropriate locations to produce the desired character. In that system X and Y sweeps were generated by conventional apparatus and the magnetic memory matrix was used to supply the intensifying Z signal. A single readout wire was threaded through the proper cores of the magnetic array in the shape of the character to be displayed and the cores were made to change states in sequence so that a series of pulses was induced in the readout wire by the flipping of the cores. Each core in the matrix, therefore, represented a possible luminous dot provided only that the readout wire was threaded through it. An initiating pulse caused successive flipping of the cores in a sequence analogous to the scanning of the electron beam across the cathode ray tube's face. Each core, in its turn, was caused to go through a complete magnetic cycle; that is, the core was caused to change from the stable state in which it resided to its second stable state and then caused to return to its initial state. Synchronizing signals were brought out of the matrix to insure that scanning of the cathode ray tube screen went on synchronously with the scanning of the cores. The pulses (i.e., video signals) induced in the readout wire by the flipping of the cores through which it was threaded, gave the proper Z-intensity signals to brighten the trace on the cathode ray tube screen, causing a luminescent character to be produced corresponding to the shape of the wire. A single readout wire was required for each character and where a plurality of different characters were to be displayed, a separate wire was threaded through the cores for each character. Electronic switching was employed to select the output of the readout wire corresponding to the character to be displayed.

It has been found in using magnetic core matrices as symbol generators in display systems that the matrices produce spurious responses which are distinctly undesirable. That is, a selected readout wire may provide an output (i.e. a spurious signal) at a time when an unthreaded core is being flipped. Ideally, the readout wire would provide an output only when threaded cores were flipped. The invention resides in threading the readout wires through the cores of the matrix so that spurious

signals can be easily distinguished from true signals. The standard method of constructing a magnetic core memory matrix has been to link, by a readout wire, only those cores corresponding to dot positions in the shape of the desired character. In the invention, all the cores corresponding to dot positions in the character are threaded by the readout wire in one direction whereas all the other cores are threaded by the wire in the opposite direction. The output obtained from the readout wire is a bi-polar waveform in which signals corresponding to character dot positions (i.e., true signals) are of one polarity, positive for example, and signals corresponding to other dot positions (i.e., spurious signals) are of the opposite polarity, viz., negative in the chosen example. The output of the readout wire at any instant is the algebraic sum of the signal and noise voltages and since noise occurs concurrently with true and spurious signals, positive noise pulses occurring at unused dot positions are effectively masked by the negative readout occurring at the same time. The term, signal-to-noise ratio, becomes almost meaningless when applied to the invention because true signals are always of one polarity and unwanted signals are always of the opposite polarity so that signal selection circuits are never required to differentiate between a true signal and an unwanted signal of the same polarity. The reliability of magnetic core matrix symbol generators is considerably enhanced by the invention since signal-to-noise considerations are largely eliminated.

The manner of constructing the invention and its mode of operation can be better understood by a perusal of the following exposition when considered in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a type of symbol display provided by the invention;

FIG. 2 depicts the synthesis of a symbol by a core matrix;

FIG. 3 represents waveforms occurring in the utilization of a magnetic core matrix symbol generator;

FIG. 4 is a graph showing the rectangular hysteresis loop characterizing the bistable magnetic cores employed in the invention;

FIG. 5 represents a magnetic core matrix of conventional construction associated with driver circuits;

FIG. 6 represents a magnetic core matrix constructed in accordance with the invention;

FIG. 7 illustrates the type of output signal obtained from the conventional matrix of FIG. 5; and

FIG. 8 illustrates the type of output signal obtained from the matrix of FIG. 6.

Referring now to FIG. 1, there is depicted the general type of display which can be obtained by employing a magnetic core matrix symbol generator. The cathode ray tube 1 is intensity modulated by video signals from the symbol generator in a manner causing each displayed character to be formed by a plurality of luminous dots. The symbols displayed on the cathode ray tube screen may be conventional alphabetic or numeric characters or may be any pictograph or unconventional symbol desired which is within the attainable resolution of the system. Except for the limitations imposed by the system resolution and the available screen area, the choice of symbol size and shape and the spacing between symbols is unrestricted. Since each character consists of a pattern of luminous dots, it is necessary to coordinate the orthogonal X and Y sweeps with the intensity modulating video signals and in order to position the character in a desired area of the screen, suitable positioning potentials must be employed. It is a matter of indifference whether electrostatic or magnetic deflection apparatus is used with the cathode ray tube to deflect the electron beam. Whatever the type of beam deflection system, the video signals from the symbol generator are

used to control the beam intensity of the cathode ray tube and the sweep of the beam is coordinated with the video signals.

Referring now to FIG. 2 which is an enlarged view of the numeral four appearing on the screen of cathode ray tube 1, it is apparent that the character consists of an array of discrete dots. For expository purposes, the numeral has been superposed upon a rectangular matrix having eight consecutively numbered horizontal rows and seven consecutively lettered vertical columns. It should be understood that the size of the matrix is a function of the resolution desired and need not be limited to a rectangular shape or to a total of fifty-six dot positions. However, a 7 x 8 matrix with fifty-six dot positions has been found to permit sharply defined, one-eighth inch high symbols to be presented on a conventional cathode ray tube screen. By applying appropriate combinations of X, Y, and Z-axis potentials, the luminous dots upon the cathode ray tube screen are caused to form the numeral four.

Assuming that the cathode ray tube is of the electrostatic deflection type and that the electron beam is swept vertically from bottom to top of each vertical row in consecutive order while the beam is simultaneously swept at a lower speed in the horizontal direction, FIG. 3 illustrates the sweep and intensity modulating signals utilized to form the numeral four on the tube's face. The sawtooth wave 2 of FIG. 3X is utilized to sweep the electron beam horizontally while the beam is simultaneously swept vertically by the higher frequency sawtooth wave of FIG. 3Y. Those X and Y waves are simultaneously applied and cause the electron beam to form a rectangular raster. Although only seven vertical columns are used in the matrix for dot positions, eight vertical columns are present in the raster. The first vertical sweep 3 (FIG. 3Y) is used to insure a spacing at least equal to one column between adjacent characters to avoid ambiguities which might be caused by overlapping symbols. If desired, the first spacing column (FIG. 2) may be omitted and overlapping of adjacent symbols may be prevented by appropriately biasing the deflection apparatus of the tube to provide a space between adjacent rasters. In this event each raster would consist of a 7 x 7 grid with 49 dot positions. The slightly skewed vertical aspect of the character in FIG. 2 results from the fact that horizontal displacement of the beam from left to right occurs during the application of the individual vertical traces. To obtain a rectangular pattern, a stepped wave would be utilized in lieu of the sawtooth depicted in FIG. 3X.

FIG. 3Z shows the Z-axis intensity modulating video signals which generate the numeral four when employed in conjunction with the sweeps of FIGS. 3X and 3Y. Each of the Z pulses represents a luminous dot on the cathode ray tube screen and those pulses occur in a time sequence such that the array of luminous dots forms the numeral four. The waveforms of FIGS. 3X, 3Y, and 3Z are plotted along the same time axis to indicate the relation of the intensity modulating pulses to the X and Y sweeps.

Having set forth the requirements of the X, Y, and Z-axis signals needed to produce dot modulation symbols, reference is now made to FIG. 5, that figure depicting a magnetic core matrix of conventional construction employed to generate Z-axis intensity modulating signals while simultaneously providing signals for synchronizing the X and Y-axis sweeps. The illustrated magnetic matrix is a 7 x 8 array of bistable magnetic cores, each of which is toroidal in shape and is characterized by a substantially rectangular hysteresis loop having two stable magnetic states. FIG. 4 shows a typical rectangular hysteresis loop characterizing the cores employed in the matrix. The two stable states are designated in FIG. 4 as $+B_r$ and $-B_r$. For ease of exposition, binary notation is employed in the discussion which follows, the $-B_r$ state being designated "0" and arbitrarily being taken as the normal state in

which the cores reside, whereas the $+B_r$ state is designated "1" and arbitrarily designated as the reversed stable state.

In order to interrogate the magnetic core matrix, row and column driver circuits 10 and 11, respectively, are provided. The matrix interrogation process is commenced by applying an initiating pulse 12 to terminal 13. The driver circuits provide output signals at terminals 14 and 15 for the actuation and synchronization of horizontal and vertical sweeps, respectively. Interrogation of a magnetic core consists of pulsing the core through a complete magnetic cycle. Normally, the core resides in the 0 state and in the cycle, the core is first flipped to the 1 state and then returned to its initial 0 state. To generate a symbol, intensity modulating video signals are obtained from those cores whose positions in the matrix correspond to the shape of the symbol to be generated. The magnetic cores are sequentially interrogated beginning at the lower left-hand corner of the matrix at core A-1 and progressing upwardly through the first column to core A-8, then returning to the bottom of the matrix and progressing upwardly through the second column, and thence upwardly through each succeeding column until core G-8 is reached. Each core, as it is interrogated, completely traverses its hysteresis loop. The driver circuits for effecting the sequential interrogation of the cores may be of the type described in Pat. No. 2,920,312, or any other suitable driver circuitry may be employed.

In the conventional core matrix of FIG. 5, generation of the appropriate video signals is accomplished by employing an output winding to link those cores having positions in the matrix corresponding to the shape of the desired symbol. An electrical signal is obtained from the output winding when a flux reversal occurs in the core through which it is wound. As the total change of flux and the speed at which it is reversed in the magnetic core is significantly large, a substantial electrical pulse is obtained from the output winding. Thus, an output winding consisting simply of an insulated conductor threaded through those cores in the matrix which are oriented in the shape of the symbol to be generated, develops a potential pulse when the flux in each of the linked cores is reversed. The output winding 16 of FIG. 5, for example, is threaded through those cores of the matrix whose positions correspond to the dots necessary to produce the symbol four. In order to have all signal pulses obtained from the output winding 16 of like polarity, the output winding is threaded in the same sense through each of the linked cores. That is, starting from the end S and proceeding along the output winding 16 in FIG. 5, that winding passes over, through, and under each linked core. However, at the crossover point, i.e., core F-3, the output winding 16 is not looped through twice, as threading the winding twice through the same core gives rise to a double amplitude pulse when that core is scanned.

Assuming the driver circuits uniformly pulse all the cores in the matrix of FIG. 5, in the sequence previously described, a train of pulses is obtained from output winding 16 which correspond to the pulses illustrated in FIG. 3Z. To generate any desired symbol, it is necessary only to thread through the cores of the matrix an output winding configured in the shape of the symbol. A single magnetic core matrix having multiple output windings is usually adequate to generate all the symbols to be displayed by the system.

In operating the type of matrix shown in FIG. 5, it is conventional to apply horizontal pulses to the matrix at a rate of about 50,000 pulses per second. Each horizontal pulse is amplified and is applied by row driver circuit 10 to the bottom row of the cores causing a current pulse to flow in those cores. The horizontal pulse is applied to each of the rows, the row driver circuit causing a delay to be introduced between the actuation of

each succeeding row so that the pulsing of the rows advances upwardly until a current pulse has been sent through the top row of cores. The polarity of the horizontal pulse is such as to saturate the cores negatively as shown in FIG. 4, so that all the cores are placed in the ZERO state.

When a symbol is to be displayed, an initiating pulse 12 is impressed at input terminal 13 of the column driver circuit 11 and causes a trigger device in that circuit to be set. The first subsequent horizontal pulse to reach the top row trips the trigger device, causing a signal to be generated in driver circuit 11 which sets all the cores in vertical column A into their ONE state. The next horizontal pulse resets the cores in column A to their original ZERO state, one core at a time, starting with the bottom core and proceeding to the top core. Since output winding 16 is threaded through core A-3, a voltage pulse is induced in that winding when core A-3 is reset to the ZERO state. The resetting of the top core in column A causes driver circuit 11 to generate a pulse which sets all the cores in vertical column B into their ONE states. The following horizontal pulse then resets the cores in column B, one at a time, to the ZERO state. As output winding 16 is threaded through cores B-3 and B-4, the resetting of those cores induces two pulses in the output wire. Resetting of the top core B-8 causes the column driver circuit to generate a pulse which sets all the cores in vertical column C into their ONE state and the next horizontal pulse resets the cores in that column, successively, to the ZERO state. The process of sequential scanning of the cores goes on until the last core in the column G is reached.

Referring now to FIG. 7, there is illustrated the output signals obtained from winding 16 when columns A and B in the matrix of FIG. 5 are scanned. The large amplitude negative-going pulse 20 is due to the driver pulse which sets all the cores in column A into their ONE state and the negative-going pulse 21 arises from the driver pulse which sets all the cores in column B into their ONE state. Positive-going pulse 22 represents the voltage induced in the output winding by the resetting of core A-3 and positive pulses 23 and 24 are the signals induced in the output winding by the resetting of cores B-3 and B-4. The positive-going pulses of lesser amplitude, such as the pulses 25 and 26, are spurious responses. A spurious response is any output pulse occurring at a time when an unthreaded core is switched. Spurious responses may originate for a number of different reasons. Some of the spurious responses may be caused by partial reversal of the magnetic state of a core arising from overshoot on the trailing edge of a driving pulse. Other spurious responses appear as a result of stray coupling between cores brought about by common impedances in the matrix and its drivers. Another reason for spurious responses is that the hysteresis characteristic of the cores employed in the matrix exhibits a departure from a precisely rectangular loop.

From FIG. 4, it can be seen that the vertical driver pulse 17 has a peak magnetizing force H_1 which causes the core through which that current pulse passes to have a peak flux density $+B_m$, the point $+B_r$ representing the magnetic flux density remaining in the core when the magnetizing force has decayed to zero. The ONE state of the core is represented by the residual flux density $+B_r$. The horizontal drive pulse 18 has a magnetizing force equal to H_2 so that when that current pulse passes through a core winding, the maximum flux density in the core attains the $-B_m$ level which recedes to the $-B_r$ upon the removal of the magnetizing pulse. The $-B_r$ flux density level represents the normal ZERO state of the magnetic core. In an ideal matrix, a core in the normal ZERO state would be unaffected by the horizontal pulse 18. It is apparent from FIG. 4, however, that where a core is in the normal ZERO state and a horizontal pulse is applied to the row winding of that

core, the flux density will change from $-B_r$ to $-B_m$, the change in flux consequently giving rise to a spurious signal if the output winding happens to pass through that core.

The effect of employing cores whose hysteresis characteristics is not a precisely rectangular loop can be more fully apprehended by considering the core matrix of FIG. 5 in conjunction with the waveforms shown in FIG. 7. Assuming that all the cores in column A have been set into their ONE state by a driver pulse from circuit 11, a horizontal current pulse, such as the horizontal pulse 18 of FIG. 4, is caused to flow in the winding which passes through all the cores in row 1. During the application of the horizontal pulse, core A-1 changes from $+B_r$ flux level to the $-B_m$ flux level and all the other cores in row 1 change from the $-B_r$ to the $-B_m$ level. Because output winding 16 is threaded through core F-1 the change in flux in that core induces a spurious signal in the output winding, that spurious signal being indicated by the low amplitude positive pulse 27 of FIG. 7. Consider now what happens when the horizontal pulse is applied to row 4. Since the output winding 16 is threaded through cores B-4 and F-4, the change of flux in those cores will induce voltages in the output winding which are additive and result in the spurious pulse 25 (FIG. 7). The difficulty in working with signals of the type shown in FIG. 7 is similar to that existing in any system where a desired signal must be reliably recognized in the presence of noise. FIG. 6 shows a core matrix similar to that shown in FIG. 5, the important difference being that the output winding 19 of FIG. 6 is threaded through the cores in a manner quite different from the disposition of output winding 16 of FIG. 5. The shaded cores in FIG. 6 represent dot positions in the numeral 4. Output winding 19 is threaded through the shaded cores in a direction such that when a shaded core is switched from its ONE state to its ZERO state, the change in flux induces a positive-going signal in the output winding. All the unshaded cores are also threaded by the output winding but the winding passes through them in the opposite direction so that when an unshaded core is switched from its ONE state to its ZERO state a negative pulse is induced in the output winding. The output obtained from winding 19 is a bi-polar waveform as indicated in FIG. 8. In FIG. 8, the readout signals corresponding to character dot positions are of one polarity, i.e., positive, and signals corresponding to any other positions are negative. Since the output of winding 19 at any instant is the algebraic sum of signal and noise voltages, positive noise pulses occurring at unused character dot positions are effectively masked by the negative pulses occurring when the unshaded cores are switched.

To illustrate the operation of the core matrix of FIG. 6, assume that the cores in column A have been placed in their ONE state by a driver pulse circuit 30 and that a horizontal pulse, such as the pulse 18 of FIG. 4, is impressed by row driver circuit 31 upon the horizontal winding threaded through the first row of cores. The horizontal pulse causes the flux in core A-1 to change from the $+B_r$ level to the $-B_m$ level and that change in flux induces a negative pulse 32 (FIG. 8) which masked any positive noise occurring at this time. When the horizontal pulse is next impressed by row driver circuit 31 upon the second row of cores, core A-2 is caused to change from its ONE state to its ZERO state so that a negative pulse 33 (FIG. 8) is induced in the output winding 19. Subsequently, the horizontal pulse is impressed upon the third row of cores, causing core A-3 to change from its ONE state to its ZERO state and in doing so that core induces positive-going pulse 34 (FIG. 8), in output winding 19. It can be seen, therefore, that flipping of the shaded cores causes a positive pulse to be induced in the output winding. The flipping of any core of the matrix of FIG. 6 always gives rise to a signal which is either of the negative or the positive polarity and selection circuits

which are coupled to the output winding 19 are never called upon to differentiate between two signals of the same polarity. In contrast, selection circuits to which signals of the type shown in FIG. 7 are coupled, must be capable of distinguishing between true signals and spurious responses. The extraction of true responses from the raw matrix signals of FIG. 7 is essentially one of amplitude selection and the process is unipolar in that only signals appearing above a selected threshold level, indicated by the broken line 35, are amplified while those responses having insufficient amplitude are rejected.

The novel matrix symbol generator of FIG. 6 eliminates signal-to-noise considerations since the output obtained from winding 19 is a bi-polar waveform in which true signals (i.e. signals corresponding to character dot positions) are of one polarity and all signals occurring at unused dot positions are of opposite polarity. Reliability is enhanced considerably because there is no critical dependence on threshold levels.

It should be realized that the output winding 19 of FIG. 6, while it is depicted as threaded columnar-wise through all the cores, may be threaded in other paths without affecting the operation of the matrix. For example, the output winding 19 may be threaded row-wise or diagonally through the matrix. The configuration of the path is not of great importance so long as the output winding is threaded through the symbol dot cores in one sense and is threaded in the opposite sense through the other matrix cores.

In a practical matrix symbol generator, a large number of output windings are threaded through the matrix to provide a multitude of symbols and each output winding usually is arranged to provide output signals representing a different one of the symbols. By selecting one output from among the many available, any one of a multitude of symbols can be displayed.

It is apparent that changes which do not depart from the essence of the invention may be made, and indeed, are evident to those skilled in the symbol generator art. Accordingly, it is intended that the invention not be limited to the precise structure illustrated in the drawings, but rather than the scope of the invention be construed in consonance with appended claims.

What is claimed is:

1. Apparatus for generating an electrical signal characteristic of a predetermined symbol comprising, a matrix constituted by an array of bistable magnetic cores aligned in rows and columns, means for first setting the flux state of all the magnetic cores and then sequentially altering the flux state of each of the magnetic cores, and a single output winding magnetically linked with those cores in said matrix having positions corresponding to dots on said symbol to provide output signals of one polarity, said output winding being magnetically linked with other cores of said matrix to provide output signals of opposite polarity.

2. Apparatus for generating bipolar electrical signals characteristic of a predetermined symbol comprising, a matrix of toroidal magnetic cores having first and sec-

ond stable residual flux states of opposite polarity and arranged in a substantially rectangular pattern of rows and columns, a first driver circuit for sequentially setting said rows of said toroidal cores in said matrix to said first stable state, a second driver circuit synchronously actuated from said matrix for sequentially setting said columns of toroidal cores in said matrix to said second stable state, means for initiating the operation of said second driver circuit subsequent to the setting of a predetermined row of said toroidal cores to said first stable state, and a single output winding inductively linked with selected cores of said matrix which are disposed in position corresponding to the configuration of said symbol for providing electrical signals of one polarity and inductively linked with other cores of said matrix for providing electrical signals of opposite polarity.

3. Apparatus for generating bipolar electrical signals characteristic of a predetermined symbol comprising, a substantially rectangular matrix formed of rows and columns of toroidal magnetic cores, scanning means for sequentially pulsing a magnetic flux in each of the toroidal cores in the first of said matrix columns progressively from the first to the last of said matrix rows, means responsive to the pulsing of the toroidal core in the last row of each of said columns for initiating the sequential pulsing of the toroidal cores in the next succeeding column, and a single output winding magnetically linked with those cores in the matrix disposed in positions corresponding to the configuration of said symbol in a manner such that alteration of the flux state of those cores induces pulses of one polarity in said winding, said output winding being magnetically linked to other cores in the matrix in a manner such that alteration of their flux states induces pulses of a different polarity in said winding.

4. A symbol generator comprising a matrix of bistable magnetic cores arrayed in rows and columns, all of the matrix cores normally residing in a first stable magnetic state, each column having its own driver winding connecting all the cores in the column, means for energizing the column driver windings in a sequence to cause the cores to be set to the second stable state, each row having its own driver winding connecting all the cores in the row, means for energizing the row driver windings in a sequence to cause the set cores of a column to be consecutively reset to their first stable states, and a single output winding threaded in one sense through those cores in the matrix disposed in positions corresponding to the configuration of a symbol and threaded in the opposite sense through other cores of said matrix.

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