Nov. 22, 1966 W. E. MILROY 3,287,492

REAL TIME COLOR-CODED TACTICAL DISPLAY

Filed June 10, 1963 2 Sheets-Sheet 1

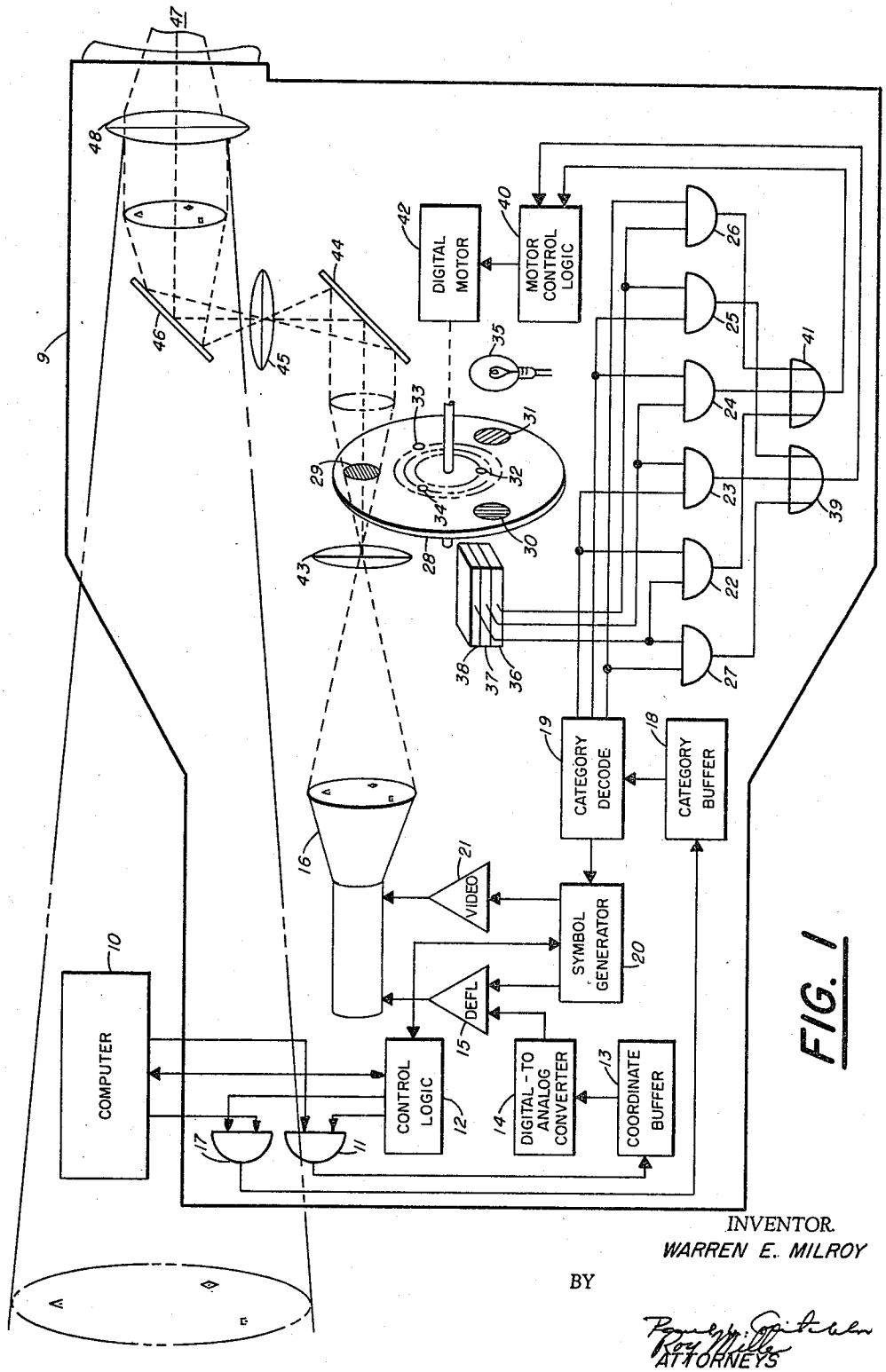


FIG. 1

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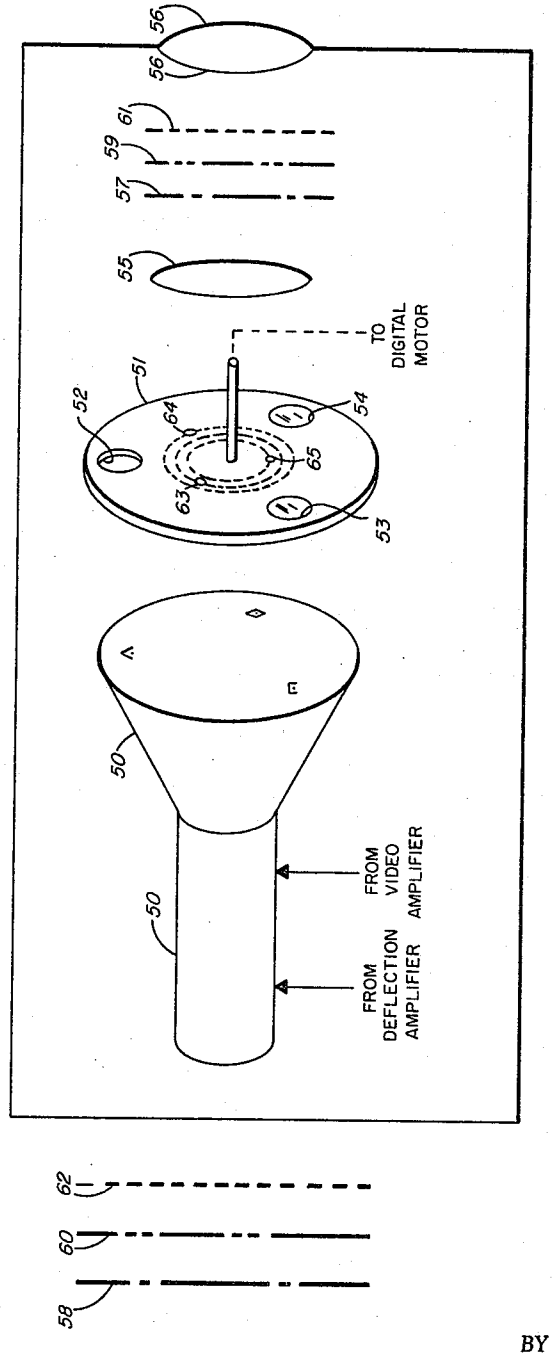


FIG. 2

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3,287,492

REAL TIME COLOR-CODED TACTICAL DISPLAY

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6 Claims. (Cl. 178—5.4)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a real time tactical display system and more particularly, to a real time tactical display system utilizing micro-display concepts and specifically to a real time tactical display system with color and three-dimensional capabilities.

In present tactical display systems CRT equipment is used on which symbols are generated representative of targets. For instance, utilizing friendly, enemy and unknowns, the observer watching the CRT would see symbols representative of each of the respective friendly, enemy and unknown targets. In that the CRT is monochromatic the symbols would be generated in one color. If there were a great number of symbols generated simultaneously the observer could differentiate between the symbols only through the shape of the symbols. At the same time the symbols displayed lie in a single plane so that there is no feeling of depth which might enhance the discrimination of the observer between different symbols displayed on the face of the CRT.

It is well known that the eye is very discriminating as to color, assuming that the observer is not color blind. Therefore, if the symbols were generated on the face of the CRT were color-coded as well as being of different shapes or configurations the observer could differentiate between the various symbols more easily than if the symbols were monochromatic. In addition if the illusion of depth were also present i.e., the symbols generated appeared to lie at different levels, the observer might also differentiate as to surface, air and sub-surface symbols more easily than if the symbols were only color-coded and the symbols lying in a single plane.

An object of the present invention is to provide an improved code display system.

Another object of the present invention is to provide a real time tactical display system incorporating low cost non-critical components.

A further object of the present invention is to provide a real time color coded tactical display system.

Another object of the present invention is to provide a real time color-coded three-dimensional tactical display system which is low cost and extremely portable in nature.

A further object of the present invention is to provide a real time three-dimensional tactical display system which is low cost and takes up a minimum of space.

Various other objects and advantages will appear from the following description of the several embodiments of the invention and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

The invention is illustrated and described in conjunction with the accompanying drawings when like numerals indicate like elements and wherein:

FIG. 1 is a diagrammatic showing of a proposed micro-display having color capability; and

FIG. 2 is a diagrammatic showing of a proposed micro-display having three-dimensional capability.

In the embodiment of FIG. 1 the entire display unit is contained within a housing **9** with external connections to a computer **10**. In the system, an XY coordinate word

from the computer **10** is coupled to a group of AND gates **11**. Another input to the AND gates **11** comprises an output from control logic **12**. The control logic **12** is adapted to be operative in accordance with the principles of Boolean algebra, appropriately derived truth tables or similarly determined response characteristics to produce actuating signals commensurate with a predetermined code of digital input signals. Accordingly, the control logic circuits contained in element **12** operate to provide the symbol generator **20** with actuating signals correlated to the coded digital input to the control logic element **12** so as to generate the particular symbol represented by each distinctive digitally coded input and to provide the appropriate deflection to position such symbol appropriately on th face of the cathode ray tube **16** through the deflection means **15**. The output of the AND gates **11** is coupled into a coordinate buffer **13** the outputs of which are coupled to a digital-to-analog converter **14** where the digital output of the computer is converted to an analog function. The output of the converter **14** comprises two analog voltages which are supplied to deflection amplifiers **15** of a CRT **16** in order to position the beam at the appropriate spot on the face of the CRT **16**.

Another output from the computer **10** comprises a category word which is ANDED against an output of the control logic **12** in a group of AND gates **17**. The output of the AND gates **17** is buffered through a category buffer **18** to a category decode **19** the output of which is coupled to a symbol generator **20**. The deflection outputs of the symbol generator **20** are coupled to the input of the deflection amplifiers **15** and another output to a video amplifier **21** and then to the CRT **16**. In addition an output of the symbol generator **20** is fed back to the control logic **12**.

Three outputs of the category decode **19** number are shown in the present example and for the purposes of illustration correspond to friendly, enemy and unknown. It is to be understood that any type and number of symbols might be displayed but for the purposes of illustration only three are shown. The friendly output is coupled as one input to two legged AND gates **22** and **23**; the enemy output as one input to two-legged AND gates **24**, **25**; and the unknown output as one input to two legged AND gates **26**, **27**.

Positioned in front of the face of the CRT **16** as a filter wheel **28** carrying, for instance, gelatin filters **29**, **30**, **31** spaced 120° apart corresponding to red, blue and green respectively. Also forming a part of wheel **28** are holes **32**, **33**, **34** spaced approximately 120° apart and at different radii from the center of wheel **28**.

On one side of wheel **28**, in the present instance on the right-hand side of the wheel looking at FIG. 1, is a lamp **35** and on the opposite i.e. left-hand side of wheel **28** in optical alignment with lamp **35** are three photo diodes **36**, **37** and **38** corresponding to green, blue and red respectively.

The output of diode **36** is coupled as the other input to AND gates **25**, **26**; the output of diode **37** is coupled as the other input of AND gates **23**, **24**; and the output of diode **38** is coupled as the other input of AND gates **22** and **27**.

The output of AND gates **27**, **23** and **25** are buffered through an OR gate **39** and form a clockwise, CW, pulse for a motor control logic circuit **40**. The motor control logic **40** is arranged to be operative in a manner similar to the control logic **12** through the use of a Boolean algebra or similar appropriate techniques whereby the input signals are caused to produce output signals in such a sense as to properly actuate the digital motor **42** in accordance with the particular category of symbol being de-

picted by the corresponding digitally coded input information.

The outputs of AND gates **22**, **24** and **26** are buffered through an OR gate **41** as a counter-clockwise, CCW, input to motor control logic circuit **40**. The output of the motor control logic **40** drives a stepping motor **42** which is coupled to filter wheel **28** and is used to position filter wheel **28** in front of the CRT **16**.

In addition a lens system is provided comprising lens **43** between the face of the CRT and the filter wheel **28** in optical alignment with a front surface mirror **44** which is positioned at the right side of the filter wheel **28**. The front surface mirror is positioned at 45° with respect to a vertical axis in FIG. 1 so that an image will be reflected from the front surface mirror **44** vertically to a lens **45** to another front surface mirror **46** positioned at 45° with respect a vertical axis. An image reflected from the front surface mirror **46** is reflected horizontally toward the eye of the viewer positioned at **47** and between the eye of the viewer and the front surface mirror **46** is another lens **48**.

The deflection amplifiers, digital-to-analog converter, coordinates buffer, category buffers, control logic, symbol generator and category decode comprise conventional circuitry and therefore for the purposes of simplicity are not shown or explained in the present invention as they do not form the inventive concept of the present disclosure.

In general, using a micro-display concept it would be possible to generate a real-time tactical display having color capability with very little additional complexity and cost over monochrome counterpart. Such capability can be used in a number of ways. For instance, all enemy targets could be displayed in red, all friendly targets in green, and all unknowns in blue. Another application might entail showing all surface targets in red, all sub-surface targets in green, and all air targets in blue. It is to be understood that these are but two of the many applications that can be visualized.

In order to explain the operation of this system and how the system is implemented the example chosen will deal with targets which are color-coded on the basis of friendly, enemy and unknown.

The computer **10** originates the digital words corresponding to the various symbols which are to be generated and also indicates where on the face of the CRT the symbols will be positioned. The display **9** accepts into its buffers **13** and **18** track information transmitted by thte computer **10**. Looking at FIG. 1, the coordinate buffer **13** will accept a digital word describing the X and Y position of the target. The category buffer **18** will accept a digital word describing the known characteristics of the target. These digital words are coupled into the buffers in sequential fashion under command of the control logic **12**. The control logic **12** allows the digital information to be transmitted into the buffers just as rapidly as the display can process it and display it.

For a given track the following sequence of events would take place. An XY coordinate word is coupled into the coordinate buffer **13**. The corresponding category word is simultaneously coupled into the category buffer **18**. The digital-to-analog converters **14** converts the XY coordinate word into two analog voltages which are then applied to the deflection amplifiers **15** so as to position the electron beam at the appropriate spot on the face of the CRT **16**. In the meantime the word in the category buffer **18** has been decoded in the category decode circuit **19** and the symbol generator **20** directed to generate a symbol describing the target. One of the three lines coming out of the right-hand side of the category decode **19** will then be energized depending on whether the target is a friendly, enemy or unknown. The three lines coming out of the right side of the category decode are applied to a group of AND gates **22** through **27** as previously explained. These three lines are "anded" with the outputs of the three photo diodes **36** through **38** in such a way as to position the filter wheel **28** in accordance with the nature of the data to be written on the CRT in the next instant of time. This is accomplished as follows. The digital motor moves 120° for each input pulse. A CW, clockwise, pulse drives the motor 120° in a clockwise direction. A CCW, counterclockwise, pulse drives the motor 120° in a counter-clockwise direction. The motor shaft, and hence the filter wheel **28** can only come to rest in three specific positions and the photo diodes **36** through **38**, lamp **35**, and holes **32** through **34** on the inner part of the wheel are arranged so that the red diode is energized when the red filter is in position, the green diode when the green filter is in position and the blue diode when the blue filter is in position. If an enemy target is to be indicated in the next symbol generator cycle and the red filter is already in position from the preceding cycle then no pulse is supplied to the motor **42** and the red filter remains in place. If, on the other hand, a friendly target is to be indicated next, and the enemy, i.e. red, filter is in position the logic gates generate a CCW pulse which moves the green filter **31** into place. If an unknown target is to be indicated next, and the enemy filter i.e. red, **29** is in place, the logic gates would generate a CW pulse which moves the blue filter into position. In any case, no matter what the sequence of the targets, no more than one increment of movement is required between two targets. It is obvious, however, that it would be desirable to program the computer **10** so that the targets are transmitted in group sequences, i.e., all friendlies, all enemies, all unknowns, all friendlies—ad infinitum. This, in effect would limit the required movement of the wheel **28**, in the worst case, to three increments of movement for each scan of a complete target listing.

The symbol generator **20** is given to the command to generate the desired symbol as soon as the logic gates determine that the proper filter is in position. When the symbol generator has completed generating the symbol it signals the control logic **12** to bring in the next target to the buffers **13** and **18** and the series of events is recycled.

In the present display system a micro-miniature CRT **16** is utilized and therefore a lens system is used so that the symbols appearing on the one inch CRT face will appear in a manner that may be utilized by a viewer. This is accomplished by utilizing a lens system in which images are formed for the user to see. A user looks into an eye piece as at **47**, or eye pieces depending on whether a monocular or binocular type display is desired. To simplify the explanation let it be assumed that a monocular display is utilized. An image is displayed on the face of the small high-resolution CRT. Lens **43** forms a demagnified real image of the CRT face plate slightly to the right of the filter wheel as shown. Depending on which filter is in place at the time the image will now have been color-coded. This real image is then transferred, and magnified back to original size, via lens **45** and the front surface mirrors **44** and **46** to a point in front of lens **48** which actually is the eye piece. The user, looking through lens **48** will see a magnified virtual image of the CRT face plate as shown in FIG. 1. This image can be made to appear at any point from infinity on in, depending on the physical position and characteristics of lens **48**. The size of the virtual image is determined by the focal length of lens **48** and its positioning. For instance, a 1 inch diameter CRT face plate could be made to appear as a 10 foot diameter display if desired.

FIG. 2 illustrates an embodiment of the invention which provides a three -dimensional effect. In this instance, symbols are generated on the face of a CRT **50**. Placed in front of the CRT **50** is a disc **51** having apertures **52**, **53** and **54**. In the present instance aperture **52** could be left open while apertures **53** and **54** would have ⅛" and ¼" glass respectively, in their openings. A lens **55** is positioned between the disc **51** and a viewing lens **56**

in line with the CRT **50**. Holes spaced at 120° as at **63**, **64** and **65** are utilized in the manner set forth with respect to FIG. 1 wherein the photo diodes are positioned on the left-hand side of the disc **51** and the light on the right-hand side of disc **51**. This is not shown in that the details are exactly the same as those shown in FIG. 1. Neither is the connection of the shaft on which disc **51** is mounted to the digital motor and the connections from the deflection amplifier and from the viedo amplifier set forth in that the circuitry and logic involved is exactly the same as that set forth in FIG. 1 and to show it again would amount to duplication at best.

In the operation of FIG. 2, let it be assumed that symbols representative of undersea, surface and aircraft are to be generated. Information from the computer **10** shown in FIG. 1 would be sent to the CRT **50** and the signals generated sequentially and disc **51** rotated in timed sequence with the symbols generated. Let it be assumed that undersea symbols are being generated. Aperture **52** would be aligned with the CRT **50** which would locate a real image at **57** and a virtual image at **58**. Next, symbols representing surface targets would be generated on CRT **50**. Disc **51** would be rotated until aperture **53** is aligned with CRT **50** which would cause a real image at **59** and a virtual image at **60**.

Finally, symbols representing aircraft would be generated and aperture **54** rotated into position in front of CRT **50**. This would locate a real image at **61** and a virtual image at **62**.

The effect on the viewer looking through lens **56** is that the symbols are spaced in depth.

It is to be understood that instead of only three apertures one might use any number of apertures and lenses or instead, might have a disc comprising glass of a continuously varying thickness which would allow one to use more computer information, i.e. the height and/or depth for various types of craft.

General considerations that might apply will apply to the flicker-free rate at which the symbol must be regenerated, the phosphor to be used and the inertia of the filter wheels and lens wheels involved.

In order to produce a flicker-free display for the user to see it would be necessary to regenerate each symbol at a 20 c.p.s. rate, i.e. once every 50,000 microseconds.

An appropriate phosphor would be used in the CRT such that the colors to be displayed are all contained in the spectral energy emitted from the phosphor. A white phosphor, for instance, would allow any color in the spectrum to be available with the proper filter in the embodiment of FIG. 1. The phosphor should also have short persistence so that a given symbol would decay within the time it takes to move the wheel one increment.

The digital motor used should be capable of fast response in order to keep the usable display time at a maximum. Putting this conversely, the time required to get a given filter or lens into position should be kept to a minimum. Small digital motors are currently available which have instantaneous start and stop rates of 800 c.p.s. This means that the time required to move a given filter or lens into position would be 1250 microseconds.

In the instance of the embodiment of FIG. 1 lens **43** should be selected on the basis of the amount of demagnification required to allow the filter wheel to be small enough to be driven by the motor selected. Lens **45** could be exactly the same as lens **43**. One example of lenses which might be used for **43** and **45** would be common microscope lenses which are of good quality and are quite cheap. It should be pointed out that it is conceivable that no demagnification would be required if the filter wheel were designed sufficiently well to keep the inertia down to a value which the motor could drive easily. This could be accomplished by using a light weight frame material and gelatin filters.

A study of the timing considerations reveals that an extremely large track list could be handled by such a

device with presently available components. For instance, using an 800 c.p.s. digital motor and a symbol generator having a cycle time of 10 microseconds the following analysis indicates the capacity obtainable:

Maximum time allowable for each scan through target list without encountering flciker=

$$T_1=\frac{1}{20 \text{ c.p.s.}}=50{,}000 \text{ microseconds}$$

Time required to move filter wheel one increment= $T_2=1250$ microseconds.

Time lost in each period T_1, worst case, due to movement of wheel=$3T_2=3\times1250=3750$ microseconds.

Time available for generating symbols=$T_3=T_1-3T_2=$ 50,000—3,750=46,250 microseconds.

Number of tracks that could be handled by system=

$$\frac{T_3}{\text{symbol generator cycle time}}=\frac{46{,}250}{10 \text{ microseconds}}=4{,}625$$

It is very unlikely that any tactical display system would be called on to handle this many tracks. Therefore, it is a safe assumption that a display of the type described would not be capacity limited.

It should be pointed out that such a display is by no means limited to three colors. Using a different digital motor and filter wheel would allow for color-coding a display in any number of colors. The three color device is described in order to keep the explanation simple and also because three colors are ideal in many military situations.

The device described is, by its very nature, quite small. It might be desirable in some cases to design the display to be worn on the operator's head with most of the circuitry placed in a remotely located auxiliary chassis. In other cases it might be desirable for the display to be designed in the form of binoculars which could be picked up and used by the operator when desired. In other cases the display might be designed as conventional sit-down type console with the exception that it would be a great deal smaller than the conventional console.

The details of the present invention have been set forth as two separate embodiments, one a colored display and the other a display having three-dimensioned capability. However, it is to be understood that the two could very easily be combined if one desired to have both color and three-dimensional information applied to the symbols generated on the face of the CRT in a display system. Another advantage of the present invention is that the components are off the shelf items and easily obtainable at low cost and are not critical in nature i.e. they do not require critical handling and/or tuning and are easily maintained. A further advantage is the extreme portability due to the small size of the micro-display and the ease with which the micro-display accepts the information from a computer and converts the digital information to analog function which are used to generate the symbols.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A system for displaying a plurality of categories of digitally coded information to a viewer in visually distinguishable forms commensurate with each respective category comprising;

a cathode ray tube having beam deflection means and beam intensity control means,

digital-to-analog conversion means connected to receive and convert said digitally coded information for controlling said beam deflection means,

symbol generator means arranged to receive said digitally coded information and responsive thereto for producing signals to cause said beam deflection

means and said beam intensity control means to visually display symbolic information on the face of said cathode ray tube in accordance with said received coded information,

decoding means connected to receive said digitally coded information for producing outputs correlated to the category data of said received digitally coded information,

optical means interposed between said viewer and said cathode ray tube display or visually distinguishing each of said categories responsive to an input control signal, and

logic means arranged to receive said decoding means outputs for producing input control signals correlated to said categories, said means including means for developing signals indicative of the position of said optical means.

2. A system as claimed in claim **1** wherein said optical means comprises an arrangement for visually distinguishing each of said categories by color.

3. A system as claimed in claim **1** wherein said logic means is responsive to produce input control signals minimizing re-positioning of said optical means.

4. A system as claimed in claim **1** wherein said optical means is radially disposed on a rotatable member.

5. A system as claimed in claim **1** wherein said optical means comprises an arrangement for varying the speed of light therethrough whereby to produce virtual images at different planes.

6. A system as claimed in claim **5** wherein said arrangement for varying the speed of light comprises a plurality of different thicknesses of transparent material positionable between said viewer and said cathode ray tube.

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