RS

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/782,889	01/10/97	SHANNON P	1644.0010000

LM21/0916

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

EXAMINER	
PEESE, T	
ART UNIT	PAPER NUMBER
2??4	7

DATE MAILED: 09/16/98

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

PTO-90C (Rev. 2/95)

☆U.S.GOVERNMENT PRINTING OFFICE 1996-411-516/40275

1- File Copy

Notice of Allowability	Application No. 08/782,889	Applicant(s) Shannon
	Examiner Thomas Peeso	Group Art Unit 2764

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance and Issue Fee Due or other appropriate communication will be mailed in due course.

☒ This communication is responsive to *Application papers filed* .

☒ The allowed claim(s) is/are *2-11, 13-56 (renumbered as 54)* .

☐ The drawings filed on ________ are acceptable.

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ________ .

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ________ .

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

A SHORTENED STATUTORY PERIOD FOR RESPONSE to comply with the requirements noted below is set to EXPIRE THREE MONTHS FROM THE "DATE MAILED" of this Office action. Failure to timely comply will result in ABANDONMENT of this application. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

☐ Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL APPLICATION, PTO-152, which discloses that the oath or declaration is deficient. A SUBSTITUTE OATH OR DECLARATION IS REQUIRED.

☐ Applicant MUST submit NEW FORMAL DRAWINGS

☐ because the originally filed drawings were declared by applicant to be informal.

☐ including changes required by the Notice of Draftsperson's Patent Drawing Review, PTO-948, attached hereto or to Paper No. ____ .

☐ including changes required by the proposed drawing correction filed on ________ , which has been approved by the examiner.

☐ including changes required by the attached Examiner's Amendment/Comment.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the reverse side of the drawings. The drawings should be filed as a separate paper with a transmittal lettter addressed to the Official Draftsperson.

☐ Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Any response to this letter should include, in the upper right hand corner, the APPLICATION NUMBER (SERIES CODE/SERIAL NUMBER). If applicant has received a Notice of Allowance and Issue Fee Due, the ISSUE BATCH NUMBER and DATE of the NOTICE OF ALLOWANCE should also be included.

Attachment(s)

☒ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). *5*

☒ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

☐ Interview Summary, PTO-413

☐ Examiner's Amendment/Comment

☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material

☒ Examiner's Statement of Reasons for Allowance

The following is an examiner's statement of reasons for allowance: Applicant has claimed uniquely distinct features in the instant invention which are not found in the prior art, either singularly or in combination. These features are illuminating a gemstone model using an illumination model, wherein said gemstone model defines the geometry and position of the gemstone facets, and wherein said illumination model produces a light beam; refracting said light beam into said gemstone model through a first facet of said gemstone model to produce a refracted light beam; reflecting said refracted light beam within said gemstone model from a second facet of said gemstone model to produce a reflected light beam; refracting said refracted and reflected light beams out of said gemstone model through a third facet of said gemstone model to produce an exiting light beam; and measuring said exiting light beam. These features are not found or suggested in the prior art.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any response to this action should be mailed to:

Commissioner of Patents and Trademarks

Washington, D.C. 20231

or faxed to:

(703) 308-9051, (for formal communications intended for entry)

Or:

(703) 308-5356 (for informal or draft communications, please label "PROPOSED" or "DRAFT")

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington. VA., Sixth Floor (Receptionist).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mr. Thomas Peeso whose telephone number is (703) 305-9784. The examiner can normally be reached on Monday -Thursday from 7am to 5pm. The examiner can also be reached on alternate Fridays. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mr. Emanuel Voeltz, can be reached on (703) 305-9714.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-3800.

Thomas Peeso
Primary Examiner
Art Unit 2764
11 Sep 98

Notice of References Cited

Application No.	Applicant(s)		
08/782,889	Shannon		
Examiner		Group Art Unit	
Thomas Peeso		2764	Page 1 of 1

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUBCLASS
x	A	3,947,120	30 Mar 76	Bar-Issac et al.	356	30
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUBCLASS
	N						
	O						
	P						
	Q						
	R						
	S						
	T						

NON-PATENT DOCUMENTS

*		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	DATE
	U		
	V		
	W		
	X		

* A copy of this reference is not being furnished with this Office action.
(See Manual of Patent Examining Procedure, Section 707.05(a).)

U. S. Patent and Trademark Office
PTO-892 (Rev. 9-95)

Notice of References Cited

Part of Paper No. 7

FORM PTO 948 (REV. 01-97) U.S. DEPARTMENT OF COMMERCE-Patent and Trademark Office Application No. 8/782889

NOTICE OF DRAFTPERSON'S PATENT DRAWING REVIEW

The drawing filied (insert date) 1/10/97 are:

A. ✓ not objected to by the Draftperson under 37 CFR 1.84 or 1.152.

B. ____ objected to by the Draftperson under 37 CFR 1.84 or 1.152 as indicated below. The Examiner will require submission of new, corrected drawings whe necessary. Corrected drawings must be submitted according to the instructions on the back of this notice.

1. DRAWINGS. 37 CFR 1.84(a): Acceptable categories of drawings: Black ink. Color.
   - ____ Color drawing are not acceptable until petition is granted. Fig.(s)____
   - ____ Pencil and non black ink is not permitted. Fig(s)____
2. PHOTOGRAPHS. 37 CFR 1.84(b)
   - ____ Photographs are not acceptable until petition is granted,
   - ____ 3 full-tone sets are required. Fig(s)____
   - ____ Photographs not properly mounted (must brystol board or photographic double-weight paper). Fig(s)____
   - ____ Poor quailty (half-tone). Fig(s)____
3. TYPE OF PAPER. 37 CFR 1.84(e)
   - ____ Paper not flexible, strong, white and durable. Fig.(s)____
   - ____ Erasures, alterations, overwritings, interlineations, folds, copy machine marks not acceptable. (too thin)
   - ____ Mylar, vellum paper is not acceptable (too thin). Fig(s)____
4. SIZE OF PAPER. 37 CFR 1.84(F): Acceptable sizes:
   - ____ 21.0 cm by 29.7 cm (DIN size A4)
   - ____ 21.6 cm by 27.9 cm (8 1/2 x 11 inches)
   - ____ All drawings sheets not the same size. Sheet(s)____
5. MARGINS. 37 CFR 18.4(g): Acceptable margins:
   Top 2.5 cm Left 2.5 cm Right 1.5 cm Bottom 1.0 cm SIZE: A4 Size
   ✓ Top 2.5 cm Left 2.5 cm Right 1.5 cm Bottom 1.0 cm SIZE: 8 1/2 x 11
   - ✓ Margins not acceptable. Fig(s) 1,3A,4,13A-15, 19,20,25,29,34, 36,40,41-43,44, 47,50,52,56
   - ✓ Top (T) ✓ Left (L)
   - ✓ Right (R) ____ Bottom (B)
6. VIEWS. CFR 1.84(h)
   REMINDER: Specification may require revision to correspond to drawing changes.
   - ____ Views connected by projection lines or lead lines. Fig.(s)____

   Partial views. 37 CFR 1.84(h)(2)
   - ____ Brackets needed to show figure as one entity. Fig.(s)____
   - ✓ Views not labeled separately or properly. Fig.(s) 28 w/ Fig legends
   - ____ Enlarged view not labeled separately or properly. Fig.(s)____
7. SECTIONAL VIEWS. 37 CFR 1.84(h)(3)
   - ____ Hatching not indicated for sectional portions of an object. Fig.(s)____
   - ____ Sectional designation should be noted with Arabic or Roman numbers. Fig.(s)____
8. ARRANGEMENT OF VIEWS. 37 CFR 1.84(i)
   - ____ Words do not appear on a horizontal, left-to-right fashion when page is either upright or turned, so that the top becomes the right side, except for graphs. Fig.(s)____
   - ____ Views not on the same plane on drawing sheet. Fig.(s)____
9. SCALE. 37 CFR 1.84(k)
   - ____ Scale not large enough to show mechansim with crowding when drawing is reduced in size to two-thirds in reproduction. Fig.(s)____
10. CHARACTER OF LINES, NUMBERS, & LETTERS. 37 CFR 1.84(l)
    - ____ Lines, numbers & letters not uniformly thick and well defined, clean, durable and black (poor line quality). Fig.(s)____
11. SHADING. 37 CFR 1.84(m)
    - ____ Solid black areas pale. Fig.(s)____
    - ____ Solid black shading not permitted. Fig.(s)____
    - ____ Shade lines, pale, rough and blurred. Fig.(s)
12. NUMBERS, LETTERS, & REFERENCE CHARACTERS. 37 CFR 1.48(p)
    - ____ Numbers and reference characters not plain and legible. Fig.(s)____
    - ____ Figure legends are poor. Fig.(s)____
    - ____ Numbers and reference characters not oriented in the same direction as the view. 37 CFR 1.84(p)(3) Fig.(s)____
    - ____ English alphabet not used. 37 CFR 1.84(p)(3) Fig.(s)____
    - ✓ Numbers, letters and reference characters must be at least .32 cm (1/8 inch) in height. 37 CFR 1.84(p)(3) Fig.(s)____
13. LEAD LINES. 37 CFR 1.84(q)
    - ____ Lead lines cross each other. Fig.(s)____
    - ____ Lead lines missing. Fig.(s)____
14. NUMBERING OF SHEETS OF DRAWINGS. 37 CFR 1.48(t)
    - ____ Sheets not numbered consecutively, and in Ababic numerals beginning with number 1. Fig.(s)____
15. NUMBERING OF VIEWS. 37 CFR 1.84(u)
    - ____ Views not numbered consecutively, and in Abrabic numerals, beginning with number 1. Fig.(s)____
16. CORRECTIONS. 37 CFR 1.84(w)
    - ____ Corrections not made from PTO-948 dated____
17. DESIGN DRAWINGS. 37 CFR 1.152
    - ____ Surface shading shown not appropriate. Fig.(s)____
    - ____ Solid black shading not used for color contrast. Fig.(s)____

COMMENTS
- Gray areas on (Fig 1, 28, 29, 31)
- Fig legend placed incorrectly (Fig 25)

REVIEWER WJS DATE 6/12/97 TELEPHONE NO. 7033058404

ATTACHMENT TO PAPER NO. 7

PTO COPY

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

NOTICE OF ALLOWANCE AND ISSUE FEE DUE

LM21/0916

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/782,889	01/10/97	054	PEESO, T	2764	09/16/98

First Named Applicant: SHANNON, PAUL T. SR.

TITLE OF INVENTION: SYSTEM AND METHOD FOR OPTICAL EVALUATION OF GEMSTONES

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
3 1644.0010000	702-035.000	J18	UTILITY	YES	$660.00	12/16/98

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED.

THE ISSUE FEE MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED.

HOW TO RESPOND TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.
If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is changed, pay twice the amount of the FEE DUE shown above and notify the Patent and Trademark Office of the change in status, or
B. If the status is the same, pay the FEE DUE shown above.

If the SMALL ENTITY is shown as NO:

A. Pay FEE DUE shown above, or
B. File verified statement of Small Entity Status before, or with, payment of 1/2 the FEE DUE shown above.

II. Part B-Issue Fee Transmittal should be completed and returned to the Patent and Trademark Office (PTO) with your ISSUE FEE. Even if the ISSUE FEE has already been paid by charge to deposit account, Part B Issue Fee Transmittal should be completed and returned. If you are charging the ISSUE FEE to your deposit account, section "4b" of Part B-Issue Fee Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give application number and batch number.
Please direct all communications prior to issuance to Box ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PATENT AND TRADEMARK OFFICE COPY

PTOL-85 (REV. 10-96) Approved for use through 06/30/99. (0651-0033)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/782,889	01/10/97	SHANNON	P 1644.0010000

75F1/0212

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

EXAMINER	
PEESO, T	
ART UNIT	PAPER NUMBER
2764	08

DATE MAILED: 02/12/99

NOTICE OF ABANDONMENT

This application is abandoned in view of:

☐ Applicant's failure to timely file a proper response to the Office letter mailed on __________.

- ☐ A response (with a Certificate of Mailing or Transmission of __________) was received on __________, which is after the expiration of the period for response (including a total extension of time of ____ month(s)) which expired on __________.
- ☐ A proposed response was received on __________, but it does not constitute a proper response to the final rejection.

  (A proper response to a final rejection consists only of: a timely filed amendment which places the application in condition for allowance; a Notice of Appeal; or the filing of a continuing application under 37 CFR 1.62 (FWC).
- ☐ No response has been received.

☑ Applicant's failure to timely pay the required issue fee within the statutory period of three months from the mailing date of the Notice of Allowance.

- ☐ The issue fee (with a Certificate of Mailing or Transmission of __________) was received on __________.
- ☐ The submitted issue fee of $_____ is insufficient. The issue fee required by 37 CFR 1.18 is $_____.
- ☑ The issue fee has not been received.

☐ Applicant's failure to timely file new formal drawings as required in the Notice of Allowability.

- ☐ Proposed new formal drawings (with a Certificate of Mailing or Transmission of __________) were received on __________.
- ☐ The proposed new formal drawings filed __________ are not acceptable.
- ☐ No proposed new formal drawings have been received.

☐ The express abandonment under 37 CFR 1.62(g) in favor of the FWC application filed on __________.

☐ The letter of express abandonment which is signed by the attorney or agent of record, the assignee of the entire interest, or all of the applicants..

☐ The letter of express abandonment which is signed by an attorney or agent (acting in a representative capacity under 37 CFR 1.34(a) upon the filing of a continuing application.

☐ The decision by the Board of Patent Appeals and Interferences rendered on __________ and because the period for seeking court review of the decision has expired and there are no allowed claims.

☐ The reason(s) below:

Diane Terry
Allowed Files Branch
703-305-8203

FORM PTO-1432 (REV. 10-95)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/782,889	01/10/97	SHANNON	P 1644.0010000

75F1/0316

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

EXAMINER	
PEESO, T	
ART UNIT	PAPER NUMBER
2764	9

DATE MAILED: 03/16/99

NOTICE OF RESCINDED ABANDONMENT

☐ In response to your communication filed ____________

☑ Through inadvertence, a Notice of Abandonment was mailed in the above identified application. The Notice of Abandonment is hereby rescinded. The ~~issue fee receipt will be mailed within six weeks.~~

[signature]
Manager, Publishing Division
Office of Publication and Dissemination

Form PTOL - 393 (Rev. 4-92)

Please type a sign(+) inside this box → ⊞

PTO/SB/29 (8/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

CONTINUED PROSECUTION APPLICATION (CPA) REQUEST TRANSMITTAL

Submit an original, and a duplicate for fee processing.

(Only for Continuation or Divisional applications under 37 CFR § 1.53(d))

CHECK BOX if applicable: ☐ DUPLICATE

OIPE JC1 DEC 16 1998 PATENT & TRADEMARK OFFICE

Address to: Assistant Commissioner for Patents
Box CPA
Washington, DC 20231

Attorney Docket No. of Prior Application	CPA Application of 08/782,889
First Named Inventor	Paul T. Shannon, Sr.
Examiner Name	Peeso, T.
Group/Art Unit	2764
Express Mail Label No.	

RECEIVED DEC 21 1998 Group 2700

This is a request for a ☒ continuation or ☐ divisional application under 37 CFR § 1.53(d), (continued prosecution application (CPA)) of the prior application number 08/782,889, filed on January 10, 1997, entitled: System And Method For Optical Evaluation Of Gemstones

NOTES

FILING QUALIFICATIONS: The prior application identified above must be a nonprovisional application that is either: (1) complete as defined by 37 CFR § 1.51(b) or (2) the national stage of an international application in compliance with 35 U.S.C. 371. A Notice will be placed on a patent issuing from a CPA, except for reissues and designs, to the effect that the patent issued on a CPA and is subject to the twenty-year term provisions of 35 U.S.C. § 154(a)(2). Therefore, the prior application of a CPA may have been filed before, on or after June 8, 1995.

C-I-P NOT PERMITTED: A continuation-in-part application cannot be filed as a CPA under 37 CFR § 1.53(d), but must be filed under 37 CFR § 1.53(b).

EXPRESS ABANDONMENT OF PRIOR APPLICATION: The filing of this CPA is a request to expressly abandon the prior application as of the filing date of the request for a CPA. 37 CFR § 1.53(b) must be used to file a continuation, divisional, or continuation-in-part of an application that is not to be abandoned.

ACCESS TO PRIOR APPLICATION: The filing of this CPA will be construed to include a waiver of confidentiality by the application under 35 U.S.C. 122 to the extent that any member of the public who is entitled under the provisions of 37 CFR § 1.14 to access to, copies of, or information concerning, the prior application may be given similar access to, copies of, or similar information concerning, the other application or applications in the file jacket.

35 U.S.C. 120 STATEMENT: In a CPA, no reference to the prior application is needed in the first sentence of the specification and none should be submitted. If a sentence referencing the prior application is submitted, it will not be entered. A request for a CPA is the specific reference required by 35 U.S.C. 120 and to every application assigned the application number identified in such request, 37 CFR § 1.78(a).

1. ☐ Enter the unentered amendment previously filed on _______________ under 37 CFR § 1.116 in the prior nonprovisional application.
2. ☒ A preliminary amendment is enclosed.
3. This application is filed by fewer than all the inventors named in the prior application, 37 CFR § 1.53(d)(4).
   - a. ☐ *DELETE* the following inventor(s) named in the prior nonprovisional application:
     ....
     ....
   - b. ☐ The inventor(s) to be deleted are set forth in a separate sheet attached hereto.
4. ☐ A new power of attorney or authorization of agent (PTO/SB/81) is enclosed.
5. Information Disclosure Statement (IDS) is enclosed:
   - a. ☐ PTO-1449
   - b. ☐ Copies of IDS citations

12/18/1998 AIBRAHIM 00000085 08782889 380.00 OP 486.00 OP 351.00 OP

Burden Hour Statement: this form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box CPA, Washington, DC 20231.

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR § 1.16(c) or (j))	74-20* =	54	x $ 18.00 =	$972.00
	INDEPENDENT CLAIMS (37 CFR § 1.16(b) or (i))	12-3** =	9	x $ 78.00 =	$702.00
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR § 1.16(d))			x $ 260.00 =	$ 0.00
				BASIC FEE (37 CFR §1.16)	$ 760.00
		Total of above Calculations =			$2,434.00
	Reduction by 50% for filing by small entity (Note 37 CFR §§ 1.9, 1.27, 1.28).				$1,217.00
	* *Reissue claims in excess of 20 and over original patent.* ***Reissue independent claims over original patent.* TOTAL =				$1,217.00

6. Small entity status:
   - a. ☐ A small entity statement is enclosed, if (b) and (c) do not apply.
   - b. ☒ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.
   - c. ☐ Is no longer claimed.

7. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 19-0036:
   - a. ☐ Fees required under 37 CFR § 1.16.
   - b. ☐ Fees required under 37 CFR § 1.17.
   - c. ☐ Fees required under 37 CFR § 1.18.

RECEIVED
DEC 2 1 1998
Group 2700

8. ☒ SKGF Check No. *23313* in the amount of *$1,217.00* is enclosed.

9. ☐ New Attorney Docket Number, if desired ____________________

[Prior application Attorney Docket Number will carryover to this CPA unless a new Attorney Docket Number has been provided herein.]

10. a. ☐ Receipt For Facsimile Transmitted CPA (PTO/SB/29A)
    b. ☒ Return Receipt Postcard (Should be specifically itemized, See MPEP 503)

11. ☒ Other: Authorization To Treat A Reply As Incorporating An Extension Of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate).

NOTE: *The prior application's correspondence address will carry over to this CPA UNLESS a new correspondence address is provided below.*

12. NEW CORRESPONDENCE ADDRESS

☐ *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* *or* ☐ *New correspondence address below*

Name					
Address					
City		*State*		*Zip Code*	
Country		*Telephone*		*Fax*	

13. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED	
Name (Print/Type)	Edward J. Kessler
Signature	[signature]
Registration No. (Attorney/Agent)	25,688
Date	12/18/98

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.
ATTORNEYS AT LAW
1100 New York Avenue, N.W.
Suite 600
Washington, D.C. 20005-3934

Facsimile Cover Sheet

urgent ☐ return reply requested ☒ original will be sent as confirmation ☐

DATE:	February 19, 1999 **PHONE NO.:** (703) 308-5864
PAGES:	4 (including this cover sheet)
TO:	U.S. Patent and Trademark Office
ATTN:	Ms. Diane Terry/Allowed Files Branch
FROM:	Edward J. Kessler/alw
RE:	Notice of Abandonment received for U.S. Appl. No.: 08/782,889 originally filed January 10, 1997; CPA filed December 16, 1998
OUR REF:	1644.0010000

MESSAGE

Dear Ms. Terry:

As discussed in a phone conversation with my secretary, Adria Wimmer, on February 19, 1999, enclosed is a copy of the return date stamped post card evidencing filing of the CPA on December 16, 1998, as well as the CPA Transmittal Form (Form PTO/SB/29).

If you have any questions or need additional information, please feel free to contact me (202) 371-2550 or my secretary (202) 371-2614 at the numbers provided. Thank you in advance for your attention to this matter.

I hereby certify that this paper is being facsimile transmitted to the Patent and Trademark Office on the date shown
--Adria L. Wimmer--

Adria L. Wimmer 2/19/99
Signature Date

please sign and return this page as acknowledgment of receipt

If any portion of this transmission is not received clearly or in full, contact us at any of the following numbers:

TELEPHONE NUMBER	FACSIMILE NUMBER
(202) 371-2600	(202) 371-2540

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.
1100 NEW YORK AVENUE, N.W.
SUITE 600
WASHINGTON, D.C. 20005-3934

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.
1100 NEW YORK AVENUE, N.W.
SUITE 600
WASHINGTON, D.C. 20005-3934

COPY

Due Date: December 16, 1998

		Due Date:	December 16, 1998
Applicant:	Paul T. Shannon, Sr.	Art Unit:	2764
		Examiner:	Peeso, T.
Application No.:	CPA of Appln. No.: 08/782,889 originally filed January 10, 1997	Docket:	1644.0010000
Filed:	December 16, 1998	Atty:	EJK:alw
For:	**System And Method For Optical Evaluation Of Gemstones**		

When receipt stamp is placed hereon, the USPTO acknowledges receipt of the following documents:

1. SKGF Patent Office Cover Letter (in duplicate);
2. Fee Transmittal Form PTO/SB/17 (in duplicate);
3. CPA Transmittal Form PTO/SB/29 (in duplicate);
4. Preliminary Amendment;
5. Authorization to Treat a Reply As Incorporating An Extension of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate);
6. SKGF Check No. *23313* in the amount of *$1,217.00* to cover:
   $380.00 Basic filing fee (37 C.F.R. § 1.16(a));
   $486.00 Additional Claims Over Twenty;
   $351.00 Additional Independent Claims Over Three; and
7. One (1) Return Postcard.

PLEASE DATE STAMP AND RETURN TO OUR COURIER
BOX CPA

OIPE DEC 16 1998 JC80 PATENT & TRADEMARK OFFICE

#10/CPA mB 4-12-99

original MRD 12-16-98

Please type a sign(+) inside this box → ⊞

COPY

PTO/SB/29 (6/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

CONTINUED PROSECUTION APPLICATION (CPA) REQUEST TRANSMITTAL

Submit an original, and a duplicate for fee processing.

(Only for Continuation or Divisional applications under 37 CFR § 1.53(d))

CHECK BOX if applicable: ☐ DUPLICATE

Address to:		
Assistant Commissioner for Patents Box CPA Washington, DC 20231	*Attorney Docket No. of Prior Application*	CPA Application of 08/782,889
	First Named Inventor	Paul T. Shannon, Sr.
	Examiner Name	Pecso, T.
	Group/Art Unit	2764
	Express Mail Label No.	

This is a request for a ☒ continuation or ☐ divisional application under 37 CFR § 1.53(d), (continued prosecution application (CPA)) of the prior application number 08/782,889, filed on January 10, 1997, entitled: System And Method For Optical Evaluation Of Gemstones.

NOTES

FILING QUALIFICATIONS: The prior application identified above must be a nonprovisional application that is either: (1) complete as defined by 37 CFR § 1.51(b) or (2) the national stage of an international application in compliance with 35 U.S.C. 371. A Notice will be placed on a patent issuing from a CPA, except for reissues and designs, to the effect that the patent issued on a CPA and is subject to the twenty year term provisions of 35 U.S.C. § 154(a)(2). Therefore, the prior application of a CPA may have been filed before, on or after June 8, 1995.

C-I-P NOT PERMITTED: A continuation-in-part application cannot be filed as a CPA under 37 CFR § 1.53(d), but must be filed under 37 CFR § 1.53(b).

EXPRESS ABANDONMENT OF PRIOR APPLICATION: The filing of this CPA is a request to expressly abandon the prior application as of the filing date of the request for a CPA. 37 CFR § 1.53(b) must be used to file a continuation, divisional, or continuation-in-part of an application that is not to be abandoned.

ACCESS TO PRIOR APPLICATION: The filing of this CPA will be construed to include a waiver of confidentiality by the application under 35 U.S.C. 122 to the extent that any member of the public who is entitled under the provisions of 37 CFR § 1.14 to access to, copies of, or information concerning, the prior application may be given similar access to, copies of, or similar information concerning, the other application or applications in the file jacket

35 U.S.C. 120 STATEMENT: In a CPA, no reference to the prior application is needed in the first sentence of the specification and none should be submitted. If a sentence referencing the prior application is submitted, it will not be entered. A request for a CPA is the specific reference required by 35 U.S.C. 120 and to every application assigned the application number identified in such request. 37 CFR § 1.78(a).

1. ☐ Enter the unentered amendment previously filed on ______________ under 37 CFR § 1.116 in the prior nonprovisional application.
2. ☒ A preliminary amendment is enclosed.
3. This application is filed by fewer than all the inventors named in the prior application, 37 CFR § 1.53(d)(4).
   - a. ☐ ***DELETE*** the following inventor(s) named in the prior nonprovisional application:
     ....
     ....
   - b. ☐ The inventor(s) to be deleted are set forth in a separate sheet attached hereto.
4. ☐ A new power of attorney or authorization of agent (PTO/SB/81) is enclosed.
5. Information Disclosure Statement (IDS) is enclosed:
   - a. ☐ PTO-1449
   - b. ☐ Copies of IDS citations

Burden Hour Statement: this form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box CPA, Washington, DC 20231.

COPY

Please type a sign(+) inside this box → ⊞

PTO/SB/29 (8/98)
Approved for use through 08/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR § 1.16(c) or (j))	74-20* =	54	x $ 18.00 =	$972.00
	INDEPENDENT CLAIMS (37 CFR § 1.16(b) or (i))	12-3** =	9	x $ 78.00 =	$702.00
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR § 1.16(d))			x $ 260.00 =	$ 0.00
				BASIC FEE (37 CFR §1.16)	$ 760.00
		Total of above Calculations =			$2,434.00
	Reduction by 50% for filing by small entity (Note 37 CFR §§ 1.9, 1.27, 1.28).				$1,217.00
	* Reissue claims in excess of 20 and over original patent. ** Reissue independent claims over original patent.		TOTAL =		$1,217.00

6. Small entity status:
   - a. ☐ A small entity statement is enclosed, if (b) and (c) do not apply.
   - b. ☒ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.
   - c. ☐ Is no longer claimed.

7. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 19-0036:
   - a. ☐ Fees required under 37 CFR § 1.16.
   - b. ☐ Fees required under 37 CFR § 1.17.
   - c. ☐ Fees required under 37 CFR § 1.18.

8. ☒ SKGF Check No. *23313* in the amount of *$1,217.00* is enclosed.

9. ☐ New Attorney Docket Number, if desired ________ ________

(Prior application Attorney Docket Number will carryover to this CPA unless a new Attorney Docket Number has been provided herein.)

10. a. ☐ Receipt For Facsimile Transmitted CPA (PTO/SB/29A)
    b. ☒ Return Receipt Postcard (Should be specifically itemized, See MPEP 503)

11. ☒ Other: Authorization To Treat A Reply As Incorporating An Extension Of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate).

NOTE: *The prior application's correspondence address will carry over to this CPA UNLESS a new correspondence address is provided below.*

12. NEW CORRESPONDENCE ADDRESS

☐ *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* or ☐ *New correspondence address below*

Name					
Address					
City		*State*		*Zip Code*	
Country		*Telephone*		*Fax*	

13. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Name (Print/Type)	Edward J. Kessler
Signature	[signature]
Registration No. (Attorney/Agent)	25,688
Date	12/16/98

GAU 2764 $

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.
ATTORNEYS AT LAW
1100 NEW YORK AVENUE, N.W., SUITE 600
WASHINGTON, D.C. 20005-3934
(202) 371-2600
FACSIMILE: (202) 371-2540; (202) 371-6566

ROBERT GREENE STERNE
EDWARD J. KESSLER
JORGE A. GOLDSTEIN
SAMUEL L. FOX
DAVID K.S. CORNWELL
ROBERT W. ESMOND
TRACY-GENE G. DURKIN
MICHELE A. CIMBALA
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CAMERON H. TOUSI**
VINCENT L. CAPUANO**
DONALD R. BANOWIT**
DAVID P. MAIVALD**

*BAR OTHER THAN D.C.
**REGISTERED PATENT AGENTS

OIPE JC60 DEC 16 1998 PATENT & TRADEMARK OFFICE

December 16, 1998

WRITER'S DIRECT NUMBER:
(202) 371-2550
INTERNET ADDRESS:
EKESSLER@SKGF.COM

RECEIVED
DEC 21 1998
Group 2700

BOX: CPA

Assistant Commissioner for Patents
Washington, D.C. 20231

RECEIVED
FEB 08 1999
Publishing Division
Issues/Allowed Files (05)

Re: U.S. Utility Patent Application
Request for Continued Prosecution Application (CPA) for
Appl. No. 08/782,889 originally filed: January 10, 1997
CPA Filed: December 16, 1998
For: **System And Method For Optical Evaluation Of Gemstones**
Inventor: Paul T. Shannon, Sr.
Our Ref: 1644.0010000

Sir:

Transmitted herewith for appropriate action are the following documents:

1. Fee Transmittal Form PTO/SB/17 (in duplicate);

2. CPA Transmittal Form PTO/SB/29 (in duplicate);

3. Preliminary Amendment;

4. Authorization to Treat a Reply As Incorporating An Extension of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate);

5. SKGF Check No. *23313* in the amount of *$1,217.00* to cover:

   $*380.00* Basic filing fee (37 C.F.R. § 1.16(a));
   $*486.00* Additional Claims Over Twenty;
   $*351.00* Additional Independent Claims Over Three; and

6. One (1) Return Postcard.

It is respectfully requested that the attached postcard be stamped with the filing date of these documents and returned to our courier.

In the event that extensions of time are necessary to prevent abandonment of this patent application, then such extensions of time are hereby petitioned. The U.S. Patent and Trademark Office is hereby authorized to charge any fee deficiency, or credit any overpayment, to our Deposit Account No. 19-0036. A duplicate copy of this letter is enclosed.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Edward J. Kessler
Attorney for Applicant
Registration No. 25,688

EJK:alw
P:\USERS\AWIMMER\EJK\1644\001.cvr.wpd

PTO/SB/17 (2/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL

Patent fees are subject to annual revision on October 1. These are the fees effective October 1, 1997. Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB/09-12. See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT ($)1,217.00

Complete if Known	
Application Number	CPA Application of Appln. No.: 08/782,889 originally filed January 10, 1997
Filing Date	December 16, 1998
First Named Inventor	Paul T. Shannon, Sr.
Examiner Name	Peeso, T.
Group / Art Unit	2764
Attorney Docket Number	1644.0010000

METHOD OF PAYMENT (check one)

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any overpayment to:

Deposit Account Number: 19-0036
Deposit Account Name: Sterne, Kessler, Goldstein & Fox P.L.L.C.

☐ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17
☐ Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance

2. ☒ Payment Enclosed: ☒ Check No. *23313* ☐ Money Order ☒ Other*

*Charge any deficiencies or credit any overpayments in the fees or fee calculations of Parts 1, 2 and 3 below to Deposit Account No. 19-0036.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	760	201	380	Utility filing fee	$380.00
106	310	206	155	Design filing fee	
107	480	207	240	Plant filing fee	
108	760	208	380	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 380.00

2. EXTRA CLAIM FEES

	Extra	Fee from below	Fee Paid
Total Claims 74 - 20** =	54	X $9.00	= $486.00
Indep. Claims 12 - 3** =	9	X $39.00	= $351.00
Multiple Dependent Claims			= $0.00

** or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependant claim
108	78	209	39	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 837.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	380	216	190	Extension for reply within second month	
117	870	217	435	Extension for reply within third month	
118	1,360	218	680	Extension for reply within fourth month	
128	1,850	228	925	Extension for reply within fifth month	
119	300	219	150	Notice of Appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,210	241	605	Petition to revive - unintentional	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	760	246	380	Filing a submission after final rejection (37 CFR 1.129(a))	
149	760	249	380	For each additional invention to be examined (37 CFR 1.129(b))	

Other fee (specify):
Other fee (specify):
*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

[Stamp: OIPE — DEC 16 1998 — PATENT & TRADEMARK OFFICE]
RECEIVED DEC 21 1998 Group 2700

SUBMITTED BY		Complete (*if applicable*)	
Typed or Printed Name	Edward J. Kessler	Reg. Number	25,688
Signature	[signature] Date 12/16/98	Deposit Acct. User ID	

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are

DEC 1 6 1998

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Paul T. Shannon, Sr.

Appl. No.: CPA Application of 08/782,889 originally filed January 10, 1997

Filed: December 16, 1998

For: **System And Method For Optical Evaluation Of Gemstones**

Art Unit: 2764

Examiner: Peeso, T.

Atty. Docket: 1644.0010000

Authorization To Treat A Reply As Incorporating An Extension Of Time Under 37 C.F.R. § 1.136(a)(3)

RECEIVED

DEC 2 1 1998

Group 2700

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The U.S. Patent and Trademark Office is hereby authorized to treat any concurrent or future reply that requires a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. The U.S. Patent and Trademark Office is hereby authorized to charge all required extension of time fees to our Deposit Account No. 19-0036, if such fees are not otherwise provided for in such reply. A duplicate copy of this authorization is enclosed.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Edward J. Kessler
Attorney for Applicant
Registration No. 25,688

Date: 12/16/98

1100 New York Avenue, N.W.
Suite 600
Washington, D.C. 20005-3934
(202) 371-2600

EJK:alw
P:\USERS\AWIMMER\EJK\1644\001.eot.wpd

CONTINUED PROSECUTION APPLICATION (CPA) REQUEST TRANSMITTAL

Submit an original, and a duplicate for fee processing.

(Only for Continuation or Divisional applications under 37 CFR § 1.53(d))

CHECK BOX if applicable:
☐ DUPLICATE

OIPE DEC 1 6 1998 PATENT & TRADEMARK OFFICE

Address to:	*Attorney Docket No. of Prior Application*	CPA Application of 08/782,889
Assistant Commissioner for Patents **Box CPA** **Washington, DC 20231**	*First Named Inventor*	Paul T. Shannon, Sr.
	Examiner Name	Peeso, T.
	Group/Art Unit	2764
	Express Mail Label No.	

This is a request for a ☒ continuation or ☐ divisional application under 37 CFR § 1.53(d), (continued prosecution application (CPA)) of the prior application number 08/782,889, filed on January 10, 1997, entitled: System And Method For Optical Evaluation Of Gemstones.

NOTES

FILING QUALIFICATIONS: The prior application identified above must be a nonprovisional application that is either: (1) complete as defined by 37 CFR § 1.51(b) or (2) the national stage of an international application in compliance with 35 U.S.C. 371. A Notice will be placed on a patent issuing from a CPA, except for reissues and designs, to the effect that the patent issued on a CPA and is subject to the twenty-year term provisions of 35 U.S.C. § 154(a)(2). Therefore, the prior application of a CPA may have been filed before, on or after June 8, 1995.

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1. ☐ Enter the unentered amendment previously filed on ________________ under 37 CFR § 1.116 in the prior nonprovisional application.
2. ☒ A preliminary amendment is enclosed.
3. This application is filed by fewer than all the inventors named in the prior application, 37 CFR § 1.53(d)(4).
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   ....
   ....
   b. ☐ The inventor(s) to be deleted are set forth in a separate sheet attached hereto.
4. ☐ A new power of attorney or authorization of agent (PTO/SB/81) is enclosed.
5. Information Disclosure Statement (IDS) is enclosed:
   a. ☐ PTO-1449
   b. ☐ Copies of IDS citations

RECEIVED
DEC 2 1 1998
Group 2700

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR § 1.16(c) or (j))	74-20* =	54	x $ 18.00 =	$972.00
	INDEPENDENT CLAIMS (37 CFR § 1.16(b) or (i))	12-3** =	9	x $ 78.00 =	$702.00
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR § 1.16(d))			x $ 260.00 =	$ 0.00
				BASIC FEE (37 CFR §1.16)	$ 760.00
		Total of above Calculations =			$2,434.00
	Reduction by 50% for filing by small entity (Note 37 CFR §§ 1.9, 1.27, 1.28).				$1,217.00
	* *Reissue claims in excess of 20 and over original patent.* ** *Reissue independent claims over original patent.*	TOTAL =			$1,217.00

6. Small entity status:

a. ☐ A small entity statement is enclosed, if (b) and (c) do not apply.

b. ☒ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.

c. ☐ Is no longer claimed.

7. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 19-0036:

a. ☐ Fees required under 37 CFR § 1.16.

b. ☐ Fees required under 37 CFR § 1.17.

c. ☐ Fees required under 37 CFR § 1.18.

8. ☒ SKGF Check No. *23313* in the amount of *$1,217.00* is enclosed.

9. ☐ New Attorney Docket Number, if desired ____________________

[Prior application Attorney Docket Number will carryover to this CPA unless a new Attorney Docket Number has been provided herein.]

10. a. ☐ Receipt For Facsimile Transmitted CPA (PTO/SB/29A)

b. ☒ Return Receipt Postcard (Should be specifically itemized, See MPEP 503)

11. ☒ Other: Authorization To Treat A Reply As Incorporating An Extension Of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate).

NOTE: *The prior application's correspondence address will carry over to this CPA UNLESS a new correspondence address is provided below.*

12. NEW CORRESPONDENCE ADDRESS

☐ *Customer Number or Bar Code Label* — *(Insert Customer No. or Attach bar code label here)* — or ☐ *New correspondence address below*

Name					
Address					
City		*State*		*Zip Code*	
Country		*Telephone*		*Fax*	

13. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED	
Name (Print/Type)	Edward J. Kessler
Signature	[signature]
Registration No. (Attorney/Agent)	25,688
Date	12/18/98

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.
ATTORNEYS AT LAW
1100 New York Avenue, N.W.
Suite 600
Washington, D.C. 20005-3934

Facsimile Cover Sheet

urgent ☐ return reply requested ☐ original will be sent as confirmation ☐

DATE:	April 9, 1999	**PHONE NO.:**	(703) 305-9784
PAGES:	7 (including this cover sheet)		
TO:	U.S. Patent and Trademark Office		
ATTN:	Examiner Tom Peeso Group Art Unit: 2764		
FROM:	Edward J. Kessler		
RE:	Preliminary Amendment for U.S. Serial No.: 08/782,889		
YOUR REF:	08/782,889		
OUR REF:	1644.0010000		

MESSAGE

As requested in our phone conversation of April 8, 1999, enclosed is a copy of the Preliminary Amendment initially filed with the CPA filing on December 16, 1998.

If any portion of this transmission is not received clearly or in full, contact us at any of the following numbers:

TELEPHONE NUMBER	FACSIMILE NUMBER
(202) 371-2600	(202) 371-2540

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Paul T. Shannon, Sr.

Appl. No. CPA Application of 08/782,889 originally filed January 10, 1997

Filed: December 16, 1998

For: **System And Method For Optical Evaluation of Gemstones**

Art Unit: Peeso, T.

Examiner: 2764

Atty. Docket: 1644.0010000

Preliminary Amendment

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please add the following claims.

IN THE CLAIMS

55. A method for grading the cut of a gemstone, comprising the steps of:

illuminating a gemstone model with a light source, wherein said gemstone model defines the geometry and position of the gemstone facets;

refracting said light source into said gemstone model through a first facet of said gemstone model to produce a refracted light;

reflecting said refracted light within said gemstone model from a second facet of said gemstone model to produce a reflected light;

refracting said refracted and reflected lights out of said gemstone model through a third facet of said gemstone model to produce an exiting light; and

measuring said exiting light.

56 ~~58~~. The method of claim 55 ~~57~~, further comprising the step of generating said gemstone model for a gemstone to be graded, wherein said gemstone model comprises a data representation of the cut of the gemstone.

57 ~~59~~. The method of claim 56 ~~58~~, further comprising the step of: defining said facet types and facet locations of the gemstone to be graded in a global coordinate system.

58 ~~60~~. The method of claim 56 ~~58~~, further comprising the step of: defining said facet types and facet locations in a linked list data structure.

59 ~~61~~. The method of claim 55 ~~57~~, further comprising the step of: generating said gemstone model to represent an existing cut or a proposed cut.

60 ~~62~~. The method of claim 55 ~~57~~, further comprising the steps of:

illuminating said gemstone model using an illumination model, wherein said illumination model produces a light beam;

refracting said light beam into said gemstone model through a first facet of said gemstone model to produce a refracted light beam;

reflecting said refracted light beam within said gemstone model from a second facets of said gemstone model to produce a reflected light beam;

refracting said refracted and reflected light beams out of said gemstone model through a third facet of said gemstone model to produce an exiting light beams; and

measuring attributes of said exiting light beam.

61 ~~63~~. A system for grading the cut of a gemstone, comprising:

means for illuminating a gemstone model with a light source, wherein said gemstone model defines the geometry and position of the gemstone facets;

means for refracting said light into said gemstone model through a first facet of said gemstone model to produce a refracted light;

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means for reflecting said refracted light within said gemstone model from a second facet of said gemstone model to produce a reflected light;

means for refracting at least one of said refracted and reflected light out of said gemstone model through a third facet of said gemstone model to produce an exiting light; and

means for measuring said exiting light.

~~64.~~ 62 The system of claim ~~63~~ 61, further comprising:

means for generating data defining facet types and facet locations for the gemstone.

~~65.~~ 63 The system of claim ~~64~~ 62, further comprising:

means for defining said facet types and facet locations in a global coordinate system of the gemstone.

~~66.~~ 64 The system of claim ~~64~~ 62, further comprising:

means for defining said facet types and facet locations in a linked list data structure.

~~67.~~ 65 The system of claim ~~63~~ 61, further comprising:

means for defining a plurality of light sources arranged in an array above a crown of said gemstone model.

~~68.~~ 66 The system of claim ~~63~~ 61, further comprising:

means for defining a light source to simulate specified lighting conditions for the gemstone to be evaluated.

~~69.~~ 67 In a system for grading the cut of a gemstone, a computer program product comprising a computer usable medium having computer readable program code means embodied in said medium for causing an application program to execute on a computer, said computer readable program code means comprising:

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a first computer readable program code means for causing said computer to illuminate a gemstone model, wherein said gemstone model defines the geometry and position of the gemstone facets;

a second computer readable program code means for causing said computer to refract said light beam into said gemstone model through a first facet of said gemstone model to produce a refracted light;

a third computer readable program code means for causing said computer to reflect said refracted light beam within said gemstone model from a second facet of said gemstone model to produce a reflected light;

a fourth computer readable program code means for causing said computer to refract at least one of said refracted and reflected light out of said gemstone model through a third facet of said gemstone model to produce an exiting light; and

a fifth computer readable program code means for causing said computer to measure said exiting light.

68 ~~70.~~ The computer program product of claim ~~69~~ 67, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to generate said gemstone model.

69 ~~71.~~ The computer program product of claim ~~70~~ 68, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to generate data defining facet types and facet locations for the gemstone.

70 ~~72.~~ The computer program product of claim ~~71~~ 69, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to define said facet types and facet locations in a global coordinate system of the gemstone.

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~~73.~~ 71. The computer program product of claim ~~71~~ 69, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to define said facet types and facet locations in a linked list data structure.

~~74.~~ 72. The computer program product of claim ~~69~~ 67, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to generate an illumination model to illuminate said gemstone model with a light beam.

~~75.~~ 73. The computer program product of claim ~~74~~ 72, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to define a plurality of light sources arranged in an array above a crown of said gemstone model.

~~76.~~ 74. The computer program product of claim ~~69~~ 67, wherein said computer readable program code means further comprises:

a computer readable program code means for causing said computer to define a light source to simulate specified lighting conditions for the gemstone to be evaluated.--

REMARKS

Claims 2-11 and 13-76 are presented for consideration. Claims 2-11 and 13-56 have previously been allowed. Claims 57-76 are added to further define features of this invention. Prompt and favorable action on this application is respectfully requested.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Edward J. Kessler
Attorney for Applicant
Registration No. 25,688

Date: 12/16/98

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EJK:slw
P:\USERS\A WIMMER\EJK\1644\001.pa.wpd

UNITED STATES :PARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR		ATTORNEY DOCKET NO.
08/782,889	01/10/97	SHANNON	P	1644.0010000

LM61/0413

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

EXAMINER	
PEESO, T	
ART UNIT	**PAPER NUMBER**
2764	10

DATE MAILED: 04/13/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

PTO-90C (Rev. 2/95) 1- File Copy

Notice of Allowability	Application No. **08/782,889**	Applicant(s) **Shannon**	
	Examiner **Thomas Peeso**	Group Art Unit **2764**	

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance and Issue Fee Due or other appropriate communication will be mailed in due course.

☒ This communication is responsive to *amendment filed on 16 Dec 98*.

☒ The allowed claim(s) is/are *1-74(renumbered)*.

☐ The drawings filed on ________ are acceptable.

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ________.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ________.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

A SHORTENED STATUTORY PERIOD FOR RESPONSE to comply with the requirements noted below is set to EXPIRE **THREE MONTHS** FROM THE "DATE MAILED" of this Office action. Failure to timely comply will result in ABANDONMENT of this application. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

☐ Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL APPLICATION, PTO-152, which discloses that the oath or declaration is deficient. A SUBSTITUTE OATH OR DECLARATION IS REQUIRED.

☒ Applicant MUST submit NEW FORMAL DRAWINGS

☐ because the originally filed drawings were declared by applicant to be informal.

☒ including changes required by the Notice of Draftsperson's Patent Drawing Review, PTO-948, attached hereto or to Paper No. 7.

☐ including changes required by the proposed drawing correction filed on ________, which has been approved by the examiner.

☐ including changes required by the attached Examiner's Amendment/Comment.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the reverse side of the drawings. The drawings should be filed as a separate paper with a transmittal lettter addressed to the Official Draftsperson.

☐ Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Any response to this letter should include, in the upper right hand corner, the APPLICATION NUMBER (SERIES CODE/SERIAL NUMBER). If applicant has received a Notice of Allowance and Issue Fee Due, the ISSUE BATCH NUMBER and DATE of the NOTICE OF ALLOWANCE should also be included.

Attachment(s)

☐ Notice of References Cited, PTO-892

☐ Information Disclosure Statement(s), PTO-1449, Paper No(s). ________

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

☐ Interview Summary, PTO-413

☐ Examiner's Amendment/Comment

☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material

☐ Examiner's Statement of Reasons for Allowance

THOMAS PEESO
PRIMARY EXAMINER
ART UNIT 2764

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

NOTICE OF ALLOWANCE AND ISSUE FEE DUE

LM61/0413
STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/782,889	01/10/97	074	PEESO, T	2764	04/13/99

First Named Applicant: SHANNON, 35 USC 154(b) term ext. = 0 Days.

TITLE OF INVENTION: SYSTEM AND METHOD FOR OPTICAL EVALUATION OF GEMSTONES

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
3 1644.0010000	702-035.000	R81	UTILITY	YES	$605.00	07/13/99

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED.

THE ISSUE FEE MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED.

HOW TO RESPOND TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.
If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is changed, pay twice the amount of the FEE DUE shown above and notify the Patent and Trademark Office of the change in status, or

B. If the status is the same, pay the FEE DUE shown above.

If the SMALL ENTITY is shown as NO:

A. Pay FEE DUE shown above, or

B. File verified statement of Small Entity Status before, or with, payment of 1/2 the FEE DUE shown above.

II. Part B-Issue Fee Transmittal should be completed and returned to the Patent and Trademark Office (PTO) with your ISSUE FEE. Even if the ISSUE FEE has already been paid by charge to deposit account, Part B Issue Fee Transmittal should be completed and returned. If you are charging the ISSUE FEE to your deposit account, section "4b" of Part B-Issue Fee Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give application number and batch number. Please direct all communications prior to issuance to Box ISSUE FEE unless advised to the contrary.

***IMPORTANT REMINDER:** Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.*

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94 09310 9-1
7530 #13
KW
9-15-99

PAT. & TRADEMARK OFFICE JUL 1 3 1999

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Paul T. Shannon, Sr.

Appl. No. 008/782,889

Filed: January 10, 1997

For: **System and Method for Computerize Evaluation of Gemstones (Amended)**

Art Unit: 2764

Examiner: T. Peeso

Atty. Docket: 1644.0010000

Batch No. R81

Letter to PTO Draftsman: Submission of Formal Drawings

Assistant Commissioner for Patents
Washington, D.C. 20231

RECEIVED

JUL 1 5 1999

Sir:

Submitted herewith are 56 sheets of formal drawings with Figures 1-56, corresponding to the informal drawings submitted with the above-captioned application. The application number, group art unit and attorney docket number appear on the back of each sheet. Acknowledgment of the receipt, approval, and entry of these formal drawings into this application is respectfully requested.

It is believed that all corrections required by the Official Draftsperson have been accommodated. If any further changes are required, it is requested that the Draftsperson contact the undersigned at the telephone number below.

It is not believed that an extension of time is required, other than any already provided herewith. However, if an extension of time is needed to prevent abandonment of the application, then such extension of time is hereby petitioned. The U.S. Patent and Trademark Office is hereby authorized to charge any fee deficiency, or credit any overpayment, to our Deposit Account No. 19-0036. A duplicate copy of this Letter is enclosed.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Edward J. Kessler
Registration No. 25,688

Date: July 13, 1999

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Suite 600
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(202) 371-2600

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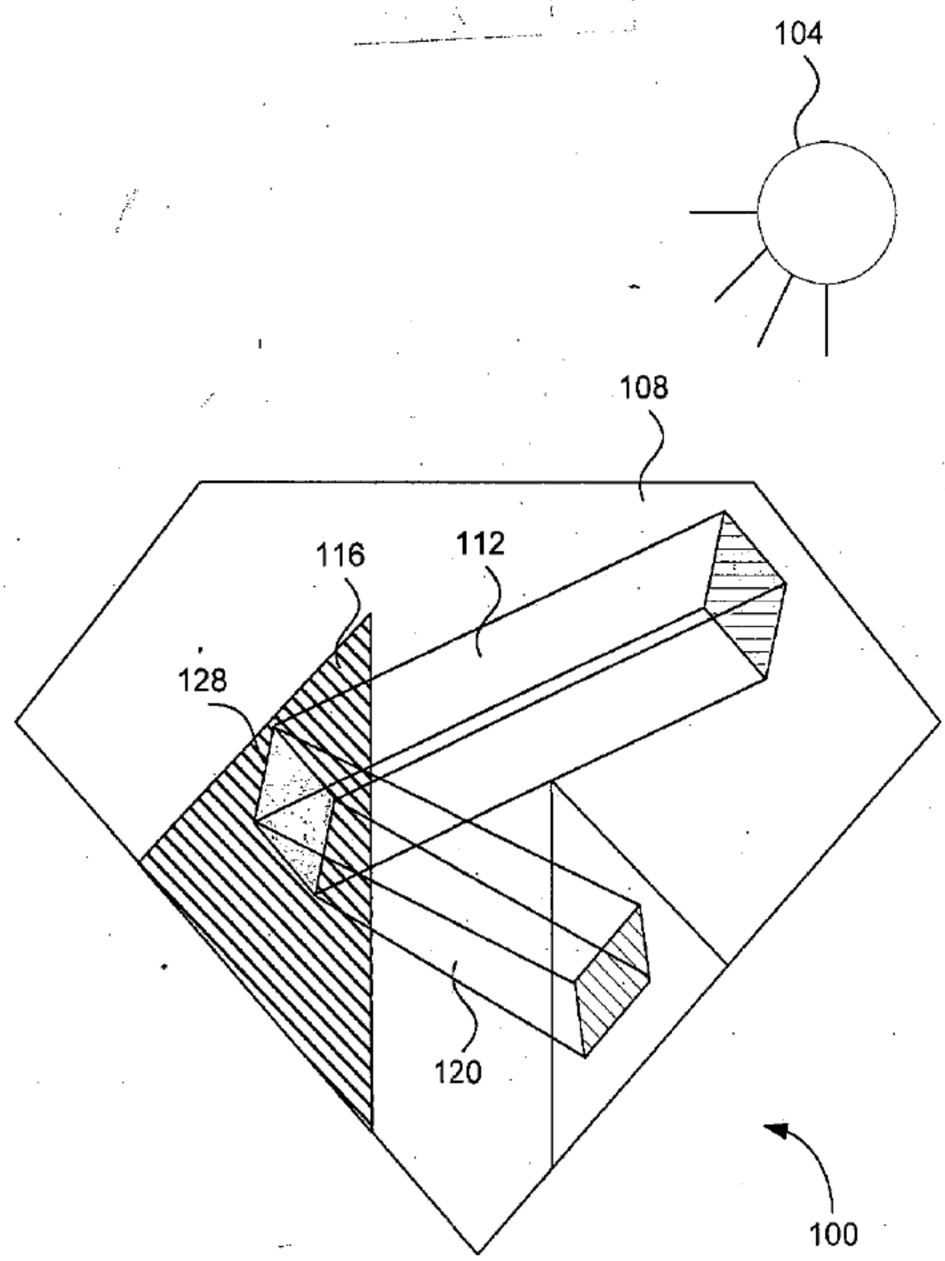


FIG. 1

9906-35.vsd/1

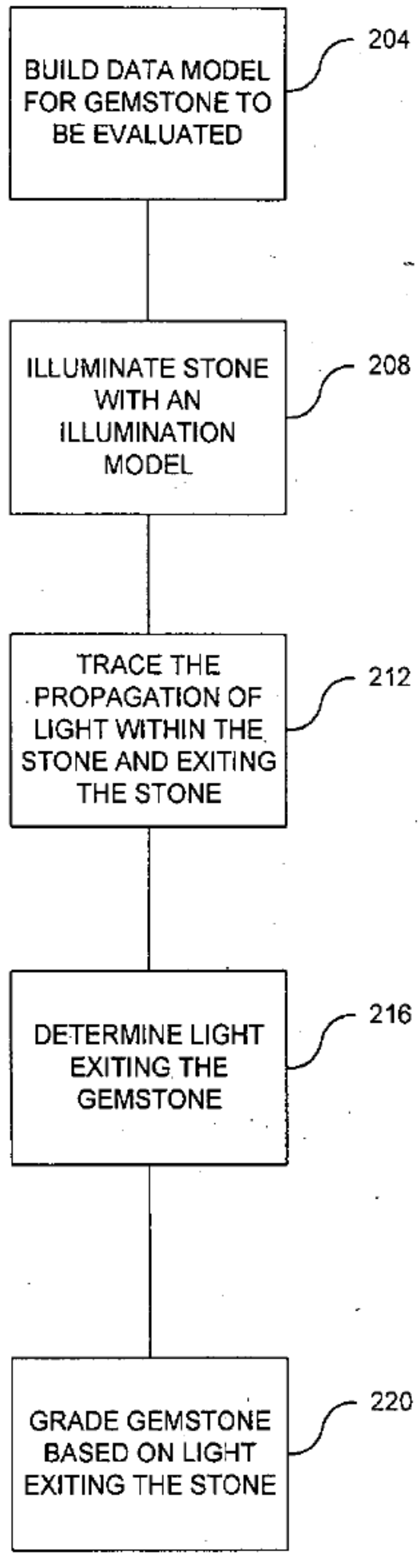


FIG. 2

9906-35.vsd/2

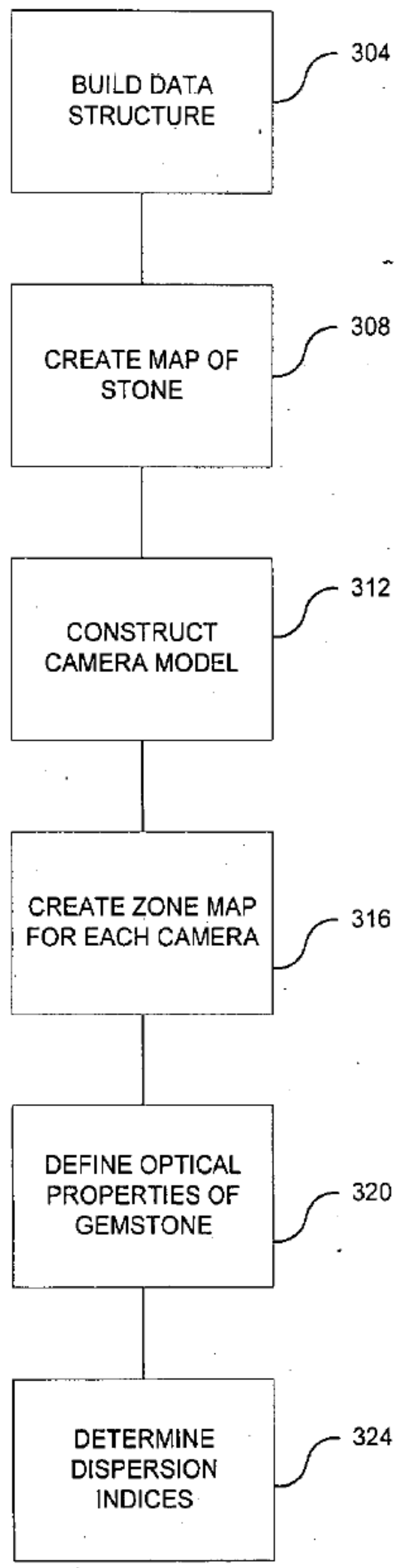


FIG. 3(a)

9906-35.vsd/3

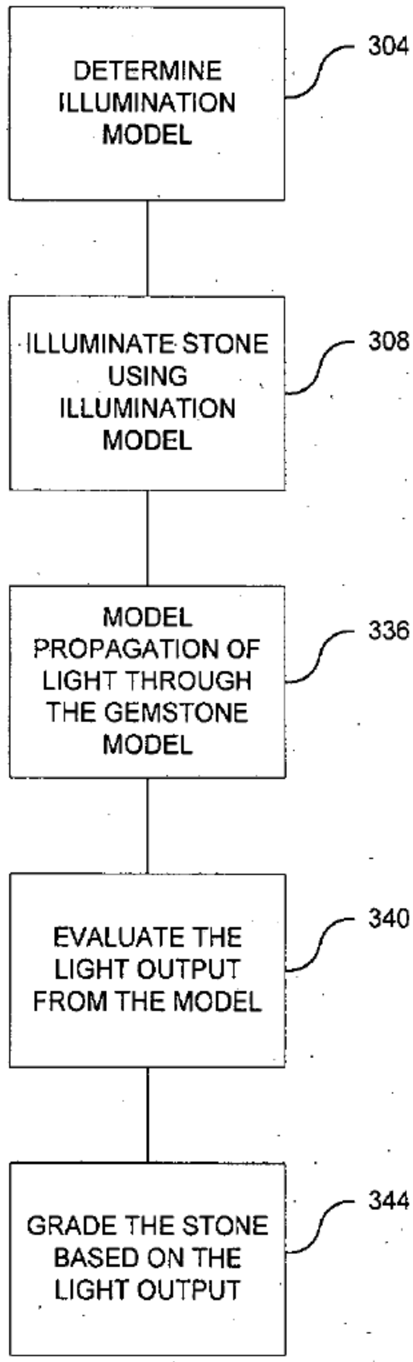


FIG. 3(b)

9906-35.vsd/4

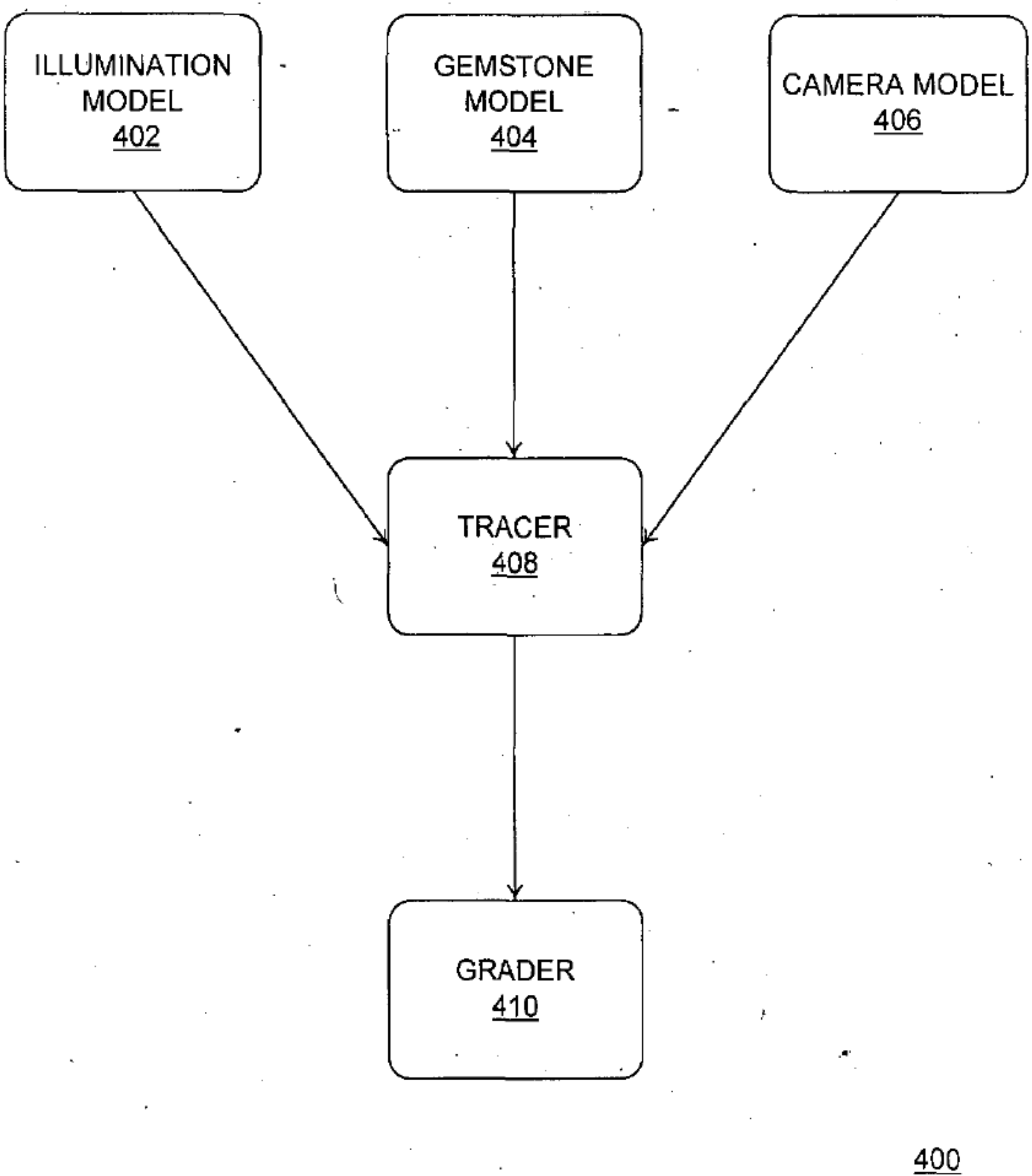


FIG. 4

9906-35.vsd/5

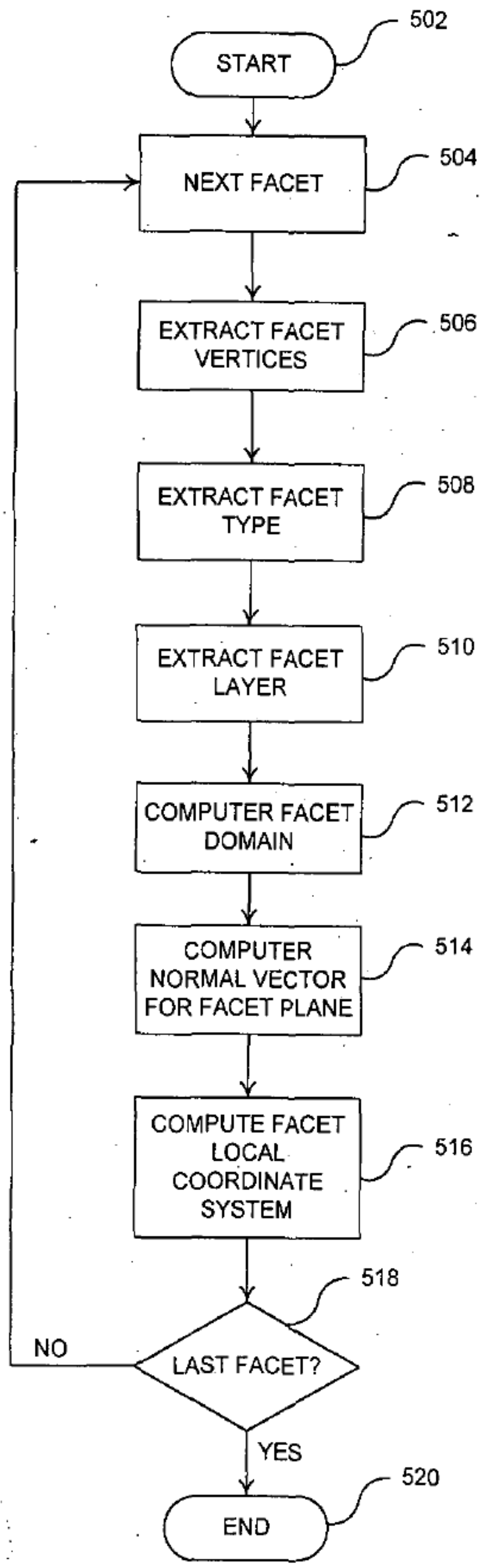


FIG. 5

9906-35.vsd/7

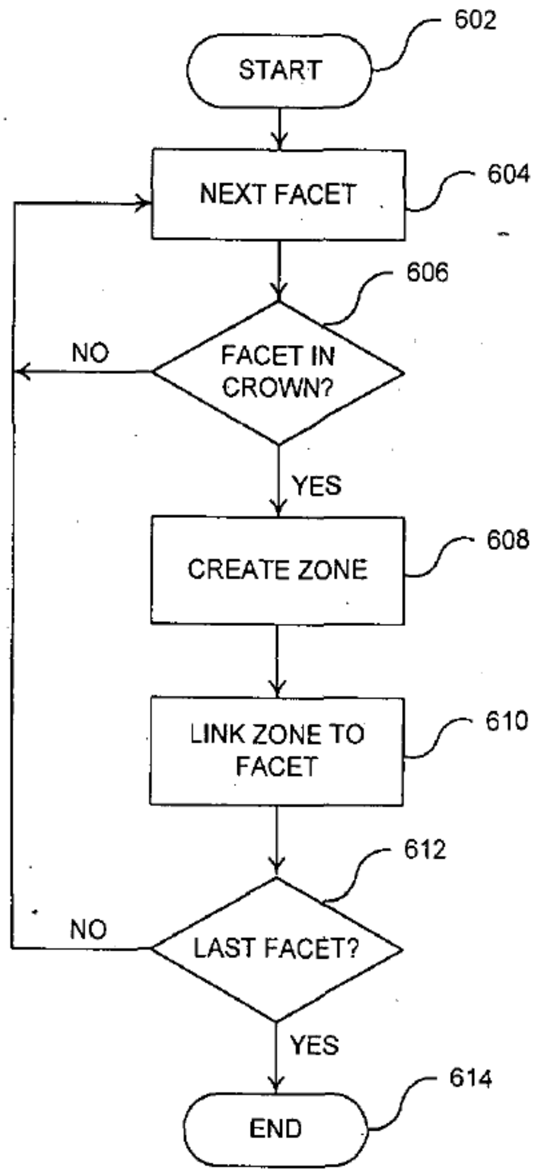


FIG. 6

9906-35.vsd/6

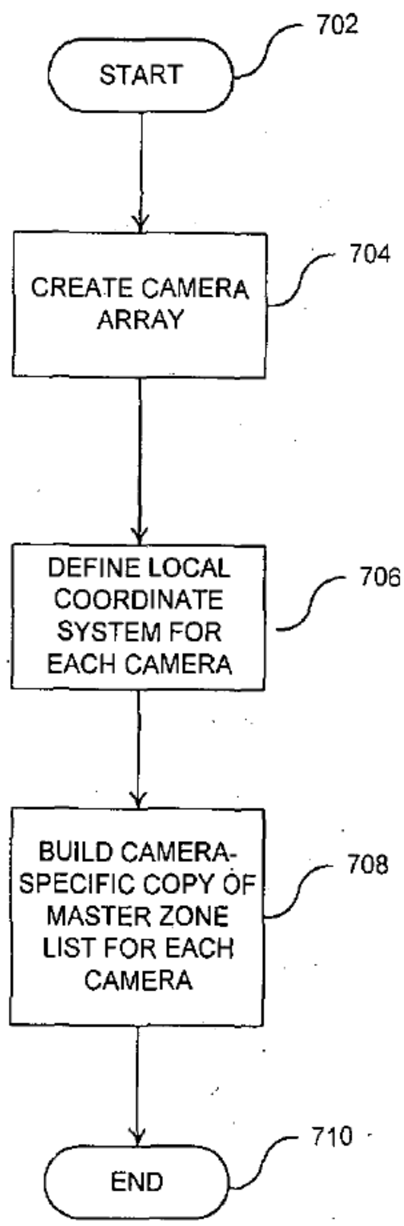


FIG. 7

9906-35.vsd/8

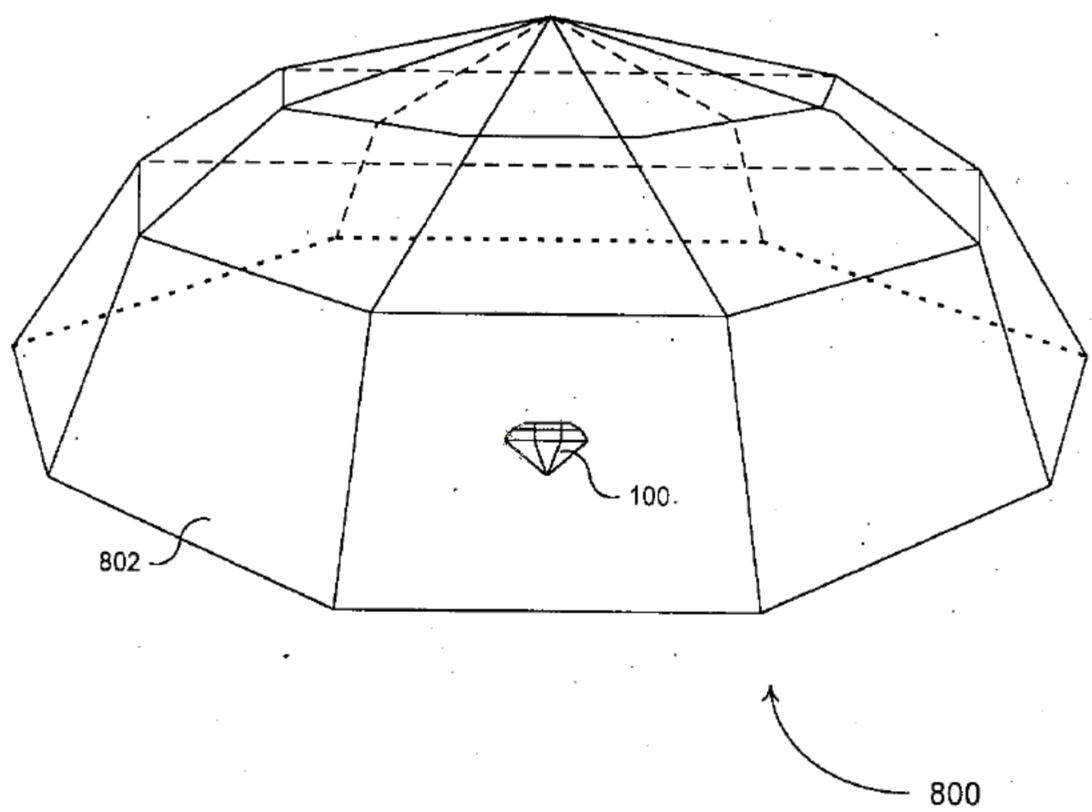


FIG. 8

9906-35.vsd/9

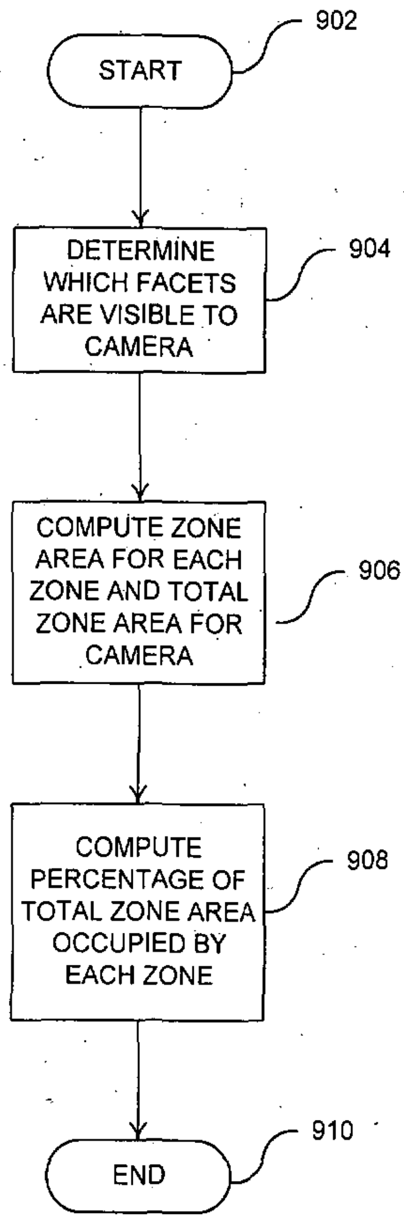


FIG. 9

9906-35.vsd/10

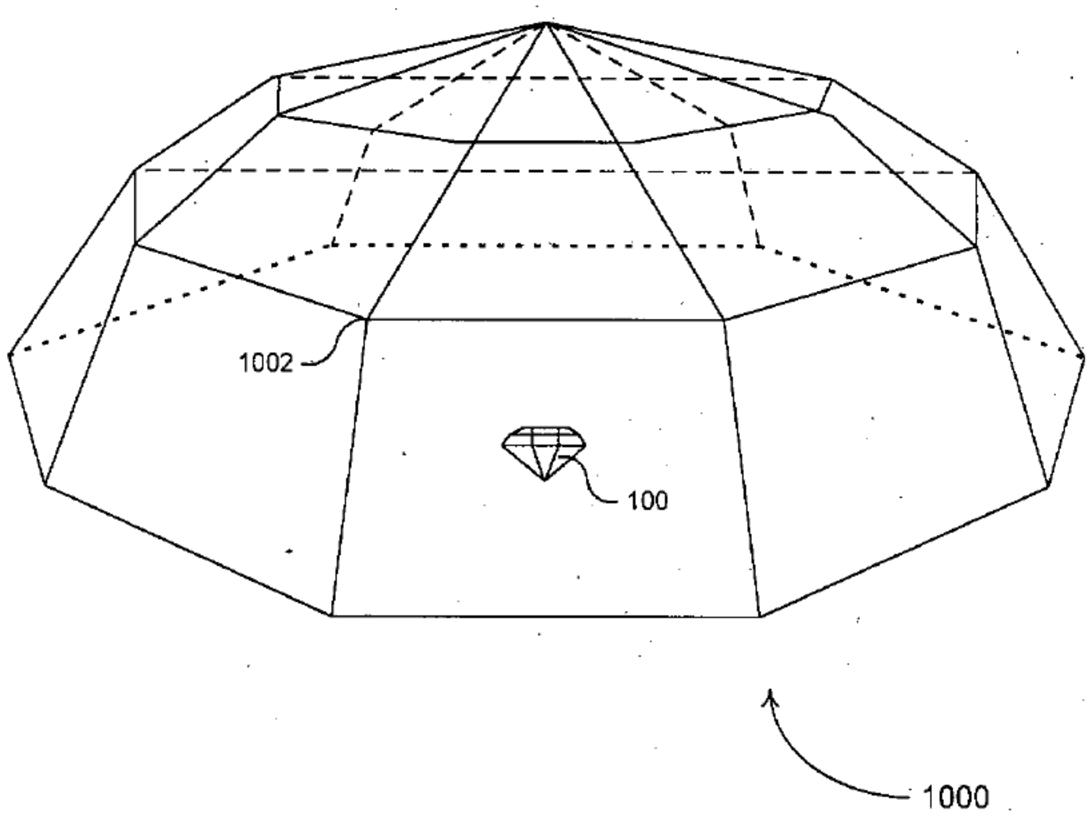


FIG. 10

9906-35.vsd/11

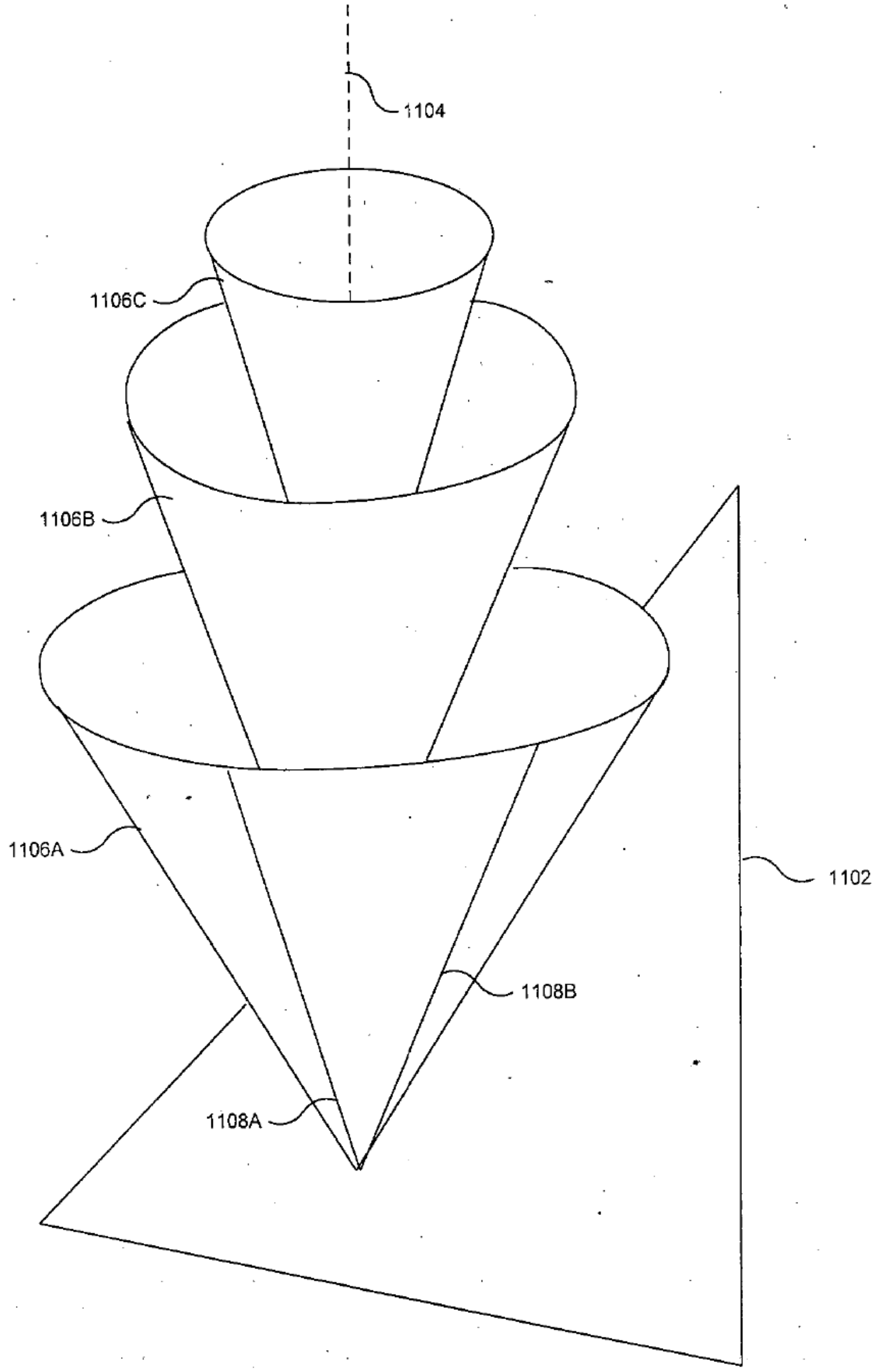


FIG. 11

9906-35.vsd/12

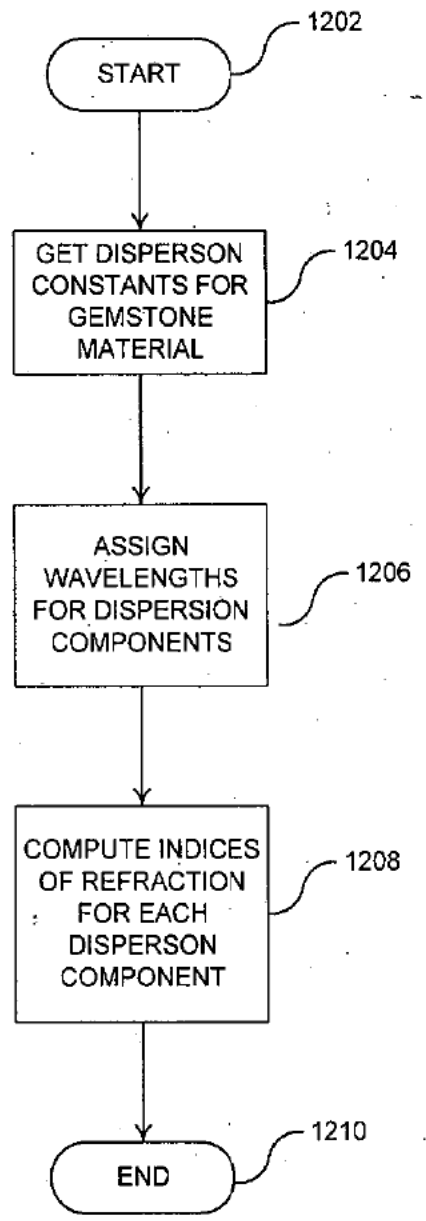


FIG. 12

9906-35.vsd/13

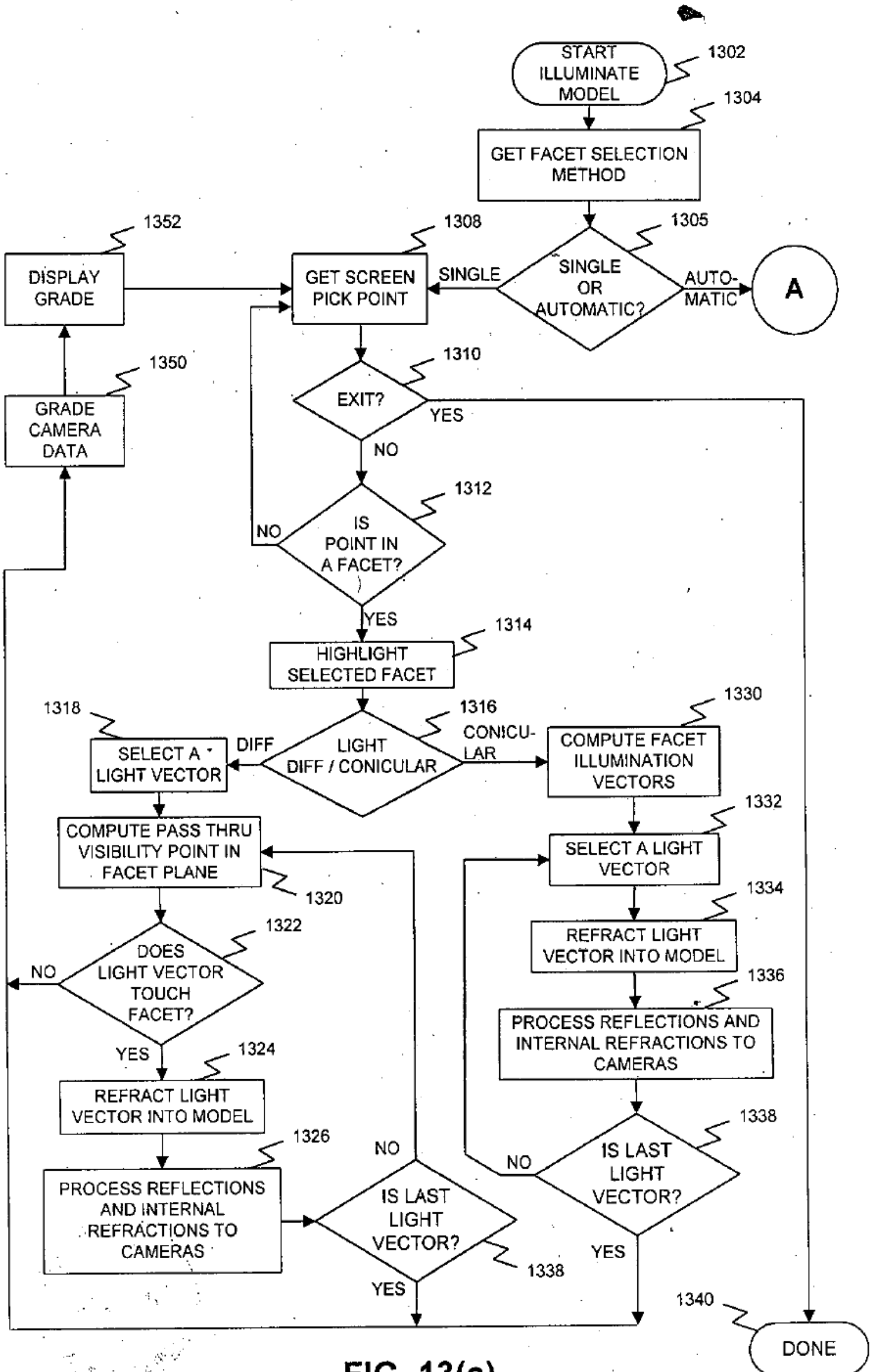


FIG. 13(a)

9906-35.vsd/14

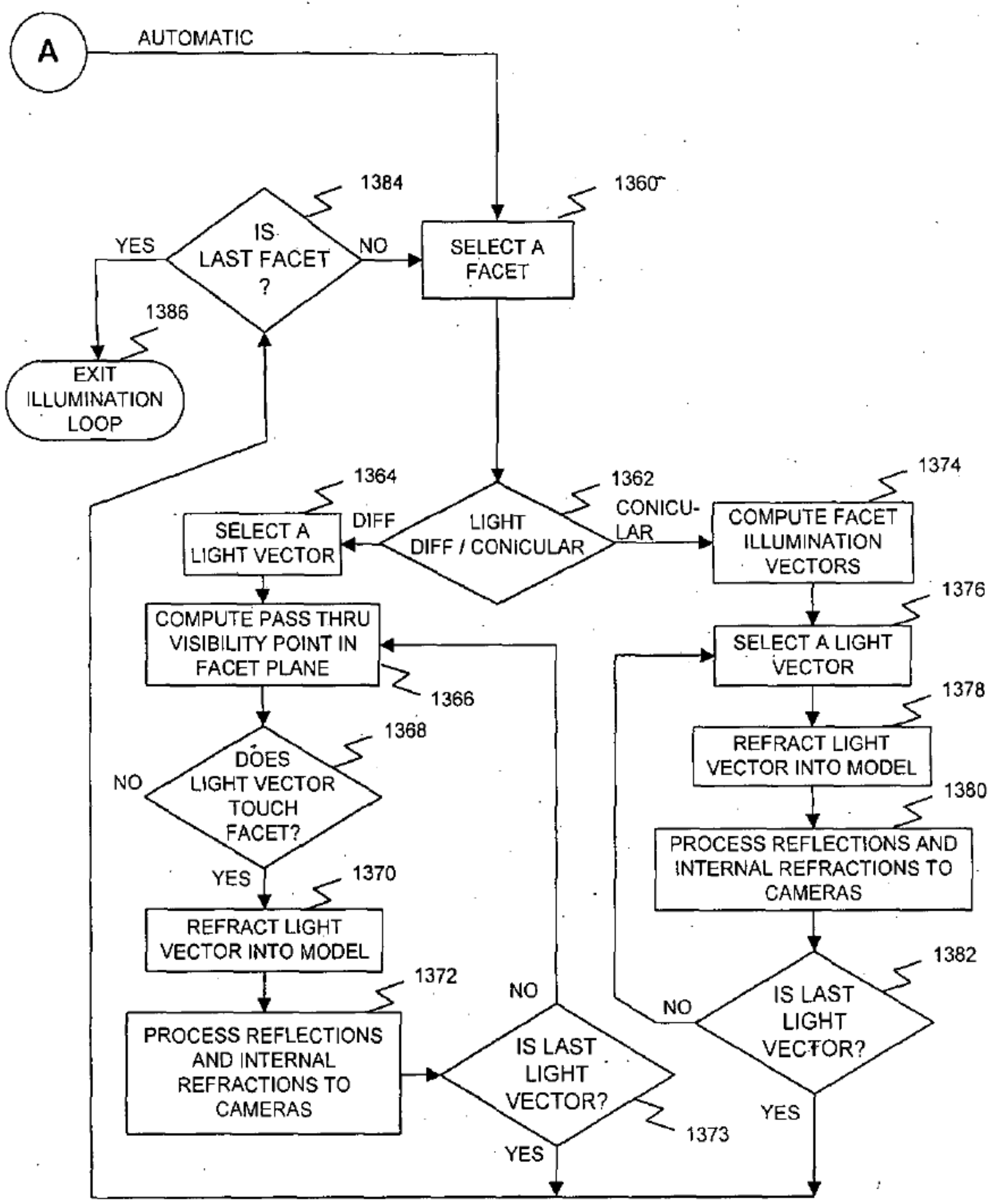


FIG. 13(b)

9906-35.vsd/15

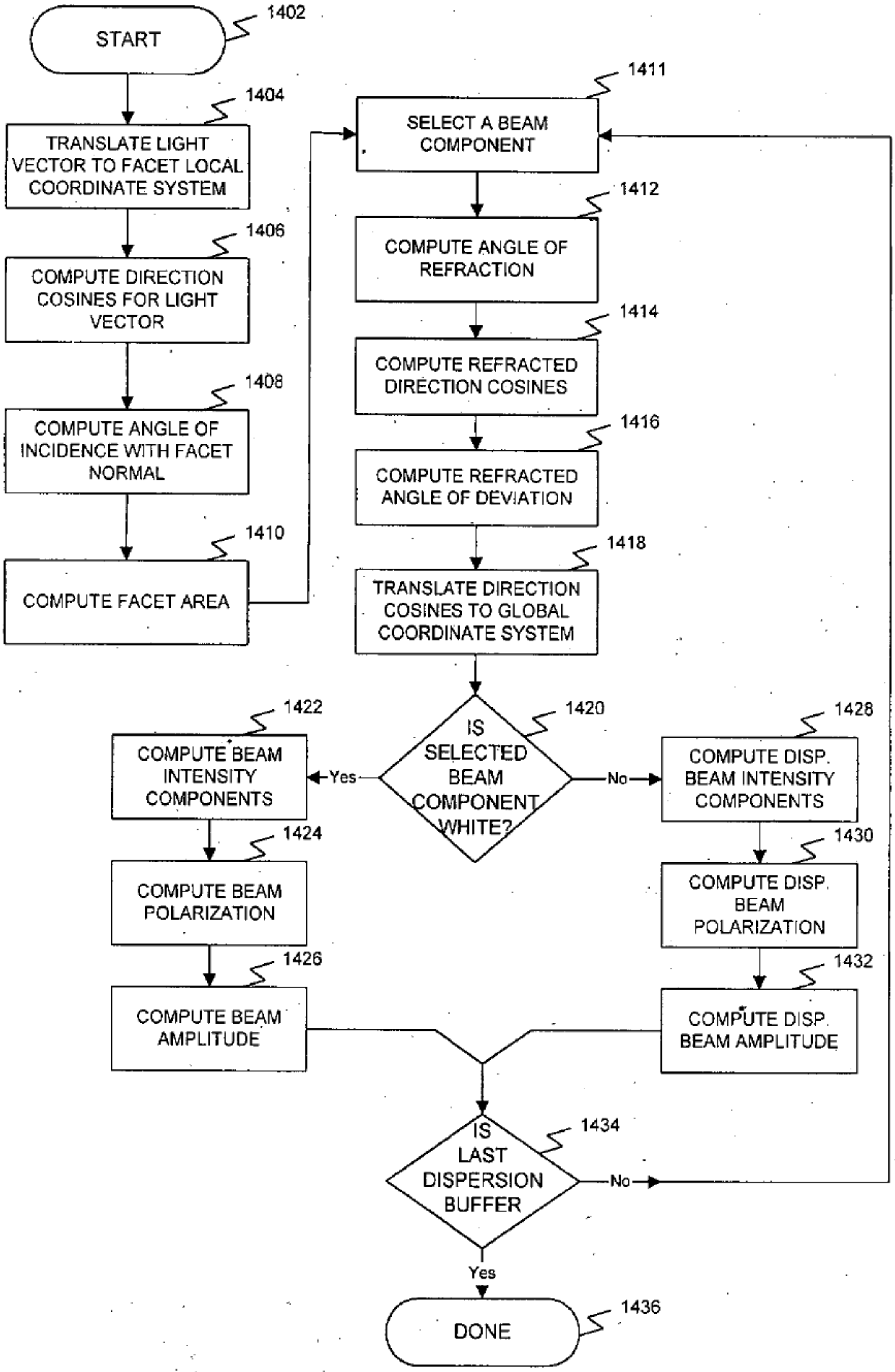


FIG. 14

9906-35.vsd/16

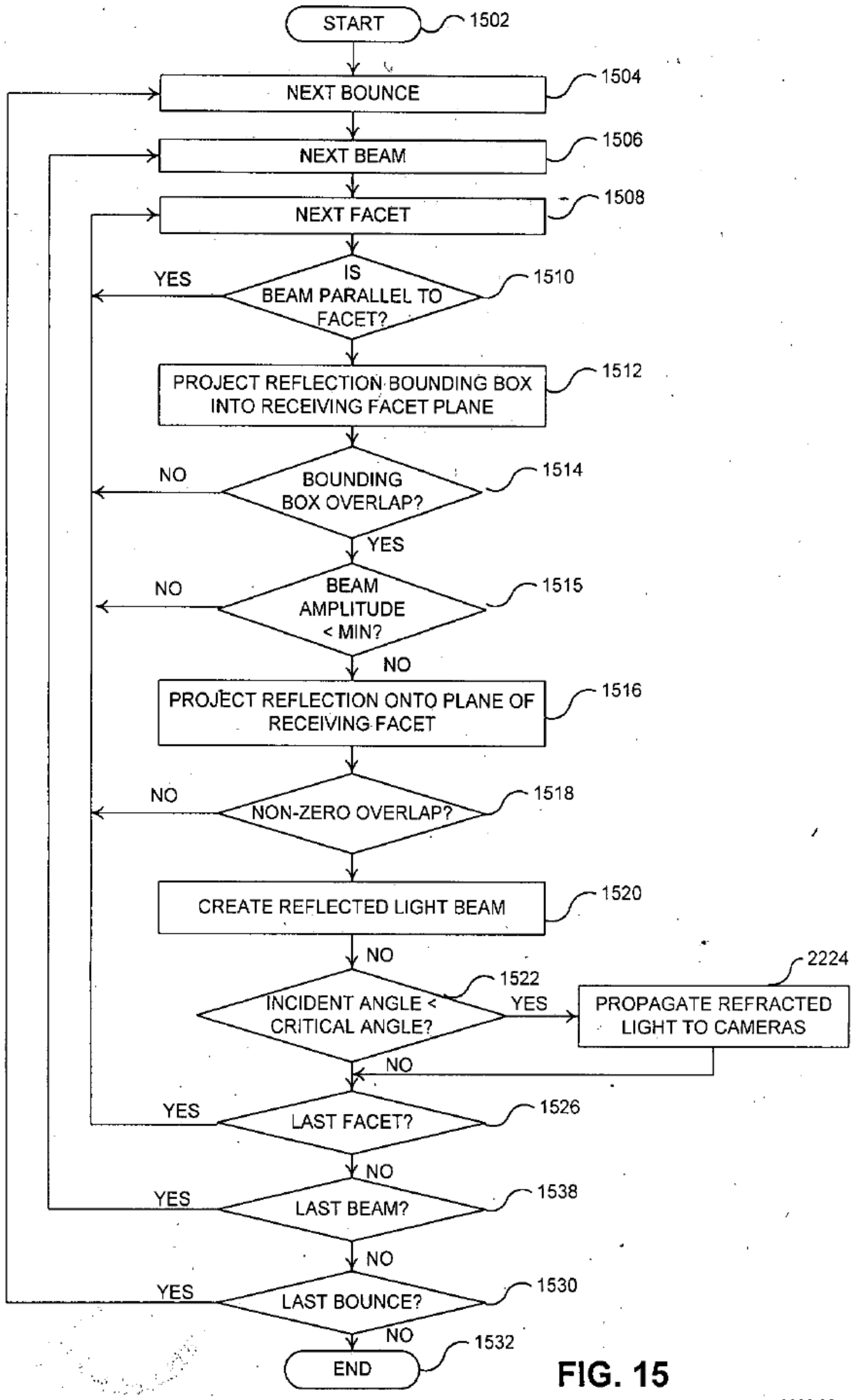


FIG. 15

9906-35.vsd/17

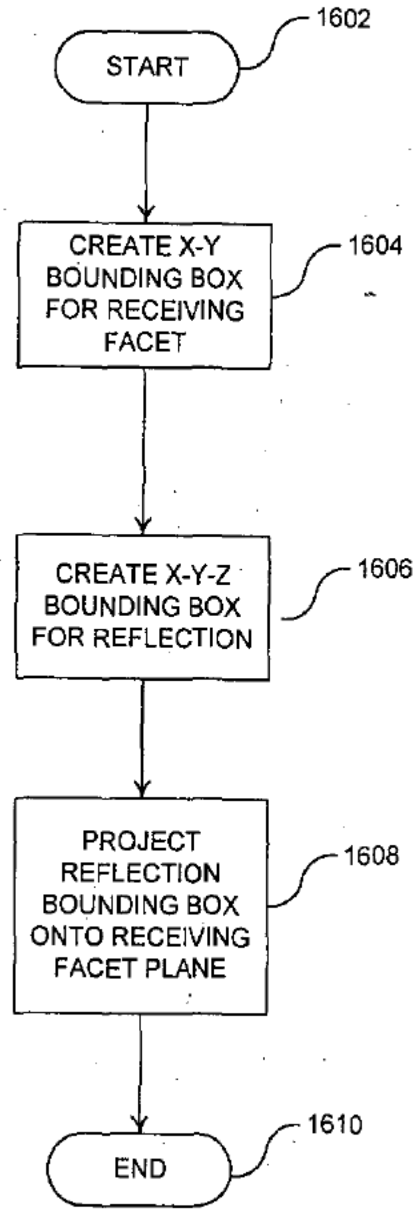


FIG. 16

9906-35.vsd/18

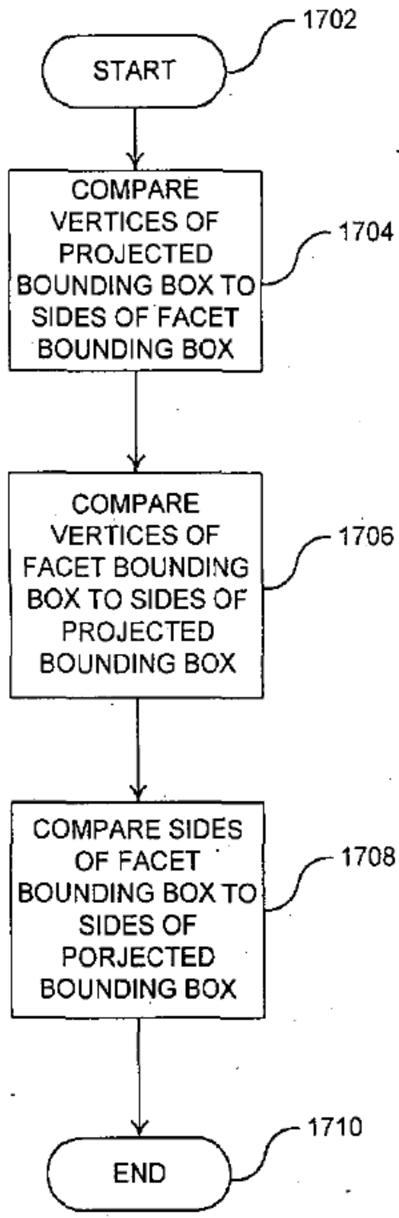


FIG. 17

9906-35.vsd/19

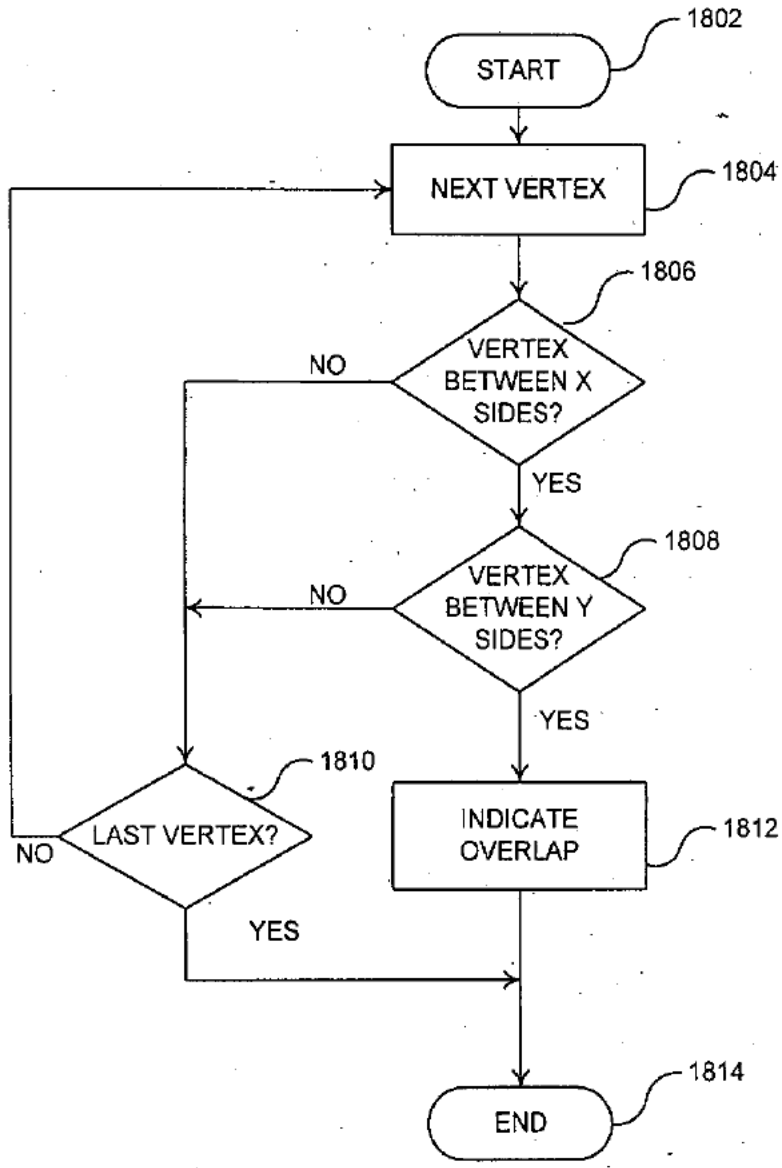


FIG. 18

9906-35.vsd/20

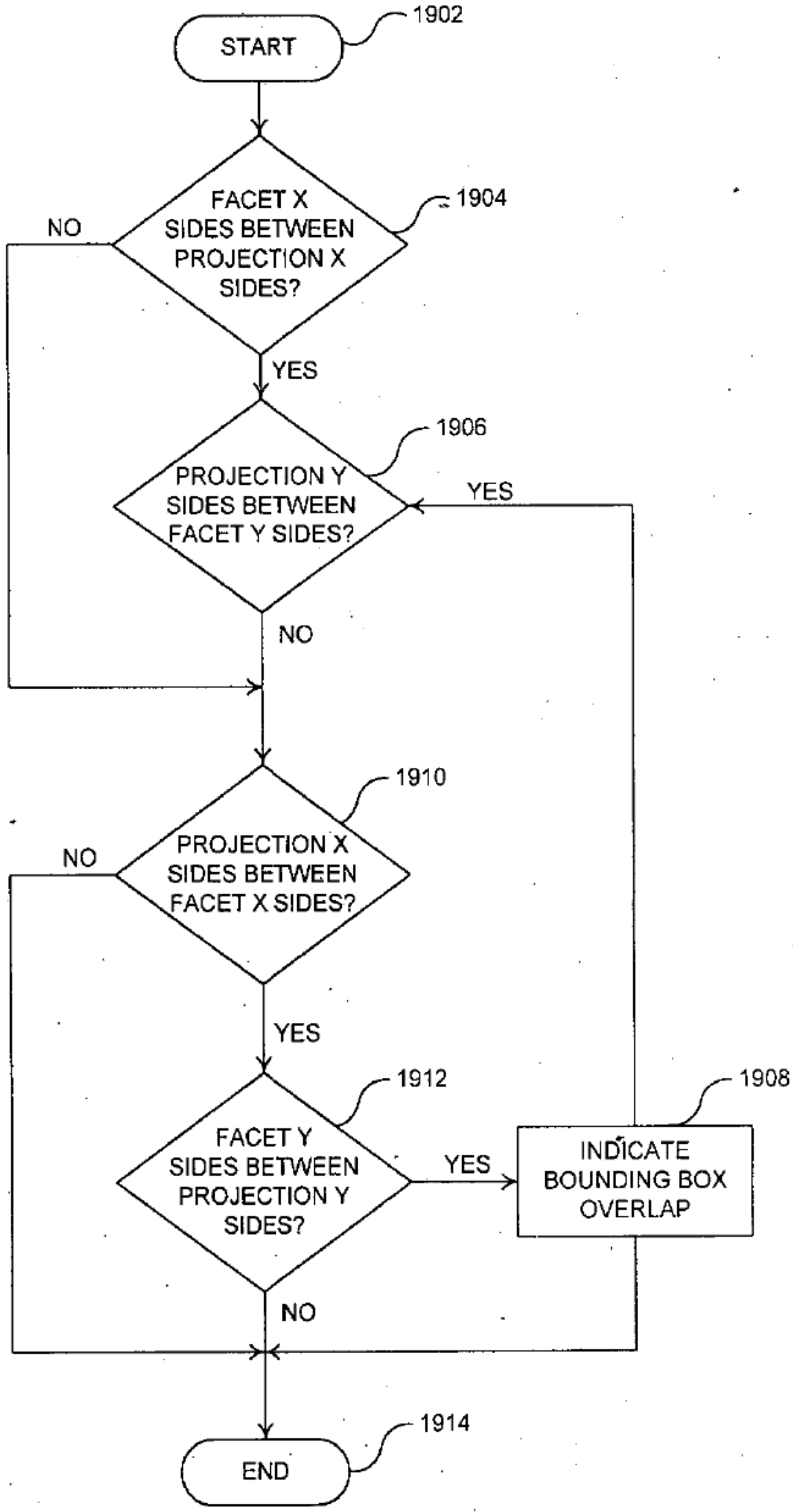


FIG. 19

9906-35.vsd/21

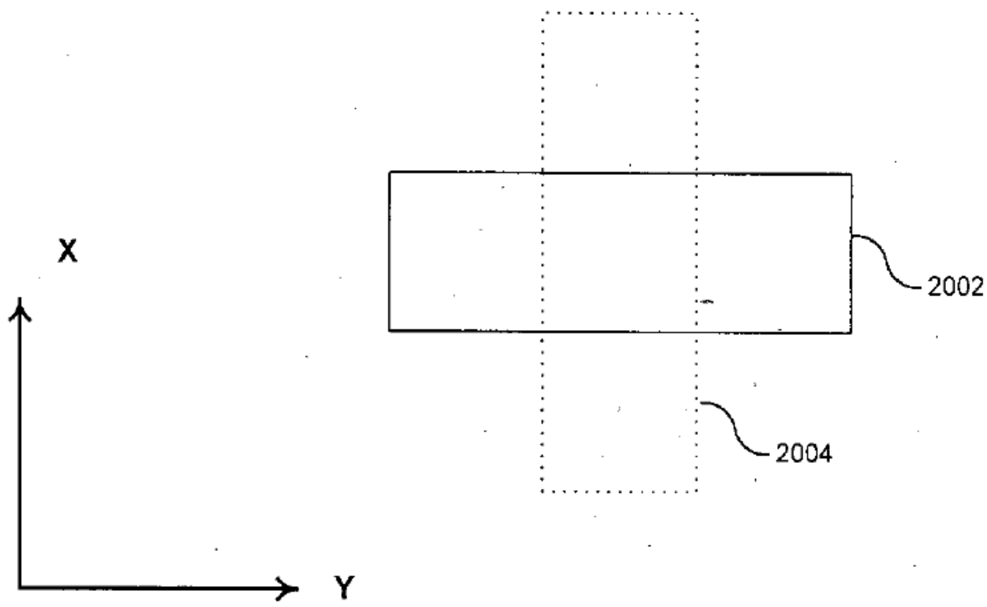


FIG. 20

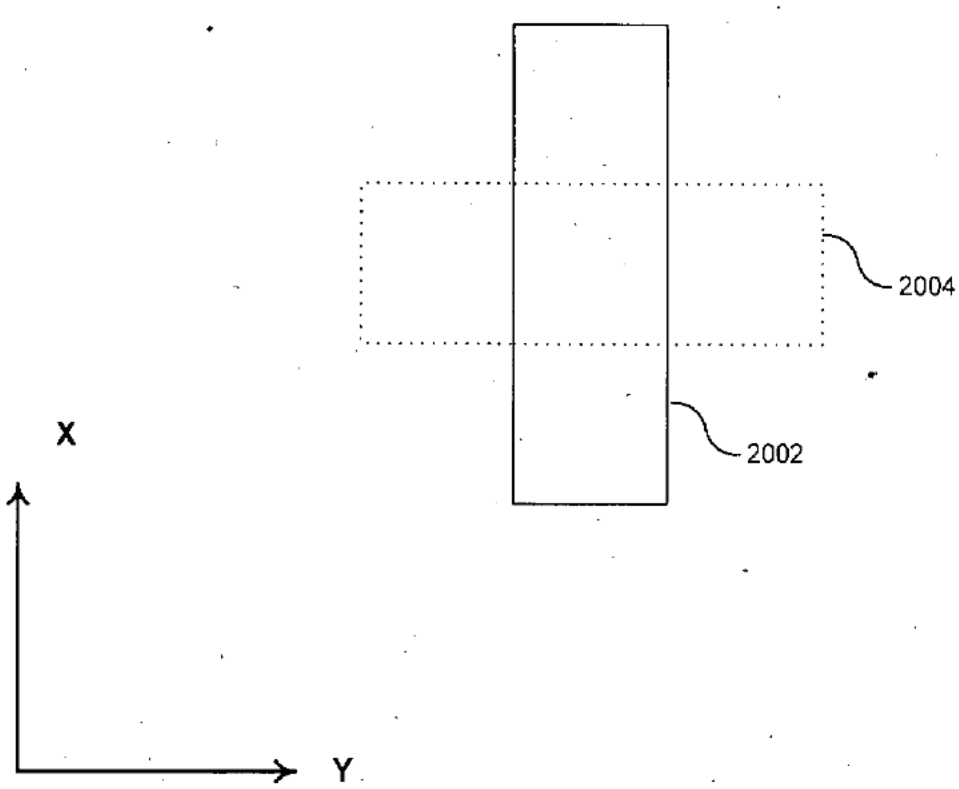


FIG. 21

9906-35.vsd/22

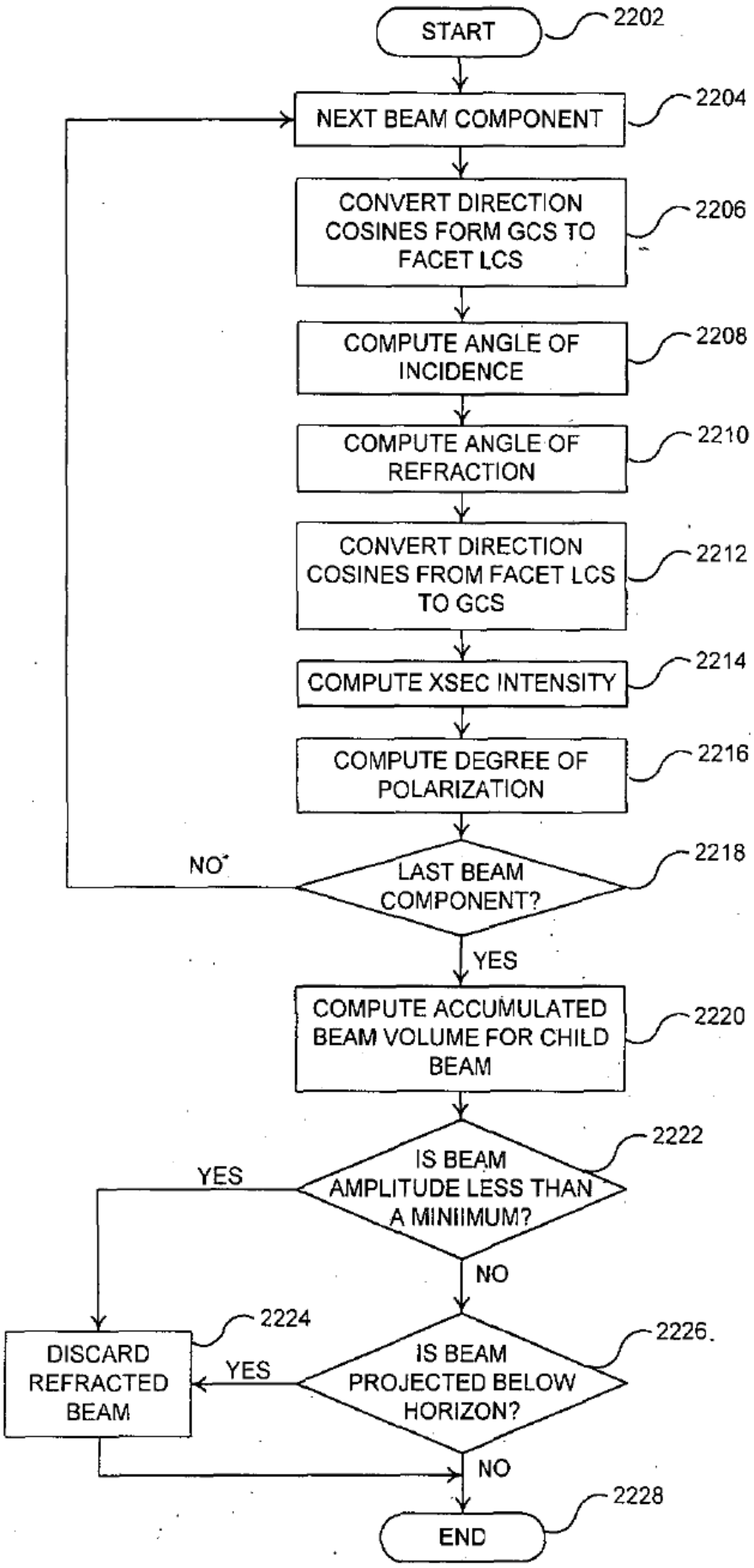


FIG. 22

9906-35.vsd/23

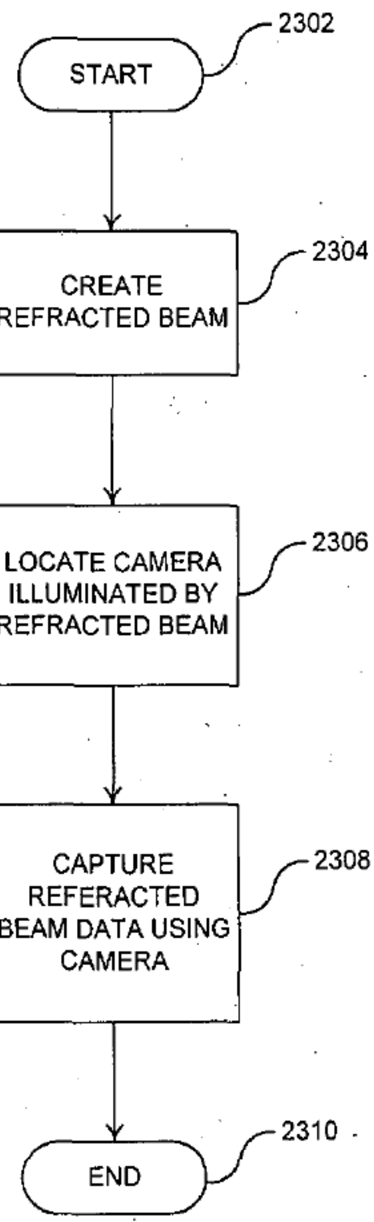


FIG. 23

9906-35.vsd/24

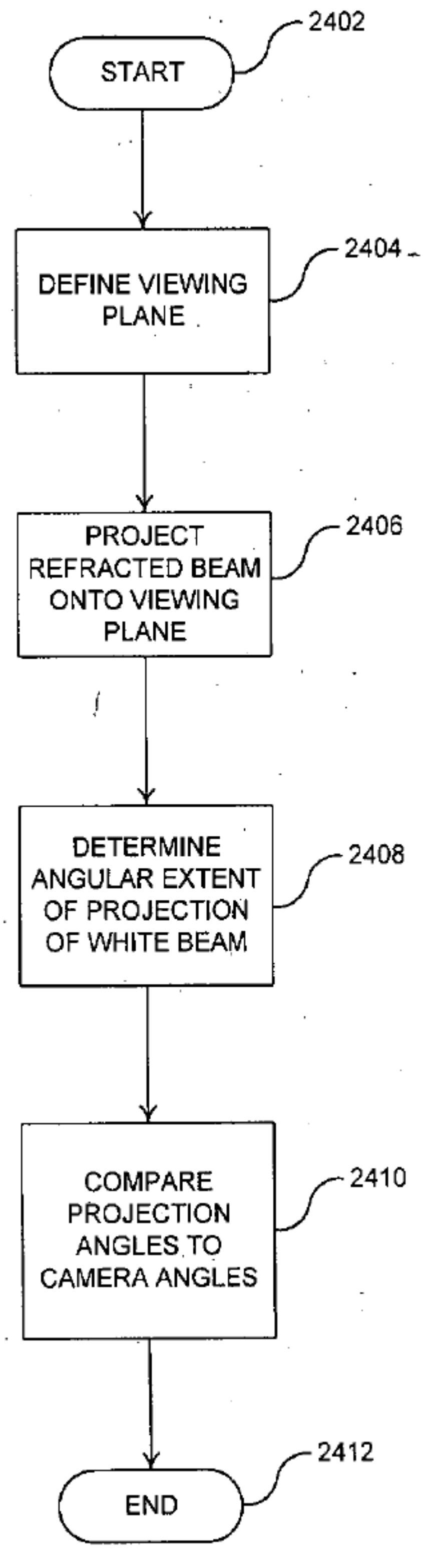


FIG. 24

9906-35.vsd/25

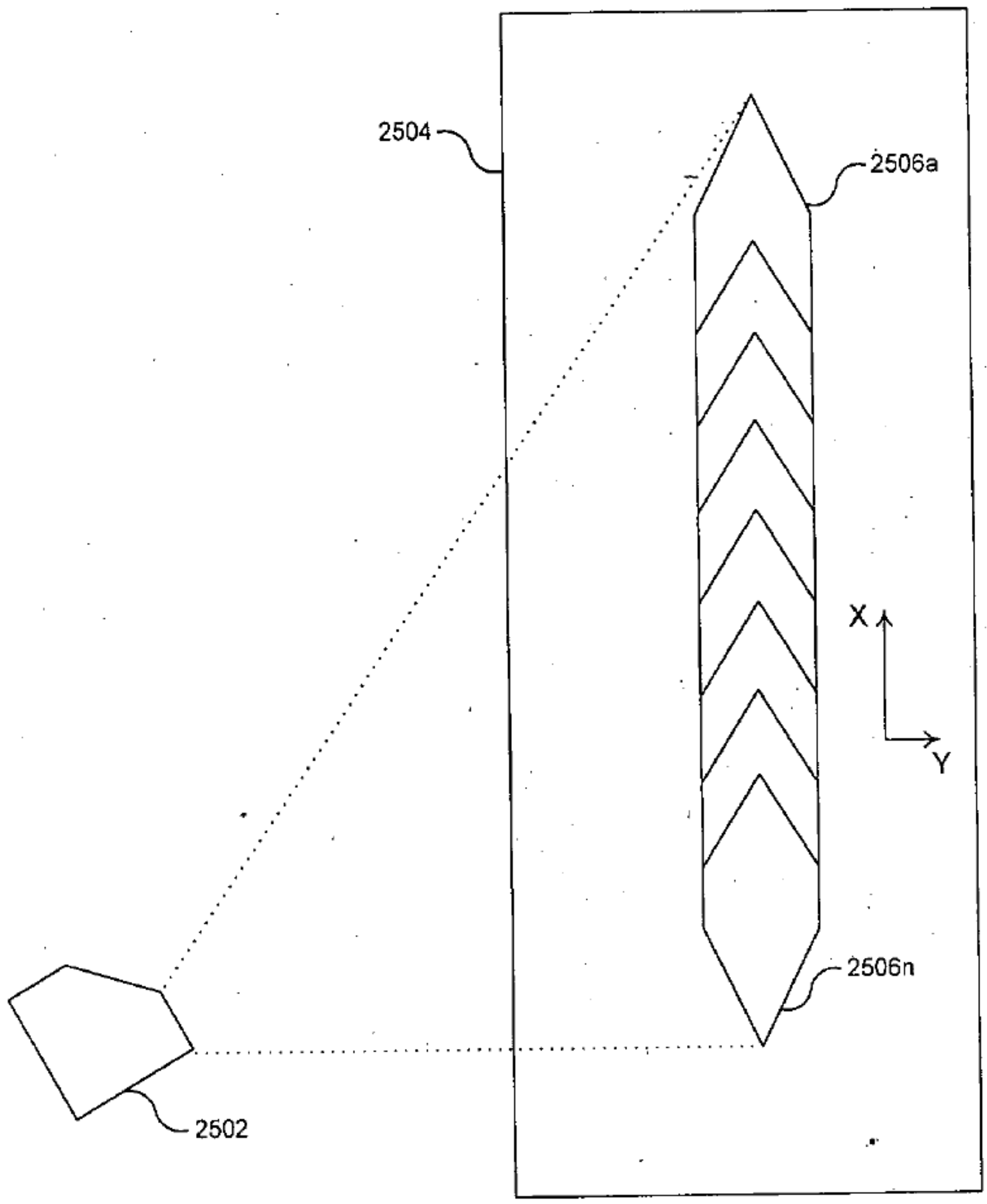


FIG. 25

9906-35.vsd/26

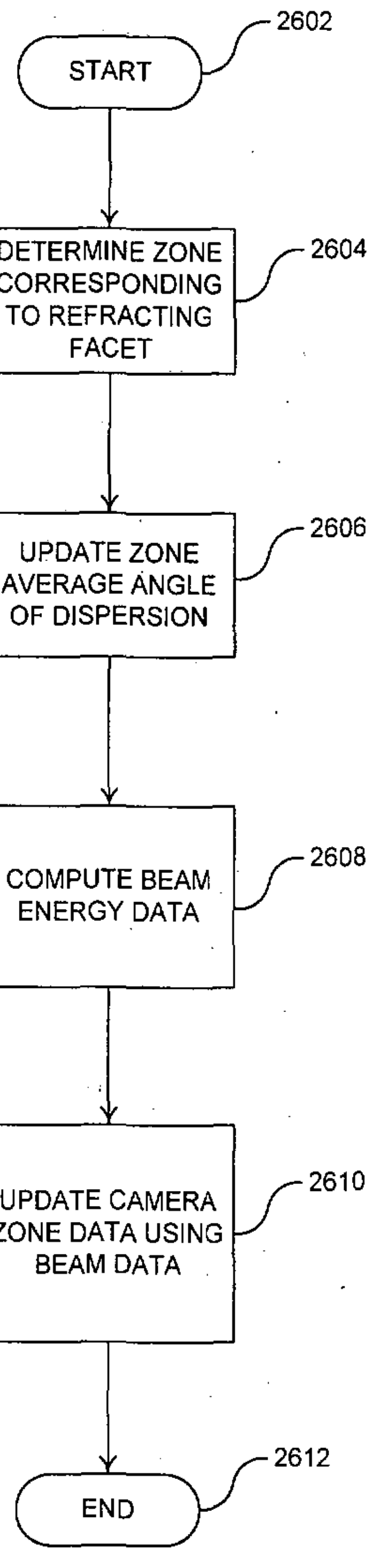


FIG. 26

9906-35.vsd/27

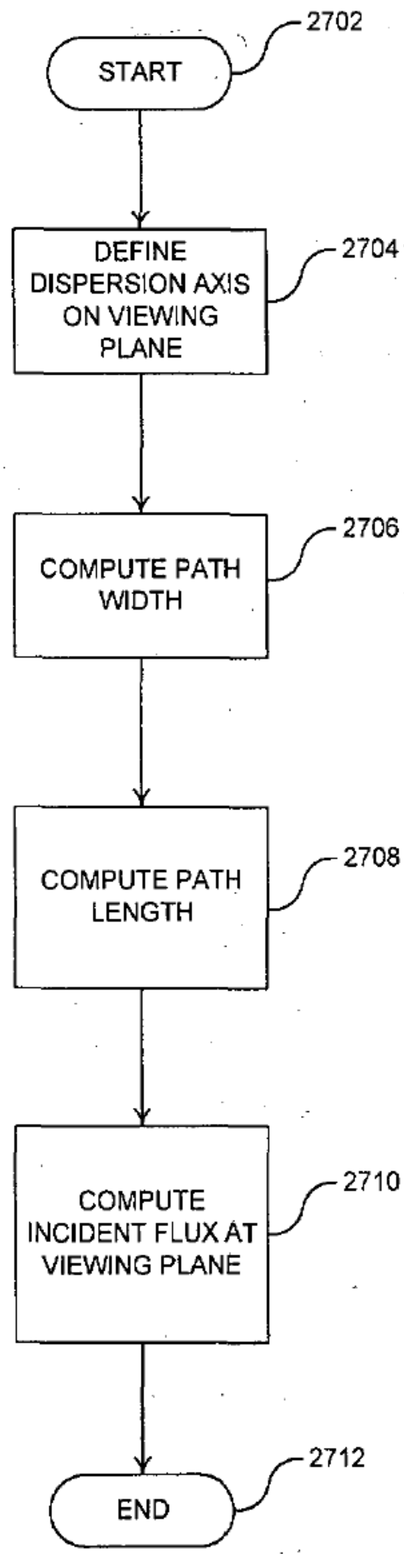


FIG. 27

9906-35.vsd/28

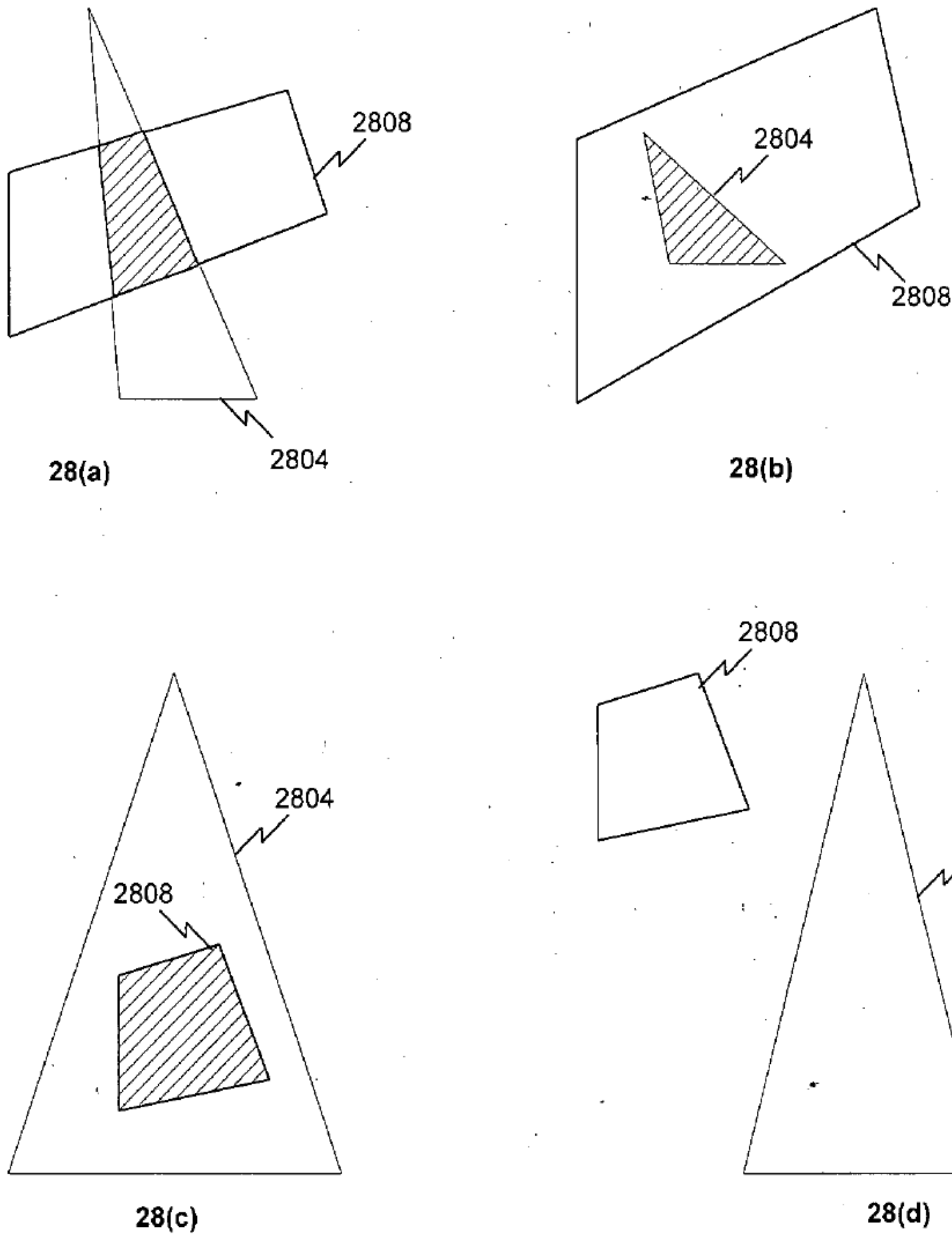
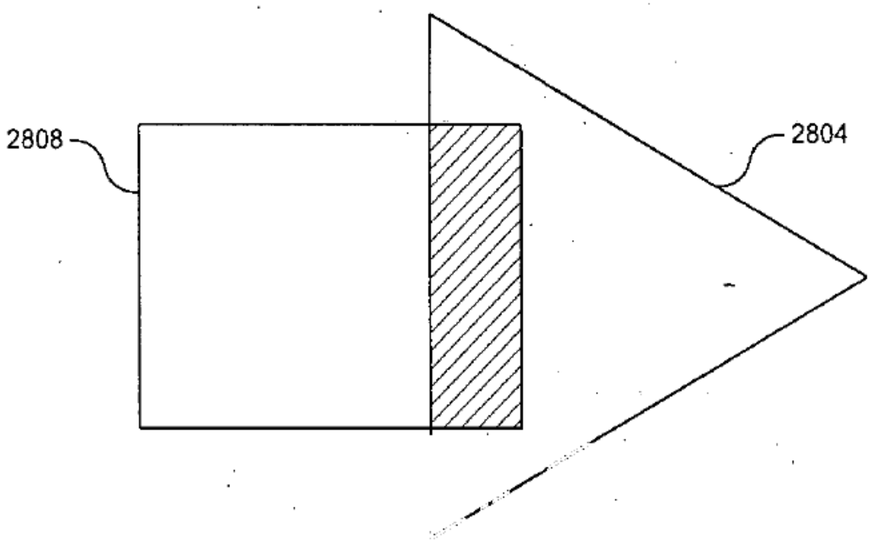


FIG. 28

9906-35.vsd/29



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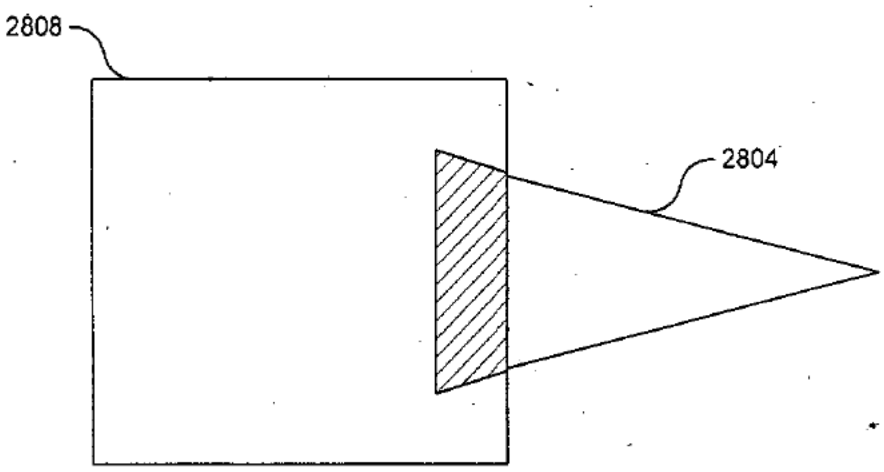


29(b)

FIG. 29

9906-35.vsd/30

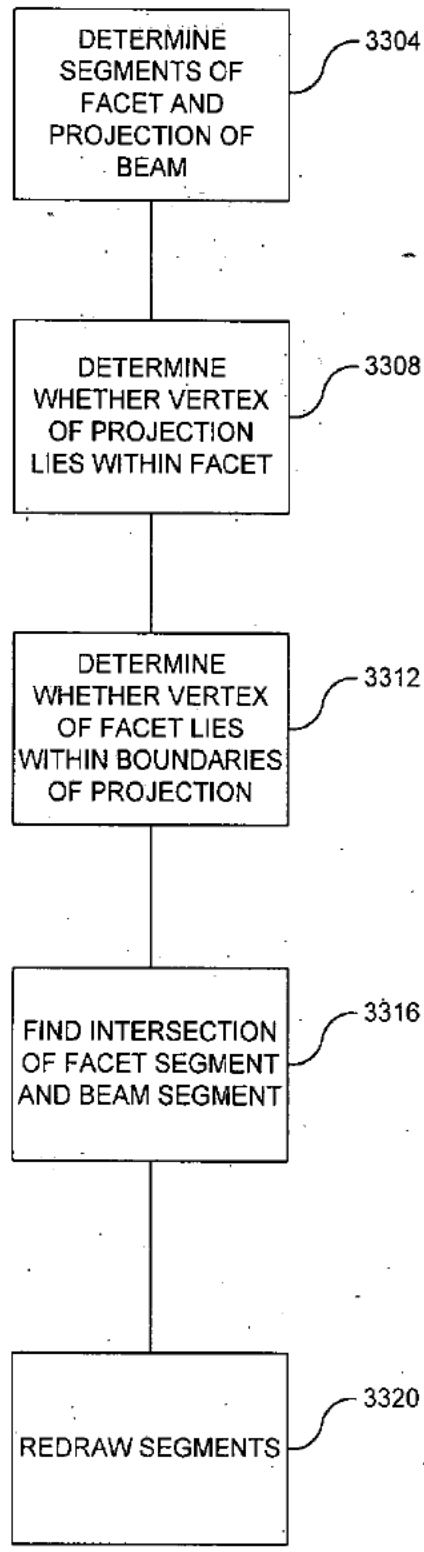


FIG. 30

9906-35.vsd/31

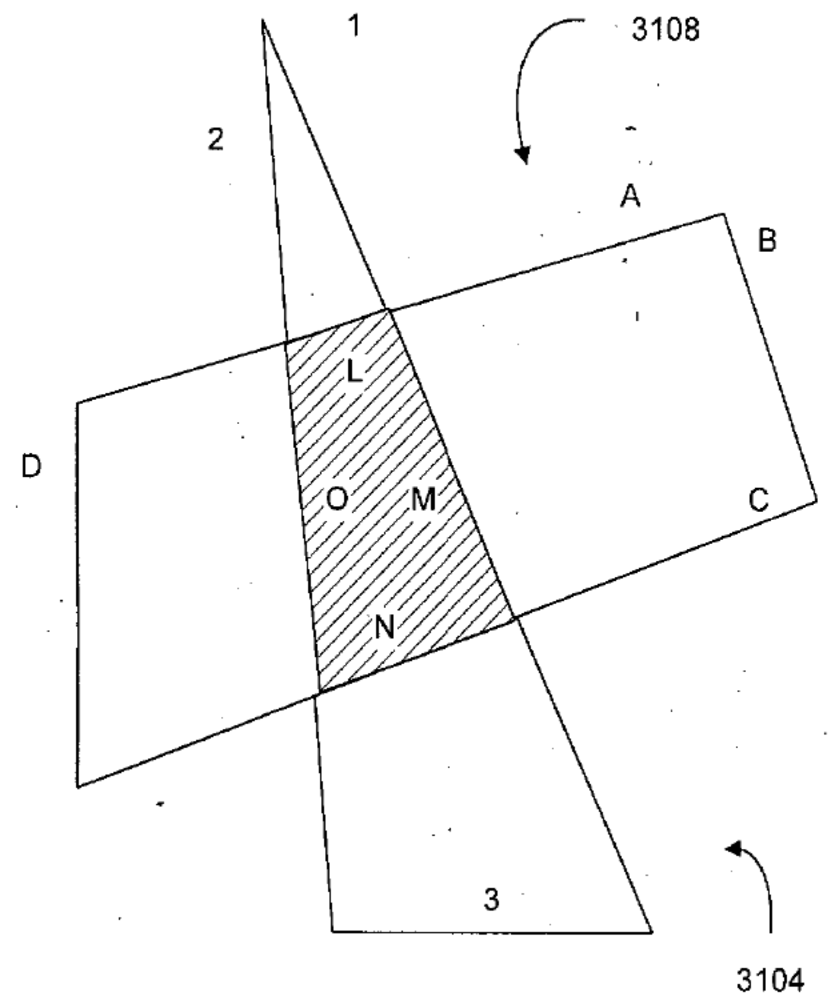


FIG. 31

9906-35.vsd/32

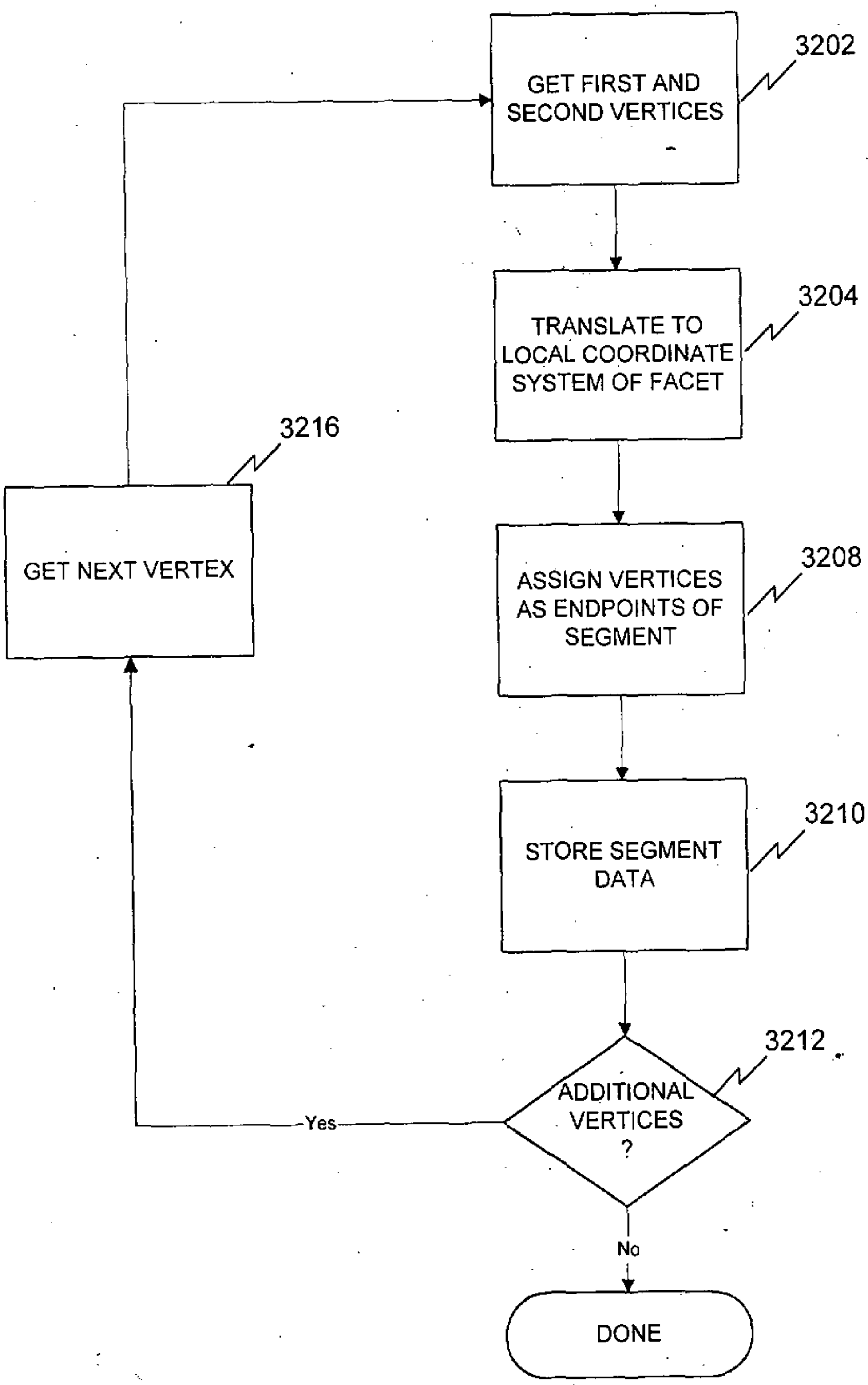


FIG. 32

9906-35.vsd/33

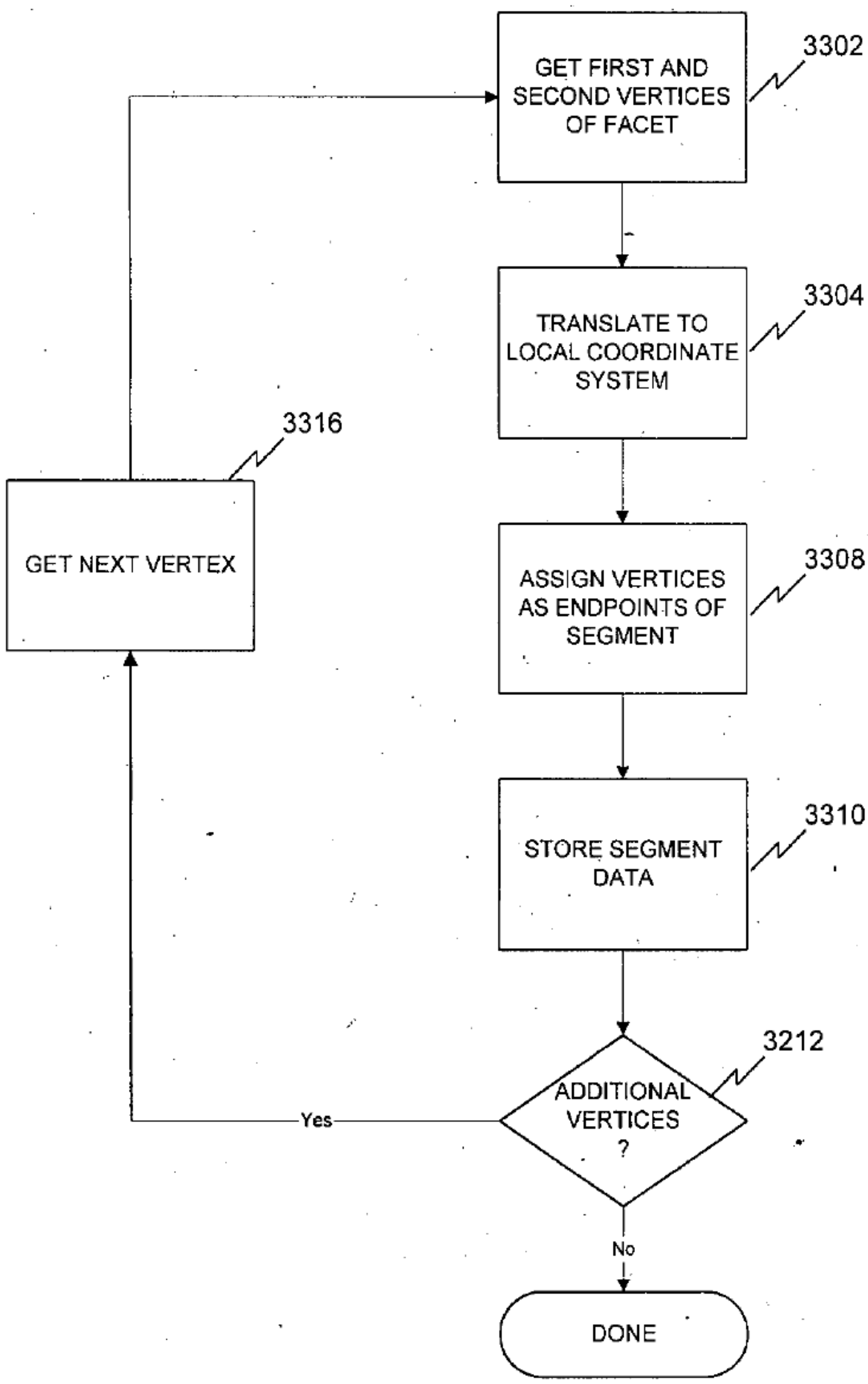


FIG. 33

9906-35.vsd/34

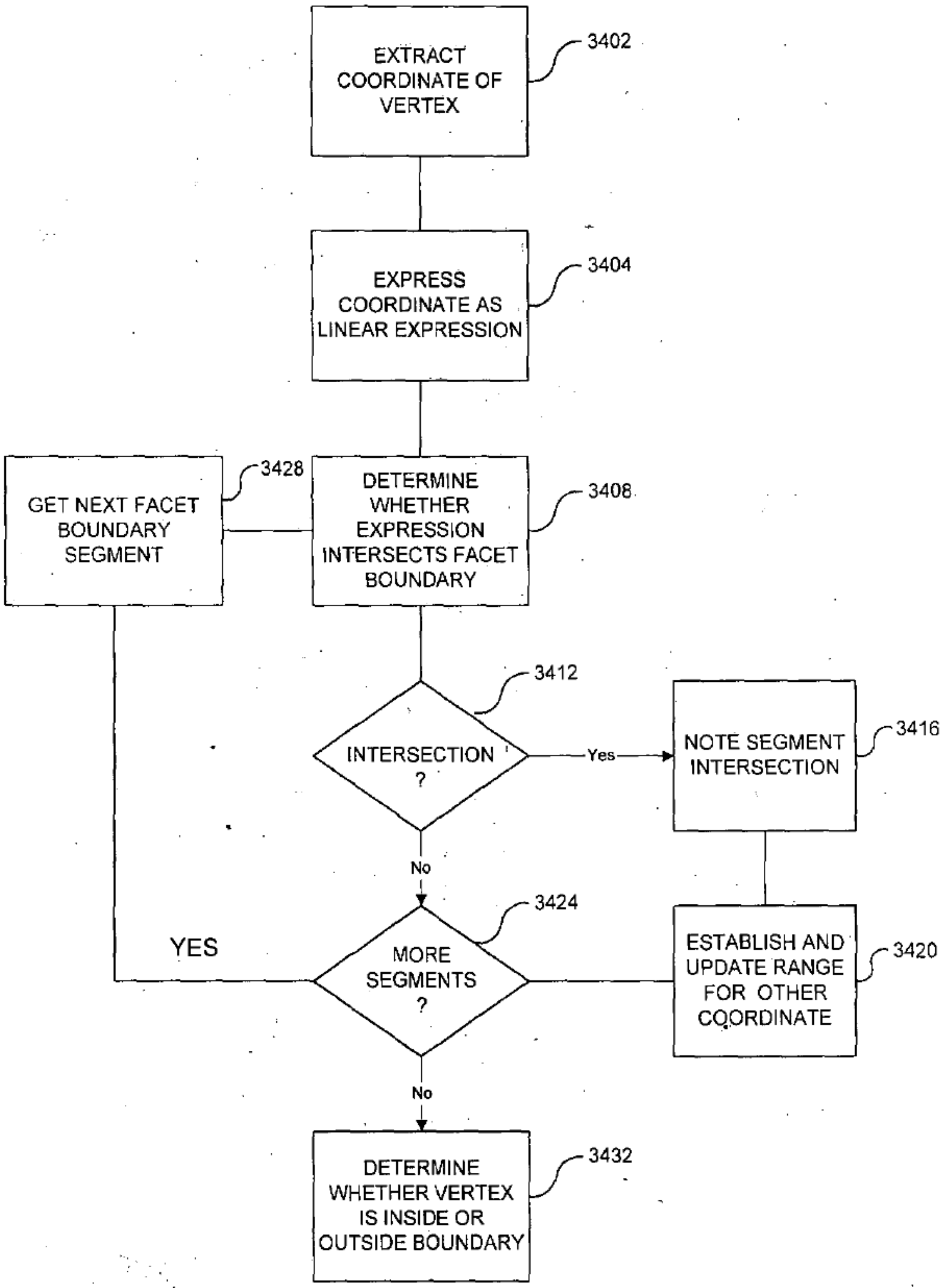


FIG. 34

9906-35.vsd/35

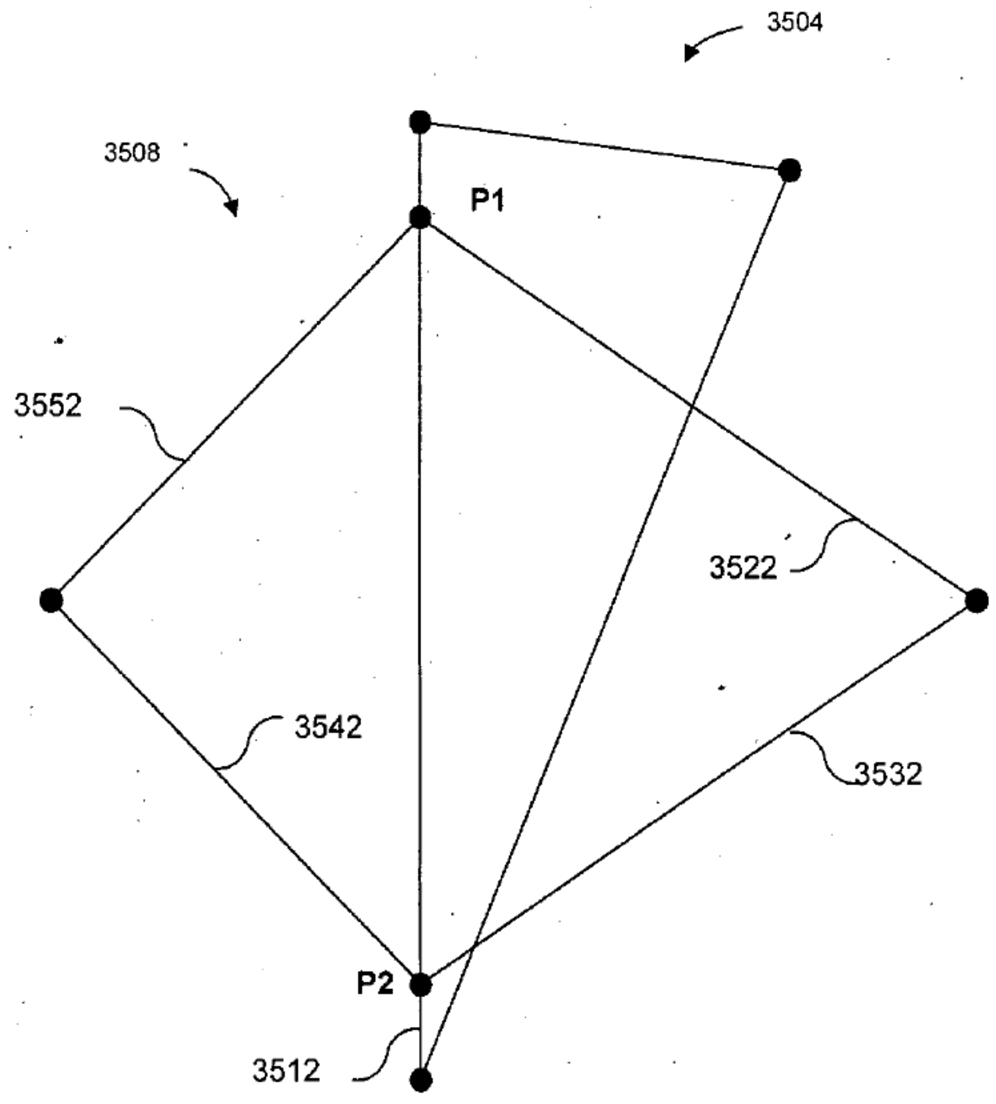


FIG. 35

9906-35.vsd/36

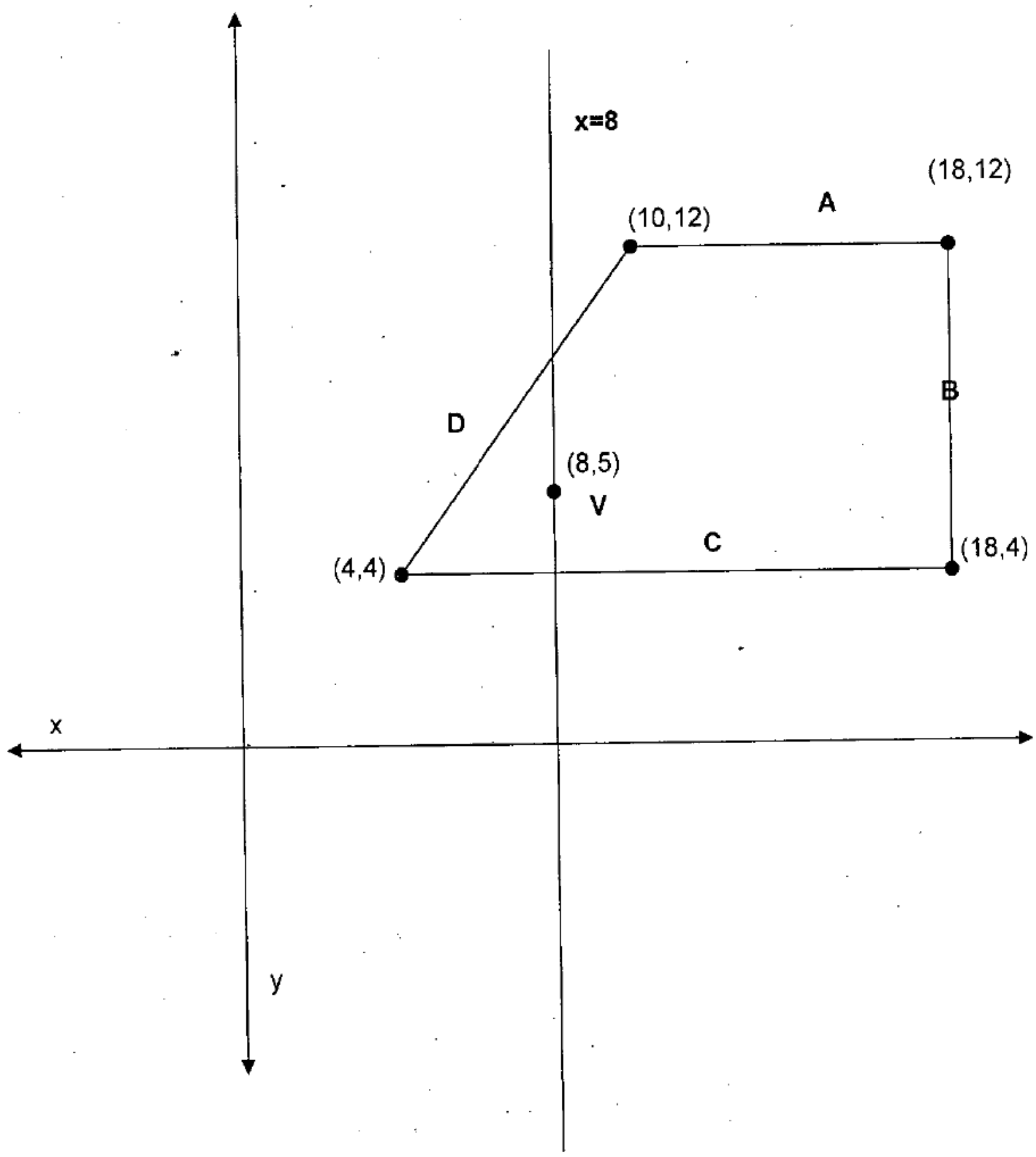


FIG. 36

9906-35.vsd/37

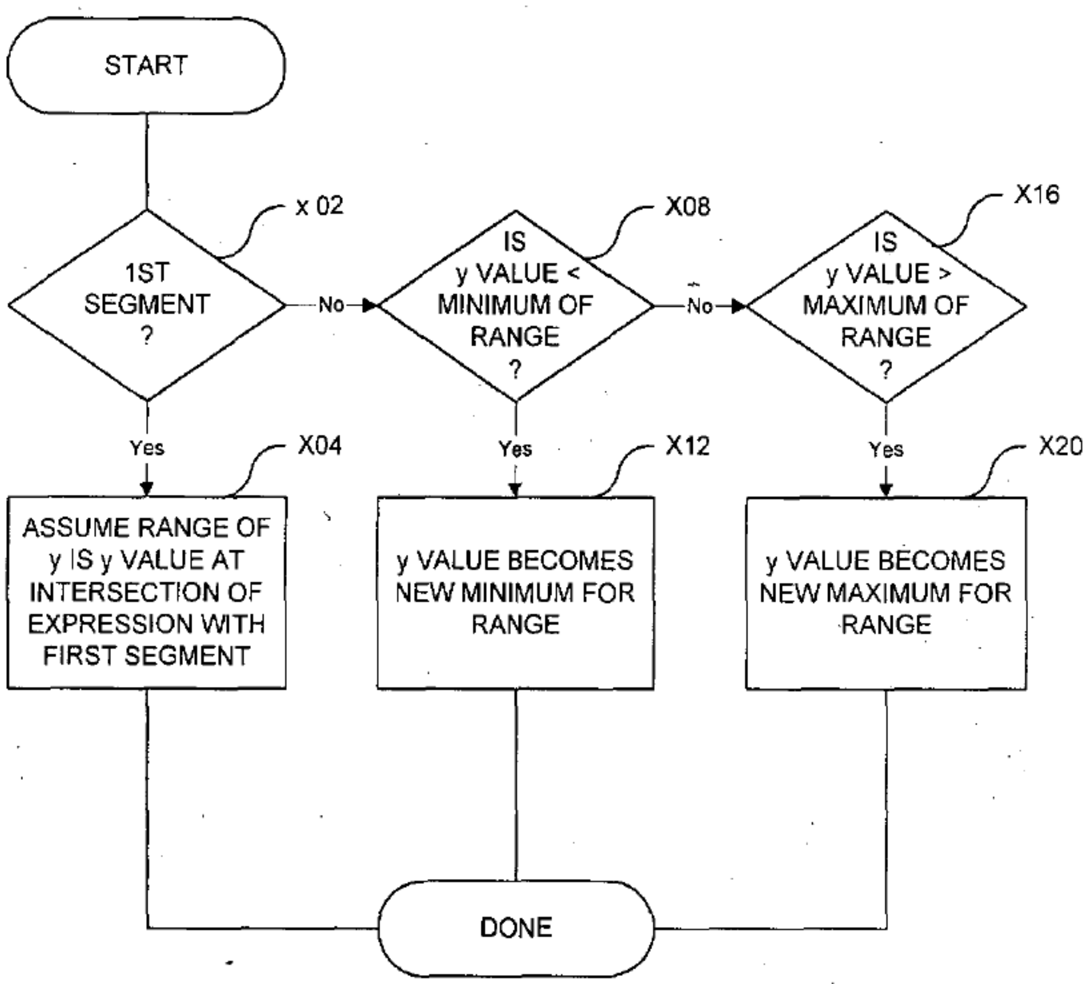
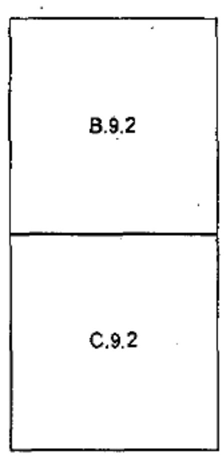


FIG. 40

FIG. 37



9906-35.vsd/38

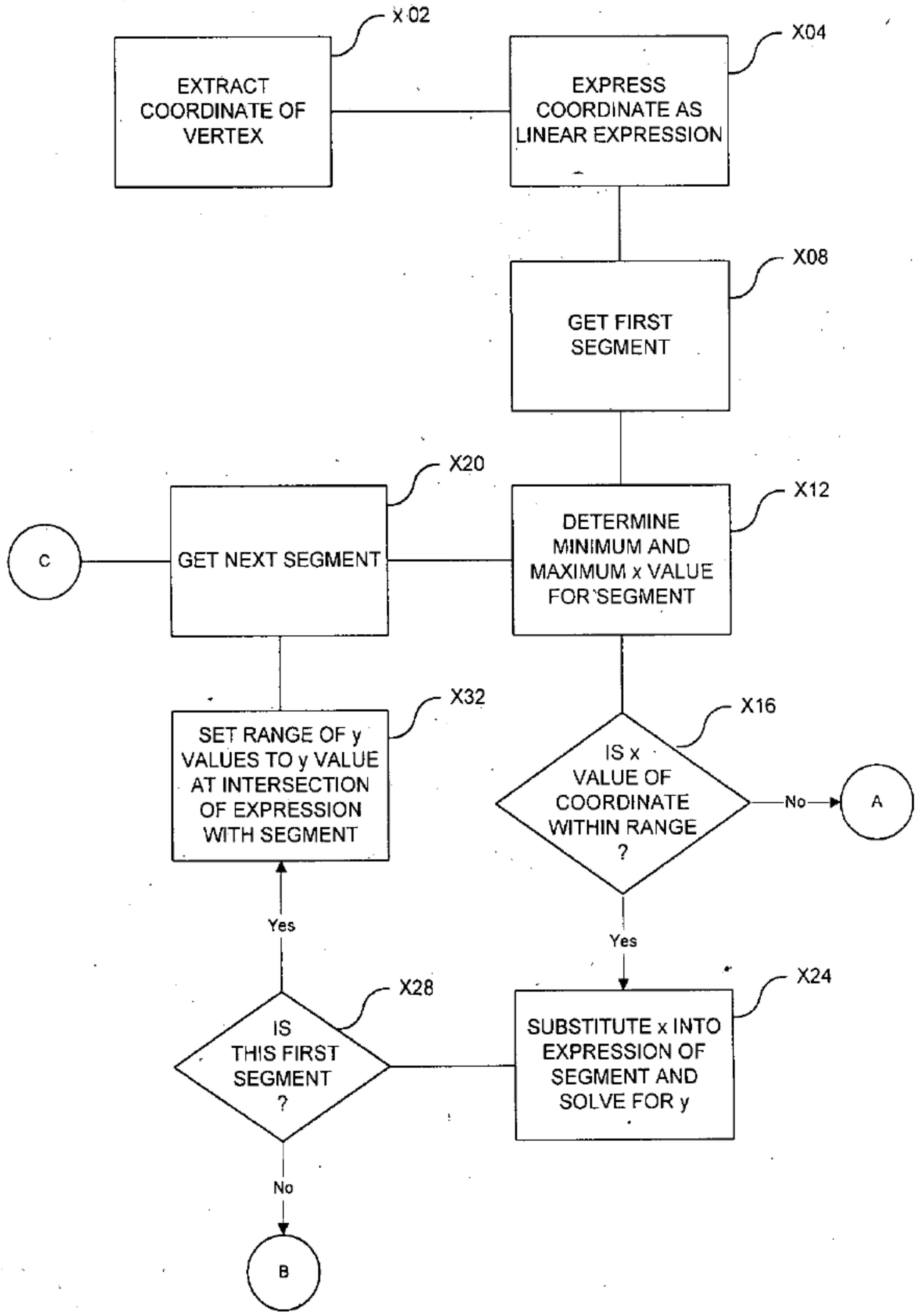


FIG. 38

9906-35.vsd/39

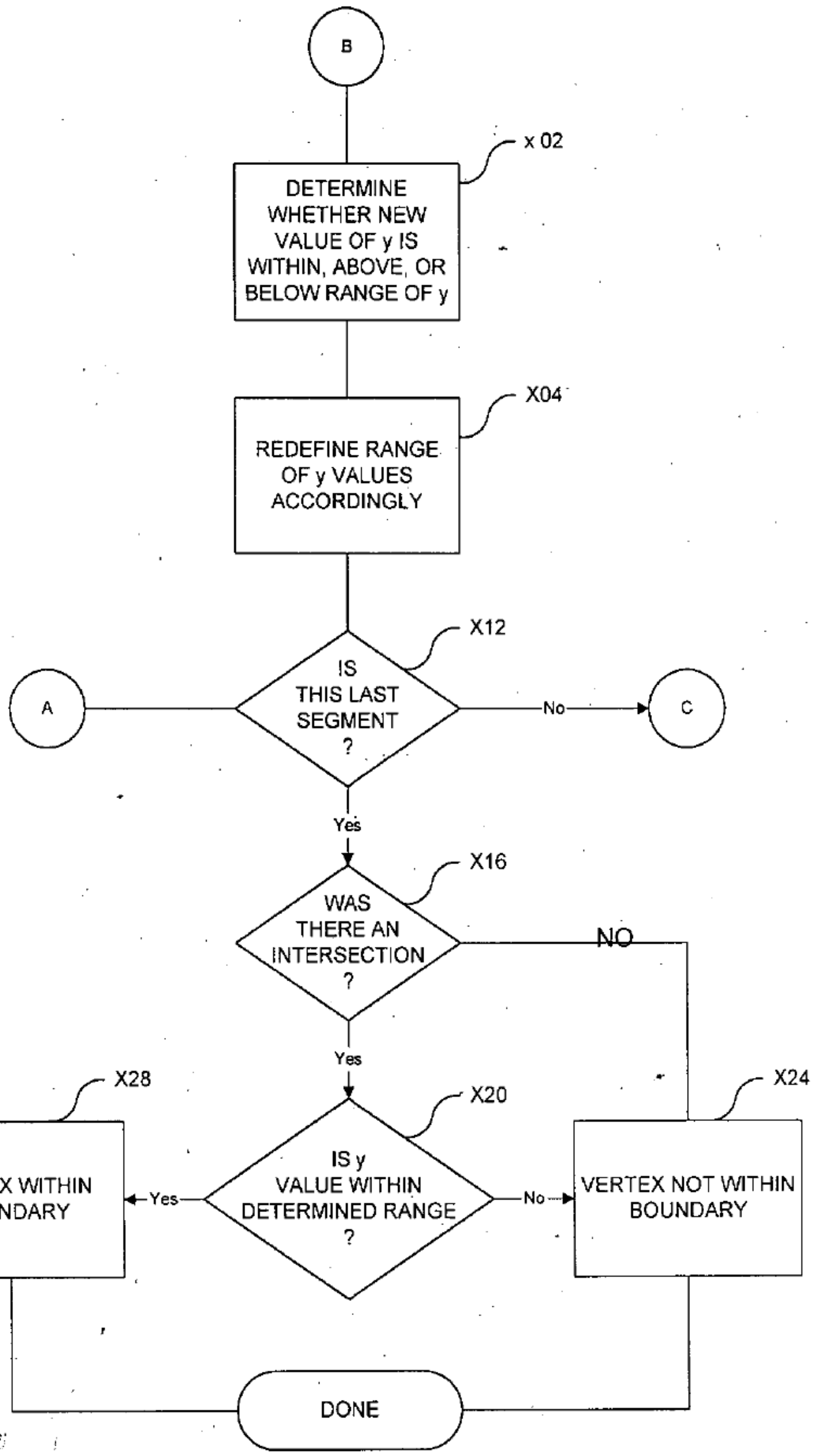


FIG. 39

9906-35.vsd/40

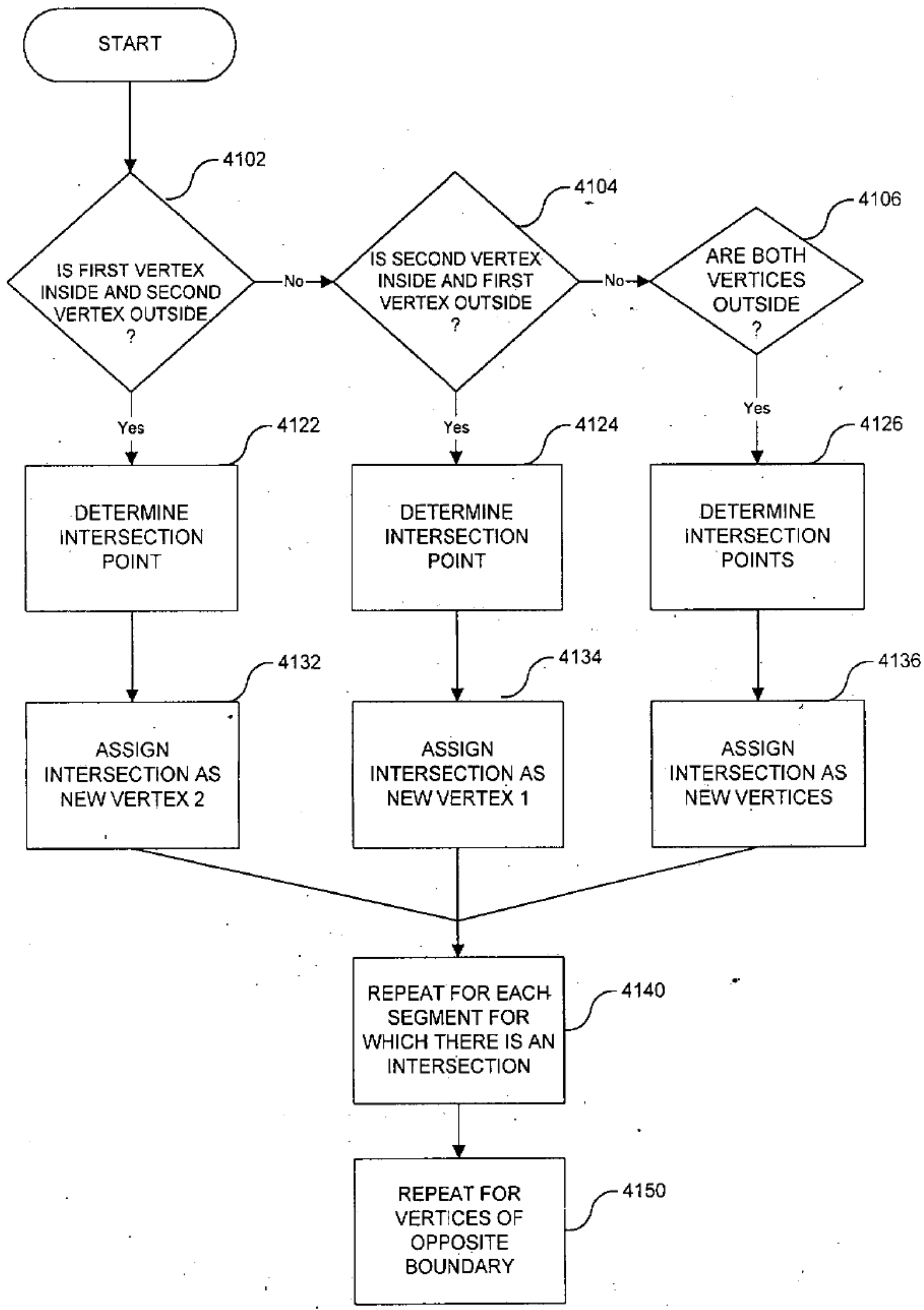


FIG. 41

9906-35.vsd/41

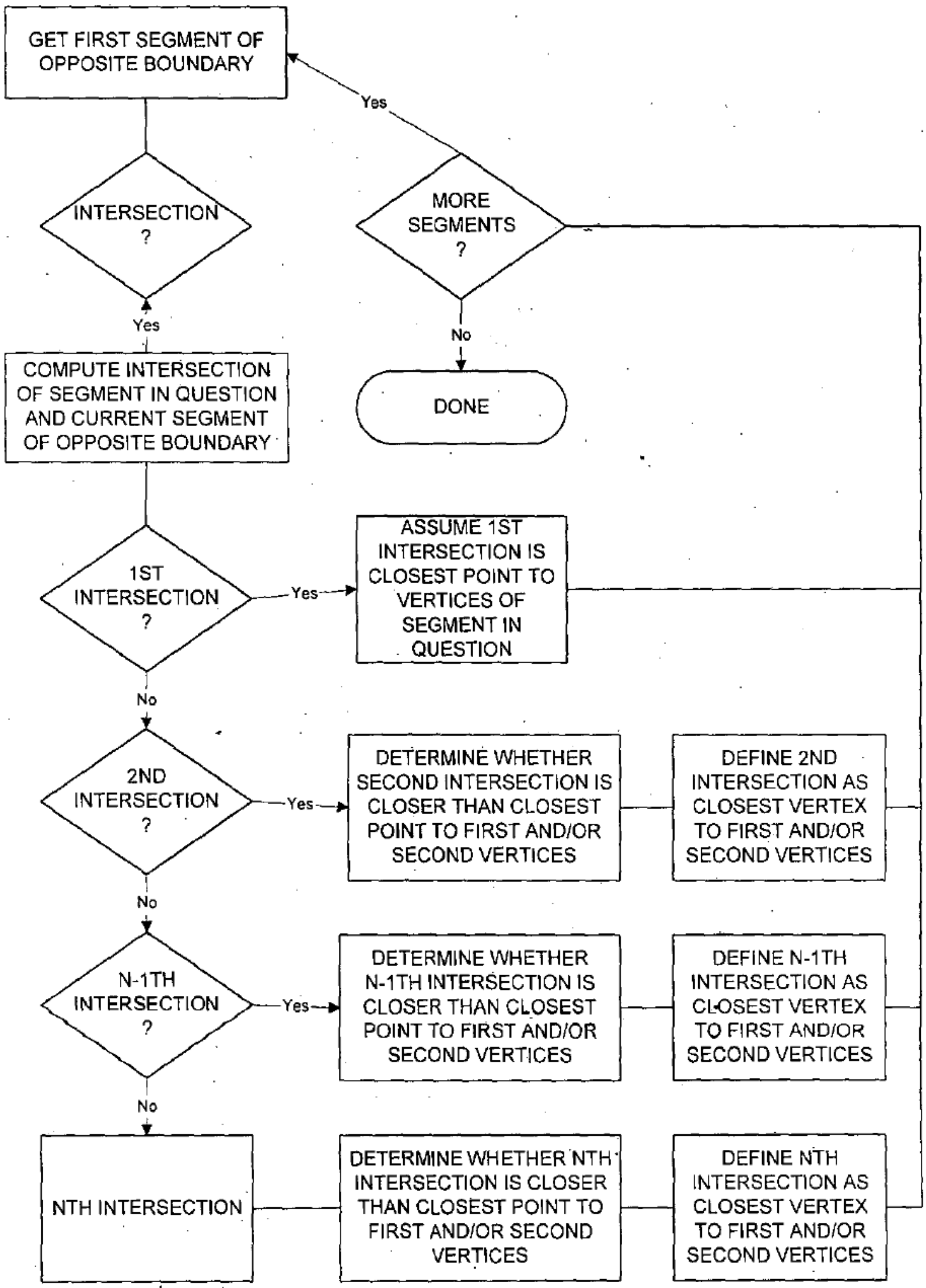


FIG. 42

9906-35.vsd/42

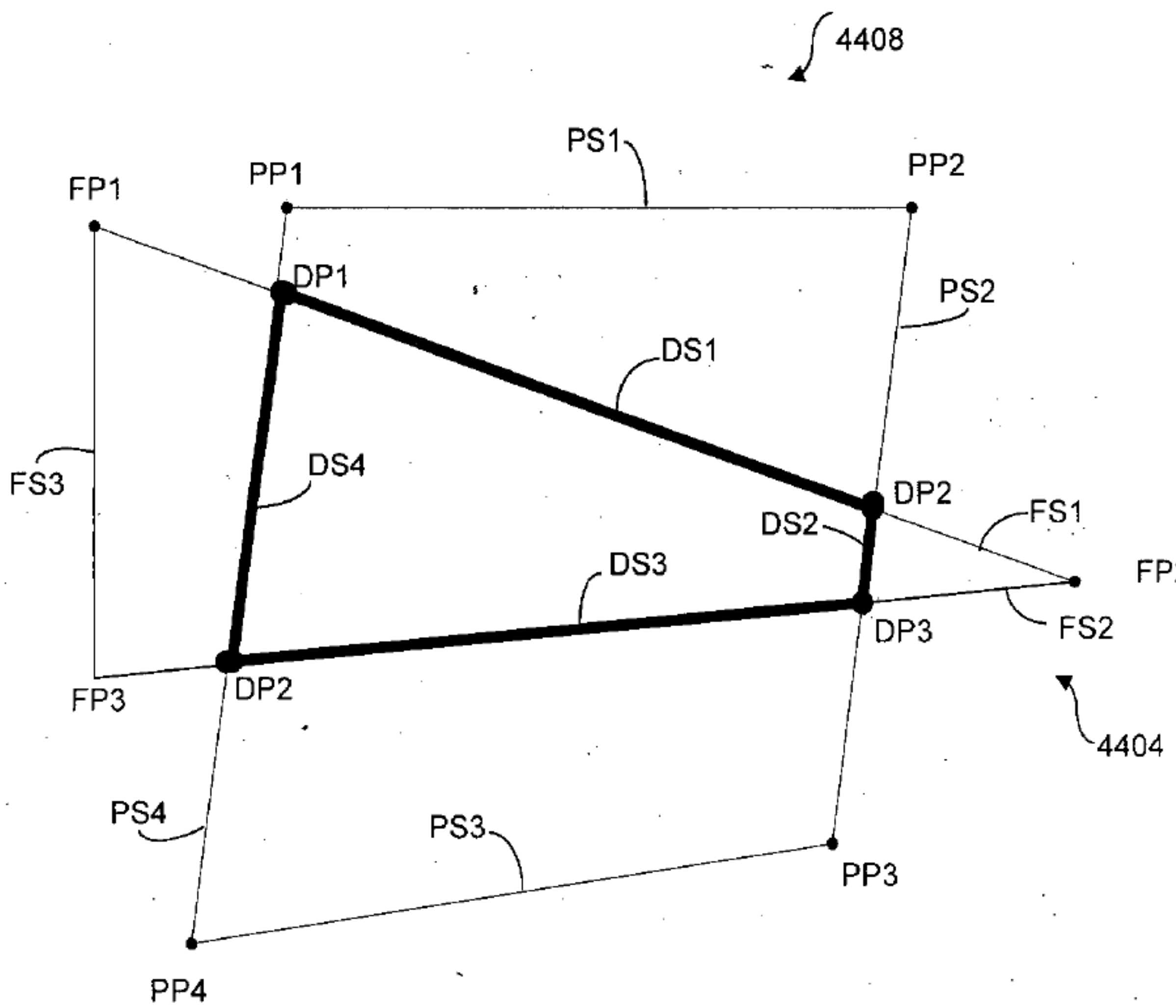


FIG. 43

9906-35.vsd/43

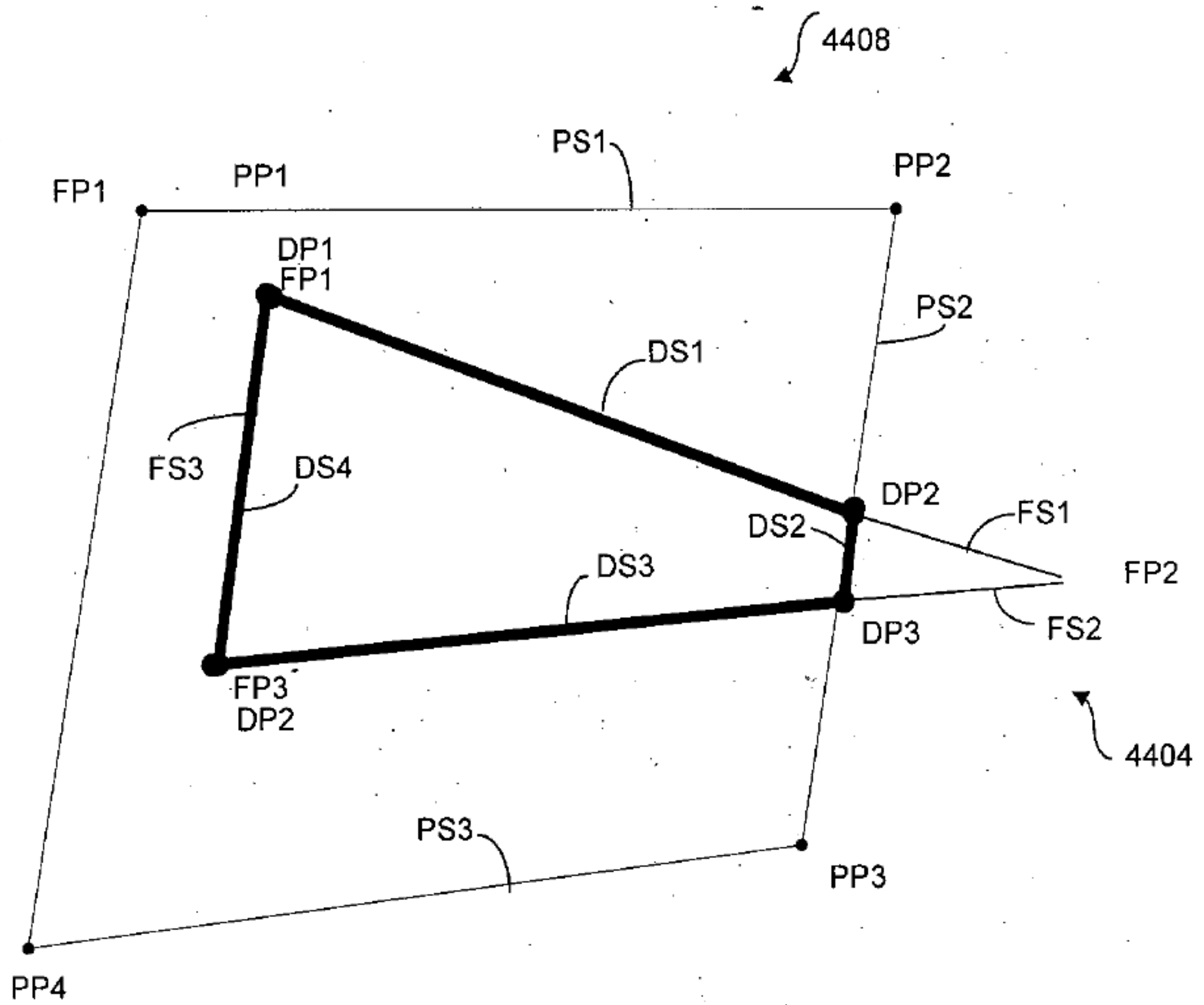


FIG. 44

9906-35.vsd/44

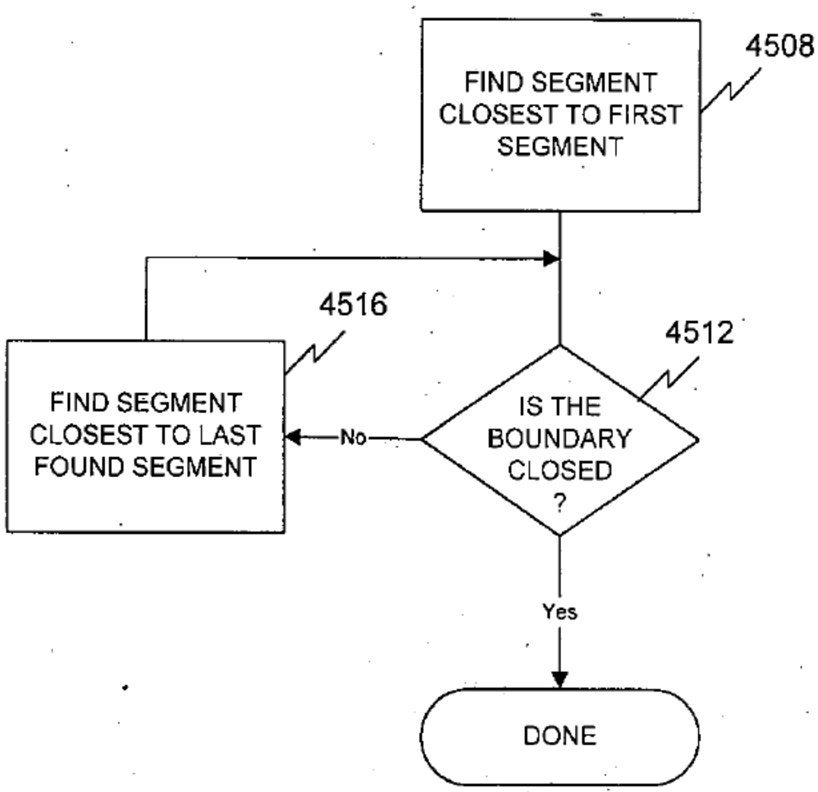


FIG. 45

9906-35.vsd/45

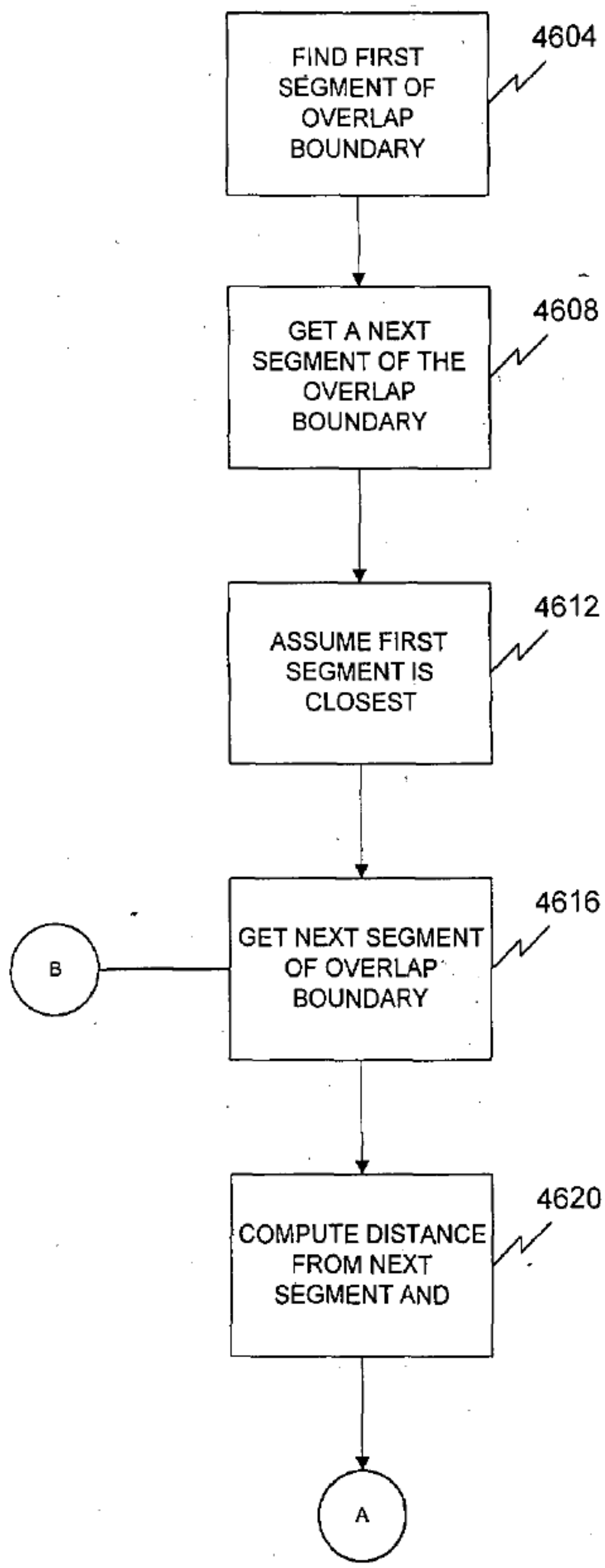


FIG. 46

9906-35.vsd/46

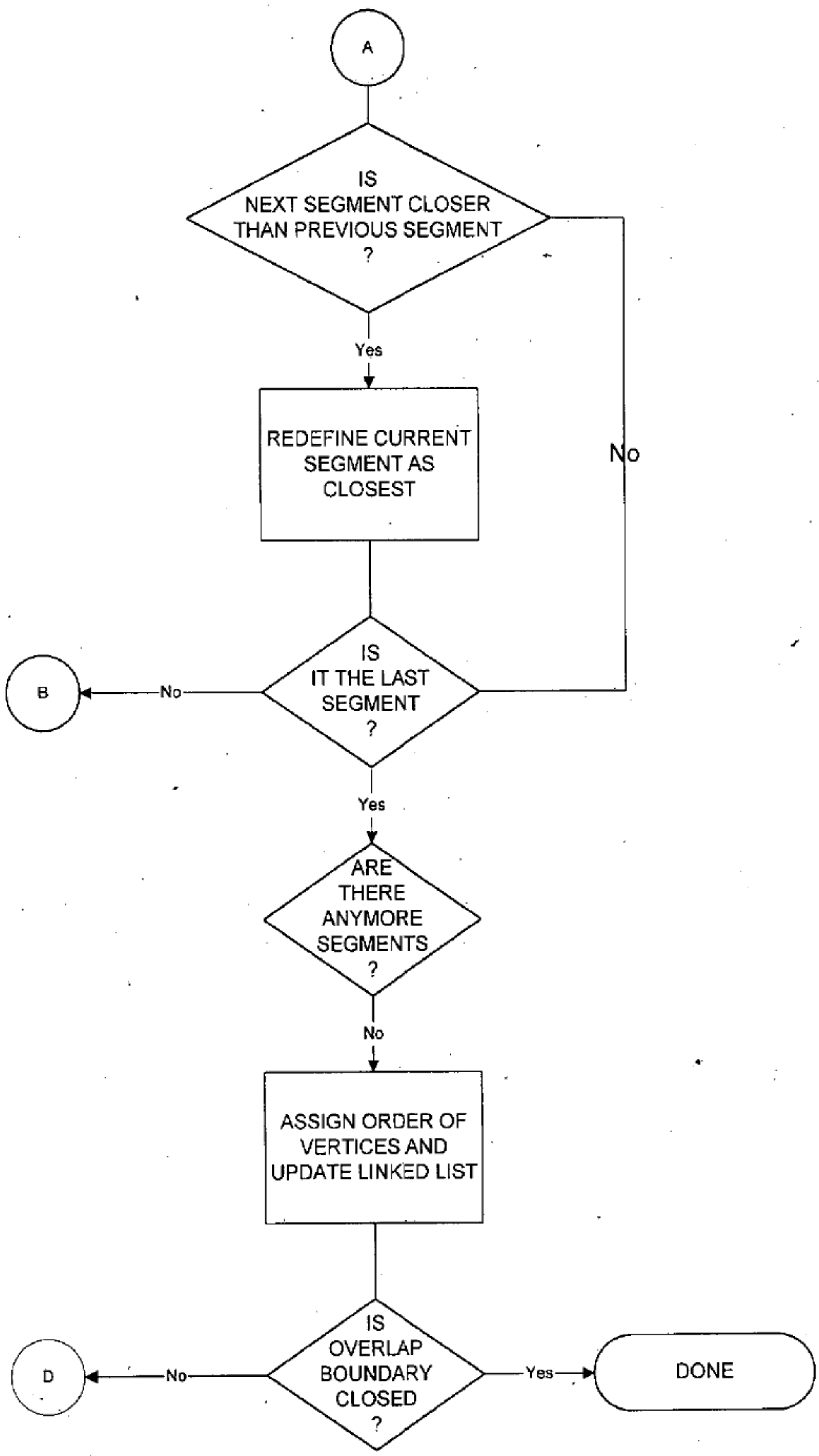


FIG. 47

9906-35.vsd/47

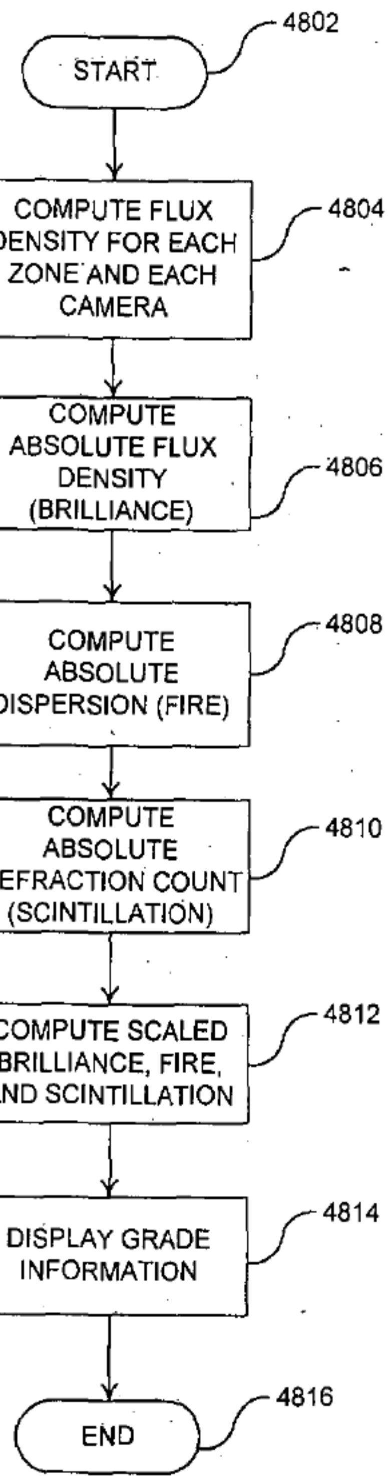


FIG. 48

9906-35.vsd/48

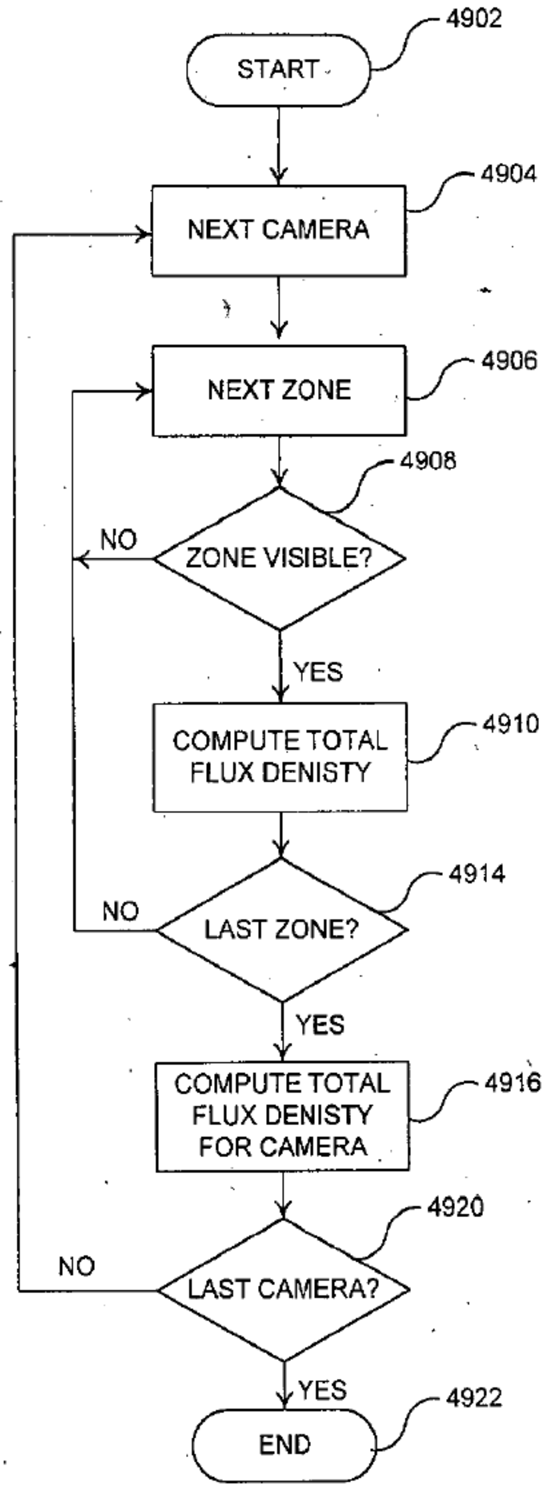


FIG. 49

9906-35.vsd/49

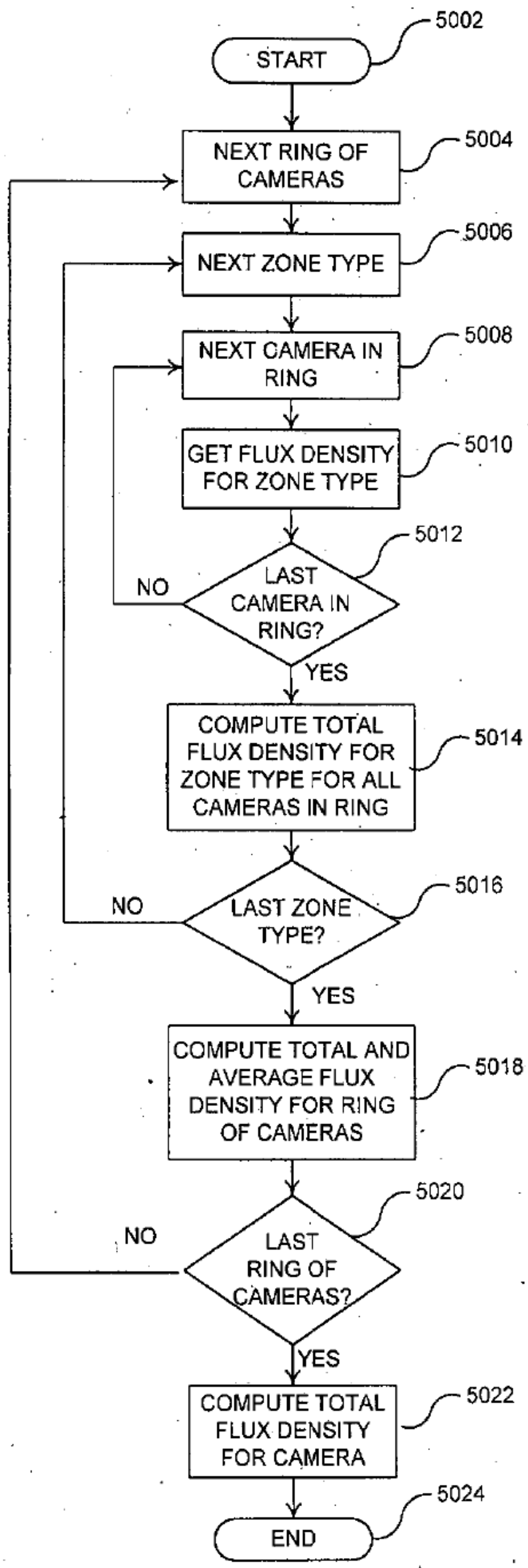


FIG. 50

9906-35.vsd/50

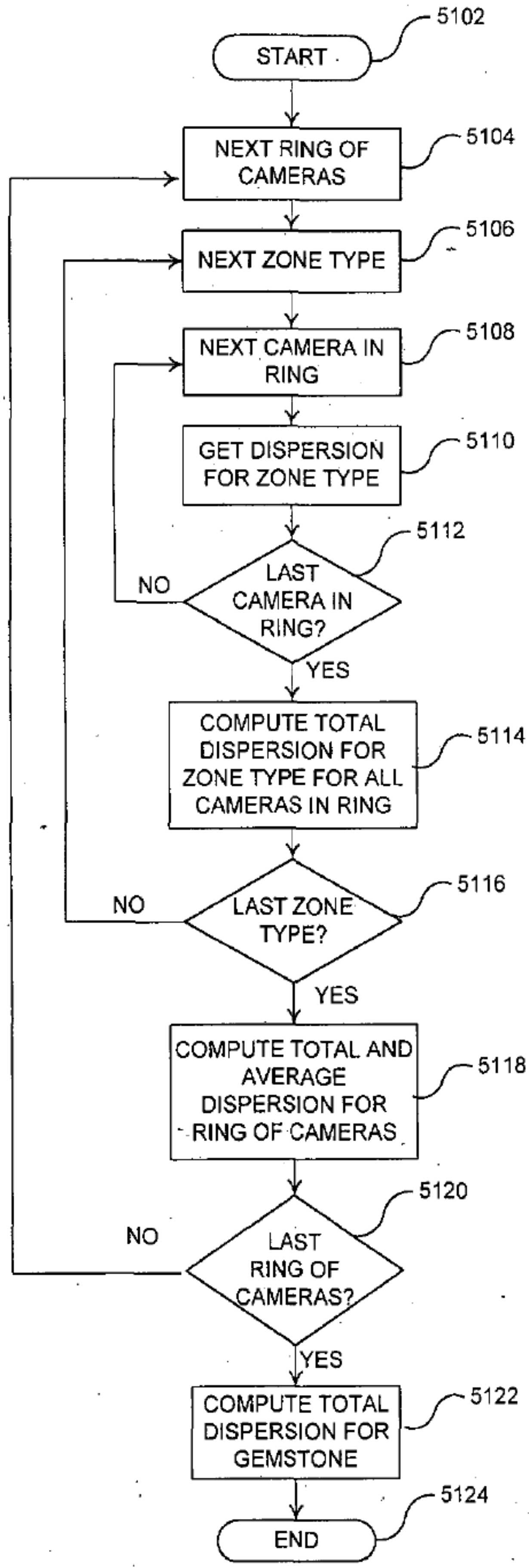


FIG. 51

9906-35.vsd/51

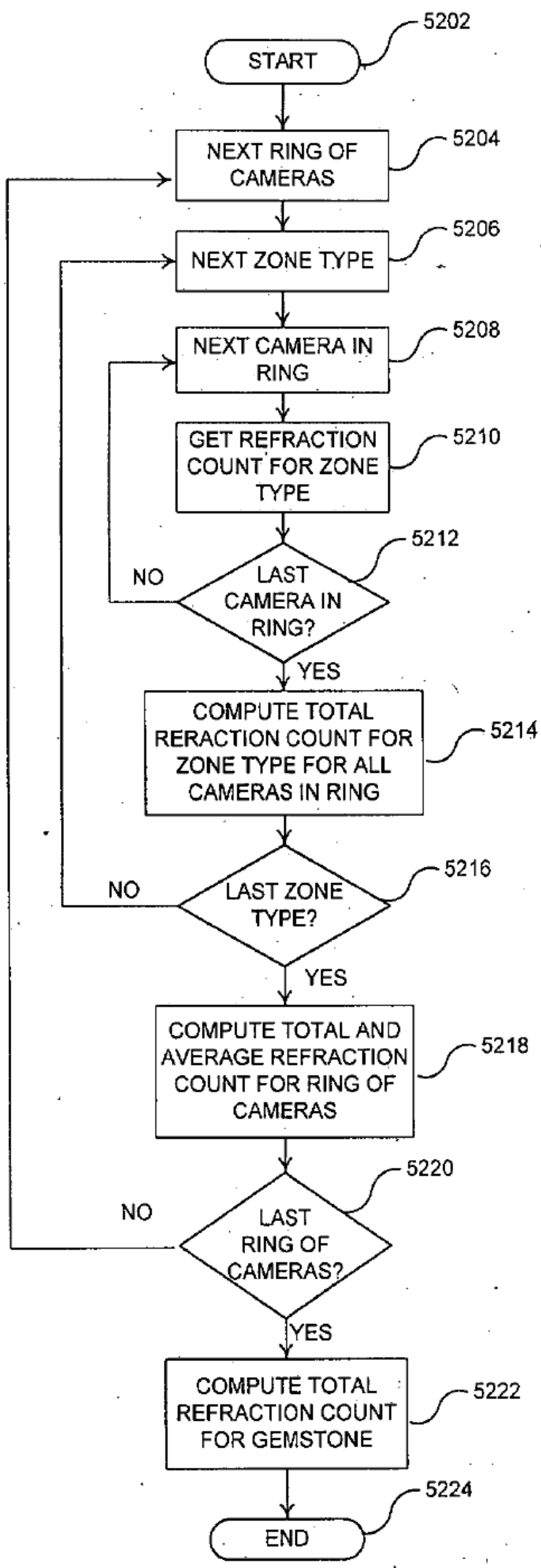


FIG. 52

9906-35.vsd/52

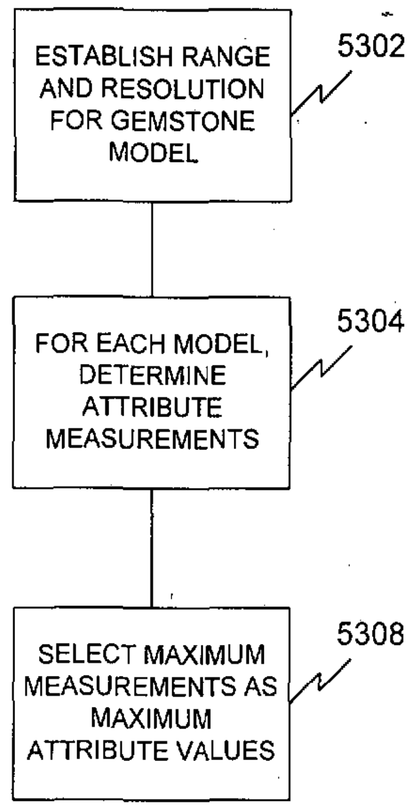


FIG. 53

9906-35.vsd/53

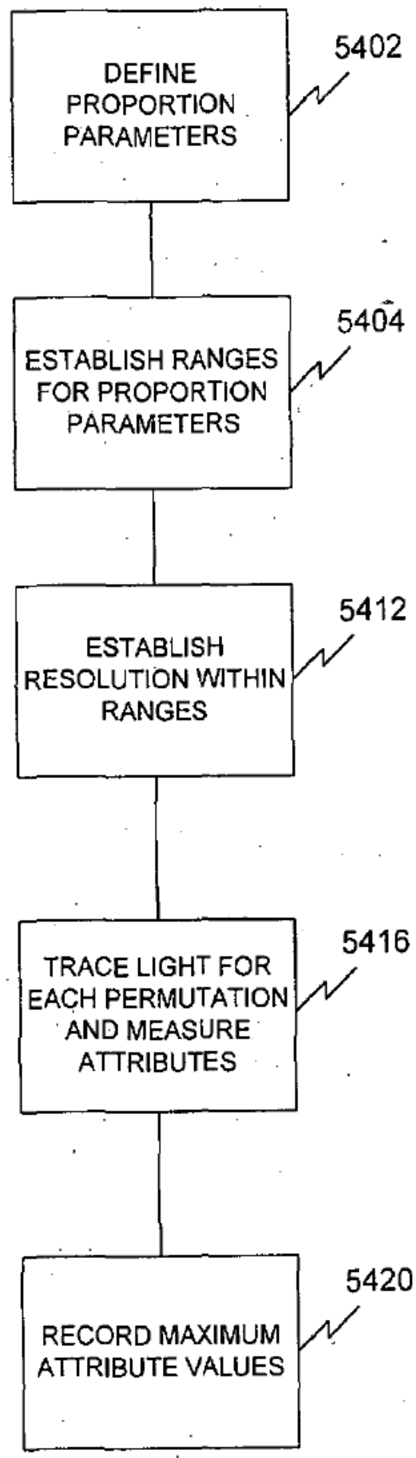


FIG. 54

9906-35.vsd/54

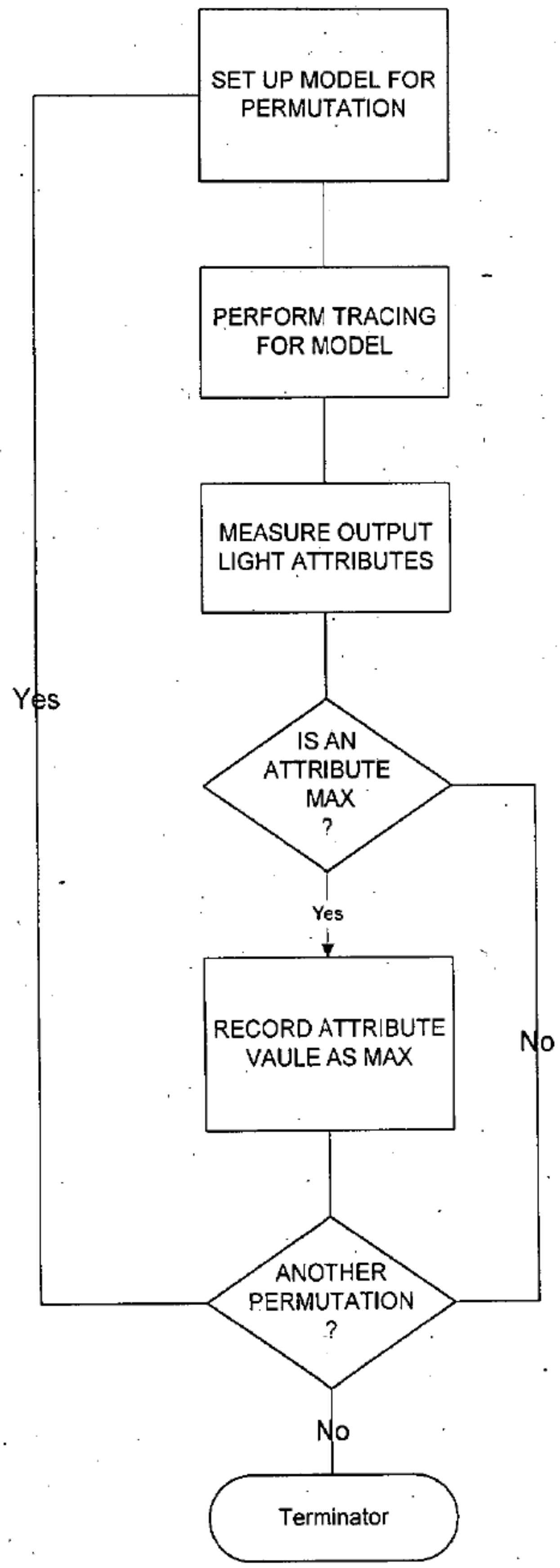


FIG. 55

9906-35.vsd/55

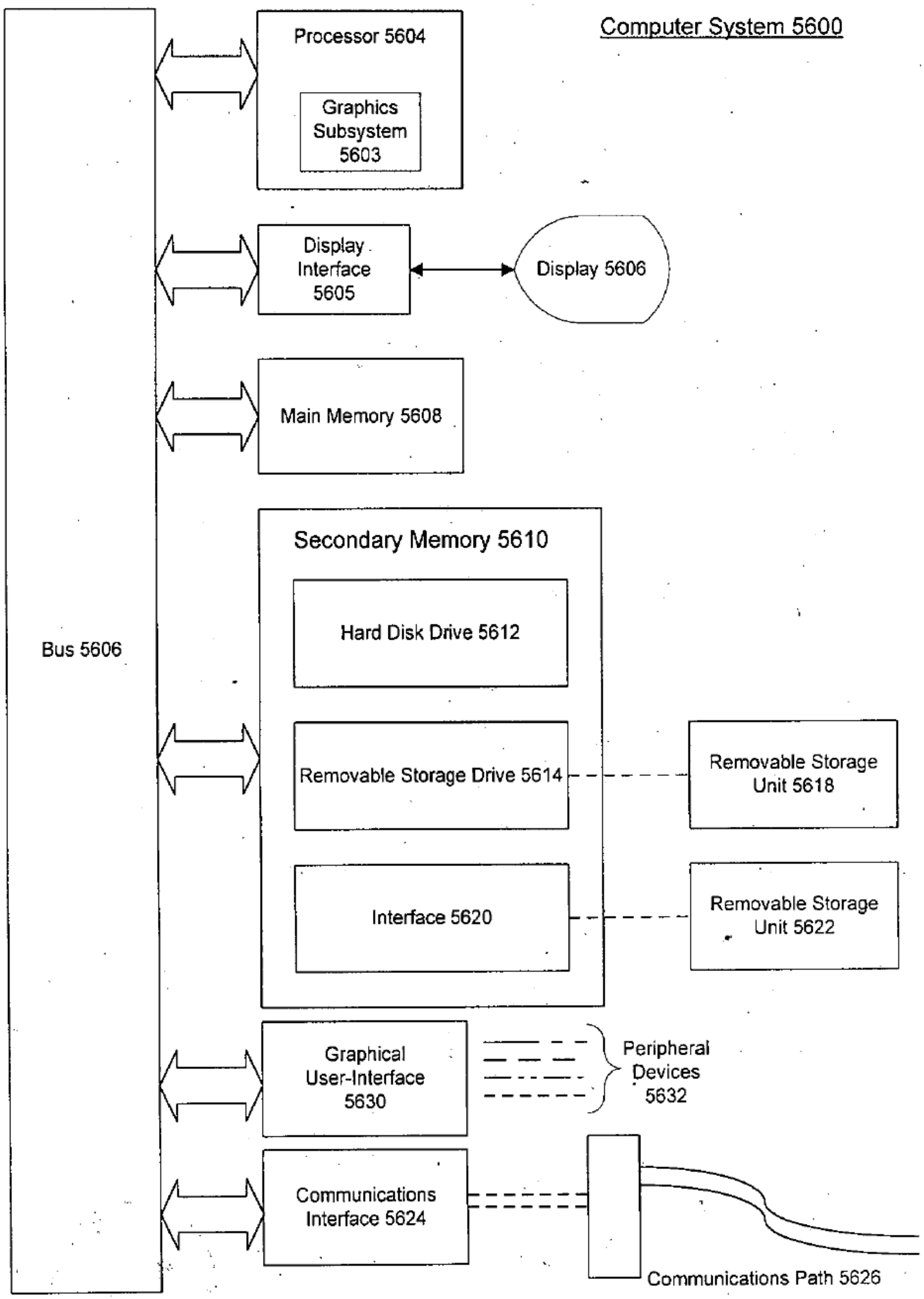


FIG. 56

9906-35.vsd
9906-35.vsd/56

PART B—ISSUE FEE TRANSMITTAL

..this form, together with app[illegible] fees, to: **Box ISSUE FEE**
Assistant Commissioner for Patents
Washington, D.C. 20231

MAILING INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE. Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Issue Fee Receipt, the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

LM61/0412

STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

OIPE JCG0 JUL 1 3 1999 PATENT & TRADEMARK OFFICE

Note: The certificate of mailing below can only be used for domestic mailings of the Issue Fee Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing.

Certificate of Mailing

I hereby certify that this Issue Fee Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/782,889	01/10/97	074	PEESO, T	2764	04/13/99

First Named Applicant: SHANNON, 35 USC 154(b) term ext. = 0 Days.

TITLE OF INVENTION: SYSTEM AND METHOD FOR OPTICAL EVALUATION OF GEMSTONES

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
3 1644.0010000	702-035.000	R81	UTILITY	YES	$605.00	07/13/99

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363). Use of PTO form(s) and Customer Number are recommended, but not required.

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" indication form PTO/SB/47) attached.

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents, OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Sterne, Kessler, Goldstein & Fox P.L.L.C.
2 ____
3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)
PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropiate when an assignment has been previously submitted to the PTO or is being submitted under separate cover. Completion of this form is NOT a subsititue for filing an assignment.

(A) NAME OF ASSIGNEE Diamond Technologies, Inc.

(B) RESIDENCE: (CITY & STATE OR COUNTRY) Macon, Georgia

Please check the appropriate assignee category indicated below (will not be printed on the patent)
☐ Individual ☐ corporation or other private group entity ☐ government

4a. The following fees are enclosed (make check payable to Commissioner of Patents and Trademarks):
☒ Issue Fee
☒ Advance Order - # of Copies 10

4b. The following fees or deficiency in these fees should be charged to:
DEPOSIT ACCOUNT NUMBER 19-0036
(ENCLOSE AN EXTRA COPY OF THIS FORM)
☐ Issue Fee
☐ Advance Order - # of Copies ____

The COMMISSIONER OF PATENTS AND TRADEMARKS IS requested to apply the Issue Fee to the application identified above.

(Authorized Signature) [signature] (Date) 7/13/99

Edward J. Kessler, Reg. No. 25,688

NOTE; The Issue Fee will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the Patent and Trademark Office.

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Publishing Division

07/14/1999 VVAN22 00000159 08782889
01 FC:242 605.00 OP
02 FC:561 30.00 OP

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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMIT THIS FORM WITH FEE.

PTOL-85B (REV.10-96) Approved for use through 06/30/99. OMB 0651-0033

Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	
Paul T. Shannon, Sr.	Art Unit: 2764
Appl. No. 08/782,889	Examiner: Tom Peeso
Filed: January 10, 1997	Atty. Docket: 1644.0010000
For: **System And Method For Computerized Evaluation of Gemstones (Amended)**	**Batch No. R81**

Amendment Under 37 C.F.R. § 1.312(a)

Attn: Box Issue Fee

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Submitted herein is an Amendment Under 37 C.F.R. § 1.312(a). As payment of the issue fee has not yet been made or is filed herewith, Applicant respectfully submit that filing under paragraph (a) of 37 C.F.R. § 1.312 is proper. (M.P.E.P. § 714.16.)

It is believed that extensions of time are not required beyond those that may otherwise be provided for in documents accompanying this Amendment. However, if additional extensions of time are necessary to prevent abandonment of this application, then such extensions of time are hereby petitioned under 37 C.F.R. § 1.136(a), and any fees required therefor are hereby authorized to be charged to our Deposit Account No. 19-0036.

Please enter the following Amendment:

In the Title:

System And Method For Computerized Evaluation of Gemstones

Remarks

The foregoing Amendment adds no new matter. The amendment is submitted to correspond the title more closely to the claimed invention. Accordingly, Applicant respectfully requests that this Amendment be entered.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Edward J. Kessler
Attorney for Applicant
Registration No. 25,688

Date: 7/13/99

1100 New York Avenue, N.W.
Suite 600
Washington, D.C. 20005-3934
(202) 371-2600

EJK:nh
P:\USERS\NHARRIS\egroup\Ejk\1644.0010000amendment

Diamond Grading Technologies LLC
6136 Frisco Square Blvd, Suite 385
Frisco, TX 75034

April 12, 2011

U.S. PATENT AND TRADEMARK OFFICE
P. O. Box 1450
Alexandria, VA 22313-1450

Re: Notice of Loss of Entitlement to Small Entity Status
U. S. Patent No. 5966673

To Whom It May Concern:

Pursuant to 37 CFR 1.27 and 1.33(b), please consider this letter Notification of Loss of Entitlement to Small Entity Status for the above referenced patents.

Very truly yours,

Matthew Vella
Registration No. 50,204

PTO/SB/45 (08-07)
Approved for use through 04/30/2009. OMB 0651-0016
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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MAINTENANCE FEE TRANSMITTAL FORM

(Do not submit this form electronically via EFS-Web)

Address to:
U.S. Patent and Trademark Office
P.O. Box 979070
St. Louis, MO 63197-9000

- OR -

Fax to: 571-273-6500

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to "United States Patent and Trademark Office, P.O. Box 979070, St. Louis, MO 63197-9000" on 5/5/11 05/11/2011 DALLEN 00000008 5966673

Signature [signature] 2055.00 OP

Typed or printed name Cheryl Willeford

Received US Bank
MAY 09 2011
Gov't. LBX Operations

Enclosed herewith is the payment of the maintenance fee(s) for the listed patent(s).

1. ☑ A check for the amount of $ 2,055.00 for the full payment of the maintenance fee(s) and any necessary surcharge is enclosed.
2. ☐ Payment by credit card. Form PTO-2038 is enclosed.
3. ☐ The Director is hereby authorized to charge $ ________ to cover the payment of the fee(s) indicated below to Deposit Account No. ________.
4. ☐ The Director is hereby authorized to charge any deficiency in the payment of the required fee(s) or credit any overpayment to Deposit Account No. ________.

* Information required by 37 CFR 1.366(c) (columns 1 & 2). Information requested under 37 CFR 1.366(d) (columns 3, 4, & 5)

Item	Patent Number* Column 1	U.S. Application Number* [e.g., 06/555,555] Column 2	Maintenance Fee Amount (37 CFR 1.20 (e)-(g)) Column 3	Surcharge Amount (37 CFR 1.20(h)) Column 4	Payment Year (select one below) Column 5: 3.5 yrs	7.5 yrs	11.5 yrs
1	5966673	08/782889	2,055.00				
2							
3							
4							
5							

THIS IS AN ADDITIONAL PAYMENT FOR LARGE ENTITY.
SMALL ENTITY RATE PREVIOUSLY PAID.

Subtotals: Columns 3 & 4

Total Payment 2,055.00

☐ ___ additional sheets attached for listing additional patents.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on Form PTO-2038.

Respectfully submitted, **

Customer's Signature: ________

Customer's Name: ________ Registration Number, if applicable: ________

Telephone: ________ Fax: ________

Note: All correspondence will be forwarded to the "Fee Address" or to the "Correspondence Address" if no "Fee Address" has been provided. See 37 CFR 1.363.

Payment of small entity fee is appropriate if small entity status still exists, see 37 CFR 1.27(g). To establish small entity status or to change status from small to large entity, a written assertion is required. See 37 CFR 1.27 and 1.33(b).

** WHERE MAINTENANCE FEE PAYMENTS ARE TO BE MADE BY AUTHORIZATION TO CHARGE A DEPOSIT ACCOUNT, BOTH THE NAME AND SIGNATURE OF AN AUTHORIZED USER ARE REQUIRED.

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STERNE KESSLER GOLDSTEIN & FOX
1100 NEW YORK AVENUE NW
SUITE 600
WASHINGTON DC 20005-3934

MAILED

JUN 20 2011

OFFICE OF PETITIONS

In re Patent No. 5,966,673 :
Issued: October 12, 1999 :
Application No.: 08/782,889 : NOTICE
Filed: January 10, 1997 :
Attorney Docket No: **1644.0010000** :

This is a notice regarding your request for acceptance of a fee deficiency submission under 37 CFR 1.28. On September 1, 1998, the Court of Appeals for the Federal Circuit held that 37 CFR 1.28(c) is the sole provision governing the time for correction of the erroneous payment of the issue fee as a small entity. **See DH Technology v. Synergystex International, Inc. 154 F.3d 1333, 47 USPQ2d 1865 (Fed. Cir. Sept. 1, 1998).**

The Office no longer investigates or rejects original or reissue applications under 37 CFR 1.56. **1098 Off. Gaz. Pat. Office 502 (January 3, 1989)**. Therefore, nothing in this Notice is intended to imply that an investigation was done.

Your fee deficiency submission under 37 CFR 1.28 is hereby **ACCEPTED**.

This application is no longer entitled to small entity status. Accordingly, all future fees paid in this application must be paid at the large entity rate.

Inquiries related to this communication should be directed to the undersigned at (571) 272-3222.

/Kenya A. McLaughlin/

Kenya A. McLaughlin
Petitions Attorney
Office of Petitions

cc:
Matthew Vella
Diamond Grading Technologies, LLC
6136 Frisco Square Blvd.
Suite 385
Frisco, TX 75034

PATENT APPLICATION FEE DETERMINATION RECORD

Effective October 1, 1996

Application or Docket Number: 08/782889

CLAIMS AS FILED - PART I

FOR	NUMBER FILED (Column 1)		NUMBER EXTRA (Column 2)	SMALL ENTITY RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
BASIC FEE					385.00	OR		770.00
TOTAL CLAIMS	13	minus 20 =	* 0	x$11=		OR	x$22=	
INDEPENDENT CLAIMS	3	minus 3 =	* 0	x40=		OR	x80=	
MULTIPLE DEPENDENT CLAIM PRESENT				+130=		OR	+260=	
				TOTAL	385	OR	TOTAL	770.00

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	* 56	Minus	** 13	= 36	x$11=	396	OR	x$22=	
Independent	* 8	Minus	*** 3	= 5	x40=	200	OR	x80=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE	596	OR	TOTAL ADDIT. FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x40=		OR	x80=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x40=		OR	x80=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 10/96)

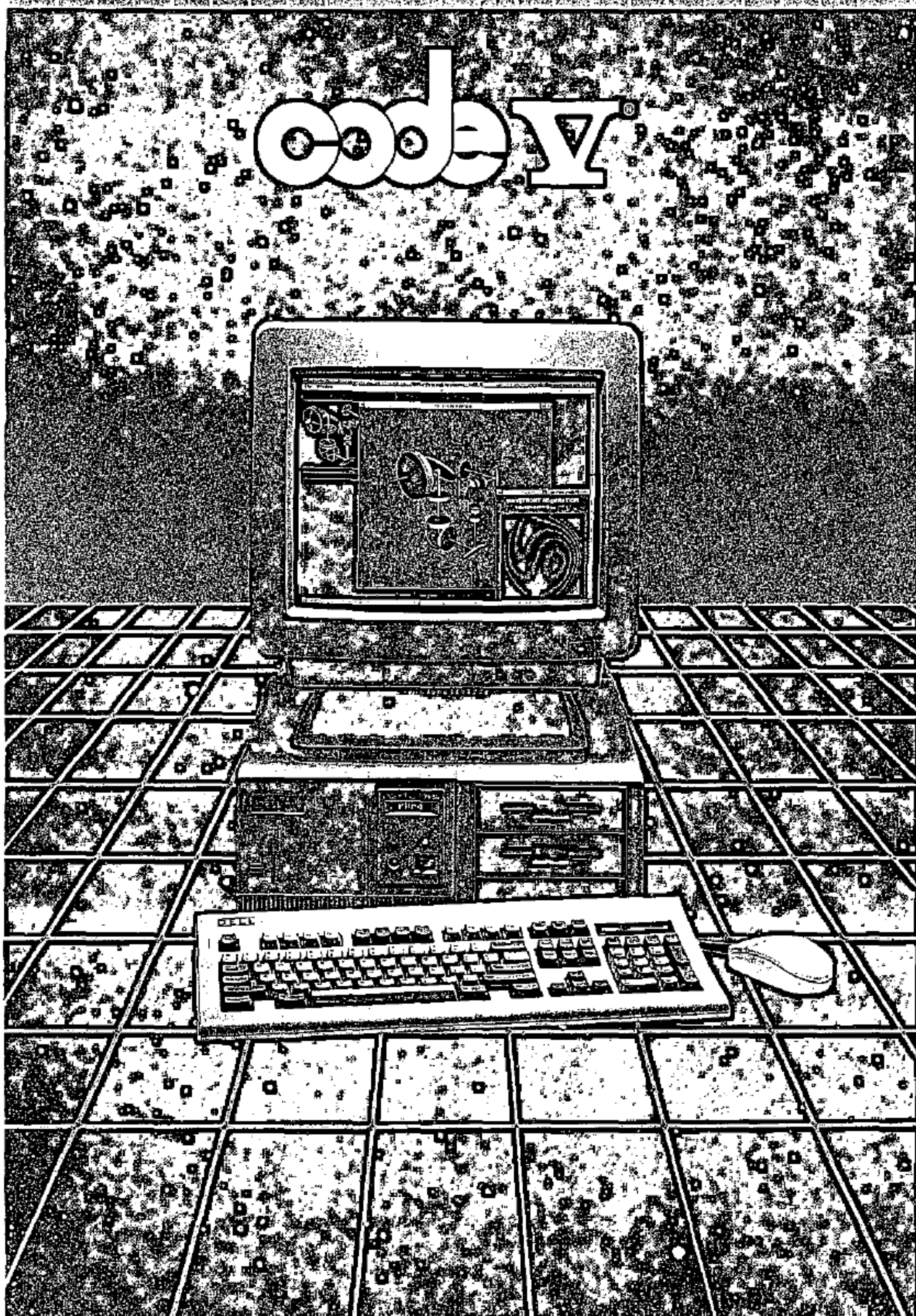
*U.S. Government Printing Office: 1996 - 413-288/49191

Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

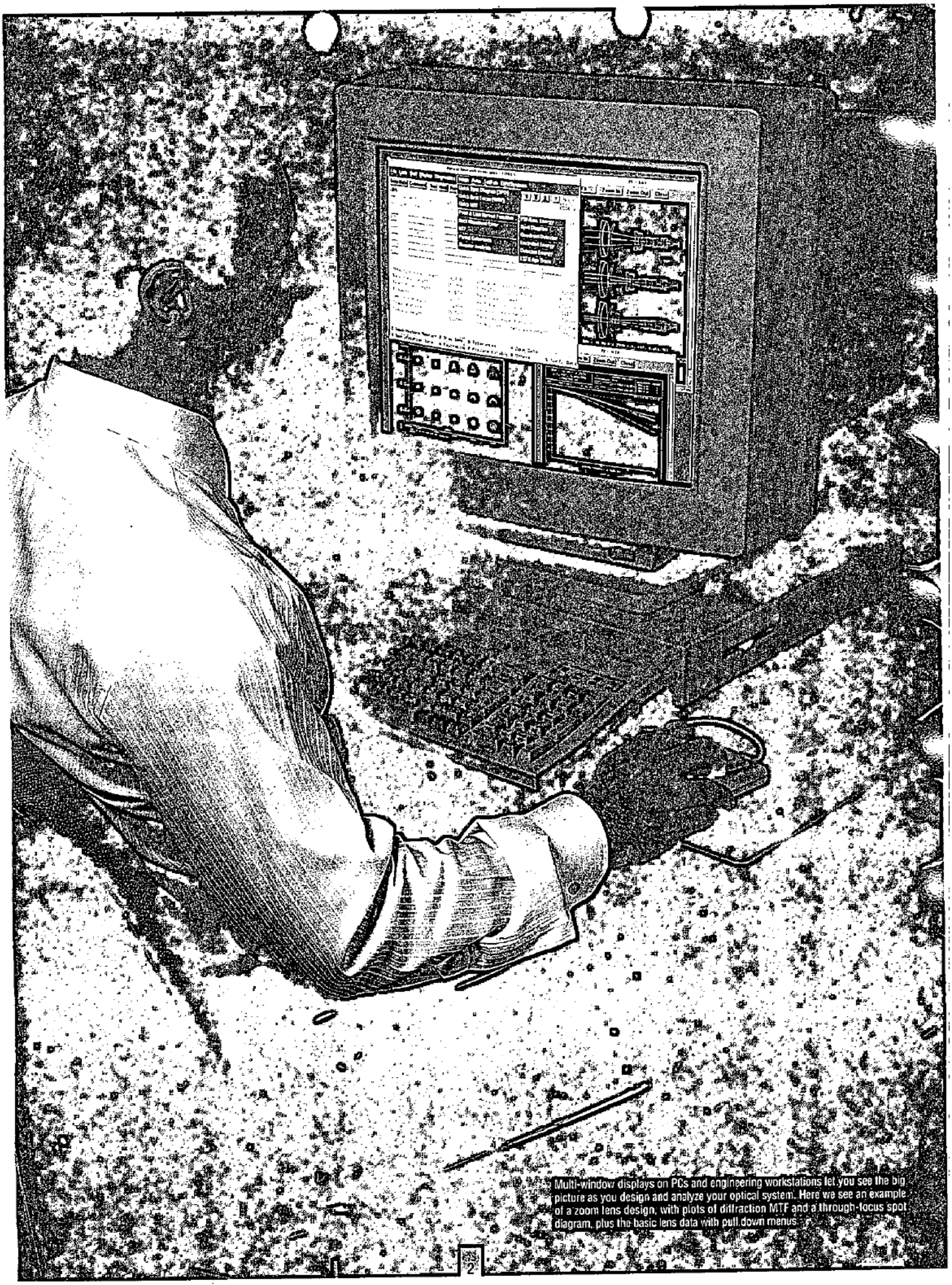
Document No. AR1
Appl. No. 08/782,889

OPTICAL RESEARCH ASSOCIATES

OPTICAL DESIGN AND ANALYSIS SOFTWARE



"CODE V Improves Your Image."



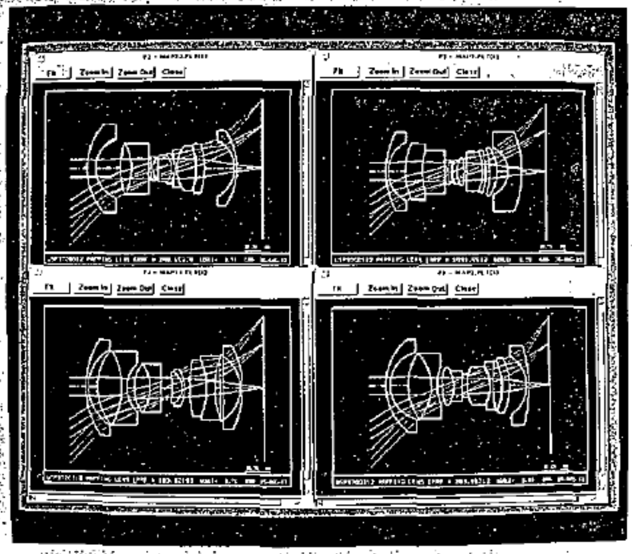
Multi-window displays on PCs and engineering workstations let you see the big picture as you design and analyze your optical system. Here we see an example of a zoom lens design, with plots of diffraction MTF and a through-focus spot diagram, plus the basic lens data with pull down menus.

E

• Innovation and quality • Superior productivity

• First-class support • Experience and commitment

To succeed, you need the right tools, productive tools. Your time is simply too valuable to accept less. CODE V is the most productive optical software you can use, period.



Global Synthesis is a major technological breakthrough in global optimization. GS will find and save multiple, alternate solutions to an optimization problem, with each solution locally optimized and meeting all imposed constraints. Shown are four different forms found during one optimization run on a low distortion mapping lens with 59 variables and over 30 active constraints.

The Standard

CODE V is the most comprehensive optical design and analysis program in the world and has set the standard for programs of its type for many years. Hundreds of organizations around the world use it to design and analyze optical systems for countless applications. These applications range from laser printers to satellite reconnaissance systems, from infrared sensors to complex ultraviolet optical systems for integrated circuit fabrication.

Consider the following good reasons why so many engineers and scientists have selected CODE V as their performance standard.

Innovation & Quality

Innovative concepts and quality execution are two primary reasons CODE V users are so successful. Innovation has brought them such industry-leading features as:

- Zoom/multi-configuration optimization and analysis
- Environmental analysis
- MTF and RMS wavefront-based tolerancing
- User-defined constraints in optimization
- Comprehensive holographic/diffractive optical element modeling
- Optional menu-driven (mouse/keyboard) interface
- Solids modeling (including full-color smooth shaded solids)
- Interferometric interface and closed-loop computer-aided alignment
- Non-sequential surfaces for segmented, multi-path, and other unusual systems
- "Black box" lens modules for modeling systems based on measured properties
- Vector diffraction calculations including polarization effects and surface coatings
- Global Synthesis®, the first practical global optimization method for optical design

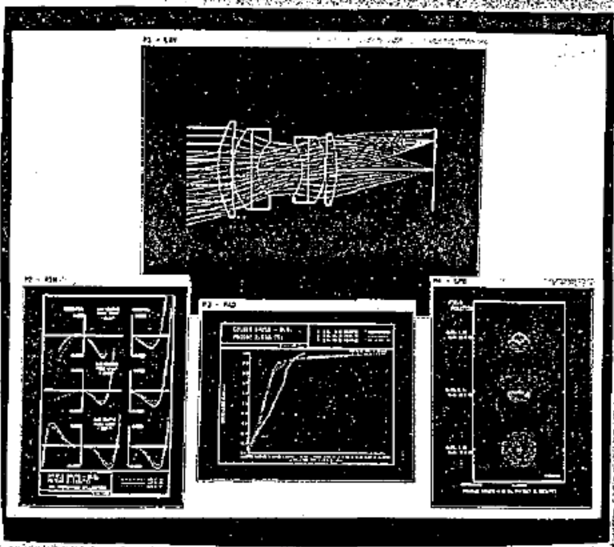
While we are proud of these and many other innovative features, we are prouder still of the quality, depth, and usefulness of CODE V's capabilities. We know our customers need to develop world-class products, so quality and reliability are the highest priorities in CODE V development and support.

Superior Productivity

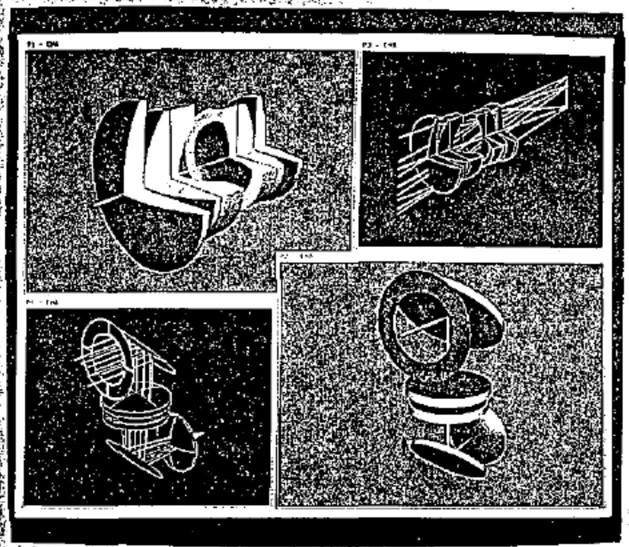
Optical design software should help you to achieve better results than you could otherwise attain. It should provide the fastest possible response to your customers' needs. That's what "productivity" means. All of the features of CODE V are designed with this fundamental objective in mind.

Ease of Use – CODE V's assumptions, structure, and commands are designed to be fast and "natural" to the engineer or scientist using it on a regular basis. To make its many features accessible to new or occasional users, CODE V also includes a modern, menu-driven graphical user interface (GUI). With this advanced GUI interface, pull-down menus and buttons help you quickly navigate through the program, using the mouse or keyboard. Fill in a few values in the input window to define your calculation and click the GO button — it's that easy. Special "quick menus" let you do frequent tasks with just a single click. Multiple windows for input, output, and graphics (with full zoom/pan control) help you organize and control your work. Switch modes anytime to directly access the power of CODE V's commands and Macro-PLUS™ programming language.

Database/Modeling Features – All the data used in modeling your lens - from radii and glass names to coatings, decenters, tolerance values, polarization parameters, and more - are referred to as the "lens database." The top level of CODE V is the "lens data manager" (LDM),



Geometrical optical analyses still are important for those systems which are not limited by diffraction. CODE V has many geometrical image evaluation options, including ray trace curves, radial energy distribution, and spot diagrams, as shown here. These outputs show examples of CODE V report-ready graphics.



CODE V provides the user with extensive and flexible lens drawing capabilities. Shown here are solid model drawings with smooth shading of a Double Gauss lens and of an infrared scanning system. The same systems are also displayed using the VIEW option, which offers customized 2-D or 3-D lens drawings including hidden line removal.

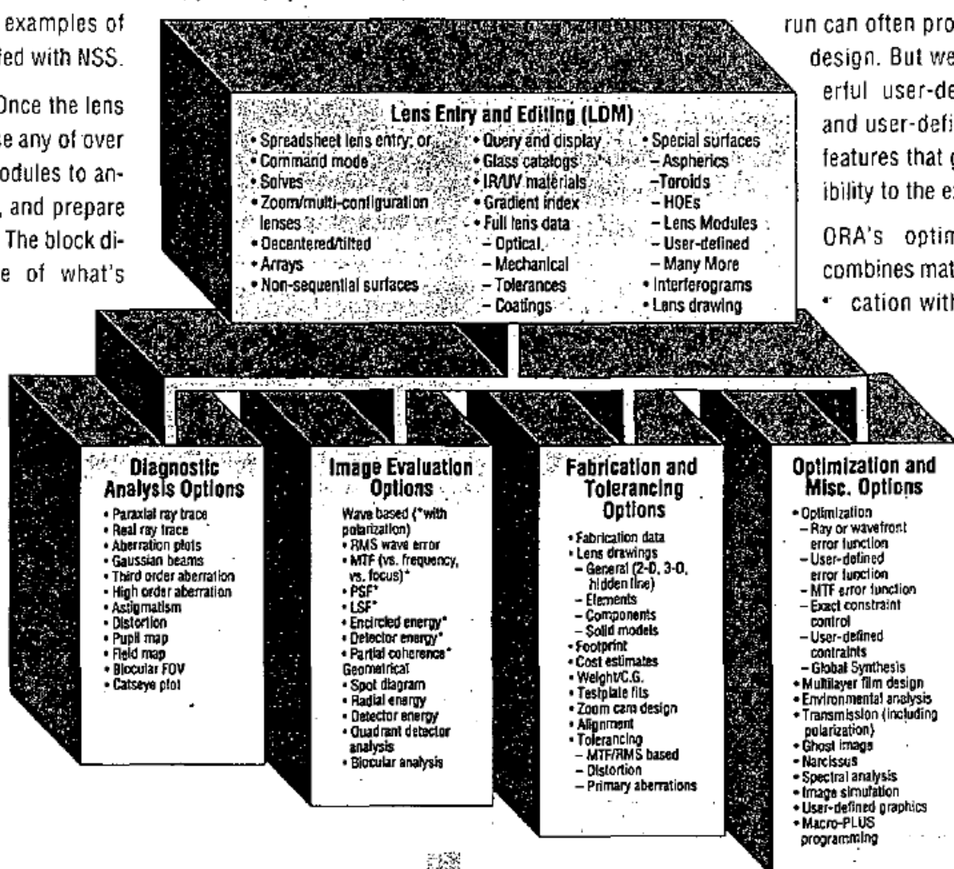
which gives you full control over the contents of this lens modeling database. Editing this database is as easy as filling in the cells of a spreadsheet.

One of CODE V's most powerful features is non-sequential surface (NSS) modeling. In NSS models, optical elements are defined in global coordinates and ray path sequences are determined by CODE V. Segmented windows, corner cube reflectors, prisms, optical fibers, and light pipes are a few examples of systems that can be modeled with NSS.

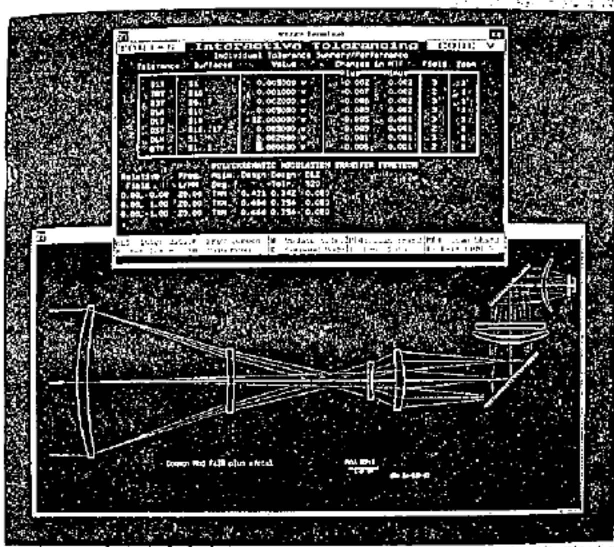
Optical Calculations – Once the lens data is defined, you can use any of over 40 specialized program modules to analyze, optimize, tolerance, and prepare your optics for fabrication. The block diagram shows the scope of what's available — everything from aberration curves to lens cost data, MTF to Gaussian beams, paraxial ray trace to automatic testplate fitting. Three of the most powerful features are:

Optimization – With a library of patent-derived starting points, simple default operation, and pre-defined constraints, new users can get useful optimization results in minutes. And thanks to a remarkably versatile default error function and exact constraint control, such a simple run can often produce a reasonable design. But we also supply powerful user-defined constraints and user-defined error function features that give unlimited flexibility to the experienced user.

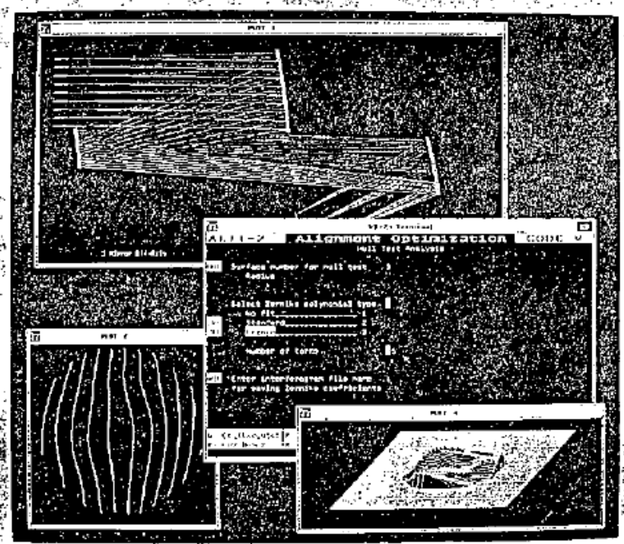
ORA's optimization research combines mathematical sophistication with extensive design



CODE V major features summary (space does not permit the inclusion of many capabilities and important details).



Interactive, ray-based MTF tolerancing is a powerful simulation tool that allows you to quickly refine your tolerance budget. Changes in tolerance values are evaluated instantly to show the effect on your system performance. You save time and money by addressing production problems before production begins.



Using measured system interferograms, alignment optimization predicts assembly parameter adjustments for an optical system that has already been built. It is particularly useful for aligning systems without rotational symmetry.

experience to make such advanced features as polychromatic diffraction MTF optimization practical, powerful, and easy to use. And CODE V also includes Global Synthesis (GS), the first global optimization tool for lens design that can handle constrained optimization problems of 60 variables or more. GS is a practical tool — not a research project — that helps you find real solutions to real design problems, better and faster. And GS is easy to use — a single command turns a standard optimization run into a global run.

Tolerancing – ORA's technical leadership in optical tolerancing saves your company money by minimizing your optical fabrication costs. CODE V's tolerance method is based on *measurable* performance qualities (MTF, RMS wavefront error, distortion), and it even simulates compensating adjustments done during assembly. Automatic error budgeting and powerful statistical analysis help to make often massive data more manageable. The happy result: production problems are solved *before* you go into the shop.

Interferogram Interface – ORA's interferogram interface is a major contribution to optical fabrication support. It allows measured surface or wavefront data to be used as part of a CODE V lens model. Wavefront data can also guide the alignment of an already-built optical system. CODE V predicts the needed alignment parameter changes even without knowing what the errors are in the system.

Graphic Features – CODE V was one of the first optical programs to include extensive graphics. "Report-ready" graphics have always been one of its hallmarks. Another first was our use of solid modeling techniques (color "smooth shaded" 3-D solid views are particularly effective in presentations). CODE V has a variety of lens picture display methods to help you in visualizing complex systems. Automatic lens pictures let you instantly see changes made in interactive lens editing or during optimization.

Connectivity and Open Architecture – CODE V, the most powerful optics program available, is also able to communicate with other systems to meet a variety of special needs. Connectivity refers to its ability to transfer and accept information. For example, you can export 3-D lens pictures to CAD programs via IGES files, or export any program graphic in DXF or Encapsulated PostScript formats. Measured interferometric data (from Zygo or WYKO interferometers, as well as NASTRAN-simulated surface deformation data) can be imported through INT files.

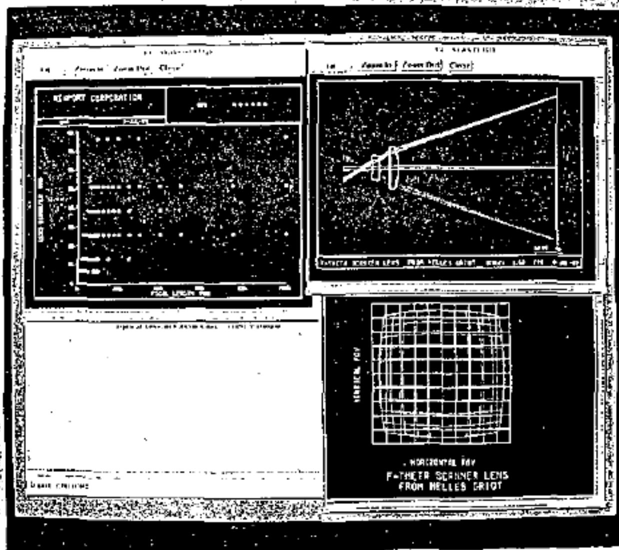
Open architecture gives CODE V users flexibility. Using the built-in Macro-PLUS™ language, users can extend or customize CODE V calculations. Macro-PLUS is a high-level programming language that offers full access to the lens database as well as such programming constructs as variables, expressions, loops, tests, input/output, spreadsheet-like Worksheet Buffer™, and file handling. Applications range from simple lists of commands to automated control of CODE V options to completely new calculations and graphical outputs. ORA also supplies a large library of ready-to-use standard macros.

Other user-definable features include surface equations, index gradients, optimization error functions, and graphics drivers. Building on these features, ORA is committed to making CODE V even more versatile in the future.

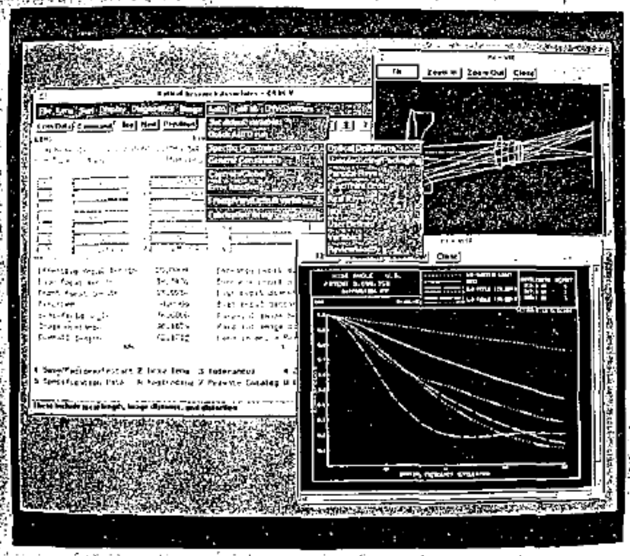
First-Class Support and Updates

Optimum engineering solutions require more than a program installed on your computer. You should expect first-class technical support when you need it — plus regular program updates, installation assistance, training options, and documentation that is both complete and useful.

This support should not be an afterthought or a secondary, part-time activity for an otherwise busy programmer. Your time is too valuable



Macro-PLUS programming allows you to extend CODE V's capabilities. ORA supplies over a hundred macros with CODE V. Shown are the DIST macro to plot the full field distortion of a lens (in this case a laser scanning lens) and the SEARCH macro for finding the manufacturer's catalog lens most closely fitting specified requirements for focal length and diameter.



CODE V has an easy to use graphical user interface which uses the mouse, pull down menus, and command buttons to help you confidently navigate through the program. CODE V graphics can be zoomed with mouse clicks or mouse selection, and the enlarged picture can be panned with scroll bars.

to rely on a program with marginal or nonexistent support. That's why every CODE V license includes these essential services:

Technical Support and Training – "First-class" is not just a slogan at ORA. Technical support is critically important, so we offer a toll-free support "hot line" (U.S. and Canada) and a full-time technical support staff, all with optical design experience, to help you when questions arise. If you are overseas, we can respond overnight via fax or e-mail. On-site installation help is available (though seldom needed). Several forms of training are offered, including regular seminars several times a year in the U.S., with additional seminars in Europe and Japan. On-site seminars are also available.

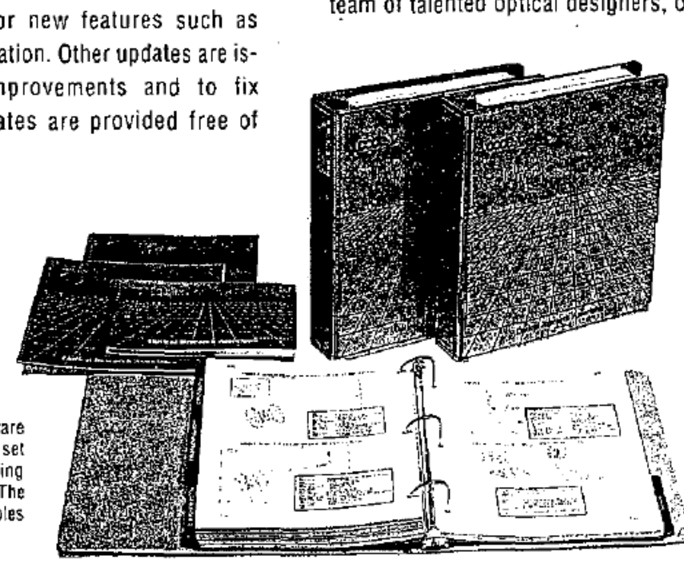
Program Updates – Extensive program updates are issued approximately once a year to add major new features such as interferometric analysis and MTF optimization. Other updates are issued as needed to make minor improvements and to fix customer-reported problems. All updates are provided free of charge as a standard part of the license.

Documentation, Tutorials, Newsletter – Our tutorial and reference materials are complete, easy to use, and include many examples (though many customers report that our detailed on-line help greatly reduces their dependence on manuals). Regular manual updates and quarterly newsletters help you keep your CODE V knowledge up-to-date.

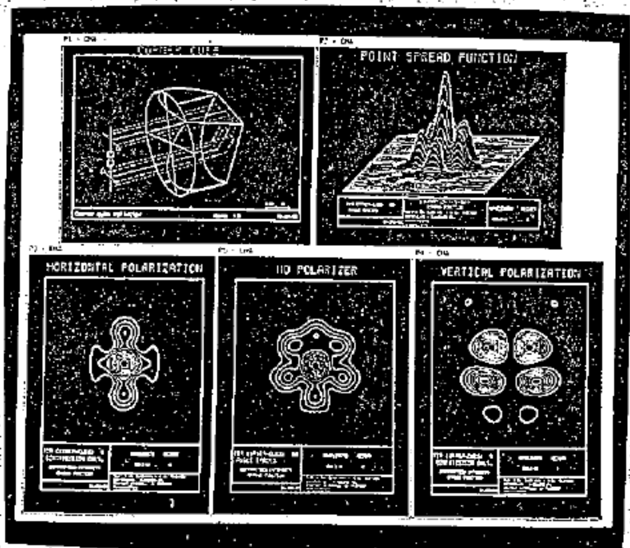
ORA's Special Advantage

Experience – Someone once said, "There is no substitute for experience." At ORA, we bring more experience to optical design and the creation of optical design software than any other organization of our kind. And the result is greater success for our customers. Our team of talented optical designers, optical engineers, and software professionals combine their efforts to support two closely related business areas:

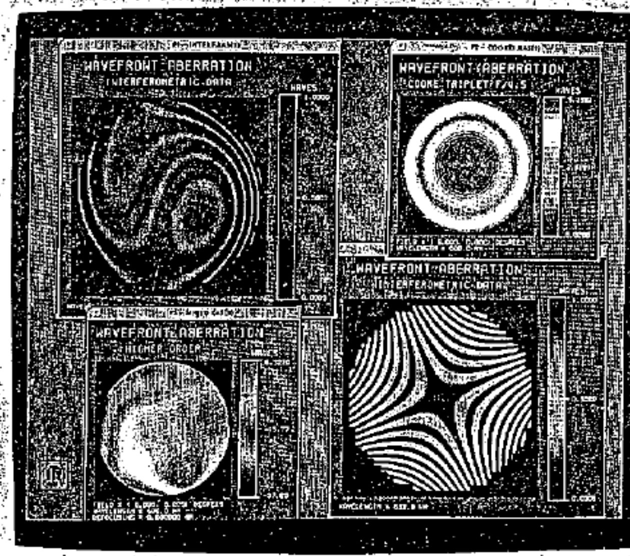
- Optical software
- Optical systems engineering and lens design



CODE V also sets the standard in optical software documentation. A complete CODE V documentation set includes the three volume Reference Manual, Prompting Guide, Introductory Users Guide, and Test Drive. The documentation is extensive and includes many examples to demonstrate all aspects of CODE V usage.



Another powerful CODE V feature is polarization modeling for diffraction based options, such as PSF and MTF. These diffraction point spread function (PSF) plots show the polarization effects of light passing through a corner cube prism, with and without linear polarizers placed in the optical path.



High resolution color workstations allow dramatic display and analysis options, such as shaded contour maps of wavefront, PSF, and interferogram data. Such visualization tools help turn abstract and often massive amounts of data into useful information for design, engineering, and decision making.

Getting Access to CODE V

CODE V License – Because continuing customer service and regular program updates are such important parts of our product, CODE V is not sold — it is provided under several license forms, all of which include monthly or annual license fees, or on a "pay as you go" network service. CODE V can be installed in your facility on 486 or Pentium-based PCs (Windows 3.1 or later), on Sun SPARCstations, or on any of Digital Equipment Corp.'s VAX/VMS workstations and computers. See our price sheet and platform-specific data sheets for more details.

ORA Network – When the need for CODE V is moderate or occasional, ORA's Network Service may be the ideal solution. An international data communications network allows local telephone access from nearly anywhere. Only a modem and terminal (or PC/Macintosh with terminal emulator) are required.

Call or Write ORA Today - Find out how CODE V, the world standard in optical design and engineering software, can start working for you.

code V®

OPTICAL RESEARCH ASSOCIATES

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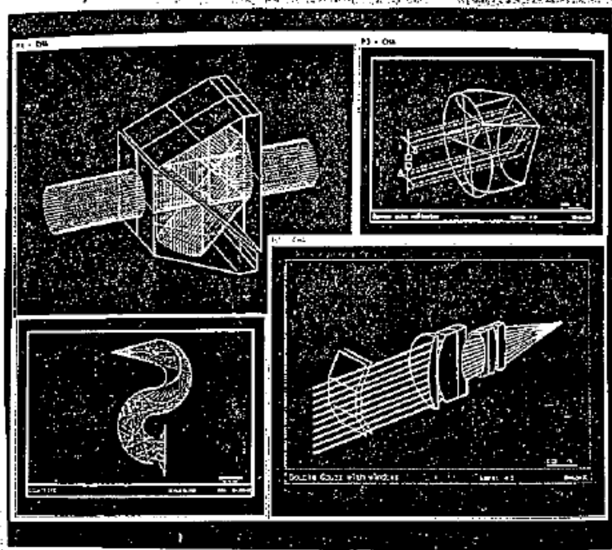
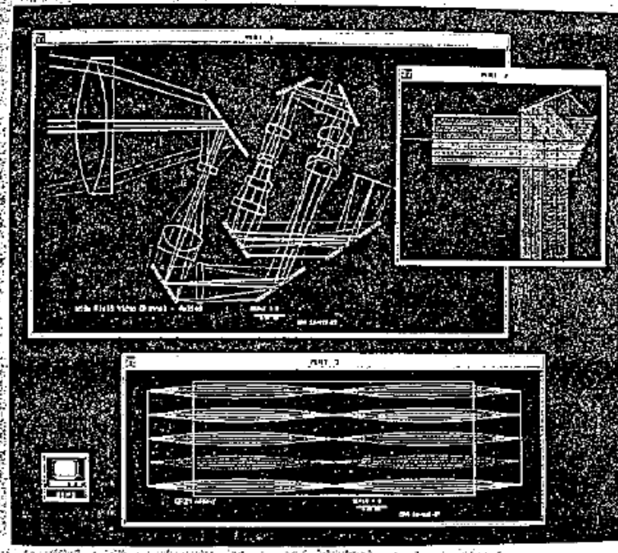


CODE V's non-sequential surface (NSS) capability greatly extends the range of systems that can be modeled. The NSS ray trace dynamically determines the ray paths within globally-specified NSS surface ranges. Systems such as light pipes, corner cubes, and segmented windows can be modeled efficiently and effectively.



CODE V graphical output makes effective use of color workstations and terminals. In many optical systems, the use of color helps you visualize your optical system and light paths more clearly.

One of ORA's most important strengths is the synergistic interplay between our design and software development efforts. Our engineers provide ideas, guidance, testing, and feedback for the development of CODE V. In turn, CODE V provides them with the tools to solve an incredible volume and variety of design and engineering problems routinely and cost-effectively.

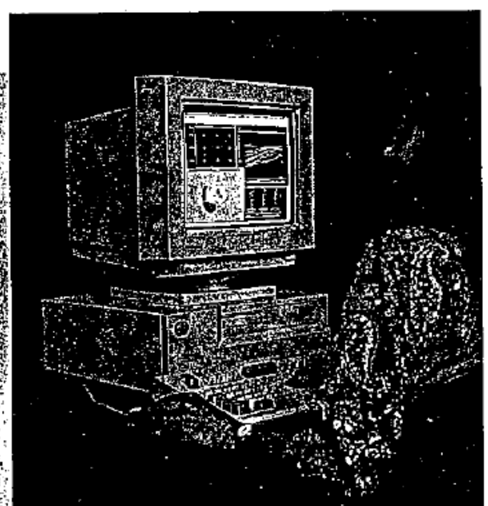
As an engineer or scientist, you may face a wide variety of optical design or analysis problems and challenges. You need a correspondingly diverse range of software capabilities to meet those challenges. It takes a software supplier who understands the problems you face to effectively develop those capabilities.

Our engineers have proven CODE V's abilities on a large variety of optical systems in production or in use today. A few examples:

- Optical disc lenses (audio, video, memory)
- 35 mm and video camera optics
- Laser scanner systems (bar code, laser printers, and others)
- Holographic head-up and helmet-mounted displays
- FLIR and other infrared systems
- Simulators
- Microlithography optical systems

Thanks to ORA's extensive design and engineering experience, we can fully appreciate the problems you face. As a result, we have created in CODE V a tool that meets these challenges head-on. The concept: an integrated package of optical programs, built on a common database and user interface, that addresses the full range of your optical needs. You shouldn't settle for less!

Commitment – We have long recognized that if you succeed, we succeed. Since our founding in 1963, ORA has consistently worked to make this happen. This commitment to customer success has helped us grow to be the largest optical consulting firm *and* the largest supplier of optical design software in the world. Our success has not dimmed our vision or reduced our determination to provide the best services and products possible. Given the expanding importance of optical technologies, we see a growing market for the skills and productivity tools we provide.



CODE V is available on the most popular models of engineering workstations: 486 and Pentium based PCs, SPARCstations from Sun Microsystems, and VAXstations from Digital Equipment Corporation.

COMPUTERS AND SOFTWARE

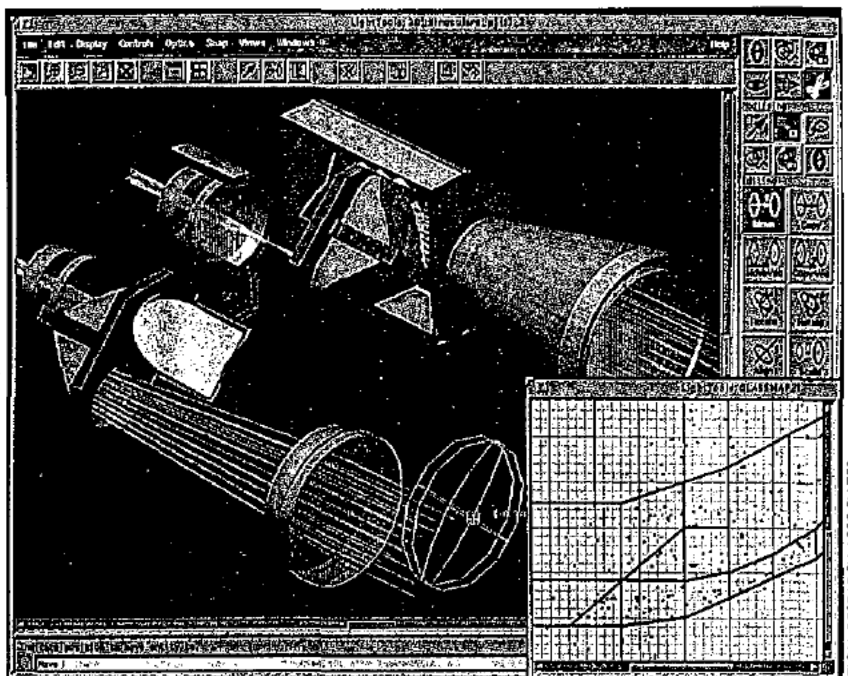
Laser Focus World

Three-dimensional modeling program simplifies optomechanical design

Optical engineers can construct and analyze systems of optical components as well as mechanical structures with LightTools, a three-dimensional (3-D) modeling program from Optical Research Associates (ORA, Pasadena, CA). Unlike traditional optical-design software in which systems are entered and evaluated as a series of surfaces, each system component is specified as a 3-D object that can then be manipulated in space through simple drag and drop operations. Nonsequential ray-tracing capabilities, including refraction, reflection, and amplitude splitting at each surface, allow the designer to introduce user-defined ray patterns into the system at any point and observe how the light is propagated. Currently the software runs on SUN Sparcstations; a version for Microsoft Windows is planned for mid-1995 release.

Components are either specified through the use of an icon toolbox containing common optical shapes or drawn using mouse-based, mechanical CAD-style operations. Mechanical and optical surfaces can be given refractive or reflective characteristics. They can also be specified as binary optics or diffraction gratings, requiring the software to simulate scattered light from surfaces.

Because each object in the program is a complete 3-D shape, the program is able to analyze the interaction of light with the entire component. For example, by making a lens edge reflective, the user can quickly determine if light reflected from that edge propagates through the system. This technique can be applied to the mechanical elements of the system such as lens barrels, retaining rings, or screw heads, allowing designers to assess their contributions to system obscuration or stray light.



OPTICAL RESEARCH ASSOCIATES

Both three-dimensional model of binoculars with light paths and cutaway of mechanical structure can be manipulated with LightTools; glass map in corner allows interactive graphical glass selection.

Fast track to real world solutions

John Tamkin of Polyscan Inc. (Tucson, AZ) worked with LightTools in the optomechanical design of his company's laser-based direct-imaging equipment, which is used to manufacture printed-circuit boards, multichip modules, and flat-panel displays. As in many industrial applications, space is critical in Polyscan's products, and designers frequently resort to complex folded optical paths in order to minimize system size. Using LightTools to model these systems, Tamkin has been able to quickly identify mechanical interferences in the ray path (see figure). Such obstructions can be difficult to visualize with traditional optical-design programs.

Once a rough optomechanical design is achieved by the optical designers, it is imported to AutoCad for refinement by mechanical engineers. Tamkin likes the capability of LightTools to transfer data to AutoCad through the DXF file format as a useful asset, although he would like to see this function further developed to include more sophisticated model parameters.

The ability to fully model both mechanical and optical structures of system prototypes allows designers to converge quickly on a real-world solution. "The software allows an optical-design team to explore mechanical constructs before turning the design over to the mechanical engineers," says Tamkin. Optical designers are thus able to come up with system configurations that the mechanical designers can use more readily.

Object-oriented approach

Researchers at the MIT Artificial Intelligence Laboratory (Cambridge, MA) have used LightTools in the design of eyeglass-mounted virtual-reality displays. Project member Phillip Alvelda was able to model the complete environment in which the system would operate, including the wearer's face and mechanical elements of the eyeglasses such as hinge screws. The program allowed him to analyze optical obscurations caused by facial features and pinpoint potential sources of glare or stray light. In Alvelda's opinion, no other currently available software would provide this capability while remaining easy to use.

Alvelda believes that the utility of the package stems from its object-oriented approach. "LightTools reflects how you work with real elements," he says. "Using it is just like constructing an actual prototype. It really allows you to spot potential problems in manufacturing, assembly, and operation before they occur." The MIT group may also use the program as a teaching tool, helping students visualize optical systems and understand how reshaping and adjusting elements affects system performance.

The ability to fully model both mechanical and optical structures of system prototypes allows designers to converge quickly on a real-world solution.

Probing for stray light

LightTools helped engineers at Ball Aerospace (Boulder, CO) design the Near-IR Camera Multi-Object Spectrometer (NICMOS) destined for use in the Hubble Space Telescope. Project engineer Michael Kaplan created the original optical design in ORA's CODE V design program. The file was then imported to LightTools, where mechanical structures were added to the model.

Stray light is a major concern in this tightly packaged, multipath system. Using the software, Kaplan introduced various ray sets to probe for potential stray light problems and test the effectiveness of different baffle designs. He found the ability to arbitrarily specify the reflectivity of any surface highly useful in identifying potential problems with specular reflection.

To improve the software in future releases, Kaplan suggests that ORA add the capability for importing objects that already exist in other CAD packages. By adding this feature and further refining the interface between LightTools and CODE V, he says, ORA could create a seamless development environment for optomechanical design.

Kristin Lewotsky
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A Building-Block Approach to Optical-Design Software

by Michael Hayford
and David Brown

After years of doing things the same old way, designers get a crack at 3-D modeling.

Despite advances in both the power and ease-of-use of commercial optical-design software over the past few years, the basic way in which systems are mathematically modeled in these programs remains fundamentally unchanged. This has largely limited their use to the traditional areas of optical-element design and optimization.

Here we'll examine a new approach that provides for three-dimensional system modeling and allows nonsequential ray tracing. Specifically, we'll describe how this type of program helps designers analyze nonimaging optics, such as illumination systems, as well as examine the effects of mounts and optomechanical components in traditional lens designs.

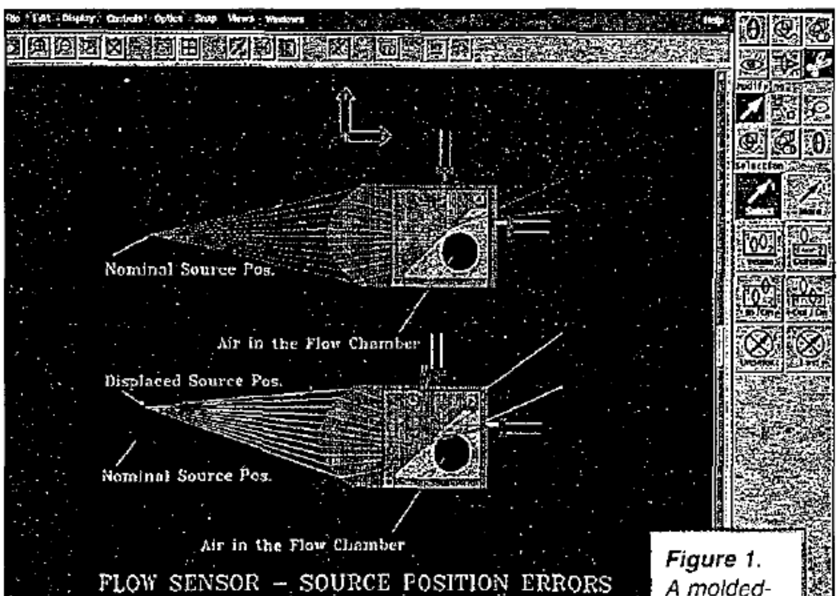

Figure 1. A molded-plastic fluid-flow sensor.

Stuck in the past

The conventional approach to optical design is to designate a system as a collection of surfaces separated by breaks of various indexes of refraction, and then to trace rays that propagate sequentially through the system from one surface to the next. There has been a general trend among optical-design software providers to allow for ever more sophisticated and complex surface geometries. In some cases, these programs even include the effects of components such as diffraction gratings or optical coatings. Until now, there has not been any significant departure from this basic method.

LightTools, a new software from Optical Research Associates in Pasadena, Calif., approaches systems as a collection of 3-D objects, having both optical and nonoptical surfaces, such as edges, flanges, mounting holes and so forth. Additionally, more mechanical structures such as retainer rings, lens mounts, spacers and barrels can be included. Model construction is aided by a toolbox of commonly required shapes and the ability to stretch and resize components or surfaces with a mouse.

Once the model is built, the program can perform nonsequential ray tracing. Arbitrary bundles of rays can be introduced into the optical system at any point or orientation and their propagation through the system studied.

This approach can be useful in analyzing stray light, flare, ghost imaging and obstructions in the image path because it considers the optical effects of all system objects. In addition, the program can trace rays regardless of the order in which they encounter surfaces.

The attractive alternative

For very high-volume production, molded plastic optics can offer an attractive economic alternative to glass. Furthermore, the manufac-

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turing process lends itself to producing complex part geometries where mechanical functionality can be included along with optical surfaces. However, this same part complexity can make such systems difficult to analyze rigorously because light can propagate through what are intended to be purely mechanical features as easily as it can through those meant tc be optical.

A molded-plastic fluid-flow sensor is an example of just such a product. The LightTools model of one possible design is shown in Figure 1. In a single unit, it includes a cylindrical aspheric lens for focusing a light source, a 45°-fold total-internal-reflection mirror, through holes for mounting and mechanical features for detector mounting. This fairly complex geometry is quickly built up by employing a library of common shapes, together with the ability to perform Boolean operations (intersection, subtract, union, etc.) on surfaces.

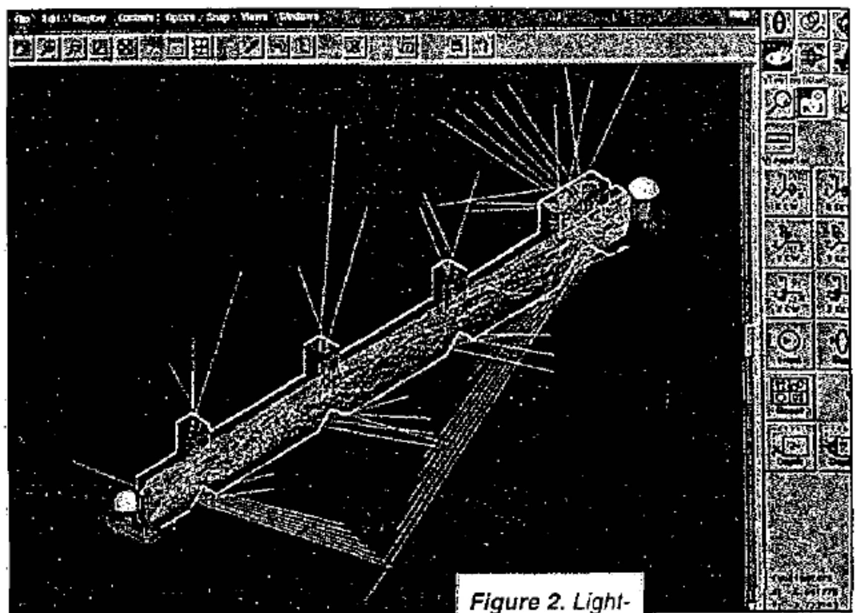
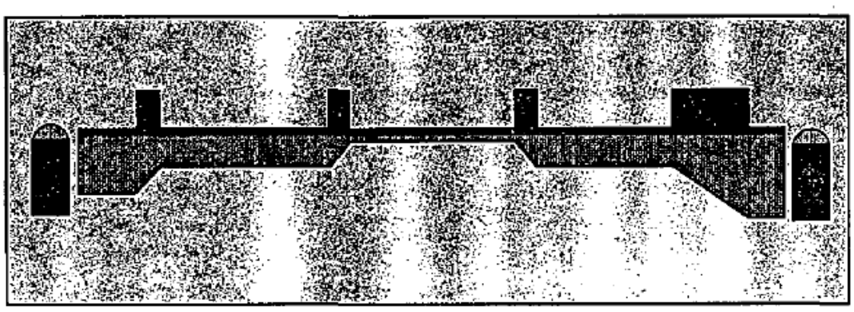
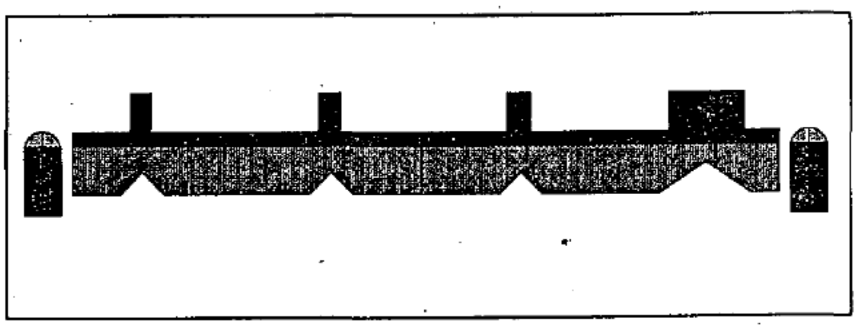
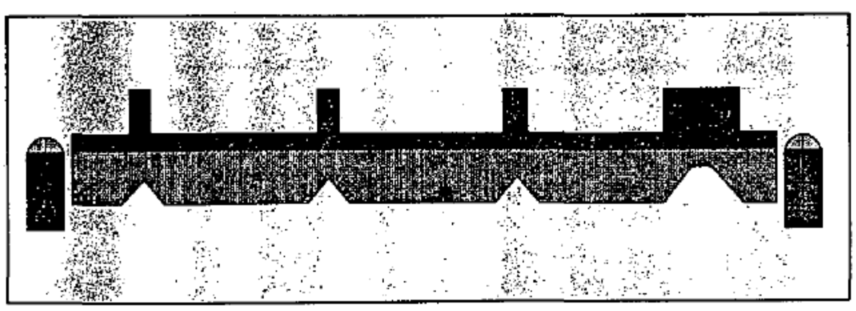


Figure 2. Light-pipe design starting point.







Three stages in design of an automated light pipe.

Changing the focus

In operation, when liquid is present in the flow chamber, total internal reflection is defeated and the source is focused onto the second detector. This is modeled by changing the refractive index of the cavity.

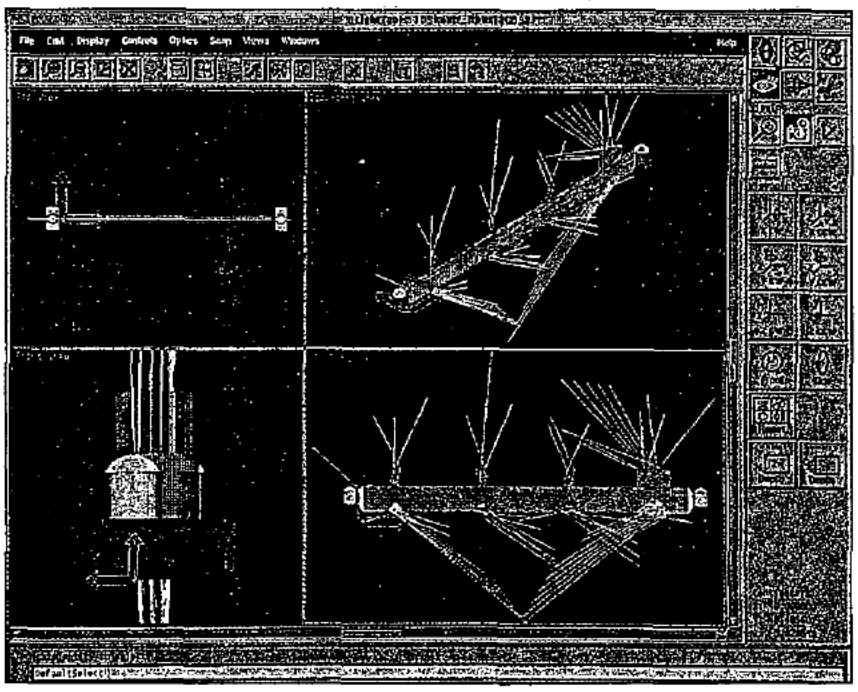
Simply tracing rays through the system quickly establishes the sensitivity of the system to manufacturing and assembly tolerances. For example, when the source is displaced from its nominal position, light no longer reaches the correct detector and some is even directed to the wrong detector.

Tracing fans of rays through the system backwards — that is, starting rather than ending at each of the detectors — is a valuable tool to determine the system's sensitivity to stray light. Possible paths for stray light from external sources that can enter the system and propagate through to the detectors can easily be seen by using this method.

Thick plastic waveguides (light pipes) are frequently used to pipe light from a source to an output surface, such as a button or graphic, in automotive interiors. This technique minimizes the number and cost of sources. The goal is typically to provide uniform illumination, but it is complicated by the geometry of the system, which may require the light to travel around PC boards and wiring contacts and may necessitate illuminating movable objects such as gauges or sliding switches.

There has been a general trend among optical design software providers to allow for ever more sophisticated and complex surface geometries.

John Van Derlofske, David Lamb and Lloyd Hillman at the University of Alabama in Huntsville are investigating approaches for illuminating the in-dash display systems of Chrysler automobiles. In the past, design of such systems required the construction and testing of actual working prototypes. The design would then be modified and the cycle repeated until satisfactory results were obtained. This process is both expensive and time-consuming. The group found LightTools effective for producing "virtual prototypes," in which the part is constructed and its performance accurately modeled only on the computer, thus reducing the time and expense of the prototype cycle.



Two bulbs, four buttons

Figure 2 shows the starting point in the design of a light pipe intended to use two bulbs to illuminate four buttons on a car radio; the first three buttons contain a single character, and the final button requires that four characters be illuminated. The bulbs are placed so that other pipes can be positioned near them to take light to other parts of the instrument.

The initial design essentially consists of three 45°-fold mirrors for the single-character graphics, and one 30°-fold mirror for the multicharacter graphic. The larger mirror is set at a shallower angle to minimize the height of the light pipe and the graphic's greater length. In each case, to direct light impinging upon the surface in the desired direction, total internal reflection is used.

To analyze this system, the bulbs were modeled as objects with the same shape as the outer envelope of the actual bulb; ray fans with 129 rays each were then traced from several different starting points on the bulbs' surfaces. While this is in no way a rigorous, radiometric analysis, it still allows the designer to examine the basic characteristics that the system will display when it is actually operating.

A series of subsequent analyses of ray traces showed that light was unevenly distributed because the lighting was not uniform. Using the program to add components and change their orientation eventually resulted in an optimal design.

While further analysis and refinement of the design will be required using software that provides more accurate radiometric analysis, the process to this point took only a few hours and did not require the construction of any actual prototypes. Several weeks might have been needed to produce and test actual prototype units if the program had not been used.

An added dimension

The program adds another dimension of capability to the area considered probably the most traditional domain of optical design — camera lens design — in which LightTools can be used to analyze the optical effects of mechanical mounting structures within a lens and to probe for ghost images.

Leslie Foo of Nikon Precision has used the program as an adjunct to CODE V, which is used to design and optimize the basic optical system. After design with CODE V is completed, the system is imported to LightTools, where various mechanical mounting structures are added.

Foo uses the program's ability to automatically generate a 2-D grid of ray fans to probe for stray light and ghost images. The system is traced backwards, from the focal plane through the lens, to determine what parts of the mount can be "seen" at the film plane. During this process, various parts of the lens structure can be "turned on or off," i.e., their reflectivity can be altered to assess the contribution of each surface or feature to the stray light reaching the focal surface. Once again, the nonsequential ray-tracing ability of LightTools is necessary to follow rays that undergo multiple reflections within the lens.

Higher level of confidence

While precise, quantitative analysis of ghost images and stray light still need to be performed using other software, Foo has found that the program provides an additional level of confidence in a design before bringing it to the physical prototyping stage. Foo also commented that its ability to produce presentation-quality 3-D graphics can be useful in presenting design concepts to nontechnical personnel.

We believe that our new software has already made an impact on optical design, providing an easier method to input complex optical and optomechanical structures for further analysis as well as allowing nonsequential ray tracing for analysis of nonimaging systems and stray light. The result is a streamlined optomechanical design process with greatly reduced prototyping costs. More capabilities to enhance its use as a quantitative analysis tool are planned. □

The goal is typically to provide uniform illumination, but it is complicated by the geometry of the system.

Meet the authors

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Document No. AR2
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Snapshot: Abernathy provides a history of illumination software, discusses several applications, and describes the key challenges that must be overcome so that the world may become a brighter place.

By Michael Abernathy

Non-Sequential Raytracing: Enlightened Software for Illumination Engineering

Those of us who can remember punch cards and paper tape readers may find capabilities like Graphical User Interfaces, abundant memory, and desktop computing to be a dream come true. Fourteen years ago, I asked a friend why raytrace codes were not much used in lighting design, and he responded that you had to tell the raytrace code the exact order in which each ray struck each surface. Why not have the computer calculate this automatically? The common wisdom of the time was that the effects of partial reflection at transmissive surfaces created a $2n$ complexity problem, which was unsuitable to a computational solution. That challenge was the birth of unconstrained non-sequential raytracing and OPTICAD®. This article summarizes the progress I have observed since the early 1980s.

There was, however, relevant work in progress toward non-sequential raytracing occurring in another field entirely. In the field of computer graphics, Turner Whitted had reported a method for synthetically gener-

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ating imagery using raytracing. In this method a ray was traced backwards from the detector, through the simulated scene, and ultimately to a light source. This is possible because Fresnel equations work the same way following a ray backwards and forwards.

The trick, however, was not in calculating the light paths at refractive or reflective surfaces, but rather in managing the formation of secondary (ghost) rays at surfaces. Imagine a system of two flat mirrors facing each other, with a glass plate between them, and a ray starting between them, normal to the faces. The ray would bounce back and forth. Each time it passes through the glass, ghost rays would be generated. First one ray creating two, which create four, and so on, generating ray segments, until the computer (which has to keep track of each segment) ran out of memory. So, sophisticated adaptive techniques were developed that allowed the user to manage the formation of ray segments by controlling parameters such as the maximum number of ray segments, maximum number of ghost rays, and minimum transmittance. We implemented this technology as the OPTICAD® program, and for the last decade it has found an ever increasing variety of applications.

In the intervening years, non-sequential raytracing has been used to describe a variety of systems. However, our use of the term refers to programs that automatically trace rays through a design space, based strictly on the physical size, optical characteristics, and location of the component objects in space. The user does not have to coax the program into non-sequential raytracing by setting up "regions" with input and output apertures. A true non-sequential raytrace program must be able to trace a 4π steradian bundle of rays at once, as shown in Figure 1.

For the illumination engineer, non-sequential raytracing technology has been a tremendous time and money saver. It permits analysis of complex parts like automobile dash panel lightpipes—predicting a part's lighting performance before the part is even built. Prior to the advent of these technologies, lightpipe designers (and other illumination engineers) found themselves designing a part, having to build and test the part in the lab, and then improving the design. This was slow and inefficient—but non-sequential raytracing changed that by allowing the designer to create a part in a CAD program, then import it for analysis to see how well light would travel through it. Where did the light escape? Where did it concentrate? Where is the best location for a bulb? The design was thus refined before the first lightpipe was built. This tool proved to be a quantum leap in lighting system design.

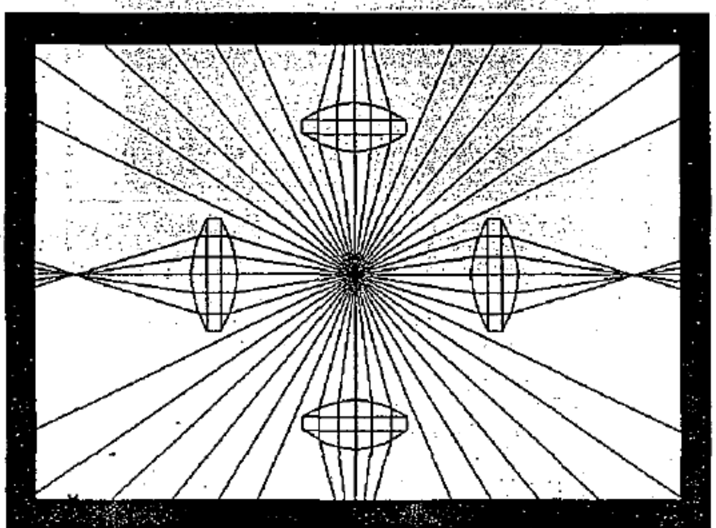

Figure 1. Non-sequential raytracing automatically finds the ray-surface intercepts. Here a 360° ray fan impinges on four lenses—the rays that strike objects bend with Fresnel's Law, and those that miss, pass on.

Monte Carlo raytracing

So far we have talked about specular reflection and transmittance, but much of lighting design is concerned with diffuse light. Diffuse light occurs when a light ray strikes a surface that does not produce one reflected and one transmitted ray segment, but rather produces a statistical distribution of possible ray paths. For example, a light ray striking sand-blasted glass may reflect and transmit in any number of directions. So how can we use raytracing to model a statistical distribution of light rays?

An effective solution is Monte Carlo simulation. Taken from the statistical technique of the same name, Monte Carlo raytracing uses a statistically significant number of rays, and analyzes system performance by random surface normal realizations at each diffuse surface. Surfaces can be modified to permit Lambertian, Gaussian, and x-y power law statistical surface normal distributions at each diffuse component. The process many seem computationally intensive, but modern desktop computers easily perform the task. Thus non-sequential raytracing was adapted to meet the challenge of diffuse reflection and transmittance.

The interface revolution

"All evolution in thought and conduct must at first appear as heresy and misconduct," said George Bernard Shaw, and so it was in optical software interface design. Many of the major raytracing codes in the early 1980s were written in FORTRAN and were the legacy of government development contracts, university research, and specific optical design projects. They were (and are) powerful, but each had its own unique interface, which was typically a command or script language that the user typed in. Plots could be sent to plotters. Output tables were sent to the terminal or line printer. Most software was expensive, leased rather than sold, and a short course was really required for a user to learn how to use the software. But that was about to change.

In 1989, when a young University of Arizona graduate named Ken Moore developed ZEMAX™, he designed it from the ground up with the goals of being extremely easy to use, reliable, and affordable. Moore believed that software, even optical design software, should be easy to learn—like the commercial spreadsheets and word processors available on personal computers. He created a user interface that combined graphical output with a handy spreadsheet-like data input. He made the program truly interactive so that a user could make a design change and immediately see the result.

Moore continued to improve the interface and usability of ZEMAX™, and it seems his insights about ease-of-use have paid off. ZEMAX™ raised the bar several notches for optical engineering software, and user's expectations for both usability and the quality of user interface were going to be higher, henceforth, because they had seen what was possible. Illumination software would have to follow suit, and we developed a Windows™ version of OPTICAD® that aimed at superior user interface.

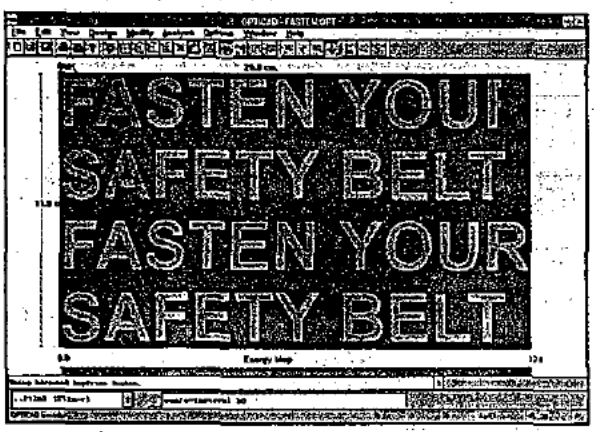

Figure 2. Two lightpipe designs are tested in this pseudocolor intensity map. Note superior uniformity on the lower sign design.

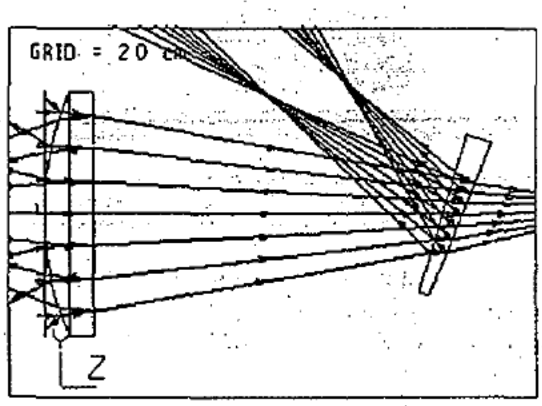

Figure 3. Ghost foci above laser beam path.

The challenges

With the advent of non-sequential raytracing, the illumination engineer was now equiped with a tool which could be used to address three major challenges:

- Predicting design lighting efficiency performance,
- Predicting design lighting uniformity performance, and
- Scattering prediction and stray light control.

Simple lighting efficiency is a basic challenge for many illumination engineers. Consider the engineers who design lighting for undersea search equipment, or engineers designing radiative heaters for semiconductor drying. They must be concerned with efficient delivery of light to a particular region of space. Non-sequential raytrace tools were ideally suited to this because they could follow a ray striking a reflector, once or perhaps bouncing several times, and compute the transmittance losses due to absorption at the surfaces and in the media (volume absorption) along the path.

Lighting uniformity is a major goal for the illumination engineer. Figure 2 shows two designs for an illuminated sign, which uses a lightpipe. What the designer needs to know, in addition to how bright the sign will be, is how evenly or uniformly illuminated it will be. Anyone who has tried to read a digital watch in the dark can relate. The left half of the watch display is extremely bright and the right half is too dim to read. Modern tools provide a mechanism to quantify this problem and solve it in the design stage. The upper sign in Figure 2 is not evenly illuminated—too much of the light is concentrated in the center, and people are likely to have difficulty reading the sign (as evidenced by the variation in pseudocolors representing intensity levels). Armed with awareness of this problem, the illumination engineer concludes that the light should be diffused, and elects to frost the back of the plastic lightpipe. The result is shown in the bottom sign, which is much more evenly illuminated. The software can show the result either as naturally polychromatically shaded as black and white, or use pseudo color to enhance subtle changes across the field.

Too much light in the wrong place can be as undesirable as having too little. As a result, stray light analysis is an important function of lighting software.

Telescope and celestial instruments are often designed with baffles to control the movement of stray light, as ghost rays can completely eclipse the signal the instrument is intended to collect. These ghost rays can form as Fresnel reflections from refractive surfaces, or simple reflections from interior surfaces of the instrument. Laser systems are also good candidates for stray light analysis. Figure 3 shows a case, analyzed by William Swantner, in which a ghost focus occurred just above a CO_2 laser. This focus still possessed enough energy to cause harm to a person standing in the wrong place.

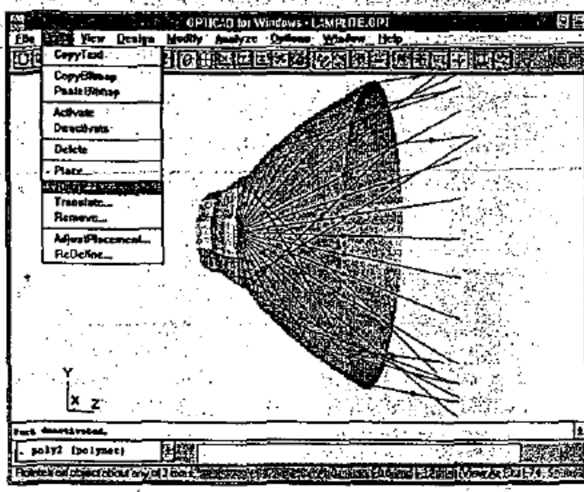

Figure 4. Non-sequential ray trace of a reflector shows multiple reflections on a single surface.

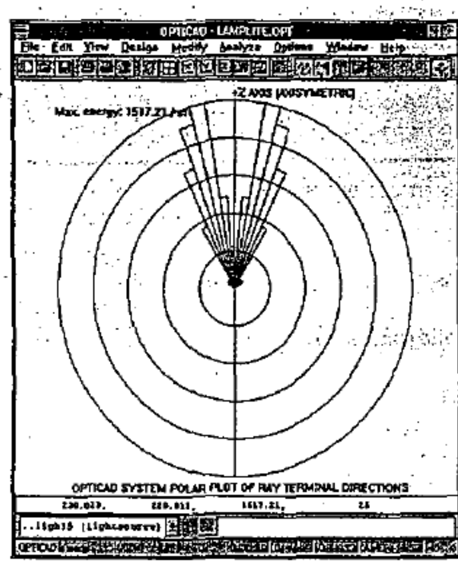

Figure 5. A polar plot of the lamp reflector shows an uneven distribution in angle space.

Applications

Maximizing the efficiency of a lamp reflector is often desirable. Figure 4 shows a desk lamp with rays traced. Note that some of the rays strike the surface multiple times and others do not. A polar plot from the desk lamp (See Fig. 5) is extremely useful because it shows how light is distributed in angle space, and in this case the design produces strong lobes just off the Z-axis, which might be desirable for its application. As is often the case, it is desirable to ensure that the design places light in a particular angular distribution.

The automobile industry is highly competitive, and cost-consciousness is part of every engineering decision. If a part, like a headlamp, can be made even a few cents less expensively while still meeting design performance, the manufacturer becomes more competitive in the marketplace by improving the design.

Here's how the process works. First, for a given application, figures of merit are established—in this case the engineer determines from specifications exactly how much energy should be deposited on the surface in front of the car and in angle space. The basic design for the part (in this case a bulb/reflector assembly) arrives, usually in an auto company specific CAD format. The designer converts it to an exportable form—typically IGES. This design is then imported into the illumination software for analysis. A performance profile (probably consisting of the polar plot and intensity map) is built for the system, which becomes the baseline. The engineer then modifies the design, either to reduce cost, increase performance, or both, and re-evaluates the design. This iteration occurs until design goals are met. The modified design is made into a prototype, tested, and then sent to production.

The market

The illumination software market is an emerging market, because easy-to-use software tools have become available only in the last few years. Unlike other areas such as lens design, there are relatively few specialists, but many general engineers who find themselves analyzing and improving illumination system performance. My experience with OPTICAD® has introduced appli-

Glossary

International Graphics Exchange Standard (IGES): A non proprietary format for the exchange of 3-D data.

Non-Sequential Raytracing: A method of calculating light ray paths through a simulated environment of optical surfaces and media in which the ray intercepts are automatically calculated by the program without the user having to enter surface intercept order.

Non-Uniform Rational B-Spline (NURBS): A type entity already found within IGES, DXF, and some other standards. It is useful because one single entity can describe many very different 3-D mathematical surfaces, thus simplifying data exchange for programs that have adopted and support it.

The Standard for Exchange of Product Model Data (STEP): Intended as multi-industry standard as a successor to IGES. It is under the control of the International Standards Organization (ISO) and has been assigned ISO#10303. ANSI has adopted the initial release of STEP as a national standard, as "Product Data Exchange using STEP" (PDES).

cations I would never have expected—starting with a German engineer working on an improved bread toaster for a large consumer appliance manufacturer. Here are just a few of the other application areas that are beginning to make use of non-sequential raytracing technology:

- Highway retro-reflectors used for lane separation;
- Lighting display panels in consumer products;
- Heads-up displays in aircraft;
- Outdoor lighting for sidewalks, runways, and heliports;
- Light movement analysis in carpet fibers;
- Lightpipes to illuminate controls in cellular phones and radios;
- Airport beacon lens design;
- Optical flow cell instruments used in biology and medical diagnostics; and
- Laser optics for diode-pumped solid-state lasers.

The future of lighting design software

The future of lighting design software is, forgive the pun, very bright indeed. Users expect to see an ever increasing level of integration between lighting software and other applications. Already, better software products are offering a high degree of document export and import capability. Technologies like Object Linking and Embedding (OLE) offer an approach for a higher degree of integration between software applications, which is desirable. OLE is a means of allowing programs, and the data within programs, to interact in a useful way. A simple example is the ability to place a spreadsheet in a word processor's document, and yet retain the calculational capabilities of the spreadsheet program within the new compound document. There are, however, other approaches to integration. The technology is still maturing, but holds promise.

A subtle, but important advantage, for Windows™ users, is that a good Windows™ interface follows the Microsoft guidelines for Windows™ Interface—things like what happens when the File Open menu item is selected, and what functions are assigned to the left and right mouse buttons. By adhering to the Windows™ interface, programs are much more user friendly. Every day more lighting software becomes available under Windows™. While it is true that some of these programs are simply using a bolt-on front-end to their command driven program, others are truly integrated Windows™ products, supporting all standard Windows™ functionality. The easy way to judge the quality of software interface is to "Fly it before you buy it," by obtaining a demo copy of the software either from Internet homepages or requesting by mail. The most useful demos are actually working models of the software that permit users to test features of the code, albeit in a restricted way, so you can see what it is like to actually use the code.

For 3-D model interchange, IGES has been a defacto standard for the past few years. However, it is a redundant standard, and most vendors do not support all of the hundreds of IGES entities. STEP will eventually replace this standard, depending on how rapidly mechanical CAD manufacturers accept and implement it. Other proprietary standards offer their own advantages, but broad acceptance would require industry-wide input and accessibility. The Non-Uniform Rational Bicubic Spline (NURBS) is seen as a good hope for a single, unified entity for general 3-D surfaces within other standards like IGES, however, support is still spotty.

This article has presented a discussion of lighting design software, based on the author's experience. However, there are other good software tools offered by many companies including Lambda Research, Breault Research Organization, Optical Research Associates, and others. All in all, look for more features, better integration, and improved price-performance, as market competition works to the benefit of the end user. Finally, you should expect to be able to buy a digital watch that you can actually read in the dark!

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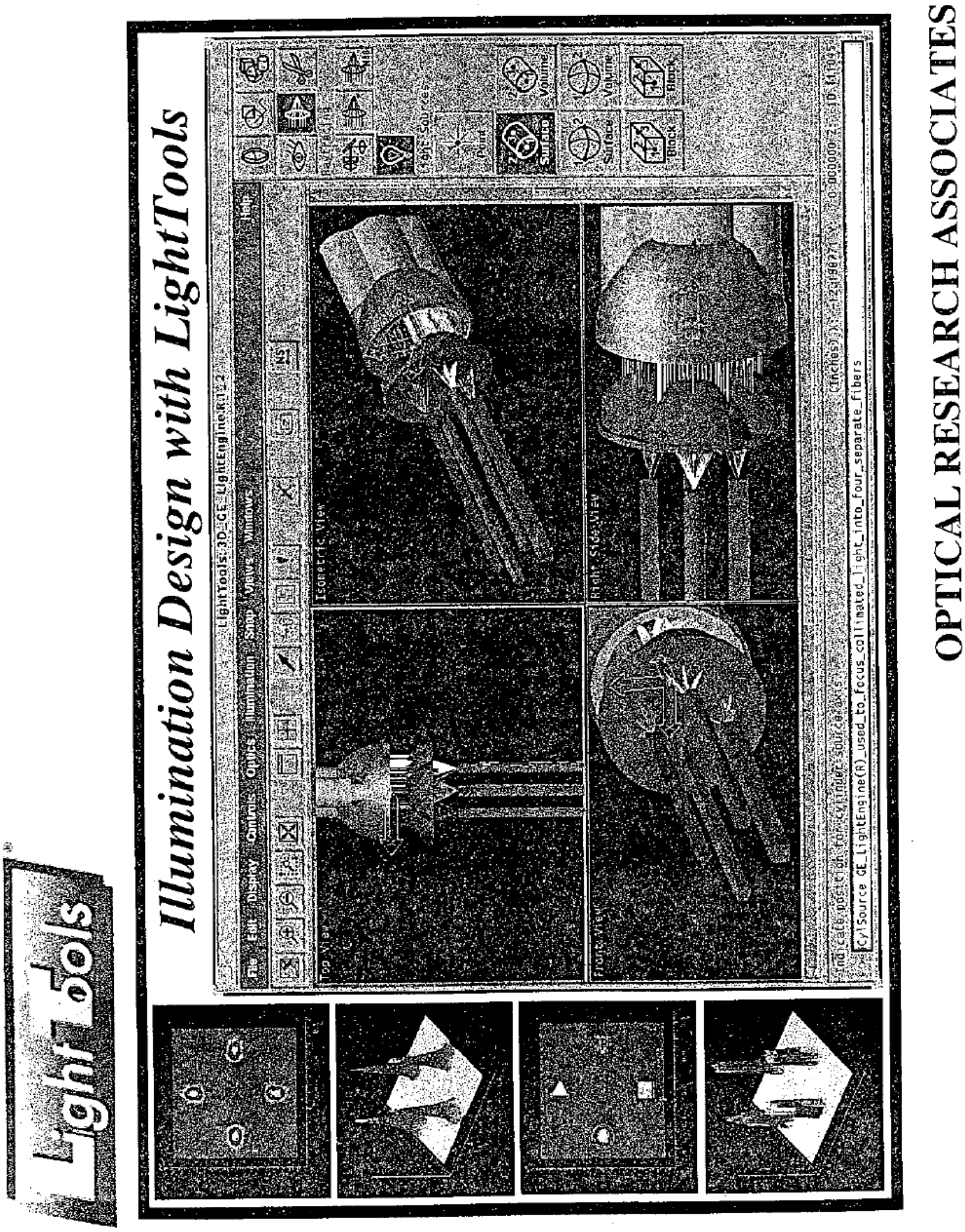
Michael Abernathy is co-founder of OPTICAD Corp., and principal author of the OPTICAD® optical analysis program.


LightTools
Illumination Design with LightTools
OPTICAL RESEARCH ASSOCIATES

Overview

The *LightTools®* product line from Optical Research Associates is being extended to specifically address the illumination design and analysis needs of optical and illumination engineers.
The *LightTools* Illumination Module will become available in the second quarter of 1997. Beta Test begins in January 1997. This document describes the capabilities of this new product.

Topics included in this document:

LightTools Illumination Module Introduction
Description of some benefits of using the Illumination Module
A listing of Illumination Module features
The *LightTools* product line
LightTools hardware requirements
Optical Research Associates software licensing policy
Optical Research Associates company overview

LightTools Illumination Module Introduction

The *LightTools* Illumination Module runs in conjunction with the *LightTools* Core Module. Many enhancements to the Core Module have been made specifically with illumination design requirements in mind.

The *LightTools* Illumination Module can save companies design time and prototyping efforts. It can allow designers and engineers to quickly explore and analyze the functional and performance trade-offs of alternative design forms. It can increase the quality of the end product. It can decrease the lead time from need identification to market introduction of a new product.

These significant benefits are accomplished by accurately representing the combined mechanical and optical system, then analyzing and clearly communicating the effect on light propagating through it. Real models, "sculpted" in software, interact with non-sequential (NSS) "rays" simulating the light, to produce virtual prototypes of potential systems.

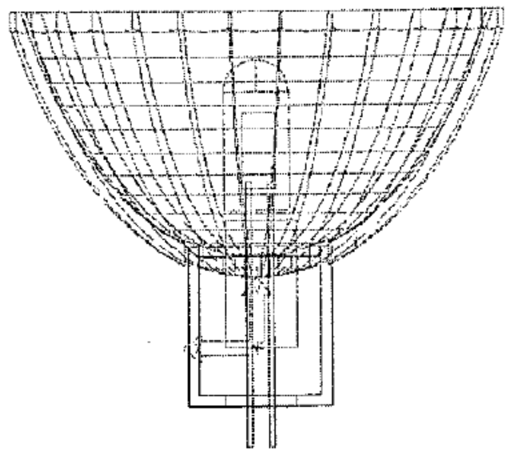
In addition to the ability to quickly create and analyze design prototypes, *LightTools* allows users to visualize the end result with photographic quality graphics that can be zoomed or rotated in three dimensional space. Complex areas can be viewed in detail while simultaneously viewing the entire system. Up to four "ports" or viewpoints of any system can be displayed simultaneously.

LightTools has a large number of features and capabilities to facilitate the design and analysis of many different types of illumination systems. Complex light pipes, for a variety of applications including the back lighting of vehicle dashboards, are one type of system that requires complex modeling coupled with flexible analysis capabilities. Systems that *LightTools* Illumination Module can assist in designing include projection systems, flat panel displays, interior vehicle lighting, segmented mirrors, sign lighting, machine vision systems, medical optics illumination, luminaires, and many others.

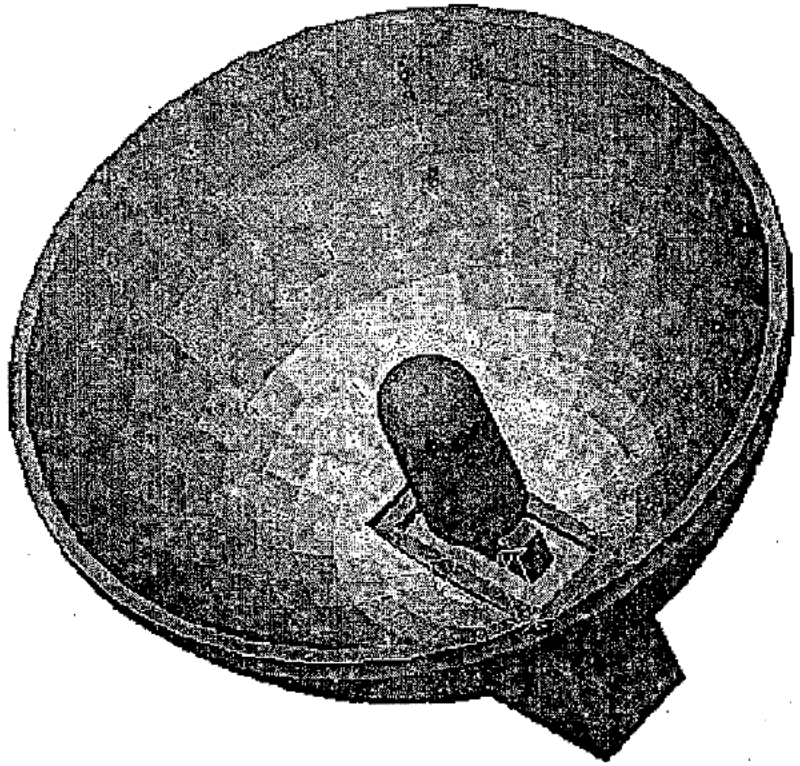
The *LightTools* Illumination module allows for a wide variety of illumination analysis, can output the data in a several different formats, permits very complex volume and surface emitting sources, and handles many types of surfaces including scattering surfaces. Optical and mechanical elements can be formed by complex Boolean operations (union, subtraction, intersection) on basic *LightTools* primitives. Other shapes can be formed from revolving sweeps of profile shapes or by importing complex surface or solid data from other CAD software packages.

LightTools Illumination Module is a powerful new tool that will lead to many new, creative, and high-quality illumination systems.

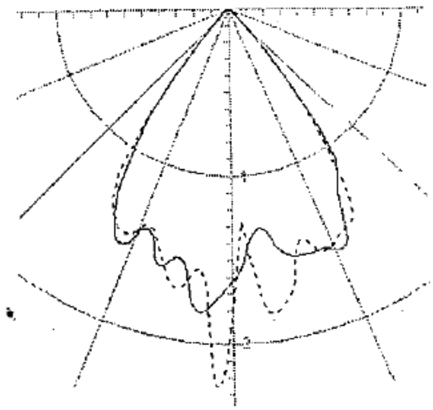
Segmented Reflector with Halogen Source



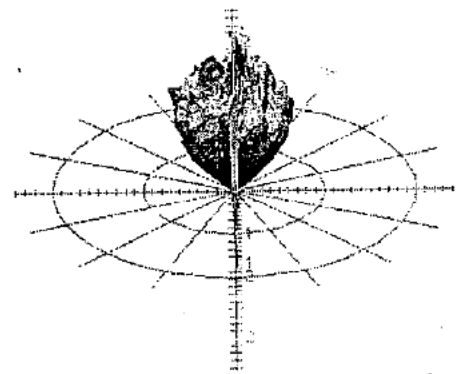
Side View in Wire Frame



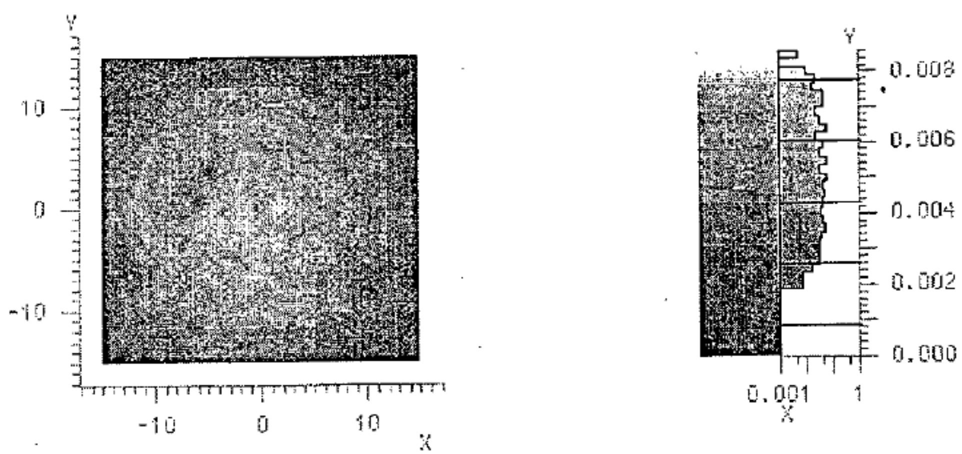
Isometric View in Solid Rendering



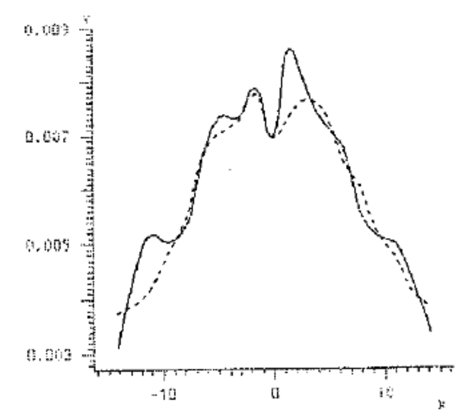
2D Candela Plot



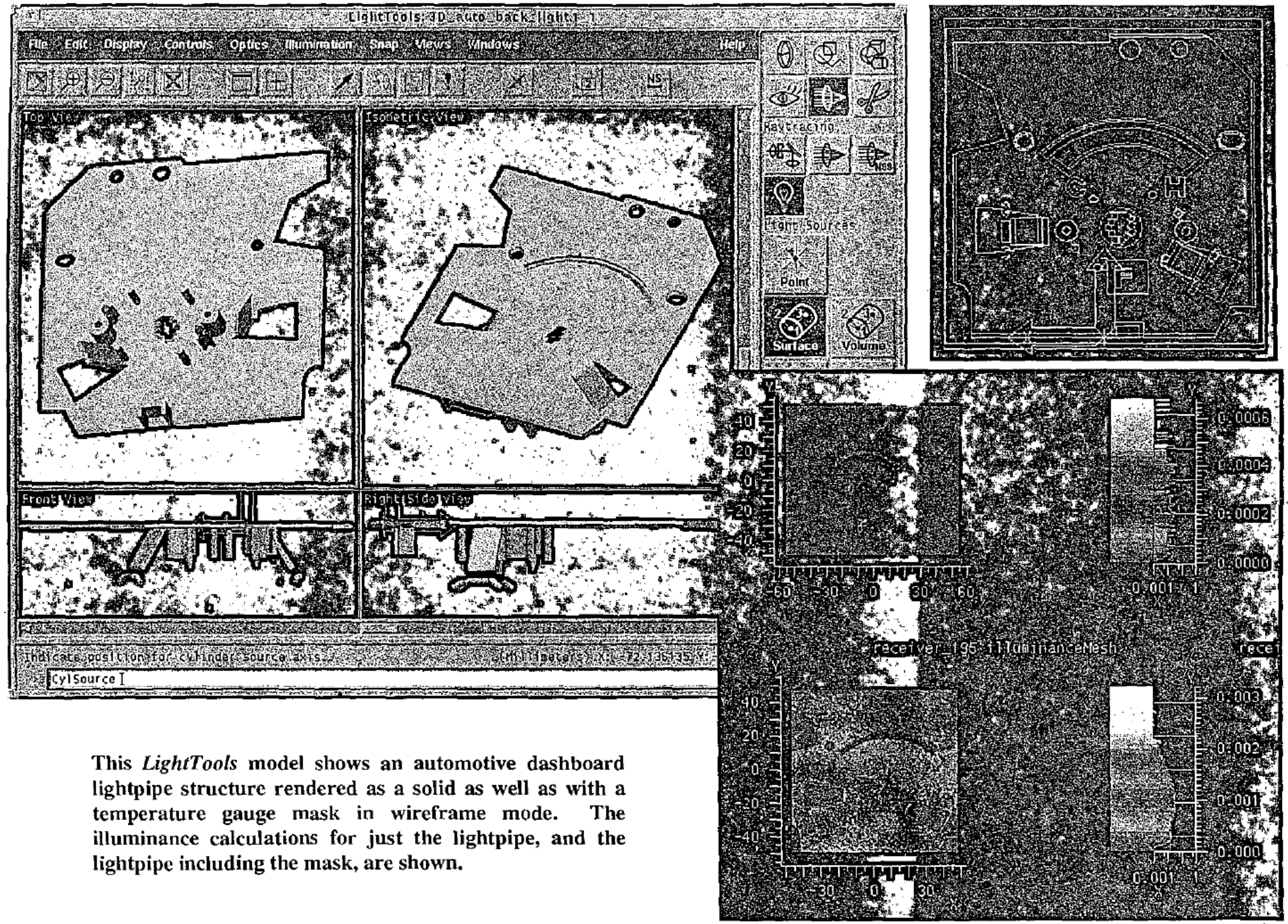
3D Candela Plot



2D Irradiance Raster Plot



Irradiance Through X an Y Axis



This *LightTools* model shows an automotive dashboard lightpipe structure rendered as a solid as well as with a temperature gauge mask in wireframe mode. The illuminance calculations for just the lightpipe, and the lightpipe including the mask, are shown.

LightTools Illumination Module: Benefits

LightTools facilitates the design and engineering of illumination systems by providing state-of-the-art interactive solid modeling user interface whereby users can quickly create complex optical systems in three dimensional space. Mechanical and optical components (including sources, receivers, light pipes, reflectors, lenses, diffusers, prisms, beam splitters, diffractive and binary optical elements, etc.) all share the same database and ability to interactively propagate light throughout the system, duplicating the physical effects of geometric optics.

The *LightTools* Illumination module calculates the illuminance (photometric spatial distribution) on one or more surfaces simultaneously. The intensity (far field distribution) from all of the selected surfaces is also calculated. With both illuminance and/or intensity information, *LightTools* results can be compared with typical photometric measurements. The units can also be changed to radiometric for cases where the human eye response is not necessary.

Monte Carlo ray tracing, essential for many illumination design problems, is efficiently and uniquely implemented. Analysis output updates at user-defined periods throughout the Monte Carlo simulation. Users have the ability to stop, then change the graphical data displays, and restart the Monte Carlo ray trace. The data display modifications include, changing the size of the receiver data collection area, the number of rays changing the resolution of the receiver "buckets", color mapping, and data smoothing.

The Monte Carlo ray trace can also be restarted after the completion of a previous Monte Carlo run. "Aim directions" can be defined that determine the direction of the rays to maximize the efficiency of the ray trace and calculations derived from it. A user option enables the path of a fraction of the traced rays to be displayed graphically during the Monte Carlo ray trace. The Monte Carlo based ray tracing features provide the flexibility necessary for designers who want to iterate and evolve initial design concepts to maximize the utility and functionality of their illumination system design.

Source definition benefits from the flexibility and power of the solid modeling foundation of the *LightTools* software. Boolean operations allow for the design of extremely complex shapes, and any shape that can be created in *LightTools* can act as a surface emitting source. Surface emitters can have an angular distribution that is Lambertian, Gaussian, Cosine to the Nth, or user defined. And the user has control of the emittance on each individual surface. Volume emitting sources, defined as a combination of points, spheres, cylinders and blocks, can be nested to simulate the output of discharge lamps.

Surfaces, both optical and mechanical, can have a wide variety of optical properties including specular transmission, diffraction, reflection, absorption, and transmission. The surface properties can be quickly defined and edited by selecting a surface and choosing from among the available options in the dialog box.

Specialized systems characteristics that can be accommodated by *LightTools* include polychromatic analysis, scattering, amplitude beam splitting, absorption through volume, and Fresnel surface loss calculations. A script language allows a non-interactive means for programmatically communicating with *LightTools*.

The output can be displayed as raster color or gray-scale plots, three dimensional contour plots, candela plots, encircled energy plots as well as several other output formats. This output can be displayed alongside the illumination system on the computer monitor and can be saved or output to a hardcopy printer or plotter.

LightTools Illumination Module: Features

The outline below includes primarily those features found in the Illumination Module, but also includes some features that are illumination-related in the *LightTools* Core Module. Those features in the *LightTools* Core Module are denoted by a "(C)". Note that the *LightTools* Core Module has many times more features than those listed here. For a more complete list of *LightTools* Core Module features, please request a copy of the *LightTools* Technical Description.

I. Source Definition

A. Multiple sources (including setting the flux)

B. Volume Emitting Shapes
1. **Point**
2. **Sphere**
3. **Cylinder**
4. **Block**

C. Surface Emitting Shapes:
1. **Disk**
2. **Rectangle**
3. **Sphere**
4. **Cylinder**
5. **Block**
6. **Any Booleaned solid**

D. Surface Emitter Angular Distributions:
1. **Lambertian**
2. **Cosine to the Nth**
3. **Gaussian**
4. **user defined**

E. Surface emittance from either/both sides

F. Control emittance of individual surfaces -- apodization

G. Polychromatic analysis

H. Starter library of sources

I. Saving source data after it has been traced to the lamp surface(s).

II. Ray Tracing

A. Monte Carlo ray trace

B. Non-sequential ray trace (C)

C. Scattering with 1 ray in, 1 ray out

D. Scattering with 1 ray in, multiple rays out

E. Scattering in reflection and/or transmission
1. **Lambertian scatterer**
2. **Gaussian scatterer**
3. **Cosine to the Nth scatterer**

F. Control and display of which elements are ray traced

G. Aim Direction

H. Ray restarting from end point of previous simulation

I. Specular transmission, reflection, and diffraction (C)

J. DRAT (Diffract, Reflect, Absorb, Transmit) (C)

K. Simple R, T, A loss model (C)

L. Amplitude beam splitting (C)

M. Ray trace tracks ray intensity (C)

N. Optical coating support including Fresnel losses (C)

O. Absorption through volume (C)

P. Autocalculated DRAT (C)

Q. Toggle ray splitting for autocalculated surfaces (C)

R. Absorption coefficient tied to materials data base (C)

III. Analysis and Calculations

A. Irradiance/Illuminance on a surface

B. Luminous Intensity of a source

C. Average Luminance (for use with encircled energy)

D. Source luminous intensity over a full sphere

E. Encircled flux for a user defined square or circle

F. Radial and planar symmetry data smoothing

G. Statistics for the ray data (average, std-dev., max)

H. Summary data of ray termination points

IV. Output Display

A. 2D Line plots - rectangular and polar

B. Raster psuedo color/greyscale plots

C. Candela plots

D. Iso-illuminance Contour plots

E. 3D surface plots -- rectangular and polar

F. Smoothing of ray trace data

G. "Spot diagram" display of Monte Carlo rays on receiver surface

H. Encircled energy plots

I. Tabular displays of 1D and 2D data

J. Adjustable binning of irradiance/illuminance distributions

K. Display of Monte Carlo traced rays in Design views

L. Combining data from different runs using the same receiver

M. Overlay of line plots from different runs

N. Labeling with radiometric/photometric units

O. Tab-delimited file import/export of illumination data

V. System Modeling (Core Module)

A. Spheres, Cylinders, Blocks (C)

B. Toroid (C)

C. Swept surfaces (C)

D. Linearly Extruded Polygons (C)

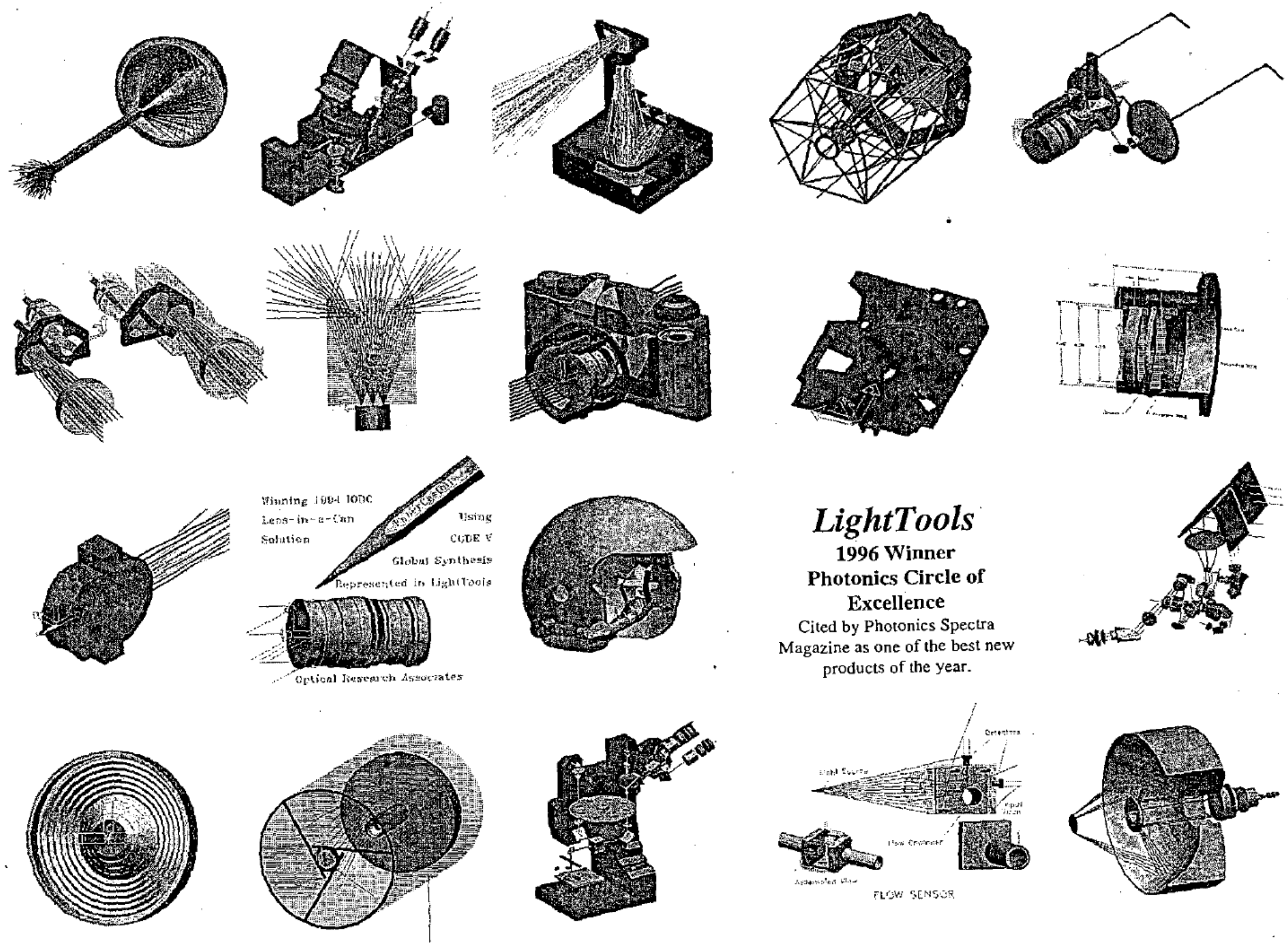
E. Lens and Mirror Elements (C)

F. Boolean Operations on solids (C)

G. User defined element library (C)

H. Thin Fresnel surface modeling (C)
   1. radial (C)
   2. cylindrical (C)

I. Materials database incl plastics and user defined materials (C)



LightTools

1996 Winner
Photonics Circle of Excellence

Cited by Photonics Spectra Magazine as one of the best new products of the year.

Optical Research Associates

Optical Research Associates ("ORA®") is a leader in the optics industry both as the largest independent optical engineering services organization and as the developer of the world's leading optical design software packages, CODE V® and *LightTools*.

Founded in 1963, ORA has experienced continual growth by focusing its technical leadership in the single area of optical design and through an unwavering commitment to its customers' success. ORA employs over forty engineers among its sixty employees including members of a dedicated technical support staff available to all users of its software products. We have customers in over twenty countries.

CODE V is used for the design, analysis and tolerancing of image-forming optical systems. Its many unique capabilities include Global Synthesis®, MTF-based tolerancing, environmental analysis, partial coherence analysis, gradient index and DOE/HOE support, polarization ray tracing, and lens cost appraisal. It is unmatched in function, quality, accuracy, ease-of-use and technical support.

LightTools is three dimensional interactive solid modeling software that provides state-of-the-art means for directly and simultaneously representing optical and mechanical structures as well as point-and-shoot interactive ray tracing. *LightTools* is ideal for setting up complex lens systems, illumination design and analysis, opto-mechanical design, stray light investigations, and proposal work.

ORA's Engineering Services group provides imaginative cost-effective solutions across the entire spectrum of optical design from X-ray telescopes through IR communication systems, from micro-optics for surgery to proposed large deployable adaptive systems, and in environments ranging from commercial to cryogenic to high energy lasers. Since 1963, ORA's pre-eminent Engineering Services staff has successfully completed over 3500 projects for government, commercial, and consumer clients.

Optical Research Associates has won many awards for its outstanding contributions to the field of optical design. Some of these, such as awards from NASA, have been for our optical engineering contributions to key national projects. Others, such as recent awards by industry magazines like *Photonics Spectra*, *Laser Focus World*, and *Lasers and Optronics*, have been for product breakthroughs and innovations breakthroughs in the field of optical design software

Optical Research Associates is committed to our customers' success. We maintain a staff of experienced optical engineers that are available full time to assist our customers in using our software to accomplish their jobs in the best and most efficient manner.

Optical Research Associates has three offices in the United States in Pasadena, California (near Los Angeles), in Lynhurst, Ohio (near Cleveland) and in Framingham, Massachusetts (near Boston). We also have distributors in Japan, Korea, Taiwan, People's Republic of China, Germany and France. By contacting our corporate office in Pasadena via one of the means provided below, we can either assist you directly or put you in contact with one of our offices or distributors. Please do not hesitate to call or write us if we may assist you in any way.

Telephone:	(818) 795-9101
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WWW:	http://www.opticalres.com/

Optical Research Associates
3280 East Foothill Boulevard,
Pasadena, California
91107

The *LightTools* Product Line

LightTools is a software product for the design and analysis of optical systems. It is based on a three dimensional interactive solid modeling system with optical accuracy that provides state-of-the-art means for directly representing lenses, mirrors, sources and receivers, diffractive optics, prisms, Fresnel lenses, mechanical structures, and light paths.

LightTools provides a variety of ways to represent and interact with the opto-mechanical model. Users directly interact with the 2D, 3D wireframe, and 3D shaded solid views. Straightforward interactive creation and modification capabilities include graphical place, move, rotate, copy, and scale of any individual or group of components, either with the interactivity of mouse input or precise keyboard input.

With its "point and shoot" or Monte Carlo non-sequential ray tracing combined with the integration of optical and mechanical components in a single system, *LightTools* is ideal for the design and management of complex systems, illumination design and analysis, opto-mechanical design, stray light investigations, conceptual design, and for marketing or proposal work.

LightTools is a modular software offering. The primary module is the Core Module which is a prerequisite for all other modules and can support many applications with no additional modules. The Image Path Module allows the creation of sequential ray tracing and performs some basic analysis for image forming systems. It also compliments CODE V when they are used together in multi-path or folded lens system designs or those that contain irregularly shaped or prism elements.

Other modules under development, that will be released concurrently with the Illumination Module, include Data Transfer Modules for IGES and SAT files. We are hoping that a STEP translator will follow shortly thereafter.

LightTools Hardware Requirements

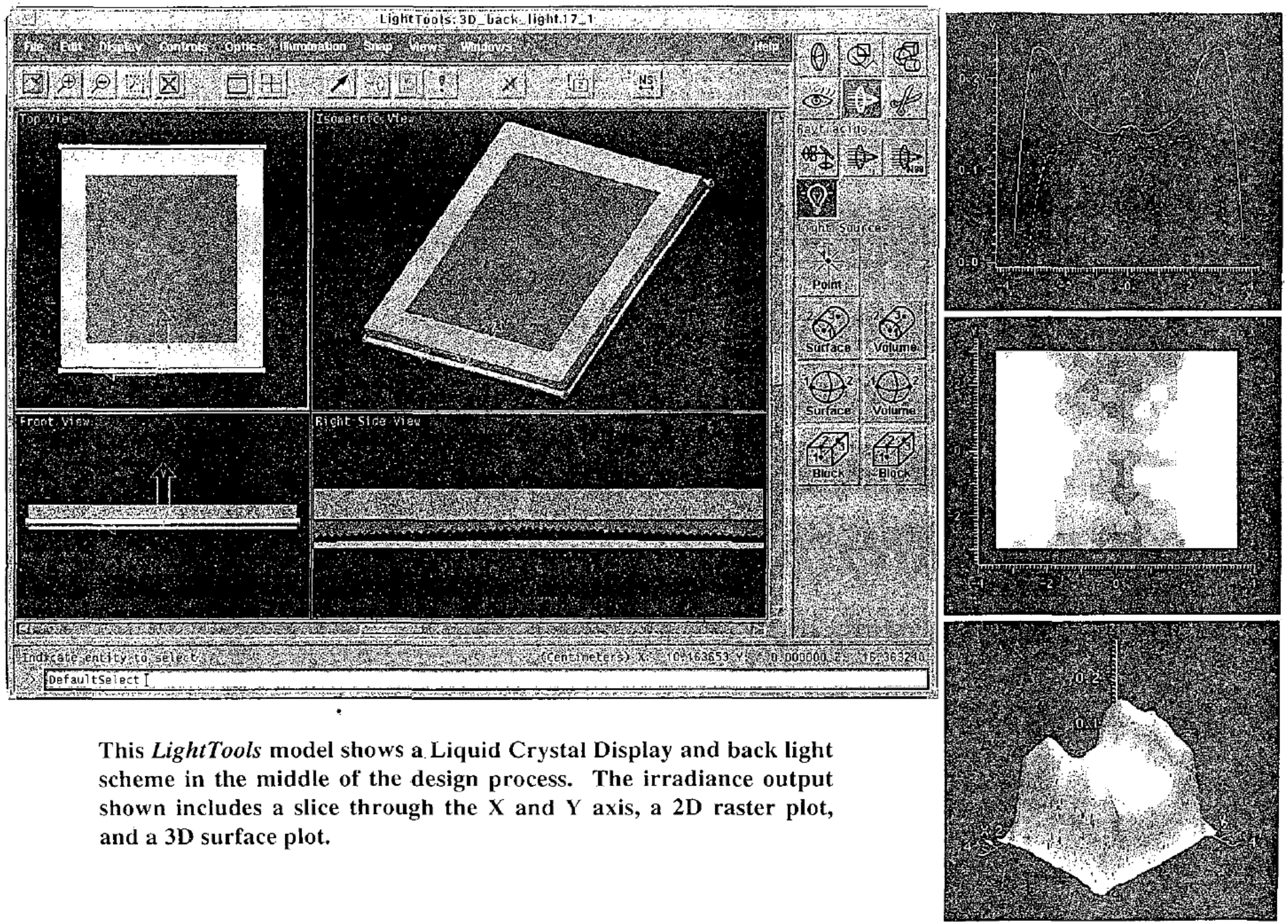
LightTools supports two different hardware platforms: the IBM-compatible personal computer, and SUN Microsystems' SPARCstation.

LightTools runs on any IBM or IBM compatible PENTIUM or PENTIUM PRO PC with a 90 MHz or faster processor. We recommend the faster personal computers (120 MHz), especially those based on the PENTIUM PRO processor in order to improve the speed of large Monte Carlo based illumination calculations. A 17" monitor running at a minimum resolution of 1024X768 with 256 colors is required (1152X864 or higher resolution is strongly recommended). The *LightTools* installation requires between 20 and 75 MB of hard disk space depending on the options chosen.

LightTools runs on any SUN SPARCstation 5 or faster. We recommend the UltraSPARC processors in order to improve the speed of large Monte Carlo based illumination calculations. The minimum RAM requirement is 32 MB. The minimum hard disk space is 110 MB, which includes 50 MB for the *LightTools* installation and 60 MB of disk space per *LightTools* process.

Licensing Software from ORA

ORA software is available on a lease basis. This ensures that all of our customers have the latest software and documentation, and rapid turnaround on technical questions. And, after an initial six month period, if customers are ever dissatisfied with the benefits of using the software, the license and payments may be terminated with thirty days notice. Because of this, our company's success is predicated on providing customers' with on-going value. If an investment in ORA software is not achieving the expected return, you have not purchased software that will then go unused.

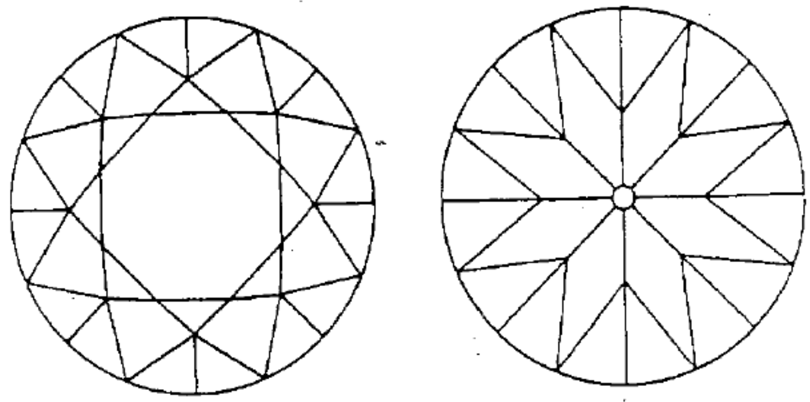


This *LightTools* model shows a Liquid Crystal Display and back light scheme in the middle of the design process. The irradiance output shown includes a slice through the X and Y axis, a 2D raster plot, and a 3D surface plot.

What Tolkowsky Really Said

By AL GILBERTSON with research by CRAIG WALTERS

This is the second of a three-part series re-examining how the diamond cut is measured, judged and graded.



Top and bottom views of a round brilliant diamond.

In the first part of this series, we examined Tolkowsky's writing on the effects of girdle thickness and pavilion angles on the brilliant-cut diamond's reflection and refraction. In Part II, we look at the meaning behind Tolkowsky's work.

Having reviewed what Tolkowsky said, we now turn our attention to what he meant, and nowhere is it clearer than in his final pages. Tolkowsky was living in a world where diamonds were cut to no standard at all. He was trying to show why certain diamonds had more beauty, and how cutting to certain "standards" would produce a more beautiful diamond. His heading "Best Proportions of a Brilliant" is illustrated by a figure that shows the girdle facets on the pavilion only reaching barely past halfway to the culet and a culet that would be large by today's standards. The stars are smaller and the girdle facets taller, which causes the lines from the stars to bow out, rather than in, as in our modern "ideal-cut" diamonds (see figure 1 above). The illustration is clearly not how we view the "ideal" cuts today.

In the final three pages he discusses a group of diamonds that he compares to his theoretical ideals: "In the course of his connection with the diamond cutting industry, the author has assisted in the control of the manufacture of some million pounds' worth of diamonds, which were all cut regardless of loss of weight, the only aim being to obtain the liveliest fire and the greatest brilliancy. The most brilliant larger stones were measured and the measures noted. It is interesting to note how remarkably close these measures, which are based on empirical amelioration and rule of thumb correction, come to the calculated values." His results can be seen in the accompanying table below.

Note that total depth is from 55.4 to 64.4 percent, crown height is from 13.3 to 18.6 percent, etc. He doesn't even report table sizes. Why not? He concludes, stating, "The very slight difference between the theoretical and the measured values is due to the introduction of a tiny facet, the collet, at the apex of the pavilions. This facet is introduced to avoid a sharp point which might cause a split or breakage of the diamond." He simply sees the above figures as very slightly different from his calculations and so close that he feels comfortable using them as examples. His defense about their variation is due the culet, which he has not defined for size in his text at all.

When we think of the sample diagram he provided, the fact that his calculations are based on a knife-edge girdle, that there is no clear mathematical basis for the angles for girdle facets or star facets and now see his table of illustrations which he deems to have "very slight differences" we suddenly realize that he was speaking to a world that viewed diamond cutting differently than today. We can conclude that he was merely attempting to bring the cutting world close to where we see most diamonds now cut, but he did not have all the answers, nor did he claim to. This is why he made the statement "based on empirical amelioration and rule of thumb correction." He is telling us that while some of his calculations are empirical, some of the numbers he gives us are based on "rule of thumb"—what he deems to "look good." What Tolkowsky really did for us was to make us realize that diamonds could consis-

(continued on page 37)

TOLKOWSKY PROPORTION TABLE

Stone Numbers	#1	#2	#3	#4	#5
Pavilion Angle	40.75	40.75	40	41	41
Crown Angle	35	35	34.5	33	33
Depth Percentage	58.7	61.4	55.4	58.5	58.9
Crown Height Percentage	15.7	18.6	13.3	15.7	17.8
Pavilion Depth Percentage	43.0	42.8	42.1	42.8	42.6

What Tolkowsky Really Said

(continued from page 35)

tently be cut to be very beautiful and by doing so set us on a quest to find the true ideal. Modern science and technology are now bringing us closer to discovering that true ideal.

GIA has been researching "ray tracing," attempting to understand what really creates the most brilliance and fire in a diamond. More groups are realizing that certain diamonds look better and are becoming more sensitive to cut grading. Price guides base their prices on a certain quality of cut. Given that Tolkowsky introduced us to the concept of defining a well cut diamond, what will it take to finish the definition? Tolkowsky knew that there have to be two factors considered in defining how well a diamond is cut. He spoke about them when he said, "we conclude that the correct value for pavilion angle is 40 degrees 45' and gives the most vivid fire and greatest brilliancy, and that although a greater angle would give better reflection, this would not compensate for the loss due to the corresponding reduction in dispersion." There has to be a balance of both maximum reflection and maximum dispersion. Can one have no leakage of light through the pavilion and achieve maximum dispersion? Is some leakage through the pavilion required to have maximum dispersion? Tolkowsky gave us his opinion and defended it mathematically in a limited fashion. The answers may be just around the corner.

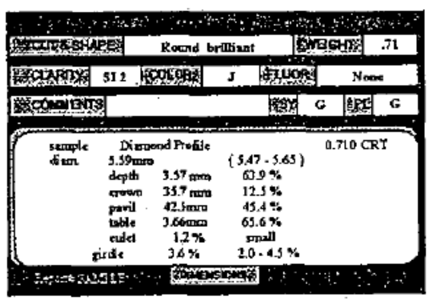
In the next, final part of this series, we will look at other variables in measuring a diamonds beauty, and new technology for accomplishing the task.◆

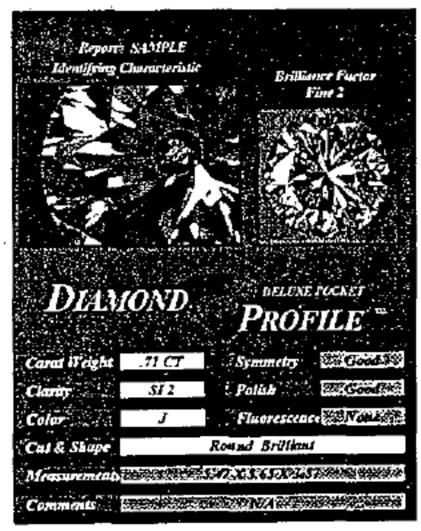
Al Gilbertson authored part one of this series using research funded by Craig Walters.

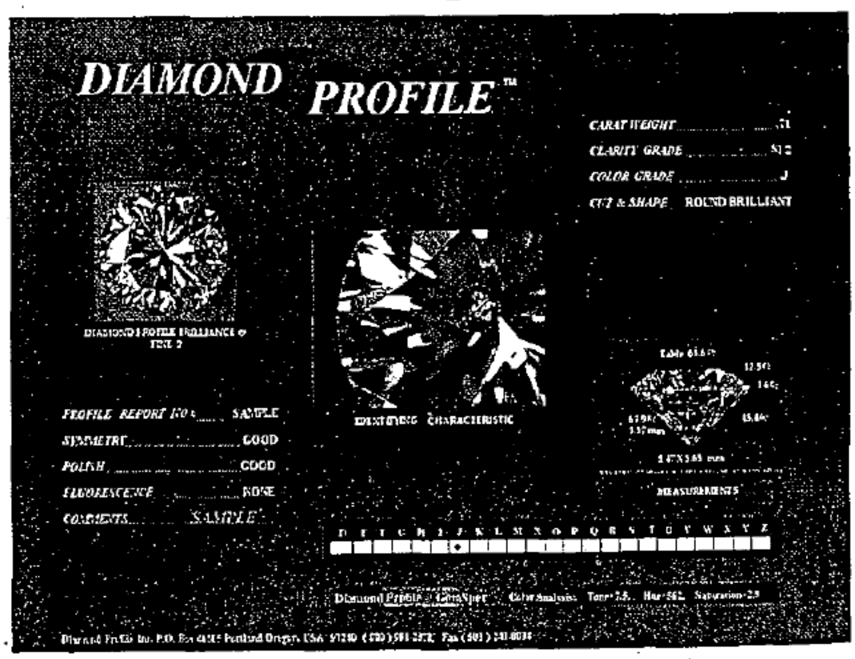
CERT FEATURES BRILLIANCE GRADE

Diamond Profile seeks to offer a grading report that breaks new ground. Its features include:

- **Brilliance measurement:** Computer imaging provides a map of light's path through the stone, allowing leakage to be measured. Various ranges receive different brilliance grades.
- **Dimensions:** Exact proportions are measured with Sarin's Dia-Mension. However, there is no cut grade — buyers assess the information according to their own needs.
- **Color:** Three master sets are used to determine color. An imaging photospectometer is also employed, but final grades are determined by eye.
- **Microphotography:** This provides buyers with an easy-to-identify record of a stone's identifying characterists.
- **Reference information:** Additional information on the cover and back of the report reinforce consumers' understanding of grading standards.
- **Supplement:** For buyers using the Diamond Profile primarily for brilliance measurement and stone identification, the Supplement includes information from GIA or EGL certificates already issued on a stone.◆







Document No. AR3
Appl. No. 08/782,889

Fax Today! See page 62.

GLAD

General Laser Analysis and Design Software

What is GLAD?

GLAD represents the state-of-the-art in laser and physical optics analysis. GLAD can model almost any type of laser or physical optics system with a complete end-to-end analysis, including full diffraction propagation, detailed treatment of laser gain, and many other laser and physical optics effects.

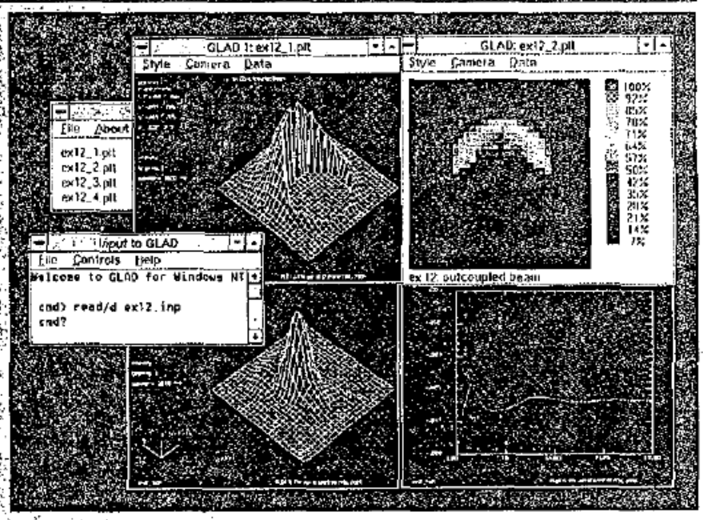
GLAD is a product of Applied Optics Research (AOR), the leading company in laser modeling with 20 years of experience in developing physical optics design and analysis software, and is distributed by Focus Software, Inc. GLAD is the only commercially available program designed to be a comprehensive physical optics tool and is by far the most widely used program for optical and laser analysis. It is used in hundreds of industrial companies and national laboratories, worldwide.

GLAD uses a complex amplitude description of the wavefront which allows modeling of diffraction throughout the propagation path of the optical beam. Conventional geometric ray tracing programs are fine for traditional lens design for imaging applications, but are unable to treat general diffraction, laser gain, nonlinear optics, coherent and incoherent interactions, and other physical optics effects at which GLAD excels.

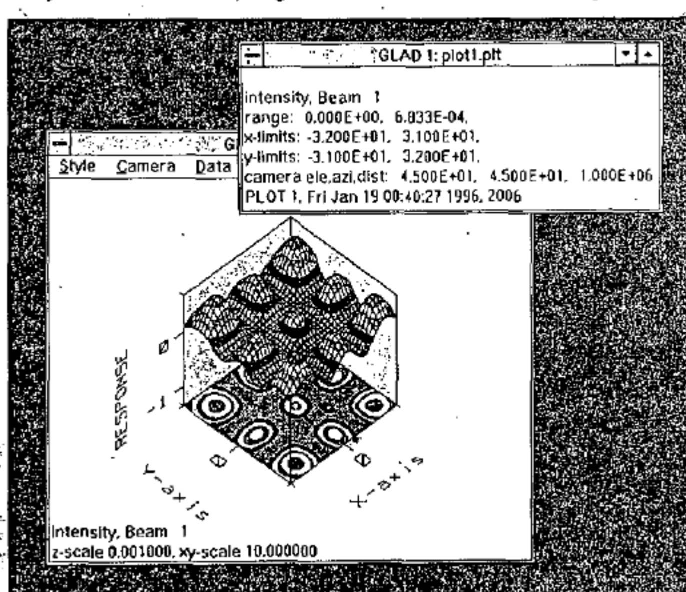
GLAD is available in two levels: GLAD and GLAD Pro. Glad Pro includes all the features found in GLAD plus advanced features as described in this brochure.

Applications for GLAD

Everyone who works with coherent (or partially coherent) light can benefit from the program. GLAD has been applied to a wide variety of the most advanced physical optics modeling applications including commercial laser design, laser research experiments, stable and unstable resonator design, transient laser response, photolithography, high performance phase plates for beam control, diffraction effects, and single and multiple mode waveguides.



This screen capture illustrates GLAD performing a calculation for an unstable resonator with tilt misalignment; including near-field and far-field intensity diagrams. Also shown is a plot of eigenvalues as a function of iteration cycles to indicate progress towards mode convergence.



This plot demonstrates the advanced 3D color graphics capability of GLAD. Shown is the intensity profile of a Hermite Gaussian TEM(2,2) mode using a combined isometric and contour display.

FOCUS SOFTWARE, INC.

Focus Software, Incorporated
P. O. Box 18228
Tucson, Arizona 85731 USA
Tel: (520) 733-0130 Fax: (520) 733-0135
E-Mail: sales@focus-software.com
http://www.focus-software.com

An overview of GLAD

GLAD is highly flexible and powerful, and yet is simple to learn and use. With GLAD, the user is able to model both simple optical systems and highly complicated, multiple laser configurations. The code is designed to analyze all types of beam trains and laser devices including the effects of diffraction, active media, apertures, lenses and mirrors, and aberrations.

In GLAD, optical beams are represented using rectangular computer arrays of complex valued amplitude. The complex representation accounts for both the beam intensity and the phase of the electric field as the beam propagates. This is the most general and powerful technique available. Simpler methods, such as ray tracing, Gaussian ray propagation, ABCD methods, and rotationally symmetric propagation methods can not compare in power, accuracy, or versatility.

The input to GLAD is a simple text command script, which defines the initial beam parameters, the number of beams, wavelengths, and other data. The script uses the GLAD command language to define events that occur as the beam propagates, interacts with gain media, diffracts at apertures, reflects or refracts through conventional optics, or other events.

The command script supports user defined variables, subroutines, loops, in-line equations, and other high level language constructs.

GLAD Capabilities

Code Architecture:
- Fully 32-Bit
- Multithreaded for fast response; dual CPU support

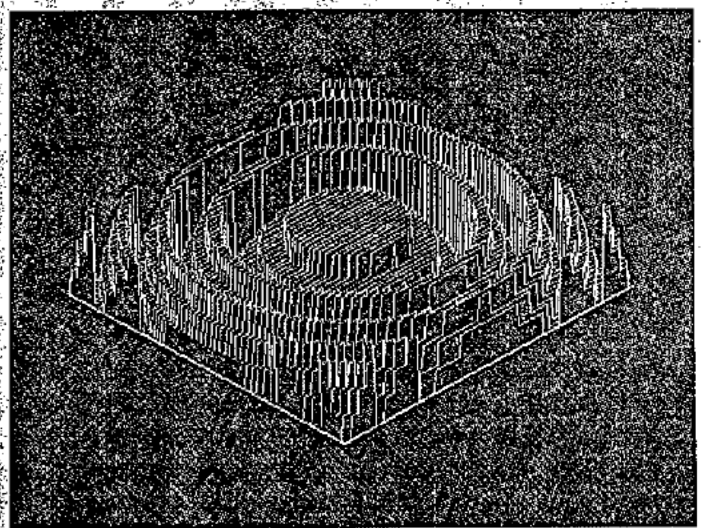
User Interface:
- Interactive command structure
- Multiple output windows
- Simple text command scripts

Graphical Displays:
- Isometrics, profiles, polarization, contour plots
- Windows support for Postscript, metafiles (*.wmf)
- DOS support for Postscript, HPGL, and HP Laser Jet

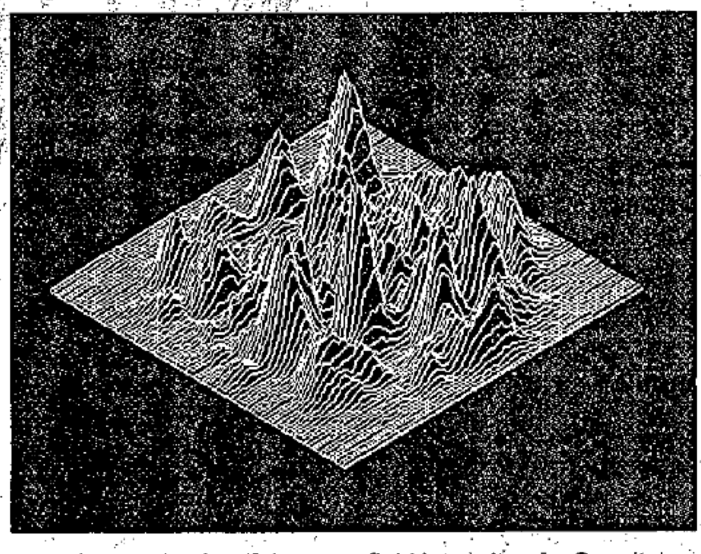
Macros of Commands:
- Algebraic expressions
- User-defined variables in commands
- Interface with user programs for pre/post-processing

Comprehensive Documentation:
- GLAD Theoretical Description
- GLAD Command Description
- GLAD Examples Manual
- Supplementary Examples Manual

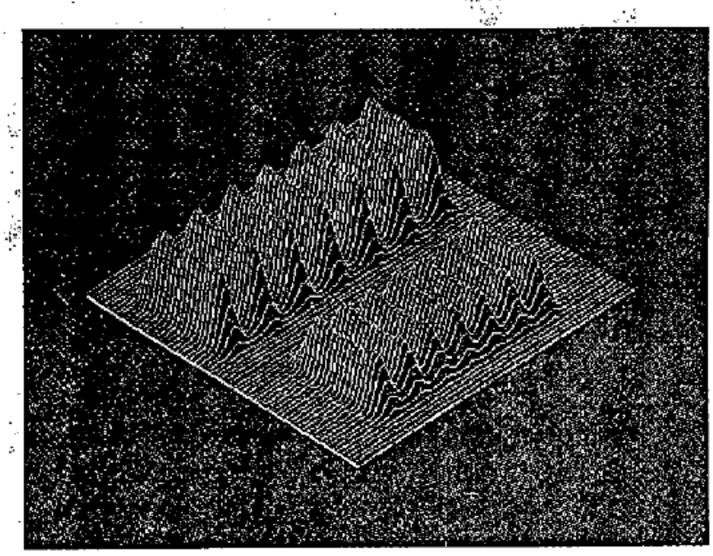
Extensive Examples:
- More than 90 complete examples
- A wide variety of systems are included for illustration



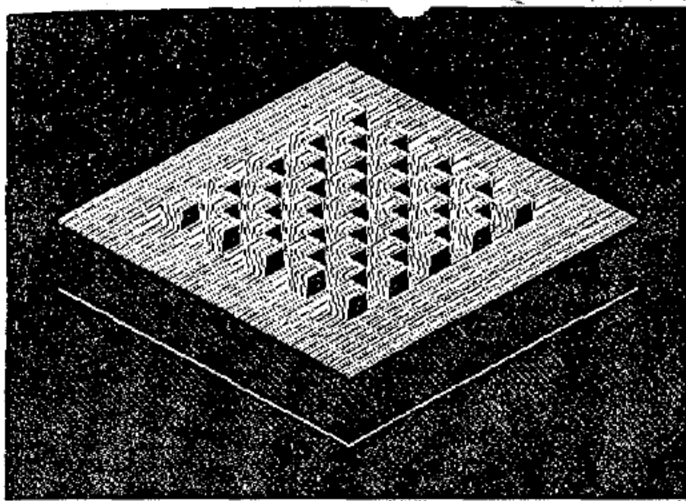
An isometric profile plot of the phase imparted by a simulated four layer binary optic.



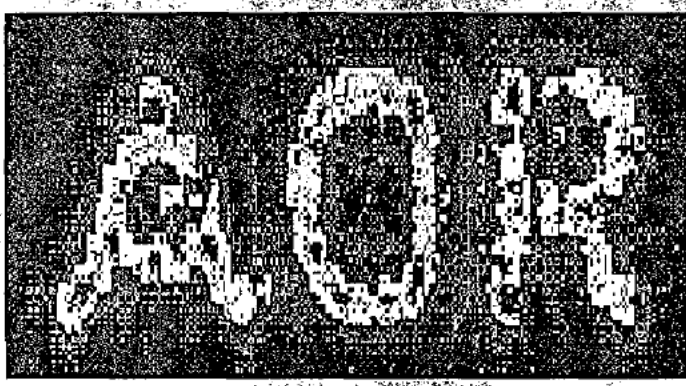
An isometric plot of the near-field intensity of a Q-switch laser, 40 nanoseconds after start. The speckle size indicates the instantaneous beam quality.



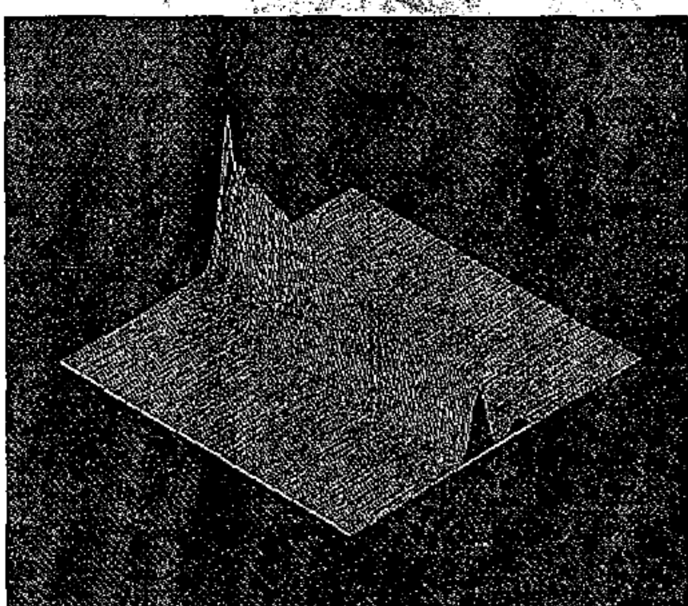
This isometric plot shows the image simulation capability of GLAD. Here is the partially coherent image of two different seven bar targets.



Schlieren system with checkerboard phase representation.



A false color diffraction image of the wavefront after transmission through a complex aperture in the shape of the letters "AOR". Note the edge effects which are ignored in geometrical ray tracing codes.



An isometric intensity plotting illustrating energy exchange between two parallel waveguides. The beam propagates from left to right in this view. The energy from the upper guide initially couples into the lower guide, and then begins to migrate back to the upper guide.

GLAD Features:

- Integrated design environment (IDE)
- Simple or complex multiple laser beam trains
- Coherent and incoherent interactions
- Nonlinear laser gain models
- Lenses and mirrors: spherical, toroidal or cylindrical
- General aperture shapes
- Near- and far-field diffraction propagation
- Stable and unstable resonator modeling
- Special features for resonator design
- Seidel, Zernike, and phase grating aberrations
- Smoothed random wavefront aberrations
- Lens and mirror arrays
- Variable size arrays to 1024 x 1024 and beyond
- Rectangular arrays and separable diffraction theory
- Propagation of multiple, independent laser beam trains
- Automatic propagation technique control
- Gain sheets
- Global coordinate system
- Arbitrary mirror locations and rotations.
- Geometrical aberrations
- High Fresnel numbers
- Zonal adaptive optics model
- Phase conjugation
- Polarization modeling
- Partially coherent modeling
- ABCD propagators
- Fiber optics and 3-D waveguides
- Binary optics and gratings
- Vector diffraction for high NA objective lenses
- M-squared characterization
- Finite-element thermal modeling
- Phase retrieval optimization
- Simulated annealing optimization

GLAD Pro Additional Features:

- Nonlinear optics:
  - Raman amplification, Four-wave mixing
  - Frequency doubling
  - Self-focusing effects
- Laser effects:
  - Rate equation gain
  - Laser startup and Q-switching
- Optimization:
  - Least squares optimization of any configuration
  - User-defined merit functions
  - Any system parameters may be optimized
- Geometrical optics:
  - Exact surface by surface raytracing
  - Lens groups may be defined and analyzed
- Atmospheric effects:
  - Kolmogorov turbulence
  - Thermal blooming

Documentation

Comprehensive documentation is provided in several volumes. The GLAD Theoretical Description describes in detail the theoretical and numerical basis of the program. The GLAD Command Description is a comprehensive description of all commands, with detailed explanations of GLAD syntax and command options and use.

Command files for over 90 examples are distributed with the program. These may be used as provided or modified as required for new applications. The GLAD Examples Manual describes in detail the most commonly used examples with the remainder being described in the Supplementary Examples Manual.

Supported Platforms

GLAD is available for IBM PC computers running Windows 3.1, Windows 95, or Windows NT. See the current price list for version numbers appropriate for each operating system.

GLAD is also available for many Unix workstations including Sun, HP 700, and Cray computers. Under Unix GLAD provides multiple graphic displays through X-Windows. A client/server architecture allows GLAD to be run on a remote computer.

Technical Support

Free technical support on the use of GLAD is provided directly by AOR for one full year from the date of purchase. Technical support is offered via telephone, fax, or e-mail. For international customers fax and e-mail allow quick and convenient support because of GLAD's text-based command format.

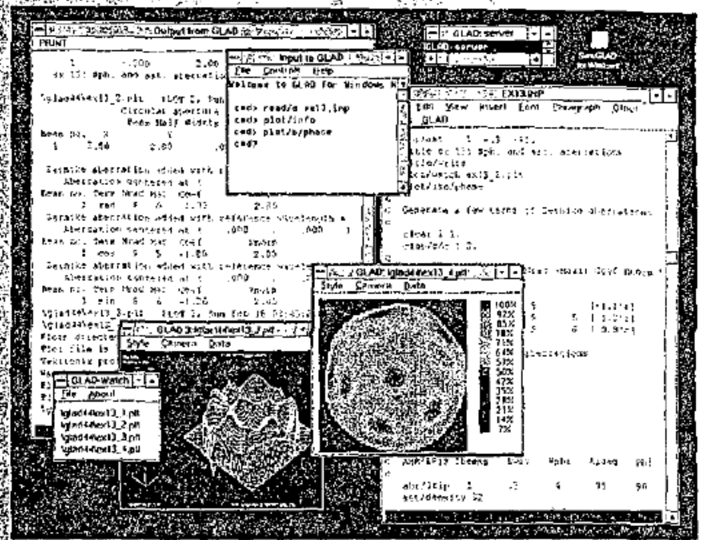
Additional technical support beyond the first year is available through the purchase of either a technical support contract or a version upgrade. One full year warranty is provided with purchase. Any reported defects will be repaired at no cost.

Evaluation Kit

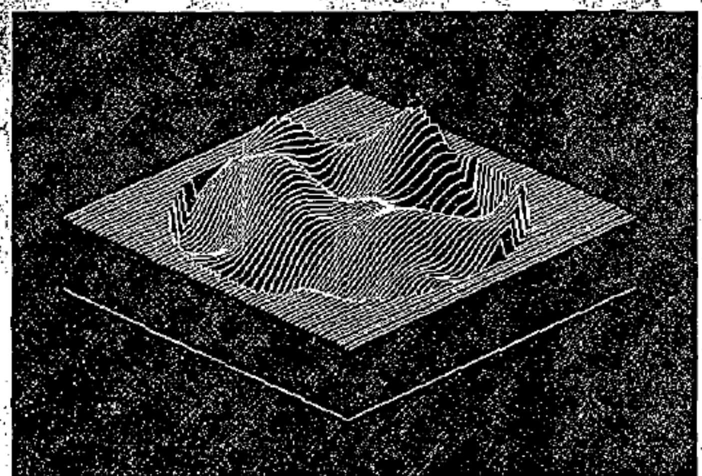
The Evaluation Kit provides an exact "test drive" of GLAD so you can try the program before buying. The kit includes the complete GLAD documentation as well as a fully working copy of GLAD for up to 30 hours use. The price of the evaluation kit is fully credited toward the purchase of GLAD.

For more information...

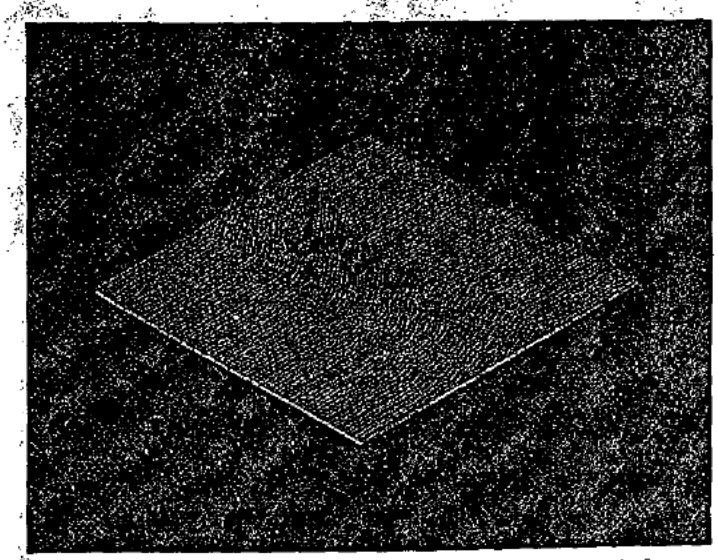
For more information on GLAD, or on other Focus Software Inc. optical engineering products, call, fax, or visit our web site at http://www.focus-software.com, or e-mail any questions to sales@focus-software.com.



The GLAD Integrated Design Environment (IDE). The IDE allows rapid and straightforward analysis of physical optics systems. Multiple diagnostic windows may be simultaneously displayed, and data input may be easily altered to perform interactive design and "What if?" analysis.



An isometric plot of a randomly generated and smoothed phase aberration. Arbitrary phase aberrations may be added to the beam train at any point.



The intensity of a focusing beam shown as a through-focus plot. Note the full diffraction intensity is displayed as the energy propagates through focus.

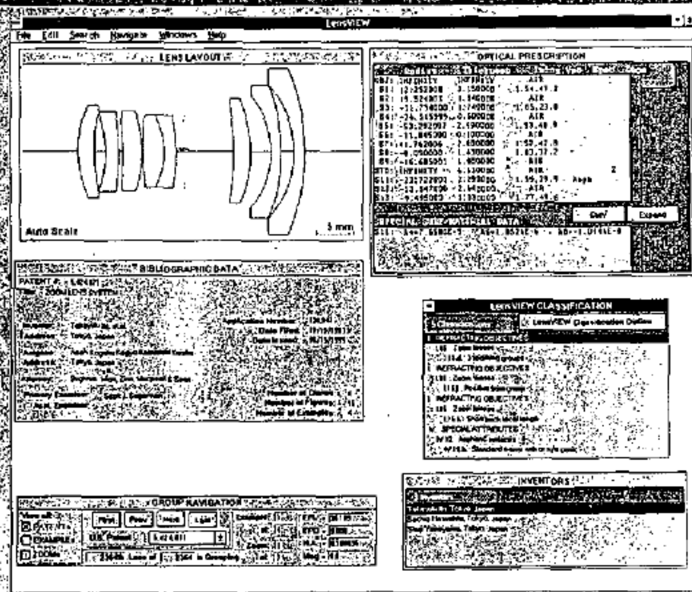
Document No. AT3
Appl. No. 08/782,889

LensVIEW™

Over 9,000 optical designs on CD-ROM!

What is LensVIEW?

LensVIEW is a database of most of the optical designs found in the United States Patent literature. More than 9,000 complete optical designs with multiple examples and zoom positions for each patent are included. With data from the late 1800's through the latest optical designs, LensVIEW is without peer in its scope. The extensive LensVIEW database includes not only the optical prescription data, but complete inventor information, abstract data, sample claims text, references, U. S. and International classification data, and more. LensVIEW also generates several aberration plots for a quick diagnosis of the lens, and generates a cross-sectional drawing of the design.



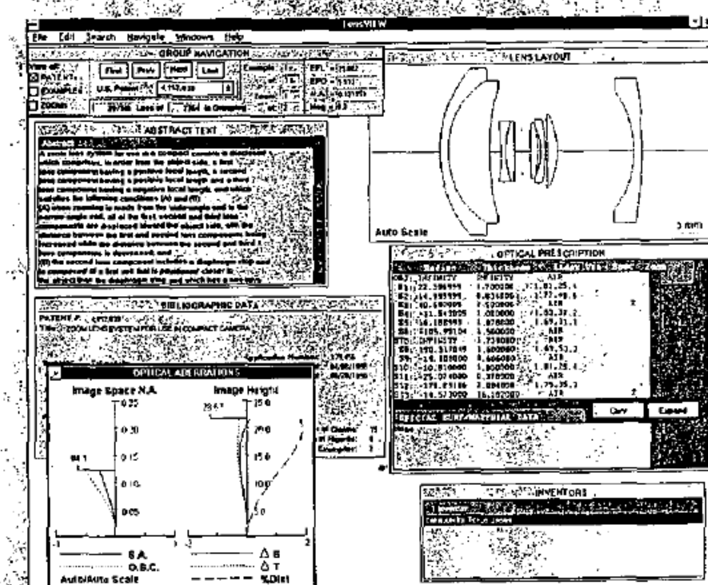
The LensVIEW user interface is simple to learn and use. There are windows for searching the database, listing lens data, drawing graphics, and more.

Complete search capability

LensVIEW has a very powerful search engine which permits searching through the more than 9,000 optical designs (about 15,000 including zoom positions) using simple or complex queries. LensVIEW supports searches using numerical aperture, field of view, magnification, number of elements, wavelength, and much more; there are 57 searchable parameters in all! Searches may include ranges on the patent number, the inventor(s) name, and may use Boolean operators to look for certain keywords in the abstract.

LensVIEW exports to ZEMAX!

Best of all, LensVIEW exports all these patented designs in ZEMAX format! At the click of a button, you can generate a ZEMAX format lens file. If you also have ZEMAX, then you can load up the file and begin modification of the lens for your specific requirements. The extensive data base of LensVIEW, coupled with the powerful search engine and ZEMAX file format export capability, make LensVIEW an invaluable productivity enhancer for every optical designer and technical patent researcher. LensVIEW also exports data in CODE V® .SEQ and other lens design program formats.



LensVIEW displays the optical prescription in detail, abstract, bibliographic data, the inventors name(s), and optical aberration curves, including spherical aberration, OSC, and astigmatic field curves.

FOCUS SOFTWARE, INC.

Focus Software, Incorporated
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Tucson, Arizona 85731 USA
Tel: (520) 733-0130 Fax: (520) 733-0135
E-Mail: sales@focus-software.com
http://www.focus-software.com

LensVIEW: The indispensable resource

Every optical designer should have a copy of LensVIEW. Using LensVIEW to do the background research on existing optical designs can save countless hours of frustration and wasted effort. Using LensVIEW to search for designs which are similar to the design you need takes only minutes, and gives you a great source of starting points for optical design. Once you have found a candidate design, exporting the lens to a ZEMAX format file is quick and easy. Once in ZEMAX, the design may be modified to suit the specific requirements at a hand. LensVIEW will likely pay for itself the very first time you use it, and will prove to be an invaluable resource for every optical design project.

Intuitive graphical interface

The intuitive interface supports multiple graphic windows, including cross-sectional layouts, aberration plots, and numerous dialog boxes and text display windows. The aberration plots include longitudinal spherical aberration, offense against the sine condition, sagittal and tangential astigmatism, and distortion.

LensVIEW displays multiple text windows, including optical prescription data, optical system data, LensVIEW classification data, bibliographic data, references cited, inventors, abstract text, sample claims, and application data. There are also windows which display user-defined data, so that notes may be added to each lens for future reference, and windows which provide online help, and a complete reference of the US and LensVIEW classification systems.

LensVIEW: always up to date

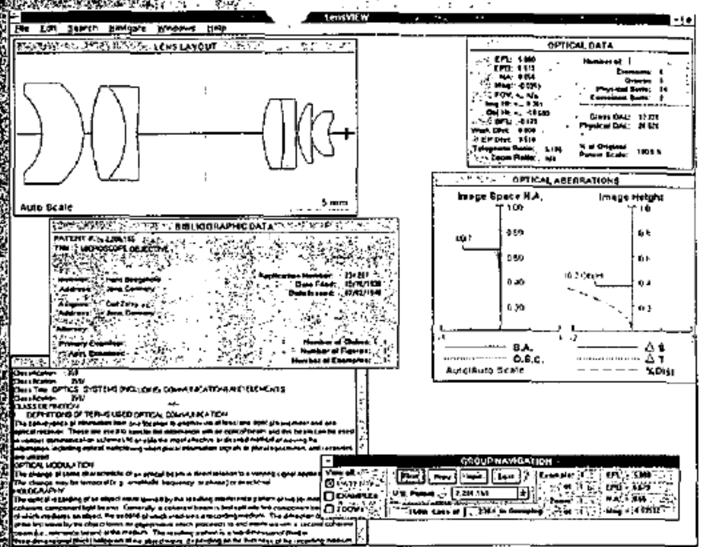
LensVIEW is updated quarterly, and the initial purchase price includes the first year of updates. The frequent upgrades keep you current as to developments in optical design technology, to help keep you ahead of your competition!

System requirements

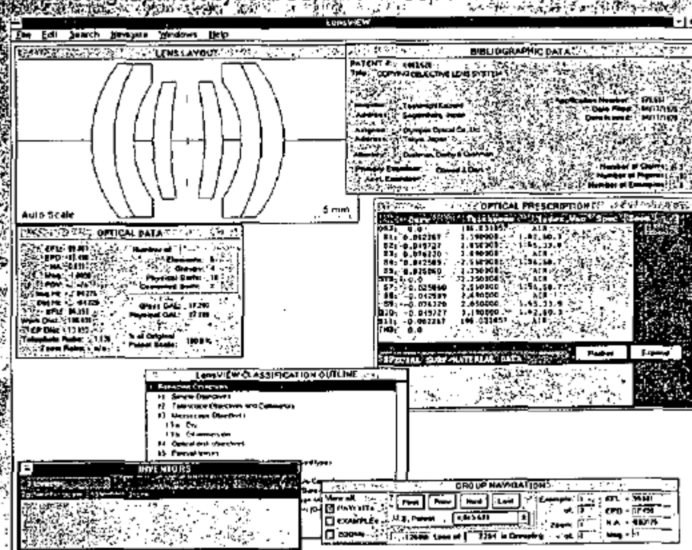
LensVIEW runs under Windows 3.1 or Windows 95. LensVIEW requires 8 Mb of RAM, a CD-ROM player, and 20 Mb of free hard disk space. A separate lens design program, such as ZEMAX, is helpful but not required.

For more information...

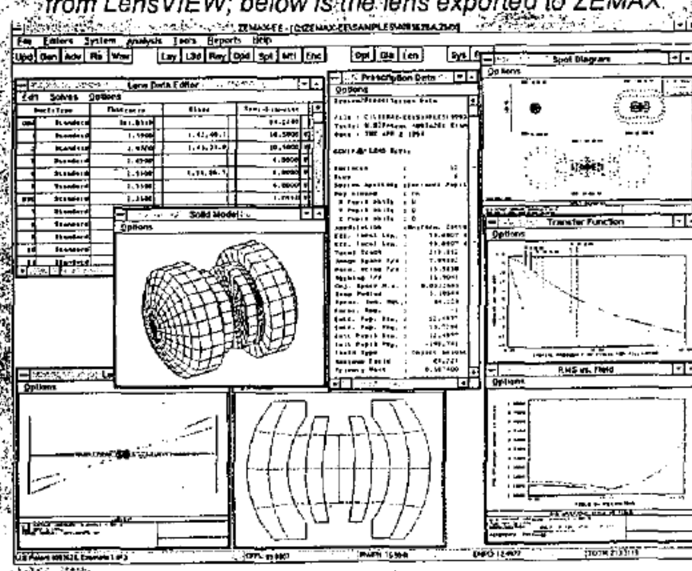
LensVIEW is a product of Optical Data Solutions, Inc., and is distributed worldwide by Focus Software, Inc. For more information on LensVIEW, or on other Focus Software optical engineering products, call, fax, or visit our web site at http://www.focus-software.com, or e-mail any questions to sales@focus-software.com.



LensVIEW includes a wide range of optical system types, including wide angle lenses, copy machine lenses, photographic objectives, microscope lenses, and more.



Once the desired lens is located, LensVIEW exports the data into a ZEMAX lens file. Above is a copy machine lens from LensVIEW; below is the lens exported to ZEMAX.



Here is a screen capture of ZEMAX analyzing a copy machine lens exported from LensVIEW. LensVIEW converts any patent design into a ZEMAX lens file. LensVIEW also generates CODE V® sequence files.

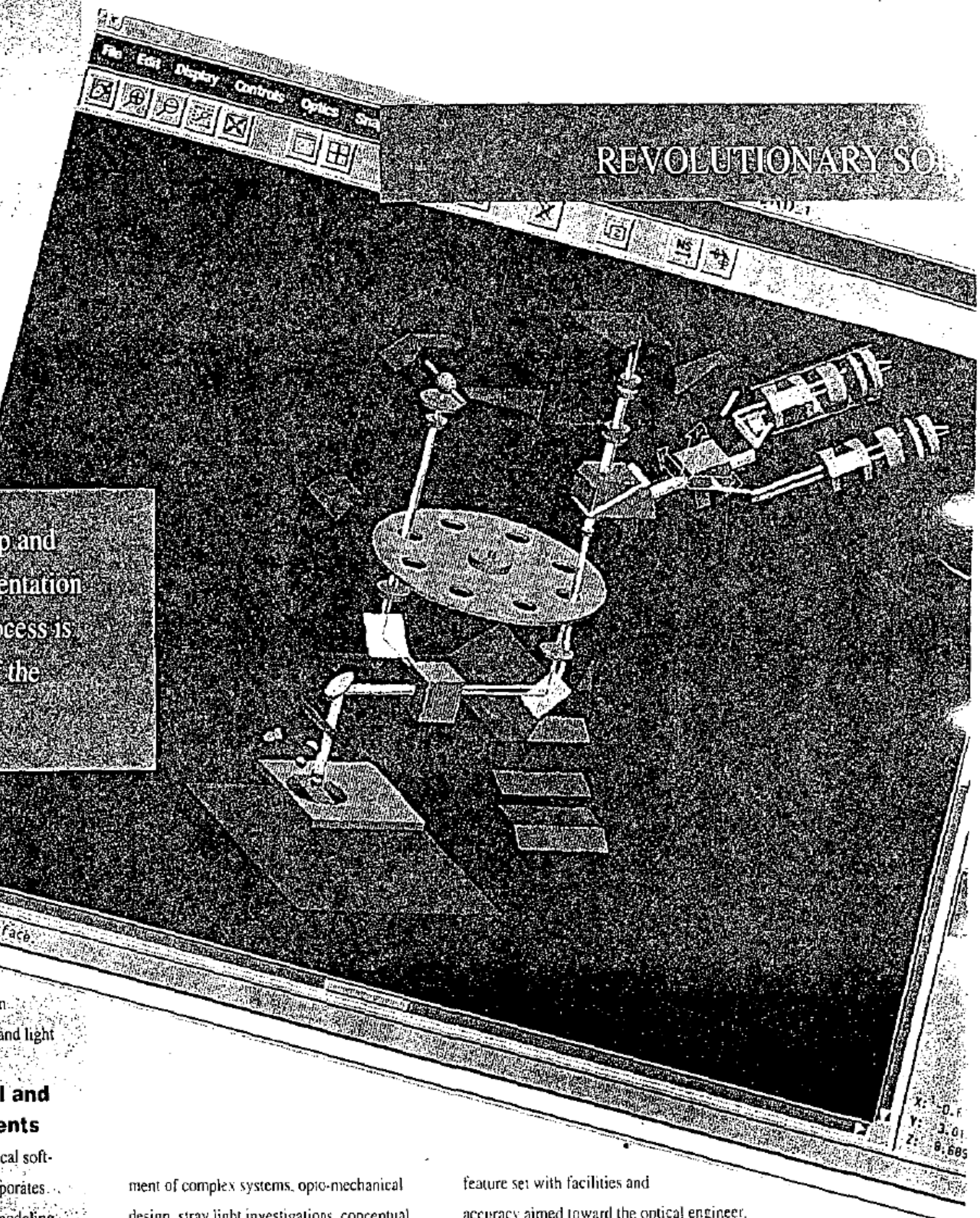
OPTICAL RESEARCH ASSOCIATES

OPTICAL SYSTEM AND MODELING SOFTWARE

LightTools™

"See what you haven't been able to see before."

REVOLUTIONARY SO



LightTools™ is a revolutionary, three dimensional, interactive solid modeling system with optical accuracy, developed by Optical Research Associates (developers of CODE V®). It provides a state-of-the-art means for directly representing lenses, mirrors, beamsplitters, diffractive optics, prisms, polygon scanners, mechanical structures, and light paths.

> The ability to develop and see a true 3-D representation during the design process is a major advantage of the *LightTools* approach.

Integration of optical and mechanical components

LightTools is unique among optical software products in the way it incorporates the latest developments in solid modeling techniques for visualization of as-built designs. This greatly facilitates communication both internally and externally for the company responsible for the lens or systems designs.

LightTools' easy-to-use "point and shoot" non-sequential ray tracing, combined with integration of optical and mechanical components in a single system, makes it ideal for the design and management of complex systems, opto-mechanical design, stray light investigations, conceptual design, interdepartmental communication and data exchange, and for marketing or proposal work.

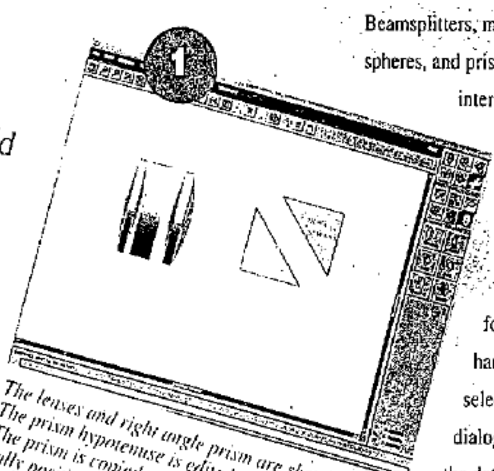
CAD/CAM programs can't match LightTools' optical accuracy

Purely mechanical-based CAD systems often lack the optical accuracy or ability to easily handle common optical shapes. *LightTools* provides a robust mechanical feature set with facilities and accuracy aimed toward the optical engineer.

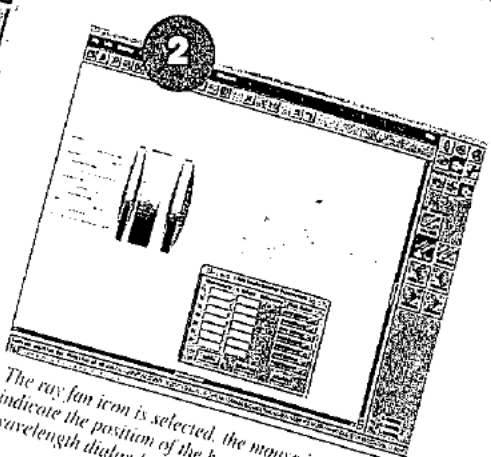
LightTools provides a variety of ways to represent and interact with the complete opto-mechanical model including 2D, 3D wireframe, and 3D shaded solid (or translucent) views.

Interactive creation and modification capabilities include graphical place, move, rotate, copy, and scale functions on any individual or group of components.

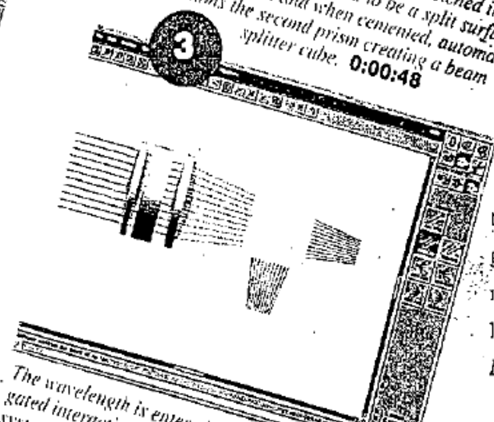
This series of five photographs illustrates the ease of quickly entering optical elements as a solid three dimensional *LightTools* model. **The entire five-photo sequence took a total of less than ninety seconds to complete.**



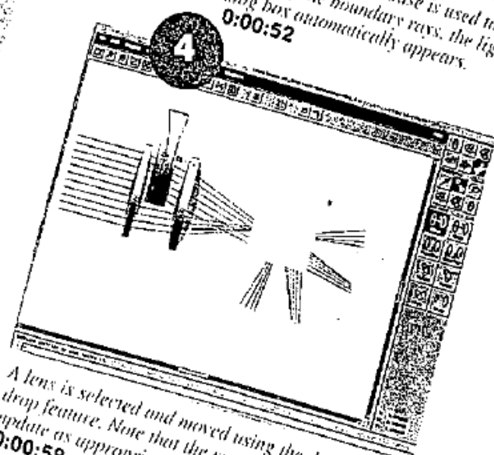
The lenses and right angle prism are sketched in. The prism hypotenuse is edited to be a split surface. The prism is copied, and when cemented, automatically positions the second prism creating a beam splitter cube. **0:00:48**



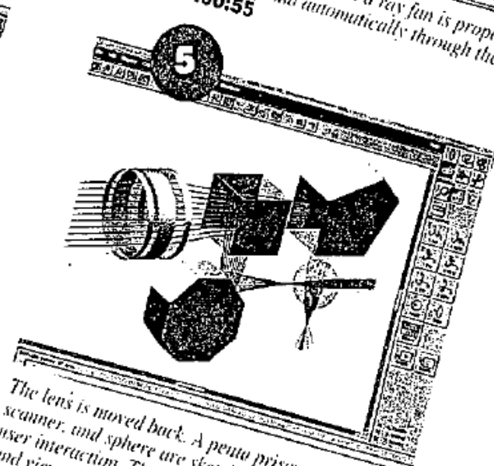
The ray fan icon is selected, the mouse is used to indicate the position of the boundary rays, the light wavelength dialog box automatically appears. **0:00:52**



The wavelength is entered and a ray fan is propagated interactively and automatically through the system. **0:00:55**



A lens is selected and moved using the drag and drop feature. Note that the rays automatically update as appropriate, given the new lens position. **0:00:58**



The lens is moved back. A penta prism, polygon, scanner, and sphere are sketched in with minimal user interaction. The solid model can be rotated and viewed from any angle. **0:01:24**

Creating and modifying a LightTools model

Lenses can be entered with three to six mouse clicks. Light rays update interactively when a lens is selected, dragged and dropped to a new position. Beamsplitters, mirrors, polygons, spheres, and prisms can all be entered interactively by indicating positions and dimensions with either mouse or keyboard input.

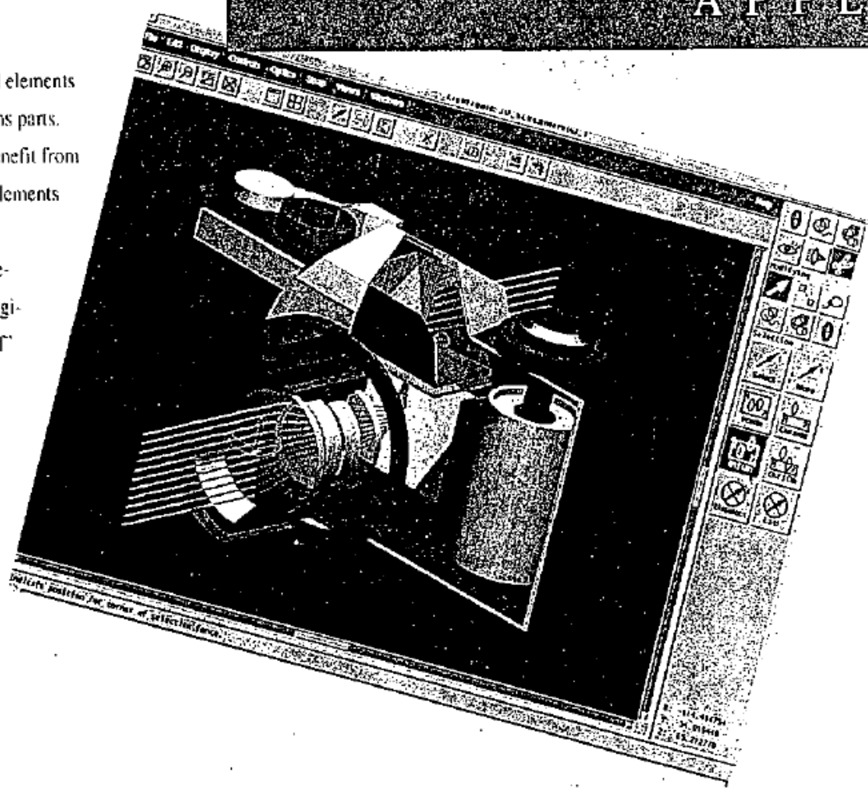
Editing is straightforward. Use the right-hand mouse button to select any element and a dialog box appears with all the data used to define that element. The user can edit any dialog box entry, edit the model via the table view (which, in spreadsheet format defines the entire *LightTools* model), interactively edit any aspect of a single or grouped set of elements using the mouse or keyboard entry, or use a script language to develop or modify the *LightTools* model.

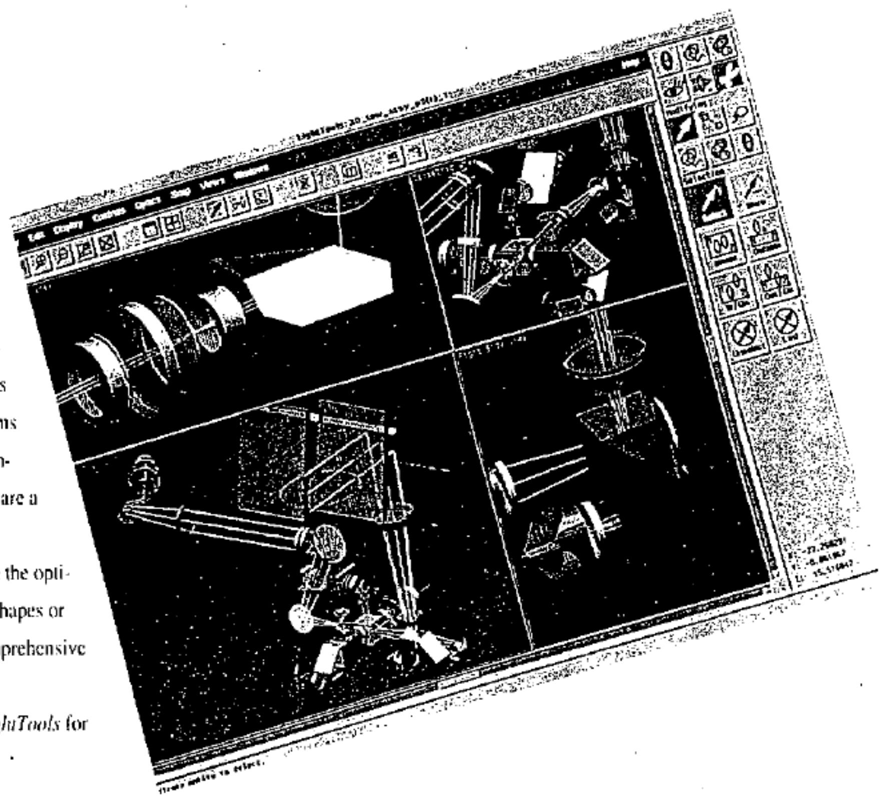
Opto-mechanical Design

With *LightTools*, designers can lay out optical and structural elements while simultaneously considering the optical effects of all systems parts.

The design of baffles, structures, mounts, and flexures all benefit from immediate access to the location and exact shape of the optical elements and the light propagating through the system. Using the same *LightTools* features, commands, and user interface as the lens elements, opto-mechanical designers, lens designers, and optical engineers can easily share data and perform cross-functional "what-if" design trade-offs.

LightTools allows the packaging to be a part of the same model as the optical system, designed simultaneously with the optical system, or as input criteria not to be violated by the optical design. *LightTools* provides tools for handling the complexity of irregular or folded three dimensional envelopes as a physical boundary condition for complex optics systems.





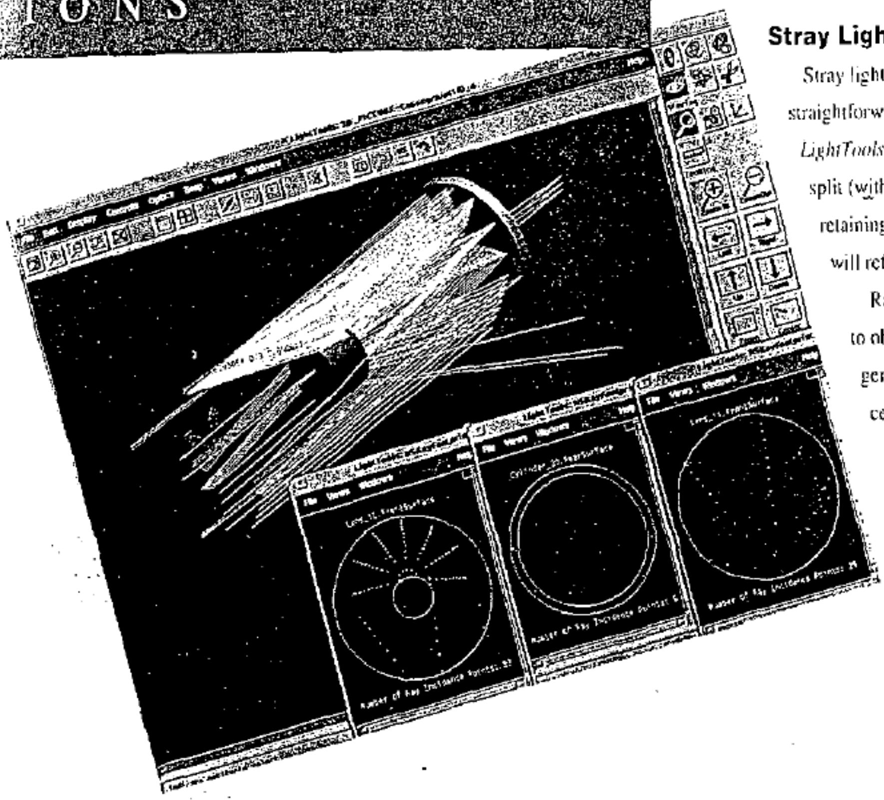
Complex Optical System Setup

LightTools is particularly useful in the set-up and visualization of multi-path or folded lens systems, or systems with prisms or irregularly shaped optical elements. With *LightTools*, problems with sign conventions, complex tabular modeling of prisms, non-modeled structural elements, and simplified lens/optical shapes are a thing of the past.

Once a basic layout is in *LightTools*, lens designers can use the optical calculator function to manually iterate on element-specific shapes or focal length objectives. Data can be passed to CODE V for comprehensive system-wide optimization and analysis.

A system optimized in CODE V can be transferred into *LightTools* for integration with the structural elements for final visual check.

IONS

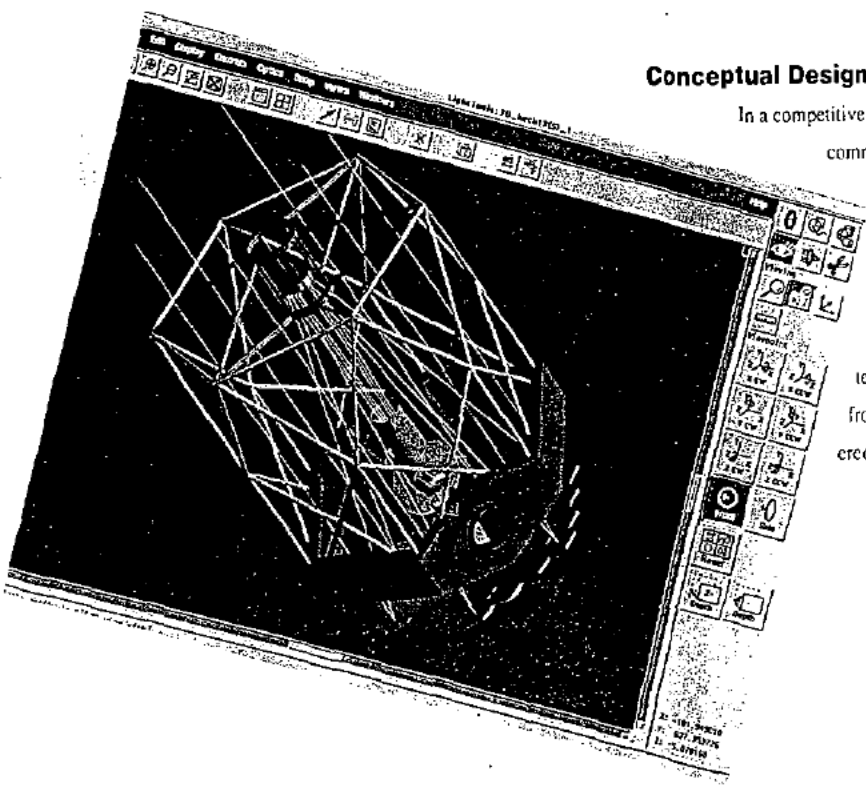


Stray Light Investigations

Stray light, energy tracking, and ghost image investigations are easy and straightforward using *LightTools*. This is because every surface in *LightTools* has optical characteristics such as refract, reflect, absorb, or split (with defined split percentages). For example, a lens edge or even a retaining ring can be made reflective and light rays striking the edge will reflect and continue propagating through the system.

Ray patterns can be defined anywhere in the system at any point to observe how the light propagates. *LightTools* will automatically generate any required multiple ray "branches" and track the percent of energy remaining with each ray.

A grid footprint plot, combined with tabular data specifying energy percentages at each point where a ray passes through a specified surface, provides quantitative information. This data can be viewed directly or passed via a tab-delimited file to a spreadsheet or to mathematical software for further manipulation.



Conceptual Design & Proposals

In a competitive environment, business is usually won by the company that best communicates its vision. For developers describing ideas, methodologies and end products to potential customers, the benefits of a complete, accurate, and exciting visual description of the solution cannot be overemphasized. Only *LightTools* provides these benefits in the optical design arena.

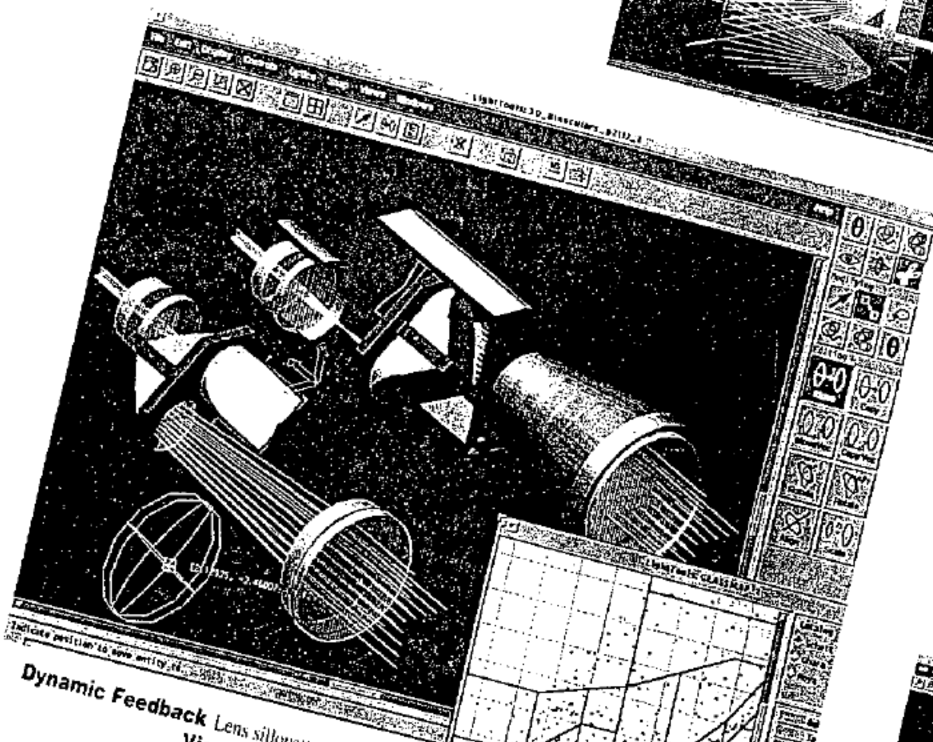
Optical engineers can quickly trade off alternative optical system approaches in the early design phase, incorporating inputs from other engineering disciplines. Potential problems are discovered and corrected early, avoiding costly downstream changes.

FEATURES

LightTools has many powerful interactive features which empower the user to work in the most efficient manner possible. The guiding philosophy in *LightTools* development is to produce a software tool that allows the user to concentrate on the design task, rather than on how to use the software.

Output Includes encapsulated PostScript, DXF, IGES, CODE V lens data, CODE V plot file, *LightTools* script, and tab-delimited spreadsheet formats.

Table view Provides unprecedented ease of access to an interactive solids system database which defines the entire model via a user-expandable, outline-form spreadsheet for system investigation or modification.



Dynamic Feedback Lens silhouette provides visual feedback during copy and move operations.
Viewing Glass map allows graphical glass selection.

LightTools allows you to concentrate your efforts on the design task rather than on how to use the software.

Construction tools Layers, grid support, local and global coordinate systems, sketch options for common optical shapes, and standard CAD manipulation features give unprecedented ease-of-use for the creation and modification of optical systems.

Boolean operations Union, intersect, and subtract operations allow for full creation and editing of solids. All element types are supported. Cutaways can be made to show internal details of optical elements or structure.

Non-sequential ray trace Physical representation of light propagation supporting split rays, amplitude/energy tracking of individual rays, grid footprint and tabular representations of energy intersecting a surface.

Diffractive surfaces Any surface can be specified as diffractive and the light propagates appropriately through and/or off of the surface. An unlimited number of multiple orders can be concurrently traced.

Viewing View options include 2D, 3D (wireframe, hidden line, silhouette, solid, translucent), field point, glass map, and tabular data representations with interactive real-time simultaneous updating of all views.

Windowing Maximum flexibility with pre-defined and user definable view angles, including rotation of the 3D model; one, two, and four panes (allowing multiple viewing angles and magnification factors for a single model).

User interface State-of-the-art interface includes a toolbar, pull-down menus, dialog boxes, console panel, on-line help including one-line prompt, and icon palette. Each icon contains explanatory ciphers.

Dynamic feedback Dynamic "rubberband" style feedback during copy/move functions via silhouette image "attach" to selected element (s) to the cursor.

No data limits *LightTools* has essentially no data limits. For instance, it supports an unlimited number of surfaces, elements, wavelengths, reference rays, and fields. Aperture stops are definable at any location. All elements and rays can be positioned at any location.

Boolean After Boolean subtract leaving cutaway.

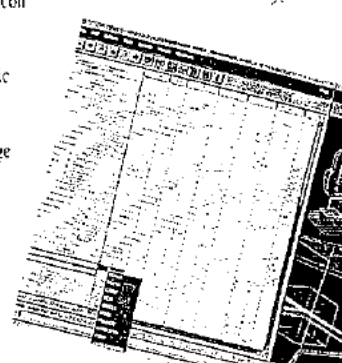
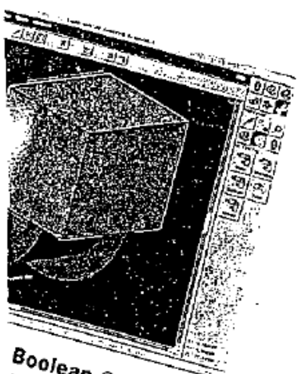
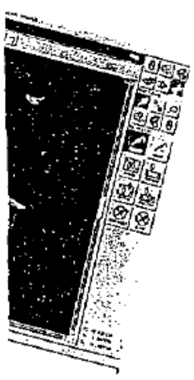


Table View Allows modification of parameters and attributes

Diffractive Surface Multiple-order diffractive surface simulates scattering by dust.
User Interface The Info dialog box allows modification of element parameters.



Boolean Cube positioned for cutaway of mechanical structure



IMAGING PATH MODULE

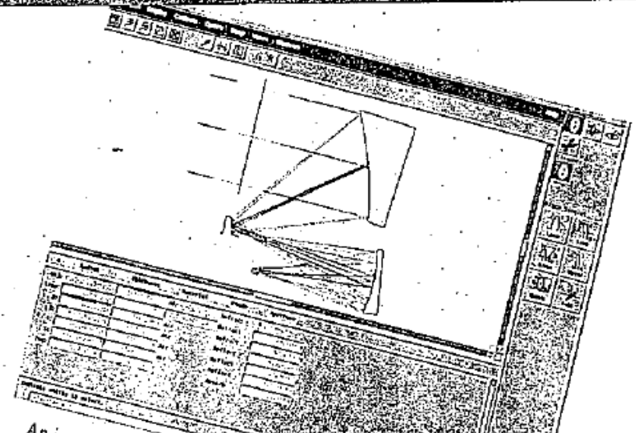
Imaging Path Module

An Imaging Path Module may be licensed for use with *LightTools*. It allows the creation of a sequential surface-based definition for lens design and analysis, for use directly in *LightTools*, or in conjunction with CODE V.

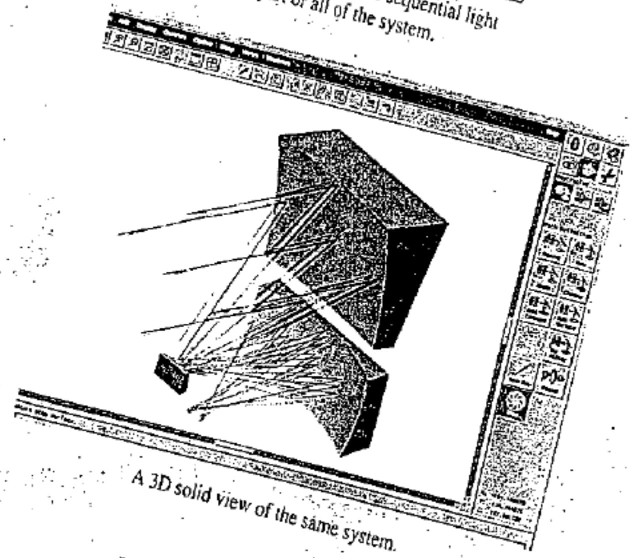
Analysis of the imaging properties of optical systems requires identification of a specific sequence of surfaces along which paraxial and real rays are traced. *LightTools* lets you designate any number of these surface sequences, called imaging paths, for which paraxial properties and solves, ray aberration curves, and other quantitative measures of optical performance can be calculated.

LightTools automatically ensures that complex systems involving multiple passes through surfaces and beamsplitters are correctly and consistently modeled.

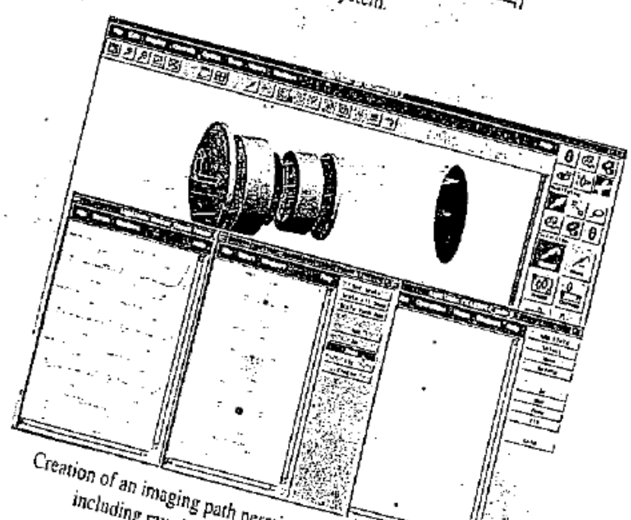
The sequential surface definition in the imaging path does not support multiple light paths in the same imaging path, but instead creates a distinct imaging path at each split. The definition of these image paths can be either automatic via using a "point and shoot" technique where a non-sequential ray is propagated through the system, or user-definable via surface-by-surface selection.



An imaging path represents a single, unambiguous sequential light path, propagating through part or all of the system.



A 3D solid view of the same system.



Creation of an imaging path permits analysis within LightTools including ray aberration curves and spot diagrams.

OVERVIEW

Optical Research Associates

Optical Research Associates (ORA®) is a leader in the optics industry both as the largest independent optical engineering services organization and as the developer of CODE V®, the world's leading optical design software package.

Founded in 1963, ORA has experienced continual growth by combining optical design and engineering leadership with an unwavering commitment to its customers' success.

Technical Support

We are committed to providing our customers with high quality software with state-of-the-art functionality. But this is not an end in and of itself. Our ultimate goal is to assist our users in achieving greater productivity, shorter lead times, and superior products.

Therefore, included with each license of *LightTools* is unlimited telephone support provided by a full-time team of highly skilled, technical experts — trained not only in the use of our software, but having backgrounds in real-world optical design.

We are dedicated to setting the standard in the field for the timeliness of our response and the technical completeness and accuracy of our assistance to all users.

Documentation, Training

User and installation documentation is supplied with each copy of *LightTools*. Regular manual updates and quarterly newsletters help keep your knowledge up-to-date. Training is available either through regularly scheduled classes or on-site training at customer facilities.

Licensing LightTools

LightTools is licensed on a lease basis. This ensures that *all* of our customers have the latest software and documentation. And, after an initial six month period, if customers are ever dissatisfied with the benefits of using *LightTools*, the license and payments may be terminated with thirty days notice. Because of this, our company's success is predicated on providing our customers with on-going value.

Call or write ORA today

LightTools™

OPTICAL RESEARCH ASSOCIATES
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East Coast Office: 945 Concord Street, Framingham, Massachusetts 01701

Front cover helmet mounted display system based on Honeywell patent number: U.S. 4,854,688

OPTICAD®

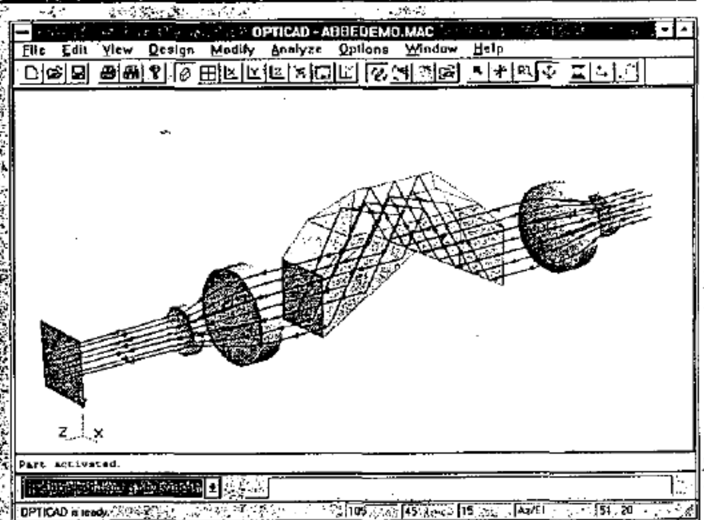
Non-Sequential, Stray Light, and Illumination Analysis Software

What is OPTICAD?

OPTICAD is a flexible, easy to use non-sequential, stray light, and illumination optical system modeling program for Windows. OPTICAD can perform analysis on arbitrarily placed optical components, with the capability to do unconstrained ray tracing, reflection, refraction, scattering, and illumination modeling.

OPTICAD supports lenses, mirrors, light pipes, prisms, geometric shapes, and other optical components. Sources may be modeled as points, lines, or surfaces. Sources may be diverging or collimated, and multiple sources may be placed at any location. Surfaces may be refractive or reflective, and be diffuse, specular, or a mixture of both.

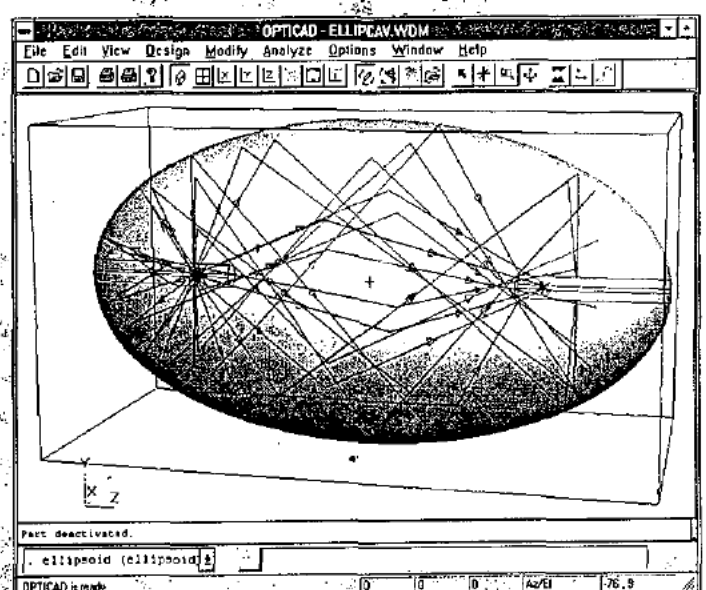
Arbitrary shapes, including arbitrary light pipes, prisms, and user-defined geometrical objects may be created using the powerful polynet modeling capability. Entire system models may be created and modified using either macro like scripts or by using stock parts selected from pull-down menus.



This screen capture illustrates OPTICAD performing a non-sequential ray trace of an Abbe prism. Note the collimated beam entering from the left. The beam passes through a beam expander and then through an Abbe prism with an internal roof, and then finally through a beam reducer.

Applications for OPTICAD

- Parabolic or arbitrarily shaped concentrators
- Light pipes of any shape or complexity
- Automobile instrument and display panel lighting
- Illumination systems, headlights, taillights
- Conventional optics, including lenses and mirrors
- Systems with prisms or beam splitters
- Laptop computer displays
- Slide and television projectors
- Flow-cells, and other bio-medical instruments
- Uniform illumination reflectors
- Stray light analysis, baffle design
- Optical scanners
- Flashlamp and diode pumped lasers
- Grazing incidence conics, x-ray telescopes
- Reflective highway markers, solar collectors
- Axiconal optics
- Fiberoptical design and multimode fibers



This plot demonstrates how OPTICAD can easily handle sources which radiate in a full spherical pattern. All the rays exiting the source point are collected by the elliptical reflector and imaged to the other focal point.

An Overview of OPTICAD

OPTICAD uses a simple Windows interface to define, manipulate, and analyze arbitrary optical systems. User input may be via the pull-down menu system, or by externally defined macros.

Macros are generally used to define complex parts such as light pipes, faceted surfaces, or prisms. The macros are written in a simple ASCII script.

The polynet macro commands are used to define arbitrary objects which are composed of multiple facets. Groups of polynet defined objects may be used to implement systems of arbitrary complexity.

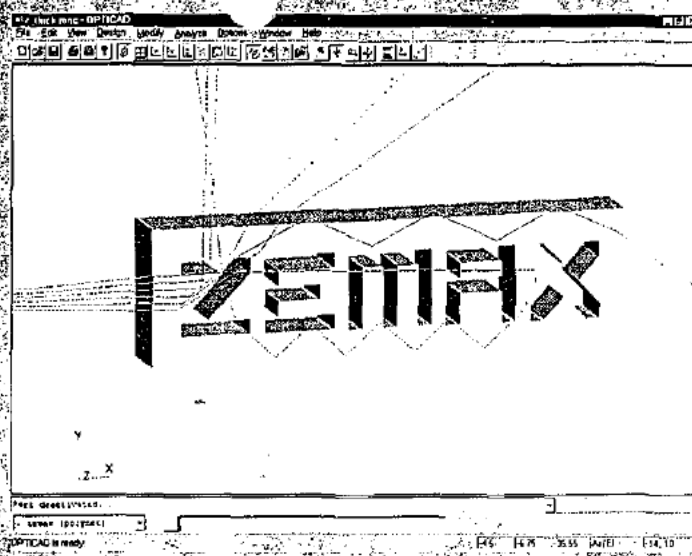
Once the optical components are defined, sources may be located, also via direct placement or macro script. Sources may be collimated or divergent. Options allow sources to illuminate in a variety of distribution functions, including cones, squares, Gaussian or Lambertian profiles, and more.

Ray densities may be selected, and then OPTICAD will draw the rays propagating through the system. OPTICAD determines where the rays go once the geometry is defined. Rays may intersect components in an arbitrary order. There is no need to define the sequence of ray intersections as is the case with conventional ray trace codes.

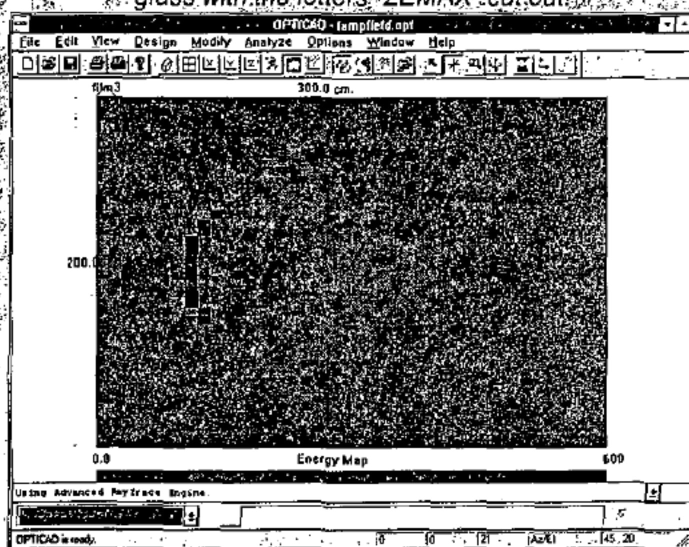
Finally, OPTICAD produces 3-D isometric views of the optical system and rays, as well as wireframes and (optionally) solid shaded models. Illumination distributions on arbitrary surfaces are also available.

OPTICAD Capabilities

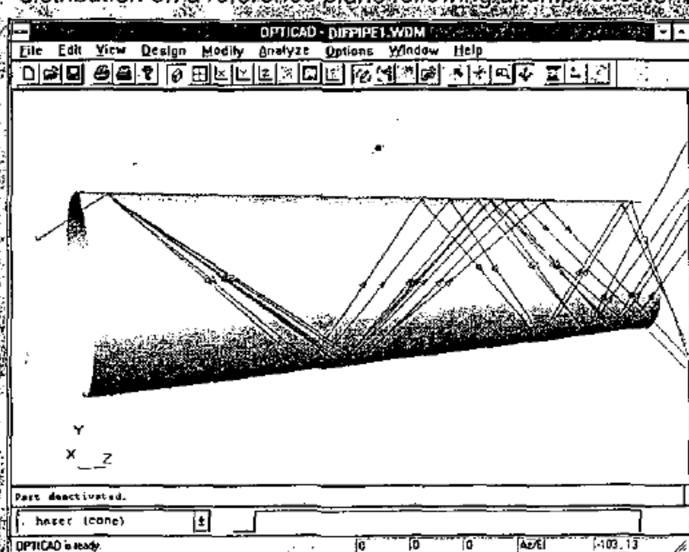
- Code Architecture:
  - Fully 32-Bit Windows code
- User Interface:
  - Pull down menus
  - Toolbar for frequently used functions
  - Powerful macro scripts
  - Full 3-Dimensional CAD format
  - Export IGES and HPGL line work files
  - Outstanding interactive graphical interface
  - Online help
- Graphical Displays:
  - Isometric and arbitrary angle 3-D view
  - 3-D ray trace view
  - Spot diagrams
  - Energy plots
  - 2-D Intensity maps
  - Optional 3-D solid display
  - 3-D Global coordinate system
- Documentation:
  - Users Manual
  - Application Notes
  - More than a dozen complete examples



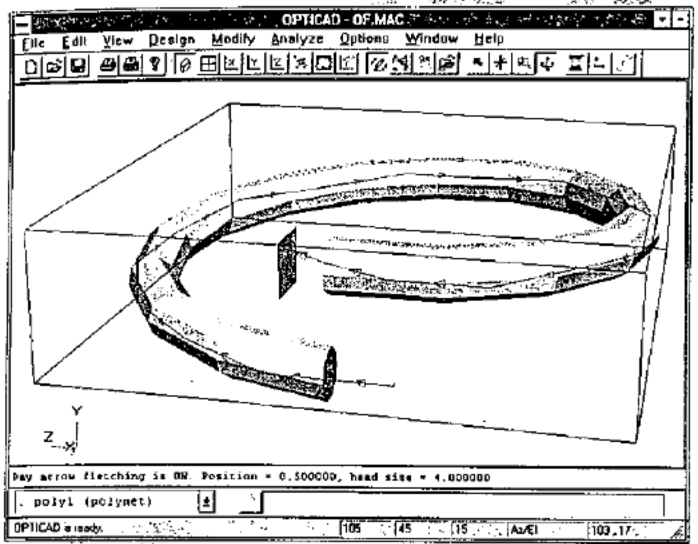
The incredible flexibility and power of OPTICAD allows definition of very general shapes, including this block of glass with the letters "ZEMAX" cut out!



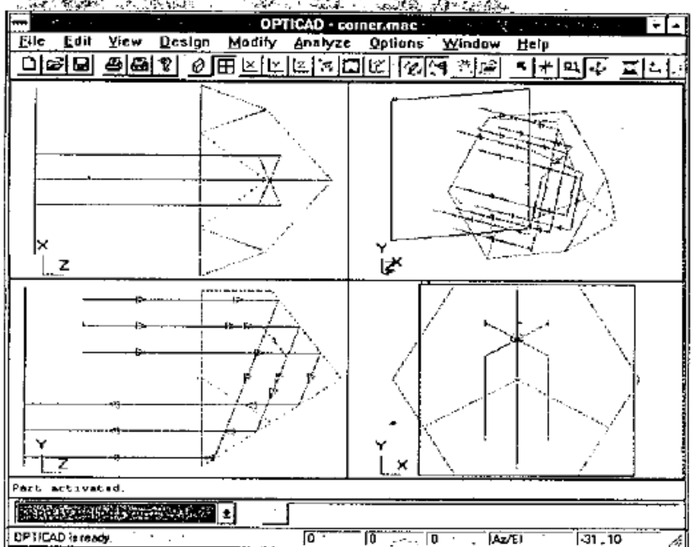
A false color energy distribution map. The variation in intensity levels is represented by colors. This is the distribution on a reference plane following a lamp reflector.



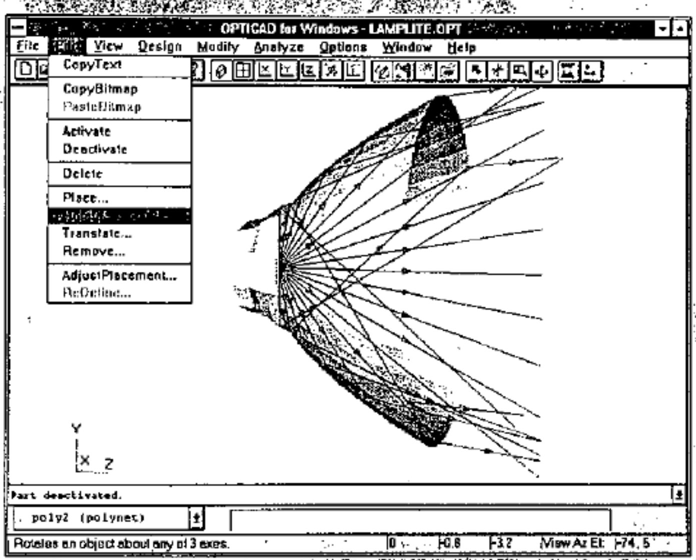
This screen shot illustrates a partially diffuse surface model for stray light evaluation. Note that after the first reflection through the cone, the ray bundle begins to disperse. Each succesive reflection causes further break up of the beam.



Here is a sample of a very general light pipe modeled with OPTICAD. Completely arbitrary shapes may be modeled with the powerful polynet feature.



Four isometric views are simultaneously drawn; viewing down the X, Y, Z and an arbitrary, rotated axis.



This polygon reflector model was created in AutoCAD, then imported into OPTICAD using the optional IGES translator. Note the structural detail near the light source.

OPTICAD Features

OPTICAD features a true point and shoot non-sequential ray trace engine, unlike some so-called non-sequential ray trace programs which add on non-sequential ray tracing as an afterthought. OPTICAD *does not* require the use of "entry" and "exit" ports; simply place the sources anywhere at all in a true 3D space, and OPTICAD determines automatically where the rays go!

OPTICAD incorporates all of these powerful features:

- Ray Tracing
  - Diverging or collimated ray bundles
  - True non-sequential ray trace
  - Multiple independent ray paths
  - Automatic ray branching
  - Multiple point sources may be placed anywhere
  - Total internal reflection, and Fresnel reflection
  - Energy distribution and radiometric analysis
  - Diffuse scattering at any surface:
    - Lambertian, Gaussian, Power Law, X-Y exponential
  - Monte Carlo simulation
  - Volume absorption (Beer's law)
- Mirrors
  - Full and partial spheres, ellipsoids, cylinders
  - On- and off-axis parabolas
  - Elliptical and parabolic troughs
  - Arbitrary 3-D faceted reflectors
  - Import from CAD programs via optional IGES translator
  - Cones and conics
  - Compound Parabolic Concentrators (CPC)
  - Winston collectors
  - Diffraction gratings
- Lenses
  - Spherical
  - Cylindrical
  - Aspherics
  - Torics
  - Rods
  - Fresnel Lenses
  - Diffraction gratings
- 3D Faceted Solids
  - Simple and complex prisms
  - Corner cubes
  - Arbitrary 3D surfaces
  - Import from CAD programs via optional IGES translator
  - Arbitrary light pipes
  - Apertures of finite extent

In addition to a wide variety of conventional components, OPTICAD can model unusual, complex, user-defined solids and faceted surfaces using the powerful polynet model. Complex geometries and structures may also be defined in an external CAD program, then imported into OPTICAD using the optional IGES translator.

Optional Features

Two optional OPTICAD features are available:

The 3D Solid Model display option adds the capability to render arbitrary optical systems using a shaded polygon model. This feature greatly enhances the visualization of the optical system. The shading may be made partially transparent so that the ray paths within the solid optics may be observed.

The Opti-IGES CAD translator option permits translation between OPTICAD and IGES format files. This permits IGES standard CAD files to be imported into OPTICAD for further non-sequential and illumination analysis. OPTICAD can export to IGES files without this option.

System Requirements

OPTICAD is available for IBM PC computers running Windows 3.1, Windows 95, or Windows NT.

System Requirements:

i486, Pentium, or Pentium Pro CPU

Minimum 8 Megabytes RAM

10 Megabytes of free hard disk space

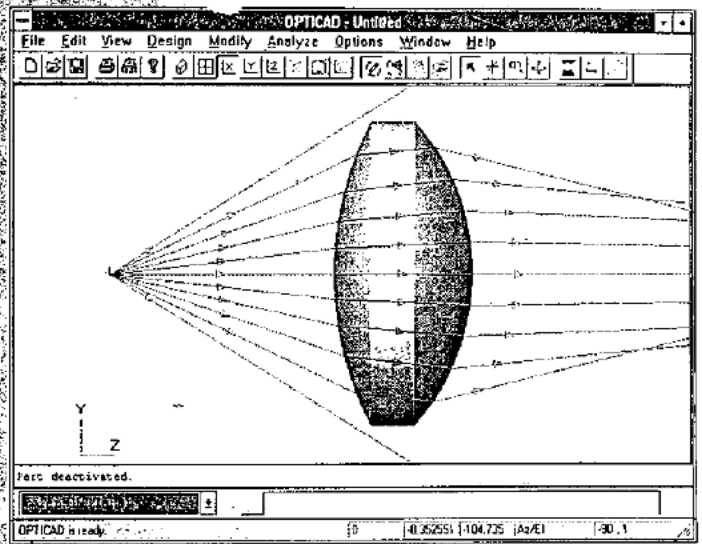
Technical Support

OPTICAD comes with 90 days of technical support. Additional technical support and upgrades are sold by the year.

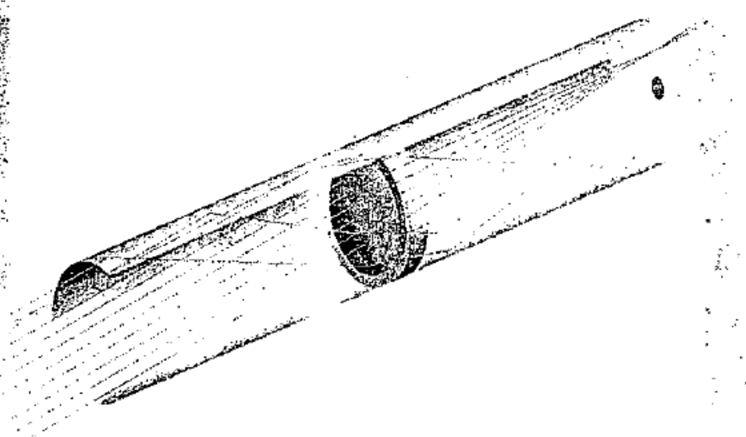
For More Information...

OPTICAD is a product of the OPTICAD Corporation, and is distributed by Focus Software, Inc.

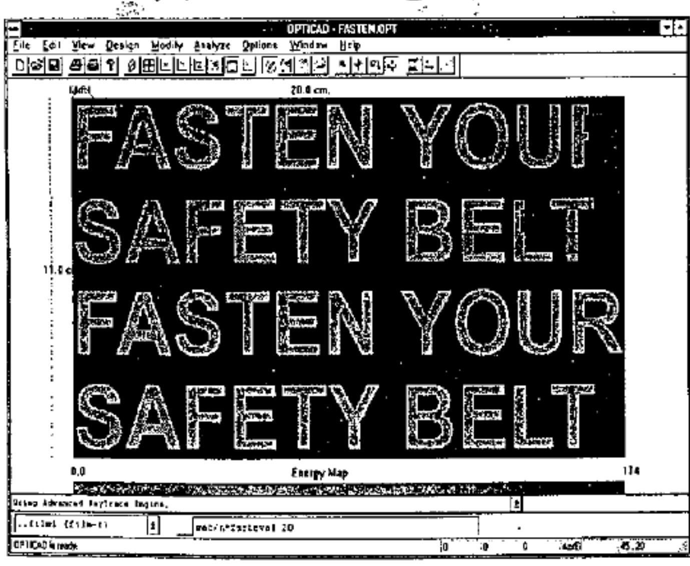
For more information on OPTICAD, or on other Focus Software optical engineering products, call, fax, or visit our web site at http://www.focus-software.com, or e-mail any questions to sales@focus-software.com.



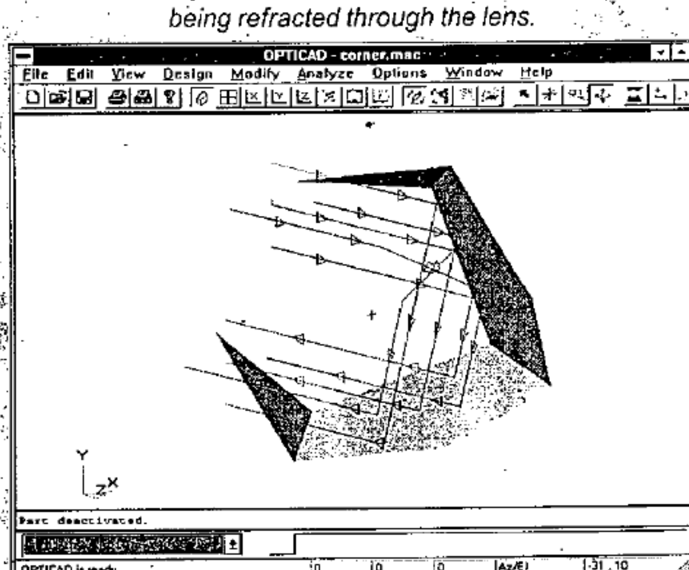
This figure illustrates the non-sequential nature of OPTICAD. Note that rays which do not strike the lens pass undeviated beyond the lens apertures.



This image was created by OPTICAD to illustrate rays passing through a lens mounted inside of a barrel. Note some of the rays reflect off the inside of the barrel prior to being refracted through the lens.

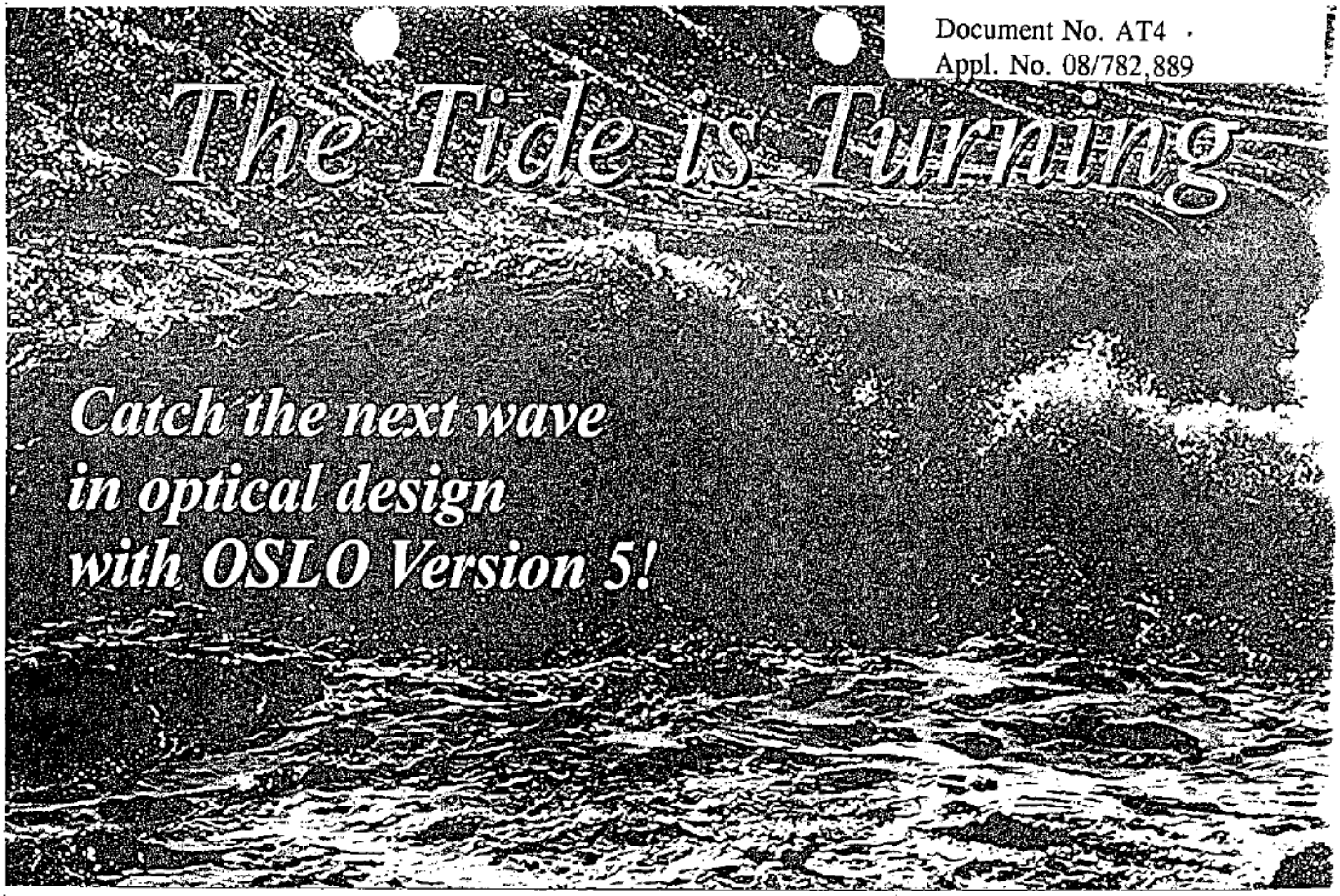


Arbitrary masks may be placed over illumination distributions, which permits analysis of instrument lighting.



The powerful polynet feature allows easy definition of general component shapes, including this prism.

Document No. AT4
Appl. No. 08/782,889



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OSLO Light really shines in optical systems design. It handles more types of systems than programs that cost three times as much, and gives you SCP macro optimization, which provides the power to "optimize anything!" Call for details, or ask about OSLO LT, our free trial version.

OSLO PRO

OSLO PRO has established a well-deserved leadership position in contemporary lens design. It provides the new capabilities you need, such as gradient index and diffractive optics, the best Windows interface of any optical design program, plus a new command interface for maximum speed and power.

OSLO SIX

OSLO SIX provides the power and accuracy of the FORTRAN legacy programs, but uses new software technology to provide more speed and usability, at a much lower cost. It's based on 40 years of optics experience and 20 years of PC experience. If you're looking for the best in optical design software, check it out!

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Available for Windows, Windows NT, and UNIX workstations. Please write or call for more information.

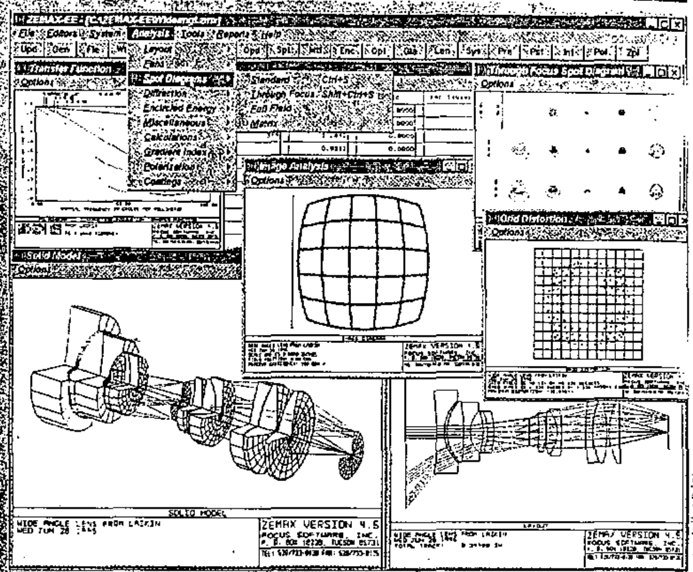
Fax Today. See page 62.

ZEMAX: STATE OF THE ART OPTICAL DESIGN

The ZEMAX Optical Design Program is the worldwide standard for lens design software. ZEMAX integrates all the features required to conceptualize, design, optimize, analyze, tolerance, and document optical systems.

All of these powerful features are integrated into an exceptionally intuitive user interface which can be mastered in minutes, not months. Best of all, ZEMAX does all this without breaking your budget. Nothing comes close to the power, ease of use, and value of the ZEMAX Optical Design Program.

Three different editions of ZEMAX are available: ZEMAX-SE, ZEMAX-XE, and ZEMAX-EE. Each edition offers different features and capabilities. This brochure covers the major features available. Some features described are only available in the XE or EE editions of ZEMAX. For a summary of which features are supported in each edition, see the table on the back page.

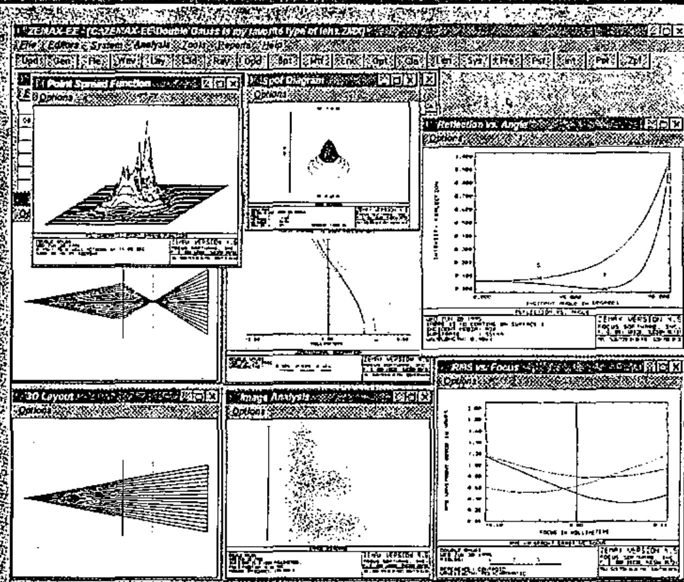


SOURCE TYPES

ZEMAX supports several different types of sources to accurately model the optical system. Conventional point sources are available, and field points may be defined using angles, object heights, or image heights. ZEMAX also supports astigmatic and elliptical sources. These sources are used for modeling laser diode collimators and other types of lenses used with astigmatic sources.

Extended sources are also available. These sources are user defined using an ASCII format similar to a bitmap image. The number of pixels is user defined, and the intensity can vary at each pixel. It is possible to create sources which vary in intensity as a function of wavelength and position.

These extended sources can then be imaged through the optical system to see what the images would look like. Once an extended source file is created, it can be scaled, rotated, inverted, and relocated to any position in the field of view. Sources may be Lambertian, Gaussian, or uniform in distribution.

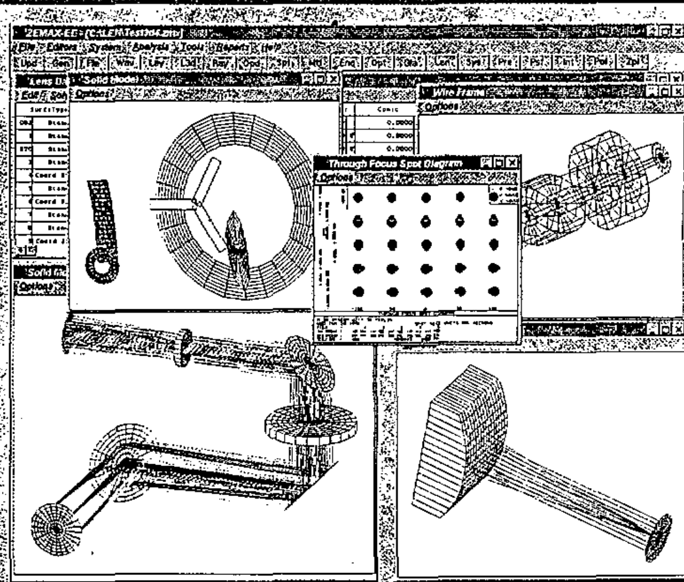


APERTURES AND OBSCURATIONS

ZEMAX has several different types of apertures. First, there is a system aperture which defines the size of the beam traveling through the optics on axis. This aperture may be specified by the entrance pupil diameter, image space F/#, object space numerical aperture, or by the system stop size.

ZEMAX can trace rays which are launched either at the paraxial pupil, or at the real, aberrated pupil. This feature is absolutely essential in wide angle or fast optical systems. Vignetting factors are also supported. The coefficients allow for pupil shrinkage and shift as a function of field.

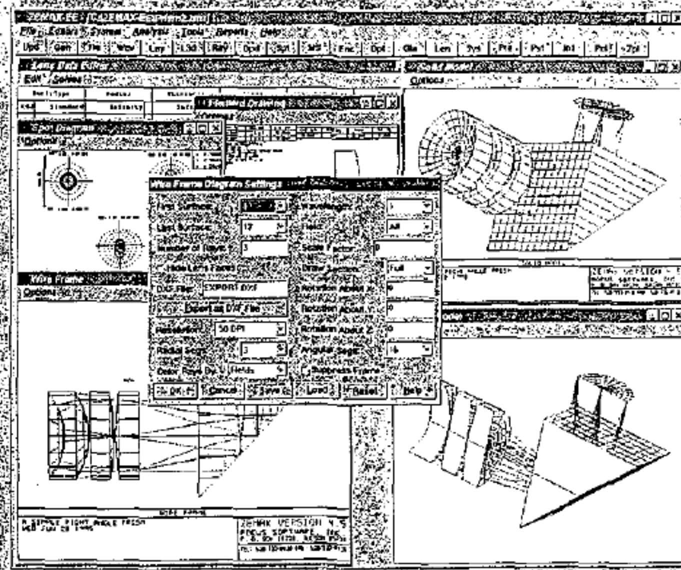
There are also apertures which only allow a portion of the beam to pass. ZEMAX supports circular, annular, rectangular, elliptical, and spider shaped apertures. Obscurations are the complement to apertures, and they are also available in circular, annular, rectangular, and elliptical forms. ZEMAX accounts for the effects of apertures, obscurations, vignetting, and aberrated pupils in all computations.

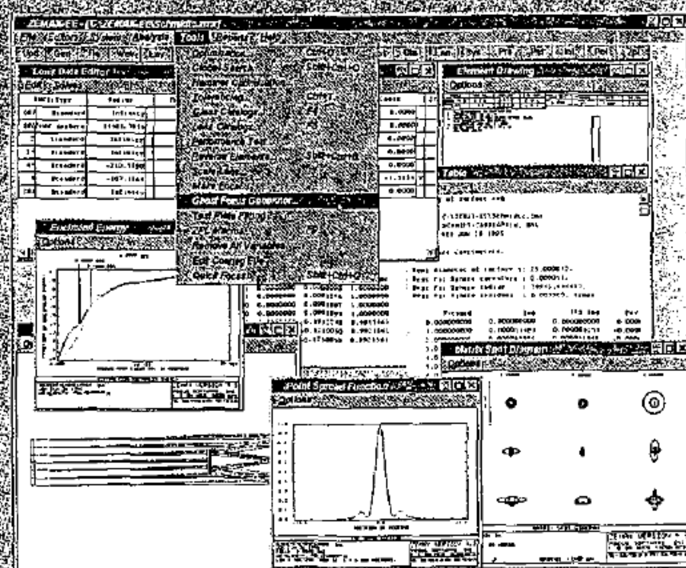


SURFACE TYPES

ZEMAX supports many different types of surfaces. Different surface types are combined to model virtually any optical system.

Type	Description
Standard	Includes planes, spheres, and conics
Even aspheric	A polynomial asphere up to 16th power
Odd aspheric	A polynomial asphere using odd powers
Paraxial lens	A perfect thin lens
Paraxial cylinder	A perfect thin cylinder lens
Toroidal	Cylindrical aspheres and toroids
Toroidal grating	A toroid with a grating superimposed
Toroidal hologram	A toroid with a hologram superimposed
Cubic spline	A spline of arbitrary shape
Irregular	For modeling fabrication errors
Hologram	Two point optically fabricated hologram
Diffraction grating	Straight line grating, standard substrate
Coordinate break	For tilts and decenters of element groups
Polynomial	Nonsymmetric polynomial asphere
Fresnel	Fresnel zone aspheric
ABCD	Paraxial ABCD for "black box" optics
Alternate	Alternate surface intersection surface
Conjugate	Two point perfect image surface
Gradient index	Multiple types, including axial, radial, traverse, spherical, and dispersive gradients
Zernike	Sag defined by Zernike polynomials
Zernike phase	Zernike terms used to define phase profile
Extended polynomial	Up to 65 term polynomial term asphere
Binary optic	Up to 65 term phase profile polynomial
Extended asphere	Up to 198th power rotational asphere
Extended spline	Up to 98 arbitrary sag points to define sag
VLS grating	Variable line space grating
Elliptical grating	Elliptical grating geometry
Super conic	A unique aspheric expansion
User defined	A user defined refractive or diffractive surface





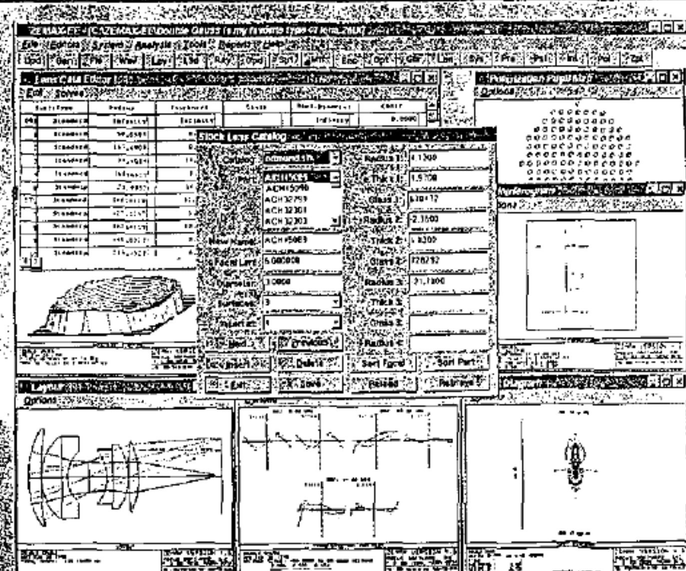
GLASS, LENS, AND TEST PLATE CATALOGS

Optical glass catalogs from Schott, Hoya, Ohara, and Corning are provided. Additional catalogs are supplied which include infrared materials, plastics, and natural materials such as silica. The catalogs include data for about 1000 materials, and include dispersion, thermal, and other data.

Stock lens catalogs from several major vendors are included. The stock lens catalogs include components available from Spindler and Hoyer, Newport, Edmund Scientific, Melles Griot, Rolyn, JML, and Optics For Research.

ZEMAX supports automatic test plate fitting. This feature automatically adjusts an optical system to fit the tooling of a particular vendor. Test plate lists are provided for many lens fabricators.

New glass, stock lens, and test plate catalogs may be created by the user, or new data may be added to the existing catalogs. As many catalogs as desired may be created and maintained.

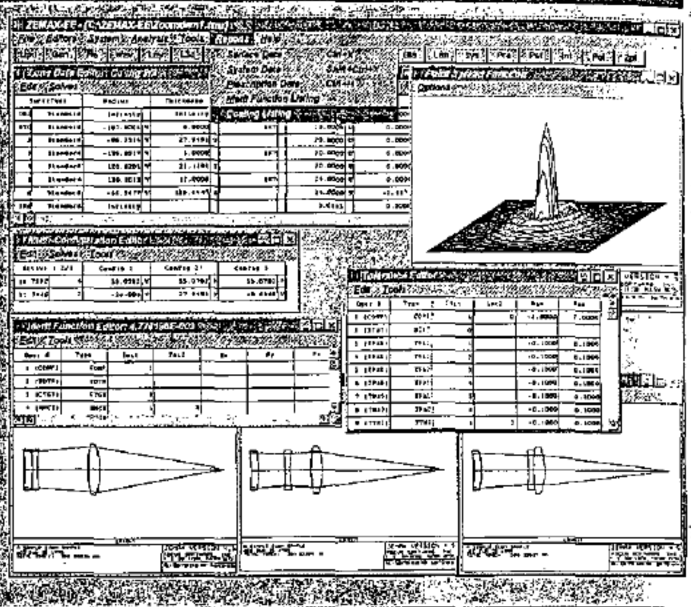


ZOOM AND MULTI-CONFIGURATIONS

ZEMAX supports zoom lens analysis and design as a special case of the more general multi-configuration concept. Virtually any parameter in ZEMAX, such as a wavelength, aperture value, field position, radius, thickness, glass type, or other data, may take on multiple values. Each configuration may have multiple values for many different parameters.

This feature can be used to design conventional zoom lenses, scanning systems, or multiple path systems, and has numerous other applications.

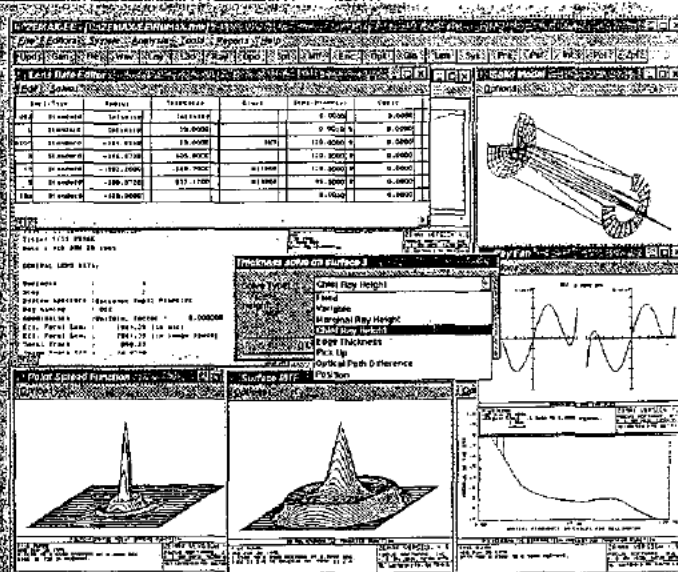
Optimization for multi-configuration systems is also supported. Each configuration may have identical or unique merit functions. Variables and constants may be common to all configurations or unique to just a few. This powerful feature is also used to athermalize optical systems by simultaneously optimizing over a range of temperatures and pressures. Simultaneous optimization over multiple configurations is supported, and the feature is very easy to use.



SOLVES

Solves are used to actively adjust surface data to maintain a specific condition. For example, a "pick up" solve causes one parameter to have the same value as another parameter, with an optional scaling factor applied. The solves are summarized in the following table.

Curvature solves	Marginal ray angle, normal Chief ray angle, normal Pick up, aplanatic
Thickness solves	Marginal, chief ray height Edge thickness OPD Position Pick up
Glass, Diameter, Conic, etc.	Pick up
Multi-configuration	Pick up, thermal pick up

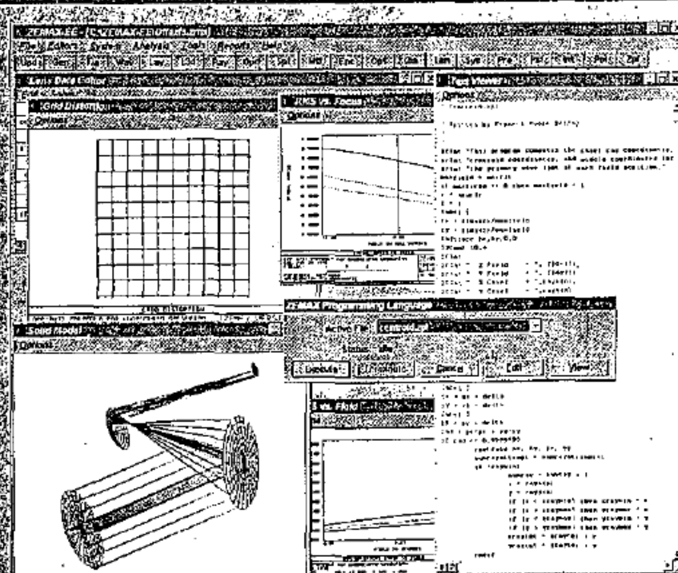


MACRO LANGUAGE CAPABILITY

ZEMAX has hundreds of features that cover the vast majority of user needs for optical design and analysis. However, no matter how many features a program has, there always seems to be the need for a custom analysis or computation. For these cases, ZEMAX supports an extensive macro language called the ZEMAX Programming Language (ZPL).

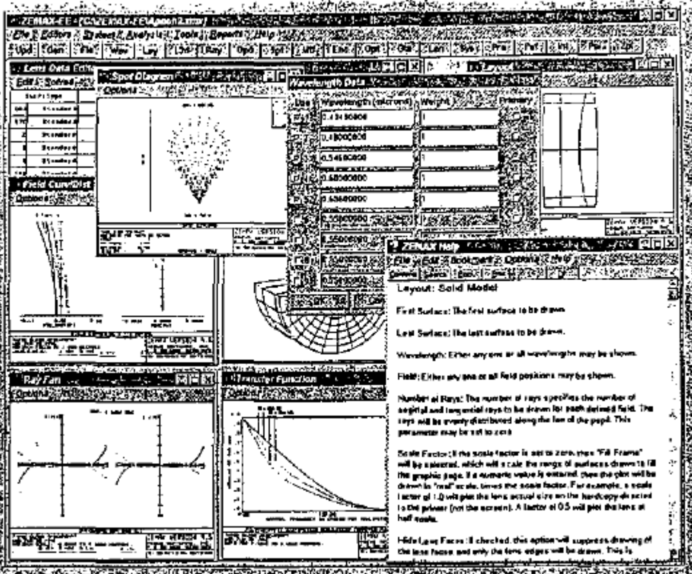
Rather than create a difficult to learn new language, ZPL is structured like BASIC. ZPL uses simple BASIC commands like PRINT and GOTO, and also adds new keywords such as RAYTRACE and GETMTF that can be used to extract data computed by ZEMAX.

ZPL supports inline function calls, user defined array, numeric, and string variables, text and graphical output, and a simple interface to the ray tracing algorithms. ZPL macros can read and write ASCII files to format custom data reports.

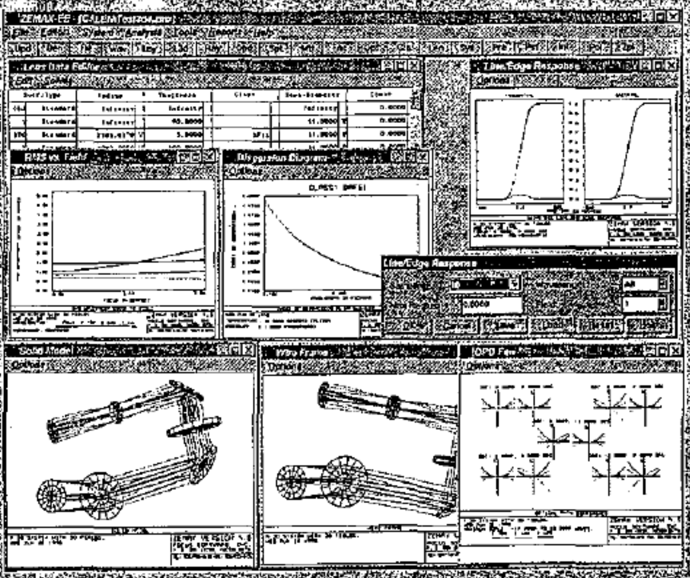


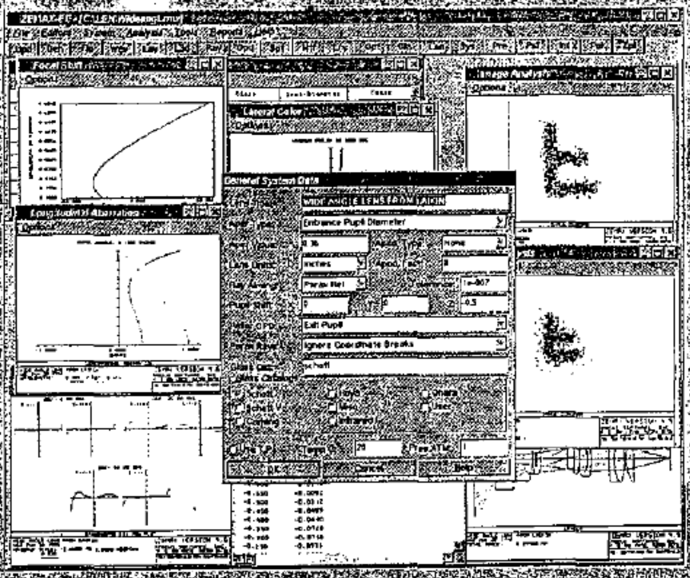
ANALYSIS CAPABILITIES

ZEMAX supports a wide variety of analysis tools. All have extensive options which can be set to customize the method of calculation or presentation. Defaults are used by the software to provide useful data quickly. ZEMAX includes the following analysis tools:

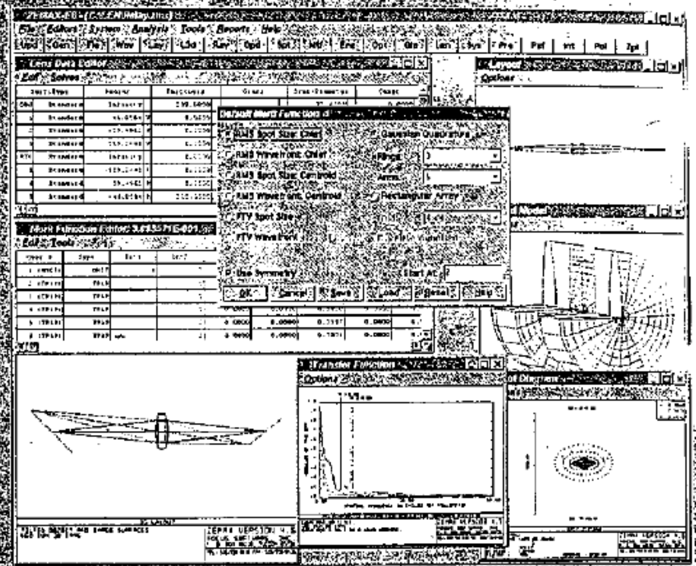


- **Layouts**
  - 2D cross section
  - 3D perspective with rotation
  - Wireframe 3D with rotation, pan, zoom
  - Solid model (hidden line) with rotation, pan, zoom
  - Singlet and doublet element shop drawing
- **Fans**
  - Ray aberration
  - Optical path difference
  - Pupil aberration
- **Spot Diagrams**
  - Standard field-by-field
  - Through focus
  - Full field, Matrix
- **Diffraction Analysis**
  - Modulation transfer function (MTF), including phase
  - Square wave MTF
  - Through focus MTF (sine or square)
  - Point spread function, cross section
  - Surface 3D MTF
  - Geometric transfer function (GTF)
  - Through focus GTF
  - Wavefront map surface plot
- **Encircled Energy**
  - Diffraction, radial
  - Geometric radial, x, y
  - Line/Edge response
- **Miscellaneous**
  - Grid distortion
  - Longitudinal aberration
  - Lateral color
  - Field curvature and distortion
  - RMS vs. field, RMS vs. focus
  - Image analysis (extended source imaging capability)
  - Interferograms
  - Y-Ybar diagram
  - Chromatic focal shift
  - Vignetting plot
  - Dispersion plot, glass map diagrams
- **Numerical Computations**
  - First order system data
  - Surface power, volume, edge thickness data
  - Ray trace data, real and paraxial
  - Gaussian beam parameters
  - Seidel and Zernike aberrations
  - Wavefront, transverse, and longitudinal aberrations
  - YNI contributions
  - Sag tables, maximum aspheric deviation
- **Polarization Ray Tracing**
  - Polarization state evolution
  - Polarization ellipse pupil map
  - System transmission
  - Coating reflection, transmission, and absorption plots
  - Polarization aberrations





OPTIMIZATION CAPABILITIES

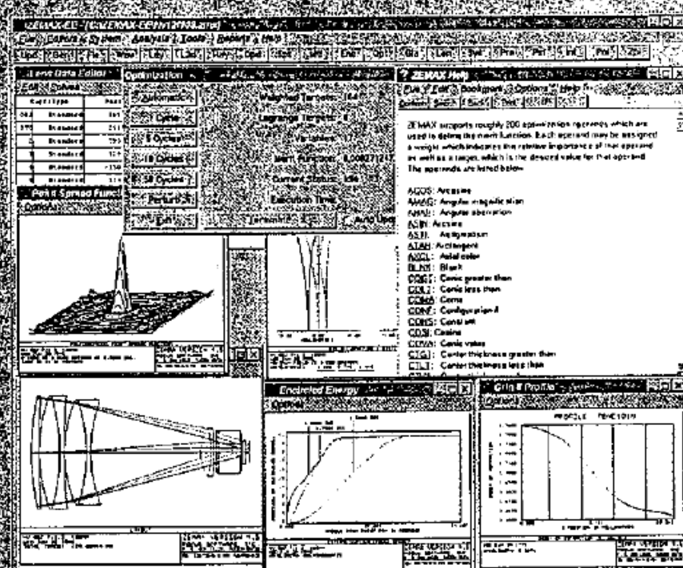


Optimization is used to improve the performance of an optical system based upon an initial design.

ZEMAX uses a powerful actively damped least squares optimization algorithm. Any number of variables may be simultaneously optimized, using either a user defined or one of the default merit functions. An unlimited number of optimization goals or targets may be simultaneously defined, using any combination of different predefined targets.

The 12 default merit functions include RMS spot size and RMS wavefront error, referenced to either the chief ray or the centroid, and peak-to-valley spot size or wavefront error. Other physically significant merit functions are available such as best MTF response or encircled energy.

The predefined targets include ray and construction data, as well as detailed boundary controls on lens and system data. An infinite number of different user defined targets may be created using any of the hundreds of predefined controls. The merit function may be easily edited and customized.



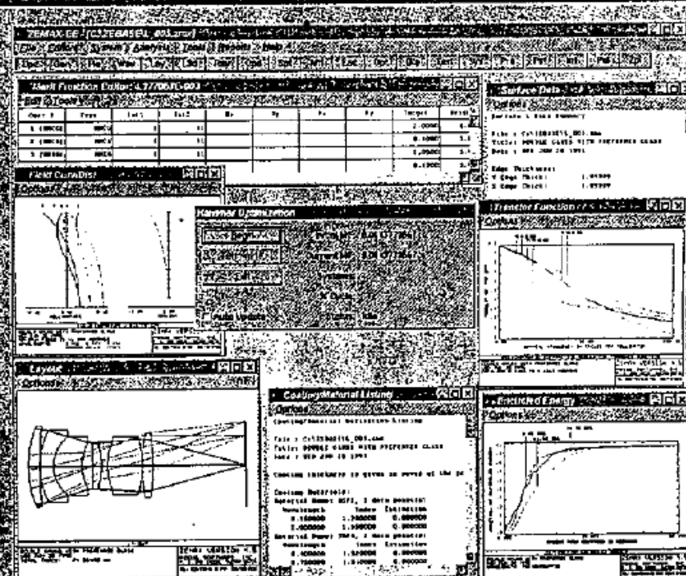
Optimization over multiple configurations is simple and transparent. Equality, inequality, and Lagrange multiplier constraints are all supported with arbitrary weighting.

ZEMAX can optimize virtually any parameter in the system, including radii, thickness, glasses, conics, aspheric coefficients, grating spacings, apertures, wavelengths, fields, and more.

Optimization is very simple to use. First, define which variables ZEMAX is free to optimize. Then define a merit function using the default merit function dialog box. Lastly, click on "Automatic" and ZEMAX does the rest. ZEMAX chooses optimal derivative increments and damping factors automatically at every iteration.

ZEMAX can optionally display and update other windows during optimization, which provides valuable feedback of the evolution of the optical system.

GLOBAL OPTIMIZATION



Global optimization refers to the capability of ZEMAX to seek out not only an improved design but the best possible design available for a given set of goals and constraints.

ZEMAX supports two global optimization algorithms. The first algorithm, called global search, is used to seek out new design forms and then optimize them in search of the ten best design forms available. The search runs in an infinite loop until terminated by the user.

The second algorithm is called hammer optimization and is used for exhaustively searching for a better variation of the current design form. Hammer optimization is used in the final stages of a design effort to verify that the best possible design has indeed been selected.

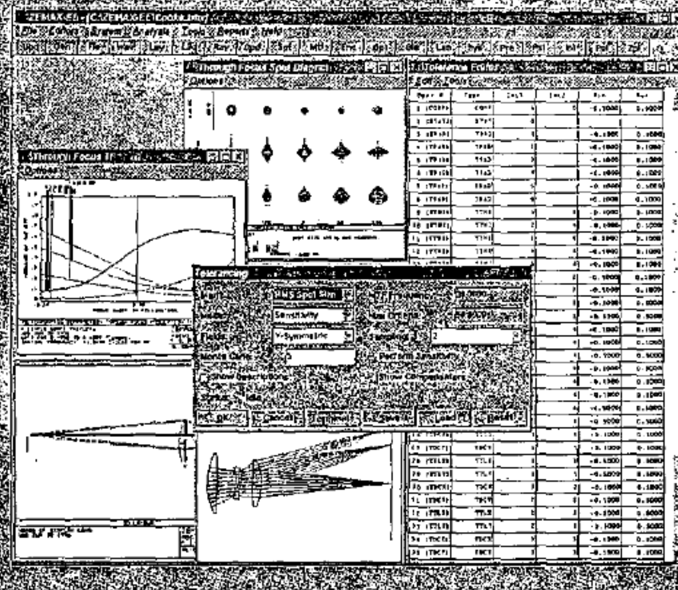
Both algorithms use the same user defined or default merit function as the standard optimization feature, and can be run as background tasks for effortless optimization.

TOLERANCING

ZEMAX supports a comprehensive, flexible, and powerful integrated tolerance analysis capability. Default tolerances are set using a combination of user selectable options, including tolerances on radii, thicknesses, lens position, tilt, decenter, irregularity, and wedge. Compensators may be defined, including focus, tilt, or position of any optical element, surface, or element group. A tolerance criteria is then selected. ZEMAX supports RMS spot size, RMS wavefront error, MTF, or a user defined criteria.

ZEMAX conducts a two part analysis. The first part is a sensitivity analysis where each tolerance is considered independently. The optimum value of each compensator is determined. The second part is a Monte Carlo analysis where random systems are generated and all tolerances are considered at once. A report describing the results is then presented.

ZEMAX also computes inverse sensitivity tolerances. These are tolerance values given a maximum acceptable decrease in performance.

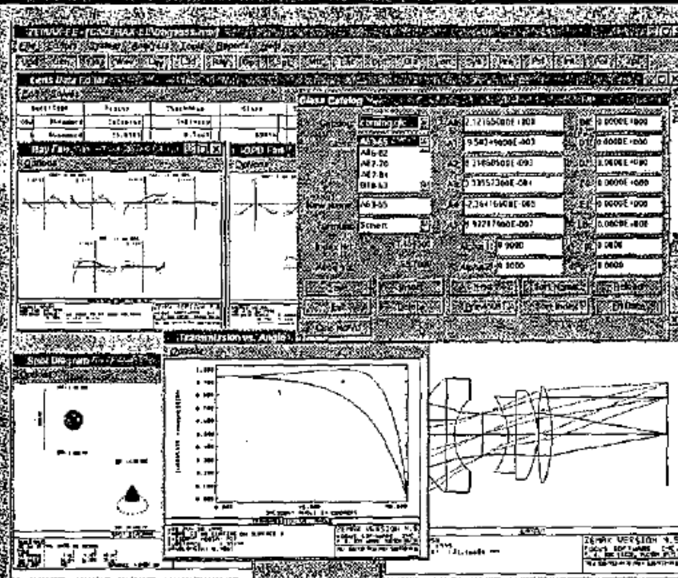


THERMAL ANALYSIS

Optical systems which are used over a wide temperature range or at temperatures different from the standard 20 degrees Celsius require consideration of thermal effects on the index of refraction and material expansion. ZEMAX uses an accurate nonlinear thermal model, not a simple dn/dt approximation.

ZEMAX supports specification (and optimization) of the thermal coefficient of expansion (TCE) for spacers between lens elements or groups. The TCE data is used to create multiple configurations which reflect performance at various user defined temperatures.

The glass catalogs supported by ZEMAX contain thermal expansion and index variation with temperature and pressure data which are used to compute the effects of temperature on individual elements and the optical system as a whole. Since ZEMAX can optimize across multiple configurations simultaneously, this feature can be used to design athermalized lenses, as well as estimate performance changes with temperature.

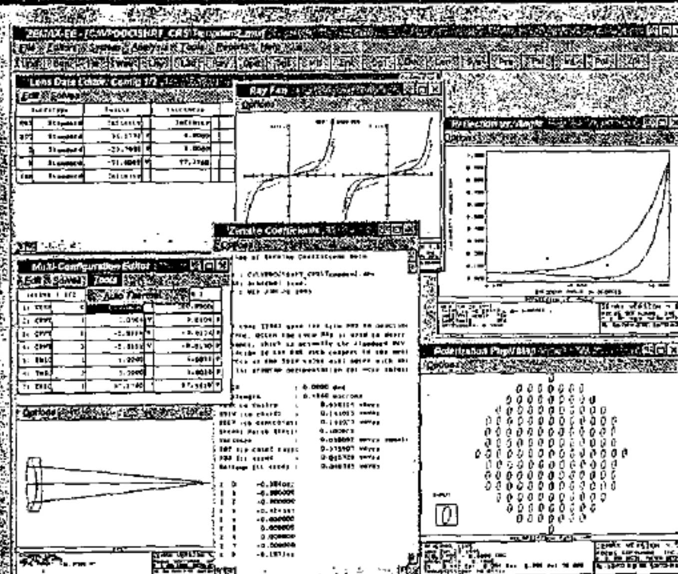


POLARIZATION RAY TRACING

ZEMAX incorporates a complete polarization ray tracing and analysis capability. Any input polarization state may be defined, and the polarized light may be traced through any optical system. ZEMAX accounts for and reports transmission, reflection, absorption, polarization state, diattenuation, and retardance.

Polarization ray tracing results may be presented in tables, or may be summarized by graphical displays.

ZEMAX has an extensive thin film modeling capability to support the polarization analysis. Multilayer film dielectric and metallic coatings may be defined, from either a predefined or user defined material database. Coatings may be applied to either dielectric or metallic substrates. ZEMAX computes the diattenuation, phase retardance, reflection, transmission, or absorption of any coating as a function of wavelength or angle.



FEATURE SUMMARY

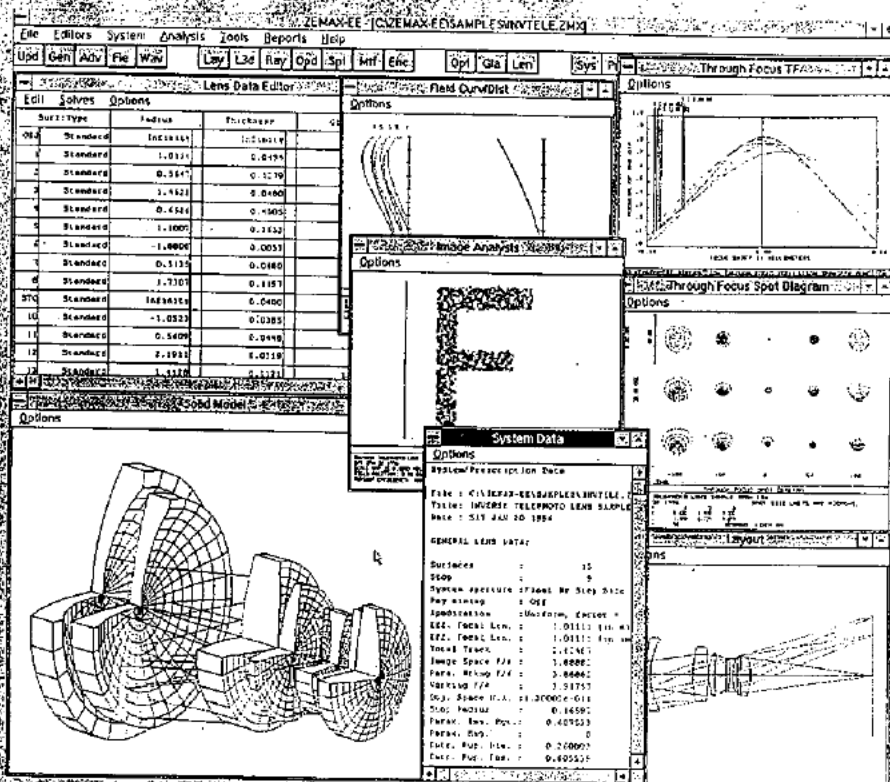
		SE	XE	EE
ARCHITECTURE	32 bit code architecture	✓	✓	✓
	Unlimited number of surfaces, variables, targets, etc.	✓	✓	✓
GENERAL	3D optics placement (tilts, decenters, rotations)	✓	✓	✓
	Circular, rectangular, elliptical, spider shaped apertures, obscurations	✓	✓	✓
DOCUMENTATION	Electronic documentation with jumps, online help, reference material	✓	✓	✓
	Printed documentation, tutorials	✓	✓	✓
SURFACE TYPES	Spheres, aspheres, conics, polynominal aspheres	✓	✓	✓
	Cylinders, toroids, x-y polynomials, splines, axicons	✓	✓	✓
	Holograms, gratings, paraxial lenses, ABCD surfaces, Fresnel	✓	✓	✓
	Gradient index lenses (9 different kinds)		✓	✓
	Binary/diffractive optics, Zernike deformed surfaces			✓
	65 term polynomial surfaces, Zernike deformed surfaces			✓
	Elliptical and VLS gratings, 65 term polynominal surfaces, extended splines			✓
	User defined refractive and diffractive surfaces			✓
SOURCE TYPES	Point, diode, elliptical, extended, uniform, gaussian, lambertian	✓	✓	✓
	Define field points using angles, object heights, image heights	✓	✓	✓
PUPIL TYPES	Paraxial or real (ray aiming supported on real pupils)	✓	✓	✓
	Gaussian, uniform, and tandential pupil apodization	✓	✓	✓
	Vignetting factors for decentered or compressed pupils	✓	✓	✓
OPTIMIZATION	Damped least squares algorithm with 12 default merit functions	✓	✓	✓
	Completely user-defined merit function, 220 flexible operands	✓	✓	✓
	Global optimization (2 different algorithms)		✓	✓
	MTF and diffraction encircled energy optimization		✓	✓
	Binary/diffractive optics optimization			✓
	Optimization of macro language computations			✓
TOLERANCING	Integrated tolerancing with RMS, MTF or user defined criterion, Monte Carlo	✓	✓	✓
	Inverse sensitivity analysis	✓	✓	✓
	MTF and diffraction encircled energy tolerancing		✓	✓
SOLVES	Angle, heights, aplanatic, pickup, OPD, edge thickness, normal, length	✓	✓	✓
CALCULATIONS	Effective focal length, pupil positions, magnification, F/#	✓	✓	✓
	Gaussian beam, exact real and paraxial ray trace data	✓	✓	✓
	Element volume, surface powers, edge thickness, clear apertures	✓	✓	✓
	Seidel and Zernike coefficients, transverse, longitudinal, wavefront	✓	✓	✓
TOOLS	Ghost focus generation, 1 and 2 surface bounces	✓	✓	✓
	Stock lens and glass catalogs	✓	✓	✓
	Element reverse and scale	✓	✓	✓
	Best fit sphere and sag table listing for asphere fabrication	✓	✓	✓
	ZPL macro language		✓	✓
	Automatic test plate fitting		✓	✓
	Thermal optimization and analysis, TCE, dn/dt			✓
ANALYSIS	2D layouts, 3D layouts, solid models, wire frame, element drawing	✓	✓	✓
	2D and 3D DXF file generation, ray fans, OPD fans, pupil aberration fan	✓	✓	✓
	Spot diagrams, through focus spot diagrams, full field spot diagrams	✓	✓	✓
	Encircled energy, geometric and diffraction, Y-Ybar	✓	✓	✓
	MTF, point spread, through focus MTF plots, wavefront maps	✓	✓	✓
	Dispersion, glass maps, vignetting, RMS vs. field, surface plots	✓	✓	✓
	Image analysis, intensity histograms, user defined source imaging	✓	✓	✓
	Interferograms, chromatic shift, field curvature and distortion	✓	✓	✓
	Polarization ray tracing, thin films modeling, coating definition and analysis			✓

ZEMAX

Optical Design Software

ZEMAX is the perfect tool to layout, design, optimize, and analyze refractive, reflective, or diffractive optical systems.

ZEMAX is simple to use, extremely powerful, and very affordable. ZEMAX runs under Windows 3.1, Windows 95, or Windows NT. There are three levels of ZEMAX.



This sample ZEMAX screen shows just a few of the graphic and text displays available. Shown are a solid model, layout, extended source image, field curvature & distortion, spot diagram, and through focus MTF plot.

ZEMAX-SE: $900

- 32 bit Windows architecture
- Unlimited surfaces, variables, targets
- Excellent documentation, tutorials
- Extensive context sensitive help
- Point and extended sources
- Diode, astigmatic, elliptical sources
- Spheres, conics, general aspheres
- Tilts, decenters, splines, thin lenses
- Holograms, gratings, toroid gratings
- Cylinders, Fresnels, polynomials
- Spot diagrams, layouts, MTF, PSF
- FFT and Huygens PSF analysis
- Field curvature, distortion, ray fans
- OPD, vignetting, through-focus
- Wave maps, ghost focus analysis
- Diffraction encircled energy
- Gaussian beams, Zernike terms
- Powerful, fast, flexible optimization
- User defined/default merit function
- Complete, easy to use tolerancing
- Exact or fast rough tolerancing
- Complete flexible zoom capability
- Multiple glass, stock lens catalogs
- Apertures, rectangles, circles, more
- Element drawings, solid models
- DXF export of lens data
- Automatic/user vignetting factors

ZEMAX-XE: $1,500

- All ZEMAX-SE features plus:
- Effective global optimization
- Completely automatic global search
- Powerful "Hammer" optimization
- Extensive macro language
- Gradient index materials (9 kinds)
- Dispersive axial/radial gradients
- Automatic test plate fitting
- MTF optimization
- MTF tolerancing
- Encircled energy optimization
- CCD image response modeling

ZEMAX-EE: $2,400

- All ZEMAX-XE features plus:
- Polarization ray tracing
- Thin films modeling, transmission
- Binary diffractive optical elements
- Complete environmental analysis
- Designs athermalized lenses, TCE
- User defined sag/phase surfaces
- Zernike phase and sag surfaces
- Optimization of macro computations
- Multi-platform support
- Multiprocessor support option
- Atmospheric modeling option

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