SMPTE Engineering Report

15th International Congress on High-Speed Photography and Photonics

By Lincoln L. Endelman

The 15th International Congress on High Speed Photography and Photonics was held August 21 to August 27, 1982 in San Diego, California, in conjunction with the SPIE 26th Technical Symposium. The Congress was co-sponsored by the Aeroballistic Range Association, American Society of Photogrammetry, Society of Motion Picture and Television Engineers, Society of Photographic Scientists and Engineers, and the Society of Photo-Optical Instrumentation Engineers.

The Society of Photo-Optical Instrumentation Engineers was responsible for the organization and arrangements for the Congress. It acted as the Secretariat and provided the staffing and facilities to put on the sessions and workshops. The Congress was very well attended and the papers were interesting and informative. Almost 600 people registered for the Congress and about 150 papers were read. About 205 papers will be printed in connection with the proceedings.

Several innovations were introduced in the 15th Congress. A secretariat was formed which handled all the correspondence, assigned the papers, and provided the personnel to make all the arrangements. This was a tremendous help in the smooth operation of the Congress. The SPIE will provide this secretariat on an ongoing basis to preserve the continuity from Congress to Congress and will serve as a central distribution point for information and correspondence on the Congresses.

Workshops

Eight workshops were held during the week, as described below.

High-Speed Videography

Instructor: Charles E. Miller, Massachusetts Institute of Technology

Brian J. Thompson, General Chairman of the Congress.

This workshop provided information on the latest developments in high-speed video systems. Representatives from several equipment manufacturers demonstrated the operation of various systems and discussed methods of utilizing high-speed videography to acquire data. The demonstration included video systems acquiring data at frame rates equivalent to ranges from 200 frames/sec to 10,000 frames/sec, in both color and black and white with digital and analog recording capabilities.

Rotating Prism and Intermittent Frame Cameras

Instructor: Robert D. Shoberg, Photonic Systems, Inc.

The workshop provided a hands-on opportunity to work with the latest type of camera equipment and accessories. The emphasis was on rotating prism and intermittent frame-type cameras. Several different types of cameras were explained, and experts in each one provided information and assistance in solving specific problems. Among the applications discussed were test range instrumentation, industrial usage for solving manufacturing problems, scientific investigations, and data acquisition.

Electronic Cameras

Instructor: Joseph H. Owren, Marco Scientific, Inc.

This workshop provided an opportunity to observe the various types of image-converter camera systems and discuss their applications. Experts in the field demonstrated the capabilities of the systems and explained how to determine the best equipment for each application. Several of the different modes of operation with these cameras include framing photography — acting as the equivalent of a still camera; standby framing — where the event triggers the camera; streak photography — determining movement along one axis including picosecond streak photography for temporal and spatial resolution of ultra-short-event phenomena; ballistic synchrophotography — recording a projectile moving across a slit; high speed radiography — photographing opaque regions including plasma or thin metal sheets; and other applications.

Mechanical Streak and Rotating Mirror Cameras

Instructor: Sidney J. Nebeker, Cordin Co.

The workshop provided information on camera systems utilizing rotating drums with film on the inner surface of the drum. The images are synchronized by use of a rotating mirror in conjunction with various optical elements. The system uses a 1-m-long piece of film providing rates from 1000 to 10,000 frames/sec. Other types of cameras discussed include a rotating mirror camera that can take 130 pictures at rates up to 25 million frames/sec, and streak-type cameras which can record changes in movement occurring in 2 nsec (10^{-9} sec). These camera systems are used by numerous laboratories and government research organizations for ballistic research, flame propagation studies, and similar applications.

Targets

Instructor: Austin L. Vick, White Sands Missile Range

This workshop provided an insight into various methods used to determine

A report received on January 10, 1983 from Lincoln L. Endelman, who was SMPTE Vice-President of Photonic Affairs for the 1980-81 term. Mr. Endelman is also a member of the Photo-Sonics Achievement Award Committee.

targets, fiducial markings, color bands, and other reference points for the purpose of correlation of test data. There were discussions of the methods and markings used to provide position, velocity, and rotational characteristics of various objects being photographed. Among applications discussed were the determination of earth movement and other unique tests by the Sandia Laboratories; test object evaluation and film selection, resolutions, RMS granularity, and modulation transfer by Eastman Kodak Co.; and other unique applications for special tests and data collection at some of the missile test ranges.

Lighting

Instructor: Dr. James D. Trolinger, Spectron Development Laboratories

This workshop discussed lighting techniques and equipment used to provide illumination for high-speed motion-picture cameras and video systems. Included was information on self-illuminating events, laser sources, holography, schlieren systems, and shadowgraphs. There also was a presentation of special requirements for infrared, ultraviolet, and x-ray photography. Special attention was paid to lighting techniques or explosive studies in order to provide information on the unusual requirements of this area.

Photosensitive Materials

Instructors: John Norris and John McDonough, Eastman Kodak Co.

This workshop provided information on the types of film available for instrumentation purposes. It included discussions on handling, storage, and processing techniques toward the best use of film under sometimes adverse light and environmental conditions. Unique applications and troubleshooting techniques were included among the topics.

"The Winning Shot," photograph by William G. Hyzer.

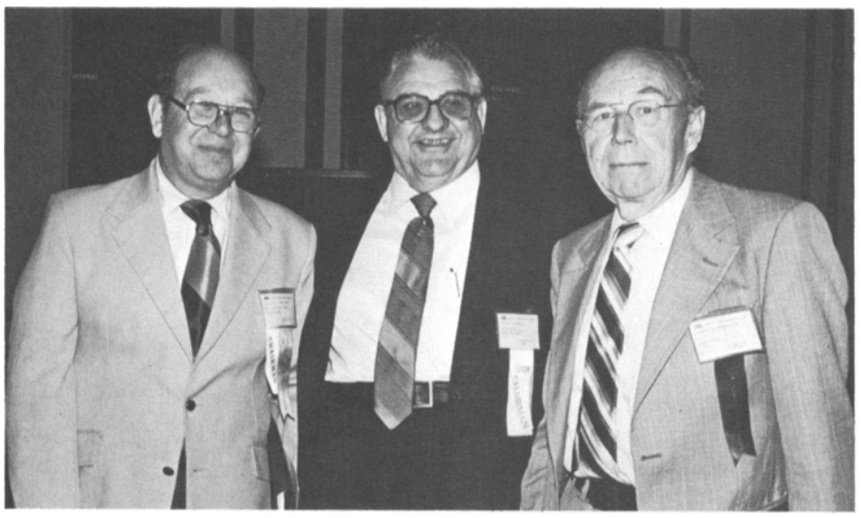
High Speed Cinematography and Videography for Biomechanics Research

Instructor: Juris Terauds, University of Alberta, Canada/Research Center for Sports, U.S.

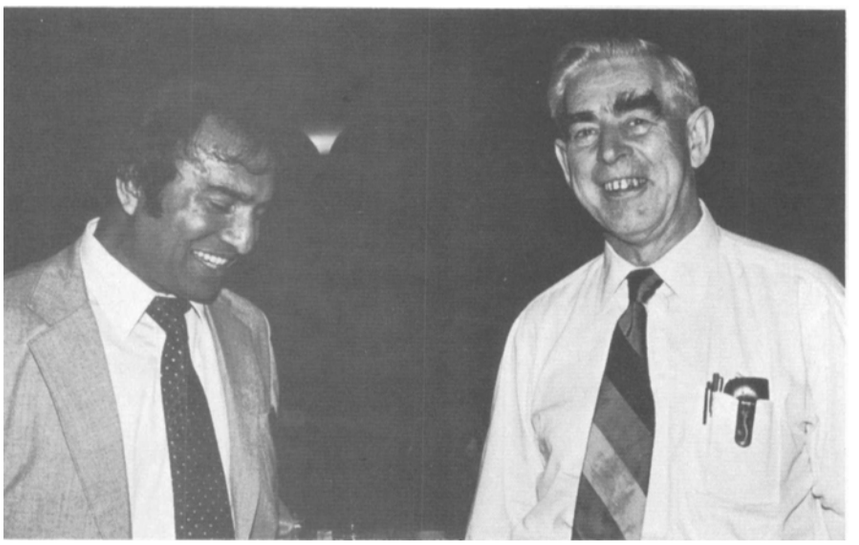
This workshop was directed primarily to people interested in research for movement analysis. Topics covered included applications for physics, engineering, sports and medical biomechanics, and similar fields of study. Those attending were given the opportunity to observe how high-speed cinematography, still photography, and videography are used to provide information and data for movement analysis. Demonstrations and discussions were held on the accessories, procedures, and equipment for generating software and data display. The workshop covered the field of biomechanics from the planning for data acquisition requirements through data analysis, interpretation, and evaluation.

There were several dozen entries in the high-speed photo contest. This is the first time such a contest and exhibit combined were part of a High Speed Congress. The winner was William G. Hyzer for his picture, "The Winning Shot." Hyzer described the high-speed photography which was able to show a head-on view of a 38-caliber bullet leaving the muzzle of a pistol. He photographed the bullet moving about 1000 ft/sec with a Hasselblad camera at an exposure time of 10 μsec (10/1,000,000 sec) using electronic flash illumination. The micro-flash was triggered automatically as the bullet emerged from the 4-in. curtain of smoke in front of the muzzle. To avoid hitting the camera (or the photographer) the pistol was fired into mirrors, which were sacrificed for each shot. The original picture was in full color. A black and white version of the

Photographs by Elizabeth Sisco.



(L to R) Lincoln Endelman, Robert Shoberg, and Dr. Harold Edgerton at the meeting.



(L to R) M. M. Chaudhri and J. S. Courtney-Pratt.

picture has appeared on the cover of *Science News* magazine, and a full-color version was published on the cover of *Photomethods* magazine.

Papers Presented

There were 11 invited papers presented by many well-known personalities in the Instrumentation and High-Speed Photography fields. The papers are described below.

Advances in High-Speed Photography 1972–1982

J. S. Courtney-Pratt, Bell Laboratories, U.S.

The paper discussed the increase in the variety, range, and precision of methods for photographic recording of high-speed phenomena. The author pointed out that at the lower speed ranges, the advances have been primarily resolution improvements. At the higher end, there has been an increase in dynamic range, understanding, and acceptance of the new electronic cameras with the imaging tube as the display and recording sensor.

Current and Future Activities in High-Speed Photography/ Photonics

H. F. Swift, Physics Applications Inc., Dayton, Ohio, U.S.

Mr. Swift pointed out the developments in high-speed systems now using video as the recording equipment. There are color systems up to 400 frames/sec and black and white systems that are now capable of rates up to 2000 full frames/sec and up to 12,000 partial frames/sec. Mr. Swift mentioned the use of microprocessors and light-emitting diodes to print accurate information on each frame. This printout would provide the analysts with a more complete data base and assist in manual and automatic data reduction techniques. The other points he mentioned were simplifying ultra-high-speed cine and streak camera setup and operation controls, increasing the optical efficiency of the systems, and employing microprocessor technology to improve the data acquisition capability. These cameras operate in the speed ranges below one-nsec time resolution. The trend is toward improving their optical performance and light-gathering capabilities. Mr. Swift's closing remarks included a challenge to the field to develop systems that could essentially be automatic in their operation. Sensors could acquire and analyze data to control the camera automatically for proper exposure, vary auxiliary lighting, focus the lens, determine event and operating times, and achieve other parameters.

Synchronous Streak Camera Systems

W. Sibbett, Blackett Laboratory, Imperial College, England

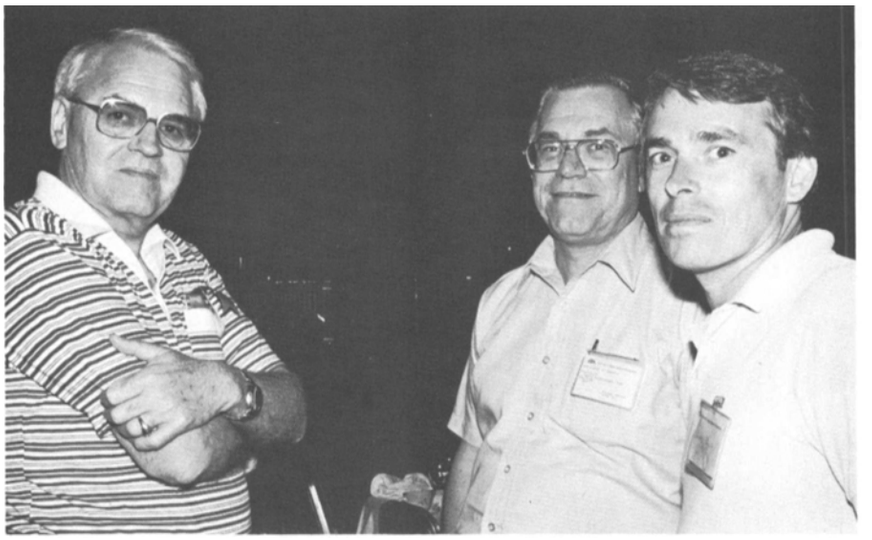
Mr. Sibbett described how during the past decade there have been extensive developments of mode-locked continuous wave lasers. To exploit the applicability of the ultra-short pulses generated by these lasers to time-resolved spectroscopic studies in research areas within photophysics, photochemistry, photobiology, etc., it is necessary to use diagnostics which have linear response and picosecond or subpicosecond resolution over a wide spectral range. These requirements are best satisfied by streak cameras which are repetitively operated in synchronism with the repetition frequency of the pulses from the mode-locked cw lasers. The assorted general principles of operation and the salient features of high sensitivity, large dynamic range, and low jitter were reviewed and results presented to demonstrate that a time resolution ~1 ps can be achieved. Further developments that are aimed at improving the temporal resolution over an extended spectral region were outlined, and some practical applications, which illustrate the unique capabilities and advantages of the synchronously operating streak cameras, were mentioned.

Picosecond Chronoscopy of Mode-Locked Semiconductor Diode Lasers and Applications to Ultra-Rapid Communications and Data Processing

D. J. Bradley, Trinity College, Ireland

Professor Bradley discussed the mode-locked semiconductor diode laser as a source of psec pulses using continuous trains of bandwidth-limited pulses of peak powers ~1 W that can be obtained readily for applications of gigabit (Gbit) to terrabit (Tbit) communications and data processing systems, based upon electro-optical and non-linear optical interactions. The synchronously driven streak camera operating in real time with resolution of <5 psec has been developed by Professor Bradley for detailed studies

Professor Tsuneyoshi Uyemura.



(L to R) William Hyzer, Hallock Swift, and Dennis Paisley.

of the transient behavior of the semiconductor diode laser. For example, the modulation frequency (~400 MHz) has to be maintained stable to <10 kHz. (Autocorrelation temporal measurements do not reveal the presence of low-level background noise.)

The streak camera system is being employed for the study of optical bistability in a double-diode external cavity semiconductor laser system, and the latest results will be reported. Such a system has exciting possibilities for optical logic and data processing particularly when the double diode laser is mode locked. Other applications discussed include micro-radar, psec phase conjugation, and ring laser systems.

Recent Developments in High-Speed Photography in Japan and China

Tsuneyoshi Uyemura, University of Tokyo, Japan

Professor Uyemura described the continuing work on various high-speed projects that are being conducted in Japanese universities and Chinese laboratories. He described several new camera systems that have been developed and some others that are now being used in special study programs.

High-Speed Photomicrography

William G. Hyzer, Consultant in Engineering and Applied Science, U.S.

Mr. Hyzer said that one of the most challenging applications of high-speed photography and videography in the plant and laboratory is the recording of rapid events at macro- and microscopic scales. Depth of field, exposure efficiency, working distance, and required exposure time are all reduced as optical magnification is increased, which severely taxes the skill and ingenuity of workers in recording any fast-moving phenomena through the microscope or with magnifying lenses. He discussed the problems inherent in photographing within macro- and microscopic ranges, and a systematic approach to optimizing the selection of equipment and choice of applicable techniques.

Videography Developments

C. E. Miller, Massachusetts Institute of Technology, U.S.

Mr. Miller discussed the trend toward simpler, less expensive videography systems in those applications wherein their modest frame-rate capability will suffice. Mechanically shuttered color cameras and electronically amplified and shuttered black-and-white cameras provide excellent results with off-the-shelf CCTC components at low cost. The capabilities of the most sophisticated systems continue to expand, making them truly quantitative measuring instruments. Extraction of x-y data is simplified and automatically fed to a computer for processing. Software for short-range photogrammetry is being developed. The performance of film and video systems was compared and a case made for the development of a videography system having approximately 720-frame/sec capability.

High-Speed Photography in the Federal Republic of Germany

M. Hugenschmidt, Deutsch-Französisches Forschungsinstitut Saint-Louis, West Germany

Dr. Hugenschmidt discussed the high-speed photographic and cinematographic recordings in various spectral ranges used to provide outstanding experimental techniques for the investigation of rapid transient phenomena. Numerous applications in the fields of scientific research and technical engineering were commented on. Higher temporal and spatial resolutions, both classical optical systems, have been improved, and new recording methods have been developed.

Various types of high-speed cameras are used in conjunction with novel short-duration light sources. These include sparks with rise times below one ns or monochromatic pulse trains originating from laser diodes, and multiple streak techniques developed to yield information on wave expansion in strongly self-luminous phenomena in detonics. High-speed electro-optical shutters combined with microchannel

(L to R) Dr. M. Hugenschmidt and Michel André.

plates are in use for the investigation of lower intensity self-illuminated processes.

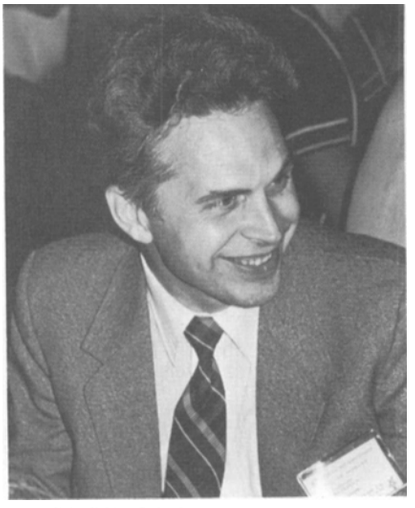
One of the most powerful tools is the laser. Using solid-state lasers, gas lasers and dye lasers, classical optical techniques have been applied as well as holographic or speckle-photographic methods. New switching techniques for Nd:YAG lasers provide reproducible pulse trains. Due to their tunability, dye lasers are most suitable for spectroscopic applications. The shortest pulses in the sub-psec range still need mode-locked systems. Subnsec pulses have been generated reliably by transversely excited Blumlein-type gas lasers. With single channel lasers, repetition rates up to 10 kHz (with multichannel systems up to the GHz range) were achieved. The wavelengths of these pulses can easily be changed by the use of dyes throughout the visible and near-infrared spectral range.

Recent investigations of electrical-pulse power systems, such as pseudo-sparks or plasma focus devices, reveal some interesting features. These systems provide not only intense short-duration light pulses but also considerable x-ray emissions and particle fluxes of high energies. Applications to high-speed photography and photonics can therefore be expected in the near future.

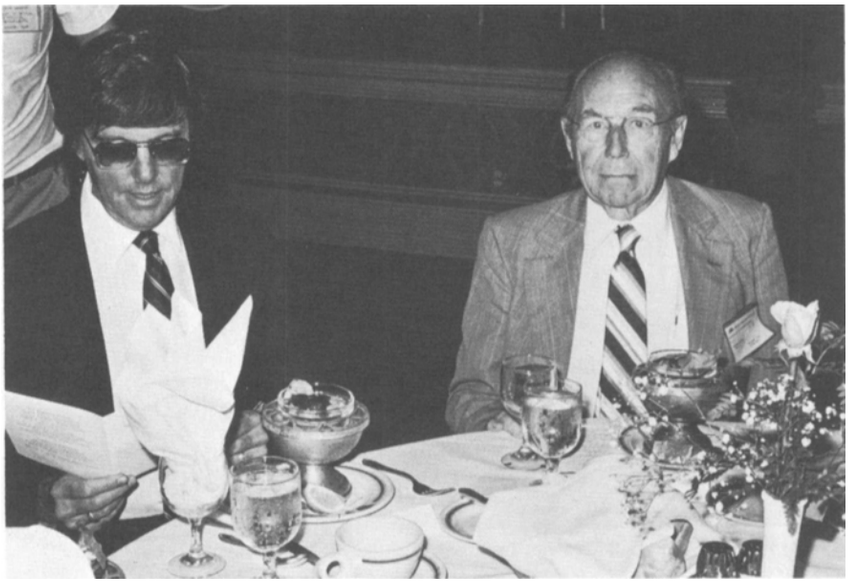
The Nature of Kirlian Photography

Thelma Moss, The Prism Center, U.S.

Dr. Moss provided an insight into electrical (or Kirlian) photography. This technique has been a source of controversy and curiosity for some 50 years, giving rise to questions like, "What are those mysterious emanations? Why does electricity make a complete photograph of organic and inorganic objects? How can one explain the 'phantom leaf effect?' "



Dr. Mikhail Ya. Schelev.



(L to R) Dr. James A. Dunne and Dr. Harold Edgerton at the banquet.

Alternative hypotheses were explored. A series of slides, showing possible applications of this photography to agriculture, medicine, and biology were presented. The skeptical audience could not help but find interest in the photographs, which showed missing parts of leaves and flowers. There were many examples of the auras which seem to surround living things. The conclusion of the presentation left most of the audience still uncertain as to the origin of the emanations.

Exposure Time Can Be Important

Dr. Harold Edgerton, Massachusetts Institute of Technology, U.S.

Dr. Edgerton discussed the rapid acceptance of electronic flash sources of light for photography. In the past few years this has revolutionized thought on many types of photography. He discussed the important factor of exposure time (flash duration) and its effects upon "blur" of typical image subjects. Some of the factors influencing the flash duration of electronic lamps were also covered. He presented an excellent series of hummingbird photographs that were taken all over the world. His pictures showed unusual varieties in different positions. The photographs demonstrated the ability of the stroboscope-light to stop the hummingbird's rapid wing movements.

New Trends in Picosecond Photonics

M. Ya. Schelev, P.N. Lebedev Physical Institute of the USSR Academy of Sciences, USSR

Dr. Schelev discussed the current topical problems connected with further developments of image-converted streak tube diagnostics aimed at overcoming the 1-psec temporal resolution limit. In this connection some approaches in streak tube design were treated, and some evidence of 0.1 psec temporal resolution was given for laser radiation recording in streak mode.

Lasers capable of generating sub-psec radiation pulses were mentioned, as well as various means for ultra-short x-ray pulse generation. One conclusion is the necessity of designing a psec electron-optical measuring system (EOMS) rather than streak cameras alone. Such measuring systems include up-to-date streak tubes and cameras as well as modern readout devices and psec lasers. The systems provide temporal analysis of transient events with sub-psec temporal resolution, conversion of the recorded images into digital information, and storage of such information in frame memory with following image processing and display.

Some examples of applications of the developed EOMS in laser experiments were presented. The results confirmed the efficiency and versatility of such systems in experimental diagnostics.

Technical Sessions

Eleven technical sessions met.

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Session 1: Millisecond to Microsecond Applications

Robert Shoberg of Photonic Systems, Inc., U.S., was Chairman; Donald Clayton, Photographic Analysis Ltd., Canada, was one Assistant Chairman, and Professor Hou Xun of China, the other Assistant Chairman. Eighteen papers were presented in this session.

Session 2: Picosecond to Femtosecond and Beyond Applications

The scheduled Chairman was Martin Richardson, University of Rochester, U.S. Professor Richardson was unable to attend, however, and Professor D. J. Bradley, University of Dublin, Ireland, acted as Chairman instead. Assisting him in this all-day session were Alex Huston, Hadland Electronics, United Kingdom; Mikhail Ya. Schelev, P. N. Lebedev Physical Institute, USSR; and Serge Prohoroff, Université Libre de Bruxelles, Belgium. Thirty-five papers were presented in this session.

Session 3: Video Techniques and Applications

Chairman Robert Jaynes, Video Logic Corporation, U.S., was assisted by Avner Erez, Ministry of Defense, Israel. There were six papers presented during this session.

Session 4: Microsecond to Nanosecond Applications

The Chairman was John M. Dewey, University of Victoria, Canada, who was assisted by Dr. M. Hugenschmidt, German-French Research Institute Saint-Louis, Federal Republic of Germany; Professor Tsuneyoshi Uyemura, Tokyo University, Japan. This session had a large number of papers (23) and evoked a great deal of interest.

Session 5: Light Sources and Lighting

The Chairman was Thomas M. Lemons, TLA-Lighting Consultants, Inc., U.S. Mr. Lemons was assisted by Professor Sung Soo Lee, Advanced Institute of Science and Technology, Korea. There were five papers presented in this session.

Session 6: Holographic Techniques and Applications

The Chairman was Emmett N. Leith, University of Michigan, U.S., assisted by George Lunn (ret.), formerly with the Atomic Weapons Research Establishment, United Kingdom. There were 13 papers presented in this session.

Session 7: Ultraviolet, Infrared, and X-Ray Applications

The Chairman, François Charbonnier, Hewlett-Packard Corp., U.S., was assisted by Jacques Marilleau, Commissariat à l'Energie Atomique, France, and Michel L. André, Association National pour la Recherche Technique, France. Fifteen papers were presented in this session.

Session 8: Image Enhancement Techniques

The Chairman was Professor Ernest M. Hall, University of Tennessee, U.S., assisted by Harrold Biram, John Hadland, Ltd., Australia. There were four papers presented in this session.

Session 9: Medical, Educational, Legal, Sports Applications

Chairman Allan H. Gott, The Aerospace Corp., was assisted by Karl N. Lochar, Interstaatlich Ingenieurschule Neu-Technikum, Switzerland. There were nine papers presented.

Session 10: Characteristics of Conventional and Unconventional Photosensitive Materials

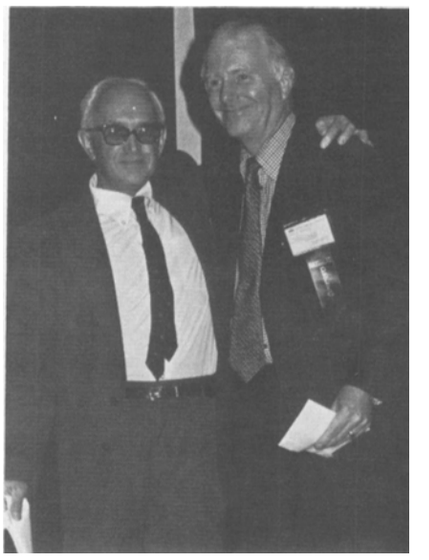
The session was chaired by Sheldon Phillips, Eastman Kodak Co., U.S., assisted by M. M. Chaudhri, University of Cambridge, United Kingdom. There were three papers in this session.

Session 11: Data Analysis and Techniques

The Chairman was David Stern, Northrup Corporation, U.S., assisted by Professor Tung-Cheng Chung, Shan Institute of Science and Technology, Lung-Tan, China. Eleven papers were presented at this session.

A National Delegates Meeting was held during the Congress. The delegates discussed the continuation of the secretariat and approved the SPIE's acting in that capacity for the next Congress which is to be held in Strasbourg, France, in 1984. The 1986 Congress was requested to be held in South Africa. Preliminary approval was approved at the meeting.

An extensive equipment exhibit was combined with the SPIE Symposium and was very well attended. There were 150 exhibitors and about one-third of those were specially for the International Congress. Several social events and get-togethers were held, including an outing to the San Diego Wild Animal Park and a trip to the Big Oak Ranch, a replica of an 1880 California Western Town.



(L to R) George Lunn and Alex Huston.

The final event was the Awards Banquet held at the Hotel del Coronado. The Navy Band played for the group and gave an excellent performance. Speakers for the evening included Professor Karl Vollrath, who spoke on "The Life and Work of Hubert Schardin."

The featured speaker was James A. Dunne, Manager of International Initiatives, Office of Strategic Planning at the Jet Propulsion Laboratory operated for NASA by the California Institute of Technology. Dr. Dunne traced the evolution of the techniques used in deep space imaging experiments during the past 20 years. He showed the results from the early missions through the latest fly-bys of the planets. The photographs of the Moon, Mercury, Venus, Mars, Jupiter, and Saturn gave breathtaking detail and beautiful color representation. Dr. Dunne described the spacecraft and the equipment which gathered the information for the evaluation by the NASA scientists.

The Awards Ceremonies concluded the evening's program. Dr. Harold Edgerton, U.S., presented the Schardin Medal to Noel Fleurot of France for his work on picosecond image tubes. George Lunn from the United Kingdom presented the Coleman Award to Alex Huston of the United Kingdom; and Richard Wollensak, President of the SPIE, presented the Gold Medal of the SPIE to Dr. Harold Edgerton.