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ABSTRACT

Slow, Red-green
Counterphase (Parvo) and
Fast, Black-white (Magno) Snow in the
Detection of Scotomata in Primary Open-Angle Glaucoma

by

Rey Favis

No one knows why Primary Open Angle Glaucoma sufferers can detect their glaucoma induced blindspots by monocularly fixating on a mark in the center of a screen of television snow. An attempt was made to determine which of two pathways from retina to lateral geniculate nucleus is more involved in the detection of the blindspots. Previous studies demonstrated that the large diameter axon, magno cellular pathway is maximally stimulated by 30 Hertz high contrast black-white patterns. The small diameter axon, parvo cellular pathway is known from past research to be maximally stimulated by 12 Hertz red-green counterphase patterns. It was found that patients when viewing a black-white noise presentation (snow) could more accurately determine glaucoma induced blindspots than when viewing a 5 Hertz red-green counterphase pattern. The possible presence of visual pathway fiber damage in the patients was indicated by subnormal results from a spatial frequency test that utilized a neutral density filtered Visitech Chart.

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FAST, BLACK-WHITE (MAGNO) SNOW IN THE
DETECTION OF SCOTOMATA IN PRIMARY OPEN-
ANGLE GLAUCOMA.**

by

Rey Favis

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1. INTRODUCTION

In the late 1980's, (Aulhorn et al.), while working at the Department of Pathophysiology of Vision and Neuro-Ophthalmology of Tübingen University, made a remarkable finding. If true, the result could radically alter the diagnosis of visual field damage in certain types of glaucoma patients. She claims that patients, while fixating on television snow, could notice and trace out on the television screen previously unrecognized blindspots on their retinas that were caused by a variety of visual system diseases, including glaucoma, [1].

Patients afflicted by Primary Open-angle Glaucoma require periodic measurement of the extent of their visual field damage. The amount of time consumed in measuring the size of glaucoma induced blindspots in the visual field could be decreased dramatically utilizing Aulhorn's discovery. Furthermore, this phenomenon may be used to provide more evidence on exactly which physiological components of the visual system are damaged by Primary Open-angle Glaucoma. The underlying physiological damage of Primary Open-angle Glaucoma, though a target of intensive investigation, remains largely a mystery.

1.1 Nature of Primary Open-angle Glaucoma

Primary Open-angle Glaucoma (POAG) is the type of glaucoma which ophthalmologists most often must treat and with which they have the most difficulty. In diagnosis of this condition, the intraocular fluid pressure is often slightly above the normal value for the eye and the angle α , between the cornea and the iris has not been narrowed, [2]. There may be a family history of glaucoma, and changes in the appearance of the optic disk may also occur. In spite of this, the angle α , between the cornea and the iris shows no evidence of being narrower than

normal and does not prevent aqueous humor from reaching the trabecular network, (Figure 1). However, the fluid does not drain well into the canal of Schlemm (so it is described

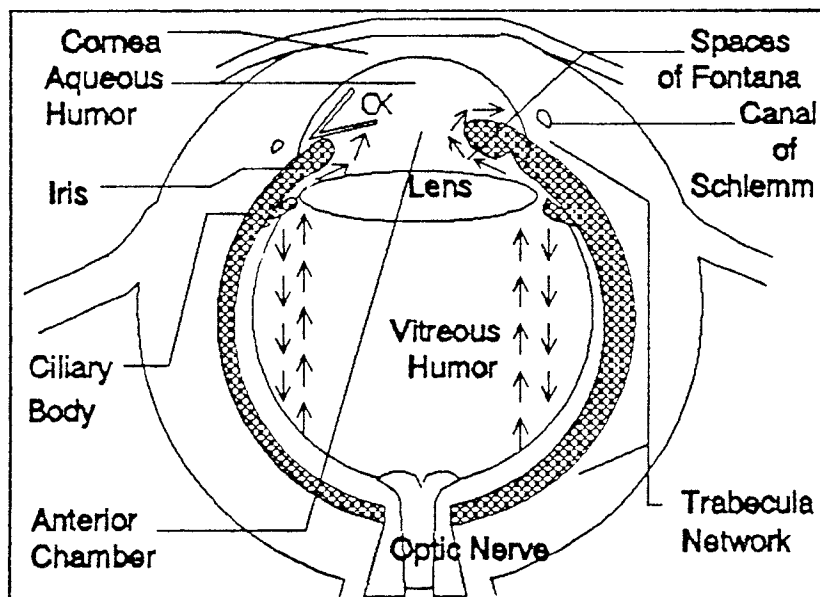


Figure 1 Angle α Between Cornea and Iris Not Narrowed to Prevent Fluid Draining Through Canal of Schlemm

as open-angle glaucoma). In some instances, the same pathology occurs without apparent increase in intraocular pressure (low tension glaucoma). Because no clear causal

symptoms which account for the eye damage are present, this type of glaucoma is described as primary, and the set of symptoms and results is termed Primary Open-angle Glaucoma.

The upper limit of "normal" intraocular fluid pressure in the human eye is considered to be between 21 - 23 mmHg, [2]. If the fluid pressure rises to the neighborhood of 60 to 70 mmHg because of angle-closure due to shallow anterior chamber, then blindness may result in a few days, [3]. This is due to harmful pinching of the optic nerve where the nerve enters the eyeball and also due to compression of the blood vessels in the retina cutting off the retinal blood supply.

Primary Open-angle Glaucoma produces a much milder sustained elevation of intraocular fluid pressure. It is suspected that spikes in the pressure cause the damage. These spikes may only be found by taking several pressure readings over the course of the day. The gradual loss of vision that accompanies untreated Primary Open-angle Glaucoma is attributed to the effects of a sustained mild elevation of pressure on the optic nerve causing a decreased axoplasmic flow or due to a decrease in the perfusion of blood through the capillaries in the optic nerve head and subsequent destruction of ganglion cells in the surface of the retina.

Primary Open-angle Glaucoma is frequent among the elderly, African Americans, diabetics, and families with glaucoma. After less severe techniques have been unsuccessfully applied, a typical treatment in this population

for reduction of intraocular fluid pressure is to administer drugs such as those which prevent function of beta-adrenergic nerve receptors (beta-blocker eyedrops). However, such pressure-reducing medications also have a wide range of undesirable side effects. Hence, if there is no visual field loss due to suspected Primary Open-angle Glaucoma, these medications are generally not prescribed. When visual field loss is detected, or some other indication of visual loss is present, these medications are administered to a patient to retard or prevent further visual loss.

Visual field loss initially appears in the form of a blindspot or a scotoma. A scotoma can be relative, meaning that the threshold for light detection is raised. A scotoma can also be absolute, meaning that a light stimulus at any level cannot be detected inside a circumscribed area of the visual field. In untreated Primary Open-angle Glaucoma, visual field deterioration manifests itself first as small relative scotomata, typically in an arc that maps the fibers going to the optic nerve head, between 15 and 20 degrees from the center of function. If left untreated, these small relative scotomata grow larger and become absolute scotomata.

1.2 History of Glaucoma Diagnostic Methods

Currently, the method of determining the onset visual loss due to Primary Open-angle Glaucoma is a procedure called perimetry. Static threshold perimetry measures the level of light threshold that can be detected by an eye at fixed locations within the visual field by varying the luminance of the test objects at fixed locations on the surface of a Ganzfeld, (Figure 2), [4]. This involves the flashing on and off of more than a hundred test points over the entire visual field for period of up to twenty minutes. A typical device for static

perimetry consists of a hollow spherical chamber (Ganzfeld) with a small entrance at one side, (Figure 2). In complete darkness, a patient with his head fixed at

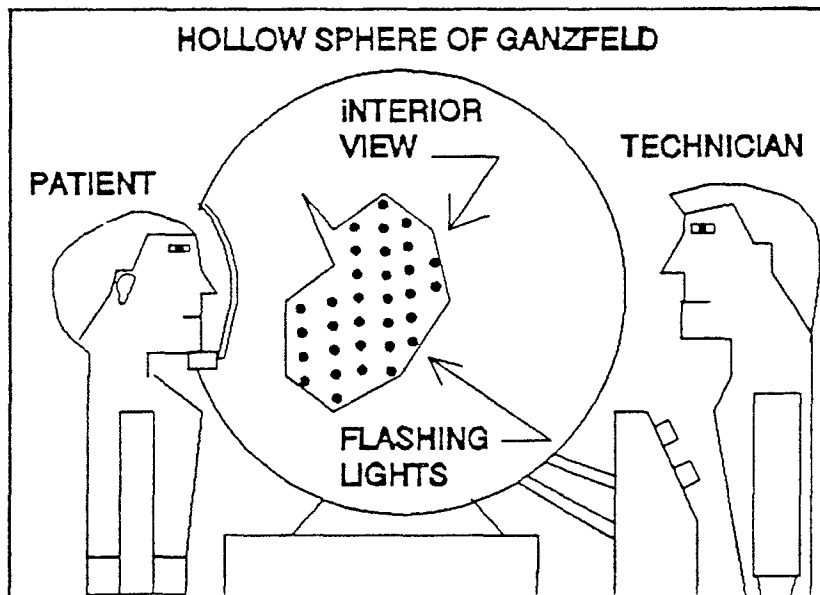


Figure 2 Conventional Static Perimetry Test with Patients Head Fixed at Entrance of Ganzfeld Chamber

the entrance of the Ganzfeld indicates whether or not he detected randomly presented lights in the walls of the chamber, when the small lights are turned on and off at

different levels of luminance, [5]. Since this test is time consuming and equipment is not portable, and moderately expensive and time consuming, there is a need for simpler screening devices which may find scotomata.

A faster method for the detection of peripheral scotomata called snow campimetry was introduced by Elfriede Aulhorn and Gerd Kost in 1988, [1]. Patients with scotomata suffering from Primary Open-angle Glaucoma are able to notice their blind spots in the periphery of the visual field (which are ordinarily invisible to them) by monocularly fixating a mark at the center of a television screen on which is displayed the noise that

appears when there is no station signal on a channel, (Figure 3). This noise is usually described as resembling heavy snow in a blizzard and is

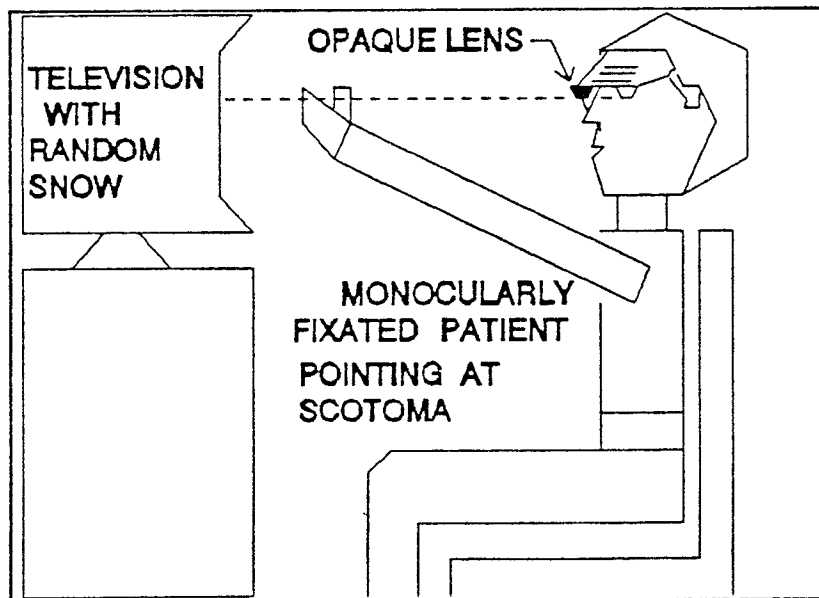


Figure 3 Patient Perceives Scotomata While Viewing Black and White Television Snow

termed "snow." Hence, this perimetric method has been referred to as snow perimetry, [1].

A television screen is essentially uniplanar (flat), and

not spherical as is a Ganzfeld. Hence, scotomata lying beyond the central 30 degrees of the visual field cannot be detected with such a planar display. Because of the uniplanar nature of the stimulus source area, snow perimetry may more accurately be termed snow campimetry, [1].

Elderly patients suffering from Primary Open-angle Glaucoma have to be regularly monitored for the onset and progression of scotomata. Fixating on a spot at the center of a snowy television screen is much less taxing on these patients than is trying to detect the flashing on and off of points of lights for an hour, [1]. It is also faster for the technician and allows a higher volume of patients to be monitored in a given period of time. In addition, it would be easy to use such a test in a glaucoma screening program.

While there are evident advantages to snow campimetry, disadvantages appear. Scotomata would have to be limited to the central 30 degrees of the visual field; for relative scotomata, the threshold luminance below which a light stimulus cannot be seen is not measurable, so the severity of relative scotomata is not as easily indexed as with a perimeter.

1.3 Source of Primary Open-angle Glaucoma

The eye is largely a system of parallel nerve pathways, starting with the receptor cells (rods and cones) running from the retina through the visual pathways to the visual areas of the brain. Part of the pathway, the lateral geniculate nucleus (LGN) found in Old World primates including humans, has generally been thought to be a mere synapse station on the way to the brain. The LGN is divided into six distinguishable layers of cells. These consist of four dorsal layers composed of numerous, dense small-bodied (parvocellular) neurons and two ventral layers composed of larger bodied (magnocellular neurons). There is a substantial body of evidence that characterizes the parvo pathway as a system to relay color information with a relatively slow temporal modulation from the retina to the visual cortex, while the magno pathway relays brightness information with the possibility of more rapid temporal modulation (up to the flicker limit) from the retina to the visual cortex, [6, 7]. Thus, there seem to be at least two major parallel retino-cortical pathways for the processing of color and brightness [8].

The human retina's color receptor cells (cones) can be classified into s, m, l (for short, medium, and long wavelength) receptors. These correspond to l cones with a peak response at 560 nm (long wavelength), m cones with a peak response at 530 nm (medium wavelength), and s cones with a peak response at 440 nm (short wavelength). Through a complex

process of interconnections, connected via the intermediate bipolar cell layer to a ganglion cell layer in the front of the retina, the cones produce responses for red and green opponent process cells as well as yellow and blue opponent processes. Axons of the ganglion cells lead via the optic disk and the optic nerve neurons to the lateral geniculate nucleus.

From a combination of anatomical and functional studies, ganglion cells that connect to m pathways are related to retinal centers that are dominated by l cones. Roughly, there are two l cones for every m cone in the retinal centers of m pathway ganglion cells, [8]. Parvo pathway ganglion cells with retinal centers corresponding to the central 5 degrees of the visual field have their centers dominated by m cones. The proportion of P pathway ganglion cells with retinal centers dominated by l cones increases as one goes from the fovea to the periphery. This means that the farther away from the fovea that their retinal centers are located, the greater is the proportion of P pathway ganglion cells with retinal centers dominated by l cones. Therefore, at any point in periphery, the P cells are dominated by a particular balance of red and green. The s excitatory ganglion cells in the retina only provide excitatory synaptic inputs to parvocellular neurons in the lateral geniculate nucleus. Hence, s excitatory ganglion cells are considered to be P pathway ganglion cells.

Some purely functional differences of these pathways have been found as well. Magnocellular neurons increase their rate of firing eight times faster than do parvocellular neurons in response to the same increase of the difference in light levels (contrast), [8]. That is magnocellular neurons exhibit an eight times more frequent firing than do parvocellular neurons in response to the same degree of increased contrast, and are thus highly sensitive to faint to moderate gray differences in black-white displays. Contrast is defined as:

$$\text{CONTRAST} = \frac{(\text{PEAK AMOUNT OF LIGHT}) - (\text{LEAST AMOUNT OF LIGHT})}{(\text{PEAK AMOUNT OF LIGHT}) + (\text{LEAST AMOUNT OF LIGHT})}$$

A parvocellular neuron will increase or decrease its rate of firing dependent on the wavelength (color) of the stimulating light that fills the receptive field of that particular parvocellular neuron. If the retinal center of a parvocellular neuron corresponds to the central 5 degrees of the visual field, then the center is dominated by m cones and the parvocellular neuron increases its rate of firing when its center is filled with medium wavelength light typically called green, [7, 8]. If the retinal center of a parvocellular neuron corresponds to outside the central 5 degrees of the visual field, then the center is dominated by l cones and the parvocellular neuron increases its rate of firing when its center is filled with long wavelength light typically called red, [7, 8]. P pathway s excitatory ganglions receive

excitatory inputs from s cones also receive inhibitory inputs from l and m cones. Hence, a parvocellular neuron deriving synaptic inputs from a P pathway s excitatory ganglion will exhibit a decrease in the rate of firing in response to long wavelength (red) l light or medium wavelength (green) m light. Likewise, a parvocellular neuron with a m cone dominated center corresponding to the central 5 degrees of the visual field should exhibit a decrease in the rate of firing when its center is filled with long wavelength (red) l light.

Similarly, a parvocellular neuron with a l cone dominated center corresponding to outside the central 5 degrees of the visual field should exhibit a decrease in the rate of firing when its center is filled with medium wavelength (green) m light which mainly causes m cones to fire. Retinal centers in the fovea almost exclusively stimulate parvocellular neurons. Centers in the retinal periphery stimulate either magnocellular or parvocellular neurons with the centers becoming stimuli almost exclusively for magnocellular neurons as the center locations become ever more peripheral, [7, 8]. The scotomata associated with Primary Open-angle Glaucoma are in the periphery of the visual field and correspond to damage in the periphery of the retina.

In addition to the clear differences in structure and function of M and P pathways, it has been proposed that the larger diameter M pathway axons are more susceptible to pressure damage than are P pathway axons [9, 10]. Quigley

[11] through histological studies demonstrated that optic nerve fibers larger than the mean diameter of all optic nerve neurons die sooner under chronically elevated intraocular pressure than do smaller than average fibers. Large axons in the optic nerve do not necessarily provide synaptic inputs to magnocellular neurons in the lateral geniculate nucleus. Quigley has found that larger diameter ganglion cells in the human retina atrophy faster than do smaller diameter ganglion cells in patients suffering from glaucoma [12-13]. There is putative evidence that this damage extends specifically to magnocellular layers of the LGN, [Quigley and Hendrickson, 1984], and therefore, a reasonable supposition that the glaucomatous damage to the larger diameter axons either eliminates the input to the M layer or through degenerative processes destroys the M layer in the LGN.

It is not implausible to hypothesize that the larger diameter ganglion cells in the retina have larger diameter axons and that the smaller ganglion cells have smaller diameter axons. Under this hypothesis, the axons supplied to the optic nerve by the larger diameter retinal ganglion cells are the larger diameter axons in the optic nerve. It is also not implausible to hypothesize that the larger bodied magnocellular neurons in the lateral geniculate nucleus receive synaptic inputs from the larger diameter axons and that the smaller bodied parvocellular neurons in the lateral geniculate nucleus receive synaptic inputs from the smaller

diameter axons. This would place larger diameter retinal ganglion cells and larger diameter optic nerve axons in the M pathway, while smaller retinal ganglion cells and smaller diameter

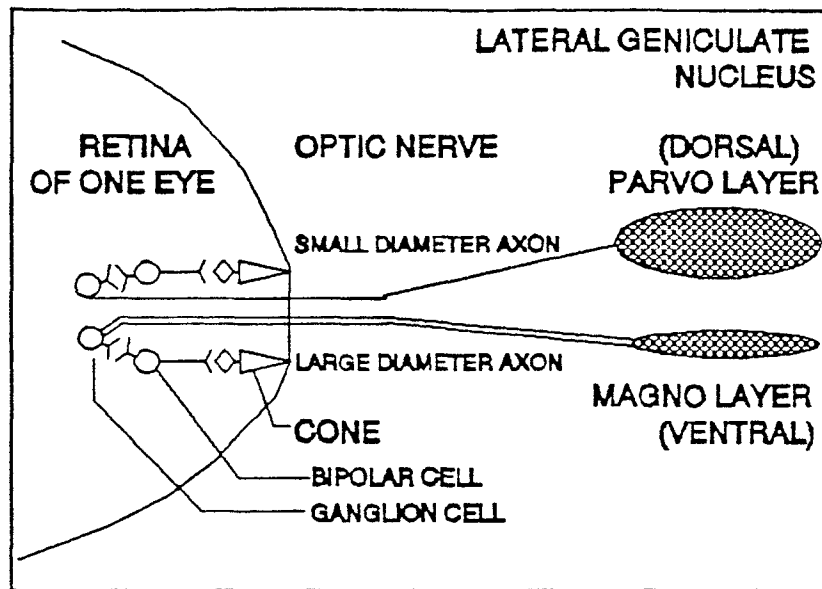


Figure 4 Arrangement of Large Axon Diameter Magno Pathway and Small Axon Diameter Parvo Pathway, proposed by Quigley et al [11]

optic nerve axons would be placed in the P pathway, (Figure 4). Since the larger retinal ganglion cells and optic nerve axons are known to be more susceptible to pressure and have been assigned to the M pathway, the M pathway would be more susceptible to pressure than the P pathway.

As a result of this sort of evidence, scotomata detected in patients suffering from Primary Open-angle Glaucoma are hypothesized to be associated more with defects in the M pathway than defects in the P pathway because M pathway cells are assumed to be more sensitive to pressure. Furthermore M pathway cells dominate the retinal periphery and it is the periphery of the visual field where scotomata first appear in Primary Open-angle Glaucoma.

The present study tests the hypothesis that the slightly

excessive pressure of Primary Open-angle Glaucoma preferentially damages the M pathway resulting in peripheral scotomata. It is known that high contrast black and white television snow temporally changing at 30 Hertz causes magnocellular neurons to exhibit a high level of excitation while not affecting parvocellular neurons very much [8]. It is also known that parvocellular neurons are preferentially excited over magnocellular neurons by a red and green patchwork display with the red and green luminance intensities varying sinusoidally at 12 Hertz and 180 degrees out of phase with each other, red-green counter phase, [14]. If a patient with Primary Open-angle Glaucoma can see scotomata much better when fixating at a mark at the center of a television screen of 30 Hertz black and white snow than the red and green presentation, then the hypothesis is supported. In this investigation, the red and green patchwork is replaced by a red and green checkerboard.

1.4 Development of Testing Methods

If Primary Open Angle Glaucoma (POAG) patients can see their scotomata better with black-white snow in the neighborhood of 30 Hertz, then there is evidence that POAG involves damage to the M (magno) pathway. If the patients can see their scotomata better with red-green counterphase at 12 Hertz or lower, then there is evidence that POAG involves damage to the P (parvo) pathway. An attempt was made to provide both of these types of stimuli as precisely as possible.

1.4.1 Black and White Random Snow Presentation

Professor Aulhorn reported a 50 Hertz flicker rate as the condition under which her patients were asked to monocularly fixate the center of a random black-white display and then search for possible scotomata. This may not have been the optimum flicker rate for the display and it certainly was not the rate of intensity change for a physical location on a standard black-white television in the late 1980's Federal Republic of Germany. Such a physical point on a German television screen would have changed at 25 Hertz, which is half the vertical retrace rate of 50 Hertz, since each German television frame is composed of interlaced scan lines belonging to two separate 25 Hertz fields 180 degrees out of phase with each other. However, Professor Aulhorn employed a black-white computer monitor to test her patients. A physical point on a non-interlaced German computer monitor would have

a flicker rate of 50 Hertz. In the United States, the frame rate is 30 Hertz for an interlaced display and 60 Hertz for a non-interlaced display. These values cannot be varied on a U.S. television or computer monitor without extensive, costly re-engineering. A change in black-white snow flicker from a frame rate of 25 Hertz to a display rate of 30 Hertz should not be physiologically significant. Both rates should elicit a high level of excitation from magnocellular neurons while not affecting parvocellular neurons very much.

The detection of glaucoma induced blindspots appeared to be effective even when a glaucoma patient was fixating on the center of ordinary television snow, [1]. Shot noise in the television Radio Frequency amplifier accounts for most of this snow, [15, 16]. Shot noise is always associated with direct current flow and is present in diodes, transistors and vacuum tubes. Passage of carriers across a region, such as a diode junction, is a purely random event dependent on a carrier having sufficient energy and velocity in the correct direction. Hence, a direct current passing through diodes, transistors or vacuum tubes is composed of a large number of random independent current pulses. These random independent current pulses are shot noise. They are the dominant noise component added to a video signal. When there is no video signal, amplification and video demodulation of shot noise produces television snow.

Shot noise is equally distributed at all frequencies.

Noise having this quality is classified as white noise. Therefore, the amount of shot noise power is uniform across the operating bandwidth of a television cathode ray tube (CRT) display. In the United States, the vertical retrace rate is 60 Hertz and the horizontal retrace rate is 525 scan lines per frame multiplied by 30 frames per second, which is 15,750 Hertz. A maximum of 700 distinguishable pixels of information per scan line can be displayed on a U.S. television, [17]. In other words, there are a maximum of 700 distinguishable changes of electron gun intensity per scan line. Hence, the upper frequency of the operating bandwidth of a U.S. television cathode ray tube is $700 \times (15,750 \text{ Hertz})$ or 22 megaHertz. The lower frequency limit of the cathode ray tube is the frame rate of 30 Hertz, which is half the 60 Hertz vertical retrace rate, since a frame is composed of the interlaced scan lines of two different fields each created by a separate vertical retrace. The maximum rate at which a spot on an American television set can randomly change between being black or white is 30 Hertz. There is sufficient shot noise power at frequencies up to the 22 megaHertz upper limit of the operating bandwidth of a television cathode ray for all 700 distinguishable pixels composing a television scan line to change randomly at 30 Hertz due to shot noise in the Radio Frequency amplifier. In other words, the random rate of change in electron gun intensity, as a scan line is produced, is sufficiently high that when that scan line is repeated

1/30th of a second later, the next sequence of random electron gun intensity changes composing that scan line will be completely different from the preceding one.

So in U.S. television, snow consists of 30 different random frames per second and in European television, snow consists of 25 different random frames per second. Although any point on a U.S. television screen can change at a maximum rate of 1/30th of a second, the entire television screen does not remain the same every 1/30th of a second. Different points on a U.S. screen can change 180° out of phase with each other. The time between the changes of different points on the U.S. screen can be 1/60th of a second. The television screen viewed as a single unit can change once every 1/60th of a second and be different from its previous state. In this sense, an American television screen as a single unit has a 60 Hertz flicker rate and a European television screen as a single unit has a 50 Hertz flicker rate.

To create high contrast random black and white snow as described in [1], a digital pseudo white noise generator, (Figure 5), which was sending out a random stream of high and low states with a bandwidth from 0 Hertz to 2.13 megaHertz, was connected directly to the intensity control of a red electron gun in a color television. The 2.13 megaHertz pseudo white noise generator was also connected through an inverter to the intensity control of the green electron gun in a color television.

x These guns were part of the red, green and blue color gun system of a 1969 Zenith color television receiver, model 19DC20, (Figure 6). So when the red electron gun was at maximum

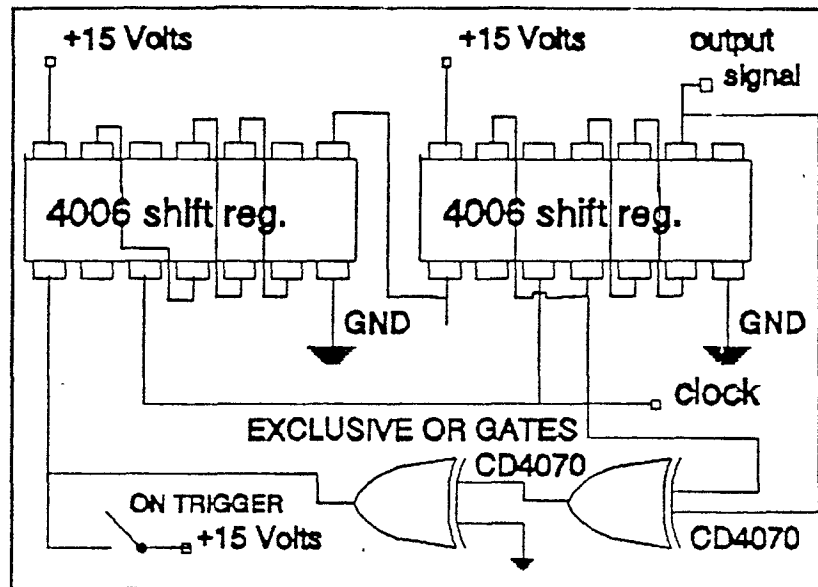


Figure 5 Pseudonoise Generation Via Exclusive-Or Feedback of Output and Intermediate Stage of Shift Registers to Input. Design based on [18].

intensity, the green electron gun was at minimum intensity and vice versa. This resulted in a random display of red and green dots with a spot on the television screen having the chance to randomly change between red and green at 30 Hertz. The random red-green 30 Hertz display was then recorded via a black and white video cam corder and a standard video cassette recorder. When the tape was played back on a black and white television set, a random black and white 30 Hertz display was presented to glaucoma patients.

In American television, each frame consists of 525 scan lines and there are 30 complete frames per second. In this experiment, the pseudo white noise generator produced a random stream of highs and lows at frequencies up to 2.13 megaHertz. This was the upper limit of the LM556 dual 555 timer chip that

was used as the clock signal for the shift registers of the pseudonoise generator.

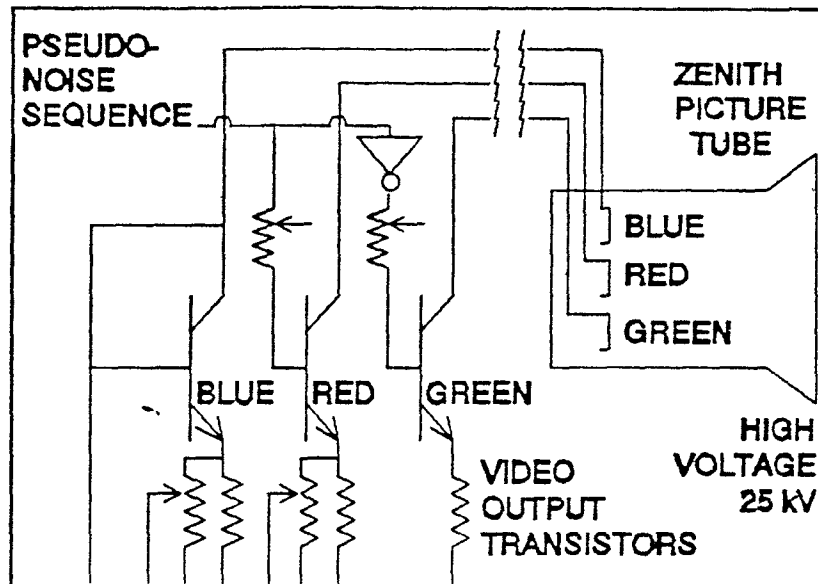


Figure 6 Introduction of Pseudonoise Sequence to Zenith Color Guns to Produce Random Red-Green Pattern on Screen

A special circuit arrangement was necessary to produce a symmetrical square wave with a frequency of 2.13 megaHertz, (Figure 7). The 50% duty cycle of the square

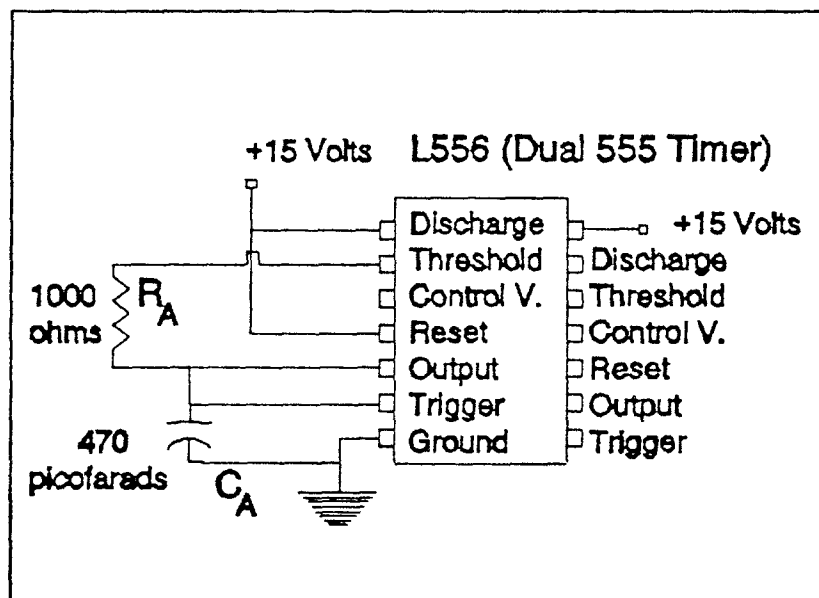


Figure 7 2.13 MegaHertz 50% Duty Cycle Square Wave from a Dual 555 Timer. Design based on [19].

wave insured uniform random dot size on the television screen, (although it was still possible to get a series of high

intensity dots or low intensity dots giving the illusion of a larger than usual high intensity or low intensity random dot). The square wave frequency for the circuit of Figure 6 is calculated by the following formula:

$$\text{square wave frequency} = \frac{1.44}{C_A \times R_A}$$

The minimum resistor size of R_A for a dual 555 Timer is one thousand ohms, 1 kilo-ohm (1 k Ω). The minimum capacitor size of C_A for a dual 555 Timer is one hundred picofarads, (100 pF). Using a 470 picofarad capacitor and a 1 kilo-ohm resistor produces the upper limit of the stable frequency range that the LM556 is capable of generating:

$$\text{square wave frequency} = \frac{1.44}{470 \times 10^{-12} \text{ F} \times 10^3 \Omega}$$

$$\text{square wave frequency} = 2.13 \text{ MegaHertz}$$

Hence, a stream of electron gun intensity changes causing the black and white spots was also changing at frequencies up to a maximum of 2.13 megaHertz. The result of this is that the maximum number of spots that could fit on a single scan line is 120 spots per scan line. It takes 63.5 microseconds for the electron gun cathode ray to move across the television screen exciting a line of phosphor to cause that scan line to be seen and only 8 microseconds for the electron gun cathode

ray to fly back to the other side of the screen to start producing the next visible scan line of a frame. Dividing the number of random spots produced per second by the number of scan lines per second and then multiplying by the fraction 63.5/71.5 gives the number of visible random spots per scan line. The result of this calculation is 120 dots per scan line as follows:

$$\frac{2.13 \times 10^6 \text{ random dots/sec.}}{525 \times 30 \text{ scan lines/sec.}} \times \frac{63.5}{71.5} = 120 \frac{\text{dots}}{\text{lines}}$$

WHERE: forward trace time = 63.5 μ sec.

(forward trace time) + (reverse trace time) = 71.5 μ sec

Out of the 525 scan lines in a television frame, only 485 are actually

used to display a video picture and the rest are used for vertical retrace to allow the electron gun cathode ray to fly back to the

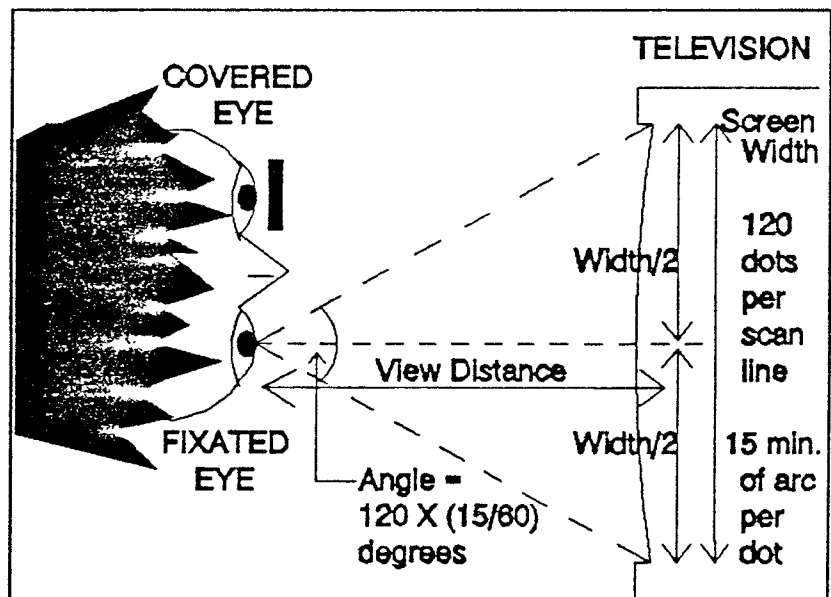


Figure 8 Geometric Setup to Calculate Patient's View Distance to Produce 15 Minutes Arc Sized Random Black-white Dots

screen when the bottom of the screen has been reached. Therefore, a patient views a presentation of random spots that are 120 spots wide and 485 spots high. The individual spots are wider than they are high because a television set's width is greater than its height and the number of spots along the screen width is less than the number of spots along the screen height. The dot size used in [1] were dots of 15 minutes arc when viewed monocularly by a patient. It is the number of spots per scan line that determines whether a spot has a maximum size of 15 minutes of arc and not the number of spots along the vertical column of a screen. To achieve a snow-like quality to the random black-white dot presentation, it is important to limit the maximum size of the dots. To insure that the random spots are no bigger than 15 minutes of arc, the width of the television screen has to be measured. Then the distance of the patient's viewing eye from the television screen can be calculated as per Figure 8. The distance must be 1.866 X width of the television screen.

This can be demonstrated by solving the below equation:

$$\tan\left(\frac{120 \times (15/16)^\circ}{2}\right) = \frac{(TV \text{ width})/2}{View \text{ Dist.}}$$

Solving the equation gives the results:

$$View \text{ dist.} = 1.866 \times TV \text{ width}$$

Under ideal conditions, a subject sitting 1.866 X width

of the television screen away from a black and white television should have seen black and white spots of 15 minutes arc with a spatial and temporal frequency distribution of pure white noise. Unfortunately, the desired spatial and temporal frequency spectra were not produced. The left half of the television screen corresponding to the start of horizontal scan lines showed a relatively high horizontal spatial frequency of random black and white spots. However, these random spots elongated into horizontal black or white lines as the scan lines progressed to the right side of the screen. Random high and low voltage pulses of uniform amplitude applied to the color gun intensity controls produced the random black and white spots. Apparently as the electron beam of a color gun sweeps to the right, it is not moving horizontally at a constant rate. The rate of sweep increases as the beam moves right. Hence, a pulse duration, which would produce a spot on the left half of the screen, produces a line on the right half of the screen. This makes sense, since the electromagnetic deflection coils of a television picture tube are what moves a color gun electron beam horizontally. These electromagnetic deflection coils actually produce horizontal beam acceleration according to electromagnetic force equations and do not produce uniform horizontal velocity. Normal television transmission does not have to take this into account because the television signal results from an electron beam in a television camera scanning a phosphor screen on

which an image is optically focused. This changes a current flow according to the degree of electrical charge of the photosensitive phosphor screen. The electron beam inside a television camera is not scanning the phosphor screen at a uniform horizontal rate. However, this does not matter as a television receiver reproduces the image on the television screen at the same left to right rate of increase at which it was originally captured by the horizontal scan of a television camera electron beam.

A pure white noise spectrum for the random black and white 30 Hertz presentation could not be produced in a controlled fashion as planned from the circuits that had been built. Spatially there was a progressive increase in dot size from the left to the right side of a television screen. In the actual testing of Primary Open-angle Glaucoma patients, ordinary television snow was used. The testing procedure is described in detail in Section 2.1 of this report. Hence forth this ordinary television snow will be referred to as black-white 30 Hertz snow. This terminology is derived from the fact that the maximum random rate of change of a spot on a snow filled television screen is 30 Hertz, although not all the spots on the screen at any given time may be changing as fast as 30 Hertz.

1.4.2 Isoluminant Red-Green Counterphase Presentation

The parvocellular pathway is maximally stimulated by isoluminant red-green counterphase at 12 Hertz, [8]. However, as the frequency of the isoluminant red-green counterphase is decreased from 12 Hertz, the parvocellular layer continues to be strongly stimulated while the magnocellular pathway stimulation drops off sharply. Hence, in the neighborhood of 5 Hertz, the parvocellular layer is still relatively strongly stimulated and the magnocellular layer is essentially unstimulated, [15].

To produce isoluminant red-green counterphase at 5 Hertz, a C program was written to generate a high intensity red and low intensity green checkerboard followed by a low intensity red and high intensity green checkerboard, (Appendix A). Borland's Turbo C 2.00 had a graphics features demonstration program entitled, bgidemo.exe. One of the subroutines of this program produced a checkerboard display. The C source code for this subroutine was modified and incorporated into a program whose main purpose was to produce on the computer monitor a high intensity red and low intensity green checkerboard followed by a low intensity red and high intensity green checkerboard, and to have this change as rapidly as possible. The high speed display alternation was implemented in such a manner that a high intensity red check was replaced by a low intensity red check and a low intensity green check was replaced by a high intensity red check. This

resulted in a square wave of red intensity changes and a counterphase square wave of green intensity changes.

In [8], the parvocellular layer was preferentially stimulated by 12 Hertz sinusoidal red-green counterphase color intensity changes. The fastest possible display rate available came from running the program on a 25 MHz 80386 microcomputer equipped with a Video Graphics Adapter board. The speed of the Video Graphics Adapter (VGA) board limited the display producible by the C program on a 25 MHz 80386 microcomputer to square wave red-green counterphase color intensity changes in the neighborhood of 5 Hertz. The exact display frequency is dependent on the exact model of microcomputer utilized. However, according to [14], though 12 Hertz sinusoidal counterphase red-green intensity changes evoke the maximal response from the parvocellular pathway, 5 Hertz square wave counterphase red-green intensity changes evoke less strong parvocellular pathway stimulation while the magnocellular pathway remains essentially unstimulated.

A 75 column wide by 50 row high checkerboard of alternating red and green squares was generated by the C program. The criterion for the checkerboard squares to have the same size as the dots in the snow display of [1] is for them to occupy 15 minutes of arc in the monocular field of vision. The number of squares per row of the checkerboard is 133% greater than the number of squares per column. Individual checkerboard squares had the same length heights

and widths. To insure that the red and green squares are no bigger than 15 minutes of arc, the width of the checkerboard display or the height of the checkerboard display could be

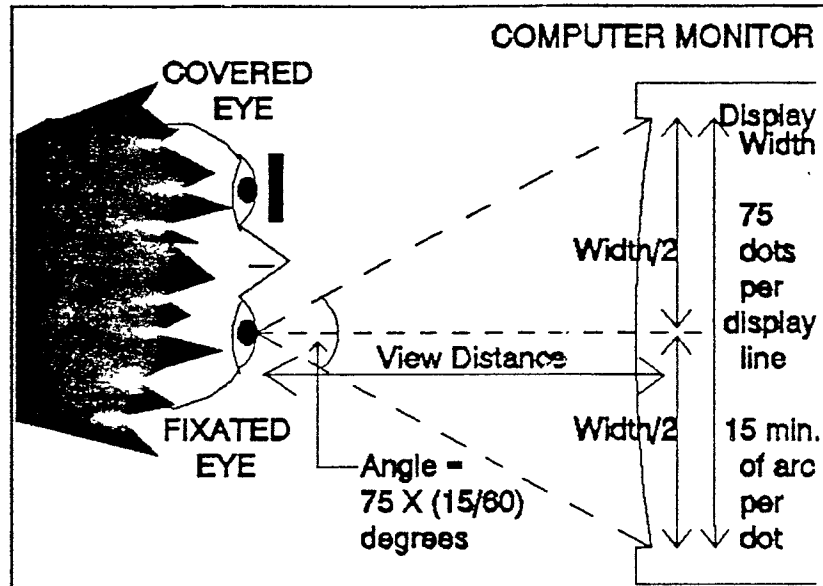


Figure 9 Geometric Setup to Calculate Patient's View Distance for 15 Minutes Arc Sized Red-Green Counterphase Checkers

measured. As there were more checker squares per row than per column, a better estimate of square size could be obtained by measuring a row than by measuring a column. A ruler with divisions up to a tenth of a centimeter would distribute its error in length over a greater number of checker squares row-wise as compared to column wise. Hence, the width of the checkerboard display has measured. Then the patient's viewing distance from the computer monitor can be calculated as per Figure 9. The distance must be 3.028 X width of the computer monitor as shown below:

$$\tan\left(\frac{75 \times (15/60)^\circ}{2}\right) = \frac{(\text{Display width}) / 2}{\text{View dist.}}$$

Solving the equation gives the results:

$$\text{View dist.} = 3.028 \times \text{Display width}$$

The isoluminant red-green counterphase display that was developed, though slower than the optimum 12 Hertz stimulus for the P pathway, proved satisfactory. There was clearly a counterphase red and green component as measured with a Gossen Ultra Pro light meter. The isoluminance of the display was a subjective quality dependent on the individual test patient. How the actual test sought to achieve isoluminance is covered in detail along with the rest of the test procedure in Section 2.2 of this report.

1.4.3 Neutral Density Filter Spatial Frequency Test

There is a problem with determining visual field damage inflicted by foveal fiber loss. The results of a Snellen acuity test remain normal with up to a 40% loss of optic nerve fibers, [20]. In the Snellen acuity test, central visual acuity is tested by having patients read the Snellen test chart consisting of rows of different sized block letters or numbers. Visual acuity for distance is recorded as a fraction where the numerator is the test distance in feet and the denominator is the distance in feet at which the smallest letter or number discriminated by the patient would subtend 5 minutes of arc in the visual field. Hence, a 20/20 central visual acuity means that the patient can read the Snellen test chart at 20 feet and 20 feet is also the distance at which the smallest letter or number discriminated by the patient would subtend 5 minutes of arc in the visual field. Even when 40% of the fibers of the optic nerve of an eye have been damaged, the Snellen chart measurement of the eye remains the same, [20].

Haupt et al. , [20], demonstrated that over the full range of spatial frequencies, eyes known to have visual fiber loss were less sensitive than normal eyes. One way of testing the sensitivity of an eye to a spatial frequency pattern is to interpose neutral density filters between the eye and the spatial frequency pattern. Neutral density filters do not selectively block out (filter) specific wavelengths of light.

Such filters block approximately the same amount of light at all wavelengths and hence are called neutral. An eye less sensitive to spatial frequency would require a filter with a lower optical density to prevent the eye from distinguishing the spatial frequency pattern. An eye with normal sensitivity to spatial frequency would require a filter with a higher optical density to prevent the eye from distinguishing the spatial frequency pattern.

Lack of sensitivity to spatial frequency patterns over a range of frequencies is a good indication that the eye has experienced visual fiber loss. It was previously hypothesized that Primary Open Angle Glaucoma (POAG) resulted from elevated pressure damage to magno optic nerve fibers. If POAG patients exhibit reduced sensitivity to spatial frequencies, then this would be a strong indication of damage to the visual fibers. However, the fibers that were damaged could be magno fibers, parvo fibers or both magno and parvo fibers together. Reduced spatial frequency sensitivity is not selective evidence for the magno or the parvo pathway damage being the primary cause of POAG. It is still useful to determine whether neutral density filters with lower optical densities than normal are capable of preventing glaucoma patients from distinguishing a range of spatial frequency patterns. Visual pathway fiber damage is indicated by the neutral density spatial frequency test. The patient's ability to pick out scotomata when viewing 30 Hertz black-white television snow or 5 Hertz red-green

counterphase snow will narrow the pathway damaged to predominantly the magno or parvo pathway.

2. PROCEDURE

This chapter describes the procedures used to accumulate data. They were strictly followed in the testing of all patients. However, the advanced age of some of the test subjects resulted in their being incapacitated from ailments in addition to Primary Open Angle Glaucoma. Hence, the ability of some patients to comply with the instructions of the test technician was limited. Poor results in some instances may not indicate that the diagnostic procedures did not work. In some cases, patients may not have been able to fixate, although they reported to the test technician that they were fixating. In other cases, patients could not trace out for themselves the contours of the areas that may have coincided with actual scotomata. Instead, these patients had to verbally direct the test technician what areas to outline.

2.1 Black and White Random Snow Presentation at 30 Hertz

By varying the contrast and brightness controls of a black and white television receiver, it is possible to achieve the same high contrast as did Aulhorn, [1], who used light dots of 60 candela/cm² luminance and dark dots of 0.8 candela/m² luminance. Snow on stationless Channel 12 received by a 1976 Zenith Model H121Y black and white television in Newark, New Jersey was used. The light dots were set at 42.0 candela/cm² and the dark dots were set at 1.2 candela/m². This was measured on a Gossen Ultra Pro light meter.

The serious lack of control, which arises in using ordinary television snow from an unaltered television receiver, is that there is no way of precisely setting the size of the random black and white dots so as to achieve the 15 minute arc size of Aulhorn, [1]. By videotaping a television channel portraying snow, freezing a frame and counting the approximate number of horizontal dots visible, an estimate of the dot size can be calculated. The number of random dots per horizontal line in the television snow of a 1976 Zenith Model H121Y black and white television on Channel 12 in Newark, New Jersey is on the order of 100 to 140 dots per horizontal line. The random dots tend to have greater widths than heights. Hence, the number of dots per horizontal line of the screen is what determines the arc size of the dots for a glaucoma patient monocularly fixating on the center of the screen. For the worst case of a 100 dots per horizontal

line, to achieve a 15 minute arc size per dot, the patient's viewing eye must be no closer to the television screen than 2.2553 X width of the television screen. This is calculated below:

$$\tan \left(\frac{100 \times (15/60)^\circ}{2} \right) = \frac{(TV \text{ width})/2}{View \text{ dist.}}$$

$$View \text{ distance} = 2.2553 \times (TV \text{ width})$$

POAG patients were tested at the Eye Institute of New Jersey in Newark, NJ. The scotomata of these glaucoma patients had previously been measured and recorded with computerized static perimetry systems. Specifically, an Octopus 2000 or a Humphrey static perimeter were employed. Both the Octopus static perimeter and the Humphrey static perimeter tested and recorded light thresholds in the central 30° of the patient's visual field.

To compare the results of snow campimetry with classical static perimetry, it was necessary to search for scotomata in the same location of a patient's visual field using both forms of perimetry. As a mapping of patients' POAG scotomata had already been performed on the central 30° of the visual field, it was desirable to locate monocularly fixated test subjects at a distance from the television screen such that the central 30° of the visual field were covered by the black and white television screen. The rectangular shape of a television screen precluded the screen's interception of the central 30°

of the visual field both horizontally and vertically. As the vertical length of a television screen is always shorter than the horizontal length, one option would have been to make sure that vertically the television screen intercepted the central 30° of the visual field. The portions on the right and left ends of the screen that horizontally exceeded the central 30° of the visual field could have been masked by opaque material, such as black paper.

A 30° - 60° - 90° triangle has sides opposite to each other in the ratio of 1 to $\sqrt{3}$ to 2.

corresponding to the ratios of $\frac{1}{2}$ to $\frac{\sqrt{3}}{2}$ to 1, (Figure 10). A vertical interception of the television screen with the central 30° of the visual field would have meant that a patient's

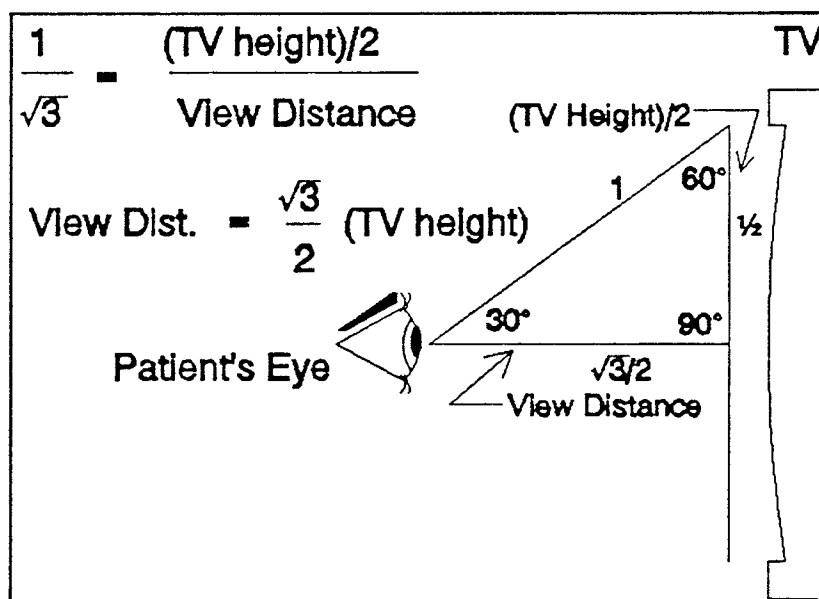


Figure 10 Geometric Setup for Vertical Interception of TV Screen with Central 30° of Visual Field

view distance is equal to only 0.8660 X the height of the television screen as demonstrated in Figure 10. The height to width aspect ratio of an American television screen is typically a 3 to 4 ratio. This would result in a patient's

view distance equal to only 0.6495 X the width of the television screen. The relationship is clearly demonstrated by the following equations:

$$\text{View distance} = \frac{\sqrt{3}}{2} \times \text{TV Height}$$

$$\frac{\text{TV Height}}{\text{TV Width}} = \frac{3}{4}$$

$$\text{TV Height} = \frac{3}{4} (\text{TV Width})$$

$$\text{View distance} = \frac{\sqrt{3}}{2} \left[\frac{3}{4} (\text{TV Height}) \right]$$

$$\text{View distance} = 0.6495 \times (\text{TV width})$$

If a patient's view distance is less than 2.2553 X the width of the television screen, then the dot size may be much greater than 15 minutes of arc in a patient's visual field. This is certainly true when there are 100 dots per horizontal line, which is the worst case scenario. To try to keep the arc size of the random black-white dots at a reasonably small size, there should be a horizontal interception of the television screen with the central 30° of the visual field.

Figure 11 depicts the central 30° of a patient's visual field as being horizontally intercepted by the black and white television screen. To accomplish the horizontal interception of the central 30° of the visual field, a glaucoma patient's eye must be located a distance away from the television screen

equal to 0.8660
 X the width of
 the screen as is
 calculated from
 Figure 11. This
 results in the
 television
 screen not being
 sufficiently
 large vertically
 to encompass the
 entire central

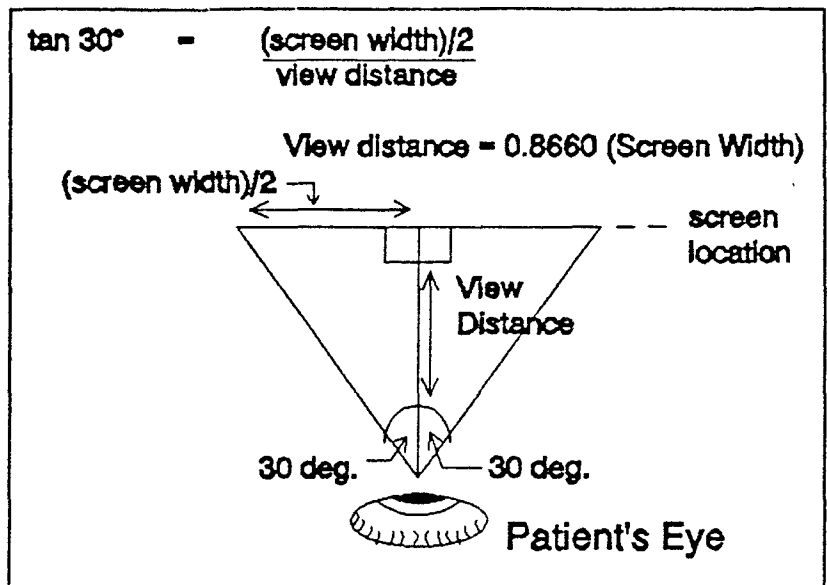


Figure 11 Geometric Setup for Horizontal Interception of TV Screen with Central 30° of Visual Field

30° of the visual field. However, the resulting view distance of Figure 11 is 133% of the length of the view distance required for a vertical interception of the central 30° of the visual field. The longer distance away of the eye decreases the arc size occupied by the random black-white dots in the visual field. The arc size of these dots is not precisely fixable and probably varies with great frequency within a given range. Ordinary, unaltered television snow is being viewed. The noise source is not a controllable circuit board and the number of dots per horizontal display line varies randomly as well as the level of luminance of each dot. However, the arc size of the random dots can become critical and the overall presentation can lose its snow-like qualities if the patient is too close to the television screen.

In the worst case scenario of 100 random dots per horizontal display line, a random black-white dot occupies an arc size in a glaucoma patient's visual field of 36 minutes. This is quite far off from the 15 minutes of arc with which Aulhorn tested her patients, [1]. The arc size of the dots in this experiment is over 200% the arc size of the dots in Aulhorn, [1]. The arc size was calculated from the same equation that designated the patient's view distance in order for a 120 dot per scan line display and a 75 squares per row checkerboard to have dots or squares occupying 15 minutes of arc in the visual field. The calculation is performed below:

$$\tan\left(\frac{100 \times (\text{Arc Size})}{2}\right) = \frac{(\text{TV width})/2}{\text{View Dist.}}$$

$$\text{Arc Size} = \frac{1}{100} \times 2 \times \arctan\left(\frac{\text{TV width}/2}{\text{View dist.}}\right)$$

$$\text{Arc Size} = \frac{1}{100} \times 2 \times \arctan\left(\frac{\text{TV width}/2}{0.8660 \times \text{TV width}}\right)$$

$$\text{Arc Size} = \frac{1}{100} \times 2 \times 30^\circ$$

$$\text{Arc Size} = 0.60^\circ = 36 \text{ minutes}$$

The arc size of the dots would even be larger for a vertical interception of the central 30° of the visual field. To avoid a difference much greater than 100% between the arc size of the dots in this experiment and Aulhorn, [1], the

central 30° of the visual field will be intercepted by the television screen horizontally. This results in only 23.41° of the visual field being intercepted vertically by the television screen. The calculation of this vertical visual angle is shown below:

$$\text{Vertical Visual } \angle = \tan\left(\frac{\text{TV height}/2}{\text{View dist.}}\right)$$

$$\text{Vertical Visual } \angle = \tan\left(\frac{(0.75 \times \text{TV width})/2}{0.8660 \times \text{TV width}}\right)$$

$$\text{Vertical Visual } \angle = 23.41^\circ$$

The screen of the Zenith H121Y black and white television was 25.0 cm. wide. Therefore the glaucoma patient had to view the screen from a distance of 21.65 cm. in order for the central 30° of the visual field to intercept the television screen. This was the view distance employed to test all glaucoma patients.

A 23.41° interception of the visual field along the central vertical axis of the television screen is acceptable in order to keep the random black-white dot size reasonably close to that of Aulhorn, [1]. In measuring the effectiveness of black-white 30 Hertz snow in detecting scotomata, it will have to be taken into consideration that as depicted in Figure 12, some of the top and bottom locations in the central 30° of the visual field that were tested and recorded by the Octopus or Humphrey system are beyond the range of the black and white

television screen. These locations will be so indicated in any mapping of scotomata by the Octopus or Humphrey perimeter that are presented in this report.

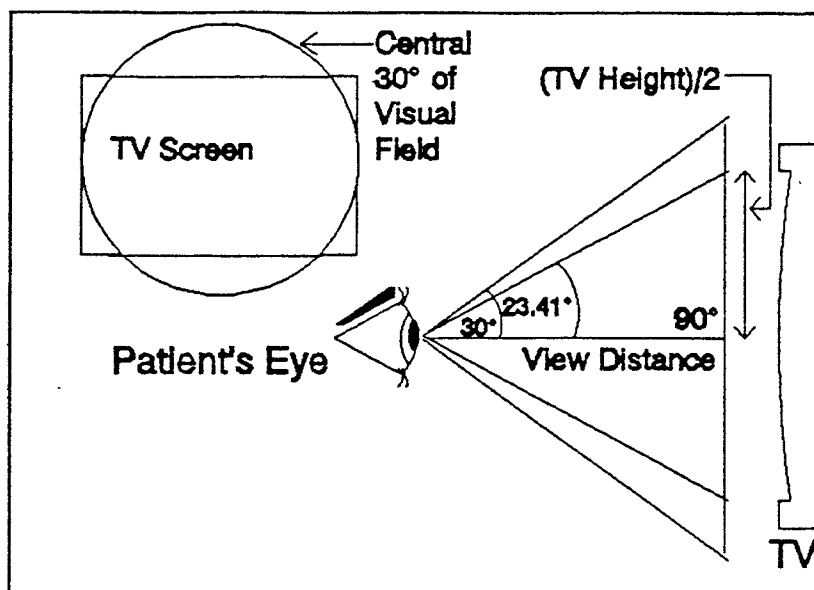


Figure 12 Untested Top and Bottom of the Central 30° of the Visual Field

The exact instruction steps according to which glaucoma patients were tested with 30 Hertz black-white television snow are listed in Appendix H.

2.2 Isoluminant Red-Green Counterphase Presentation at 5 Hertz

Luminance is photometric brightness. It is defined as candela per unit area. As defined by [21], a candela is the luminous intensity, in the direction of the normal, of a black body surface $1/600,000$ square meter in area, at the temperature of the solidification of Platinum (2042°K) under a pressure of 101,325 newtons per square meter. Luminous intensity is luminous flux (lux) per unit solid angle, [21]. Lux is the total visible energy emitted by a source per unit time, [21].

Green and red are isoluminant for m cones when the green to red luminance ratio is 0.4, [8]. Green and red are isoluminant for l cones when the green to red luminance ratio is 1.2, [8]. For perfect optical isoluminance, the ideal red-green counterphase transition would be to change between a first and second checkerboard pattern having the two different ratios. The first checkerboard pattern would be low intensity green checks and high intensity red checks having a green to red ratio of 0.4. The second checkerboard pattern would be high intensity green checks and low intensity red checks having a green to red ratio of 1.2. Using a Gossen Ultra Pro light meter, the low intensity red was measured to be 25 lux. The high intensity red was measured to be 70 lux. The low intensity green was measured to be 65 lux. The high intensity green was measured to be 150 lux. Hence, for low intensity

green and high intensity red, the green to red ratio was 0.93. For high intensity green and low intensity red, the green to red ratio was 6.00. Though a light meter would not show the red-green counterphase transition to be isoluminant in terms of optical physics, the display appears to be isoluminant to the unaided human eye. The display is considered to be psychologically isoluminant.

The computer monitor vertical retrace rate is 60 Hertz. Theoretically, the possible maximum display rate frequency should be the 60 Hertz vertical retrace rate. In other words, for a 60 Hertz display rate, each successive screen could be different. However, for a 30 Hertz display change rate, two sequential screens would have to be the same. For a 20 Hertz display change rate, three sequential screens would have to be the same. For a 15 Hertz display change rate, four sequential screens would have to be the same. It is possible to achieve display rates less than 60 Hertz by having successive screens the same. But it is not possible to exceed a maximum display rate of 60 Hertz.

In a red-green counterphase display, to complete one entire period, a red check must go from a high intensity red color to a low intensity red color and then back to a high intensity red color. Hence, there are two screens for a red-green counterphase transition. A high intensity red and low intensity green screen is followed by a low intensity red and high intensity green screen. Thus the red-green counterphase

transition frequency is always half the display rate frequency. Since the theoretical maximum display rate is 60 Hertz, the theoretical maximum red-green counterphase transition frequency is 30 Hertz. A 33 MegaHertz, 80386 based microcomputer with an Enhanced Graphics Adapter (EGA) video card became available to test glaucoma patients. The maximum achievable display rate with the available computer system was a little bit under 10 Hertz.

Entering as input 10 seconds of waiting time between color changes in the red-green counterphase display program, meant that the display would start out with a low intensity

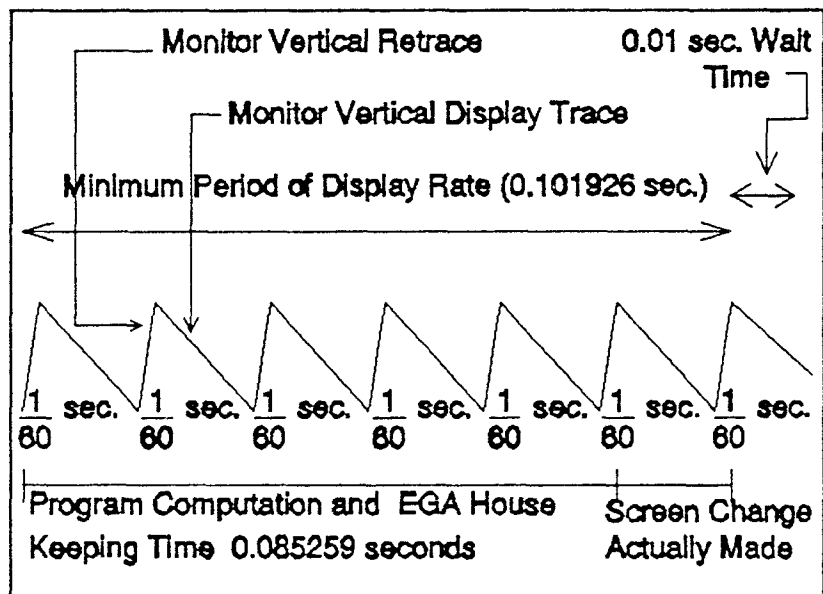


Figure 13 Timing Diagram Showing Why Checkerboard Display Change Rate Cannot Exceed Approx. 10 Hz and Why Delays Below 1/60th of a second Will Not Alter Frequency

red check that remained low intensity for 10 seconds and then turned high intensity and remained high intensity for 10 seconds before returning back to low intensity. Hence, theoretically, the red-green counterphase period is twice the waiting time between color changes. However, the red-green counterphase frequency is not simply half the inverse of the

waiting time between color changes. Computation time is needed for the red-green counterphase program to scan the monitor screen pixels that are mapped in memory and change high intensity colors to low intensity as well as low intensity colors to high intensity by manipulation of input/output memory addresses. Computation time is also needed for the EGA video card to perform necessary housekeeping tasks that have to do with maintaining the video image after it has been specified by the central processing unit. For the 33 MegaHertz 80386 computer and EGA video card employed, this computation time could be calculated by setting the waiting time between color changes to zero and measuring the display rate frequency. The inverse of this observed frequency is the sum of the 1/60th of a second vertical trace time to effect the actual screen change on the monitor, the EGA housekeeping tasks time and the code execution time necessary to change from one checkerboard pattern to another checkerboard pattern. As the measured display rate frequency with zero waiting time between color changes was 9.811 Hertz, the inverse of this frequency minus the 1/60th vertical trace time to actually change the screen is the overhead time. The computation time is 0.101926 seconds minus 1/60th of a second, which is equal to 0.085259 seconds. This is depicted in Figure 13. A transition from one checkerboard pattern to another can happen no faster than once every 0.101926 seconds.

Another consideration in the timing diagram of Figure 13

is that increasing or decreasing the waiting time between color changes by an amount less than 1/60th of a second (0.016667 seconds) may or may not alter the display rate frequency or the red-green counterphase frequency. This is because you cannot alter the screen image until the start of the downward vertical display trace of the monitor electron gun. The start of a downward vertical display trace occurs once every 1/60th of a second. Trying to alter the waiting time between color changes by an amount less than 1/60th of a second would probably not affect the display rate frequency as the computer has to wait for the start of a vertical display trace anyway before changing the screen. Adding an amount of time less than 1/60th of a second may or may not bring the waiting time past the start of the next vertical retrace. This is clearly demonstrated in Figure 13 where an additional delay of 0.01 second to the waiting time is not sufficient to increase the computation time past the next vertical retrace. Adding a delay of 0.014 second or 0.05 second will be the same as adding a delay of 0.01 seconds. All these delays are less than 1/60th of a second (0.016667 second) and will not extend the time due to computation past the next vertical retrace.

Figure 14 is a plot of the actual frequency of change of display produced versus the waiting time (entered on the keyboard) between color changes for the 33 Megahertz 80386 computer and EGA video card. The relationship between display rate and entered delay appears to be quantized in terms of

frequency. A continuous range of frequency is not possible for a continuous range of entered delay times. In other words, the computer is only capable of changing the display at certain rates. This is to be expected. The computer can only change the screen display every 1/60th of a second at the start of a downward vertical display trace. This is clearly demonstrated by the step like relationship of frequency of display change compared to entered delay time as plotted in Figure 14. The entered delay has to be changed by approximately 1/60th of a second (0.016667 sec.) in order for the display change rate to alter. Fortunately, a red-green counterphase frequency fairly close to 5 Hertz is achievable for an entered waiting time between color changes of zero seconds. Zero waiting time between color changes results in a display rate frequency of 9.811 Hertz. This corresponds to a red-green counterphase frequency of 4.9055 Hertz.

The values of the plot of Figure 14 were obtained by altering the C program to perform 200 changes from one checkerboard display pattern to another and then halt execution. Using a subroutine from the library provided with Borland's Turbo C 2.0, the duration required to perform 200 changes from one checkerboard display pattern to another could be measured in seconds to a precision dependent on the frequency of the computer system clock. From this duration, the frequency of the display change rate could be calculated

SCREEN CHANGE FREQUENCY VERSUS ENTERED WAITING TIME
BETWEEN SCREEN CHANGES FOR RED-GREEN COUNTERPHASE DISPLAY

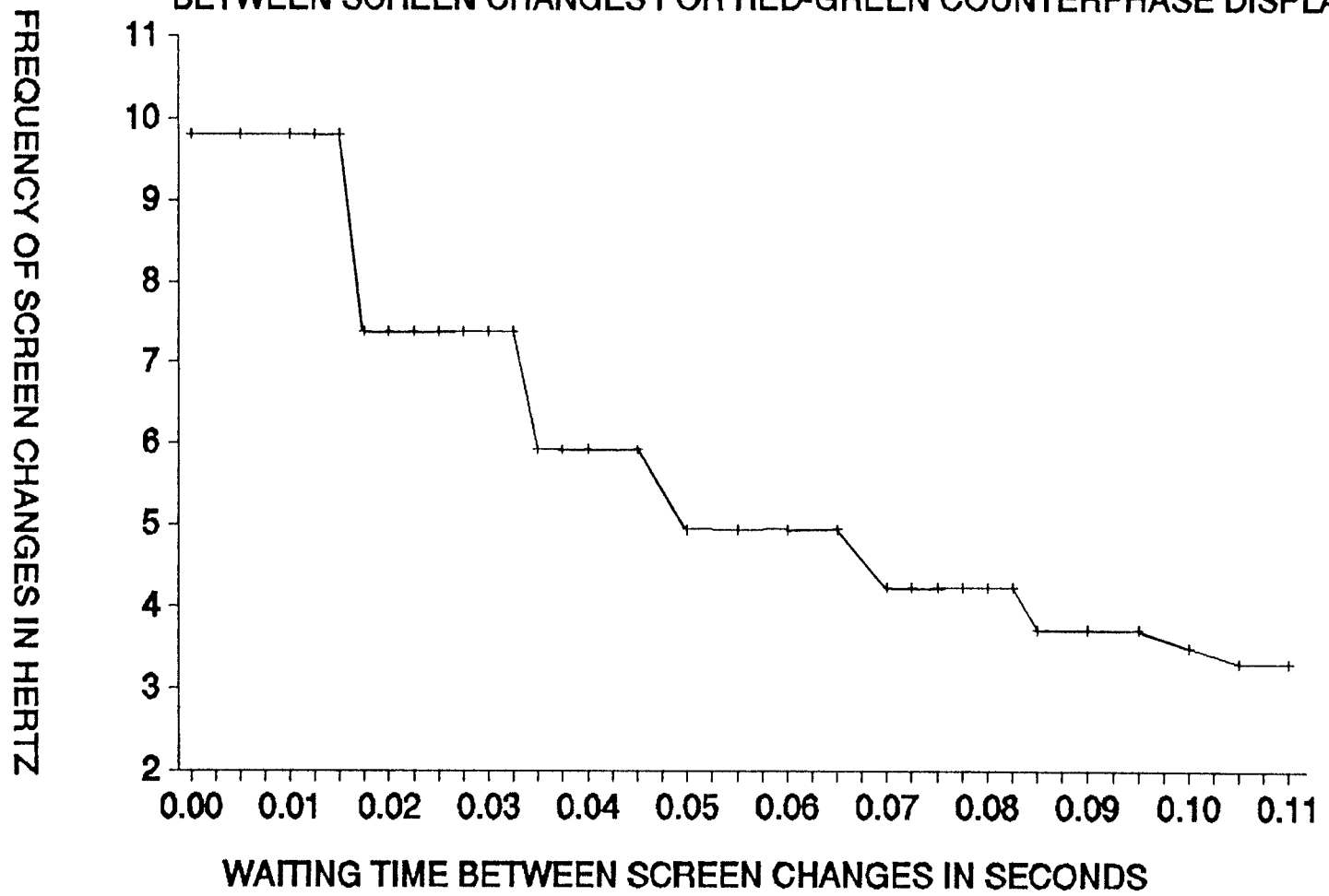


Figure 14

for a range of entered waiting times between color intensity changes. The following Table 2.2.1 contains all the values that were plotted in Figure 14.

Table 2.2.1 Screen Change Frequencies for Entered Waiting Times Between Red-green Counterphase Color Changes

Entered Waiting Time Between Color Intensity Changes (seconds)	Duration to Perform 200 Changes Between Checkerboard Patterns (seconds)	Checkerboard Display Change Rate Frequency (Hertz)
0.0000	20.3846	9.811
0.0050	20.3846	9.811
0.0100	20.3846	9.811
0.0125	20.3846	9.811
0.0150	20.3846	9.811
0.0175	27.0879	7.383
0.0200	27.0879	7.383
0.0225	27.0879	7.383
0.0250	27.0879	7.383
0.0275	27.0879	7.383
0.0300	27.0879	7.383
0.0325	27.0879	7.383
0.0350	33.7912	5.919
0.0375	33.7912	5.919
0.0400	33.7363	5.928
0.0450	33.7912	5.919
0.0500	40.4396	4.946
0.0550	40.4945	4.939
0.0600	40.4396	4.946
0.0650	40.4396	4.946
0.0700	47.1978	4.238

0.0725	47.1429	4.242
0.0750	47.1429	4.242
0.0775	47.1978	4.238
0.0800	47.1429	4.242
0.0825	47.1429	4.242
0.0850	53.8462	3.714
0.0900	53.8462	3.714
0.0950	53.8462	3.714
0.1000	57.1978	3.497
0.1050	60.4945	3.306
0.1100	60.4945	3.306
0.5	214.51	0.932

In Figure 15, a glaucoma patient's view distance from the checkerboard is calculated in order to achieve a horizontal interception of the central 30° of the visual field with the red-green checkerboard. The red-green checkerboard's width was greater than its height. This can easily be deduced from the

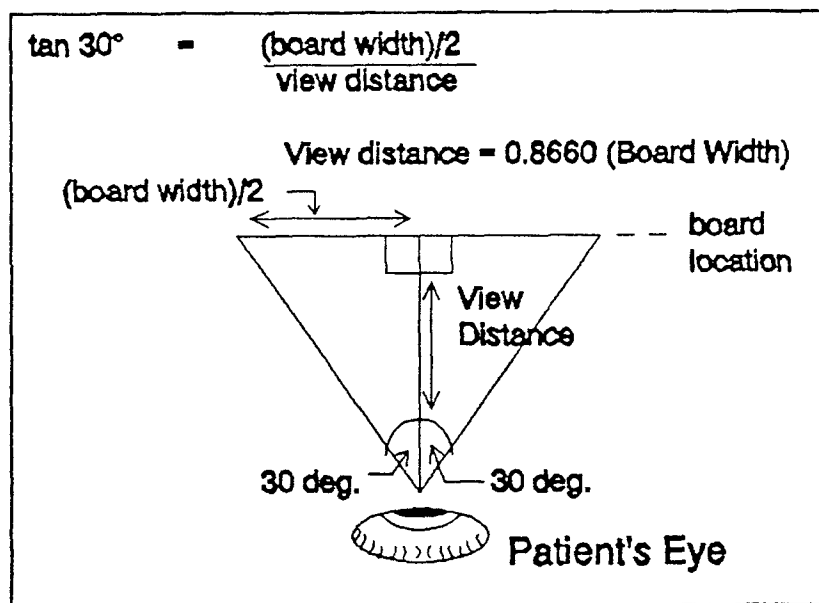


Figure 15 Geometric Setup for Horizontal Interception of Red-Green Checkerboard with Central 30° of Visual Field

facts that the individual checks were square and that the checkerboard was composed of 75 columns and only 50 rows. The same problem with arc size of checks existed as described in Section 2.1 for the arc size of random dots of the black and white television snow. It is desirable to stay in the range of the 15 minutes of arc which was the size of random dots that Aulhorn used, [1]. If the central 30° of the visual field is to intercept the red-green checkerboard vertically, the arc size of the checks will exceed the desired size by a much greater amount than if the central 30° of the visual field horizontally intercepts the checkerboard. The 48 minute arc size of a check resulting from a horizontal interception of the checkerboard is calculated as follows:

$$\tan\left(\frac{75 \times (\text{Arc Size})}{2}\right) = \frac{(\text{Board width})/2}{\text{View Dist.}}$$

$$\text{Arc Size} = \frac{1}{75} \times 2 \times \arctan\left(\frac{\text{Board width}/2}{\text{View dist.}}\right)$$

$$\text{Arc Size} = \frac{1}{75} \times 2 \times \arctan\left(\frac{\text{Board width}/2}{0.8660 \times \text{Board width}/2}\right)$$

$$\text{Arc Size} = \frac{1}{75} \times 2 \times 30^\circ$$

$$\text{Arc Size} = 0.80^\circ = 48 \text{ minutes}$$

The red-green checkerboard possessed a width of 24.50 cm on the EGA monitor that was employed to test glaucoma patients. Hence, the view distance that a glaucoma patient

was located away from the computer monitor had to be 21.22 cm in order for the central 30° of the visual field to horizontally intercept the checkerboard. With normal room lighting switched on and the computer monitor switched off, the Gossen Ultra Pro light meter measured a luminance of 110 lux at the patient's viewing distance from the computer monitor. The same Gossen Ultra Pro light meter measured a luminance of 120 lux at the patient's viewing distance from the computer monitor with normal room lighting switched on and the computer monitor switched on. Finally, with normal room lighting switched off and the computer monitor switched on, a luminance of 10 lux was measured at the patient's viewing distance from the monitor. Thus the average luminance presented by the checkerboard at the patient's viewing distance was 10 lux. All glaucoma patients were tested with normal room lighting switched on, which means there was always a background luminance of 110 lux.

The exact instruction steps which technicians followed to test all glaucoma patients with the red-green counterphase presentation are listed in Appendix H.

2.3 Neutral Density Filter Spatial Frequency Test

The neutral density filter test employs a pair of specially crafted spectacles described by Haupt et al., [20]. A

rotatable ring of neutral density filter segments was located where a lens would be

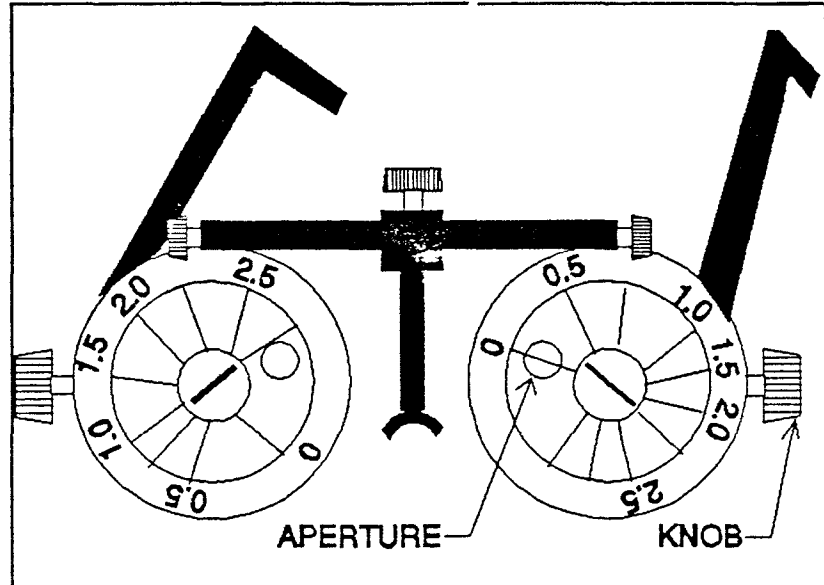


Figure 16 Linearly Variable Neutral Density Filter Device

located on a normal pair of spectacles. This specially constructed device is portrayed in Figure 16. There was a linear relationship between the angular rotation of a ring of neutral density filter segments and the amount of logarithmic optical density placed in front of a glaucoma patient's eye. Hence, a rim around the ring of neutral density filter segments could be labeled with uniformly spaced and uniformly increasing units of logarithmic optical density from 0 to 2.5 in range.

A Visitech Chart consists of five rows of circles. Each circle has what appear to be dark and light vertical stripes of uniform width, but are actually sinusoidally varying

reflectance gratings. So that a white and dark strip are actually a range of sinusoidally varying reflectance with a maximum at the center of the light stripe and a minimum at the

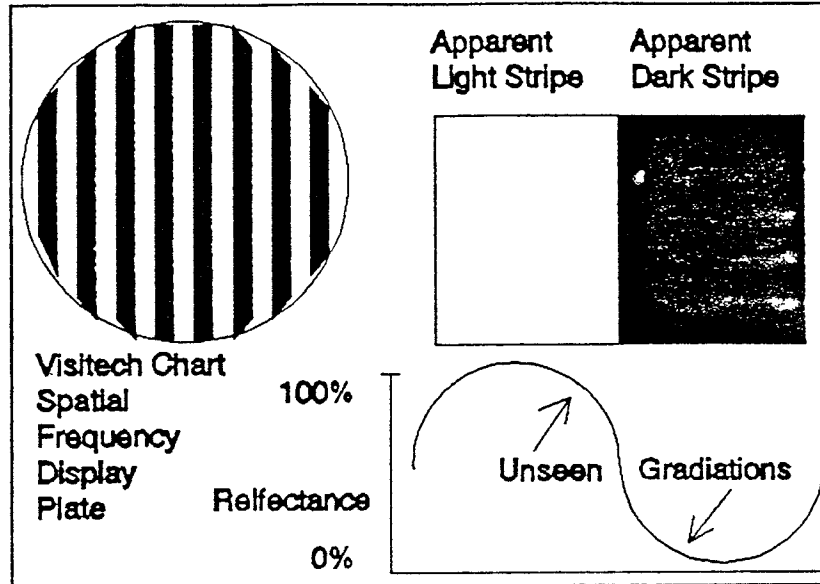


Figure 17 Sinusoidally Varying Reflectance Gratings of Visitech Chart Spatial Frequency Display Plate

center of the dark stripe as per Figure 17. The vertical stripes of the circles belonging to the same row, all have the same widths and spatial frequency. The left most circle in each row had the highest contrast difference between dark and light apparent vertical stripes. Then progressing from left to right, the amount of contrast difference between the dark and light vertical stripes decreased until the right most circle had the least contrast difference. This was because the amplitudes of the sinusoidal rate of change of reflectance decreased from left to right for circles in a row.

Since the circles in a row were not composed of vertical light stripes of uniform high reflectance followed by vertical dark stripes of uniform low reflectance, it is possible to have an alternative measurement of spatial frequency in place

of the obvious measurement which would be the number of stripes per angular degree of visual field. In the Visitech Chart, each circle is assigned a spatial frequency measurement in units of contrast change per angular degree of visual field, (c/deg.). Only the left most circles of each row was used to test glaucoma patients. The left most circles of the Visitech Chart from top row to bottom row had spatial frequencies of 1.5 c/deg., 3.0 c/deg., 6.0 c/deg., 12.0 c/deg. and 18.0 c/deg respectively.

The exact instruction steps according to which glaucoma patients were always tested is given in Appendix H. This procedure was always carried out with normal room ceiling fluorescent lighting switched on and the room door closed to block external hall lighting. As measured with a Gossen Ultra Pro light meter at the position of the seated glaucoma patient, the room luminance level was 110 lux.

3. EVALUATION AS SCOTOMATA DETECTION DIAGNOSTIC TOOL

To evaluate the 30 Hertz random black-white snow diagnostic test and the 5 Hertz red-green counterphase diagnostic test, the areas in the visual field picked up in both test procedures have to be compared against the results of classical static perimetry. The specific classical static perimeters employed were a computerized system manufactured by Humphrey Instruments and

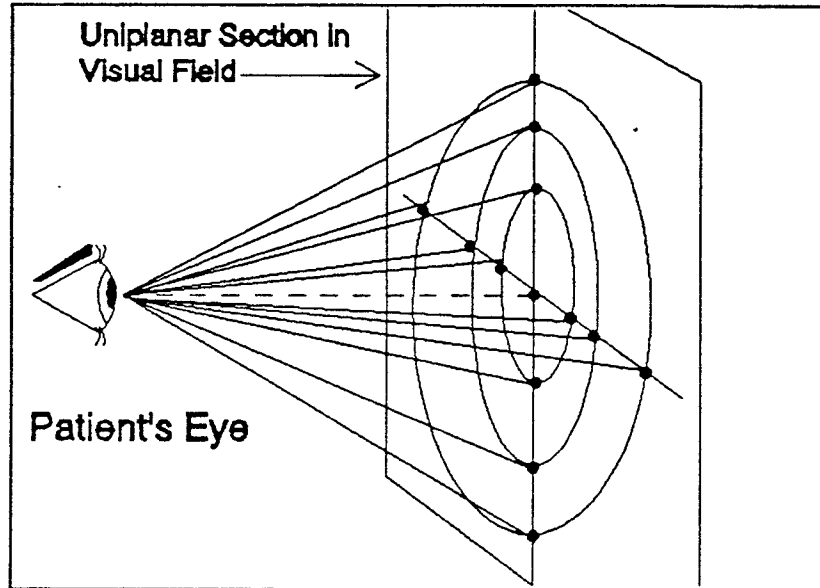


Figure 18 Uniplanar Interception of Test Points in the Visual Field

classical static perimetry. The specific classical static perimeters employed were a computerized system manufactured by Humphrey Instruments and

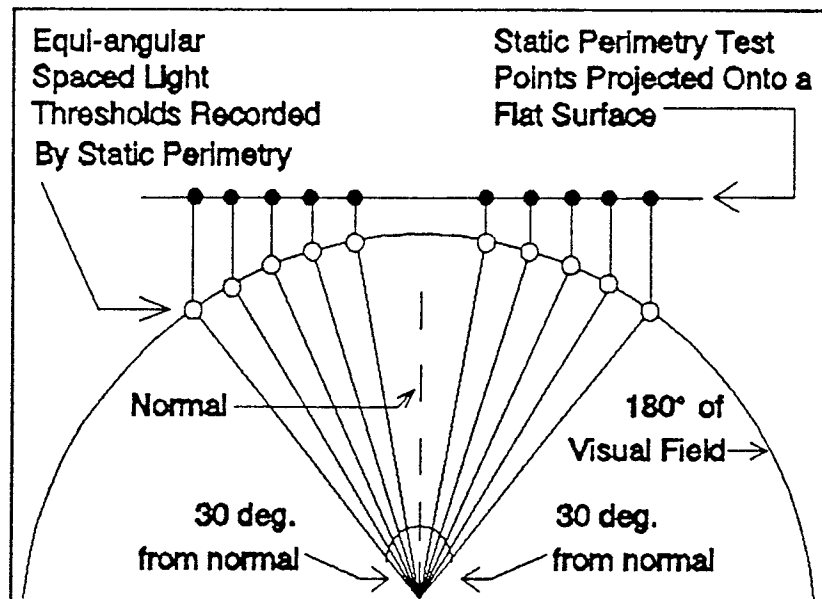


Figure 19 Uniplanar Transformation of Three-Dimensional Static Perimetry Data

a similarly computerized Octopus 2000 manufactured by Interzeag, Inc. Both perimeters record 76 data points tested for thresholds of light detection. These points are distributed uniformly in the central 30° of the visual field. The data points are recorded as a set of uniplanar two-dimensional angular deflections as measured from a central point in a planar cross section of the visual field. This cross sectional interception results in two-dimensional concentric circles of test points as depicted in Figure 18. The actual numerical storage is as computer printouts having lines of digital values which are the light thresholds at the equi-angular test points. The computer printouts are presented in Appendix D. Figure 19 shows how the equi-angular test points of the Humphrey and the Octopus 2000 data printouts have to be translated in order to be compared to the areas traced by glaucoma patients on transparencies.

A transparency was taped to the front of a television screen exhibiting 30 Hertz black-white snow or to the front of a computer monitor screen displaying a 5 Hertz red-green counterphase checkerboard. The uniplanar interception of the visual field by a transparency in front of a television or computer monitor screen resulted in a two-dimensional mapping of those portions of their visual fields that patients noticed as different.

The test records produced by the Octopus and Humphrey computerized perimetry systems are light thresholds arranged

i n f i v e
 c o n c e n t r i c
 c i r c l e s ,
 (Appendix D).
 The inner most
 c i r c l e
 represents the
 edge of the
 central 6° of
 the visual
 field. The next
 inner most

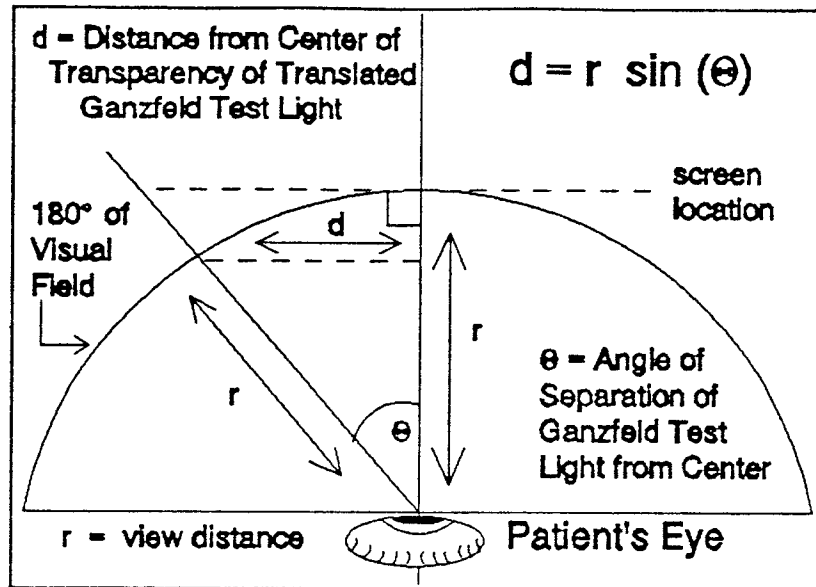


Figure 20 Transformation of Octopus or Humphrey Light Threshold Data on to a 2-D Projection

circle represents the edge of the central 12° of the visual field. This continues progressively in increments of 6° until the outer most circle is reached, which represents the edge of the central 30° of the visual field. The position of these circles in relation to a transparency on which a patient has traced possible scotomata can be calculated as per Figure 20. Light threshold points along each circle are spaced uniformly around the circle and with mirror symmetry to central x and y axes. Hence, light thresholds on each circle are separated by an equal rotational angular amount from each other with regards to a central point in the plane of the circle. Once the position of the concentric circles as radial distances away from the center of the transparency have been calculated by the method demonstrated in Figure 20, the symmetrically

located light threshold points on each circle are easy to position as was done in the plots of Appendix E.

Of the 76 light threshold points in the central 30° of the visual field that are recorded by the Humphrey Instruments or Octopus 2000 computerized perimeter, only 68 data points are in the area of the visual field covered by black-white snow or red-green counterphase campimetry. Both forms of campimetry intercept the central 30° of the visual field horizontally, but intercept only 23.41° of the visual field vertically. Hence, the four top most and four bottom most of the 76 data points recorded by the Humphrey and the Octopus perimeters lie outside the ranges of the black-white and red-green campimetries. These eight points are plotted in the figures of Appendix E where the Octopus and Humphrey static perimetry data are mapped over the areas noticed by the new scotomata diagnosis methods. However, these eight points are never considered in the evaluation of the black-white and red-green campimetries as scotomata detection diagnostic tools. All error calculations are performed with the 68 data points of the Humphrey and Octopus perimetries that lie within the 23.41° vertical interception of the visual field.

In the evaluation of the black-white snow campimetry of upcoming Section 3.1 and in the evaluation of the red-green counterphase campimetry of upcoming Section 3.2, the threshold levels for detection of Ganzfeld light test points are expressed in decibels (dB). This is clearly discerned with

the computer printouts from Humphrey Instruments and the Octopus 2000 that are presented in Appendix D. By testing a large population of normals for given ages, standard threshold levels at which humans of a certain age group normally can detect test lights at various positions in their visual fields have been established for static perimetry. This set of standardized light threshold points is referred to as norms. For both Humphrey Instruments and Octopus 2000, the threshold light intensity (brightness) level at which the glaucoma patient can first notice the light test point has a possible luminance level from 0.01 apostilb (asb) to 1000 asb. An apostilb is a static perimetric unit of threshold luminance equal to 0.318 candela/m², [4]. For convenient readings of the human eye's luminance sensitivity, this luminance level is recorded as a decibel scale where every luminance value in the range from 0.01 asb. to 1000 asb. is assigned a decibel value from 50 to 0. The mathematical relationship between an apostilb and the decibel scale is given below:

$$\text{decibel scale} = -10\text{dB} \times \log_{10}(\text{luminance as apostilbs}) + 30\text{dB}$$

The values that result from this mathematical relationship for values from 0.01 apostilb to 1000 apostilbs are given in Table 3.0.1 that follows.

Table 3.0.1 Relationship of Apostilbs to Candela/m² and Defect Depth in Decibels

LUMINANCE (candela/m ²)	LUMINANCE (apostilbs)	DEFECT DEPTH (dB scale)
318.0000 cd/m ²	1000 asb.	0 dB
31.8000 cd/m ²	100 asb.	10 dB
3.1800 cd/m ²	10 asb.	20 dB
0.3180 cd/m ²	1 asb.	30 dB
0.0318 cd/m ²	0.1 asb.	40 dB
0.0032 cd/m ²	0.01 asb.	50 dB

The maximum possible luminance stimulus producible by an Octopus 2000 or Humphrey Instruments perimeter is 1000 asb. or 0 dB. Absolute scotomata test points are points where the light cannot be seen at any luminance level up to the maximum possible level of 1000 asb. Absolute scotomata points have recorded light threshold values of 0 dB. As explained in their respective computer printouts, light test points that can be detected by glaucoma patients within 4 dB above the expected normal values are considered to be normal for both the Humphrey Instruments and Octopus 2000. Light test points within 4 dB above the expected normal levels constitute normal vision points in the visual field tested. Perimetric test points where a patient cannot detect a test light until its luminance level is 4 dB above the norm for that visual field location are considered to be points of relative scotomata. At a relative scotomata location, there is considered to be partial loss of vision, but not absolute blindness as at an

absolute scotomata point.

The amount in dB above the normal level at which a glaucoma patient can detect the Ganzfeld test light is referred to as the depth of the defect at that position in the visual field. A point in the visual field is considered to be a normal vision point when the depth of the defect at that location is 0 dB. Depth of defect plots are part of the recorded data in the computer printouts of Appendix D.

The plots of Appendix E are depth of defect plots with the areas noticed by glaucoma patients from black-white snow and red-green counterphase campimetry traced over the plots. Normal vision points have 0 dB depths of defect and no normal vision point is labeled by a dB value. Relative and absolute scotomata points are labeled with a dB value. For an absolute scotomata point, the defect depth dB value is 0 dB subtracted from the normal threshold level value in dB. For a relative scotomata point, the defect depth dB value is the actual threshold value of light detection in dB subtracted from the normal threshold value in dB. Hence, the difference between an actual threshold value and the normal threshold value is referred to as the depth of the defect because the actual threshold value at a damaged location of the visual field will always be less than the normal threshold value. The defect threshold values are below the normal threshold values. At an absolute scotomata point, the defect depth is equal to the normal threshold luminance level for detection in dB. In the

plots of Appendix E, to distinguish absolute scotomata points from relative scotomata points, the absolute scotomata points are circled. If a test point is within 1 dB of being an absolute scotomata point, it is circled and treated as an absolute scotomata point as this is a strong indication that it is very close to a region of absolute scotomata. A test point did not necessarily have to be enclosed by the outline traced by a glaucoma patient, in order to be considered as a detected point. A test point actually represented a section in the visual field at which the test point was the center. If the distance between a test point outside the contour traced by a glaucoma patient and the contour line was less than half the distance between the external test point and the nearest test point enclosed by the contour, then the section represented by the external test point was partially enclosed by the contour. A significant portion of the section represented by the external test point had been enclosed by the contour and the external test point is treated as having been detected by the glaucoma patient.

3.1 Black and White Random Snow Presentation at 30 Hertz

As demonstrated by below Table 3.1.1, the average amount of absolute scotomata detected with black-white 30 Hertz snow by a patient comprised 13.12% of the test points classified as absolute scotomata by static perimetry. The average amount of relative scotomata detected by a patient comprised 18.50% of the test points classified as relative scotomata by static perimetry. The average amount of normal test points in the central 30° of the visual field that were noticed by a patient comprised 13.99% of the test points classified as normal by static perimetry.

Table 3.1.1 Average Absolute Scotomata, Relative Scotomata and Normal Vision Detected with 30 Hz Black-white Snow

Eyes of Glaucoma Patients	% Absolute Scotomata Detected	% Relative Scotomata Detected	% Normal Visual Field Noticed as Different
1	10.34	0.00	5.26
2	26.1	11.5	5.26
3	31.6	26.1	35.7
4	0.00	0.00	0.00
5	22.1	51.5	26.5
6	7.41	8.33	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	----	40.0	29.3
10	13.3	41.2	50.0
11	46.6	70.0	----
12	0.00	0.00	----
13	0.00	2.94	6.06

14	----	7.41	9.76
Averages	13.12	18.50	13.99

The correlation between six different types of measurements is represented in the Pearson Product Moment Correlation Square shown in Table 3.1.2. Each cell in this table shows the correlation r , sample size n and one-tailed significance probability p . The upper quantity in each cell is the correlation between the two measurements which label the row and column intersecting at that cell. The bottom quantity in each cell is the probability that the positive correlation of the two measurements for our sample populations is greater than the top value in the cell solely as a result of random selection of the sample populations of the two measurements from general populations where the probability density functions of the two measurements are both independently Gaussian.

Table 3.1.2 Pearson Product Moment Correlation Square for 30 Hz Black-white Snow

NORMDET = % normal vision noticed in central 30° of visual field

ABSSCOT = % absolute scotomata in central 30° of visual field

RELSCOT = % relative scotomata in central 30° of visual field

NORM = % normal vision in central 30° of visual field

ABSDET = % absolute scotomata detected in central 30° of visual field

RELDET = % relative scotomata detected in central 30° of visual field

	ABSSCOT	RELSCOT	NORM	ABSDET	RELDET	NORMDET
ABSSCOT	1.0000 n: 12 p:0.000	-0.9147 n: 12 p:0.000	-0.8355 n: 10 p:0.001	0.4767 n: 12 p:0.059	0.4267 n: 12 p:0.083	-0.0046 n: 12 p:0.494
RELSCOT	-0.9147 n: 12 p:0.000	1.0000 n: 14 p:0.000	-0.5015 n: 12 p:0.048	-0.2564 n: 14 p:0.188	-0.3186 n: 14 p:0.133	0.0799 n: 14 p:0.393
NORM	-0.8355 n: 10 p:0.001	-0.5015 n: 12 p:0.048	1.0000 n: 12 p:0.000	-0.5350 n: 12 p:0.037	-0.0362 n: 12 p:0.455	-0.1560 n: 12 p:0.314
ABSDET	0.4767 n: 12 p:0.059	-0.2564 n: 14 p:0.188	-0.5350 n: 12 p:0.037	1.0000 n: 14 p:0.000	0.7139 n: 14 p:0.002	0.2137 n: 14 p:0.232
RELDET	0.4267 n: 12 p:0.083	-0.3186 n: 14 p:0.133	-0.0362 n: 12 p:0.455	0.7139 n: 14 p:0.002	1.0000 n: 14 p:0.000	0.5191 n: 14 p:0.029
NORMDET	-0.0046 n: 12 p:0.494	0.0799 n: 14 p:0.393	-0.1560 n: 12 p:0.314	0.2137 n: 14 p:0.232	0.5191 n: 14 p:0.029	1.0000 n: 14 p:0.000

Pairwise deletion of missing data in effect.

Maximum number of cases used: 14

If measurement type X is the label for the row and measurement type Y is the label for the column, then the correlation value r_{xy} that is the top value of the box at which row X and column Y intersect is calculated by the relation:

$$\frac{\sigma_{xy}^4}{\sigma_x^2 \sigma_y^2} = \frac{[N(\sum_{n=1}^N X_n Y_n) - (\sum_{n=1}^N X_n)(\sum_{n=1}^N Y_n)]^2}{[N(\sum_{n=1}^N X_n^2 - (\sum_{n=1}^N X_n)^2) [N(\sum_{n=1}^N Y_n^2) - (\sum_{n=1}^N Y_n)^2]}$$

One way of interpreting the probability at the bottom of each box is by assigning probability density functions $f_x(x)$ for measurement type X and probability density function $f_y(y)$ for measurement type Y as follows:

$$f_x(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(x-\mu_x)^2}{2\sigma_x^2}}$$

$$f_y(y) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(y-\mu_y)^2}{2\sigma_y^2}}$$

The assigned probability density functions of measurement type X and measurement type Y are assumed to be independent such that the joint probability function of X and Y represented as $f_{xy}(x,y)$ is the product of the individual probability density functions:

$$f_{xy}(x,y) = f_x(x) \times f_y(y)$$

This means that r_{xy} is zero for the total populations of all possible measurements of types X and Y. However, in a sample population of measurements X and Y, there can be a nonzero r_{xy} for that sample population. The probability of the r_{xy} of the sample being greater than a certain positive value or less than a certain negative value can be calculated. In the Pearson Product Moment Correlation Square that follows, this was done and the probability is the bottom value in each box composing the square. This probability is referred to as

the one-tailed significance of the correlation value at the top of each box. The probability is referred to as one-tailed because if the correlation value for the sample is positive, it is assumed that the hypothesis of a positive correlation between measurement X and Y is being tested and the tester wants to know the probability of getting a sample correlation value greater than the present correlation value given that the null hypothesis is true that X and Y are independent and uncorrelated with Gaussian probability density functions. Similarly, if the correlation value for the sample is negative, it is assumed that the hypothesis of a negative correlation between measurement X and Y is being tested. Hence, the tester would be interested in knowing the probability of getting a sample correlation value more negative than the present correlation value given that the null hypothesis is true that X and Y are independent and uncorrelated with Gaussian probability density functions. For both a positive and negative correlation value for the sample population, a low probability means that the correlation value may be considered significant as it is less likely to have occurred within a randomly generated sample.

Hence, in the Pearson Product Moment Correlation Square, the correlation of measurement X with itself is 1.0 and is highly significant as the probability of two different measurement types being exactly correlated in a sample population formed through random combination is very low. The

probability of the correlation being greater than 1.0 is zero and the probability of the correlation being greater than 0.9999 is only slightly greater than zero.

Also note that a correlation of 0.2 for a sample population of 100 pairs of measurements is more significant than for a sample population of 10 pairs of measurements. It is much less likely to have a correlation greater than 0.2 due to the random combination for a sample population of 100 pairs than for a sample population of 10 pairs.

The cutoff probability for a correlation being not due to mere chance was $p < 0.05$ in Table 3.1.1. If the probability of achieving the correlation through random combination was less than 5%, then there might actually be a positive or negative correlation between the two measurements being correlated. Based on this criterion, there was no significant correlation with respect to black-white snow as a diagnostic tool.

3.2 Isoluminant Red-Green Counterphase Presentation at 5 Hz

As demonstrated by Table 3.2.1 below, the average amount of absolute scotomata detected with a red-green counterphase checkerboard by a patient comprised 10.57% of the test points classified as absolute scotomata by static perimetry. The average amount of relative scotomata detected by a patient comprised 12.51% of the test points classified as relative scotomata by static perimetry. The average amount of normal test points in the central 30° of the visual field that were noticed by a patient comprised 8.35% of the test points classified as normal by static perimetry.

Table 3.2.1 Average Absolute Scotomata, Relative Scotomata and Normal Vision Detected with Red-green Counterphase

Eyes of Glaucoma Patients	% Absolute Scotomata Detected	% Relative Scotomata Detected	% Normal Visual Field Noticed as Different
1	27.6	0.00	0.00
2	21.7	0.00	0.00
3	21.1	34.8	64.3
4	8.33	10.3	17.7
5	6.67	2.86	0.00
6	0.00	8.33	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	----	30.0	13.8
10	0.00	8.82	0.00
11	41.4	80.0	----
12	0.00	0.00	----
13	0.00	0.00	2.94

14	----	0.00	1.47
Averages	10.57	12.51	8.35

In the Pearson Product Moment Correlation Square (Table 3.2.2) that follows, the upper quantity in each box is the correlation between the two measurements which label the row and column intersecting at that box. The bottom quantity in each box is the probability that the positive correlation of the two measurements for our sample populations is greater than the top value in the box solely as a result of random selection of the sample populations of the two measurements from general populations where the probability density functions of the two measurements are both independently Gaussian. If the correlation is negative, the probability is that the correlation of the sample population is less than the give value due to random combination of the sample population.

Table 3.2.2 Pearson Product Moment Correlation Square for Red-green Counterphase

Each cell shows the correlation r , sample size n , and one-tailed significance probability p .

ABSSCOT = % absolute scotomata in central 30° of visual field

RELSCOT = % relative scotomata in central 30° of visual field

NORM = % normal vision in central 30° of visual field

ABSDET = % absolute scotomata detected in central 30° of visual field

RELDET = % relative scotomata detected in central 30° of visual field

NORMDET = % normal vision noticed in central 30° of visual field

	ABSSCOT	RELSCOT	NORM	ABSDET	RELDET	NORMDET
ABSSCOT	1.0000 n: 12 p:0.000	-0.9147 n: 12 p:0.000	-0.8355 n: 10 p:0.001	0.4716 n: 12 p:0.061	0.5343 n: 12 p:0.037	-0.0728 n: 12 p:0.411
RELSCOT	-0.9147 n: 12 p:0.000	1.0000 n: 14 p:0.000	-0.5015 n: 12 p:0.048	-0.3636 n: 14 p:0.101	-0.4996 n: 14 p:0.034	0.0456 n: 14 p:0.439
NORM	-0.8355 n: 10 p:0.001	-0.5015 n: 12 p:0.048	1.0000 n: 12 p:0.000	-0.3592 n: 12 p:0.126	0.1900 n: 12 p:0.277	-0.0529 n: 12 p:0.435
ABSDET	0.4716 n: 12 p:0.061	-0.3636 n: 14 p:0.101	-0.3592 n: 12 p:0.126	1.0000 n: 14 p:0.000	0.6512 n: 14 p:0.006	0.1960 n: 14 p:0.251
RELDET	0.5343 n: 12 p:0.037	-0.4996 n: 14 p:0.034	0.1900 n: 12 p:0.277	0.6512 n: 14 p:0.006	1.0000 n: 14 p:0.000	0.3107 n: 14 p:0.140
NORMDET	-0.0728 n: 12 p:0.411	0.0456 n: 14 p:0.439	-0.0529 n: 12 p:0.435	0.1960 n: 14 p:0.251	0.3107 n: 14 p:0.140	1.0000 n: 14 p:0.000

Pairwise deletion of missing data in effect.

Maximum number of cases used: 14

The cutoff probability for a correlation being not due to mere chance was $p < 0.05$ in the above table. If the probability of achieving the correlation through random combination was less than 5%, then there might actually be a positive or negative correlation between the two measurements being correlated. Based on this criterion, one significant correlation with respect to red-green counterphase as a diagnostic tool was a positive correlation between percent relative scotomata detected and percent absolute scotomata present. Another significant correlation was a negative

correlation between percent relative scotomata present and percent relative scotomata detected. These correlations suggest that red-green counterphase is not a good detector of relative scotomata.

3.3 Correlation of Neutral Density Filter Test Results

Below in Figure 21 are plotted the curves of log contrast sensitivity versus spatial frequency for six normal eyes. These curves define a ceiling which the curves of glaucoma afflicted patients are consistently below. This is clearly discernible from the curves of glaucoma patients plotted in Figure 22.

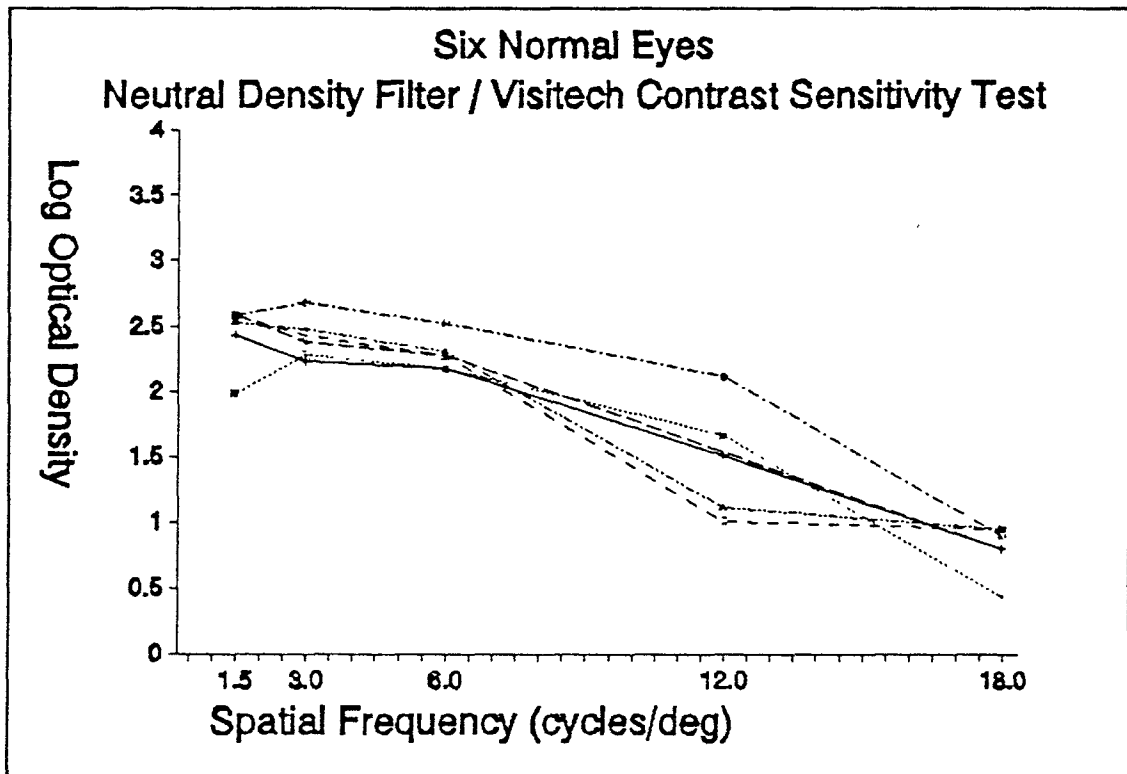


Figure 21 Six Normal Eyes Establishing an Envelope of Normality Encompassing the Scores of Most Eyes with Glaucoma

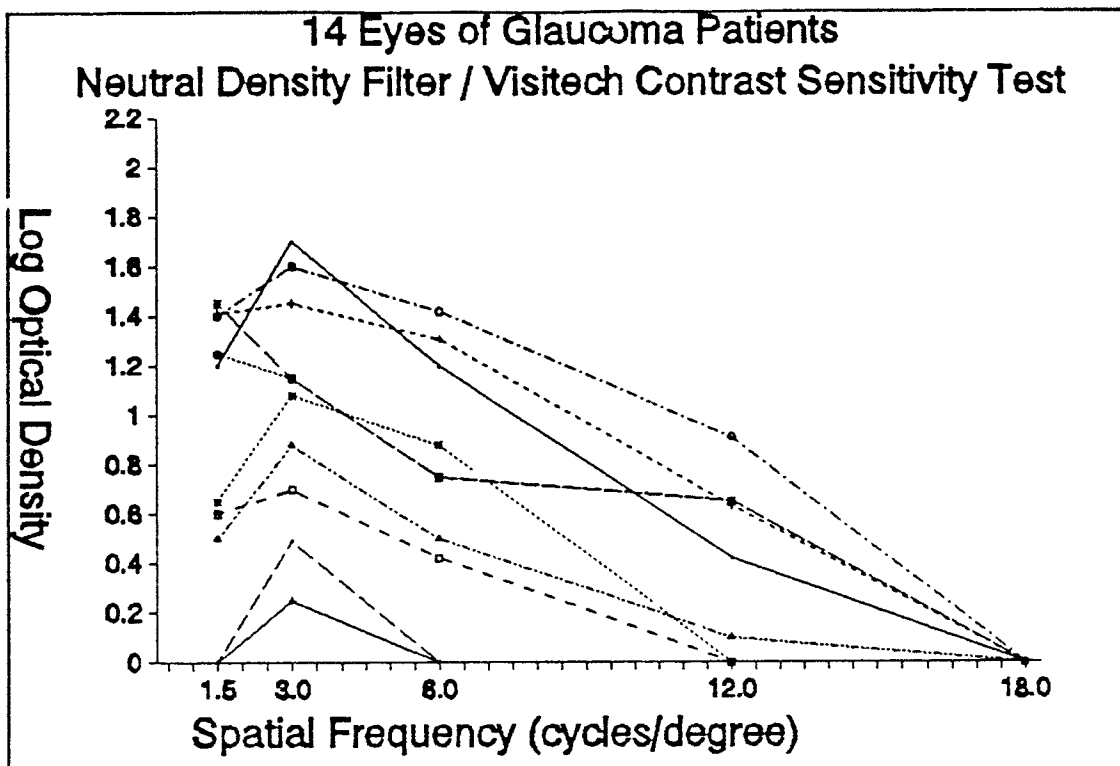


Figure 22 Curves of 14 Eyes of Glaucoma Patients (These Curves are Consistently below the Curves of Normal eyes in Figure 21)

In the Pearson Product Moment Correlation Square (Table 3.3.1) that follows, the upper quantity in each box is the correlation between the two measurements which label the row and column intersecting at that box. The middle quantity in each box is the number of pairs of data that were correlated. The bottom quantity in each box is the probability that the positive correlation of the two measurements for our sample populations is greater than the top value in the box solely as a result of random selection of the sample populations of the two measurements from general populations where the probability density functions of the two measurements are both independently Gaussian. If the correlation is negative, the

probability is that the correlation of the sample population is less than the give value due to random combination of the sample population.

Table 3.3.1 Pearson Product Moment Correlation Square for Neutral Density Filter/Visitech Contrast Sensitivity Test

c/deg = cycles per visual field degree

% Abs Scot = % absolute scotomata in central 30° of visual field

% Rel Scot = % relative scotomata in central 30° of visual field

% Norm = % normal vision in central 30° of visual field

r = correlation coefficient

n = number of pairs of data that were correlated

p = probability of getting the correlation value from random sampling of two sets of measurements that are actually independent of each other and uncorrelated

(Probability p is the one-tailed significance.)

	% Abs Scot	% Rel Scot	% Norm	1.5 c/deg	3.0 c/deg	6.0 c/deg	12.0 c/deg	18.0 c/deg
r =	corr num	corr num	corr num	corr num	corr num	corr num	corr num	corr num
n =	prob	prob	prob	prob	prob	prob	prob	prob
p =	prob	prob	prob	prob	prob	prob	prob	prob
% Abs Scot	1.00 n=12 0.00	-.91 n=12 0.00	-.84 n=10 0.00	0.20 n=12 0.27	0.13 n=12 0.34	0.24 n=12 0.23	0.43 n=12 0.08	0.66 n=12 0.01
% Rel Scot	-.91 n=12 0.00	1.00 n=14 0.00	-.50 n=12 0.05	-.16 n=14 0.29	-.07 n=14 0.41	-.13 n=14 0.33	-.34 n=14 0.12	-.56 n=14 0.02
% Norm	-.84 n=10 0.00	-.50 n=12 0.05	1.00 n=12 0.00	0.52 n=12 0.04	0.43 n=12 0.08	0.40 n=12 0.10	0.45 n=12 0.07	0.18 n=12 0.29
1.5 c/deg	0.20 n=12 0.27	-.16 n=14 0.29	0.52 n=12 0.04	1.00 n=14 0.00	0.96 n=14 0.00	0.95 n=14 0.00	0.93 n=14 0.00	0.62 n=14 0.01
3.0 c/deg	0.13 n=12 0.34	-.07 n=14 0.41	0.43 n=12 0.08	0.96 n=14 0.00	1.00 n=14 0.00	0.98 n=14 0.00	0.88 n=14 0.00	0.59 n=14 0.01
6.0 c/deg	0.24 n=12 0.23	-.13 n=14 0.33	0.40 n=12 0.10	0.95 n=14 0.00	0.98 n=14 0.00	1.00 n=14 0.00	0.91 n=14 0.00	0.65 n=14 0.01
12.0 c/deg	0.43 n=12 0.08	-.34 n=14 0.12	0.45 n=12 0.07	0.93 n=14 0.00	0.88 n=14 0.00	0.91 n=14 0.00	1.00 n=14 0.00	0.78 n=14 0.00
18.0 c/deg	0.66 n=12 0.01	-.56 n=14 0.02	0.18 n=12 .29	0.62 n=14 0.01	0.59 n=14 0.01	0.65 n=14 0.01	0.78 n=14 0.00	1.00 n=14 0.00

The cutoff probability for a correlation being not due to mere chance was $p < 0.05$ in the above table. If the probability of achieving the correlation through random combination was less than 5%, then there might actually be a positive or negative correlation between the two measurements being correlated. Based on this criterion, there was a

positive correlation between percent absolute scotomata and Neutral Density Filter/Visitech Chart Test scores. This was wholly unexpected and is probably just an unlikely random occurrence rather than the true relationship. As the glaucoma worsens, the Neutral Density Filter/Visitech Chart Test scores should decrease. Also based on the 5% confidence level criterion, there was a negative correlation between percent relative scotomata and the lowest spatial frequency Neutral Density Filter/Visitech Contrast Sensitivity Test scores. This is more expected to be due to more than random chance. As a patient's relative scotomata increases, the accompanying Neutral Density Filter/Visitech Contrast Sensitivity Test scores get lower.

Section 3.4 Correlation of Total Areas

As a locator of absolute or relative scotomata, both 30 Hertz black-white snow and the red-green counterphase checkerboard display are poor diagnostic tools. But they may still be general indicators of whether the magno or parvo cellular pathway is more involved in glaucoma. A positive correlation between percent absolute or percent relative scotomata and the percent of the central 30° of the visual field that was noticed with 30 Hertz black-white snow would be evidence that glaucoma is more involved with damage to the magno cellular pathway. Zero or a very small correlation between percent absolute or percent relative scotomata and the percent of the central 30° of the visual field that was noticed with red-green counterphase would be evidence that glaucoma is less involved with damage to the parvo cellular pathway. Below is the Pearson Product Moment Square (Table 3.4.1) which explores this possibility.

Table 3.4.1 Pearson Product Moment Correlation Square for Total Areas Detected by 30 Hz Black-white Snow and Red-green Counterphase

Each cell shows the correlation r , sample size n , and one-tailed significance probability p .

ABSSCOT = % absolute scotomata in central 30° of visual field

RELSCOT = % relative scotomata in central 30° of visual field

NORM = % normal vision in central 30° of visual field

BLKWHT = % of central 30° of visual field noticed with 30 Hz black-white snow

REDGREEN = % of central 30° of visual field noticed with red-green counterphase

	ABSSCOT	RELSCOT	NORM	BLKWHT	REDGREEN
ABSSCOT	1.0000 n: 12 p:0.000	-0.9149 n: 12 p:0.000	-0.8349 n: 10 p:0.001	0.4567 n: 12 p:0.068	0.4200 n: 12 p:0.087
RELSCOT	-0.9149 n: 12 p:0.000	1.0000 n: 14 p:0.000	-0.5015 n: 12 p:0.048	-0.4055 n: 14 p:0.075	-0.3887 n: 14 p:0.085
NORM	-0.8349 n: 10 p:0.001	-0.5015 n: 12 p:0.048	1.0000 n: 12 p:0.000	-0.0176 n: 12 p:0.478	-0.0617 n: 12 p:0.424
BLKWHT	0.4567 n: 12 p:0.068	-0.4055 n: 14 p:0.075	-0.0176 n: 12 p:0.478	1.0000 n: 14 p:0.000	0.8598 n: 14 p:0.000
REDGREEN	0.4200 n: 12 p:0.087	-0.3887 n: 14 p:0.085	-0.0617 n: 12 p:0.424	0.8598 n: 14 p:0.000	1.0000 n: 14 p:0.000

Pairwise deletion of missing data in effect.
Maximum number of cases used: 14

The cutoff probability for a correlation being not due to mere chance was $p < 0.05$ in the above table. If the probability of achieving the correlation through random combination was less than 5%, then there might actually be a positive or negative correlation between the two measurements being correlated. Based on this criterion, there was no strong evidence for 30 Hertz black-white snow or red-green counterphase as broad indicators of the level of glaucoma of a patient.

4. CONCLUSION

A system was developed to test the hypothesis that the M (magno) visual pathway is preferentially damaged over the P (parvo) visual pathway in Primary Open Angle Glaucoma (POAG). In the small number of patients tested (seven), both 30 Hertz black-white snow and red-green counterphase failed to detect a majority of the absolute and relative scotomata induced in a patient's eye by POAG. There was no strong definitively conclusive evidence that scotomata resulting from POAG are better detected with 30 Hertz black-white snow than with a red-green counterphase checkerboard. Nor was there any significant correlation between the amount of scotomata and the amount of area noticed by 30 Hertz black-white snow or red-green counterphase. Hence, there was no strong supportive evidence that the M visual pathway is preferentially damaged as opposed to the P visual pathway in POAG.

By the Pearson Product Moment Correlation Square, there was no strong definitively conclusive evidence of lower scores from the Neutral Density Filter / Visitech Contrast Sensitivity test with severer degrees of POAG. Hence, the presence of visual pathway fiber destruction in POAG cannot be deduced from the Neutral Density Filter/Visitech Contrast Sensitivity Test scores of POAG patients according to the one-tailed significance probabilities of the Pearson Product Moment Correlation Square. However, an examination of the log optical density versus spatial frequency curves of Appendix C

shows that for the seven patients in the study, the curves tended to be lower for glaucoma patients than for normals. If more patients were tested, the Pearson Product Moment Correlation Square might indicate lower test scores with increased amounts of scotomata. This would be strong evidence of visual pathway fiber destruction in POAG.

The system that was developed could be utilized by future studies which could conclusively demonstrate whether or not 30 Hertz black-white snow has any value as a diagnostic tool for POAG. The Neutral Density Filter/ Visitech Contrast Sensitivity Test shows promise as a broad indicator of the level of POAG. Future studies with larger numbers of patients are needed to establish the indicative strength of the Neutral Density Filter/Visitech Contrast Sensitivity Test.

APPENDIX A

RED-GREEN COUNTERPHASE C PROGRAM SOURCE CODE

```

/*
equalize.c
Isoluminant counterphase red-green for detecting glaucoma
scotoma.
version 1.0    Rey Favis    August 2, 1991

    compile using turbo C 2.0:
        tcc bgidemo graphics.lib

*/

#ifdef __TINY__
#error BGIDEMO will not run in the tiny model.
#endif

#include <dos.h>
#include <math.h>
#include <conio.h>
#include <stdio.h>
#include <stdlib.h>
#include <stdarg.h>

#include <graphics.h>

#define ESC    0x1b    /* Define the escape key */
#define TRUE   1       /* Define some handy constants */
#define FALSE  0       /* Define some handy constants */
#define PI     3.14159 /* Define a value for PI */
#define ON     1       /* Define some handy constants */
#define OFF    0       /* Define some handy constants */

int    GraphDriver;    /* The Graphics device driver */
int    GraphMode;     /* The Graphics mode value */
double AspectRatio; /* Aspect ratio of a pixel on the screen
*/
int    MaxX, MaxY;    /* The maximum resolution of the screen
*/
int    MaxColors;    /* The maximum # of colors available */
int    ErrorCode;    /* Reports any graphics errors */
struct palettetype palette; /* Used to read palette
info */
float seconds;
int red, green, light_red, light_green;

/*                                     */
/* Function prototypes                 */
/*                                     */

```

```

void Initialize(void);
void vertest(void);
void Pause(void);
void MainWindow(char *header);
void StatusLine(char *msg);
void DrawBorder(void);
void changetextstyle(int font, int direction, int charsize);
int  gprintf(int *xloc, int *yloc, char *fmt, ... );
float boardsec();
/*                                     */
/*   Begin main function               */
/*                                     */

int main()
{
    int color;

    seconds=boardsec();

    Initialize();          /* Set system into Graphics mode */

                          /* Begin actual demonstration */
    if( GraphDriver==CGA || GraphDriver==EGA ||
GraphDriver==EGALO || GraphDriver==VGA )
        while(1)
            vertest();

    closegraph();        /* Return the system to text mode */
    return(0);
}

/*                                     */
/*   INITIALIZE: Initializes the graphics system and */
/*   reports any errors which occurred.             */
/*                                     */

void Initialize(void)
{
    int xasp, yasp;      /* Used to read the aspect ratio */

    GraphDriver = DETECT; /* Request auto-detection */
    initgraph( &GraphDriver, &GraphMode, "" );
    ErrorCode = graphresult(); /* Read result of
initialization */
    if( ErrorCode != grOk ){ /* Error occurred during init */
        printf(" Graphics System Error: %s\n", grapherrormsg(
ErrorCode ) );
        exit( 1 );
    }

    getpalette( &palette ); /* Read the palette from board */
    MaxColors = getmaxcolor() + 1; /* Read maximum number of

```



```

colors */

    MaxX = getmaxx();
    MaxY = getmaxy();           /* Read size of screen */

    getaspectratio( &xasp, &yasp ); /* read the hardware
aspect */
    AspectRatio = (double)xasp / (double)yasp; /* Get
correction factor */
}

void vertest()
{
    int i, j, x, y, color, test, red, green, light_red,
light_green;
    struct viewporttype vp;
    int height, width, MaxColors;
    long l;

    getviewsettings( &vp );
    width = (vp.right - vp.left) / 75; /* get width of the
box */
    height = (vp.bottom - vp.top) / 50; /* Get the height of
the box */

    printf("\n\n\n\n 0  1 2  ==>");
    printf("\n\nAbove are colors Numbers 0 through 30 from
left to right.");

    MaxColors=getmaxcolor();
    printf("\n\nMaximum number of colors: %i",MaxColors);

    for ( i=0; i<31; ++i) {
        setfillstyle ( SOLID_FILL, i);
        bar (10 + i*20, 10, 20 + i*20, 20);
    }

    printf("\n\nInput integer for color intense red => ");
    scanf("%i",&red);

    printf("\n\nInput integer for color intense green =>");
    scanf("%i",&green);

    printf("\n\nInput integer for color light red => ");
    scanf("%i",&light_red);
}

```

```

printf("\nInput integer for color light green => ");
scanf("%i",&light_green);

putchar(12);

MainWindow( "Isoluminant Red Green Counter Phase" );
StatusLine( "Press any key to change speed, ESC to Abort"
);

x = y = 0;                               /* Start in upper corner */
color = green;
test=1;                                   /* Begin at 1st color */

for( j=0 ; j<50 ; ++j ){                 /* For 10 rows of boxes*/
    for( i=0 ; i<75 ; ++i ){             /* For 15 columns of boxes */
        setfillstyle( SOLID_FILL, color ); /* Set the color of
box */
        bar( x, y, x+width, y+height ); /* Draw the box */
        x += width + 1;                 /* Advance to next col */
        test *= -1;                      /* Set new color */
        if(test<0)
            color=light_red;
        else
            color=green;
    }                                     /* End of COLUMN loop */
    x = 0;                               /* Go to 1st column */
    y += height + 1;                     /* Go to next row */
}                                         /* End of ROW loop */

while( !kbhit() ){                       /* Until user enters a key...*/
    delay(seconds);
    palette.colors[light_red]=red;
    palette.colors[green]=light_green;
    palette.colors[red]=red;
    palette.colors[light_green]=light_green;
    setallpalette( &palette);
    delay(seconds);
    palette.colors[light_red]=light_red;
    palette.colors[green]=green;
    palette.colors[red]=light_red;
    palette.colors[light_green]=green;
    setallpalette( &palette);

}

setallpalette( &palette );

Pause();                                 /* Wait for user's response */
}

```

```

void Pause(void)
{
    static char msg[] = "Esc aborts or press a key...";
    int c;

    StatusLine( msg );      /* Put msg at bottom of screen */

    c = getch();           /* Read a character from kbd */

    if( ESC == c ){       /* Does user wish to leave? */
        closegraph();     /* Change to text mode */
        exit( 1 );        /* Return to OS */
    }

    if( 0 == c ){         /* Did use hit a non-ASCII key? */
        c = getch();      /* Read scan code for keyboard */
    }

    cleardevice();        /* Clear the screen */
    boardsec();

}

/*
/* MAINWINDOW: Establish the main window for the demo      */
/* and set a viewport for the demo code.                  */
/*
void MainWindow( char *header )
{
    int height;

    cleardevice();      /* Clear graphics screen */
    setcolor( MaxColors - 1 ); /* Set current color to white */
    setviewport( 0, 0, MaxX, MaxY, 1 ); /* Open port to
full screen */

    height = textheight( "H" ); /* Get basic text height */

    changetextstyle( DEFAULT_FONT, HORIZ_DIR, 1 );
    setttextjustify( CENTER_TEXT, TOP_TEXT );
    outtextxy( MaxX/2, 2, header );
    setviewport( 0, height+4, MaxX, MaxY-(height+4), 1 );
    DrawBorder();
    setviewport( 1, height+5, MaxX-1, MaxY-(height+5), 1 );

}

/*
/* STATUSLINE: Display a status line at the bottom of the

```

```

screen.*/
/*
*/

void StatusLine( char *msg )
{
    int height;

    setviewport( 0, 0, MaxX, MaxY, 1 ); /* Open port to
full screen */
    setcolor( MaxColors - 1 ); /* Set current color to white
*/

    changetextstyle( DEFAULT_FONT, HORIZ_DIR, 1 );
    setttextjustify( CENTER_TEXT, TOP_TEXT );
    setlinestyle( SOLID_LINE, 0, NORM_WIDTH );
    setfillstyle( EMPTY_FILL, 0 );

    height = textheight( "H" ); /* Determine current height */
    bar( 0, MaxY-(height+4), MaxX, MaxY );
    rectangle( 0, MaxY-(height+4), MaxX, MaxY );
    outtextxy( MaxX/2, MaxY-(height+2), msg );
    setviewport( 1, height+5, MaxX-1, MaxY-(height+5), 1 );
}

/*
*/
/* DRAWBORDER: Draw a solid single line around the */
/* current viewport. */
/*
*/

void DrawBorder(void)
{
    struct viewporttype vp;

    setcolor( MaxColors - 1 ); /* Set current color to white
*/

    setlinestyle( SOLID_LINE, 0, NORM_WIDTH );

    getviewsettings( &vp );
    rectangle( 0, 0, vp.right-vp.left, vp.bottom-vp.top );
}

/*
*/
/* CHANGETEXTSTYLE: similar to setttextstyle, but checks
for */
/* errors that might occur while loading the font file.
*/
/*
*/

void changetextstyle(int font, int direction, int charsize)

```

```

{
    int ErrorCode;

    graphresult();                /* clear error code */
    settextstyle(font, direction, charsize);
    ErrorCode = graphresult();    /* check result */
    if( ErrorCode != grOk ){      /* if error occurred */
        closegraph();
        printf(" Graphics System Error: %s\n", grapherrormsg(
ErrorCode ) );
        exit( 1 );
    }
}

/*                                     */
/* GPRINTF: Used like PRINTF except the output is sent to
the */
/*   screen in graphics mode at the specified co-ordinate.
*/
/*                                     */

int gprintf( int *xloc, int *yloc, char *fmt, ... )
{
    va_list argptr, format        /* Argument list pointer */
    char str[140];                /* Buffer to build sting into */
    int cnt;                       /* Result of SPRINTF for return */

    va_start( argptr, format ); /* Initialize va_ functions
*/

    cnt = vsprintf(str, fmt, argptr); /* prints string to
buffer */
    outtextxy(*xloc, *yloc, str); /* Send string in graphics
mode */
    *yloc += textheight( "H" ) + 2; /* Advance to next
line */

    va_end( argptr );            /* Close va_ functions */

    return( cnt );              /* Return the conversion count */
}

float boardsec()
{
    float seconds;

    printf("Input time between color changes (seconds)=> ");
    scanf("%f",&seconds);

    return(seconds *= 1000);
}

```

APPENDIX B

COMPARISON PER INDIVIDUAL PATIENT
OF AREAS NOTICED BY 30 HZ BLACK-WHITE
SNOW AND RED-GREEN COUNTERPHASE TO
STATIC PERIMETRY DETERMINED AREAS

Sex: Female

Age: 75

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (HUMPHREY)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	4	5.88%	8	11.76%
NORMAL VISION POINTS	19	1	5.26%	0	0.00%
RELATIVE SCOTOMATA PTS.	20	0	0.00%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	29	3	10.34%	8	27.59%

RIGHT EYE

	STATIC PERIMETRY: HUMPHREY	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	10	14.71%	5	7.35%
NORMAL VISION POINTS	19	1	5.26%	0	0.00%
RELATIVE SCOTOMATA PTS.	26	3	11.54%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	23	6	26.09%	5	21.74%

Sex: Female

Age: 75

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (HUMPHREY)	RIGHT EYE: STATIC PERIMETRY (HUMPHREY)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	19	19
% TEST POINTS NORMAL	27.94%	27.94%
RELATIVE SCOTOMATA PTS.	20	26
% TEST POINTS REL. SCOTOMATA	29.41%	38.24%
ABSOLUTE SCOTOMATA PTS.	29	23
% TEST POINTS ABS. SCOTOMATA	42.65%	33.82%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	4	8	10	5
NORMAL VISION POINTS	1	0	1	0
% NOTICED POINTS NORMAL	25.00%	0.00%	10.00%	0.00%
RELATIVE SCOTOMATA PTS.	0	0	3	0
% NOTICED PTS. REL. SCOTOMATA	0.00%	0.00%	30.00%	0.00%
ABSOLUTE SCOTOMATA PTS.	3	8	6	5
% NOTICED PTS. ABS. SCOTOMATA	75.00%	100.00%	60.00%	100.00%

Sex: Male

Age: 74

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (HUMPHREY)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68 *	31	45.59%	30	44.12%
NORMAL VISION POINTS	14	5	35.71%	9	64.29%
RELATIVE SCOTOMATA PTS.	23	6	26.09%	8	34.78%
ABSOLUTE SCOTOMATA PTS.	19	6	31.58%	4	21.05%

* 12 points are illegible from original Humphrey Instruments computer printout.

RIGHT EYE

	STATIC PERIMETRY (HUMPHREY)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	0	0.00%	8	11.76%
NORMAL VISION POINTS	17	0	0.00%	3	17.65%
RELATIVE SCOTOMATA PTS.	39	0	0.00%	4	10.26%
ABSOLUTE SCOTOMATA PTS.	12	0	0.00%	1	8.33%

Sex: Male

Age: 74

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (HUMPHREY)	RIGHT EYE: STATIC PERIMETRY (HUMPHREY)
TOTAL POINTS CONSIDERED	56	68
NORMAL VISION POINTS	14	17
% TEST POINTS NORMAL	25.00%	25.00%
RELATIVE SCOTOMATA PTS.	23	39
% TEST POINTS REL. SCOTOMATA	41.07%	57.35%
ABSOLUTE SCOTOMATA PTS.	19	12
% TEST POINTS ABS. SCOTOMATA	33.93%	17.65%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	17	21	0	8
NORMAL VISION POINTS	5	9	0	3
% NOTICED POINTS NORMAL	29.41%	42.86%	----	37.50%
RELATIVE SCOTOMATA PTS.	6	8	0	4
% NOTICED PTS. REL. SCOTOMATA	35.29%	38.10%	----	50.00%
ABSOLUTE SCOTOMATA PTS.	6	4	0	1
% NOTICED PTS. ABS. SCOTOMATA	35.29%	19.05%	----	12.50%

Sex: Male

Age: 63

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	8	11.76%	2	2.94%
NORMAL VISION POINTS	18	0	0.00%	0	0.00%
RELATIVE SCOTOMATA PTS.	35	4	11.43%	1	2.86%
ABSOLUTE SCOTOMATA PTS.	15	4	26.67%	1	6.67%

RIGHT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	4	5.88%	2	2.94%
NORMAL VISION POINTS	17	0	0.00%	0	0.00%
RELATIVE SCOTOMATA PTS.	24	2	8.33%	2	8.33%
ABSOLUTE SCOTOMATA PTS.	27	2	7.41%	0	0.00%

Sex: Male

Age: 63

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (OCTOPUS)	RIGHT EYE: STATIC PERIMETRY (OCTOPUS)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	18	17
% TEST POINTS NORMAL	26.47%	25.00%
RELATIVE SCOTOMATA PTS.	35	24
% TEST POINTS REL. SCOTOMATA	51.47%	35.29%
ABSOLUTE SCOTOMATA PTS.	15	27
% TEST POINTS ABS. SCOTOMATA	22.06%	39.71%

	LEFT EYE: POINTS NOTICED W/ 30 HZ Black- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	8	2	4	2
NORMAL VISION POINTS	0	0	0	0
% NOTICED POINTS NORMAL	0.00%	0.00%	0.00%	0.00%
RELATIVE SCOTOMATA PTS.	4	1	2	2
% NOTICED PTS. REL. SCOTOMATA	50.00%	50.00%	50.00%	100.00%
ABSOLUTE SCOTOMATA PTS.	4	1	2	0
% NOTICED PTS. ABS. SCOTOMATA	50.00%	50.00%	50.00%	0.00%

Sex: Male

Age: 65

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	0	0.00%	0	0.00%
NORMAL VISION POINTS	27	0	0.00%	0	0.00%
RELATIVE SCOTOMATA PTS.	39	0	0.00%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	2	0	0.00%	0	0.00%

RIGHT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	0		0	
NORMAL VISION POINTS	30	0		0	
RELATIVE SCOTOMATA PTS.	36	0		0	
ABSOLUTE SCOTOMATA PTS.	2	0		0	

Sex: Male

Age: 65

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (OCTOPUS)	RIGHT EYE: STATIC PERIMETRY (OCTOPUS)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	27	30
% TEST POINTS NORMAL	39.71%	44.12%
RELATIVE SCOTOMATA PTS.	39	36
% TEST POINTS REL. SCOTOMATA	57.35%	52.94%
ABSOLUTE SCOTOMATA PTS.	2	2
% TEST POINTS ABS. SCOTOMATA	2.94%	2.94%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	0	0	0	0
NORMAL VISION POINTS	0	0	0	0
% NOTICED POINTS NORMAL	-----	-----	-----	-----
RELATIVE SCOTOMATA PTS.	0	0	0	0
% NOTICED PTS. REL. SCOTOMATA	-----	-----	-----	-----
ABSOLUTE SCOTOMATA PTS.	0	0	0	0
% NOTICED PTS. ABS. SCOTOMATA	-----	-----	-----	-----

Sex: Female

Age: 79

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	21	30.88%	11	16.18%
NORMAL VISION POINTS	58	17	29.31%	8	13.79%
RELATIVE SCOTOMATA PTS.	10	4	40.00%	3	30.00%
ABSOLUTE SCOTOMATA PTS.	0	0	----	0	----

RIGHT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	20	29.41%	3	4.41%
NORMAL VISION POINTS	4	2	50.00%	0	0.00%
RELATIVE SCOTOMATA PTS.	34	14	41.18%	3	8.82%
ABSOLUTE SCOTOMATA PTS.	30	4	13.33%	0	0.00%

Sex: Female

Age: 79

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (OCTOPUS)	RIGHT EYE: STATIC PERIMETRY (OCTOPUS)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	58	4
% TEST POINTS NORMAL	85.29%	5.88%
RELATIVE SCOTOMATA PTS.	10	34
% TEST POINTS REL. SCOTOMATA	14.71%	50.00%
ABSOLUTE SCOTOMATA PTS.	0	30
% TEST POINTS ABS. SCOTOMATA	0.00%	44.12%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	21	11	20	3
NORMAL VISION POINTS	17	8	2	0
% NOTICED POINTS NORMAL	80.95%	72.73%	10.00%	0.00%
RELATIVE SCOTOMATA PTS.	4	3	14	3
% NOTICED PTS. REL. SCOTOMATA	19.05%	27.27%	70.00%	100.00%
ABSOLUTE SCOTOMATA PTS.	0	0	4	0
% NOTICED PTS. ABS. SCOTOMATA	0.00%	0.00%	20.00%	0.00%

Sex: Male

Age: 29

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	34	50.00%	32	47.06%
NORMAL VISION POINTS	0	0	----	0	----
RELATIVE SCOTOMATA PTS.	10	7	70.00%	8	80.00%
ABSOLUTE SCOTOMATA PTS.	58	27	46.55%	24	41.38%

RIGHT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	0	0.00%	0	0.00%
NORMAL VISION POINTS	0	0	----	0	----
RELATIVE SCOTOMATA PTS.	9	0	0.00%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	59	0	0.00%	0	0.00%

Sex: Male

Age: 29

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (OCTOPUS)	RIGHT EYE: STATIC PERIMETRY (OCTOPUS)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	0	0
% TEST POINTS NORMAL	0.00%	0.00%
RELATIVE SCOTOMATA PTS.	10	9
% TEST POINTS REL. SCOTOMATA	14.71%	13.24%
ABSOLUTE SCOTOMATA PTS.	58	59
% TEST POINTS ABS. SCOTOMATA	85.29%	86.76%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	34	32	0	0
NORMAL VISION POINTS	0	0	0	0
% NOTICED POINTS NORMAL	0.00%	0.00%	----	----
RELATIVE SCOTOMATA PTS.	7	8	0	0
% NOTICED PTS. REL. SCOTOMATA	20.59%	25.00%	----	----
ABSOLUTE SCOTOMATA PTS.	27	24	0	0
% NOTICED PTS. ABS. SCOTOMATA	79.41%	75.00%	----	----

Sex: Female

Age: 45

Glaucoma Patient

LEFT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	3	4.41%	2	2.94%
NORMAL VISION POINTS	33	2	6.06%	2	6.06%
RELATIVE SCOTOMATA PTS.	34	1	2.94%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	1	0	0.00%	0	0.00%

RIGHT EYE

	STATIC PERIMETRY (OCTOPUS)	POINTS DETECTED BY 30 HZ BLACK-WHITE SNOW	% STATIC PERIMETRY PTS. DETECTED BY BLACK-WHITE	POINTS DETECTED BY 5 HZ RED-GREEN COUNTERPHASE	% STATIC PERIMETRY PTS. DETECTED BY RED-GREEN
TOTAL POINTS	68	6	8.82%	1	1.47%
NORMAL VISION POINTS	41	4	9.76%	1	2.44%
RELATIVE SCOTOMATA PTS.	27	2	7.41%	0	0.00%
ABSOLUTE SCOTOMATA PTS.	0	0	----	0	----

Sex: Female

Age: 45

Glaucoma Patient

	LEFT EYE: STATIC PERIMETRY (OCTOPUS)	RIGHT EYE: STATIC PERIMETRY (OCTOPUS)
TOTAL POINTS CONSIDERED	68	68
NORMAL VISION POINTS	33	41
% TEST POINTS NORMAL	48.53%	60.29%
RELATIVE SCOTOMATA PTS.	34	27
% TEST POINTS REL. SCOTOMATA	50.00%	39.71%
ABSOLUTE SCOTOMATA PTS.	1	0
% TEST POINTS ABS. SCOTOMATA	1.47%	0.00%

	LEFT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	LEFT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE	RIGHT EYE: POINTS NOTICED W/ 30 HZ BLACK- WHITE SNOW	RIGHT EYE: PTS NOTICED W/ 5 HZ RED-GREEN COUNTERPHASE
TOTAL POINTS NOTICED	3	2	6	1
NORMAL VISION POINTS	2	2	4	1
% NOTICED POINTS NORMAL	66.67%	100.00%	66.67%	100.00%
RELATIVE SCOTOMATA PTS.	1	0	2	0
% NOTICED PTS. REL. SCOTOMATA	33.33%	0.00%	33.33%	0.00%
ABSOLUTE SCOTOMATA PTS.	0	0	0	0
% NOTICED PTS. ABS. SCOTOMATA	0.00%	0.00%	0.00%	0.00%

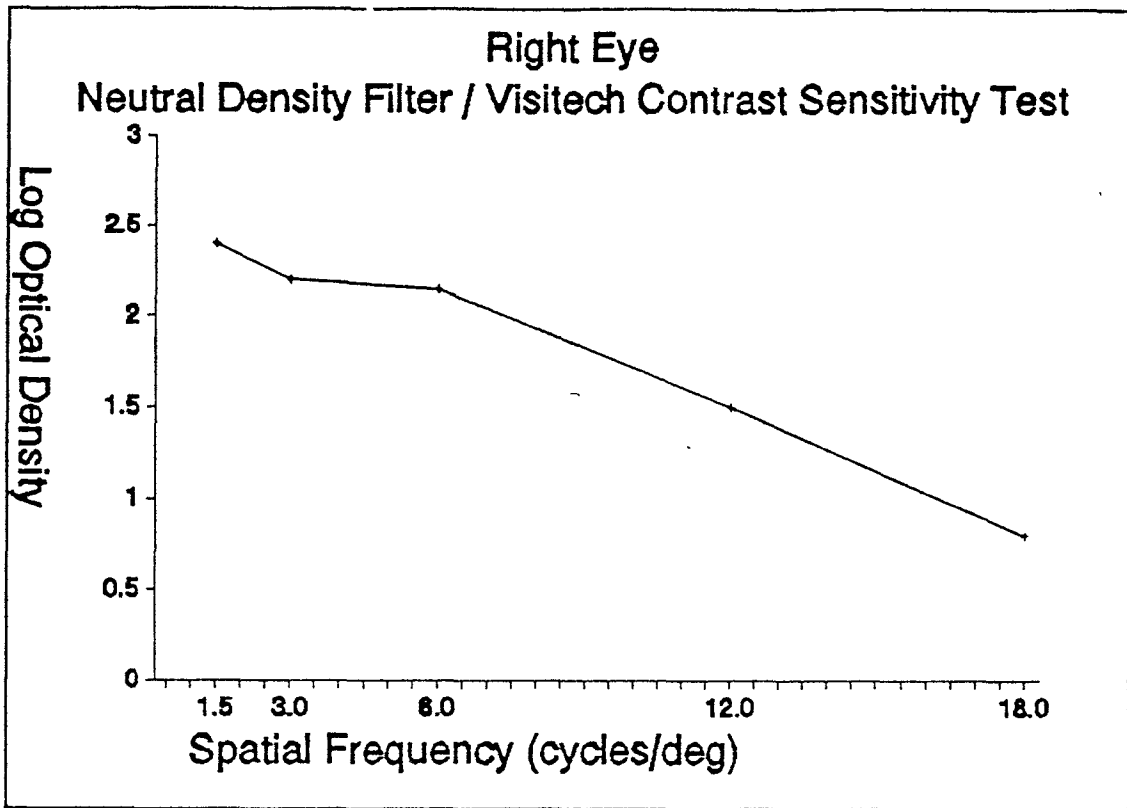
APPENDIX C

ANALYSIS PER INDIVIDUAL PATIENT OF
NEUTRAL DENSITY FILTER/VISITECH
CONTRAST SENSITIVITY TEST SCORES

Sex: Male Age: 60 Normal

Results of Neutral Density Filter / Visitech Contrast Test

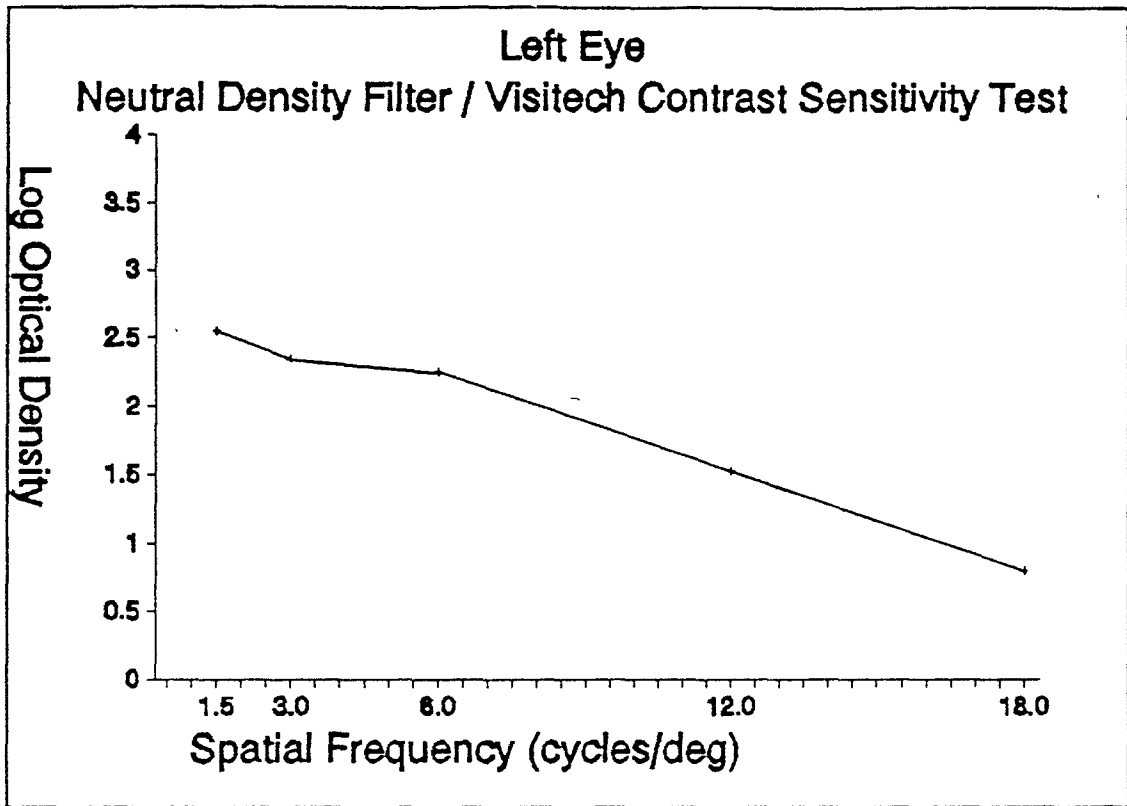
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	2.55	2.40
3.0	2.35	2.20
6.0	2.25	2.15
12.0	1.525	1.50
18.0	0.80	0.80



Sex: Male

Age: 60

Normal



Sex: Male

Age: 60

Normal

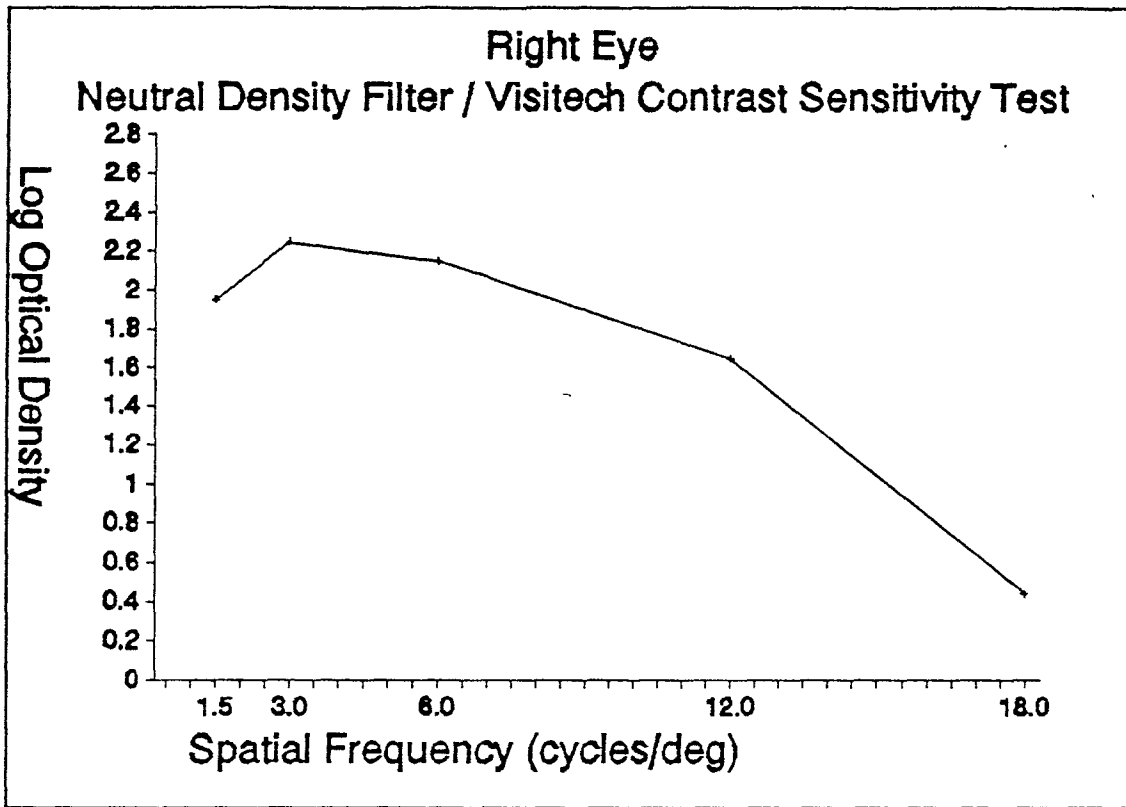
Sex: Male

Age: 64

Normal

Results of Neutral Density Filter / Visitech Contrast Test

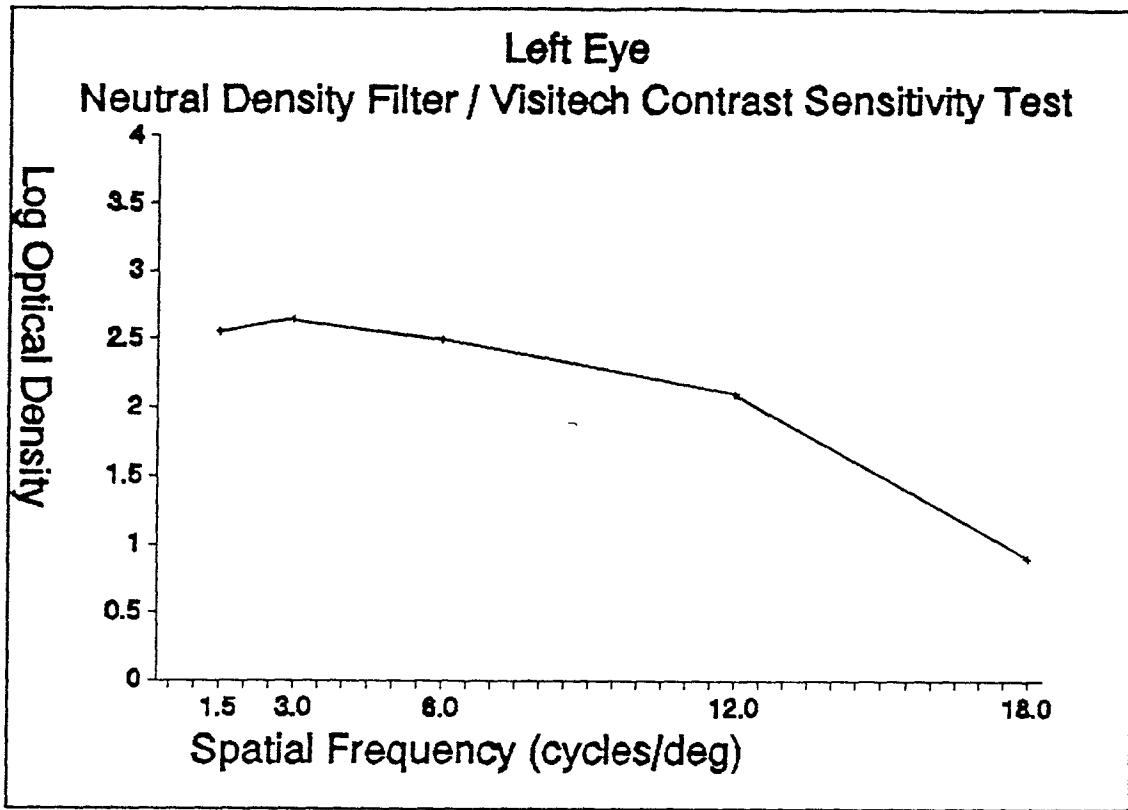
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	2.55	1.95
3.0	2.65	2.25
6.0	2.50	2.15
12.0	2.10	1.65
18.0	0.90	0.44



Sex: Male

Age: 64

Normal



Sex: Male

Age: 64

Normal

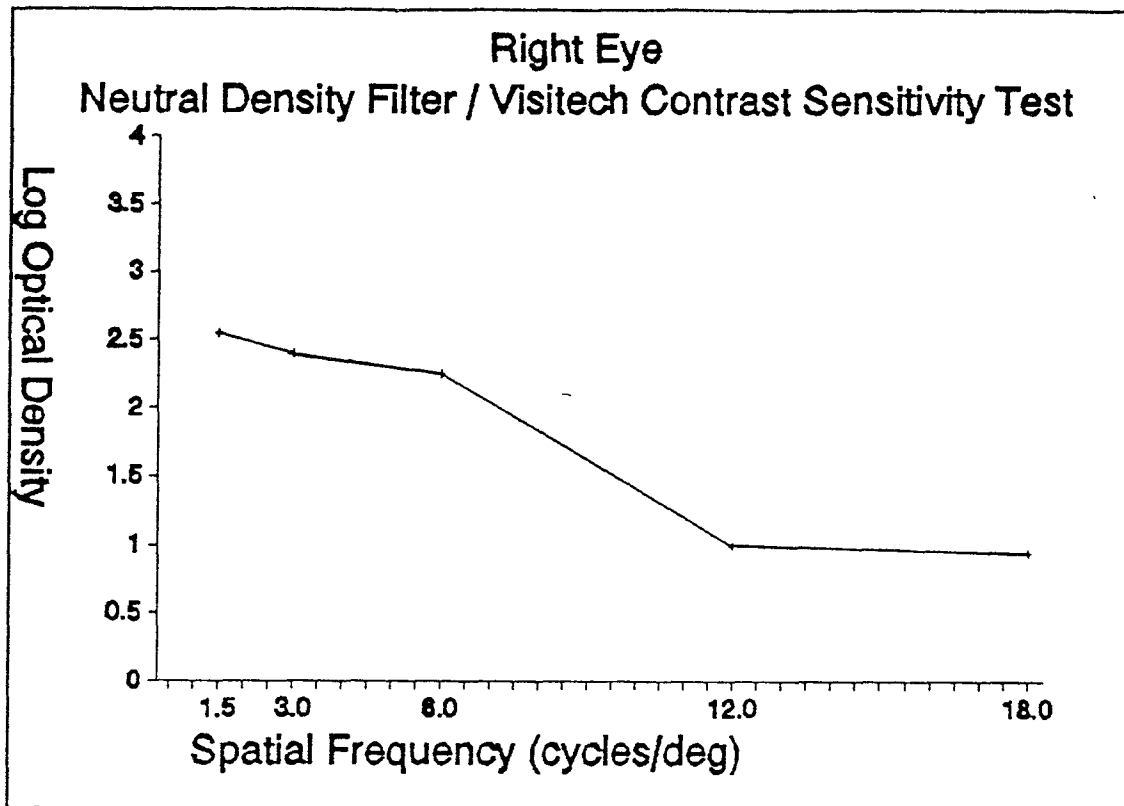
Sex: Male

Age: 24

Normal

Results of Neutral Density Filter / Visitech Contrast Test

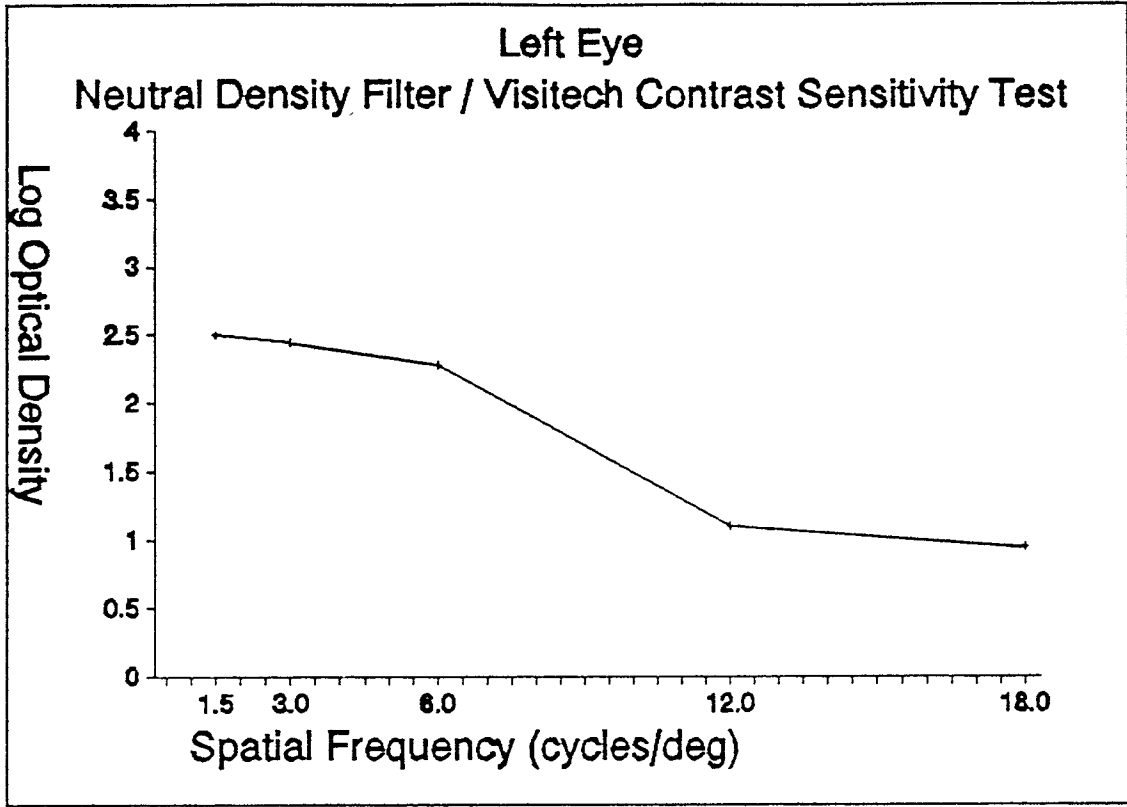
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	2.50	2.55
3.0	2.45	2.40
6.0	2.28	2.25
12.0	1.10	1.00
18.0	0.95	0.95



Sex: Male

Age: 24

Normal



Sex: Male

Age: 24

Normal

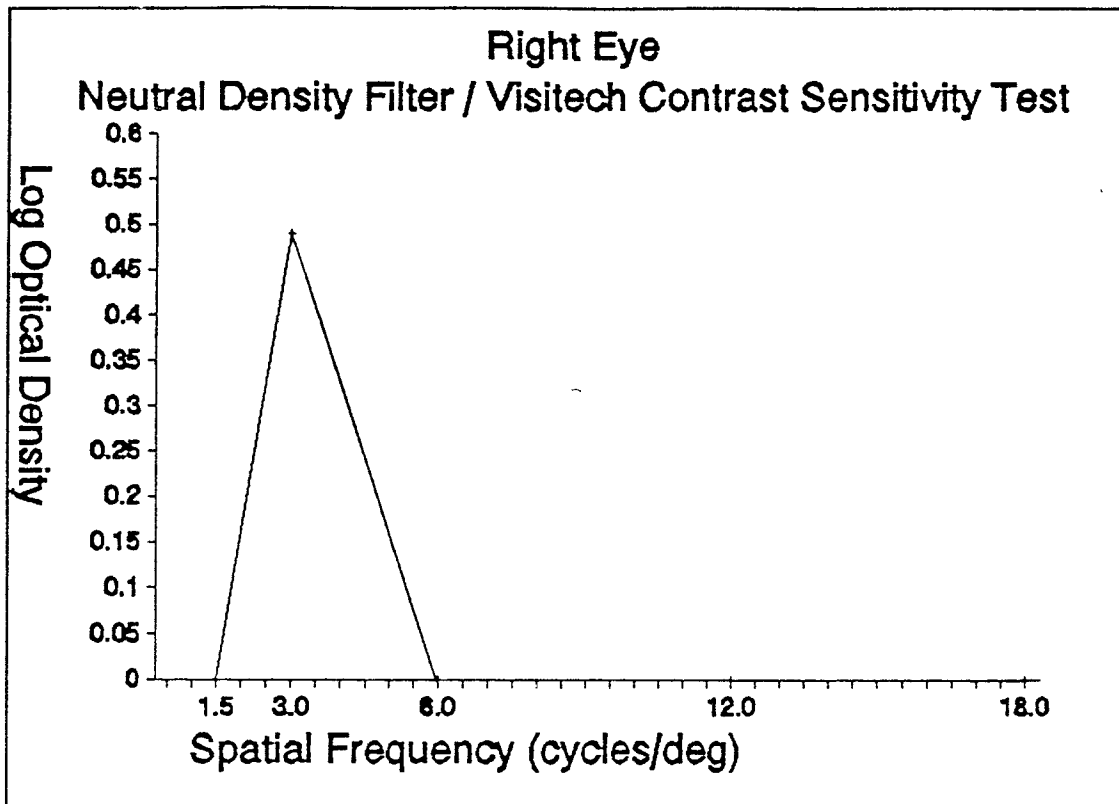
Sex: Female

Age: 75

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

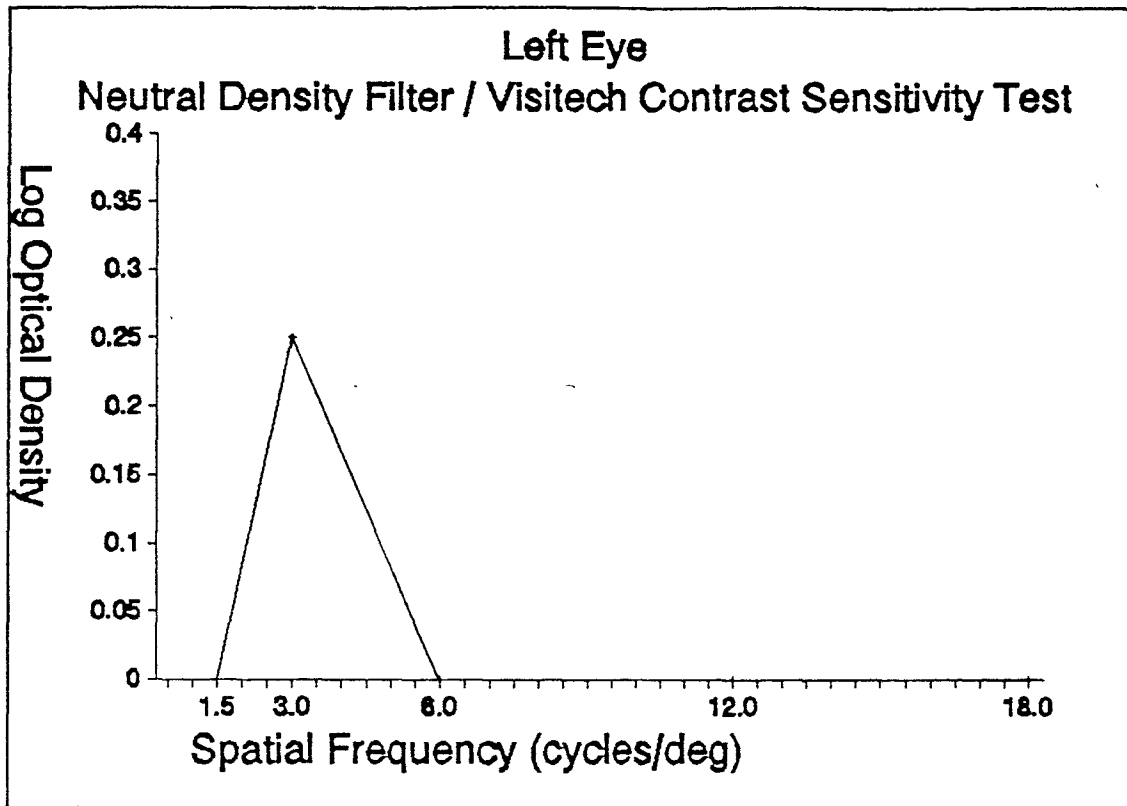
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	----	----
3.0	0.25	0.49
6.0	----	0.00
12.0	----	----
18.0	----	----



Sex: Female

Age: 75

Glaucoma Patient



Sex: Female

Age: 75

Glaucoma Patient

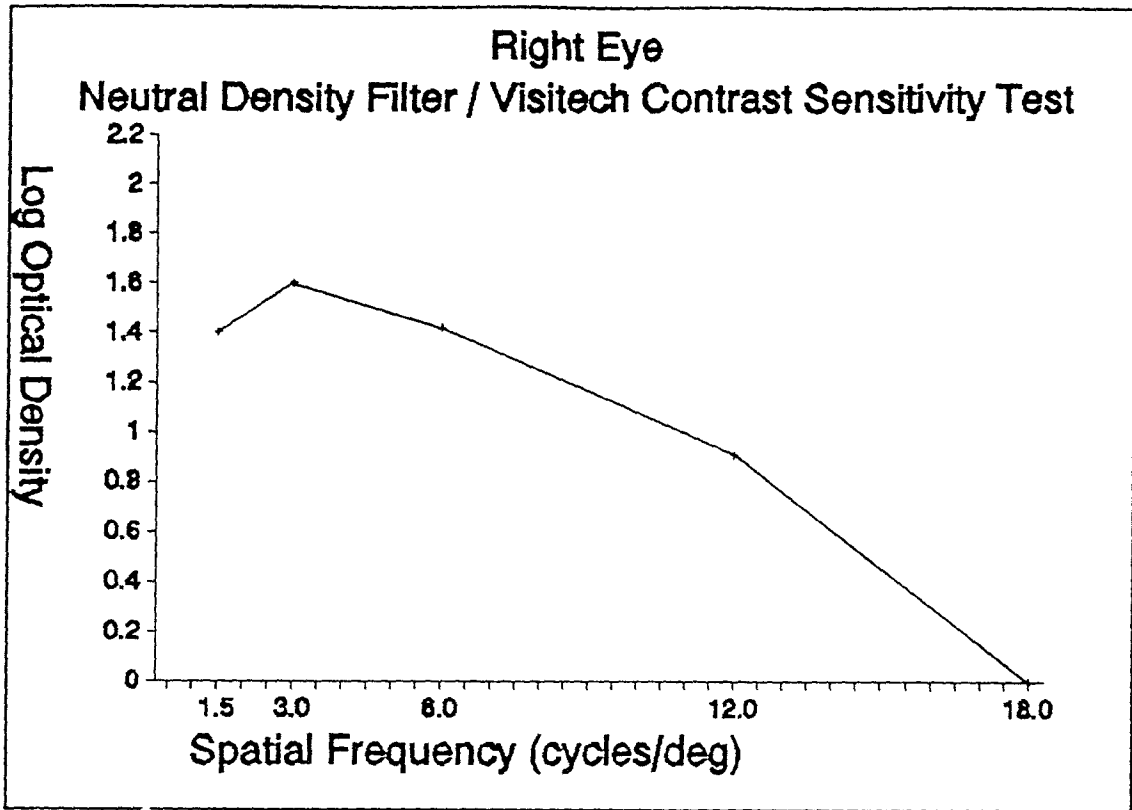
Sex: Male

Age: 74

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

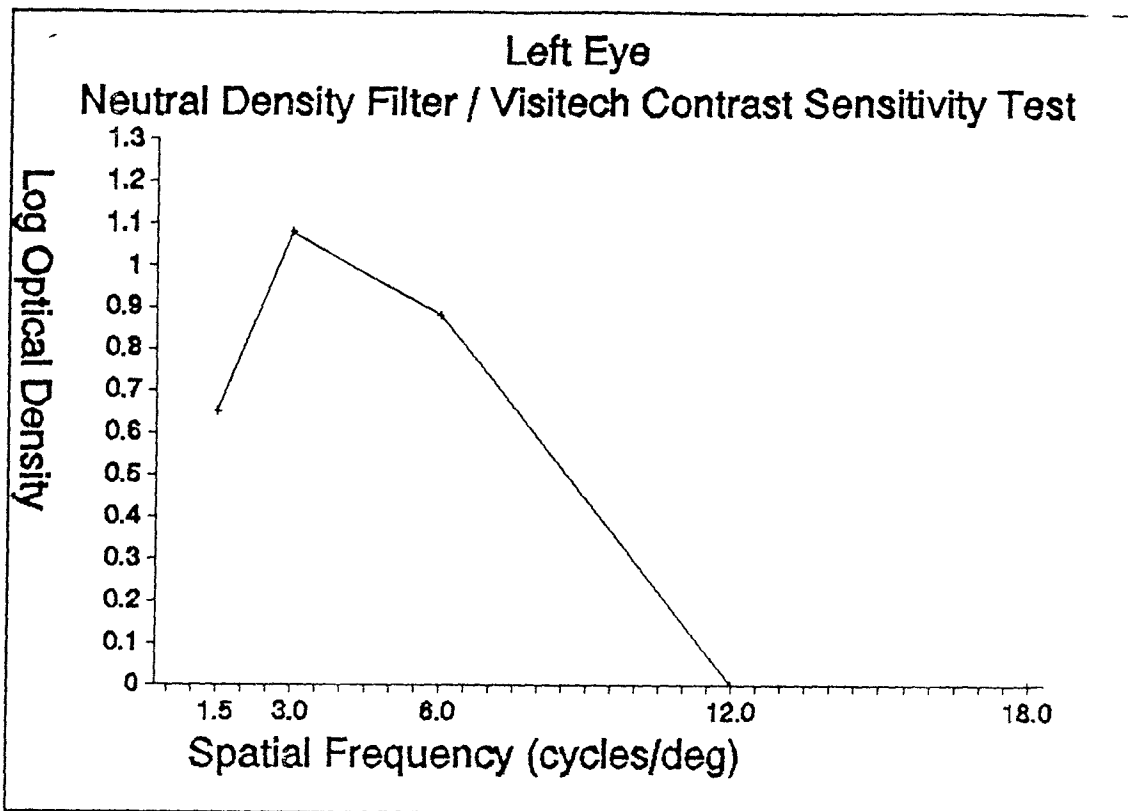
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	0.65	1.40
3.0	1.08	1.60
6.0	0.88	1.42
12.0	----	0.91
18.0	----	----



Sex: Male

Age: 74

Glaucoma Patient



Sex: Male

Age: 74

Glaucoma Patient

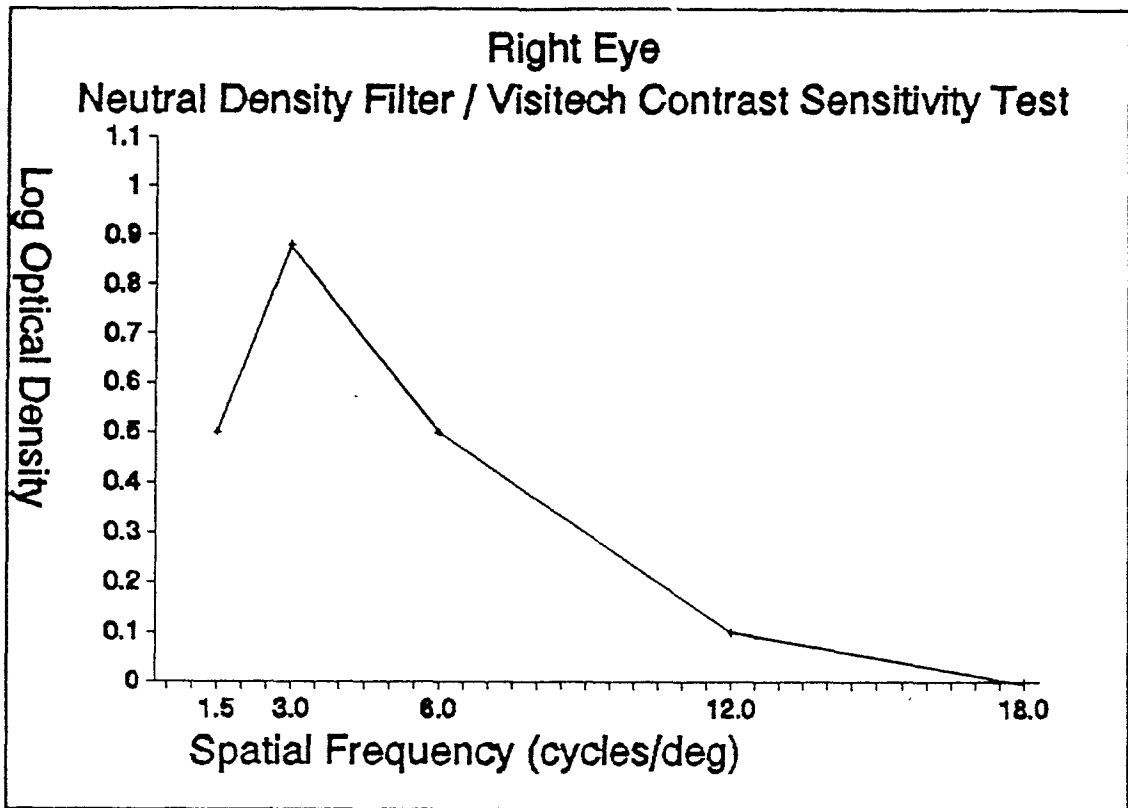
Sex: Male

Age: 63

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

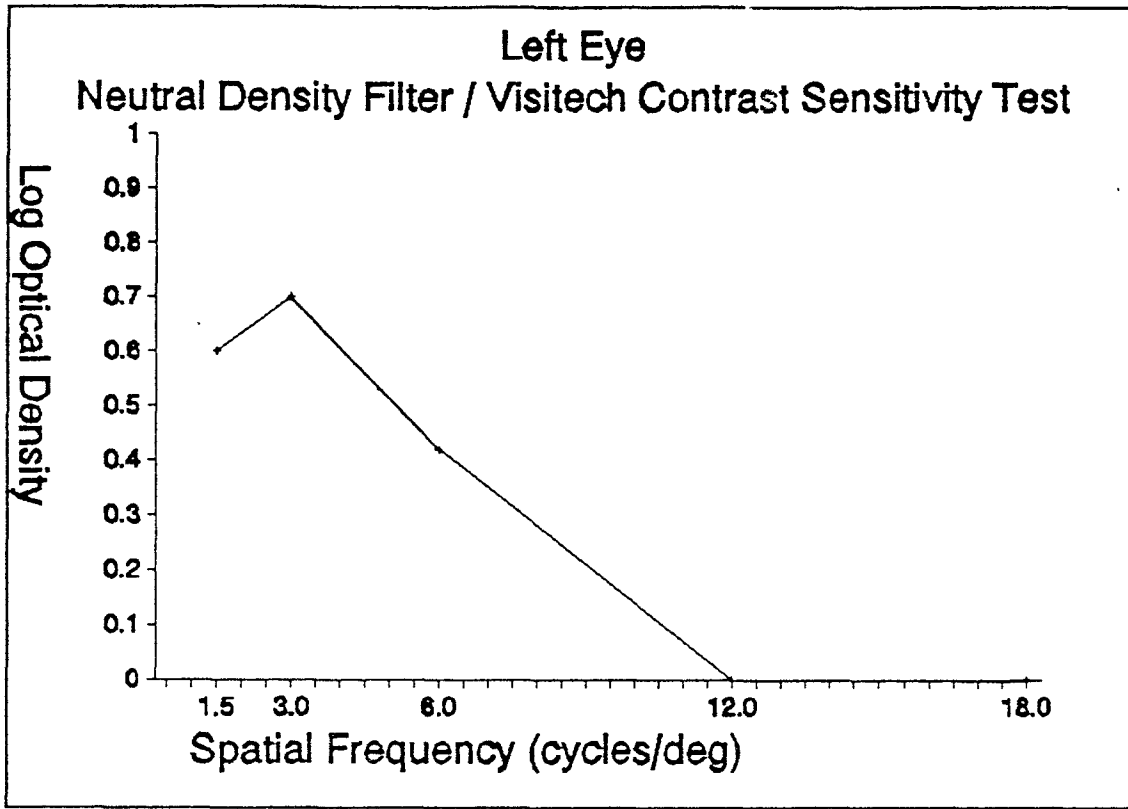
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	0.60	0.50
3.0	0.70	0.88
6.0	0.42	0.50
12.0	----	0.10
18.0	----	----



Sex: Male

Age: 63

Glaucoma Patient



Sex: Male

Age: 63

Glaucoma Patient

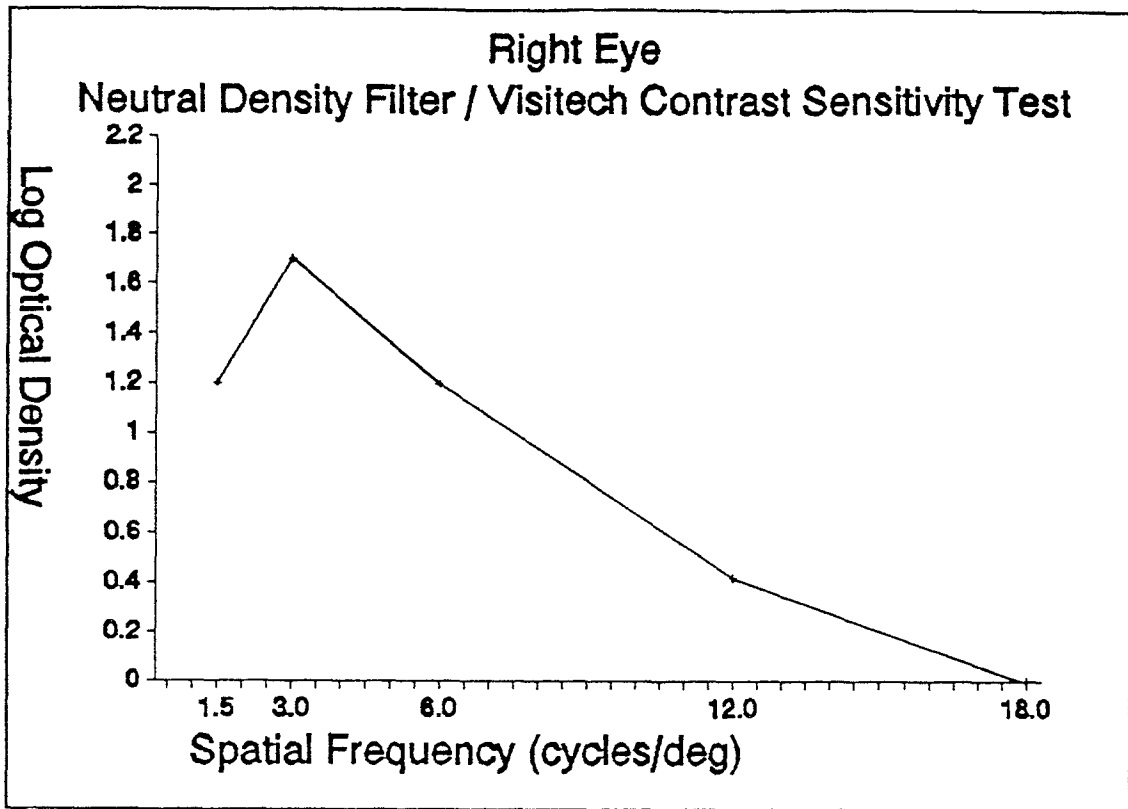
Sex: Male

Age: 65

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

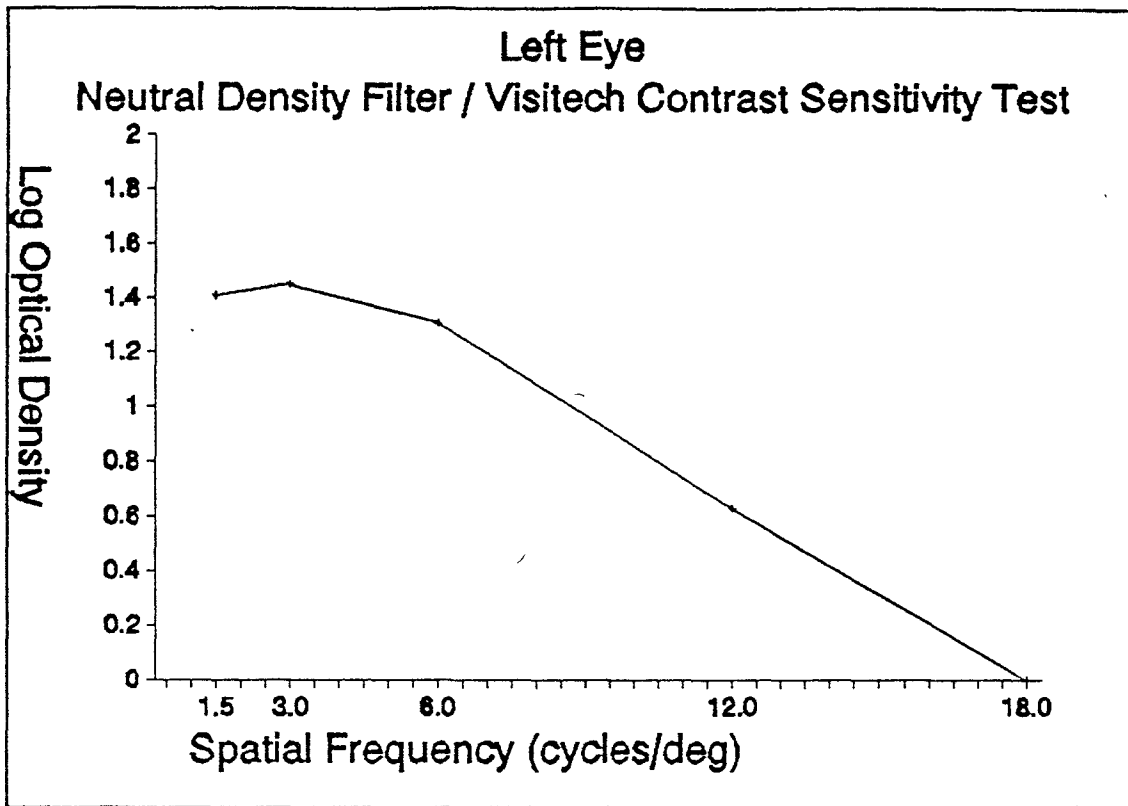
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	1.41	1.20
3.0	1.45	1.70
6.0	1.31	1.20
12.0	0.63	0.42
18.0	----	----



Sex: Male

Age: 65

Glaucoma Patient



Sex: Male

Age: 65

Glaucoma Patient

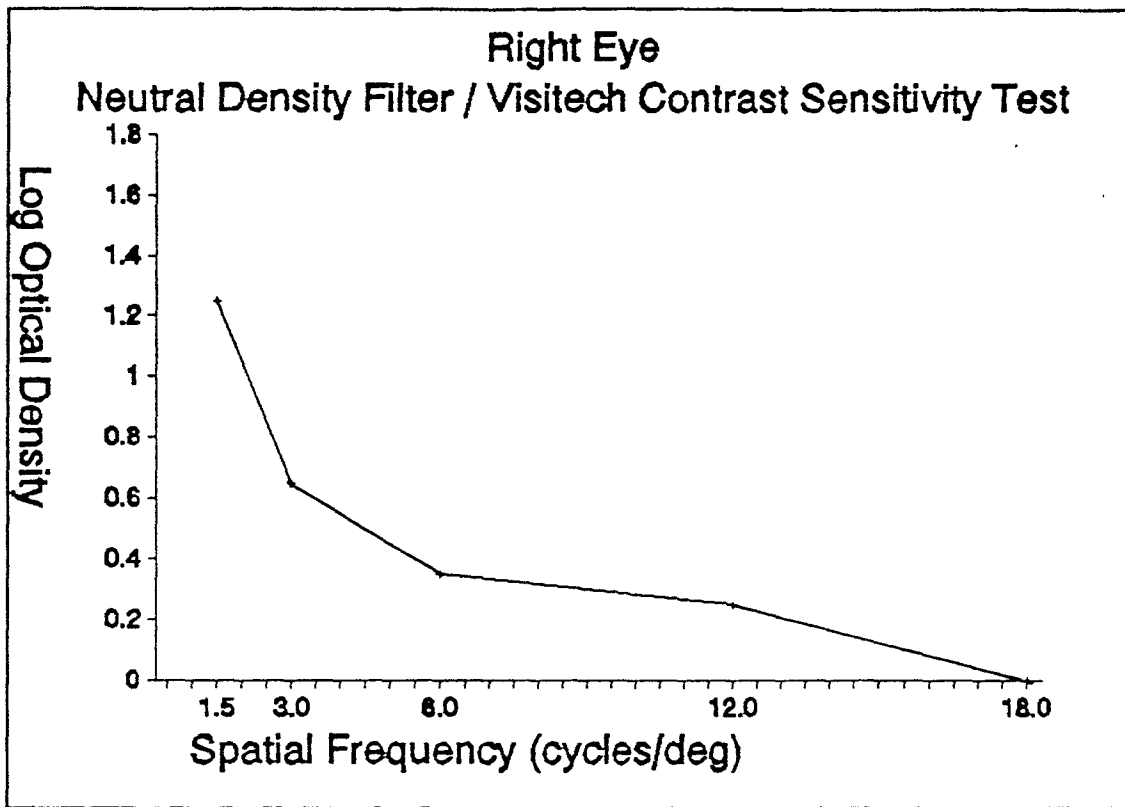
Sex: Female

Age: 79

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

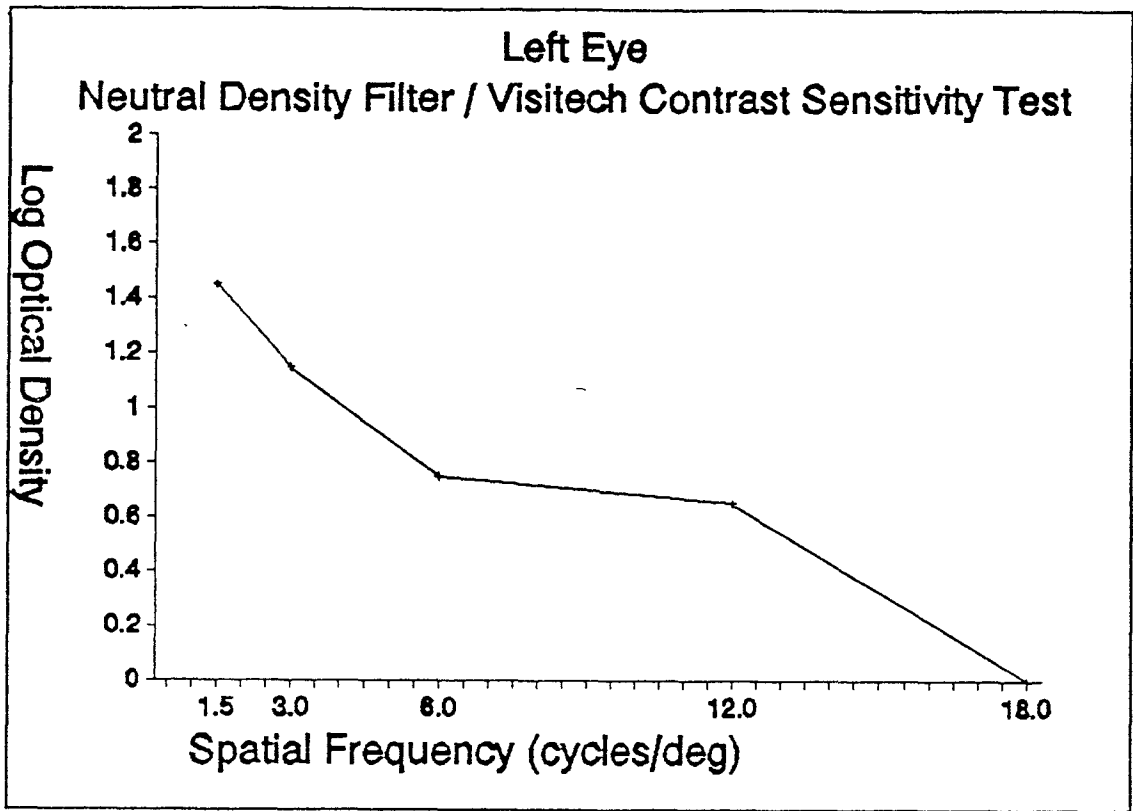
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	1.45	1.25
3.0	1.15	1.15
6.0	0.75	0.75
12.0	0.65	0.65
18.0	----	----



Sex: Female

Age: 79

Glaucoma Patient



Sex: Female

Age: 79

Glaucoma Patient

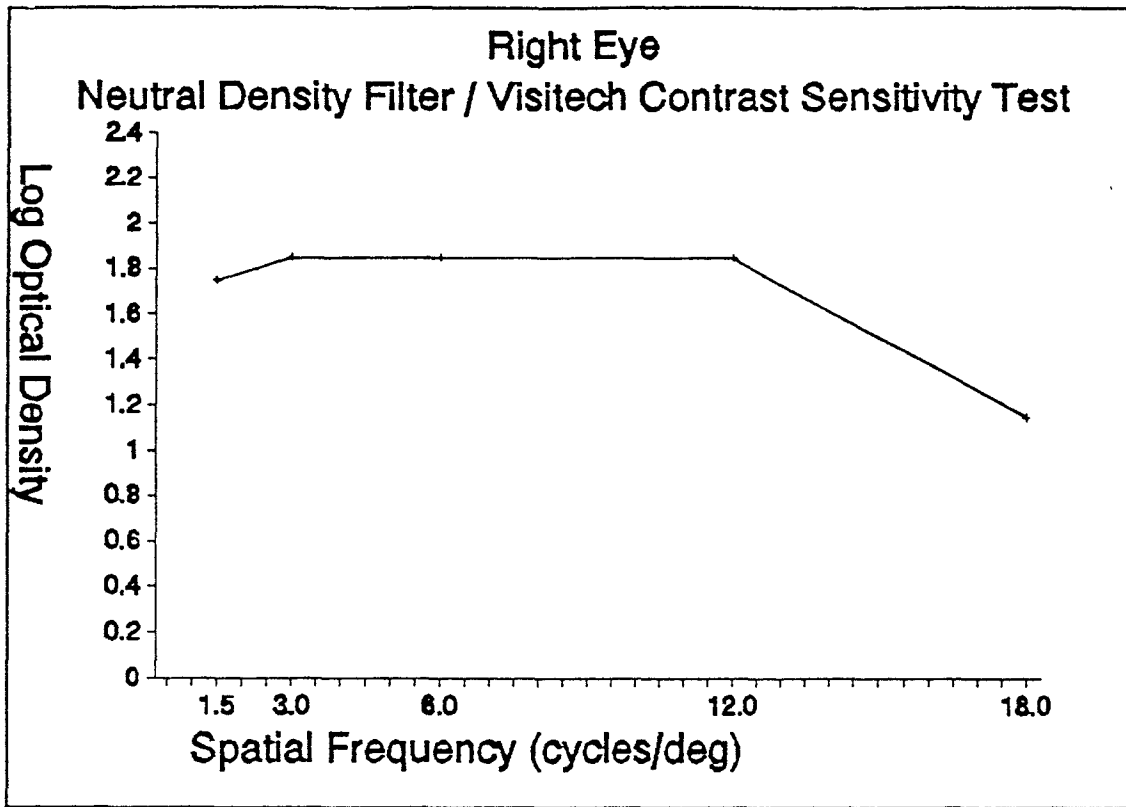
Sex: Male

Age: 29

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

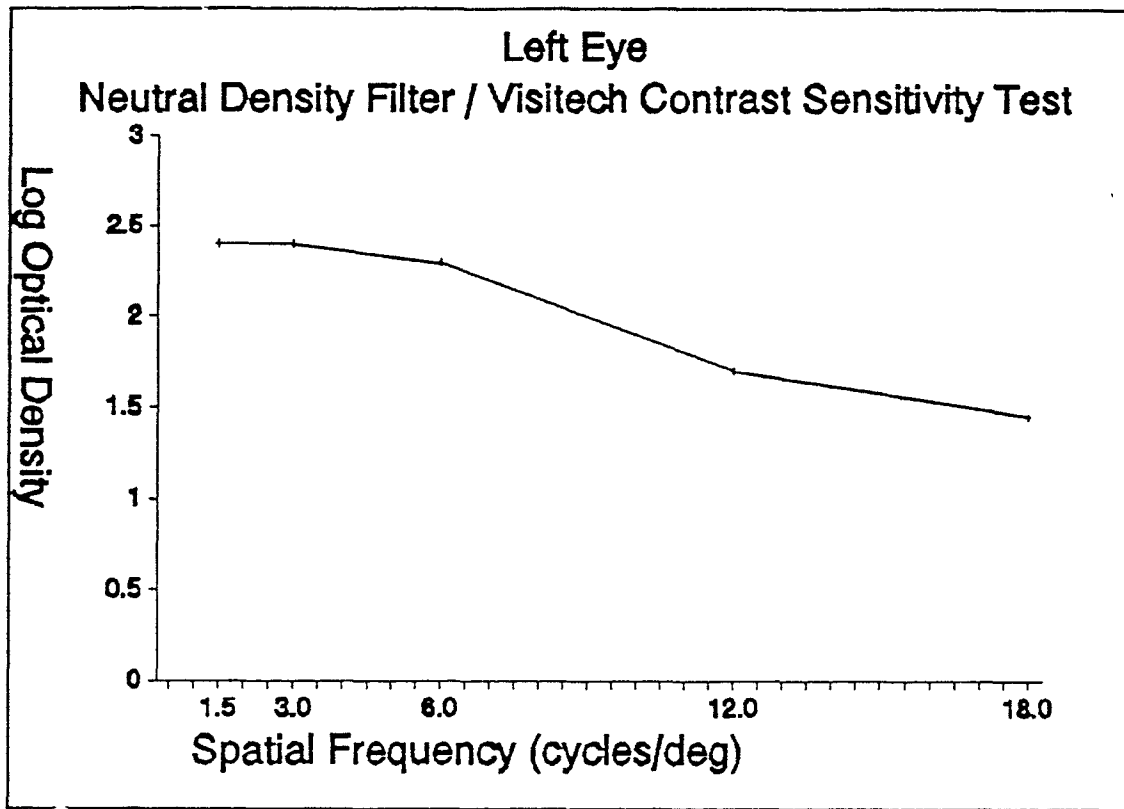
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	2.40	1.90
3.0	2.40	1.85
6.0	2.30	1.85
12.0	1.70	1.85
18.0	1.45	1.15



Sex: Male

Age: 29

Glaucoma Patient



Sex: Male

Age: 29

Glaucoma Patient

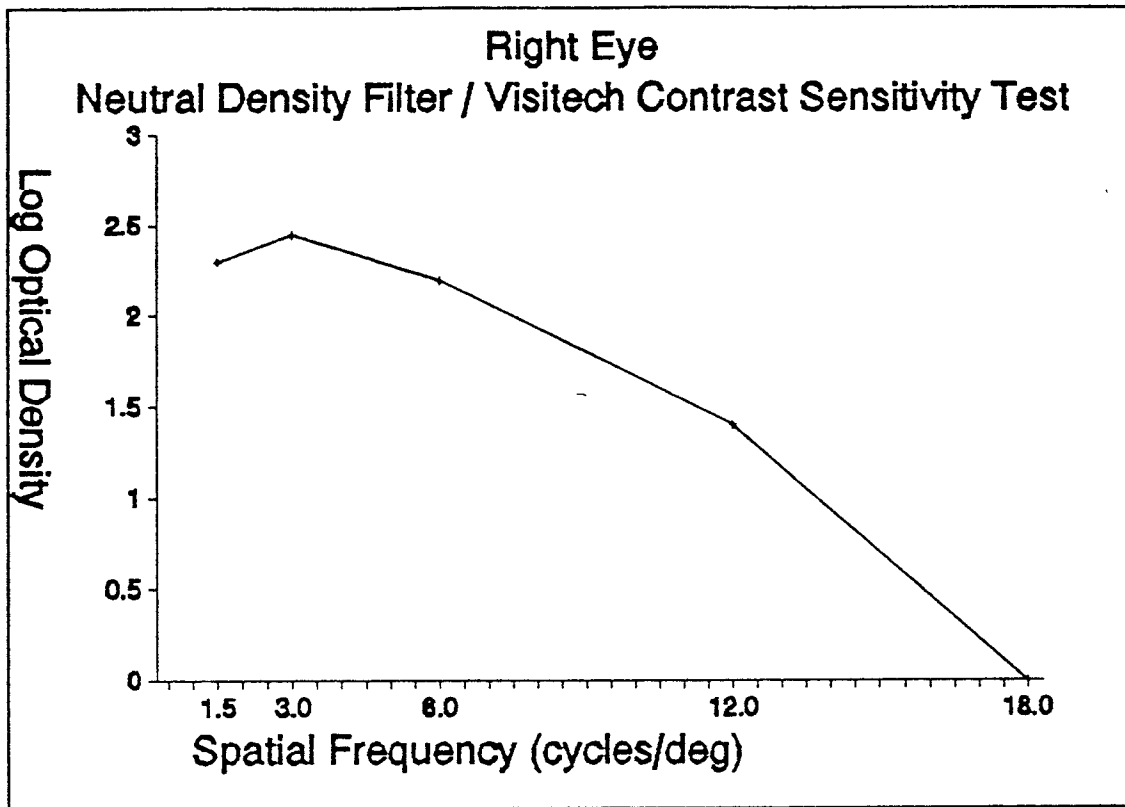
Sex: Female

Age: 45

Glaucoma Patient

Results of Neutral Density Filter / Visitech Contrast Test

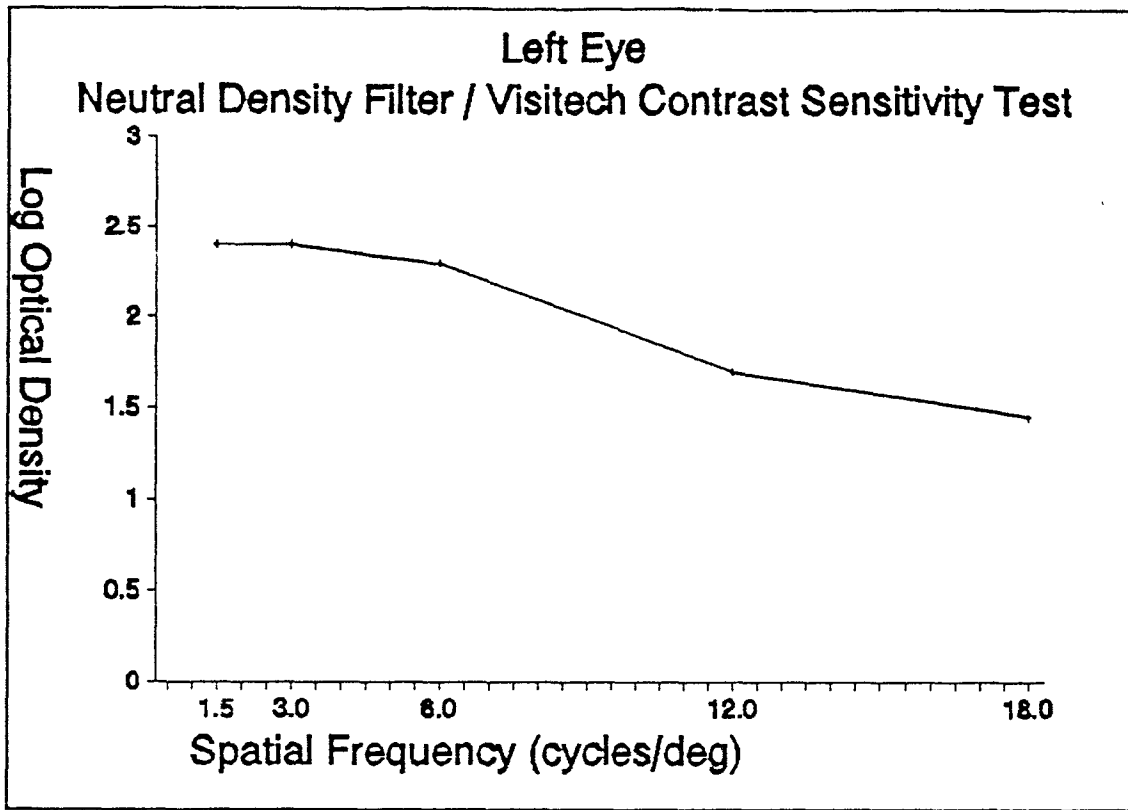
SPATIAL FREQUENCY (c/deg)	Left Eye (Log Optical Density Units)	Right Eye (Log Optical Density Units)
1.5	2.20	2.30
3.0	2.20	2.45
6.0	1.80	2.20
12.0	1.45	1.40
18.0	0.75	----



Sex: Female

Age: 45

Glaucoma Patient



Sex: Female

Age: 45

Glaucoma Patient

APPENDIX D
ORIGINAL HUMPHREY AND OCTOPUS 2000
STATIC PERIMETRY TEST DATA

Sex: Female

Age: 75

Glaucoma Patient

Humphrey Instruments Computer Printout for Left Eye

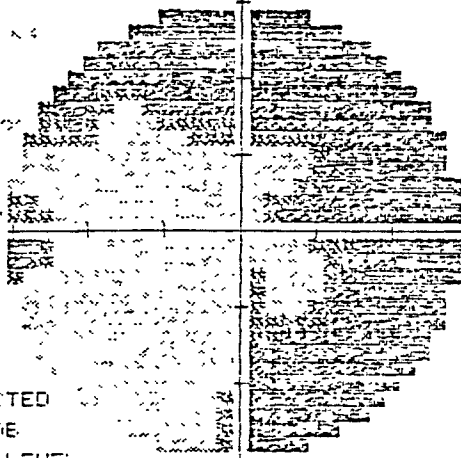
CENTRAL 30 - 2 THRESHOLD TEST

STIMULUS III, WHITE, BCKGND 31.5 ASE NAME ██████████
 BLIND SPOT CHECK SIZE II ID 83-44-78 BIRTHDATE 01-20-26
 FIXATION TARGET CENTRAL DATE 05-15-91 TIME 10:47:45 AM
 STRATEGY FULL THRESHOLD PUPIL DIAMETER VA 20/25
 RX USED DS DCX DEG

FIXATION LOSSES 19 25 * *
 QUESTIONS ASKED 48E
 FALSE POS ERRORS 0/10
 FALSE NEG ERRORS 8/14 *
 FLUCTUATION OFF

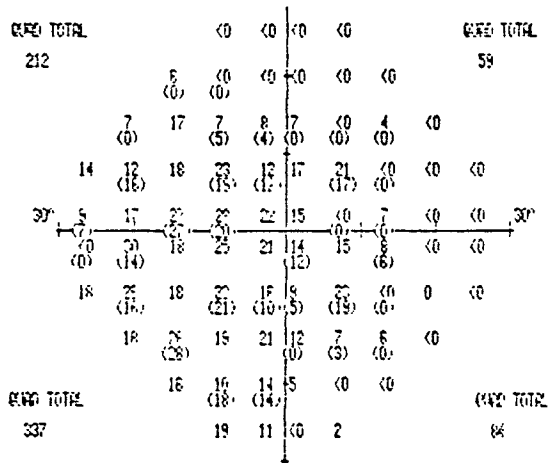
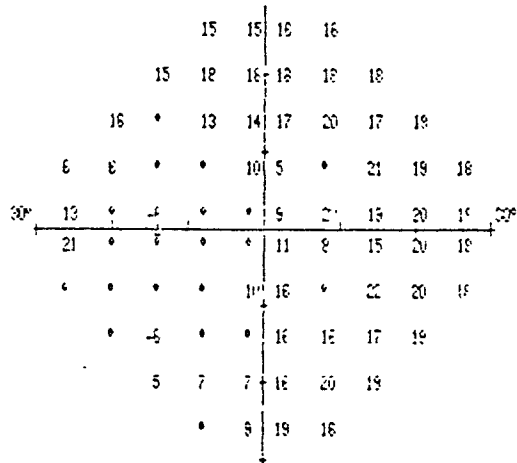
LEFT

TEST TIME 00:12:50 30° 30°



* = WITHIN 4 DB OF EXPECTED
 NO. = DEFECT DEPTH IN DB
 26 DB ** = CENTRAL REF LEVEL

NO. = THRESHOLD IN DB
 (NO.) = 2ND/3RD TIME



SMI.										
HSE	1.5	2.5	3	3.5	4	4.5	5	5.5	6	6.5
LE	50	40	30	20	10	0	0	0	0	0

HUMPHREY INSTRUMENTS

Sex: Female

Age: 75

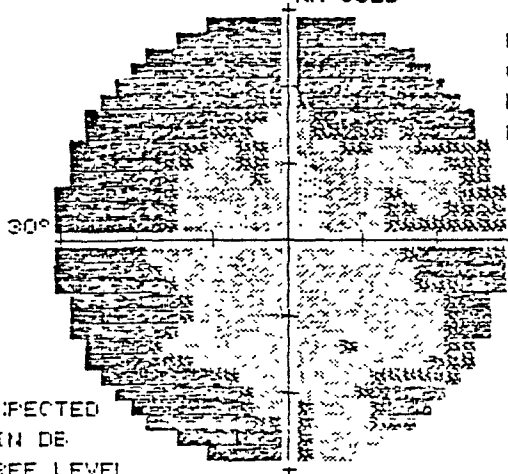
Glaucoma Patient

Humphrey Instruments Computer Printout for Right Eye

CENTRAL 30 - 2 THRESHOLD TEST

STIMULUS III, WHITE, BKGRND 31.5 ASB NAME XXXXXXXXXX
 BLIND SPOT CHECK SIZE II ID 63-44-76 BIRTHDATE 01-20-26
 FIXATION TARGET CENTRAL DATE 05-15-91 TIME 10:32:15 AM
 STRATEGY FULL THRESHOLD PUPIL DIAMETER VA 20/25
 RX USED OS DCX DEI

RIGHT



FIXATION LOSSES 2/28
 QUESTIONS ASKED 582
 FALSE POS ERRORS 0/15
 FALSE NEG ERRORS 6/9 **
 FLUCTUATION OFF
 TEST TIME 00:15:38

* = WITHIN 4 DB OF EXPECTED
 NO. = DEFECT DEPTH IN DB
 26 DB ** = CENTRAL REF LEVEL

NO. = THRESHOLD IN DB
 (NO.) = 2ND/3RD TIME

	18	18	15	15						
	18	18	16	13	18	17				
	18	19	14	7	5	18	6	16		
	16	19	11	*	16	*	8	*	12	
30°	18	20	16	*	*	*	13	10	14	30°
	15	20	*	*	5	*	26	15		
	18	20	22	*	5	*	5	8	21	
	19	0	*	10	*	14	*	9		
	19	20	*	11	*	20				
	16	16	13	*						

GRID TOTAL	00	00	00	00					GRID TOTAL		
106	00	5	00	10	00	2			185		
	00	00	00	10	12	3	13	00			
	00	2	7	13	10	13	00				
	00	00	00	10	00	00	13	00			
	00	00	10	21	7	24	19	10	16	8	
	00	00	00	15	05	00	10	14			
30°	00	00	5	22	21	22	20	9	11	5	30°
	00	0	20	22	16	19	19	18	00	8	
									(2)	(4)	
	00	00	00	21	15	18	23	16	14	0	
	00	00	00	15	00	00	21	00	12		
	00	14	17	12	19	8	24	14			
				(12)	(7)			(10)			
BLDG TOTAL	00	00	17	46	14	2					BLDG TOTAL
159	2	3	7	27	17						250

© HUMPHREY INSTRUMENTS

0.8	2.5	8	25	79	251	794	2512	7943	2		
0.1	1	3.2	10	32	100	316	1000	3162	10000		
41	36	31	28	21	18	11	8	1	10		
50	40	30	20	15	10	7	5				

SVN.
 AGE
 DB

Sex: Male

Age: 74

Glaucoma Patient

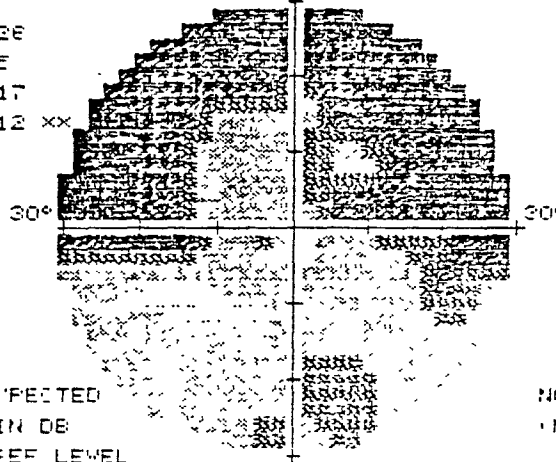
Humphrey Instruments Computer Printout for Left Eye

CENTRAL 30 - 2 THRESHOLD TEST

IMULUS III, WHITE, BACKGROUND 31.5 ASB NAME [REDACTED]
 BLIND SPOT CHECK SIZE III ID BIRTHDATE 02-18-28
 FIXATION TARGET CENTRAL DATE 06-15-90 TIME 03:30:20 PM
 STRATEGY FULL THRESHOLD PUPIL DIAMETER VA
 RX USED +2.5 DS DCY DEG

FIXATION LOSSES 0/28
 QUESTIONS ASKED 505
 FALSE POS ERRORS 0/17
 FALSE NEG ERRORS 4/12 XX
 FLUCTUATION OFF

TEST TIME 03:15:36



LEFT

° = WITHIN 4 DB OF EXPECTED
 NO. = DEFECT DEPTH IN DB
 24 DB = CENTRAL REF LEVEL

NO. = THRESHOLD IN DB
 (NO.) = 2ND/3RD TIME

15	15	16	15		
12	15	16	15	11	13

QUAD TOTAL	0	0	0	0	QUAD TOTAL
102	6	0	0	0	63
	(0)	(0)	(0)	(7)	

← THIS IS OF GREAT HELP, TRY IT! →

15	21	21	5	14	8	12	12	16
6	6	6	8	8	6	17	6	
6	6	6	8	6	6			
6	6	13	13	6				
11	7	8						

6	0	0	17	15	15	22	2	12
(10)	(0)	(0)	(5)	(24)	(15)	(20)	(4)	
16	24	24	21	20	15	22	2	12
(14)	(16)	(25)	(19)		(15)	(20)	(4)	
22	16	24	23	23	14	15	22	13
	(14)	(16)			(9)	(8)	(16)	
QUAD TOTAL	22	16	20	7	6	13		QUAD TOTAL
309		(14)	(9)	(8)				235
	21	15	15	10				
	(3)	(9)						

SYM.									
PSE	6	2.5	6	25	79	251	794	2512	7943
	.1	1	3.2	10	32	100	316	1000	3162
DB	41	36	31	26	21	16	11	6	1
	50	40	35	30	25	20	15	10	5

HUMPHREY INSTRUMENTS

Sex: Male

Age: 74

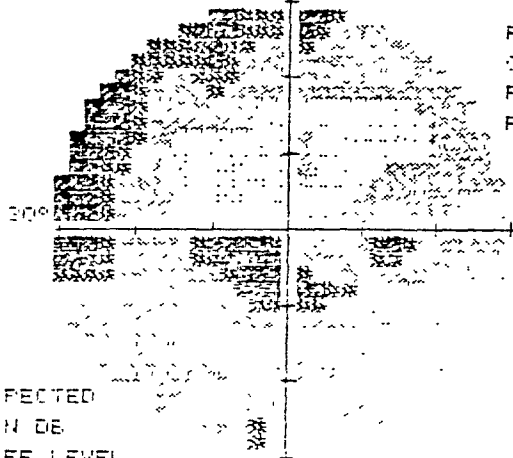
Glaucoma Patient

Humphrey Instruments Computer Printout for Right Eye

CENTRAL 30 - 2 THRESHOLD TEST

STIMULUS III, WHITE, BCGND 31.5 REF NAME [REDACTED]
 BLIND SPOT CHECK SIZE III ID BIRTHDATE 02-18-29
 FIXATION TARGET CENTRAL DATE 06-15-90 TIME 02:01:10 PM
 STRATEGY FULL THRESHOLD PUPIL DIAMETER WA
 RX USED +2.5 DS OCCL OED

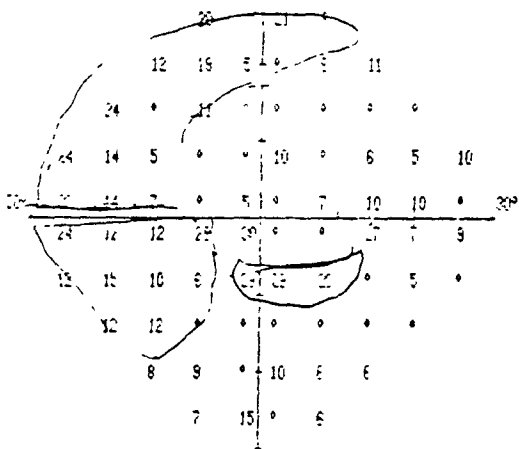
RIGHT



FIXATION LOSSES 1 33
 QUESTIONS ASKED 835
 FALSE POS ERRORS 0 23
 FALSE NEG ERRORS 6 30
 FLUCTUATION OFF
 TEST TIME 00:20:47

* = WITHIN 4 DB OF EXPECTED
 NO. = DEFECT DEPTH IN DB
 NO DB = CENTRAL REF LEVEL

NO. = THRESHOLD IN DB
 (NO.) = 2ND SPD TIME



30°	1	11	13						30°
	(4)	(7)	(10)						
		11	7	19	20	14	12		
		(12)	(5)	(13)	(14)	(13)	(14)		
	1	22	19	23	22	23	25	21	
	(6)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	
		14	22	26	27	20	28	20	16
	(8)	(4)	(7)	(7)	(12)	(2)	(18)	(22)	
30°	0	15	19	28	26	26	22	17	25
	(0)	(1)	(1)	(0)	(0)	(2)	(4)	(0)	(1)
		14	16	10	10	15	14	10	18
	(0)	(0)	(0)	(0)	(0)	(2)	(1)	(0)	(2)
	12	8	18	25	10	17	28	22	24
	(14)	(14)	(8)	(0)	(0)	(5)	(25)	(22)	(22)
		13	14	28	28	24	26	26	26
		(18)	(18)	(23)	(24)	(22)	(22)	(22)	(22)
				17	16	23	17	21	21
				(18)	(18)	(17)	(17)	(21)	(21)
30°	14	11	24	26					30°
	(20)	(8)	(24)	(26)					

S.M.										
HSE	3.5	3.5	3.5	3.5	7.4	251	784	2512	7843	-
	.1	1	1.2	10	32	100	318	1000	3162	1mm
DB	41	36	31	36	21	15	11	6	1	20
	50	40	35	30	25	20	15	10	5	

HUMPHREY INSTRUMENTS

Sex: Male

Age: 63

Glaucoma Patient

Octopus 2000 Computer Printout for Left Eye

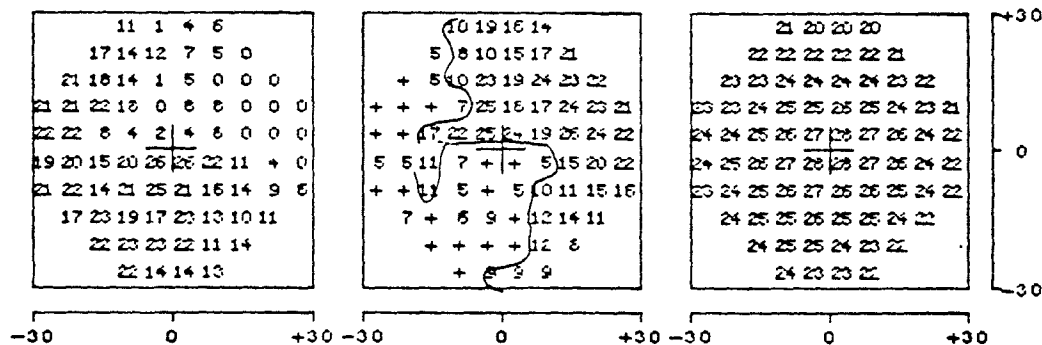
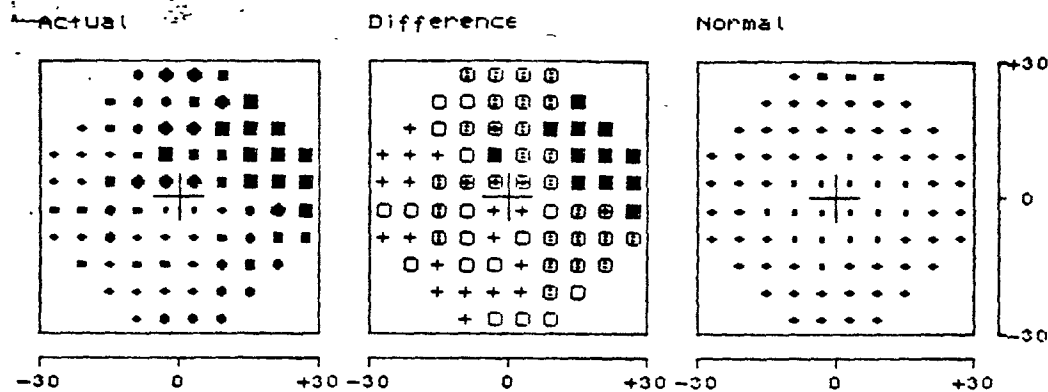
OCTOPUS 2000

interzeag inc.

Ophthalmic Technology

71 Lyman Street
Northboro, MA 01832
800-627-6286

asb	0.02- 0.25	0.31- 0.8	1- 2.5	31- 8	10- 25	31- 80	100- 250	315- 800	1000
Symb.	■
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deviation < 4 dB
 □ Deviation 5..9 dB
 ⊕ Deviation 10..19 dB
 ⊗ Deviation > 19 dB
 ■ Absolute defect

Surname [redacted]
 Date of birth Sep/ 4/1927

Given name [redacted]

OCTOPUS 2000

Correction: D.S. 2.00
 Diameter of pupil 3.0
 Size of stimulus 3

D.C. -.-

axis -
 Date of ex. Jun/ 4/1991
 Time 11.30



False positive answers 2/20
 False negative answers 3/21

Questions 381
 Repetitions 14

Fluctuation

Program 34

Sex: Male

Age: 63

Glaucoma Patient

Octopus 2000 Computer Printout for Right Eye

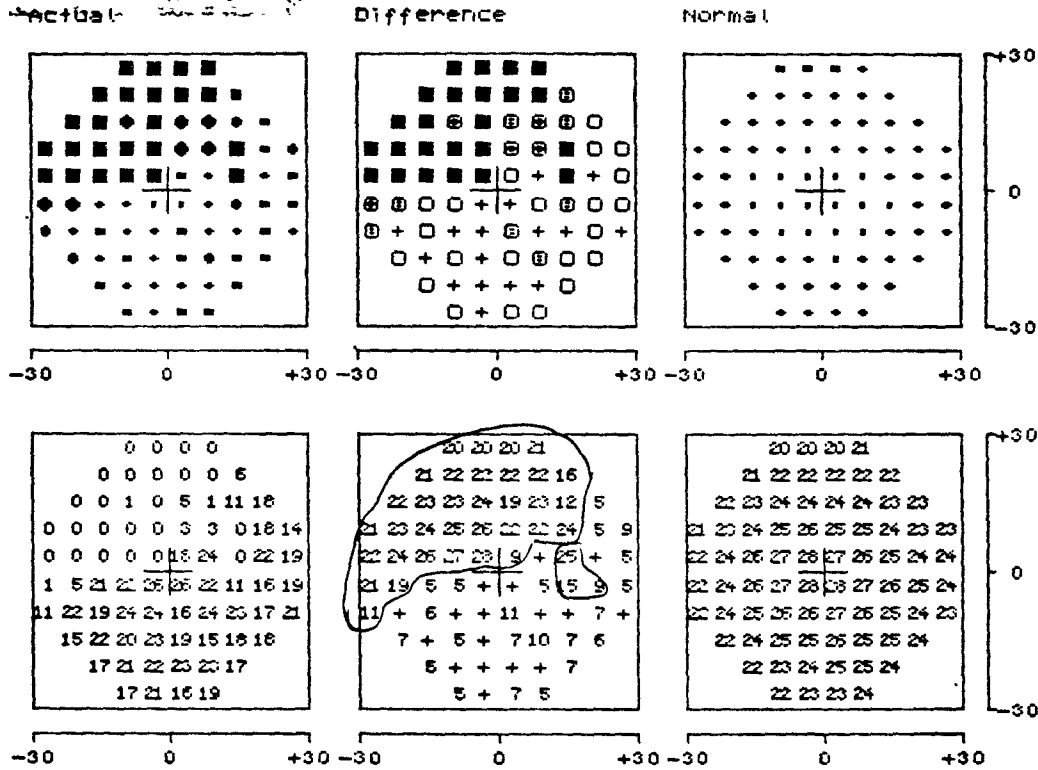
OCTOPUS 2000

interzeag inc.

Ophthalmic Technology

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Northboro, MA 01532
800-827-8298

asb	002-025	031-08	1-25	31-8	10-25	31-80	100-250	315-800	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	■
dB	47-36	35-31	30-26	25-21	20-18	15-11	10-8	5-1	0



Difference table
 + Deviation <= 4 dB
 O Deviation 5.. 9 dB
 ⊕ Deviation 10..19 dB
 ⊗ Deviation > 19 dB
 ■ Absolute defect

Surname	XXXXXXXXXX	Given name	XXXXXXXXXX	OCTOPUS 2000
Date of birth	Sep/ 4/1927			
Correction: D.S.	3.00	D.C.	--	axis
Diameter of pupil	1.5			Date of ex.
Size of stimulus	3			Time
False positive answers	1/17	Questions	315	Fluctuation
False negative answers	0/17	Repetitions	4	--



Program 34

Sex: Male

Age: 65

Glaucoma Patient

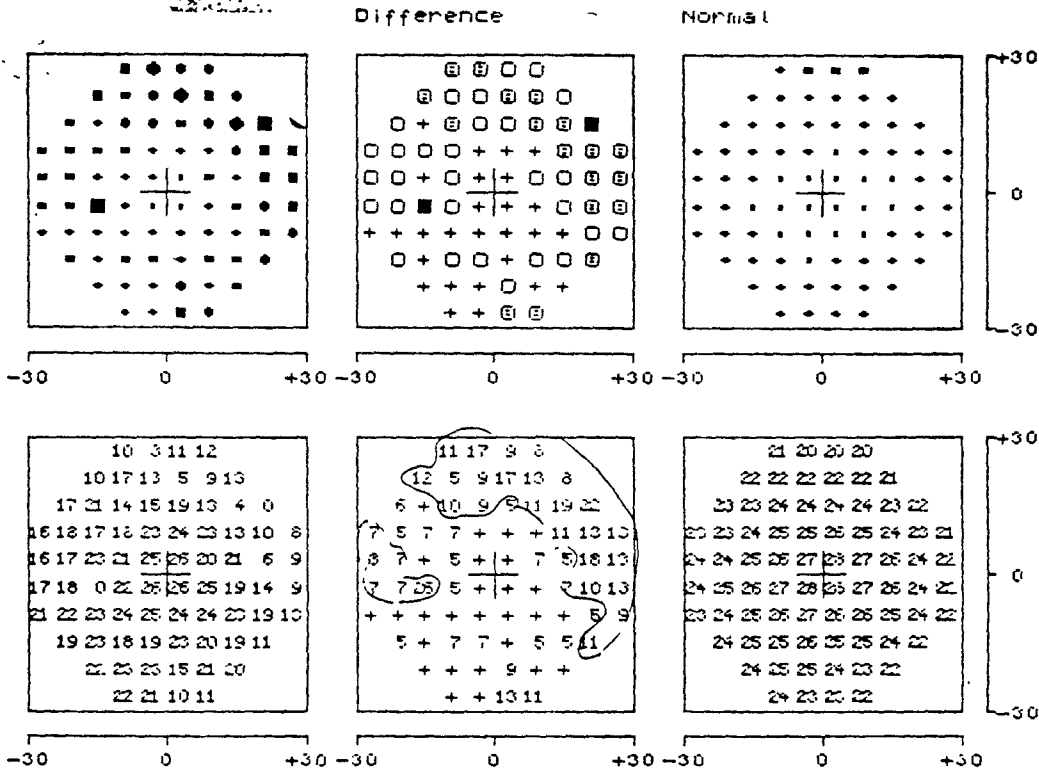
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asb	0.02- 0.25	0.31- 0.8	1- 2.5	3.1- 8	10- 25	31- 80	100- 240	315- 800	1000
Symb.	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	■
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deviation <= 4 dB
 O Deviation 5..9 dB
 @ Deviation 10..19 dB
 ⊕ Deviation > 19 dB
 ■ Absolute defect

Surname [redacted]
Date of birth Mar/13/1926

Given name [redacted]

OCTOPUS 2000

Correction: D.S. 4.00
Diameter of pupil 3.0
Size of stimulus 3

D.C. --

axis -
Date of ex. Oct/10/1991
Time 10.40



False positive answers 0/17
False negative answers 0/18

Questions 326
Repetitions 5

Fluctuation --

Program
34

Sex: Male

Age: 65

Glaucoma Patient

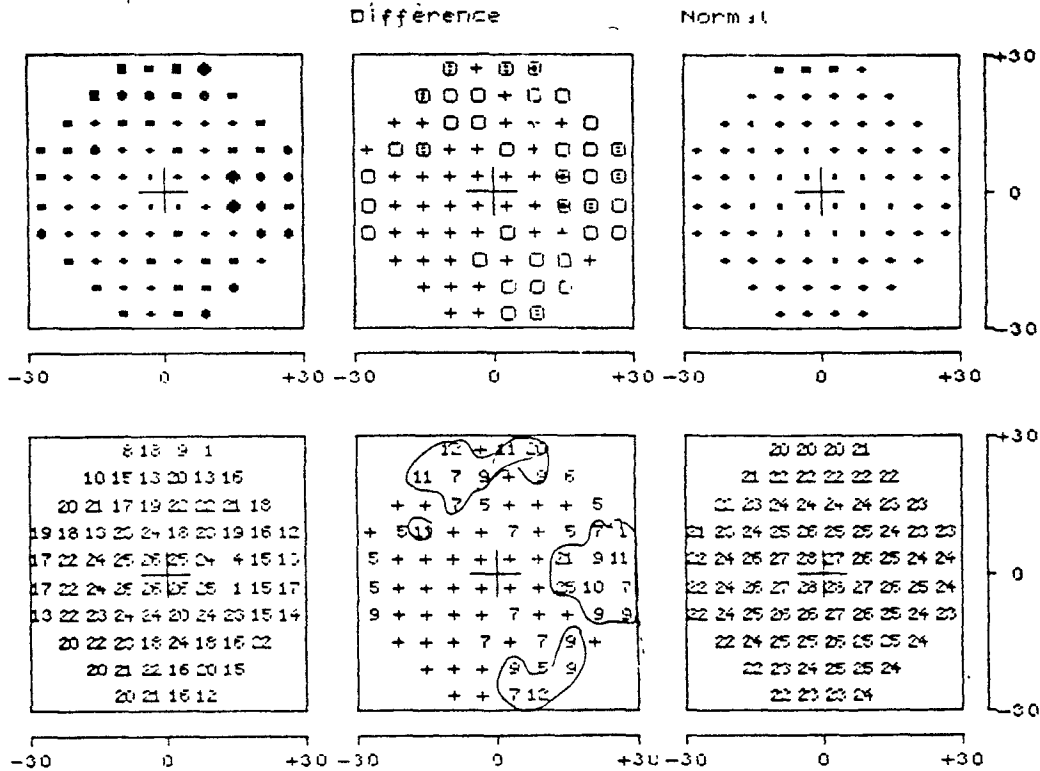
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aED	0 02- 0 25	0 31- 0 8	1- 2 5	3 1- 8	10- 2 5	3 1- 8 0	100- 2 5 0	3 15- 8 0 0	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	■
dP	47- 3 6	3 5- 3 1	3 0- 2 6	2 5- 2 1	2 0- 1 6	1 5- 1 1	1 0- 6	5- 1	0



Difference table
+ Deviation <= + dB
O Deviation 5.. 9 dB
@ Deviation 10..19 dB
⊕ Deviation > 19 dB
■ Absolute defect

Surname [redacted]
Date of birth Mar/13/1926

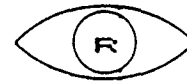
Given name [redacted]

OCTOPUS 2000

Correction: D.S. 4.50
Diameter of pupil 3.5
Size of stimulus 3

D.C. --

Fluctuation --
Date of test Oct/10/1991
Time 10.25



False positive answers 1/15
False negative answers 0/15

Questions 280
Repetitions 3

Fluctuation --

Program 34

Sex: Female

Age: 79

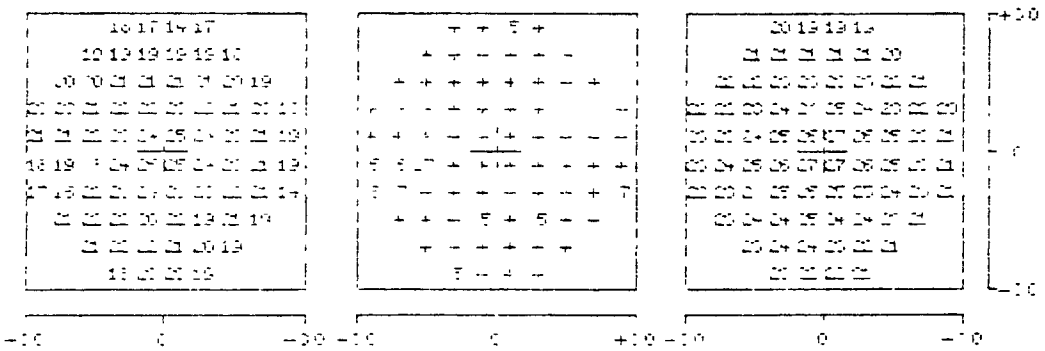
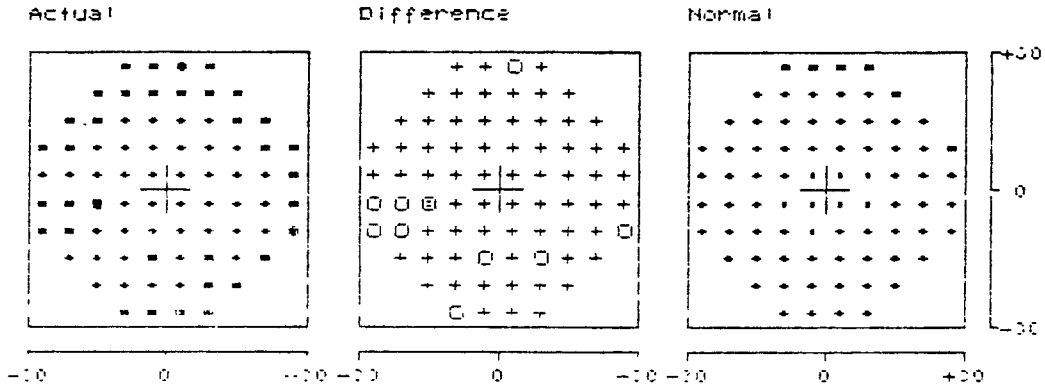
Glaucoma Patient

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Ophthalmic Technology

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asb	0.02-0.25	0.31-0.8	1-2.5	3-8	10-25	31-80	100-250	315-800	1000
Symb.	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	⋮⋮⋮	■
dB	47-36	35-31	30-26	25-21	20-16	15-11	10-6	5-1	0



Difference scales
 + Deviation = + dB
 O Deviation 0...9 dB
 @ Deviation 10...19 dB
 @ Deviation 20...29 dB
 ■ Absolute Deviation

Surname [redacted]
Date of birth Nov/22/1912

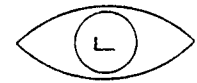
Given name [redacted]

OCTOPUS 2000

Correction: D.S. 7.00
Diameter of pupil 4.0
Size of stimulus 3

D.C. -1.50

axis 80
Date of ex. Mar/20/1992
Time 1.20



False positive answers 0/11
False negative answers 1/11

Questions 206
Repetitions 5

Fluctuation -.-

Program
34

Sex: Female

Age: 79

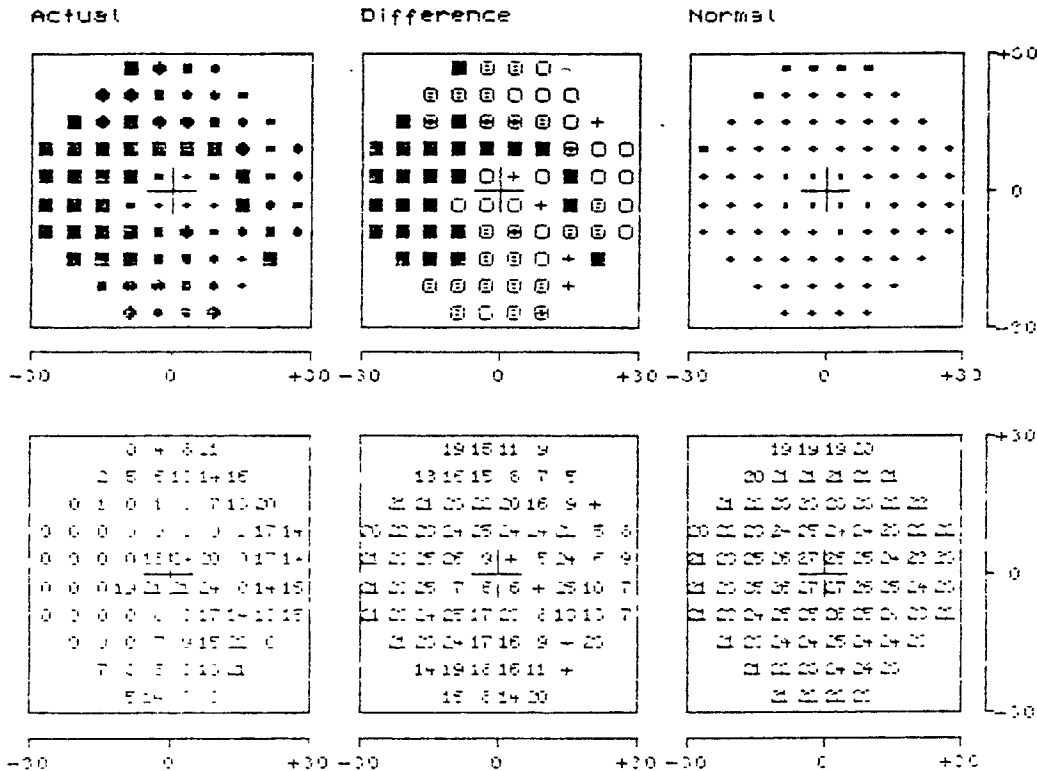
Glaucoma Patient

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asb	0.02- 0.25	0.31- 0.8	1- 2.5	3.1- 8	10- 25	31- 80	100- 250	315- 800	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	■
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deviation = - dB
 O Deviation 5..9 dB
 @ Deviation 10..19 dB
 @ Deviation > 19 dB
 ■ Absolute defect

Surname [redacted]
Date of birth Nov/22/1912

Given name [redacted]

OCTOPUS 2000

Correction: D.S. 6.00
Diameter of pupil 4.0
Size of stimulus 3

D.C. -1.00

axis 170
Date of ex. Mar/20/1992
Time 1. 0



False positive answers 0/21
False negative answers 1/22

Questions 399
Repetitions 8

Fluctuation -.-

Program 34

Sex: Male

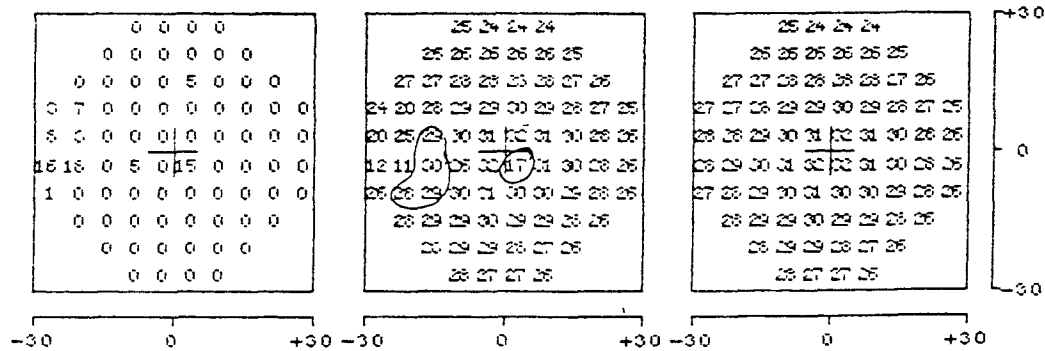
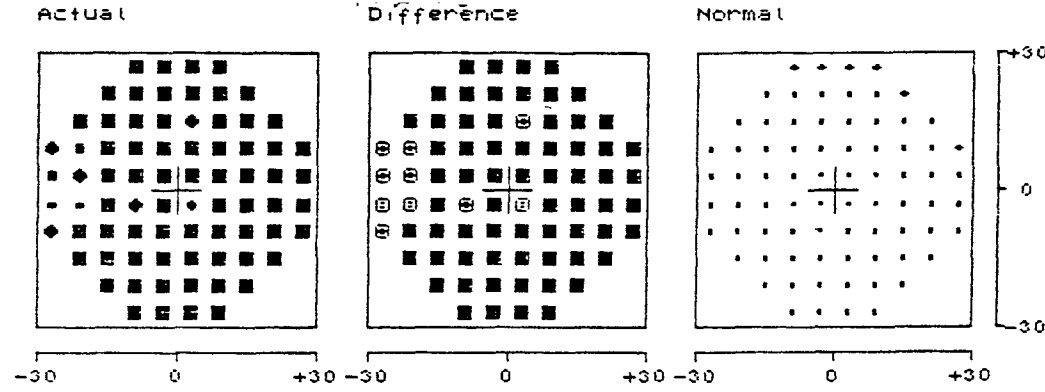
Age: 29

Glaucoma Patient

Octopus 2000 Computer Printout for Left Eye

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asb	0 02- 0 25	0 31- 0 8	1- 2 5	3 1- 8	10- 2 5	3 1- 8 0	100- 2 5 0	3 15- 8 0 0	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	■
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deviation <= 4 dB
 ○ Deviation 5..9 dB
 ⊕ Deviation 10..19 dB
 ⊗ Deviation > 19 dB
 ■ Absolute defect

Surname: [redacted] Given name: [redacted] OCTOPUS 2000
 Date of birth: Apr/15/1961
 Correction: D.S. -1.25 D.C. axis
 Diameter of pupil: 7.0 Date of ex: Jan/23/1991
 Size of stimulus: 3 Time: 9:10
 False positive answers: 0/13 Questions: 238 Fluctuation:
 False negative answers: 2/13 Repetitions: 2 Program:
 34

Sex: Male

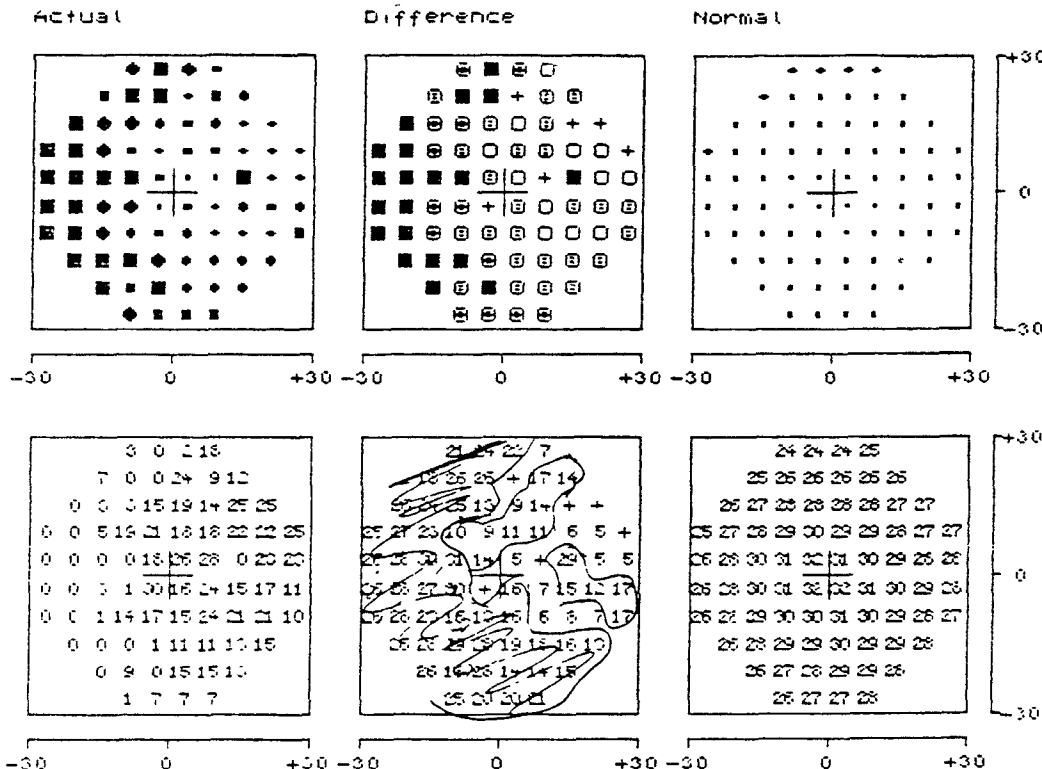
Age: 29

Glaucoma Patient

Octopus 2000 Computer Printout for Right Eye

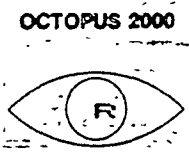
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asb	0.02- 0.25	0.31- 0.8	1- 2.5	3.1- 8	10- 25	31- 80	100- 250	315- 800	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deviation <= 4 dB
 □ Deviation 5..9 dB
 ⊖ Deviation 10..19 dB
 ⊗ Deviation > 19 dB
 ■ Absolute defect

Surname [redacted] Given name [redacted]
 Date of birth Apr/15/1961
 Correction: D.S. -1.25 D.C. axis
 Diameter of pupil 2.0 Date of ex. Jan/23/1991
 Size of stimulus 3 Time 8.45



False positive answers 0720 Questions 378 Fluctuation
 False negative answers 13/21 Repetitions

Sex: Female

Age: 45

Glaucoma Patient

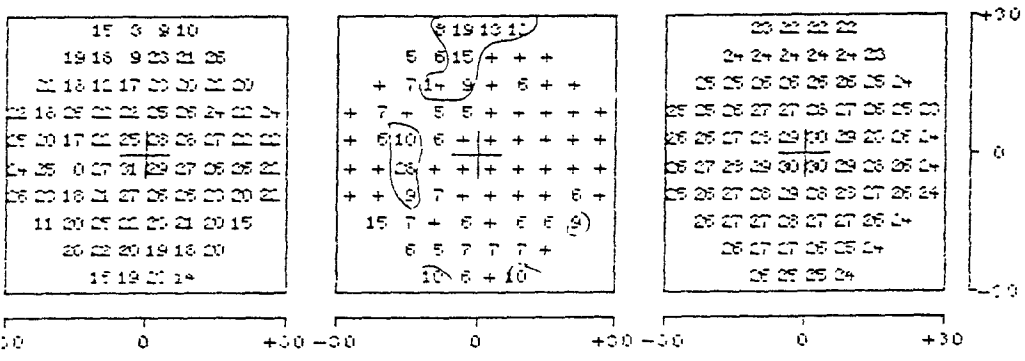
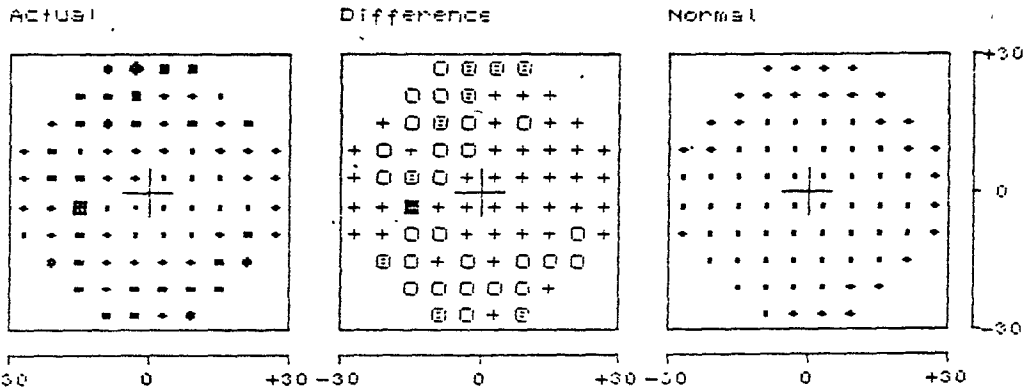
Octopus 2000 Computer Printout for Left Eye

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asb	0.02-0.25	0.31-0.8	1-2.5	3.1-8	10-25	31-80	100-250	315-800	1000
Symb.	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
dB	47-36	35-31	30-26	25-21	20-16	15-11	10-6	5-1	0

... you nearest you call: 800-672-3109 ext. 3304 in California 800-742-0099 ext. 3304



Difference table

- + Deviation <= + 05
- O Deviation 5.. 9 05
- @ Deviation 10..19 05
- ⊕ Deviation 20..29 05
- ⊗ Deviation 30..39 05
- Absolute defect

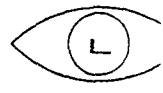
Surname [redacted] Date of birth Mar/31/1946

Given name [redacted]

OCTOPUS 2000

Correction: D.S. -0.50
Diameter of pupil 4.0
Size of stimulus 3

D.C. -.- axis -
Date of ex Oct/16/1991
Time 2.50



False positive answers 0/18
False negative answers 0/19

Questions 471
Repetitions 8

Fluctuation 2.4

Program 32

Sex Female

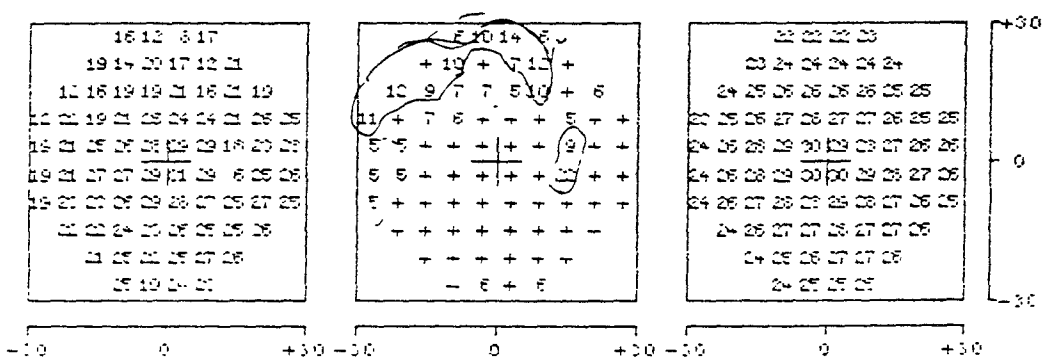
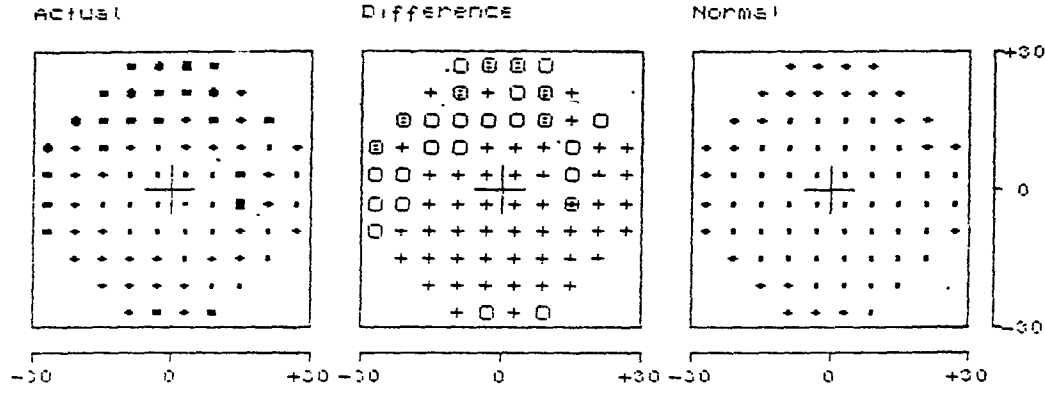
Age: 45

Glaucoma Patient

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 800-627-6286

asb	0.02- 0.25	0.31- 0.8	1- 2.5	3.1- 8	10- 25	31- 80	100- 250	315- 800	1000
Symb.	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯
dB	47- 36	35- 31	30- 26	25- 21	20- 16	15- 11	10- 6	5- 1	0



Difference table
 + Deflection = 4 dB
 O Deflection 5..9 dB
 @ Deflection 10..19 dB
 @ Deflection 20 dB
 ■ Absolute defect

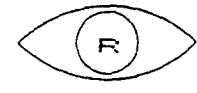
Surname [REDACTED]
 Date of birth Mar/31/1946

Given name [REDACTED]

OCTOPUS 2000

Correction: D S -0.50
 Diameter of pupil 4.0
 Size of stimulus 3

D.C. -.- axis -
 Date of ex. Oct/13/1991
 Time 2.15



False positive answers 0/19
 False negative answers 2/19

Questions 457
 Repetitions 5

Fluctuation 4.1

Program 32

APPENDIX E
STATIC PERIMETRY TEST DATA MAPPED
OVER AREAS NOTICED WITH 30 HERTZ
BLACK-WHITE SNOW

Sex: Female

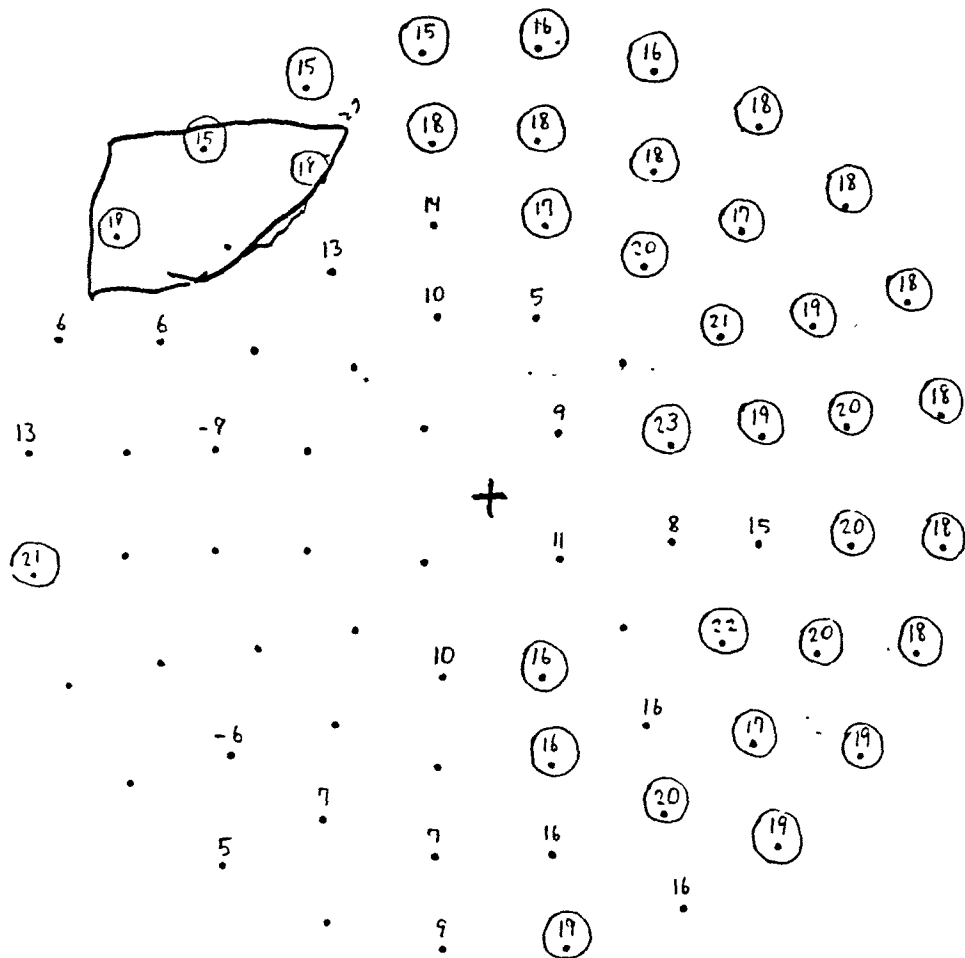
Age: 75

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

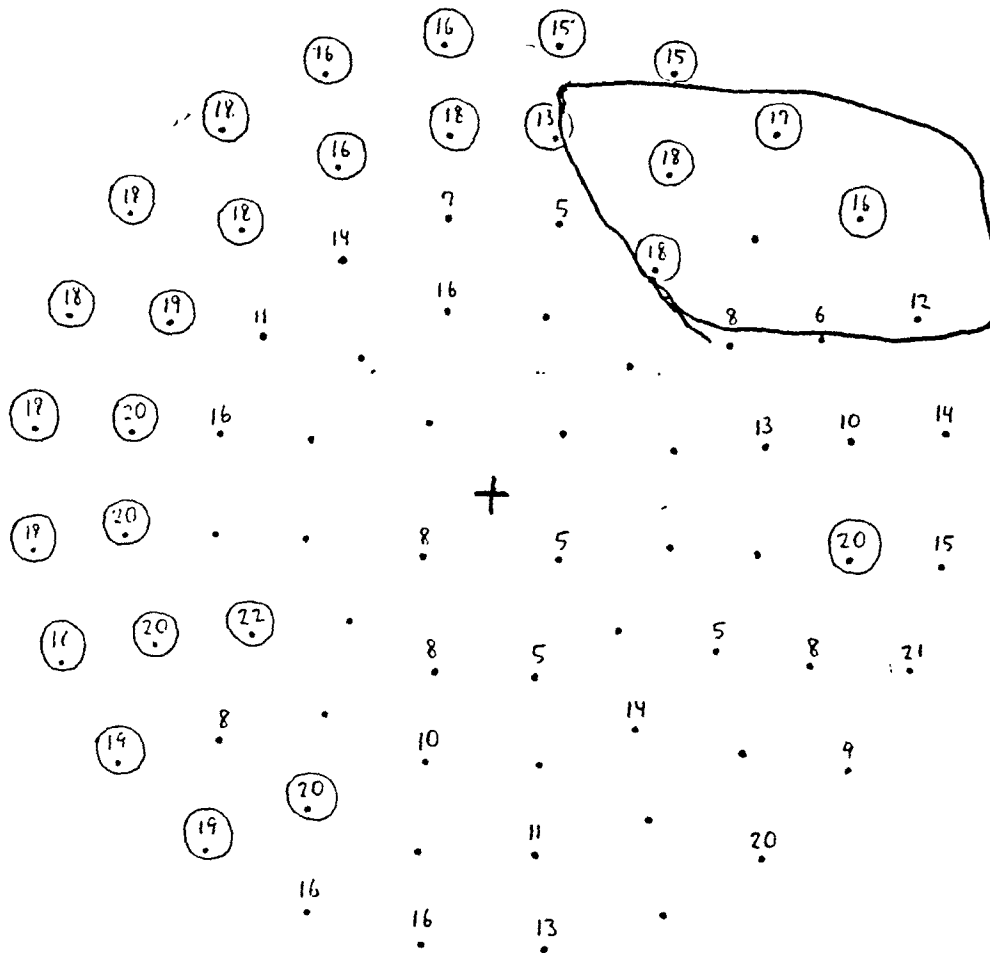
Age: 75

Glaucoma Patient

Right Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

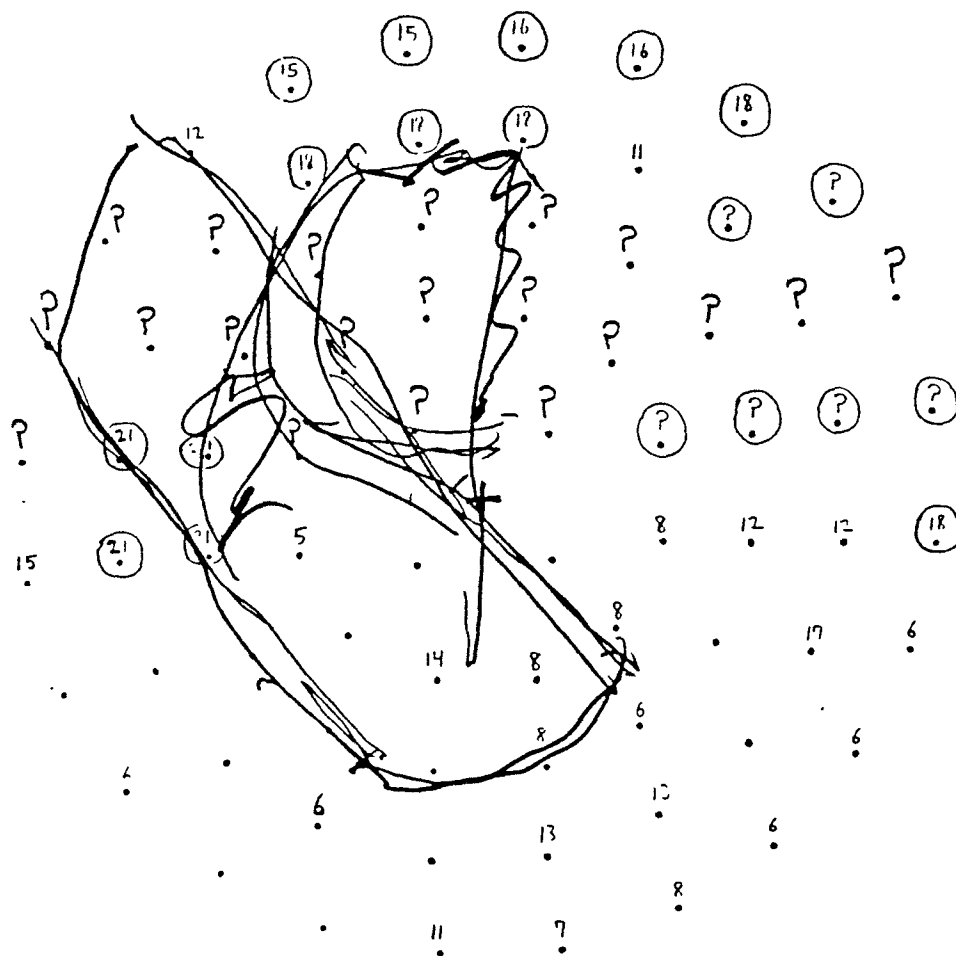
Age: 74

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata
(Question marks indicate exact Defect Depth value was lost.)



Sex: Male

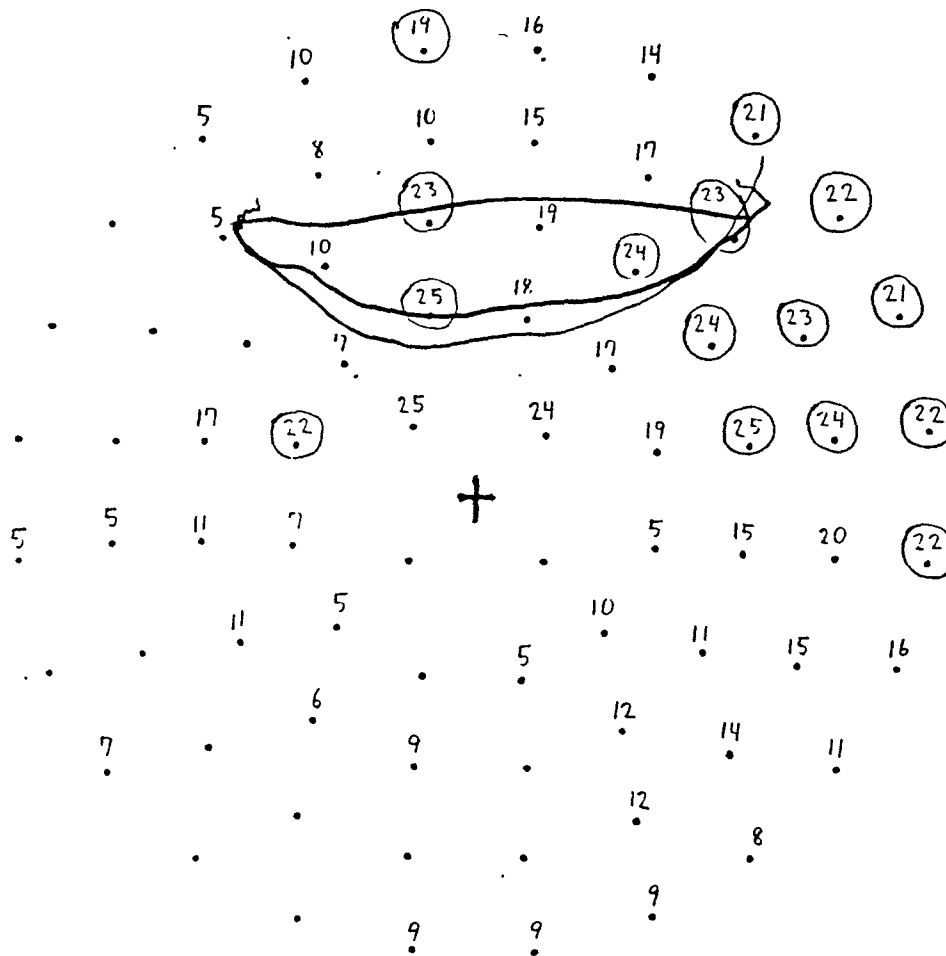
Age: 63

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

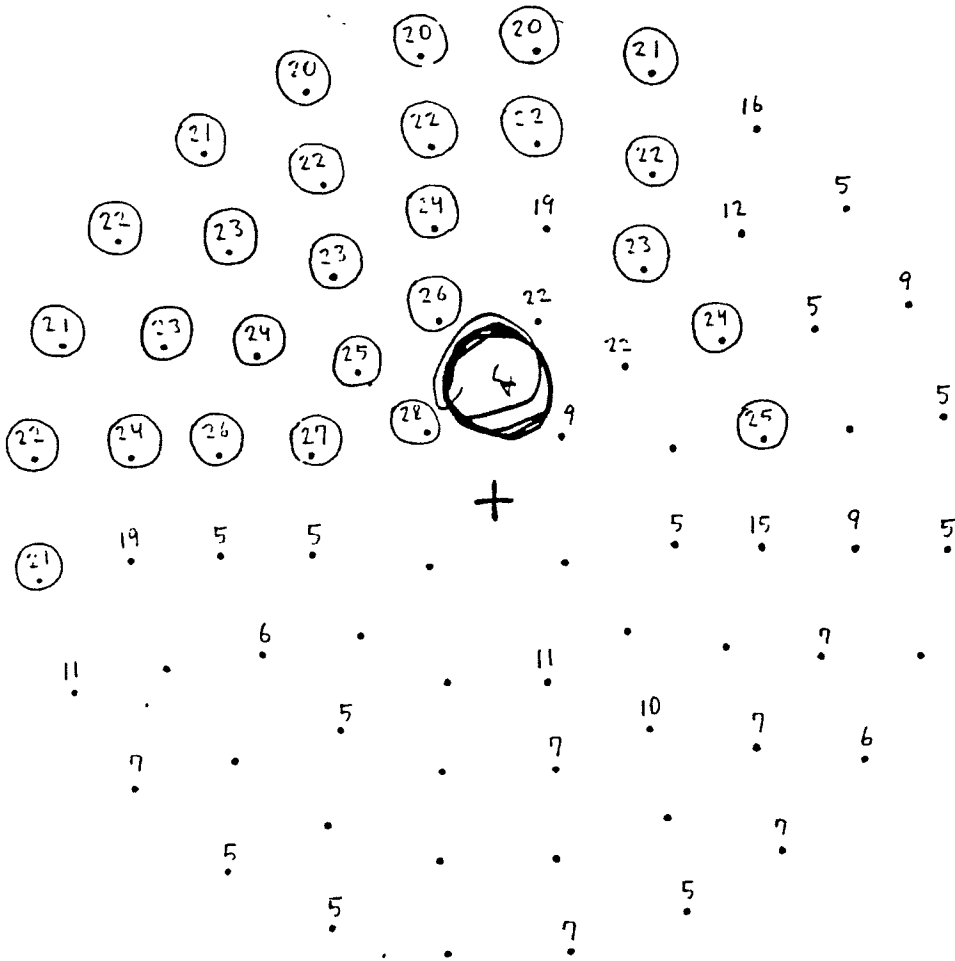
Age: 63

Glaucoma Patient

Right Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

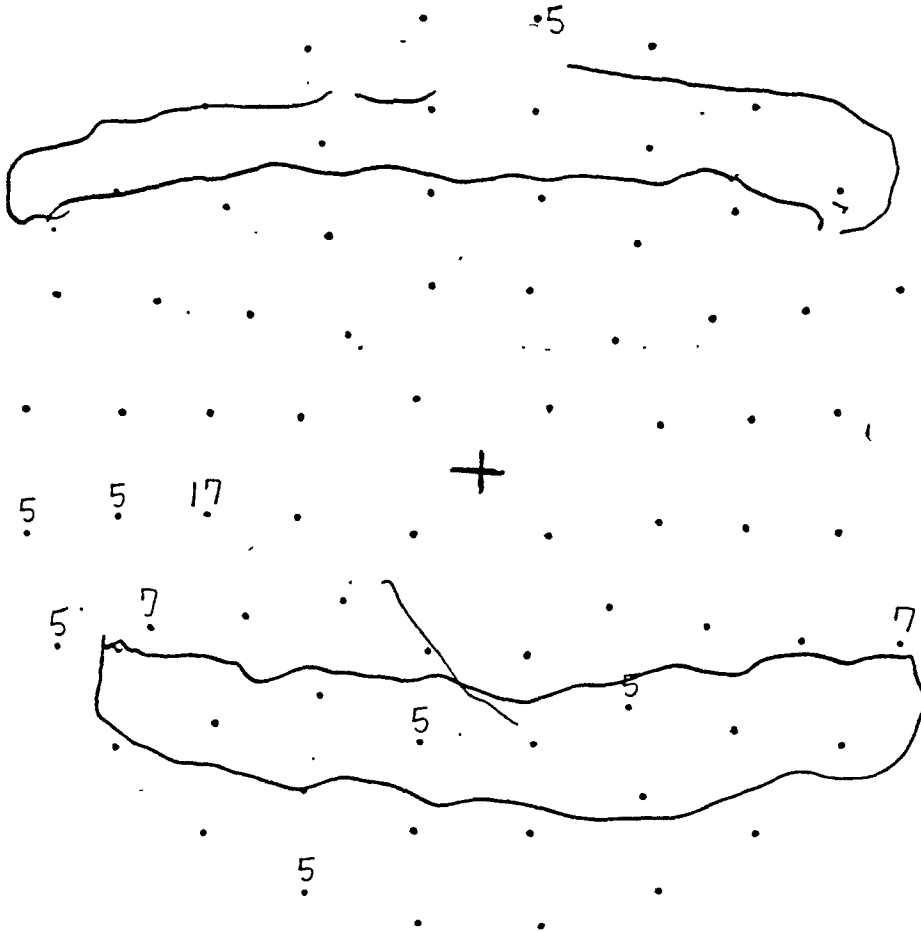
Age: 79

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

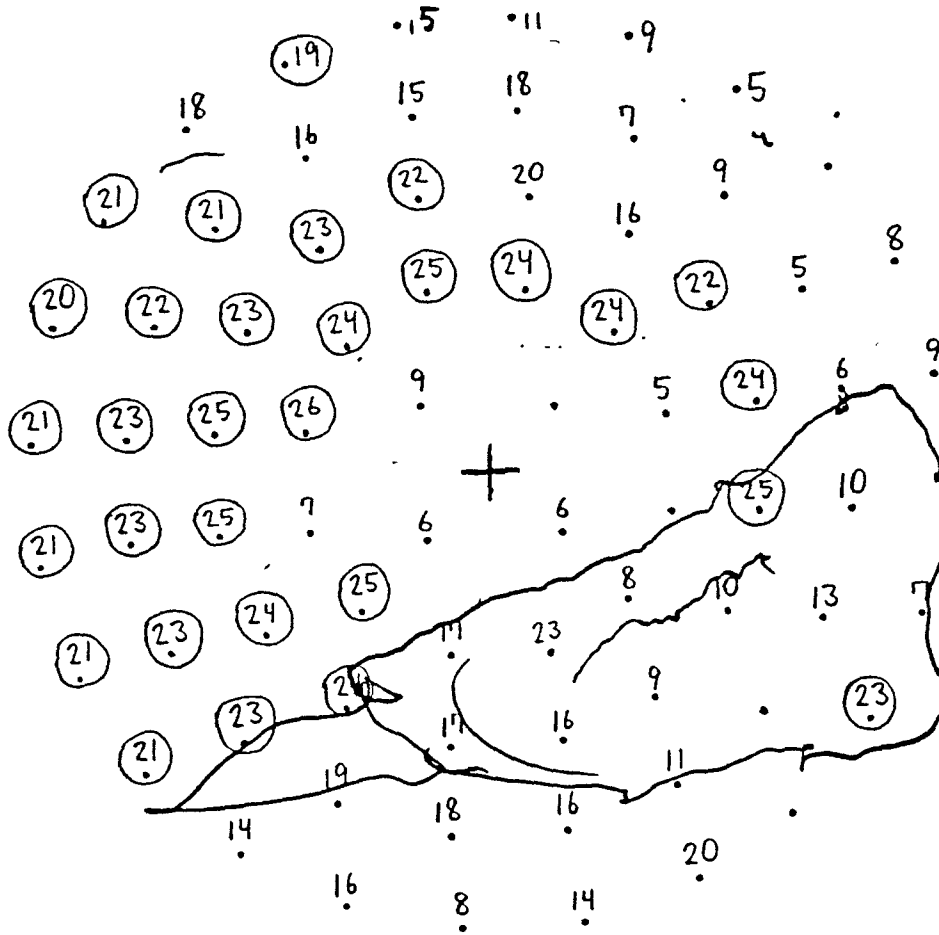
Age: 79

Glaucoma Patient

Right Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

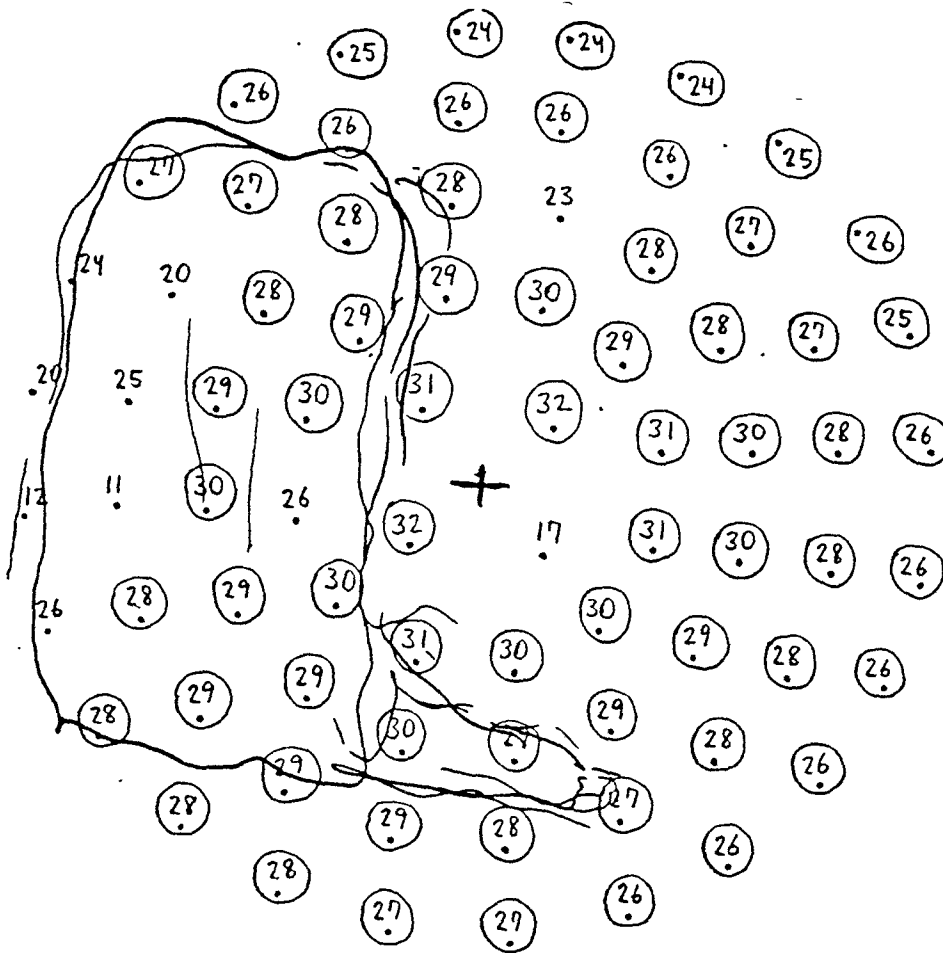
Age: 29

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

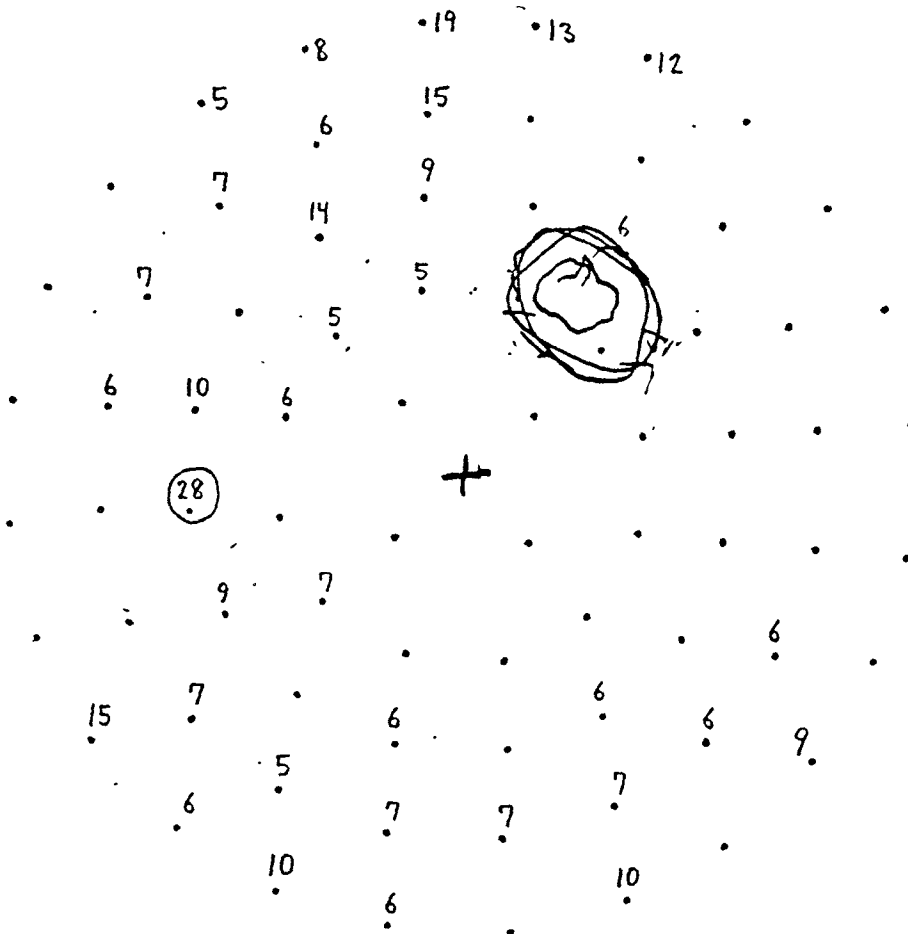
Age: 45

Glaucoma Patient

Left Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex Female

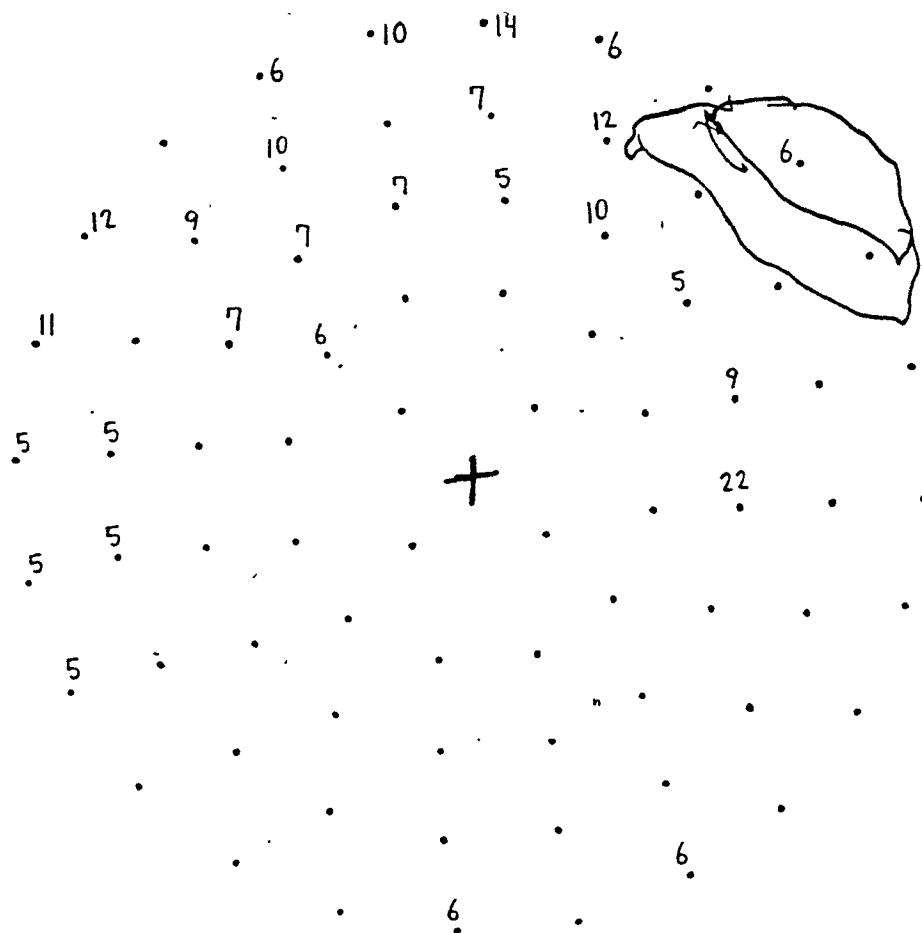
Age: 45

Glaucoma Patient

Right Eye

Areas Noticed with 30 Hz Black-white Snow Mapped Over Static
Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



APPENDIX F
STATIC PERIMETRY TEST DATA MAPPED
OVER AREAS NOTICED WITH RED-GREEN
COUNTERPHASE CHECKERBOARD

Sex: Female

Age: 75

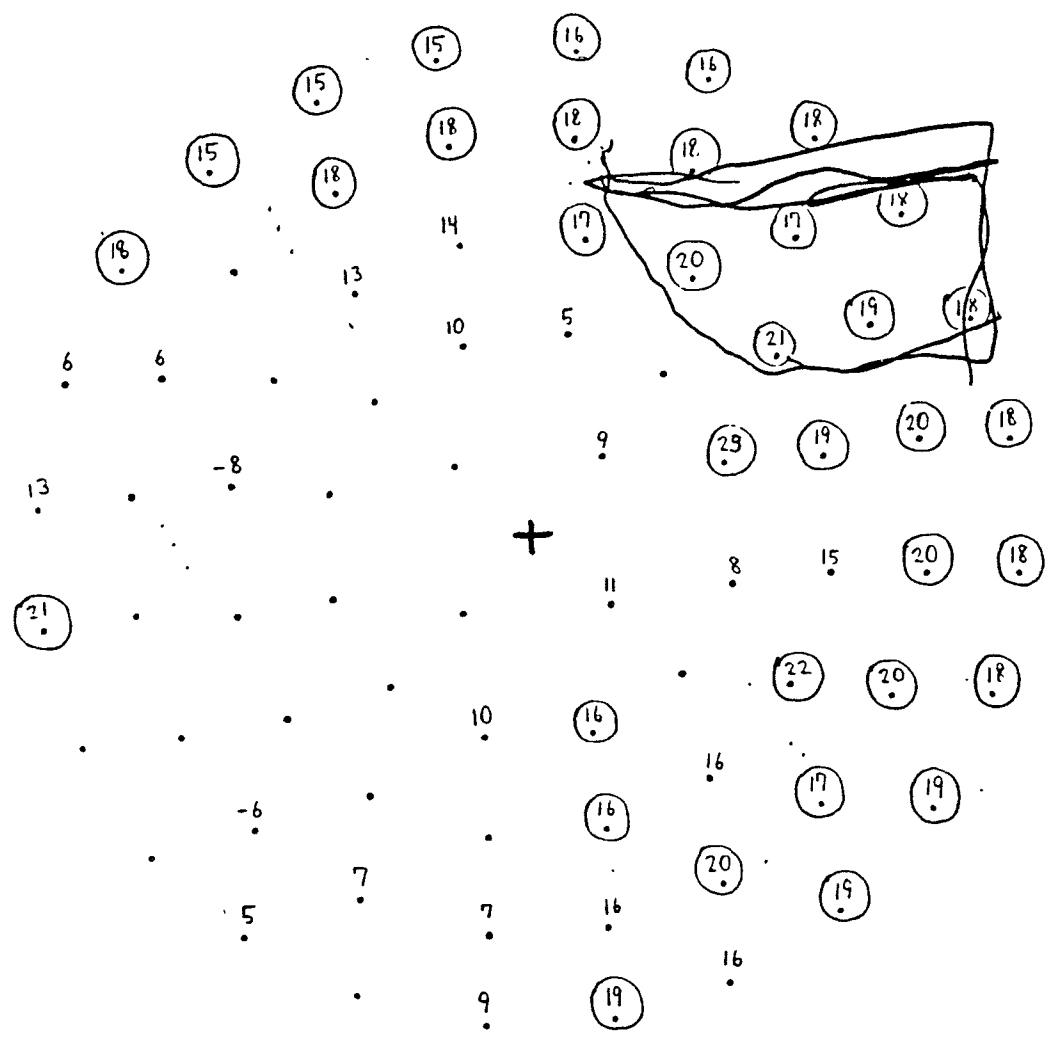
Glaucoma Patient

Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

Age: 75

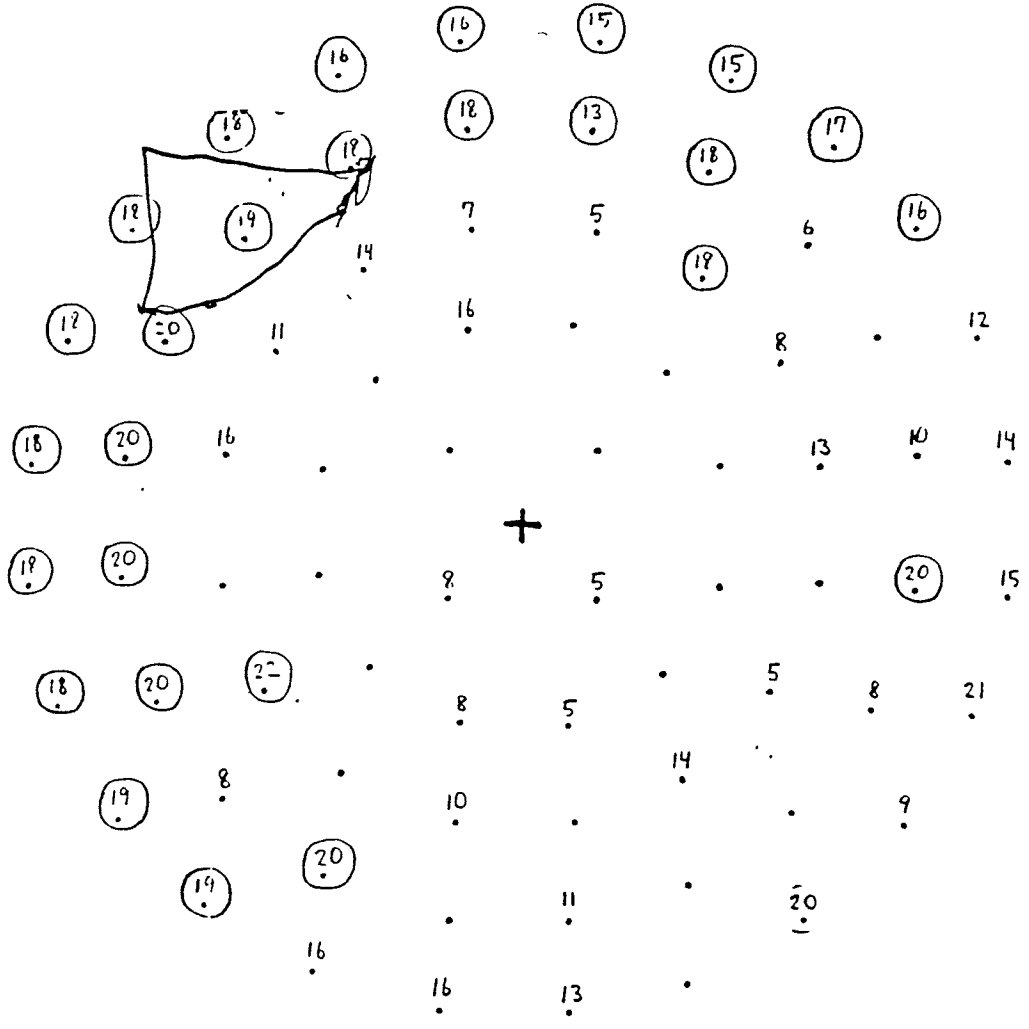
Glaucoma Patient

Right Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

Age: 74

Glaucoma Patient

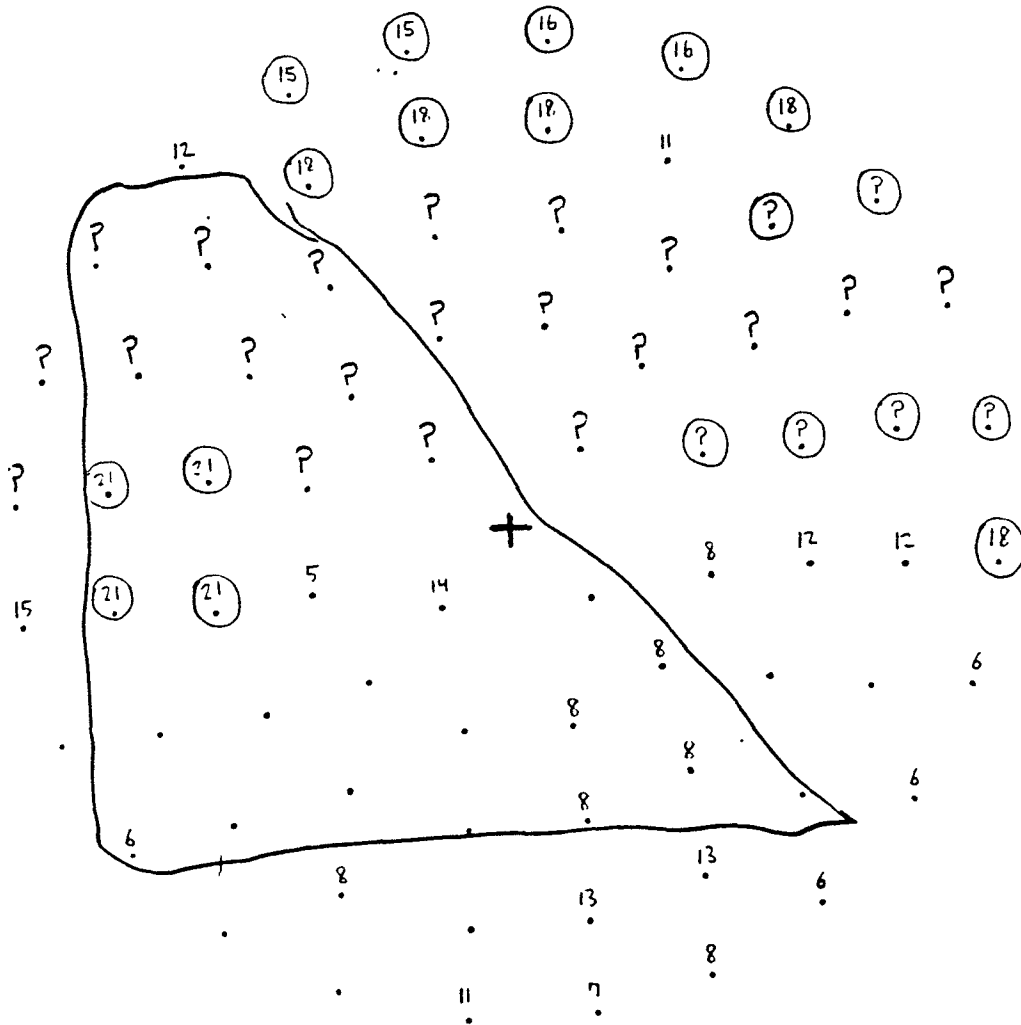
Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata

(Question marks indicate exact Defect Depth value was lost.)



Sex: Male

Age: 74

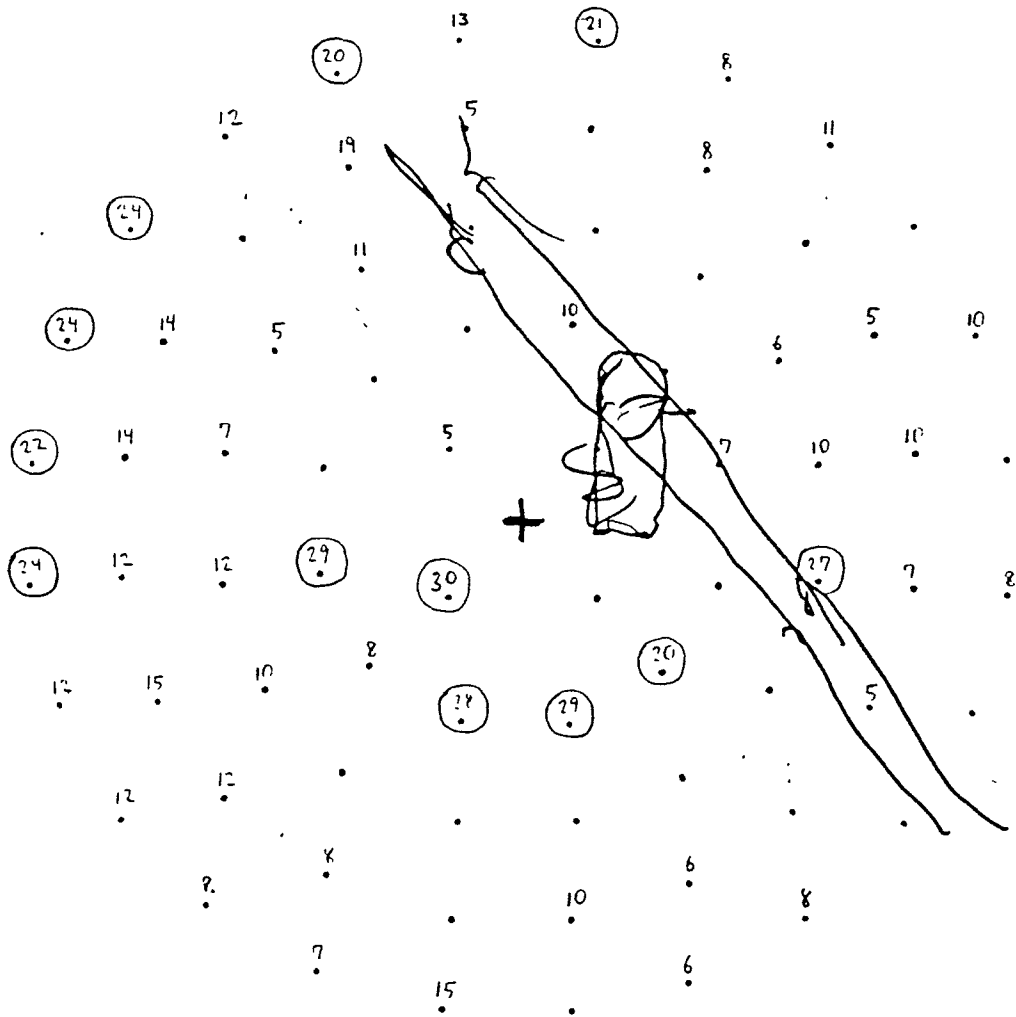
Glaucoma Patient

Right Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

Age: 63

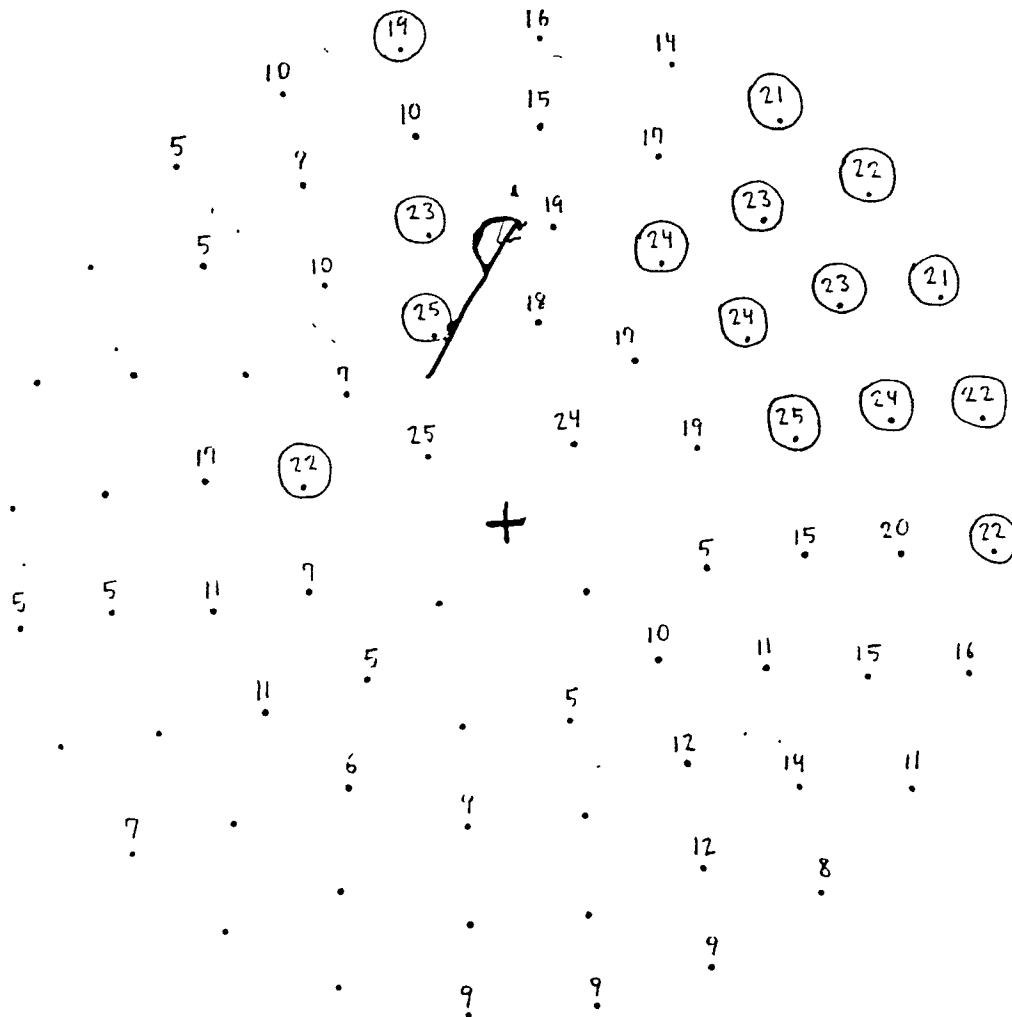
Glaucoma Patient

Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

Age: 63

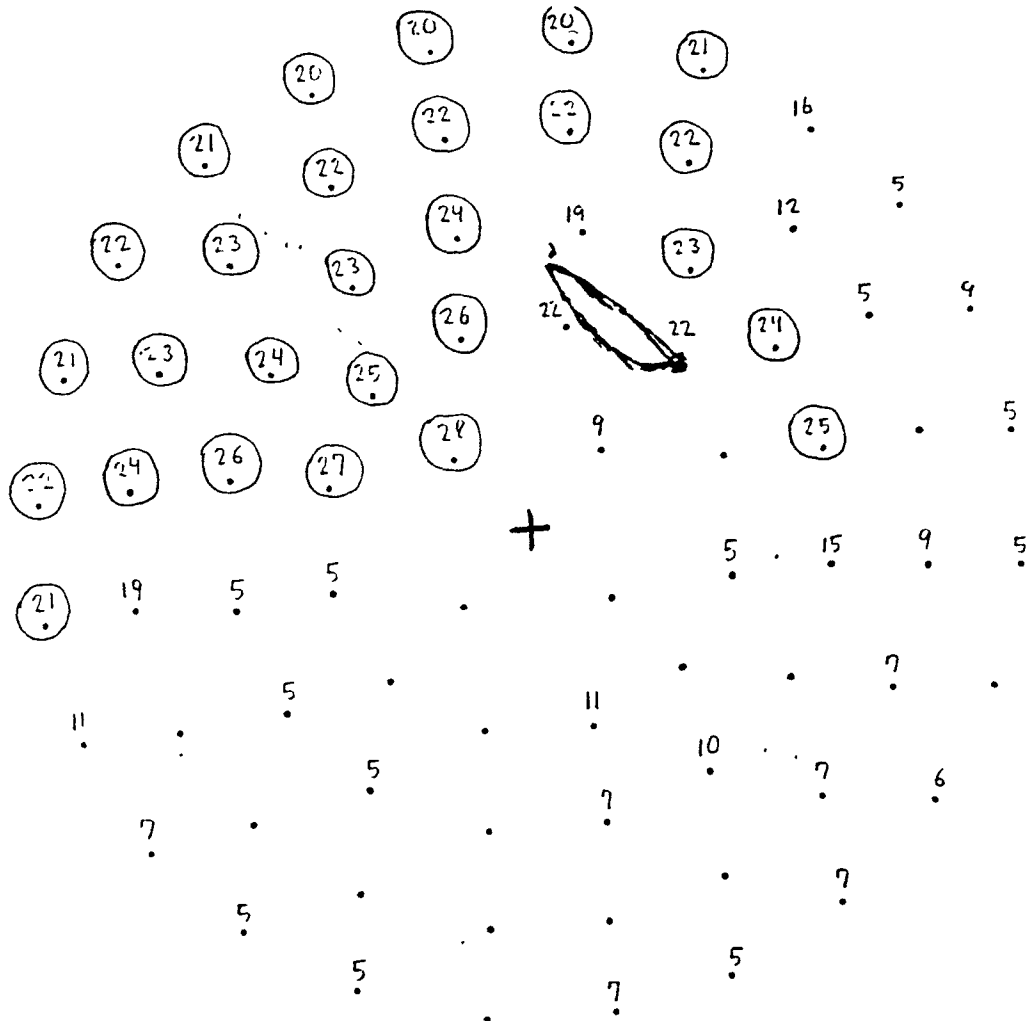
Glaucoma Patient

Right Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

Age: 79

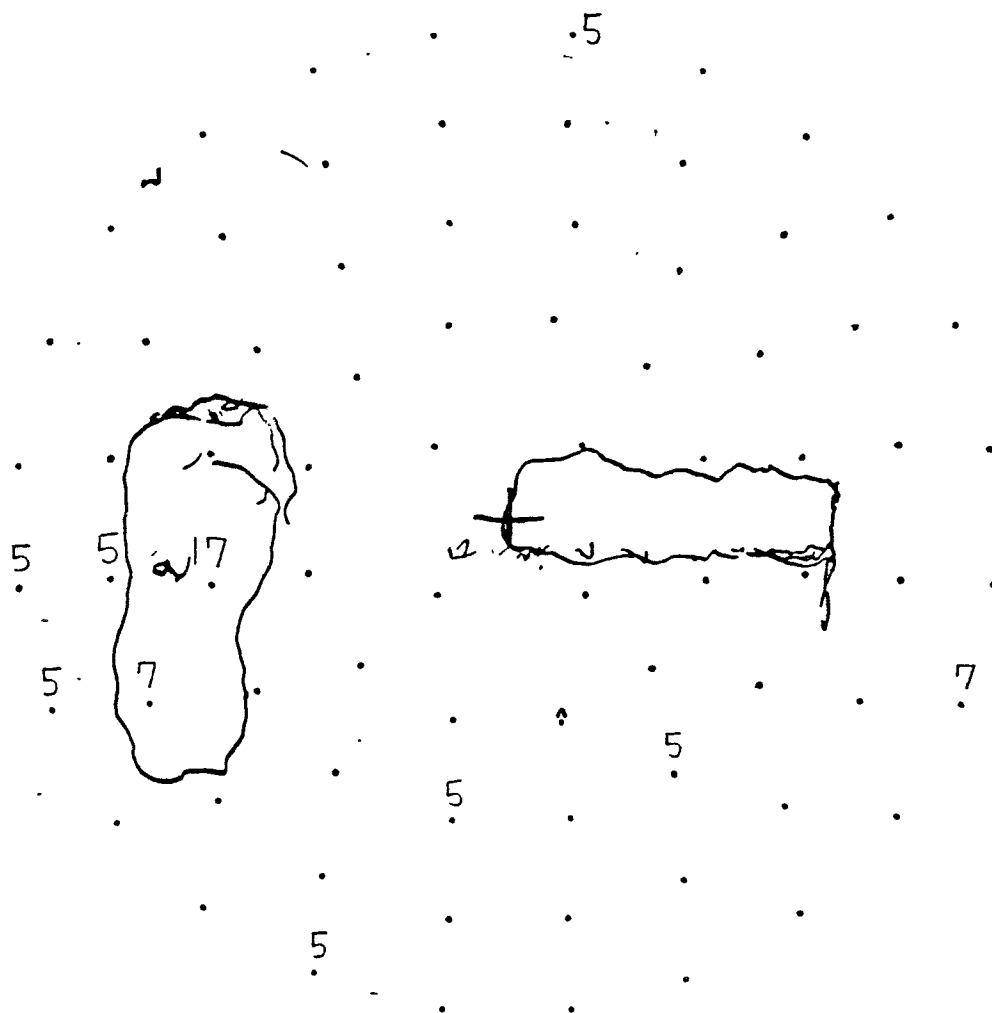
Glaucoma Patient

Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

Age: 79

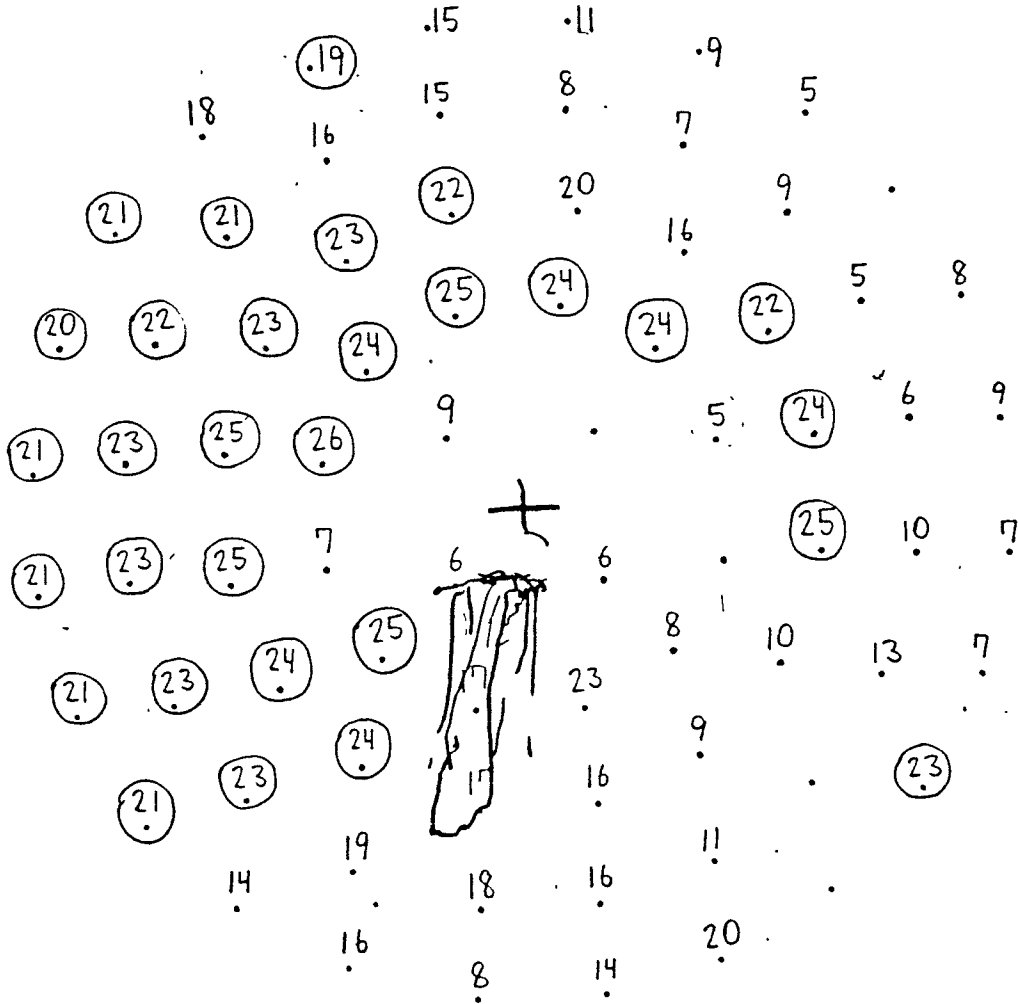
Glaucoma Patient

Right Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Male

Age: 29

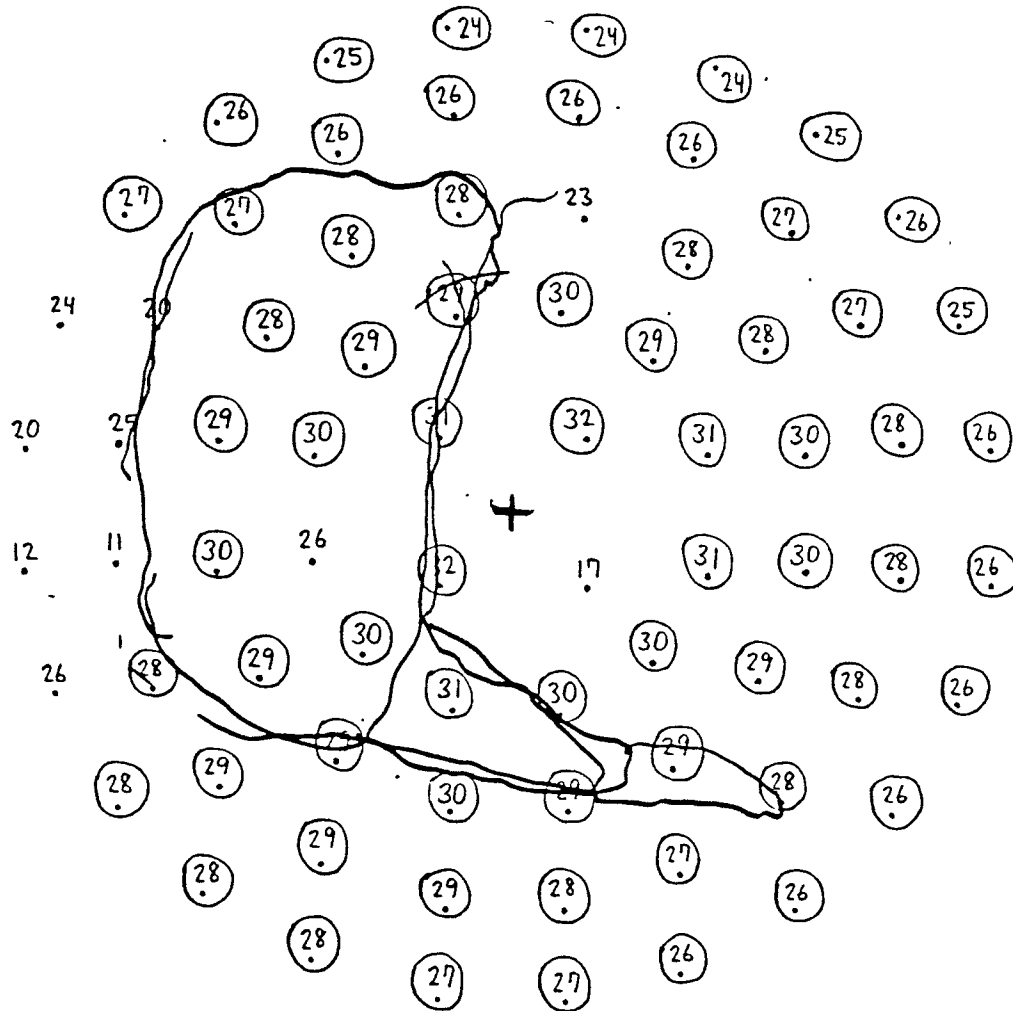
Glaucoma Patient

Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex: Female

Age: 45

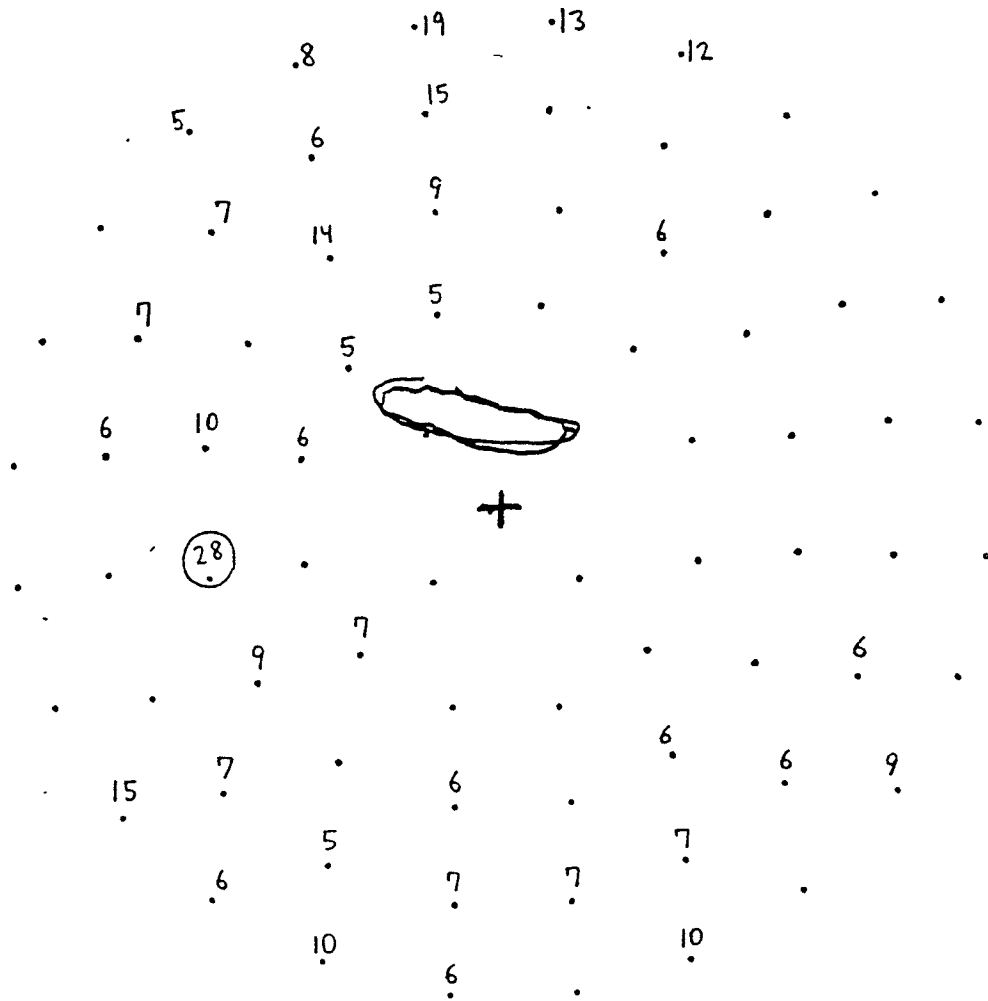
Glaucoma Patient

Left Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

Circled Defect Depths are within 1 dB of Absolute Scotomata



Sex Female

Age: 45

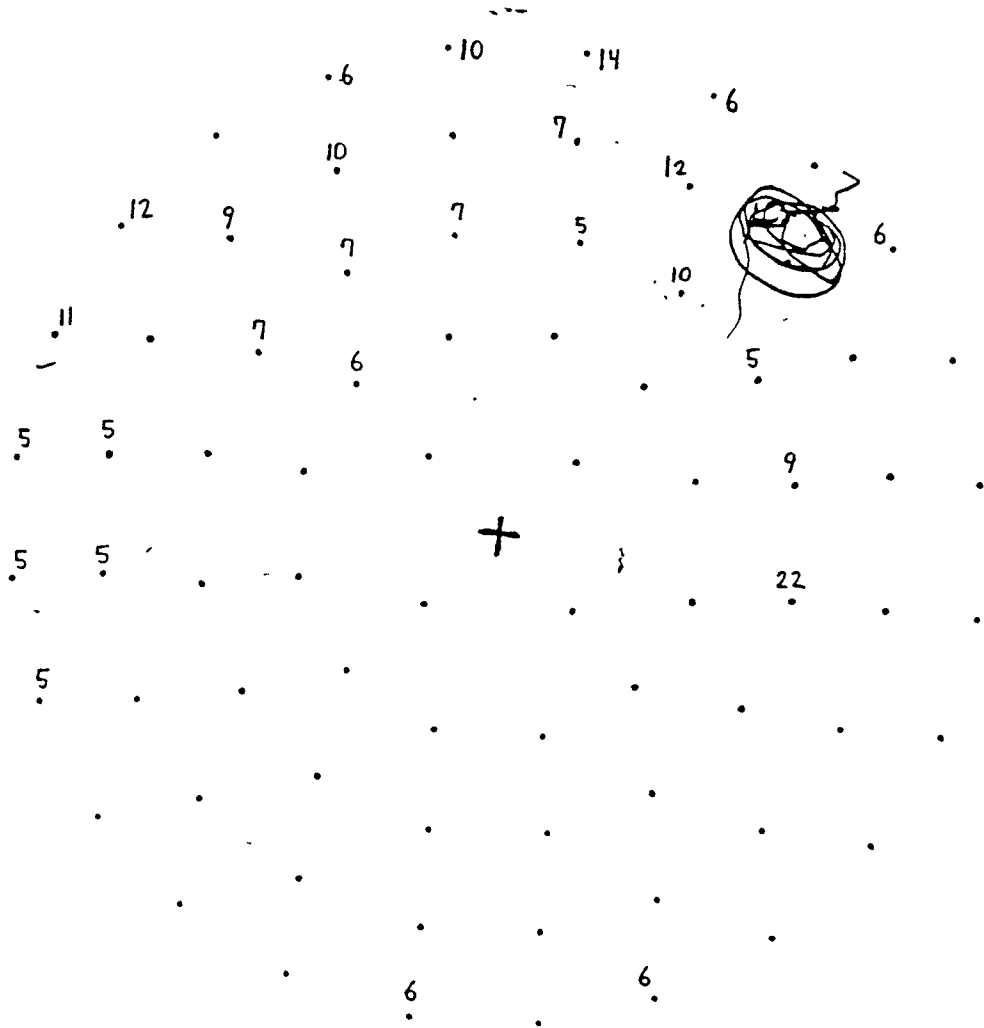
Glaucoma Patient

Right Eye

Areas Noticed with Red-green Counterphase Checkerboard

Mapped Over Static Perimetry Obtained Defect Depths

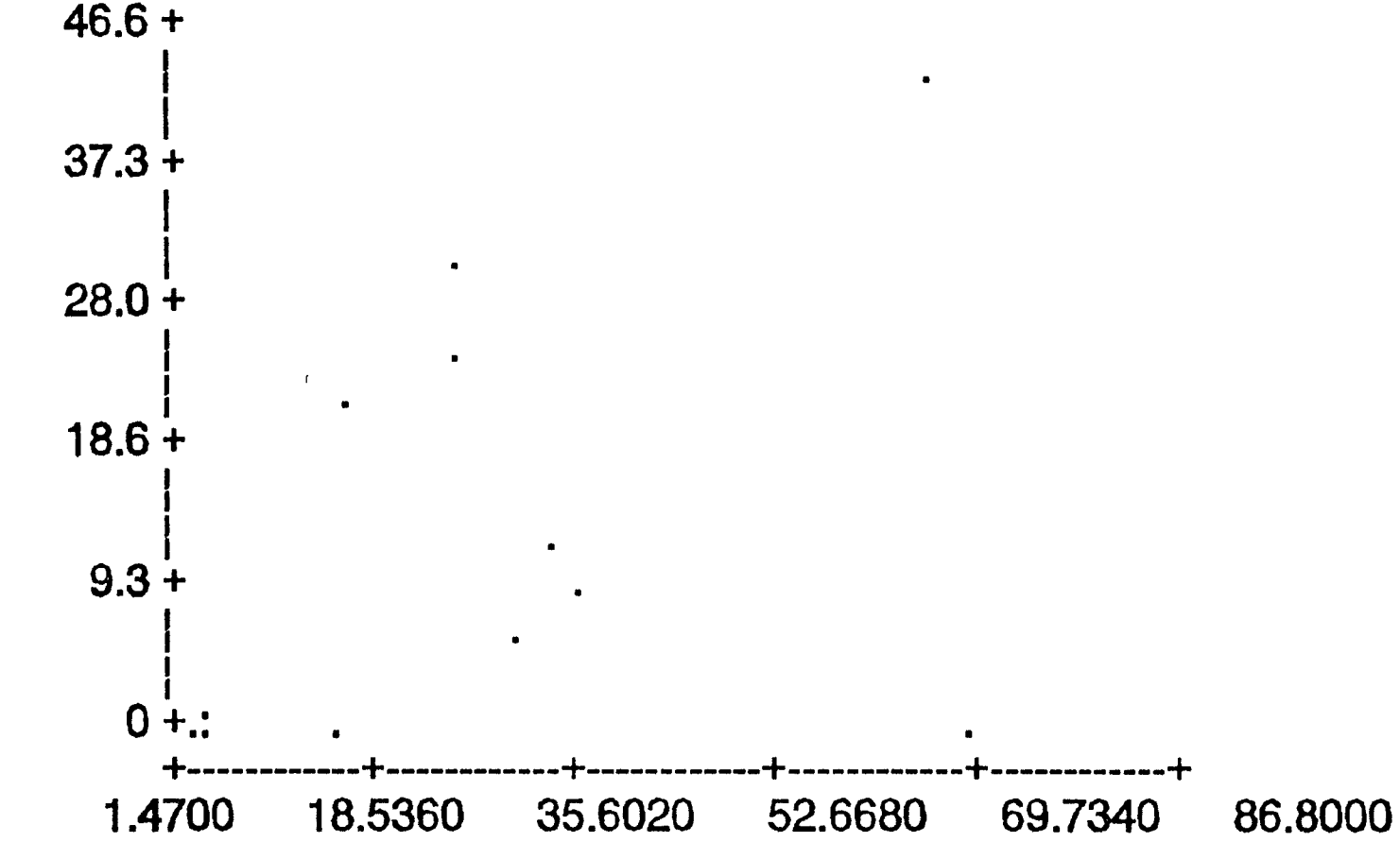
Circled Defect Depths are within 1 dB of Absolute Scotomata



APPENDIX G

SCATTER PLOTS OF AREAS NOTICED BY
30 HERTZ BLACK-WHITE SNOW OR RED-GREEN
COUNTERPHASE VERSUS STATIC PERIMETRY
DETERMINED AREAS

EcStatic - Scatterplot - 4/19/92 19:44 - File: BLKWHT
Vertical axis: ABSDET % Absolute Scotomata Present Detected
Horizontal axis: ABSSCOT % Absolute Scotomata Present in Central 30°

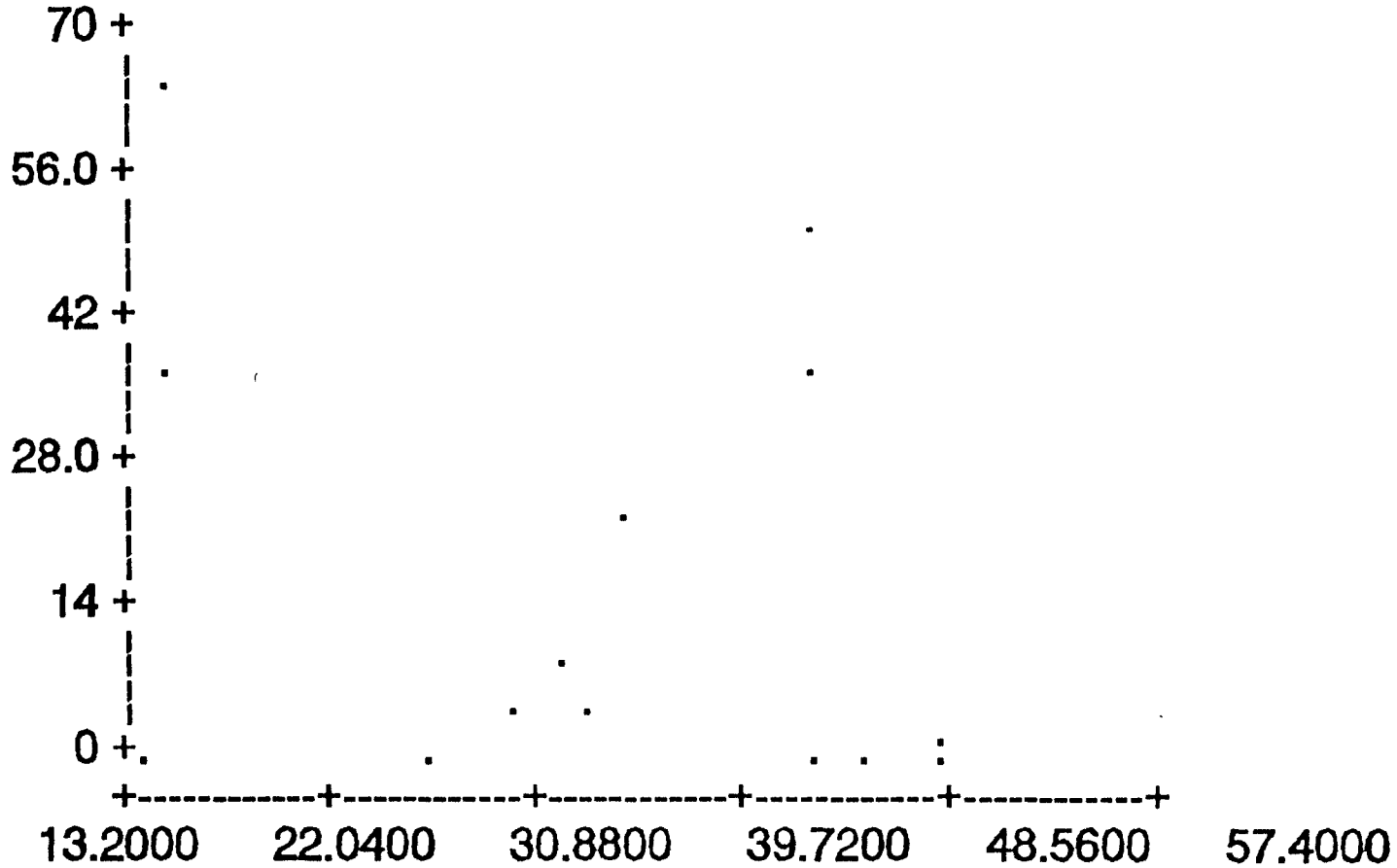


Valid cases: 12 Missing cases: 2

EcStatic - Scatterplot - 4/19/92 19:45 - File: BLKWHT

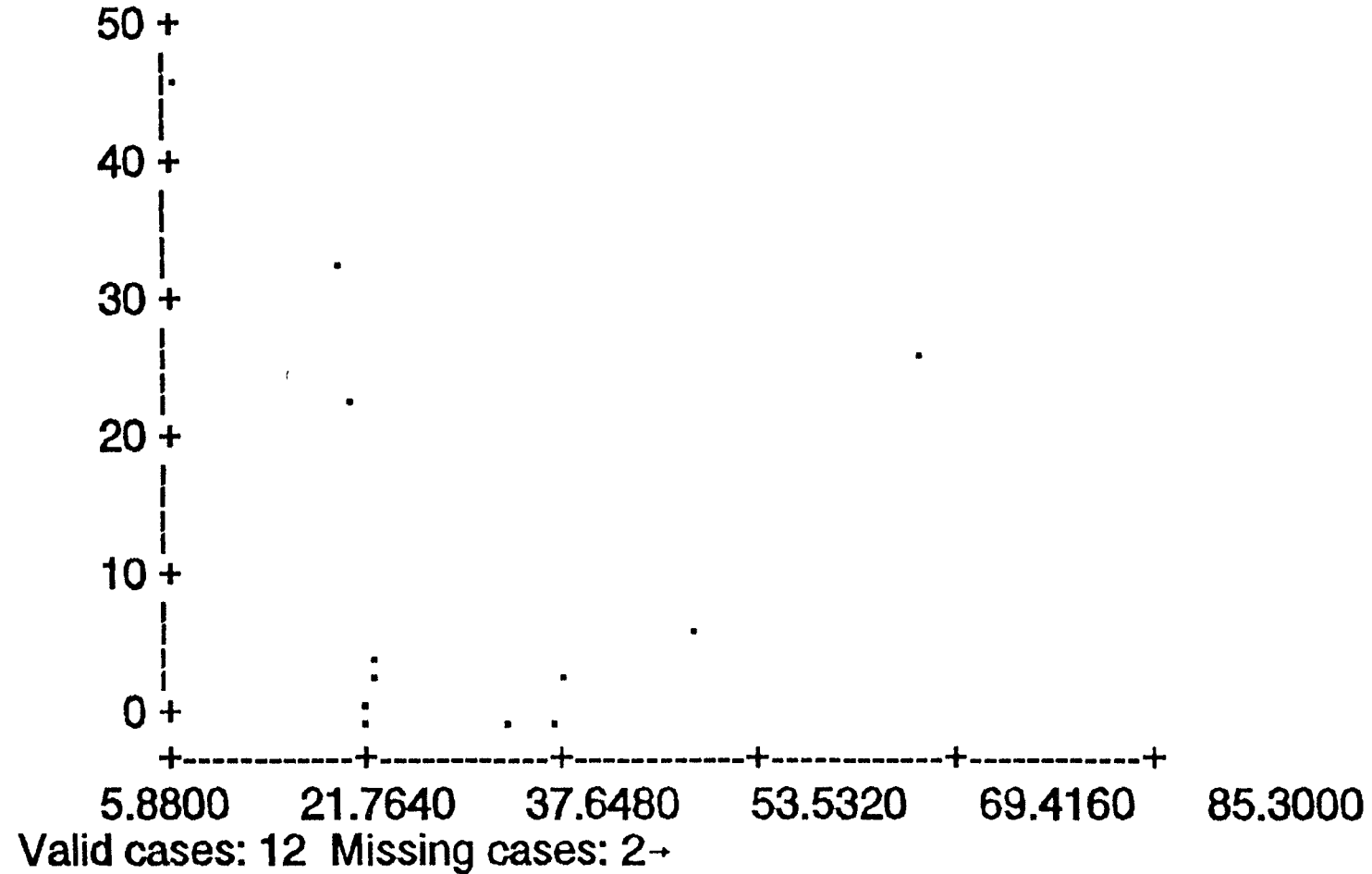
Vertical axis: RELDET % Relative Scotomata Present Detected

Horizontal axis: RELSCOT % Relative Scotomata Present in Central 30°



Valid cases: 14 Missing cases: 0→

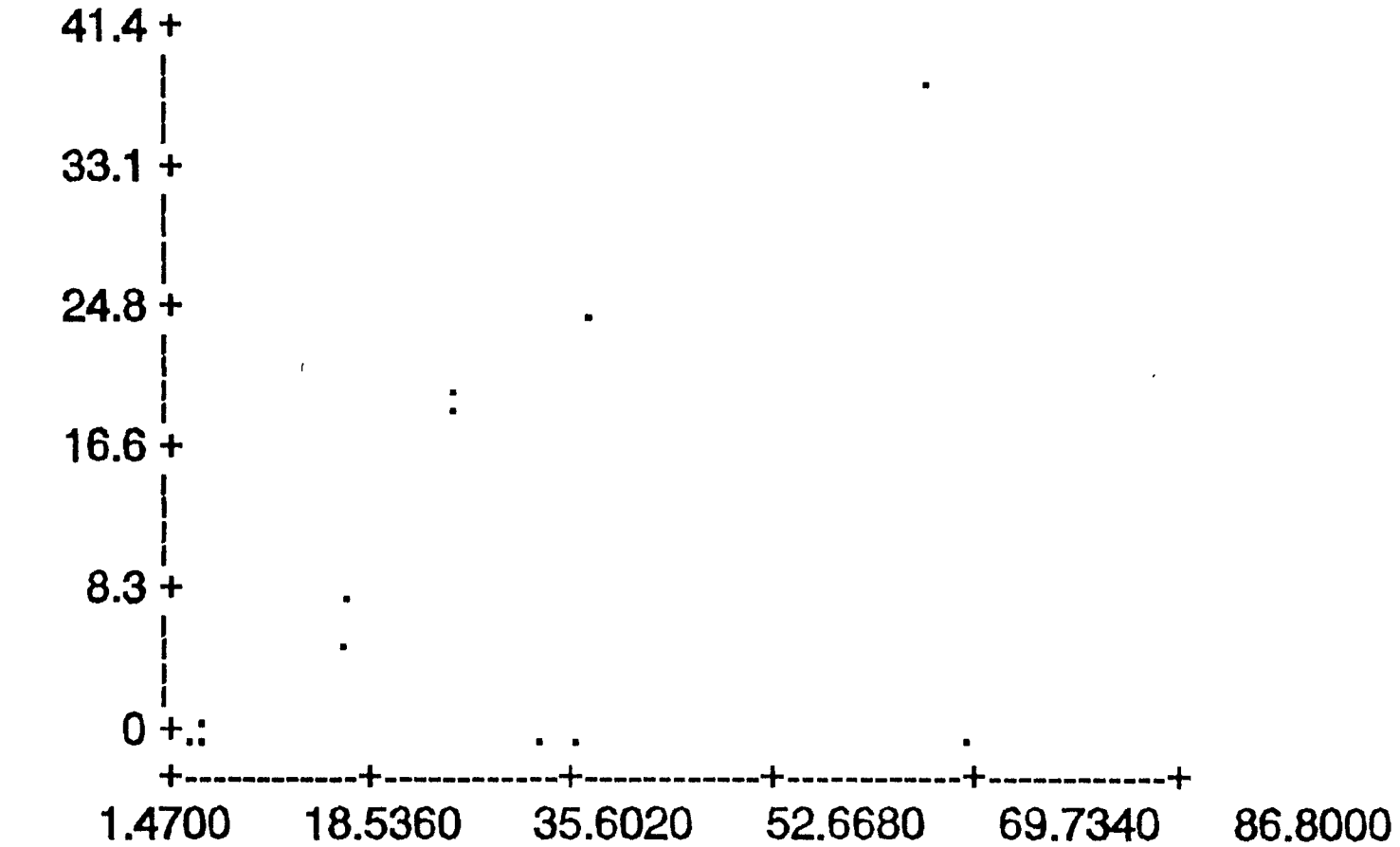
EcStatic - Scatterplot - 4/19/92 19:46 - File: BLKWHT
Vertical axis: NORMDET % Normal Vision Present Detected
Horizontal axis: NORM % Normal Vision Present in Central 30°



EcStatic - Scatterplot - 4/19/92 19:47 - File: REDGREEN

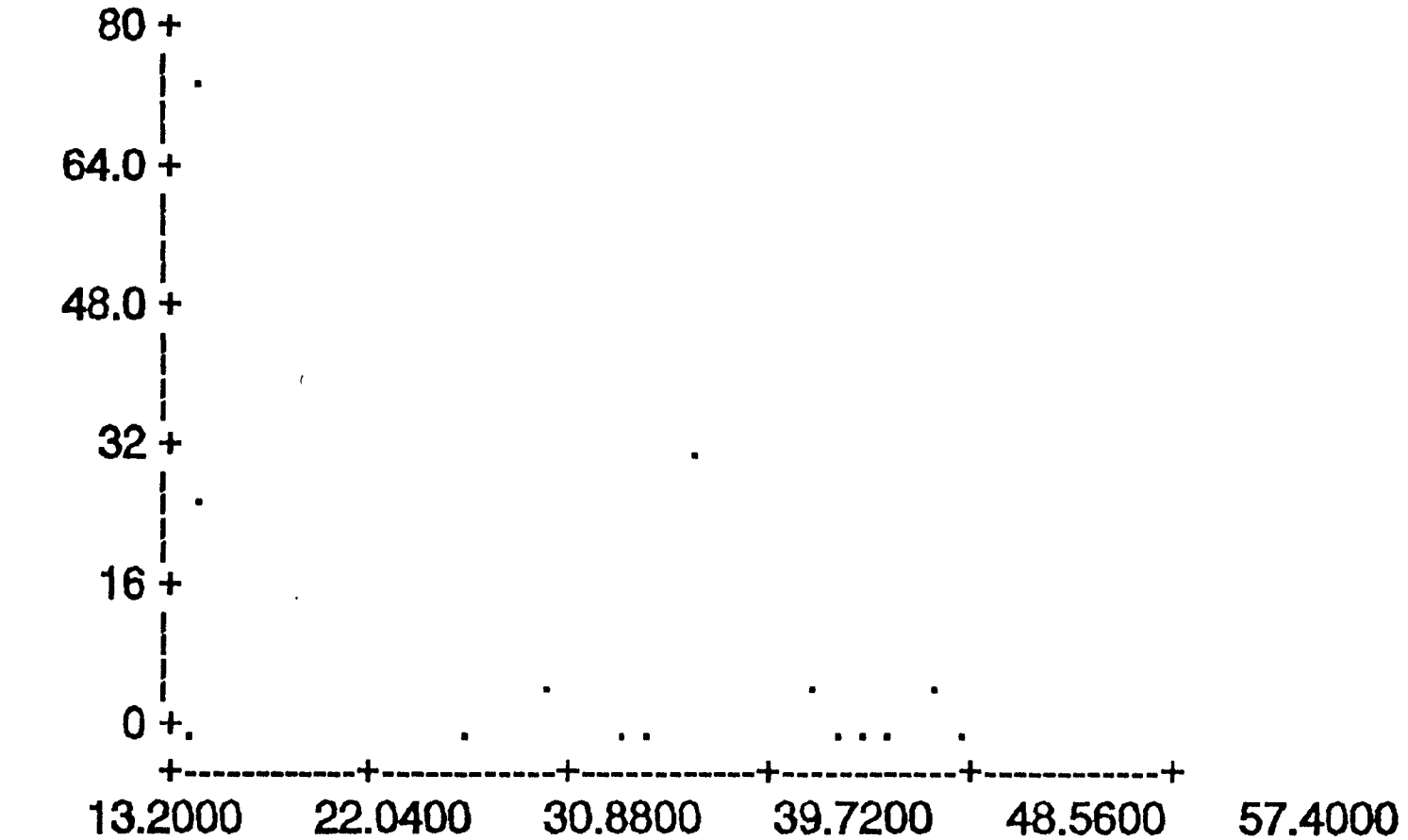
Vertical axis: ABSDET % Absolute Scotomata Present Detected

Horizontal axis: ABSSCOT % Absolute Scotomata Present in Central 30°



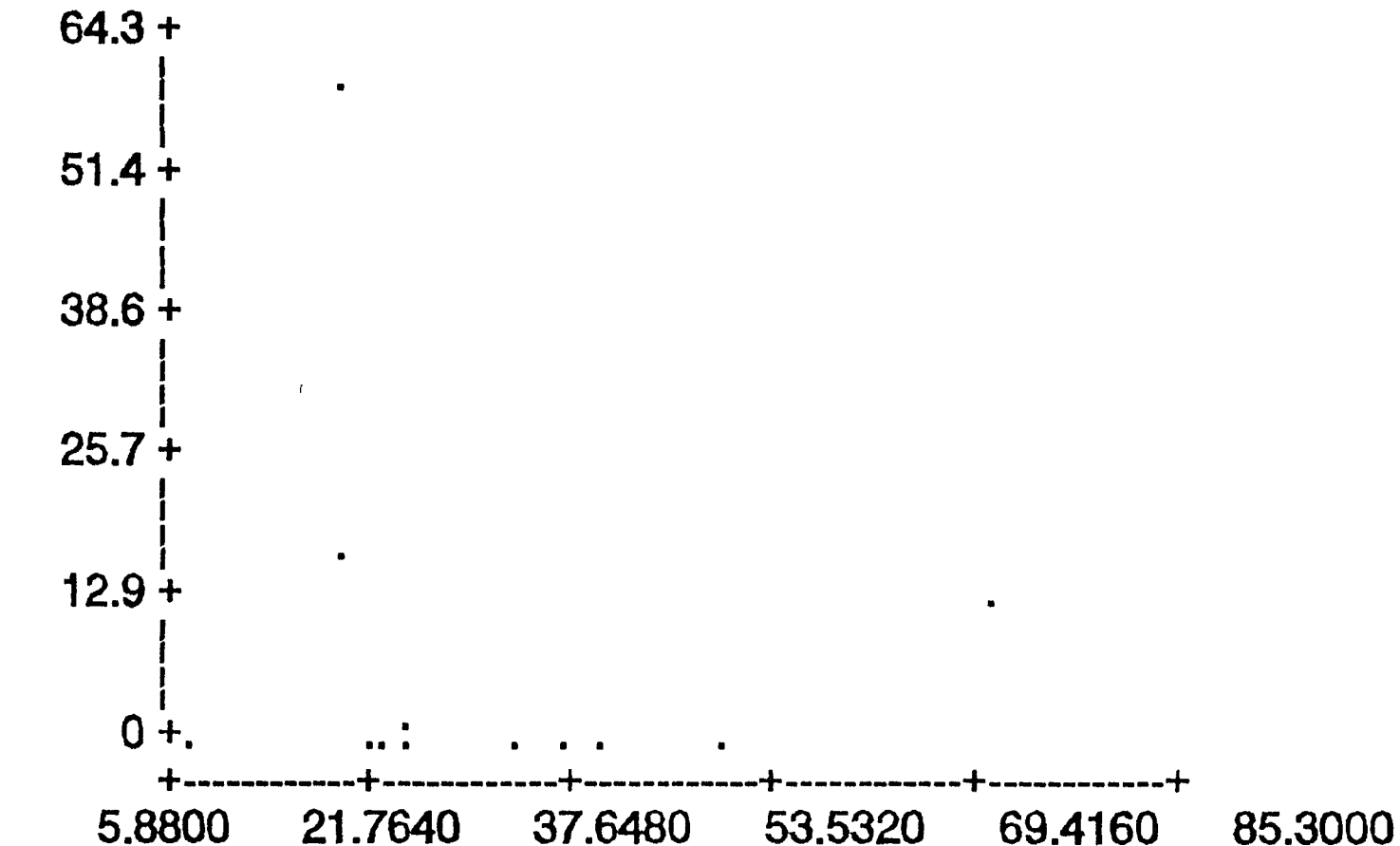
Valid cases: 12 Missing cases: 2

EcStatic - Scatterplot - 4/19/92 19:48 - File: REDGREEN
Vertical axis: RELDET % Relative Scotomata Present Detected
Horizontal axis: RELSCOT % Relative Scotomata Present in Central 30°



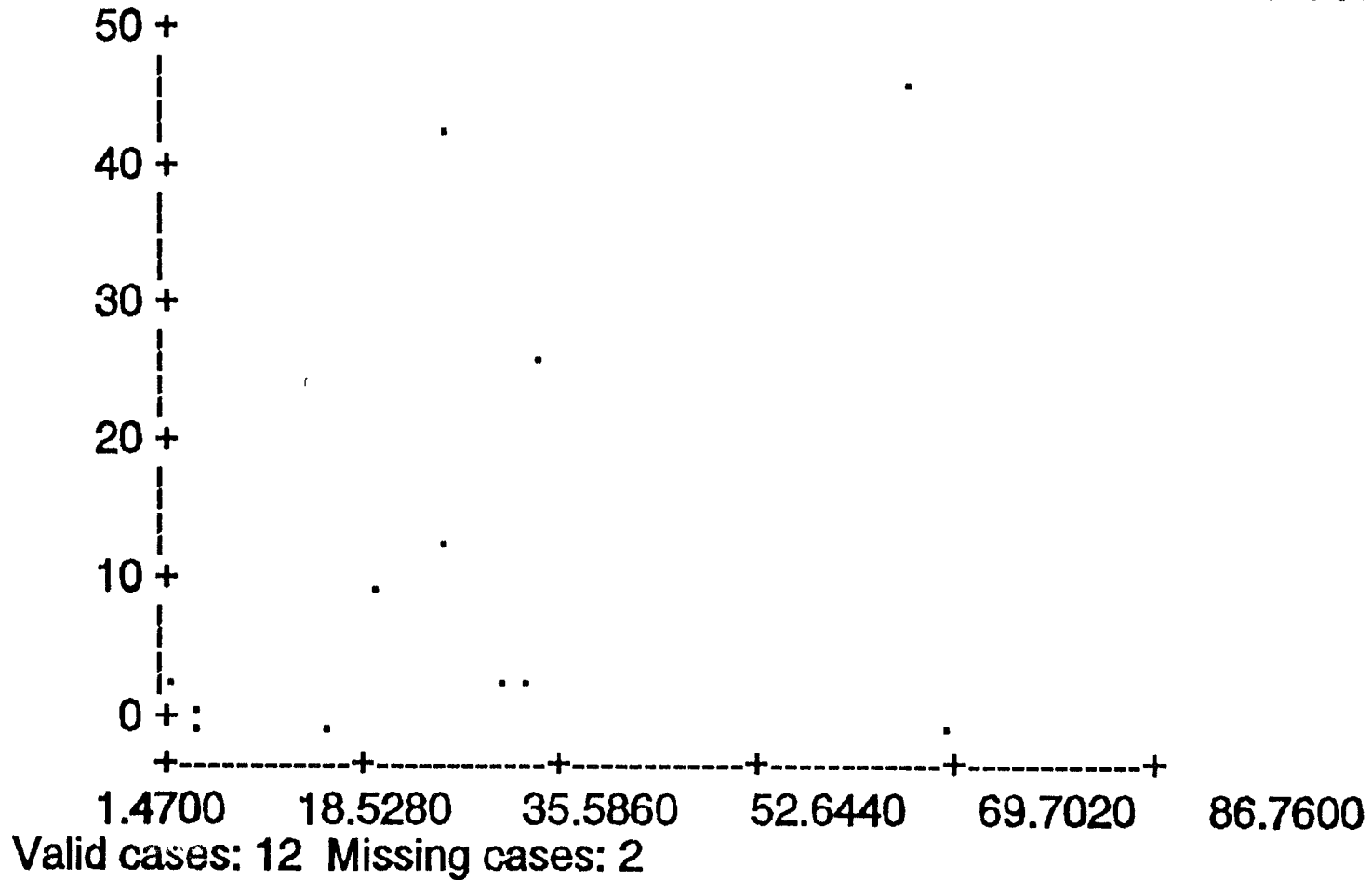
Valid cases: 14 Missing cases: 0

EcStatic - Scatterplot - 4/19/92 19:49 - File: REDGREEN
Vertical axis: NORMDET % Normal Vision Present Detected
Horizontal axis: NORM % Normal Vision in Central 30°

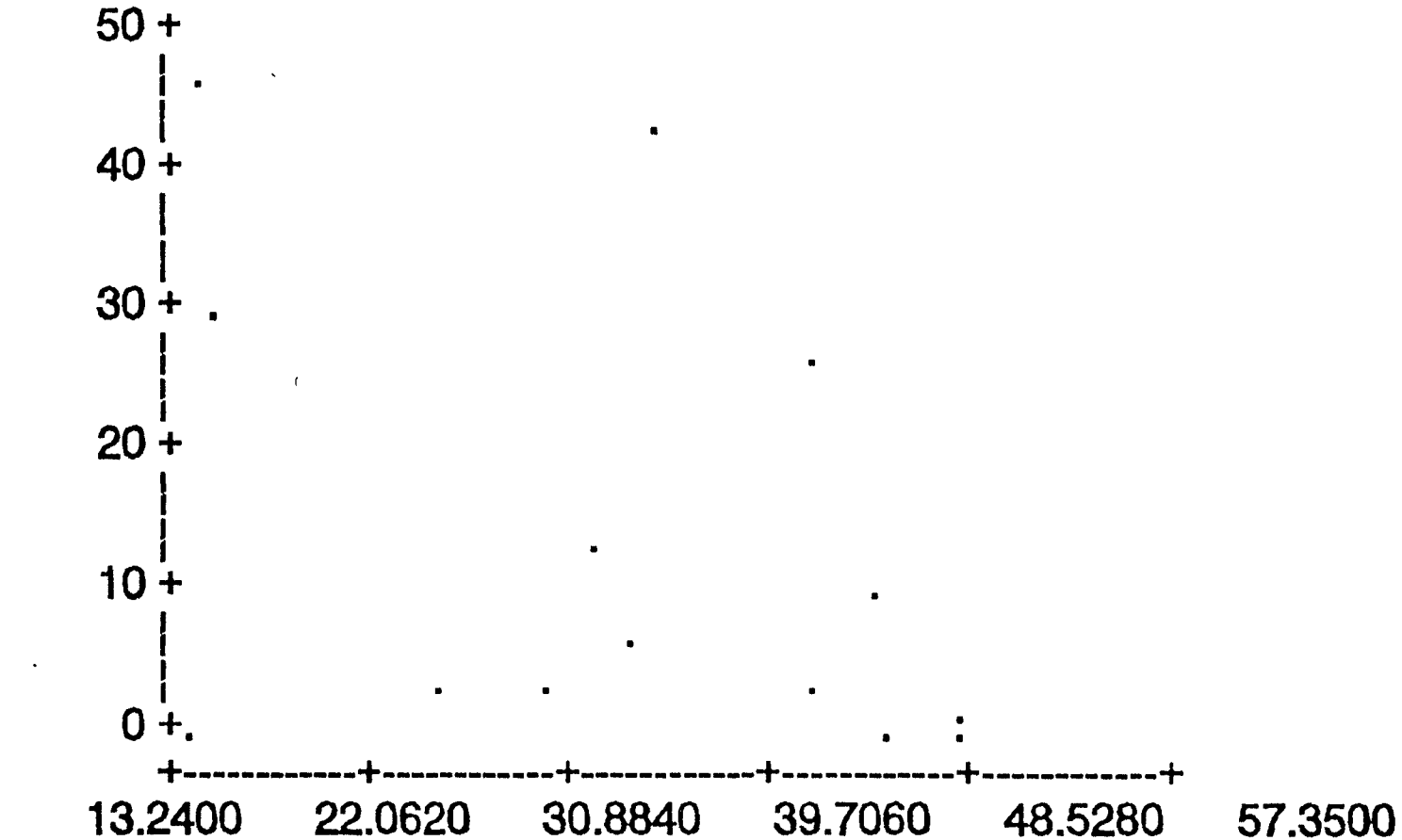


Valid cases: 12 Missing cases: 2-

EcStatic - Scatterplot - 4/19/92 20:08 - File: AREAS
Vertical axis: BLKWHT % Area in Central 30° Noticed by Black-White
Horizontal axis: ABSSCOT % Absolute Scotomata Present in Central 30°

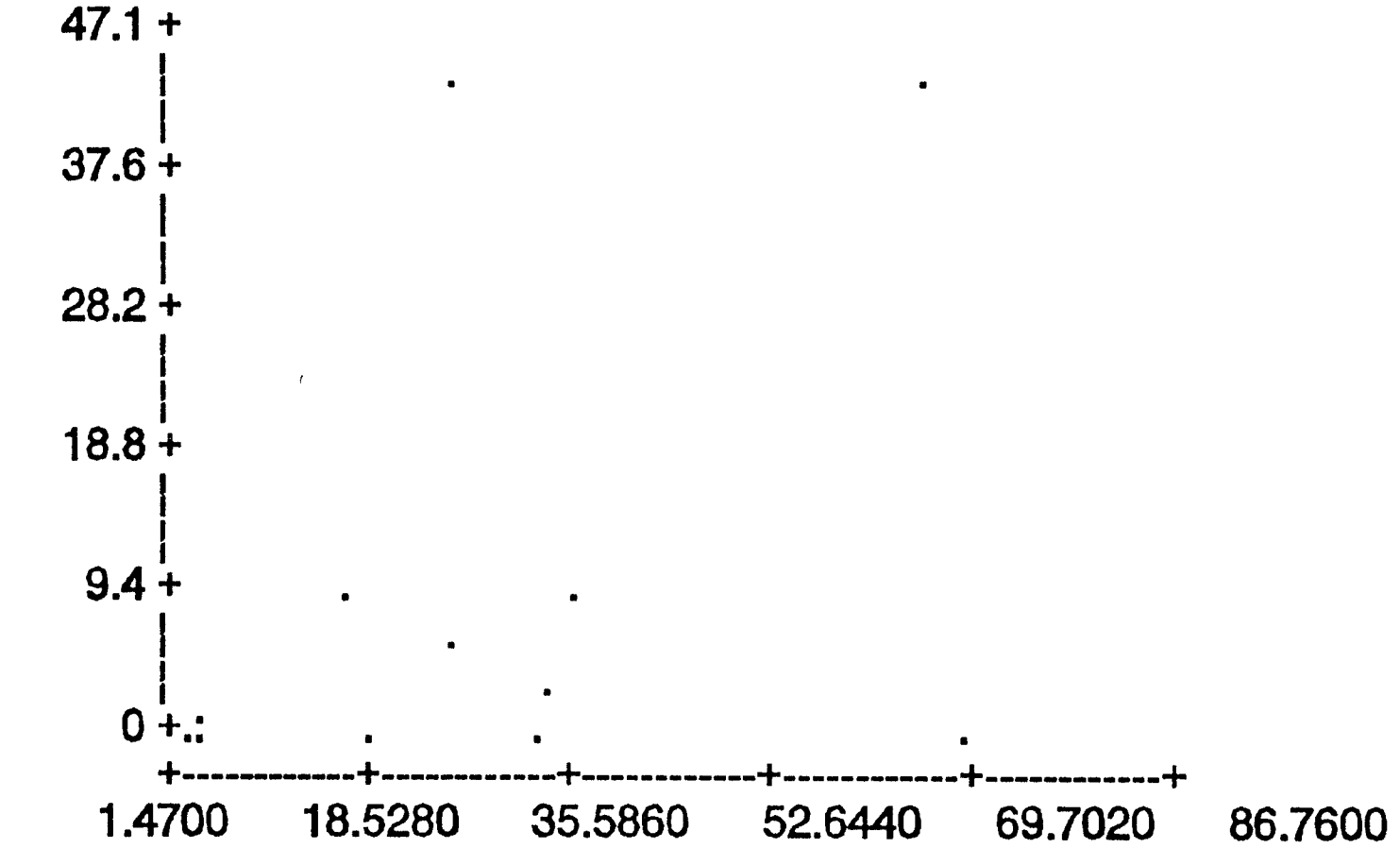


EcStatic - Scatterplot - 4/19/92 20:16 - File: AREAS
Vertical axis: BLKWHT % Area in Central 30° Noticed By Black-White
Horizontal axis: RELSCOT % Relative Scotomata Present in Central 30°



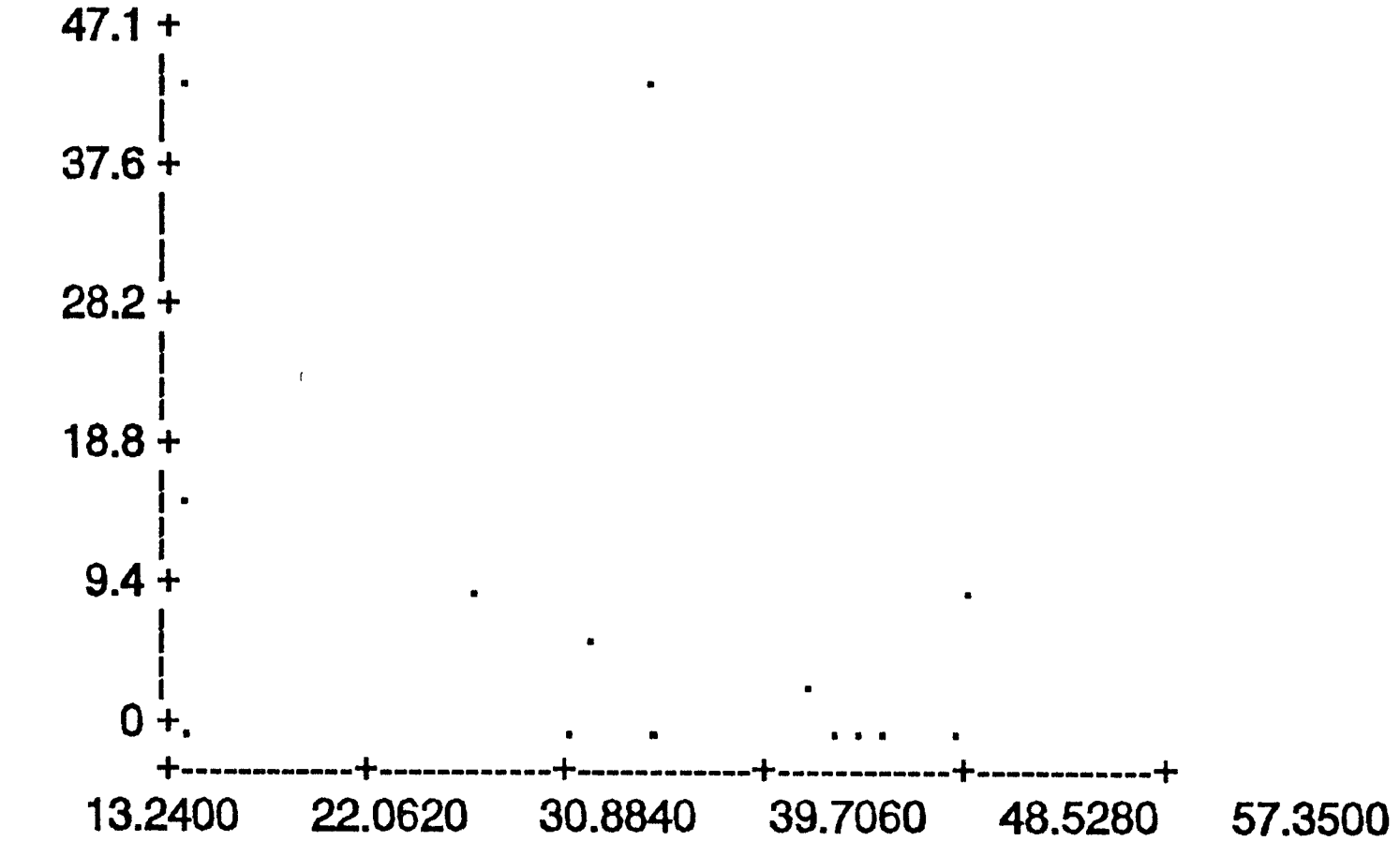
Valid cases: 14 Missing cases: 0

EcStatic - Scatterplot - 4/19/92 20:09 - File: AREAS
Vertical axis: REDGREEN % Area in Central 30° Noticed by Red-Green
Horizontal axis: ABSSCOT % Absolute Scotomata Present in Central 30°



Valid cases: 12 Missing cases: 2

EcStatic - Scatterplot - 4/19/92 20:16 - File: AREAS
 Vertical axis: REDGREEN % Area in Central 30° Noticed by Red-Green
 Horizontal axis: RELSCOT % Relative Scotomata Present in Central 30°



Valid cases: 14 Missing cases: 0

APPENDIX H
INSTRUCTION SHEETS
FOLLOWED BY TECHNICIANS
TO TEST GLAUCOMA PATIENTS

INSTRUCTION SHEET OUTLINING PROCEDURE FOR TESTING
30 HERTZ RANDOM BLACK AND WHITE SNOW.

STEPS:

- (1) Mark an acetate sheet with id data--b/w TV, L or R eye and a cross in the middle. Attach this to the TV with the cross in the middle.
- (2) Measure width of television screen.
- (3) Place patient's head a distance away from television screen equal to $0.866 X$ (width of television screen), providing a visual angle of 30.0 degrees.
- (4) Patient wears any glasses that are normally used at this distance.
- (5) Cover one eye of patient.
- (6) Instruct patient to fixate on cross at center of screen with uncovered eye while TV is tuned to snow.
- (7) Instruct patient to trace blind spot on transparency with marker. If he/she has difficulty, then trace for patient, any area which does not appear like snow on transparency with marker. Ask the patient for a description of the spot and record the description.
- (8) Record patient and uncovered eye identification information directly on transparency.
- (9) Exchange covered and uncovered eye of patient.
- (10) Repeat steps (5) through (8) for other eye.

INSTRUCTION SHEET OUTLINING PROCEDURE FOR TESTING

5 HERTZ RED-GREEN COUNTER-PHASE DISPLAY.

STEP:

- (1) Mark an acetate sheet with id data--R/G, L or R eye and a cross in the middle. Attach this to the monitor with the cross in the middle.
- (2) Patient wears any glasses that are normally used at this distance.
- (3) Cover one eye of patient.
- (4) Run program "equalize.exe".
For parameters, set $t = 0.00$ sec.
Pick bright red number and dim red number from color bar display. Do same for bright and dim green.
- (5) Measure width of checkerboard display.
- (6) Place head of patient a distance away from the monitor screen equal to $0.866 X$ (width of checkerboard).
- (7) Instruct patient to fixate on tape at center of monitor screen.
- (8) Instruct patient to trace blind spot on transparency with marker. If he/she has difficulty, then trace for patient, any area which does not appear like snow on transparency with marker. Ask the patient for a description of the spot and record the description.
- (9) Record patient and uncovered eye identification information directly on transparency.
- (10) Exchange covered and uncovered eye.
- (11) Repeat steps (5) through (9) for other eye.

PROCEDURE FOR TESTING

VISITECH CHART TEST

- (1) In room 6510 of Doctor's Office Center, University of Medicine and Dentistry of NJ, the patient is seated at the back of the room, in chair located 10 feet away from Visitech Chart hanging on opposite wall.
- (2) The Linearly Variable Neutral Density Filter (LVNDF) is set so the left side is blocked and the right side is in the maximally clear zone. Then the patient is asked to place the LVNDF over any glasses that he/she normally uses to see at this distance.
- (3) Patient looks at circle A on the visitech chart and indicates whether he/she can see pattern.
- (4) Patient rotates knob until pattern becomes invisible, then to visible again, then finally invisible. Read the stopping point off on the marker on the lens.
- (5) The test is repeated for circles B-E for the right eye and then for circles A-E for the left eye.

(In this procedure, the top most circle was designated A, the circle below was designated B and the next lower circles were assigned subsequent letters down to the bottom most circle which was designated E.)

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