United States Patent [19]
Ebeling et al.

[11] **3,775,560**
[45] **Nov. 27, 1973**

[54] **INFRARED LIGHT BEAM X-Y POSITION ENCODER FOR DISPLAY DEVICES**

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[73] Assignee: **University of Illinois Foundation,** Urbana, Ill.

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[52] **U.S. Cl.** .... **178/18,** 250/83.3 HP, 178/6.8
[51] **Int. Cl.** **G08c 21/00**
[58] **Field of Search** .... 178/6.8, 17, 18, 178/19, 20; 340/173 LT, 173 PL, 173 CR; 250/83.3 HP, 83 UV; 35/9 R

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494, Vol. 9, No. 5, Oct. 1966, IBM Technical Disclosure Bulletin, "Light Beam Matrix Input Terminal," P. Betts.

Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Kenneth Richardson
Attorney—Charles J. Merriam et al.

[57] **ABSTRACT**

A crossed light beam position encoder including *x* and *y* coordinate arrays of paired infrared light sources and detectors for covering a display device surface with *x* and *y* crossed light beams, scanning means coupled to the sources and detectors for electronically sequentially scanning the *x* and *y* arrays so that only one source is emitting light and its associated detector is detecting light at any particular time. Means are included for noting the digital address of the beams during sequential scanning and for stopping the scan when the beams are interrupted, the digital address and therefor the position of the broken beams are transferred back to a computer.

13 Claims, 3 Drawing Figures

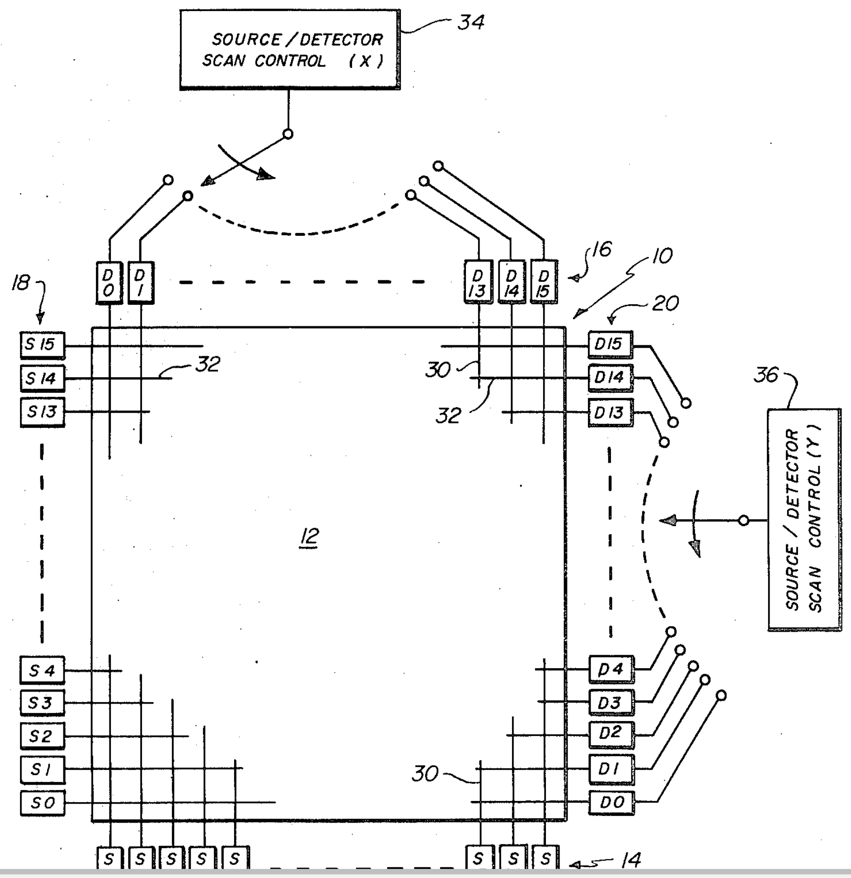


FIG. 1

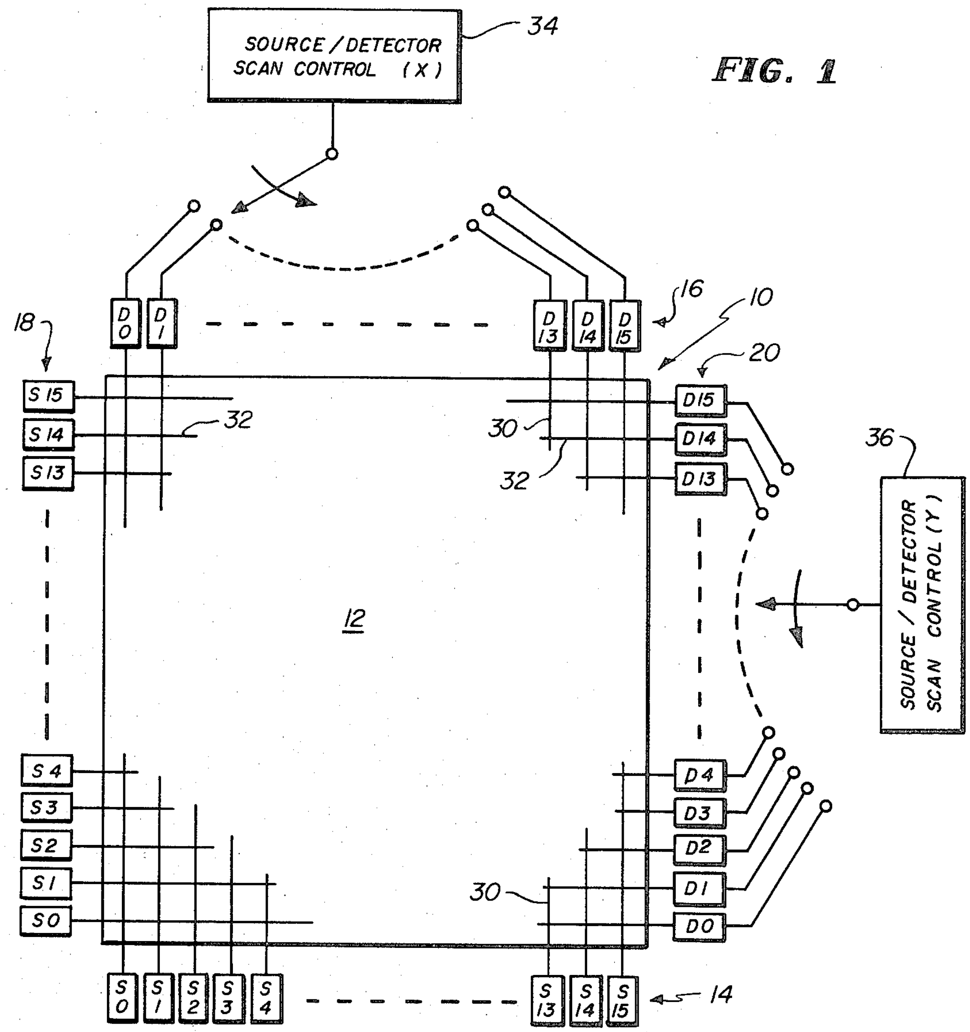

SOURCE / DETECTOR
SCAN CONTROL (X)
34
16
10
18
20
D0
D1
D13
D14
D15
S15
S14
S13
32
30
D15
D14
D13
36
SOURCE / DETECTOR
SCAN CONTROL (Y)
12
S4
S3
S2
S1
S0
D4
D3
D2
D1
D0
30
S0
S1
S2
S3
S4
S13
S14
S15
14

FIG. 2

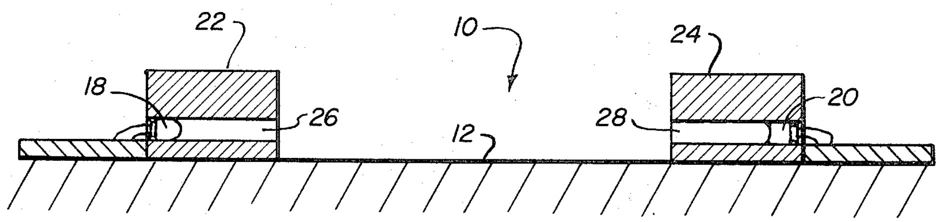
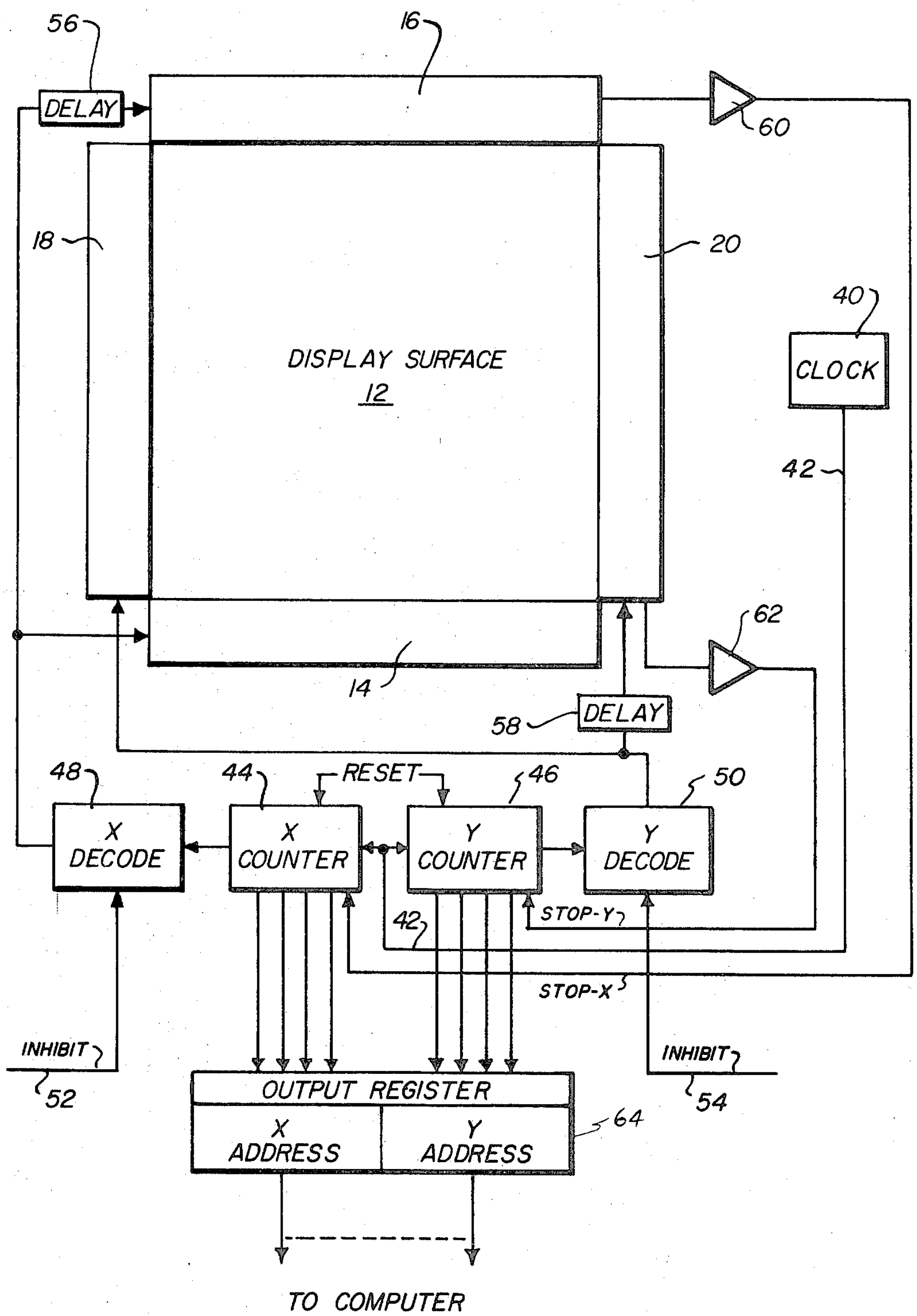

22
10
24
18
26
28
20
12

FIG. 3


56
16
DELAY
60
18
20
40
CLOCK
DISPLAY SURFACE
12
42
62
14
58
DELAY
48
44
RESET
46
50
X
DECODE
X
COUNTER
Y
COUNTER
Y
DECODE
42
STOP-Y
STOP-X
INHIBIT
52
INHIBIT
54
OUTPUT REGISTER
X
ADDRESS
Y
ADDRESS
64
TO COMPUTER

INFRARED LIGHT BEAM X-Y POSITION ENCODER FOR DISPLAY DEVICES

This invention relates to position encoder apparatus and in particular to infrared light beam position encoders for display devices.

Input devices used in conjunction with a computer control display for interactive information exchange between man and computer, via display, generally function as position encoders, that is, light pens, Rand Tablets, etc. Numerous devices and techniques that can be used to accomplish this task have been reported in the literature, such as the following:

1. A.M. Hlady, "A Touch Sensitive X-Y Position Encoder for Computer Input," AFIPS FJCC Proc. Vol. 35, 545, 1969.
2. R.J. Fitzhugh and D. Katsuki, "The Touch Sensitive Screen as a Flexible Response Device in CAI and Behavioral Research," Behavioral Research Meth. and Instru., Vol. 3 (3), page 159, 1971.
3. R.K. Marson, "Conducting Glass Touch-Entry System", Society of Information Display Digest of Technical Papers, May 1971.
4. M.R. Davis and T.O. Ellis, "The RAND Tablet: A Man-Machine Communication Device," AFIPS FJCC Proc. Vol. 26, p. 325, 1964.
5. "Crossed Light Beams Bridge Operator/Display Interface," Electronics, Oct. 11, 1971.

Although many of the devices such as illustrated in the aforementioned literature can be used with various display devices, such as plasma display panels, cathode ray tubes, etc., they are generally very expensive and would not be used where low cost is an overall system requirement.

As an example of the low cost requirement, reference may be made to U.S. Pat. No. 3,405,457 wherein there is disclosed a computer controlled teaching system which includes a display device at each student station. The system therein illustrated is capable of servicing at least 32 student stations although this is by no means a limitation since current designs for such a system specify 4,000 stations, each of which would include a display device. Because of the large number of display devices in such a system, and the application of such a system to the educational field, it becomes extremely important to meet low cost system requirements, particularly where it is desired to add to the system an x-y position encoder for each display device.

Several primary objectives can be defined:

1. The device must encode absolute positions indicated by the user.
2. The input surface must be superimposed upon the display surface and provide for a minimum of parallax.
3. Positions are to be indicated with a passive stylus, in particular, the human finger.

Although crossed light beam systems have been discussed in earlier literature (see literature list, item 2 above), such systems are extremely expensive, the excessive costs being due to the complex nature of the photosensing portion thereof. The complex nature of such systems is mandatory to assure that light from a particular source arrives only at its associated detector and does not impinge upon other nearby active detectors. Thus, in such prior crossed light beam systems it is necessary to construct rather elaborate optical collimation schemes, generally involving lenses to produce the required beam collimation.

SUMMARY OF THE INVENTION

A crossed light beam position encoder in accordance with the present invention includes *x-y* coordinate arrays or sets of paired light sources and detectors for covering the display device surface with *x* and *y* crossed light beams. Prior requirements for beam collimation at all of the sources and detectors has been eliminated in the present invention by activating only one source/detector pair at a time, that is, the *x* and *y* array of source/detector pairs is electronically scanned so that only one source is emitting light and its associated detector is detecting light at any particular time. The digital address of the beams are noted during sequential scanning.

If a broken beam is detected during this scanning operation, the scan is stopped at that point and the digital address (or position) of the broken light beam is transferred back to the computer. After this operation is completed, the scanning operation is resumed. This operation is of course completed for both the *x* and *y* arrays. Using this technique, the problems of optical cross talk are completely and simply eliminated without the aid of complex collimation schemes. There is thus provided a low cost position encoder which can be used in conjunction with computer controlled displays to function as a position encoder.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of the *x-y* position encoder in accordance with the present invention;

FIG. 2 is a cross-sectional view of the mounting arrangement for the 16 element *x-y* source/detector arrays for providing a crossed light beam adjacent the display device surface; and

FIG. 3 illustrates a 16 × 16 element *x-y* position encoder system with the necessary electronic scanner apparatus in accordance with the principles of the present invention.

DETAILED DESCRIPTION

Referring now to FIG. 1, there is illustrated a display device **10** having a display surface **12.** An *x* array of **16** infrared sources **14** are mounted along one side of the display device and are paired with a corresponding *x* array of infrared light detectors **16** suitably mounted on the opposite side of the display device **12.**

A similar *y* array of paired infrared sources **18** and detectors **20** are mounted along the remaining two opposite sides of the display device as illustrated in FIG. **1.** Thus, 32 pairs (16 per *x* and *y* axis) are mounted around the perimeter of display panel **10.**

Reference may be made to FIG. **2** wherein there is illustrated the display panel **10** and the mounting blocks **22** and **24** containing the infrared sources and detectors. For ease of illustration, only a partial sectional view is illustrated since the mounting for the sources and detectors along the *x* and *y* axis is substantially similar. Thus, mounting block **22** mounted on or adjacent the surface **12** contains a series of passageways **26** at one end of which there is mounted, for instance, an infrared light source **18.** Similarly, mounting block **24** on the opposite side of the display panel contains a series of passageways **28** each having an infrared light detector **20** mounted at one end of the passageway in mounting block **24** in order to provide for maximum noise protection from possible ambient sources of infrared emission near the display panel. addresses

Since the use of light sources which emit in the visible part of the spectrum is undesirable from both a human viewer standpoint and because of ambient light noise problems, gallium arsenide LED's (light emitting diodes, emitting at 900 nm) and infrared phototransistors are used as the source/detector pairs.

As shown in FIG. **1**, the paired arrays of **16** infrared sources and detectors on respective sides of the display panel are arranged so as to provide crossed light beams such as the *x* light beam **30** from source S_2 to detector D_2, and the *y* light beam **32** from source S_{14} to detector D_{14}. The *x* source/detector scan control **34** electronically scans the *x* sources and detectors in order to activate only one source/detector pair at a time so that only one beam along the *x* direction (such as beam **30**) is present at any particular time. Similarly, a *y* source/detector scan control apparatus **36** is provided to electronically scan the *y* sources and the detectors to selectively activate only one source/detector pair at a time and provide only one beam along the *y* direction (such as beam 32) at any particular time. Thus the *x* and *y* arrays of source/detector pairs are sequentially scanned to provide corresponding crossing beams.

Referring now to FIG. **3**, there is illustrated an *x-y* position encoder for supplying the position in the form of a digital signal for computer input. The *x* and *y* arrays of paired infrared sources and detectors are arranged in connection with the display surface **12** as illustrated in FIG. **1**. As previously described, this system of sources and detectors can be used to detect the presence and position of a passive stylus, that is, the finger, when it is placed into the plane of the array. The passive stylus will block a sufficient amount of light from the infrared source so that the signal output of the associated light detector (the detector directly opposite this source) will be decreased by an electronically detectable amount. When a blocked light beam is electronically detected, this beam position in the array is converted into a digital signal which identifies the position of the beam to the digital system being used with this encoder. The array in FIGS. **1** and **3** provides a grid of **256** addressed positions which can be detected.

The infrared light beams are sequentially scanned across the display surface **12** with an "effective" beam diameter of approximately 1/16 inch. This configuration was selected on the basis of the typical finger diameter, that is approximately 7/16 inch. Although it is obvious that the technique can be extended to higher resolution grids, the particular application described here did not require a resolution greater than two positions per inch.

A constructed embodiment of the present invention was utilized in connection with a plasma display and memory device similar to that shown in the D.L. Bitzer et al. U.S. Pat No. 3,559,190 for incorporation as a display device at each terminal in the teaching system of the aforementioned D.L. Bitzer U.S. Pat. No. 3,405,457. On this plasma display, it is desired that the 8 ½ inches × 8 ½ inches square display surface be divided into 256 areas (a 16 × 16 matrix) which are sensitive to the selection and/or touch of the human finger. That is, the position or address of the area which is selected by pointing or touching of the human finger is automatically sent back to the central computer system in a manner similar to that used to send back key set information. The present infrared position encoder combines very effectively with the plasma display panel because the display surface can also function as a rear projection screen for projecting additional information onto the display surface.

While the present embodiment of the present invention is herein described in respect to its application to a plasma display and memory unit, it is to be understood that the application thereof is not so limited and can as well be applied to other types of display devices, such as cathode ray tubes, solid state displays, etc.

The need for optical collimation is eliminated in the present system by activating only one source/detector pair at a time in the *x* and *y* arrays. Since the LED's and phototransistors exhibit rise and fall times of 2–5 microseconds, large numbers of source/detector pairs can be scanned within time intervals which correspond to human finger reaction times. For example, if each source/detector pair is turned on for a 100 microseconds, than a source/detector array of 100 pairs could be scanned in 10 milliseconds.

Sensing the presence and absence of the source produced light beams is achieved with a phototransistor that is matched to the LED emission. The signal produced by currently available type of phototransistors, however, is much too small (approximately 100 millivolts) to be detected with a standard logic unit and as a result must be amplified. Since a detector has need for an amplifier only once per scan and since no two detector signals need to be amplified at the same time, only one multiplexed amplifier is needed per *x* and *y* array.

The circuit blocks used to perform the scanning, sensing and control functions of a 16 element *x* and *y* array are shown schematically in FIG. **3**. The logic units used were of standard TTL type.

In general, the scanning, sensing and control functions are accomplished by electronically scanning the *x* and *y* arrays sequentially while keeping a record of the particular *x* and *y* address of the selectively activated source/detector pair in each array. The display surfaces are scanned from top to bottom and from left to right as shown in FIG. **3**. Upon interruption of the light beams, the particular *x* and *y* address of the source/detector pairs in the *x* and *y* arrays are noted and transferred to the computer. The apparatus providing such functions and operations are shown in FIG. **3**. In particular a free running clock **40** operates through line **42** to operate the *x* counter **44** and *y* counter **46** so as to sequentially select the address designations for each of the 16 source/detector pairs in the *x* and *y* arrays. Each of the *x* an *y* counters **44, 46** contains a four bit counter for specifying the digital address of each of the 16 associated paired sources and detectors.

Respective *x* and *y* decoders **48, 50** contains suitable logic gating circuits for decoding the respective four bit addresses from the *x* and *y* counters into one of the associated 16 lines. Each of the decoders **48, 50** is normally inhibited through respective inhibit lines **52, 54** for a preset delay time following the sequencing of a new address in the counters. This delay time eliminates the possibility of errors arising from noise erroneously gating the infrared sources and detectors through the decoders. As shown in FIG. **3**, the output of the decoders is coupled into the respective *x* and *y* arrays of paired sources/detectors. Thus, during the time the *x*

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