(54) Title: AN OPHTHALMIC DEVICE AND A METHOD OF OPHTHALMIC ASSESSMENT

(57) Abstract: A improved opthalmic device (1) including a plurality of charts for assessment of vision, visual acuity and/or contrast sensitivity, wherein said device provides a glare screen positioned in front of a variable illumination source of up to 6000 cd/m² and wherein the charts are adapted to be placed over the glare screen for retro illumination by the variable illumination source, and wherein said device provides a photometric sensor that detects the external luminance of said screen, said photometric sensor having a feedback mechanism to the variable illumination source of the opthalmic device thereby maintaining the luminance of the screen at a desired level.
AN OPHTHALMIC DEVICE AND A METHOD OF
OPHTHALMIC ASSESSMENT

The present invention relates generally to an ophthalmic device and a method of
ophthalmic assessment, more particularly to an ophthalmic device adapted to enable a
plurality of ophthalmic measurements and to derive measures of visual performance.

Background to the Invention

The determination of a subject’s vision and visual acuity is of particular relevance to
ophthalmologists, optometrists, medical practitioners, occupational health assessors and
visual scientists. Visual acuity and vision are typically measured in terms of the resolution
of high contrast square wave tasks. This is routinely achieved by using vision charts
having black letters on a white background. Traditionally letters or symbols on a chart are
viewed at a specified distance, usually 6 metres, or in the USA, 20 feet. (The Snellen
fraction of 6/6 is equivalent to 20/20).

Vision is the measure of visual performance with the eyes in the uncorrected state and
visual acuity is assessed when the refractive error of the eyes is corrected.

A limit or threshold for the resolution of a certain size of black letters on an eye chart has
come to be the standard for many occupational and vocational activities, such as the driving
licence standard. The rationale is that the tests are:

- easy to administer,
- widely available, with inexpensive technology,
- repeatable, and
- a sensitive way of determining associated human performance attributes such as
driving ability.

It is generally accepted that the resolution of letters in a line on a chart is a function of:

- aspect ratio,
- font style,
- recognition,
- print quality,
• veiling luminance [e.g. sun in your eyes],
• contrast [background of the chart may have yellowed, be dirty or damaged], and
• working distance – as distinct from the calibrated distance – usually 6 metres (or 20 feet).

Resolution may also be affected by the manner of presentation to the viewer. Letters may be printed or photographically reproduced, viewed directly, indirectly in a mirror, retro or directly illuminated, projected on a screen or computer generated, viewed on a Cathode Ray Tube, Thin Film Transistor Liquid Crystal Displays or plasma screen. Chart systems printed on cardboard are readily available but these are difficult to hang in a convenient position in a bedroom, industrial environment, and the like. The results from these charts are highly variable and provide only a gross indication of visual performance.

A major disadvantage of using high-contrast letters as test objects to measure visual acuity is the well-known fact that they are not of equal legibility. In other words, near threshold, some letters are identified correctly much more often than others. To overcome this problem, many charts only use letters that have been shown to have similar legibility. Visual acuity charts adhering to British standard BS 4274 (1968) and the Bailey- Lovie charts use the 10 letters D,H,N,V,R,Z,F,P,E and U. The legibility of these letters is considered to differ by less than 20%. Many American charts use the Sloan letters, D,H,N,V,R,Z,S,K,O and C.

The legibility of letters is affected by neural interaction at a retinal level and is associated with spacing between letters, adjacent lines of letters and the boundaries to the chart. The logMAR chart system devised by Profs. Ian Bailey and Jan Lovie-Kitchen, overcomes these deficiencies by spacing the letters one letter width between them. Each line is separated from the line above by a space equal to the height of the line.

Though the importance of vision in many daily tasks is plain, conventional visual acuity tests are rarely correlated to functions such as mobility, face recognition, sports, or for driving, because the ‘real world’ is composed of objects of varying sizes (spatial frequencies) and contrasts. Current visual acuity assessments are too simplistic to provide a true reflection of visual performance for everyday visual tasks. This is because many
objects we discriminate do not have a high contrast, nor do they have ‘hard’ edges. For example we may detect the detail in homogenous, single colour objects with subtle changes in contrast, such as the ripples in the surface of a garment.

The BEGAT system of vision assessment was developed and designed for a 1 metre working distance as a result of the development of the Berkley Glare Test. The 1 metre working distance exposed an expanded visual angle of illuminated retina to accurately assess glare disability.

The BEGAT system utilises the backlighting source of glare at lower luminance levels as the background illumination for charts. The luminance can be stabilised by a microprocessor controlled feed-back circuit, calibrated in 0.5 log unit steps from 3,100cd/m², to 1000cd/m² and 310 cd/m² for the determination of glare disability.

The BEGAT device represents a break from all traditional chart systems in that it operates as a direct chart at 1M instead of 6M. The foreshortened working distance of 1 m is useful for assessing visual acuity because it enables more lines of letters in the larger sizes to be included on the charts. With the chart only 1 metre away from the patient, the practitioner can easily point to individual letters and lines.

The Berkeley Glare Test [BGT] included a letter chart and Profs. Ian Bailey and Mark Bullimore, the inventor of the BGT, proposed using a working lens of +0.75D to compensate for the Working Distance [WD]. Theoretically the working lens should be 1D for a distance of 1M, however it should be pointed out that tests using a 6M chart with a vergence of 1/6 = +0.17D are conducted without a working lens. There is also some latency in the visual system of about +0.25D. On that basis plus the calculation for the working lens of +0.75D is:

\[ +0.75 + 0.17 = +0.92D \] (which is close enough to 1D for practical purposes).

The greater viewing angle allows a larger area to be used for the chart, hence for the larger letters, complete lines of letters at low spatial frequencies can be accommodated. This means that not only can charts at low spatial frequencies be produced – but previously the largest letters on the chart was a single 6/60 [20/200 or logMAR 1.0] letter that was easily
memorised and of little value as an object to be recognised. To measure vision below this point the practitioner either has to move the subject towards the chart if it is fixed, or move the chart towards the subject. The measurement fraction then assumes a numerator value of the WD, hence for 4 metres the fraction becomes 4/60 [or 15/200].

With the larger viewing angle chart, five 6/60 letters can be accommodated, along with several lines of letters larger than logMAR1.0, extending to 6/190 or logMAR 1.5 overcoming the need to move the chart closer to the subject for low vision assessment.

10 **Comprehensive Central Visual Performance [CVP] assessment with the BEGAT**

Chart systems are traditionally restricted to the measurement of high contrast vision and visual acuity, with some additional features to assess binocular vision. However, there remains a need for more advanced vision assessment and visual acuity tests to predict 'real world' visual performance, for example, to predict driving ability, or to investigate differences between children who are 'good' readers and those who are 'disabled' readers. This is because of the current difficulties in assessing contrast sensitivity. For driving and other vocational or occupational tasks performed against a background of glare, the metrics of glare visibility becomes a significant issue that may compromise safety.

20 **Contrast Sensitivity**

The response of the visual system to the various qualities of tasks may be plotted for a range of spatial frequencies and levels of contrast, or its reciprocal - sensitivity. Contrast sensitivity function provides a more complete investigation of visual function. (The higher the spatial frequency, the smaller the detail to be resolved.) Contrast sensitivity may be used to detect visual problems at an early stage before serious symptoms develop, to understand the patient's problem and to help manage that problem (for example, by advising a patient of increased risks if driving in low contrast conditions).

The plot of spatial frequency [X axis] against sensitivity [Y axis] is termed the Contrast Sensitivity Threshold [CST] curve. See Figure 1.
It is important to note that black letters on a white background representing the maximum contrast [minimum sensitivity], measure only one point on the contrast sensitivity curve.

The assessment of contrast sensitivity has been largely left to academia for a variety of reasons, including:

- a lack of convenient, inexpensive technology,
- the time consuming nature of the tests, and
- a denial/rejection of the validity of the functional assessment in terms of everyday human performance.

The available CST technology is generally designed to assess either two points on the curve in addition to the high contrast black letters/white background, the so called ‘low contrast’ - 10% Michelson contrast, and edge detection [such as the Melbourne Edge Test]. See Figures 2 and 3 below respectively.

\[
\text{Michelson Contrast} = \frac{l_{\text{max}} - l_{\text{min}}}{l_{\text{max}} + l_{\text{min}}},
\]

where \(l_{\text{max}}\) is the background luminance, and \(l_{\text{min}}\) is the letter or target luminance.

Veiling luminance \([l_{\text{veil}}]\) from extraneous sources or through scatter within the eye adds to both \(l_{\text{max}}\) & \(l_{\text{min}}\), hence contrast is reduced thus:

Veiled [or disability glare] Contrast
\[
= \frac{(l_{\text{max}} + l_{\text{veil}}) - (l_{\text{min}} + l_{\text{veil}})}{(l_{\text{max}} + l_{\text{veil}}) + (l_{\text{min}} + l_{\text{veil}})}
\]

**Edge Detection**

Is the threshold at which the eye can just perceive a border of contrast differential at a spatial frequency of around 1 cycle/deg. (See Figure 3 below)

Other charts have used rows of patch gratings of different spatial frequencies with a reduction in contrast along the row such as the Vistech chart, VectorVision CSV-1000 or triplets of letters with a fixed spatial frequency, such as the Pelli-Robson chart.
Current methods of measuring contrast sensitivity are also affected by stray light entering the eye from surrounding [wall] surfaces and from the scattering within the ocular media. This is known as veiling luminance.

5 **Glare Disability**

Glare disability is measured as a reduction in vision acuity from the normal when subjected to glare conditions, such as from oncoming headlights and is prevalent particularly in older people who are developing cataract, or when driving into the sun with a dirty windscreen.

10 **Glare Recovery**

Glare recovery may be a problem, particularly in the aging population afflicted with age related maculopathy. Significant but temporary reduction in visual performance may occur when the eye is exposed to direct sunlight until the bleaching of the retina is overcome by regeneration of the visual pigments. This phenomenon can be quantified by exposing the eye to a strong source of light, then measuring how long it takes to recover ‘normal’ acuity.

**Mesopic Vision**

The central retina is endowed with high concentrations of cone cells to resolve fine detail and perceive colour. In normal illumination when cone cells are stimulated, we function with Photopic vision. In ‘twilight’ conditions cone cells are desensitized and the more peripheral ‘rod’ cells become activated. In this state we are said to be using Mesopic vision.

Aberrations in the optical system become more apparent in low luminance, mesopic conditions when the pupil is larger.

To measure mesopic vision the subject must resolve letters at 1%, or for certain FDA tests, at 3% light levels, achieved by viewing the chart through goggles with 1% or 3% transmission filters. Subjects must be dark adapted for 5mins before undertaking the test.
Traditional chart systems do not compensate for veiling luminance and cannot measure glare disability, glare recovery or contrast sensitivity. To do so a range of instruments is required for each individual test, examination time is extended and procedure disrupted while transferring from instrument to instrument.

It is an object of the invention to provide an improved ophthalmic device and a comprehensive method of ophthalmic assessment of visual performance, to overcome the deficiencies of existing systems, or to at least provide a useful choice.

**Summary of the invention**

In a first aspect, the present invention provides an ophthalmic device including a plurality of charts for assessment of vision, visual acuity and/or contrast sensitivity, wherein said device provides a glare screen positioned in front of a variable illumination source of up to 6000 cd/m² and wherein the charts are adapted to be placed over the glare screen for retro illumination by the variable illumination source, and wherein said device provides a photometric sensor that detects the external luminance of said screen, said photometric sensor having a feedback mechanism to the variable illumination source of the ophthalmic device thereby maintaining the luminance of the screen at a desired level.

In a preferred embodiment, the illumination source is adapted to provide calibrated chart luminance. More preferably the contrast densities of one or more images on the charts are corrected for veiling luminance.

In a preferred embodiment, the photometric sensor is positioned on a forehead of a subject to be tested using the ophthalmic device. More preferably, the photometric sensor is able to relay information to the device by wire, infra-red transmission, Bluetooth, or alternate WiFi protocol.

In a preferred embodiment, the photometric sensor is adapted to detect veiling and/or ambient illumination reflection from the chart.

In a preferred embodiment, the device is programmable and is more preferably pre-programmed to provide a predetermined level of luminance specific to each chart. More
preferably a control unit within the device will control a chart dispenser. It is further preferred that the control unit will dispense a selected chart as well as adjusting the luminance levels for the selected chart.

5 In a preferred embodiment, the device provides a chart dispenser that is capable of holding two or more charts, and dispensing and retrieving a chart to the screen for use and storage. Preferably, the dispenser is able to detect information stored within chart. More preferably the information stored within the chart includes any one of, chart type, chart orientation, chart calibration information, and a chart correction factor. Even more preferably the information is stored on the chart as a bar code or an RF Tag.

10 In a further embodiment, the device as adapted for a working distance of 1 meter. Preferably, a working lens for the subject to be tested is provided for.

15 In a preferred embodiment the device includes a modulation transfer chart, in one version of the chart systems which is adapted to enable the measurement of at least 9 and in another 16 or more points on the contrast sensitivity curve.

In a preferred embodiment the device may include charts for the assessment of glare disability.

20 In a more preferred embodiment, the device may further include charts for binocular vision assessment, fixation disparity, duochrome, cross cylinder targets and astigmatic fan.

25 In a preferred embodiment the device includes an extended range 10% Michaelson Contrast chart and Melbourne Edge, Bailey Border, or alternate border contrast test.

25 Preferably, the charts are low contrast positive film charts.

30 In a preferred embodiment, the device includes a ranging device to establish the working distance between the screen and the subject to be tested. Preferably, the ranging device comprises convergent beams of light, ultrasonic detection, and the like. More preferably,
the ranging device is adapted to provide a signal when the subject is in the optimum working distance. Preferably, the signal is a visual or an audio signal.

In a second aspect the present invention provides a method of making an ophthalmic assessment of a subject’s vision, visual acuity, binocular visual status and/or contrast sensitivity, by using a device as defined above including the steps of

a) presenting to the subject one or more charts from a selection of charts, including binocular vision, fixation disparity, duochrome, cross cylinder targets and/or astigmatic fan charts,

b) illuminating one or more of the charts before a subject, and

c) obtaining responses from the subject for each chart.

 Preferably, the method further includes the step of
d) analysing the subject’s responses to make one or more ophthalmic assessments of the photopic or mesopic vision or visual acuity, glare disability and/or contrast sensitivity of the subject, and
e) assessing the refractive status of the subject.

In a third aspect, the invention provides one or more ophthalmic charts suitable for use in the device and method defined above, wherein said charts are adapted for retro illumination.

Preferably, in one embodiment the charts are prints on acrylic film or slides. In an alternative embodiment, the charts are preferably printed as positive film charts. In both instances, it is more preferred that the charts are laminated to protect the printed surface of the slides.

Further aspects of the present invention will become apparent from the following detailed description, which is given by example only, with reference to the accompanying figures in which:

Figure 1 shows schematically the Contrast Sensitivity Curve

Figure 2 shows schematically the Contrast Sensitivity Curve.
Figure 3 shows schematically the Contrast Sensitivity Curve.

Figure 4 shows schematically a perspective view of one embodiment of the ophthalmic device.

Figure 5 shows schematically a perspective view of a part of the ophthalmic device with a remote control unit.

Figure 6 shows schematically a side view of an ophthalmic device and its relationship to that of a subject undergoing assessment.

Figure 7 shows schematically an exploded view of the arrangement of the source of illumination and a diffuser panel of the ophthalmic device.

Figure 8 shows schematically a view of an ophthalmic chart for determining low vision high contrast.

Figure 9 shows schematically a view of an ophthalmic chart for determining high contrast vision and visual acuity.

Figure 10 shows schematically a view of an ophthalmic chart for determining high and low contrast [10% Michaelson] glare disability.

Figure 11 shows schematically a view of an ophthalmic chart for determining extended high and low contrast [10% Michaelson]

Figure 12 shows schematically a view of an ophthalmic chart for a Melbourne edge test determination

Figure 13 shows schematically a view of a children's ophthalmic turtle chart for determining high contrast vision and visual acuity.
It is to be appreciated that the examples and embodiments described are given by way of example only and are not limiting on the scope of the invention.

**Detailed Description of the Invention**

With reference to Figure 4, the invention provides an ophthalmic device 1 having a glare screen 2. Behind the glare screen is a source of variable illumination (not shown) that may provide luminance up to 6000cd/m². The preferred source of illumination behind the glare screen will be a mercury free discharge source, generating light using pulsed dielectric impeded discharge into Xenon gas. Such a lamp, known as the Planon lamp is manufactured by Osram. To diffuse the light evenly across the entire glare screen 2, a diffuser panel 11 is positioned in front of the flat Planon lamp 12 as shown in Figure 7. The diffuser panel 11 is separated by a space 13 from the lamp and is bordered by an internally reflecting box/frame 14.

Neutral density filters interposed between the PLANON light source and the charts in conjunction with electronic dimming will enable continuous variation of the luminance under the direct control of the operator. A wide dynamic range will be available for specific tests.

It is to be noted that the source of illumination in the embodiment illustrated is completely housed. The desirable feature is that the chart system is self-contained and independent of the room illumination. For greatest accuracy assessments will be conducted with the room lights off, however the contribution of the ambient light is detected by external sensors and compensatory adjustments made to the Planon luminance by a microprocessor controller to maintain the selected set-point.

A chart dispenser 3, in the embodiment illustrated, dispenses calibrated charts 4 over the front of the glare screen 2. In one embodiment a control unit (not shown) within the device may not only dispense a selected chart but may also adjust the luminance levels for the selected chart. The chart dispenser 3 may be accessible to the practitioner for replacement of the charts for any reason, including charts that have been damaged, recalibrated, reordered, or substituted for a new specification or design.
Figure 5 shows one embodiment of the device including additional external illumination sources 5. These may be used in a situation where there is a need to directly illuminate the likes of an opaque chart that has to be read against the glare screen.

The device also provides a photometric sensors (not shown) that would detect the veiling and/or ambient illumination reflecting from the chart surfaces. Such a sensor would feedback the veiling/ambient luminance level to the ophthalmic device, adjusting the source of retro illumination to counter the veiling/ambient luminance. This will ensure that the retro illumination is calibrated and standardised appropriately to maintain control levels. The photometric sensor comprises a sensor capable of detecting and measuring light levels. An external photometric sensor ensures that the illumination remains constant and correct for a particular measurement. Ideally the photometric sensor is placed on the head of the patient ensuring the illumination level is correct for the user. This provides the benefit that veiling luminance at the user can be accounted for ensuring an accurate light level at the patient.

In one embodiment, critical assessments involved with for example, clinical studies, the photometric sensor may be mounted on the forehead of the subject, accurately measuring the luminance along the visual axis.

The output of this photometric sensor may be transmitted to the master controller of the instrument by wire, infra-red transmission, Bluetooth or alternate WiFi protocol. At the instant of recording the result of the test, the luminance value may be factored into the calculation of the visual performance.

**Chart encoding & Calibration**

The chart cartridge on the eye-C holds 14 charts plus a neutral density filter and an occluder.

As the charts can be selected from a library by the practitioner and inserted in any order into the cartridge of the dispenser, it is necessary to create a register of their position in the rank and to ensure that they have been inserted with the correct orientation. This is achieved by encoding a rail along the top of the chart that is read by sensors during an initial scan of the cartridge when the unit is powered up.

These sensors will determine the:

- order of the charts in the stack, that the
• orientation of the chart is correct, & the
• the type of chart, batching information, etc.

For general practice it is intended to maintain levels of quality control for the production charts that will be superior to existing products and therefore calibration will be unnecessary. However for pre-employment assessment, adjudicating employment qualification or litigation issues, disease detection and research, a complete calibration will be undertaken. The values will be embedded in technology such as proximity security tags, e.g. bar code, or RF Tags positioned on or near the top of the chart.

The calibrated values will be detected and introduced as a correction factor for the performance profile.

It is further envisaged that the luminance levels from the glare screen may be preset at 0.5log unit intervals for a glare disability test, plus several other presets for special tests. These levels may be controlled within a narrow range determined by analysing current research publications. The control parameters may be further refined as information becomes available from research using the device to measure statistically significant cohorts of subjects for each visual performance classification. Alternatively the practitioner may specify the luminance for a specific test.

The very high levels of illumination of around 6000cd/m², achieved by the ophthalmic device will enable the surface to be viewed directly as a source to test for glare recovery. Following the subject’s exposure to these high levels of illumination, the appropriate chart will be dropped into position and the recovery in visual acuity noted.

It is preferred that the device is further adapted to provide remote control over the device through control panel 6. Such remote control may be provided through a palm display unit 7 or the like to provide wireless or infra-red control of the ophthalmic device. It is anticipated that the device will have the capacity to process the results from the patient and transmit the output to the patient management system for integration with their records or for further processing. The patient management system may generate a printed summary of the test results including the contrast sensitivity curve and information about the impact of the results on the visual performance of the subject.
In use, the device is set up so that the distance between the glare screen and the eyes of a subject 8 is a working distance 9 of approximately 1 metre. It is to be appreciated that another working distance could also be utilised provided the device is appropriately calibrated to account for the working distance. One embodiment of the invention would provide the device being set up with extendable legs 10 (optionally on rollers) to enable the movement of the device into the correct alignment and position to enable measurements to be taken.

Another embodiment envisaged is the inclusion of a ranging mechanism in the device to maintain the working distance of the device. It is envisaged that the ranging device will sense the position of the subject from the chart and provide an audible or visual signal to the operator. It will be appreciated that the ranging device can comprise any method for measuring a distance, but may include a sensor involving convergent beams of light or, ultrasonic detection and the like.

The current development utilising ultrasonic detection, is accurate to within +/- 1cm and signals the range of the instrument to the practitioner with an array of colour LED’s. For more accurate determination of the range, the sensor system provides a RS232 output with the exact reference distance. This data may be factored into the calculation of visual performance by correcting the angle subtended by the symbols or letters.

In a preferred embodiment, the device is programmable and is more preferably pre-programmed to provide a luminance profile specific to each chart.

In use, an operator of the device will determine the range of assessments the subject is to undertake. The optionally remote control unit held by the operator may be programmed to receive the patient responses and may process the data to provide an output in various formats compatible with most common patient management systems. It is also envisaged that the subject’s response will provide an output directly to a printer for a graphical analysis of the subject’s visual performance.
Figures 8 to 13 show examples of a variety of ophthalmic charts for assessing a number of visual variables.

The extended range of letter sizes that may be featured on the charts provides an accurate assessment method for Low Vision performance (including subjects registered as blind) without reducing the WD between the subject. It is to be appreciated that the charts and preferred WD of 1 meter do not however preclude reducing the WD. Further this technology provides a method of calibrated assessment, rather than a completely unscientific statement about C.F. [counting fingers] at 1 metre -- a frequent notation on record cards. It is also strategically preferred that the charts in a particular format are available in different letter sequences for each eye where it is important to eliminate the possibility of memorization.

All the charts may be printed directly onto acrylic slides which have been preferably laminated on the printed surface with a protective film, or alternatively as positive film charts which have been preferably laminated face down onto acrylic slides to protect the printed surface. The lamination step must be conducted under strict conditions to ensure that dust or the like is not captured on the charts.

It is envisaged that the positive film charts will be computer generated and printed with advanced pixelating printers capable of maintaining the contrast levels with minimum drift. Further research is being conducted to improve the production technology at very low contrast levels <2.5%.

The present 10% glare disability chart has been manufactured as a bromide print laminated onto an aluminium substrate. The correction factor to convert from a negative to the bromide has been complicated by temperature drift during the manufacturing process, variability in the metrics of the film, the developer activity and other factors.

More consistent results may be achieved by laminating a 10% positive film chart onto a high reflectance board or plastic sheet, rather than aluminium. A further line of investigation will be to print the glare disability charts in three different densities, one for each of the preset glare levels. Each chart will be printed at a contrast density calibrated to
be 10% [Michaelson Contrast] above the background luminance of 80 cd/m² to 100 cd/m² when allowance is made for veiling glare. Effectively this will produce the same effect as viewing a positive film chart through a neutral filter overlaid on the glare screen and with a density sufficient to reduce the background luminance of 80 cd/m² to 100 cd/m². The three charts will be dispensed sequentially to provide the spectrum of measurements at the 0.5log unit steps of glare.

For general practice it is intended to maintain levels of quality control for the charts that will be superior to existing products and therefore calibration will be unnecessary. However for pre-employment assessment, adjudicating employment qualification or litigation issues, disease detection and research, a complete calibration will be undertaken. The values will be embedded in technology such as proximity security tags [RF tags or Bar codes] positioned on the top of the chart. The calibrated values will be detected and introduced as a correction factor for the performance profile. The controller will be programmed to receive the patient responses and will process the data to provide an output in various formats compatible with the most common patient management systems.

There is the potential to retain the subject results in a database in the practice management computer then to subsequently mine this data via the internet for international epidemiological studies.

It is an advantage that the invention incorporates features and tests for many metrics of visual performance in one convenient, efficient device that will cost less to produce than the sum of all other instruments to perform the same range of functions. It is also an advantage that the device of the invention may be incorporated into a portable unit and thereby provides one with the ability to undertake a full range of tests in any environment. For example, the device of the present invention will be easily transportable between branch practices while still providing a standardised chart system for subject assessment in difficult environments such as residential care facilities, beside a hospital bed, industrial screening and the like.

It is an advantage of the present invention in that the instrument will reduce the length required and provide greater flexibility in the layout of consulting rooms. Charts are viewed directly at a working distance of 1M for accessibility and a greater visual angle. It
allows monocular and binocular assessment of visual performance factors and is independent of inter pupillary distance.

It is an advantage to be able to illuminate the charts through a wide dynamic range of luminance, accurately maintained at specified set points by sensing the ambient conditions and compensating for veiling luminance along the visual axis.

It is an advantage that the working range of the instrument may be sensed by ultrasonic or optical measuring devices providing a visual or audible output. For very accurate control of the visual angle, a RS232 output may be factored into the calculations for the CVP.

More accurate visual function assessment may:

- provide help to prevent medical malpractice cases. Poor quality of vision after corneal surgery, measured by contrast sensitivity testing, has been used as an argument for the plaintiffs to imply surgeon malpractice. A key defense in these cases may be the plaintiffs' poor contrast sensitivity profile before surgery. Documentation of this would provide an additional protection from a medico-legal standpoint

- monitor ocular pathology – e.g. readiness for cataract extraction, detection of early glaucoma, diagnosis of forme fruste keratoconus and corneal dystrophies and the progression multiple sclerosis are some examples

- assess Central Visual Performance [CVP] to support forensic investigations

- assess Contrast Sensitivity [CS] pre- and post-Photo Dynamic Therapy [PDT]

- screen for pre and post-employment industry visual standards

- monitor CVP during employment to meet health, safety and performance standards.

- monitor the CVP of the elderly under photopic and mesopic conditions for driving vision
• critically assess new contact lens systems and the aging of lenses

Wherein the foregoing description reference has been made to integers having known equivalents thereof, those integers are herein incorporated as if individually set forth.

It is to be appreciated that modifications and variations may be made to the embodiments and invention described herein without departing from the spirit or scope of the invention.
What I Claim Is:

1. An ophthalmic device including a plurality of charts for assessment of vision, visual acuity and/or contrast sensitivity, wherein said device provides a glare screen positioned in front of a variable illumination source of up to 6000 cd/m² and wherein the charts are adapted to be placed over the glare screen for retro illumination by the variable illumination source, and wherein said device provides a photometric sensor that detects the external luminance of said screen, said photometric sensor having a feedback mechanism to the variable illumination source of the ophthalmic device thereby maintaining the luminance of the screen at a desired level.

2. A device according to claim 1, wherein the illumination source is adapted to provide calibrated chart luminance.

3. A device according to claim 1, wherein the contrast densities of one or more images on the charts are corrected for veiling luminance.

4. A device according to claim 1, wherein the photometric sensor is positioned on a forehead of a subject to be tested using the ophthalmic device.

5. A device according to claim 1, wherein the photometric sensor is able to relay information to the device by wire, infra-red transmission, Bluetooth, or alternate WiFi protocol.

6. A device according to claim 1, wherein the photometric sensor is adapted to detect veiling and/or ambient illumination reflection from the chart.

7. A device according to claim 1, wherein the device is programmable.

8. A device according to claim 7, wherein it is pre-programmed to provide a predetermined level of luminance specific to each chart.
9. A device according to claim 1, wherein a control unit within the device controls a chart dispenser.

10. A device according to claim 9, wherein the control unit will dispense a selected chart as well as adjusting the luminance levels for the selected chart.

11. A device according to claim 1, wherein the device provides a chart dispenser that that is capable of holding two or more charts, and dispensing and retrieving a chart to the screen for use and storage.

12. A device according to claim 1, wherein the dispenser is able to detect information stored within chart.

13. A device according to claim 12, wherein the information stored within the chart includes any one of, chart type, chart orientation, chart calibration information, and a chart correction factor.

14. A device according to claim 12, wherein the information is stored on the chart as a bar code or an RF Tag.

15. A device according to claim 1, wherein the device as adapted for a working distance of 1 meter.

16. A device according to claim 1, wherein a working lens for the subject to be tested is provided for.

17. A device according to claim 1, wherein the device includes a modulation transfer chart, in one version of the chart systems which is adapted to enable the measurement of at least 9, at least 16 or more points, on the contrast sensitivity curve.
18. A device according to claim 1, wherein the device may include charts for the assessment of glare disability.

19. A device according to claim 1, wherein the device may further include charts for binocular vision assessment, fixation disparity, duochrome, cross cylinder targets and astigmatic fan.

20. A device according to claim 1, wherein the device includes an extended range 10% Michaelson Contrast chart and Melbourne Edge, Bailey Border, or alternate border contrast test.

21. A device according to claim 1, wherein the charts are low contrast positive film charts.

22. A device according to claim 1, wherein the device includes a ranging device to establish the working distance between the screen and the subject to be tested.

23. A device according to claim 22, the ranging device comprises convergent beams of light, ultrasonic detection, and the like.

24. A device according to claim 22, wherein the ranging device is adapted to provide a signal when the subject is in the optimum working distance.

25. A device according to claim 22, wherein the signal is a visual or an audio signal.

26. A method of making an ophthalmic assessment of a subject’s vision, visual acuity, binocular visual status and/or contrast sensitivity, by using a device as defined above including the steps of
   a) presenting to the subject one or more charts from a selection of charts, including binocular vision, fixation disparity, duochrome, cross cylinder targets and/or astigmatic fan charts,
   b) illuminating one or more of the charts before a subject, and
   c) obtaining responses from the subject for each chart.
27. A method according to claim 26, wherein the method further includes the step of
d) analysing the subject’s responses to make one or more ophthalmic assessments of
the photopic or mesopic vision or visual acuity, glare disability and/or contrast sensitivity
of the subject, and
e) assessing the refractive status of the subject.

28. One or more ophthalmic charts suitable for use in the device and method defined
above, wherein said charts are adapted for retro illumination.

29. A chart according to claim 28, wherein the charts are prints on acrylic film or
slides.

30. A chart according to claim 28, wherein the charts are preferably printed as positive
film charts.

31. A chart according to claim 28 or claim 29, wherein the charts are laminated to
protect the printed surface of the slides.
100% Contrast on the Contrast Sensitivity Curve
10% Contrast on the Contrast Sensitivity Curve
Figure 3

Border Contrast Threshold

Equivalent Visual Acuity

Border contrast threshold measures peak sensitivity.

Contrast Sensitivity

VA @ Peak Sensitivity

Spatial Frequency (cycles/degree)
Figure 8

Low Vision Chart
Figure 9

Universal Chart
Disability Glare Chart

Background luminance = 100 cd/m^2

Range from logMAR 0.9

Surround luminance adjustable from 310 cd/m^2 to 1000 cd/m^2 to 3100 cd/m^2

logMAR -0.3
MELBOURNE EDGE TEST

1  2   9   13  14
15  16  17  18  19
20  21  22  23  24

Horizontal  Vertical  Left  Right
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. A61B 3/032 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI: IPC A61B 3/- and keywords variable, illumination, chart, backlit and similar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 5592247 A (TROKEL) 7 January 1997 Column 5 line 66–Column 6 line 50; Figures 1–4</td>
<td>1–3, 16, 18–20</td>
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<tr>
<td>Y</td>
<td>US 4285580 A (MURR) 25 August 1981 Whole document</td>
<td>1, 2, 4–7, 15–16</td>
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<tr>
<td>Y</td>
<td>JP 2003325452 A (NIPPON TENGANYAKU KENKYUSHO KK) 18 November 2003 Whole document</td>
<td>1–3, 7, 8, 12–15, 21</td>
</tr>
<tr>
<td>Y</td>
<td>US 5568209 A (PRIESTER et al) 22 October 1996 Column 14 line 34–Column 18 line 19</td>
<td>1, 2, 4, 5–7, 9–11, 15, 21</td>
</tr>
</tbody>
</table>

☐ Further documents are listed in the continuation of Box C  ☒ See patent family annex

*A* Special categories of cited documents:

*"A"* document defining the general state of the art which is not considered to be of particular relevance

*"E"* earlier application or patent but published on or after the international filing date

*"L"* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

*"O"* document referring to an oral disclosure, use, exhibition or other means

*"P"* document published prior to the international filing date but later than the priority date claimed

*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

*"Y"* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

*"&"* document member of the same patent family

Date of the actual completion of the international search 29 March 2006

Date of mailing of the international search report 1 APR 2006

Name and mailing address of the ISA/AU

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Form PCT/ISA/210 (second sheet) (April 2005)
**INTERNATIONAL SEARCH REPORT**

### Box No. II  Observations where certain claims were found unsearchable (Continuation of Item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.☐ Claims Nos.: 
   because they relate to subject matter not required to be searched by this Authority, namely:

2.☒ Claims Nos.: 17, 26 – 31 
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
   - Claim 17: It is unclear as to how many points on the contrast sensitivity curve the chart system is adapted to measure.
   - Claims 26 – 31: It is unclear which claims the phrase “...device and method as defined above...” attempts to claim dependency from.

3.☐ Claims Nos.: 
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

<table>
<thead>
<tr>
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<tr>
<td>US 5592247</td>
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<td>JP 56068089</td>
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<tr>
<td>US 5568209</td>
<td>WO 9632880</td>
</tr>
</tbody>
</table>

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX