United States Patent

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[73] Assignee **CSF-Compagnie Generale De Telegraphie Sans Fil**
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[33] **France**
[31] **63,080**

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[54] **MEMORY FOR RECORDING A FUNCTION OF FOUR INDEPENDENT VARIABLES**
7 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **340/173,** 340/166
[51] **Int. Cl.** **G11c 13/04**
[50] **Field of Search** ..... 340/173 (LSS), 173 (LM), 173 (Light), 166 (EL), 166; 250/224, 219 (Id); 350/272

[56] **References Cited**

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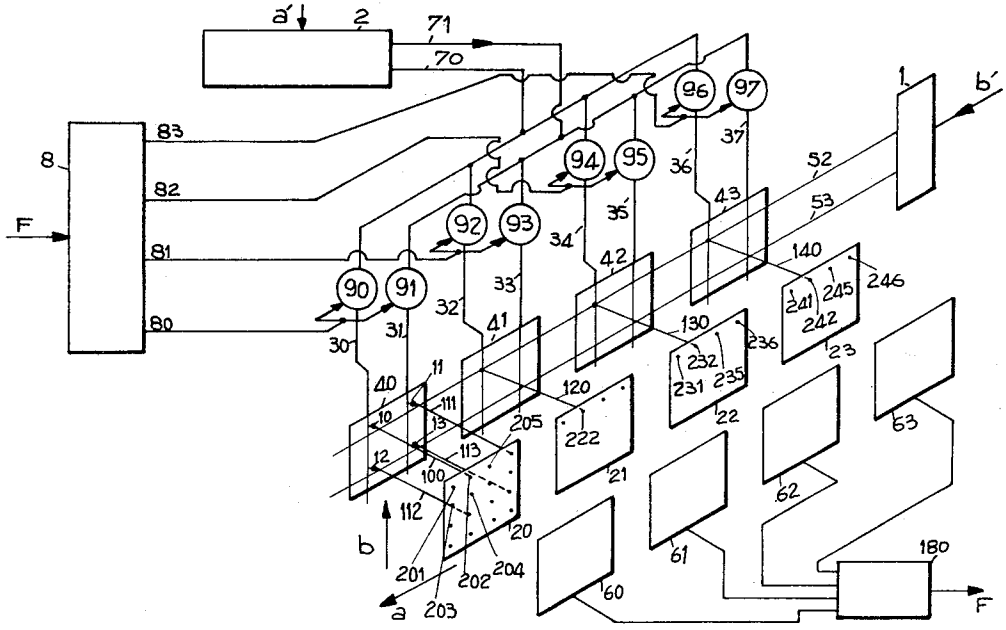
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ABSTRACT: A storage system capable of recording on a photographic material information items corresponding to the values of a function of four independent variables and capable of retrieving the stored values of said function for any predetermined combination of said variables. To this end the position of sources of light is controlled as a function of said variables and these positions are impressed on photographic plates.



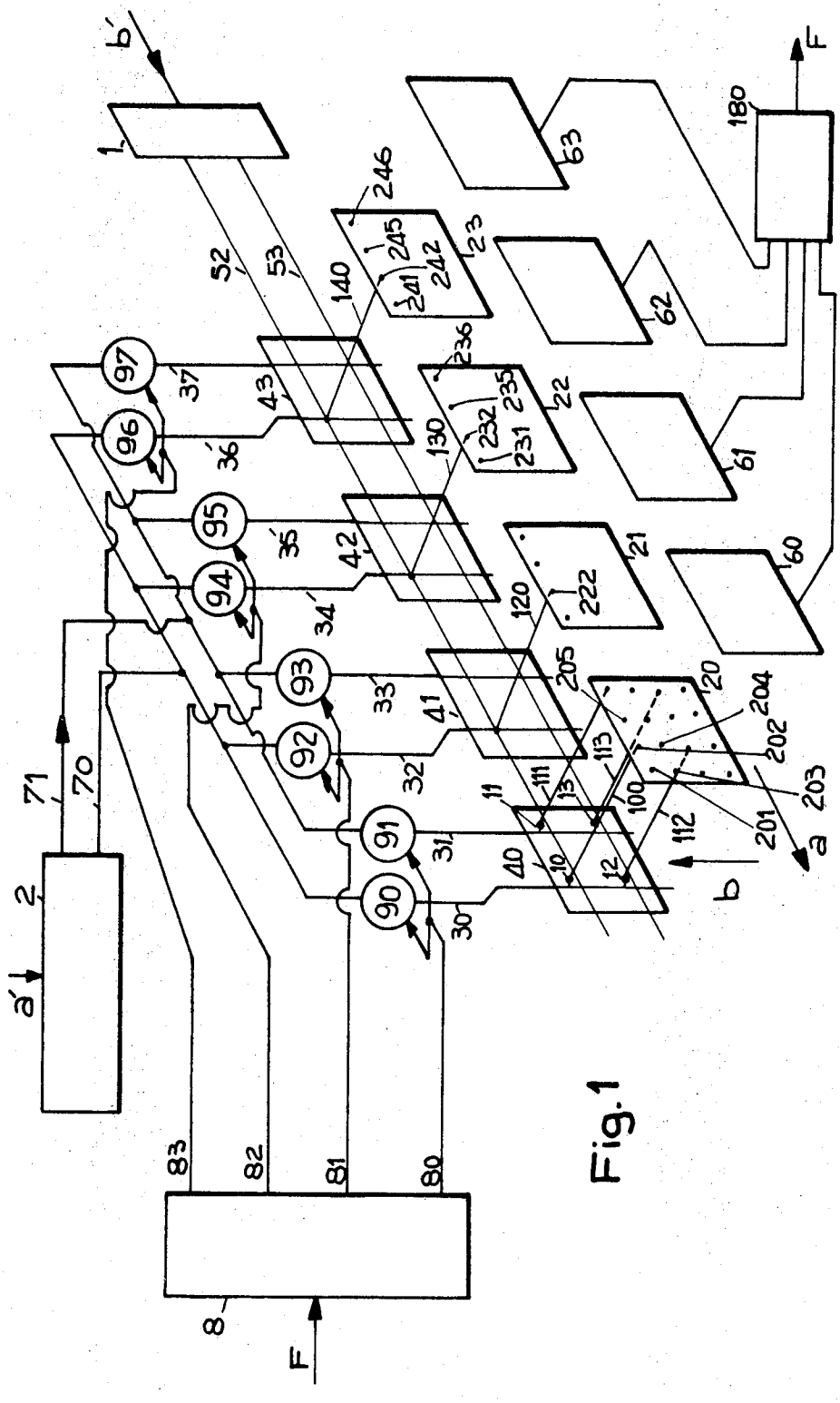

b'
1
246
245
241
242
23
63
180
F
52
53
140
62
236
235
232
231
22
61
130
97
96
95
94
93
92
91
90
37
36
35
34
33
32
31
30
43
42
41
120
222
21
60
205
20
204
202
203
201
a
b
111
113
13
100
112
11
10
12
40
71
70
2
a'
83
82
81
80
8
F

Fig. 1

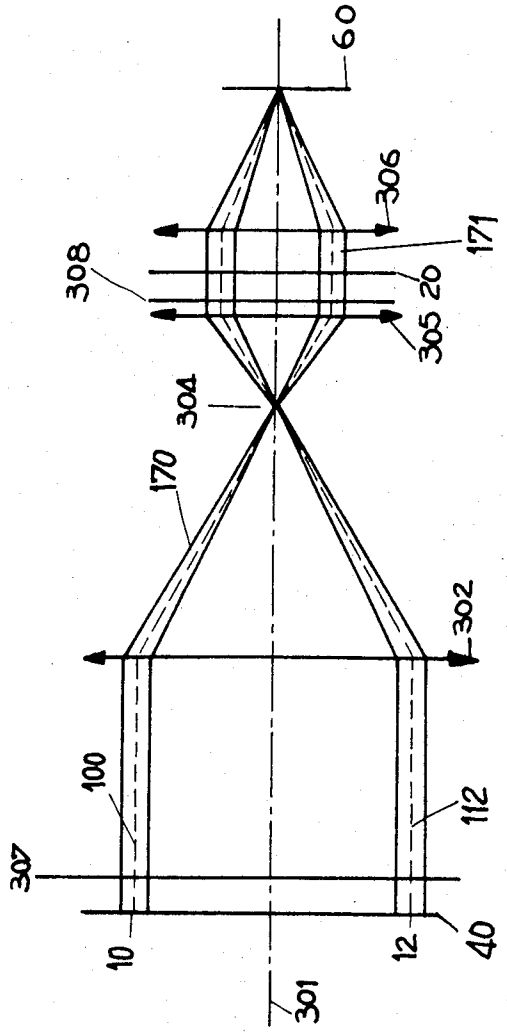


Fig.2

MEMORY FOR RECORDING A FUNCTION OF FOUR INDEPENDENT VARIABLES

The present invention relates to a memory for recording a function of four independent variables.

There are known a large number of types of memories, the development of which has been linked with that of numerical computers. There are, for example, memories with ferrite cores, memories with drums, memories with discs, magnetic tapes, to name but a few of them.

These memories have valuable characteristics, such as a high access speed and a large storage capacity. However, the exploitation of these memories requires under certain conditions certain arrangements which are either costly or bulky because of their weight or volume, or both.

It is an object of this invention to avoid such drawbacks.

According to the present invention there is provided an optical storage system for recording and retrieving sampled values of a single valued function F of four independent variables a, b, a', b', said system comprising: analog-to-digital converter means having an input for receiving said values and a plurality of outputs; a plurality of point sources of light, respectively controlled by said outputs; means for changing the location of said sources as a function of variables a' and b'; means for positioning photographic means in a position for storing said locations; means for controlling the position of said photographic means as a function of variables a and b; photoelectric means having a plurality of outputs positioned for reading-out the information stored in said photographic means; and digital-to-analog converter means coupled to said photoelectric means outputs for retrieving the stored values of said function F.

For a better understanding of the invention and to show how the same may be carried into effect reference will be made to the drawing accompanying the following description and in which:

FIG. 1 is a diagram of a memory according to the invention; and

FIG. 2 shows one embodiment of the light beams.

FIG. 1 shows a diagram of the principle of the invention for recording a function of four independent variables. The memory according to the invention is a memory adapted to store permanently the information written therein and to pass this information to a computing system by means of a non-destructive operation. By way of nonlimitative example it will be assumed that each of the independent variables can assume only two distinct values.

Under these conditions, the function F (a', b', a, b) of four independent variables can assume **16** values, which are are represented in binary code by four digits.

The knowledge of the values of the four variables a', b', a, b, makes possible during the writing operation to arrange the digits representing the function F at suitable locations in the memory, and during the readout operation, to interrogate the memory in order to obtain instantaneously the value of F which corresponds to any given set of variables.

Under these conditions it is necessary to draw a distinction between the "readout" elements and the "writing" elements, but it must be understood that certain elements are common to both functions as will become apparent as the description proceeds.

The memory comprises a photographic plate which, for the sake of easier description, has been divided into four plates **20**, **21**, **22** and **23**, each of which corresponds to one digit of the function F. The memory system also comprises assemblies of light sources **40**, **41**, **42** and **43** and photoelectric cells **60**, **61**, **62** and **63**, the number of these elements being equal to that of the digits of the function F.

Each assembly of light sources provides four regularly spaced light beams. The assembly of light sources **40** is shown, by way of nonlimitative example as comprising, four lamps **10**, **11**, **12**, **13**, arranged in the form of a matrix and producing by means of any suitable optical arrangements parallel light beams. The columns and lines of the matrix are represented,

respectively, by conductors **30**, **31** and **52**, **53**. The lamps are connected between a line and a column; for example, the lamp **10** is connected between the conductors **30** and **52**.

The conductors **30** and **31** receive signals representing the value of the variable a'; at any given time, such a signal may be present only in one of these two conductors. In the same way, the conductors **52** and **53** receive a signal representing the value of the variable b'. The lamp connected between, a line and a column receiving simultaneously the signals a' and b', produces a beam which illuminates the photographic plate at a point, the position of which is a function of the value of variables a' and b'.

The conductors **52** and **53** are common to all assemblies of light sources and receive the signals coming from a device **1**, having as input value the variable b'. The device **1** is a coder permitting the transformation of the variable b' into digital form, if the same is in analog form.

The conductors, such as **30**, **32**, **34** and **36** of the assemblies of light sources **40**, **41**, **42** and **43** are connected, respectively, to the outputs of AND-circuits **90**, **92**, **94** and **96**.

Each of these AND-circuits has two inputs, one of which is connected to the output **70** of a coder **2**, which receives the variables a'. The other inputs of these AND-gates are connected, respectively, to the outputs **80**, **81**, **82** and **83** of a coder **8**, which receives in analog form a value proportional to the function F and delivers in parallel to the four outputs **80**, **81**, **82** and **83** the digits of the function F in digital form. The presence of a signal at the output means digit **1**, and the absence of such a signal means digit **0**.

Similarly, the conductors **31**, **33**, **35** and **37** of the assemblies of light sources **40**, **41**, **42**, **43** are connected, respectively, to the outputs of the AND-circuits **91**, **93**, **95** and **97**. One of the inputs of each of these AND-circuits is connected to the output **71** of the coder **2** and the other, respectively, to lines **80**, **81**, **82** and **83**. The lamp **10** forms, for example, a light beam **100** when the signals appear simultaneously at the points **80**, **70** and **52**.

The photographic plates are movable along two axes a and b. Movements along these axes are produced by any known means to translate the signals representing a and b in the form of proportional displacements along the respective axes a and b. Under these conditions, for a given pair of values of variables a', b', corresponding for example, to the beam **100**, the photographic plate **20** may be exposed at four distinct locations **201**, **202**, **203** and **204** according to the values of the variable a and b.

Although only a single beam can be produced for a given pair of values of variables a' and b', four beams **100**, **101**, **112**, **113**, corresponding to the lamps **10**, **11**, **12** and **13**, are shown in FIG. **1**, in order to show the maximum amplitude of the displacements a and b.

Let l be the distance between two beams, such as **100** and **111**; the maximum value of the displacement of a and b must be less than $l/2$ so that it should be possible to distinguish two information items, such as **202** and **205**, produced by exposing the photographic plate to the light beams **100** and **111**.

The recording of the function F takes place as follows:

The coder **8** receives the analog signal representing the function F and delivers the same function in coded binary form at the outputs **80**, **81**, **82** and **83**. The digits defining the function F are, for example, **1**, **0**, **1**, **1** and are represented, respectively by the presence or the absence of signals in the leads **80**, **81**, **82** and **83**. Assuming by way of example the values of the variables a' and b' are such that signals exist simultaneously in the conductors **70** and **52**, the AND-circuit **92** does not transmit the signal produced in the conductor **70** to the column **32**. As a consequence, the assembly **41** of light sources does not produce any beam and the photographic plate **21** is not impressed, which absence of impression characterizes the digits **0** of the function F. On the other hand, the circuits **90**, **94** and **96** transmit the signal produced in the conductor **70** to the columns **30**, **34** and **36** of the light source assemblies **40**, **42** and **43**.

The assemblies of light sources 40, 42 and 43 produce light beams 100, 130 and 140 which illuminate the photographic plates 20, 22 and 23. The imprint on the corresponding plates characterizes the digits 1 of the function F appearing at 80, 82 and 83.

The light beam 100 impresses the plate 20 at a point 202, corresponding to a value of the couple of variables (a, b). The beams 130 and 140 impress, respectively, the plates 22 and 23 at the points 232 and 242 whose relative positions on the respective plates is the same as that of the point 202. For the three other possible values of the variables (a, b), the imprinting positions on each of the plates would be those corresponding to the points 202, 203 and 204.

The digits appearing at the outputs 80, 81, 82, 83 of the coder 8 are recorded, respectively, on the plates 20, 21, 22 and 23, the digits 1 corresponding to an imprint on the plates and the digits 0 producing no imprint on the plates.

At the end of the recording, and in the example considered, the four photographic plates contain 16 coded information items which represent the function F. The photographic plates are then processed according to a reversal process and repositioned in their corresponding frames.

The elements necessary for the readout of the memory system shown in FIG. 1, are the following:

all the elements described with reference to the recording operation with the exception of the coder 8 and the AND-circuits 90, 91, 92, 93, 94, 95, 96 and 97; the conductors 30, 32, 34 and 36 are connected in parallel to the output 70 of the coder 2; in a similar way, the conductors 31, 33, 35 and 37 are connected in parallel to the output 71 of the coder 2;

an assembly of four photoelectric cells 60, 61, 62 and 63, receiving the light beams produced by the assemblies of sources 40, 41, 42 and 43 and passed by the photographic plates 20, 21, 22 and 23;

a decoder 180 comprising four inputs connected, respectively to the photocells 60, 61, 62 and 63; this decoder 180 supplies an analog value proportional to F as a function of signals delivered by the photocells and representing the digits of F in coded form.

The readout operation takes place as follows:

To each pair of variables a' and b' correspond four light beams, one per each set of light sources. Similarly, to each couple of variables a and b corresponds an accurately defined position of the set of photographic plates relative to the assemblies of light beams. The beams which impinge during their travel upon an unexposed surface portion of a photographic plate do not reach the corresponding photocell. On the other hand, the exposed portions of the plates transmit the light beams and cause the excitation of the corresponding photocell. In the case of the above-mentioned example, given with regard to the recording, the digits representing a certain value of F are 1, 0, 1, 1. In this instance, the photographic plates 20, 22 and 23 transmit, respectively, the beams 110, 130 and 140 which excite the cells 60, 62 and 63, which deliver to the decoder 180 the signals corresponding to the digit 1. The plate 21 is not transparent and the beam 120 does not reach the cell 61. This cell is not excited and delivers to the decoder 180 a signal which represents zero.

FIG. 2 represents an embodiment of the light beam. If the number of distinct values of the variables a' and b' is high, for example, higher than 10 for each of them, the dimensions of such an assembly of light sources, such as 40, may be large compared with those of a photographic plate 20. The recording density on such a photographic plate is high, for example 100 points per square millimetre, and it is therefore useful to show, by way of nonlimiting example a system of light sources 40, having dimensions larger than those of the photographic plate 20 and associated with a system of lenses and diaphragms producing narrow light beams, which set of beams represents the assembly 40 on a reduced scale.

FIG. 2 is a cross section of the system shown in FIG. 1 along a plane perpendicular to the plane of the light sources and comprising the beams 100 and 112.

The optical axis of the system is represented by the line 301. This system comprises the assembly of light sources 40, a diaphragm 307, a lens 302 with the focus 304, a second lens 305 so arranged that its focus coincides with the focus 304, a diaphragm 308, the photographic plate 20, a third lens arranged in such a manner that its image focus coincides with the plane of the photoelectric cell 60.

The operation of the system is as follows:

The beam 100 of parallel rays in stopped down by means of the diaphragm 307 and gives rise to a beam 170 which converges in the focus 304. A lens 305 transforms the beam into a beam of parallel rays 171 which pass through the diaphragm 308. By means of a suitable choice of the focal lengths and of the positions of the lenses, the distance from the beam 171 to the optical axis 301 can be reduced relative to that of the beam 100 from this axis.

The beam 171 of parallel rays transmitted by the photographic plate 20 is transformed into a converging beam focused on to the photocell 60 by means of a lens 306.

Of course the invention is not limited to the embodiments described and shown which are given solely by way of example.

I claim:

1. An optical storage system for recording and retrieving sampled values of a single valued function F of four independent variables a, b, a', b', said system comprising: analog-to-digital converter means having an input for receiving said values and a plurality of outputs; a plurality of point sources of light, respectively controlled by said outputs; first means for changing the location of said sources as a function of variables a' and b'; photographic means located in a position for storing said locations and the information in said locations; second means for controlling the position of said photographic means as a function of variables a and b; photoelectric means having a plurality of outputs positioned for reading-out said information stored in said photographic means; and digital-to-analog converter means coupled to said photoelectric means outputs for retrieving the stored values of said function F.

2. A system as claimed in claim 1, wherein said point sources are positioned in a first plane; said photographic means being positioned in a second plane, and said photoelectric means being positioned in a third plane.

3. A system as claimed in claim 2, wherein first and second stigmatic optical devices are respectively interposed between said first and second plane and between said second and third plane.

4. A system as claimed in claim 1, wherein said first location changing means comprise: two further analog-to-digital converters having respective inputs for receiving variables a' and b' and a plurality of outputs; AND-gate means coupled to said outputs of said analog-to-digital converters and matrix means having rows and columns for feeding said sources; said rows and columns of said matrix means being controlled by said gate means for building up said light locations.

5. A system as claimed in claim 1, wherein said light sources are incandescent lamps arranged for providing light dots.

6. A system as claimed in claim 1, wherein at least one of said variables has a predetermined value; the remaining variables controlling the storage and the retrieval of the sampled values of a function of the remaining variables only.

7. A system as claimed in claim 3, wherein said first stigmatic device comprise a pair of convergent lenses having a common focus; said second stigmatic device being a convergent lens whose focus coincides with said third plane.