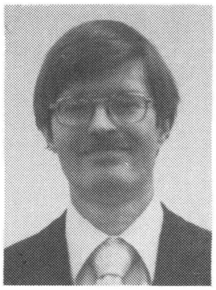

Editorial

H. J. Caulfield, Editor

Optical Engineering Going Monthly in 1984

As the field of optical engineering grows, *Optical Engineering* is growing with it. The next step in that growth has been approved by the SPIE Board of Governors. In this editorial, I want to suggest some of the effects we can expect from that decision and why that decision was a difficult one to make.

The advantages of monthly publication to the optics community are numerous and obvious: there will be more papers; there will be more subjects receiving the benefit of in-depth treatment in special issues; and more frequent publication will make more rapid publication possible.

The disadvantages of monthly publication are equally real but less obvious. Publishing more pages requires more of the publications department of SPIE in terms of equipment, personnel, and management. In addition to the increased frequency and number of pages, each year we will do twice the number of mailings. The net effect is that costs will go up as we attempt to make this journal more beneficial to the optics community.

What does all of this mean? If you regard journal evolution as a spectator sport, you will find *Optical Engineering* fun to watch. If you regard *Optical Engineering* as a journal that you want to see grow and flourish, you can help with this evolution. You can contribute your ideas directly to the editor. You can publish in our journal. You can honor publication charges. You can advertise your products with us.

As editor, I am very confident that *Optical Engineering* will be a brilliant success as a monthly journal. My basis for that confidence is the degree of support you have given it so far. With your help, the future will be extremely bright.

OPTICAL ENGINEERING EDITORIAL SCHEDULE

March/April 1983
Submicron Lithography
Phillip Blais
Westinghouse Research and Development Center
Building 501, Room 2D20
1310 Beulah Road
Pittsburgh, PA 15235
412/256-7585

May/June 1983
Raman Spectroscopy
Stanley M. Klainer
1140-90
Lawrence Berkeley Laboratory
Berkeley, CA 94720
415/486-6729

July/August 1983
Laser Damage in Materials
Theodore T. Saito
FGRL/NH
USAF Academy, CO 80840
303/472-3133

September/October 1983
Fluorescence
Stanley M. Klainer
1140-90
Lawrence Berkeley Laboratory
Berkeley, CA 94720
415/486-6729

November/December 1983
Spatial Light Modulators
Armand Tanguay
Department of Electrical Engineering
University of Southern California
University Park
Los Angeles, CA 90007
213/743-6152

January 1984
Optical Computing
Demetri Psaltis
California Institute of Technology
1201 California Ave.
Pasadena, CA 91125
213/356-4856

Forum

UNDERSTANDING PATENTS AND THE PATENT SYSTEM

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Hanscom Patent Prosecution Board
Waltham, Massachusetts 02154

INTRODUCTION

This article presents a simplified review of the patent system. It is not designed to cover all aspects of the laws and regulations pertaining to patents, but rather to provide easily understood answers to commonly asked questions about patents and the patent system. Since patents are governed by federal law, reference will be made throughout this article to pertinent sections of Title 35 of the U.S. Code and Title 37 of the Code of Federal Regulations (hereafter referred to as 35 USC and 37 CFR, respectively), which are readily available in law libraries and some public libraries. In addition, this article attempts to remove the cloud of mystery surrounding patents, and correct many of the preconceived misconceptions regarding patents and the present system.

1. A PATENT

According to the provisions of Article I, Section 8, of the United States Constitution, Congress is empowered to "... promote the progress of science and the useful arts, by securing for a limited time to authors and inventors the exclusive right to their respective discoveries." As a consequence, the U.S. Patent and Trademark Office (also referred to in this article as the PTO) has been provided with the authority to grant patents to inventors in order to provide legal protection for their discoveries, that is, inventions. The inventor may be either an individual or group of individuals (more commonly referred to as joint inventors). However, the inventor must be an individual and not a corporation, partnership, joint venture, or other legal business entity. A patent can only be granted to a person. An inventor may assign his or her rights in the patent to other individuals or legal entities such as corporations, but a U.S. patent cannot be granted to other than a person or persons.

The life of a patent is limited to a period of 17 years from the date of issuance of the patent (not from the date of filing of the patent application). Patents issued on applications filed prior to December 12, 1980, remain in force for the full 17 years. On the other hand, as a result of a recently enacted change in the patent laws, patents which have been issued, or which will be issued, on applications filed on or after December 12, 1980, will remain in force only four years from the date of issuance unless a first maintenance fee is paid. If this maintenance fee is paid, the life of the patent will be extended to 8 years. For those patents to remain in force beyond 8 years after issuance requires the payment of a second maintenance fee, and beyond 12 years (that is, the full 17 year term) requires the payment of a third maintenance fee.

The legal protection that the U.S. Government bestows upon an inventor by the issuance of a patent gives the patent owner the right to prevent others from making, using, or selling the invention within the United States, its territories, and its possessions. Contrary to the belief of many, the granting of a U.S. Patent does not give the inventor or patent owner the absolute right to make, use, or sell his or her invention but only the right to prevent other from doing so. In fact, there are many instances when an inventor may be granted a patent on his or her invention and yet, due to prior unexpired more basic patents, be unable to make, use, or sell his or her own invention without obtaining permission, generally in the form of a license, from the holder of the unexpired basic patent.

For example, if Inventor A is the first person to obtain a patent on a pail, and at a later date Inventor B obtains an improvement patent on a pail having a handle, Inventor B, although granted a patent to a pail having a handle, cannot make, use, or sell the pail having the handle without obtaining permission from Inventor A, the holder of the more basic patent on the pail. Since Inventor A may find the pail unacceptable to the public without the utilization of a handle thereon, Inventor A may approach Inventor B with the idea of getting together and granting rights to one another in their respective inventions by cross-licensing their patents. In fact, Inventors A and B may even start a business together which can produce and sell the desirable pail having a handle.

Once the term of a patent has expired, at the end of either the 4, 8, 12, or 17 year period, the patent is placed in the public domain and anyone may make, use, or sell the invention described therein as long as an unexpired patent is not infringed.

2. SUBJECT MATTER UPON WHICH A PATENT MAY BE GRANTED

Title 35, Section 101 of the United States Code provides the statutory basis for determining the type of subject matter upon which a patent may be granted. More specifically, this section states, "Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefore subject to the conditions and requirements of this title." The term "process" is defined in 35 USC 100 as meaning a "process, art or method and includes a new use of a known process, machine, manufacture, composition of matter, or material."

As seen from the above law, which sets forth the statutory criteria establishing subject matter that is eligible for patenting, one does not have to invent a basic process, machine, (article of) manufacture, or composition of matter to obtain a patent since an inventor of an improvement on any of the above statutory classes of inventions as well as an unobvious combination of old elements may also be entitled to a patent. This, however, does not mean that everything under the sun falls within the above statutory categories. For example, printed matter, things naturally occurring in nature, methods of doing business, and pure scientific principles do not fall under the scope of subject matter upon which patents can be granted.

As technology changes, the scope of the subject matter upon which a patent can be granted comes under more careful scrutiny. More specifically, a recently decided U.S. Supreme Court case, Diamond versus Chakrabarty, 206 USPQ 193 (1980), can be broadly interpreted to hold that anything manmade, in contrast to things which already exist in nature, is eligible for patent protection. Specifically, the case ruled that microorganisms produced by genetic engineering fall under the realm of patentable subject matter.

Although it has been established that laws of nature, physical phenomena, and abstract ideas are excluded from patent protection, Section 2110 of the *Manual of Patent Examining Procedure* (MPEP), a guide published by the PTO for patent examiners, states, "... a claim is not unpatentable under 35 USC 101 merely because it includes a step(s) or element(s) directed to a law of nature, mathematical algorithm, formula, or computer program so long as the claim as a whole is drawn to subject matter otherwise statutory." Since it is the Supreme Court decisions which generally form the basis for the patent law, the above section of the MPEP has for its basis the recently decided U.S. Supreme Court case, Diamond versus Diehr, 209 USPQ (1981), which concludes that "a claim drawn to subject matter otherwise statutory does not become nonstatutory simply because it uses a mathematical formula, a computer program, or a digital computer." This case, however, does not deal with the patentability of computer programs, per se, and therefore the PTO currently takes the position that computer programs, per se, do not fall within the realm of patentable subject matter established by 35 USC 101. The final decision on the patentability of computer programs is still up to the courts to decide or for Congress to legislate.

As described above, although 35 USC 101 defines the type of subject matter which can be patented, the specific interpretation of this section of the statute is left to the courts. Once it has been established that an invention is directed to subject matter upon which a patent can be granted, then the responsibility for issuing a patent falls within the authority of the PTO and the decision to issue will rest upon other statutory requirements. These other statutory requirements are considered later in this article.

3. CONTENTS OF A PATENT APPLICATION

A complete patent application contains the following elements:

(1) an oath or declaration;
(2) a specification including at least one claim, a title, and an abstract;
(3) a drawing, if necessary; and
(4) a filing fee.

More specifically, in the oath or declaration, the inventor must make certain allegations which fulfill specific statutory requirements with respect to the invention. Examples of some of the allegations which the inventor must make are as follows: the inventor must state that he or she believes himself or herself to be the original and first inventor; the inventor does not know and does not believe that the invention was ever known or used in the United States before his or her conception of the invention; and, to the best of the inventor's knowledge and belief the invention had not been in public use or sale in the United States for more than one year prior to the filing of the application, or patented or described in any printed publication in any country before conception of the invention for more than one year prior to the filing of

Continued on Page SR-010

Continued from Page SR-008

the application, or patented or made the subject of an inventor's certificate in any foreign country prior to the date of the filing of the application in this country on an application filed in a foreign country by the inventor or his or her legal representatives or assignees more than twelve months prior to the filing of the application in this country.

Additionally, the inventor must disclose information to the PTO that he or she is aware of which is material to the examination of the application, such as prior art in the form of publications or patents. This "duty of disclosure" usually takes the form of a "prior art statement" filed in conjunction with the filing of the patent application. Remaining allegations to be made in the oath or declaration are set forth in Title 37, Section 1.65 of the Code of Federal Regulations. The above summary is merely presented to give an inventor an idea of what type of information is required at the time of signing an oath or declaration.

The specification, which in essence fully describes the invention, is generally made up of a number of sections. It is headed by the title of the invention. Following the title are any cross references to related applications, if any, and any statements as to rights of invention made under federally sponsored research and development grants or contracts. Thereafter, the specification contains sections defining the background of the invention, the summary of the invention, a brief description of the drawing (if required), a detailed description of the preferred embodiment or embodiments, one or more claims, and an abstract of the invention.

In general, the background of the invention describes prior art which pertains to the present invention, as well as problems which may be found in the prior art and which the invention solves. This section provides sufficient information to establish why, in fact, the invention was made, as well as an understanding as to the problems associated with past apparatus or methods attempting to solve the same problems.

The summary of the invention is a short, narrative description of the invention pointing out the advantages of the invention and how the invention solves the problems previously set forth in the background of the invention. It is more detailed than the abstract of the disclosure, yet not as detailed as the detailed description of the preferred embodiment or embodiments. For example, the summary of the invention does not contain reference numerals or references to the drawing, while the detailed description does, as pointed out below.

The detailed description of the preferred embodiment or embodiments, the most significant portion of the specification other than the claims, is required to contain a description of the invention in such full, clear, concise, and exact terms as to enable any person skilled in the art to make and use the invention. In addition, the best mode, that is, the preferred or desired operation or implementation contemplated by the inventor of carrying out the invention at the time of filing the application, must be set forth in this description. Furthermore, this section of the specification relates directly to the drawing (when required) and includes reference numerals identifying the various elements of the invention so that one can easily understand the invention and relate the components described in the specification to the drawing.

If there are any doubts as to whether or not information should be included in the detailed description of the invention, all doubts should be resolved in favor of including that information. Failure to include the information often raises serious legal implications since, if the information is later required by the PTO, its insertion within the specification may be considered new matter and this newly inserted information will therefore not be given the benefit of the filing date of the original application. Such additional information can thereafter only be inserted by filing another application, referred to as a continuation-in-part application. Not only does the inventor have to pay additional filing fees for the second application, but the inventor also loses benefit of the early filing date with respect to the new information.

The application must include at least one claim defining the scope of the invention. In general, however, an application will contain many claims ranging in scope from a first very broad claim defining the inventive concept to a series of more specific claims further limiting the invention. It is essential, however, that all claims be fully supported by the description of the invention within the specification. Furthermore, all subject matter set forth in the claims must be shown in the drawing, if such a drawing is deemed necessary.

In essence, the claims establish a contractual relationship between the inventor and the U.S. Government and define the legal limits (or scope) of the invention to which the inventor is entitled protection. Therefore, when determining the actual invention covered by a patent, it is essential to read the specification and to carefully analyze the claims. It is the claims which define the limits to which the invention is protected.

Although the drawing is not an absolute requirement in patent applications, in a majority of cases it is absolutely essential. This is particularly true in mechanical and electrical type cases. When included, the figures of the drawing must show every feature of the claimed invention. In addition, the drawing generally contains sufficient detail so that the entire invention may be easily understood by one skilled in the art when taken in conjunction with the detailed description of the invention. It does not, however, have to be drawn to scale or include nonessential features of the invention. Elements which are not essential to the invention, but are relevant and assist in a better understanding of the invention, are generally included within the drawing in schematic form.

In order to obtain a filing date for a patent application, the application must also include an appropriate filing fee. It is important to note that all fees have been substantially increased as of October 1, 1982. For example, the filing fee has increased from $65.00 to $300.00. However, under the new fee structure, a two-tier fee schedule provides reduced fees ($150.00 filing fee, for example) for small businesses, independent inventors, and nonprofit organizations.

4. EXAMINATION OF A PATENT APPLICATION BY THE U.S. PATENT AND TRADEMARK OFFICE

Once filed in the United States Patent and Trademark Office (PTO), the application generally remains in limbo for approximately 1 to 1 (1/2) years before being acted upon by a Patent Examiner. In rare instances, such as in potential infringement or an invention, patent applications may be acted upon more quickly by the PTO. During the entire pendency period of the patent application, that is, until the application is either abandoned or issued as a patent, the inventor may place the words "patent pending" on the invention. It should be realized, however, that the inventor is not afforded any legal protection until the actual patent is issued.

When the patent application is ready for examination, the Patent Examiner carefully reads the entire patent application and (1) determines whether the application including the claims meets the appropriate statutory requirements concerning the description, best mode, and disclosure; (2) searches the prior art based upon the scope of the invention claimed; and (3) prepares an Office Action in which objections and/or rejections of the claims are set forth in detail based upon the findings of items (1) and (2) listed above.

More specifically, the Examiner can object to the specification and reject the claims under a number of statutory provisions. The most common non-prior art related rejection falls under the criteria established by 35 USC 101 and 35 USC 112. A rejection under 35 USC 101 will be made if the Examiner feels the subject matter claimed is not the type of subject matter entitled to patent protection, as explained in the second section of this article. Objections or rejections based upon 35 USC 112 are made by the Examiner if the specification fails to set forth the invention in such full, clear, concise, and exact terms as to enable a person skilled in the art to make and use the invention or if the claims fail to particularly point out and distinctly claim the disclosed invention. Since the 35 USC 112 rejection is not based upon prior art, in most instances it can be easily overcome by the inventor by appropriately amending the specification including the claims or by filing a continuation-in-part application.

The rejections based upon prior art are generally based upon 35 USC 102 or 35 USC 103 in a manner described later in this section of the article. The prior art which the Examiner relies upon is, in most instances, uncovered by the search, but may also include prior art submitted by the inventor with the "prior art statement." The Examiner's search encompasses prior U.S. patents, foreign patents, and publications available to the examiner in the PTO and any other prior art of which he or she may be aware. With these prior art references, the Examiner will make a determination whether or not the invention, as defined by the claims, is patentable over the references. In order to convey this information to the inventor, the Examiner provides the Office Action, which explains any objections that the Examiner may have to the specification and/or objections and rejections of the claims. An objection deals with problems relating to form while a rejection deals with substance.

Those claims, which the Examiner does not feel patentably distinguish over the prior art in substance, are made a basis for a rejection of the claims. Claims which are rejected under 35 USC 102 are considered to be clearly anticipated by a single reference. That is, all elements of the claimed invention are fully described in a single reference. Rejections under 35 USC 103 consider the claimed invention, although not exactly shown by a single reference, to be in the Examiner's opinion an obvious extension of the single or basic reference when combined with other references found by the Examiner. The criteria which the Examiner uses in establishing "obviousness" is based upon the knowledge of "one of ordinary skill in the art." It has been recognized that a scientist working in the field is generally considered "highly skilled" and, therefore, would normally exceed the requirements of one of "ordinary skill."

It should be of solace to the inventor that most patent applications will receive some form of rejection in the first Office Action. However, this rejection should not be considered by the inventor as a complete rejection of the invention. In many

Continued on Page SR-012

Continued from Page SR-010

instances, sufficient persistence together with good reasons supported by adequate persuasion may remove the initial rejection. In the patent system, removal of the rejection leads to an allowance of the claims. If any doubt as to patentability exists, the Examiner will surely render a rejection in the first Office Action in order to receive from the inventor a response specifically pointing out where the Examiner has either misconstrued or misapplied the references in the rejection of the claims.

The response of the first Office Action includes not only a detailed rebuttal of the rejection but, in some instances, if the Examiner is correct in the rejection of the claims, a modification or amendment of the claims in order to overcome the rejection. These amendments to the claims will be considered by the Examiner and must be entered into the application as long as they do not contain new matter (that is, material which does not have a basis within the original specification). Upon receipt of this response, the Examiner will reconsider the rejection and, in some instances, conduct a further search of the prior art based upon the amendments to the claims. The Examiner may also, at this time, find the claims to be allowable.

The Examiner's next Office Action, if it is a substantial repetition of the original rejection or is a new rejection based upon new prior art found by the Examiner necessitated as a result of the amendments to the claims, generally contains a Final Rejection of the claims. This Final Rejection still may not mean that the invention is unpatentable. It may mean that there are still further arguments to be made by the inventor or a minor change to the claims which will render the claims allowable.

The inventor, therefore, under the provisions of 37 CFR 1.116, has an opportunity to submit the PTO a further response including an amendment to the claims. The amendment to the claims after a Final Rejection will only be entered into the application if this amendment places the case in appropriate condition for allowance or in better form for appeal. The Examiner need not enter the amendment in response to a Final Rejection.

If claims still remain rejected, generally the inventor's only recourse is the filing of an appeal of the rejected claims to the Board of Appeals of the PTO. This necessitates the submission of a brief pointing out in detail to the PTO the reasons why the claims should be considered patentable and the patent application allowed to issue as a patent. Upon receipt of the appeal brief, the Examiner still may reconsider the rejection of the claims and allow the application. If, however, the Examiner stands by the Final Rejection, the Examiner will send an Examiner's Answer to the inventor. The inventor has an opportunity to respond to the Examiner's Answer. Eventually the entire application, appeal brief, and Examiner's Answer go before the Board of Appeals for a determination as to the patentability of the claimed invention. If the Examiner's position is upheld by the Board of Appeals, the inventor has further recourse by appealing the decision of the Board of Appeals through the Federal Court system.

In most instances, Examiners are extremely reasonable and, if sufficient persuasive arguments are presented by the inventor, the Examiner will make a just and appropriate determination as to the patentability of the invention based upon the prior art before the Examiner. It is preferable to receive an allowance of claims defining the invention in broad terms. However, in cases where these broad claims are truly unpatentable, specific claims may be found allowable and thereby result in the issuance of a patent. Although a patent containing specific claims (sometimes referred to as picture claims) does not provide the legal protection afforded broad claims, the inventor does obtain a U.S. Patent for the invention and has the right to place the U.S. Patent Number on the invention. In some instances, this may be sufficient to prevent potential infringers from making the patented invention.

5. THE BENEFITS OF OBTAINING A PATENT

Once a U.S. Patent is obtained on an invention, the scope of legal protection afforded the inventor or patent owner on the invention is defined by the claims which have been allowed and which form part of the issued patent. By obtaining a patent to an invention, the inventor can now prevent others from making, using, or selling the invention as defined by the claims within the United States, its territories and possessions. In addition, the inventor's patent now becomes part of the prior art and other inventors having inventions which are similar to that described in the issued patent may find themselves unable to obtain a patent either over the issued patent alone or in combination with other patents. Furthermore, as pointed out in the first section of this article, the patent obtained by the inventor may now be licensed or assigned to others, thereby resulting in a monetary gain to the inventor.

Finally, the inventor has received, by the issuance of a U.S. patent, recognition by the U.S. Government that the invention is worthy of patent protection. The inventor may now use this patent as a basis for starting a new business and/or developing improvements thereon and, perhaps, obtain more patents. If none of the above benefits derive to the inventor, he or she may at least have an item of conversation at the next cocktail party, thereby impressing "noninventor" friends.

6. CONCLUSION

As previously stated, this article is not meant as an all-encompassing article on patents and the patent system but as an article to acquaint individuals with the patent system. This article should not be used as a basis for preparing one's own application, since, in setting forth generalities, many of the intricacies and exceptions to the information contained herein have been omitted. It is, therefore, recommended that any detailed patent questions or any filing and preparing of patent applications be directed to a patent attorney. A list of such patent attorneys may be obtained through local bar associations and patent law associations. In additon, there are other articles, pamphlets, and books written which further expand one's knowledge of patents and the patent system obtainable through your local library and the U.S. Patent and Trademark Office. A pamphlet and a book which the author considers to be helpful in understanding the patent system and which are easily obtainable are listed below:

(1) *Your Idea: Evaluating it, Protecting it, Selling it,* available for 50¢ through the Boston Patent Law Association, 130 Water Street, Boston, MA 02109;

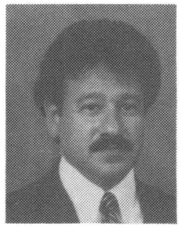
(2) *How to Protect and Benefit from Your Ideas,* available for $9.95 through the American Patent Law Association (APLA), 2001 Jefferson Davis Highway, Suite 203, Arlington, VA 22202. Also included with this book is a supplement which contains a list of inventor assistance organizations and clubs throughout the United States and a form which, when completed and mailed to the APLA, entitles the purchaser of the book to a free half-hour consultation with a local APLA patent attorney.

(3) In addition, copies of issued U.S. patents can be obtained from U.S. Patent and Trademark Office, Washington, D.C. 20231, at a cost of $1.00 per copy.

7. ACKNOWLEDGMENT

I am grateful to Wm. Stoner of SAI, Bedford, MA, who suggested this topic.

Author's Note: Although the above article contains information which is currently applicable, proposed rule changes set forth in the Federal Register, Vol. 47, No. 208, dated October 27, 1982, may shortly become effective. Since these proposed changes liberalize current rules, with respect to the inventor receiving a filing date on a patent application, they should also be consulted.



Jacob N. Erlich, holds a B.S. in Mechanical Engineering from Worcester Polytechnic Institute and a Juris Doctor from Georgetown University Law School. He is admitted to practice law before the bars of the District of Columbia and Massachusetts and, in addition, is registered to practice as a patent attorney before the U.S. Patent and Trademark Office and Canadian Patent Office. Erlich presently holds the position as a Patent Adviser for the U.S. Air Force, having been employed as a Patent Examiner in the U.S. Patent and Trademark Office prior to his current position. In addition, Erlich is Vice-President of the Boston Patent Law Association as well as being a member of their Board of Governors.

Optics at .... KMS Fusion, Inc.

Clark J. Charnetski
KMS Fusion, Inc.*
Ann Arbor, Michigan 48107

TRIPLE BOUNCE ILLUMINATION SYSTEM USED FOR EXPERIMENTS AT KMS FUSION

1. INTRODUCTION

Laser fusion experiments aimed at achieving high density and uniform compressions require nearly uniform illumination over the entire target surface with high power laser beams.

One approach is to use a large number of beams and a like number of focusing lenses with their focal spots slightly overlapped so that each spot covers a small percentage of the target surface. This technique is used at the University of Rochester's OMEGA laser and at Rutherford Laboratory.

The KMS Fusion CHROMA I laser has two twenty-centimeter diameter beams, each of which delivers up to 350 joules infrared or 200 joules

*Work supported by the U.S. Department of Energy under Contract No. DE-AC08-82DP40152.

Continued on Page SR-015

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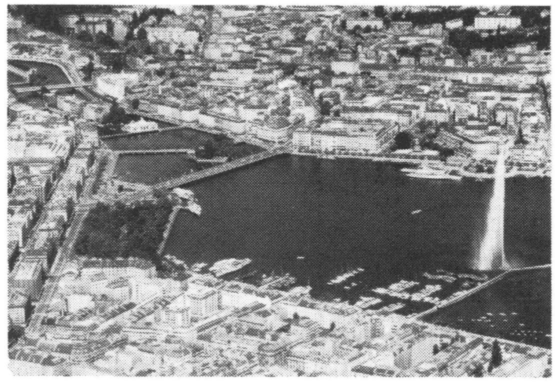

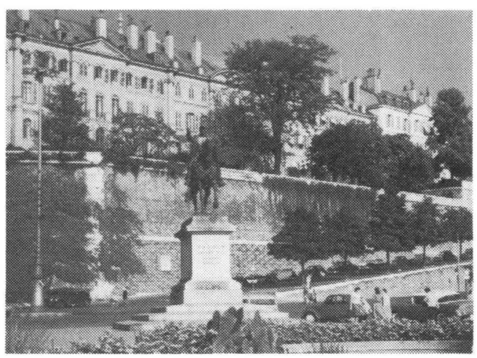

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Continued from Page SR-012

green in a 1 ns pulse. Therefore, an optical system must be used to convert these two beams into spherical illumination.

2. SINGLE BOUNCE

The system used on the predecessor of CHROMA I had two ellipsoidal reflector halves or "clamshells" arranged with the outside focus of one ellipsoid at the vertex of the other (Fig. 1).[1–3] The conjugate focus of each ellipsoid was placed at a point midway between the vertices. It was here that the target was placed. Each ellipsoid then illuminated half the target surface after reflecting light only once. With a two inch space between the ellipsoids to allow diagnostic equipment to "see" the target and to leave room for target replacement, each target half was illuminated by a full cone angle of 144°.

So that light might enter the system, each 12.5 inch diameter ellipsoid had a 0.150 inch hole bored into each vertex. Single-element aspheric lenses with a full cone angle of 80° focused the 10 cm diameter laser beams. The system was designed for infrared, and corrector plates were placed upstream of the focusing lenses for green frequency-doubled experiments. The beam diameter was later increased to 14 cm.

These single bounce ellipsoids, developed by C. E. Thomas, were used for several years at KMS Fusion and, on May 1, 1974, were instrumental in producing the first thermonuclear neutrons from a laser-driven implosion in the U.S. Similar clamshells were used at the Lawrence Livermore National Laboratory and Osaka University.[4]

Unfortunately, the refracting elements involved made it difficult to change from infrared to green since special corrector plates had to be added. Also, in the late 1970s, interest was shown in bandwidth broadening experiments which, because of dispersion, precluded the use of refracting optics. In addition, the thickness of the focusing lenses greatly increased the B-integral* self-focusing problems for short-pulse, high-power experiments. An all-reflecting focusing system was needed.

Several configurations utilizing single-bounce ellipsoids were investigated. Usually these required replacing the 80° focusing lenses with very fast off-axis parabolas or supplementary ellipsoids located outside the inner ellipsoids, but these devices appeared to be too difficult to fabricate or too unwieldy, especially since the entire focusing apparatus had to be sealed inside a vacuum chamber. Off-axis parabolas or supplementary ellipsoids would also increase the system's sensitivity to coma and make alignment more difficult.

3. DOUBLE BOUNCE

David R. Shafer of Parkin-Elmer invented a "double bounce" system which had each laser beam strike the ellipsoids twice—once on each ellipsoid—before being focused onto the target (Fig. 2). The vertex radii were chosen so that, thinking of these vertices as spherical mirrors for paraxial rays, the vertex opposite the entrance vertex focused the light short of the target. The light then expanded to fill the opposite ellipsoid, where it was reflected a second time and focused onto the target. The conic constant of the ellipsoids was chosen to similarly focus the marginal rays. Corrector plates or other optical components with higher order aspheric terms were required to focus rays that lay between the paraxial and marginal rays.

*Cumulative phase shift along the optical path due to the intensity dependence of the refractive index, sometimes referred as the breakdown integral.

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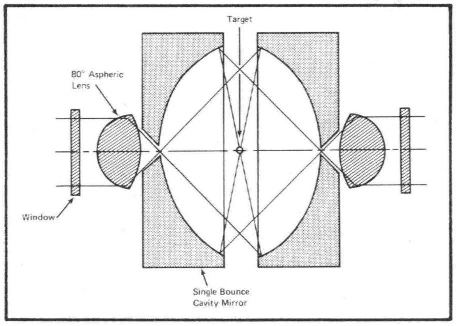

Fig. 1. Single bounce illumination system.

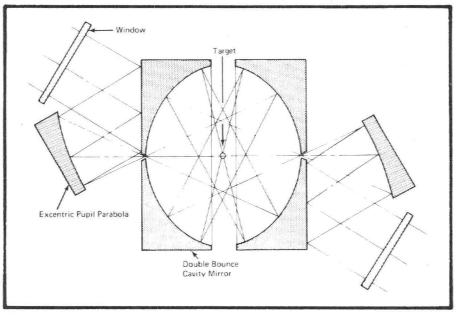

Fig. 2. Double bounce illumination system.

Unfortunately, the double bounce system, like the single bounce if used in an all-reflective configuration, also required very fast parabolas or outside ellipsoids, although with a more mild 45° full angle focusing cone. The double bounce system was never built.

4. TRIPLE BOUNCE

The desire to have an all-reflecting system with more reasonable optics led Robert Sigler, then with KMS Fusion, to invent the triple bounce illumination system (TBIS).[5–6] TBIS took the double bounce system one step further in that vertex radii were chosen to focus light twice before focusing it onto the target (Fig. 3). Each beam of light underwent three reflections on the 12.85 inch diameter ellipsoids before striking the target. The input angle multiplication effect was even greater than that from the double bounce—a target full cone angle of 144° was achieved by using an on-axis parabola with a full cone angle of only 31°.

This relatively shallow cone angle also meant that the vertex thickness of each ellipsoid could be increased sufficiently to allow a flat reflector to be fabricated on the backside of each ellipsoid at an angle of 22.5° so as to direct each 20 cm diameter laser beam onto each focusing parabola. This allowed more easily fabricated on-axis parabolas to be used. Vertex radii and the conic constants of the ellipsoids were chosen to focus the paraxial and marginal rays on target. The focal positions of other rays were adjusted to the target position by use of corrector plates that doubled as target chamber vacuum windows. This reduced the amount of glass in the laser beam paths.

5. FABRICATION

The triple bounce illumination system was fabricated during 1978–79 by Opti-Systems, Inc., of Santa Ana, CA. The ellipsoids and parabolas are Cervit and the corrector windows are fused silica. Aspheric surfaces were produced by a numerically-controlled generating lathe. A special interferometer was constructed to monitor final hand-figuring. A microscope objective combined

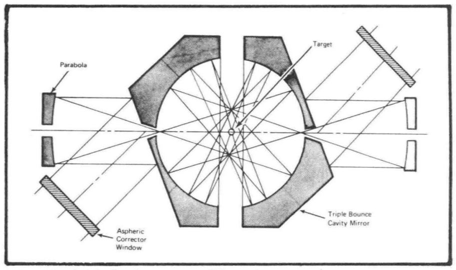

Fig. 3. Triple bounce illumination system.

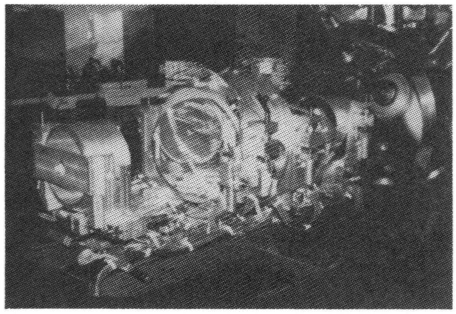

Fig. 4. Triple bounce illumination system being inserted into a target vacuum chamber.

with a three-element expanding lens was located at the outer focus of each ellipsoid, and a retroreflecting 0.500 inch diameter sphere was placed at the conjugate inner focus. The wavefront reflected off the ellipsoidal surface was combined with the original wavefront using a beam splitting cube within the interferometer. TRI, Inc., Ann Arbor, MI, completed the final hand-figuring.

Design Optics, Sunnyvale, CA, applied the special dual-frequency (0.527 and 1.054 μm) dielectric mirror and antireflective coatings. These coatings were developed by Design Optics and Coherent, Inc., under development contracts for KMS Fusion. Damage tests on samples were performed by KMS prior to TBIS coating. Laser damage tests were also run on the flat surfaces on the backside of the ellipsoids outside the clear apertures.

A mounting system was designed and constructed especially for TBIS. Since it must be aligned and operated within a vacuum chamber, twenty-four dc electric motors with digital readout encoders provide translation, tilt, and rotational movements. Including input beam angles and corrector plate positioning, TBIS has 40 degrees of freedom.

A computer ray trace simulation of TBIS was written to develop alignment algorithms and to study the variation of target illumination uniformity with alignment and optical element spacing. This computer simulation, combined with actual longitudinal focusing error measurements made with a retroreflecting sphere in place of a target, was then used to determine manufacturing errors that were then translated into modifications of corrector plate sag. Tables of material removal verus beam radius were developed for each corrector plate. TRI performed the hand-figured removal operation guided by holographic interferometry. After several iterations, the TBIS corrector plates were modified during the summer of 1981 to correct green longitudinal errors to within ± 5 μm of focus for the entire beam.

6. EXPERIMENTS

Fusion experiments using TBIS began in October 1981 using deuterium and deuterium-tritium-filled

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115 μm diameter targets with wall thicknesses of 2 to 5 μm. The goal of these studies was to compare compressed fuel densities achieved with infrared and green illumination on targets at room temperatures and those cooled to cryogenic temperatures at which the fuel is frozen out in a uniform solid layer on the inside of the glass shell. The imploded core size was measured using an x-ray streak camera, x-ray pinhole cameras, and x-ray spectroscopy.

Energies used for these experiments ranged from 200 to 350 joules in 200 to 500 psec for infrared and 30 to 120 joules in 100 to 300 psec for green.

Following the implosion experiments, TBIS was used in a series of energy transport experiments which are still in progress. These experiments compare the roles of thermal (≤ 1 keV) and superthermal (≥ 20 keV) electrons in transporting energy into the target. Specially constructed targets with multiple layers are illuminated with infrared and with green light.

7. PERFORMANCE

The triple bounce illumination system has performed well with respect to uniformity of target illumination (as determined by x-ray pinhole photographs), focal spot size, ease of alignment, and stability. Alignment took some time to master, but now may be accomplished within the experimental schedule of 60 to 90 minutes between target shots (90 to 120 minutes for cryogenic experiments). This time includes target replacement, vacuum chamber purge and pumpdown, laser cooling, and alignment.

The major difficulty has been laser damage to reflecting surfaces. Damage to the flat backside dielectric coatings was corrected by attaching thin flat plates with new coatings over the damaged surfaces. The inside ellipsoidal surfaces where the higher-energy-density first bounces occur have also suffered slowly increasing damage, which is probably the result of the combined effects of the high energy levels and the accumulation of target debris. The damage threshold for green appears to be lower than that for infrared light. Similar dual wavelength coatings on the parabolas and on the turning mirrors and the antireflective coatings on the corrector plates have held up very well. The only solution for the ellipsoidal damage is to repolish and recoat them. The possible use of debris blast shields and coatings with higher damage resistance is being investigated.

8. REFERENCES

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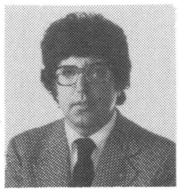

Clark J. Charnetski received his B.S. degree in physics from the University of Michigan in 1964. After two years of teaching high school physics, he went to Conductron Corp., Ann Arbor, MI, where he was responsible for producing very large display holograms and devised the method that Conductron used to mass-produce over a half-million holograms.

In 1972, he joined the instructional television unit at the University of Michigan School of Dentistry and subsequently managed audiovisual services and an instructional media center for the U. M. College of Pharmacy.

Returning to research in 1980, he is now with the Laser Group, Fusion Experiments Department at KMS Fusion. His major responsibility at KMS is the triple bounce illumination system, which focuses high power laser light onto spherical targets. He is also involved with the optical design and testing of other target illumination and diagnostic optical systems.

His first published works were in the field of holography. He is a member of the Ann Arbor section of OSA and is chairperson of the Michigan Association of Railroad Passengers.

Book Reviews

Optical Instruments and their Applications

Douglas F. Horne, 273 pp., illus., indexes, references. ISBN 0-85274-345-9. Adam Hilger Ltd., Techno House, Redcliffe Way, Bristol, BS1 6NX, England (1980) $90.00.

Reviewed by John H. Ward, SORL Division of Optronics International Inc., 7 Stuart Road, Chelmsford, MA 01824.

This book is intended to provide a summary description of optical instruments for the design engineer and instrument maker. Reading the book offers a partial solution to problems created by the necessary specialization of people within the broad field of optics. The author writes with enthusiasm and respect for the profession of optical engineering and instrument making. This feeling is most apparent in his description of the important central role of optics in recent scientific and commercial history.

The first chapter, covering the history of the British optical industry 1720 to 1970, is very enjoyable reading. It is easy to relate to this colorful description of the early forming and building of companies around inventions, patents, and development contracts. Although this chapter goes back beyond Isaac Newton's conclusion that an achromat was impossible and Chester Hall's (an amateur optician) unappreciated fabrication of one in 1792, the events sound current and significant to optics today. This book might serve as motivational material to a student considering a career in optics.

The remaining nine chapters are each directed at various areas of instrumentation. Each chapter gives a short history of the related inventions and development progress, a statement of the principles involved, a list of applications, and a description of actual products and their workings for each area of instrumentation.

The chapters on microscopes, surveying and photogrammetry, and metrology are most complete. Subsections describing phototypesetting color scanners, laser gravure, and lithography are covered within the chapter on cameras for industry and commerce. The chapters on telescopes, spectrochemical analysis, and ophthalmic and medical instruments are sketchy.

In short, this book contains a great deal of useful information. It is a good record of engineering practice over a broad range of applications. It could help prevent the reinvention of already existing devices or these summaries could help transfer existing methods to solve new problems. It could also be used to gain an understanding of a particular class of instruments prior to purchase.

Most of the equipment described is of English or German manufacture. Many of the more recent areas of instrumentation not covered are laser interferometry, holographic testing, electro-optical components, and infrared imaging systems. This omission of material is an unavoidable necessity, but the title could use some qualifying. The book is properly nonmathematical and well written. Its index is short, which is a drawback unless one becomes familiar with the organization of the book. The main use of the book is likely to be as a reference source of classical instruments. However, a most unique and interesting aspect is the historical summary of the several companies and inventions.

Microwave Remote Sensing: Active and Passive—Volume I: Microwave Remote Sensing Fundamentals and Radiometry

Fawwaz T. Ulaby, Richard K. Moore, and Adrian K. Fung, xviii + 456 pp., illus., index, references, appendices. ISBN 0-201-10759-7. Addison-Wesley Publishing Co., Inc., Advanced Book Program/World Science Division, Reading, MA 01867 (1981) $46.50.

Reviewed by Richard W. Larson, ERIM, Radar and Optics Division, P.O. Box 8618, Ann Arbor, MI 48107.

Volume I of a new three volume series on remote sensing is authored by three persons, each with very long and distinguished careers in the fields of microwave remote sensing and education. This volume consists of six chapters; Chap. 1 presents an introduction and history of microwave sensing. Clearly, the three authors are well qualified to write such a history because, during the past two decades, each has made a significant contribution to that history. Chapter 2 presents a review of plane waves and Chap. 3 provides an excellent discussion of microwave antennas as related to microwave remote sensing. A review of radiometry is presented in Chap. 4 and a discussion of radiometer systems is given in Chap. 6. Chapter 5 presents an excellent review of the interactions between electromagnetic waves and atmospheric constituents. Overall, Volume I consists of 456 pages, 26 tables, and 185 figures (the latter are mostly well-layed-out line drawings). Finally, four appendices are included; these provide lists of (1) constants, (2) common functions and transforms, (3) symbols, and (4) abbreviations and acronyms for remote sensing systems and satellites.

The goal of this series, as given in the preface, is twofold: to provide (1) a text for a graduate level course in microwave remote sensing and (2) a reference for engineers and scientists in the field of microwave remote sensing. I believe that, for Volume I, this goal has been satisfied. The material covered is very relevant to the fundamentals of microwave remote sensing. Although much of the material (except for sections of Chaps. 4 and 6) is available in other texts, having the material in a single volume provides the student with an excellent text and the researcher and professional with a handy reference volume.

The organization follows a logical sequence, with each chapter utilizing formulas and concepts developed in previous sections. Each chapter includes a reference list and (with the exception of Chap. 1) a set of interesting problems designed to emphasize concepts presented in the chapter. (Having had experience in teaching courses in microwave remote sensing, I found the material included in this volume to be very applicable to such courses.) As stated by the editor, the book is written from the viewpoint of the engineer or physicist rather than from the perspective of the user of microwave remote sensing data.

Chapter 1 presents a history of the development of both active and passive microwave remote sensing. A number of potential applications are given along with a list of references for the reader who wishes to obtain more details or to refer to the original published papers and books.

A review of plane waves in lossless and lossy media is given in Chap. 2. The major aspects of plane wave propagation (polarization, reflection, and refraction) are given, particularly with regard to layered media (this problem is important in microwave remote sensing). Chapter 2 concludes with 27 problems.

The review of antenna systems given in Chap. 3 summarizes basic antenna theory relative to remote sensing applications. References are made in subsequent chapters to particular antenna parameter relationships derived in this chapter. Basic antenna parameters such as radiation patterns, directivity, effective area, and gain are derived. This is followed by short sections describing polarization, apertures, illumination considerations, arrays, and antenna types. It appears to me that the selection of material given in Chap. 3 has been filtered so as to provide particular antenna relationships and information for use in subsequent discussions on various remote sensing systems in this volume (and possibly in the other two volumes also). There are 15 problems relating to Chap. 3.

The discussion on microwave radiometry in Chaps. 4 and 6 represents, I believe, a very complete and interesting discussion of this subject. The quantity that is measured with a microwave radiometer is carefully defined in the early sections of Chap. 4. The remainder of Chap. 4 includes sections dealing with radiative transfer, derivation of the apparent temperatures of (1) an absorbing and scattering medium and (2) atmosphere and terrain. These quantities are then utilized in the derivation of brightness and scattering temperatures for homogeneous terrains having uniform and nonuniform temperature profiles. Chapter 4 has 16 problems.

Chapter 5 is entitled, "Microwave Interaction with Atmospheric Constituents." This chapter reviews the fundamentals of propagation, absorption, and scattering necessary for the radiometer systems discussion (and, clearly, for radar and other instrumentation to be discussed in Volumes II and III). Absorption characteristics of the atmosphere are reviewed and key relationships defining emission and absorption are derived or given. Following are sections in which (1) scattering and absorption by hydrometers, (2) volume scattering, and (3) absorption coefficients, as well as (4) extinction and backscatter by clouds, fog, rain, and snow, are discussed. Chapter 5 concludes with sections deriving the radar equations for meteorology and the emission by clouds and rain. Relationships derived in Chap. 4 are utilized in Chap. 5; where relationships are utilized, but are not derived, references are given (this is the case in other chapters as well). The chapter concludes with 11 problems and a reference list.

Chapter 6, the last chapter, summarizes radiometer system design and includes (1) receiver design considerations (noise temperature, noise in cascaded systems, and equivalent noise temperature), (2) the Dicke radiometer, and (3) a summary of other radiometer systems. Finally, calibration and imaging are discussed. The chapter concludes with 9 problems on radiometer systems and a list of references.

In summary, the authors have coupled into one volume the material necessary for a course on the fundamentals of microwave remote sensing and microwave radiometric systems. The basic background material in this volume is presented in a very understandable writing style. Examples of real data are given throughout the text to demonstrate various facts and relationships. I assume that much of the data used in this volume result from previous work of the authors. I did not have adequate time available to verify the many derivations and relationships; however, a quick spot check revealed no errors. This volume should be very useful to remote sensing scientists (as intended by the authors) and I recommend its use.

Never at Rest: A Biography of Isaac Newton

Richard S. Westfall, 908 pp., illus., bibliography, references. ISBN 0-521-23143-4. Cambridge University Press, Trumpington Street, Cambridge CB2 1RP, England (1980) $49.50.

Reviewed by D. J. Lovell, D. J. Laboratories, 40 Barton Road, Stow, MA 01775.

To understand the significance of Newton's contributions to optics and to science in general, one must review his life in the perspective of the intellectual climate of his time. Westfall's excellent biography *Never at Rest* provides a thorough description of the vicissitudes of Newton's life with this background.

Westfall, in fact, begins with an accounting of scientific understanding that existed at the time of Newton's matriculation at Cambridge in 1661. We thus begin our study of Newton with descriptions of the philosophies being discussed during this revolutionary period in science. Mechanical philosophers demanded that phenomena be explained in terms of particles in motion. Could this be done, argued the religiously serious, without excluding the spirit from the physical nature? For the scientifically serious, the problem lay more in reconciling observation with rigorously imposed mathematical laws. Newton thus found a new world which had been discovered, but had yet to be explored.

How was this lad prepared to enter the lofty realm of academia at Cambridge? Westfall tells us, in the second chapter, of the events known to have occurred in Newton's life between Dec. 25, 1642, when he was born and that day eighteen and a half years later when he entered Cambridge. Newton was a posthumous child whose mother soon remarried. His stepfather refused to take Isaac with his mother, leaving the three-year-old boy to be raised by his grandmother. Possibly, the trauma associated with this experience contributed to Newton's neurotic nature in later years. At any rate, the boy grew aloof becoming a "sober, silent, thinking lad."

During his days at Cambridge he was a solitary scholar who seldom mixed in the social life. Aristotelian physics and cosmology were still the traditional core of instruction, introducing the provincial youth to the canons of rigorous thought. However, Newton discovered the works of Galileo before he completed his undergraduate days. In 1665 the university dispersed for two years due to a plague. Returning to his home in Woolsthorpe, the young man never rested. In fact, the years 1664 to 1666 are known as his "anni mirabiles." In this period he laid the foundations of the calculus and did his pioneering experiments in optics.

Newton's ascendency in scientific circles began in 1672 when he sent a letter to the Royal Society describing his optical observations. This was met with a critique by Robert Hooke who misunderstood the objective of Newton's effort and proceeded to dispute the results with some asperity. Others, however, received Newton's work with acclaim. Nevertheless, Newton attempted to avoid controversy in the future. In this he was disappointed.

An embittered dispute arose when Leibnitz claimed precedence in the development of the calculus. That battle began in about 1676 when Newton's notes were shown to a man who relayed the information to Leibnitz. It effectively ended with Leibnitz' death over 40 years later, but the embers smoldered for some time beyond that.

Newton's vanity and arrogance are evident in Westfall's description of this period of priority dispute. However, Westfall also describes Newton's tenure at the Mint where he displayed his talents as an administrator. We also see Newton as President of the Royal Society, leading it from near oblivion to its position as one of the foremost scientific societies.

Since we are familiar with Newton's contribution to science, I have not dwelt on this phase of his life in this review. Suffice it to say that Westfall provides a thorough description of the relevance of these discoveries. Many fascinating details are provided that enlighten this biography and provide the reader with added insight into Newton's contributions.

The prospective reader should be warned, however, that this is not light reading. It is a lengthy book providing details of Newton's life and contributions. It is thoroughly documented and the index provides ready access to specific accounts. I believe this to be an important contribution to our understanding of the man who was enabled to "... have seen further... by standing on the shoulders of Giants."

Directory of Publishing Sources

Sarojini Balachandran, 341 pp., index. ISBN 0-471-09200-2. John Wiley & Sons, Inc., New York, NY (1982) $27.50.

Reviewed by Joseph L. Horner, Optical Devices Branch, RADC, Hanscom AFB, MA 01731.

This book is exactly what its title says, an alphabetical listing of some 400 engineering and scientific periodical journals. About a page and a half is given to each journal. Most of the entry is devoted to copying the editor's page of the journal, e.g., scope and content, manuscript submission procedures, references, illustrations, etc. The remainder of the entry is the response to a questionnaire the author sent each editor. It lists number of references per manuscript, time allowed for review process, average time from submission of manuscript to publication, acceptance rate, and percentage of invited manuscripts. The numbers are unsurprisingly uniform.

In the preface the author says that the book was written to help researchers find the right channel for communicating the results of their research. This is a time-consuming occupation, the author says, because of the proliferation of subject-oriented journals catering to specialist audiences. That may be. But it's hard to imagine a young scientist, optics or otherwise, spending months or years on a piece of research, writing it up, and then being stymied because he doesn't know where to send it. Since this book is written by a librarian, I surmise it would be of more use to the library community than the working scientific community.

Meetings

FEBRUARY 1983

Feb. 1-3 Electronics Manufacturing Technologies and Systems '83 (EMTAS '83), Phoenix, AZ. Sponsored by Electronics Manufacturing Council of the Society of Manufacturing Engineers together with the Components, Hybrids and Manufacturing Technology Society of IEEE. Contact Anthony Corte, Society of Manufacturing Engineers, P.O. Box 930, Dearborn MI 48128. 313/271-1500, Ext. 372.

Feb. 28-March 2 OSA/IEEE Topical Meeting on Optical Fiber Communication (OFC '83), New Orleans, LA. Optical Society of America, 1816 Jefferson Place, N.W., Washington, D.C. 20036. 202/223-8130.

MARCH 1983

Mar. 13-17 SPIE • Two Conferences on Microlithography and Exhibit, Santa Clara, CA. March 13, Tutorials: Optical Characterization Techniques for Microfabrication. Instructor: Samuel S. So, San Jose IBM Research Lab. Fundamentals of Polymeric Resist Materials. Instructor: C. Grant Willson, San Jose IBM Research Lab. An Overview of Plasma Etching. Instructor: David W. Benzing, ANELVA Corp. Characterization Techniques for Lithographic Equipment and Processes. Instructors: Talat Hasan, Philips Research Labs./Sunnyvale and Susan Powell, Advanced Micro Devices. **March 14-15: Electron-Beam, X-Ray, and Ion-Beam Techniques for Submicron Lithographies II.** Chairman: Phillip D. Blais, Westinghouse Research & Development Ctr. **March 16-17: Optical Microlithography II, Technology for the 1980s.** Chairman: Harry L. Stover, TRE Semiconductor Equipment Corp. **Abstract deadline: Feb. 14, 1983.** SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

Mar. 21-23 International Symposium on Still Camera Technology, Las Vegas, NV. Society of Photographic Scientists and Engineers. 7003 Kilworth Lane, Springfield VA 22151. 703/642-9090.

APRIL 1983

April 4-8 SPIE • Technical Symposium East '83 and Instrument Exhibit, Arlington, VA. Program will include related tutorial short courses and the following conferences: **Laser and Fiber Optic Inertial Sensors II.** Chairman: Emery L. Moore, Litton Industries, Inc., Guidance and Control Systems Div. **Fiber Optic Sensors.** Chairman: O. Glenn Ramer, Hughes Research Labs. **Fiber Optics Multiplexing and Modulation.** Chairman: Edward J. Miskovic, Farinon Electric/Div. of Harris Corp. **Integrated Optics III.** Chairmen: Lynn D. Hutcheson, Honeywell Corporate Technology Ctr. and Dennis G. Hall, Univ. of Rochester. **Laser Beam Propagation in the Atmosphere.** Chairman: J. Carl Leader, McDonnell Douglas Research Labs. **Coherent Infrared Radar Systems and Applications II.** Chairman: