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June 1, 2009

Dr. Marijke Bekken
Staff Air Pollution Specialist
Clerk of the Board
California Air Resources Board
10011 I Street
Sacramento, California 95814

Dear Marijke:

(By Priority Mail)

RE: COOL CAR STANDARDS AND TEST PROCEDURES

PUBLIC RECORDS ACT: This letter and the attachments to it may be released to any person requesting it, including the press. There is no confidential information in any of this material.

As I spoke to you last week, I am opposed to the Cool Car Standards and Test Procedures as proposed by the California Air Resources Board. It is not that I am opposed to the standard per se.

What the standards would do would preclude the adoption of Neodymium Oxide doped windshields as a safety measure to be installed on vehicles.

Neodymium Oxide, as a component of glass, selectively filters out yellow light. There is a very sharp absorption band in the yellow between 565 and 595 nanometers.

I hold United States Patent Number 6,459,652, issued September 17, 2002, "Neodymium Oxide Doped Motor Vehicle Windshield and Safety Glazing Material. I have also filed international patents in the European Union, China, Korea, Japan, and the Chech republic.

A copy of this patent is included as an attachment to this letter. This patent may also be accessed through my website at www.danielkarpen.com.

As written in column 1, lines 31 to 34, of the patent:

> It has long been recognized that the visual discomfort from headlights of oncoming vehicles from the opposite direction and from the rising or setting sun is a major problem that has been unrecognized up to this time.

The patent provides the scientific and technical basis for the invention. The chemistry of Neodymium Oxide doped glass is discussed in the patent, as well as the properties of Neodymium Oxide doped glass. In column 6 of the patent, a discussion is provided of the optical properties of Neodymium Oxide doped glass. This discussion continues through columns 7 to 9.

Graphs are provided in the patent showing the absorption of yellow light by Neodymium Oxide in glass.

The patent claims are made clear in Claims 1 to 9 describing a glass with a light transmission coefficient of 70 percent containing up to 0.0225 grams of Neodymium Oxide per square centimeter of glass surface area for use as windshield material. Other claims describe the use of Neodymium Oxide in safety glazing material (glass used for side and rear windows), and in bullet resistant shields.

The glare problem

A question is asked: How significant is the glare problem in causing motor vehicle crashes?

This questions is answered in two ways. First, two articles are enclosed from Newsday, Long Island's daily newspaper, describing two deadly crashes, both caused by sun glare, in one accident, there was a fatality, in the other accident, a critical injury.

A comprehensive study of distracted drivers was conducted by Virginia Commonwealth University. They found that of the 2,792 crashes, 18 were due to lighting conditions attributable to glare or sun. See page 55 of the report. Thus, .645 percent of all crashes were due to glare or sun problems. I regard this percentage as being high. A complete copy of this report is attached to this material.

Research on vision with Neodymium Oxide doped glass

I obtained a research grant from the Transportation Research Board, and with Dr. Gordon Harris, a research optometrist, conducted research on the visual properties of Neodymium Oxide doped glass. This research was published as an SAE Technical Paper number 2005-01-0440, entitled "Recent Research on Neodymium Glass as Applied to Headlights, Rear View Mirrors, and Windshields", and presented at the 2005 SAE World Congress in Detroit, Michigan held between April 11-14, 2005.

Our research consisted of a series of 9 vision tests done under clinical conditions in an optometric examination room, followed by a road test with standard headlights and Neodymium Oxide doped headlights.

One of our tests (Test 1) compared the ability of persons to read lettering on a standard Snellen eye chart through a standard windshield glass having a light transmission of 78.6 percent compared with a sample of Neodymium Oxide doped glass having a total transmission of 70 percent. Our tests no significant difference, even though the Neodymium Oxide doped glass had a lower light transmittance.

A more difficult vision task is being able to read a license plate at night between two glaring headlights. Test 3 showed a slight but statistically significant improvement in vision with the Neodymium Oxide doped glass as compared with standard windshield glass.

Test 5 showed that yellow turn signals would be visible though the Neodymium Oxide doped glass as well as the standard windshield glass.

Test 7 showed that depth perception abilities did not change even though the Neodymium Oxide doped glass had a lower light transmission than the standard windshield glass.

Test 9 showed a significant reduction in the after image decay time between the Neodymium Oxide doped glass and a neutral density filter. The mean decay time for the after image through the Neodymium Oxide doped glass was 17 percent lower.

Test 10 was a road test of Neodymium Oxide doped headlights compared with standard headlights.

SAE Paper 2002-01-0011

An earlier SAE paper determined the amount of Neodymium Oxide to be added to glass to have a improvement in the de Boer glare scale. Adding 0.0221 grams of Neodymium Oxide per square centimeter would result in a de Boer score of 4.523 which is slightly below just acceptable. As noted in the paper, most windshields are sloped at an angle. At this angle, the motorist would see through .3125 Kgs/square meter of glass surface. This amount of Neodymium Oxide would provide reasonable glare control utilizing a minimum of the rare earth compound.

Cost of Implementation

As discussed in SAE paper 2002-01-0011, a windshield 30 inches by 54 inches would require approximately 231 grams of Neodymium Oxide to achieve a light transmittance of 70 percent. At a cost of $20.00 per Kilogram of Neodymium Oxide, the cost per windshield of the Neodymium Oxide is $4.62. This cost is significantly less than adding solar infrared materials to automotive glazing as described in the Staff Report: Initial Statement of Reasons for Rulemaking. The mark-up costs for adding Neodymium Oxide to a windshield have not been estimated.

A copy of SAE paper 2002-01-0011 is attached to this letter.

Status of the Invention

The necessary R&D to implement Neodymium Oxide glazing to vehicles is minimal. The amount of Neodymium Oxide doping necessary to achieve a total light transmittance of 70 percent is known. It would be necessary to dedicate a glass furnace and a float line to manufacture Neodymium Oxide doped glass in large quantities.

Glass manufacturers such as Asahi Glass, Guardian, Pilkington, Saint Gobain, and Zeledyne are aware of the patent, and have been shortly after the patent was issued by the U. S. Patent Office.

Chrysler, Ford, General Motors, Toyota, and Honda have been aware of the patent.

Technical objection to Cool Car Standards and Test Procedures

I have spoken verbally to the windshield manufacturers. All of them have told me verbally that if solar infrared control materials are incorporated into the windshield, it become impossible to incorporate Neodymium Oxide in the glass due to Federal safety standards for light transmission for windshields.

My own thoughts

I have taken a sample of Neodymium Oxide doped glass, with a 70 percent light transmittance, and I have held it up to the rising and setting sun, and there is a huge reduction in glare.

I would have no objection whatsoever to the proposed regulation if windshields were taken out of the regulation, and it would apply only to side windows, rear windows, and sun roofs.

I have never owned a vehicle with an operable air conditioning system. When I park it in hot weather, I leave the two front seat windows open two inches to ventilate the vehicle.

Perhaps the California Air Resources Board needs to begin a public awareness campaign to get people to leave the windows open a lttle bit to ventilate their vehicles.

How about a sticker on the dash ?

Here is another idea: Put in thermostatically controlled front seat windows that would automatically open 2 inches when the internal space temperature of the vehicle is too high.

Yours truly,

Daniel Karpen
Professional Engineer

FAX 916 322-3928

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June 9, 2009

Monica Vejar
Clerk of the Board
California Air Resources Board
10011 I Street
Sacramento, California 95814

Dear Monica:

RE: URL LINKS FOR MY ATTACHMENTS - LETTER OF JUNE 1, 2009

U. S. Pat. No. 6,459,652

The easiest way to get the link is to go to www.danielkarpen.com, click on patents, and find it there.

http://patft.uspto.gov/netacgl/ngh-Parser?Sectl=PTO28&Sect2-HITOFF &P=1&U=%2Fnetahmtl%2FPTO%2Fsearch=bool.ht

Or, go to uspto.gov, and search for U. S. Pat. No. 6,459,652.

SAE papers. SAE charges a fee to down load them.

http://www.sae.org/servlets/productDetail?PROD_TYP=PAPER&PROD_CD=2002-01-0011
http://www.sae.org/servlets/productDetail?PROD_TYP=PAPER&PROD_CD=2005-01-0440

Virginia Commonwealth University Distracted Drivers Study.

Go to Google and search "Distracted Drivers""Virginia Commonwealth University"

http://www.dmvnow.com/webdoc/pdf/distracted_driver_report.pdf

The two Newsday articles may or may not be accessible on the web.

Please call me at the above number if you have any questions.

Yours truly,

Daniel Karpen

Daniel Karpen

US006450652B1

(12) **United States Patent**
Karpen

(10) **Patent No.:** **US 6,450,652 B1**
(45) **Date of Patent:** **Sep. 17, 2002**

(54) **NEODYMIUM OXIDE DOPED MOTOR VEHICLE WINDSHIELD AND SAFETY GLAZING MATERIAL**

(76) Inventor: **Daniel Nathan Karpen**, 3 Harbor Hill Dr., Huntington, NY (US) 11743

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/865,096**

(22) Filed: **May 24, 2001**

(51) **Int. Cl.**[7] **G02B 27/00**; C03C 3/095

(52) **U.S. Cl.** **359/603**; 359/601; 359/884; 501/26; 501/62

(58) **Field of Search** 359/603, 601, 359/884, 883, 885; 501/26, 60, 64, 62, 66, 67, 51, 53, 55

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4,769,347 A		9/1988	Cook et al.	
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Dannmeyer F.; "Das Neophanglas als nautisches Hilfsmittel bei unklarer Sicht"; Die Glashutte; 1934; No. 4; pp. 49–50. (also includes translation of above articel).

Bouma, P.J.; The Colour Reproduction of Incandescent Lamps and "Philiphane Glass"; Philips Technical Review; 1938; vol. 3; pp. 27–29.

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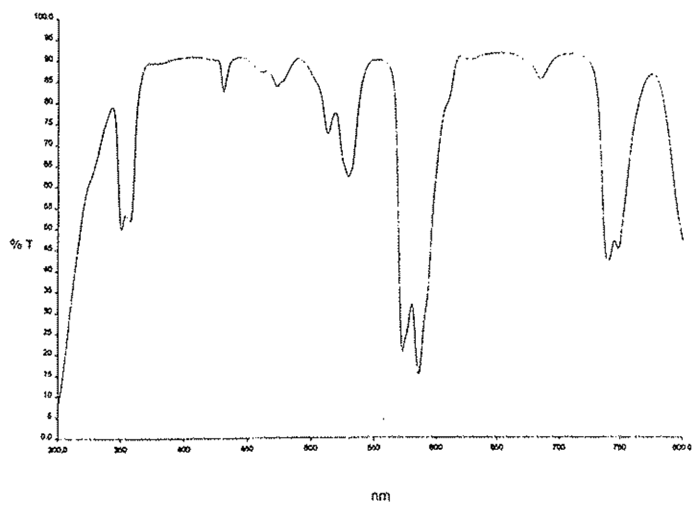
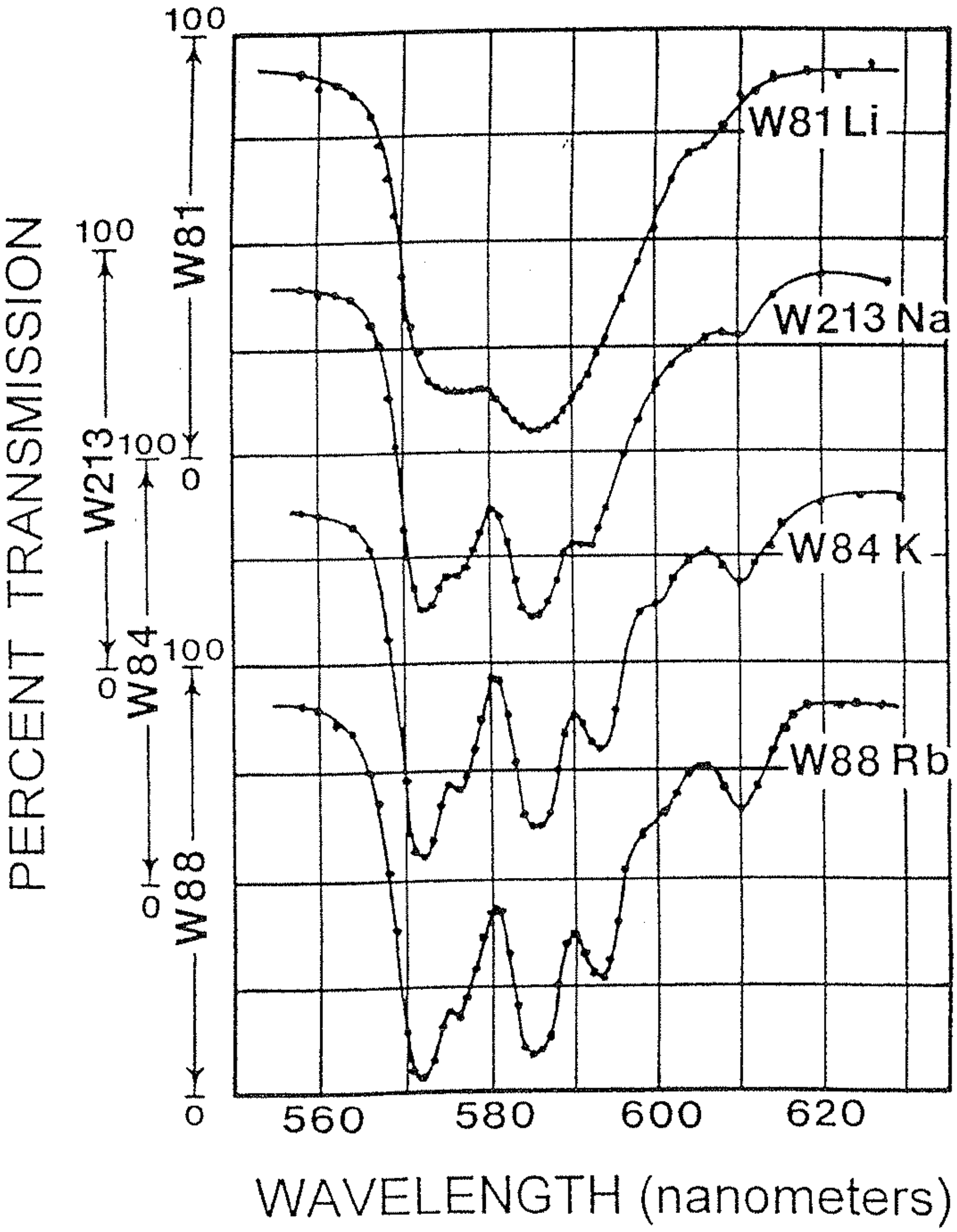
Primary Examiner—Mohammad Sikder
(74) *Attorney, Agent, or Firm*—Alfred M. Walker

(57) **ABSTRACT**

Motor vehicle windshields and safety glazing material, suitable for use as motor vehicle windshields and safety glazing material for automobiles, trucks, buses, motorcycles, locomotives, sport utility vehicles, all terrain vehicles, and vans. The motor vehicle windshields and safety glazing material contains Neodymium Oxide, a rare earth compound. The Neodymium Oxide filters out the yellow portion of the spectrum, reducing glare. Incorporation of yellow light in the spectrum desaturates colors and reduces contrast. Improvement in contrast and a reduction in glare permits, for example, a motor vehicle driver to better discriminate the contrast of objects when there is no daylight and the only illumination is artificial. For drivers, in particular, elimination of the yellow light lessens eye strain currently resulting from light emitted by the conventional headlights of oncoming vehicles during hours of darkness. Neodymium Oxide can also be added to safety glazing materials for use in bullet resistant shields.

27 Claims, 4 Drawing Sheets

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W84 K
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PERCENT TRANSMISSION
560
580
600
620
WAVELENGTH (nanometers)

FIG. 1

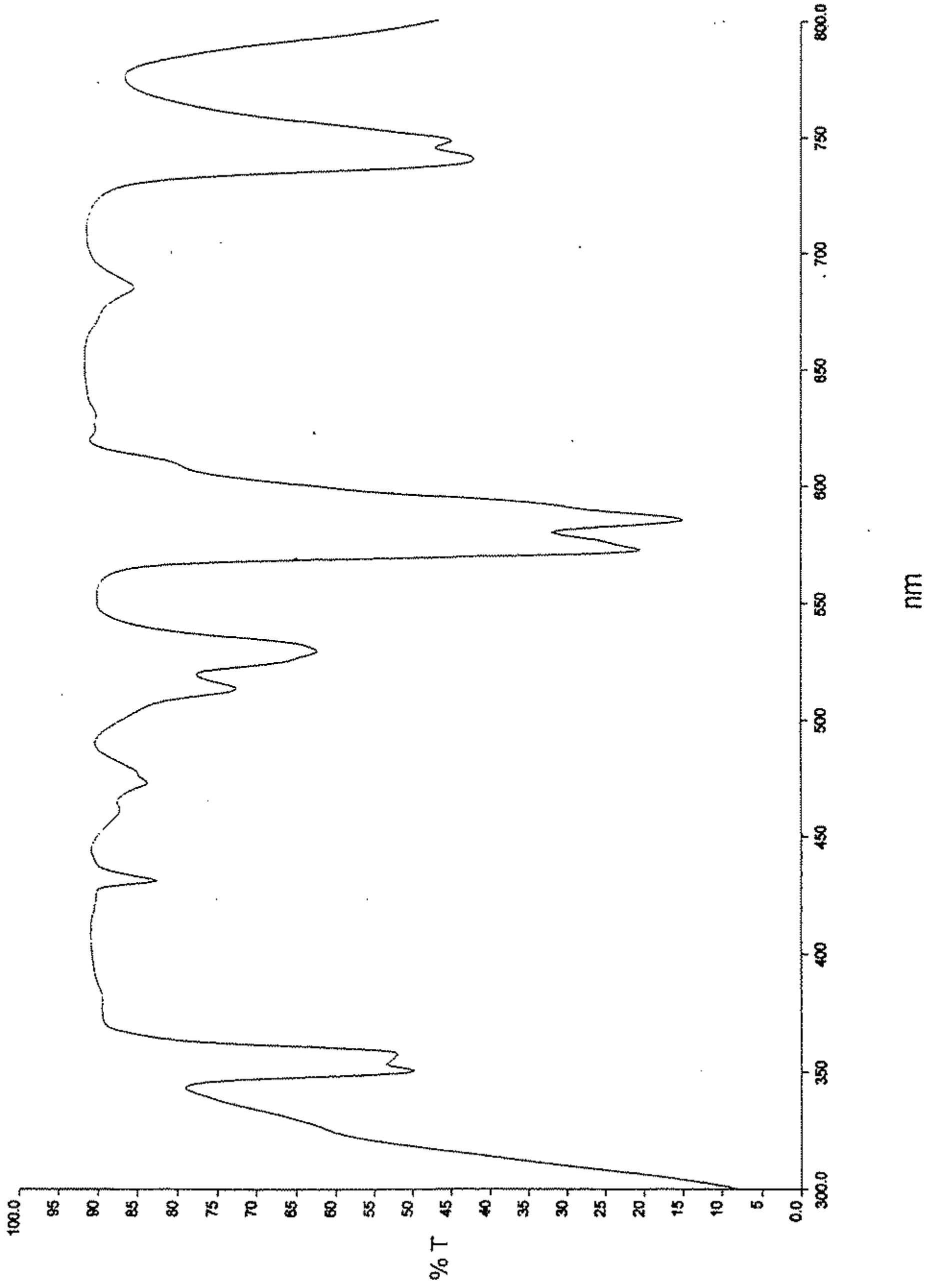
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FIGURE 2

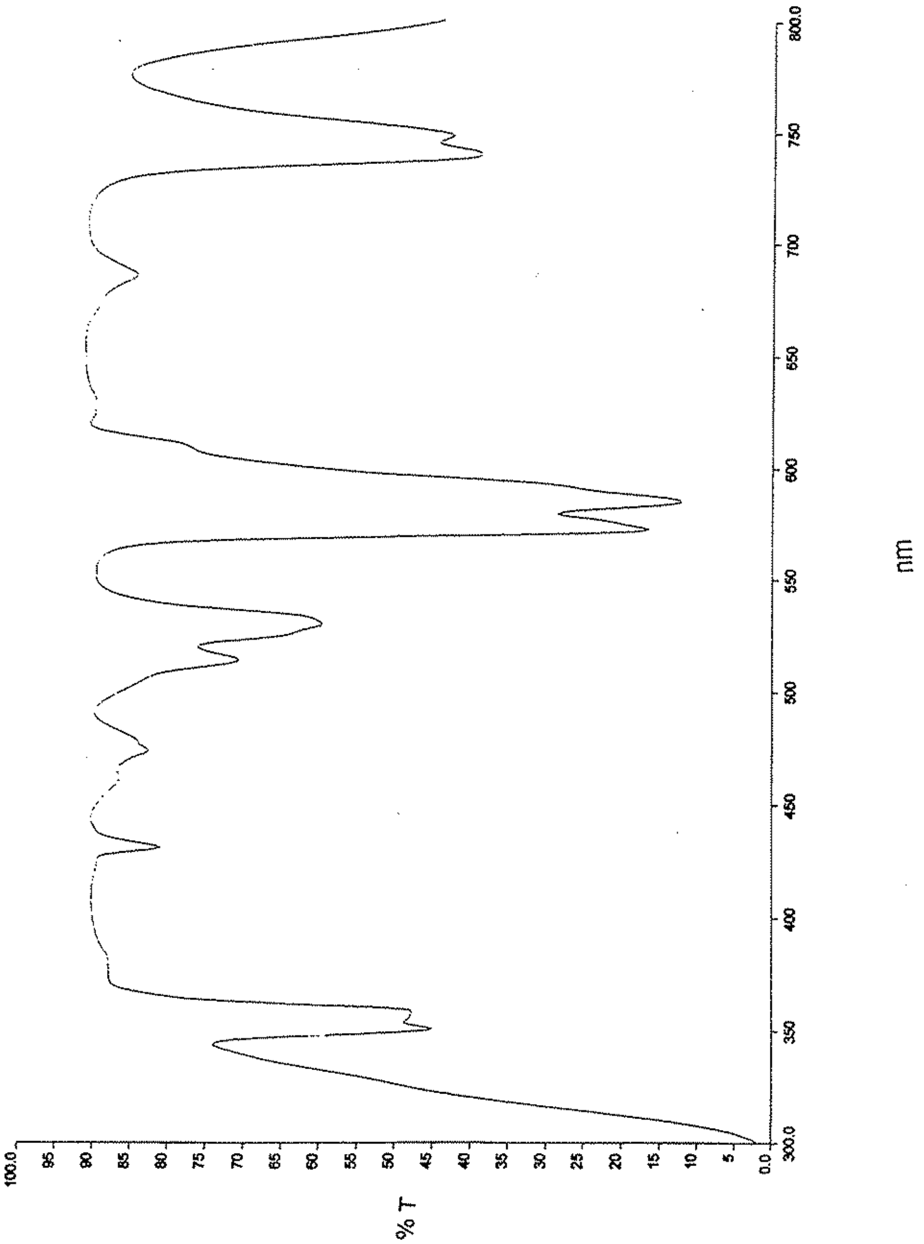

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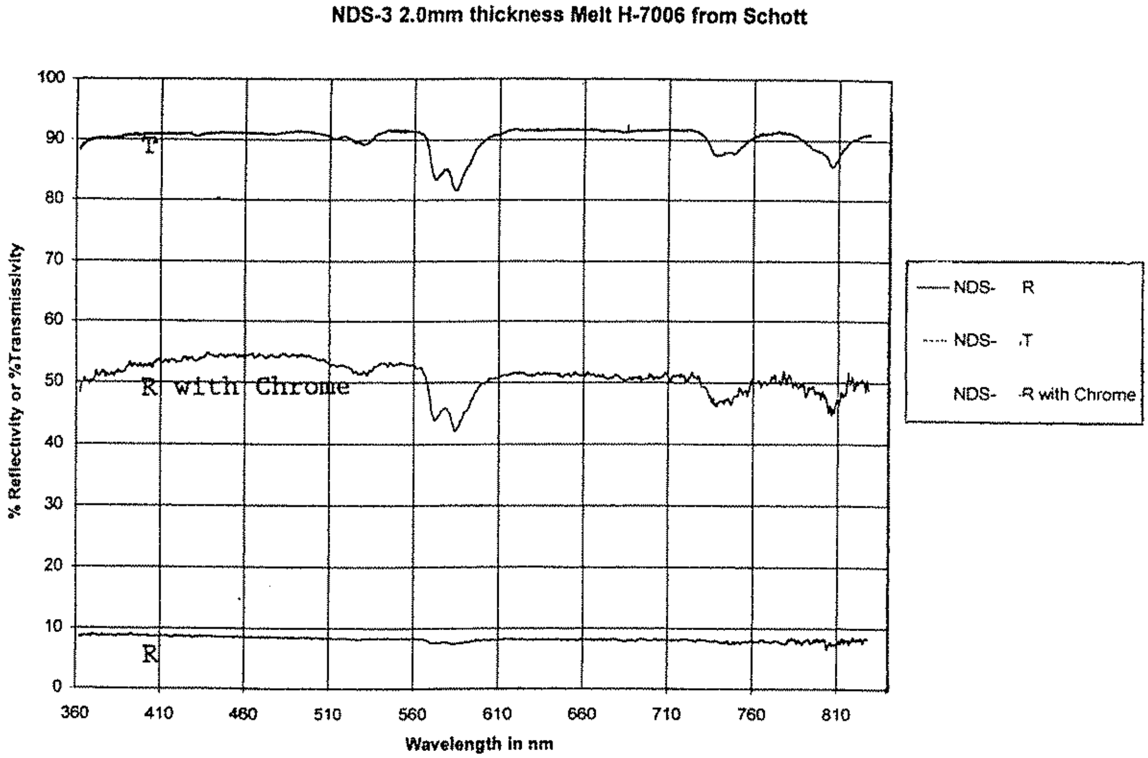
FIGURE 3


NDS-3 2.0mm thickness Melt H-7006 from Schott
100
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80
70
60
50
40
30
20
10
0
% Reflectivity or %Transmissivity
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410
460
510
560
610
660
710
760
810
Wavelength in nm
T
R with Chrome
R
NDS- R
NDS- T
NDS- R with Chrome

FIGURE 4

NEODYMIUM OXIDE DOPED MOTOR VEHICLE WINDSHIELD AND SAFETY GLAZING MATERIAL

FIELD OF THE INVENTION

The invention relates to the development of a new reduced glare motor vehicle windshield and safety glazing material, and in particular, a new motor vehicle windshield and safety glazing material that will be capable of providing improved vision at the levels of illumination necessary to see while driving during daylight or at night, and to eliminate much of the discomfort experienced by drivers seeing the headlights of motor vehicles coming from the opposite direction. It will also reduce the glare from the rising or setting sun while traveling east or west. The new Neodymium Oxide doped motor vehicle windshield and safety glazing material will be capable of improving the color rendition of viewed objects under all conditions of illumination. It can be used on new motor vehicles, and for older vehicles as a replacement for the motor vehicle after-market.

DOCUMENT DISCLOSURE PROGRAM

The application for patent is based on a disclosure received by the United States Patent and Trademark Office on May 27, 1999, as Disclosure Document No. 456,992, under the Document Disclosure Program.

BACKGROUND AND THEORY OF THE INVENTION

It has long been recognized that the visual discomfort from headlights of oncoming vehicles from the opposite direction and from the rising or setting sun is a major problem that has been unrecognized up to this time.

One such proposed solution was to install polarizers on motor vehicle headlights. The concepts behind such technology have been summarized by Shurcliff (Shurcliff, William A., *Polarized Light Production and Use, Harvard University Press*, Cambridge, Mass., 1962, pp. 129–133). To avoid the absorption of light that is inevitable in dichroic polarizers, a number of inventors have proposed systems using specially designed pile of plate polarizers (see, for example, MARKS, British Patent No. 762,678, 1956). Difficulties involving bulk, fragility, a tendency to become cloudy, polarization defect, and manufacturing costs, prevented the implementation of this technology.

The present invention extends the concept of a color corrected motor vehicle headlight from an incandescent sealed beam or tungsten halogen lamp, as disclosed in U.S. Pat. No. 5,548,491 (KARPEN, 1996), and from a Neodymium Oxide doped rear view mirror, as disclosed in U.S. Pat. No. 5,844,721 (KARPEN, 1998), and also from a color corrected high intensity discharge motor vehiche headlight, as disclosed in U.S. Pat. No. 5,961,208 (KARPEN, 1999), which are hereby incorporated by reference, to a Neodymium Oxide doped motor vehicle windshield and safety glazing material. (U.S. Pat. No. 5,830,814, (1998)), discloses glass composition suitable for the manufacture of glazings for use in the architectural field or for fitting in motor vehicles. These compositions contain the following constituents, expressed in weight percentages, defined by the following limits: SiO_2 69 to 75%, Al_2O_3 0 to 3%, CaO 2 to 10%, MgO 0 to 2%, Na_2O 9 to 17%, Fe_2O_3 (total iron) 0.2 to 1.5%. These compositions can also contain fluorine, as well as oxides of zinc, zirconium, titanium, and less than 4% barium oxide, the sum of the percentages of the alkaline earths remaining equal to or below 10%.

SAGAGUCHI et al. (U.S. Pat. No. 5,958,811, (1999)), discloses an ultraviolet and infrared radiation absorbing glass having excellent ultraviolet radiation absorbing power and a bronze or neutral gray tint which is suitably used as window glass for automobiles or motor vehicles and also as a window glass for construction materials is provided. The glass comprises in % by weight, basic glass components comprising 65 to 80% SiO_2, 0 to 5% B_2O_3, 0 to 5% Al_2O_3, 0 to 10% MgO, 5 to 15% CaO, 10 to 18% Na_2O+K_2O, and coloring components comprising 0.20 to 0.50% total iron oxide (T-Fe_2O_3), in terms of Fe_2O_3, 0 to 3% CeO_2, 0.025 to 6.0% La_2O_3, 0 to 2% TiO_2, 0.0002 to 0.005% CoO, 0.0002 to 0.005% Se, 0 to 0.01% NiO, and 0 to 1% SnO_2, wherein 5 to 25% of said T-Fe_2O_3 is terms of Fe_2O_3 is FeO.

HAYDEN et al. (U.S. Pat. No. 4,470,922, (1991)) discloses a strengthenable, high Neodymium Oxide containing glass comprising 40 to 60% Si_O2, and 10 to 30% Neodymium Oxide, and various other inorganic compounds in minor amounts.

KOBAYSHI (U.S. Pat. No. 4,454,446, (1984)) discloses a cathode ray tube for a light source with a face plate being made of a glass material containing the rare earth oxides Nd_2O_3 and Pr_2O_3, so that satisfactory color light and contrast are obtained even under sun light.

MATSUURA (U.S. Pat. No. 3,714,055, (1973)) discloses glass color filters for use in color photography under white and warm white fluorescent lights prepared from a glass composition, containing various glass components one of which is Neodymium Oxide in the amount of 0.3 to 2.5 percent.

YAMASHITA (U.S. Pat. No. 4,521,524, (1985)), discloses contrast enhancement filters for color CRT display devices which have between 5 and 40% Neodymium Oxide as a component of the glass.

COOK et al. (U.S. Pat. No. 4,769,347, (1988)) discloses contrast enhancement filter glass for color CRT displays which has between 10 and 25% Neodymium Oxide as a component of the glass.

HIRANO et al. (U.S. Pat. No. 4,315,186, (1982)) discloses a reflective lamp with a Neodymium Oxide doped front lens section fused to a reflective mirror section. HIRANO restricts the amount of Neodymium Oxide in the front lens section to a range of 0.5 to 5.0 percent by weight. At an amount of Neodymium Oxide above 5 percent, the difference in the thermal expansion coefficient between the resultant glass material and that constituting the reflective mirror becomes too great, so that it becomes difficult to fuse the front lens section to the reflective mirror base.

AYKANIAN (U.S. Pat. No. 3,354,025, (1967)) discloses color gradated laminates. Laminated panels and interlayers are disclosed wherein the interlayer used to bond the laminate is characterized by having a pigmented band or gradient across the interlayer. The pigmented band tapers in thickness for a maximum thickness at one edge to a minimum thickness at the other edge to give a uniform color gradient. Safety laminates generally comprise two or more pellucid panels with a plastic transparent layer interposed between each of the panels. The interlayer conventionally used is composed of a plasticized polyvinyl acetal resin and is generally extruded or formed into films having thicknesses of 0.015 inches and greater. The most important application for laminates of this type are windshields for automotive, military vehicles, and aircraft.

Although the use of dyes to produce a gradual fading color band serve to reduce the effects of glare and heat, it has been found that overall improvement in these properties may be obtained by the use of pigments incorporated into the body of the sheet. The pigment concentration can vary within wide limits depending on the transmission desired after lamination. To obtain the desired effect, the transmission of the darker portion of the laminate should be less than 25 percent and more preferably less than 10 percent with a minimum of 1 percent.

In the present invention, anti-glare materials are incorporated into the glass of the windshield and safety glazing material, not just the interposed laminate. Additionally to distinguish the art of AYKANIAN, the entire windshield, and not just a band across the top of the windshield, has the anti-glare compound.

LYMAN (U.S. Pat. No. 5,076,674, (1991)) discloses a reduced first surface reflectivity electrochemichromic rearview mirror assembly. In the art of LYMAN, Neodymium Oxide is one of a number of possible materials of high refractive index in a triple layer thin film stack.

What the present invention does, and what the prior art failed to do, is to reduce the amount of yellow light transmitted through the Neodymium Oxide doped motor vehicle windshield and safety glazing material, since reducing the amount of yellow light in the spectrum improves color saturation and reduces glare. The approach of the present invention to the problem of visual discomfort and visual disability is to add Neodymium Oxide, a rare earth oxide, to the glass of the windshield and safety glazing material to absorb yellow light and reduce its presence in the light spectrum. The Neodymium Oxide can be added to the windshield in an amount up to 0.0225 grams per square centimeter of glass area to satisfy the requirement of 49 Code of Federal Regulations 571.205 and ANSI/SAE Z26.1-1996, as approved by ANSI on Aug. 11, 1997, which requires a regular (parallel) luminous transmittance of not less than 70 percent of the light. For safety glazing materials for use in bullet resistant shields, the Neodymium Oxide can be added in an amount up to 0.04 grams per square centimeter of area to satisfy the requirements of 48 Code of Federal Regulations 571.205 and ANSI/SAE Z26.1-1996, as approved by ANSI on Aug. 11, 1997, which requires a combined regular (parallel) luminous transmittance at normal incidence through both the shield and the permanent vehicle glazing of not less than 60 percent.

The Insurance Institute for Highway Safety has letters in its files concerning glare from motor vehicle high intensity discharge lamps, even though at the time of the filing of this patent application, the absolute number of these vehicles is very small, according to a verbal telephone conversation with Mike Cammisa, a staff member, on or about Jan. 26, 1998. As more vehicles are equipped with high intensity discharge lamps, or use them as daylight running lamps, the glare problems are going to increase. In addition, Vivek Bhise, at Ford Motor Company, and Michael Perel, at the National Highway Traffic Safety Administration, in telephone conversations with the inventor on or about Feb. 2–3, 1998, have both expressed concern about the glare from daylight running lamps.

To explain the importance of the present invention, a discussion of its Neodymium Oxide component is as follows:

Neodymium Oxide is a rare earth element, having an atomic number of 60 and an atomic weight of 144.24. It combines with oxygen to form Neodymium Oxide, Nd_2O_3, having a molecular weight of 336.48.[1]

The elucidation of the rare earths in elemental form took the better part of the nineteenth century, and the properties of Neodymium that are important to the lighting art in this patent application were known even before Neodyium was prepared in metallic form. In 1803, Klaproth discovered the mineral ceria. It was also found about the same time by Berzelius and William Hisinger.[2] This mineral proved to be a mixture of various rare earth oxides. In 1814, Hisinger and Berzelius isolated Cerium Oxide from the ceria earth.[3] In 1839, Moslander found the rare earth lanthana in the ceria.[4] In 1841, Moslander treated lanthana with dilute nitric acid, and extracted from it a new rose colored oxide which he called didymium, because as he said, it seemed to be "an inseparable twin brother of lanthana".[5]

It was believed that didymium was a mixture of elements. The separation proved difficult. In 1882, Professor Bobuslav Brauner at the University of Prague examined some of his didymium fractions with the spectroscope and found a group of absorption bands in the blue region (λ=449–443 nanometers) and another in the yellow λ=590–568 nanometers).[6] In 1885, Welsbach separated didymium into two earths, praseodymia and neodymia.[7] The neodymia has the aborption bands in the yellow region. The neodymia earth is Neodymium Oxide.

The spectra of rate earths became of great interest to a number of investigators. The most impressive feature about the spectra of rare earth ions in ionic crystals is the sharpness of many lines in their absorption and emission bands. As early as 1908, Becquerel realized that in many cases these lines can be as narrow as those commonly observed in the spectra of free atoms of free molecules.[8]

However, many solids that are of practical use today are amorphous or glassy rather than crystalline. That means that in the immediate vicinity of like ions in such substances is similar, but that there is no long range order in the sample. Rare earth ions can be easily incorporated into many glasses. It was noted quite early that in glasses, as might be expected, the most prominent feature of the rare earth crystal spectra, the extreme sharpness of the optical lines, vanishes.

From a simplified point of view, a glass is a supercooled liquid. It can therefore be assumed that the spectra of rare earth ions in glasses will be similar to those of rare earth ions in liquids. The spectra in liquids show a "crystal field splitting", although with very wide lines. This is an indication that the rare earth ions in a liquid are surrounded by a near neighbor shell of ligands—similar to the configuration found in a solid and the same for every dissolved rare earth ion, and that the uncorrelated structure is only beyond the near neighbor shell. If the near neighbor coordination in a liquid is the same as in a solid, one can understand the similarity in the magnitude of the crystal field splitting and the solution. In glasses the rare earth ions are incorporated as oxides. From the reasoning just cited one can expect that rare earth spectra in glasses to be similar to those of the stable oxide modification of the particular rare earth ion; this expectation is verified by experimental findings.[9]

The absorption of an ion may undergo a fundamental change when placed in different surroundings. A great variety of colors which can be obtained with divalent copper, cobalt, or nickel ions have been attributed to the differences in co-ordination numbers and the nature of the surrounding atomic groups. The change of an ionic bond into a covalent bond produces a completely different absorption spectra. The close interdependence of light absorption and chemical change is not surprising when it is realized that the electrons which are responsible for the visible absorption are also responsible for the chemical interactions and the formation of compounds.

The case, however, is different with the rare earth compounds. Their colors depend on the transitions taking place in an inner, well protected, electronic shell, whereas the chemical forces, as in other elements, are restricted to deformations and exchanges of electrons within the outer electronic shells. Consequently, the color of Neodymium compounds remains practically independent of the nature of the atoms in which the element is linked. The hydrated salts are amethyst colored, just as the water free salts, the ammoniates, the hydroxide, or the oxide. Chemical changes affect color only to a minor extent.[10]

A number of studies of Neodymium Oxide containing glasses have been conducted to examine the absorption spectra. Weidert conducted a systematic study in 1922. Samples of pure Neodymium Oxide were made available for the first time, relatively fee of contamination from impurities such as praseodymium.[11] Spectra were published showing the absorption of yellow light in a broad band from 565 to 598 nanometers.[12]

According to Rosenhauer and Weidert, the absorption spectra of the Nd^{+3} ion in glasses signals any change of the structure which affects the stability of the glassy state. Composition changes which increase the tendency of a glass to devitrify also blur the normally sharp absorption bands of the Nd^{+3} ions. The absorption indicators can be used therefore for studying the compatibility of oxide systems.[13] In their studies, the base glasses differed in their alkalis. The smaller the atomic radius of the alkali the more diffuse is the absorption band. The fine structure of the rubidium glass gradually disappears when this large alkali is replace by the smaller potassium, sodium, or lithium ion. The corresponding lithium glass could be obtained only by rapid cooling; otherwise crystal-lization took place. Thus, there seems to be a general connection between the tendency of a glass to devitrify and its absorption spectrum. In all the glasses which crystallize readily Neodymium causes only a somewhat diffuse absorption spectrum.[14] Regardless of the alkali base of the underlying glass, the absorption of yellow light between 565 and 598 nanometers is seen in all samples of glass (see FIG. 1).[15]

Glasses containing Neodymium Oxide experience "dichroism". In artificial light, the Neodymium Oxide glass appears as a brilliant red. The color sensation not only varies with the type of illumination, but also with the thickness of the glass layer. In thin layers or with low concentrations of Neodymium Oxide these glasses are blue, in thick layers or with high concentration, red.[16]

V. Ctyroky made a study of the dichroism of glasses containing various concentrations of Neodymium and Vanadium. It was his attempt to calculate the thickness of the glass and the concentration of the colorants which produce the maximum dichroism. The color play of these glasses is caused by the Neodymium Oxide, for the Vanadium Oxide produces a green color which serves only to modify the original blue-red dichroism of the rare earth. The absorption of the yellow light between 565 and 598 nanometers is so intense that even a faintly colored Neodymium Oxide glass absorbs yellow light almost completely. Thus the transmitted spectra is divided into two parts, a blue one and a red one. The color sensation which such a glass produces depends on the intensity distribution of the light source. In daylight the blue part predominates; in artificial light (incandescent), which is relatively poor in short-wave radiation, the red predominates.[17]

Theoretically, it was to be expected that a filter having a sharp absorption band in the red and green basic sensation curves would lead to an increase in the saturation of practically all colors with medium saturation. An optimum improvement is obtained by an absorption band at 573 nanometers which falls in the middle of the Neodymium Oxide absorption band in glass.[18]

The characteristic absorption of a Neodymium Oxide glass, especially its narrow intense band in the yellow part of the spectrum, affects color vision in a unique way. Looking through such a glass at a landscape or a garden in bloom, the red and green hues are strongly accentuated; especially do all colors containing red stand out very clearly.[19]

Another interesting feature when looking through a Neodymium Oxide containing glass is the distinction between the green of vegetation and a similar green hue produced by the blending of inorganic pigments. Whereas the hues of both greens may be the same, the reflection spectra are fundamentally different in respect of their intensity distribution; for the chlorophyll of plants possesses a spectrum rich in fine structure.[20]

Bouma explains how the electric light (incandescent lamp) can be improved by the introduction of a colored envelope using a glass containing Neodymium Oxide, known as "Neophane" glass (for the purposes of clarity, an envelope refers to the outer shell of the lamp bulb). It is clear that large portions of the spectrum must not be weakened to any extent. Otherwise, there would be too great a decrease in the efficiency. Only an improvement of the color which can be obtained with a relatively slight loss of light can be considered.[21]

The only possibility thus consists of the absorption of one or more relatively small regions of the spectrum. The pertinent question is what colors may be considered in this connection? In general, absorption of a given color is accompanied by the following two objections:

1. An object which reflects almost exclusively this color appears too dark.
2. Objects which exhibit the color under consideration in a less saturated form will appear still less saturated.

The first objection holds primarily for the colors at the extremities of the spectrum, thus for red and blue. Very saturated red, for example, can only occur when a material reflects practically exclusively red and orange. The same is true for blue.

For yellow, the situation is different. Highly saturated yellow occurs in nature as a rule, not only because a narrow region of the spectrum is reflected, but because red and green as well as yellow are fairly well reflected, and only blue and violet are absorbed to a large extent.

The second objection also holds particularly at the extremities of the spectrum; the blue, which is reproduced in electric light in a much less saturated form than in daylight, may certainly not be made still duller. The saturation of the red may also not be decreased too much, since otherwise the reproduction of skin color would be made worse.

For the reasons mentioned above, the second objection is also of much less importance in the case of yellow.

Bouma surrounded an incandescent lamp with a bulb of the Neodymium Oxide containing Neophane glass, and compared the color rendition to an incandescent lamp surrounded by an ordinary opal glass bulb. His results indicated the majority of the colors become more saturated, a change which is to be desired, especially at relatively low levels of illumination. In particular, the blue, which upon changing from daylight to incandescent has become considerably less saturated is again reproduced in a more saturated form.

The orange is shifted toward the red: the shift in the direction yellow to red is in general experienced as an increased "warmth" of that color.

The green, which upon translation from daylight to incandescent light had become a somewhat dubious yellow-green, goes back to green again under the influence of the Neophane glass.

Finally, Bouma notes that white and the very unsaturated colors are shifted in the direction of blue-violet. This may certainly not be considered an advantage since however the change is not very great, and moreover since it lies almost in the same direction as the shift on transition from daylight to incandescent light, the shift is not disturbing.[22]

In summary, Bouma found that the use of the Neodymium Oxide containing Neophane glass has the advantage of reproducing most colors in a more saturated form and of making the orange-yellow warmer. Various disadvantages of incandescent: light, such as the faded appearance of blue and the shift of green towards yellow-green, are partially overcome. The most important advantage of the incandescent light such as the high saturation of the orange and of the colors in its neighborhood, the greater intensity of red, are retained.

Dannmeyer made an investigation of Neodymium Oxide containing Neophane glass as a vision aide in bad weather for navigational purposes.[23] If one looks at a spectrum through this glass, one will notice that yellow is eliminated, but red and green appear much clearer. If one looks at a landscape, even in murky weather, one will see wonderful lustrous colors, emphasizing everything red and even green. But there is another special effect: the discomforting blinding effect created primarily by yellow disappears at the same time. If one looks at the branches of a bare tree against a bright sky, one won't be able to see the ends. They disappear in the general glaze. If, however, one looks though the Neodymium Oxide glass—or as it is now technically called, Neophane glass—even the slightest differences are emphasized. All blinding effects against the clear sky or the sun, disappear and the elements of the optical picture appear more sharply even when looking toward the sunset and twilight pictures have more contrast.

As further noted by Dannmeyer,[24] the effects of using the Neodymium Oxide containing Neophane glass was studied during the summer and fall on the Elbe River and in the North and Baltic Seas. It was shown that clear sighting made red and green as already mentioned, especially clear. External identification of a ship by the color of its smoke stack, bottom paint, ensign and other elements was made much easier. If the weather was hazy or misty, so that one could see the other ship only as a silhouette grey against grey, color differences could still be seen that could not have been recognized with unaided sight. But what was immensely important was that ships that in hazy weather seemed to be the same distance apart, were seen to be at varied distances from one another; both location and movement were much easier to differentiate.

It is well known that on the Elbe, at sunset, outgoing ships looking into the sunset have on occasion had optical difficulties caused by the blinding of the sun. Markers are difficult to distinguish, and even though ship pilots are exceedingly well informed, discerning an oncoming ship is sometimes exceedingly difficult.

According to Dannmeyer, Neodymium Oxide containing Neophane glass prevents all of these things from happening to the eye. Along the lower Elbe one is able to distinguish a lengthening of the coast line even in hazy weather, and thus seeing distances are actually extended by about a nautical mile. On the North Sea, it is possible to make out various vessels that would not have been discernible in the misty weather. The grey of the vessels appears darker than the surroundings through the eyeglasses. In the reflection of the sinking sun,. in which the eye could not distinguish objects, the vessels were clearly discerenible through the Neodymium Oxide containing Neophane glass.[24]

The aforementioned studies of Neodymium Oxide containing glass in window and indoor light bulb applications can be applied to the previously undiscovered use of the present invention for vehicular windshields and safety glazing material, for better vision during both daylight and night driving.

According to the present invention, when the Neodymium Oxide glass is used in a motor vehicle windshield and safety glazing material for both daylight, and night and bad weather driving, the discomforting undesirable yellow light is filter out, making objects more clear with improved contrast and color rendition. In addition, the eyestrain caused by the intense point sources of on-coming headlights coming from the opposite direction, is eliminated, ending once and for all the discomfort experienced from light from headlights coming from the opposite direction.

A physiological explanation of how the eye sees colors provides an explanation of the visual effectiveness of Neodymium Oxide doped glass for motor vehicle windshields and for safety glazing material. The following explanation is provided by Gouras:[25]

There are three cone mechanisms in the human visual system, with peak sensitivities near 440 nanometers in the blue-violet, 540 nanometers in the green, and 610 nanometers in the orange. These mechanisms are loosely called "blue", "green", and "red" processes in vision because they may be roughly thought of as being affected, respectively, by blue, green, and red light.

There are approximately 6 to 7 million green plus red cones per eye, and less than 1 million blue cones. The green and red cones contribute towards seeing fine detail and contrasts; the blue cones do not. The blue cones are through to provide, mainly, the means of distinguishing between yellow and light appearing objects; the blue-cone mechanism is excited by blue and light and inhibited by yellow light.

When mid-spectral (yellowish) images are in sharp focus on the retina, bluish wavelengths are out of focus. Low visual acuity is associated with the blue-cone mechanism, and high visual acuity with the green plus red cone mechanism. The term "yellowisn images" does not necessarily imply any yellow content in the light, since green plus red yields the sensation of yellow.

The cones feed their signals into various kinds of cells in and beyond the retina. Strongly cone opponent cells are those cells that are excited by one color of light and inhibited by another. The "red-green contrast detectors" contribute heavily to both luminance and color contrast, and also to the detection of differences between elements of a scene. They supply information on fine spatial detail.

The strongly cone-opponent cells (associated with the green and red cones) are turned off or on by green or red light, and are very unresponsive to yellow light. The red-green contrast detector is totally inhibited by yellow light.[26]

Thus, a motor vehicle windshield and safety glazing material with Neodymium Oxide containing glass appears to provide the maiximal filtering effect of the discomforting yellow light in order to improve contrast, visual acuity, and color recognition.

Two recent studies of the functioning of the eye for people of low vision are of interest. Neodymium Oxide type motor vehicle windshields and safety glazing material will be of help not only to people who have normal vision, but also to people who may be visually impaired.

Faye reports that the visual impression in viewing colored objects is a vivid "true" color similar to the view in full sunlight.[27] In viewing high contrast acuity charts, contrast sensitivity charts (Vistech VCTS 6500), and reading material, there is an increased contrast between black and white, when incandescent light bulbs containing Neodymium Oxide are used indoors. White appears whiter and black blacker because of the decrease yellow emission of the Neodymium Oxide containing bulb.

To date, while no specific recommendations can be made, it appears that a history from visually impaired patients that they need sunlight for best reading (or can't read by artificial light), indicates a favorable response to the Neodymium Oxide containing light bulbs. Favorable responses have been elicited from patients with retinitis pigmentosa, optic atrophy, glaucoma with visual field effects, and diabetes with proliferative retinopathy who have undergone panretinal photocoagulation.

A study of low vision patients was conducted by Cohen and Rosenthal at the State University of New York School of Optometry in New York City.[28] Their study also found more accurate color rendering and an improvement in visual acuity, contrast, and a reduction in eye fatigue. Tests were conducted on 51 low vision patients using standard incandescent lamps and standard "A" type Neodymium Oxide lamps on the Vistech 6000 Contrast Test and high and low contrast acuity charts. Results showed a small, but statistically significant performance enhancement when using Neodymium Oxide bulbs. Subjective preference also favored the Neodymium Oxide bulbs in a 5 to 1 ratio when a preference was present. The patient population had such pathologies such as achromotopsia, albinism, cataracts, congenital cataracts with aphakia, cortical anoxia, diabetic retinopathy, optic atrophy, pathological myopia, primary nystagmus, retinitis pigmentosa, POP, and SMD.

As a result, it is shown that the use of Neodymium Oxide as a doping agent in the glass of a motor vehicle windshield and safety glazing material will filter out yellow light, thus favoring vision promoting red-green contrast detectors, to improve visual contrast, visual acuity, and better color recognition.

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SUMMARY OF THE INVENTION

The present invention is for a Neodymium Oxide doped windshield and safety glazing material which will provide a significant improvement in visual performance, color rendition, and contrast of objects being seen.

The transmittance of light through glass is governed by the Lambert-Beers Law, which relates the amount of light transmitted through a certain thickness of glass by an absorption coefficient:

$$Ln(T)=-AL$$

In the above equation, L is the thickness of the glass, A is the absorption coefficient, T is the percentage of light being transmitted, and Ln represents the natural logarithm.

For the purpose of manufacturing Neodymium Oxide containing glasses, the Neodymium Oxide must be reasonably pure. Impurities can reduce transmittance of light other than yellow, which is absorbed by the Neodymium Oxide.

The use of Neodymium Oxide as an ingredient in glass making, especially for the production of millions, if not tens of millions of square feet of glass motor vehicle windshields and safety glazing materials, requires a substantial quantity of Neodymium Oxide of purity of 96.0 to 99.0 percent. The absorption properties of Neodymium Oxide containing glasses were known prior to World War II. However, the cost of producing reasonably pure Neodymium Oxide was quite high, because the chemical properties of the lanthanides are similar, and separation is difficult. During World War II, while working on the separation of the fission products as part of the atomic bomb project, scientists developed the elution chromagraphic ion exchange method for separating the rare earth elements. A major breakthrough occurred in the 1950's when Frank H. Spedding and co-workers developed the band-displacement ion exchange method, which was capable of producing macro quantities of extremely pure individual elements. Within 10 years, liquid-liquid extraction methods were developed which provided even lower priced individual rare earth elements.

Thus, it is possible to manufacture Neodymium Oxide containing windshields and safety glazing material that does not add significantly to the price of a new motor vehicle, and the Neodymium Oxide containing motor vehicle windshields and safety glazing material can be reasonably priced to compete in the aftermarket.

DESCRIPTION OF THE DRAWINGS

The invention can be best understood with reference to the following drawings in which:

FIG. **1** is a graph comparing the transmittance of a number of Neodymium Oxide containing glasses.

FIG. **2** is a graph of a light transmission curve of a Neodymium Oxide doped glass with a total light transmittance of 70.08 percent, which would satisfy the requirements of 49 CFR 571.205 and ANSI/SAE Z26.1-1996 for motor vehicle windshields and safety glazing material.

FIG. **3** is a graph of a light transmission curve of a Neodymium Oxide doped glass with a total light transmittance of 62.46 percent, which would satisfy the requirements for safety glazing materials for use in bullet resistant shields as per 49 CFR 571.205 and ANSI/SAE Z26.1-1996.

FIG. **4** is a graph of a light transmission curve of a Neodymium Oxide doped glass with a total light transmittance of 89 percent, which would satisfy the requirements for motor vehicle windshields and safety glazing materials as per 49 CFR 571.205 and ANSI/SAE z26.1-1996.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the transmission of light of various glasses containing Neodymium Oxide. It is shown that the smaller the atomic radius of the alkali, the more diffuse is the absorption band. The fine structure of the rubidium glass gradually disappears when this large alkali is replaced by the smaller potassium, sodium, or lithium ion. The importance for the invention at hand is that regardless of the base tape of the glass. the absorption of yellow light between 565 and 598 nanometers is seen in all samples of class. It is seen that the W87 lithium base Neodymium Oxide glass is absorbing 95 percent of the yellow light at 585 nanometers.

FIG. **2** is a light transmittance curve of a piece of Neodymium Oxide doped glass with a total light transmittance of 70.08 percent as supplied by Schott Glass Technologies, Inc., of Duryea, Pa. This glass is doped at 0.0221 grams of Neodymium Oxide per square centimeter of surface area. At 584 nanometers, the light transmittance is 15 percent; thus the glass is filtering out 85 percent of the yellow light. This glass satisfies the requirement of 49 CFR 571.205 and ANSI/SAE Z26.1-1996, for motor vehicle windshields and safety glazing material, which requires a regular (parallel) luminous transmittance of not less than 70 percent.

FIG. **3** is a light transmittance curve of a piece of Neodymium Oxide doped glass with a total light transmittance of 62.46 percent, as provided by Schott Glass Technologies, Inc., of Duryea, Pa. This glass is doped at 0.0356 grams of Neodymium Oxide per square centimeter of surface area. At 584 nanometers, the light transmittance is 12.5 percent; thus the glass is filtering out 87.5 percent of the yellow light. This glass satisfies the requirements of 49 CFR 571.205 and ANSI/SAE Z26.1-1996, for safety glazing materials for use in bullet resistant shields, which requires a combined (parallel) luminous transmittance at normal incidence through both the shield and the permanent vehicle glazing of at least 60 percent.

FIG. **4** is a graph showing three light transmission and reflection curves. The top curve, which is the curve of interest, is a light transmission curve for a piece of Neodymium Oxide doped glass with a total light transmittance of 89 percent. It is labeled "T" on the graph. The glass was supplied by Schott Glass Technologies, Inc, of Duryea, Pa., and the graphs were produced by Gentex Corporation, Zeeland, Michigan. This glass is doped at 0.00524 grams of Neodymium Oxide per square centimeter of surface area. At 584.5 nanometers, according to data supplied by Gentex Corporation, the light transmission is at a minimum and it is 81.67 percent; thus the glass is filtering out 18.33 percent of the yellow light at that frequency. This glass satisfies the requirements of 49 CFR 571.205 and ANSI/SAE Z26.1-1996 for motor vehicle windshields, safety glazing material, and for safety glazing material for use in bullet resistant shields.

DETAILED DESCRIPTION OF THE PREFERRIED EMBODIMENT

The present invention constitutes a Neodymium Oxide containing glass windshield and safety glazing material to filter out much of the yellow light between 565 and 598 nanometers.

As shown in FIG. **2**, a piece of Neodymium Oxide doped glass with 0.0221 grams of Neodymium Oxide per square centimeter has a total light transmittance of 70.08 percent. A doping level above this amount would result in a total light transmittance below 70 percent, which would be in violation of 49 CFR 571.205 and ANSI/SAE Z26.1-1996. In the preferred embodiment, the amount of Neodymium Oxide doping is kept below 0.0225 grams of Neodymium Oxide per square centimeter of glass surface.

At 584 nanometers, the glass absorbs 85 percent of the yellow light at that wavelength, and transmits 15 percent. It is important that a certain amount of yellow light be transmitted through the Neodymium Oxide containing glass so that objects with a predominant color in the yellow can be seen through the Neodymium Oxide doped windshield and safety glazing material. The minimum transmittance occurs at 584 nanometers. Additionally, it is imperative that yellow traffic signals be seen, as well as yellow and orange caution lights and warning signs. In the preferred emobodiment, the transmission of light at 584 nanometers is kept to a minimum of 15 percent and the absorption of light at 584 nanometers is kept to a maximum of 85 percent.

As shown in FIG. **3**, a piece of Neodymium Oxide doped glass with 0.0356 grams of Neodymium Oxide per square centimeter has a total light transmittance of 62.46 percent. A doping level above 0.040 grams of Neodymium Oxide per square centimeter of surface area would result in a total light transmittance of below 60 percent, which would be in violation of 49 CFR 571.205 and ANSI/SAE Z26.1-1996 for safety glazing materials for use in bullet resistant shields. In the preferred embodiment, the amount of Neodymium Oxide is kept below 0.040 grams of Neodymium Oxide per square centimeter of surface area.

As also in FIG. **3**, the glass absorbs 87.5 percent of the yellow light at 584 nanometers, and transmits 12.5 percent of the yellow light at that wavelength. It is important that a certain amount of yellow light be transmitted through the Neodymium Oxide containing glass so that objects with a predominant color in the yellow can be seen through the Neodymium Oxide containing safety glazing material for use in bullet resistant shields. The minimum transmittance occurs at 584 nanometers. Additionally, it is imperative that yellow traffic signals be seen, as well as yellow and orange caution lights and warning signs. In the preferred embodiment, the transmission of light at 584 nanometers is kept to a minimum of 12.5 percent and the absorption of light at 584 nanometers is kept to a maximum of 87.5 percent.

As to the maximum percentage of Neodymium Oxide being present in the windshield glass and the safety glazing material, there is an upper limit. For example, according to U.S. Pat. No. 5,077,240 of Hayden, discussed in the "Background and Theory of the Invention" herein, glass can be included doped therein Neodymium Oxide at a maximum concentration of 30 percent by weight. Otherwise, devitrification of the glass would occur. In actual practice, the concentration of Neodymium Oxide will vary with the thickness of the glass in the motor vehicle windshield and safety glazing materials.

Moreover, when less than the maximum amount of Neodymium Oxide is present in the glass, the filtering out of the yellow light between 565 and 598 nanometers is decreased. However, even minimal amounts of Neodymium Oxide will have a reduction in the amount of yellow light transmitted through the glass. For example, FIG. 4 shows the light transmission curve of a glass containing just 0.00524 grams of Neodymium Oxide per square centimeter of surface area. At 584.5 nanometers, the light transmission is minimized at 81.67 percent; thus the glass is filtering out 18.33 percent of the yellow light at that frequency. The total light transmittance of this glass is 89 percent, and it satisfies the requirements of 49 CFR 571.205 and ANSI/SAE Z26.1-1996 for motor vehicle windshields, safety glazing material, and for safety glazing materials for use in bullet resistant shields.

The Neodymium Oxide doped windshield, safety glazing material, and safety glazing material for use in bullet resistant shields can be used in such vehicles as an automobile, a truck, a bus, a motorcycle, a locomotive, a sport utility vehicle, and all terrain vehicle, and a van.

Modifications may be made to the method used for making the device, the device itself as well as the process described above for the Neodymium Oxide doped motor vehicle windshield, safety glazing material, and safety glazing material for use in bullet resistant shields without departing from the spirit and scope of the invention as exemplified in the appended claims.

I claim:

1. A motor vehicle windshield, and a means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers by up to 85 percent, said means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers comprising said motor vehicle windshield including glass material containing Neodymium Oxide up to 0.0225 grams per square centimeter of glass area.

2. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for an automobile.

3. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a truck.

4. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a bus.

5. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a motorcycle.

6. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a locomotive.

7. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a sport utility vehicle.

8. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for an all terrain vehicle.

9. The motor vehicle windshield as in claim 1 wherein the motor vehicle windshield is a motor vehicle windshield for a van.

10. Safety vehicle glazing, and a means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers by up to 85 percent, said means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers comprising said safety glazing material including glass material containing Neodymium Oxide up to 0.0225 grams per square centimeter of glass area.

11. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for an automobile.

12. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a truck.

13. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a bus.

14. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a motorcycle.

15. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a locomotive.

16. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a sport utility vehicle.

17. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for an all terrain vehicle.

18. The safety glazing material as in claim 10 wherein the safety glazing material is safety glazing material for a van.

19. Safety glazing material for use in bullet resistant shields, and a means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers by up to 87.5 percent, said means for reducing the amount of transmitted yellow light in the range of 565 to 598 nanometers comprising said safety glazing material for use in bullet resistant shields including glass material containing Neodymium Oxide up to 0.040 grams per square centimeter of glass area.

20. The safety glazing material for use in bullet resistant shields as in claim 19 wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for an automobile.

21. The safety glazing material for use in bullet resistant shields as in claim 19 wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a truck.

22. The safety glazing material for use in bullet resistant shields as in claim 19 wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a bus.

23. The safety glazing material for use in bullet resistant shields as in claim 19 wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a motorcycle.

24. The safety glazing material for use in bullet resistant shields as in claim **19** wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a locomotive.

25. The safety glazing material for use in bullet resistant shields as in claim **19** wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a sport utility vehicle.

26. The safety glazing material for use in bullet resistant shields as in claim **19** wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for an all terrain vehicle.

27. The safety glazing material for use in bullet resistant shields as in claim **19** wherein the safety glazing material for use in bullet resistant shields is safety glazing material for use in bullet resistant shields for a van.

* * * * *

Local Inventor Sees The Light

Receives New Patent For Reduced-Glare Windshield Glass

By David Ambro

One part at a time, Lloyd Harbor inventor Daniel Karpen is trying to make motor vehicle travel safer.

Using the rare-earth element neodymium oxide, Mr. Karpen has developed and obtained a United States patent for a low-glare vehicle headlight, which has for many years been on the market. In addition, Mr. Karpen has developed and obtained a patent for a motor vehicle rearview doped with neodymium, which cuts glare from approaching vehicles.

Now, Mr. Karpen has obtained two new patents, one issued July 9 for a reduced glare neodymium oxide containing window glass and the second issued September 17 for a neodymium oxide doped motor vehicle windshield.

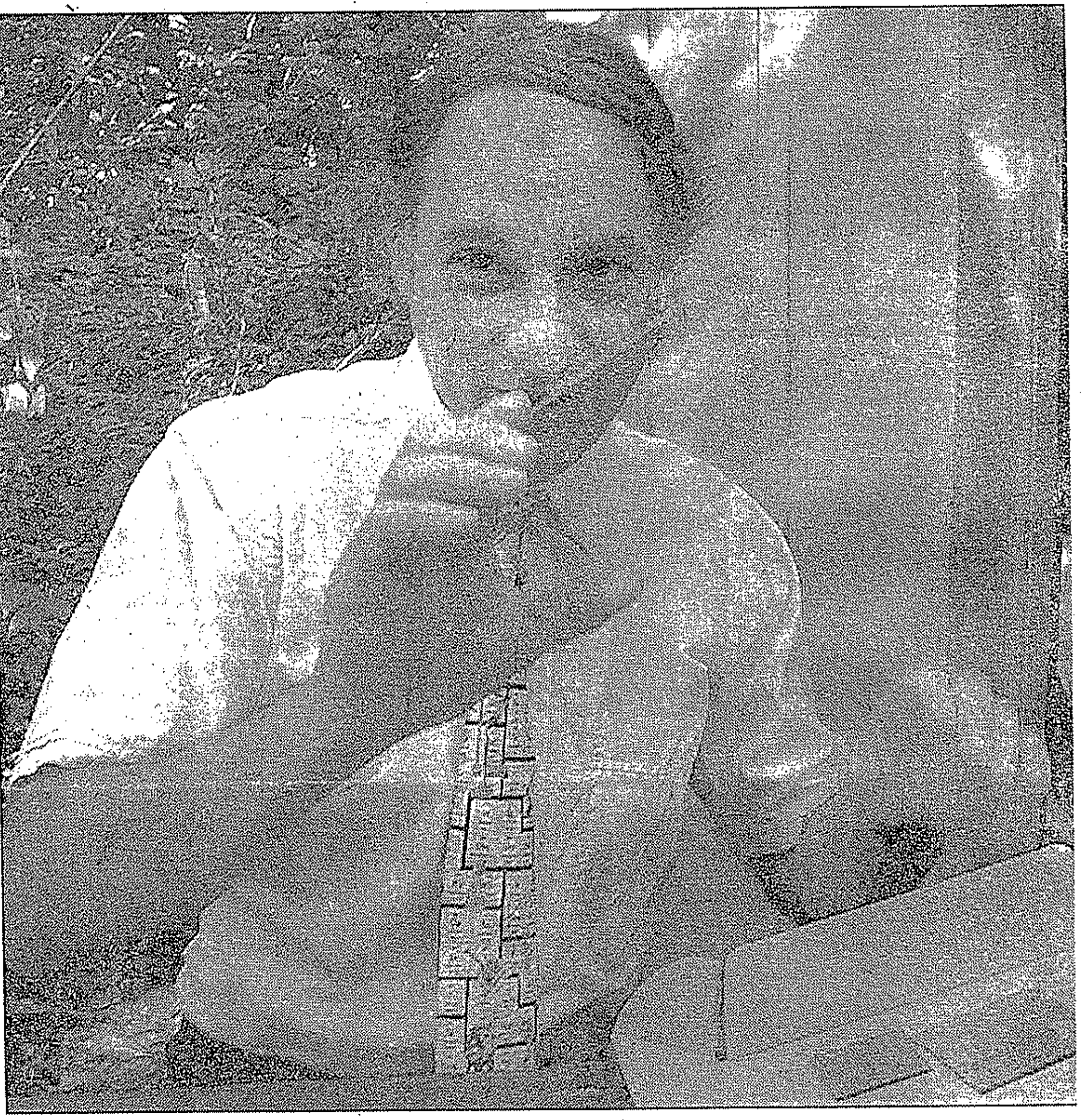
The neodymium oxide, according to Mr. Karpen, filters out a percentage of the yellow light of the spectrum, thereby providing improved vision. The yellow light in the spectrum desaturates colors and reduces contrast in objects.

"The result will be safer cars and someday this will become the standard technology," Mr. Karpen said during a recent interview at his Lloyd Harbor home. "It is going to happen. There has been a lot of interest shown by Detroit. They are talking about it."

According to Mr. Karpen, there are significant differences in his two latest patents. The July patent is for a window that will filter the glare of light entering a building, which allows for an unregulated amount of neodymium to be added to the glass. With respect to the windshield patent, the federal government requires a minimum light transmission of 70 percent, therefore, Mr. Karpen had to limit the amount of neodymium used in order to comply with federal standards.

Through his research, Mr. Karpen determined that in glass 2.88 millimeters thick—your average windshield—three percent neodymium will achieve the 70 percent threshold required by the federal government. "When the patent comes out, it is anticlimactic. The work is done before," Mr. Karpen said.

Mr. Karpen perfected the research that led to his last two patents—his seventh and eighth patents—with a grant from North East Utilities in Connecticut. The $74,000 research grant was awarded to study glare reduction using neodymium in glass. The study took Mr. Karpen about a year.



CLEARED UP: Lloyd Harbor inventor Daniel Karpen with a piece of the neodymium oxide doped glass, which he developed and ha obtained a patent to begin using in motor vehicle windshields to reduce glare. Mr. Karpen's latest patent compliment others he has fc low-glare headlights and rearview mirrors which are reaching the market place. *-David Ambro phot*

Mr. Karpen said that the major car companies have expressed interest in the product since the patent has been issued. In addition, AGC America Inc. is interested in manufacturing neodymium doped windows. In the meantime, Mr. Karpen said large scale manufacturing of his neodymium headlights is expected to begin in March or April 2003 and millions will be mass produced. He also said the neodymium rearview mirrors will begin being manufactured later this year. Schott Glass Technology Inc. of Duryea, Pennsylva nia will manufacture the mirror glass

Mr. Karpen is a product of the Col Spring Harbor School District. He gradu ated from the University of Washingto and received post-graduate degrees fror State University of New York at Ston Brook and Adelphi University. He is

Suffolk County Arson investigators determined that the fire was not suspicious. Boden said it could

across from Riverhead High School, said the only resident of the four-room trailer was an elderly man named Percy Tann.

bor Ed Alicea said.

Some neighbors felt sorry for Tann, Alicea said, because he was often

doctor because he had been sick," Alicea said. "He just said, 'Don't worry about me, I'll be all right.'"

Man Dies in Crash Caused by Glare

By Jennifer Sinco Kelleher
STAFF WRITER

Glare from the setting sun Tuesday afternoon prevented a man driving a beverage truck from seeing a red light in Glen Cove, which caused him to crash into a car, killing the driver, Nassau police said.

The truck driver, Steven Podstupka, 46, of Great Neck, told police he didn't see the red light at the intersection of Forest Avenue and Phillips Road about 4 p.m. He ran the light and hit the driver's side of a 1981 Oldsmobile.

The driver of the Oldsmobile, Donald Groth, 81, was taken to North Shore University Hospital in Glen Cove, where he was pronounced dead at 4:39 p.m., Second Squad Det. Sgt. John MacEwen said. Groth's wife, Carrie, 64, who was in the front passenger seat, was taken to the same hospital, where she remained in stable condition yesterday with broken ribs and internal injuries.

Podstupka was not injured in the accident and does not face any criminal charges, MacEwen said. Podstupka, who works for DSSR Beverage, Inc. in Great Neck, could not be reached for comment yesterday.

"The truck [driver], because of the glare, didn't see the red traffic light facing him," MacEwen said. "There's no criminality."

Podstupka was given a ticket for not stopping at the light. It was not known how fast the vehicles were traveling, MacEwen said. The Groths were wearing seat belts, he said.

Neighbors of the Groths said the couple had no children and kept to themselves.

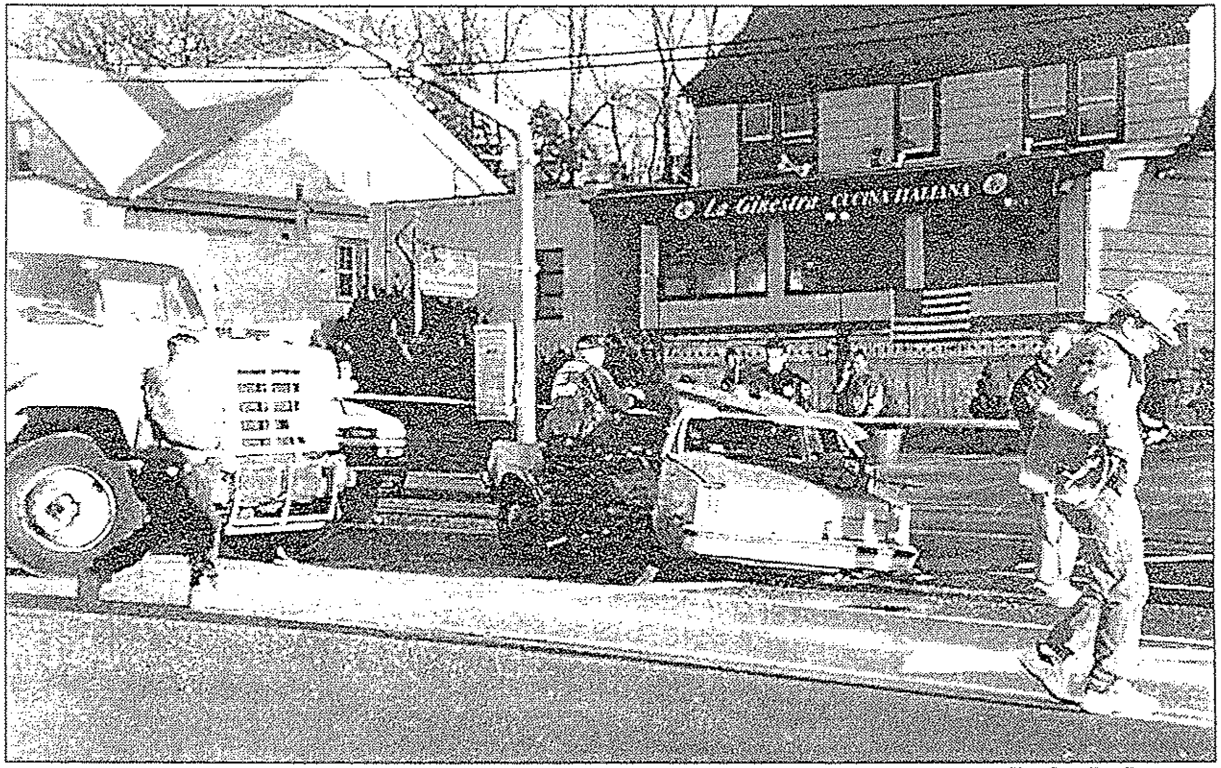


Photo by Alexander Van Santvoord / Glen Cove Fire Department

Police and firefighters work at the scene of an accident between a delivery truck and a passenger car in Glen Cove.

2 Nassau Women Injured in Separate Blazes

By Keiko Morris
STAFF WRITER

Two women were injured in two separate fires Tuesday, Nassau police said.

One, a 59-year-old Baldwin woman, suffered second- and third-degree burns when her cigarette ignited her nightgown. The other, a 60-year-old Long Beach woman, suffered burns to both of her arms after her stove's pilot light ignited vapors from a turpentine-soaked rag and a can of spray paint.

Police said the Baldwin woman, whom they did not identify, had just lighted a cigarette in bed Tuesday morning when she dozed off. The cigarette fell onto her nightgown and the woman, who

mond Kurz. She began to scream and tried to put the fire out with her hands and the bedspread before running to the bathroom.

Neighbors who heard her screaming called 911 around 8 a.m. First Precinct Officer William Schnell arrived and snuffed out the flames, which had melted her nightgown, Kurz said. Much of the fire was contained to her clothing. There was minor damage to her apartment.

The woman was taken to Nassau University Medical Center in East Meadow, where she was listed yesterday in critical but stable condition with burns over 35 percent of her body.

The second fire occurred about 2:45 p.m., when a a paint can with a turpentine-soaked rag, she popped it open on top of her stove, Kurz said, and the vapors burst into a flash that swept up her kitchen curtains.

With her arms burned up to her elbows, she ran to a neighbor's apartment to call the fire department. Meanwhile, the fire spread to the apartment above her, where nobody was home. The superintendent unsuccessfully tried to extinguish the flames.

About 150 residents in the complex were evacuated until the Long Beach Fire Department, with help from Island Park, Baldwin and Oceanside firefighters, put out the fire, police said.

The woman was taken to NUMC, where she was treated and released.

Scott McClellan said. "But these marshals appear to have acted in a way that's consistent with the extensive training that they have received. And we'll see what the investigation shows, and lessons learned from that will be applied to future training and protocol."

Similarly, Dave Adams, a spokesman for the Federal Air Marshal Service, said the marshals followed proper procedures. "We only react when there is a threat to the aircraft, passengers or crew," he said.

Passengers on the Orlando-bound American Airlines flight said they saw a man bolt from his seat and run down the aisle with his arms flailing shortly after boarding, with his screaming wife and a man in a Hawaiian shirt — an undercover air marshal — behind him.

He was gunned down moments later on a jetway after he apparently reached for his back, authorities said. Two air marshals were on the flight, and both fired at Alpizar, Adams said.

AP PHOTO

Police explode a suspicious object Wednesday after Rigoberto Alpizar, below, said he had a bomb.

It was the first time since the Sept. 11 attacks that an air marshal shot at someone.

Jeanne Jentsch, the sister of Alpizar's wife, read a short statement yesterday outside the couple's suburban Orlando home, calling him "a loving, gentle and caring husband, uncle, son and friend." Relatives took no questions from reporters, and the statement did not address Alpizar's mental condition.

James Bauer, agent in charge of the air marshals' Miami field office, would not comment on Alpizar's mental state but said that before Alpizar ran off the plane, he "uttered threatening words that included a sentence to the effect that he had a bomb."

Witnesses said Alpizar's wife, Anne, tried to explain he was bipolar, a mental illness also known as manic depression.

"She said it was her fault, that he was bipolar," said passenger Mike Beshears. "He was sick and she had convinced him to get on the plane."

The Bush administration hired thousands of additional air marshals after the Sept. 11 attacks, when the nation had only 33. The exact number is classified. Marshals fly undercover, and which planes they are on is a closely guarded secret.

Adams, the air marshals spokesman, said the two marshals joined the force in 2002. One previously worked with the Border Patrol, the other as a Customs inspector.

Officials declined to say how many times Alpizar was shot, but passengers reported hearing four to six shots.

Wondering why
Family, neighbors say it's a mystery how this could happen to Rigoberto Alpizar, above.

A70

Iowa, from Cairo, Egypt, were deemed suspicious, said Ann Davis, a spokeswoman for the Transportation Security Administration, which is responsible for airport security.

The shoes, on which one sole was loose and another held together with tape and a rubber band, were then examined by trace detection equipment, Davis said.

Alarms went off, and the man's shoes were confiscated while his luggage was screened and his body patted down.

Although the man missed his flight, Davis said he spent time in the airport and boarded a flight to Des Moines the next day, without his shoes.

An analysis of the shoes, performed Monday at the FBI Laboratory in Quantico, Va., determined there was no explosive material on the shoes, FBI spokesman Bill Carter said.

Student struck on campus crosswalk critical

PHOTO BY JAMES CARBONE

Stony Brook accident site at Circle Road and Roosevelt Drive.

BY JENNIFER SINCO KELLEHER
STAFF WRITER

A 19-year-old student at Stony Brook University was in critical condition yesterday after a car hit her while she was walking in a crosswalk on campus, school police said.

Simona Grabocka of Ridgewood, Queens, was walking near Roosevelt Quad at about 8:45 a.m. when a Hyundai Elantra struck her, Stony Brook University Police Assistant Chief Doug Little said.

She was taken to the university hospital where she was fighting for her life.

The driver, Umaima Mahmood, 30, a senior at the school, told police the sun's glare prevented her from seeing a stop sign and Grabocka, Little said.

Mahmood, of Hauppauge, who was driving south on Circle Drive, is not expected to be charged with any crime, Little said.

"She was terribly upset," he said.

Mahmood could not be reached last night. Her sister-in-law, who did not give her name, said that Mahmood had returned to campus yesterday evening to take an exam.

University spokesman Patrick Calabria said the counseling center would be available for students and staff.

COURTESY OF NEWS12 LONG ISLAND

Simona Grabocka, 19

"Our heartfelt condolences go out to the family and friends of Simona in the wake of this terrible tragedy," he said.

Staff writer Samuel Bruchey contributed to this story.

'Clearer, Brighter, More Vivid

Karpen's Headlight Invention Earns Superior Praise In RPI Stu

By David Ambro

Turn the spotlight on Lloyd Harbor inventor Daniel Karpen.

A study recently undertaken at Rensselaer Polytechnic Institute has concluded that the neodymium car headlight invented and patented by Mr. Karpen is by far preferable to other alternative options.

"The report is fantastic," Mr. Karpen said during an interview at his home Monday, September 3. "It is one of the best lighting studies in the United States in the last five years."

The study was conducted by Dr. Michele McColgan, Dr. John VanDerlofske and Insiya Shakar—all of Rensselaer's Lighting Research Center, Transportation Lighting Group. The exercise was carried out for Corning Inc., which will produce the neodymium-doped glass necessary to manufacture the Karpen headlight.

For the past 20 to 30 years, automotive headlights have been made of clear glass with halogen lamps. "Recently, there has been a proliferation of commercially available lamps with spectral light output differing from conventional halogen lamps for use in vehicle headlighting systems," says the report.

Among those alternative lighting types are the Karpen light using neodymium-doped glass, high-intensity discharge lights and coated blue halogen lamps. "With all of these new headlamp sources being used with difference spectral light output, the question arises about the appearance of common roadway objects under difference headlamp illumination," says the study.

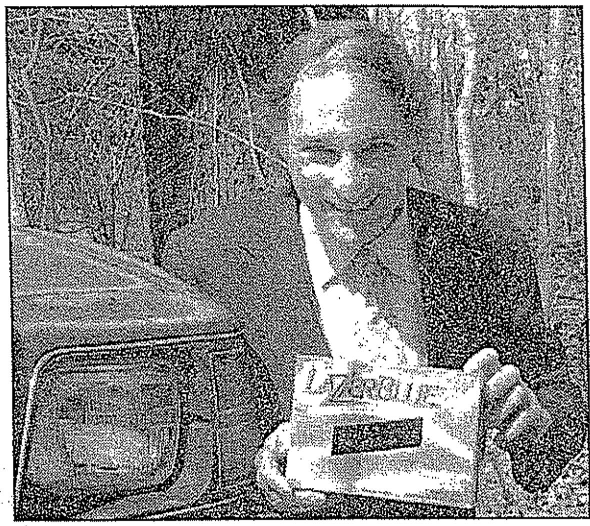
Using a randomly selected group of motorists as the subjects, the study group set up two road scenes using materials for [illegible] colored road signs. [illegible] lamps—neodymium, high-intensity discharge, blue coated and standard halogen—were used to illuminate the road scenes. Two separate test comparisons were made: (1) sets of the lights were compared side-by-side and (2) the lights were compared in sequence.

"The results of the study show that roadway sign material illuminated with neodymium tungsten halogen lamps (the Karpen light) were preferred in side-by-side and overall comparisons over standard tungsten halogen, high intensity discharge and blue coated tungsten halogen lamps," concludes the Rensselaer study. "People used words like 'clearer,' 'more vivid,' brighter' and 'more natural' (to describe the Karpen lamp) in comparison to the other lamps."

According to data collected in the study, 92 percent of the subjects preferred the Karpen lamp in side-by-side comparisons and 64 percent preferred the Karpen lamp in the sequential comparison.

"The results of this study show that subjects preferred the color-rendering provided by the neodymium lamps to all of the other lamps," the study concludes. "This preference for the neodymium lamps was significant for both side-by-side comparisons and when each of the lamps was shown to the subjects sequentially. The other studies, such as color-naming and color-difference, did not show any favorable or unfavorable results for any of the lamps. In other words, the number of color-naming errors was spread equally across all of the lamps."

According to Mr. Karpen, Corning spent over $1 million to develop the neodymium-doped glass for use in his headlight. Five models (H6024BK, H4656BK, H4651BK, H6545BK and H6054BK Karpen headlight are pre in production and bein keted for older vehicle trucks by Federal Mog Wagner Lighting Divisio vice stations interested taining the lights can ca manager Larry McAul (248) 354-1807. In addi 9004 series of the Karper light is in production fo new Fords, Chryslers an Japanese cars.



ILLUMINATED: Lloyd Harbor inventor Daniel Karpen with his new neodymium-doped car headlight, which recently received glow results in a comparison study undertaken by Rensselare Polytechnic Institute.

Tuesday, August 19, 2003

AUTO SUPPLIERS

New headlights may cut glare

Federal-Mogul will sell lights made with rare compound.

By Jeff Plungis
Detroit News Washington Bureau

WASHINGTON — The growing controversy over headlight glare has presented an opportunity for Federal-Mogul Corp.

The Southfield-based auto supplier hopes a New York inventor's anti-glare technology will give it a wedge in the competitive business of headlight replacement.

Later this month, Federal-Mogul will begin selling glare-resistant "TruView" headlamps under the company's Wagner Lighting name.

The lights use a rare earth compound called neodymium oxide to filter out glare-producing yellow light. As a result, TruView headlights cast a pure-white beam more akin to daylight than the more common yellowish halogen lamps.

"It's truer, whiter light," said Brian Tarnacki, director of brand marketing at Federal-Mogul.

Neodymium oxide has been used for indoor lighting since the 1980s. Long Island, N.Y., inventor Daniel Karpen patented the neodymium technology for use in automotive headlights. After the compound is mined, he said, it can be refined and ground into glass before it is blown. The neodymium in the glass then filters out a portion of yellow light.

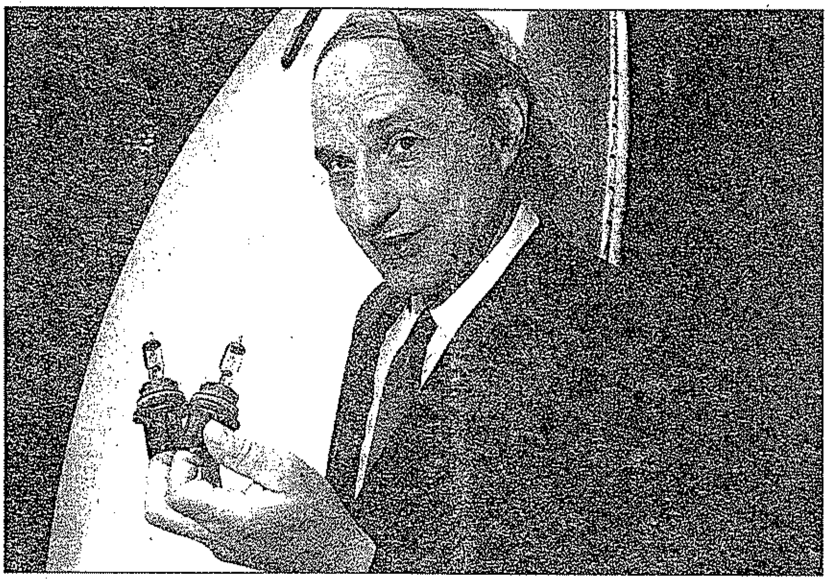
Karpen said the lights make road markings and signs pop out at night. Colors are more visible, and objects on the side of the road enter the driver's peripheral vision faster, he said.

"The neodymium-doped headlights will make other technology immediately obsolete."

Conventional halogen lights sell for less than $10 per bulb. The glare-resistant lights are set to retail for $14.99 per lamp, and have many of the same benefits as high-intensity discharge, or HID, headlights that have become popular on luxury models, Tarnacki said.

Optional HID systems range from several hundred dollars to $1,600 on models from Mercedes Benz and Lexus. The lamps are popular with their owners, but the intense glare they emit if viewed from the wrong angle has caused consternation among other motorists. The National Highway Traffic Safety Administration has logged thousands of complaints about HID glare.

Karpen said his technology can be used on rearview and side-view mirrors and can also be ground into windshields to reduce glare from oncoming traffic. There aren't any companies investing in those technologies yet, but the engineer said he is in discussion with several automakers and suppliers.



Louis Lanzano / Associated Press

Long Island, N.Y., inventor Daniel Karpen patented the neodymium technology for use in automotive headlights. The compound filters out glare-producing yellow light.

Lighting experts give Karpen's invention mixed reviews.

The Rensselaer Polytechnic Institute in Troy, N.Y., published research in 2001 that showed test subjects preferred neodymium lamps in side-by-side comparisons with halogen and HID lamps.

But John Van Derlofske, director of the institute's transportation lighting group, emphasized the study tested only the subjective preferences of the test participants. And there is little other research to back Karpen's claims on glare.

"We really have no idea how this might impact safety," Van Derlofske said. "It might help. We just don't know."

Tarnacki said he is confident that TruView will find a good market. Before deciding on the launch, Federal-Mogul conducted focus groups at night in Pontiac Silverdome's parking lot.

The TruView lights went over well with the test subjects on both visibility and glare. They were asked to rate their interest in the technology before and after the demonstration.

After the demonstration, Tarnacki said, "their interest went way up."

You can reach Jeff Plungis at (202) 662-7378 or jplungis@detnews.com.

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Recent Research on Neodymium Glass as Applied to Headlights, Rear View Mirrors, and Windshields

Daniel Karpen
Professional Engineer

Gordon Harris
Optometrist

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Recent Research on Neodymium Glass as Applied to Headlights, Rear View Mirrors, and Windshields

Daniel Karpen
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ABSTRACT

Neodymium Oxide, as a component of glass, selectively filters out a portion of the yellow light. Neodymium Oxide can be incorporated into the glass of the headlight lamp, the rear view mirror, and the windshield of a motor vehicle. A series of tests was conducted with 30 subjects recruited to quantify the reduction in glare and improvement in vision by the use of Neodymium Oxide doped glass for these applications. Subjects were put through a series of tests in an optometric examination room setting. The group was then divided in half, and one half received new standard headlights, and the other half received Neodymium headlights in a road test.

INTRODUCTION

The problem of glare from headlights continues to attract the attention of regulators and others who are concerned with motor vehicle safety. NHTSA has received several thousand comments on the issue in response to a request for comments in Docket No. 01-8885.

The purpose of this research was to do clinical optometric research and field trials to quantify the possible reduction in glare and improvement in vision from the use of Neodymium Oxide doped headlights, rear view mirrors, and windshields.

TEST PROCEDURES

The office of Dr. Gordon Harris were used for the optometric research. Subjects for research were recruited through advertising in local papers. As a condition of grant research funding, subjects were required to have current commercial driver's licenses. All subjects were paid $100.00 for their participation in the research.

All subjects were first given an optometric examination to determine their best vision under optimal viewing conditions. A total of 30 subjects were recruited for the research. Subject ages ranged from 29 to 75 years of age, with only two subjects under 40 years old. Subjects were both male and female. All subjects resided in Nassau and Suffolk counties on Long Island.

For the clinical optometric portion of the research, nine different tests were set up. These tests were designed to duplicate seeing tasks that might be expected of a motor vehicle driver. These tests are described in detail below:

1. Distance Vision Under Varying Illumination Levels.

Distance vision was tested through a Neodymium Oxide doped glass and a standard windshield glass. A sample of Neodymium Oxide doped glass with a total light transmittance of 70 percent was obtained from Schott Glass Technologies in Duryea, Pennsylvania. Pilkington (England) supplied a piece of Siglasol windshield glass with a total light transmission of 78.6 percent. The piece of Neodymium Oxide doped glass was solid without the plastic interlayer between the two pieces of glass in a standard windshield.

Distance vision was tested at three levels of illumination, 200, 2,000, and 20,000 millilux of direct illumination projecting a standard vision chart 14 feet in front of the subject at the far end of the optometric examination room. The light level was adjusted using a diaphragm aperture.

All vision was tested through the subject's best correction. Vision was recorded as 20/40, 20/30, 20/25, 20/20, or 20/15. When subjects were able to read all but several of the letters in a single line, vision was recorded as 20/20--, meaning two letters were missed.

A transmission curve for the Neodymium Oxide doped glass was provided by Schott Glass Technologies, and is Figure 1. Note a minimum transmission of 15 percent of the yellow light at 586 nanometers.

2. Distance Vision Under Varying Levels of Illumination With Different Colors

Under Neodymium lighting, colors appear more vivid, in particular the colors red, green, and blue. Therefore, it should be possible to perceive these colors at lower levels of illumination.

Especially critical at night is the ability of a motorist to see traffic signs at very low levels of illumination. Samples of traffic sign materials were obtained from the Traffic Control Materials Division of 3M Corporation. The materials are sold under the trade names "3M™ Scotchlite™ ElectroCut™ Film Series 1170" The following colors were obtained from 3M:

Color	Product Code
Yellow	1171
Red	1172
Orange	1174
Blue	1175
Standard Green (Worboy)	1176 (dark green)
Green	1177 (lighter green)
Brown	1179

These materials were mounted over a 3M 3990VIP Reflective Sheeting attached to 11" x 11" sheets of 1/4 inch thick masonite. At the bottom of each piece, a 1 1/2" x 1 1/2" square was cut out. A head for the photometer was mounted in that location.

A Gigahertz-Optik P-9710-1 Optometer with a VL-3702-2 Photometric Detector was purchased to measure illuminance. This photometer can measure light levels down to 1 millilux. A 5 meter detector cable was set up between the photometric detector and the photometer.

Subjects sat 14 feet from the colored sign materials. Light was projected onto the sign materials through the optometric projector. The illumination was varied using an Iris diaphragm placed in front of the projected light source.

Light was projected through the Neodymium Oxide doped windshield material (70 percent total transmittance) and through the standard windshield material (78.6 percent total transmittance).

Light silver colored reflective lettering used for road signs, 1" and 4" high, was purchased form Letterco, Inc., Sounderton, Pennsylvania. The following lettering was applied to the various colored sign materials as shown in the table at the top of the next column:

Color	4" Letters	1" Letters
Yellow	1C	730
Orange	4A	4395
Red	G2	846
Blue	F0	164
Standard Green	D7	9852
Green	B6	130
Brown	5E	752

The diaphragm was opened very slowly from almost total darkness (some stray light is necessary in order to see the control on the diaphragm). Lighting measurements were taken at the point where the subject can identify the 4 inch high lettering properly, the 1 inch lettering, and at the point where the subject can properly identify the sign color.

The test started with the standard windshield and proceeded through the 7 sign materials. Then the Neodymium Oxide doped windshield glass was used for the 7 sign materials. For every other subject, the order of presentation of Neodymium Oxide doped glass and the standard windshield glass was alternated in the test. Thus, the second subject started with the Neodymium Oxide doped glass.

Prior to the start of the testing of the 7 colored sign materials, the room was darkened for three minutes to produce adaptation.

3. Vision at a Distance - Glare Interference

This test modeled the ability of a motorist to read the license plate of an oncoming vehicle at night.

Two tungsten halogen lamps were placed 12 inches apart facing the subject from a distance of 14 feet. The two lamps are 75 Watt MR-16 tungsten halogen line voltage (120 Volt) lamps. The lamps are JX1015 made by Iwasaki Electric Co, LTD, and are of Japanese manufacture. The lamps are rated at 1500 axis candela.

The apparent angle subtended by the lamps mounted 12 inches apart at a distance of 14 feet models the headlights of an oncoming vehicle at a distance of about 90 feet. At that distance, the vehicle in low beam projects 26 lux of light on a target, and in high beam projects 34 lux of light at the maximum intensity of the beam.

Subjects were asked to read letters projected on an aluminum screen which is mounted between the two lamps. Letter sizes are 20/40, 20/30, 20/25, and 20/20. Subjects were given 10 seconds to read the letters. Data was recorded as in Test 1.

Subjects were asked to first read the letters through a piece of standard windshield glass having a total light transmission of 78.6 percent. In the second phase of the test, subjects were asked to read the letters through a piece of Neodymium Oxide doped glass with a total light transmission of 70 percent. For every other subject, the order of presentation was reversed in this test.

4. Rear View Mirror Comparison

Three different rear view mirror technologies were compared in this test. Testing was done on standard single reflectance mirrors, Neodymium Oxide doped mirrors, and on electrochromic mirrors.

A standard side view truck mirror was provided by Beach Manufacturing, Inc. (Donnelsville, Ohio). The mirror was 7 inches by 16 inches. Standard mirror glass, chromed on the front surface, is 62 percent reflective. Beach also provided a piece of Neodymium Oxide doped glass with a total reflectivity of 37 percent (supplied to them by Schott). The standard glass was cut in half, and on the right side of the rearview, set horizontally, the Neodymium Oxide doped mirror was mounted in the mirror frame.

An electrochromic mirror (self dimming) inside rear view mirror, manufactured by Gentex Corporation (Zeeland, Michigan), was purchased from an aftermarket supplier.

The electrochromic mirror is the NVS Auto Dimming Rearview Mirror. It automatically reduces the total reflected light back to the driver through electrochromic methods in the presence of a glare source. When there is very little light in the rear view mirror, the total reflectance is 75 percent. When there is a glare source, the total reflectance is 6 percent.

The total viewing distance from the subject to the mirrors to the screen of projected letters is 20 feet. A vision chart with reverse lettering is projected onto the aluminum screen at the front of the room. The subjects were seated with their back to the vision chart which is at the front of the examination room. The subjects sat three feet from the mirrors and the distance from the mirrors to the projected reverse vision chart is 17 feet. The 3 mirrors are arranged so that all of them are aligned so that the reverse lettering can be seen without the subject having to change position.

A black cloth was placed over two mirrors not being read so the subject is reading only one mirror at a time. Subjects were given 10 seconds to read each line of letters. The order of presentation between the 3 mirrors was randomized from subject to subject.

The subject's left eye was blacked out. The geometry of the apparatus makes it impossible to do this test with both eyes. The 3 mirrors are very close to each other, and it is impossible to see each mirror with both eyes.

Subjects were asked to read the vision chart in the standard mirror, the Neodymium Oxide doped mirror, and in the electrochromic mirror. Initially the two tungsten halogen lamps was turned off. Subject's ability to read the lettering were recorded as in test 1.

In the second phase of this test, the two tungsten halogen lamps were turned on to produce a glare source, and the subjects will be asked again to read the reverse lettering in the three mirrors.

5. Will Yellow Turn Signals be Visible in the Rear View Mirror and in the Windshield?

Neodymium Oxide doped glass is an efficient filter for yellow light. A yellow turn signal must be visible in the rear view mirror and through a windshield.

On a theoretical basis, a yellow turn signal should be visible in a Neodymium Oxide doped rear view mirror or windshield For a windshield to meet Federal safety standards, it must have a minimum light transmission of 70 percent. A piece of Neodymium Oxide glass satisfying Federal safety standards will transmit a minimum of 15 percent of the yellow light at 586 nanometers, and somewhat more to the higher and lower frequency yellow to either sides of the maximum absorption point.

The human eye is sensitive to yellow light, and many sources of yellow light are not pure, and depending upon the filtering media used to produce them, may contain some green light along with some orange light in the side bands.

A Ford turn signal, part number F.L.20.85, E6EB-13215-AD, was purchased from a local auto parts recycler. It was mounted inside a wooden box with the wires leading out of the back to a 12 Volt power supply and a standard automotive flasher.

The box has a slot so that 3" x 6" pieces of neutral density filters may be mounted in front of the turn signal. Five neutral density filters with transmittances of 70%, 60%, 50%, 25%, and 10% were purchased from Schott.

<u>Visibility in the rear view mirror</u>

The turn signal was mounted so that the sight distance from the subject to the rear view mirror is 20 feet as described in the previous test. The turn signal will be visible through a hole 1.75 inches in diameter in front of the box, to model a turn signal at a distance of 20 feet to the rear. The turn signal was turned on and off with the standard automotive flasher. Visibility of the turn signal was tested with the tungsten halogen lamps turned on and off.

All five of the neutral density filters were placed in front of the turn signal. They were placed so the arrangement from front to rear is the least dense (70%) to the most dense (10%) at the back. The total transmission is the product of the 5 filters, or a total light transmission of .525 percent.

When the turn signal is flashed on and off, subjects were asked if they can see it in each of the three mirrors, the standard mirror, the Neodymium Oxide doped mirror, and the electrochromic mirror. Subjects viewed the rear view mirror through their right eye.

If the subject can not see the turn signal in any one mirror, first the 70 percent neutral density filter was removed to increase the light transmission to .75 percent.

If the subject can not see the turn signal with the 70 percent filter removed from the filter stack, then the 60 percent filter was removed to increase the light transmission to 1.25 percent.

This process will continue until the turn signal is visible.

Visibility through windshields

This subtest checks the visibility of turn signals through a standard windshield and a Neodymium Oxide doped windshield.

Subjects viewed the turn signal with the headlights on and with the headlights off for both the Neodymium Oxide doped windshield and through the standard windshield.

If the turn signal can not be seen through the windshields with the 5 neutral density filters in front of it, then the process of removing filters as above was performed until the signal is visible.

For this test, each subject viewed the turn signal with both eyes.

6. Illumination and subjective fatigue

Neodymium lighting is said to be less fatiguing than standard incandescent lighting. Subjects will be tested for their response to the illumination.

The testing proceeds as follows: The lights are turned off in the examination room. Then two standard incandescent lamps are turned on, being mounted in a fixed position. The lamps are turned on for 30 seconds. The subject would be asked on a 1 to 9 scale as to the degree of fatigue. There would be a 30 second rest period, and the two Neodymium lamps would be turned on for 30 seconds. The subject would be asked again on a I to 9 scale with 1 being no fatigue and 9 being extremely fatigued.

The subject would be challenged for a second time with the Neodymium lamps, and for the fourth time, with the standard incandescent lamps. This ABBA pattern would be reversed for every other subject. To match photopic illuminance it was necessary to use 75 watt soft white lamps and 100 watt Neodymium Oxide "A" type lamps.

7. Stereoscopic Depth Perception Comparison Between Neodymium Oxide Doped Windshields and Standard Windshields

Utilizing a Howard Dolman apparatus, depth perception measurements were made viewing targets through Neodymium Oxide doped windshields and standard windshield materials. The Neodymium Oxide doped windshield used in this test is the same as the above tests; it has a total light transmittance of 70 percent, and the standard windshield has a total light transmittance of 78.6 percent.

Subjects viewed two pins, one fixed one movable, and pulled strings to line them up Six measurements were made under each viewing condition.

Subjects were seated 13 feet away from the zero point of the fixed pin. The movable pin was set 6 inches in front of the fixed pin for the first test, and 6 inches behind the fixed pin for the second test. The ABABAB presentation would be made for the standard windshield and BABABA for the Neodymium windshield. The presentation order would be reversed for every other subject. Measurements were made with an accuracy of .04 inches.

Standard incandescent lamps were used to illuminate the room at the time of the testing. There is a white painted surface at the back of the apparatus which provides contrast for the pins, which are painted black.

8. Equality of Distant Glare Comparison

This test compared subjective glare through standard windshield materials, a piece of Neodymium Oxide doped glass, and a neutral density filter. The Neodymium Oxide doped glass and the standard windshield glass were the same as used in the earlier tests. The neutral density filter had a total light transmission of 70 percent.

To model oncoming headlights, a pair of tungsten halogen lamps were mounted 12 inches apart 14 feet in front of the subject. Two line voltage 75 watt MR-16 lamps with a rating of 1500 axis candela and a beam spread of 28 degrees, as manufactured by Iwasaki Electric Co., LTD, were used for this test.

The two lamps were turned on for 10 seconds to mimic an oncoming driver. The subject was asked to rate the glare through the 3 glass media according to the DeBoer scale:

Rating	Meaning
1	Unbearable
2	
3	Disturbing
4	
5	Just Acceptable
6	
7	Satisfactory
8	
9	Just Noticeable

The order of presentation was randomized between subjects. Between each challenge, there was a rest period of 1.5 minutes.

9. After Image Decay Time

This test measured the length of time of after image decay for the Neodymium Oxide doped glass and the neutral density filter. Both pieces of glass have a total light transmittance of 70 percent.

The after image decay time test was performed after seven minutes to produce adaptation. The overhead incandescent lamps will be turned off for one minute following this adaptation period.

The 70 percent neutral density will be placed in a holder in front of the optometric examination eyepiece. Both tungsten halogen lamps will be turned on for five seconds to model headlights coming from the opposite direction.

The subject will be asked to blink every 5 seconds until the after image of the lamps is not discernible. The total time will be recorded as the time necessary for the after image to decay to the point it is not noticeable.

At that point, the subject will rest for 30 seconds, and then will be challenged with the piece of Neodymium Oxide doped glass with a total light transmission of 70 percent. As before, the subject will be asked to blink every 5 seconds until the after image is not discernible. There will be another rest period of 30 seconds, and the test with the Neodymium Oxide doped glass will be repeated, and then the test will be repeated a second time with the 70 percent neutral density filter as in the start of the test. This ABBA presentation will be changed to a BAAB presentation for every other subject.

The lamps used for this test are the same as in the earlier tests, a pair of JX1015 MR-16 tungsten halogen line voltage lamps made by Iwasaki Electric Co., LTD. These lamps are rated at 1500 axis candela, and are mounted 14 feet away from the subject.

10. Road Test

After completion of the optometric examination and the clinical testing, subjects were asked to obtain a new set of headlights for their vehicle at Centre Service in Syosset, New York. They were asked to drive at night north and south along the Seaford Oyster Bay Expressway, which has 3 lanes in each direction, a total of 23.6 miles, to road test the new headlights.

The subjects were divided into two groups randomly by Centre Service. The "A" group received the new Neodymium Oxide doped headlights, the "TruView" headlights supplied by Wagner Lighting Products, a division of the Federal-Mogul Corporation. The "B" group received new Osram Sylvania standard halogen headlights.

After completion of the test drive, subjects were asked to fill out a questionnaire with 12 questions to rate the performance of the headlights on a scale of 1 to 9 and to strongly agree or disagree. These questions were on the quality of the light and the ability to see at night. Subjects were asked to clock in tenths of a mile the maximum distances at which they could see the large green highway signs along the expressway, both in high beam and in low beam. Subjects were also asked to check off weather conditions at the time of the test drive.

Subjects were not aware that the panel was being divided into two groups, and were only told that they were getting new headlights. A copy of the instructions to the subjects and the questionnaire is included in this paper on the next page.

Name:.

Address:

ROAD TEST NEW HEADLIGHTS

As part of the research on glare and visibility, two new headlights will be provided for your use. Please make an appointment with Centre Service, 30 Underhill Boulevard, Syosset, at 516 921-1300 to obtain a new set of headlights for your vehicle.

Drive south at night on the Seaford Oyster Bay Expressway from Jericho Turnpike to Sunrise Highway. Get off at Sunrise Highway going east, go under the underpass, and head back north on Seaford Oyster Bay Expressway back to Jericho Turnpike.

After the test drive, please fill out this form and mail it back in the return envelope. As soon as Dr. Gordon Harris receives the filled out questionnaire, you will be promptly mailed a check in the amount of $100.00 for participation in this study.

PLEASE COMPLETE WITHIN TWO WEEKS

			Strongly Agree				Strongly disagree			
1.	Is the light close to daylight?	1	2	3	4	5	6	7	8	9
2.	Is the light free of glare?	1	2	3	4	5	6	7	8	9
3.	Is the light easy on your eyes?	1	2	3	4	5	6	7	8	9
4.	Green signs are brighter?	1	2	3	4	5	6	7	8	9
5.	Red color is much redder?	1	2	3	4	5	6	7	8	9
6.	Blue color is much bluer?	1	2	3	4	5	6	7	8	9
7.	Good contrast of black and white road markings	1	2	3	4	5	6	7	8	9
8.	I car, see the shoulders of the road better at night?	1	2	3	4	5	6	7	8	9
9.	Yellow signs easy to read?	1	2	3	4	5	6	7	8	9
10.	I can see better at night?	1	2	3	4	5	6	7	8	9
11.	I can perceive distances better?	1	2	3	4	5	6	7	8	9
12.	The light is whitish in color?	1	2	3	4	5	6	7	8	9

With your odometer, clock in tenths of a mile the maximum distance which you can see the large green highway signs?

High Beam (circle highest distance)	.1	.2	.3	.4	.5	.6	.7	.8
Low Beam (circle highest distance)	.1	.2	.3	.4	.5	.6	.7	.8

Weather conditions at time of test drive: Clear ______ Rain ______ Fog ______ Snow ______

Please provide us with any other comments below about these headlight lamps.
You may continue on the back of this form.

RESULTS

Statistical analysis of the data was performed using SPSS Version 9.0 A univariate analysis of variance (ANOVA), general linear model, was conducted to determine the factors that were significant, wherever t-tests were not appropriate by themselves. The subject is always used as a factor, so there is always two or more factors.

A "t" test was conducted for the test dependent variable (acuity, time, error) for the various types of glass or headlights. These statistics would augment the ANOVA statistics to distinguish the effects when the factor had more than two values. Paired sample "t" tests were performed when the subjects were challenged with different types of glass, mirrors, or headlights. Independent sample "t" tests were performed when the panel of subjects was broken into two groups.

For a number of tests there were only two means that needed comparison. When there are more than two means the "t" tests were used between the Neodymium case and the other cases only if the ANOVA showed that the null hypothesis was rejected, and if there were no repetitions of the measurements over the subjects. When there are multiple measurements per subject, Tukey's multiple comparison test was used in place of the "t" test.

The general hypothesis for all tests was that the variations in the dependent variable results because of the glass or the mirror used was due to chance. This hypothesis was rejected if the F value or t value exceeded the F(.05) or t(.05) value. If the hypothesis was rejected, the result was termed "significant".

Test 1 - Distance Vision Under Varying Illumination Levels.

In this test, there were 30 subjects, 3 brightness levels, and vision was tested through the standard windshield glass (78.6% total light transmission) and through the Neodymium Oxide doped glass (70% total light transmission). The three brightness levels were 200 millilux, 2 lux, and 20 lux. The dependent variable was best acuity.

The data from Test 1 was not in a form for direct statistical analysis when recorded in the optometric examination. For example, when there were two missed values on the 20/20 line, the data was recorded as 20/20 - -. There is a method for evaluating visual acuity when not all of the values on a line are not read correctly. What one does is to convert acuity to its logmar value (log10 of the minimum angle of resolution). For 20/20 vision, the logmar is 0. For 20/30, it is log10 (30/20) = .176, and so on.

If a person reads only some of the letters on a line, then linear interpolation of the logmar values of the previous line and the partially read line is used to get to an estimated logmar. The analysis is performed on the logmar values and converted back to an acuity value after completion of the statistics.

An example should make the procedure clearer: Assume that the subject reads all of the 20/25 line, and 5 of the 8 letters on the 20/20 line. The difference in logmar value is 0.097. Since the subject missed 3 out of 8 letters, the estimated logmar is increased above the 20/20 value by 3/8 times 0.097, which is 0 + .375 x 0.097 = 0.0306.

Acuity is known to vary with light level, so there was no need to run an ANOVA to test for differences in acuity with light level. The question of interest was whether there were any differences in acuity between the Neodymium Oxide doped windshield and the standard windshield glass at any of the light levels. Three paired sample "t" tests were run on each of the three illumination levels. For each of the "t" tests, there were 29 degrees of freedom. As shown in the table below, no significant differences were found between the two glass types.

Lighting Level	Mean Neo	Mean Normal	"t" Value	"t" Probability
200 Millilux	20/53.12	20/51.98	- .655	.518
2 Lux	20/27.54	20/26.9	-1.399	.172
20 Lux	20/21.71	20/22.45	1.036	.309

Test 2 - Distance Vision Under Varying Levels of Illumination With Different Colors.

In this test, there were 30 subjects, 7 colored sign materials, 3 types of targets (ability to read 4" lettering, ability to read 1" lettering, and ability to correctly identify the color of the sign material), and vision was tested through the standard windshield glass and through the Neodymium Oxide doped glass. The dependent variable was the light meter reading.

All of the light meter readings on the target were multiplied by .786 for the standard glass and .7 for the Neodymium Oxide doped glass to normalize the transmission of light through the glass to the subject's eyes. In this way, the spectral effect is being tested directly. This test does not test whether visibility is the same at the slightly reduced illuminance (.7/.786) of the target illuminated to the same level and seen through the Neodymium Oxide doped glass versus being seen through the standard glass.

In a review of the data, it was noticed in a number of cases that the subjects were only able to identify the color at the same light level as being able to discertain the 1" high lettering. In every case, the subjects were able to read the 4" high lettering before being able to read the 1" high lettering.

For the statistical analysis, light levels were averaged over all of the data points for being able to identify the color of the target material, and being able to read the different size lettering. ANOVAs were run for each of the 7 sign materials as a function of subject, target size, and glass type. For all 7 of the ANOVAs the subject and target type were significant, while the glass type was not significant. The mean light levels over the three target types are shown below, along with the probabilities for a glass effect.

Color	Neodymium Glass	Standard Glass	Probability
Yellow	486.6	448.2	0.409
Red	295.7	302.7	0.779
Orange	457.7	401.1	0.224
Green (Worboy)	277.3	284.8	0.726
Green (lighter)	201.6	240.0	0.067
Brown	305.6	350.5	0.270
Blue	264.1	254.9	0.847

Test 3 - Vision at a Distance - Glare Interference.

In this test, there were 30 subjects, and testing was done between the standard windshield glass and the Neodymium Oxide doped glass. Subjects attempted to read lettering projected between two tungsten halogen lamps. As in Test 1, the logmar method was used to perform the data reduction and the subsequent statistical analysis.

A paired samples "t" test was run. There was a slight but statistically significant ($p = .013$) improvement in mean acuity with the Neodymium Oxide doped glass (20/36.6 vs. 20/38.8).

Test 4 - Rear View Mirror Comparison

In this test, there were 30 subjects, 4 mirror types, and subjects were tested with the headlights off and the headlights on. The 4 mirror types were the standard mirror, the electrochromic mirror in a dimmed state, the electrochromic mirror in an undimmed state, and the Neodymium Oxide doped mirror. The dependent variable was the best visual acuity.

Data was analyzed for the two cases of the headlights on and the headlights off. The ANOVA showed that the significant factors were the subjects and whether the headlights were on or off. The mirror type was a significant factor with a probability of 0.025.

In the case where the headlights were on, there were 5 subjects out of 30 where the visual acuity values for some or all of the 4 mirror types were recorded at 20/200 or worse. Three of the five subjects were the same subjects who had visual acuities of 20/200 for both glass types in Test 3.

Multiple paired sample "t" tests were run between the Neodymium Oxide doped mirrors and the other 3 mirror types, both with the headlights on and the headlights off. For each paired samples "t" test, there were 29 degrees of freedom.

Results are provided in the table below:

Headlights Off			
Mirror Type	Mean Visual Acuity	"t" Value	"t" Probability
Neodymium Oxide	20/26.02		
Standard Glass	20/25.38	1.436	0.162
Electrochromic, undimmed	20/25.43	2.027	0.052
Electrochromic, dimmed	20/30.48	-4.575	<0.0001
Headights On			
Neodymium Oxide	20/53.85		
Standard Glass	20/50.00	1.681	0.103
Electrochromic, undimmed	20/56.88	-1.236	0.226
Electrochromic, dimmed	20/60.28	-2.21	0.035

Test 5 - Will Yellow Turn Signals be Visible in the Rear View Mirror and in the windshield?

In this test, there were 30 subjects, 4 mirror types, and the headlights were turned on an off. For the windshield portion of this test, there were 30 subjects, 2 windshield types, and the headlights were turned on and off.

Recorded values were the minimum percentage transmission of the light through the set of neutral density filters placed in front of the turn signal.

The ANOVA showed for the rear view mirror that neither the subjects, the headlights, nor the mirror type were significant. With the headlights off, all of the subjects could see the turn signal in all four mirrors at the lowest level of light transmission through the filter stack (0.00525). With the headlights on, the mean transmittances are provided below:

Mirror Type	Mean Transmittance
Neodymium Oxide	.145
Standard Glass	.097
Electrochromic, undimmed	.128
Electrochromic, dimmed	.172

The ANOVA for the windshield showed that the headlights being on or off was a significant factor. There were no significant differences between the subjects or the windshields. The probability for the windshield was 0.613, and the probability for the headlight was 0.013. The mean transmittance for the standard windshield was 0.022, and the mean transmittance for the Neodymium Oxide doped windshield was 0.031.

Test 6 - Illumination and Subjective Fatigue.

This test did not give any results. None of the subjects could determine that one light, the standard incandescent bulbs or the Neodymium Oxide doped bulbs, was better than the other in reducing fatigue.

Test 7 - Stereoscopic Depth Perception Comparison Between Neodymium Oxide Doped Windshields and Standard Windshields

Of the 30 subjects in the panel, two had no depth perception, and another subject did three trials through the standard windshield and the Neodymium Oxide doped windshield of the 6 trials planned for the research. Of the 360 possible data points (30 subjects x 12 trials) there were a total of 330 data points. The dependent variable was the error in distance assessment which was measured in inches.

The ANOVA showed there were differences between subjects and there was no significance between windshield types with a probability of 0.881. The mean error for the Neodymium Oxide doped glass was 0.389 inches, and the mean error for the standard windshield glass was 0.396 inches.

Test 8 - Equality of Distant Glare Comparison.

In this test there were 30 subjects, 3 types of glass, and three replications for each glass type. The dependent variable was the glare rating from 1 to 9 on the DeBoer scale. A rating of 1 is unbearable and a rating of 9 is just noticeable.

The ANOVA showed that the significant factors were the subject and the glass type. The probability was 0.026. Means are provided below:

Glass Type	Mean DeBoer Rating
Neodymium Oxide	5.81
Neutral Density Filter	6.27
Standard Windshield Glass	6.08

Each subject made more than one glare rating, so the Tukey multiple comparison test was used to evaluate which differences were significant. The mean DeBoer ratings between the Neodymium Oxide doped glass and the neutral density filter were significant at the .05 level. The critical value of the Tukey multiple comparison test with 266 degrees of freedom and 3 classifications is 3.31 at the .05 significance level. The critical value between the Neodymium Oxide doped glass and the neutral density filter was 3.78, so there was significance. However, the differences for the other two classifications was not significant with critical values of 2.3 and 1.5.

Test 9 - After Image Decay Time

Of the 30 subjects in the panel, only 23 were able to perform this test to obtain usable data. Subjects either had no response or had no after image. The analysis in this test was done only on subjects where it was possible to determine and record an after image decay time.

In this test, there were two types of glass tested, the neutral density filter and the Neodymium Oxide doped windshield. Subjects were asked to provide the after image decay time for 4 replications for each type of glass. The dependent variable was the after image decay time in seconds.

The ANOVA showed the significant factors were the subject and the filter type. The mean decay time for the Neodymium Oxide doped windshield glass was 21.90 seconds and the mean decay time for the neutral density filter was 26.29 seconds. The mean decay time for the after image decay of the Neodymium Oxide doped windshield was 17 percent lower than the neutral density filter. The probability as provided by the ANOVA was .002.

Test 10 - Road Test of New Headlights

Of the 30 subjects, 28 subjects completed the road test. Two subjects took the road test without changing their headlights; their data was dropped from analysis. There were 13 subjects in each group that had either new standard headlights or new "TruView" headlights which contain Neodymium Oxide in the glass of the bulb.

Both sealed beam and capsule type headlights were used in the study. Vehicle types included both foreign and domestic vehicles, with a mixture of passenger sedans, sport utility vehicles, and vans. None of the subject vehicles had high intensity discharge type headlights. All of the subjects in the group with the "TruView" headlights received new capsule type headlights. In the group with the standard headlights, there were 8 vehicles with capsule type lamps, and 5 vehicles with new sealed beam lamps.

Subjects were asked about weather conditions at the time of the test drive. Of the 26 subjects included in the statistical analysis, one subject in the group with the Neodymium headlights reported a slight fog at the time of the test drive. A review of the submitted questionnaire noted a similar pattern of responses compared with those subjects who drove in clear weather.

As the group with the Neodymium Oxide doped headlights did not included any sealed beam lamps, an ANOVA was run to determine if there was a significant difference in responses between the subjects who received sealed beam lamps and those subjects who received capsule type lamps. No significance was found.

Each of the 12 statements in the questionnaire, and the two questions relating to seeing distances in low beam and in high beam, were analyzed statistically using an independent samples "t" test. There were 24 degrees of freedom for each of the 14 independent samples "t" test.

A negative "t" value indicates that the Neodymium doped headlight is favored over the standard headlights. The "t" values and "t" probabilities are provided in the table below:

"t" Test Comparison Between Neodymium and Standard Headlights

Road Test

Question Number	Statement	"t" Value	t" Probability
1	Is the light close to daylight?	-1.316	.200
2	Is the light free of glare?	-1.136	.270
3	Is the light easy on your eyes?	-2.225	.040
4	Green signs are brighter?	-1.277	.220
5	Red color is much redder?	-2.248	.035
6	Blue color is much bluer?	-2.008	.045
7	Good contrast of black and white road markings?	-1.023	.310
8	I can see the shoulders of the road better at night?	0.209	.850
9	Yellow signs easy to read?	-2.097	.045
10	I can see better at night?	-0.542	.590
11	I can perceive distances better?	-0.310	.750
12	The light is whitish in color?	0.684	.500
In high beam, the mean seeing distance was .531 miles with the Neodymium Oxide doped headlights and .550 miles with the standard headlights. In low beam, the mean seeing distance was .408 miles with the Neodymium Oxide doped headlights and .408 miles with the standard headlights.			
13	High beam seeing distance	0.223	.820
14	Low beam seeing distance	0.000	1.0

DISCUSSION

The purpose of the research was to quantify the possible reduction in glare and improvement in vision resulting from the use of Neodymium Oxide doped headlights, rear view mirrors, and windshields.

The research found some unexpected results. In general, the Neodymium Oxide doped headlights, rear view mirrors, and windshields performed as well as standard glass for the same applications.

Test 1 showed that one could see visually as well through the Neodymium Oxide doped glass (70% total light transmission) as the standard windshield glass (78.6% total light transmission). The three independent samples "t" tests provided significance of .518, .172, and .309 for the 200 millilux, 2 Lux, and 20 Lux light levels, showing no statistical significance at the .05 level. Despite the lower transmittance of the Neodymium Oxide doped glass, there was no statistically significant difference in visual acuity, and no consistent trend favoring the higher transmittance glass.

Test 2 looked at whether one could see colors better through the Neodymium Oxide doped glass compared with standard windshield glass compared of equal transmittance. ANOVA tests on the 7 sign color materials provided a very wide range of probabilities ranging from .067 for the lighter green to .847 for the blue.

Test 3 tested glare interference when reading lettering projected between two glare sources. As described in the investigation section of the report, the test models the ability of a motorist to read a license plate on an oncoming vehicle at night. The mean visual acuity for the Neodymium Oxide dopes glass was 20/36.6 compared with 20/38.76 for the standard windshield glass. The paired samples "t" test provided a probability of 0.013, indicating significance. Note that this visual task is far more difficult than simply reading a Snellen chart without glare sources as in Test 1. Also note that the Neodymium Oxide doped glass had a lower total light transmittance (70.0%) compared with the sample of standard windshield glass (78.6%). This result is a highly important finding.

Test 4 compared the visual acuity in 4 rear view mirrors with the headlights on and with the headlights off. Multiple paired sample "t" tests were run between the Neodymium Oxide doped glass and the other mirror types. Despite having approximately half the reflectance of the standard mirror and the undimmed electrochromic mirror, there was no significant loss of visual acuity with the Neodymium Oxide doped mirror. The Neodymium Oxide doped mirror provided better visual acuity than the dimmed electrochromic mirror, both with and without headlight glare. With the headlights off, the dimmed electrochromic mirror, when compared with the Neodymium Oxide doped mirror, had a probability <.0001 which is highly significant.

Test 5 showed that yellow turn signals will be visible in the Neodymium Oxide doped rear view mirror and in the Neodymium Oxide doped windshield. As discussed in the results section, with the headlights off, all of the subjects could see the turn signal in all 4 mirrors at the lowest level of light transmission through the filter stack. The ANOVA showed no significant differences between mirror types. For the windshield, the type of windshield was not significant. This finding is very important, as concern has been raised that the use of Neodymium Oxide doped glass for these applications would make yellow turn signals difficult to see.

Test 6 testing the differences in illumination and fatigue between the Neodymium Oxide doped lamps and the standard lamps, did not give any results.

Test 7 compared stereoscopic depth perception through the Neodymium Oxide doped glass and through the standard windshield glass. The mean errors in judgement for both types of glass were almost identical, with 0.389 inches for the Neodymium Oxide doped glass and 0.396 inches for the standard windshield glass, even though the Neodymium Oxide doped glass had a lower total light transmittance than the standard windshield glass (70.0% vs 78.6%, respectively). The ANOVA showed no significance in glass types with a probability of 0.881.

Test 8 showed a significant difference in glare between the Neodymium Oxide doped glass and a neutral density filter. There were no significant differences between the standard windshield and the other glass types. Note that the finding of significance between the neutral density filter and the Neodymium Oxide doped glass is academic, because neutral density filter glass is not used for motor vehicle windshields.

Test 9 showed a very significant difference in the decay time of after images in the eye. For the Neodymium Oxide doped glass, the mean decay time was 21.90 seconds compared with 26.29 seconds for the neutral density filter. Both types of glass had a total light transmission of 70%. The reduction in mean decay time was 17 percent. The ANOVA provided a probability of 0.002, giving a very significant difference in performance in favor of the Neodymium Oxide doped glass. While no comparison was made in the research in the decay time between a standard windshield and a Neodymium Oxide doped glass, it should be expected that the mean decay time would rise with the standard windshield glass as it has a higher total light transmittance of 78.6 percent.

Test 10 was the road test. There were 4 statements out of the 12 statements where the independent samples "t" probability was below .05, showing significance. Subjects found that the Neodymium Oxide doped headlights were easy on their eyes (0.040), that the red color was redder (0.035), that the blue color was much bluer (0.045), and that the yellow road signs were easy to read (0.045).

A surprise in the study was that the subjects found that yellow road signs were easy to read. It should be noted that yellow road signs usually have black lettering against a yellow background. In Test 2, for uniformity purposes, silver lettering was tested against colored backgrounds, as red, green, blue, and brown road signs use silver lettering. This finding may be a reflection of the wording of the statements, as the statement that the Neodymium Oxide doped headlights were easy on their eyes used the word "easy" as did the statement that yellow signs were "easy" to read.

The Neodymium Oxide doped headlights, as utilized in the road test, filter out a maximum of 70 percent of the yellow light at 586 nanometers, thus allowing a minimum of 30 percent of the light generated by the filament to be emitted from the lamp to illuminate the roadway. (See Figure 2.)

A reflectance curve of the yellow sign material is provided in Figure 3. From 590 to 690 nanometers, the percent reflection is about 40 percent. Thus, while some of the yellow light illuminating the yellow is reduced by the Neodymium Oxide doped headlights, there is about the same reflectance in the orange and in the red, which tends to make the sign have a more saturated color hue.

There was no significant difference in the seeing distances between the Neodymium Oxide doped headlight lamps and the standard headlight lamps, and the mean seeing distances were very close.

The road test also confirms the work of McColgan et. al. in judging lamp preference. In that study, subjects used words such as "clearer", "more vivid", "brighter", and more natural in comparison with other headlight lamps. In side by side comparison, for all the times the Neodymium Oxide doped lamp was shown, it was chosen 92% and 96% of the time for the low and high luminance tests, respectively.

CONCLUSION

Neodymium Oxide doping of the glass of the headlight bulb, rear view mirror, and windshield improves the visual performance for the motor vehicle driver.

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McColgan, Michele; Van Derlofske, John; and Insiya Shakir; Color Preference Benefits Evaluation of Neodymium Glass for Automotive Forward Lighting. Lighting Research Center, Rensselaer Polytechnic Institute, June, 2001. 20 p.

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Figure 1

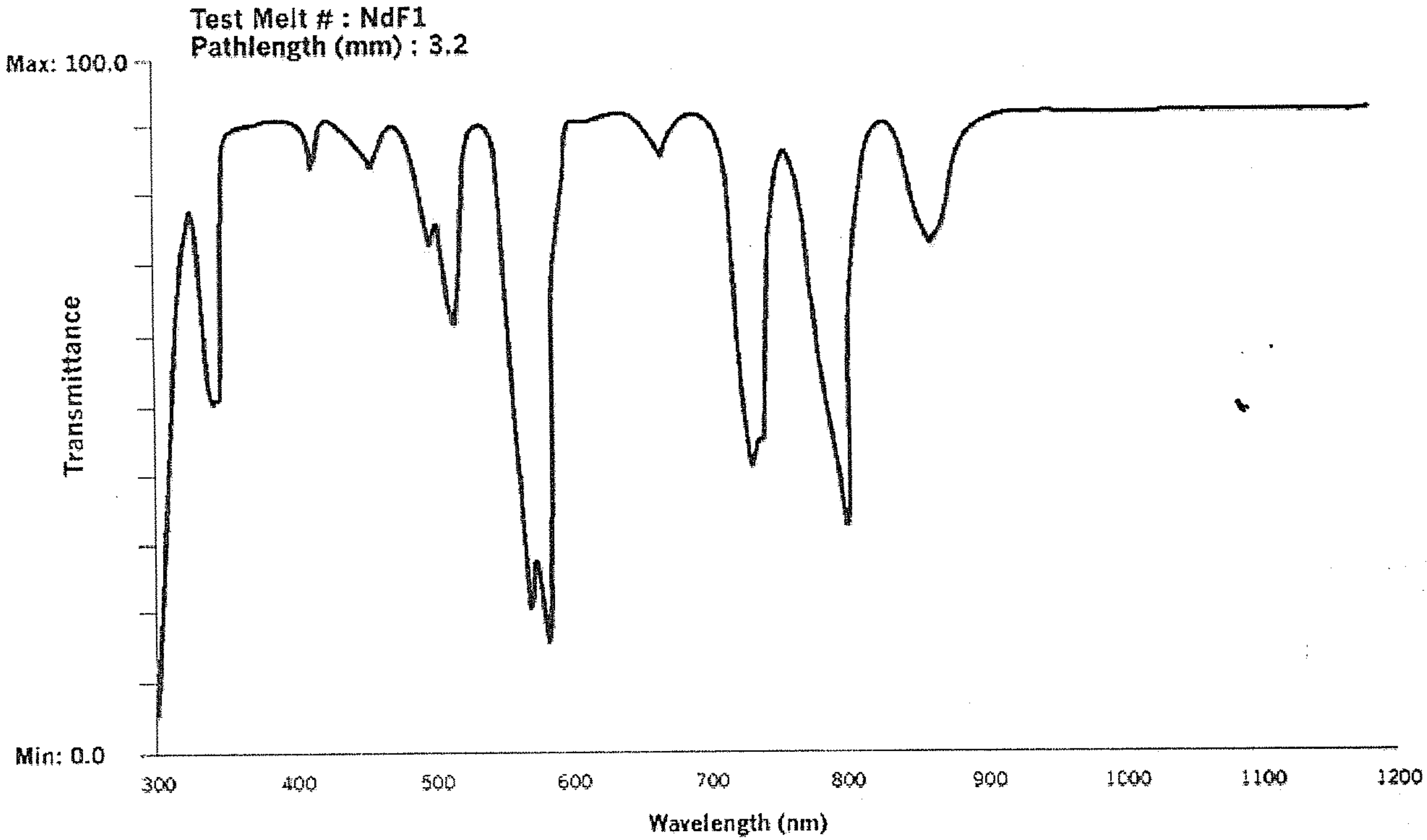
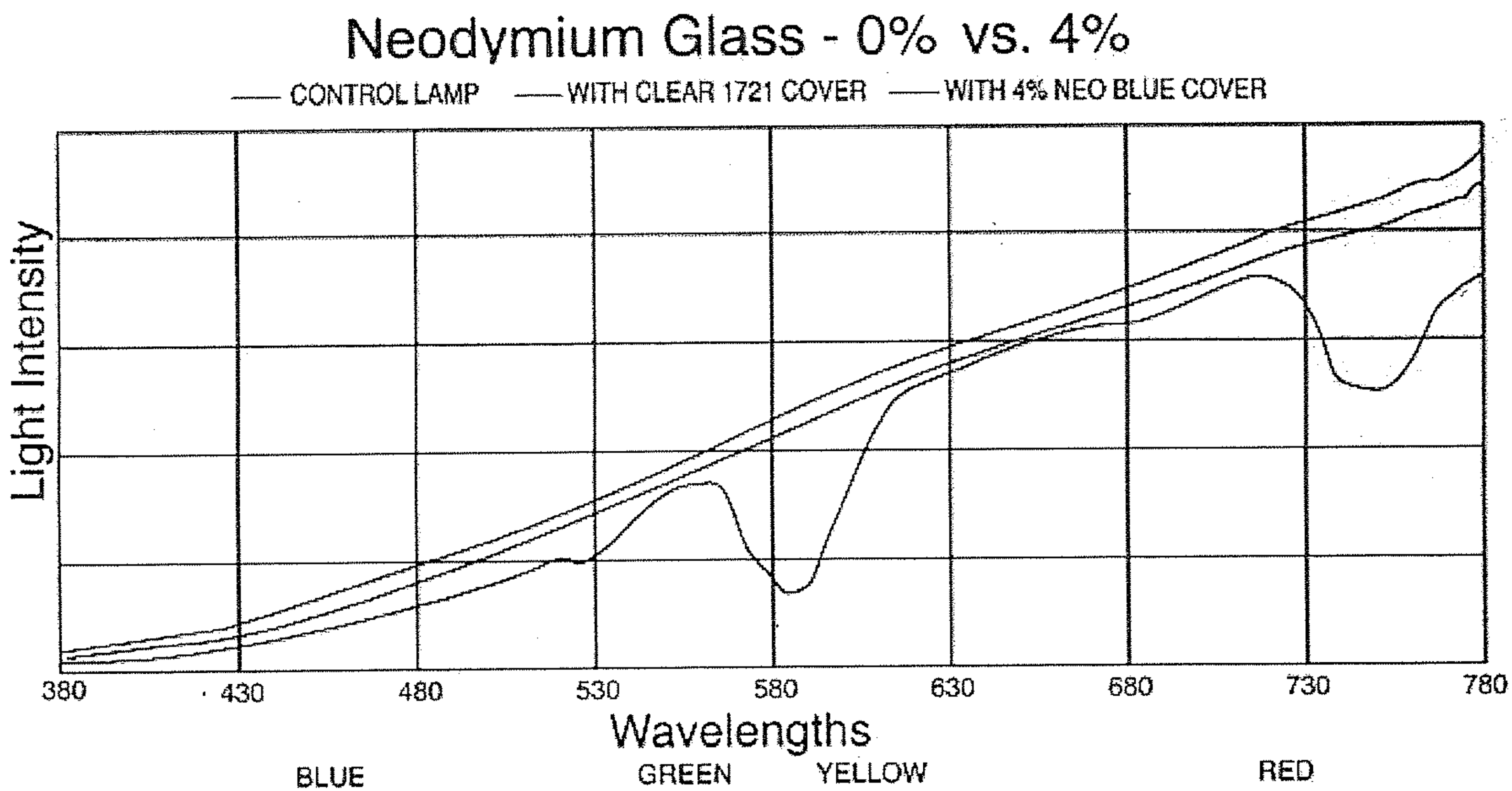
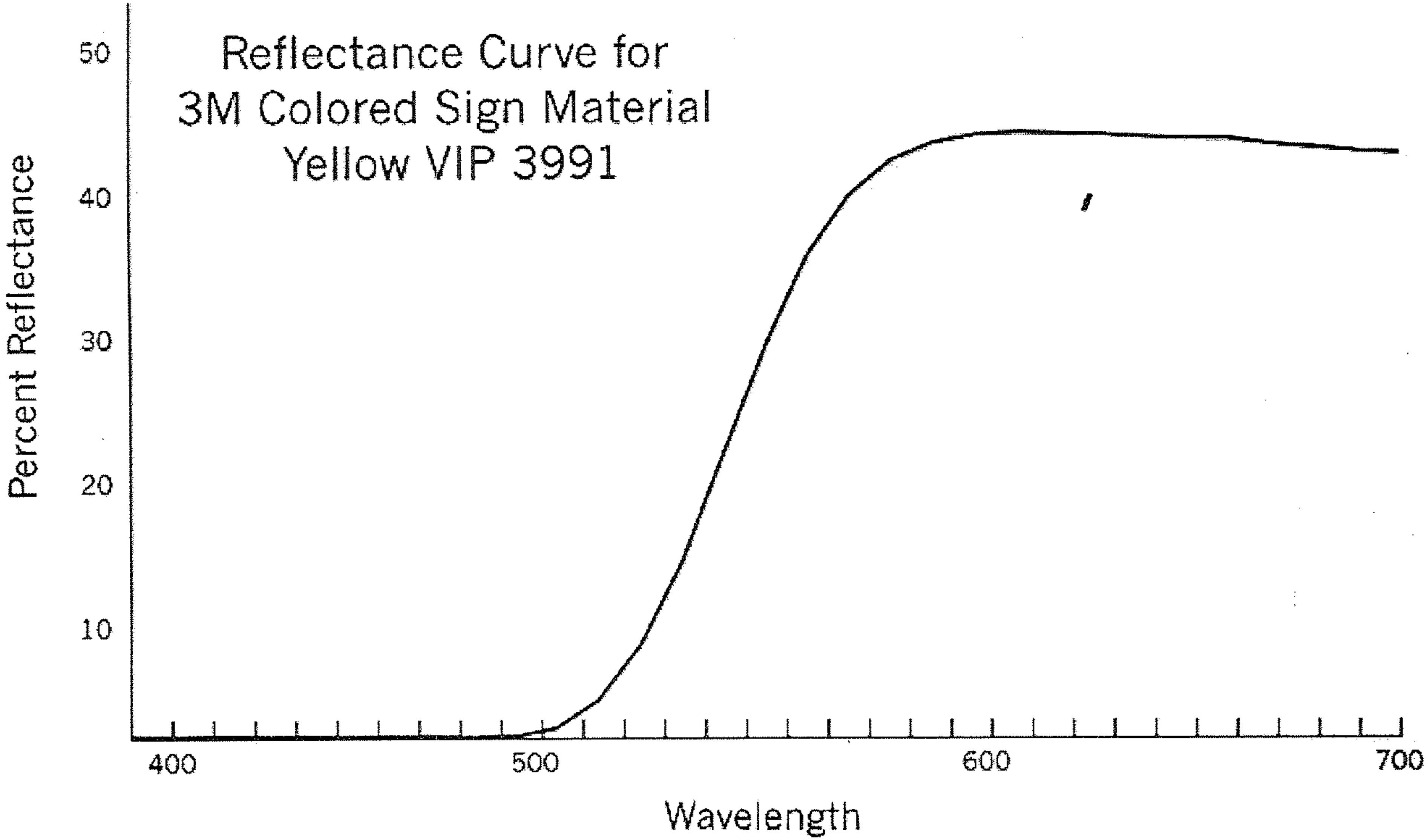

Test Melt # : NdF1
Pathlength (mm) : 3.2
Max: 100.0
Min: 0.0
Transmittance
300
400
500
600
700
800
900
1000
1100
1200
Wavelength (nm)

Figure 2



Neodymium Glass - 0% vs. 4%
CONTROL LAMP
WITH CLEAR 1721 COVER
WITH 4% NEO BLUE COVER
Light Intensity
380
430
480
530
580
630
680
730
780
Wavelengths
BLUE
GREEN
YELLOW
RED

Figure 3


Reflectance Curve for
3M Colored Sign Material
Yellow VIP 3991
Percent Reflectance
50
40
30
20
10
400
500
600
700
Wavelength