NASA CR 101860

FINAL REPORT

DESIGN, DEVELOPMENT AND PRODUCTION OF PRESSURE SUIT SPECTACLES

PREPARED FOR

NASA MANNED SPACECRAFT CENTER
R & D PROCUREMENT BRANCH

CONTRACT NAS 9-8090

SUBMITTED BY

UNIVIS, INC.-OMNITECH DIVISION
ROUTE #131
DUDLEY, MASSACHUSETTS 01550

PREPARED AND EDITED BY

ALBERT J. LALIBERTE

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SUMMARY

Under the terms of Contract #NAS-9-8090, issued by NASA to UNIVIS, INC., OMNITECH DIVISION; design, research, and development tasks were carried out to produce Pressure Suit Spectacles of three types, having various attenuative and transmissive characteristics in the ultra-violet, visible and infra-red regions of the spectrum, and a total of 130 such spectacles were produced in three successive phases.

INTRODUCTION

The unusual and demanding conditions, characteristic of the hostile environment encountered in space requires that spectacles worn by astronauts be of special construction and design to fulfill needs that are particular and specific. In addition to the usual requirement of providing correction for ocular refractive errors, such spectacles must also provide protection against solar radiation. Unattenuated solar radiation carries dangerous and damaging amounts of ultra-violet and infra-red energy. Under normal terrestrial conditions, much of this harmful energy is absorbed, and/or reflected by the atmosphere, and the human eye is adapted to tolerate the amount that does reach the earth. In space, however, this radiant flux is not attenuated by natural means, and the human eye cannot tolerate, without damage, the amount of flux to which it can be subjected.

Astronauts must therefore be provided with protective spectacles or goggles which first must attenuate visible light, so that the wearer is not blinded by the sheer brilliance of the visible energy encountered, and that the process of "seeing" is carried out within a tolerable visible light level. In addition, provision must be made to filter, or reflect as much of the damaging, invisible ultra-violet and infra-red energy, as possible to avoid eye damage.

Mechanically, the spectacles should provide the widest possible field of vision, and be capable of positive, proper and comfortable positioning. They should be able to withstand high gravitational forces without dislodging or changing position, since they cannot be reached at all times for adjustment. Design should be such to provide maximum comfort as worn, and to minimize pressure points, which can be irritating when worn under inaccessable conditions for prolonged periods of time. For obvious reasons, materials used in spectacle construction should not support combustion insofar as possible, and the structure should resist breakage to the greatest possible degree.

Under the terms of Contract NAS-9-8090, UNIVIS, INC., OMNITECH DIVISION has conducted research and development work, having as its objective, the development and production of initial quantities of spectacles meeting the requirements of NASA'S EHIBIT DB4, which details the requirements summarized above.

PURPOSE AND SCOPE

I. GENERAL

Under the terms of this contract, UNIVIS, INC. OMNITECH DIVISION has carried out design, research, and development activities in successive stages, to provide pressure suit spectacles meeting the requirements outlined in EXHIBIT DB4, and has produced an evaluation quantity of 130 spectacles as required.

In order to provide for the requirements of said exhibit, our objective has been:

1. To develop a suitable design for spectacle configuration.
2. To fabricate tooling required to produce the components from which spectacles of the various types are assembled.
3. To produce and submit, in three phases, three types of spectacles as required.

A. SPECTACLE DESIGN AND STRUCTURE

A spectacle frame structure was designed, of suitable geometry to meet fitting requirements to the Anthropometric 95 percentile head supplied by Wright Field for this purpose. An eye size and shape was selected to provide for maximum field of vision, and the spectacle design included use of a self-adjusting bridge; metal temples with slotted spatula endpieces, and an elastic headband strap for retension.

The spectacle "front" is fabricated from 1/10 12 Karat gold filled metal composition, conforming to requirements of MIL-G-25948 D and is provided with a means whereby "Floating" saddle bridges of two sizes can be interchangeably inserted. Saddle bridges are designed to fit the nasal area of the anthropometric head, and are injection molded from clear, transparent polycarbonate.

The frames are fitted with plastic lenses, cast from thermosetting CR-39 (allyl digylcol carbonate) resin, in clear, 10% neutral tint, and 2% transmitting gold-overcoated green tint. The temple assembly comprises a nickle silver, wide band temple, gold plated, having a slotted spatula endpiece laminated to the temple end, made from clear transparent polycarbonate. For temples to be used on spectacles having grey tinted lenses, or gold coated bidensity lenses, an ultra-violet and infra-red attenuating sideshield is attached to, and made part of the temple. This is a molded polycarbonate part, contoured to fit the eye wire, gold coated to exclude side radiation. An adjustable elastic band, with slide, is assembled through the two temple slots to provide positive retension to the wearer's head. Each complete spectacle is provided with a protective carrying case, designed especially for the unit, and fabricated from high impact plastic sheeting.

The spectacle assemblies are fabricated in three types, and each type is supplied with a "large" and a "medium" self- adjusting bridge.

Type I Comprises a spectacle assembly as described, fitted with clear, CR-39 lenses having "plano" optics. The CR-39 lens attenuates ultra-violet radiation, but does not attenuate infra-red, or visible energy, and its visible transmittance is of the order of 90%. The Type I temple structure is not provided with sideshields.

Type II Comprises a spectacle assembly fitted with grey tint, CR-39 lenses, having "plano" optics and a visible transmittance of 10%. This provides attenuation in the ultra-violet, and in the visible region of the spectrum, but provides little attenuation in the infra-red. Temples used with Type II structure are provided with 2% visible transmitting gold coated sideshields which gives protection in ultra-violet, visible and infra-red regions.

Type III Comprises a spectacle assembly fitted with gold-coated, bidensity CR-39 lenses, having "plano" optics. Visible transmittance in the gold-coated area is 2% and in the uncoated area 10%. The gold-coated "upper" lens area provides attenuation in the ultra-violet, visible and infra-red region, while the uncoated "bottom" lens area attenuates in the ultra-violet and visible region. Temples are provided with a 2% visually transmitting gold-coated sideshield, which provides attenuation in the ultra-violet visible, and infra-red regions.

II. TOOLING

Develop and fabricate tooling required to produce components from which spectacles of the various types are produced. This comprises the following:

A. Injection Molds

1. To produce "large" and "medium" self-adjusting bridges.
2. To produce sideshields.

B. Metal Frame Tooling

1. Bridge Blanking.
2. Re-inforcing Bar Shaping.
3. Eyewire Forming Tools.
4. Eyewire Bending Tools.
5. Endpiece Blanking Tools (upper and lower).
6. Soldering Fixtures - bridge to eyewire.
7. Soldering Fixture - re-inforcing bar to eyewire.
8. Soldering Fixture - R H & LH endpiece assembly.

C. Metal Temple Tooling

1. Reducing and Swaging Tools.
2. Hinge Lug Blanking Die.
3. Soldering Fixture - hinge lug to temple.
4. Cutting Tool.

D. Temple Lamination Tooling

1. Compression Mold

E. <u>Gold Coating Fixtures</u>

1. Fixture for applying gold to sideshield.

2. Fixture for applying gold to lenses.

F. <u>Lens Shaping Tools</u>

G. <u>Case Tools</u>

1. Vacuum forming tools (top & bottom)

2. Assembly & drill jigs.

III. PROGRAM PHASING

In accordance with contract requirements, this work program was conducted in three successive phases:

PHASE #1

Design and fabrication of 5 each, of Type I, Type II, and Type III spectacles, with subsequent evaluation of units produced by NASA MSC.

PHASE #2

Redesign of spectacles to incorporate changes requested by NASA, and submission of one "modified" pair of spectacles incorporating requested changes; followed, upon approval of this model, by production of 5 each, Type #I, Type #II and Type #III spectacles and cases to the approved structure.

PHASE #3

Production of 25 each Type #I, 50 each Type #II, and 25 each Type #III spectacles with cases.

DETAIL

PHASE #1

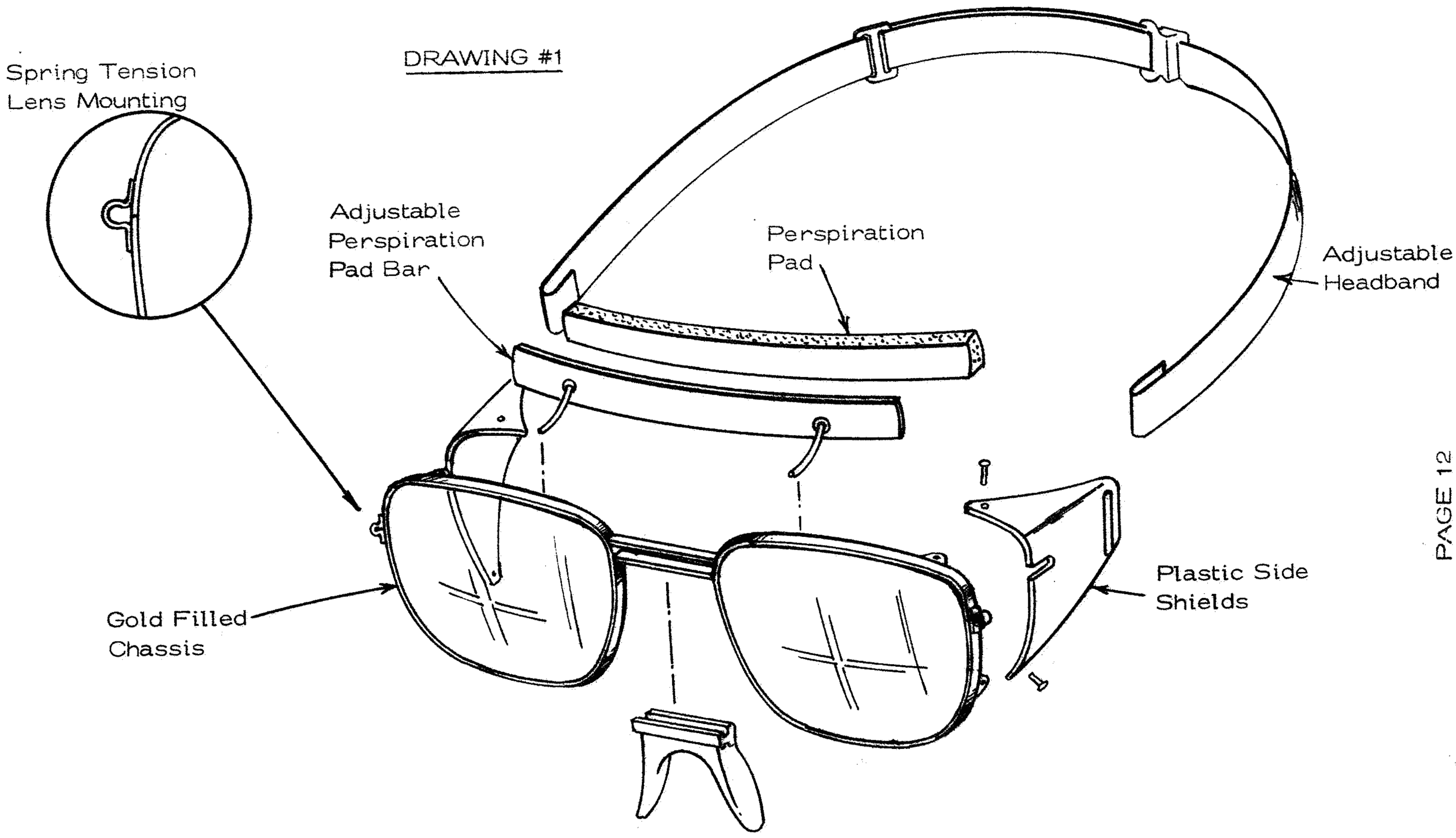
I. GENERAL

The detailed interpretation of the basic design as required in EXHIBIT DB4, dated 12 December 1967 required that the spectacle be constructed without metal temples. Reference to the accompanying drawing #1 shows the basic design as originally requested. It comprised a gold filled metal front, to which is assembled a self-adjusting plastic bridge. Instead of temples, sideshields are attached directly to the metal front, and an adjustable headband is assembled through slots in the sideshield.

Fastened to top of each "eye" are metal extensions, which carry a contoured metal retainer to which is attached a sweatband. Also, included in the design, is a means for insertion and retension of lenses without screws. This is accomplished using a tension spring, which can be extended during lens insertion, and which snaps back and retains the lens. This is the basic design structure and was utilized to produce the initial PHASE #1 items.

PRESSURE SUIT SPECTACLE (Exploded View)

DRAWING #1



UNIVIS, INC.-Omnitech Div.
May 20, 1969
Albert J. Laliberte

II. COMPONENTS -PHASE #1 OUTPUT

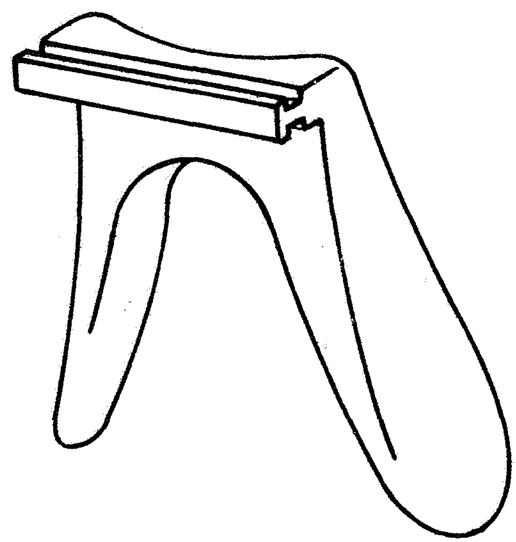
A. METAL FRONT

In order to provide maximum strength and rigidity for the "front", material used was 1/10 12 carat gold filled metal over a base of not less than 15% nickle silver. Prior to assembly, the metal parts were 18 carat gold plated. This is in accordance with 3.2.1 of MIL-G-25948D (HGU 4P Sunglass). The gold filled eyewire used conformed dimensionally to requirements outlined in section D-D of Quartermaster, Dwg. #8-2-67, dated 13 Feb., 1962, which is a part of above specification. Use of these materials provided a structure which is essentially equivalent to the military HGU 4/P sunglass, which are considerably more rigid than similar commercial gold filled frames.

B. SELF ADJUSTING PLASTIC BRIDGE

To establish the ultimate configuration for the self-adjusting bridge, models were sculptured from acrylic plastic, and dimensioned until they were geometrically compatable with the metal frame, and provided a proper fit on the nasal section of the anthropometric head. Models were made in a "large" size and "medium" size, for 21 and 23mm distance between the lenses, having dimension to provide a 13 millimeter spectacle distance as worn. When the model has been completely checked for conformance to exhibit requirements they were used as masters to prepare beryllium copper negative castings, which were subsequently finished to become inserts in an injection mold. The injection mold was fitted with two such cavities, one medium, and one large.

The self-adjusting bridge used in all spectacle assemblies were



DRAWING #2

Sketch of Self Adjusting Bridge
Dwgs. 543011 & 543012
Used on Pressure Suit Spectacles

UNIVIS, INC. - Omnitech Division
May 22, 1969
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injection molded using "LEXAN" polycarbonate resin (General Electric Co.), type 141-112 clear transparent.

Drawings of the Medium and Large adjustable bridge are enclosed (#2).

C. SIDESHIELDS

In order to provide the ultimate in optical properties, sideshields were designed to be of cylindrical configuration. This allowed for mold inserts to be polished by optical finishing techniques, resulting in no distortion in the molded parts. An injection mold was fabricated to produce the sideshields, and parts were molded using transparent, and tinted polycarbonate. To provide the proper and matching tints for both lenses and sideshields, a neutral grey color was first applied to CR-39 lenses to attain a visual transmittance of 10%. This color was then matched as closely as possible by General Electric Co. in Type 141 polycarbonate. Color matches were obtained for both a 10% and a 3% visually transmitting sideshield to provide for requirements of Type II and Type III spectacles. The following materials were developed for this purpose.

SIDESHIELD TYPE NO.	G.E. COLOR NUMBER	VISUAL TRANSMITTANCE	MEETS REQUIREMENTS FOR
I	141-112	Clear-90%	3.3.4.1
II	MVCL-5125	10% at .060 thick	3.3.4.2
III	MVCL-5411	3% at .060 thick	3.3.4.3

D. LENSES

Lenses provided with the PHASE #I units were made of CR-39 resin (allyl diglycol carbonate). This is a clear, transparent thermosetting resin produced by Pittsburg Glass Company. When catalyzed with a peroxide, the resin "sets" or cures to a hard, infusable state. Lenses are "cast" from this resin by introducing catalyzed liquid resin between two optically ground and polished glass molds contained as a "cell", and polymerized under heat and in the absence of oxygen. After removal from the "molds", clear lenses are edged to proper shape, or in the case of tinted lenses, are dyed in an aqueous dye, to the required transmittance of 10%, then edged and bevelled for insertion in the frames.

The lens blanks used for PHASE #I output were cast as 57mm round blanks. This size just allows a bevelled and edged lens to be cut from such a blank, with no material to spare, and extreme care must be taken in edging, in order to obtain a full lens. For subsequent requirements, lens blanks were produced in 63mm round blank sizes to facilitate edging and bevelling.

Grey lenses were produced from clear lenses by dyeing with Americal Optical Company M-750-W-True-Tone (Pewter) dye mixture, following the dyeing procedure recommended by the manufacturer. Immersion time in the dye solution was controlled to provide a 10% visual transmittance, which was continuously monitored to insure compliance with specification requirements.

CR-39 lenses were produced with UV absorber additives, to provide for ultra-violet absorption as required in 3.2.7.

E. ASSEMBLY - OUTPUT

A total of ten (10) pressure suit spectacles, comprising 2/3 of the PHASE #1 output, were submitted to NASA on 31 Oct., 1968. These consisted of the following:

1. 5 each - Type #I - Spectacle assemblies having clear, transparent CR-39 lenses, and clear, transparent sideshields.
2. 5 each - Type II - Spectacle assemblies, having 10% neutral grey transmitting CR-39 lenses and 10% neutral grey transmitting sideshields.

Prior to submission of Phase #1 output, the NASA Technical Monitor had requested that Type III lenses be of the gold coated, bidensity type. Technology for application and overcoating of gold on CR-39 had not been evolved by this time, and submission was delayed for this reason. Before the gold coating technology could be developed, NASA had conducted a physical evaluation of Type I and Type II structure, and had determined that extensive design changes would be required. We were therefore instructed to defer submission of the Type II units, and include these in a subsequent submission utilizing the improved design. The additional 5 units of Type III were therefore included as output under Phase 3, in which the number of Type III units were increased from 25 to 30.

PHASE #2

I. MODIFICATIONS REQUESTED BY NASA

Following an evaluation of PHASE #1 items by NASA, we were directed by the contracting officer to incorporate the following changes in the PHASE #2 units. (ref: letter BG721(8) dated Nov. 26, 1968 from Contracting Officer).

A. EYEWIRE

Remove beryllium tension spring, and replace with a convertional screw fastening means for lens insertion. Lens size and shape to be the same as PHASE #1 items.

B. SIDESHIELD

The sideshield shall be changed such that it is attached to a heavy gold temple. The temple shall be approximately 6mm wide, and shall be attached to the eyewire endpiece using a hinge joint and screw. The temple shall have a plastic paddle end slotted for attachment of headband. Temple screw shall be accessable from below when spectacles are in the as worn position. Sideshields for use on Type II and III spectacles shall be fabricated of neutral density polycarbonate having 10% transmittance, and coated with gold to give a final transmittance of one to three percent. Sideshields shall be attached to the temple by rivets, with a plate on the outside. Sideshields shall not be required in Type I spectacles.

C. <u>HEADBAND</u>

Shall be one half inch wide, doubled, with one polycarbonate adjustment slide fastener required in the center back.

D. <u>SWEATBAND</u>

Shall be removed and replaced with a gold filled stiffening bar placed between eyewires, center to center, at top.

E. <u>LENSES</u>

For Type III bidensity spectacles, the lenses will be fabricated from 10% visually transmitting neutral grey ultra-violet absorbing CR-39 and gold coated to give 2 percent visual transmittance in the upper or gold coated area.

F. <u>CASE</u>

To be fabricated using pewter grey "Kydex" or equivalent with dust proof cover and polyurethane lining.

G. <u>SAMPLE</u>

Prior to fabrication of PHASE #2 items, one sample shall be submitted incorporating design and mechanical changes outlined above.

II. EFFECT OF MODIFICATION ON WORK PLAN

The foregoing instructions, as received from the contracting officer, delineating PHASE #2 output, in effect required a complete redesign of the entire spectacle structure. A comparison of Dwg. #1 illustrating PHASE #1 structure with Dwg. #3 illustrating PHASE 2 requirements, will reveal the following:

A. Spring tension lens mounting device eliminated, and replaced with a conventional screw fastening means for insertion and retension of lenses.

B. Sweatband eliminated, and a frame reinforcing bar inserted in its place.

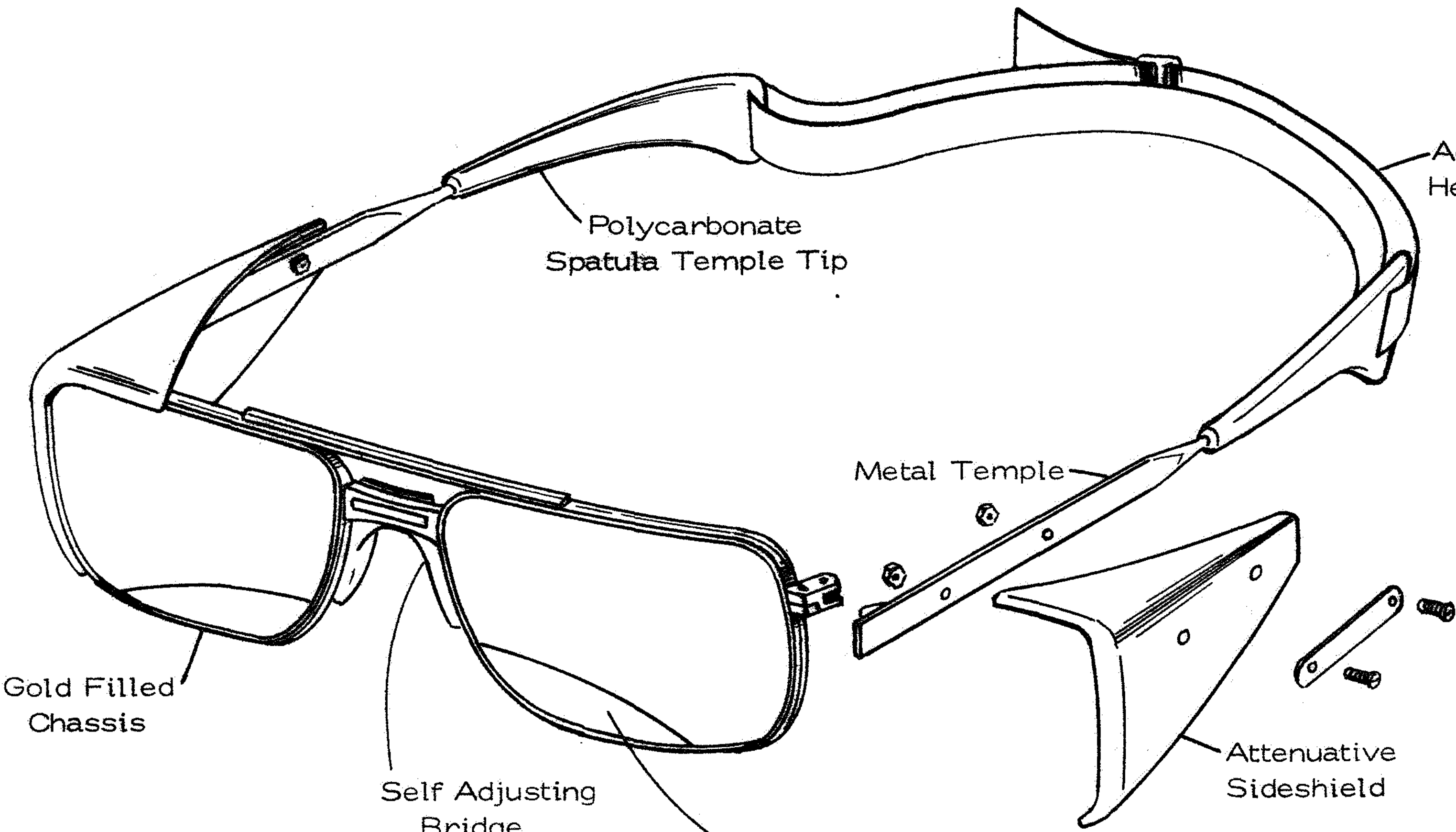
C. Sideshields eliminated, and replaced with a metal temple, attached directly to the metal frame using hinge and screws; said temple carrying plastic, gold coated sideshields for Type II and Type III spectacles, so contoured to provide maximum side protection. Plastic spatula tips are laminated to the metal temple, and provided with a slot for attachment of headband.

The only portions of the spectacle assembly remaining the same are the:

A. Self-adjusting plastic bridge.

B. Eyewire shape and size.

C. Lenses.



DRAWING #3

Pressure Suit Spectacle
PHASE II Design and Structure

UNIVIS, INC. - Omnitech Division
May 20, 1969
Albert J. Laliberte

From a design and engineering point of view, this required:

A. Redesign of the unit, and preparation of new drawings for the modified assembly.

B. Obsolescense of metal working tooling and fixtures prepared in PHASE #1 , and replacement with new tooling and fixtures to provide the new design.

C. Development of a new metal temple, and a means for attachment and integration to the new front.

D. Redesign of sideshield, and fabrication of a new mold to produce the sideshields.

E. Development of a technique for imbedment lamination of polycarbonate spatula tips, and fabrication of a compression mold to perform this.

F. Development of techniques and tooling for application of gold; formulation of a protective overcoating, and technique for applying protective overcoating to the gold surface of the sideshields.

G. Development of technique, and tooling for application of gold and fabricating the bidensity gold lenses; as well as formulation of a protective over coating and method of application to the gold surface without altering optical characteristics of the lenses.

H. Development of techniques for surface finishing the polycarbonate spatula tips laminated to the metal temple core.

I. To assure that the new structure would meet NASA requirements, an advance model, illustrating structure alone was fabricated and submitted prior to total committment for Phase 2 output.

The foregoing represents engineering and expense effort considerably beyond the scope and extent outlined in the original contract, in addition, much of this effort represented work on OMNITECH's part to include new requirements for transmittance characteristics subsequently determined by NASA to be reeded and to be included in the optical requirements for the spectacle.

III. PRELIMINARY SAMPLE SUBMISSION - PHASE 2

In compliance with the requirements of paragraph (H) in letter from contracting officer dated Nov. 26, 1968, a hand made model, illustrating PHASE #2 structure, and incorporating changes requested was fabricated and submitted to NASA on Jan. 10, 1969. Purpose of this submission was to evaluate the mechanical and geometrical configuration only. Although the metal components were made using required 1/10 12 carat gold filled material to MIL-G-25948 D, tooling was not available such that proper tempering and hardening of the structure could be accomplished, and the sample submitted was "soft". (This was corrected in subsequent PHASE 2 items upon completion of required tooling). Plastic paddles attached to the temples were cellulose acetate, since procedures and methods were not then available for fabrication from polycarbonate. Sideshields were vacuum formed to required dimension and size from cellulose acetate sheeting, and met no optical, or transmittance requirements. The sample was evaluated for structure and fit only by the Technical Monitor, and within a week, we were authorized to proceed with the fabrication of the remaining 15 PHASE 2 items, with instructions to increase the "set back" angle by 8-10 degrees.

IV. COMPONENTS - PHASE #2 OUTPUT

A. METAL FRONTS

Design of the modified metal front was in accordance with instruction received from the contracting officer. Materials used were essentially the same as for PHASE 1, and employed 1/10 12 carat gold filled material, conforming in all respects to requirements outlined in 3.2.1 of MIL-G-25948 D. with an eyewire being dimensionally to Quartermaster Dwg. #8-2-67, Section D-D, dated 13 Feb, 1969. Design of the eyewire includes a conventional screw fastening means for insertion of retension of lenses, and includes the slotted female temple hinge element, as well as a strengthening and reinforcing gold filled metal bar across the top of the eye wires. Provision for insertion, and retension of the self-adjusting saddle bridge remain identical to the PHASE 1 units.

B. TEMPLES

1. DESIGN

The metal temple used is of special design, and comprises a band 3/16 in. wide to which is attached a 0.055 diameter core wire. The front end of the temple carries the male hinge element, and its overall length, including core wire is 5 3/4". The male hinge element, is integrated with the slotted female receptor in the eyewire, and hinge attachment is made using a screw, inserted from underneath. Because of the structure and geometry of this temple, it is not possible to fabricate the unit from "gold-filled" material, and it is therefore made from a nickle silver composition, and provided with a heavy gold plate.

Reference to dwg. #543001 illustrates the design and structure of the front and temple assemblies, and details the mechanics for integration and attachment of the temple to the front.

2. PLASTIC SPATULA TIP ON TEMPLE

The 0.055 diameter wire core section of the temple is imbedded within a plastic spatula-like tip, carrying a slot for attachment of headband. Although the requirements call for "plastic," which could be a variety of substances, the specific plastic requested by the technical monitor is polycarbonate. Techniques for core imbedment using conventional plastics are well established and comprise "driving" methods, solvent lamination, etc. however; imbedment of cores in polycarbonate cannot be accomplished by any technology, or procedures commercially used, and a new method had to be developed to accomplish this. In our attempts to produce imbedded spatula tips, the following techniques were evaluated.

a) SOLVENT LAMINATION

Two rectangular pieces of polycarbonate sheeting, .060 thick, are ground with a half round slot, .030 inch in diameter to receive the core. Various solvents, solvent combination and techniques were attempted to cement "Laminate" the core within sandwiched plastic elements; however, results were completely unsatisfactory. Internal bubbles, and inability of the core to be properly imbedded and secured resulted from these attempts.

b) CORE DRIVING

In this application, a rectangular piece of plastic is heated, and the heated core wire section of the temple mechanically driven into the plastic. Because of the high softening temperature of polycarbonate, and its retension of "toughness" at high temperatures, it was impossible to "drive" a core into the material.

c) INJECTION MOLDING

We evaluated the possibility of injection molding polycarbonate around the wire core. Because of the expense required to develop the process, and fabricate a mold to perform this function, this method was not considered feasable. We feel that this method does provide the ultimate answer, however; it can only be attained at a cost in excess of $6,000 for which no funds were available.

d) DRILLING OF POLYCARBONATE, & INSERTION OF CORE

This method was evaluated, and comprised drilling a 3 inch long hole, 0.055" diameter into a rectangular piece of polycarbonate .120" thick, followed by inserting the core wire, and retaining through use of a solvent cement. Again, this proved to be unsatisfactory since it was impossible to obtain a well adhered, bubble free retension of the wire core.

e) COMPRESSION LAMINATION

This method was developed, and finally used to produce the laminated core assemblies. To accomplish this, it was necessary to fabricate a compression mold, contoured to the final spatula shape, in which pre-blanked spatula components were inserted. The mold provides a means for positioning and retaining the core wire between two .060 thick polycarbonate blanks. Heat is applied to the mold until the polycarbonate softens, whereupon the mold is closed under pressure to imbed the core, and fuse the plastic sections together. Because of the nature of polycarbonate, the blanked components were heated for 24 hours in an oven to expel moisture prior to laminating which otherwise resulted in bubbles throughout the material, and also in undesirable surface imperfections.

This procedure, although slow, and tedious, provided acceptable core imbedment in polycarbonate.

3. FINISHING OF SPATULA ENDPIECES

Again, it was necessary to resort to new methods to develop an acceptable surface finish on the polycarbonate spatula tips produced in 2. (e). Temples were processed by usual tumble-grind and polishing techniques. This is necessary to "round" and smooth the plastic, and to provide a high gloss. This method involves placing temples successively in "grind-tumble", and "wax finish tumble" barrels. Basically, these are octagonal wooden barrels of heavy construction, containing various mixtures of abrasive (for grind) media, and polish (for shine) media. The barrels are rotated to provide mechanical grinding, or polishing effect on the part being processed. The operation is sequential, the parts first being rounded and ground with abrasive, then polished in a different barrel.

After one week in the tumble "grind" operation, which suffices to grind conventional plastics, the polycarbonate spatula tips were not touched or affected by the abrasive - apparently, the inherent toughness and resiliency of the polycarbonate prevents its being finished by this method. Alternate grinding methods in which the metal temple portion was masked in a rubber tubing, and tumbling carried out in a coarse wet abrasive mixture were also ineffective.

It was finally necessary to "mud grind" the polycarbonate. By this method, a thick slurry of fine abrasive and pumice is impregnated in a 1 1/2 foot diameter rag wheel, and the part is mechanically "buffed". This "cut" the surface, and allowed for reduction to a suitable ground finish, which was subsequently polished using a rag wheel impregnated with a fine abrasive-wax compound.

Use of the above method leaves considerable to be desired in the way of a surface finish. It does not compare with an acetate temple, finished by either tumbling, or hand finishing techniques, however, it was the only method which could be used to finish polycarbonate, and is very costly.

All temples, used for Type I, II, and III spectacle frames produced in PHASE 2 were prepared by the foregoing method.

C. <u>SIDESHIELDS</u>

As previously mentioned, the sideshields as used, and molded for PHASE 1 output were inadequate for the requirements of PHASE 2. Reference to Dwgs. #1 and #3 will reveal the difference in structure required in the two units and illustrates the means by which they are attached to and become a part of the spectacle assembly.

Reveiw of the PHASE 1 output by the Technical Monitor indicated that sideshields are not required to have flawless, or "plano" optics. As long as the wearer can see through the sideshield, or be aware of motion, or lights, this suffices for visual needs. Since the sideshield structure required in PHASE 2 is much more complex it could not be made to provide flawless optics, and since we had already expended funds for a mold which is no longer useful, the decision was made to produce the sideshield by vacuum forming procedures, and in implementation of this, a master shield was sculptured which served to establish the dimension and contour of the vacuum forming mold, which was subsequently fabricated from aluminum and highly polished.

In PHASE 2 output, no sideshields are to be supplied with Type I spectacles, and gold coated polycarbonate sideshields are supplied for Types II and III. Since vacuum forming procedures are used, the polycarbonate sheeting prior to forming must be .070 thick, and have a visual transmittance of 10% when stretched to .060 inch thick; and must also be neutral in color. This requirement became very difficult and involved. We were able to locate a source (Scranton Laminators, in Scranton, Pa.), who produces a polycarbonate sheeting in optical grades for Boeing, which meets our requirements, however, we were informed that 1 sheet, 21 x 50 inches costs $400, and that we must procure this in minimum quantities of 1000 lbs. Costs on this basis would have been completely unwarranted. While we were in process of resolving this, and trying to procure at least one sheet from which to fabricate the 10 units required, we were informed by the Technical

Monitor that polycarbonate currently used, does not provide UV attenuation suitable for NASA requirements, and he requested that the sideshields be fabricated using Acrylic sheeting, as supplied by Rohm & Haas (#UF4 UV absorbing) which would provide for an optical density 5 or greater in the 210-320 millimicron range.

This resulted in additional problems. Delivery from Rohm & Haas for such material was 6 weeks, and it is produced only in clear transparent colors (no tints). This, coupled with the fact that acrylic sheet cannot be vacuum formed sharply to precise dimensions compounded our difficulties. In addition, protective coatings used over gold, and already developed for use with polycarbonate were inadequate for the UV acrylic sheeting.

We had available from American Cyanamid Company, a limited amount of acrylic sheeting equivalent in UV absorptive characteristics, to the Rohm & Haas UF4 material, having the proper thickness. A sample of this was checked spectrophotometrically for transmittance and was found to have attenuating characteristics in the ultraviolet region, in excess of optical density 5. This sheeting was clear, transparent, and we were able to dye it a neutral color, using the Du Pont Merpentene dyeing system, to a visual transmittance of 10%.

We subsequently used this sheet to produce, by vacuum forming methods, a sufficient number of sideshields for PHASE 2 output and coat these with gold to a final transmittance of 2%. We were also able to compound a protecting overcoat for the gold surface to provide mar protection. Our PHASE 2 Type II and III items as submitted, were provided with sideshields as described.

The sideshields so produced met optical density requirements completely. Since we started with a clear transparent material having optical density of 5+, application of dye, followed by deposition of gold to a final visible transmittance of 2% improved this to a minimum of 6.5, well in excess of NASA requirements; however, the sideshields were not satisfactory for appearance, and were very difficult to produce. The acrylic sheeting does not vacuum form well, and the parts were difficult to produce to dimension. They were covered with numerous pit imperfections and scratches, which after application of gold resulted in a very poor and unacceptable appearance. Because of a high concentration of oily UV absorber, numerous internal bubbles resulted when the sheet was formed, and adhesion of gold was poor. It was imperative that the quality and appearance of the sideshield be improved in the PHASE 3 items.

To provide for UV attenuation, IR attenuation, and an acceptable surface finish, and also to fabricate the part from polycarbonate, which is desired as the structural material, use of a green polycarbonate base, instead of a neutral base was suggested. It makes no difference, if a green base is used, since a gold film transmits in the green, and the sideshield after being coated with gold, will be green in color, whether a neutral grey, or green base is used.

In addition, a green base having transmittance characteristics very similar to the photopic eye sensitivity curve will mean that to attain a given visual transmittance, more attenuating dyes are required. In addition, the application of gold over a green base to a final desired visible transmittance allows for the deposit of more gold than if the base were neutral. The combination of additional green dye, and gold, although giving the same visual transmittance, will provide significant additional protection in both the ultra-violet and infra-red regions.

To prove this, a .060 thick plate of polycarbonate, molded from LEXAN 141-3113 green, and having a visible transmittance of 15% was overcoated with gold to a final visual transmittance of 1.5%. Upon being checked in a spectrophotometer, this combination revealed an optical density in excess of 5 in the 220-320 millimicron region - which meets the requirements called for by the Technical Monitor.

Furthermore, such a composition allows us to produce the part from injection molded polycarbonate. Since we had already expended funds to fabricate a sideshield mold we could not use, our problem was to fabricate a mold, quickly, and at minimum cost. This was accomplished inexpensively, or relatively so, by a unique method, not heretofore attempted, and described as follows:

Two sideshield masters, one each RH and LH were formed from .060 inch thick brass. These were fabricated to precise, and exact dimensions, checked for frame fit, and were optically polished insofar as possible considering the combination of compound curvatures called for in the design. These highly polished masters were then coated with a thin layer of silver, whereupon nickle was applied by electroforming methods until it had built up to a thickness of 3/16 inch. Upon separation, and removal of the brass master, a highly polished metal cavity resulted, which was subsequently encased in an epoxy carrying ring, and machined to fit a mold cavity. The mold was in operation 3 weeks after submission of master parts for electroforming, at a cost 1/3 of the usual cost for fabricating such a mold.

We were authorized by the Technical Monitor to use the green polycarbonate gold coated, in lieu of the acrylic, and the parts produced for PHASE 3 output are much improved from a quality standpoint, than the acrylic shields provided in PHASE #2. Our preferred, and recommended procedure to produce sideshields is now as follows:

1. Injection mold green sideshields, in RH and LH configuration, from "LEXAN" polycarbonate 141-3113, in a thickness of .060 inch to a visual transmittance of 15%.
2. Without removing the sideshields from the sprue, clean with alcohol, dry thoroughly, and apply gold coating by vacuum metallizing procedures to a final visual transmittance of 1-2%.

3. Without touching, or removing sideshields from the sprue, dip first the RH, then the LH shield configuration in a compounded polyurethane coating solution, diluted with butyl alcohol.

4. Allow to air dry overnight, then bake for 2 hours in an air circulating oven at 230°F.

5. Remove shields; drill and attach to temples, using the outer gold coated bar as a retainer, and rivets or screws for retension.

D. CASES

Until approval was received, and authorization given to utilize the modified PHASE 2 structure, no work was carried out on the development and fabrication of a carrying case for the spectacles. The reason for this is that changes requested can (and did) alter the physical dimension of the spectacles, so that a case designed and made for PHASE 1 structure would have been inadequate for the modified, or PHASE 2 structure and any work done on the case prior to final configuration would have been repeated at unnecessary expense and effort.

In considering the case design, it must be so constructed to effectively contain the folded spectacle, with a minimum amount of free space. It should be as flame-proof as possible, and should retain the spectacles in a firm manner without movement within the case. The specification required that the case be lined with polyurethane foam, (paragraph "g" of Nov. 26 letter), to prevent marring of the lenses, and our search for such a material having flame-proof, or flame-retarding characteristics was fruitless. In order to overcome the obvious objection of having to use a liner which is not flame-proof, a design was proposed, and accepted by the Technical Monitor, wherein the case body is not lined, and in which the case top carries a tension spring. When the folded spectacles are placed in the case; lenses up, and the case top closed, the tension spring engages against the metal bridge, and forces the metal spectacle elements firmly against the case bottom, effectively holding and preventing movement. The case top does not touch the lenses, or sideshields, so that the lenses or shields cannot be abused or damaged. The only portion of the spectacle touched by the restraining spring is the metal front.

Using the approved hand made model as a quide, a carrying case was designed, and vacuum forming tools made to produce the case top and bottom. Trimming and drilling tools were also made to finish the vacuum formed parts into top and bottom case components. A conventional spring activated hinge closure, which also incorporates the spectacle retaining tension spring is assembled to the case top and bottom to complete the assembly.

A total of 14 such cases were produced and supplied with the PHASE #2 output, fabricated from .090 thick "Kydex" PVC-acrylic alloy sheeting supplied by Rohm and Haas Company.

E. ELASTIC HEADBAND

In order to provide for headband requirements calling for a flame-proof elastic band which does not contain rubber, we contacted many manufactures of this type of product, but have not yet located a source which can supply the item precicely as needed. From such people as Flightex Fabrics, and United Elastic, we obtained flame-proof elastic straps, all of which contained rubber, or neoprene synthetic rubber. From Moore Fabrics, Pawtucket, Rhode Island, we procured a headband material with no rubber, and attempted to have this flame-proofed by Prestex, Inc. who are specialists in government specification fabrics. Samples of the Moore fabrics were submitted to Prestex for flame-proofing, with the result that elasticity was lost in treatment, and the headband expanded 25% after treatment.

As of this moment, we are supplying the headband in the Moore material. It is not flame-proof, or flame-retardent, and is identified as "Spandex", Quality #4270-L, in 1/2 inch width, having an elongation of 135-145. Its color is white.

Should a suitable headband material be located and procured at a future date, headbands now on the spectacles can be easily replaced.

V. ASSEMBLY - OUTPUT- PHASE #2

A. A total of 15 each, Pressure Suit Spectacles, were produced and submitted to NASA on 14 March, 1969, in accordance with contract requirements, which included modification requested by contracting officer (letter 11/26/68).

1. 5 each - Type #I Spectacle assemblies, having clear CR-39 lenses, metal temples with no sideshields, having slotted polycarbonate spatula tips with headband.
2. 5 each - Type #II Spectacles, having 10% neutral grey transmitting CR-39 lenses, metal temples having sideshields made from UV attenuating acrylic material gold coated to 1.5% UT. and slotted polycarbonate spatula tips with headband.
3. 5 each - Type III Spectacles, having bidensity gold coated lenses, made by depositing gold over a 10% neutral grey lens to a final visual transmittance of 2%; with metal temples, carrying sideshields made from UV attenuating acrylic material, gold coated to 1.5% UT, and having slotted polycarbonate spatula tips with headband.

B. A total of 14 each, carrying cases for Pressure Suit Spectacles were produced, and submitted to NASA on 9, April, 1969.

PHASE #3

I. GENERAL

Upon submission of PHASE #2 samples, we were authorized immediately by the Technical Monitor to proceed with the manufacture, and produce the PHASE 3 output of 100 units to design and structure identical to that of PHASE #2.

For PHASE #3, an improved sideshield was made part of the items produced. As detailed previously, the improved sideshield was made by injection molding the plastic part from green polycarbonate having 15% visual transmittance, and overcoating with gold to a final VT of 1.5%. This shield met and exceeded NASA's requirements for UV transmittance, and was used on all Type II and Type III units produced in PHASE #3.

II. SPECTROPHOTOMETRIC EVALUATION-PHASE #3 ITEMS

The pressure suit spectacles are required for two reasons, first to serve as a means for providing occular correction, and secondly to provide protection against harmful solar radiation.

Since solar radiation outside the atmosphere is not attenuated, the protective lens must be capable of absorbing, and/or reflecting harmful ultra-violet and infra-red energy to such a degree that the amount which reaches the eye is not harmful. It must also attenuate visable light to such a degree that the wearer receives a proper amount of light for seeing, and is not blinded by the sheer brilliance and magnitude of the visible energy encountered.

Although not delineated in the contract, NASA's guidelines for ultra-violet attenuation are that the lenses and shields should be opaque to an optical density of at least 5 in the range between 210 and 310 millimicrons, and our objectives have been to meet, or better this requirement. No specification requirements have been made for infra-red attenuation, and our objective has been to reduce IR transmission by use of specularly reflective gold coatings to an absolute minimum, meanwhile providing a visible transmittance of 1-3%.

The various types of lenses and sideshields produced for final delivery under the terms of this contract were subjected to detailed spectrophotometric analysis to determine the effectiveness of the visual components for providing the protection required.

A. LENSES

The contract requires that lenses be of three types, each to provide specific characteristics.

Type #I - Clear, transparent, with attenuative characteristics in the ultra-violet region only.

Type #II-Neutral grey, with attenuative characteristics in the ultra-violet region, and in the visible region of the spectrum.

Type#III -Neutral grey base, bidensity gold surfaced on "Upper" portion, such upper portion attenuating in the ultra-violet, visible and infra-red region.

Spectrophotometric readouts on the three types of lenses were obtained in the ultra-violet range between 200 and 340 milli-microns, and in the infra-red region between 700 and 2000 milli-microns.

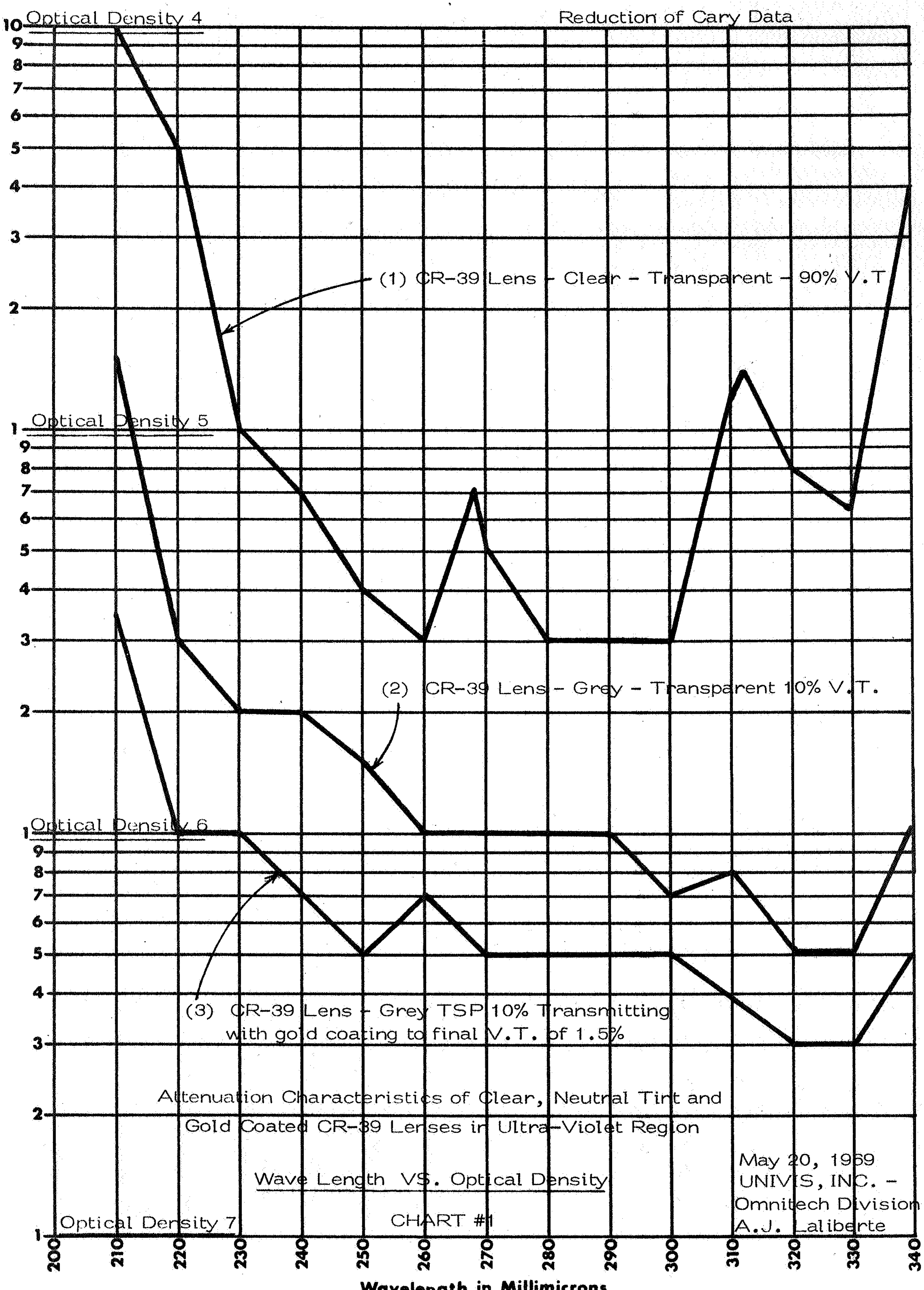
In the ultra-violet region, the CARY Spectrophotometer was scaled, and provided with neutral attenuating filters such that recording and readouts of significance were obtained in the range between optical density 4 to 7. Data was obtained from each of the clear, grey tint, and gold coated lenses, and the readout calculated and plotted in terms of optical density. Chart #1 plots the transmission characteristics of each lens over the ultra-violet range.

From this chart, it is apparent that clear, transparent, CR-39 lens, with ultra-violet absorbers added attenuates essentially as desired and expected, at an average of optical density 5. The grey transparent lenses, made from the clear transparent lenses by dyeing to a visual transmittance of 10%, attenuates nearly one order of magnitude greater, averaging close to 5.8. Application of gold to the Type 2 lenses further attenuates to an average optical density of 6.4.

In view of NASA's requirements for at least an optical density 5, it is apparent that in the ultra-violet range, all lenses meet, or surpass these requirements by a substantial and significant amount.

Type II and III lenses (grey and gold coated) were measured in the Cary Spectrophotometer in the infra-red region between 700 and 2000 millimicrons. Results are plotted on Chart #2, and reveal the very effective attenuation in infra-red by application of gold. This results from the selective specular reflection of the gold coating, which is particularly effective in the infra-red region.

As expected, the 10% visually transmitting grey lens is essentially transparent in the infra-red region (Curve #1 Chart #2) since the dyes used are effective in the visual region only. Application of gold to the outer surface of this grey lens sufficient to reduce the visual transmittance to 1.5% results in almost complete attenuation of IR, as shown on curve (2).

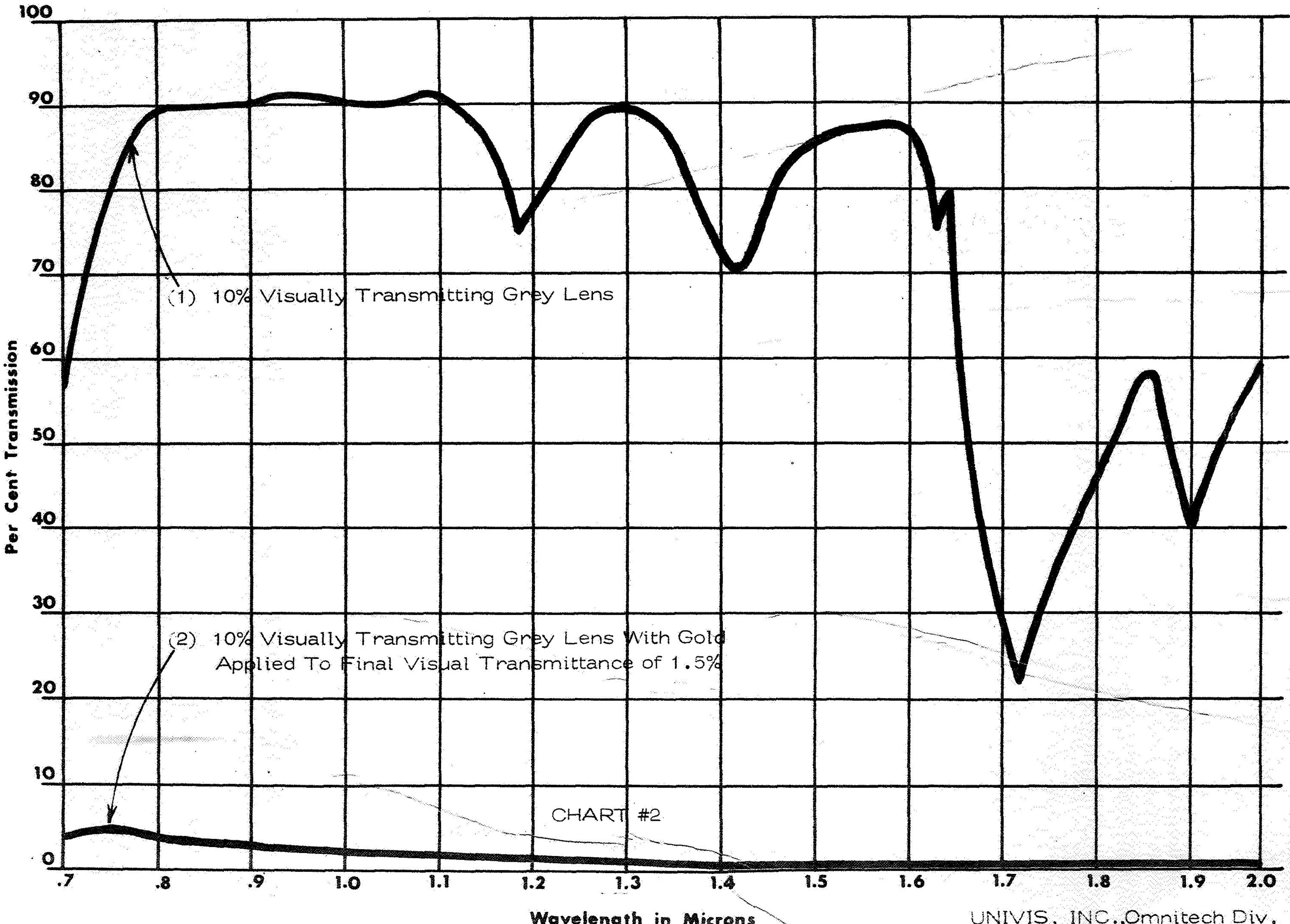


Attenuation Characteristics of Clear, Neutral Tint and Gold Coated CR-39 Lenses in Ultra-Violet Region

Wave Length VS. Optical Density

CHART #1

May 20, 1969
UNIVIS, INC. -
Omnitech Division
A.J. Laliberte



IR Transmittance - CR-39 Lenses - Grey Versus Grey Gold Coated.
Curve #1 = Grey CR-39   Curve #2 = Grey CR-39 - Gold Coated

UNIVIS, INC., Omnitech Div.
May 21, 1969
Albert J. Laliberte

A study of this data indicates that additional significant improvement in IR attenuation can be accomplished if desired, and as follows:

1. By using a grey lens visually transmitting at 15% and depositing gold to 0.9% to 1.0%, the IR transmittance would be reduced still further to approximately half of that indicated on (2).
2. If the use of a green base is permitted, a green lens, having a visual transmittance of 15%, with gold applied to 0.9% to 1.0% final transmittance should reduce IR transmittance to approximately 1/8 of that obtained in (2).

It is our recommendation that the foregoing information and data be considered by NASA, and that if additional protection in the IR region is desired, the approaches outlined in (1.) and (2.) above be evaluated.

Since the "gold" lens is of the bidensity type, we wish to point out that the one inherent weakness in this structure is in the "lower" section, which is not gold coated. This transmits essentially as shown in curve #1. Curve #2 applies only to "upper" portion of the lens which is coated with gold.

B. SIDESHIELDS

Since particular significance and importance was attached to the requirement for developing a sideshield which is highly attenuative in the ultra-violet region and since previous data supplied by NASA had indicated that "LEXAN" seems to be inadequate for this purpose, considerable work was carried out to develop an acceptable polycarbonate structure. Previous experience in this area had indicated that if we start with a green instead of neutral polycarbonate, and superimpose gold over such a material, UV requirements can be met. This was thoroughly evaluated, and the sideshields used for PHASE III were produced from such a structure. Data presented shows transmissive characteristics in ultra-violet, visible and IR regions of the spectrum for the molded components, and finished sideshields.

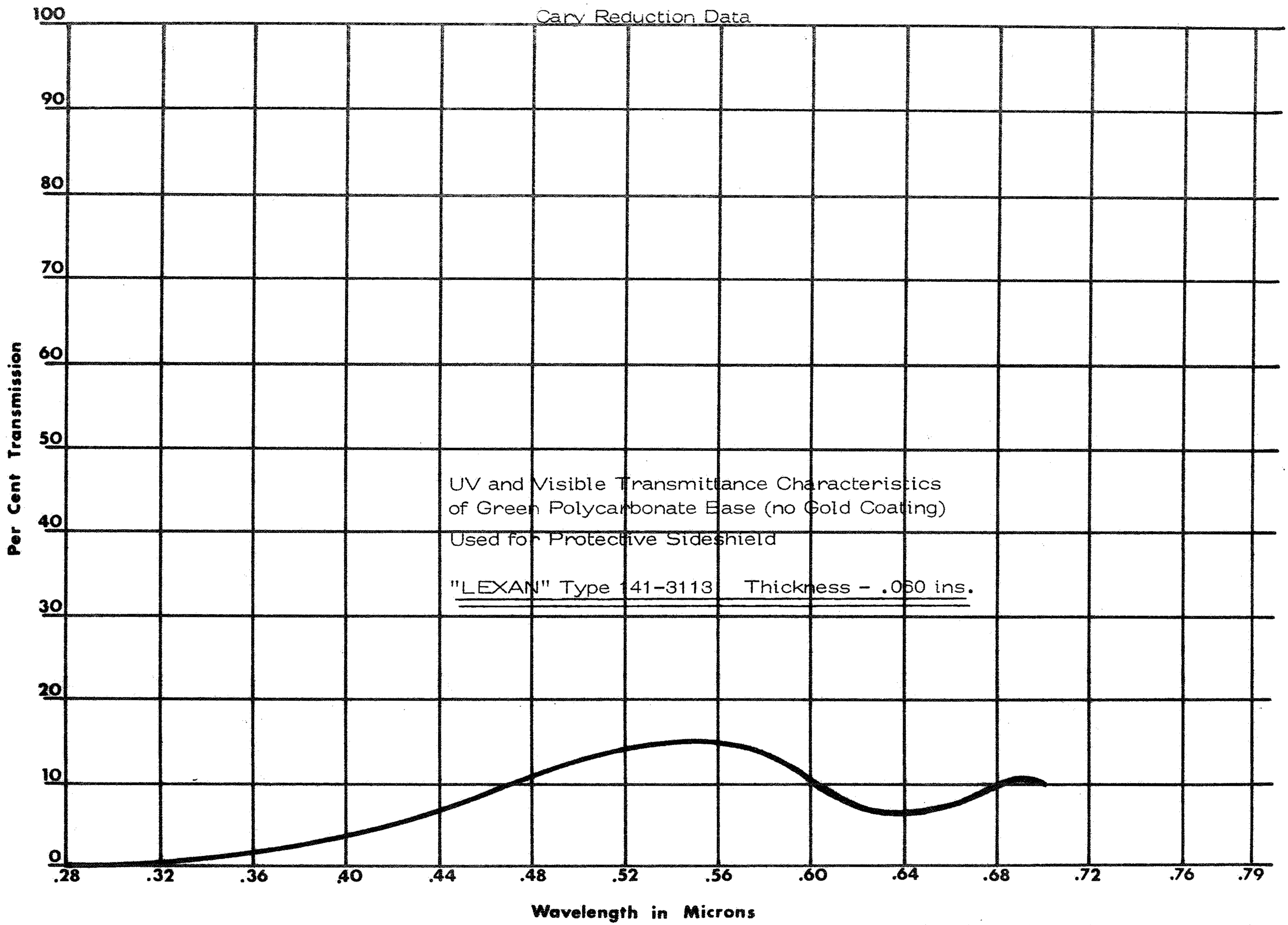
1. Chart #3 presents the transmission curve for "LEXAN" polycarbonate, Type 141,-3113, green color, in a thickness of .060 between 280 and 790 millimicrons. This base material shows significant attenuation in the ultra-violet region.

2. Chart #4 plots wave length against optical density in the ultra-violet range between 200 to 340 millimicrons, for the finished sideshield, as used in PHASE III output. Its construction is a .060 thick molded shield, using "LEXAN" 141-3113, to which gold is applied to attain a final visual transmittance of 1.5%. This reveals very satisfactory attenuations to an optical density greater than 6.

3. Chart #5 presents infra-red data for the "as molded" sideshield (1), and for the sideshield with gold applied (2).

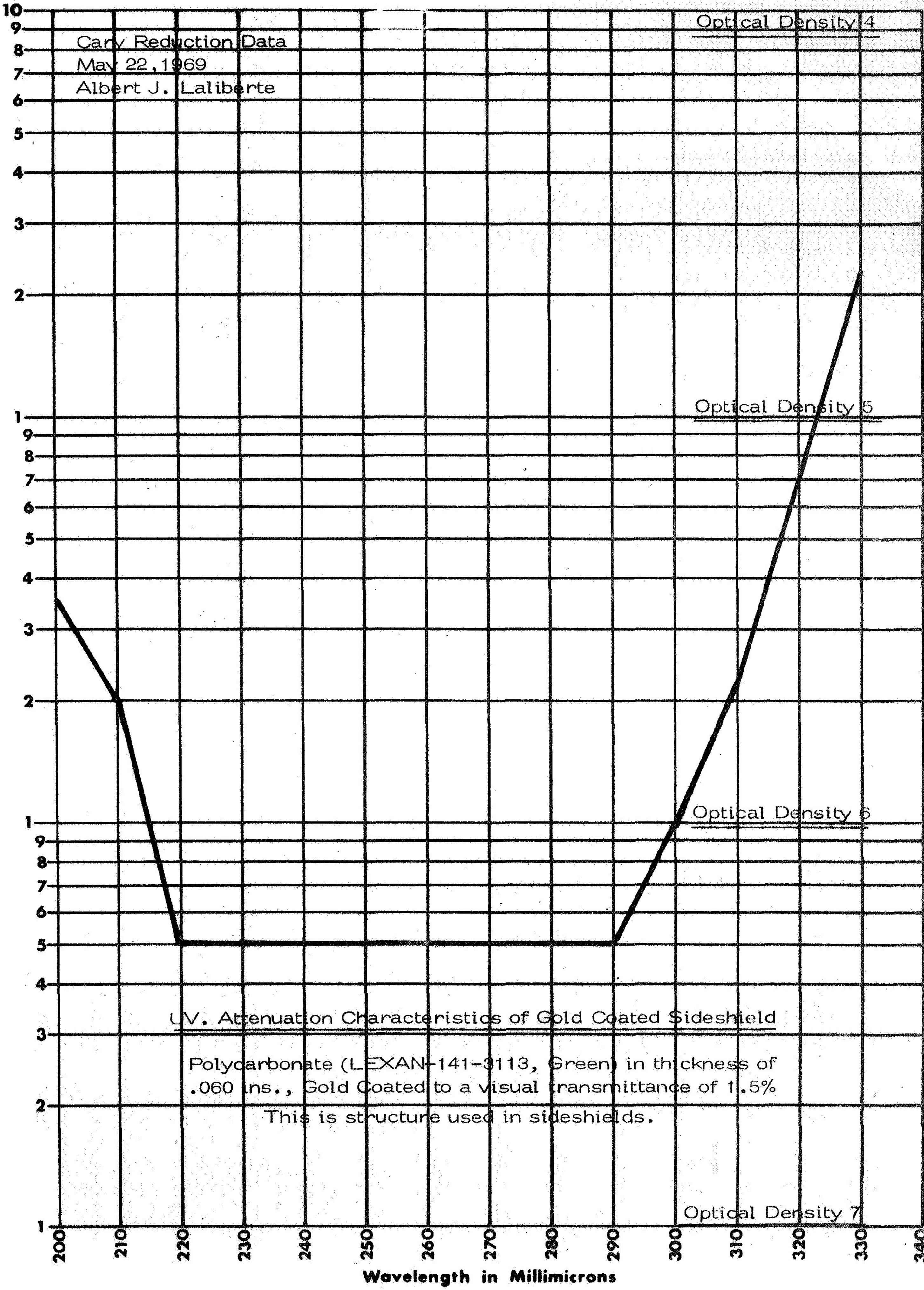
Curve #1, for the basic green material does reveal a significant IR attenuation, not really typical of such materials (we would expect considerably more IR transmittance), however, when gold is applied to reduce this to 1.5% visual, the amount of attenuation is very significant. Although this has been plotted on a 100% scale, to show a direct comparison, our actual data was taken with the spectrophotometer set with full scale reading 10%. In the region between 900 and 1200 millimicrons, the transmittance was not over 0.2% at any one point. In all other areas, the spectrophotometer indicated near zero readings, within the "noise level", or error limit of the spectrophotometer itself.

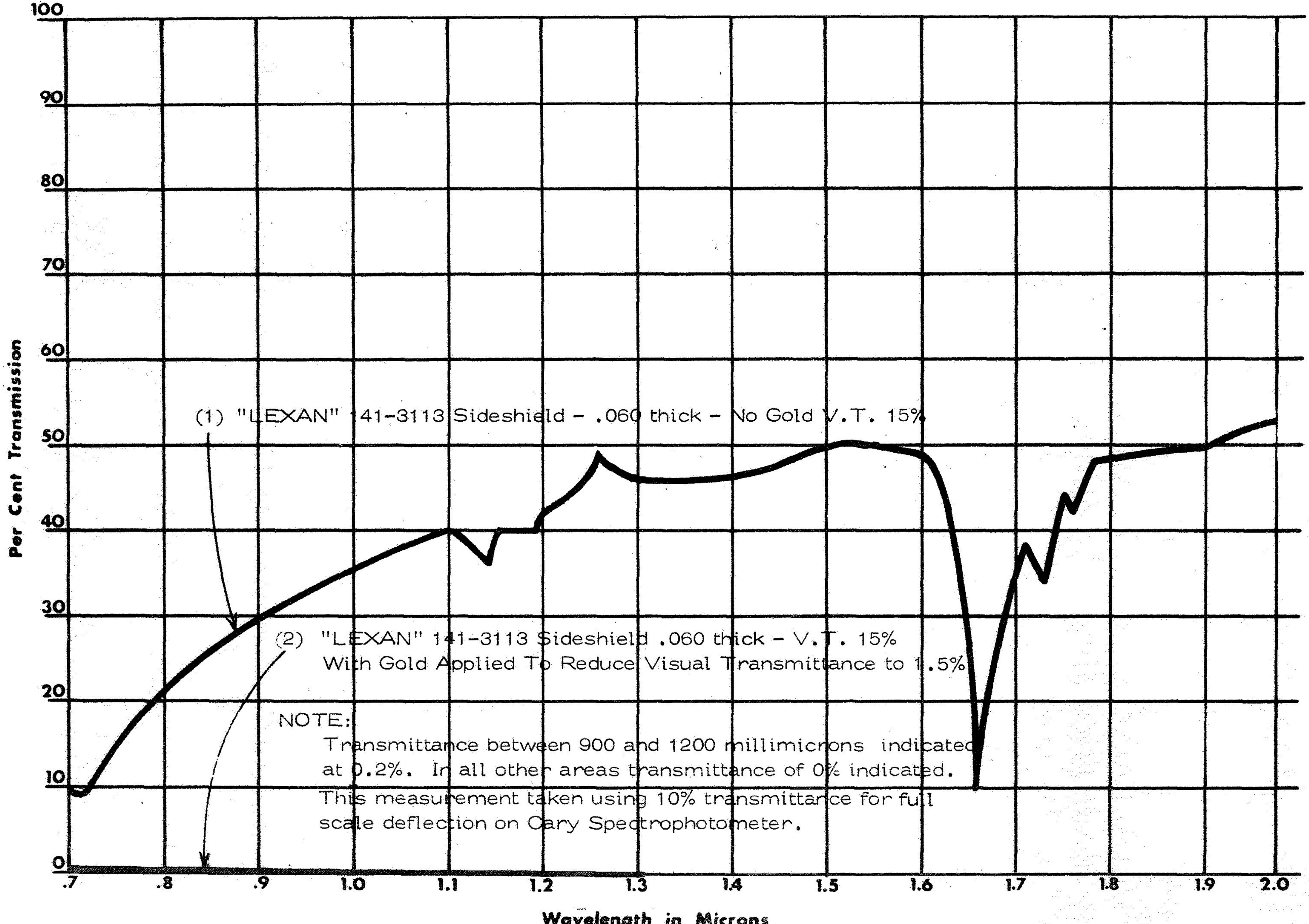
As a result of this analysis, it is our conclusion that the sideshields, as developed and used for the Type #2 and Type #3 spectacles submitted under PHASE III meet the UV and IR NASA requirements.



Transmittance of "LEXAN" Polycarbonate #141-3113, Uncoated
in Thickness of .060

UNIVIS, INC. - Omnitech Division
May 22, 1969


Cary Reduction Data
May 22, 1969
Albert J. Laliberte
Optical Density 4
Optical Density 5
Optical Density 6
Optical Density 7
U.V. Attenuation Characteristics of Gold Coated Sideshield
Polycarbonate (LEXAN-141-3113, Green) in thickness of .060 ins., Gold Coated to a visual transmittance of 1.5%
This is structure used in sideshields.
10
9
8
7
6
5
4
3
2
1
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
Wavelength in Millimicrons



IR Transmittance - Lexan 141-3113 (green) Sideshields
VS. Lexan 141-3113+ Gold Coating

UNIVIS, INC. - Omnitech Division
May 22, 1969
Albert J. Laliberte

CHART #5

III. ASSEMBLY - OUPTUT - PHASE #3

A. A total of 105 Pressure Suit Spectacles with carrying cases were produced and submitted to NASA on May 29, 1969 to approved PHASE 2 configuration, and incorporating the improved sideshield for Type II and Type III spectacles. Items delivered were as follows:

1. 13 each - Pressure Suit Spectacles, Type I, with large bridge.
2. 12 each - Pressure Suit Spectacles, Type I, with medium bridge.
3. 25 each - Pressure Suit Spectacles, Type II, with large bridge.
4. 25 each - Pressure Suit Spectacles, Type II, with medium bridge.
5. 15 each - Pressure Suit Spectacles, Type III, with large bridge.
6. 15 each - Pressure Suit Spectacles, Type III, with medium bridge.

Items #5 and 6 include 5 extra units not called for in PHASE 3 which are provided to complete the requirements for PHASE #1 - Type III units, 5 of which were not submitted at that time.

B. One each, carrying case. To complete requirements for PHASE 2 for 15 cases. 14 had previously been submitted.

TECHNICAL REPORTS AND DATA

A. PROGRESS REPORTS

In accordance with 5.1.1, four informal progress reports were submitted to NASA as follows:

REPORT #	REPORT PERIOD	DATE SUBMITTED
1	June 12, 1968 - Sept. 12, 1968	Jan. 21, 1969
2	Sept. 13, 1968 - Dec. 12, 1968	Mar. 20, 1969
3	Dec. 13, 1968 - Mar. 12, 1969	Mar. 20, 1969
4	Mar 13, 1969 - April 25, 1969	April 25, 1969

B. FINAL TECHNICAL REPORT (5.1.2)

Preliminary Draft Submitted - June 16, 1969

C. DRAWINGS AND SPECIFICATIONS (5.2)

The following drawings, detailing structure and specification for final PHASE III Spectacle Design were prepared, and submitted for approval on June 16, 1969.

Dwg. Size	DWG. NO.	DESCRIPTION
C	543001	ASSEMBLY
C	543002	FRONT DETAILS
C	543003	CASE DETAIL & ASSY.
B	543004	SIDE SHIELD
B	543005	END PIECE
B	543006	TEMPLE
B	543007	LENS SPECIFICATIONS
B	543008	HEADBAND
A	543009	EYEWIRE
A	543010	SIDESHIELD RETAINING BAR
C	543011	BRIDGE (SMALL)
C	543012	BRIDGE (LARGE)