United States Patent

Grolitzer et al.

[15] **3,678,459**

[45] **July 18, 1972**

[54] OPTICAL CROSSBAR SWITCHING DEVICE

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[22] Filed: **April 23, 1971**

[21] Appl. No.: **137,087**

Related U.S. Application Data

[63] Continuation of Ser. No. 762,746, Sept. 26, 1968, abandoned.

[52] **U.S. Cl.** .....**340/166**, 179/18 GA

[51] **Int. Cl.** **H03k 19/14**

[58] **Field of Search**.....340/347 DD, 166 R, 166 EL; 179/18 GA

[56] **References Cited**

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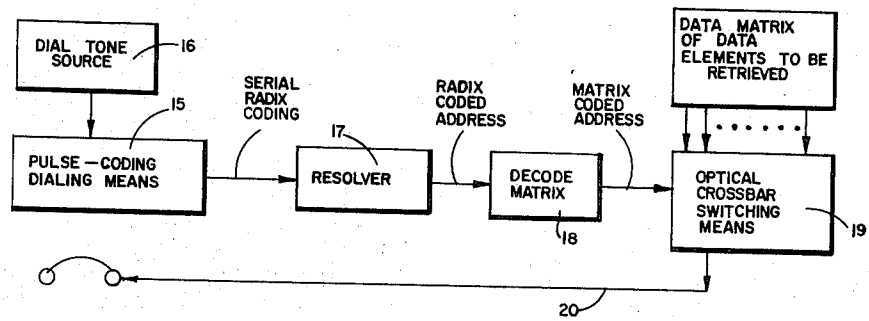
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Primary Examiner—Ralph D. Blakeslee
Attorney—Harris, Kiech, Russel & Kern

[57] **ABSTRACT**

Electronic data matrix retrieval means employing an optical crossbar switching device. A resolver means adapted to be responsive to a radix-coded pulse code address provides an output set corresponding to the radix coded address. A matrix decoder responsive to the resolver converts the radix-coded address to a matrix coded address. The photo-electric crossbar switching device is responsive to the matrix coded address to connect an addressing terminal to an addressed terminal of a data element in a data storage matrix.

6 Claims, 10 Drawing Figures



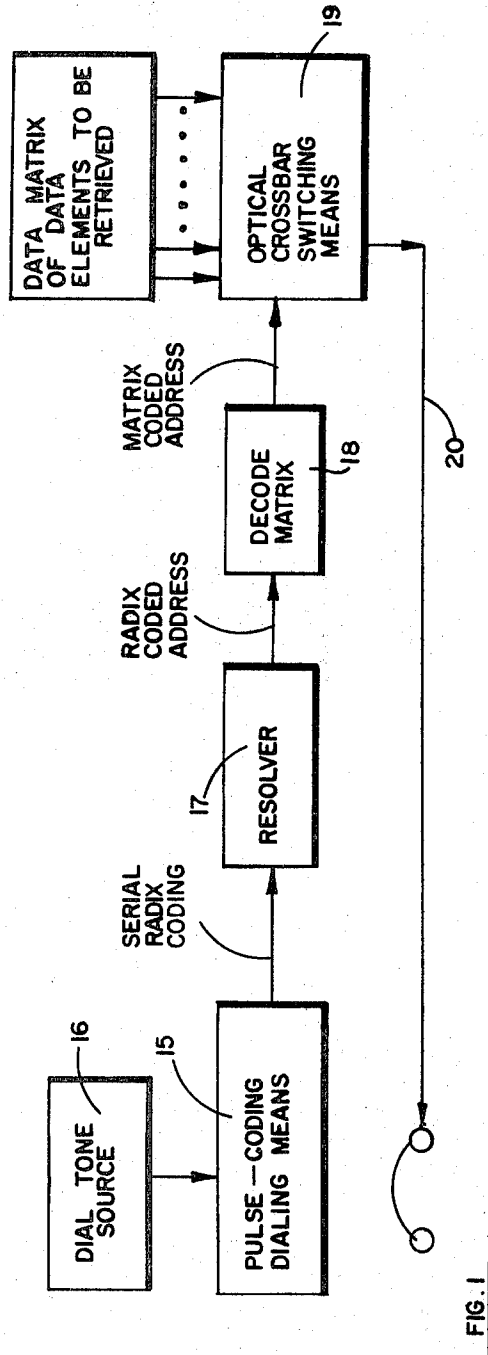


FIG. 1

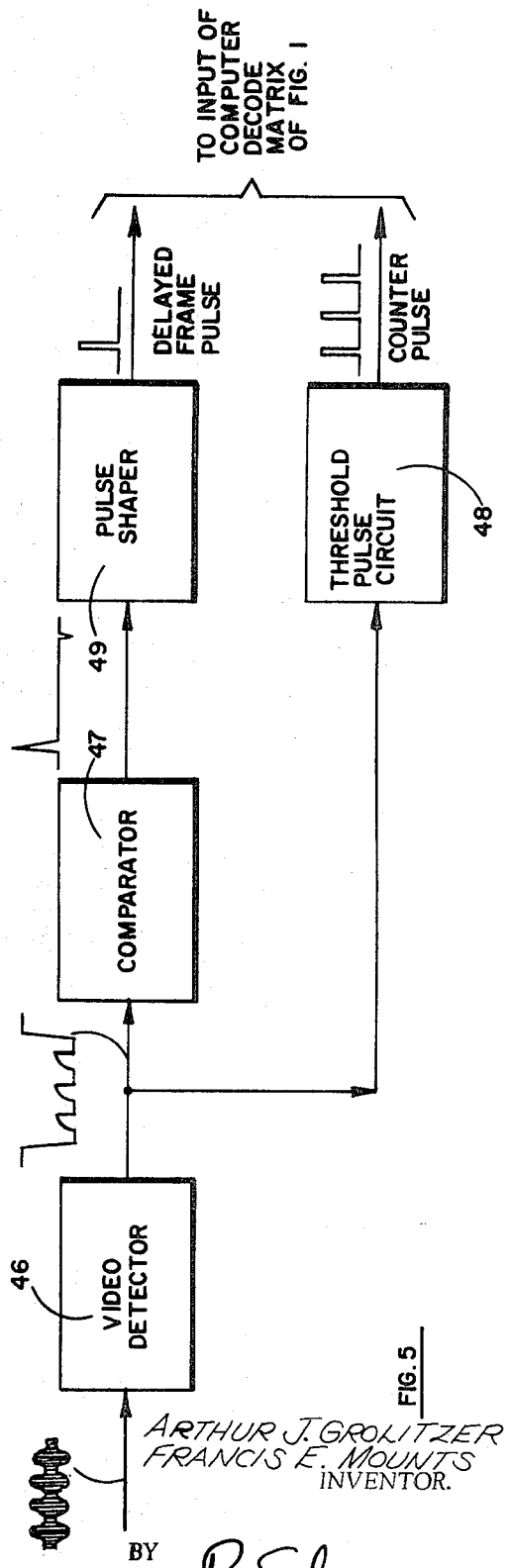


FIG. 5

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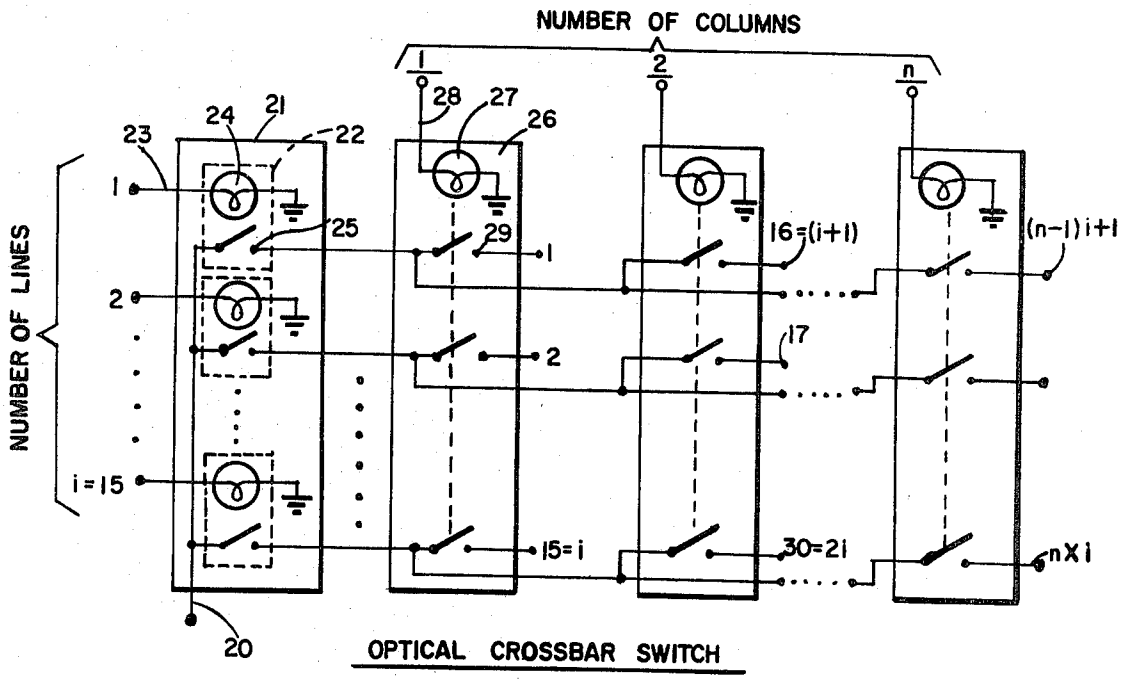


FIG. 2

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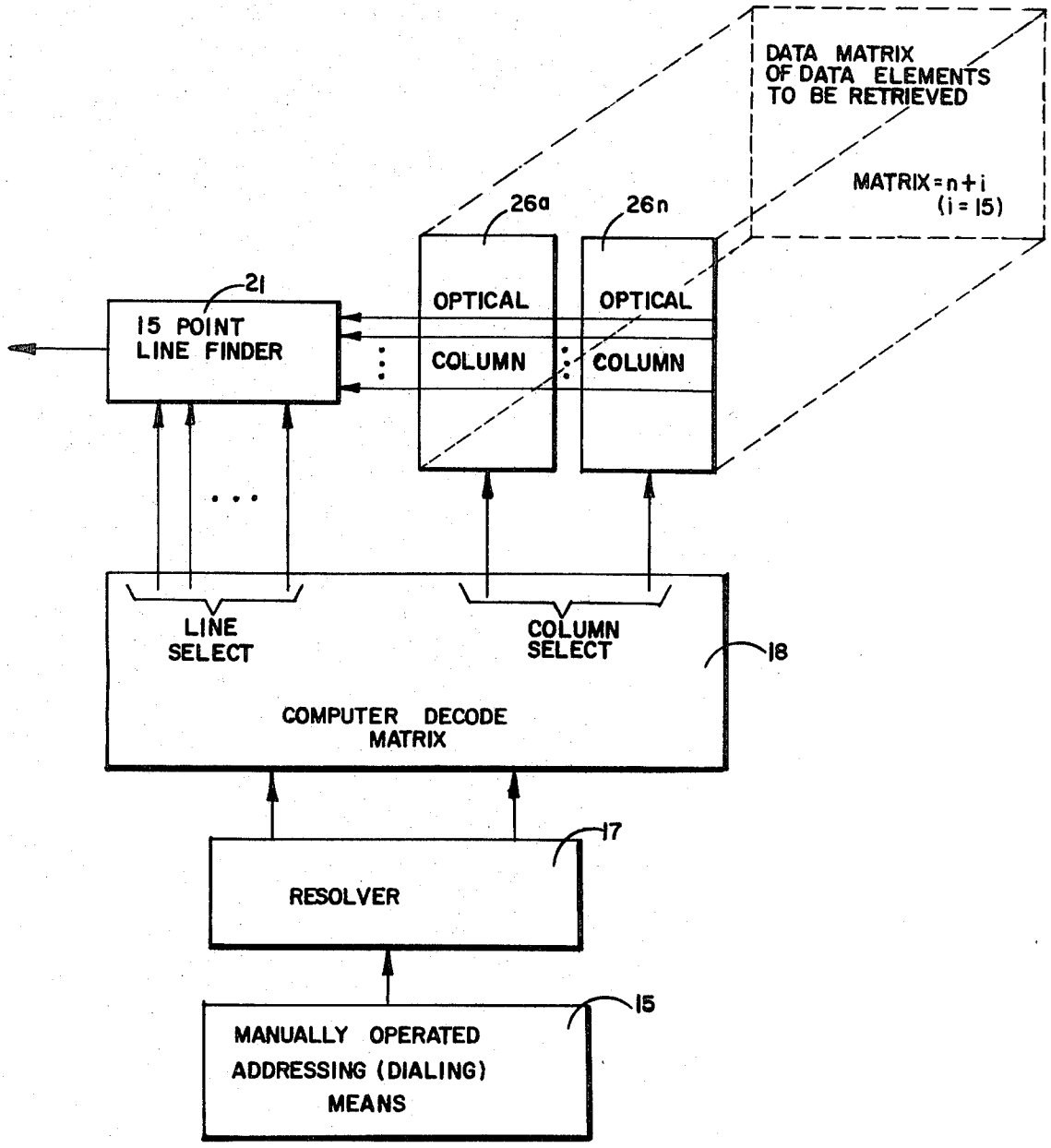


FIG. 3

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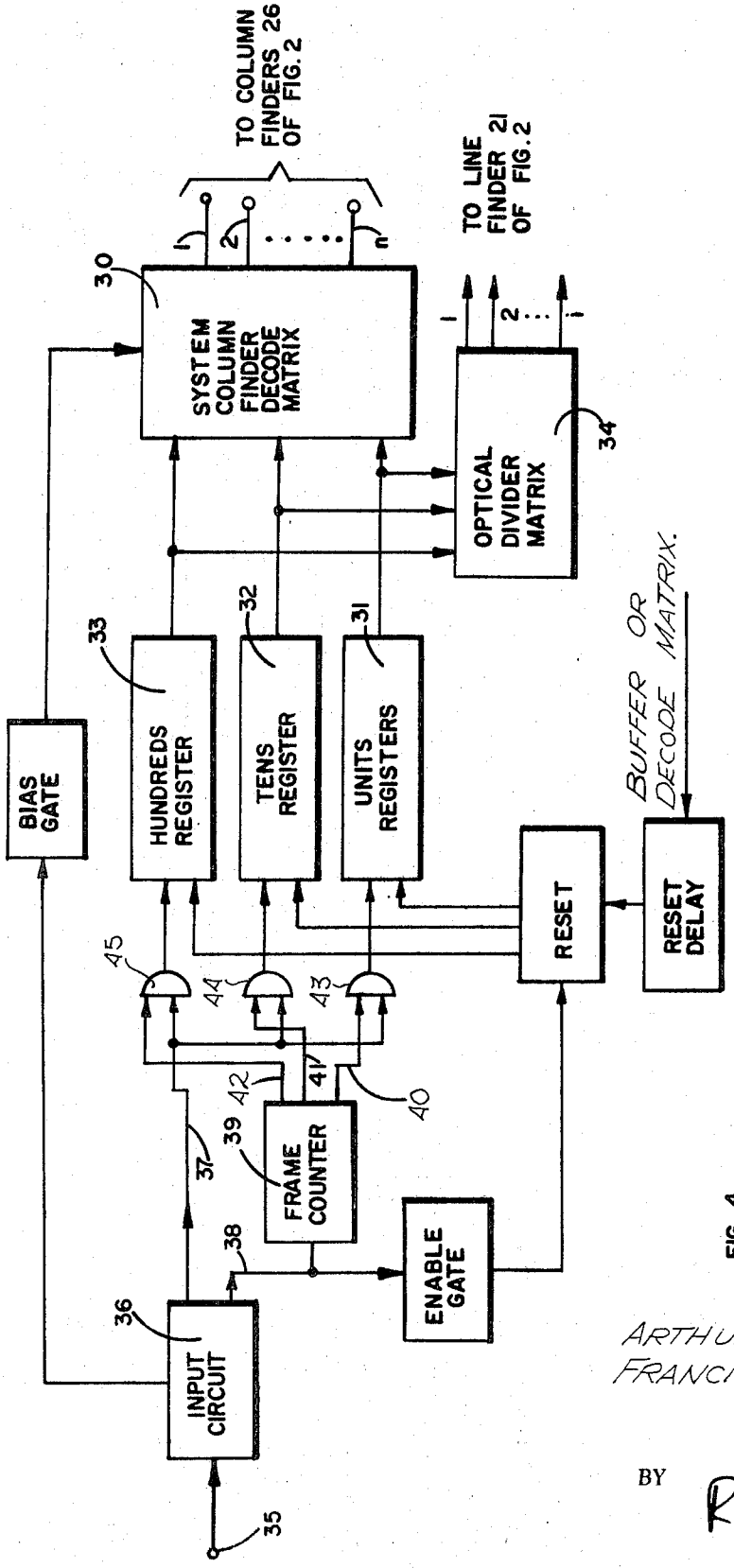


FIG. 4

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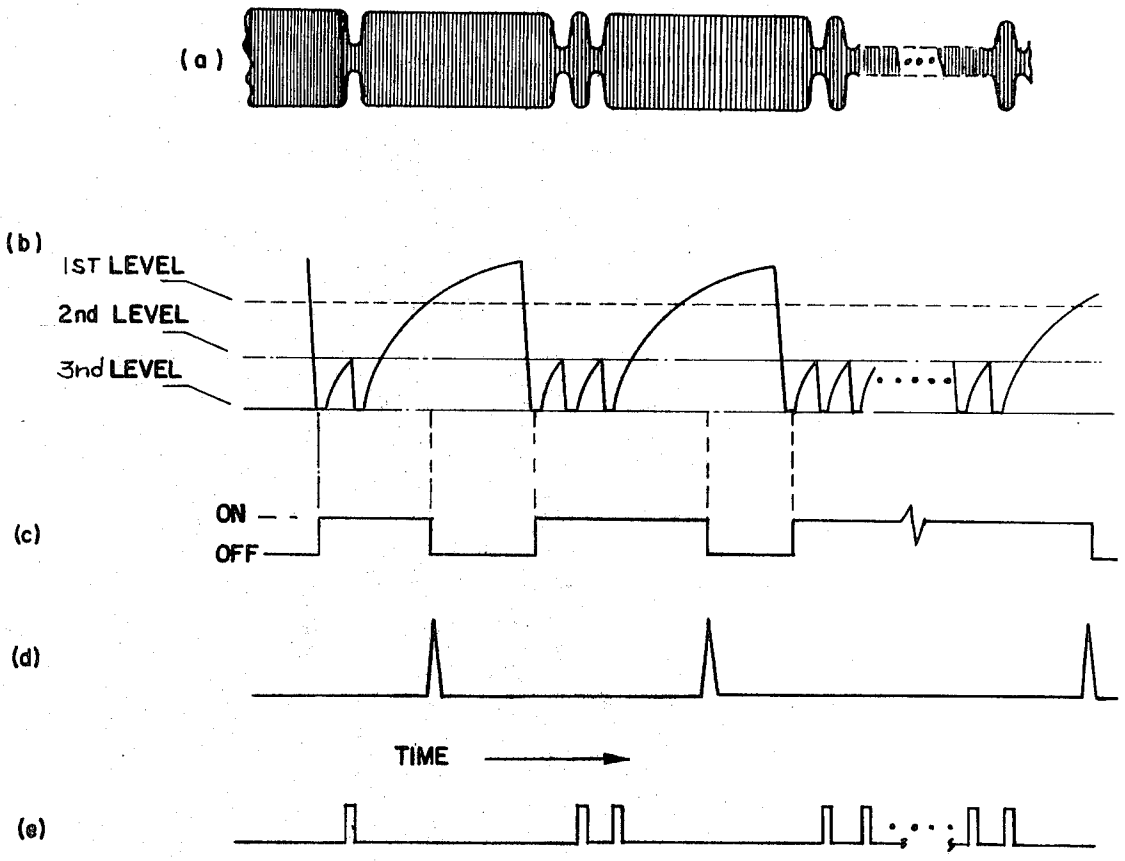


FIG. 6

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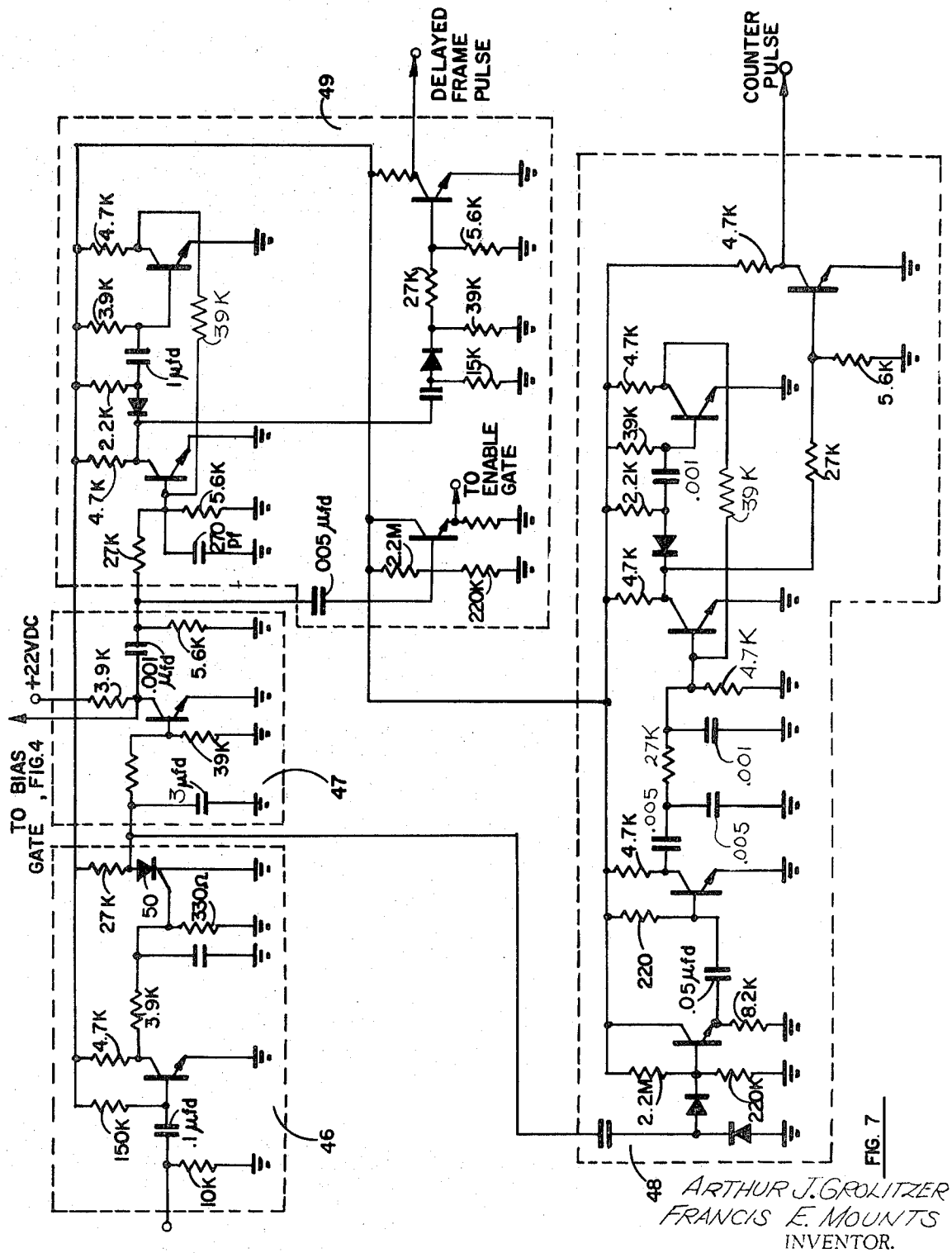


FIG. 7

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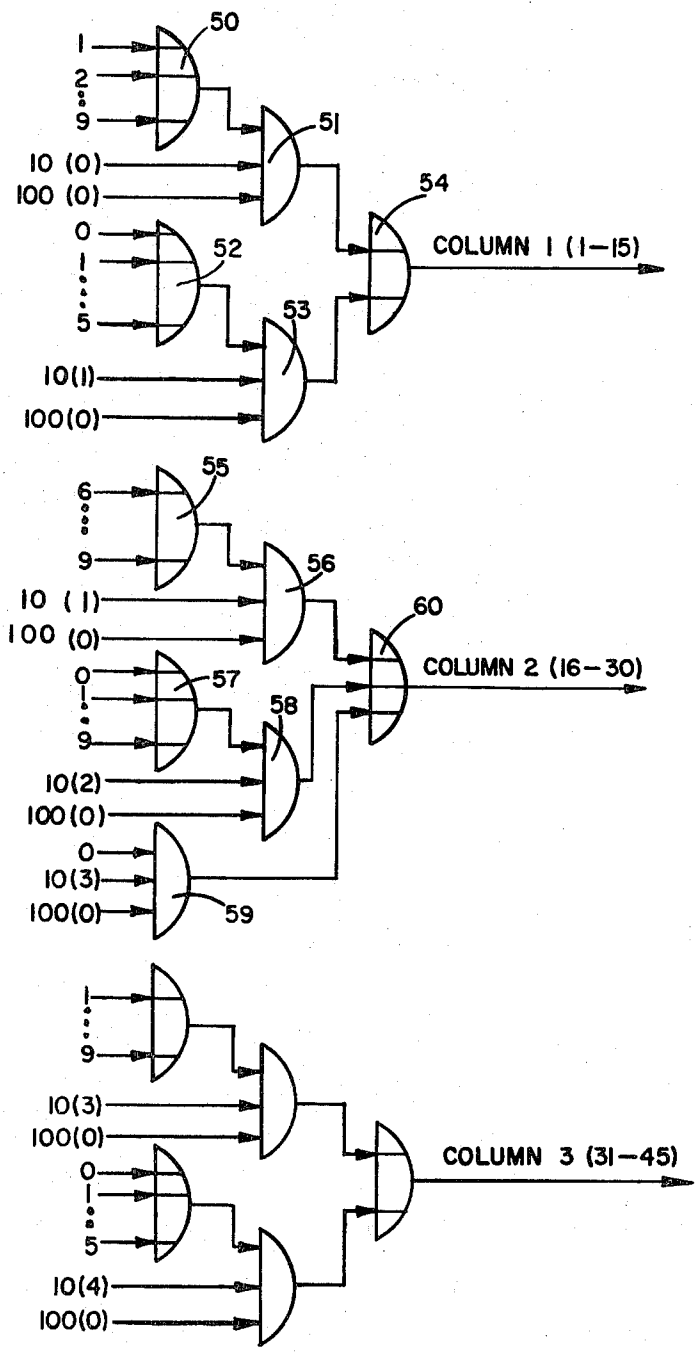


FIG. 8

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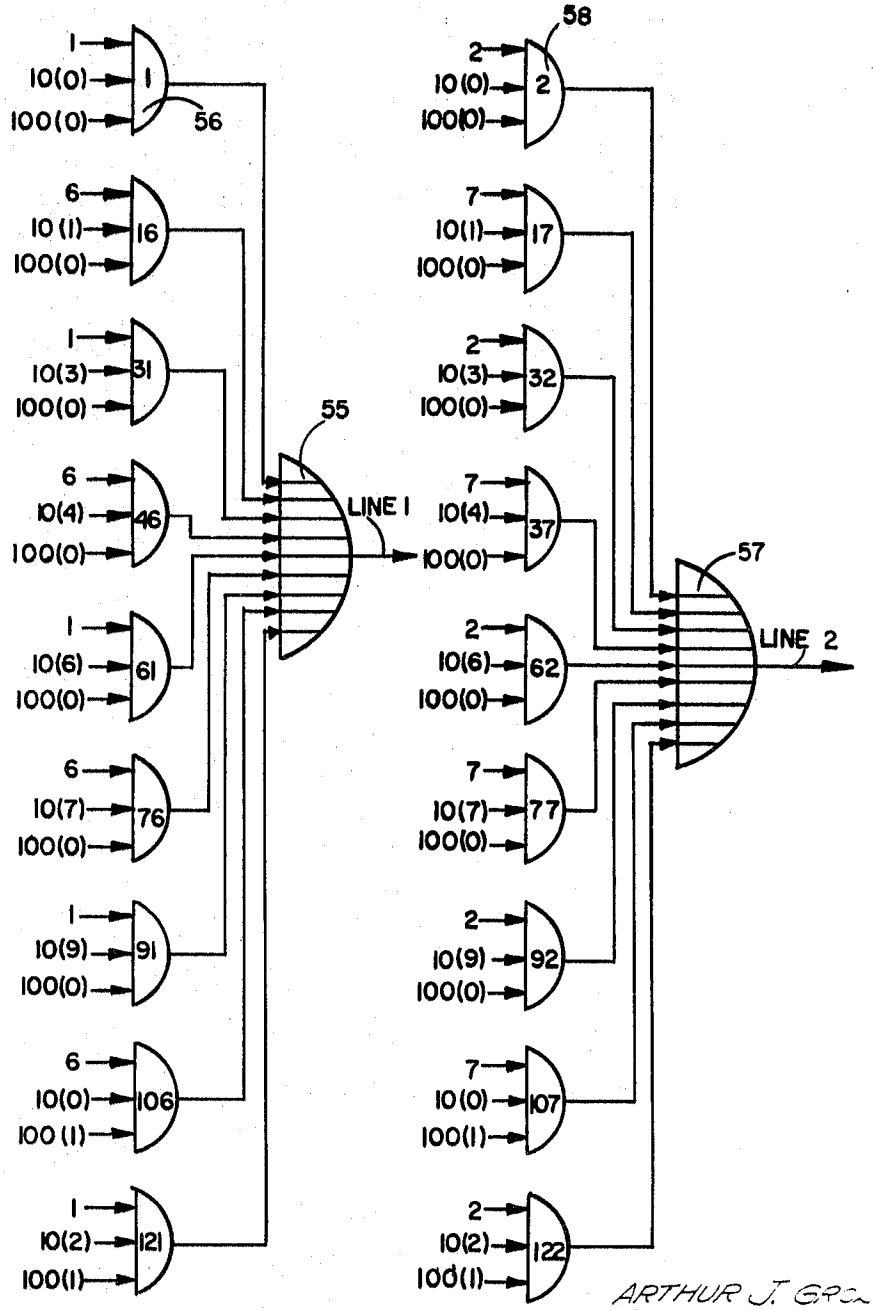


FIG. 9

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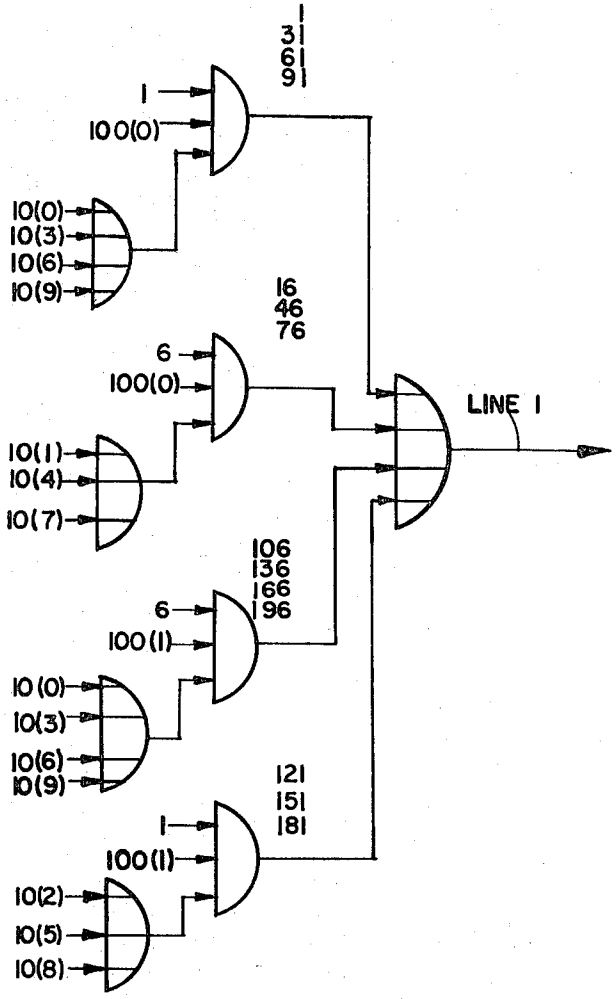


FIG. 10

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OPTICAL CROSSBAR SWITCHING DEVICE

This is a continuation of U.S. Pat. application Ser. No. 762,746, filed Sept. 26, 1968 and now abandoned.

BACKGROUND OF THE INVENTION

Modern electronics has made available varied and different forms of communication and means of storing information or the recording of data. In order that one may have convenient access to a selected piece of such stored data when desired, an efficient data retrieval system is required. For example, in the field of eduction such as in a laboratory for the teaching of foreign languages, instruction may be provided by means of selected tape recordings, utilized in accordance with a schedule or sequence based on the individual student's progress. The effective utilization of such mass method of instruction requires, however, a convenient method of manually addressing or selecting the desired tape or tape recorder of interest.

The prior art of data retrieval includes the telephone switching art in which a desired message line is identified by a preselected numerical designation employing a radix coded designation, with the number ten as the radix. The function of the telephone dialing or switching system is to connect an addressor's station with a selected one of a plurality of stations or lines, employing the radix-coded address. In other words, the addressor is connected to a selected element of a matrix of elements, utilizing the radix coded address. Accordingly, it is necessary to include in the addressing function, decoding means for converting the radix code to a matrix code.

For example, the number 120 represents a radix code for the radix 10, corresponding to $0+20+100$ or $0xR^{\circ}+2xR^{1}+1xR^{2}$, where $R=10$, as shown in Table I.

RADIX CODING

FOR RADIX, R-10

R^2	R^1	R^0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
0	0	0

TABLE I

The matrix in which the data element-to-be-addressed and corresponding to the radix 10 code 120, may consist of $i \times n$ elements arranged in i columns of n elements in each column or n rows or lines of i elements, as shown in Table II for $n=15$, the matrix element corresponding to 120 occurring in column 8 and row 15.

MATRIX CODING FOR

MATRIX, $i \times n$, WHERE $n=15$

Column i / Row n	1	2	3	4	5	6	7	8
1	16	31	46	61	76	91	106	
2	17	32	47	62	77	92	107	
3	18	33	48	63	78	93	108	
4	19	34	49	64	79	94	109	
5	20	35	50	65	80	95	110	
6	21	36	51	66	81	96	111	
7	22	37	52	67	82	97	112	
8	23	38	53	68	83	98	113	
9	24	39	54	69	84	99	114	
10	25	40	55	70	85	100	115	
11	26	41	56	71	86	101	116	
12	27	42	57	72	87	102	117	
13	28	43	58	73	88	103	118	
14	29	44	59	74	89	104	119	
15	30	45	60	75	90	105	120	

TABLE II

In other words, by identifying that row and column in which the element occurs, the element is identified in the matrix. Where more (k) than one deck, or single matrix, is employed, it is necessary to also include the identity of such deck: $k(i\ n)$.

In the prior telephone switching art, electro-mechanical rotary stepping switches have been used to process a radix coded serial pulse, and electromechanical crossbar switching assemblies have been used to effect switching or retrieval of an element within a matrix of elements. Such electromechanical devices, however, have many serious limitations, not the least of which is the bulk and size of such devices, making difficult the realization of small and efficiently packaged devices for effective utilization in special purpose applications. Other disadvantages include the electromagnetic interference and noise inherent in the operation of the moving parts of such electromechanical devices and the mechanical failures due to the wearing-out of such moving parts.

SUMMARY OF THE INVENTION

By means of the concept of the subject invention, the above-noted disadvantages of prior art data retrieval systems are avoided.

In a preferred embodiment of the invention, there is provided electronic data matrix retrieval means employing an optical crossbar switching device. Electronic resolver means, employing no electromechanical moving parts, provides an output set corresponding to a radix-coded serial pulse code input. Diode matrix decode means converts the radix coded address to a matrix coded address for operation of the photoelectric crossbar switching means.

Because no electromechanical parts are used in the crossbar switching system, solid state circuitry may be employed and highly compact and efficient packaging of custom equipment can be conveniently provided for specialized data retrieval applications. Accordingly, it is an object of the subject invention to provide an improved data retrieval system.

It is another object of the invention to provide a data retrieval system employing optical crossbar switching.

Still another object is to provide a data retrieval system employing a minimum of moving parts.

A further object is to provide optical crossbar switching means for convenient use in specialty data retrieval systems.

These and further objects of the invention will become apparent from the following description, taken together with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a system embodying the inventive concept;

FIG. 2 is a schematic arrangement of the optical crossbar switching means of FIG. 1;

FIG. 3 is a block diagram illustrating in further detail the organization of the system of FIG. 1;

FIG. 4 is a block diagram illustrating in further detail the organization of the resolver of FIGS. 1 and 3;

FIG. 5 is a block diagram of a preferred arrangement of the input circuit of FIG. 3;

FIG. 6 is a family of time histories of the response of the device of FIG. 4 to a representative input;

FIG. 7 is a circuit diagram of an exemplary embodiment of the input circuit of FIG. 4;

FIG. 8 is a representative arrangement of the logic for block element 30 of FIG. 4;

FIG. 9 is a representative arrangement of the logic for block element 34 of FIG. 4; and

FIG. 10 is an alternate arrangement of the logic of FIG. 9.

In the figures, like reference characters refer to like parts.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is illustrated in block diagram form a system in which the concept of the invention may be advantageously employed. There is provided a data retrieval system comprising pulse coding dialing means **15** such as a telephone type dialing device or like means known per se, and responsively coupled to a dial tone source **16**, such as for example a 400 cps oscillator or other audible tone source. Dialing means **15** comprises manually-operated addressing means for pulse modulating source **16** to provide serial radix coding thereof, for a radix of, say, (1 to 0), the specific code dialed corresponding to an address of a data element to be retrieved. The series of groups of pulses, corresponding to a selected radix-10-coded number or address, is converted by means of a resolver **17** to a concomitant plurality or set of signals representing such number. Conventionally, a set of 10 output lines may be provided by resolver **17** for each order of the radix. Thus, a first set of ten lines represents 0–9, a second set, 10–90; and a third set, 100–900; and the $(n+1)$ set, 1×10^n -9×10^n. An output on a selected line of each set of lines of resolver **17** corresponds to the radix-coded address of the data element to be retrieved.

The radix-coded output of resolver **17** is applied to the input of a decode matrix **18** such as a diode matrix or like means for converting the radix coded input thereto to the corresponding matrix element of a preselected storage matrix. Hence, although the input to decode matrix **18** is shown as a single line in the block diagram of FIG. **1**, it is to be understood that a plurality of sets of input lines are thus represented.

Similarly, the output of decode matrix **18** comprises two sets of lines, corresponding to the rows and columns of the preselected storage matrix. Where the storage matrix is constructed of stacked decks, or pluralities, of like matrixes, the output may further include a set of lines corresponding to such decks. Accordingly, a radix coded input signal applied to decode matrix **18** results in an output on a corresponding line of each set of output lines of decode matrix **18**, which output sets are represented as a single line in FIG. **1**.

The output of decode matrix **18** is applied as an input to optical crossbar switching means **19** for connecting a read-out line **20** to an addressed one of a matrix of data elements to be retrieved. As shown more particularly in FIG. **2**, the crossbar switch for a single deck of a matrix of, say, *nxi*–15×15 or 225 elements, is comprised of a line finder having a number (*i*) of photoelectric-responsive switches **22**, each having a switch control input **23** connected to a mutually exclusive one of the corresponding set of *i* outputs of decode matrix **18**, for excitation of a lamp or other light source **24** for operation of an associated photo-electric or light-responsive switching impedance **25**. Each of switches **22** is arranged such that each photoelectric impedance is adapted to respond to only its associated lamp. There is further provided in the arrangement of FIG. **2** a number *n* of column finder switches corresponding to the number of columns of the matrix. Each column finder **26** is comprised of a single lamp or light source **27** having a switch control input **28** connected to a mutually exclusive one of the corresponding set of n outputs of decode matrix **18**, and further includes a like plurality (*i*) of photoelectric switching impedances **29** as rows (*i*) of the matrix-to-be- served (*nxi*). Each switching impedance **29** is arranged to be commonly responsive to only the lamp **27** associated with such column finder switch **26**, and is connected in series with the corresponding switching impedance **25** of line finder **21**. In other words, the corresponding switching impedance **29** of each column finder is commonly connected in series with an associated one of the line finder switching impedances. Thus, a first terminal of each of line finder switches **25** is commonly connected to read-out line **20**, while a first terminal of a like switching impedance **29** of each of column finders **26** is commonly connected to a second terminal of a corresponding one of the line finder switches **25**, a second terminal of each of column switches **29** being adapted to be connected to a mutually exclusive element of a storage matrix of data elements-to-be-retrieved.

In normal operation of the arrangement of FIG. **2**, the concomitant excitation of one of line finder lamps **24** (by application of a source of excitation to the control line **23** of such single lamp) and one of column finder lamps **27** (by application of a source of excitation to the control line **28** of such single lamp), results in the closure of a corresponding set of line finder and column finder switches, as to interconnect line **20** (or an addressing terminal thereof) to the selected matrix element corresponding to such concomitant line and column excitation. Accordingly, the arrangement of FIG. **1** may be alternatively represented as shown schematically in FIG. **3** in which a line finder **21** and plurality of column finders **26***a*–**26***n* represent the optical crossbar switching means **19** of FIG. **1**. Because such optical crossbar switching means employs no moving parts, solid state circuits maybe employed in a high density packaging arrangement to provide a high-speed, compact and reliable assembly.

Although the optical crossbar switching means of FIG. **2** has been described in terms of photocell elements such as cadmium sulfide cells excited by incandescent lamps, the device is not so limited and other types of arrangements may be used for excitation of the photoelectric elements. For example, electroluminescent phosphor panels maybe used for such excitation; an integrated assembly may formed as a suitable three-layer deposition of electroluminescent phosphor, silver pattern and cadmium sulfide on a substrate.

The organization of resolver **17** (of FIGS. **1** and **3**) to convert the serially pulse coded address to a radix coded input to the decode matrix is shown more particularly in FIG. **4**.

Referring to FIG. **4**, there is illustrated in further detail a block diagram of the cooperation of the resolver and decode matrix elements of FIGS. **1** and **3**. The decode matrix is shown as comprising system column finder decode matrix **30** for providing an output on an appropriate one of a matrix column selector line (lines **28** in FIG. **2**) in response to a radix-10 coded address, provided by the units, tens and hundreds register **31**, **32** and **33** of the resolver. The decode matrix further comprises an optical divider matrix **34**, responsive to registers **31**, **32** and **33** for exciting an appropriate one of the line finder lines (lines **23** in FIG. **2**).

The registers **31**, **32** and **33**, cooperate with logic means to store the radix-10 coded address which is employed by the decode matrix elements **30** and **34**, the radix coded address being applied as a pulse-coded input to an input terminal **35** of an input circuit **36**. Such input pulses, coupled with preselected output thresholds of input circuit **36** provide a combination of radix counts on a first output line **37** and radix order shift signals on a second output line **38**.

A frame counter **39** or shift register is responsively coupled to the radix order shift, or frame shift, output line **38** of input circuit **36** for providing an output on one of three output lines **40**, **41** and **42** corresponding to a successive radix order or frame number. (i.e. a successive one of the units, tens and hundreds frames.) Such output lines apply such signals as gate control inputs to mutually exclusive ones of coincident gates **43**, **44** and **45** for control of a a respective one of registers **31**, **32** and **33**.

The radix counting pulses (counter per frame) are applied by line **37** to each of the three coincidence gates **43**, **44** and **45**, while the gate control input on a successive one of lines **40**, **41** and **42** controls the appreciation of a successive set of counts per frame to the input of a successive one of registers **31**, **32** and **33**.

Also included in the arrangement of FIG. **4** are associated starting (or bias or enable) gates and a reset delay for resetting the registers at the end of an address/message interval (i.e., "-hangup").

The input circuit **36** (of FIG. **4**) which serves to distinguish the counts per frame from the frame counts in response to an applied serially radix-coded pulse count, employs selected combinations of thresholds and time constants to effect such

discrimination, as may be better appreciated from a more detailed block diagram of the input circuit (shown more particularly in FIG. 5) and a family of time histories of the response modes thereof (shown in FIG. 6).

Referring to FIG. 5, there is illustrated in block diagram form a preferred embodiment of the input circuit 36 of FIG. 4. There is provided a wave shape forming circuit 46 responsive to an applied pulse-modulated tone signal for providing a video detected output. The applied pulse-coded tone employs a series or bursts of pulses, each burst corresponding to a frame or radix order, and the number of pulses in each burst corresponding to a radix count per frame plus one more count. The extra pulse per frame is employed by the cooperation of input circuit 36 and frame counter 39 (of FIG. 4) to effect the frame count. For example, the number 120 may be represented by an initial absence of one period of carrier, such as 200 milliseconds; the absence of two periods of carrier; and, a terminal absence of ten periods of carrier, as depicted in FIG. 6*a*. The response of the video detector stage 46 (of FIG. 5) is depicted in FIG. 6*b* as being that of a clipped fast charge, slow-discharge type SCR switch circuit for which three general threshold levels are defined: a first or least level; a third or saturation level; and a second or intermediate level defined by the combination of pulse burst rate, saturation or third level and the discharge time constant. The discharge, or turn-off time of the switch is selected to be longer than two pulse intervals. A comparator circuit 47 coupled to detector stage 46 (of FIG. 5) and employing the first threshold level, cooperates with an output differentiator 49 for providing a delayed frame count pulse in response to the high, fast rise of the first pulse of each burst of pulses. Such threshold testing of the video detector output rate is shown by FIG. 6*c*, while the delayed unipolar pulse output of the comparator response is shown as FIG. 6*d*. A pulse circuit 48 responsively coupled to the output of detector 46 provides a unipolar pulse output (FIG. 6*e*) in response to the short pulse rises in the output of detector 46.

In other words, detector stage 46 is a switch that turns on very fast and turns off very slow in response to the presence or absence of a tone pulse input, while comparator 47 corresponds to a second switch, the state of which is responsive to the first level (FIG. 6B) of the output of switch 46 of FIG. 5 to provide a frame count pulse. Because of the slow turn-off speed of first switch 46, it remains on after an initial input pulse (of a burst or frame of pulses) until after the end of such burst, corresponding to FIG. 6*b*, whereby third switch 48 responds to the output level, as well as the subsequent output rates of change of switch 46 between the second and third levels (in FIG. 6*b*), to provide the pulse burst output of FIG. 6*e*.

A detailed circuit of the embodiment of FIG. 5 and utilizing a silicon controlled rectifier 50 or SCR in the fast turn-on, slow turn-off switch of block element 46, is shown in FIG. 7. Capacitive coupling is employed between stages in pulsing circuit 48, together with suitably poled shunt diodes and series input diodes, to effect a combination of DC blocking shorting of pulses of one polarity and transmission of pulses of another polarity, whereby only unipolar pulses of a preselected polarity are transmitted by pulse circuit 48. Pulse shaping circuit 47 is directly coupled to SCR 50 and interconnects pulsing circuit 49 to carrier-separator circuit 46 for providing a delayed frame count pulse.

A further description of a SCR circuit for separating the digitally encoded information from the carrier of a digitally encoded carrier is included at pages 138 and 140 of the January 1968 issue of the periodical "Electronic Design."

In the matrix decoder 18, the use of a data matrix comprising columns of 15 elements or lines each conveniently lends itself to diode matrix conversion from a radix-coded address of base 10. Referring to FIG. 8, for example, the column finder logic of block element 30 (of FIG. 4) for the first column (1–15) comprises a first OR gate 50′ (in FIG. 8) responsive to lines 1–9 of unit register 31 of FIG. 4, a first AND gate 51 responsive to the first OR gate 50′ and to a "not" (or 0) line of each of the ten's and hundred's registers 32 and 33 of FIG. 4, a second OR gate 52 responsive to the 0–5 lines of the unit register 31 of FIG. 4, a second AND gate 53 responsive to the second OR gate 52 and to a "1" line of ten's register 32 and to a "not" (or 0) line of hundred's register 33 (of FIG. 4). A third OR gate 54 responsive to AND gates 51 and 53 provides the first-column finder control signal.

Similarly, the logic for the second column may comprise a first OR gate 55 responsive to the 6–9 lines of units register 31 (of FIG. 4), a first AND gate 56 responsive to first OR gate 55 and to the "1" line of ten's register 32 (of FIG. 4) and to the "not" (or 0) line of the hundred's register 33 (of FIG. 4), a second OR gate 57 responsive to the 0–9 lines of the units register, a second AND gate 58 responsive to second OR gate 57 and to the "2" line of the ten's register and the "0" line of the hundred's register, and a third AND gate 59 responsive to the "0" line of the unit's register and the "3" line of the ten's register and the "0" line of the hundred's register. A third OR gate 60 responsive to the three AND gates 56, 58 and 59, completes the column finder logic for the second column (16–30) of the matrix.

By a parity of reasoning, the arrangement of the column finder logic for successive columns may be determined. Further, although only a limited size matrix (of less than 100 elements) is employed in the column finder logic of FIG. 8, it is to be distinctly understood that larger matrices involving a larger number of columns of 15 elements each is contemplated.

The line finder logic of block element 34 (of FIG. 4) may involve a separate OR gate for each of the fifteen lines, as shown more particularly in FIG. 9, each OR gate being responsive to a plurality of AND gates, for determining the line number or remainder number left over after dividing out, or subtracting an integer multiple of 15's from the radix-10 coded address. For example, the logic for line 1 may (as shown in FIG. 9) comprise an OR gate 55 responsive to a plurality of AND gates 56, each AND gate indicative of a mutually exclusive one of the numbers 1, 16, 31, 46, 61, 76, 91, 105, up to $(i \times 15+1)$, where i is an integer including zero, which numbers are provided by combining the appropriate outputs of the units, ten's and hundred's registers 31, 32 and 33 of FIG. 4.

Similarly, the line finder logic for line 2 (of the data matrix) comprises an OR gate 57 responsive to a plurality of AND gates 58, each AND gate responsive to a mutually exclusive one of the numbers 2, 17, 32, 47, 62, 77, 92, 106, up to $(i \times 15 +2)$. By a parity of reasoning, the arrangement of the line finder logic for successive lines may be determined.

Of course, it is possible to reduce the number of logic stages involved for such purposes, as illustrated in FIG. 10. By a judicious use of OR gates, logic inputs commonly combined with a like logic function may themselves be combined to effect a net reduction in the total number of logic elements required, while yet being able to handle a larger number of columns (i.e., a larger matrix).

Accordingly, a data retrieval system has been described which lends itself to solid state circuit techniques and which employs no electromechanical elements in the data matrix retrieval means.

We claim:

1. Electronic data matrix retrieval means employing optical crossbar switching, with the matrix addresses in a digital code comprising at least three digits, and comprising:

resolver means adapted to be responsive to a radix-10 type pulse coded dialing tone signal for providing 10 point count per frame, and having radix 10 frame count output signal lines corresponding to 10^n, 10^1, 10^0 of a radix 10 coded address of at least three digits;

matrix decode means for converting said radix-10 coded address to a line select and column select output pair corresponding to the matrix address of a stored data element in a data storage matrix; and

photo electric crossbar switching means having sets of addressing terminals and terminals to be addressed and responsive to said line select and column select outputs of said matrix decode means for interconnecting a selected addressed terminal set with a preselected addressing terminal set.

2. Electronic data matrix retrieval means for a matrix having digitally coded addresses with at least three digits, and comprising:

resolver means adapted to be responsive to a preselectively radix coded pulse coded address of at least three digits for providing serial output lines corresponding to a radix count per frame and frame count corresponding to r^n, r^1, r^0,

matrix decode means responsive to said resolver for converting said radix-coded address to a set of concomitant decode outputs corresponding to the matrix address of a selected stored data element of a data storage matrix; and

photo electric crossbar switching means responsive to said matrix decode means for interconnecting a selected set of addressing and addressed terminals, said addressed terminals being selected from a plurality of terminals corresponding to the elements of said data storage matrix.

3. Photoelectric optical crossbar switching means for selecting a given element in a matrix of decks of lines and columns of elements and each deck comprising:

a column finder having a first plurality of columns of photoelectric responsive switching means, said first plurality corresponding to the number of columns of each deck of said data matrix;

each said column of photoelectric responsive switching means comprising a single switchable light source and a second plurality of photoelectric responsive switches commonly responsive to said light source, said second plurality corresponding to the number of lines in each deck of said data matrix; and

a line finder comprising a like plurality of switchable light sources as said second plurality of photoelectric responsive switches, and further comprising a corresponding plurality of associated photoelectric responsive switches, each associated switch being responsive to a mutually exclusive light source of said second plurality of light sources, a like terminal of each said line finder switches being commonly connected to form an addressing terminal, like switches of each column of switches being commonly connected in series with a preselected one of said line finder switches, whereby the concomitant excitation of a mutually exclusive one of the line finder light sources and a mutually exclusive one of the column finder light sources results in the interconnection of said addressing terminal and an addressed terminal.

4. Photoelectric optical crossbar switching means for selecting a given element in a matrix of rows and columns of elements and comprising:

a first and second plurality of separately excitable light sources corresponding to the respective number of rows and columns of said data matrix,

a like plurality of photoelectric responsive line finder switches as said first plurality of rows of said matrix, with each line finder switch in an electric circuit separate from and electrically isolated from said light sources and responsive to a mutually exclusive source of said first plurality of light sources, and

a like plurality of sets of photoelectric responsive switches as said second plurality of columns of said data matrix, each set having a like number of switches as said number of rows of said matrix and each set of switches being responsive to a mutually exclusive source of said second plurality of light sources, a corresponding switch of each set of switches being commonly connected in series with a mutually exclusive one of said line finder switches, with each of said switches in an electric circuit separate from and electrically isolated from aid light sources.

5. In a data retrieval system for operation with a source of radix-coded pulse code addresses to connect an addressed terminal of a data matrix to an addressing terminal, where the terminal address comprises at least three digits, the combination of:

a resolver having an input responsive to a radix-coded serial pulse code address which corresponds to the matrix address of a data element to be retrieved, and providing $n+1$ output sets radix-coded r^n, r^1, r^0, with an output set corresponding to a digit of the terminal address and with n at least 2, with an output signal on a line of each output set corresponding to the radix-coded address of said data element;

a decode matrix having said output sets of said resolver as an input and having a line output set and a column output set corresponding to the rows and columns, respectively, of said data matrix, said decode matrix providing outputs on a line and column output pair corresponding to the address in said data matrix of said input serial pulse code address; and

a photoelectric crossbar switching unit having a plurality of addressed terminals corresponding to data elements and having said decode matrix line and column output sets as inputs and responsive to outputs on a line and column pair for connecting a selected addressed terminal to the addressing terminal.

6. In a data retrieval system for operation with a source of radix-coded pulse code addresses to connect an addressed terminal of a data matrix to an addressing terminal, the combination of:

a resolver having an input responsive to a radix-coded serial pulse code address which corresponds to the matrix address of a data element to be retrieved, and providing $n+1$ output sets radix-coded r^n, r^1, r^0, with n at least 2, with an output signal on a line of each output set corresponding to the radix-coded address of said data element;

a decode matrix having said output sets of said resolver as an input and having a line output set and a column output set corresponding to the rows and columns, respectively, of said data matrix, said decode matrix providing outputs on a line and column output pair corresponding to the address in said data matrix of said input serial pulse code address; and

a photoelectric crossbar switching unit having a plurality of addressed terminals corresponding to data elements and having said decode matrix line and column output sets as inputs and responsive to outputs on a line and column pair for connecting a selected addressed terminal to the addressing terminal, said crossbar switching unit including:

a first plurality of separately excitable light sources corresponding to the number of rows of said data matrix with said decode matrix line output set connected thereto in driving relation;

a second plurality of separately excitable light sources corresponding to the number of columns of said data matrix with said decode matrix column output set connected thereto in driving relation;

a corresponding first plurality of photoelectric responsive line finder switches, each line finder switch responsive to a mutually exclusive source of said first plurality of light sources; and

a corresponding second plurality of sets of photoelectric responsive switches, each set having a like number of switches as said number of rows of said matrix and each set of switches being responsive to a mutually exclusive source of said second plurality of light sources, a corresponding switch of each set of switches being commonly connected in series with a mutually exclusive one of said line finder switches.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,678,459 Dated July 18, 1972

Inventor(s) Arthur J. Grolitzer and Francis E. Mounts

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

Title page, Column 2: "Attorney-Harris, Kiech, Russel & Kern" should read --Attorney-Harris, Kern, Wallen & Tinsley --.

Column 1: Line 11, "eduction" should read --education--;

Lines 62-75 should appear as shown below:

Column i	1	2	3	4	5	6	7	8
Row n	1	16	31	46	61	76	91	106
	2	17	32	47	62	77	92	107
	3	18	33	48	63	78	93	108
	4	19	34	49	64	79	94	109
	5	20	35	50	65	80	95	110
	6	21	36	51	66	81	96	111
	7	22	37	52	67	82	97	112
	8	23	38	53	68	83	98	113
	9	24	39	54	69	84	99	114
	10	25	40	55	70	85	100	115
	11	26	41	56	71	86	101	116
	12	27	42	57	72	87	102	117
	13	28	43	58	73	88	103	118
	14	29	44	59	74	89	104	119
	15	30	45	60	75	90	105	120

Column 2: Lines 6, 7, "k(i n)" should read --k(i x n)--.

Column 3: Line 12, after "say" insert --ten--.

Column 6: Line 37, "the" should read --a--.

Column 8: Line 1, "aid" should read --said--.

Signed and sealed this 27th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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