[54] DISPLAY SYSTEM WITH SOLID MATRIX DISPLAY BOARD

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#### Abstract

Display system utilizing a solid matrix display board having a plurality of display lines each of which is made up of lamps arranged in vertical columns and horizontal rows, the display lines and display element columns being locatable by address code data. A shift register is associated with each row, and each storage stage thereof is sequentially related to a lamp in the row. The control circuits for the system select a display line indicated by the input data and the encoded signals for desired data characters are shifted through the shift register to a desired column location indicated by the input data. Cycling means are provided to enable changing any display character on a board by addressing the line and column of the character to be changed. Provisions are also made for selectively forming the encoded signal and bypassing an input data to encoded signal converter to provide random access to any displayed element on the board.


## 8 Claims, 5 Drawing Figures

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## SHEET 1 OF 4



SHEET 2 OF 4


SHEET 3 OF 4


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## SHEET 4 OF 4



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## DISPLAY SYSTEM WITH SOLID MATRIX DISPLAY

 BOARDThis invention relates to display systems utilizing display boards having a solid matrix of display elements, and more particularly to display systems in which the display elements are operated by means of shift registers which may be controlled to function in a variety of modes to give different visual effects. Furthermore, this invention relates to a solid matrix display system in which all types of displays including alphanumeric messages, pictures, or animated cartoons may be run, utilizing digital data input means. The system shown herein is an improvement of the systems disclosed in the copending application Ser. No. 626,038 , filed Mar. 27, 1967 by Gardberg et al. and U.S. Pat. No. 3,493,956, issued Feb. 3, 1970 to Andrews et al.

Display boards for forming messages as well as pictorial displays may generally be categorized into two separate classes which can be designated as the individual indicator type and the solid matrix or individual lamp type. An example of the first type is shown in the copending application previously mentioned and comprises a large number of individual indicators positioned at discreet positions on the board. Each of the indicators is made up of a matrix of lamps which may be actuated to form desired display characters. The indicators are separately addressed and then actuated to form the display characters in accordance with the data from an input source. An alphanumeric character may be displayed on each indicator to form a message or a special character may be displayed on each indicator to form a pictorial representation. Although such systems were quite suitable for message displays, the fixed indicator approach limited the character width and spacing that could be used. Furthermore, the pictorial representations were limited because of the number of special characters that could be economically programmed.

The solid matrix type displays comprise a field of individual display elements, such as lamps arranged in closely spaced rows and columns, and therefore permit greater flexibility in the type of presentations to be made. The ones in existence today can be used to display message type and pictorial type displays but generally not on the same board at the same time. In most previous systems the pictorial representations had to be formed with the use of optical projection systems and could not operate by programmed digital data input. In these systems movie films were projected on a matrix of photocells, each of which controlled a lamp in the display board matrix. Thus, the light conditions on the photocells as the movie plays thereon caused a replica of the picture on the film. Since the pictorial displays were formed by optical means and the message characters were formed of data input means, the two types of displays could not be formed on the same board at the same time unless the message was included in the movie film used to form the pictorial display. In addition, two separate control systems were required, one for message display and one for pictorial display, making a very costly display system.
The present invention provides for a much more efficient system for the display of alphanumeric messages as well as the display of pictorial representations wherein the same control system is utilized for both types of display. Messages can be displayed in copy changer mode, or traveling message mode and in the former mode two types of formatting can be used for maximum flexibility. The particular control means for the display permits random access to any location on the display board so that any one or more display characters can be changed without reforming any unaffected portion of the display. Furthermore, any lamp on the board can be individually reached for changing its condition by proper data input. These provisions permit the display of intricate animated cartoons as well as readable messages utilizing only the ordinary well known type of digital data input devices available on the market. Furthermore, the system operates in a more efficient manner than heretofore was possible, so that operating personnel and display programmers can perform their functions more efficiently.

## SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the broader aspects of this invention, a display system is provided which comprises a display board having a matrix of display elements arranged in equispaced, vertical columns at locatable column addresses and parallel horizontal rows to form a solid matrix. A shift register is associated with each row of display elements and each of the shift registers has a storage stage sequentially corresponding to a display element in its associated row. Means are included for receiving input data corresponding to desired display characters and the address of the particular column of elements in which the first display character is to appear. The control system for the display includes means for converting the display character data into display character encoded signals as well as means for sequentially entering the encoded signals into the input of the shift registers, for shifting the encoded signals from stage to stage, and stopping the shifting when the first display character encoded signals reach the shift register stages associated with the display elements at the particular column indicated by the input data. Means are also provided for actuating the display elements corresponding to the shift registers having encoded signals therein. Additional display lines may be used to increase the size of the total display and if so, means are provided for selecting a particular line addressed by the input data.

In accordance with some of the narrower aspects of this invention, the entering, shifting and stopping means comprises a column location counter which is set by the input data to the address of the particular column in which the first display character is to appear. After the encoded signals are entered into the shift registers, they are shifted to the stages corresponding to the address read into the column location counter. To enable random access to any display character for message update or cartoon movement without disturbing the rest of the display, a cycling loop is connectable to pass data from the last stage of each of the shift registers to its input which is controllable by the receipt of column address input data to circulate the data in the shift register. A cycle counter is also provided which is caused to shift its count simultaneously with the shifting of data within the shift register until the particular column address number is reached. Means responsive to the attainment of that number sequentially enters the new display character encoded signals into the shift register while simultaneously advancing the count of the cycle counter. When this is done the shift register continues to shift and the cycle counter advances until the cycle counter reaches a number equal to the number of stages in the shift register. The display character then is positioned at its programmed location on the board.

These and other features of this invention will be more fully understood upon a reading of the remaining specification especially when taken in view of the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation of a display board for use with the system of this invention;

FlG. 2 is a partial view of the solid matrix of display lamps making up the message portion of the display board;

FIGS. 3 and $\$$ are block diagrams of the circuits making up the control means for the display system; and

FlG. 5 is a schematic diagram of a portion of the message board circuits including the input circuits for the display lamp row shift registers.

## DESCRIPTION OF THE PREFERRED EMBODIMENT 72 decoder dependent immediately

The display system of this invention is especially adaptive for use in sports arenas or the like in which the Display Board 10 comprises a Game-In-Progress section 12 in conjunction with a Message section 14. The Game-In-Progress section 12 comprises a number of fixed indicators 16 on which numeric
characters are formed such as the display of the Home and the Guest scores and the relevant Time information. The indicators 16 are separately addressable and operable to form any of the decimal digits by manipulation of buttons or switches in a Game-In-Progress Keyboard 18 through appropriate Signal Logic Circuits 20 which may be of the type disclosed in the aforementioned Gardberg application.

The Message section 14, on the other hand, is comprised of a solid matrix of display devices, such as incandescent lamps 17, which are operable to form an infinite variety of messages and/or pictorial representations at any location on the board. This section is controlled through the Signal Logic 20 by means of any sort of digital data input means 33 such as a Keyboard 22, magnetic tape recorder 27 or a Punch Tape Reader 24, the tapes of which can be prepared by a Punch Tape Typewriter 26 or an associated Lamp Code Punch 28. The input devices feed data into the Signal Logic byte by byte in appropriate code form such as ASCII code for alpha-numeric characters and in a lamp code prepared by the Lamp Code Punch 28 for special effects as will be described later. In addition, a settable timer 29 may be used to control the time period each message programmed on a punch tape is displayed by stopping the tape reader 24 fo: a set time after each message data entry. It is this Message section 14 of the board and its control to which this invention is particularly directed. Hence, a more detailed description of that portion of the board and its system follows.

As an example of a particular Message board 14 there is shown herein a solid lamp matrix board containing 2,940 lamp bulbs arranged in an array 49 lamps high and 60 lamps long. This board is divided into individually reachable horizontal sections of the board indicated as Line 1 through Line 7 on the drawings. Each Line 1-7 is seven lamp rows high and 60 lamp columns long (FIG. 2). For ordinary messages, the Signal Logic 20 is designed to display alphanumeric and punctuation characters which are five lamps high so that a seven-line message can be displayed with two lamp spaces between each line of the message. The width of these characters varies between one lamp wide and five lamps wide, as can be seen in the display shown in FIG. 1 which shows a display for basketball games indicating the number of fouls made by the Home and Guest players. This type of character is also exemplified in FIG. 2 by the display characters shown on lines 1 and 4.

As previously mentioned, the flexibility with which such display characters may be positioned on the board to form a message and by which individual characters may be reached to make changes in the message or picture is an important feature of this invention. The system is designed so that all the information is read into the board from the right side and either moved to a proper position before lighting the lamps for forming a stationary copy changer message or shifted from lamp column to lamp column across the board as a traveling message. Thus, under certain operating conditions the system operates similar to the one shown in the previously mentioned Andrews Patent. As in that patent, each of the lamp rows is associated with a shift register 31 (see FIG. 3) having a storage stage ( $\mathrm{Col} .1-\mathrm{Col} .60$ ) corresponding to each lamp in the row. It will be seen later in the discussion that a number of the circuits used in the traveling message system of that patent are utilized in the handling of the data signals in this system.

A static or nonmoving display such as the one illustrated on Message board 14 in FIG. 1 may be formed in one of two ways, hereinafter referred to as noncycling mode and cycling mode. In the noncycling mode the characters are set in one after the other by the input data on a desired addressed Line 1-7 with the spacing between letters automatically formed. As the data for each character is received the Signal Logic 20 forms the proper column-by-column encoded signals and reads them into the message board circuits. Each character will thus be formed column-by-column with the appropriate number of shifts to the left required by the character and the column spacing before the next character begins. When the last display character on a Line has been formed, it will of
course be located on the rightmost columns of the line and if centering of the display is desired, an appropriate number of column spaces must be included in the input data after the last display character.

To form the display shown in FIG. 1 by the noncycling mode in the described system, the input data must start with appropriate address data to select Line 1 followed by the display character data. Thus, the input data would begin with *100 in ASCII code, the asterisk serving as a Special Address Character indicating that the next three following numerals pertain to address information rather than display information. The numeral 1 indicates Line 1 on the board and the two zeros are required for processing the data in the Signal Logic as will be described in more detail later. The address data is followed by the display character data which is decoded by the Signal Logic 20 to provide encoding signals to the display board for forming the display character at the right side of the board. Thus, when the letter P, starting the work PLAYER, appears in ASCII code at the input to the Signal Logic after the address data, encoding signals are sent to the display board 14 to form the letter $P$ at the right side of the display board one column at a time. The lamps in the four columns forming the letter $P$ are energized and an additional nonilluminated column is provided for the spacing before the next character. If no further data follows the $P$, the display character with its subsequent space column remains in the five columns at the right side of the board. However, since the $P$ is followed by data for the letter $L$, the letter $P$ moves over five more spaces at the same time that the letter $L$ and its subsequent spaces are formed at the right side of the board. The formation of the remaining characters as well as the space between the two words PLAYER and FOULS keeps the formed characters moving to the left until the last letter $S$ is formed at the right5 hand side. If it is desired to center the characters on the message board 14, all of the display characters may have to be moved to the left a determined number of columns by the appropriate insertion of data indicating single column spacing after the input of the letter $\mathbf{S}$. The number of additional columns that must be added after the last display character to center the display can be easily calculated at the time that the program is prepared. To form the second line of the display in the noncycling mode, Line 2 need not be specially addressed in the data. Rather, a Carriage Return code may be used to automatically address Line $\mathbf{2}$ after Line $\mathbf{1}$ has been completed.

The cycling mode is programmed differently and operates differently than that previously described to form the desired display. In this case the specific column at which the first character in each line is to be located and the display character is written in to that specific location with the subsequent characters properly positioned therebehind. The address data, in this case, includes not only the Line 1-7 data but also data to the particular column of lamps Col. 1-Col. 60 at which the first column of the first display character is to appear. Referring again to the display of FIG. 1, the first column of the letter P appears at the first column Col. 1 on Line 1. Therefore, the input data for the first line display will appear as *101 followed by each of the display characters to be displayed in the line. The first numeral after the asterisk again addresses Line 1 and the second and third numerals 01 addresses Column 1, Column 1 being the leftmost column on the line and Column 60 being the rightmost one. Once the address has been read in the data for the display character $P$ is immediately entered into the Signal Logic and the encoding signals are shifted into the message board circuit so the letter $P$ appears immediately at Column 1 of Line 1 . The next letter L will automatically appear at Column 6 after its data is read in and likewise for each succeeding character. However, each 70 Line and the location of the first character must be addressed in this mode as the carriage return code input will not automatically address the proper location.

The cycling mode of operation makes it possible to change any one or more display characters being displayed on the 5 board without rewriting other parts of the display. For exam-
ple, during a basketball game, it may be necessary to change the indication of the number of fouls of any one 4 . the ball players. If during a game, Guest player 25 commits his fourth foul, the 3 appearing as the last character on Line 4 should be changed to a 4 . In the system of this invention the operator can accomplish this by merely addressing the particular line and the particular column followed by the new display character to make the correction. Referring to the display in Line 4 of FIG. 2 which shows that portion of the display of FIG. 1 in detail, it will be seen that the address of the number 3 is Line 4 , Column 56. Thus, the address $* 456$ will locate Column 56 of Line 4 and the following data number 4 will cause the Signal Logic to change the 3 to a 4.

The ease with which data display characters may be changed in this mode over the noncycling mode will be readily appreciated. In the noncycling mode, the whole line would have to be reprogrammed with the appropriate line address, display characters, spacing, etc. It will be appreciated however that corrections may be made to the display using the cycling mode even though the original display was formed on the board using the noncycling mode, simply by addressing the desired line and column followed by the data for the new display character. This ability adds to the operator's convenience in the use of the board to convey information to the audience.

As previously mentioned, the system of this invention is also capable of forming displays on the solid matrix board which depart from the ordinary encoded alphanumeric characters. The large word GO in Lines 2 and 3 of FIG. 2 is an example of such a display. Such a display is not formable by the use of ASCII code in the input data, those codes forming normal matrix characters such as shown in Line 1 of FIG. 2. As may be seen, the large letters $G$ and $O$ each overlap onto the two lines, line 2 and line 3, and each is wider in the number of columns used than the same letters normally encoded and displayed as on Line 1 of FIG. 2. The large GO is just exemplary of the infinite variety of pictorial representations which could be formulated. Pictures, abstract designs and other fancy letters could be displayed in any manner desired and applicable for formation on a solid matrix board.
To form this type of display each lamp on the board is specifically controllable by the input means. Advantage is taken of the byte-by-byte readout of the various input means, each byte of which contains a specific number of parallel bits. When the ASCII code is being used for the display of alphanumeric messages the seven bit bytes are recognized as such and the decode characters are displayed on the board. In the picture forming mode the seven bits forming each byte are used to signify the condition of the seven lamps forming a Column on a Line of the board and these codes are hereinafter designated as Lamp Codes. The Lamp Codes are distinguished from display character codes by the presence of a true signal in the eighth bit channel ordinarily used for parity in normally operating devices. Since the present system does not require a parity check, a special input device such as the Lamp Code Keyboard 28 may be provided for forming the eight-bit code. The Lamp Code Keyboard consists of a key (not shown) for each of the seven lamps in a column which will cause a hole to be punched in a tape or a signal to appear in one of the seven bit channels feeding to the Signal Logic representation of each lamp in an addressed column to be lit. An additional punch or signal is provided automatically in the eighth bit position by the device 28 to indicate a lamp code byte rather than an ASCII coded display character data byte.

Therefore, to form the display of the large GO in FIG. 2 the input data first addresses Line 2 and Column 37 by the code *237, this data being insertable preferably, but not necessarily, on a punch tape by the punch tape typewriter 26. The next byte of the input data would be prepared by the operator depressing the keys associated with the lamp rows 3 through 7 for illuminating the bottom five lamps 30-3 through 30-7 in Column 37, Line 2 as shown in FIG. 2. This data byte would also include a true bit in the eighth bit channel to distinguish the code from an ASCII code character such as used in the ad-
dress data. The data for the illumination of the lamps in Column 37 need not be prefaced by the address code as this will be arranged for automatically by the Signal Logic 20. Thus, the next data byte need merely contain a true in bits 2 through 8 to indicate that the lamps in rows 2 through 7 are to be lit. The next byte of information contains a true in bits 2,3 and 8 only and so on, to form the rest of the top half of the letter $G$ and the top half of the letter $O$ appearing on the Line 2 of the display. THe input data for Line 3 immediately fol lows that of Line 2, and the line and first column must again be addressed by the code ${ }^{3337}$. The next byte of Lamp Code signals provided to the Signal Logic after the line and column address would show true in bits 1 through 4 and 8 to indicate that the lamps in the rows 1 through 4 of that column are to be lit, foilowed by a data byte indicating that the lamp rows 1 through 5 in column 38 are to be lit, etc., to form the rest of the bottom half of the display.

It is to be noted that the noncycling mode could also be used to form a display such as the large GO in FIG. 2. In this case the Line address *200 only is used, followed by the Lamp Code data bytes for each column forming the upper half of the letters $G$ and $O$. Since the information is being shifted from the right hand side, an additional number of bytes indicating column spaces has to be entered to position the display at the desired location on the board. This is followed by the address for line 3, and the Lamp Code data bytes to form the bottom half of the letters $G$ and $O$ and the column spaced to properly position this part of the display.

For all displays other than the traveling message type it is possible to read in and position the encoding signals for the total display into the message board circuits before actuating the lamps to give the effect that the whole message is being formed at one time in a copy changer manner. This type of operation is controlled by blanking codes in the input data which may be inserted into the Signal Logic prior to the display data. The blanking code in the exampled system consists of the number sign (*) immediately followed by a line address digit or digits 1 through 7 and an On and Off command code such as $\uparrow$ or $>$. If all seven lines of the board are to be blanked, the line address digit 9 is used following the blanking symbol rather than the code for each of the lines 1 through 7 . Thus, to operate the board in the copy changer manner, the address and display character data is preceded by the blanking command codes $\$ 9>$ code data. The message data is then inserted for the whole message followed by the lamp turn on command code \# $9 \uparrow$ signal. Thus, the Off command data will maintain the lamps deenergized while the following message data is written in. Upon receipt of the On command data thereafter, all of the encoded lamps will light up simultaneously.
The blanking codes may also be used to flash the message On and Off by the input of proper blanking command signals entered onto the punched tape. A series of blanking command Off codes \#9> command and blanking command On codes $\% 9 \uparrow$ codes in alternate order will cause the message to flash on and off in a sequence which is time controlled by the settable timer 29. If only one line is to be flashed on and off the appropriate line number may be addressed after the $\#$ symbol in each code sequence and only that line will turn on and off.
The techniques used for forming the large GO may also be used to form repetitive frames of pictorial displays in the programming of an animated cartoon. An automatic input device such as a programmed punched tape and tape reader, or perhaps a magnetic tape storage, is necessary for such a display because of the repeated fast input of data required. A program is prepared on a punch tape using the blanking codes and address and display character data in the manner described to form each frame. The data frames are read out by the tape reader at a rapid readout rate controlled by the settable timer 29. For example, the settable timer might be set to cause the reader to stop for perhaps a quarter or a half a second after each frame to display each frame for that period of time before going on to the next. The rapidly changing frames then give the illusion of motion in the display to give the animated cartoon effect.

Reference is now made to FIGS. 3 and 4 for a description of the circuits forming the system of this invention which enable the operation as previously described. FIG. 3 shows the circuits making up the Signal Logic for converting the input signals into the lamp encoding signals and for synchronizing the total system. FIG. 4 shows the display board circuits for handling the encoding signals and actuating the lamps in accordance therewith.
The input data signals derived from any one of the input devices 22, 24, 26, 27, 28 (for this description grouped as input means 33) are fed through a Lamp Code Control 32 to a Character Decoder 34. The Lamp Code Control tests to determine whether the signal is ASCII coded data representing a particular alphanumeric character or a Lamp Code to indicate the particular lamps for actuation in an addressed column as required in the universal mode of operation for forming pictorial displays in a manner to be described shortly.
The Character Decoder 36 recognizes whether each data byte represents a special function character such as the Special Address indicator *, the Blanking indicator *, command On $\uparrow$, command Off $>$, or any alphanumeric character. The Decoder operates to provide single conductor signals in a well known manner such as disclosed in the aforementioned Gardberg application and the single conductor signals are then routed to appropriate circuits for further handling as required.
The Character Decoder 36 must initially recognize that the data coming from the input means is a properly formatted program for the display system. This is indicated by the presence of the Special Address character * which is then used to prepare the Signal Logic for acceptance of subsequent data. When the Special Address character ${ }^{*}$ is recognized, the Character Decoder 32 sends a signal to an Address Sequencer 38 which first acts to send out a Clear signal to all appropriate circuits to prepare them for operation. The Address Sequencer 38 includes a four count counter which operates responsive to the receipt of each address character in the manner disclosed in the aforementioned Gardberg application. Thus, the * character causes the Address Sequencer to signal the Line Address Storage circuit 40 on the Stor Line conductor that the next received data byte from the input means represents the number of the particular line 1-7 on which the display is to begin. The Character Decoder 36 then decodes that next data byte and transmits a single conductor signal via the appropriate $\mathbb{1 - 7}$ and Carriage Return conductor to the Line Address Storage 40, representing the addressed line. The signal prepares the Line Address Storage $\mathbf{4 0}$ in an appropriate manner to address the particularly addressed line on the message board by preparing a circuit for transmission of Line Shift signals to the addressed line on the board on the selected one of the Line SFT 1-7 conductors. After the line address is stored the Address Sequencer 38 steps to its next count and sends a store column address enabling signal to a Column Address Counter 42. The next data byte, of course, represents the tens digit of the Column Address and when it appears the number is stored in the Column Address Counter as is the third received number representing the units digit of the Column Address.

The numbers stored in the Column Address counter 42 can now be tested to determine if the display data is to be entered in the noncycling mode or the cycling mode. If one or the other of the received column tens or unit digit data bytes is an ASCII coded digit other than 0 , the Column Address Counter will signal the Cycle Detector 44 that the Signal Logic is to work in the cycling mode. However, if both of these two digits are 0, the Column Address Counter 42 remains at zero and the Cycle Detector indicates noncycling mode.

The Address Sequencer 38 having counted the four data bytes representing the address data then sends a Sequence Address Stored signal on the SQ AS conductor to the Address Stored Control 46. Since the Signal Logic is operating in noncycling mode, The Address Stored control immediately passes an Address Stored signal on its output conductor 48 to partially enable a Strober Start gate 50 in preparation for the handling of the next received data byte from the input means 30 which should be representative of a display character.

The next data input byte from the input means is decoded by the Character Decoder 36 which sends a single conductor signal over the multi-line CHAR. conductor to an Encoder Gate Selector 52. Each one of the lines making up the CHAR. conductor is representative of a display character that the system is capable of displaying. The Encoder Gate Selector 52 may comprise a diode matrix or a series of gates to provide enabling signals to the Encoder Data Gates 34. The Encoder Data Gates are arranged in a display character matrix configuration in accordance with the disclosure of encoder means in the aforementioned Gardberg application and the Andrews patent. Briefly, the gates of this circuit are arranged in a $5 \times 7$ matrix so that individual ones may be properly enabled by the signals from the Encoder Gate Selector 52 to pass lamp encoding signals as the enabled gates are opened by the sequentially received strobe signals received from the Strober 54 on the five conductors LC 1-5. The opened gates thus pass signals in parallel form on the parallel Lamp Row 1-7 conductors in a column-by-column manner to the message board circuits.
As indicated, the signals for strobing the encoding signals out of the Encoder Data Gates 34 are provided by a Lamp Strober 54 which is similar to that disclosed in the aforementioned Andrews et al. patent. The Lamp Strober 54 operates to provide the required number of strobe pulses LC 1-5 to read the encoded signals out of the Encoder Data Gates 34 in accordance with the width of the particular character being sent. It also provides the required number of shift pulses to the message board shift registers 31 to shift the character formed at the right side of the board toward the left as each column is formed.

The Lamp Strober 54 includes a Strobe Counter 56 which is enabled by the Count Enable gate 57 to receive count shift pulses from a continuously counting 3-Count counter 58 actuated by a free-running clock 60 . The Strobe Counter 56 is actuated to provide the strobe pulses LC 1-5 to the Encoder Data gates after the address has been stored as indicated by the previously described AS signal input to the Strober Start gate 50 and a Legit signal. The Legit signal is derived from the Encoder Data Gates 34 and indicates that a proper display character has been received from the input for display on the board. When the Strober Start gate 50 is satisfied it partially enables the Strobe Enabling gate 57. At this time the signal on the EOS conductor is also in condition to satisfy the gate 57 so that the gate is prepared to pass therethrough each count 1 pulse from the 3-Count counter 58 to the trigger input of the Strobe Counter 56. The Strobe Counter causes each of the Count 1 through Count 6 gates to produce a time sequenced pulse at its respective output to the Encoder Data Gates to strobe the lamp encoding signals therefrom.
In addition, shift pulses for shifting the encoding signals through the message board shift registers are also produced by the Strobe circuit 54. The shift pulses are derived from the free-running counter 58 and are controlled by a Shift gate 62 which passes the count 2 pulses as long as the Strobe Counter 56 is in a not zero condition. The pulses from the Shift gate 62 are sent via the STR SFT conductor to the Line Address Storage circuit 40 which applies them to the particular Line Shift conductor 1 through 7 previously selected by the line address data provided. The number of strobe pulses and shift pulses provided by the Strobe Counter 56 is dependent upon the number of columns required to form the particular display character to be displayed. This is determined by a character width circuit 64 which receives column width information from the Encoder Gate Selector 52 and gates it with the appropriate count signals CT 1 through CT 6 from the Count 1 through Count 6 gates. When the proper number of strobe and shift pulses have been transmitted the Character Width circuit 64 sends out an End of Strobe signal on the EOS conductor. The EOS signal closes the Strobe Counter Enabling gate 57 to stop the Strobe Counter 56 from producing strobe pulses, and it also closes the Shift gate 52 to stop the transmission of shift pulses to the message board. As an example, if the character 5 to be formed is a four column character such as the letter $\mathbf{P}$
(FIG. 1) the EOS signal is sent after five strobe pulses and shift pulses are produced to encode the four columns forming the character and the one column space thereafter. If a onecolumn character such as the letter " $I$ " is to be encoded, two strobe pulses and shift pulses are sent-one for the formation of the character and the other from the subsequent column space.

The End of Strobe signal on the EOS conductor remains until the displayed character data is shifted out from the input means in preparation for the next character data. As the character data is shifted, the Legit signal from the Encoder Data Gate 34 is at least momentarily lost which disables the Start gate 50. The false output from the Start gate causes the Strobe Counter 56 to reset to zero. When the Counter 56 is reset to zero the character circuit discontinues the EOS signal. When the next display character data byte is received and causes a Legit signal to be sent to the Enabling Gate 57, the Strober 54 is again actuated for the readout of the new character.

The Signal Logic operates in much the same manner when the data input bytes represent Lamp Code data for forming pictorial displays. After the address data has been read in and stored the succeeding Lamp Code data hytes are detected by Lamp Control circuit 32 by the presence of a true signal in the bit 8 channel. The signals in the bit 1 through 7 channels are then sent directly to the Encoder Data Gates 34 over the L.Code 1-7 conductors. The Character Decoder 36 and the Encoder Gate Selector 52 are bypassed by the Lamp Code Signals since the true bits thereof already represent the encoding signals for the lamps to be lit.
The Lamp Code Signals are applied to the Encoder Data Gates which produces a Legit signal for starting the Strobe Counter 56. Since each Lamp Code data byte is applicable to one column of lamps on the board with no spacing therebetween, only one strobe pulse and one shift pulse is required. The Character Width circuit 64 is therefore signalled by each Lamp Code Data byte recognized by the Lamp Code Control over the L.CD Col WD conductor that the End of Strobe signal should be sent after one strobe pulse and shift pulse are generated. Each following Lamp Code data byte actuates the strober in the same manner to cause the column-by-column formation of each Line of the board.

The Lamp Row 1-7 signals and the Line Shift 1-7 signals from the Signal Logic of FIG. 3 are sent to the message board control circuit as shown in FIG. 4 over the appropriate multiline conductors. There they are received by board receive circuits 66 and distributed for operating the shift registers 31 associated with the rows of lamps forming the Lines $1-7$ on the message board. The encoding signals on the Lamp Row $1-7$ conductors are distributed through input gates 68 to the input stages of each of the shift registers 31 in the message board circuit as long as the system is operating in the noncycling manner as indicated by the absence of a signal from the Signal Logic on the CYCL conductor feeding each of the input gates 68 . However, the encoding signals will be entered only into those shift registers 31 associated with the particular Line 1-7 addressed by the input data. This is because the Line Address Storage 40 in the Signal Logic controls the routing of shift pulses onto the Line SFT 1-7 conductor designated by the Line Address data. The Line Shift signals are sent to a Shift Pulse circuit 70 which distributes them to the shift registers of the addressed line on the appropriate L.SFT 1-7 conductor.

When the system is operating in the noncycling mode, it will be recalled that a shift pulse is generated for each column of the display character being formed plus one for the column space between characters. Thus, the encoded signals are shifted from stage to stage responsive to the shift pulses as they appear in column-by-column sequence at the input to the shift registers. It will be noted in FIG. 4 that the encoding signals are read in to the shift register stages designated column 60 and are shifted therethrough to the shift register stages designated column 1. The reason for this seemingly
backward designation will become more apparent when the cycling mode of operation and the circuits therefor are discussed.

The presence of encoding signals in the shift register stages prepare circuits for actuating the light bulbs 17 associated with the stages. The actuation of the associated lamps is controlled however by the receipt of a Lamp signal applied through an appropriate LMP 1-7 conductor from a Lamp Control circuit 72. The Lamp Control circuit operates responsive to the Shift signals on the addressed Line shift $1-7$ conductor.

The operation of the message board circuits will be better understood from the following description with respect to the diagram of FIG. 5 which shows one lamp drive circuit 74 for a single lamp 17. The lamp is located at column 60 in row 1 of line 1 on the message board and is therefore connected to the appropriate shift register stage in that column and row of Line 1. As may be seen the Lamp Drive circuit 74 comprises a first NPN transistor 76 having its base connected to the LMP 1 conductor from the Lamp Control circuit 72, its emitter connected to ground and its collector connected through resistors 78 and 80 to positive voltage. The base input for a second PNP transistor 82 is taken from the junction between resistors 78 and 80 , transistor 82 having its emitter connected through resistor 84 to positive voltage and its collector connected through lamp bulb 17 to ground. The Lamp Drive circuit 74 therefore operates to illuminate lamp 17 wherever positive voltage appears at the base of transistor 76 causing it to conduct. THe positive voltage at the base of transistor 76, it may be seen, is dependent not only on the LMP 1 output of the Lamp Control circuit 72, but also the condition of the true output of the column 60 flip-flop of the Line 1 -Row 1 shift register. Thus, the lamp 17 for that stage will be illuminated by the following action.

It is assumed a true Lamp Encoding signal appears on the LR-1 conductor to the input of a NOR-gate 86 forming a part of the shift register input gate 68. The output therefrom is applied directly to the set input of the column 60 flip-flop and in inverted form to the reset input. A Shift pulse on the L.SFT 1 conductor connected to the trigger input of each of the shift register flip-flops then sets the column 60 flip-flop in accordance with the true set input signal. The true output of the flip-flop goes high. thus preparing the base circuit of the drive circuit transistor 76. However, the LMP 1 line is kept low during the Shift pulse by means of the L.SFT 1 conductor input to NOR-gate 38 forming a part of the Lamp Control circuit 72. When the Shift pulse is completed the LMP 1 output goes high causing transistors 76 and 82 to conduct to energize the lamp 17. A Lamp Drive circuit 74 is associated with each lamp and each stage of each shift register in the message board circuit so that as the encoding signals are shifted from stage to stage the respective lamps are lit after the passage of the Shift pulse. When this occurs the message is being displayed in a traveling message form.

As may be seen in FIG. 5, there is a second input to the Lamp Control NOR-gate 88 designated Blank 1. This input is used to control the simultaneous actuation and deactuation of all encoded lamps responsive to input data from the input means such as when the display is operating in a copy changer mode. Thus, Blanking commands for one or more lines may be programmed into the input data and the illumination of the encoded lamps is controlled by the Blanking signals provided to the respective Lamp Control circuits 72. As previously in dicated the Line Blanking function is recognized by the presence of a number sign \# in the input data. The Line Blanking circuit 90 (FIG. 3) receives a signal when the \#character is decoded by the character decoder 36 and, dependent upon the immediately following data, sets up Blanking signals for the lines indicated on the appropriate Blank 1-7 conductors.

Thus, if all encoded lamps on a particular line are to be turned off the program data including the address data and the Command Off signal > will cause the line blanking circuit 90 to provide a high signal on the appropriate Blank 1-7 conduc-
tor to the Lamp Control NOR-gate $\mathbf{8 8}$ for that selected line. A high input thereto will provide a low on the LMP 1 conductor to all of the Lamp Drive circuits 74 for that Line and prevent the illumination of the encoded lamps as long as the blanking signal is present. Thus, data may be read into the shift registers or shifted around and it will have no effect on the lamps. Not until the Blanking signal is removed by the later receipt of Command On data will the inputs to the encoded Lamp Drive circuits go high to illuminate the associated lamps.
The circuits as so far described cover the noncycling mode of operation in which the information is read in from the righthand side of the message board and moved along to the left in response to, and as demanded by, the insertion of each display character and space data to position the display characters as desired. As previously indicated, this mode can be used for a copy changer type display of information or traveling message type of operation. Pictorial representations and animated cartoons can also be displayed in the noncycling mode but in view of difficulties in the preparation of the input data, it is preferable to use the cycling mode by which one or more of the display characters may be read into any desired Line and Column locator on the board. The cycling mode can be used to display messages in the copy changer manner rf operation (but not traveling message type) and also may be used to change one or more display characters located anywhere on the message board without having to reprogram other display characters.
The recycling mode of operation is recognizable in the input data by the presence of a specific column address in the address data. That is, if the second and/or third digit following the special address code * represents a digit other than zero, which digits are stored in the Column Address Counter in binary coded decimal form, the Cycle Detector 34 establishes that the cycling mode is being used, and since it comprises a flip-flop it changes to its set state. The set signal from the Cycle Detector flip-flop 44 is sent to the Cycle Control flipflop 90 which sets and provides a Cycle Address Stored signal on the CYAS line to the Address Stored Control circuit 46. The CYAS signal prevents the passage of an Address Stored signal to Start gate 50 responsive to the SQAS signal until the Control flip-flop 90 is later reset. The Control flip-flop 90 also establishes a cycling signal over the CYCL conductor to partially enable a Cycle Shift gate 92 for the passage of Cycle Shift pulses derived from the free-running clock 60 as well as signal the clock to operate at a faster rate. A cycling signal is also sent through the CYCL conductor to the message board control circuit (FIGS. 4 and 5) where it is used to partially enable AND-gates 93 (FIG. 5) associated with each shift register 31. The AND-gate 93 closes a cycle loop 91 enabling encoding signals to be shifted out of the last stage of each shift register and back into the first stage thereof without being lost upon receipt of Line Shift pulses. The Line Shift pulses are derived from the output of the cycle shift gate 92 and are passed through the Line Address Storage 40 to the board on the Line Shift 1-7 conductor previously addressed. The line Shift pulses thus cause the encoding signals to cycle through the shift registers whenever the Control flip-flop 90 is in its set condition. At the same time as the cycle shift pulses are causing the data to circulate through the shift registers they are also sent to a 60 -Count Cycle Counter 94 causing it to start counting. It -Count until it reaches the number stored in the Column Address Counter 42 fed by the input address data, at which point a compare circuit 96 causes a Compare flip-flop 98 to switch to its set condition to provide a signal on the Compare conductor.
The Compare signal resets the Control flip-flop 90 to ready the circuits for read in of the display character encoding signals. The reset of Control flip-flop 90 closes the Cycle Shift Gate 92 to stop the Cycle Counter 94 and stop the circulating of the encoding signals in the shift registers. The Cycle Address Stored signal CYAS goes true to cause the Address Stored Control 46 to send the Address Stored signal over the AS conductor to the Strober Start gate 50 to partially enable same. The next following display character in the input data
and presented to the Signal Logic is decoded by the decoder circuit 36 and encoded into encoding signals. A Legit signal is sent from the Encoder Data Gates 34 to the Start gate 50 to signal the Enabling gate 57 to open and start the operation of the Strober circuit 54. The Strober then reads out the encoding signals for the display character to the message board replacing in a column-by-column manner whatever encoding signals are present in the shift register at the addressed column stages. The cycle loop for the shift registers is, of course, opened up when the new data is being strobed in because of the absence of the Cycling signal on the CYCL conductor to the AND-gate 93 (FIG. 5). During the time that the display character encoding signals are being strobed out to the message board the Cycle Counter 94 and the Column Address Counter 42 are advanced the number of counts required to strobe out the particular display character encoding signals by means of strobe shift pulses on the STR SFT conductor to an Advance Count gate 100. The Cycle counter 94 is advanced this number of counts to facilitate the return of the encoding signals back to the proper stages of the message board shift. The Column Address Counter 42 is advanced this number of counts so that the position for the next following character will be automatically addressed for inserting a new character thereat without providing further address information as will be seen shortly.

When the Strober circuit 54 completes its encoding signal read in function, the encoding signals in the shift registers must again be shifted to bring them back to their proper column location since the new encoding signals have been read into the rightmost stages of the shift register. They must therefore be shifted a number of stages to return the signal for the first column of the character to the column originally addressed. Thus, the End Of Strobe signal provided by the character Width circuit 64 at the completion of the encoding signal strobing causes the Compare flip-flop 98 to reset which in turn causes the Control flip-flop 90 to again assume its set condition by means of the not true signal on the Compare conductor. The Strober 54 is again disabled by the CYAS signal which causes the Address Storage Control to remove the Address Stored signal. The Cycle Shift gate is again opened to permit the Shift pulses to pass therethrough to the Cycle Counter and out to the message board shift registers. The Cycling signal on the CYCL line again closes the recirculation loop 91 of the shift registers so that the signals therein can continue to be circulated without signal loss as the Cycle Counter 94 continues its count.

When the Cycle Counter count reaches 60 , which is equal to the number of stages in the shift register, a reset pulse is sent therefrom to the Control flip-flop 90, which when it resets, again closes the Cycle Shift gate and stops the cycling operation with all of the encoding signals in the shift registers returned to their previous shift register stages. The Cycle Counter 94 restores to its count zero condition automatically and the Signal Logic is ready for the next received display character data for cycling input to the board.

If another character is to be inserted immediately after the one just entered, a Display Character code may be fed in from the input means as the Column Address Counter $\mathbf{4 2}$ had been stepped to the new address when the previous character was inserted. The Cycle Detector flip-flop 44 is still in its set stage and it is not reset until a Clear signal is received responsive to new address data from the input means. Thus, a complete line of display characters may be inserted by the cycling mode of operation at the properly centered board location without adding additional spacing at the end. Also, a single character, or even a single column, can be changed by the cycling made without disturbing previously programmed displays on the board.

The display system of this invention is capable of showing a series of programmed displays which automatically change one after the other, at a controlled rate of change. The display changes and the change rate are controlled by Timer 29 which is settable by the operator to determine the time each display
is shown. It operates to disable the input means 33 such as the Punch Tape reader 24, for the set length of time whenever an Input Stop Code + appears in the input data. After the set time the input means steps to the next data character in the program and the system continues on in the normal manner until another Stop code is detected or the programmed data is completed.

It may thus be seen that this system may be operated to show a series of messages such as advertising displays changed every thirty seconds or so, or show an animated cartoon with the pictorial display frames changed every half of a second or so. This is all controlled automatically by the programmed input which includes the proper sequence of Blanking Codes, Address data, Display Character or Lamp Code data, and Timer control data.

For example, the input data for a display frame such as the large GO in FIG. 2 would appear in the program as follows:
\#9> *236 Lamp Code Data *336 Lamp Code Data \#9 $\uparrow+$. The $\# 9>$ codes would indicate to the Blanking circuits that the succeeding data for all Lines of the board is to read through the Signal Logic and into the shift registers without turning on the board lamps. The Address data *236 causes the following Lamp Code display data to be read in cycling mode to the shift registers starting at Column 36 of Line 2. The data ${ }^{* 336}$ causes the read in of the Line 3 data. The board lamps do not light until the Blanking Command ON data $\# 91$ is received which simultaneously turns on the lamps for all encoded stages of the shift registers. The + symbol then indicates to the Timer that the input means is to be disabled for the preset time before reading in further display data. The next frame would thus contain the appropriate Blanking. Address and Display data for changing the display as required by the animated effect. The + symbol would again be used for time delaying the next data input.

It is to be recognized that the symbols used in the descripfion are merely exemplary and others could well be used. The particular symbols shown herein are all included on a standard punch tape typewriter such as is marketed by Teletype Corporation, Niles, Ill.

While there has been shown herein a preferred embodiment of the system embodying the teachings of this invention, it is to be understood that many additions and modifications may be made thereto without materially deviating from this invention. It is therefore intended to be bound only by the scope of the appended claims;

What is claimed is:

1. A display system comprising a display board comprising a matrix of display elements arranged in equispaced parallel vertical columns locatable by sequential numerical column addresses and parallel horizontal rows to form a solid matrix of said display elements; a shift register associated with each row of display elements, each of said shift registers having a storage stage sequentially corresponding to a display element in its associated row and an input; means providing input data corresponding to desired display characters and the particular column address of elements at which the first display character is to start; means for controlling the display, said controlling means comprising means for converting said display character data into column-by-column display character encoded signals, means for sequentially entering said encoded column-by-column signals into the input of said shift registers, for shifting said encoded signals from stage to stage, and for stopping said shifting when the first display character encoded signals reach the shift register stage associated with the display element at said particular column address indicated by said input data; means for actuating the display elements corresponding to the shift register stages having encoded signals therein; said entering, shifting and stopping means comprising a column location counter settable by said input data to said particular column address, a cycle counter, means responsive to the setting of said column location counter for causing said shift register to shift and said cycle counter to count simultaneously to said particular column address number, means
responsive to said cycle counter reaching said column address number for sequentially entering said column-by-column display character encoded signal into said shift register and simultaneously advancing the count of said cycle counter, means responsive to the completion of entering said encoded signals for causing said shift register to continue to shift and said cycle counter to advance the count, and means for stopping said shifting and said counting when the count of said cycle counter reaches the number of stages in each of said shift registers; and each of said shift registers comprising a cycling loop connectable to pass data from the last stage thereof to the input thereof; and wherein said entering, shifting and stopping means comprises means responsive to the setting of said column location counter for connecting said cycling loop.
2. In the system of claim 1 wherein said entering, shifting and stopping means comprises means for advancing the count of said column location counter simultaneously with the entering of said encoded signals into said shift registers, whereby said column location counter is automatically set to the address number for the next following display character after the operation of said stopping means.
3. In the system of claim 1 wherein said display actuating means comprises means responsive to special input data for operating the encoded display elements only after the operation of said shifting and stopping means.
4. A display system comprising a display board having a plurality of display lines locatable by line addresses, each of said display lines comprising a matrix of display elements arranged frequispaced parallel vertical columns locatable by sequential numerical column addresses and parallel horizontal rows to form a solid matrix of said display elements, a shift register associated with each row of display elements; each of said shift registers having a storage stage sequentially corresponding to a display element in its associated row and an input; means for providing input data corresponding to desired display characters, the address of the desired line on which said display characters are to appear and the particular column address of elements at which the first display character is to start; means for controlling the display, said controlling means comprising means for selecting the shift registers associated with the desired display line in accordance with said desired display line address data, means for converting said display character data into column-by-column display character encoded signals, means for sequentially entering said encoded column-by-column signals into the input of said selected line shift registers, for shifting said encoded signals from stage to stage, and for stopping said shifting when the first display character encoded signals reach the shift register stages associated with the display elements at said particular column address indicated by said input data; means for actuating the display elements corresponding to the shift register stops having encoded signals therein; said entering, shifting and stopping means comprising a column location counter settable by said input data to said particular column address, a cycle counter, means responsive to the setting of said column location counter for causing said shift register to shift and said cycle counter to count simultaneously to said particular column address number, means responsive to said cycle counter reaching said column address number for sequentially entering said column-by-column display character encoded signal into said shift register and simultaneously advancing the count of said cycle counter, means responsive to the completion of entering said encoded signals for causing said shift register to continue to shift and said cycle counter to advance the count, and means for stopping said shifting and said counting when the count of said cycle counter reaches the number of stages in each of said shift registers; and each of said shift registers comprising a cycling loop connectable to pass data from the last stage thereof to the input thereof; and wherein said entering, stopping means comprises means responsive to the setting of setting column location counter for connecting said cycling loop.
5. In the system of claim 4 wherein said entering, shifting and stopping means comprises means for advancing the count of said column location counter simultaneously with the entering of said encoded signals into said shift registers, whereby said column location counter is automatically set to the address number for the next following display character after the operation of said stopping means.
6. In the system of claim 4 wherein said display actuating means comprises means responsive to special input data for operating the encoded display elements only after the operation of said shifting and stopping means.
7. In the system of claim 1 wherein said input means com-
prises means for manually preparing said encoded signals and wherein said controlling means comprises means for recognizing said manually prepared encoded signals and disabling said data converting means, whereby any display element on said display board may be individually controlled when desired.
8. In the system of claim 4 wherein said input means comprises means for manually preparing said encoded signals, and wherein said controlling means comprises means for recognizing said manually prepared encoded signals and disabling said 10 data converting means, whereby any display element on said display board may be individually controlled when desired.

*     *         *             *                 * 


## UNITED STATES PATENT OFFICE CERTIFICATE OF CORRECTION

Patent No. $\qquad$ Dated $\qquad$ January 25. 1972

Inventor (s) Robert A. Payne

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 14, line 72, after "entering," insert - - shifting and -- ; line 74 , change "setting" to -- said -- .

Signed and sealed this 17 th day of October 1972.
(SEAL)
Attest:

EDWARD M.FLETCHER,JR. Attesting Officer

ROBERT GOTTSCHALK Commissoner of Patents

