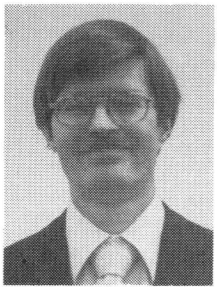

Editorial

H. J. Caulfield, Editor

Some Personal Thoughts on Listening to a Paper

It is with some trepidation that I undertake the use of the editorial as a means to express something of my individual approach to doing science. I will share the blame for my decision to "go public" with these thoughts with some outstanding researchers around the world who have urged me to do so. In addition, I will make this space available to credible scientists who wish to express other approaches. Part of the joy and charm of science is that, as a human activity, it is a highly individualized affair. All contributors with long careers develop a style of thinking that is unique and readily recognizable by their colleagues. I feel certain I could recognize the author of a paper by one of the "old timers" in my field without reading his or her name. Thus, my remarks are of a personal nature and may not be useful to most readers. With all of these caveats expressed, I will delay no longer.

My goal in optics is to invent or develop new things to do. I want to find new tasks and new approaches. This is a choice of goals made consciously many years ago against the advice of many wise and distinguished colleagues. Readers who have chosen the same goals may find these observations more useful than others will, because my approach is quite goal oriented.

Listening to a technical paper can be deadly dull and unrewarding. I combat this problem in two ways. First, I skip a lot of papers. The time I would have spent listening to an impersonal talk, I spend in the hallways and, yes, bars in smaller but livelier conversations on possible collaborative inventions. Science is not a competition among participants but a joint war on our shared ignorance and dullness. Second, I try never to miss a talk by a great scientist in my field. The idea is not to honor him by my attention (he already has far greater honors) but to use him to help me invent. He can help me with two items—topic and gimmick. What distinguishes the great scientist from the rest of us is, I believe, his ability to recognize and define important problems. Solving them takes the whole community. Nevertheless, doing your work when a field is young means (by my definition) that there are still many simple but important observations to be made. This is the time for a "feeding frenzy" of inventors. Thus, I seek the speaker's underlying goals and directions as clues to his (usually) unspoken insight into the larger problem. If the speaker is himself an inventor, I seek to adapt his latest gimmick (all good inventors I have interviewed approve of that term) to other problems. I think about how to make it work backward, how to make it work in a different domain (time, space, spectrum, etc.), how to combine it with my gimmicks, etc. Thus, paper listening becomes an active sport, not a passive recreation. It is hard, but exhilarating, work.

Finally, I offer a word of assurance to younger scientists who may not have studied under a great scientist. With only a few well-known exceptions, the best-known scientists are the most approachable. Go up to them, introduce yourself, ask questions, don't fear looking foolish. They, like almost everyone else, enjoy being helpful.

OPTICAL ENGINEERING EDITORIAL SCHEDULE

May/June 1983
Raman Spectroscopy
Stanley M. Klainer
ST&E Technical Services, Inc.
20 Belinda Court
San Ramon, CA 94583
415/829-7847

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
ST&E Technical Services, Inc.
20 Belinda Court
San Ramon, CA 94583
415/829-7847

November/December 1983
Spatial Light Modulators: Critical Issues
Armand Tanguay
Departments of Electrical Engineering and Materials Science, and Image Processing Institute
523 Seaver Science Center
University of Southern California
University Park MC-0483
Los Angeles, CA 90089-0483
213/743-6152

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

February 1984
Image Scanning & Recording Methods
Philip S. Considine
EIKONIX Corporation
23 Crosby Drive
Bedford, MA 01730
617/275-5070

March 1984
Critical Technology: Infrared Optics
Irving J. Spiro
M1/129
The Aerospace Corporation
P.O. Box 92957
Los Angeles, CA 90009
213/615-4441

Guest Editorial: Future Special Issue

Announcement and Call for Papers

Spatial Light Modulators: Critical Issues

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This Special Issue of *Optical Engineering* (scheduled for publication in November/December 1983) addresses a number of critical issues in the continuing development and characterization of spatial light modulators for optical processing and computing applications.

Although the last two decades have witnessed tremendous progress in the invention and development of optical processing techniques, architectures, and algorithms, only limited optical hardware is as yet available for the implementation of such concepts in compact systems capable of high frame rate operation. In general, three related bottlenecks exist in optical processors and computers: formatting and storage of the input data field (often for purposes of incoherent-to-coherent and/or serial-to-parallel conversion), space-variant modification of the input image (data field) in an image plane or Fourier plane, and space/time-variant detection of the optically processed image. All three require recyclable (or programmable) spatial light modulation functions.

A wide variety of candidate spatial light modulators based on diverse physical mechanisms have been proposed, including those that utilize electrooptic, photorefractive, magnetooptic, liquid crystal scattering and reorientation, deformable membrane, acoustooptic, thermoplastic, photochromic, photodichroic, and Franz-Keldysh effects. In the past several years, increased effort has been brought to bear on the critical issues in each spatial light modulator technology that inhibit the full exploitation of each physical mechanism for the optimization of device performance characteristics.

This focus on the fundamental principles of operation of the various spatial light modulator technologies will provide the principal theme of the Special Issue of *Optical Engineering.* In particular, it is of great interest to identify those current limitations in device performance characteristics that are of primarily technological, rather than of fundamental, origin. To this end, results of device characterization and modeling studies are exceedingly important, especially insofar as they are not only explanatory, but also predictive. It is hoped that the identification of such limitations will be a significant spur to focused research and development in these areas.

Authors are highly encouraged to submit manuscripts addressing these fundamental issues for inclusion in the Special Issue. Suitable topics may range from one- and two-dimensional spatial light modulators to include alternative serial-to-parallel input converters (such as light-emitting-diode or laser diode arrays) and parallel-to-serial output converters (such as CCD arrays appropriately configured for optical processing and computing applications). Please send an abstract/summary to the Guest Editor for review prior to May 1, 1983. The manuscript deadline will be June 15, 1983, to allow time for appropriate peer review prior to acceptance for publication.

Ten invited papers covering a broad range of spatial light modulator technologies are currently in process. These papers present treatments of the physical principles of operation and fundamental/technological limitations of several spatial light modulator approaches, including those involving linear array total internal reflection, magnetooptic arrays, deformable mirror arrays, silicon photoconductor and CCD-addressed liquid crystal light valves, variable grating mode liquid crystal devices, electrooptic spatial light modulators, and photorefractive materials.

Guest Editorial: Future Special Issue

Announcement and Call for Papers

Annual Issue on Optical Computing

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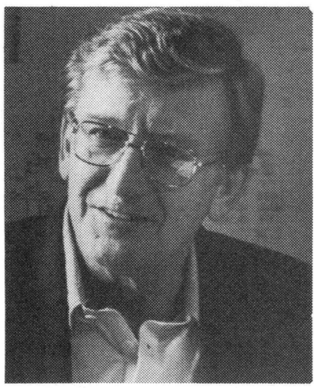
In recent years the field of optical computing has been developing rapidly and is gradually becoming a mature technology. At the same time, the number of works in the field and the level of interest in it have risen dramatically. These developments have intensified the problems that have always existed because of the dispersion of publications on the subject among numerous journals in several fields. *Applied Optics* has played a central role in the publication of research results, but it cannot focus on optical computing since it covers a much broader area of applied optics. Several special issues (*Proceedings of IEEE, Optical Engineering, Applied Optics*) and edited books have contributed significantly to the consolidation of the field. William T. Rhodes has suggested the initiation of an IEEE society on optical computing that might lead to the publication of transactions, but it will probably take several years before the time will be right for a journal dedicated exclusively to this field.

I recently proposed to John Caulfield the initiation of an annual issue of *Optical Engineering* devoted to optical computing. He liked the idea and suggested that I write this editorial to present it to our colleagues. The annual issue would offer the optical signal processing community a regular forum to present the progress in the field in a unified way, in addition to the other publications. *Optical Engineering* is a quality journal that is widely read and referenced; I believe this journal is an appropriate vehicle for a yearly issue on optical computing. We plan to publish the first annual issue in January 1984 and subsequently each January. We hope that the annual issue will consist entirely of contributed papers (as opposed to invited or solicited papers) on as many aspects of optical computing as possible. The continuation of the annual issue beyond the first year will depend entirely on the response received from our colleagues. Therefore, your comments and suggestions for the issue are welcome, as are your papers.

Forum

Dialogues in Optics

AN INTERVIEW WITH SPIE PRESIDENT WARREN J. SMITH



Warren J. Smith is director of research at Infrared Industries, Inc., Santa Barbara, California. A graduate of the Institute of Optics of the University of Rochester, he has worked in lens design and optical engineering for over 35 years. He has designed and overseen the fabrication of a diverse range of optical systems, from high volume projection lenses to specialized one-of-a-kind systems. Smith is author of the widely used text *Modern Optical Engineering* (McGraw-Hill) and regularly teaches courses in optics at universities, industrial corporations, and government installations. A Fellow of SPIE and O.S.A., Smith is the current President of SPIE and a Past President of O.S.A.

The following interview took place on July 29, 1982, at SPIE's offices in Bellingham, WA. Charles R. Batishko, SPIE's Technical Director, conducted the interview.

Charles Batishko: Warren, where, when, and how did you first become interested in optics?

Warren Smith: When you're born and raised in Rochester, New York, it gets in your blood at an early age. Actually, my first exposure to optics was as an amateur photographer. I tried to take pictures, all of which were awful, with a Kodak folding camera. But my big mistake was reading a glossy brochure about The Institute of Optics in the advisor's office in high school, and that trapped me. At that time I really didn't understand what I was doing, but I went ahead and did it anyway.

CB: At the time, did you understand what an optical engineer did?

WS: It turns out that a friend of the family, who happened to be an optics student at Rochester, which I didn't realize until many years later, lived with us for about six months. I remember that he allowed me to copy his electronics diagrams, which at that age were nothing but scribbles to me, but they were fun. So I may have been influenced there. In any case, it was one of those almost blind decisions that turned out to be a fairly good one. I went to the University of Rochester to study optics. The registrar was a gentleman who spent at least a half hour trying to convince me that it was the wrong decision. He explained that Rochester was a very difficult school in itself and that the Institute of Optics was probably the most difficult course you could take, and that if, in fact, you did manage to survive the four years there, you probably would not be able to find a job anyway because there were only, I think he said, nine places in the whole country that would possibly want to employ you. I was too naive to understand what he was saying, so I went ahead and did it anyway. Of course, he was about as wrong as can be, in terms of hindsight.

CB: Who was your first employer in optics, and what were your responsibilities?

WS: Actually, my first job in optics was with Bausch and Lomb during a couple of summers while I was in school. I was the trained technical ape for the manager of the precision optics department. Whenever they had a problem, they would send me out of the office to try to solve it. My first real employer was Simpson Optical Company in Chicago. There, I was an optical engineer working in design, both optical design and the mechanical design of the things associated with the optics. I also got into the act of trying to fabricate the optics. If the shop could not solve the problems involved, someone had to show them how, and that usually devolved to one or another of us in engineering at the company.

CB: Specifically, what sorts of problems were of most interest in optical engineering at that time?

WS: Basically what you would call consumer or production optics. We were designing such things as the optics for motion picture projectors, surveying instruments, alignment instruments—the things that made use of optics, things before lasers and then integrated optical systems came along to do it all for us. We were largely a volume production house, a species that has sort of disappeared from the American scene since then. We specialized in fairly large production runs. If you wanted to talk about 5,000 pieces or more, we were willing to talk to you. Nowadays, if you want to talk about one, we feel it is very nice of you to come in and see us. We used to make 50,000 two-inch f/1.6 16mm projection lenses every year. Those were years when the industry made fewer than 50,000 projectors, so we apparently had the market fairly well cornered. We made hundreds of thousands of stereo camera lenses for the Stereo Realist camera. That was the kind of activity everyone was concentrating on then, and we were fairly successful.

CB: Did you have a hero, somebody you particularly admired in optics and hoped to emulate, if you will?

WS: I think everybody who winds up as an optical designer has Kingslake as a hero. You can't avoid that. But going back further in history, I'd have to say Lord Rayleigh. One cannot help but be impressed by the fact that he handed us a number of very valuable criteria that have stood the test of time quite well.

CB: When and how did you first become associated with Infrared Industries?

WS: That was rather peculiar. I spent thirteen or fourteen years with Simpson in Chicago and then decided that I would like to leave the Chicago area. When you have children, it changes your criteria for what is a suitable place to live. I was recruited by an old friend and customer into moving to Santa Barbara with the infrared group at Raytheon. After spending about three years at Raytheon and deciding that government R&D work was not my preferred field, it turned out that Simpson Optical was going to merge with Infrared Industries, wonder of wonders, and move to Santa Barbara. It was truly a case of the mountain coming to Muhammed.

CB: What have been your principal responsibilities with Infrared Industries?

WS: Essentially being the chief technologist, handling optical designs, technological problems, and dealing with customers in terms of establishing their wants, needs, and requirements. It is primarily a design function, but once again you get into the responsibility for making sure things can be manufactured and that they are manufactured correctly. Anytime anybody has a technical problem, they come and ask for help. Whether you can help them or not is often another question.

CB: Over the years, what single development have you considered to be the most important in your field? By the way, I suspect I know your answer.

WS: I have to give two different answers to that. One is the electronic computer. If you interpret optical design as my field, there's absolutely no question about that answer because the computer certainly has changed the way we design lenses. It has made it both easier and harder at the same time. Now we spend our time not designing the lens but designing a way to make the computer design the lenses we want it to design. Where you broaden the question (I think of optics, in general, as my field), I suppose that the laser has to be the answer because the laser and integrated optics (the more general term) are driving the economic boom in optics as much as anything else. I don't know what the expenditure breakdown is, but it is apparent that there is an awful lot of economic health resulting from those two developments.

CB: I would have guessed the computer from the stories I heard of the old days in front of the Marchant.

WS: Yes. Of course once you had achieved a certain status, you usually managed to find someone else to punch the Marchant for you. It was a little like having a computer, but a very slow one.

CB: Over the years, what would you consider to be your most important contribution to the field of optical engineering?

Continued on Page SR-038

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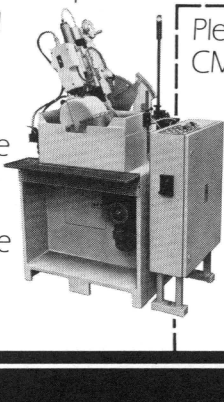

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WS: I suppose it has to be my book—the act of writing down for all to see the manner in which you practice your profession. Apparently, the optical community has found it a rewarding thing to purchase and read.

CB: Can you put a finger on a piece of hardware or device that you consider to be an important contribution of yours. I agree with you on the book.

WS: That is difficult because in our business, which is basically a job shop optical business, we made very few of our own products. We primarily made the optical guts, if you will, of hundreds of other people's products. It would be presumptuous to claim any of those as our own developments, but I guess the part we played in making them successful is fairly significant.

CB: Warren, what do you consider to be the most important areas of R&D in optical technology?

WS: I can only give you general answers--fiber optics, lasers, integrated optics, that sort of thing.

CB: From your own point of view, how would you describe the current economic climate, specifically with regard to optics?

WS: In a word, unfortunate. In terms of commercial optics, it is almost moribund; we get very small amounts of commercial business. With regard to government sponsored optics, it is reasonably healthy and even showing a moderate amount of growth. We try to maintain, at our company, a balance between government and commercial work. At the moment, we are very heavily involved in government work and, unfortunately, very lightly engaged in commercial work. There are many reasons for wanting to stress commercial work, and several years ago we were doing perhaps only ten or fifteen percent government work. Nowadays, it is just about the opposite.

CB: Do you anticipate the possibility of a turnaround in that there will be more, for instance, consumer applications of optics in the near future?

WS: I would certainly hope so. The Japanese have largely taken away from American optical companies any volume production for reasons that are perhaps ill understood. Perhaps because they have been able to invest more in capital equipment than American companies can for several reasons. I would suspect that the economic climate in optics will improve in terms of the use of optics in instruments and devices and such things, as opposed to direct consumer optics. As for American optical companies, it seems that as long as the volume involved stays in the hundreds, we can hold onto the business. The minute the volume gets up into the thousands, it becomes worthwhile for the buyer to learn how to speak Japanese.

CB: Do see any interest within the community in automated methods of production optics that would put us back in the market for the high volume business?

WS: There is a very definite interest. Unfortunately, many of the so-called automated ways of making optics are not really applicable to high precision optics. It seems that if you want to manufacture things in optics with high precision techniques, then you have to use what I've always thought of as being kinematically sound techniques, which leave the precision up to Mother Nature. The fact that you can rub two pieces of anything together and generate a couple of fairly accurate spheres is the basis on which optics have been made for centuries. To try to build that same natural precision into a machine tool is very difficult. Obviously, people are doing it with single-point diamond turning techniques, and it is rather astonishing that they are. They are still perhaps an order of magnitude away from being able to do it for ordinary visual wavelength optics, but they are certainly doing a magnificently impressive job in the ten micrometer wavelength region.

CB: What about plastics? A few years ago there seemed to be a great deal of interest in this, but it now seems to have tapered off. Is there any real hope for plastics filling the gap in terms of high volume production?

WS: I think your observation is probably applicable to almost every optical development that has come down the pike. They become fashionable, there is a tremendous amount of interest and expenditure, and then they seem to discover their own niche in the field. Plastics have done just that. Plastic optics have some tremendous advantages. An obvious one is ruggedness. When I first started in the business, the way you could distinguish a plastic lens from a glass lens was by what was known as the "bounce test." You threw the lens against the wall, and if it came back it was plastic. Also, plastic lenses are light, and, of course, if you are willing to invest in tooling, they are tremendously versatile in that you can make an aspheric surface as easily as you can make a sphere, which is certainly not true of classical production techniques. In fact, if you are in the plastic business, you realize that it is probably easier to make an accidental aspheric than to make a sphere. Plastics have a very definite place in optics, and that place is perhaps just below the precision optics level—semiprecise, if you want to call it that. For things such as inexpensive camera lenses, skillfully made plastic lenses are a very good choice, and that seems to be their future. The imagination is very greatly stimulated by the potential of things like plastic optics, but I think everyone has a natural tendency to say, "Hey, here is the answer to every problem in the world," just like fiber optics before it was the answer to every problem in the world. That, of course, is never true. As I indicated, these developments tend to find a niche or couple of niches where they are ideal. They then take them over and occupy them forever, as it were.

CB: What do you see as the key economic driver for the health of the optical industry?

WS: It is a matter of investment of two types. The obvious one is the capital investment in production and manufacturing equipment that has been neglected for years and years. The fact that you can make precison optics with a pile of junk that looks like a plumber's nightmare has, in effect, kept us out of the modern machine-tool age because optical fabrication can be done with essentially no equipment. Therefore, people keep doing it that way. Gradually, people in the business have come to realize that you have got to spend quite a bit of money keeping up to date in modern equipment. The other investment that the optics business needs is, I think, in knowledge. The manufacture of optics is simply not well understood. There is no body of scientific knowledge or body of technology that allows you to understand what is going on when you grind and polish a lens, for example. Somehow we have to understand this. The learning process is underway now, but we definitely have to finance study, research, and investigations in these fields. The manufacture of optics is still basically a black art. What people do know is that if I use a certain machine with a certain set of motions and a certain pressure, and if I apply somebody's brand of abrasive or polishing compound at a certain percentage slurry, at a certain temperature, and if I use a pitch that is derived from a Portuguese pine in the summertime, then I get a good result. If you change any of those parameters... there are perhaps a few people who understand dimly, but, by and large, the people who are making optics are totally unable to predict what will happen if you change any of those parameters; and if, for example, one of the elements of that production process becomes unavailable to you, there is no scientific or engineering answer to the problem of how to fix the process with a substitute element. It always evolves into a matter of trial and error. I think that is the big gap in optical production knowledge that somehow we have to find a way of financing. As much as I dislike government intervention in anything, perhaps government money is financing the scientific study that is going on in these fields. People like Norm Brown at Livermore, for example, are beginning to be able to talk rationally about what happens in the optical process, and this is a real pleasure to see. It's quite a welcome change from the days when you asked an optician how he tested his pitch, and he would say, "Mit da teet."

CB: You mentioned diamond turning. Let me throw in another one. A few years ago there was some interest in ion-beam figuring. Has that gone anywhere?

WS: To my knowledge it hasn't. The ion beam, however, is useful in optics for making microlithography masks. During a recent tour of Bell Labs, I noticed that they were doing that, and, of course, you can get resolutions that you can't get with light optics.

CB: Warren, shifting gears somewhat, where do you see the United States in terms of its status in the international optics community? You commented on the fact that the Japanese are picking up on the volume production aspect, but where do you see us in terms of leadership in the technology?

WS: In terms of new developments and scientific research, we're very definitely the leader, or at least one of the leaders. I don't think there is much question about that.

CB: In terms of, for instance, camera systems, I remember when the 35mm camera to own was an Exacta, and Germany was the place for excellent precision optics. Then it shifted to Japan, and it seems as if the United States, at least in terms of consumer products, has always been Kodak, the Brownie. There really hasn't been a company, not that I can remember, that was recognized as an excellent camera producer of that sort. Is that accurate?

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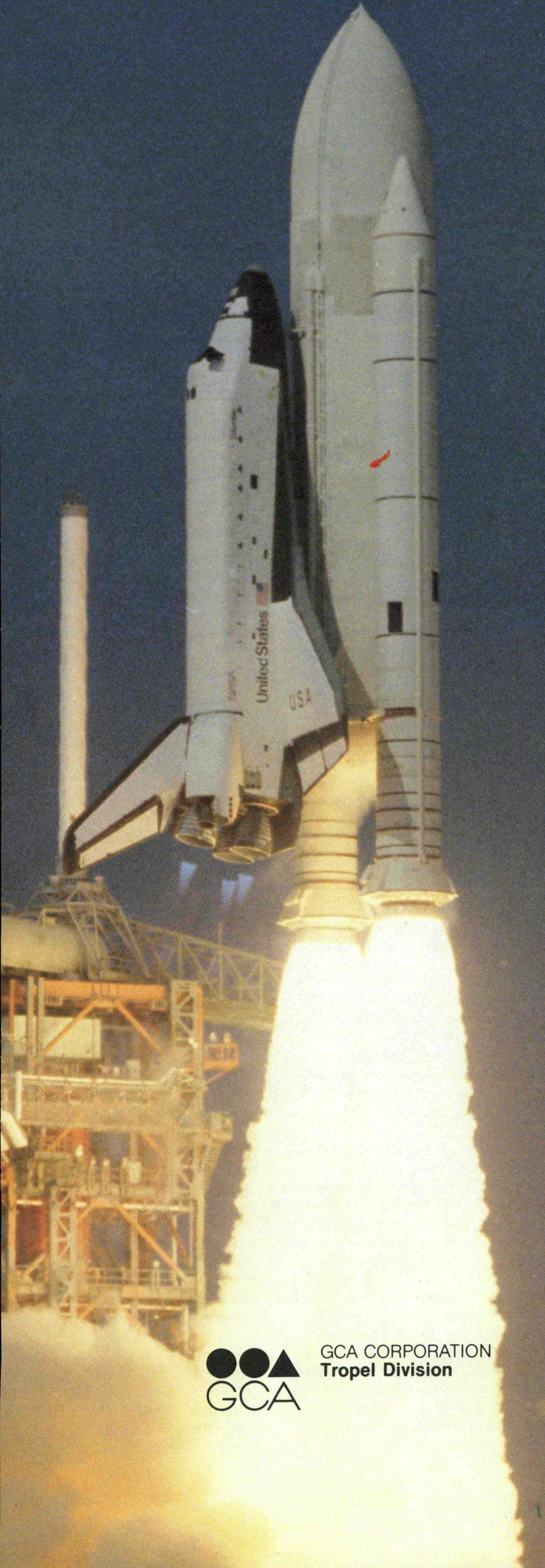

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WS: I think you're right. Some years ago Kodak did have a number of excellent 35mm cameras. I believe they were all made in Germany. In the U.S., efforts along those lines were directed toward producing a low-priced popularized product typified by the Argus series of 35mm camera, which, you may not believe, initially sold retail for, I think, twelve dollars. The United States has never really been a factor in the high precision 35mm camera field. We made a number of things like the Speed Graphic very well, but those have gone by the boards. And, of course, the Japanese took over from the Germans probably largely on the basis of imagination. I expect they sat down and thought, "Gee, what would the customers like to have?" and then proceeded to try to make it possible. They have done a magnificent job.

CB: That was a little on the side since we are really not just talking about the popular camera. Do you think that foreign policy has been a stimulant or depressant to the advancement of optics technology?

WS: I find it hard to connect foreign policy and optical technology.

CB: I am trying to lead our discussion into the idea of technology transfer and your attitude towards that.

WS: Speaking in the present tense or the future tense, I suspect it is beginning to, or may begin to, have an effect—possibly a very bad one. And I suspect that the U.S. benefits from technology transfer as much as it provides benefits to other countries and that our leadership position, whatever it happens to be, is a result of the fact that we are a free and open society. Anything that changes this is going to be to our detriment. The current drive on the part of the Commerce Department to stifle, apparently largely by intimidation, any technology transfer is, I think, going to boomerang on us in the long run because the tendency is very detrimental. A suppression of technology transfer in an open society cannot be limited to international dialogues. If you suppress an international dialogue in this country, you're effectively—I should put that in reverse order: the only way you can suppress an international dialogue in this country is to suppress a domestic dialogue, because we are an open society. As an informational society, SPIE is, of course, in a position where we are wide open, and our reason for being is to transfer technology, ideally to our members, but, in general, to the technological community at large. I think this is a positive benefit to the status of our country in terms of our scientific and technological standing and that *anything* we do to suppress dialogue is very definitely moving in the wrong direction.

CB: I see. Consider national security as the driver on the one hand and free interchange on the other hand. Let's suppose you are in a position to set policy with whatever criteria you choose, be it conscience, economic, or some other consideration. Where would you draw the line? How would you set policy in terms of technology transfer?

WS: I think the situation you're describing is similar to the situation regarding trade secrets in the commercial world. It is only a trade secret if you keep it a secret. With regard to national security information, secret or classified material can only be kept that way if you do keep it secret. There is no way you can partially transfer the technology through the scientific community because by its nature the scientific community also *has* to be open. If you transfer information to part of that community, it is very difficult to keep it from any other part. In terms of safeguarding the country's security, I think you just have to decide what information is not going to be made available to the general community at large and restrict that information to those who have the classical need to know.

CB: Clearly, you're saying that it has got to be one way or the other, and one can't really draw the line on some middle ground.

WS: Yes. The big danger that I see us facing right now is an apparently deliberate attempt to suppress technology transfer by intimidation and innuendo, the hidden threat that "something bad will happen to you if you don't stop transferring technology out of this country" without any clear definition of the forbidden technology. If you listen to the innuendos and hidden threats, you will simply never allow yourself to speak about anything or ship any product for fear that, after the fact, someone may declare that to be something that you should not do or talk about. This is a big danger because, as I indicated, our scientific and technological health depends upon everybody in the country having free access to the information that people are willing to exchange. If it becomes difficult to transfer information, it becomes difficult to educate people.

CB: So, what you are really saying is that there is a need to more clearly define what should be secret and what should not, and that, at the moment, there is an unwillingness to do that. This has resulted in a situation with one side saying, "Since we can't define it clearly, let's make sure by not allowing anything."

WS: Yes, but I think it is a dual problem. First, it is a terribly complex bureaucratic task to try to do this (and probably impossible), and second is the fact that the people who are trying to do this simply do not understand the field that they are trying to monitor. As a result, they are trying to get the people in the fields to monitor themselves by scaring them. It's unfortunate if it's allowed to go on.

CB: National security is not the only area where this represents a problem. There is talk going around about risking our leadership in technological innovation. Going back to what you said earlier, that we also benefit by technical exchange, can you identify some specific areas where we have benefitted, where we have been on the receiving side of technical exchange?

WS: You simply have to go home and look around you. Look at your camera, your television, your car. This is perhaps not the cutting edge of scientific research, but in terms of the material benefits and the quality of life that we enjoy, we certainly have benefited by the fact that many of these imports are more economically made, and perhaps better made, than corresponding products made in this country. At least we seem to prefer them.

CB: Can you think of a situation or specific situations where we have really been the source and the innovator?

WS: It is seldom all one way or the other. Look at the situation in microchips or computers. We have truly been in the forefront in the development of such products. Recently, the Japanese have stolen what I suspect is a temporary march on us by picking up on a certain size chip, which is, I think, the 64K chip. They built a big lead in these simply because manufacturers in this country didn't think it was the right market time for it. It has yet to be determined whose market judgment is correct in this case. But the situation is indicative of the way things go, in that it is a little like running a race; if you stop running, you lose.

CB: Can you speculate on any areas in which you think that we will retain our lead and also areas in which you think we might be losing our lead?

WS: It would be presumptuous to try to answer that in terms of specific fields. But projecting historical trends into the future, you can be reasonably sure that we will maintain our initiative in new scientific developments as long as people are free to look into those things, and we will start losing our lead in the application of many developments after they lose their newness.

CB: The logic behind that seems to be that we will retain our lead in new developments because of our freedom to look into those things and perhaps because we have a society that is willing to put a fair amount of money into that type of activity.

WS: And we lose our lead for the same *kind* of reasons—because our society makes it hard for someone to make a profit in business.

CB: There has been a good deal of talk this past year about the federal budget, of cutting back in areas of basic research. Do you see that as sifting down and putting a cramp in our style of having the freedom to explore new ideas, or do you think that it has just been a lot of hot wind, if you will?

WS: I really don't have much information or expertise as to how that is actually going, as compared to the perception the press tries to give you, which is not always the same thing. I am personally torn between a dislike of big government and a knowledge that an awful lot of optical research is, in fact, financed by government. Ideally, as a dyed-in-the-wool free enterpriser, I should be pushing for research that is funded through enlightened self-interest by free enterprise. I don't know whether it works that well.

CB: Do you see any increase in, first, the idea of a consortium of industrial companies supporting basic reseach? Do you foresee any of that happening from those companies that will obviously benefit from the applications?

WS: I can conceive of two companies forming a joint effort or partnership where they each have something to contribute. However, I suspect it is rather unlikely given our background in business and the social nature of this country for several companies to get together in a consortium without having a very definite immediate interest. Other than that, it is probably against the current anti-monopoly laws.

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CB: There have been various major occurrences in history that have been key drivers in science and technology. For instance, WWII was a real driver towards the development of radar, nuclear technology, and so forth. The space program has obviously been a key driver in our technological development. Do you see any other major things which are currently driving optics as part of high technology?

WS: Not any one specific thing. I think there is a tremendous driver in the appetite of our economy for improved ways of doing things and making things—the fact that we need machinery, equipment, and instruments to do certain tasks—and over the last 30 or 40 years optics has become a tremendous tool to do many of those tasks. That is a real driver for optical technology.

CB: Are you saying that what we used to call Yankee ingenuity...?

WS: It is basically that. Consider the fact that every office in the country has at least one copier and many of them have dozens. Almost all the copiers have optics of one sort or another in them. The contact print has long gone by the boards. That sort of thing drives optics as well as the more exotic outer space type of thing.

CB: So, you are saying that technological development has been driven more by the effort to satisy needs than by specific programs or events that can be isolated?

WS: You have to question—you mentioned radar—whether or not radar would have come along to protect commercial airliners had it not been brought about by WWII. It is a "what if" question.

CB: My guess is that it would have. But would it have come along this quickly because the money probably would not have been poured into it since the driver wasn't there at that time?

WS: I spent a couple of years with the Manhattan project separating uranium 235 from U238, and everything there was about as secret as you can get. It was probably the best kept, most widely known secret that has ever been. I would see professors in the halls at school and they'd say, "I understand you are going down to 'Bugeye' next week," and they knew more about it than I did. There was a book, *Particles of Modern Physics*, in the company library at Oak Ridge, and there was a page in which the author described atomic fission, told how much uranium 235 you would need to generate a chain reaction, and indicated the extent of the catastrophe that might follow by saying that "if the reader should wake up some morning to discover that Japan or the West Coast of America has disappeared, he will know that somehow, somewhere, someone has succeeded in collecting this much uranium." There are situations like that where things are essentially wide open in advance. Now, that was a development that was done under pressure of war, under the cloak of fantastic security and secrecy, but which was spelled out in a publication that came out before any of this stuff even started. Needless to say, that particular page in that particular book was greasy; you could barely read it. Everybody in lab had gone through it.

CB: Looking into the future, what major developments do you see coming along that will have a major impact in the area of lens design—let's say in systems, your own design area?

WS: In my opinion, the development in lens and system design that will have the greatest impact will be the ability to manufacture precise aspheric surfaces in volume production. This technology is already impacting the long wavelength, ten micrometer, infrared region. The fact that you can now make an aspheric surface by diamond turning with very little more expense than a spherical surface has tremendous impact on that field. If the technology improves by an order of magnitude, say, so that it can be applied to visual wavelengths, shorter wavelengths, I think that will have as much effect as anything you can imagine coming out of the field. The ability to mold aspheric surfaces has already affected the design of inexpensive commercial camera lenses, which are made of plastic, in that designers can now put in an almost unlimited number of aspherics. In the new Kodak disk camera lens—which I understand is plastic only in the sense that it is made of plastic glass—they have managed to put in an aspheric surface and have done some very interesting things with it.

I think that capability will change the art of optical design tremendously. Most lens designers look upon the ability to put in aspheric surfaces as if it were the answer to all their prayers. And I think that most of them will discover tnat, when they do get that ability, they will have to learn how to use it. The old arts of lens design, as incompletely understood as many of them are among modern designers who simply rely on the computer, will have their counterpart in the knowledge that is going to be required in the future as to what is the most economical and most efficient way to use these aspherics. For example, if you are designing a triplet at f/3.5 or f/4, there is little or no point in splitting one of the crowns to try to improve it because that kind of a tool doesn't attack the problem of that kind of a lens. But, if you are designing a high speed lens, let's say at a speed of f/2 or faster, splitting the crown definitely is a worthwhile tool. I think that this analogy applies to aspheric surfaces. There will be certain situations and problems for which the aspheric can be profitably employed, and techniques of using them which will work out well. The designer is going to have to learn that.

CB: If you were writing a science fiction story, for instance, what kind of optics related dream devices would you elect to include? In other words, let your fantasy go. Let yourself be Jules Verne for a moment.

WS: As a practical engineer, my career has been devoted to.... Let me put it this way. The first step in any development is always to make an attempt to prove it can't work. That may seem like a negative approach to development, but in the field of optics it seems to work. The first thing you do in any development is to sit down and, for example, see whether what you are trying to do exceeds the diffraction limit or the laws of thermodynamics. The first twenty minutes or so of any job seem to be, "Okay, let's prove that this doesn't violate any of the canons that we know from experience indicate that the system will work." With that kind of a mind set, I don't think that a good optical designer or good optical engineer makes a great science fiction writer. There are a few exceptions perhaps. I have always been in situations where someone comes to us and wants to do something, and we are asked, "What can you do to make it possible?"

CB: You're a problem solver then. Can you talk about some of your current projects at Infrared Industries--things that aren't proprietary?

WS: We are working on an optical system for a ten micrometer laser microcircuit trimmer that is going to be galvanometer scanned and has a rather interesting relay principle involved in it. We do a good deal of work for the motion picture industry, and there we are working on improved rear anamorphic lenses. The problem with anamorphic lenses is with trying to attach an anamorphic "front" to a zoom lens. It gets so bulky that you cannot carry it around. An anamorph as a Bravais system can be put behind the zoom lens where it can be very small. It is very difficult to design them as good as the "front" ones, but the obvious size advantage makes them worthwhile. We are into lenses and optics for lightweight TV cameras which people are using for making movies. In another field we're working with improved coatings in the intermediate infrared regions, and we're doing a good deal of work on the techniques of manufacturing both coatings and optics. The rise in infrared optics has obviously caused a rise in the use of expensive materials like germanium. You then have to adapt your equipment to find some way of recovering the costly germanium that you otherwise grind away and flush down the sewer system.

There have been significant changes in our production equipment. We have just about completed an almost 100% change in our production machinery. We used to have banks and banks and row upon row of grinding and polishing spindles, all slapping back and forth in unison with every spindle on the bank making exactly the same element. Nowadays, the emphasis has changed so that we need versatility more than anything else; thus we've gotten rid of almost all of the old style production machinery and gone to individual spindles. I think that the biggest unit we have now has four spindles on one bank, and each one of those is individually controlled. The emphasis has changed a great deal.

CB: One final question, Warren. From time to time we get the following question directed to us by students: "I'd like to be an optical engineer. What does an optical engineer do, and how do I get to be one?" In view of the fact that you've been an optical engineer for a long time and you've written a very good book which, if an individual decides to become an optical engineer, he'll probably run into, I'd be interested in hearing your viewpoint as to what an optical engineer does these days and how does one go about becoming one? Finally, do you have a key gem of advice that you could pass on to students or aspiring optical engineers as to how they might become another Warren Smith?

WS: I think you'd have trouble avoiding mention of my book because, I swear, there have been more books sold than there are people in optics. It's astonishing. When I wrote that book, I thought it might sell a thousand copies if I was lucky.

If you want to be an optical engineer, step one is obviously to get good sound grounding in the field. It is possible to take a degree in mechanical engineering, for example, and then study optics by yourself, but that's a very

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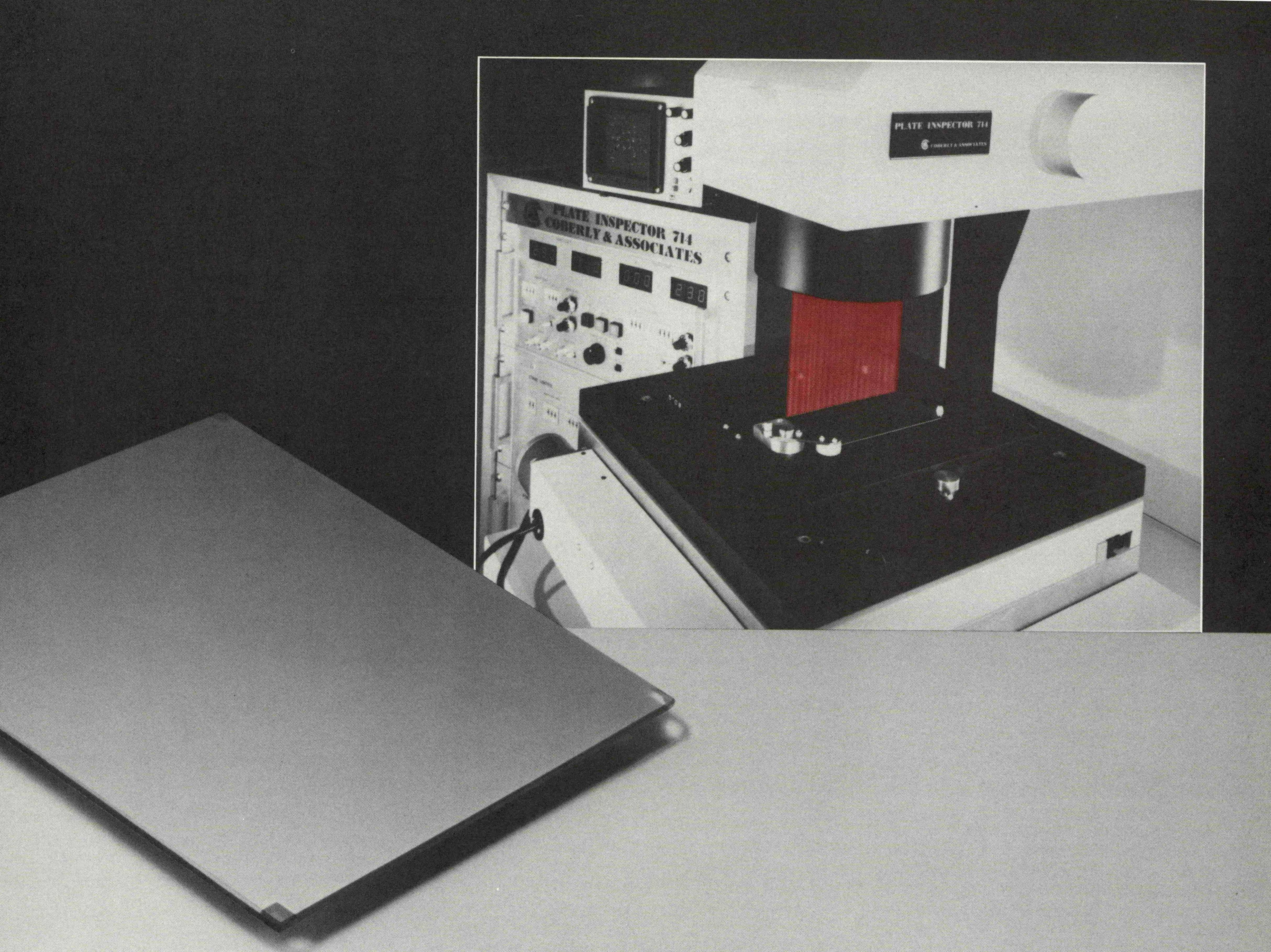
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difficult path to take. There are some very successful people that have been self-taught in the field of optics, but the easier route, not that it's a really easy route, is to go to Rochester or Arizona or someplace similar and study the subject full-time for a year or so. In any case, the advice turns out to be the same thing—that optical engineering, like anything else, is a trade, and in effect you must learn your trade one way or the other. One way is to study it in school; another is to apprentice yourself to somone who can teach it to you. Possibly the best way by far is to learn it yourself by tackling every problem as it comes along as thoroughly and exhaustively as you can until you fully understand what it is that's involved in that problem and the answers to it. My own technique was that every time I worked up something that I thought would be of value in the future, I would write it down in clean form in such a way that, hopefully, I could come back to it a few years later and understand what I had done. That was done initially as a way of passing the time while I was waiting for my wife to finish work, but it turned out to be a very valuable move on my part because when McGraw-Hill asked me to write a book on optics, it turned out I had all the notes prepared. All I had to do was make them coherent. If anyone wants advice, that's the first part of it.

The second part is to realize that everyone in every job in a sense defines their own job. You tend to do most what you do best; very few positions in industry, or in any kind of work, correspond exactly to the little boxes on an organization chart. There are a lot of people who expand their areas of responsibility to fill out or match their areas of competence, and my experience has been that in an organization of any size you usually make your own job rather than fill an assigned task. You may start out with an assignment to do a specific function, but if you can do a couple of other functions well, they soon became part of your assigned job description, and you go from there. I tend to believe that people's jobs expand to fill their capabilities. If you've "got it," there are managers all over the world who would be delighted to take advantage of your ability to handle tasks. The stories you occasionally hear about people getting suppressed or held down for one reason or another are almost totally incredible to me because, as someone who has been off and on a manager, I know that as a manager one of the first things you want is someone to do your work for you. If you find someone who does it well, you're willing to give him all the authority and responsibility it takes to get the job done, and you're glad to be rid of it.

Tricks of the Trade

WHAT'S YOUR CAPACITY?

Joseph L. Horner
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Sooner or later in the course of making a measurement (optical or otherwise), or building a circuit to do likewise, you will have to use a capacitor. You usually know what value you want, but reading the value off the unit is often a problem. Frequently, the unit is physically too small to print its value. However, it seems that manufacturers have resorted to some very ingenious schemes to obscure this information, such as using their own codes, printing with fading inks, or using bizarre colors (brown or blue for instance) which are impossible to read. Commercially available capacitance meters are expensive (typically $150.00 and up) and have more range and accuracy than is usually needed..

It was for all these reasons that I developed the meter shown in Fig. 1. It uses a single inexpensive IC chip, the #556, a dual version of the popular #555 timing IC, and a few resistors and condensers. It will measure values from 500 pF to 500 μF (full scale) and is self-calibrating. It works like this: IC1A is an oscillator whose frequency (f) is either 550 Hz, 55 Hz, or 5.5 Hz, depending on the range selected. The 5.5 Hz is used on the 500 μF range, the 550 Hz for 500 pF, and 55 Hz on all other ranges. The output of IC1A is a negative-going spike that triggers IC1B. The output of IC1B immediately goes high, and stays high for a length of time t:

$$t = 1.1\, R \cdot Cx\ , \tag{1}$$

where Cx is the unknown capacitor and R is the range resistor selected by S_{1B}. At the end of time t, the output goes low, and the cycle is repeated again with the next trigger pulse from IC1A. In other words, the output is a constant period signal whose on time is directly proportional to the unknown capacity. The metering circuit averages this waveform and displays the dc component. If T is the period of the trigger pulses from IC1A, this average is

$$Av = t/T = 1.1\, RC\ , \tag{2}$$

where T = 1/f. If we wish to read 5.0 μF full scale, and f in 55 Hz (T = 0.0182 sec),

$$1 = 1.1\, R \times 5 \times 10^{-6} \tag{3}$$

or

$$R = 3.3\ K\Omega \tag{4}$$

is the required range resistor, which is a standard value. This is why all the range resistors are multiples of 3.3. You may wonder why the range can not be increased to 1000 or 10,000 μF. The reason is that a 33 ohm or 3.3 ohm range resistor would result in a large charging current (250 mA and 2.5 A, respectively)—too large to be handled by the battery or IC.

The unit can be built in any convenient-sized box. I used one 3 in. × 4 in. × 6 in., and at these low frequencies placement of the parts is not critical. Resistor RC is adjusted for a full-scale deflection of the meter when switch S_2 is in the calibrate position. One word of caution: always check the unknown capacitor on the next higher scale to obtain a consistent reading of the unknown capacity. If the capacitor is over the full-scale value selected, an erroneous reading can result, because IC1B will stay high into a subsequent trigger cycle. Now you can face the measurement world with renewed confidence because you know your capacity!

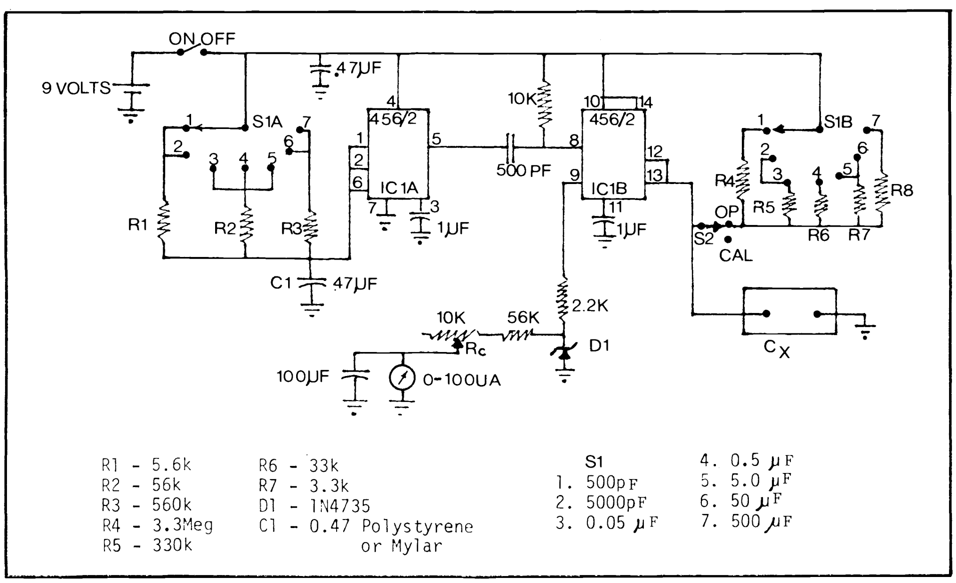

Fig. 1. Six decade capacitance meter.

Laboratory Report

Technical University, Budapest

H. J. Caulfield
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45 Manning Road
The Research Center at Manning Park
Billerica, MA 01821

The Danube River separates the Technical University (in Buda) and the Science University (in Pest) in the lovely city of Budapest, Hungary. One of the major subdivisions of the Technical University is the Institute for Applied Biophysics headed by one of *Optical Engineering*'s associate editors, Professor Pal Greguss. Having had the privilege of visiting in his laboratory recently, your editor wants to share with *Optical Engineering* readers something of what they are doing.

Their general goal is to use low power coherent radiation (both optical and acoustical) as an aid to

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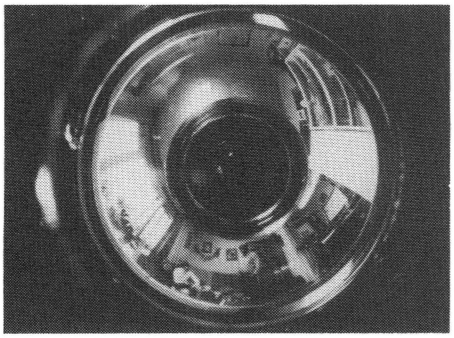

Fig. 1. Example of panoramic camera image.

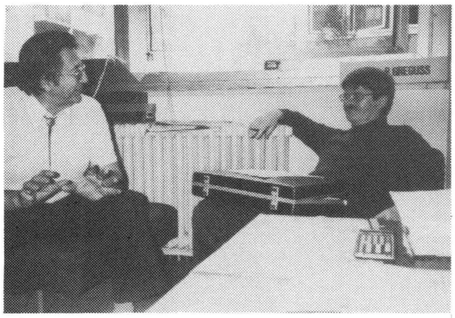

Fig. 2. Prof. Greguss (left) and H. J. Caulfield.

study, diagnostics, and even treatment of biophysical entities. With typical Hungarian verve, Greguss (also an artist, poet, playwright, actor, and composer) attacks a wide variety of important problems in very unusual ways with a great deal of success.

Among his recent projects, the easiest to demonstrate here is his panoramic camera. Greguss and his associates have designed and built a number of lightweight, inexpensive lenses which allow 360° imaging around the axis and large field of view (say, 60°) normal to it. This lens can be adapted readily to any camera or endoscope. Because the effective focal length is very short, no focus control is necessary and the focal number is low. Because the lens can be partially achromatized, good color rendition is possible. Because the image recording format is flat, it is compatible with TV and movie formats. The flat image is of circular format with a polar mapping. The image (see Fig. 1) is readily interpretable. By back projecting this image back through the lens, he can produce an undistorted image on a cylindrical screen. The viewer can walk around the screen or view the screen from the inside. Many applications in biophysics and elsewhere spring to mind.

Another project involves using ordinary black and white TV signals and achieving a great many of the effects (pseudocoloring, area measurement, histogram equalization, etc.) normally achieved by digital processing with an inexpensive, real-time analog processor. The results are very impressive.

Also in TV imaging is a system which produces Julez stereo pairs in real time from a TV camera. Greguss hopes to use this unique system in testing human stereo response ranges and changes with drugs, fatigue, age, training, etc.

Their holography laboratory is involved in the synthesis of 3-D images from 2-D data (CAT scans, B scans, etc.). Progress there is steady but not yet of a "breakthrough" nature.

The interaction of human and animal subjects with coherent radiation is being studied through evoked potentials, wound healing (which Greguss believes to be unsubstantiated and probably unimportant), etc.

Finally, the holographic model is being used to predict peculiarities in human vision which have no other simple explanation, and data are being collected to confirm or refute those hypotheses. An example is the prediction that in an untrained subject (e.g., an infant) both orthoscopic and pseudoscopic images are perceived. In most adults the "proper" orthoscopic view has come to full dominance, but in some a "confusion" persists. The "confused" subjects may make drawings with inverted perspective but have less difficulty comprehending optical holographic pseudoscopic images than "normal" subjects. My summary undoubtedly does some injustice to their analysis, but it does illustrate at least the direction of some of their studies.

Readers intrigued by any of these matters should correspond directly with Professor Pal Greguss, Applied Biophysics Laboratory, Technical University Budapest, H-1111 Budapest, Krusper u. 2-4, Hungary.

Book Reviews

Foundations of the Stereoscopic Cinema: A Study in Depth

Lenny Lipton, 311 pp., illus., bibliography, index. ISBN 0-442-24724-9. Van Nostrand Reinhold Co., New York (1982) $21.95.

Reviewed by Stephen A. Benton, Polaroid Corporation, Research Lab., 750 Main St., Cambridge, MA 02139.

The current revival of interest in "3-D movies" is only the latest phase of a hundred-and-fifty-year history of attempts to bring the richness of high quality "spatial imaging" (to embrace three-dimensional imaging in its widest sense) to bear on our everyday experience. Hopes for sustaining this revival lie in the more advanced photo-optical technology now more widely available and in the more sensitive and intelligent use of that technology. By drawing together a wide variety of historical, mathematical, and practical data, Lenny Lipton works to provide a firm intellectual footing for independent film artists considering this enhancement of their medium. For the making of a satisfying 3-D film is much more than twice as complex as for a conventional film, and the many new decisions require substantial care. They should be based on technical understanding as well as experience, from the projectionist who must align and balance his equipment (at no extra pay!) to the cinematographer who must decide how best to separate and direct the lenses for the intended effect.

In the effort, Lipton provides two very different books, one much better than the other. A comprehensive bibliography (more than 350 entries) compiled by his associate Michael Starks is the basis for the first, a widely ranging, profusely illustrated (152 figures and tables), and engagingly annotated review of the history of spatial imaging's concepts and inventions. Lipton reveals a fond interest in the offbeat and quaint before focusing on the (relatively) practical technology of modern stereoscopic filmmaking, and attempts to codify and compare six different approaches to stereoscopic filming calculations. This is a valuable reference, despite a few historical and technical flaws (and contentious opinions), but its attempt at overwhelming authoritativeness cannot overcome a lack of intelligibility and logic in supporting what follows.

It is a surprising fixation on mathematics that most erodes the "second book's" utility—surprising in view of Lipton's own remarks that binocular depth perception is not only highly idiosyncratic but also varies markedly with the scene content. Indeed, Lipton was so dismayed by the variability of his viewing audience's results that he discarded them in favor of his own observations! Even then he concludes that good 3-D is more an art than a science, which is only to say that our understanding of it is still too simplified. Yet much of the book is taken up with a belabored tracing of the stereo image differences through the many-staged filmic system to the viewer's retinas. Lipton's judgment of his intended audience hobbles the discussion with elementary algebra and proceeds so haltingly as to preclude any comprehensive understanding. Several summary tables are provided, but a straightforward computational scheme suitable for a programmable calculator would have served even better. The general confusion is probably great enough to convince a filmmaker that a stereoscopic consultant is a good investment.

Lipton is most interesting when discussing, in a rather anecdotal way, what has worked most effectively in his own films. But despite his worries, it seems that good 3-D movies can't be all that difficult to make. The Soviets have been doing it routinely for decades and have shared their methods through technical publications and demonstrations. Other filmmakers, Felix Bedrossy and Murray Lerner to name two, have worked out their own techniques by dint of observation, perseverance, and talent. The chronic ascendancy of shabby 3-D in the U.S.A. is a frustration to all who savor the richness of visual space, and its roots are only hinted at by Lipton, although with the authority of firsthand experience.

Those who care for language and logic will be dismayed by this hastily produced volume. But anyone with an abiding interest in three-dimensional imaging should be able to justify its place on an otherwise sparsely filled bookshelf.

Color and Color Vision: Selected Reprints

Paul L. Pease, Ed., 133 pp., illus. American Association of Physics Teachers, State University of New York, Stony Brook, New York (1982) $4.

Reviewed by Fred W. Billmeyer, Jr., Rensselaer Polytechnic Institute, Troy, NY 12181.

Color and Color Vision is a collection of 20 selected reprints dealing without exception with various aspects of color vision. In this respect the title is somewhat misleading since the first two words could just as well have been omitted.

One looks for a guiding principle according to which the reprints in this collection were selected.

There is no preface, but the first reprint is a resource letter by the volume editor,[1] whose affiliation is the New England College of Optometry. In it he states: "The resource material selected here focuses on color vision .... Its objective is to equip the teacher and student with an understanding of both normal and abnormal color vision. To that end, pertinent physical, physiological, psychophysical, and psychological concepts are included ...." There follow about 200 references, including the papers reprinted here. Less than 10% of the references deal with aspects of color other than color vision.

The reprints are grouped under the following headings: luminosity, cones and cone pigments, neurophysiology, mechanisms (and) psychophysics, and spatial and temporal phenomena. None of them deals even remotely with any aspect of color other than color vision. There is nothing on colorimetry, color measurement, color reproduction, optical engineering, the application of color technology in industry, or photography.

The reprints appear to have been selected for historical value; over half of them are notes, letters, brief communications, or reports in *Science*. As a consequence, developments in the field are presented in sketchy, preliminary fashion; accounts of important improvements in techniques and refinements in data that substantiate more far-reaching conclusions are missing. Although this reviewer is scarcely an expert in this limited field, it appears that coverage is far from uniform and evenhanded: for example, two long and admittedly important articles by the Hurviches are reproduced to devote a sixth of the book to the opponent theory of color vision, whereas the equally important trichromatic theory of Young, Helmholtz, and Maxwell receives no similar modern treatment.

All this might not matter if the purpose of the collection were to provide an up-to-the-minute collection of the latest advances in the field. This is clearly not the case, however, since three-quarters of the reprints are between 10 and 25 years old. In this reviewer's opinion, those who really want to know what the state of color vision is today, or what its history has really been like, would do better to consult one of the good modern books on the subject,[2] and those who want to know about *any* other aspect of color will have to look elsewhere.[3]

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2. For example, Robert M. Boynton, *Human Color Vision,* Holt, Rinehart, and Winston, New York (1979).
3. For a start, see the Annotated Bibliography in Fred W. Billmeyer, Jr. and Max Saltzman, *Principles of Color Technology,* 2nd ed., John Wiley and Sons, New York (1981).

Mode-Locking in Solid State and Semiconductor Lasers

M. S. Demokan, 227 pp., illus., index, references. ISBN 0-471-10498-1. Research Studies Press, John Wiley & Sons Ltd., 58B Station Road, Letchworth, Herts, SG63BE, England (1982) $39.95.

Reviewed by R. R. Alfano, Director, Institute of Ultrafast Spectroscopy and Lasers, Dept. of Physics, The City College, The City University of New York, 138th St. & Convent Ave., New York, NY 10031.

This is a good book on explaining various aspects of mode-locking solid state and semiconductor lasers. It is written on an advanced level and can be useful to both researchers and graduate students who are familiar with laser physics. The book is timely since ultrafast laser pulse technology is one of the most active areas of photonics.

It is a good overview but should have included the phasor sideband model of mode locking. Some of the key theoretical and experimental pioneers to this field have not been referenced. The first part of the book is more detailed than the latter part on semiconductors. The book does not discuss methods for measuring the ultrafast pulse duration and shape, nor detail mode-locked laser designs. Reliable mode-locked Nd:glass lasers have been built by a number of scientists. Chirping and dechirping of pulses are not explained.

With regard to the format and style—I found the labeling of the chapters and subchapters confusing; there is a lack of references; the references are hard to find; the print is too small; and the book lacks photographs showing the temporal emission patterns from mode-locked lasers. Overall, I rate the book good.

Introduction to Optical Fiber Communications

Yasuharu Suematsu and Ken-Ichi Iga, translated from the fourth Japanese edition by H. Matsumura, edited and revised by W. A. Gambling. 208 pp., illus., bibliography, appendices, index. ISBN 0-471-09143-X. John Wiley & Sons, New York (1982) $29.95.

Reviewed by Marvin D. Drake, The MITRE Corp., Bedford, MA 01730.

This book is organized into three parts, with the first part, Chaps. 1–3, starting with a brief history of optical communications leading up to fiber optics, followed by the basic theory of light guiding and then an exposition of how light propagates in optical fiber waveguides. The second section of the book, Chaps. 4–6, concentrates on light sources for optical fiber communications, with a brief explanation of detectors and integrated optic devices. The authors go into detail about the principles, structure, fabrication, and operation of solid state sources, particularly semiconductor LEDs and ILDs. The last two chapters then return to optical fiber waveguides, their characteristics, how they are fabricated, how they may be used in systems, and some examples. Seven short appendices, which present in a little more detail material presented in the body of the book, finish the book.

The authors state, "This is a textbook about optical communications using the optical fiber and is intended for students and younger scientists who will shoulder the responsibility for its future progress." Indeed, the book is presented in the manner of a person who is very knowledgeable in this field, passing along to a beginning colleague a heuristic approach to optical fiber communications, pointing out along the way what is important, why it is important, and where the technology is going. The book is filled with short "chunks" of important information about fiber optics that could not be found easily in the literature and represent the expert observations and conclusions of the authors. This book does assume that the reader is knowledgeable in semiconductor physics and technology with a basic background in geometrical optics and electromagnetic theory. There is some repetition of material; thus, the reader can almost delve into the book for a single topic of interest without reading all of the previous chapters.

Despite the many good points of this book, it is not, in my opinion, a textbook for either undergraduate students or graduate students in a formal course. There is not sufficient exposition of the material presented nor is there a continuity throughout the book. The formulas that do appear are often introduced simply by "it can be shown that." The weighting of the subjects presented also varies widely, from very light on modulation and detection to very heavy on the details of semiconductor structures.

Overall, this book is an introduction as well as a survey of devices and technology for optical fiber communications. Several side topics are also mentioned, such as planar optical waveguides, integrated optic devices, GRIN rod lenses, and wavelength division multiplexing. The reader, hopefully, is left wanting to know more about the topics introduced. The bibliography provided by the authors includes the key historical references, in fiber optics as well as many other topics, to start the interested reader in the proper direction. The authors thoughtfully provide titles of the articles listed, but unfortunately the references are mostly before 1978. I hope that subsequent editions will include a more recent bibliography and also that the articles cited be referenced in the appropriate points in the text.

Meetings

APRIL 1983

April 4-8 SPIE • Technical Symposium East '83 and Instrument Exhibit, Arlington, VA. Program will include 15 related tutorial short courses and the following conferences: **Critical Reviews of Technology—Optical Specifications: Components and Systems.** Chairmen: Warren J. Smith, Infrared Industries, Inc. and Robert E. Fischer, Hughes Aircraft Co. **Workshop on Optical Specifications and Military Standards.** Chairman: Warren J. Smith, Infrared Industries, Inc. **Photovoltaics for Solar Energy Applications II.** Chairman: David Adler, Massachusetts Institute of Technology. **Integrated Optics III.** Chairmen: Lynn D. Hutcheson, Honeywell Corporate Technology Ctr. and Dennis G. Hall, Univ. of Rochester. **Technical Issues in Infrared Detectors and Arrays.** Chairman: Esther Krikorian, The Aerospace Corp. **Laser Beam Propagation in the Atmosphere.** Chairman: J. Carl Leader, McDonnell Douglas Research Labs. **Electro-Optical Instrumentation for Industrial Applications.** Chairmen: Frederic M. Zweibaum, Minarad Systems, Inc. and Robert A. Carella, Barnes Engineering Co. **Fiber Optic and Laser Sensors.** Chairmen: Emery L. Moore, Litton Industries, Inc. and O. Glenn Ramer, Hughes Research Labs. **Inverse Optics.** Chairman: Anthony J. Devaney, Schlumberger-Doll Research Ctr. **Optical Engineering for Cold Environments.** Chairman: George W. Aitken, U.S. Army Cold Regions Research & Engineering Lab. **Coherent Infrared Radar Systems and Applications II.** Chairman: Robert C. Harney, Martin Marietta Orlando Aerospace. **Applications of Optical Metrology—Techniques and Measurements II.** Chairman: John J. Lee, Jr., General Dynamics/Convair Div. **Fiber Optics Multiplexing and Modulation.** Chairman: Edward J. Miskovic, Farinon Electric/Div. of Harris Corp. SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

April 6-8 10th International Optical Computing Conference: "Unconventional Imaging and Unconventional Transformations," Massachusetts Institute of Technology, Cambridge, MA. Sponsored by IEEE Computer Society and International Commission for Optics. Cosponsored by Optical Society of America, Australian Computer Society, NASA, and SPIE. For information, contact Office for Special Events, MIT Room 7-111, Cambridge MA 02139. 617/253-1703.

April 11-15 Los Alamos National Laboratory Conference on Optics '83, Santa Fe, NM. In cooperation with Los Alamos Optical Society and SPIE. SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

April 12-14 Optical Surface Technology (Fabrication, Treatment, Testing), Garmisch-Partenkirchen, West Germany. Sponsored by the German Society for Applied Optics. Cosponsored by SPIE. For further details contact Hans-Jürgen Preuss, German Society for Applied Optics, c/o Ernst Leitz Wetzlar GmbH D-633 Wetzlar/Lahn, Postfach 2020, West Germany. (06441) 292238.

April 12-14 International Symposium for Electromachining, Birmingham, England. For further details contact Prof. J. R. Crookall, Cranfield Institute of Technology, Cranfield, Bedford, England.

April 13-20 Hanover Fair '83, Hanover, West Germany. For further details contact Lloyd Darden, c/o Hanover Fairs Information Center, 2700 N. Main Street, Suite 507, Santa Ana CA 92701. 714/558-3010.

April 17-20 SPIE • Application of Optical Instrumentation in Medicine XI, Atlanta, GA. Conference chairman: Gary D. Fullerton, Univ. of Texas Health Science Ctr. **Tutorials:** New Technologies: Digital Imaging and Nuclear Magnetic Resonance. Instructors: Perry Sprawls, Jr., Emory Univ., Gary D. Fullerton, Univ. of Texas Health Science Ctr.; Interactive Graphics for Medical Applications. Instructor: Samuel J. Dwyer III, Univ. of Kansas College of Health Sciences. SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

April 18-22 SPIE • 1983 SPIE International Technical Conference/Europe, International Conference Centre, Geneva, Switzerland. Eight seminars on advanced optical/electro-optical technology, a series of tutorials to provide an in-depth introduction to related seminars, plus an extensive exhibit of pertinent instrumentation. Cooperating sponsors: Association Nationale de la Recherche Technique, Battelle-Geneva Research Centres, Comité Francais d'Optique,