United States Patent [19]

Waltuck et al.

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[45] **Date of Patent:** **Jun. 25, 1991**

[54] **VISUAL FUNCTION TESTER WITH BINOCULAR VISION TESTING**

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[73] Assignee: **Mentor O & O, Inc.**, Norwell, Mass.

[21] Appl. No.: **370,630**

[22] Filed: **Jun. 23, 1989**

[51] **Int. Cl.**[5] **A61B 3/02**; A61B 3/08

[52] **U.S. Cl.** **351/246**; 351/243; 351/201

[58] **Field of Search** 351/237, 238, 240, 243, 351/246, 201, 202; 350/132; 358/92

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Primary Examiner—Rodney B. Bovernick
Attorney, Agent, or Firm—Herbert F. Schwartz; Richard A. Inz; Gerard A. deBlasi

[57] **ABSTRACT**

A visual function tester with binocular vision testing capabilities is disclosed, which includes a video display monitor and optical means, such as stereo vision glasses, to control the patient's viewing of the display. The opening and closing of the apertures of the glasses is synchronized to the display of a variety of visual acuity images. Certain images are made visible to each eye but not visible to the other, and certain images are displayed such that they appear out of the plane of the images. Methods for use of the apparatus are also disclosed.

14 Claims, 12 Drawing Sheets

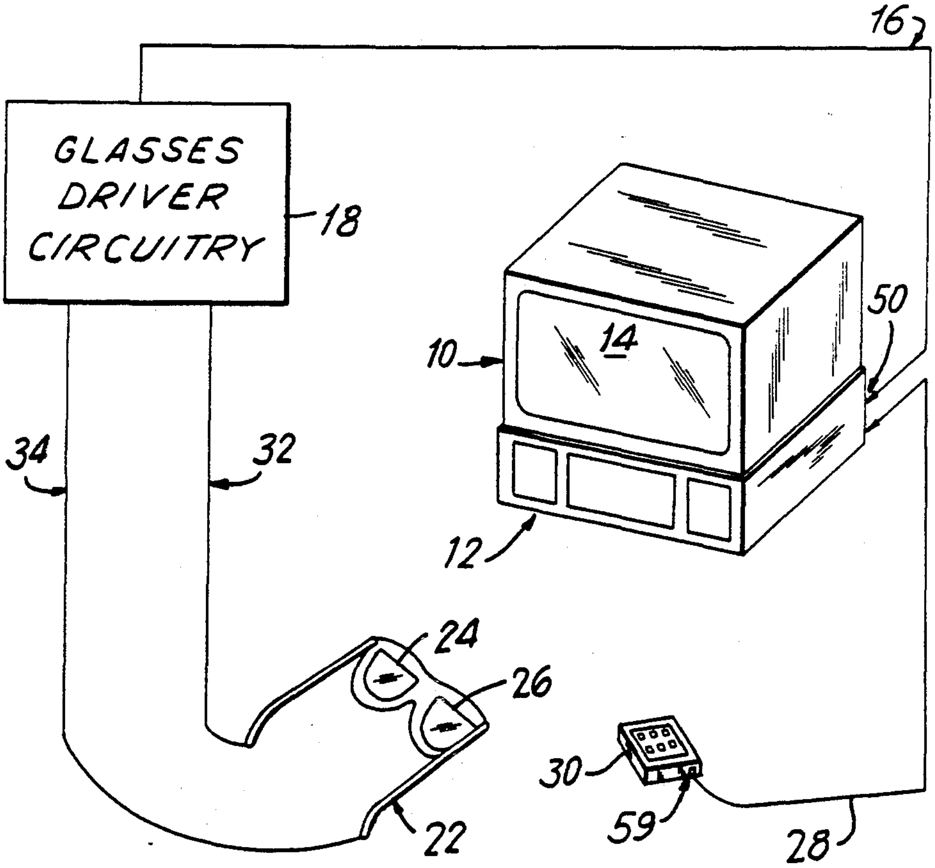
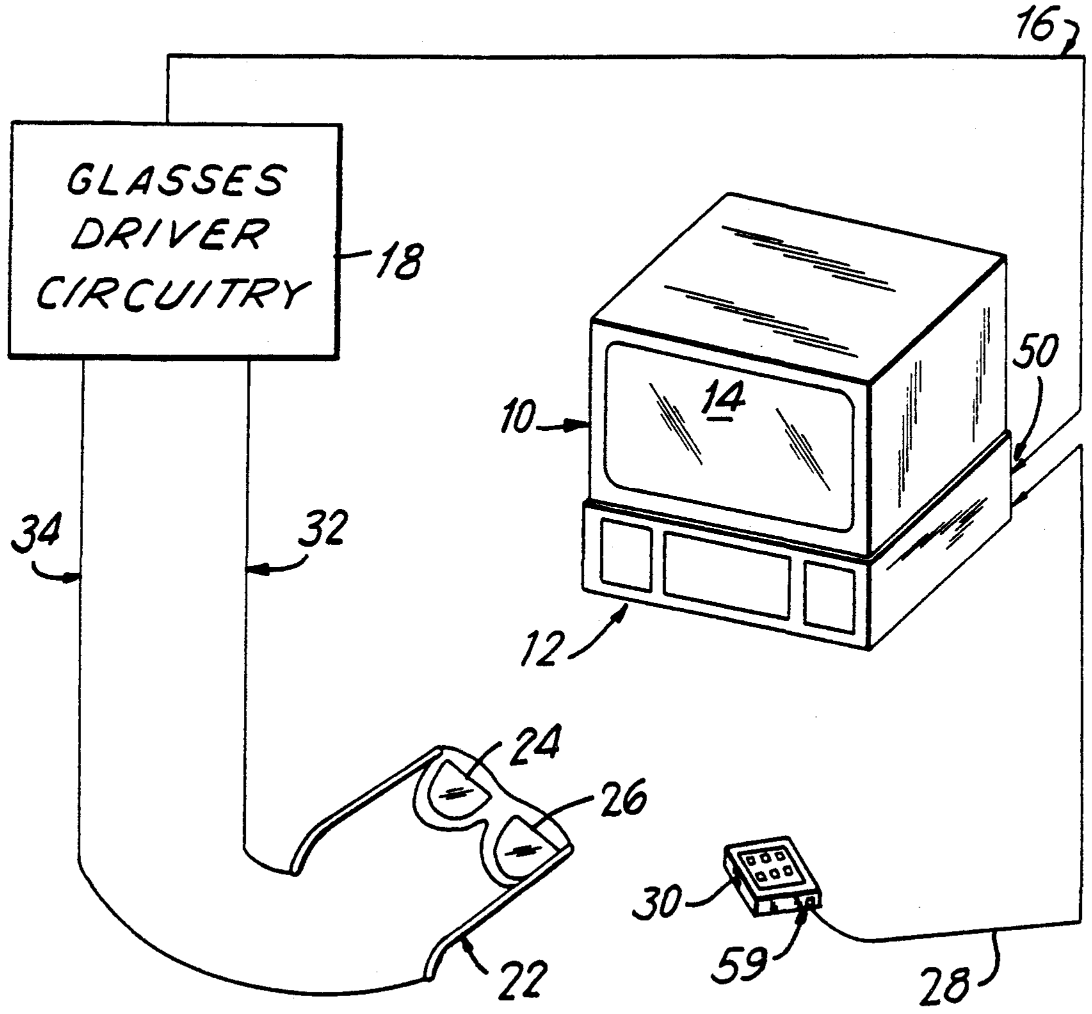


FIG. 1


16
GLASSES DRIVER CIRCUITRY
18
50
14
10
34
32
12
24
26
30
59
22
28

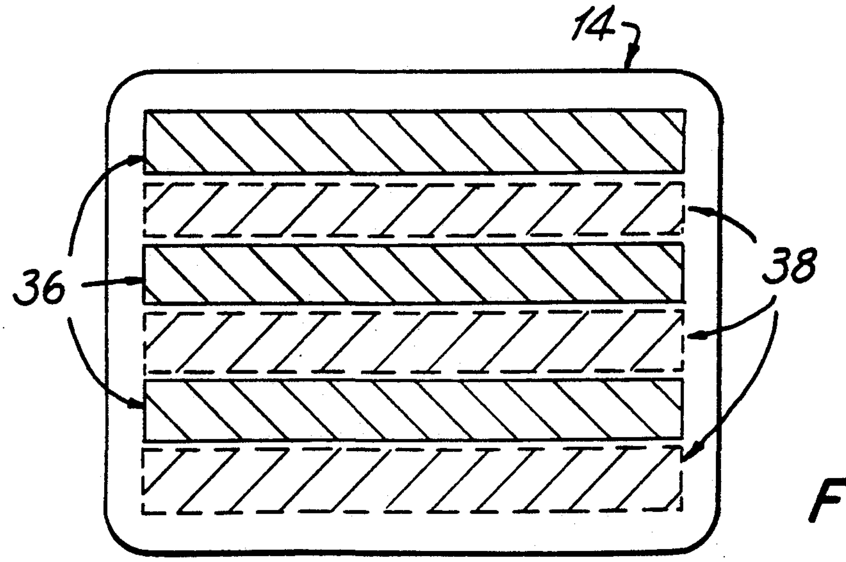

14
36
38

FIG. 2

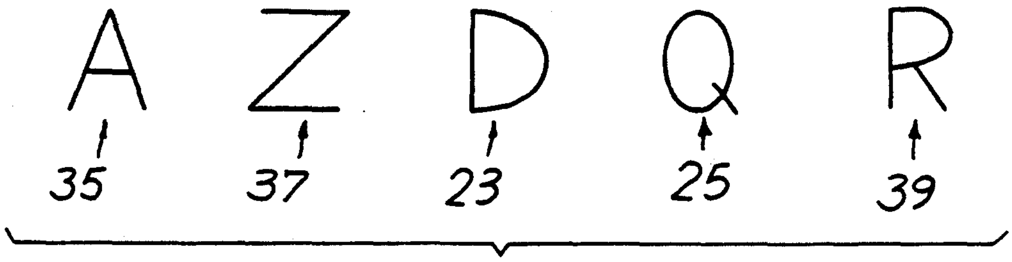


FIG. 3

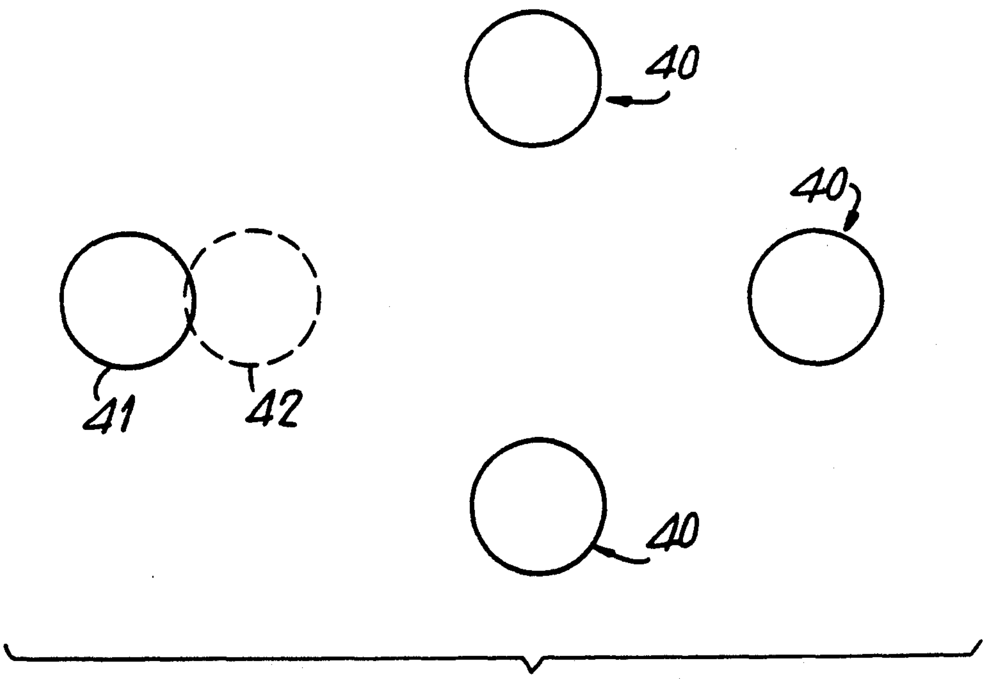


FIG. 4

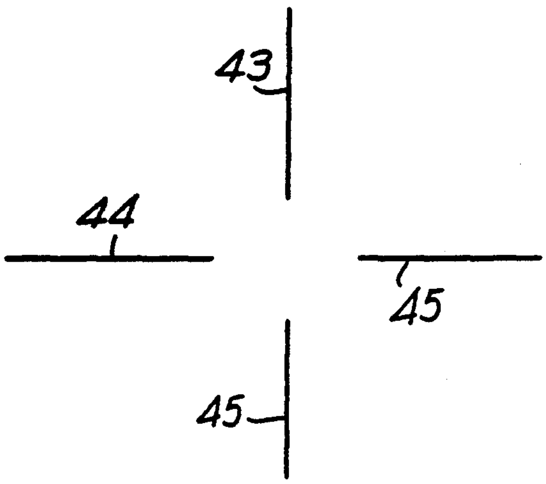


FIG. 5a

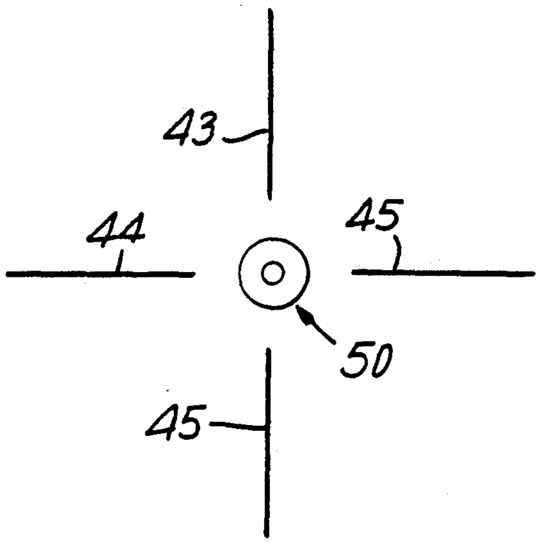


FIG. 5b

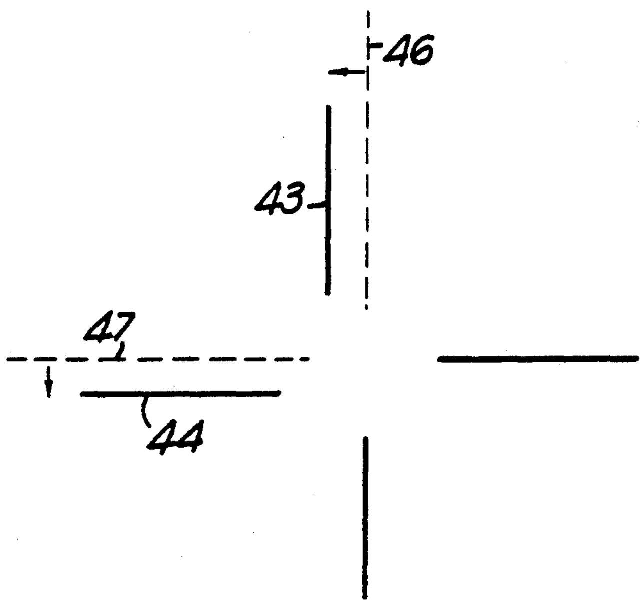


FIG. 6

FIG. 7

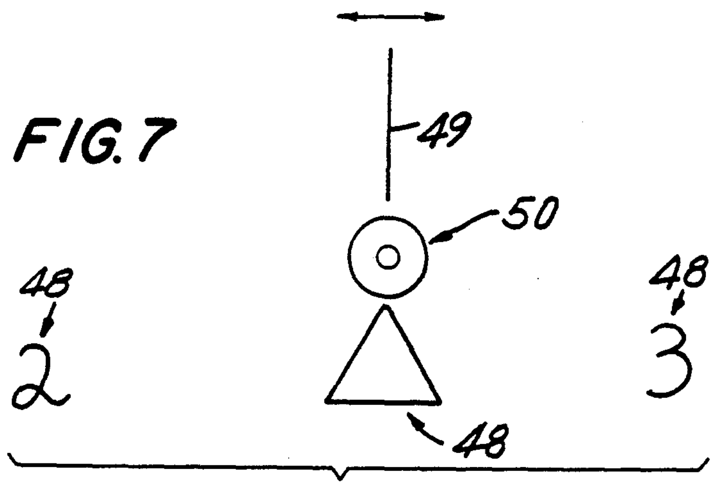
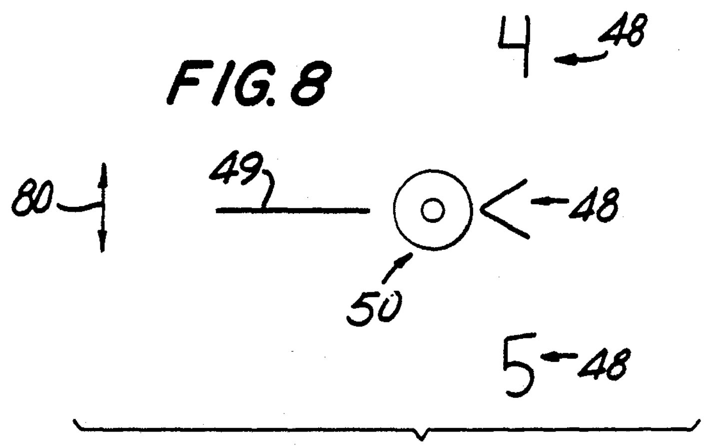


FIG. 8



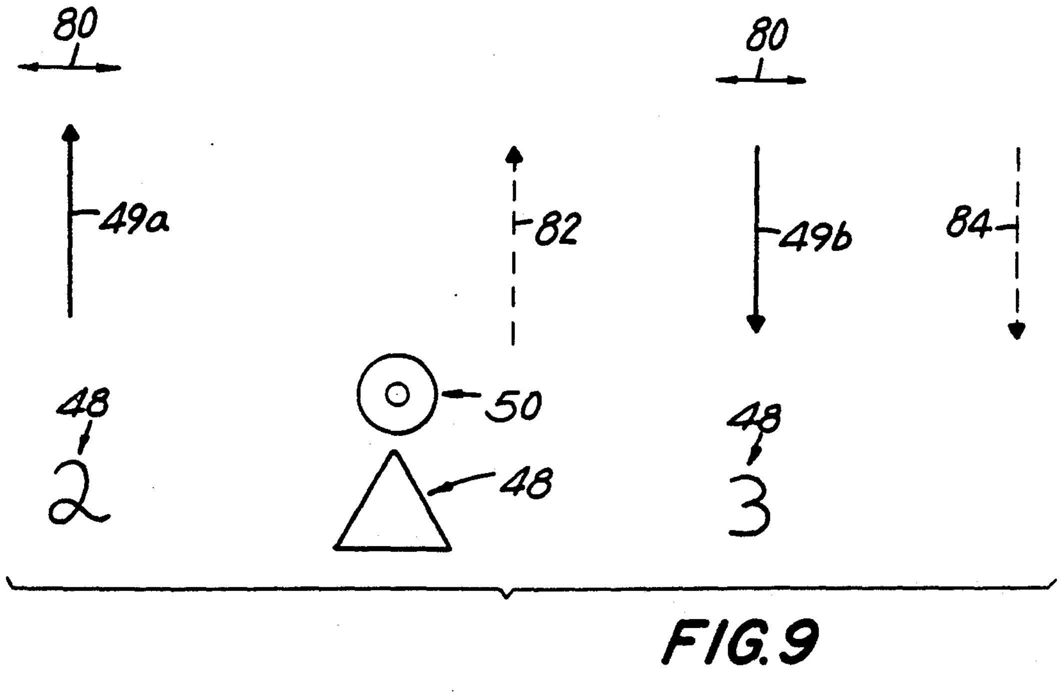


FIG. 9

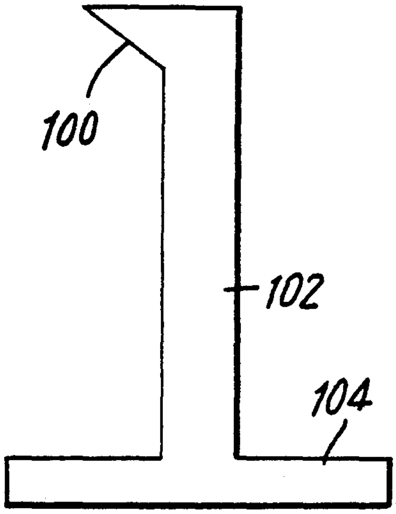


FIG. 10a

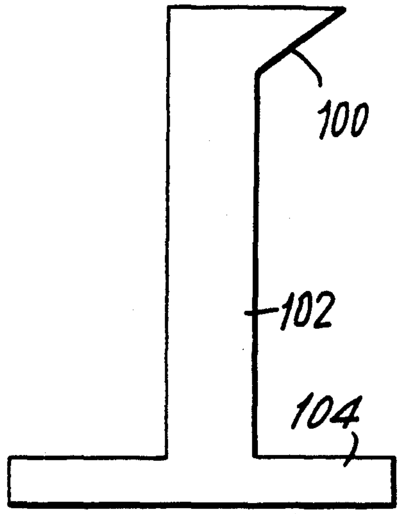


FIG. 10b

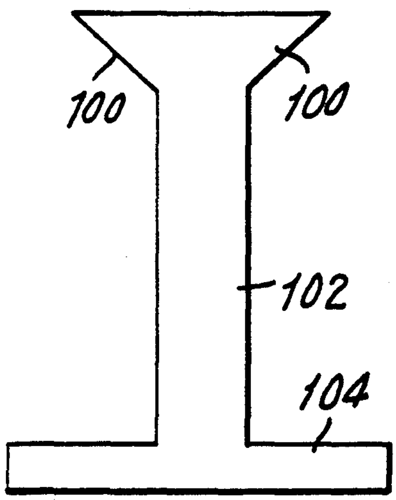


FIG. 10c

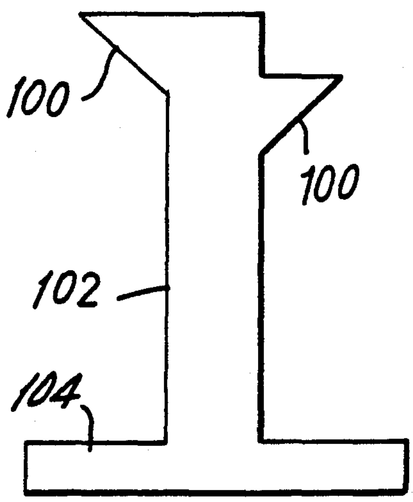


FIG. 10d

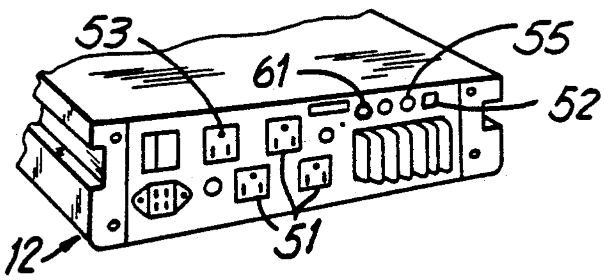

53
61
55
52
12
51

FIG. 11

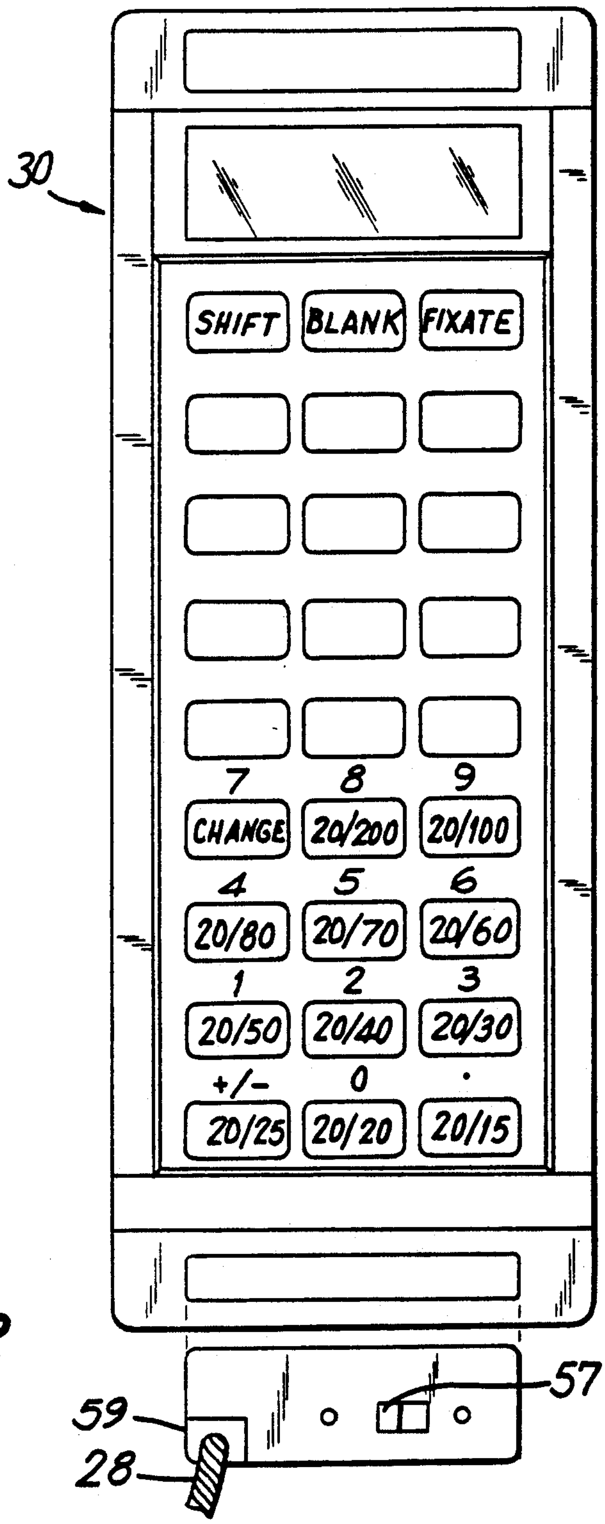
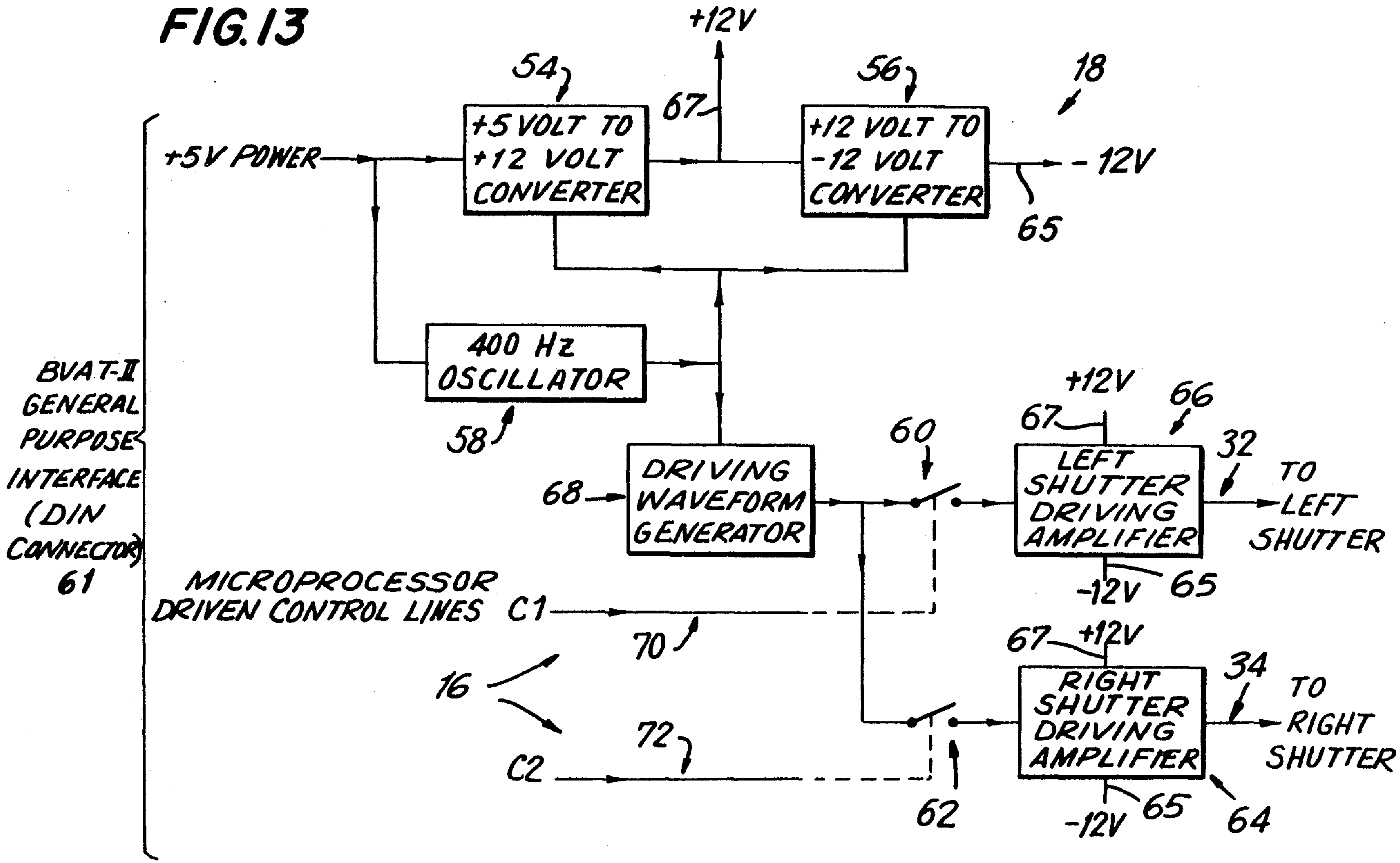

30
SHIFT
BLANK
FIXATE
7
8
9
CHANGE
20/200
20/100
4
5
6
20/80
20/70
20/60
1
2
3
20/50
20/40
20/30
+/-
0
.
20/25
20/20
20/15
59
28
57

FIG. 12

FIG. 13


+12V
54
67
56
18
+5V POWER
+5 VOLT TO +12 VOLT CONVERTER
+12 VOLT TO -12 VOLT CONVERTER
-12V
65
400 Hz OSCILLATOR
58
BVAT-II GENERAL PURPOSE INTERFACE (DIN CONNECTOR) 61
+12V
66
67
60
32
68
DRIVING WAVEFORM GENERATOR
LEFT SHUTTER DRIVING AMPLIFIER
TO LEFT SHUTTER
-12V
65
MICROPROCESSOR DRIVEN CONTROL LINES
C1
70
67
+12V
16
34
RIGHT SHUTTER DRIVING AMPLIFIER
TO RIGHT SHUTTER
72
C2
62
-12V
65
64

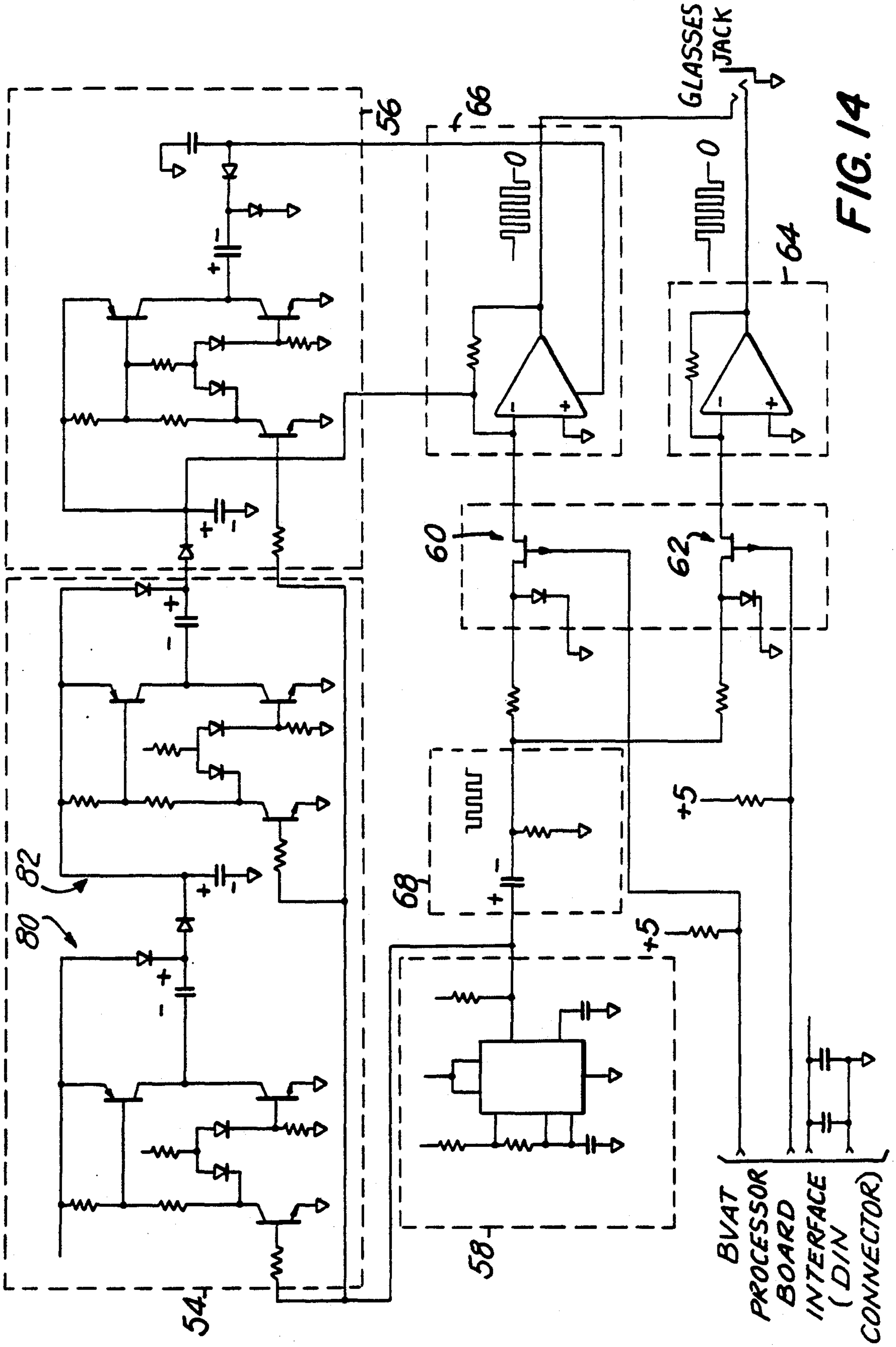
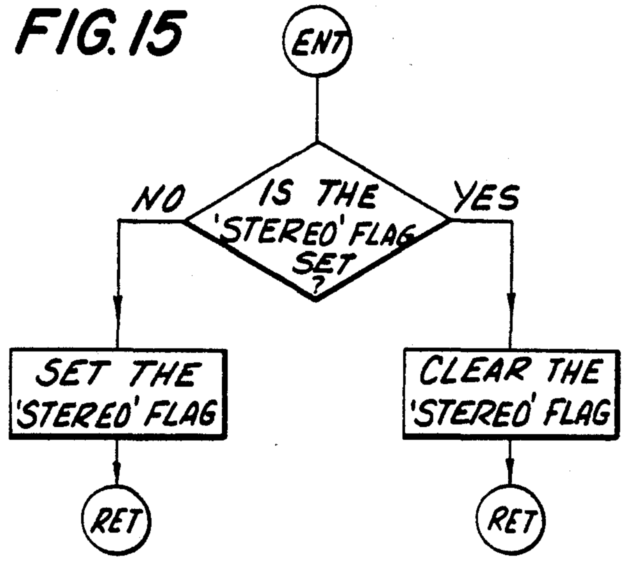

56
66
GLASSES
JACK
0
0
64
60
62
+5
+5
68
58
54
80
82
BVAT
PROCESSOR
BOARD
INTERFACE
(DIN
CONNECTOR)

FIG. 14

FIG. 15


ENT
IS THE 'STEREO' FLAG SET ?
NO
YES
SET THE 'STEREO' FLAG
CLEAR THE 'STEREO' FLAG
RET
RET

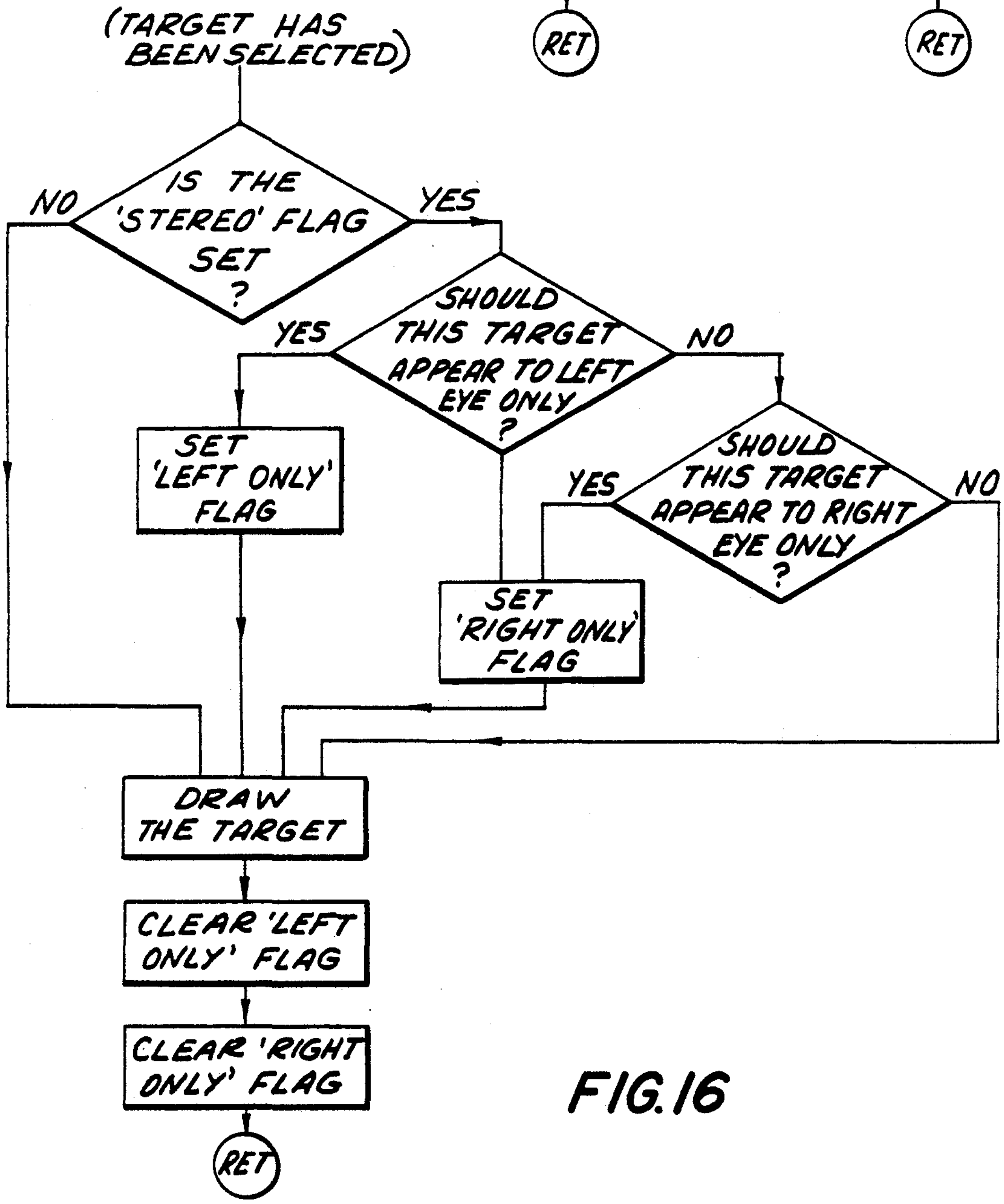
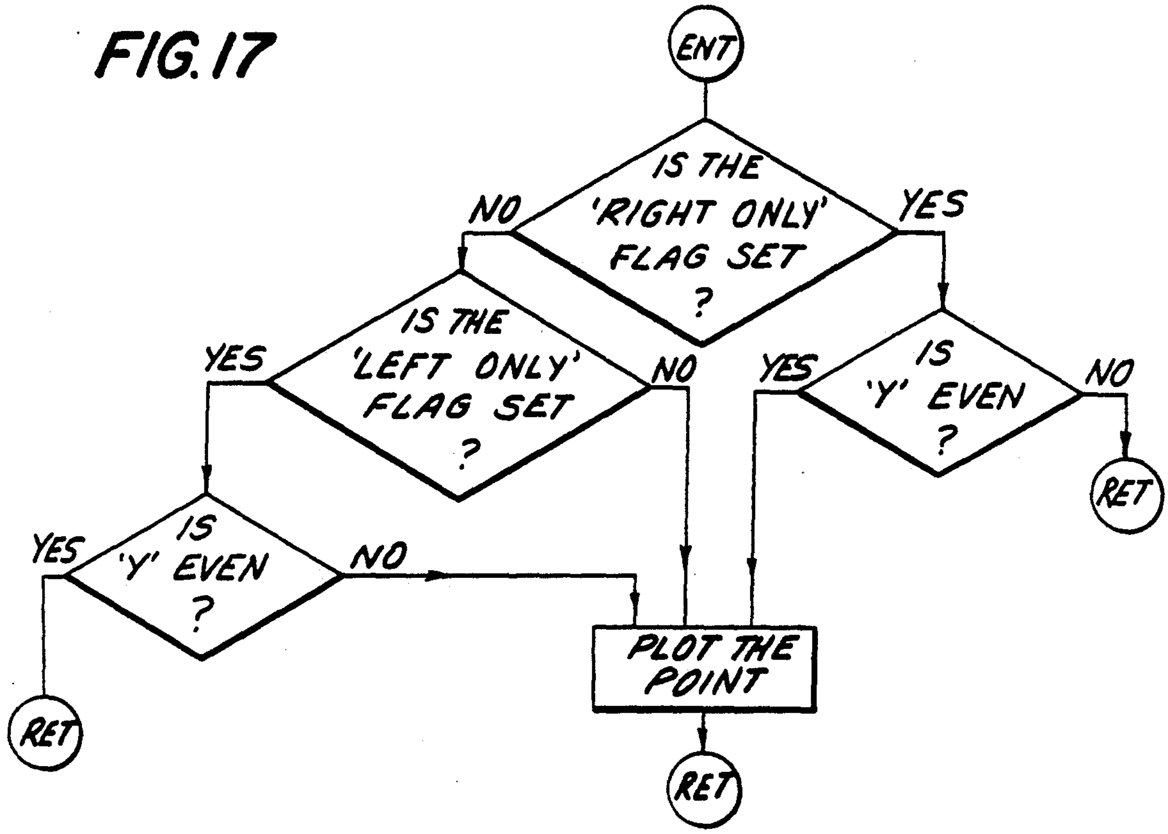

(TARGET HAS BEEN SELECTED)
IS THE 'STEREO' FLAG SET ?
NO
YES
SHOULD THIS TARGET APPEAR TO LEFT EYE ONLY ?
YES
NO
SET 'LEFT ONLY' FLAG
SHOULD THIS TARGET APPEAR TO RIGHT EYE ONLY ?
YES
NO
SET 'RIGHT ONLY' FLAG
DRAW THE TARGET
CLEAR 'LEFT ONLY' FLAG
CLEAR 'RIGHT ONLY' FLAG
RET

FIG. 16

FIG. 17


ENT
IS THE 'RIGHT ONLY' FLAG SET ?
NO
YES
IS THE 'LEFT ONLY' FLAG SET ?
YES
NO
IS 'Y' EVEN ?
YES
NO
IS 'Y' EVEN ?
YES
NO
RET
PLOT THE POINT
RET
RET

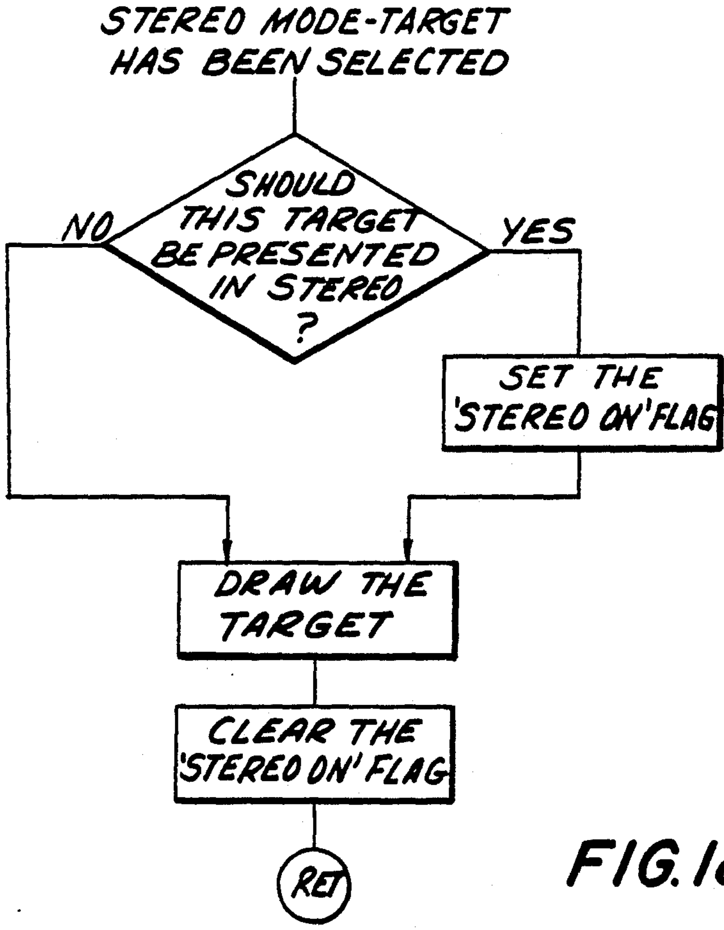

STEREO MODE-TARGET HAS BEEN SELECTED
SHOULD THIS TARGET BE PRESENTED IN STEREO ?
NO
YES
SET THE 'STEREO ON' FLAG
DRAW THE TARGET
CLEAR THE 'STEREO ON' FLAG
RET

FIG. 18

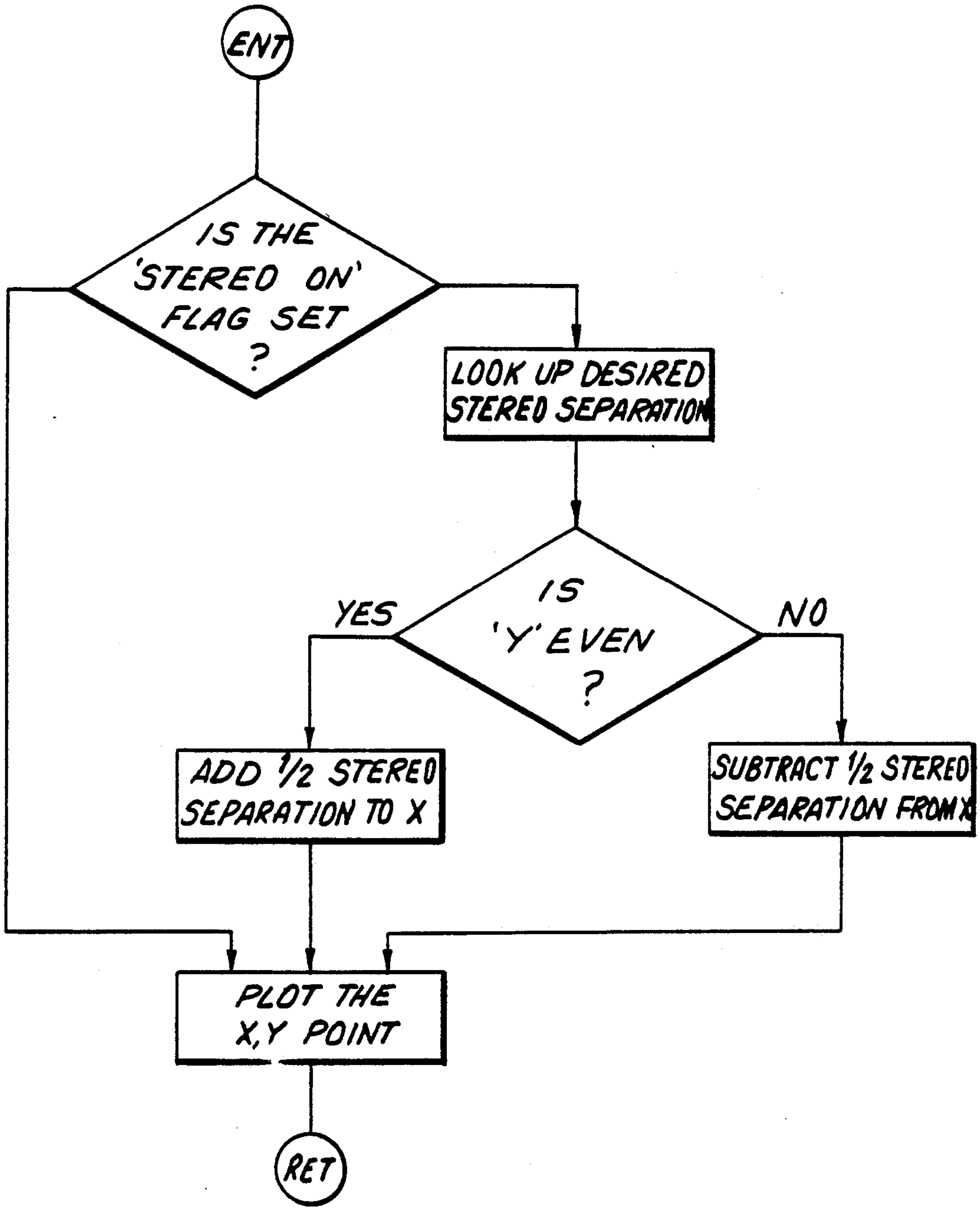

ENT
IS THE 'STEREO ON' FLAG SET ?
LOOK UP DESIRED STEREO SEPARATION
IS 'Y' EVEN ?
YES
NO
ADD 1/2 STEREO SEPARATION TO X
SUBTRACT 1/2 STEREO SEPARATION FROM X
PLOT THE X,Y POINT
RET

FIG. 19

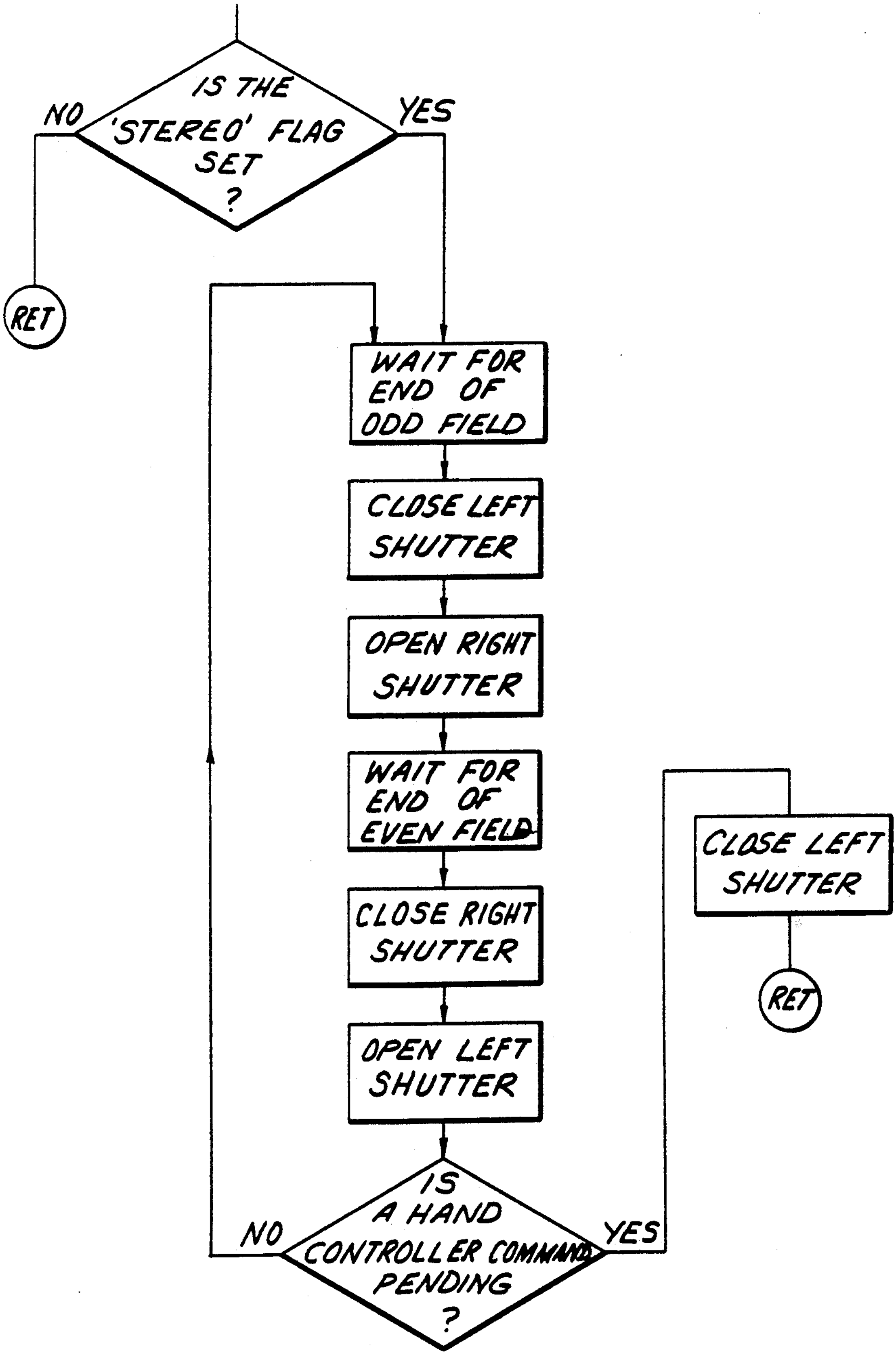

IS THE 'STEREO' FLAG SET ?
NO
YES
RET
WAIT FOR END OF ODD FIELD
CLOSE LEFT SHUTTER
OPEN RIGHT SHUTTER
WAIT FOR END OF EVEN FIELD
CLOSE RIGHT SHUTTER
OPEN LEFT SHUTTER
IS A HAND CONTROLLER COMMAND PENDING ?
NO
YES
CLOSE LEFT SHUTTER
RET

FIG. 20

VISUAL FUNCTION TESTER WITH BINOCULAR VISION TESTING

BACKGROUND OF THE INVENTION

The present invention relates to ophthalmic testing instruments, and more particularly, to apparatus and methods for testing the binocular vision of a patient, as well as for testing monocular vision during binocular viewing.

The determination of visual acuity is an essential part of every eye examination. During the course of such an examination, acuity may be measured repeatedly to ascertain the resolution of each eye independently and both eyes together. The determination of binocular function and motor function is an essential part of the process of refracting and determining the optimal corrective lenses as well as providing a means for assessing the progress of ocular pathology.

Originally, clinical methods for measuring visual acuity and binocular function involved the use of wall charts containing a fixed array of Snellen letters, "Tumbling E" targets, and other accepted acuity images and characters or symbols. The patient ordinarily viewed the charts from a fixed distance (usually 20 feet). With the advent of ophthalmic devices, clinical testing methods have become more sophisticated. Electromechanical devices were developed, including the American Optical Project-O-Chart manually operated glass slide projector, and later, a remote controlled glass slide projector. Both types of devices suffered from the inability to present more than a few different visual acuity targets at any given target size. U.S. Pat. No. 4,239,351 solved this problem by disclosing a completely digital electronic apparatus for generating and displaying symbols to be used as targets for testing visual acuity.

The present invention relates to a visual function tester for testing binocular vision, ocular motor imbalance, such as phoria, associated phoria and fixation disparity, and refining binocular refractions. The accurate diagnosis of several ophthalmic disorders requires a binocular testing environment that allows some images to be made visible to one eye and invisible to the other, while some characters may be visible to both eyes. Targets also are generated such that they appear to the patient to be out of the plane of the screen (i.e., they appear to be closer or farther away than the other targets). Such an environment is critical to the diagnosis and treatment of such disorders as, for example, monofixation, fixation disparity, amblyopia, convergence axis, divergence axis, convergence insufficiency, and for detecting malingering.

Previous efforts to provide a test environment closely approximating the normal binocular situation have not proven successful. For example, the four prism-diopter base-out test has been used to determine the existence of bifixation (central fusion) and monofixation (absence of central fusion). While the patient reads letters at a distance of six meters, a four diopter base-out prism is slipped first before one eye and then the other. The prism covered eye is watched closely for movement. Absence of movement by one of the eyes identifies a monocular scotoma in that eye. Bifixation is identified by each eye moving inward to refixate in response to the image displacement produced by the prism. (See *Clinical Ophthalmology*, by Thomas D. Duane, M.D., Ph.D., Vol. 1, Chap. 9, pp. 8 & 10.)

The four diopter base-out prism test has not proven reliable, however, because, occasionally, bifixating patients recognize diplopia when the prism is slipped before either eye, but make no attempt to restore bifixation by convergence. Also, many orthophoric monofixating patients who have good acuity in each eye rapidly alternate their fixation to the uncovered eye as the prism is slipped before the fixating eye; consequently, neither eye shows a movement response.

A second method used to approximate a binocular testing environment employs the A-O Vectographic Project-O-Chart slide (originally manufactured by the American Optical Company). A high resolution, high contrast vectograph printing process is used to produce character slides. Each character on the slide has a self-contained light polarization. When a pair of these polarized characters with axes of polarization 90 degrees to each other are superimposed, each will function independently without optical interference from the other. When the resulting single slide is projected on a non-depolarizing screen and viewed through "analyzers," or polarized glasses, some images are made visible to one eye and invisible to the other. Some portions of the slide also contain characters that are seen by both eyes.

Although the Project-O-Chart slide does provide a more rapid and dependable differentiation than the four diopter base-out prism test, it has not proven successful and has not gained industry acceptance. Production of the character slides and compatible analyzers requires an extremely tight registration of polarization, which is difficult to produce with the high degree of accuracy required for effective operation of the test and which is sensitive to head position. It also suffers from the same deficiencies presented generally by the Project-O-Chart method. There is no flexiblity in the chart printed—the characters on the slide are permanent. As the patient is tested and re-tested, he or she begins to memorize the test characters. Furthermore, dirt on the slide, readjustment of the focus of the projector, and dimming light bulbs are all problems inherent in the Project-O-Chart.

In view of the foregoing, it is an object of this invention to provide improved methods and apparatus for testing binocular vision.

It is a more particular object of this invention to provide methods and apparatus for testing binocular vision that allow an eye examiner quickly and accurately to produce a wide variety of visual targets, including targets which appear to be in front of or behind the surface of the monitor.

SUMMARY OF THE INVENTION

The present invention provides a visual acuity tester with binocular vision testing designed to satisfy the aforementioned needs. The apparatus of the invention includes a high contrast video display monitor with microprocessor control, and storage means for displaying a wide variety of visual acuity characters or images. Thus, unlike previous systems, the invention is not restricted to a fixed number of pre-existing slides (as in the case of the Project-O-Chart). Moreover, the present invention allows the eye examiner to access a wide variety of acuity charts and targets in a fraction of a second, thus providing a more versatile and efficient diagnostic instrument.

Images are made visible to one eye and are concealed from the other through the use of optical shutters controlled in conjunction with the scanning sweeps of the video display monitor. In addition, images are generated which appear to the patient to be either closer or further than the other images appear. Because no polarizer alignment in the display is relied upon, the inefficiencies and expense of those techniques are eliminated. Furthermore, the efficiency and accuracy of the operation of the invention is greatly improved over prior art systems through the use of electronic control means that monitor, control and coordinate the presentation of the images and the opening and closing of the optical shutters.

Accordingly, the present invention relates to apparatus and methods for testing binocular vision having means for generating a plurality of visual acuity targets and a display monitor for displaying the visual targets. The visual function tester also includes electrooptical means for controlling the viewing of the display monitor, and control means to coordinate the optical means and display monitor.

More specifically, the display monitor may be a raster scan cathode ray tube in which even numbered horizontal scan lines and odd numbered horizontal scan lines are displayed during alternate vertical sweeps. The means for generating the plurality of visual acuity targets may be a microprocessor-based unit. The optical means may include liquid crystal shutters to effect a light shutter action in response to related alternate vertical sweeps. Electronic control circuitry may be used to control the liquid crystal shutters in coordination with the vertical sweeps of the display monitor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial perspective view of the major components of the preferred embodiment of this invention.

FIG. **2** is a partial, enlarged view of the video sceen of the display monitor.

FIG. **3** is an illustrative embodiment of a display used for detecting suppression or bifixation.

FIG. **4** is an illustrative embodiment of a display used for evaluating stereopsis.

FIG. **5**(*a*) is an illustrative embodiment of a display used for detecting and measuring disassociated phoria.

FIG. **5**(*b*) is an illustrative embodiment of a display used for detecting and measuring associated phoria.

FIG. **6** is the display of FIG. **5**(*a*) as seen by a patient having phoria.

FIG. **7** is an illustrative embodiment of a display used for quantitatively evaluating horizontal fixation disparity.

FIG. **8** is an alternative embodiment of a display used for quantitatively evaluating vertical fixation disparity.

FIG. **9** is an illustrative embodiment of a display used for quantitatively evaluating fixation disparity.

FIGS. **10**(*a–d*) are illustrative embodiments of a display used for evaluating aniseikonia.

FIG. **11** is a rear partial perspective view of the processor module.

FIG. **12** is an elevational view of a hand-held controller for the video function tester.

FIG. **13** is a block diagram of the glasses driver circuitry.

FIG. **14** is a schematic of the glasses driver circuitry.

FIG. **15** is a flow chart of the software means for invoking binocular vision testing.

FIG. **16** is a flow chart of the software means for selecting concealed targets.

FIG. **17** is a flow chart of the software means for creating concealed targets.

FIG. **18** is a flow chart of the software means for selecting depth targets.

FIG. **19** is a flow chart of the software means for creating depth targets.

FIG. **20** is a flow chart of the software means for driving the glasses used in binocular vision testing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows apparatus for testing visual function by approximating a normal binocular viewing environment, in accordance with the principles of the present invention. The apparatus includes a video display monitor **10** for displaying a plurality of visual targets, processor module **12** for generating and storing a plurality of visual targets, optical means **22** for controlling the viewing of the display monitor, hand-held remote control unit **30** for controlling the display of the visual targets, and control circuitry **18** for coordinating the operation of optical means **22** and the presentation of images on monitor **10**.

Video display monitor **10**, processor module **12**, and hand-held remote control unit **30** may be similar to the apparatus of the visual acuity tester shown in co-pending U.S. patent application Ser. No. 116,709, filed Nov. 3, 1987, which is hereby incorporated by reference herein.

In the preferred embodiment, display monitor **10** is a raster scan cathode ray tube driven by a standard RS170 video signal. The screen of monitor **10** is refreshed at a rate of 30 frames per second. This embodiment of the invention utilizes a scheme known as interlaced scanning, whereby even and odd numbered horizontal scan lines are presented during alternate vertical sweeps. The odd and even numbered scan lines (see lines **36** and **38** shown in FIG. **2**), also known as odd and even fields, typically are presented in an alternate or interlaced manner so as to minimize perceived flicker to the viewer.

FIG. **2** shows a partial, enlarged view of the interlaced lines which create a picture on screen **14** of monitor **10**. FIG. **2** is only a partial display of screen **14**, showing only six interlaced lines. Lines **36** of screen **14** represent scan lines in the odd field. Lines **38** represent scan lines in the even field. A standard video screen has 480 visible interlaced lines. In normal viewing an observer perceives two adjacent fields as being continuous, because the screens are designed such that adjacent lines in alternate fields are related to each other. In the present invention, a given field (e.g., lines **36**) may be totally different from its adjacent field (e.g., lines **38**).

Interlaced scanning lends itself to the use of glasses for binocular vision testing. Glasses **22** (also referred to as "stereo vision glasses" or "optical means"), as shown in FIG. **1**, are constructed with separate apertures for each eye. Each aperture has a shutter **24** or **26** that can transmit or block out light independent of the other shutter. In the preferred embodiment of the invention, shutters **24** and **26** are liquid crystal shutters. The liquid crystal shutters can be opened or closed in approximately one millisecond. The shutters in this embodiment are normally open, and may be closed by applying an AC voltage (preferably a square wave, 20 volts peak-to-peak, at 400 Hertz).

Although the preferred embodiment of the invention uses an interlaced scanning scheme to display information on monitor **10**, the invention is not limited to such a scheme. In alternative embodiments, any display system which presents sequential images, including film, may be used. If film is used, alternating frames of the film are made visible to each of a patient's respective eyes. The alternative system must present the images in synchronism with the electro-optical shutters.

Because the odd and even fields are presented on video display **10** during alternate vertical sweeps, the shutter for a particular eye can be opened or closed during a vertical sweep interval either to permit or block that eye's viewing of the next vertical field presented. If the visual information displayed in the odd field is different from the information displayed in the even field, the shutters can be opened or closed such that one eye sees only the odd field, and the other eye sees only the even field. In other words, the shutters can allow a given field to be observed by only one eye, by both eyes, or by neither eye.

For example, to test for bifixation or for suppression, characters can be presented such that one or two characters are missing from the odd field (lines **36** in FIG. **2**), but are displayed in the even field (lines **38** in FIG. **2**). Different characters are omitted from the even field, and these characters are presented, as well as other characters, in the odd field. Apertures **24** and **26** of optical means **22** are controlled by processor module **12** so that the left eye of the observer sees only the odd field (characters in the even field are concealed) and the right eye sees only the even field (characters in the odd field are concealed).

FIG. **3** shows an illustrative embodiment of the test for suppression. The characters shown at **37**, **23**, and **25** are displayed in both the even and odd fields, and are therefore visible to the right and left eyes. The character shown at **35** is displayed only in the even field and is visible to only the right eye. The character shown at **39** is displayed only in the odd field and is visible to only the left eye. Alternatively, the characters displayed at **35**, **23**, and **39** are displayed in both the odd and even fields, and the characters displayed at **37** and **25** are displayed only in the even and odd fields, respectively.

Patients with normal vision see all of the characters, but patients who suppress one eye will miss a character. The test may be performed with any optotype and size that will allow at least two characters to be displayed. For example, the test may be performed using four 20/40 letters or children's symbols, or using two 20/60 characters.

To test for stereopsis, a plurality of acuity targets are presented on the display. At least one target is displayed in the same position to each eye, and at least one target is displayed such that it is displaced laterally. Referring to FIG. **4**, the preferred embodiment of the test for stereopsis includes displaying four characters, preferably four 20/80 rings, presented in a diamond-shaped pattern on screen **14** of display monitor **10**. Three characters, shown at **40**, are displayed in the same position for each eye. The fourth character **41** is displaced laterally, for one or both eyes, to test for stereo acuity. The initial position of character **41** is shown in phantom at **42**. Where the character is displaced for both eyes, displacement is in opposite directions for each eye. The patient indicates which character appears out of the plane of screen **14**.

Because each eye sees only one field, a person with normal stereopsis will see the shifted character either in front of or behind screen **14**. The perceived distance of the character from screen **14** is determined by the magnitude of the horizontal shift. The "Arrow" keys of hand-controller **30** are used to change the amount of lateral displacement. The "Change" key of hand-controller **30** is used to change the position of the displaced character to one of the other three positions on the screen, allowing a patient to be retested at the same degree of stereo acuity. Examples of the software used to generate characters visible only to a preselected eye and to offset a preselected visual target are provided in Appendices C and D.

To screen for phoria, the display of FIG. **5**(*a*) may be shown to a patient. If the patient suffers from phoria, lines **43** and **44** will appear to be displaced from their original positions (shown in FIG. **6** at dotted lines **46** and **47**, respectively). Lines **43** and **44** are in one field (either odd or even), and lines **45** are displayed in the other field. Neither eye sees the same image. An image can be displayed to both eyes to serve as a fixation lock (see FIG. **5**(*b*)) to enable the examiner to test for associated phoria. Where black symbols are displayed on a white screen, the screen may serve as the fixation lock.

In alternative embodiments, shown in FIGS. **7** and **8**, a row of characters **48**, having a center point, is displayed in either the odd or even field, while a test line **49** is displayed in the other field. The row of characters may be either horizontal (FIG. **7**), to test for horizontal imbalance, or it may be vertical (FIG. **8**), to test for vertical imbalance, if no fixation lock is displayed. For associated phoria testing, including the screening and quantitative tests, an additional target **50** may be displayed and made visible to both eyes, serving as a fixation lock. The fixation lock may be displayed at any position on the screen. When a fixation lock is displayed, test line **49** may be moved to either side of center (as indicated by bidirectional arrow **80**) to evaluate fixation disparity. The displacement of test line **49** from the center (in minutes of angle) provides a quantitative measure of the fixation disparity.

As shown in FIG. **9**, two arrows may be used to increase the range of the tests used to evaluate phoria, associated phoria, and fixation disparity. Arrows **49***a* and **49***b* are made distinguishable from each other by having one arrow point upward and the other point downward. The arrows are presented at the edges of the screen so that if the patient has a large ocular imbalance, even though one arrow is "moved" off the character line, the second arrow will remain within the range of the character line (shown in FIG. **9** at dotted lines **82** and **84**).

To measure aniseikonia, the display of FIGS. **10**(*a*) and **10**(*b*) may be superimposed and simultaneously shown to a patient. The character of FIG. **10**(*a*) is displayed in the odd field and made visible to the left eye. The character of FIG. **10**(*b*) is displayed in the even field and made visible to the right eye. The height to width ratio of markers **100** may be adjusted to improve the effectiveness of the test. Each target has a marker **100** at the end of the center line **102** that is seen extending from one side by one eye and extending from the other side by the other eye. Each target has fusion lock **104** at the other end of center line **102**. A patient with normal vision sees equal image sizes with each eye, and will set the markers at the same distance from fusion lock **104** (FIG. **10**(*c*)). A patient with aniseikonia will see one marker further from the fusion lock than the other (FIG. **10**(*d*)). The distance of one of the markers to the fusion lock can be altered until the patient perceives both of markers **100** as being equidistant to the fusion lock. The ratio of the two distances is a measure of aniseikonia.

This test can be performed at various angles. For example, this test can be performed with the measured distance 90 degrees to the horizontal (as shown in FIG. 10(*c*)), at 45 degrees, or with the measured angle horizontal (0 degrees) and the fusion lock vertical.

Processor module **12**, shown in FIG. **1**, includes means for generating the plurality of visual acuity targets. Module **12** is a microprocessor based system, which includes a dynamic bit-mapped graphics memory. Module **12** has two complete screens of memory, either of which can be displayed on monitor **10**. The microprocessor of module **12** reads from and writes to the bit-mapped graphics memory, from which the information is transmitted to screen **14** of monitor **10**. The bit-mapped memory feature is described in further detail in co-pending U.S. patent application Ser. No. 116,709, previously incorporated herein by reference.

Shutters **24** and **26** of stereo vision glasses **22** operate in conjunction with the visual information displayed on screen **14** at any particular time. The synchronization of the shutters and the vertical sweeps of the monitor are controlled by the microprocessor of module **12**. The microprocessor of module **12** transmits control signals through line **16** to the glasses driver circuitry **18** via a general purpose interface connector **61**. In the illustrative embodiment, a DIN connector is used as connector **61**.

In the preferred embodiment, control signals for optical shutters **24** and **26** are generated in the microprocessor by operating software specifically designed to perform a series of ophthalmic tests. Flow charts of the computer programs for implementing this invention are provided in FIGS. **15–20**, and are described below. Software programs which execute these flow charts appear in the appendices. In an alternative embodiment, the microprocessor of module **12** generates control signals in response to instructions received from the eye examiner. The eye examiner may directly control the operation of optical shutters **24** and **26** or, alternatively, the shutters may operate according to a pre-programmed series of video displays. In still another alternative embodiment, shutters **24** and **26** are hard-wired to module **12** and are operated without the use of software. The shutters are driven by an address line from the CRT controller which indicates whether an odd or even field is being presented.

FIG. **11** shows a rear view of processor module **12**. Module **12** includes various interfaces for connecting system components and accessories. Video display monitor **10** connects to module **12** via interface means **53** and **55**, supplying power and video signals, respectively, to monitor **10**. Interface connector **61** accepts the connection of communication line **16**. In the preferred embodiment, both control signals and electrical power are sent from module **12** to the glasses driver control circuitry **18** via line **16**.

Hand-held controller **30** is shown in detail in FIG. **12**. Cable connection **59** accepts cable **28** in order to connect controller **30** to module **12**. The distal end of cable **28** connects with keypad interface **52** of module **12**. Controller **30** is used by the eye examiner to present a variety of visual acuity images on monitor **10**. The detailed functions and operations of controller **30** are described in greater detail in co-pending U.S. patent application Ser. No. 116,709.

Glasses driver circuitry **18** powers shutters **24** and **26** of optical means **22** in response to control signals received from processor module **12** via communication line **16**. Driver circuitry **18** is connected to optical means **22** such that shutters **24** and **26** may be independently controlled. Circuit **18** and optical means **22** (shown in FIG. **1**) may be connected by two communication lines **32** and **34** such that the lines control shutters **24** and **26**, respectively.

The components of circuit **18** are shown in block diagram form in FIG. **13**. Circuit **18** includes voltage converter **54**, voltage inverter **56**, oscillator **58**, waveform generator **68**, and shutter driving amplifiers **64** and **66**. In an illustrative embodiment, power is supplied at a low voltage, preferably at five volts, via line **16**. The voltage is applied to voltage converter **54** and oscillator **58**. Voltage converter **54** includes a voltage multiplier circuit to convert the five-volt supply to a twelve-volt supply. The twelve-volt supply is output to amplifiers **64** and **66** via line **67**. Voltage inverter **56** includes a circuit which inverts the voltage applied to its terminals. The inverted voltage is output to amplifiers **64** and **66** via line **65**. Oscillator **58** creates an AC voltage waveform, preferably with a frequency of 400 Hertz. The output signals from oscillator **58** are connected to waveform generator **68**. In the preferred embodiment, waveform generator **68** includes a series capacitor and a shunt resistor (connected to ground), which eliminate the DC portion of the oscillator output signal. Two control signals **70** and **72** (both transmitted on communication line **16**) operate switches **60** and **62**, preferably electronically controlled, to activate left and right shutter amplifiers **66** and **64**, respectively. When switches **60** and **62** are closed, the signals from waveform generator **68** are sent to amplifiers **64** and **66**. The outputs of amplifiers **64** and **66** are sent to shutters **24** and **26** via lines **32** and **34**.

FIG. **14** shows a detailed circuit diagram of the preferred embodiment of glasses driver circuitry **18**. In this embodiment, voltage converter **54** includes a two stage voltage multiplier which supplies twelve volts to voltage inverter **56** and to an operational amplifier integrated circuit chip (used for amplifiers **66** and **68**). The NPN and PNP transistors used in these circuits may be 2N3904 and 2N3906 transistors, respectively.

Oscillator circuit **58** includes a "555" integrated circuit timer, resistors, and capacitors. Oscillator **58** provides the AC signal input to voltage converter **54** and and inverter **56**. The output signal of oscillator **58** is also fed to driving waveform generator **68**, which eliminates any DC component of the signal. The remaining AC component feeds the negative input of amplifiers **66** and **64** when switches **60** and **62** are "closed." Switches **60** and **62** preferably are junction field effect transistors (JFETs) which are electronically switched "open" or "closed" via control lines **70** and **72**. Each of amplifiers **66** and **64** include an operational amplifier with a 422K ohm resistor connected to form a negative feedback loop. The outputs of the amplifiers drive optical means **22**.

In an alternative embodiment, glasses driver circuitry **18** and optical means **22** are replaced with stereo vision glasses and driving circuitry of a type such as have been commercially available from Haitex Resources, Inc., 208 Carrollton Park #1207, Carrollton, Tex. 75006. The Haitex glasses driver circuit has only one control line which provides only for one shutter being open, while the other is closed. Unlike circuit **18** and optical means

22, which independently control apertures **24** and **26**, the Haitex glasses do not provide the option of simultaneously opening both apertures or closing both apertures.

FIG. **15** shows a flow chart of software means for invoking or deactivating binocular vision testing when a predetermined key sequence is entered, preferably from hand controller **30**. The software causes module **12** to check the status of binocular vision testing. If binocular vision testing is disabled, the software causes the visual acuity tester to begin binocular vision testing. If binocular vision testing is enabled, the software terminates binocular testing and returns to ordinary visual acuity testing.

FIG. **16** shows a flow chart of software means for selecting "concealed" target testing. The software selects the field (odd, even or both) which will be used to display a preselected character (and therefore, selects whether the character will be visible to only one or to both eyes). The software first checks whether binocular vision testing is enabled. If it is not, an ordinary visual acuity target is drawn. If binocular testing is enabled, the software determines whether the target should appear to only one or to both eyes, and sets the appropriate software flag. After the target is eventually drawn, the software clears these flags. Sample software code implementing these functions is provided in Appendix A.

FIG. **17** shows a flow chart of software means for creating concealed targets. The software creates characters in graphics memory for display in the odd or even field or in both fields. In the preferred embodiment, targets appearing only to the right or left eye are drawn only on even-numbered (even field) or odd-numbered (odd field) horizontal raster lines, respectively. Targets appearing to both eyes are drawn in both fields. Using the flags set by the software shown in FIG. **16**, the software of FIG. **17** determines whether a given target is to be plotted on even or odd raster lines, or on both. Sample software code implementing these functions is provided in Appendix B.

FIG. **18** shows a flow chart of software means for selecting "depth" target testing. If binocular vision testing is desired, the software sets a flag, such as the "stereo-on" flag, for use by the depth target creation software (FIG. **19**). If binocular vision testing is not desired, the flag is not set, and an ordinary target is drawn. Sample software code implementing these functions is provided in Appendix C.

FIG. **19** shows a flow chart of software means for creating depth targets. A target created by this software is made visible to both eyes, but each eye sees a different image. The image presented to the right eye is identical to that presented to the left eye, but it is laterally displaced. The images are alternately displayed to the right and left eyes. The lateral displacement of the images creates the appearance of depth. The examiner selects a desired stereo separation, and the software modifies the plot coordinates in graphics memory to display the images to the right and left eyes with the desired separation. Software code implementing these functions is provided in Appendix D.

FIG. **20** shows a flow chart of the software means for synchronizing the optical means and driver circuitry with the display of the alternating fields on the monitor. This software first determines whether binocular vision testing is enabled. If it is, the software causes module **12** to wait for the end of the odd field, and then closes aperture **24** (the left aperture) and opens aperture **26** (the right aperture). Module **12** then waits for the end of the even field, closes aperture **26**, and opens aperture **24**. At the end of this sequence, the software determines whether a command entered via hand-controller **30** is pending. If there is no command pending, the software repeats the above sequence, and continues to do so until it detects a pending command. Once a pending command is detected, the program closes both apertures, thereby preventing the viewer from seeing the next target. This last step is not possible with the Haitex glasses. Because only one control line is provided with the Haitex glasses, when a given aperture is open, the other aperture is closed. When using the Haitex glasses, screen **14** must be kept blank whenever it is desirable to prevent the viewer from seeing the next character. Software code for synchronizing the optical means with the display of the alternating fields is provided in Appendix E.

It is thought that the video acuity tester with binocular vision testing apparatus and the methods of the present invention and its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts thereof without departing from the spirit and scope of the invention.

APPENDIX A

```
L4I:        CMP STEREO_TEST,2            ;MALINGERING MODE ?
            JNE C_MAL1                   ;
;
;WE ARE IN MALINGERING MODE - THE SECOND CHARACTER SHOULD
; APPEAR TO THE RIGHT EYE ONLY, AND THE SECOND FROM THE
; LAST CHARACTER SHOULD APPEAR TO THE LEFT EYE ONLY
;
; DI HAS THE CHARACTER NUMBER IN THE LINE BEING CONSIDERED
;
            CMP DI,4                     ;DO WE HAVE AT LEAST 4
                                         ;CHARACTERS IN THE
                                         ;LINE?
            JB C_MAL1                    ;JUMP IF NOT - NOT
                                         ;ENOUGH CHARACTERS
```

```
;
; WE HAVE 4 OR MORE CHARACTERS
;
          CMP HORIZ_LINE,O          ;FIRST LINE?
          JNE C_MAL1                ;JUMP IF NOT - ONLY
                                    ;DONE IN THE FIRST
                                    ;LINE
;
; THIS IS THE FIRST LINE
;
          CMP HORIZ_NUM,1           ;IS THIS THE SECOND
                                    ;CHARACTER?
          JNE C_MAL2                ;JUMP IF NOT
;
;IT'S THE SECOND CHARACTER
;
          MOV RIGHT_ONLY,1          ;MAKL IT RIGHT ONLY
          JMP C_MAL1                ;
;
;
;NOT THE SECOND CHARACTER
;
C_MAL2:   PUSH DX                   ;SEE SECOND FROM LAST
          MOV DX,DI                 ;CHARACTER - USE DX
          SUB DX,2                  ;FOR CALCULATION
          CMP HORIZ_NUM,DL          ;
          JNE C_MAL3                ;JUMP IF NOT
;
;IT'S THE SECOND FROM THE LAST CHARACTER
;
          MOV LEFT_ONLY,1           ;MAKE IT LEFT ONLY
;
C_MAL3:   POP DX                    ;RESTORE DX
;
C_MAL1:   CALL DRAW                 ;DRAW A CHARACTER
```

APPENDIX B

```
     IN A SEPARATE EYES MODE (STEREO_TEST =2,3, OR 4)

          CMP RIGHT_ONLY,1          ;ARE WE A SEPARATE
                                    ;EYES MODE SPECIAL?
          JNE CONT_T                ;JUMP IF NOT -
                                    ;CONTINUE AS USUAL TO
                                    ;PLOT THE POINT
;
;WE ARE IN RIGHT ONLY MODE
;
          TEST BX,1                 ;CHECK LSB OF LINE
                                    ; NUMBER
          JZ CONT_S                 ;CONTINUE TO PLOT THE
                                    ; POINT IF EVEN
          JMP EXITP                 ;EXIT (SKIP) IF ODD
;
```

```
CONT_T:     CMP LEFT_ONLY,1             ;SEPARATE EYES MODE
                                        ; SPECIAL?
            JNE CONT_V                  ;JUMP IF NOT
;
;WE ARE IN LEFT ONLY MODE
;
            TEST BX,1                   ;CHECK LSB OF LINE
                                        ; NUMBER
            JZ EXITP                    ;JUMP (SKIP) IF EVEN
            JMP CONT_S                  ;OTHERWISE CONTINUE AS
                                        ; NORMAL - PLOT THE
                                        ; POINT
```

APPENDIX C

```
;STEREO_TEST = 1 - THIS IS STEREOPSIS MODE - DRAW THE FOUR
;O'S
;
;
C_0:        MOV M_L_SIZE,8              ;ESTABLISH THE
                                        ; CHARACTER SIZE
            MOV L_SIZE,8                ;
            CALL SET_SCALE              ;
            CALL TAKE                   ;TAKE CONTROL OF THE
                                        ;SCREEN MEMORY D-RAM
;
;THE FOLLOWING CODE DETERMINES WHICH OF THE FOUR O'S IS IN
;STEREO
;
            MOV AH,FIRST_CALL_S         ;SEE IF FIRST CALL
            AND AH,FIRST_CALL           ;
            JZ CT5                      ;JUMP IF RANDOM

;
;NOT RANDOM - TOP O SHOULD BE STEREO
;
            MOV AX,1                    ;CHOOSE POSITION #1
            JMP CT6                     ;
;
; CHOICE IS RANDOM - PICK A NUMBER
;
CT5:        CALL RAND                   ;GET A RANDOM NUMBER
            XOR DX,DX                   ;AND SCALE IT TO A
                                        ;VALUE BETWEEN O AND
                                        ;3
            MOV BX,16384                ;
            DIV BX                      ;AX GETS O TO 3
;
            CMP AL, LAST_CHOICE         ;SAME AS LAST TIME? -
                                        ; DON'T WANT SAME
                                        ; POSITION
            JE CT5                      ;TRY AGAIN IF SO
;
CT6:        MOV LAST_CHOICE,AL          ;CHOICE IS IN AL
            MOVE STEREO_CHAR,AL         ;STORE FOR DISPLAY
                                        ; ROUTINE
```

```
;
;
;
; NOW DRAW O'S
;
        CMP AL,O                ;IS THIS THE ONE TO DO
                                ; STEREO IN ?
        JNE CT1                 ;JUMP IF NOT
;
        MOV STEREO_ON,1         ;OTHERWISE MAKE IT
                                ; STEREO
;
CT1:    DEC AL                  ;DECREMENT FOR NEXT
                                ; POSITION
;
        MOV X_ORG,215           ;X,Y ORIGINS FOR TOP
                                ;POSITION
        MOV Y_ORG,83            ;
;
        PUSH AX                 ;SAVE AX - CALLED
                                ;ROUTINE MODIFIES IT
        CALL O                  ;DRAW THE 'O'
        POP AX                  ;RESTORE AX
;
        MOV STEREO_ON,O         ;CANCEL STEREO IF IT
                                ; WAS ON
;
;
;
        CMP AL,O                ;IS THIS THE ONE TO DO
                                ; STEREO IN?
        JNE CT2                 ;JUMP IF NOT
;
        MOV STEREO_ON,1         ;OTHERWISE MAKE IT
                                ; STEREO
;
CT2:    DEC AL                  ;DECREMENT FOR NEXT
                                ; POSITION
;
        MOV X_ORG,142           ;X,Y ORIGINS FOR LEFT
                                ; POSITION
        MOV Y_ORG,156           ;
;
        PUSH AX                 ;SAVE AX
        CALL O                  ;DRAW THE 'O'
        POP AX                  ;RESTORE AX
;
        MOV STEREO_ON,1         ;CANCEL STEREO IT IF
                                ; WAS ON
;
;
;
        CMP AL,O                ;IS THIS THE ONE TO DO
                                ;STEREO IN?
        JNE CT3                 ;JUMP IF NOT
;
        MOV STEREO_ON,1         ;OTHERWISE MAKE IT
```

```
                                    ;STEREO
CT3:        DEC AL                  ;DECREMENT FOR NEXT
                                    ; POSITION
            MOV X_ORG,289           ; X,Y ORIGINS FOR
                                    ; RIGHT POSITION
            MOV Y_ORG,156           ;
;
            PUSH AX                 ;
            CALL O                  ;DRAW THE 'O'
            POP AX                  ;
;
            MOV STEREO_ON,O         ;CANCEL STEREO IF IT
                                    ; WAS ON
;
;
;
            CMP AL,O                ;IS THIS THE ONE TO DO
                                    ;STEREO IN?
            JNE CT4                 ;JUMP IF NOT
;
            MOV STEREO_ON,1         ;OTERWISE MAKE IT STEREO
;
CT4:        MOV X_ORG,215           ;X,Y ORIGINS FOR BOTTOM
                                    ;POSITION
            MOV Y_ORG,230           ;

            PUSH AX                 ;
            CALL O                  ;DRAW THE 'O'
            POP AX                  ;
;
            MOV STEREO_ON,O         ;CANCEL STEREO IF IT WAS
                                    ;ON
;
            JMP EXIT2               ;ALL DONE
;
```

APPENDIX D

```
CONT_U:     CMP STEREO_ON,1         ;ARE WE DOING STEREO ?
            JNE CONT_S              ;JUMP IF NOT
;
;WE ARE DOING STEREO - OFFSET EVEN NUMBERED LINES TO THE
;RIGHT, AND ODD NUMBERED LINES TO THE LEFT
;
            PUSH DX                 ;SAVE REGISTER USED
;
;LOOK UP SPACING IN THE TABLE
;
            PUSH BX                 ;
            PUSH ES                 ;
;
            MOV BX,CS               ;POINT ES TO TABLE FOR
                                    ; LOOKUP
            MOVE ES,BX              ;
;
```

```
        XOR BH,BH                   ;
        MOV BL,STEREO_SPACING       ;BX HAS SPACING NUMBER
;
        MOV DL,ES:SPACING[BX]       ;FETCH VALUE INTO DL
;
        POP ES                      ;RESTORE REGISTERS
        POP BX                      ;
;
;
        MOV DH,DL                   ;SAVE SPACING IN DH
        SHR DL,1                    ;DIVIDE BY TWO =>
                                    ;OFFSET TO EITHER SIDE
;
        TEST BL,1                   ;IS THIS AN ODD
                                    ; NUMBERED LINE?
        JZ EVENX                    ;JUMP IF EVEN
;
;THIS IS AN ODD NUMBERED LINE
;
;IF STEREO_SPACING IS ODD, WE WILL TAKE THE EXTRA COUNT HERE
;ON THE ODD NUMBERED LINE
;
        AND DH,1                    ;MASK THE LSB
        ADD DL,DH                   ;ADD ON IF SET
;
        XOR DH,DH                   ;DX HAS THE OFFSET
                                    ; RESULT
        SUB AX,DX                   ;ADJUST X POSITION TO
                                    ; LEFT
;
        POP DX                      ;RESTORE DX
        JMP CONT_S                  ;AND CONTINUE - PLOT
                                    ; THE POINT ON THE
                                    ; SCREEN
;
;
; THIS IS AN EVEN NUMBERED LINE
;
EVENX:  XOR DH,DH                   ;DX HAS THE OFFSET
                                    ; RESULT
        ADD AX,DX                   ;ADJUST X POSITION
                                    ; TO RIGHT
;
        POP DX                      ;RESTORE DX - PROCEED
                                    ; WITH PLOTTING THE
                                    ; POINT
;
;
```

APPENDIX E

```
;
;
TOGGLE  PROC NEAR                   ;**********************
;
;PROCEDURE TO TOGGLE THE STEREO INTERFACE LINES FOR STEREO
;MODE
```

```
;
          PUSH AX                         ;SAVE REGSTERS USED
          PUSH CX                         ;
;
          CMP STEREO_TEST,0               ;ARE WE DOING A STEREO
                                          ; TEST?
          JNE LP_INT1                     ;PROCEED IS SO
          JMP CXXX                        ;JUMP IF NOT - EXIT
;
;
; WE ARE DOING STEREO - TOGGLE THE INTERFACE LINES
;
;
;WAIT FOR 11 VERTICAL INTERVALS TO MAKE SURE WE WON'T BE
;INTERRUPTED BY COMPLETION OF THE CURRENT INCOMING KEYBOARD
;COMMAND
;
LP_INT1:  MOV KEY_INT,0                   ;CLEAR THE FLAG - WILL
                                          ; BE SET BY KEYBOARD
                                          ; INTERRUPT
          MOV CX, 11                      ;11 VERTICALS TO WAIT

LP_INT2:  CALL V_WAIT                     ;WAIT FOR A VERTICAL
                                          ; INTERVAL
          MOV AL,KEY_BUF                  ;EXIT IF KEYBOARD
                                          ; COMMANDS ARE PENDING
          OR AL,KEY_BUF_C                 ;
          JZ C_CX                         ;PROCEED IF NONE
                                          ; PENDING
          JMP C_C                         ;OTHERWISE ABORT
;
C_CX:     CMP KEY_INT,0                   ;IS FLAG AS WE LEFT
                                          ; IT?
          JNE LP_INT1                     ;IF NOT, START OVER
;
          LOOP LP_INT2                    ;OTHERWISE CONTINUE
                                          ; TILL 11 VERTICAL
                                          ; INTERVALS COMPLETED
;
;DROPPING THRU MEANS WE WENT 11 VERTICAL INTERVALS WITHOUT A
;KEYBOARD INTERRUPT
;
;
;BE SURE D-RAM IS UNDER CONTROL OF CRTC CHIP - WE ARE ABOUT
;TO GO A LONG TIME WITHOUT INTERRUPTS.  SHOULD ALREADY BE
;CLEARED - THIS IS TO MAKE SURE
; ________
          PUSH AX                         ;SAVE AX
          MOV AL,XR5                      ;FETCH RAM IMAGE OF
                                          ;EXTERNAL REGISTER
          AND AL,7FH                      ;CLEAR THE BIT
          CLI                             ;INTERRUPTS OFF WHILE WE
          OUT 5,AL                        ;UPDATE THE REGISTER
          MOV XR5,AL                      ;AND ITS IMAGE
          STI                             ;INTERRUPTS BACK ON
                                          ; AGAIN
          POP AX                          ;RESTORE AX
```

```
;
;PROCEED WITH ODD/EVEN FIELD DETERMINATION - THIS IS DONE
;BY SAMPLING "DE" (DISPLAY ENABLE) FROM THE CRTC CHIP AT A
;SPECIFIC TIME FOLLOWING THE VETICAL SYNC "VS" PULSE.  "DE"
;WILL BE EITHER HIGH OR LOW AT THAT TIME DEPENDING UPON THE
;FIELD BEING SAMPLED
;
;
          CLI                         ;NO INTERRUPTS TILL WE
                                      ;FIGURE OUT ODD/EVEN
                                      ;FIELD

          CALL V_WAIT                 ;WAIT A VERTICAL INTERVAL
;
L_I:      CALL V_WAIT                 ;AND AGAIN
;
          MOV CX,560                  ;WAIT A WHILE - MAGIC
                                      ;TIME TO 'DE' SAMPLING
LPW:      NOP                         ;TIMING LOOP
          LOOP LPW                    ;
;
          IN AL,4                     ;BRING IN DE
          TEST AL,4                   ;LOOK AT DE
          JZ L_I                      ;JUMP IF LOW - TRY
                                      ;NEXT FIELD
;
;DROPPING THRU INDICATES WE HAVE THE STARTING FIELD THAT WE
;WANT - DE IS HIGH
;
          STI                         ;INTERRUPTS BACK ON
;
;
;
          MOV AL,XR2                  ;GET IMAGE OF REGISTER
                                      ;WHICH CONROLS STEREO
                                      ;GLASSES
          AND AL,3FH                  ;CLEAR EXISTING BITS
                                      ;FOR RIGHT AND LEFT
                                      ;EYES
          OR AL,80H                   ;SET ONE BIT DIFFERENT
                                      ;(ONE EYE OPEN)
;
          CLI                         ;NO INTERRUPTS WHILE WE
          MOV XR2,AL                  ;UPDATE THE RAM IMAGE
          OUT 2,AL                    ;AND THE REGISTER
          STI                         ;
;
;UNBLANK THE SCREEN IF APPROPRIATE
;
          CMP BLNK,1                  ;ARE WE BLANKED?
          JE C_LPX                    ;JUMP IF SO - DON'T
                                      ;WANT TO UNBLANK
;
          CMP RG,1                    ;SAME WITH RED/GREEN
                                      ;LIGHT ON
          JE C_LPX                    ;
;
```

```
         CMP FIX,1                 ;SAME WITH FIXATE LIGHT
                                   ;ON
         JE C_LPX                  ;
;
;
;WE WANT TO UNBLANK THE SCREEN
;
;THE HAITEX GLASSES TAKE A WHILE TO ACTIVATE - TOGGLE LINES
;FOR TWO VERTICAL INTERVALS TO GET THEM GOING FIRST
;
;
         CALL V_WAIT               ;WAIT FOR A VERTICAL
                                   ;INTERVAL
;
         CLI                       ;TOGGLE THE LINES
         MOV AL,XR2                ;FETCH RAM IMAGE
         XOR AL,OCOH               ;CHANGE BITS FOR BOTH
                                   ;EYES
         MOV XR2,AL                ;UPDATE RAM IMAGE
         OUT 2,AL                  ;AND UPDATE REGISTER
         STI                       ;
;
         CALL V_WAIL               ;WAIT FOR A VERTICAL
                                   ;INTERVAL
;
         CL1                       ;TOGGLE THE LINES
         MOV AL,X2                 ;
         XOR AL,OCOH               ;
         MOV XR2,AL                ;
         OUT 2,AL                  ;
         STI
         CALL V_WAIT               ;WAIT FOR A VERTICAL
                                   ;INTERVAL
;
         CLI                       ;TOGGLE THE LINES
         MOV AL,XR2                ;
         XOR AL,OCOH               ;
         MOV XR2,AL                ;
         OUT 2,AL                  ;
         STI                       ;
;
;GLASSES HAVE HAD TIME TO ACTIVATE
;
         MOV AL,XR5                ;NOW UNBLANK THE SCREEN
         AND AL,OFEH               ;CLEAR BLANKING BIT
         CLI                       ;UPDATE
         OUT 5,AL                  ;REGISTER
         MOV XR5,AL                ;AND RAM IMAGE
         STI                       ;
;
;
;NOW TOGGLE THE INTERFACE LINES UNTIL A KEY IS PRESSED
;
C_LPX:   CALL V_WAIT               ;WAIT FOR A VERTICAL
                                   ;INTERVAL
```

```
         CLI                          ;TOGGLE THE LINES
         MOV AL,XR2                   ;FETCH RAM IMAGE
         XOR AL,OCOH                  ;CHANGE BITS FOR BOTH
                                      ;EYES
         MOV XR2,AL                   ;UPDATE IMAGE
         OUT 2,AL                     ;UPDATE REGISTER
         STI                          ;
;
         ADD TIMER,19                 ;ADD 17 MSEC TO THE
         ADC TIMER+2,O                ;TIMER
;
;CHECK FOR A TIMEOUT - QUIT IF 10 MINUTES HAS GONE BY
;
         CMP TIMER+2,10               ;10 MINUTES UP?
         JAE C_C                      ;QUIT IF SO
;
;CHECK FOR ANY KEYBOARD COMMANDS PENDING
;
         CMP KEY_BUF,O                ;NO COMMANDS PENDING?
         JNE C_C                      ;JUMP IF COMMANDS
         CMP KEY_BUF_C,O              ;
         JNE C_C                      ;
;
         CMP KEY_INT,1                ;WERE WE BLANKED BY A
                                      ;KEYBOARD INTERRUPT?
         JE C_C                       ;EXIT IF SO
;
;
         JMP C_LPX                    ;LOOP TILL COMMANDS
                                      ;AVAILABLE
;
;
;TIME TO EXIT - BLANK THE GLASSES (WON'T WORK WITH HAITEX
;GLASSES DRIVER)
;
C_C:     MOV AL,XR2                   ;FETCH RAM IMAGE OF
                                      ;REGISTER
         OR AL,OCOH                   ;SET BOTH BITS TO 'OFF'
         CLI                          ;
         MOV XR2,AL                   ;UPDATE THE RAM IMAGE
         OUT 2,AL                     ;AND THE REGISTER
         STI                          ;
;
CXXX:    POP CX                       ;RESTORE REGISERS USED
         POP AX                       ;
;
         RET                          ;
;
TOGGLE   ENDP                         ;
```

We claim:

1. A method for testing binocular vision using a display comprising the steps of:

alternately displaying images on the display at a frequency sufficient to maintain fusion;

alternately blocking or permitting a patient's viewing of the display; and

synchronizing the displaying of the alternating images with blocking or permitting the patient's viewing such that some images are visible only to the patient's left eye, some images are visible only to the patient's right eye, and some images may be visible to both of the patient's eyes.

2. The method defined in claim **1** wherein the display is a video display monitor.

3. The method defined in claim **2** wherein the video display monitor uses a liquid crystal display.

4. The method defined in claim **2** wherein the video display monitor uses a raster scan cathode ray tube.

5. The method defined in claim **3** wherein the alternating images are presented on alternating interlaced screens of scan lines displayed on the monitor.

6. The method defined in claim **1** wherein the display of alternating images is achieved by means of alternating frames of a film.

7. A method of testing visual function to determine a patient's degree of stereo acuity comprising the steps of claim **1**, and further comprising:
- displaying at least one symbol such that it is displaced laterally to at least one eye than other symbols displayed.

8. The method of claim **7** wherein said predetermined pattern is diamond-shaped.

9. A method of testing visual function to evaluate ocular motor imbalance comprising the steps of claim **1**, and further comprising:
- displaying at least one target symbol to one eye of the patient and preventing the display of said target symbols to the second eye of the patient;
- displaying a test symbol at a reference position to the second eye and preventing the display of the test symbol to the first eye; and
- moving the test symbol away from said reference position in steps of predetermined distances until it appears to the patient that the test symbol is aligned with one of said other target symbols.

10. The method of claim **9**, wherein said test symbol is moved horizontally, for evaluating horizontal ocular motor imbalance.

11. The method of claim **9**, wherein said test symbol is moved vertically, for evaluating vertical ocular motor imbalance.

12. The method of claim **9**, further comprising the step of displaying at least one visual target to both of the patient's eyes to provide a fixation lock for evaluating fixation disparity.

13. A method for detecting phoria comprising the steps of claim **1**, and further comprising:
- displaying two horizontal lines in the same horizontal plane, such that the first horizontal line is visible to one eye of the patient and the second horizontal line is visible to the second eye of the patient.
- displaying two vertical lines in the same vertical plane, such that the first vertical line is visible to one eye of the patient and the second vertical line is visible to the second eye of the patient;
- determining whether the vertical and horizontal lines appear to the patient to be in the same vertical and horizontal planes, respectively.

14. The method of claim **13**, further comprising the step of displaying at least one visual target to both of the patient's eyes to provide a fixation lock for detecting associated phoria.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,026,151

DATED : June 25, 1991

INVENTOR(S) : Morey H. Waltuck et al.

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

On the cover page, under the heading References Cited, change "Blankehorn" to -- Blankenhorn --.

On the cover page, between the last cited U.S. patent (4,870,486) and the "Primary Examiner" entry, insert:

-- OTHER DOCUMENTS

B-VAT II Video Acuity Tester Instruction Manual, Mentor O & O, Inc., (1987).

"AO Custom Project-O-Chart Slides," Instruction Manual, AO American Optical. (date unknown)

"AO Vectographic Project-O-Chart Slides," product literature, AO American Optical. (date unknown)

"The TVA: True Visual Acuity," InnoMed Corp. product literature. (date unknown)

InnoMed Corp. product advertisement

Mentor O&O, Inc. B-VAT product literature (date unknown)

"B-VAT Video Acuity Tester Instruction Manual," Mentor O&O, Inc. (date unknown)

Stereo Optical Company, Inc. product literature (date unknown)

The TVA Operations Manual, Technical Enginuities Corp. (1985).

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,026,151

DATED : June 25, 1991

INVENTOR(S) : Morey H. Waltuck et al.

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

"TVA Revolutionizing Refracting," InnoMed Corp. product literature, (1985).

Fahle, M. and Erb, M., "Presenting Stereoscopic Stimuli With One Monitor," Vision Research, Vol. 27, No. 8, pp. 1391-92 (1987)

Lindblom, B. and Frisen, L., "Measuring Stereo Acuity with Liquid Crystal Shutters and Computer Graphics," Neuro-ophthalmology, Vol. 8, No. 6, pp. 283-87 (1988)

Handaya Co., Ltd. product literature, New Aniseikonia Tests (date unknown)

Duane, Clinical Ophthalmology, Vol. 1, Ch. 9, pp. 8-11 (date unknown)

Fahle, M. and Westheimer, G., "Local and Global Factors in Disparity Detection of Rows of Points," Vision Research, Vol. 28, No. 1, pp. 171-78 (1988) --

At column 2, line 35, change "flexiblity" to -- flexibility --.

At column 3, line 15, change "electrooptical" to -- electro-optical --.

At column 8, line 49, delete -- and --.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,026,151

DATED : June 25, 1991

INVENTOR(S) : Morey H. Waltuck et al.

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

At column 22, line 7, change "IS" to -- IF --.

At columns 23-24, line 4, change "VETICAL" to -- VERTICAL --.

At column 24, line 35. change "CONROLS" TO -- CONTROLS --.

At column 25, line 24, change "V__WAIL" to -- V__WAIT --.

At column 28, line 44, change "REGISERS" to -- REGISTERS --.

Signed and Sealed this

Twenty-first Day of June, 1994

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks