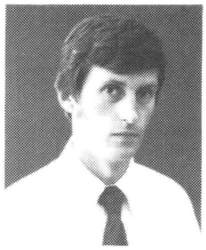
Forum

Laser Velocimetry



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One of the most rapidly developing areas in laser velocimetry is concerned with measuring aerosol velocity using methods that do not directly depend on the coherence properties of the laser. These methods do not rely on an interferometric measurement of the Doppler shift in the scattered light frequency to determine particle velocity. Some other method such as time of flight between two or more beams, particle arrival rate through a single beam, or pulse shape analysis is used. In this column I want to discuss some relatively recent work in the development of these techniques.

Pulse shape analysis

Dan Hirleman has pointed out in recent publications that advantage could be taken of the pulse shape of light scattered from a beam with Gaussian intensity profile to obtain particle speeds.[1, 2] Gaussian beams have the property that regardless of the particle trajectory through the beam, the pulse time width is a function only of the particle velocity and the spatial parameter used to characterize the beam "diameter"—say the e^{-2} radial intensity contour, $2b_o$. By measuring the time width, τ, of the Gaussian pulse at its e^{-2} amplitude points, the radial velocity

$$V_r = \sqrt{V_x^2 + V_y^2}$$

can be computed from

$$V_r = 2b_o / \tau \qquad (1)$$

where it is assumed that the velocity component down the beam transmission axis is negligible.

Hirleman has devised a convenient notational form to identify this technique, the "two-spot" time-of-flight technique, and the more conventional Doppler measurements techniques. At least for this column I will use his notation and I recommend to the rest of the laser velocimetry community that it be adopted. In Hirleman's notation, a velocimeter using only one beam is called an L1V, a "two-spot" system is called an L2V, and Doppler measurement interferometer systems are simply called LDV. LDV systems need an additional classification system of their own which will not be discussed here.

By using the velocity measuring techniques associated with L1V measurements, Hirleman has shown how the V_x, V_y velocity components can in principle be computed from measurements using L2V optical systems. Such an approach could eliminate the necessity of spot rotation in present L2V systems to obtain the true velocity vector in a plane normal to the beams.

Hirleman's present approach to signal processing L1V data is interesting. An A/D converter is used to digitize the pulses as they are detected. After a set of data is collected and stored in a computer memory, the data for each pulse are curve-fitted to a Gaussian function and the $2b_o$ value of the function computed. When the curve fit-data correlation is poor (i.e., below some present value), that signal is not used to compute the velocity. Results obtained by Hirleman and presented at a recent AIAA meeting suggest that this is a reasonable approach for signals with high signal-to-noise power ratio.[2] Future research and use by other workers should bring to the front the relative utility of this technique and other methods of signal processing.

L2V velocimetry

In my first column (*Optical Engineering* 18:6:SR-158, Nov/Dec 1979) I indicated that "no known method yet exists to quantify turbulence intensity with a single spot orientation." W. T. Mayo of Spectron Development Laboratories has sent me two reports which briefly describe SDL's approach to this problem.[3, 4] In this work Mayo indicates that Spectron's algorithm uses the RMS deviation of the transit times as an estimator of the turbulence intensity for a given spot orientation. The reports claim that the algorithms are capable of estimating mean velocity to better than 1% accuracy and with no more than a few percent error in turbulence intensity for values up to about 15%. The basis and fundamental assumptions for development of these algorithms are not presented in these reports. They do indicate, however, that the algorithms yield reasonable estimates of turbulent intensity in the experimental work which is reported. It will be interesting to compare the efficacy of these algorithms with those used by Doppler systems as more common sets of measurements are made.

Recurrence rate correlation

This approach to velocity estimation uses an L1V optical geometry. However, unlike Hirleman's approach, only the arrival rate statistics of the particle passing through a single beam are examined. This approach has been developed and reported by J. C. Erdmann and R. I. Gellert.[5,6] Basically the work of Erdmann and Gellert has shown that in systems with random distributions of particle positions, the recurrence rate autocorrelation function is equal to the velocity correlation function times a constant factor. Hence, by correlating only the arrival times of particles passing through a focused beam it is no longer necessary to perform pulse height analysis or to correlate transit times with either the L1V or L2V systems. Because the approach does not depend on pulse shape it is possible with this method to work with particles which are poor scatterers (i.e., very small sizes) and count photoelectrons as is done with L2V systems or with LDV systems employing photon counting correlators. Since in many applications involving turbulence the normalized turbulent velocity correlation function is the desired parameter, the multiplicative constant is not important, thus eliminating the need for careful measurement of a system calibration constant. It is my opinion that as correlation techniques become more common in velocimetry applications this method will find increasing acceptance and utilization. In fact, it seems reasonable to suggest that this method represents a possible cross-check of data obtained employing the more conventional LDV techniques.

Summary

The drive toward Doppler independent methods in laser velocimetry has arisen from a desire for optical simplicity or increased sensitivity to small aerosol particles. This has been accomplished by increased complexity in the mathematics required to understand data reduction and increased software capacity in the data acquisition system. The choice to use such approaches may be an entirely pragmatic one where a facility has considerable computer facilities, but little expertise or desire to use often complex optical systems. However, a word of caution about these techniques is in order. While in some cases these techniques are incredibly sophisticated, they are often based on mathematics which depend on statistical assumptions that may not be true in given applications, particularly where turbulent intensity is large. As these techniques acquire increasing use on a wide variety of applications and results are cross-checked by independent means, their boundaries and limitations can be more clearly defined, understood, and refined.

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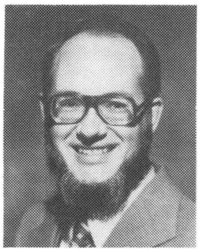
Optics Education



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INCREASING INTEREST IN EDUCATION IN OPTICS

On May 24, 1979, at the SPIE Electro-Optical Technical Symposium and Workshop, Huntsville, Alabama, there was a general session on "Education for the Electro-Optics Community." This session was particularly well attended and well received. A great deal of interest in optics education was shown by industrial, governmental, and academic personnel. A fruitful exchange of ideas occurred both through regular papers and through the panel discussion at the end of the session. Many ideas and views were discussed and all participants had an excellent opportunity to reflect on current needs and existing programs in optics education.

Partially as a result of this SPIE general session, a status report on optics education has been planned for the optics community as a whole. Specifically, the *IEEE Transactions on Education* has planned a special issue for May 1980 on the subject of "Optics Education." The purpose of this special issue is to explore the nature and extent of current educational programs in optics, primarily in the United States, to identify the need for individuals with training in optics, and to outline directions and areas of emphasis for future educational programs. The following topics will be included:

Descriptions of current programs.
Unique courses.
Optics laboratory courses.
Instructional techniques.
Optics technology programs.
Optics graduate production and job opportunities.

This special issue should be a very valuable resource to all people interested in optics education. Jack D. Gaskill, Professor at the Optical Sciences Center, University of Arizona, Tucson, Arizona, is serving as Guest Editor for this special issue.

The History of Optics

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THE INCEPTION OF MODERN OPTICS

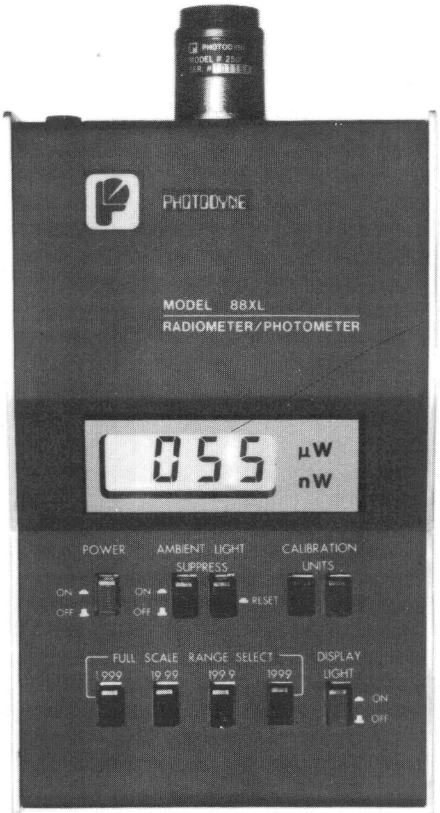
By the ninth century, towns such as Venice and Naples (later Pisa and Genoa as well) were carrying on trade throughout the eastern Mediterranean. The Crusades began at the end of the eleventh century. Marco Polo visited the Mogul Empire of Kublai Khan in the thirteenth century. These peripatetic adventures brought men into closer contact with their neighbors. At the same time, a renaissance of learning spread through Europe. These contacts enabled Europe to become aware of Arabian discoveries and those Hellenistic achievements maintained in their repository.

The study of optics was one of the dominant branches of science that prospered from the Renaissance. Some of this, it must be admitted, was based upon philosophical and metaphysical reasoning rather than on purely physical investigations. For instance, St. Augustine and other Neoplatonists regarded light as the illumination of the human intellect by divine truth.

One of the first to apply scientific methods to the study of optics was Robert Grosseteste (1168-1253), although many of his views were also based on metaphysical concepts. As an example, he regarded light as the first form to be created from corporeal matter. Optics, according to this view, was *the* fundamental science. Grosseteste did couple this philosophy by advocating the experimental method.

Another in this period to study optics was Witelo of Poland who experimentally determined new values for the angles of refraction of light passing between air, glass, and water. He probably noted that blue light is refracted less than the red, but if so he did not follow up on this observation. He also contributed a discussion on the psychology of vision that indicated remarkable insight. However, much of his writing reflected the work of Ibn al-Haitham.

Having greater originality than either of these two was Roger Bacon (1214-1292). He dissected vertebrate eyes and added knowledge to the understanding of optic nerves. He experimented with lenses to improve vision, but apparently with an imperfect understanding. At least he is attributed to claiming that Julius Caesar erected mirrors in Gaul to discern occurrences in England.



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Bacon believed that all branches of science are subordinate to theology, stating that knowledge consists of an inner sort which is of divine origin and a practical sort which is gained by observation and experiment. Together, he believed, they made up experience. His activity ranged throughout all aspects of science, prophesying mechanical transport on land and sea, aerial flight, and submarine exploration. In optics he made an attempt to revive Plato's concept of ocular beams, suggesting that something went forth from the eye when an object was viewed. Despite this, he stressed the importance of experiment, teaching that useful knowledge is gained only be elucidating the facts, rather than through unfounded speculation.

One of the better known figures in Renaissance science was Leonardo da Vinci (1452-1519). He was an illegitimate son and had no regular education. By some he is regarded as a disorderly and unsystematic thinker. However, his range of interest and his ability to observe made possible the numerous contributions associated with his life. He must have acquired some knowledge of the Greek philosophers and probably he also read some of Ibn al-Haitham's work.

Leonardo's interests were strongly artistic, which led into scientific studies. His anatomical observations were of an unsurpassed quality. Problems of perspective intrigued him, so he studied both geometrical and physical optics. He became acquainted with the structure of the eye and the function of its parts. He conceived of the eye as a form of *camera obscura*. Nevertheless, Leonardo's scientific achievements were minimal. His lack of scientific method robbed his ideas of any true fertility. He is remembered as a man of many interests and one of the keenest observers of nature of all times. His work provides us with insights into the great variety of problems under consideration by scientists at the end of the fifteenth century.

In addition to these scientific achievements, other important intellectual progress was being recorded as the Renaissance developed. Geoffrey Chaucer began the crystallization of the English language during the fourteenth century. The Black Death of the fourteenth century nearly depopulated Europe. In the aftermath a life-and-death struggle arose between capital and labor, resulting in an elevation of the stature of the peasant. About 1450, Johann Gensfleisch Gutenberg began printing with moveable type, and books soon became widely available., In 1492, Christopher Columbus, confident of Ptolemy's calculations of the size of the terrestrial globe and desirous of finding another route to the Cathay which Marco Polo had described, set forth across the Atlantic Ocean. William Shakespeare was born in 1564, the same year as Galileo. Man was searching for his place in the scheme of things and his intellectual curiosity was whetted. Several gifted thinkers began to make a significant impact on the various branches of science that helped to bring European culture out of the doldrums of the Dark Ages.

However, life at the close of the sixteenth century in Europe cannot be compared to what we today consider as civilized. The rulers of the day were governed by the ethics of the unconscienced, and the intellectuals and cultured were rarities. Religious bigotry and intolerance provided an incubator for further wars. The dispassionate pursuit of science was a hazardous enterprise.

Born into this atmosphere on 31 March 1596 at La Haye, near Tours, France, was a boy destined to make important contributions to optics and mathematics. Rene Descartes was the son of Joachim Descartes, a Councellor in the Parliament of Rennes. His mother died at his birth. The boy was raised luxuriously and he inherited a fair fortune. Thus, Descartes grew to manhood somewhat oblivious to the political inclemency of the time. He was imbued with a modern spirit, longing to taste life to the fullest.

In May 1617 he enlisted in the Army of Prince Maurice of Nassau, the Prince of Orange. However, the campaign in the Netherlands ceased temporarily, leaving Descartes

bored. He traveled to Frankfurt, where Ferdinand II was to be crowned. Enthused by the spectacle, Descartes again enlisted in an army, this time under the Elector of Bavaria.

While the army lay inactive in its winter quarters, Descartes found time for the tranquility and repose he sought. Then, on the evening of 10 November 1619 Descartes had three dreams which he says changed his life. In the first dream, Descartes was blown by evil winds from the security of his college toward a third party which the wind was powerless to budge. In the second, he found himself observing a terrific storm with the objective eye of a scientist, and noted that by doing so, the storm could do him no harm. In the third, he was reciting a poem which begins *Quod vitae secatabor iter?* (Which way of life shall I follow?). Out of these dreams, Descartes was filled with a lifetime enthusiasm to pursue science.

With this new zeal, he came to a realization that truth was to be found only after first rejecting all ideas acquired from others and to rely upon the patient questioning of his mind. By the spring of 1621, Descartes had had his fill with soldiering (although he did serve once more in later years). He sought for a quiet life in northern Europe. However, enroute by boat the crew plotted to slay their wealthy passenger, loot his belongings, and feed his body to the fish. Descartes, however, understood their language and thwarted their plan by brandishing his sword and compelling the would-be assassins to return him to shore.

Descartes arrived in Holland and spent a quiet year in developing his philosophy. We are familiar with his assurance of the thinking self, *cogito ergo sum* (I think, therefore I am). A year later he visited Italy, but failed to meet Galileo. Probably this can be attributed to Descartes's vanity. We can only conjecture on the contributions he might have made had he had the patience to exchange his views with the great philosopher.

Although Descartes enjoyed lady friends, and even had a daughter by one, he never married. Possibly, the cause (as he is credited with having said) was because he preferred truth to beauty.

Descartes is best known for his pioneering work in analytical geometry—we still plot equations by the use of Cartesian coordinates. However, his contributions to optics were also of importance. He was the first to explain the nature of the rainbow, showing that at a particular angle the light is directed toward the viewer. He also studied image formation by lenses and showed that an aspheric surface would be devoid of spherical aberration, but the technology of the time could not produce such a lens.

In these studies, Fresnel investigated the law of refraction. However, Willebrord Snell (1591-1626) had worked out the law in 1621. Snell, a mathematician at Leiden, appears to have been more interested in mathematical problems than in optical ones. He was engaged in determining the earth's radius by means of triangulation and may not have considered the

Descartes (1596-1650) during a walk in Amsterdam. (The Bettmann Archive, Inc.)

derivation of the law of refraction of great value. Moreover, he derived the law in terms of ratios of length, interpretable as a ratio of cosecants. It is a matter of conjecture as to whether Descartes knew of Snell's work. Certainly, Descartes was the first to express the law of refraction as a ratio of sines, having done so in 1637.

Descartes based his conclusions regarding the law of refraction on mechanical analogies. He considered light to consist of particles which were accelerated along the normal to the surface when entering a denser medium. The resulting increase in velocity led to the use of sines. Sometime later, a fellow countryman of Snell, Christiaan Huygens (1629-1687), proposed a wave theory of light in which the velocity would decrease in the denser medium. This led to the same law, but the technology of the seventeenth century could not resolve whether the velocity of light increased or decreased in the denser medium.

Huygens had access to Snell's notes and insisted that his countryman be given credit for having established the law of refraction. Apparently, there was some suspicion that Descartes had, indeed, plagarized Snell's discovery; the law is known today as Snell's law.

Descartes seemed to be uncertain about the nature of light, but he did make a statement which today seems somewhat prophetic. He suggested that light may be refracted by causes other than changes in the medium through which it was propagated, comparing this to the motion of a projectile. Did he thus anticipate Einstein by nearly 300 years in postulating that light rays would be bent when passing near a massive body such as the sun?

In 1646, Descartes was living in happy seclusion in Holland. He meditated, gardened, and carried on an extensive correspondence with the intellectuals of Europe. And he was content to continue this existence. But the peaceful life was not to continue. Queen Christine of Sweden had heard of him.

The Queen, then 19, was a wiry athlete who took to the rigors of the Swedish climate with enthusiasm. She could stay on the saddle of a horse for ten hours without once getting off. She regarded others who could not maintain her pace with cold contempt. With this physical domination, she sought also to achieve intellectual greatness. So she invited Descartes to her court. Had he had less of a streak of snobbery in him, Descartes would have refused.

Descartes not only longed for peace and tranquility, but his routine called for spending the morning in bed, where he wished to think. He recommended idleness as necessary to the production of good mental work. This was not what Descartes found in Sweden. Christine maintained that 5:00 a.m. was the proper time to study philosophy. At that time, in an icy library, Descartes began his lessons. That winter was regarded, even by the natives, as one of the coldest in memory.

Descartes tried to alleviate the pain of his early lectures by resting in the afternoon. However, Christine decided to establish a Swedish Academy of Sciences which would meet in the afternoons. During the winter, Descartes fell ill of inflammation of the lungs. Doctors recommended that he be bled. Descartes at first resisted, but finally consented. It did no good. Descartes died on 11 February 1650 at the age of 54.

We may consider that modern scientific enquiry dawned with Galileo, became inchoate with men such as Descartes, and bloomed in the seventeenth century.

The Business Side of Optics

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In this issue we again consider business strategy. This time we are happy to welcome Y. N. Chang to this column. Dr. Chang is the founder and president of the Business Strategy Institute, specializing in research, publication, seminars, and consultations in business strategy and general management. He is the author of *Business Policy and Strategy* and *Business Success through Strategy.* He obtained his Ph.D. from the University of Washington in 1954, served as strategic planning executive in several firms, taught at several universities in California, and is now a lecturer and consultant. This article was adapted from one appearing in *The Executive* (March 1978). We are appreciative of Dr. Chang and Executive Publications, Inc., for the privilege of using this material in this column.

TODAY'S SUCCESSFUL EXECUTIVE MUST DEVELOP A SOUND STRATEGY

Y. N. Chang

Strategy overview

Increasing business difficulties and future challenges are of deep concern to business executives. Difficulties arising from the economic uncertainty of inflation, energy shortages which heighten competition from within and abroad, and the high cost of capital caused by the limited sources of financing and high interest rates, challenge CEOs, presidents, general managers, entrepreneurs, and aspiring managers to manage their businesses for consistent performance.

A successful executive who has guided the company's early growth has no guarantee of continual success. A rapidly changing business climate can interrupt a continual growth; ill-conceived growth can lead to financial disasters. Indeed, complacency of one's initial success compounds the difficulty of managing growth.

Prudence and preparedness are the virtues of today's executives. Prudence alerts executives to the reality of business life—the vicious cycle that can propel a firm from growth to profit decline, to financial insolvency and bankruptcy. Preparedness enables executives to respond to the changing dynamics of external and internal forces that fundamentally redress opportunities. Business strategy nurtures both prudence and preparedness and thus assures a firm's continual growth.

A sound strategy defines a set of realistic and achievable business objectives, and commits resources and organized actions toward the solution of a firm's most crucial problems. Strategy thus identifies a company's posture toward growth, profit recovery, and large-scale turn-around, and attacks present and future problems simultaneously. Without solving present problems, there can be no future; without future prospective, the present is meaningless.

A fully applied business strategy galvanizes the energy of company management at all levels. It provides direction and focus to effort and results. It provides the substance for management action and the binding force of motivation.

Strategy aids management

Specifically, strategy making aids management in three areas. First, strategy provides management with a way of thinking, a sound mentality, and a positive attitude. Executives are conditioned to think intelligently and to act strategically. Management sets its sight on long-term gains rather than short-term expediencies, and relies on organized action rather than brute force.

Second, strategy offers executives a decision-making framework. It forces management to acquire a dual view of matching and calculation—the matching of one's internal strengths with corresponding opportunities, and the calculation of success and risk-taking limits. A strategy-minded management correctly deploys limited resources to maximize returns.

Third, strategy imposes a new style of management. The new style calls for new quality, the quality of an effective manager and the quality of a strategist. Executives who are impulsive in thinking, hasty in action, accustomed to one-man shows and inclined to overkill are managers of the past, when resources were spendable and the combined economic, social, and competitive forces were unmatched by today's complexity and severity. The knowledgeable executives know that the old method of developing and managing businesses are inadequate and outmoded. The rules are changing, so is the game.

Strategy is not well understood

Strategy has often been reduced to a cliche, widely used but poorly understood. In its broad sense, strategy making comprises the total process of planning (the setting of realistic objectives), formulation (the exploration of courses of action and the commitment of resources) and management (the execution and recycling of strategy). Any failure in this total process will affect the soundness of the strategy.

A total lack of strategy is fatal; ill-conceived strategy can be disastrous. And a strategy which lacks full execution and commitment, or is weak in its development, is self-deceiving. Bluntly stated, the inclusion of a strategic planning function in a company's organization chart and the development of a long-range plan are no guarantee for a sound strategy. The substance of the plan—its effectiveness in real competition and its contribution to a firm's consistent performance—is the only true test.

The apparent answer lies in a company's total effort in three areas: (1) the organization of the strategy-making function, (2) the formulation of sound strategies, and (3) the management and direction of strategic action.

Organization of strategy-making function

The organization of the strategy-making function in a business firm starts with the CEO/president. He is the single most important person in the development of sound strategy. His total commitment and participation are absolutely essential. A strategy-minded executive accepts the fact that strategy is his prime task, for he is responsible for his company's performance and its future well-being. He displays a dedication to the concept and strives to master the art. He recognizes the fact that a high degree of strategy-making ability is his trademark. That trademark distinguishes him from other officers of his firm and influences his advancement to higher positions of responsibility. He encourages his associates—his policy vice presidents, general managers, and line management—to practice strategic thinking, and makes sure that his organization rewards proven performance and penalizes those who rely on brute force (the misuse of resources) and short-sighted expediencies.

The CEO/president communicates with his Board of Directors in establishing the policies of the firm—its objectives, strategy, and resources development and utilization. He consults members of the Board on the changing dynamics of the external environment and the evaluation of ongoing strategies. Internally, he prudently selects his planning executive and considers him the next most important individual in strategy making.

The planning executive with a small staff provides the needed assistance, conducting analyses, overseeing the orderly proceeding of the process and generating company-wide enthusiasm toward advanced planning and strategic actions. The selection of the planning executive is based on professionalism, competency, and a demonstrated skill in handling staff assignments and obtaining organizational support. A planning executive who indulges in unnecessary paper work, is rigid in operation, and is unmindful of technical details, ignores the substance of strategy making. Likewise, a planning executive whose experience, disposition, and depth are not compatible with the CEO/president will not function well.

A strategy-minded CEO/president fully involves his executive committee on strategic matters. When properly managed, the committee can be very productive in consultation, information exchange, and stimulation of group thinking.

Line management plays a major role in both the formulation and execution of strategy. The general manager of operating divisions, in particular, has the responsibility of seeing that line management participation and support are secured.

Formulation of sound strategy

Strategic calculation is a test of one's experiential capacity, depth, and risk-taking ability. At best, calculation represents both a collective "gut feeling" and a reasoned judgment of what is possible and desirable.

Most writers subscribe to an itinerant process in formulating strategy. There can be five steps: (1) the analysis of the economic, social, industrial, technological factors that constitute the competitive environment within which a firm operates, (2) the internal appraisal involving the company's capacity (strengths and weaknesses) in management, and its component parts of marketing, finance, production and R&D, (3) the objective setting in defining the company's specific business objectives, (4) the exploration and testing of alternatives against resources availability, and (5) the preparation of a strategic plan.

The pitfalls of conventional planning are many, the most serious being the superficial treatment of opportunities, and threats, and the ambiguity between objectives and strategy. Both practices contribute to the faulty development of strategy; both testify to the lack of seriousness in methodology and of management participation and support.

Management of strategies

The last area of effort lies in management of strategies. A brilliantly conceived strategy could be an abstract idea if it incites no action; a fully developed strategy could be rendered ineffective if it lacks the capacity to adjust and recycle. Strategic management begins with the release of the company's strategies and functional strategies, and continues with tactical execution, control, and adjustment and response. The process permeates throughout the organization, involving managers at all levels and people in all units and posts.

Company management determines the firm's strategic posture—what precisely is the issue confronting the company: growth, stagnation, profit decline, or financial insolvency? The overall company strategy is thus formulated to attack the central issues of present and future importance. Central issues are those prime factors that either sustain or limit the firm's capacity to grow. In a technology-oriented company, for example, R&D-new product development, and financing are the two pressing issues. R&D-new product development is a long, costly high-risk process. Its effective management is central to the company's growth. Financing, however, is a restrictive factor, one that greatly limits the firm's ability to exploit its technical advantages. Research has shown that for a typical technological firm, "equity" investment of $2 to $3 million is minimum. Unless and until such central issues are identified and resolved, the firm will remain vulnerable.

To implement that company strategy and to incite tactical execution are the functional strategies and it should be the responsibility of the functional departments (marketing, finance, R&D, and production) to develop them. The functional strategy should deal with the decision areas of a function and should specify the deployment of its component forces to accomplish a given task. It also serves as a basis to direct departmental activities and as guidelines for tactical planning of a unit or an individual.

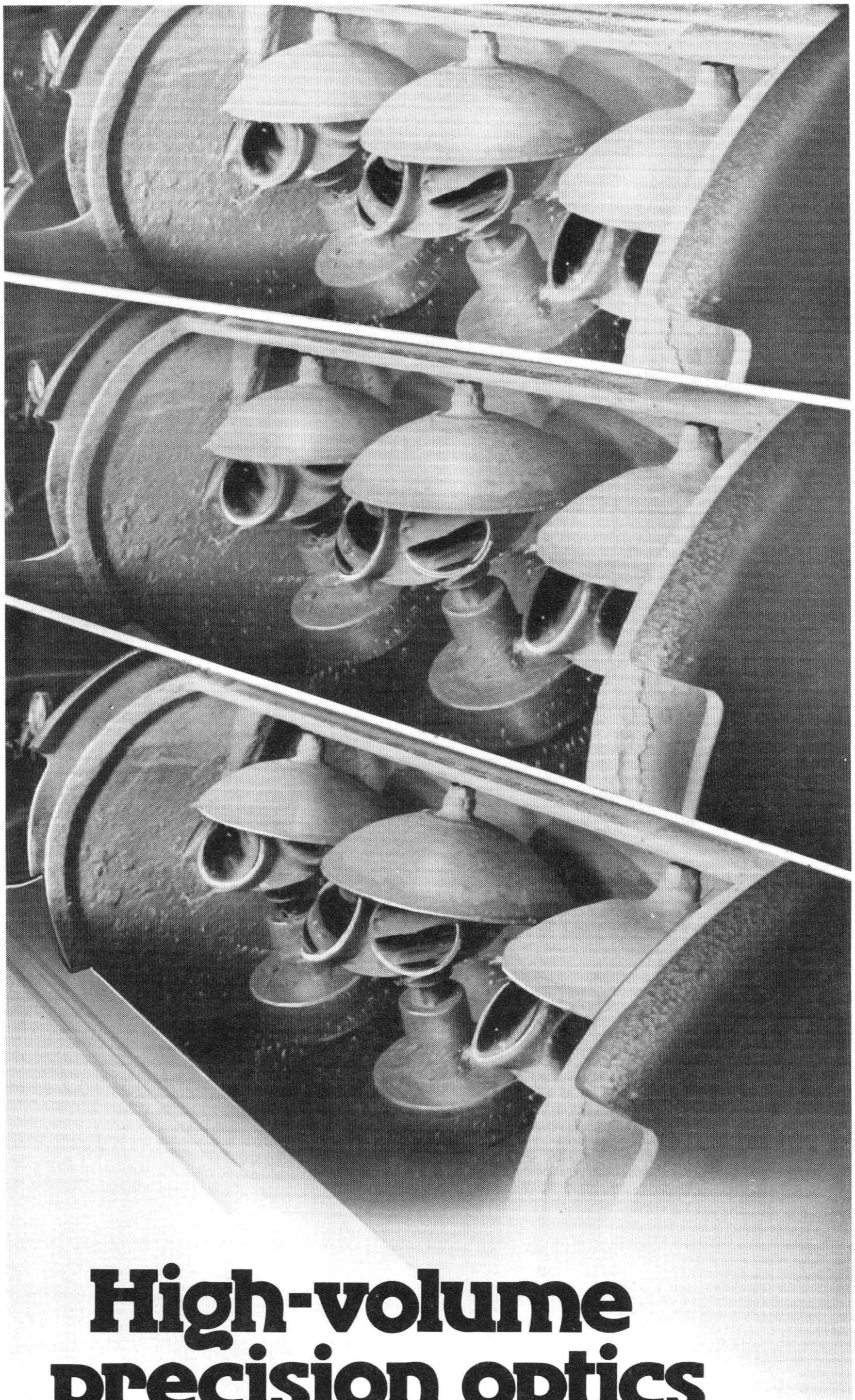
Tactical execution entails many activities—the management of an R&D project, the planning of a production run, a sales promotion campaign, or a profit improvement program. Unlike strategy which concentrates on resources and functions, tactics focus on people and action.

Strategic control of overall performance and management of adjustments and responses are essentials of strategic management. No firm can sustain its business without effective control of its internal operations.

Strategy is a dynamic process. It evolves gradually and becomes increasingly purposeful when the company moves along the basic direction that it chooses to pursue. It is continuously being updated by new information and fresh assumptions.

Summary

In summary, strategy is the game of CEO/president, general managers, entrepreneurs and all aspiring managers. The extent of the individual capacity decisively affects one's professional performance and advancement. Strategy applies to large and small, well-established and young firms. But business strategy holds special importance to small, young, and rapidly growing companies. It is simply because their resources are extremely limited, and their margin of error is significantly small.



Book Reviews

APPLIED OPTICS AND OPTICAL ENGINEERING, Vol. 7, Robert R. Shannon and James C. Wyant, Eds. 344 pp., illustrated, references, index. ISBN 0-12-408607-1. Academic Press, Inc., 111 Fifth Avenue, New York, NY 10003 (1979) $36.

Reviewed by A. Walther, Worcester Polytechnic Institute, Worcester, MA 01609.

The five volumes *Applied Optics and Optical Engineering*, edited by Rudolf Kingslake, have for the last ten years been a valued source of information for users as well as designers of optical instruments. It is, however, about 15 years ago that most of the articles in the series were written. Much has happened in optics since that time; this new volume, with updates as well as new material, is therefore very welcome.

Chapter 1, by J. E. Eby and R. E. Levin, describes the current state of the art in incoherent light sources: incandescent lamps, gaseous discharge lamps, photoflash lamps and light emitting diodes. In addition the chapter provides some useful information on the various ways in which sunlight can reach us. It should be required reading for engineers completely carried away with the use of lasers, in spite of its occasional lapses into incomprehensible jargon, such as, "For other systems where throughput (etendue) is satisfied, performance is proportional to source luminance" (Section I C, page 2).

Chapters 2, 3, and 4 deal with optical materials for lenses, mirrors, and prisms. Chapter 2, by Charles J. Parker, deals with refractive optical materials. It contains 20 pages of information about optical glass that make a perfect introduction to the reading of manufacturers' catalogs. The section on plastics is understandably brief, as the entire next chapter is devoted to the use of plastics. The short summary of infrared materials does not do justice to the subject, but readers needing this information would most likely consult the recent second edition of the *IRIA Infrared Handbook.*

Chapter 3 describes the possibilities of plastic optical components. Not having kept up with this branch of optical engineering, this reviewer was pleasantly surprised to see how useful the plastics have become. The author of this chapter, Brian Welham, should be commended for his forthright statements on the tolerances that mass-produced plastic lenses can meet.

The next chapter, by W. P. Barnes, Jr., gives a thoughtful analysis of the materials requirements for large mirrors, and then provides a detailed comparison of the various materials currently in use. A special section is devoted to lightweight structures. Particularly interesting are the interferograms accompanying this section.

The following two chapters are theoretical in nature. Chapter 5, by R. Shaw, deals with the theory underlying photographic detection. It discusses quantum efficiency, the theory of the H and D curve, the modulation transfer function, the noise spectrum, and various other concepts, but the material remains abstract and is never developed to the point that it can be used to make engineering decisions. The chapter seems to be out of place in a book otherwise devoted to optical engineering; the extensive bibliography will, however, be quite useful to those who are interested in pursuing the matter further.

Chapter 6, by H. Kogelnik, develops methods to calculate the propagation of laser beams. The first part of the chapter describes the matrix technique that has proved so useful in dealing with paraxial lens theory. It includes the treatment of the paraxial environment of a reference ray passing through a prism, but to this reviewer's surprise there is no mention of mirrors. The second part of this chapter shows how to apply the matrix technique to the calculation of the propagation of Gaussian beams through systems of lenses and prisms. The chapter ends with an all-too-brief survey of Fresnel diffraction, which does nevertheless serve the purpose of pointing the reader in the right direction if he needs a more precise treatment than that provided by the matrix methods. Fraunhofer diffraction is, however, not a special case of Fresnel diffraction (page 187).

Chapter 7 by J. M. Elson, H. E. Bennett, and J. M. Bennett deals with the singularly difficult problem of light scattering by surface imperfections. A rigorous solution of the mathematical problems involved is usually quite out of the question. The authors describe the various approximations that are commonly used: a geometrical description, scalar and vector propagation theories based on some form of the Kirchhoff assumption for the boundary values, particle scattering theory for surface contaminants, and numerical solutions to the boundary value problem. These methods are applied as they fit to a variety of surface irregularities: scratches, digs, microsurface structure, surface contaminants, as well as scattering from dielectric multilayers. Sample experimental results are provided for total integrated scattering as well as the angular scattering distribution. With so much material packed into a mere 50 pages it is easy to find fault with details; it seems, for instance, contradictory that the scatter goes with the square of the roughness but drops exponentially with the wavelength (page 192), and the first correlation function shown in Fig. 25 does not represent a wavy surface but is just a mathematical artifact. But these are indeed only details; the chapter contains a wealth of useful information and will be of great help to all who are confronted by surface scattering problems.

Finally, Chapter 8 by J. E. Pearson, R. H. Freeman, and H. C. Reynolds, Jr., describes the state of the art in adaptive optical techniques for the wavefront correction of imaging systems perturbed by atmospheric turbulence, thermal blooming, and other sources of phase error. This chapter is by far the longest in the book. It surveys techniques used for measuring the phase errors, the phase shifting elements that can be used to accomplish the correction, the systems considerations that must guide the designer, and various problem areas such as multiple glints, speckle modulation, and the lack of isoplanatism. Several references to 1978 papers indicate that this chapter is a really up-to-date summary of a rapidly moving field.

The editors state in the Foreword that this book is the first of a planned set of successor volumes. We congratulate the editors with this auspicious beginning of a new series, a series that could serve the optical engineering community as *Progress in Optics* has served those with a more theoretical inclination.

Book Reviews continued on SR-089

A HANDBOOK OF OPTICAL HOLOGRAPHY, H. J. Caulfield, Ed. 638 pp., illustrated, bibliography/references, index. ISBN 0-12-165350-1. Academic Press, Inc., 111 Fifth Avenue, New York, NY 10003 (1979) $55.

Reviewed by James C. Wyant, Optical Sciences Center, University of Arizona, Tucson, AZ 85721.

This book contains 39 separate articles by 30 authors, encompassing the field of holography. It begins with a historical review of holography by Emmitt Leith, and then travels through a chapter containing background material on physical optics, Fourier and communication theories, and silver halide photography. The middle chapters (3 through 7) contain the meat of basic holography with sections on classification and types of holograms, image formation, and cardinal points. The next two chapters cover Equipment and Procedures, and Special Problems (photographic handling, speckle, and hologram copying). The final chapter, approximately one third of the text, covers application areas of holography. The subjects covered in the last chapter are Digital Data Storage, Two-Dimensional Displays, Three-Dimensional Displays, Holographic Interferometry, Pattern and Character Recognitions, Image Processing, Microscopy, Optically Recorded Holographic Optical Elements, Spectroscopy, Holographic Contouring Methods, Multipet Image Generation, Particle Size Measurements, Holographic Portraiture, and Photogrammetry.

The articles are for the most part clearly written and self-contained; the book is well indexed and the table of contents well documented. These features make the volume useful as a handbook, for specific and limited topics can be accessed and studied without a great deal of time spent reading extraneous material. To increase the book's usefulness in this mode, a table of symbol definitions for each article or chapter would have been helpful.

The most exciting section of *AHOH* is the last chapter which contains an overview of holographic applications. These articles are an excellent introduction to current research interests, as well as past and current uses of holography. Chapter 10 might be useful to supplement a course in holography, or as an introduction to a particular holographic technique.

A criticism of *AHOH* might be that it is not truly encyclopedic in scope. For example, there is no section on computer-generated holograms. While the editor states "deliberately omitted to keep the size of the book within reasonable bounds are many important areas of nonoptical holography such as . . . computer holography," I feel the use of computer-generated holograms in such areas as interferometry and testing, and image processing, more than justify an article on this subject. If considerations of space are a problem, the review articles in Chapter 2 on physical optics, etc., could well be left to the many excellent textbooks in those fields.

Similarly, the authors of the section on recording media state "no book chapter can do justice to the broad scope and details of holographic recording media." Because of the central nature of the recording media to holography, a handbook might contain several chapters on this subject.

These are small criticisms, however. Overall, *AHOH* is a valuable reference to those working in holography, or those contemplating using holographic techniques.

PHOTOFERROELECTRICS, Springer Series in Solid State Sciences 9, Vladimir M. Fridkin. 174 pp., illustrated, bibliography/references, index. ISBN 0-387-09418-0. Springer-Verlag New York, 175 Fifth Avenue, New York, NY 10010 (1979) $32.50.

Reviewed by Ronald Goldner, Tufts University, Electrical Engineering Dept., Anderson Hall, Medford, MA 02155.

Professor Fridkin's monograph is a delightful book which should provide rewarding reading to graduate students and researchers who are especially interested in the physics, but also in the applications of ferroelectrics and pyroelectrics, materials whose day for an upsurge in applications might be near at hand.

Understanding how photoexcited electrons affect the behavior of ferroelectrics and pyroelectrics is the theme of this work. [The author defines photoferroelectrics as, " . . . crystals which change their ferroelectric properties (or properties connected with the spontaneous polarization in one way or another) when optically excited in the intrinsic or extrinsic region of the spectrum."] Some of the effects considered are: The Curie Point Shift; Changes in Spontaneous Polarization; Changes in Birefringence (Photorefractive Effect, or 'Optical Damage'); Changes in Spontaneous Deformation; Changes in Dielectric and Piezoelectric Properties; and Changes in Latent Heat and in the Heat Capacity Jump.

Much of the book focuses (although not exclusively) on Soviet research, which should be valuable to non-Soviet scientists.

There are eight chapters: the first four are devoted to fundamentals; the second four describe effects and alternative models.

Professor Fridkin has even-handedly presented the evidence and current proposed models of the anomalous photovoltaic effect and the photorefractive effect, both of which have recently aroused interest for holographic and optical storage applications. However, the engineer who needs empirical information regarding preparation conditions and comparisons of properties of various photoferroelectrics must seek other sources; nor is the bibliography focused on such information.

On the whole, this book provides a lucid treatment of the physical phenomena; it might serve as a catalyst for those interested in innovative applications for photoferroelectrics, e.g., in information acquisition, control, and processing.

There are a relatively large number of typographical errors (including the first equation of the book!), but all the errors found in the copy provided to this reviewer seemed to be self-evident.

HOLOGRAPHIC INTERFEROMETRY FROM THE SCOPE OF DEFORMATION ANALYSIS OF OPAQUE BODIES, W. Schumann and M. Dubas. 194 pp., 366 references, author and subject indexes. ISBN 0-387-09371-0. Springer-Verlag New York Heidelberg Berlin (1979) $32.50.

Reviewed by Jon E. Sollid, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545.

This trim and self-contained treatise sets the field in the conceptual framework of vector and tensor analysis. This is an intellectually satisfying approach. However, for the practicing engineer it may be a little like getting a gourmet seven-course dinner when all he wanted was a hamburger. While aesthetically pleasing, the treatment is mathematical rather than practical. It will provide food for thought for the research worker and gives an interesting unifying viewpoint. As an example, after reading this Schumann and Dubas work, it is apparent that third-order optical aberration theory can be presented in the conceptual framework and mathematical language of vector and tensor analysis. This can provide new physical insight. This may be a familiar and comfortable language for the specialized group of continuum mechanics for whom the book is primarily written, but will be very heavy going for those interested primarily in utilizing holographic interferometry as a measurement technique rather than a field of study in itself.

The level of scholarship and the care and attention to detail apparent in this work are very impressive. The authors have compiled an excellent list of 366 references and have presented the development of the application of holographic interferometry to the measurement of deformation in opaque bodies in a logical fashion. This is an excellent but highly specialized book, to be recommended primarily to research workers in the field of continuum mechanics or experimental mechanics. Others for whom differential geometry, differential operators, linear transformations, and projections are familiar ground will also gain some benefit from this high level text.

Calendar

Jun. 23-25. Thirty-Eighth Annual Device Research Conference, Cornell Univ., Ithaca, NY. Fred A. Blum, Conf. Chairman, Rockwell International, P.O. Box 4761, Anaheim CA 92803. 714/632-2584.

July 6-11. Inter. Congress on Glass XII, Albuquerque. American Ceramic Society, 65 Ceramic Dr., Columbus OH 43214.

July 15-17. Topical meeting on Coherent Laser Radar for Atmospheric Sensing, Aspen CO. OSA, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.

July 28-Aug. 1. SPIE 24th Annual Inter. Technical Symposium, San Diego. SPIE, Box 10, Bellingham WA 98225. 206/676-3290.

July 28-Aug. 8. First Inter. Workshop on Light Absorption by Aerosol Particles, Colorado State Univ., Fort Collins CO. Dr. Hermann E. Gerber, Co-Chairman, Ist IWLAAP, Atmospheric Physics Branch, Naval Research Laboratory, Washington, D.C. 20375.

Aug. 4-8. Optics in Four Dimensions, Ensenada, Mexico. Sponsored by ICO. M.A. Machado, CICESE, Applied Physics Dept., AP Postal 2732, Ensenada, B.C.N., Mexico.

Aug. 4-9. VIIth Inter. Conf. on Raman Spectroscopy, Ottawa. Ken Charbonneau, Exec. Secy., Conf. Services, Nat. Res. Council of Canada, Ottawa, Ontario, Canada K1A OR6.

Aug. 10-13. SPSE Inter. Conference on Photographic Papers, Hot Springs, VA. Robert H. Wood, SPSE, 1411 K. St. N.W., #930, Washington, D.C. 20005.

Aug. 27. Advances in Color Technology Symposium, American Chemical Society/Inter-Society Color Council, San Francisco. L. Lerner, Chairperson, Harmon Colors Corp., Box 419, Hawthorne NJ 07507.

Sep. 2-5. SPIE/ASP Thermal Infrared Sensing Applied to Energy Conservation in Building Envelopes (Thermosense III) workshop/conference, Minneapolis. SPIE, Box 10, Bellingham WA 98225. 206/676-3290.

Sep. 11-13. Internepcon/Semiconductor Inter. Exposition and Conf., Republic of Singapore. Industrial & Scientific Conf. Management, Inc., 222 W. Adams St., Chicago IL 60606.

Sep. 16-18. Wescon/80 Show & Convention, Anaheim. Electronic Conventions Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245.

Sep. 16-18. Sixth European Conf. on Optical Communication, Univ. of York, United Kingdom. Secretariat, Conf. Dept., The Institution of Electrical Engineers, Savoy Place, London WC2R OBL, United Kingdom.

Sep. 22-23. Workshop on Optical Fabrication and Testing (OF&T), North Falmouth, MA. Fee $90. OSA, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.

Sep. 23-25. European Conf. on Optical Systems & Applications, Utrecht, Netherlands. Exhibitor and delegate information: Royal Netherlands Industries Fair, Special Events Dept., P.O. Box 85000, 3503 RM Utrecht, The Netherlands.

Sep. 29-Oct. 3. SPIE Huntsville Electro-Optical Technical Symposium, Huntsville, AL. SPIE, Box 10, Bellingham WA 98225. 206/676-3290.

Oct. 6-9. Tenth Inter. Laser Radar Conf., Silver Spring, MD. Sponsored by the Univ. of Maryland and Goddard Space Flight Center of NASA. Conf. Secretariat, Tenth ILRC, c/o IPST, Univ. of Maryland, College Park MD 20742.

Oct. 7-9. SAMPE 12th National Technical Conf., Materials 1980, Seattle. Marge Smith, SAMPE, P.O. Box 613 Azusa CA 91702.

Oct. 13-17. OSA National Meeting, Chicago IL. OSA, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.

Oct. 14-16. Seventh Annual UMR/DNR Conf. on Energy, Rolla, MO. Dr. J. Derald Morgan, Conf. Director, 122 Electrical Engineering, Univ. of Missouri-Rolla, Rolla MO 65401.

Oct. 22-23. Sira Seminar on Aspheric Optics: Design, Manufacture, Testing, London. Sira Institute Ltd., South Hill, Chislehurst, Kent, BR7 5EH, England..

Oct. 28-30. 17th Annual Convention and DOD/AOC Electronic Warfare Symposium, Anaheim. Donald A. Lacer, Tech. Symposium Chairman, The Aerospace Corp., P.O. Box 92957, Los Angeles CA 90009, or Art Monahan, Conf. Chairman, 3270 Samantha Dr., Santa Ynez CA 93460.

Nov. 4-6. Midcon/80 Show and Convention, Dallas. Electronic Conventions, Inc., 999 N. Sepulveda Blvd., El Segundo CA 90245.

Nov. 10-12. Topical meeting on Spectroscopy in Support of Atmospheric Measurements, Sarasota, FL. Abstract deadline July 1, 1980. OSA, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.

Dec. 1-3. Topical meeting on Infrared Lasers, Lubock, TX. Abstract deadline Sep. 1, 1980. OSA, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.

Short Courses

Integrated Computer Systems courses

Microprocessors and Microcomputers: Comprehensive Introduction with Hands-on Workshops. Course 160, 4 days, $695. July 8-11, Los Angeles; July 15-18, Toronto; July 22-25, Minneapolis. **Troubleshooting Microprocessors, a Hands-on Course.** Course 142, 4 days, $795. July 8-11, Washington, D.C.; July 15-18, Minneapolis; July 22-25, Sunnyvale. **Interactive Computer Graphics** (Raster, Vector, and Color Techniques). Course 365, 4 days, $795. July 8-11, Denver. **Computer Communication Networks** (Packet Switching, Protocols, Design Techniques). Course 355, 4 days, $695. July 8-11, San Francisco. **Computer-Aided Design and Manufacturing** (Technology, Methodology, and Applications). Course 370, 4 days, $695. July 7-10, Washington, D.C.; July 14-17, Toronto; July 21-24, Los Angeles. **PASCAL Hands-on Workshop** (Programming in the Structured Language). Course 330, 4 days, $795. July 8-11, Montreal; July 22-25, Los Angeles. **Structured Programming** (Engineering and Real-Time Applications). Course 320, 4 days, $695. July 8-11, San Francisco; July 15-18, Denver; July 22-25, Washington, D.C. **Software /Hardware Project Management** (Systematic Approaches to Improving Productivity). Course 340, 4 days, $695. July 8-11, Los Angeles; July 15-18 Minneapolis. **Voice Input/Output for Computers** (New Dimensions in Man-Machine Communication). Course 430, 4 days, $795. July 8-11, Sunnyvale. **Digital Image Processing** (Industrial, Scientific, and Military Applications). Course 410, 4 days, $695. July 15-18, Los Angeles. **Digital Filters and Spectral Analysis** (State-of-the-art Techniques for Practical Applications). Course 412, 4 days, $695. July 8-11, Washington, D.C.; July 22-25, Los Angeles. Integrated Computer Systems, Inc., P.O. Box 5339, Santa Monica CA 90405. 213/450-2060.

Univ. of California short courses

Fiber-Optic Communication Systems, July 7-11, Santa Barbara. Topics include; opto-electronic sources (LEDs, injection lasers), optical fibers, photodetectors, receiver circuit design, repeaters, equalization, propagation characteristics, cabling, strength, connectors, data distribution, system analysis, measurements, applications, economics. **Detection of Infrared Radiation, July 21-25, Santa Barbara.** Topics include: detector physics, fabrication, performance and applications; photon and thermal detectors; direct and heterodyning modes; thermal imaging and charge-coupled devices; systems applications, detector circuit design; laboratory session for students to make measurements of D*, time constant, responsivity, Hall effect, etc. An applied short course. Dept. of Science and Management, Univ. of California Extension, Santa Barbara CA 93106.

Institute of Optics short courses

Contemporary Optics, July 7-18, Univ. of Rochester. $895. For physicists, engineers, and managers who are not specialists in optics. Topics in-