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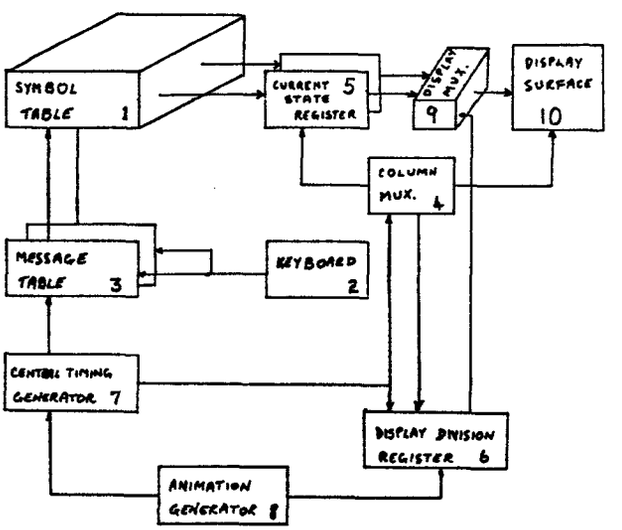
(54) Improved display method and apparatus.

(57) The present invention discloses a method and apparatus for displaying a moving graphic on a display surface formed from columns of lights. The columns of lights are arranged in two or more intermingled sets and the graphic is divided into a corresponding number of parts each of which is resolved into dot elements. The dot elements of a part of the total graphic are displayed only by the lights of the corresponding set. The dot elements are displayed in a predetermined sequence of display state periods only by those lights which for each period have the correct location given the shape of the part of the graphic and the intended motion of that part.

The invention enables animation to take place since parts of the graphic can move differently. In addition, colour mixing is possible as is a reduction in the number of lights reguired for a given resolution.



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"IMPROVED DISPLAY METHOD AND APPARATUS"

It has long been known that it is possible to create the illusion of smooth motion by displaying graphics in a sequence of positions, the full graphic being displayed at each position in the sequence just as it would be if displayed so as to appear stationary. The timing or rate at which the sequence is presented converts the stationary image to a moving image. The illusion of smooth motion is known to those skilled in the art as apparent motion. The technique of displaying the graphic in each of a sequence of positions is known as stroboscopic display. This term is used because of an analogy to the stroboscope which emits brief bursts of light at constant periodicity, thus seeming to arrest the motion of an object which is in true motion. The method of stroboscopic display is widely used in illuminated signs and strip displays to create the illusion of messages or other graphic representations in smooth motion.

In the standard application of the method of stroboscopic display, the display surface must be packed with display lights or display elements to a density which is determined by the resolution required both in the horizontal direction and in the vertical direction of the display surface. Thus, for example, if the graphics to be represented or displayed are built up on a 7 by 5 matrix format (that is a rectangular matrix of elements made up of 7 rows and 5 columns) then the display surface must be made up from blocks of display elements of identical format. Therefore graphics may be represented or displayed by selecting those lights within the 7 by 5 matrix which compose the graphics as stationary patterns on a two dimensional surface. A graphic is then displayed first in one block of matrix then in each of successive available blocks (which may or may not be overlapping) according to a timing sequence which has been predetermined. This timing sequence will create the illusion that the graphic is in smooth motion along the display surface. The time duration for which a given graphic is displayed at one given block or matrix is called "a display state period".

It is the object of the present invention to provide a method and apparatus for displaying a graphic, which are different from those used previously and which give rise to various advantages to be discussed hereinafter.

According to one aspect of the present invention there is disclosed a method of displaying a graphic on a display surface and moving said graphic over said surface wherein said display surface comprises columns of display elements arranged perpendicular to the intended direction of motion, the spacing between said columns being greater than or equal to the required resolution of said graphic in the direction of motion, and said columns being grouped into at least two mutually exclusive sets with the columns of each set intermingled; said method comprising the steps of resolving said graphic into discrete dot elements of the required resolution; dividing said dot elements into groups each forming a part of the total graphic such that the dot elements of each group have a predetermined spatial relationship and each group corresponds to one of said sets; and displaying the dot elements of each group by the display elements of the columns of the corresponding set, the dot elements of each group being displayed in a sequence of predetermined display state periods only by those display elements which, for each said period, have a location corresponding to said spatial relationship and the intended motion of the part of the total graphic corresponding to that group.

According to another aspect of the present invention there is disclosed apparatus for displaying and moving a graphic, said apparatus comprising a display surface having columns of display elements arranged perpendicular to the intended direction of motion, the spacing between said columns being greater than or equal to the required resolution of said graphic in the direction of motion and said columns being grouped into at least two mutually exclusive sets with the columns of each set intermingled; and control means to individually and selectively activate the display elements of each set for a predetermined display state period in accordance with a predetermined

sequence.

By following a principle of congruence it is possible to break the linkage between the resolution required for the graphic and the packing of display elements to a corresponding density both in the horizontal direction and in the vertical direction. By breaking this linkage it is possible to achieve a reduction in the density of display elements (and thus in the number of display elements) in the direction along which the graphic progresses in successive display state periods and along which motion is seen to occur.

According to the principle of congruence matrices overlap in a continuous rather than a discrete manner. A graphic to be represented is arranged in suitable dot matrix form having columns and rows, and appropriate cells of the matrix being either empty or occupied to give the shape of the graphic. Normally there is a one-to-one correspondence between the cells and the display elements. A graphic is advanced for each display state period by one small step, corresponding in size to the finest resolution required within the graphic. Within each display state period, all those dot elements of the graphic are displayed which are currently aligned with, or in congruence with, available display elements. Each block of 7 by 5 display elements, to use the example referred to above, may, by this principle, be reduced to a single strip of seven display elements arranged in a column, or otherwise arranged within the cells of the matrix block, one in each row and 4/5 ths of conventional display elements are eliminated. So long as the display sequence proceeds in accordance with the principle of congruence on each display state period, and provided the timing is correct, the observed resolution of the graphic will not be altered by the reduction in the number of display elements.

In practice the best perceived optical effects are obtained by using timing which ranges from 3 to 6 mSec per display state period for a sign to be viewed from a distance of up to 100 feet (30 metres). There is no

absolute time parameter, rather it is a relative parameter dependent upon the size of the display element and the spacing between the columns on the display surface.

In effect what is achieved by the principle of congruence is the substitution of the dimension of time for one of the two spatial dimensions. A given display element is switched on and off in time in a manner determined by the graphic image as it passes the co-ordinates (locations) of the display element. Fine modulation of the timing, or rate at which display lights are illuminated, in accordance with the principle of congruence, substitutes for fine packing of display elements in the dimension along which motion progresses. Therefore an observer perceives the graphic to have a spatial resolution in the direction of apparent motion according to modulation of the display elements in time, not to the physical spacing of the display elements in that direction.

In effect the viewer is caused to see display elements on a display surface where no real display elements physically exist, so long as substantially all display elements which may become active, are activated within every display state period on which any dot element of the graphic to be displayed is aligned with, or, in other words, in congruence with, the co-ordinates of a display element.

According to one embodiment of the invention, when two or more patterns, or two or more elements of the one pattern, are displayed according to the method of stroboscopic display so that they follow a common trajectory, as hereinafter explained, then they will appear to move along together occupying the same horizontal position at all times, even though they are never displayed together in the same horizontal position (assuming motion is in the horizontal direction). In this connection it is to be understood that apparent vertical motion is able to be achieved by operating on rows rather than on columns.

According to a further embodiment of the invention, when two or more patterns, or two or more elements of the one pattern, are displayed according to the method of stroboscopic display so that they follow parallel, but

different trajectories, then they will appear to move along together, separated in, say, horizontal positions at all times by the difference in their trajectories, even though they may be displayed in the same places or in different places.

In accordance with an additional embodiment of the invention, when two or more patterns, or two or more elements of the one pattern, are displayed according to the method of stroboscopic display so that the separation between their trajectories changes with time, then they will appear to move along together, and the separation between their, say, horizontal positions will change with time, corresponding to the change in the separation of their trajectories. Thus one or more patterns, or pattern elements, can be made to appear to be in, say, horizontal motion relative to another pattern, or other patterns, or pattern elements. In this way it is possible to achieve one of the two necessary components of animation, namely the relative motion of graphics, or parts of graphics, along one of the two dimensions of a two dimensional display.

Furthermore, each of the embodiments above may be modified so that each pattern, or each part of a pattern, may be displayed only on a category of display elements designated for the display of that pattern, or part of a pattern, and not for the display or representation of other patterns or parts of a pattern. Thus while a pattern or parts of a pattern are moving across a display surface, certain display elements designated as belonging to a given category corresponding to a different pattern are not activated even when in congruence with the dot elements of the moving pattern or moving parts of a pattern. It is nevertheless possible, while violating the principle of congruence in this way, to achieve a marked reduction in the number of required display elements as is also achieved when the principle of congruence is strictly obeyed.

In addition, in accordance with another embodiment, identical patterns, or identical parts of patterns, may be displayed, each in a different colour, with the result that

the colours will combine according to long established principles of additive colour mixture, so long as the identical patterns, or identical pattern parts, displayed in different colours follow a common trajectory. This effect can be achieved without having the colours to be combined switched on simultaneously or focused onto a common region, rather the colour mix is performed by appropriate timings.

In accordance with another embodiment, if different categories of display elements are offset so that they overlap the positions of display elements in the other columns like overlapping seats in a theatre, and if separate parts of the one graphic are displayed separately on either odd or even columns, the resolution in the vertical direction may be doubled, leading to at least a fourfold gain in total resolution of the graphic as a whole.

In a still further embodiment, if different groups of display elements comprise different sizes then it is possible to mix a finer with a coarser resolution in the graphic to be displayed. Preferably the display elements comprise an active light source such as incandescent bulbs, LED's, liquid crystals, and the like. However, passive sources such as replacing elements can also be used.

Furthermore, the effects described above are not confined to regular or level shapes or surfaces but will also occur on irregular surfaces, (irrespective of the shape of the display) occupying more than one plane in space. Thus if we have two categories of display elements, both categories can occupy the same plane and may exist in any shape such as rectangular or even a circle or a square. But it is also possible that one category of display elements can be on a plane closer to the viewer than the other category. The viewer then sees a graphic with three dimensional qualities, that is a graphic having the illusion of depth. It is possible to have three, or more, categories each on a different plane to create a more complex three dimensional effect. Both categories may be in the same plane or planes such as an irregularly corrugated surface so that display elements for each category occur

both in the troughs and crests of the corrugated surface resulting in an undulating pattern being seen by the viewer.

Thus it is possible to display patterns, or parts of patterns, so that they will combine and appear to move along together, in a desired direction, to change this arrangement if required so as to make the pattern or pattern parts appear in relative motion, or animation, and combining colours according to the laws of colour mixture, despite the fact that the different patterns, or parts of patterns, are displayed on display elements which are physically separated on the display surface, and despite the fact that the whole of any component pattern need never be displayed within a display state period.

Embodiments of the present invention will now be described in detail with reference to the drawings in which:

Fig. 1 is a graph of horizontal position co-ordinate versus time and illustrates the principle of trajectories,

Fig. 2 illustrates one arrangement of a display surface,

Fig. 3 is a block diagram of the preferred embodiment of the display apparatus of the present invention,

Fig. 4 illustrates one arrangement of the dot elements forming the letter "T",

Figs. 5 and 6 illustrate another arrangement of the dot elements of Fig. 4,

Fig. 7 shows in detail part of the display surface 10 of Fig. 3, and

Fig. 8 illustrates one arrangement of the dot elements forming the letter "H".

The term "trajectory", used in the foregoing description, as it applies to patterns which appear to be in motion, though in fact are displayed stroboscopically, will now be explained with reference to Figure 1 of the drawings.

Figure 1 illustrates 3 trajectories labelled A, B, and C. Each trajectory connects a horizontal

co-ordinate value X, to a time value t. An object following the trajectory labelled A would be in position X1, at time t1, position X2 at time t2, and so on. A pattern in apparent motion is said to follow trajectory A if it is displayed stroboscopically at the position X, prescribed by trajectory A at the time t, at which it is displayed.

Suppose now we have two patterns, a rectangle and +. Suppose the rectangle is displayed at time t1 in position X1, at time t3, in position X3, and so on. Suppose also that + is displayed at time t2 in position X2, at time t4 in position X4, and so on. Then both the rectangle and + follow a common trajectory, the trajectory labelled A, and, according to our discovery, both will appear to travel together, with + inside the rectangle, despite the fact that each is displayed in positions which do not overlap.

An analogy may be drawn between the rectangle pattern and a picture frame, and pattern + and a picture to be viewed within the frame. By following the principle of common trajectories the picture frame rectangle and the picture + may be displayed always in different places, i.e., the picture may precede the frame or vice-versa. By any other means, and especially when the principle of congruence is obeyed, picture and frame must be shown simultaneously together in the same place.

Trajectory B is parallel to trajectory A, their separation being dX. If the rectangle were displayed on trajectory A and + on trajectory B, then the rectangle and + would appear at all times to be separated by a horizontal distance dX, even though they might be displayed in the same position, X3 say, at different times, t1 and t3.

Trajectory C is not parallel to trajectory A. If the rectangle were displayed on trajectory A, and + on trajectory C, then the rectangle and + would appear to diverge progressively, their separation changing as the separation between the trajectories changes.

Any horizontal co-ordinate value, X3 say, may represent the position of a display element in the horizontal direction. Several display elements, arranged in

a vertical strip, for example, may occupy the same co-ordinate value. If X3 is the horizontal co-ordinate value of a display element within the vertical strip designated to describe the trajectory of a pattern, or part of a pattern, then the display element will be switched on at the start of any display state period on which the trajectory of a dot element of a pattern, or a part of a pattern, dictates that it should do so. The display element will be switched off when that display state period is completed.

Since it is the trajectories of patterns in apparent motion which determine their apparent horizontal position, patterns displayed by display elements in different positions on a display surface may be made to appear to occupy the same position in space, like a picture within its frame. Thus, it is possible to designate some display elements to display one pattern, or part of a pattern, other display elements to display another pattern, or part of a pattern, still others to display another pattern, and so on. The spatial relationship of the various patterns, or parts of patterns, will depend solely on their trajectories, and will be independent of the spatial placement of the designated categories of display elements on the display surface.

One possible arrangement of display elements, in two designated categories, is shown in Fig. 2. Display elements are arranged in strips. All display elements in the columns labelled A are designated to display patterns in category A, and all display elements in the columns labelled B are designated to display patterns in category B. The horizontal co-ordinate values (X1, X2, and so on) are identical for all display elements in a given strip. All category A display elements have a different horizontal co-ordinate value from the category B display elements. Suppose the rectangle pattern is in category A. Each dot element of the rectangle pattern can be described as following its own trajectory. Display elements on strips A1, A2, and so on will turn on for the display period, as the trajectory of each dot element of the rectangle pattern

dictates.

Similarly, each dot element of pattern + has its own trajectory. Display elements on strips B1, B2, and so on will turn on for the display period as the trajectory of each dot element of pattern + dictates. If the trajectories of the rectangle and + are chosen appropriately, + will appear to move along inside the rectangle at all times, despite the fact that the one affects only the A display elements and the other only the B display elements.

Many other arrangements of display elements are possible other than the two category case. The number of categories of display elements may be extended. Patterns in separate categories, displayed only on display elements in the category designated for each pattern category, can be extended in number by arranging the trajectories for the patterns in an appropriate manner, according to the principles outlined above.

In all moving displays constituted of lights of display elements there are two main variables (i) the arrangement of the lights or display elements on the display surface and (ii) the arrangement of the data for the graphic to be displayed and the manner in which this data is presented to the display elements or lights.

This invention is unique in respect to the first variable in that the lights or display elements are divided into categories such that no two categories need ever depict the same data. In the prior art, such as U.S. Patent Application No. 757,734 consecutive matrices, or perhaps consecutive columns spaced apart, present the same data when depicting a given constant graphic in motion. The term "constant graphic" means that the shape and configuration of the graphic does not change with time, that is the graphic is not animated. (Whether the display element or lights are in matrix form or columns spaced apart or any such arrangement is inconsequential). The display surface in this invention is inhomogeneous with respect to the grouping of display elements, other devices are homogeneous in this regard. This is particularly important in

relation to the colour-mixing aspect of the present invention since a group of 3 primary colour light sources need not be located at each display element location.

In respect to the second variable above, this invention is also unique. In the prior art, U.S. Patent Application No. 757,734 relating to the display of a moving message, the temporal and spatial presentation of the graphic is such that those dot elements of the graphic occurring spatially before other dot elements in the desired direction of movement are presented prior to those other dot elements either in space, or time, or both. In this invention the graphic is segmented and the data are presented to the display elements without regard for spatial or temporal priority. (Thus, if we want to present this graphic comprising a + in a rectangle, we can present the whole of the rectangle on the first category of display elements then the + on the second or vice-versa). For spatial and temporal presentation, the trajectory principle, or the above described variations thereof, is applied while the total graphic does not obey the sort of temporal and spatial priorities present in the prior art. Although parts of the total graphic may obey such priorities, by virtue of so doing alone they do not contribute to the overall effect.

The present invention will be better understood by reference to the following description of one specific embodiment schematically represented in Fig. 3.

The embodiment of Fig. 3 is a logical embodiment and may be implemented with either software and/or hardware by those skilled in the art.

A display surface 10 is made up of 64 columns of display elements which may be light emitting diodes (LED's). In each column there are 16 LED's. Between each column there is a blank space sufficiently wide to incorporate an extra three columns all juxtaposed. The columns of LED's are grouped into alternate categories. The 1st, 3rd, 5th, 7th, 9th, etc. columns form one category and the 2nd, 4th, 6th, 8th, 10th, i.e. the even numbers, form a second category.

Although the spatial separation of the columns can vary it is desirable, but not essential, that the spacing between columns of the same category be constant. It is of little consequence where the columns of the other category occur within the space between the adjacent columns of the same category. Thus the second column instead of being separated from the first by three blank columns could have been juxtaposed to the first column.

The information to be displayed is entered via a keyboard 2 or some other suitable input device. The message is stored in a message table 3 which is a memory such as a RAM (random access memory). There can be more than one message table, in fact as many tables as there are different messages. There can be as many message tables as there are categories of lights and each table is coded for a specific category of lights. This encoding is such that any message in that table can only be represented on a given category of lights.

Thus at the source of input e.g. a switch or keyboard 2, there must be a panel for the operator to designate which category of lights is to display a graphic character or segment thereof as explained below. Now each element, for example, a letter of the alphabet, of the message table is represented by a symbol stored in another part of memory called the symbol table 1 which may be a PROM or some suitable device e.g. a computer.

The symbol representing each element (such as a letter) may take different forms depending on the purpose of the user. Take for instance the letter T. Before a format for this letter is encoded and entered into the symbol table, artwork for it is prepared.

The artwork takes the form of a 16x16 dot matrix in accordance with the height of each display element column (16 LED's high) but other forms are possible depending on the configuration of lights on the display surface.

Fig. 4 represents such a 16x16 dot matrix with those cells composing the desired letter (T) indicated. The letter in this case is intact, or whole, but other forms are possible where the cells comprising the letter are divided into

categories or groups such as depicted in Figs. 5 and 6 where the two groups combine to form the whole.

The letter "T" can, of course, be divided into two (or more) complementary sections other than those depicted in Figs. 5 and 6.

The two treatments of the same graphic can be labelled as the "wholistic" vs. "atomistic" approach - whichever of the alternatives is selected depends on the purpose of the user. Suppose we want a display where the even letters were one colour and the odd letters a second colour. The two categories of lights are then made up of two different colours. The "wholistic" approach is used. Suppose the message were "THE QUICK BROWN FOX" with 2 consecutive blanks appearing between each word. The following sequence would appear on the first one category of lights: - H - - - Q - I - K - - - R - W - - - F - X; and on the second category would appear: T - E - - - U - C - - - B - O - N - - - O -. The latter sequence would be shown first and while the first blank time interval indicated "-" was being shown on the first and third columns the former sequence would begin and when the blank time interval was indicated the letter H would show on the second and fourth columns. By extrapolation it can be deduced how the two sequences become "interwoven".

This procedure may be better understood by considering how the letter "T" arranged in dot matrix form as illustrated in Fig. 4 and the letter "H" arranged in dot matrix form as illustrated in Fig. 8 are moved to the left over the right hand portion of the display surface 10 as illustrated in Fig. 7.

As seen in Fig. 7, the display surface 10 is made up of 64 columns of lights each of which contain 16 LED's. Only columns C1 to C4 inclusive (numbering from the right) are illustrated. Between each pair of adjacent columns is a space corresponding to the "width" of three columns. In this way only ¼ of the number of columns of lights are required compared to prior art displays having the same horizontal resolution. The lights of each column are located in one of 16 rows numbered (from the top) R1 to R16 inclusive.

In order to progressively display the "T" and "H"

of the message THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG, the LED's of the display surface 10 are activated in a controlled manner. Columns C1, C3 etc. display the letters "T", "E" etc. whilst columns C2, C4 etc. display the letters "H", "Q" etc. Selected LED's are activated for substantially all of a display state period. For a display state period of 5 mSec, for example, a given LED is initially off, turned on for 4.7 mSec and then turned off again, even if that particular LED is intended to be activated for 2 or more consecutive display state periods.

The sequence of operations to simultaneously display the "T" on columns C1 and C3 and display the "H" on columns C2 and C4 whilst moving these letters to the left along a horizontal or "row" trajectory is given below for the first 42 display state periods.

Display State Period	LED's activated		
1	-		
2	-		
3	C1 R1,2		
4	C1 R1,2		
5	C1 R1,2		
6	C1 R1,2		
7	C1 R1,2		
8	C1 R1-14		
9	C1 R1-14		
10	C1 R1,2		
11	C1 R1,2	C3 R1,2	
12	C1 R1,2	C3 R1,2	
13	C1 R1,2	C3 R1,2	
14	C1 R1,2	C3 R1,2	
15		C3 R1,2	
16		C3 R1-14	
17		C3 R1-14	
18		C3 R1,2	
19		C3 R1,2	
20		C3 R1,2	
21		C3 R1,2	
22		C3 R1,2	C2 R1-14

Display State Period	LED's activated	
23	C2 R1-14	
24	C2 R7,8	
25	C2 R7,8	
26	C2,R7,8	
27	C2 R7,8	
28	C2 R7,8	
29	C2 R7,8	
30	C2 R7,8	C4 R1-14
31	C2 R7,8	C4 R1-14
32	C2 R1-14	C4 R7,8
33	C2 R7,8	C4 R7,8
34		C4 R7,8
35		C4 R7,8
36		C4 R7,8
37		C4 R7,8
38		C4 R7,8
39		C4 R7,8
40		C4 R1-14
41		C4 R1-14
42		-

This sequence may be explained as follows:

For display state periods 1 and 2, the first portion of the "T" to be displayed (i.e. rows 1 and 2 of column 3 of Fig. 4) have not yet reached column C1. This occurs at display state 3 so that the LED's at rows 1 and 2 of column C1 are activated.

At display state period 4 the LED's at rows 1 and 2 of column C1 are again activated in order to correspond with rows 1 and 2 of column 4 of Fig. 4 and so on for display state periods 5, 6 and 7. At display state period 8, column 8 of Fig. 4 has "reached" column C1 of the display surface 10 so that the LED's of rows R1 to R14 are activated for this display period. Similarly, displays state periods 9 and 10 correspond to columns 9 and 10 of Fig. 4.

For display state period 11, the LED's of rows 1 and 2 of column C1 are activated because column 11 of Fig. 4 has "reached" column C1, however, column 3 of Fig. 4 has

simultaneously reached column C3 so that the LED's of rows R1 and R2 of column C3 are activated.

The procedure for display state periods 12, 13 and 14 is similar. For display state period 15 the "T" has "past" column C1 and so none of its LED's are activated. For display state periods 16 and 17 the stem of the "T" (i.e. columns 8 and 9 of Fig. 4) is passing column C3 and so on.

At display state period 22 that portion of the "T" corresponding to column 14 of Fig. 4 is displayed in column C3 whilst simultaneously the first portion of the "H" corresponding to column 4 of Fig. 8 is displayed at column C2. Each portion of the "H" is displayed in turn in the correctly timed sequence at columns C2 and C4 as indicated above and described in detail for the "T".

It will be apparent that at any given instant only part of the message is displayed, and that the part displayed is the part that has reached the location at which the relevant display elements are located. Furthermore, although columns C1, C3, etc. display at any given instant only a portion of one "half" of the message and columns C2, C4 etc. display at the same instant only a portion of the other "half" of the message, the viewer perceives the entire message in correct sequence.

If the user wanted the message to appear in a fused colour (i.e. a colour made by fusing the colours of each category) the complete message "THE QUICK BROWN FOX" would be fed in its entirety into both categories. A part of the "T" would first appear on column 1, then column 2, then column 3 and so on such that all three columns were displaying different parts of the "T" at a given display state period. In this example the timing relationship of column 2 to column 1 must follow the trajectory principle. On column 1 of lights graphic columns 123 and 4 of the dot matrix are displayed, each in turn, and for the same interval of time with the display state period being of fixed duration, say 5 mSec. After graphic column 4 of the dot matrix has shifted past column 1 of the LED's, column 2 of the LED's starts up. Column 3 of the LED's starts up when

graphic column 8 of the dot matrix clears column 1 of the LED's and so the message proceeds.

The symbol table 1 therefore is a repertoire of possible graphics to be displayed, pre-arranged in appropriate artform and encoded digitally for storage in the appropriate memory.

The symbol table 1 may be a single table accessible to all separate messages or there may be separate symbol tables for each message or a combination where there would be a common area (e.g. a set of letters) and other special tables (e.g. colour components of a picture). Thus wholistic letters may comprise one table and atomistic letters another table - there being a number of different atomistic approaches and each can have its own table.

In each table, each separate piece of artwork has an appropriate address which can be selected when needed by a pointer. In the message table 3 there is a condensed encoded set of pointers and these pointers select the appropriate symbol from the symbol table 1. The pointers are progressively selected in order to retract new symbols which are to appear on the display surface 10.

Once selected from the symbol table 1 the appropriate digitally encoded data are fed into the current state registers 5. This is another section of memory and there may be as many of these as there are message tables or categories of display elements. The symbols are held in these registers 5 in their entirety by which is meant all virtual and real points for the message. The distinction between "virtual" and "real" points is as follows:

On the display surface 10 there are actual and phantom columns e.g., column C1 of lights exists and is an actual column whereas the next three "columns" are phantom columns without lights. Now if a graphic were to occupy the first four columns on the display screen 10, the first three dot columns of the graphic moving from right to left occupy phantom columns of the display surface and therefore those points are called "virtual" that occupy that portion of the graphic. Those points of the graphic occupying the

fourth column are in congruence and will be represented by lights and are called "real" points. It is therefore never necessary to use all the data stored in the current state registers 5 in this embodiment.

The register 5 is continually updated from the symbol table according to the pointers in the message table(s) 3 at a rate determined by the central timing generator 7. The rate of update is not necessarily the same for each current state register 5 since the central timing generator 7 is controlled by the animation generator 8 which is discussed below. The central timing generator 7 synchronizes the operations of multiplexing the data out to the display surface 10 and updating the current state registers 5.

The display multiplexer 9 discriminate the real data in the current state register 5 from the virtual data and continuously multiplexes this real data out of the current state registers 5 onto the display surface 10. The manner of multiplexing can readily be understood by those skilled in the art.

The display multiplexer 9 selects the current state register 5 which is to supply data to the display surface 10. This latter multiplexer 9 is under the control of the display division register 6.

The display division register 6 contains the information relevant to the groupings of lights into categories on the display surface 10. This information is coded in the display division register 6 and preset by an operator once the categories are formed.

The column multiplexer 4 is continually feeding data to the light columns and "tells" the display division register 6 which column it is at and the display division register 6 then determines the category of lights relevant for the particular column. It selects via the display multiplexer 9 the data from the appropriate current state register 5.

The actual grouping of the lights on the display surface may be changed dynamically under the control of the

display division register 6. This change can be physical or mechanical but may also be a regrouping. Thus suppose the categories were (i) columns 1 3 5 7 9 and the ensuing odd numbers and (ii) columns 2 4 6 8 and the ensuing even numbers. The former category can be altered to 1, 5, 9, 13, etc., or even a new category 1 3 6 8 10 can be formed to give greater versatility and enhance animation. Within the constraints of a regular series of categories the "animation" control regulates the central timing generator 7 and the display division register 6. By adjusting the timing the appearance of motion, colour changes and differential motion effects can be generated. Suppose there are two graphic parts comprising a picture e.g., the rectangle and + and the former appears on one category and the latter on the second. If the two parts travel at the same speed the viewer will see an integration of + in the rectangle. For animation the data must be fed into the display surface 10 in parallel. Each column of the display surface 10 must be addressable separately at the animation generator 8 and the operator preset the timing for that column. By such an adjustment one graphic part can be made to appear to move faster than the other. Thus in the example above the + element can be made to appear to run ahead of the rectangle, drop back to the centre, then lag behind the rectangle and indulge in other antics across the surface of the display 10.

This description is relevant to animation in the direction parallel to the movement of the message. Motion in other directions is also possible. In the standard example given here + might appear above the rectangle, then inside the rectangle, and finally below the rectangle, then making an accedent motion. This type of animation can be achieved without the animation generator 8 or central timing generator 7. At the keyboard 2 is a set of buttons specifying the row of a column in which the graphic appears for the viewer. In the symbol table 1 in the artwork of each graphic element is a blank section above and below which can be added to or subtracted. The

row control buttons adds to, and subtracts from, the blank area surrounding the top and bottom of the graphic. The sequence fed into the message table 3 will contain step by step the animated sequence.

The foregoing described only some embodiments of the present invention and modifications, obvious to those skilled in the art, may be made thereto without departing from the scope of the present invention.

For example, a further refinement to the above-described embodiments, can be achieved with an intensity control for each category. The intensity control determines the duty cycle for the lights of each category during a display state period. This duty cycle can be variable while the display state period remains constant. Thus one element of a graphic can be lighter or darker than another element. In the case where the two categories are different coloured lights (or display elements) a great range of colour mixture is possible by varying the ratios of intensity for one colour relative to the other.

Claims

"IMPROVED DISPLAY METHOD AND APPARATUS"

1. A method of displaying a graphic on a display surface and moving said graphic over said surface wherein said display surface comprises columns of display elements arranged perpendicular to the intended direction of motion, the spacing between said columns being greater than or equal to the required resolution of said graphic in the direction of motion, and said columns being grouped into at least two mutually exclusive sets with the columns of each set intermingled; said method comprising the steps of resolving said graphic into discrete dot elements of the required resolution; dividing said dot elements into groups each forming a part of the total graphic such that the dot elements of each group have a predetermined spatial relationship and each group corresponds to one of said sets; and displaying the dot elements of each group by the display elements of the columns of the corresponding set, the dot elements of each group being displayed in a sequence of predetermined display state periods only by those display elements which, for each said period, have a location corresponding to said spatial relationship and the intended motion of the part of the total graphic corresponding to that group.

2. A method as claimed in claim 1 wherein the motion of at least one part of said graphic over said surface is different from the remainder of said graphic thereby changing the appearance of said graphic.

3. A method as claimed in claim 1 or 2 wherein the spacing between said columns is greater than one half the required resolution of said graphic.

4. A method as claimed in any one of claims 1 to 3 wherein said display elements comprise light sources of the same colour.

5. A method as claimed in any one of claims 1 to 3 wherein said display elements comprise coloured light sources, the display elements of each set being the same colour and having a colour different to all the remaining sets.

6. A method as claimed in claim 5 wherein at least some of the dot elements of one group are common with some

of the dot elements of at least one other group thereby causing parts of said graphic to overlap and resulting in the perceived colour of said graphic being the colour mixing resultant of said overlapping parts.

7. A method as claimed in any one of the preceding claims wherein the perceived intensity of the display elements of a set is different from the perceived intensity of the display elements of another set.

8. A method as claimed in any one of the preceding claims wherein the duration of each said display state period is approximately 5 mSec.

9. The method as claimed in any one of the preceding claims wherein some of said display elements are of a different size from the remainder of said display elements.

10. The method as claimed in any one of the preceding claims wherein the display elements in adjacent columns are staggered.

11. The method as claimed in any one of the preceding claims wherein the columns of each set are located in a plane parallel to, and spaced apart from, the plane(s) of the other set(s).

12. Apparatus for displaying and moving a graphic, said apparatus comprising a display surface having columns of display elements arranged perpendicular to the intended direction of motion, the spacing between said columns being greater than or equal to the required resolution of said graphic in the direction of motion and said columns being grouped into at least two mutually exclusive sets with the columns of each set intermingled; and control means to individually and selectively activate the display elements of each set for a predetermined display state period in accordance with a predetermined sequence.

13. Apparatus as claimed in claim 12, wherein said control means comprises memory means, input means connected with said memory means to enter and store in said memory means groups of data each representing dot elements into which one of the constituent parts of said graphic has been resolved, each of said groups of data corresponding to one of said sets, and output means interconnecting said memory means and

said display elements, the display elements of each set being individually and selectively actuated by the data of the corresponding group.

14. Apparatus as claimed in claim 13 wherein each group of data is stored in a corresponding independent memory storage area of said memory means.

15. Apparatus as claimed in any one of claims 12 to 14 wherein the spacing between said columns is greater than one half the required resolution of said graphic.

16. Apparatus as claimed in any one of claims 12 to 15 wherein the columns of one said set are regularly inter-spaced with the columns of the remaining set(s).

17. Apparatus as claimed in any one of claims 12 to 16 wherein said display elements comprise light sources of the same colour.

18. Apparatus as claimed in any one of claims 12 to 16 wherein some of said display elements comprise light sources of colour different from the remainder of said display elements.

19. Apparatus as claimed in any one of claims 12 to 18 wherein the intensity of the display elements of one set is different from the intensity of the display elements of another set.

20. Apparatus as claimed in any one of claims 12 to 19 wherein some of said display elements are of a different size from the remainder of said display elements.

21. Apparatus as claimed in any one of claims 12 to 20 wherein the display elements in adjacent columns are staggered.

22. Apparatus as claimed in any one of claims 12 to 20 wherein the columns of each set are located in a plane parallel to, and spaced apart from, the plane(s) of the other set(s).

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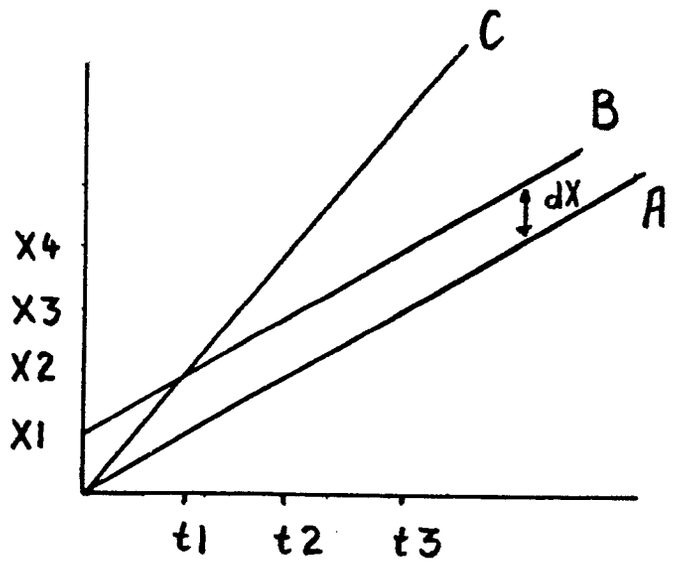

FIG. 1

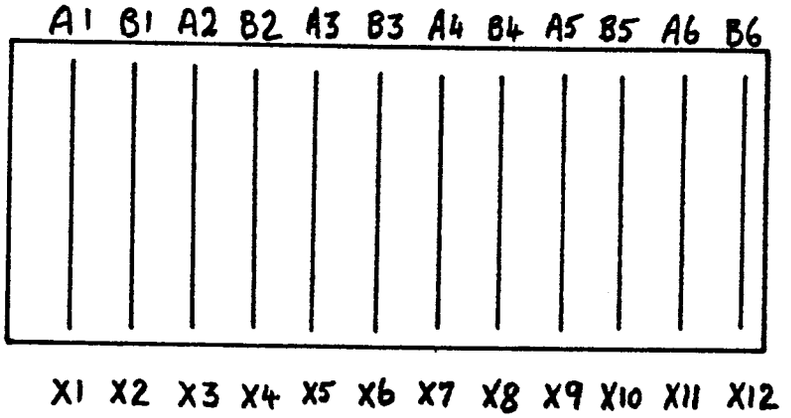

FIG. 2

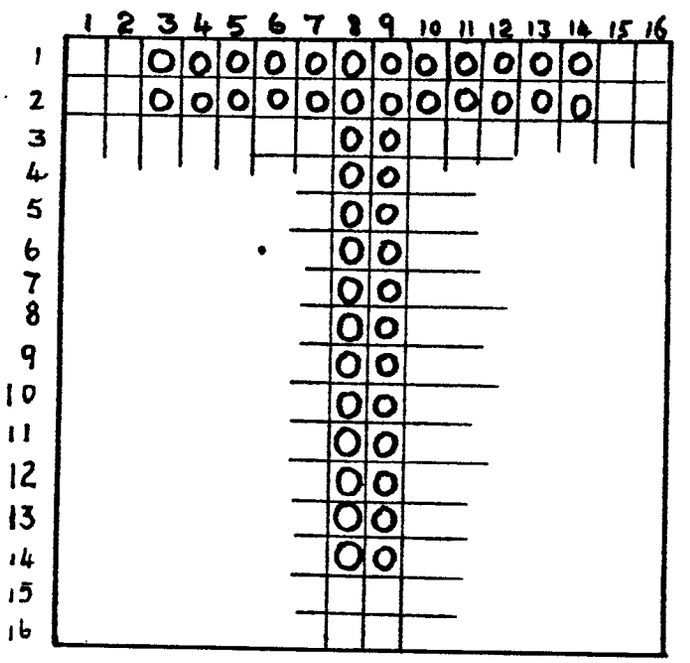

FIG. 4

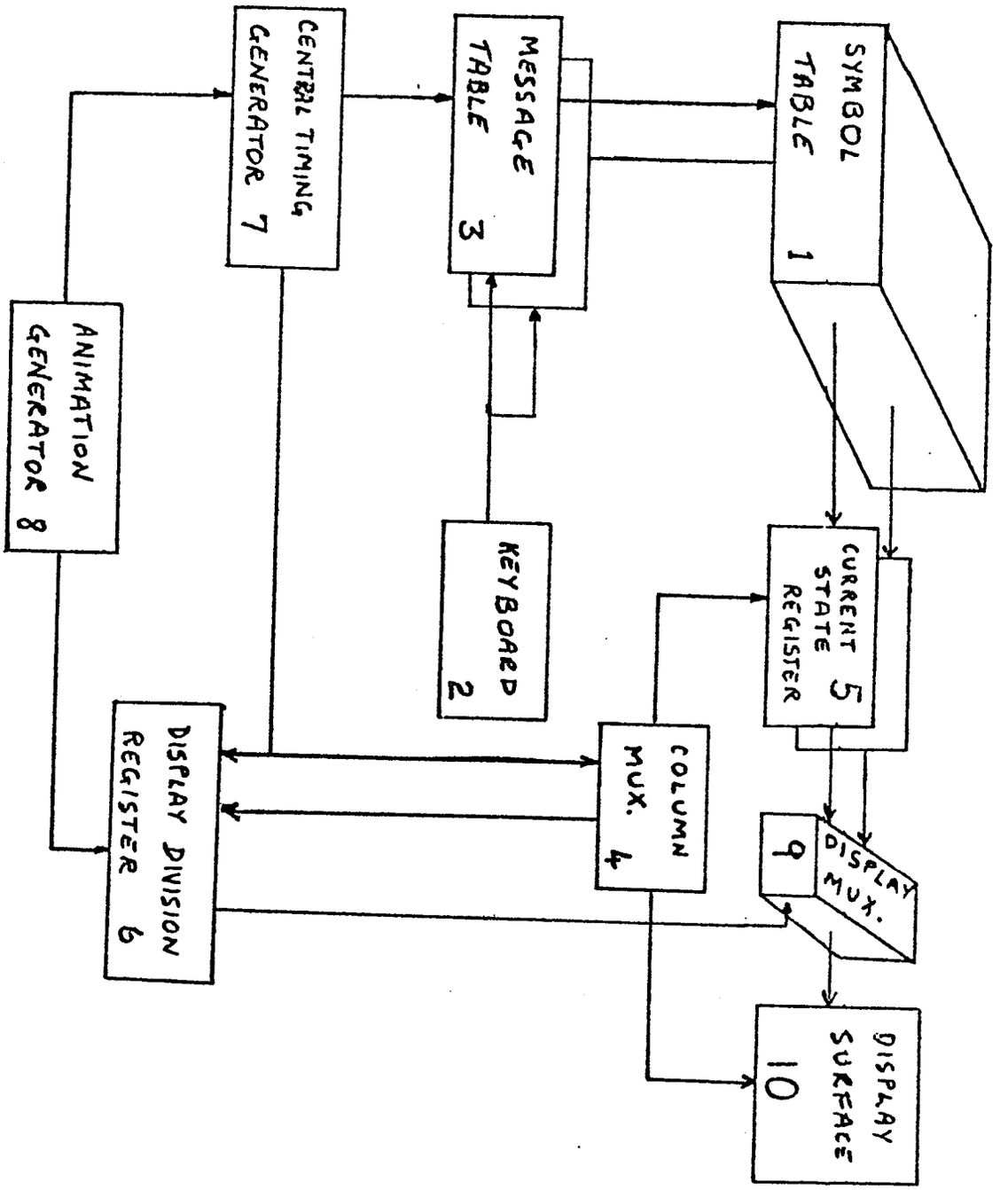
SYMBOL TABLE 1
MESSAGE TABLE 3
CENTRAL TIMING GENERATOR 7
ANIMATION GENERATOR 8
KEYBOARD 2
CURRENT STATE REGISTER 5
COLUMN MUX. 4
DISPLAY MUX. 9
DISPLAY SURFACE 10
DISPLAY DIVISION REGISTER 6

FIG. 3

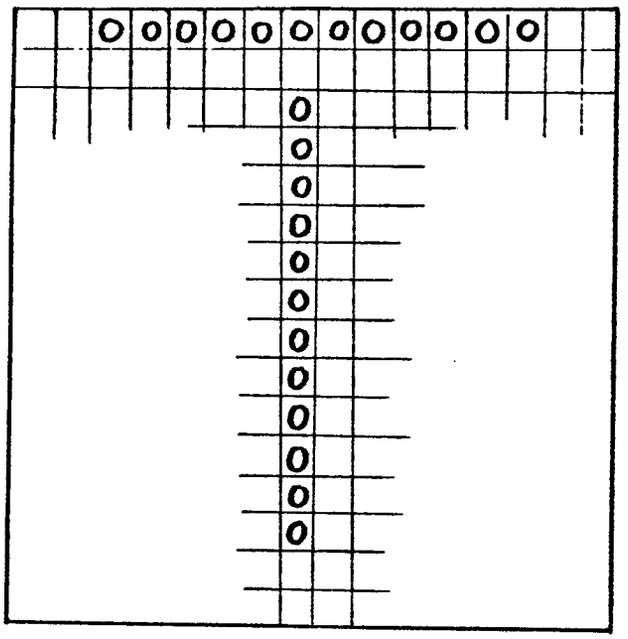

FIG. 5

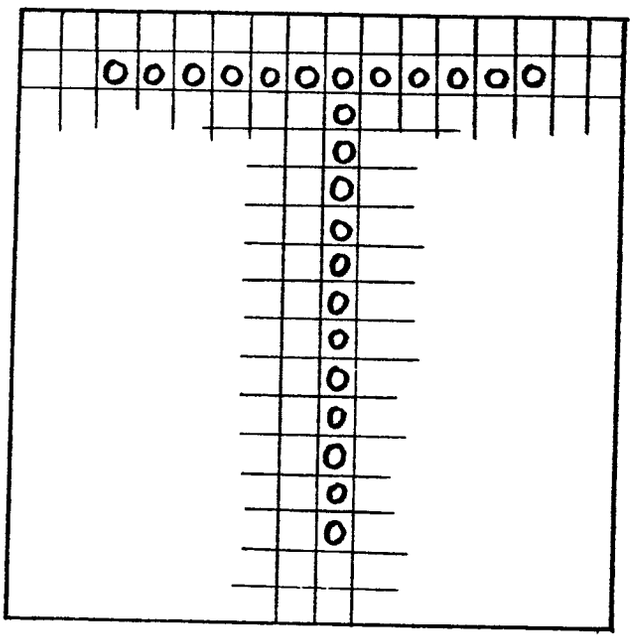

FIG. 6

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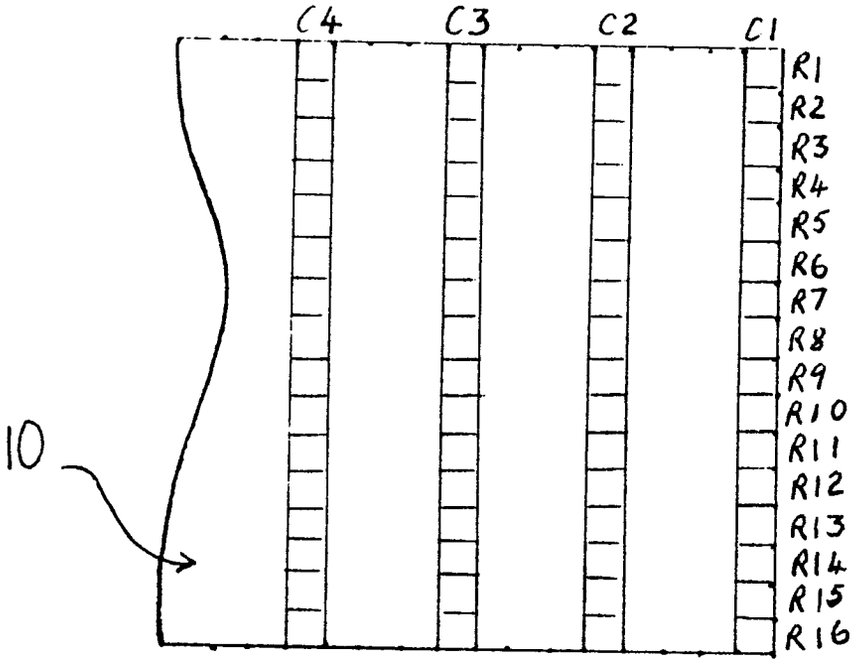

FIG. 7

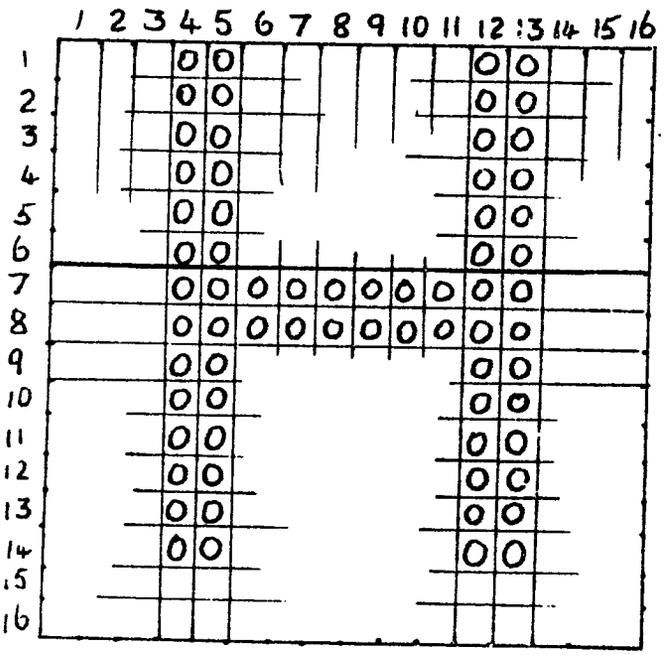

FIG. 8

European Patent Office

EUROPEAN SEARCH REPORT

0002966

Application number

EP 78 30 0918

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	FR - A - 2 338 541 (RANDOM ELECTRONICS) * Page 3, line 24 to page 4, line 10; page 4, line 29 to page 6, line 34; page 8, lines 9-11; page 9, line 22 to page 10, line 18; page 13, line 29 to page 14, line 19 and page 39, lines 23-26 *	1,3,4, 8,12, 13,15, 17
	DE - A - 2 049 335 (PHILIPS) * Page 2, line 11 to page 3, line 19 *	1,2,5, 18
	US - A - 3 999 179 (IBM) * Column 3, line 14 to column 6, line 8 *	1,4,10 12,13, 21

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

G 06 F 3/14
G 09 F 9/36

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

G 06 F 3/14

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23-03-1979	LEPEE

EPO Form 1503.1 06.78