

United States

Stein

[11] 3,824,604

[45] July 16, 1974

[54] ALPHANUMERIC PRINTING SYSTEM
EMPLOYING LIQUID CRYSTAL MATRIX3,693,517 9/1972 Clark 95/4.5 R
3,716,290 2/1973 Borel et al. 350/160 LC[76] Inventor: Edward I. Stein, 8521 N. Lotus
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[21] Appl. No.: 297,011

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& Kurz

[52] U.S. Cl. 354/5, 350/160 LC, 355/40

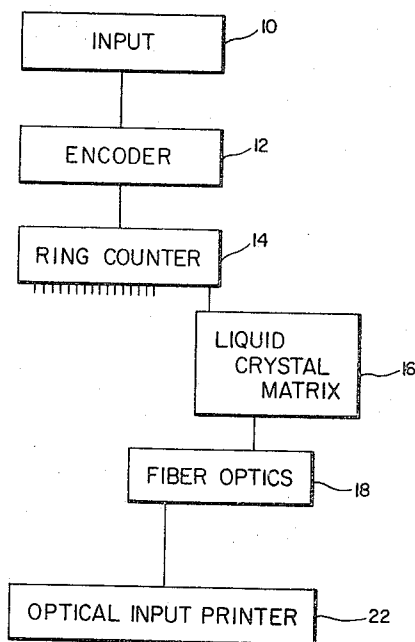
[51] Int. Cl. B41b 13/00, B41b 15/00, B41b 17/00

[58] Field of Search 355/40; 95/4.5;
350/160 LC

[57] ABSTRACT

A completely solid state printing system having a key-
board or computer input, a bit encoder or data trans-
lator, a matrix switching system, a liquid crystal matrix
to optically form the characters to be printed, a fiber
optics translator, and a xerographic printing machine
to reproduce the character impressions received from
the fiber optics translator.[56] References Cited
UNITED STATES PATENTS3,499,112 3/1970 Heilmeyer et al. 350/160 LC
3,626,830 12/1971 Sobottka et al. 95/4.5 R

15 Claims, 6 Drawing Figures



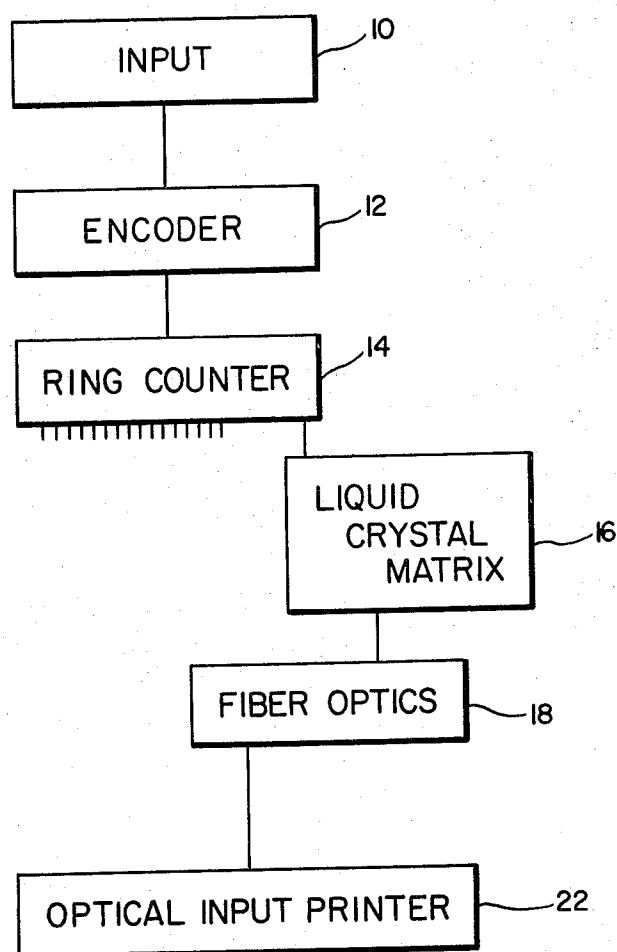


FIG. 1

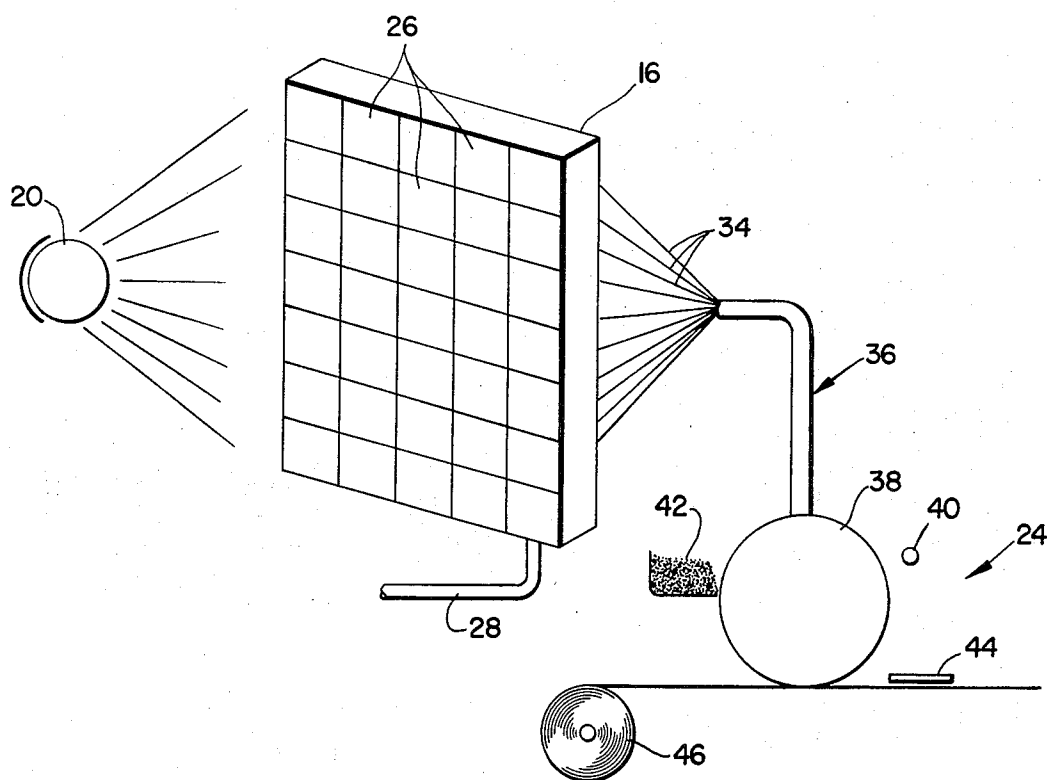


FIG. 2

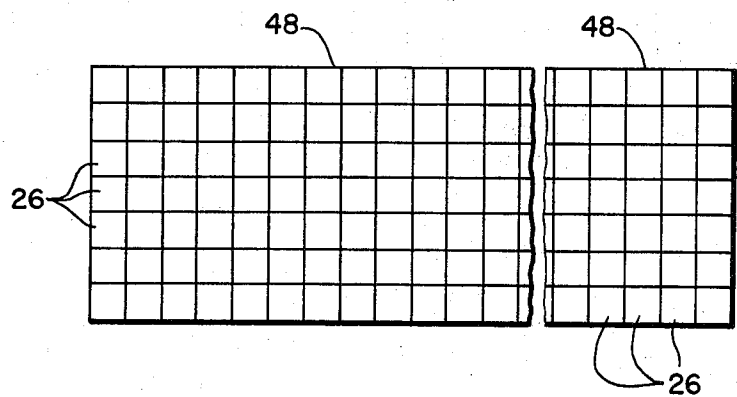


FIG. 3

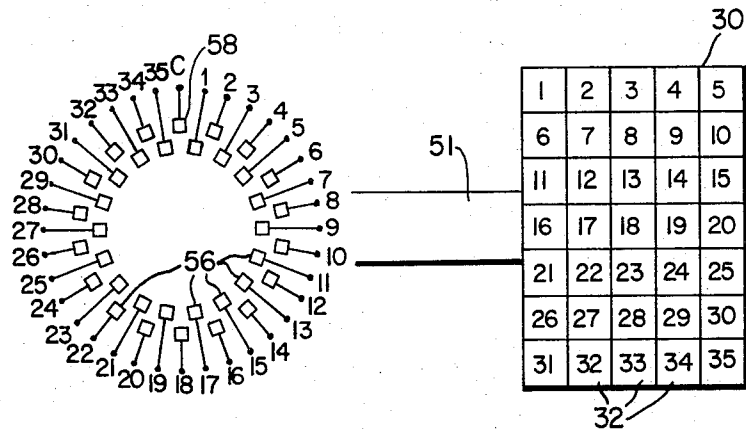


FIG. 4

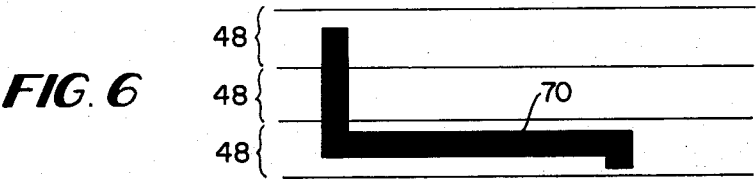


FIG. 6

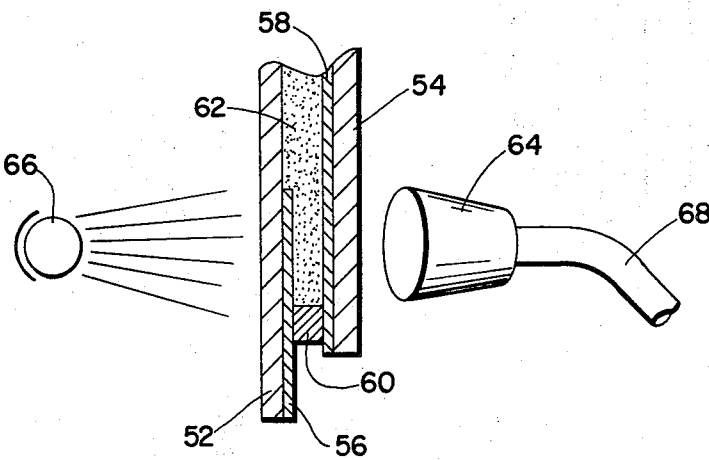


FIG. 5

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ALPHANUMERIC PRINTING SYSTEM EMPLOYING LIQUID CRYSTAL MATRIX

BACKGROUND OF THE INVENTION

A basic solid state printing system employing a memory bank output, matrix encoding means alphanumeric character forming means, and a printout means operable from the alphanumeric character forming means is not a new concept. Multiple attempts have been made to produce a satisfactory and highly reliable system. A major difficulty in the art has been to completely minimize and even eliminate all mechanical moving parts in such a system. Heretofore, this has not been possible.

The general system under discussion is clearly disclosed in three prior U.S. pats. Nos. 3,217,640 issued to Bradshaw; 3,354,817 issued to Sakurai et al. and 3,453,648, issued to Stegenga. In each case, however, mechanics enter in along the the system imparting unreliability of performance. An easily recognized example of this is found in the disclosure of the U.S. pat. No. 2,632,386 to Hyland, wherein a wire type print machine uses alphanumeric character blocks as the actual print means, each block having 35 extensible print bits to form the individual character. If one or more bits jam in high speed operation, which they invariably will, then the entire printing system is imperfect.

In major contradistinction to prior art systems and processes, the present invention calls for an optical character matrix system to optically form the characters and convey the same to optical input printing means, such as a xerographic machine.

SUMMARY OF THE INVENTION

It is the primary object of the invention to provide an alphanumeric character printing system having a light-optical character forming and conveying means to the printing means.

It is another object of the invention to provide such a printing system with a liquid crystal matrix to form an individual, light-optically readable character.

Yet another object of the invention is to provide such a printing system with a liquid crystal matrix to form one or more lines of light-optically read characters for differential character spacing resulting in even line printout.

A further object of the invention is to provide such a printing system with a two-stage alphanumeric character forming matrix, using a circular easily formed etched surface electrode to translate data into optically readable bits and a fiber optics system to convey the readable bits to an alphanumeric character display board.

A still further object of the invention is to provide such a printing system with either a steady or intermittently actuated light source to convey the formed alphanumeric character from the character display to the optical input printing means.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Preferred structural embodiments of this invention

are disclosed in the accompanying drawings in which:

FIG. 1 is a block diagram outlining the entire printing system and process;

FIG. 2 is a diagrammatic view of one embodiment of the alphanumeric character forming means, employing a liquid crystal matrix for each character;

FIG. 3 is a partial plan view showing a line matrix instead of the single character matrix of FIG. 2;

FIG. 4 is a view similar to FIG. 2 but showing a two-stage alphanumeric character forming system employing a circular liquid crystal matrix;

FIG. 5 is a partial sectional view of the liquid crystal matrix illustrated in FIG. 4; and

FIG. 6 is a partial plan view showing a multiple adjacent line matrix for forming graphic images.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The schematic block diagram of FIG. 1 clearly illustrates the entire printing system of the instant invention. Input 10 may be either a keyboard or computer input for translating the data which is to eventually be retranslated and printed. In easily understood language, input 10 is a properly programmed computer which in and of itself forms no part of the instant invention. Data from input 10 is then conveyed to a matrix bit encoder 12 which performs its usual function of transforming raw input data into proper sequence to be eventually fed to the alphanumeric character forming means and printout. Next, a ring counter 14 may be used to switch from alphanumeric character matrix to alphanumeric character matrix (e.g., FIG. 2) or, in another embodiment, the bit encoder 12 may be arranged to program an entire alphanumeric character matrix line (FIG. 3) for more acceptable, differential character spacing for even line printout.

Liquid crystal matrix 16 forms characters via a common electrode and multiple input electrodes which change each liquid crystal input bit from opaque to clear to form a complete character, as will be further explained below. Alternatively, the specific liquid crystal used may turn from clear to opaque when receiving an impulse; both types of liquid crystals are currently commercially available. Through fiber optics 18 arranged to one side of the matrix 16 and a steady or intermittent light source 20 on the other (FIG. 2) the alphanumeric character is conveyed to an optical input printer 22 which, in a preferred embodiment, comprises a xerographic machine 24 (FIG. 2).

As shown in FIG. 2 and at the right side of FIG. 4, the liquid crystal matrix 16 comprises an alphanumeric character block comprising seven rows of five liquid crystal bits each, or a total of 35 data input, binary ("off-on") bits 26 to form the desired alphanumeric character. This arrangement of bits to comprise an alphanumeric character display is classic, described in the prior art discussed above, and is clearly shown in the Hyland U.S. pat., No. 2,632,386.

As hereinbefore set forth, computer 10, encoder 12 and ring counter or matrix switcher 14 operate in the usual manner; a bundle of 35 input lines 28 electronically conveys the translated input data to the liquid crystal matrix 16, one input line being provided for each liquid crystal bit 26 (FIG. 2). By way of example, suppose it was desired to display the letter "I" on the single matrix 26. Such a single matrix is also shown in

FIG. 4, numbered 30. Each bit 32 of matrix 30 is numbered left to right by successive rows from 1 to 35. To form the letter "I," the bits 32 numbered 2, 4, 32, 34, and the central vertical column numbered 3, 8, 13, 18, 23, 28 and 33 would be activated to display the letter "I." Similarly in FIG. 2, the central vertical column of bits 26 would be charged along with the bits to either side of the vertical column at top and bottom to display the letter "I."

Unlike prior art devices, display and transfer of alphanumeric characters on the matrix 16 and transfer of the characters to printout means is entirely optico-electronically actuated to completely eliminate any need for mechanical devices and thus impart a high degree of stability and reliability to the entire printing system.

Specifically, each alphanumeric bit 26 comprises a liquid crystal, a cholesteric compound having significant electrooptical properties. These cholesteric compounds are marketed by Eastman Kodak Company of Rochester, New York, and are described and listed in detail in Eastman's Liquid Crystals Kodak Publication No. JJ-14. The compounds are of smectic and nematic varieties, the nematic one being the type possessing electro-optical properties.

By way of background, liquid crystals are incomplete or semicrystalline structures having two distinct mesomorphic states, the first being nematic, wherein the orientation of molecules or atoms making up the crystal are arranged in parallel lines but not uniformly layered, and the second state being smectic, wherein the orientation of molecules or atoms making up the crystal are oriented in parallel planes or layers. The present invention is concerned with the utilization of nematic cholesteric compounds of the type disclosed in the hereinbefore identified Eastman Kodak publication.

One suitable cholesteric liquid crystal for use in the present invention is Eastman Kodak's No. 11643 nematic mixture having the following enumerated properties:

Temperature Range: 15°-97°C.
Rise Time: 10 milliseconds
Decay Time: 350 milliseconds
Response Time: 8 milliseconds
Resistivity: 6.67×10^9 Ohm-cm.
Threshold Voltage: 4 Volts
Optimum Voltage: 40 D.C.; 50-60 A.C.
Contrast Ratio: 100 to 1
Transmittance, Clear State: 78 percent
Transmittance, Saturated State: 0.1%
Excitation Source: 200 volts, peak to peak
Measurements Made: 0.5×0.5 cm. cell nesa coated glass with a 0.5 mil. teflon spacer, in excess of 5,000 continuous A.C. hours.

This specific compound is quite suitable for the present invention particularly for its clear (uncharged) to opaque (charged) light transmission characteristics set forth above. Of course, the particular liquid crystal used could be of the opposite charged variety, or clear when charged, turning opaque when uncharged. In the present embodiment, the clear (uncharged) to opaque (charged) variety is desirable so that transfer directly to xerography printout means may be used without need of white-on-black light reversal. Additionally, it is rather easy within the present state of the art of liquid crystals to reduce the decay time from 350 milliseconds

as in the above compound to 50 milliseconds or less, for even higher speed operations.

Returning now to a further discussion of FIG. 2, specific alphanumeric liquid crystal bits 26 are electrically charged to form the individual character programmed and received from bundle 28. A steady or intermittent light source 20 shines through matrix 16, properly charged to form the letter "I" for example as hereinbefore set forth, so that individual strands 34 of a fiber optics bundle 36 collect the image rearwardly of matrix 16. Of course, in this case, there are 35 fiber optic lines 34 provided, one for each liquid crystal bit 26. Although bundle 36 is identified as a fiber optics bundle, obviously it could be a projection lens to easily serve the purpose of conveying the character image to be printed to the xerographic printer 24. In any event, the formed character is optically conveyed to the selenium drum 38 of the xerographic printer, which is plus charged in the usual manner as indicated. Other standard components shown of the xerographic printer 24 include a charging potential 40, printing resin pickup tray and contents 42, heater 44, and a paper supply roll 46 conveying an endless printing paper supply beneath drum 38 for printout of the electro-optically conveyed character.

The immediately preceding discussion concerned the entire process of image forming, conveying and printing of but a single character; obviously, an entire line of such individual alphanumeric characters will be sequentially activated from the ring counter 14 in order to print a complete line, in the present embodiment. Once a complete line has been projected, the selenium drum 38 is advanced by a signal from the input 10 to prepare drum 38 to receive another line of characters. Alternatively, the drum could also be advanced at a predetermined rate, with transmission of a signal at the time of each advance to input 10 to activate display of the next character line in the matrices 16.

Instead of a row of individual liquid crystal matrices 16 being used to form each character individually, matrix 16 may be in the form of a single complete line matrix 48, as partially shown in FIG. 3, comprising any desired number of vertical columns of seven liquid crystal bits 26 each, so that differential spacing of alphanumeric characters to form even line printout may be accomplished. Thus, the matrix switching unit 14 will be arranged to program an entire alphanumeric liquid crystal matrix line 48 with all characters in the line displayed simultaneously, rather than sequentially as in the case of an individual alphanumeric matrix 16. Similarly, several lines 48 may be provided to be actuated simultaneously to even further speed up the printout process.

The precise shape of each alphanumeric bit 26 or 32 is not crucial; the individual bit may be square as shown, circular or bar shaped, all three varieties being popular in alphanumeric character displays.

Turning now to FIGS. 4 and 5, another embodiment of the invention is illustrated wherein each alphanumeric character is formed in two stages, using a circular liquid crystal matrix 50 as a primary data receptor from the switching matrix or ring counter 14, and a secondary, alphanumeric character display or block 30 which is optically energized by suitable light conveying means from circular matrix 50, means 51 preferably being an optical fiber bundle comprising 35 strands keyed by numbers, as illustrated from circular matrix

50 to alphanumeric character block 30. The structure of circular liquid crystal matrix 50 is best illustrated in the partial cross-section view of FIG. 5. Matrix 50 comprises glass plates 52 and 54 having facing transparent electrodes 56 and 58 coated thereon respectively in a known manner. In this case, the common electrode will be 58, coating the entire surface of glass plate 54, and indicated as "C" in FIG. 4, while the individual transparent electrodes for each of the alphanumeric bits is formed on glass plate 52, by etching away electrode material to form the contacts 56 as shown in FIGS. 4 and 5. An insulated gasket spacer 60 separates common electrode 58 and each individual electrode 56 while the cholesteric nematic liquid crystal is located therebetween at 62. A lens 64 receives light or no light through crystal 62 from light source 66 and conveys the optical impulse received to a strand 68 of fiber optics bundle 51. Thus alphanumeric block 30 receives optical impulses which are displayed on the face thereof and transmitted to final printout in the same manner as shown in FIG. 2 and described above. In this embodiment then, block 30 is essentially a transparent view block rather than a liquid crystal matrix as in the embodiment of FIG. 2. The reason for forming the matrix in the manner shown in FIG. 4 is for cost savings, since each circular liquid crystal matrix 50 can be rapidly and inexpensively formed by well-known processes. The excitation of each crystal in matrix 50 is as before; an impulse is received in one or more electrodes 56 to turn crystal 62 from clear to opaque (or opaque to clear) in order to form the desired character by optical transmission to block 30.

As set forth above, several simultaneously actuated line matrices 48 may be provided to speed up the printout process. Additionally, as shown in FIG. 6, several lines 48 may be formed adjacent one another to display any graphic design desired, such as indicated at 70, by excitation of the appropriate liquid crystals in each line.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. A solid state electro-optical printing system for composing and printing an infinite variety of characters and/or designs comprising memory bank output means for outputting bit data to be translated and subsequently printed in preselected character and/or design format, matrix bit encoding means fed from said memory bank output means, matrix switching means operable by said bit encoding means, non-mechanical electro-optical graphic character display means for displaying said preselected character and/or design format, activated periodically from said bit encoding means, optical image transfer means associated in fixed, immovable relationship with said graphic character display means, said electro-optical display means functioning solely as a light shutter with said optical image transfer means to form and convey by said latter means said

preselected character and/or design format, and optical input printing means for printing images received from said optical image transfer means.

2. The invention as recited in claim 1 wherein said electro-optical graphic character display means comprise a plurality of graphic character image blocks, each block comprising a plurality of electrically actuated liquid crystals, each liquid crystal being selectively activated from said bit encoding means.

3. The invention as recited in claim 2 wherein said electro-optical graphic character display means comprise means for displaying alphanumeric characters.

4. The invention as recited in claim 2 wherein each said liquid crystal is a cholesteric nematic liquid crystal, substantially optically clear in an undisturbed state, and substantially optically opaque under influence of an electrical impulse passing therethrough.

5. The invention as recited in claim 2 wherein each said liquid crystal is a cholesteric nematic liquid crystal, substantially optically opaque in an undisturbed state, and substantially optically clear under influence of an electrical impulse passing therethrough.

6. The invention as recited in claim 1 wherein said optical image transfer means comprise a bundle of optical fibers.

7. The invention as recited in claim 1 wherein said optical input printing means comprise a xerographic printer.

8. The invention as recited in claim 7 wherein said xerographic printer means further comprise a web supply of paper.

9. The invention as recited in claim 1 wherein said electro-optical graphic character display means comprise a circular liquid crystal matrix, each liquid crystal therein being selectively activated from said bit encoding means, optical signal transfer means from said liquid crystal matrix, and graphic character display means activated by said optical signal transfer means.

10. The invention as recited in claim 9 wherein said graphic character display means comprise means for displaying alphanumeric characters.

11. The invention as recited in claim 9 wherein each said liquid crystal is a cholesteric nematic liquid crystal substantially optically clear in an undisturbed state, and substantially optically opaque under influence of an electrical impulse passing therethrough.

12. The invention as recited in claim 9 wherein each said liquid crystal is a cholesteric nematic liquid crystal substantially optically opaque in an undisturbed state and substantially optically clear under influence of an electrical signal passing therethrough.

13. The invention as recited in claim 1 wherein said electro-optical graphic character display means comprise a line display capable of differential character spacing display of alphanumeric characters.

14. The invention as recited in claim 1 wherein said electro-optical graphic character display means comprise a multiple line display capable of differential character spacing display of alphanumeric characters.

15. The invention as recited in claim 1 wherein said electro-optical character display means comprise a multiple line display capable of displaying graphic designs.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,824,604

Dated July 16, 1974

Inventor(s) Edward I. Stein

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

Column 3, line 19 insert a hyphen (-) after
"electro" and before "optical".

*Column 4, line 26 correct the spelling of "preceeding"
to --preceding--.

*Column 4, line 49 change "equentially" to
--sequentially--.

*Column 5, line 34 change spelling "matrixes" to
--matrices--.

Signed and sealed this 29th day of October 1974.

(SEAL)

Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents