Vision Aids *for* ***Impaired Peripheral Vision*** *or* ***Tunnel Vision***

The National Institute for Rehabilitation Engineering (NIRE) is a non-profit organization which operated clinics for the development and dispensing of low-vision aids from 1967 through 1987. These clinics assisted *hundreds* of people having permanent impairments of their visual fields with personalized optical aids and user training. This paper describes clinical methods and devices successfully developed and used during this period. Because the NIRE no longer operates these vision clinics, the information is being made available so that NIRE's methods and data may help vision-care professionals, everywhere, to functionally rehabilitate visually impaired individuals.

Different types of "field-expanding" eyeglasses were developed for people with REDUCED PERIPHERAL VISION … *and* TUNNEL VISION. None of these spectacles restores "normal" vision. Each of the described eyeglass types has proven helpful to their users for various activities of daily living, and for specific mobility and travel functions. Because the eyeglasses do NOT fully restore "normal" vision, intensive user field training may be needed, especially for high risk activities such as driving.

Where to Go For Help

Individuals who may be functionally helped by the information in this paper are urged to discuss their problems, and this paper, with their regular eye doctors. This is very important because some conditions which cause progressive loss of peripheral vision may be medically treatable. *A person's peripheral vision loss may be slowed, arrested or even reversed with timely and effective medical treatment.*

Once a person is under appropriate medical care and it has been established that the existing loss of peripheral vision is not reversible, consideration should be given to obtaining functionally helpful "field-expanding eyeglasses." Inquiries should be made to nearby "Low-Vision Clinics." One should look for a reputable, nearby optometrist, a local group of eye doctors (ophthalmologists, optometrists or mixed group), or a large non-profit "Low-Vision Clinic". *Most "Low-Vision" practitioners and clinics make special eyeglasses for people with reduced visual acuity, the most common vision handicap. Only a few dispense "field-expanding" eyeglasses to people with reduced peripheral vision. However, the same labs and similar supplies, materials and methods are used for making both "low acuity" and "tunnel vision" eyeglass components. Hence, the typical "Low-Vision Clinic" can usually undertake to make and fit field-expanding glasses if they desire to do so … and can expend the necessary time and effort.*

Night Blindness … may also be present with reduced peripheral vision

The same retinal cells (called "rods") that sense the peripheral images also sense "dim-light" images. Therefore, people who have lost significant amounts of their peripheral vision are likely to see poorly in very dim light. This may limit or prevent nighttime driving for those still able to drive - and may even limit personal mobility when walking at night, for those with greater losses. For more information about "Impaired Night Vision and/or Night Blindness" contact this Institute and ask for "The Night Vision Paper." It is a separate paper which discusses this topic in some helpful detail.

This Paper is based on these assumptions … unless otherwise stated:

1. Lost, reduced or missing peripheral vision is symmetric for the designated eye. Thus, for the designated eye, there is vision loss to the person's left, to his right, downward, and upward. The loss is circular, hence the term: "tunnel vision" to describe the person's remaining, functional vision. *If the peripheral vision losses are asymmetric, contact The N.I.R.E. and ask for papers dealing with "Hemianopsia," "Monocular Vision," and "Vertical Eye Gaze Disorders."*

2. The person has visual acuity correctible to 20/40 or better and sees clearly using his or her "central vision." *If best corrected acuity is 20/70 or poorer, the person should go to a "Low Vision Clinic" and request that both problems be addressed: (a) the reduced acuity … and then (b) the reduced visual fields.*

3. The person has similar acuity and peripheral vision characteristics in both eyes. *If the person is blind in one eye, with reduced peripheral vision in the other eye, he should request from The N.I.R.E. a copy of the papers for "People Sighted in One Eye." If the person has normal acuity and peripheral vision in one eye, but impaired peripheral vision in the other eye, then he should request from The N.I.R.E. the paper on "Homonymous Hemianopsia."*

Terminology

"Impaired" or "Reduced" Peripheral Vision - are used interchangeably and have the same meanings. These terms are usually reserved for use by people who have lost only a small part of their peripheral vision. Typically, these are people whose unaided horizontal visual fields are still 90 degrees or greater. (Normal unaided field widths range from 140 to 180 degrees.) *DRIVING: People in the "unaided 90-degrees-or-greater" category may still be able to drive in daylight, safely and legally - in some but not all states - with appropriate assistive devices and training.*

"Tunnel Vision" is the term often used by or for people whose unaided visual field widths are less than 90 degrees. This is because they see as if looking down a tunnel or through a tube. People with advanced tunnel vision can have field widths as small as 4 degrees – with normal acuity or sharpness of vision. Generally, the visual acuity declines rapidly once the field width is down to 5 degrees or less. *DRIVING in daylight may still be possible for some in this category (who, unaided, have 75 degrees or more of field width), with appropriate personal assistive devices, car-mounted visual aids, and driver training. Only some states will road test and license these disabled people.*

"Vision Mobility Impaired" people often have visual field widths of 30 degrees or less. This term is used because pedestrian walking can be dangerous unless field-expanding glasses are used – or a cane or dog. Field-Expanding eyeglasses can be very helpful for walking and other activities. *DRIVING should not be considered for these peo*ple, *however.*

Ophthalmologist - A medical doctor who specializes in eye care, including diagnoses, medical and surgical eye care, plus the prescribing of corrective lenses. Besides general eye care ophthalmologists there are some who specialize in such areas of eye care as: corneal disorders, cataracts, retinal disorders, eye-convergence problems, etc. In addition, there are some medical doctors who practice as "neuro-ophthalmologists" and treat such combined neurological-and-vision disorders as hemianopsia, optic neuritis, etc.

Optometrist – A doctor of optometry typically has more optics engineering training than medical training and does not perform surgery or prescribe medications. Many optometrists design, make and dispense optical aids, eyeglasses and contact lenses. They are licensed to examine eyes and test vision – and to make and dispense optical aids, with user training. Doctors of optometry may be in solo practice, at clinics, or in joint practice with ophthalmologists. Their optics engineering training makes them outstanding in the design, fabrication and dispensing of complex magnifying and field-expanding optics.

Optician or Optical Dispenser – is a licensed optics maker and dispenser who is not permitted to examine eyes, test vision or prescribe lenses. Typically, he makes, fits and dispenses lenses and optical aids to the written specifications or prescriptions of an ophthalmologist or optometrist. It is this dispenser who adjusts eyeglasses on the user's face, to make them comfortable to wear and use.

Technicians and Trainers – are often electronics, computer or other technology trained engineers or technicians. Besides optical aids, more and more electronic vision aids are being developed – some new devices even restore sight to totally blind people. As a result, these types of technicians are playing ever more important roles in visual rehabilitation.

Task Trainers – include those professionals who train disabled individuals to perform specific tasks, using appropriate methods, procedures, tools and assistive devices. There are "mobility trainers," "office equipment and computer trainers," and "driving trainers."

Federal-State Aid Programs are in place to assist almost every visually impaired person in the United States with information, counseling, referrals, education or retraining, funding, and job placements. Every visually impaired person should, therefore, contact his state's "Blind Services" agency – sometimes called the state "Commission for the Blind and Visually Impaired". Such contacts should be made as soon as the person is diagnosed as permanently visually impaired.

Causes of Peripheral Vision Impairment

Glaucoma is an insidious progressive disease causing elevated fluid pressure within the eyes. Over time, the elevated intra-ocular pressure causes loss of the image signals from the rod cells along the peripheries of the retinas. Glaucoma is often not self-detectable so that a person does not realize he has a problem until he has lost a lot of his peripheral and night vision. **This disease usually can be arrested when once detected.** The damage may or may not be partly reversible. Glaucoma tends to run in families. While it can affect people of all ages, it is more common in people over 50. *People should have eye exams at*

*least once a year which exams should always include both **eye-pressure tests** and **field of vision plotting**. Glaucoma is the most common cause of Tunnel Vision.*

Retinitis Pigmentosa is transmitted genetically as a recessive characteristic. Both parents need to be carriers in order to produce children, some of whom may be or not be carriers and others who will develop the disease. Those who are carriers do not develop the disease. Those who have both parents' RP traits may start losing peripheral vision and night vision in their teens or early twenties – or it may begin in their thirties or forties. These people often complain about poor night vision well before noticing loss of peripheral vision. The progression of Retinitis Pigmentosa can be slowed but it cannot be completely stopped. Unfortunately, there is no way for restoring the lost peripheral vision. ***People who have had any relatives with a history of RP should have regular eye exams with field-of-vision plotting plus dim-light sensitivity and regular acuity testing. They should be thoroughly tested because, if diagnosed early, RP progression can sometimes be slowed.*** *Typically, over a period of 15 to 20 years, RP patients' visual field widths decrease to as little as 4 degrees and then, within several more years, total blindness occurs.* RP is the second most common cause of Tunnel Vision.
Usher's Syndrome is similar to RP except that the patient is also deaf. Thus, the information in this paper about RP also applies to those with Usher's Syndrome.

OTHER CAUSES of peripheral vision loss

Partial Retinal or Vitreous Detachment, **Diabetic Retinopathy, and Optic Neuritis** are some less common causes of reduced peripheral vision. When one of these is the cause, it may affect only one eye and it may be asymmetric. The vision loss may be a one-time incident or it may be progressive. **It may be a "Medical Emergency" that can lead to total blindness. Always consult an ophthalmologist when symptoms are first noticed**. *When the condition is stable and permanent, the patient may, for example, lack peripheral vision to his left but have normal peripheral vision to his right. This is similar, in some ways, to a condition known as "hemianopsia".* The visual field of the affected eye must be plotted, and the eye's acuity must be tested. Since the effect is unique on each eye, this paper does not apply to most of these cases. The papers by N.I.R.E. on "Retinal Scotomas," "Hemianopsia," and "Monocular Vision" may prove helpful. Each case, in these categories, is unique. Thus, the design of compensating optics must be by each patient's own eye care professionals.

Field-Expanding Eyeglasses for Reduced Peripheral Vision – for people with symmetric visual fields, for both eyes, having overall Unaided Visual Field Angle or …

Width of: 120 to 180 degrees - no field expanding lenses are required or recommended. People in this category may have beginning night vision problems but should be able to function and drive, with conventional lenses as needed for distance correction. Special rearview mirrors or a rear-viewing video system may be helpful for safer driving.

Width of: 75 to 120 degrees - Type TV-1A Prismatic Field-Expanding Glasses are most often helpful, as described and illustrated below. These eyeglasses provide conventional distance corrections plus expanded peripheral vision to the outside, on each side of the wearer's body. These glasses can be used by people having corrected visual

acuities that are normal … or even below normal. DRIVING is usually feasible only for those whose acuity corrects to 20/40 or better. TV-1A users need to learn to use continuing eye and head scans for ***safe driving***, together with appropriate wide-angle rear view mirrors or video displays. *Night Driving may or may not be feasible depending on the person's degree of night vision loss. This can be determined by nighttime road practice with a qualified, licensed driving instructor.*

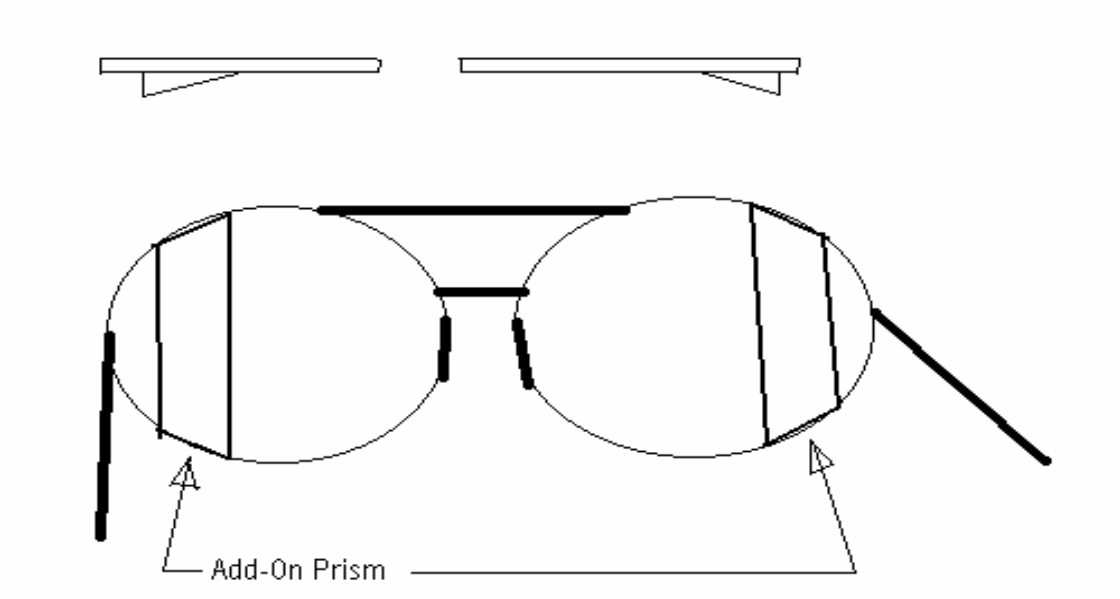

Figure 1 – TV-1A Prismatic Field-Expanding Glasses - *views from rear & top*
(for people having unaided visual field widths from 75 to 120 degrees)

The "TV-1A" Prismatic Field-Expanding Eyeglasses illustrated above can benefit people whose unaided visual fields vary in width from a low of 75 degrees to a high of 120 degrees. The round lenses are standard prescriptions lenses as required for sharpest vision. If no Rx is required, then they are non-Rx (plano) lenses. Plastic or resin lenses are preferred over glass, for light weight and other reasons.

The unique features of these eyeglasses are the vertical prism strips – one is cemented to the inside of each lens. *Plastic stick-on prisms (fresnel prisms) are <u>not</u> satisfactory because of poor image resolution*. Instead, two similar prism lenses of plastic or resin are ordered from the lab. They each have zero refractive correction but both are ground with 10 to 30 prism diopters, each. These lenses should have base curves as close as possible to the base curves of the prescription (carrier) lenses.

One prism lens is positioned and held base-right. It is cut to create a vertical strip that is 1/2 inch wide, with the prism base to the right (as viewed from the rear). The height is trimmed so that it will fit onto the inside of the right carrier lens, toward the wearer's right side.

The other prism lens is positioned and held base-left. It is then cut to create a vertical strip that is 1/2 inch wide, with the prism base to the left (as viewed from the rear). The

height is trimmed so that it will fit onto the inside of the left carrier lens, toward the wearer's left side. Both prism segments are edge-ground for smoothness where the cuts were made.

By trial and error testing, one lens at a time, the best location is determined for each prism segment. The prism should be just overlapping the user's field of active vision while he looks ahead. The prism segments should not be so far toward center as to block, lessen or interfere with the wearer's direct central vision. When the optimum location is determined for each prism segment, it is cemented in place. The wearer is then taught to see clearly ahead, not through the prisms – but to move his eyes slightly, to see to the left or right, through the applicable prism. For seeing farther to the right or left, the person rotates both his head and his eyes in the desired direction.

Prism values should be the same for both eyes. Persons having unaided field widths of 120 degrees can do well with weaker prisms, e.g. those of 10 to 20 prism diopters. Persons with field widths as low as 75 degrees may do best with stronger prisms, e.g. those of 20 to 30 prism diopters. The key to good results lies with the attention and care given to testing and detail by the optical dispenser.

TV-1A Prism Dynamics: The user must be able to see directly (not through the prisms) with both eyes in order to see clearly, comfortably and be able to judge distance. The prisms must be far enough to each side so as to not block direct vision. When the user glances, momentarily to one side (right or left), he temporarily sees far to his side but with only ONE EYE. He can see objects, people or obstacles to know they are there. But to see them clearly or to judge object size and distance, he would need to turn his head for direct observation with both eyes. EXPLANATION: Sight through the prism is with one eye; is momentary; and is to temporarily substitute for the person's missing peripheral vision. It augments, but does not replace, the person's direct vision. People with unaided field widths of 120 degrees have the prisms placed farther to each side than, say, people with unaided field widths of 75 degrees. Images seen through the prisms appear in normal size. **Type TV-1A eyeglasses are the most effective field-expanding eyeglasses, and the most convenient and natural to use. They are the preferred type for people having unaided visual field widths of 75 to 120 degrees.** Prismatic FX devices expand vision to the side - but not up or down. Accessing these prisms is not more difficult than other people's use of bifocal lenses. The needed eye and head movements become automatic with use.

Other types of field-expanding eyeglasses, described below, are best for people whose unaided visual field widths are less than 75 degrees. All are ***"Tubular" FX devices which expand vision up and down, as well as to the sides.*** *The user sees a circular, minified image of the room or outside area. A "Linear" FX device gives the sharpest, distortion free view – but cannot show as large an outside area as a "Non-Linear" FX device.* ***People having larger unaided visual field widths often choose linear FX devices*** *… while* ***those with smaller unaided field widths often choose non-linear FX devices, provided they have normal or near-normal acuity.*** *Designing field-expanding eyeglasses for people having unaided visual field widths less than 20 degrees involves many choices and compromises and is, therefore, complex.*

For Unaided Visual Field Widths: 20 to 75 degrees – "Type TV-2A" Field-Expanding Glasses were most often found to be best. Tubular and non-prismatic, they are assembled as illustrated in Figure 2 … using side-angled (diverging) tubular image minifiers. Using the same basic construction, TV-2A glasses are available with a variety of different optics. The optics to for a particular person can vary depending on the person's unaided visual field widths (for each eye and for both eyes), on the person's best corrected visual acuity, and on the tasks or functions for which the eyeglasses are wanted.

Different optical characteristics are required for people having different unaided visual field widths. The variables are: (1) field expander faceplate: distances from cornea & viewing surface (faceplate) diameters – for each eye; (2) person's unaided visual field width for each eye; (3) person's best corrected visual acuity for each eye; and (4) refractive corrections required to clearly see each field expander's faceplate image. *TV-2A field-expanding eyeglasses are excellent for walking and many other tasks …but are unsuitable and unsafe for driving.*

The TV-2A design provides for two tubular, image-minifying field expanders, one to be mounted on or through each carrier lens. In this design, one tubular field expander is mounted off-center, to the left side of the left lens - and one to the right side of the right lens. The user normally views objects directly through the carrier lenses using both eyes for fused stereoscopic vision. He sees farther to either side by turning his eyes to the left or right, at which time one eye – the eye closest to the desired side – sees the expanded image toward that side. The expanded image is minified (reduced in size) in order to be visible, all at once, in the user's small "tunnel of vision".

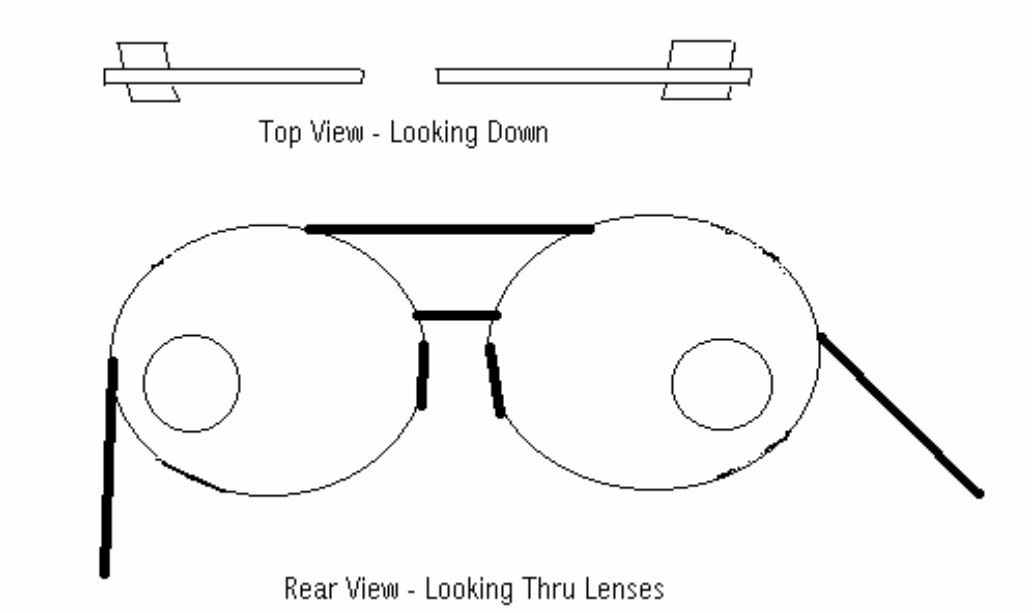

Figure 2 - TV-2A Eyeglasses with Angled or Diverging FX Tubes
(recommended for unaided visual field widths ranging from 20 to 75 degrees)

FX Characteristics - for Unaided Visual Field Widths (Angles): 20 to 75 Degrees

(continued on next page)

In Figure 2, above, the circle on each lens represents the objective lens or faceplate of a tubular field expander. A wide-angle, minified image appears on each of the faceplates. In designing these eyeglasses for a particular individual, important choices have to be made as to the characteristics of the FX devices to be used. ***It greatly helps to have sample devices on hand for comparative testing by each patient, in a trial frame.***

FX Choices include: (1) Maximum Diameter of Faceplate: this always depends on the user's unaided visual field width. Each faceplate should be the widest diameter possible with the eye being able to see all of the faceplate at the same time. A person having an unaided field width of 75 degrees should have a wider faceplate diameter than a person having an unaided field width of only 20 degrees. (2) Overall Width of the Surroundings to be Displayed … and (3) Linearity of Minified Image. Theoretically, the outside viewing angle can be set to any of these values: 180, 140, 120, 90 or 60 degrees. *Linearity is either "Linear" or "Non-Linear"… where "Linear" means the image is minified with very little distortion. "Non-Linear" can show a wider outside angle but has a lot of distortion in the viewed minified image. "Linear" is preferred but requires the user to have a wider unaided field angle and it yields a narrower outside view than would a non-linear FX device.*

Each TV-2A tubular FX is mounted toward the outside of the lens and is angled outward. The user sees through one or the other FX at a given time. Which one is determined by whether he looks left or right. He never sees through both at the same time. Using this design approach, a person can have smaller angle images that are larger and clearer, and still see almost directly to the side. Consider these possible alternatives:

1. A non-linear, reduced-size image showing *140 degrees – if the tube were straight*, not angled toward the side. This image could be useless to a person with greatly reduced acuity. To a person having normal acuity, the edges of the image are smaller than the center of the image. Yet, it is the edge (off-to-the-side) image information that one needs to see clearly. For a person having normal acuity, this type and size FX device helps mostly for walking and seeing nearby objects. *This type FX might be a commercially made "thru-the-door" wide-angle people viewer. These can be purchased with diameters of 1/4 or 3/8 or 1/2 or 3/4 inch … for different faceplate sizes. All use non-linear minification. Focus is usually adjustable by setting the length when mounting the device.* With a 140 degree FX, the user might see objects as far as 70 degrees to his side, but only close objects because of the excessive minification and image distortion. *Non-linear FX devices are useful mostly to users having excellent acuity and desiring the widest possible aided field of vision.*

2. A linear, reduced-size image showing 60 degrees – *with the tube angled* toward the side as shown in Figure 2 can be far more useful. Due to its being angled toward the side, it can enable the user to see as far as 70, 80 or even 90 degrees toward the side – but with an undistorted linear image where even moderately distant objects can be recognizable. *This type FX might be a custom made 2x, 3x or 4x biotic low-vision "telescope" mounted in reverse so as to minify rather than magnify. These devices can be ordered from the labs that make them, in different diameters. Some have focus adjustments but some must be constructed with an Rx*

correction lens affixed to the faceplate. **The "Linear" field expander is the preferred type for people whose unaided visual field widths range from 20 to 75 degrees.** *They can also help people who have both reduced visual fields and reduced visual acuity.* Eyeglasses using these custom made linear FX devices are more costly than eyeglasses using the mass-produced non-linear FX devices.

For Unaided Visual Field Widths: 2 to 20 degrees – "Type TV-2B" Field-Expanding Glasses were most often preferred. They are tubular and constructed as illustrated in Figure 3 - and as described in the text below.

People with unaided visual field widths as narrow as 2 to 20 degrees were the most difficult and time-consuming to effectively help with field-expanding eyeglasses. They needed help the most … and almost all evaluated were helped. The questions that had to be answered generally concerned each person's preferences – which could be determined only through time-consuming comparative testing of different optical configurations.

DRIVING was found to be unfeasible for people with these narrow fields, even with optical or electronic aids. Thus, the glasses were usually designed to facilitate the safest possible walking, and to facilitate each person's activities of daily living (ADL). These activities also included self care, preparing, serving and eating food, reading and writing, etc. People with narrow fields *and* reduced acuity were the most difficult to assist. *Most patients had narrowed fields with good visual acuity and were helped most effectively.*

Optics User Categories: To make these complicated issues easier to deal with, we describe the eyeglass configurations found most useful for each category:

(1) People with Unaided Visual Field Widths of: 2 to 10 degrees, good acuity
(2) People with Unaided Visual Field Widths of: 2 to 10 degrees, *reduced acuity*
(3) People with Unaided Visual Field Widths of: 10 to 20 degrees, good acuity
(4) People with Unaided Visual Field Widths of: 10 to 20 degrees, *reduced acuity*

FX Characteristics - for Unaided Visual Field Widths 2 to 20 Degrees

Figure 3, below, illustrates Type TV-2B Field-Expanding eyeglasses. As with all tubular type field expanders, these devices expand vision up and down, as well as left and right. WALKING is hazardous for people with unaided visual field widths as low as 2 to 20 degrees. Also, visual acuity may be reduced in one or both eyes as the visual fields become this constricted. For these reasons, the eyeglasses are designed for (1) fused binocular vision, directly … and through the FX devices; and (2) the FX devices can be located to permit their use in seeing downward (toward one's own feet and the ground ahead) in addition to seeing toward the sides. This greatly aids one's ability to walk safely.

Referring to (1) above, **binocular vision**, one must be aware that when the unaided visual field widths decrease to less than 20 degrees, it frequently happens that one or both eyes develop dead spots (scotomas) and/or reduced visual acuity. If binocular vision can be established, for both direct viewing and for seeing through two, centered, parallel tubular

FX devices, then the person may retain functionally better visual acuity with the two eyes than with either eye alone.

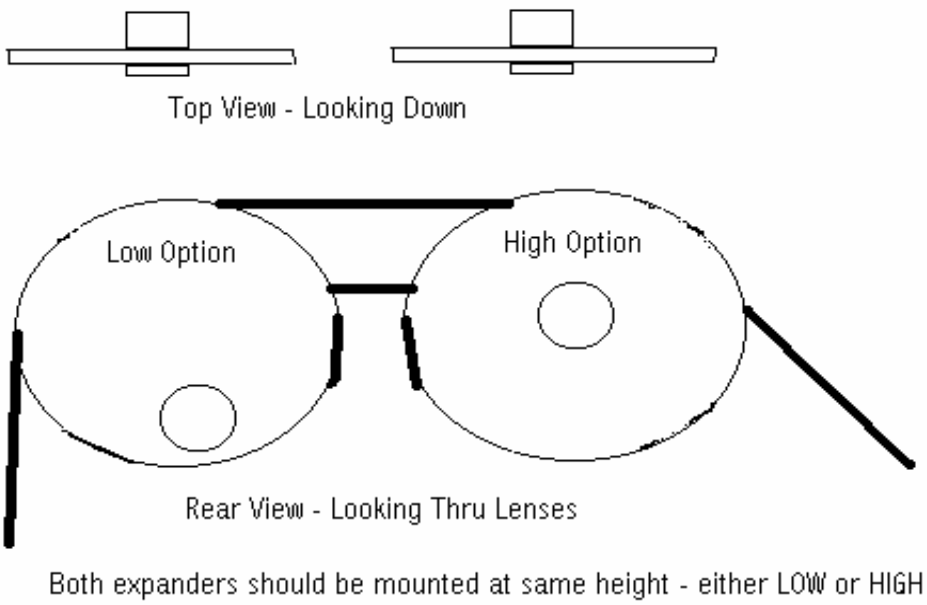

Figure 3 – TV-2B Field-Expanding Glasses for Very Narrow Visual Fields . . . . Ranging from 2 to 20 degrees, unaided
(FX devices can be mounted low- or high – but both should be the similarly mounted)

FX Choices include: (1) Maximum Diameter of Faceplate: this always depends on the user's unaided visual field width. The faceplate should be the widest diameter possible with the eye being able to see all of the faceplate at the same time without scanning. A person having an unaided field width of 20 degrees needs a wider Faceplate Diameter than a person having an unaided field width of only 2 degrees. (2) Optical Field Width of Surroundings to be Displayed reduced on faceplate … and (3) Linearity of Image. The angle can be set to any of these values: 120, 110, 90, 70 or 50 degrees. Linearity is chosen to be either "Linear" or "Non-Linear***"*** ***These choices are further detailed below for each of the "Optics Design Categories."*** Recommendation: Likely progression of the field losses should be taken into account when purchasing FX eyeglasses. An RP patient, may be better off using a design for under 10 degrees, for example, if his unaided visual field widths are 10 to 15 degrees when the glasses are ordered.

POSSIBLE DESIGNS for …

People with Unaided Visual Field Widths: 2 to 10 degrees - *with GOOD acuity*

Good visual acuity: Most patients in this category – after trying both types of field expanders (Linear and Non-Linear) – chose the **Non-Linear FX types** in order to have the widest possible expanded visual fields. They mostly chose to have the tubular FX devices mounted high (right lens as shown in Fig. 3) on both lenses. The mountings were at the users' PDs or pupillary distances, with exactly parallel mountings. The significant

variables, from patient to patient, were faceplate focus adjustments and faceplate diameters. Those with 2 degree unaided visual field widths did best with narrower faceplates (as narrow as 1/4 to 1/2 inch). Those with 10 degree unaided visual field widths did best with wider faceplates (as wide as 1/2 to 3/4 inch). The FX tubes were mounted high to allow direct vision, underneath, for seeing detail and judging distance. By slightly lowering the head and raising the eyes, the user sees through the FX devices with non-linear views of 60 to 140 degrees – the exact width depending on the design of the FX device. *A few patients chose to also have installed on each carrier lens, a second angled- out Linear FX device (mounted as shown in Fig. 2), for added and clearer-at-distance side vision (one eye at a time with eye- and head- turning).*

People with Unaided Visual Field Widths: 2 to 10 degrees - *with REDUCED* acuity

Reduced visual acuity: Most patients in this category – after trying both types of field expanders (Linear and Non-Linear) – chose the **Linear FX types** in order to have the larger and sharper expanded visual fields. They mostly chose to have the tubular FX devices mounted low (left as shown in Fig. 3) on both lenses. The mountings were at the users' PDs or pupillary distances, with exactly parallel mountings. The significant variables, from patient to patient, were faceplate focus adjustments and faceplate diameters. Those with 2 degree unaided visual field widths did best with narrower faceplates (as narrow as 1/4 to 1/2 inch). Those with 10 degree unaided visual field widths did best with wider faceplates (as wide as 1/2 to 3/4 inch). The FX tubes were mounted low to allow expanded-field vision, through them, for seeing the ground and their feet, clearly, while walking. The FX devices used were either 2x, 3x or 4x low-vision bioptic telescopes, reverse-mounted to act as linear image minifiers rather than as magnifiers. Depending on the devices used and the faceplate diameters and distances, the minified visual field width was usually in the range from 40 to 110 degrees. For one-eye-at a-time use, the FX tubes could be angled toward each side, as in Fig. 2. However, most patients preferred parallel mountings at the PD that permitted fused, binocular vision through the FX devices. This was found to be especially helpful when either or both eyes had scotomas (retinal dead spots) and/or reduced visual acuity.

By slightly lowering the head and raising the eyes, the user sees directly through the eyeglass carrier lenses, above the FX devices. This is advantageous when one needs to see detail at any distance, without image reduction or minification, and when one needs to better judge a distant object's actual distance.

People with Unaided Visual Field Widths: 10 to 20 degrees - *with GOOD acuity*

Good visual acuity: About half the patients in this category – after trying both types of field expanders (Linear and Non-Linear) – chose the **Non-Linear FX types** in order to have the widest possible expanded visual fields. The other half chose the **Linear FX devices**. In both groups, most chose to have the tubular FX devices mounted high (right lens as shown in Fig. 3) on both lenses. The mountings were at the users' PDs or pupillary distances, with exactly parallel mountings. The significant variables, from patient to patient, were faceplate focus adjustments and faceplate diameters. Those with 10 degree unaided visual field widths did best with narrower faceplates (as narrow as 3/8 or 1/2 inch). Those with 20 degree unaided visual field widths did best with wider

faceplates (as wide as 1/2 to 3/4 inch). The FX tubes were mounted high to allow direct vision, underneath, for seeing detail and judging distance. By slightly lowering the head and raising the eyes, the user sees through the FX devices with non-linear or liner views of 50 to 140 degrees – the exact width depending on the design of the FX device. *A few patients chose to have installed on each carrier lens, an angled- out FX device (mounted as shown in Fig. 2) instead of using the parallel-mounted tubes. These users had binocular direct vision, but monocular side vision through one or the other angled-out FX devices.*

People with Unaided Visual Field Widths: 10 to 20 degrees -*with REDUCED* acuity

Reduced visual acuity: Most patients in this category – after trying both types of field expanders (Linear and Non-Linear) – chose the **Linear type FX devices** in order to have the larger and sharper expanded visual fields. About half chose to have the tubular FX devices mounted low (left as shown in Fig. 3) on both lenses. The other half chose to have the Linear FX devices mounted high (right as shown on Fig. 3). The mountings were at the users' PDs or pupillary distances, with exactly parallel mountings. The significant variables, from patient to patient, were faceplate focus adjustments and faceplate diameters. Those with 10 degree unaided visual field widths did best with narrower faceplates (as narrow as 1/4 to 1/2 inch). Thus with 20 degree unaided visual field widths did best with wider faceplates (as wide as 1/2 to 3/4 inch). The FX tubes mounted low allowed expanded-field vision, through them, for seeing the ground and their feet, clearly, while walking. The FX tubes mounted high required deliberate lowering of the head for use. The FX devices used were either 2x, 3x or 4x low-vision bioptic telescopes, reverse-mounted to act as linear image minifiers rather than as magnifiers. Depending on the devices used and the faceplate diameters and distances, the minified visual field width was usually in the range from 40 to 110 degrees. For one-eye-at a-time use, the FX tubes could be angled toward each side, as in Fig. 2. However, most patients preferred parallel mountings at the PD to facilitate fused, binocular vision through the FX devices. This was found to be especially helpful when either or both eyes had scotomas (retinal dead spots) and/or reduced visual acuity.

Night Blindness may result from the reduced peripheral vision, alone. Or, for a given person, there may be other, additional causes. An informative paper titled: ***"Information About Impaired Night Vision and Night Blindness"*** is available on request from this Institute and is a recommended reference. Electronic night viewing aids can sometimes be helpful. Some use visible light, for short distances; others detect infrared for long distance night viewing.

Safe Driving may be possible for some people having impaired or reduced peripheral vision, with unaided visual field widths greater than 75 degrees. Thusly disabled people may benefit from using field-expanding eyeglasses, wide-angle non-minifying rearview mirrors in the vehicle, personalized on-the-road driver training, and residence in a state willing to road-test and license drivers with impaired peripheral vision. Even if able to drive safely and legally in daylight, some drivers will- and others will not- be able to drive at night. **REAR-VIEW video systems, for safer driving**, became available in 2003. Some come with new cars and vans; others can be installed in existing vehicles.

Local driving environments vary tremendously for all drivers, handicapped or not. The same individual may drive safely and without stress in some areas but not others. For this reason, it is recommended that all on-the-road driver training be conducted on realistic conditions where the person lives, works and desires to drive. Driving skills training and assessment services should always be provided by state licensed driver training personnel who regularly teach defensive driving and driving safety, on-the-road.

Current and Future Developments

At the time of this writing, people with glaucoma can usually, if diagnosed early, have the disease fully arrested so that there is no further progression or vision loss. Glaucoma patients are fortunate that their progression can usually be stopped. For this reason, it is best to completely avoid having one's vision impaired by glaucoma. This can be accomplished by having regular eye examinations to detect elevated intra-ocular pressure when it first occurs – so that immediate treatment can prevent retinal and optic nerve damage from even beginning.

People with retinitis pigmentosa or Usher's syndrome may have the progression of vision loss slowed – but it cannot be stopped. Eventually, most people with this disease become functionally blind – and then totally blind. Fortunately, there are some exciting new developments now being tested which show promise. Among them are:

(1) Transplants of good retinal cells from donors, to replace dead and dying cells.

(2) Transplants of whole eyes from donors to blind recipients.

(3) Stem Cell research to grow new ocular or intra-ocular tissues. Unfortunately, this is currently being delayed by the government's policy to limit stem cell therapies.

(4) Implants of electronic retinal or optic nerve stimulators within the eye, to provide artificial vision to people who may otherwise be totally blind.

(5) Artificial Vision using a TV camera to feed live, moving images directly to the brain's occipital cortex in real time.

More information about these new developments can be gotten from searching the internet, from newspapers and medical journals, from eye doctors, and from non-profit organizations such as those for "Retinitis Pigmentosa" and "Usher's Syndrome."

For additional information or free technical support, please email: nire@warwick.net or contact us by regular mail or telephone.

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