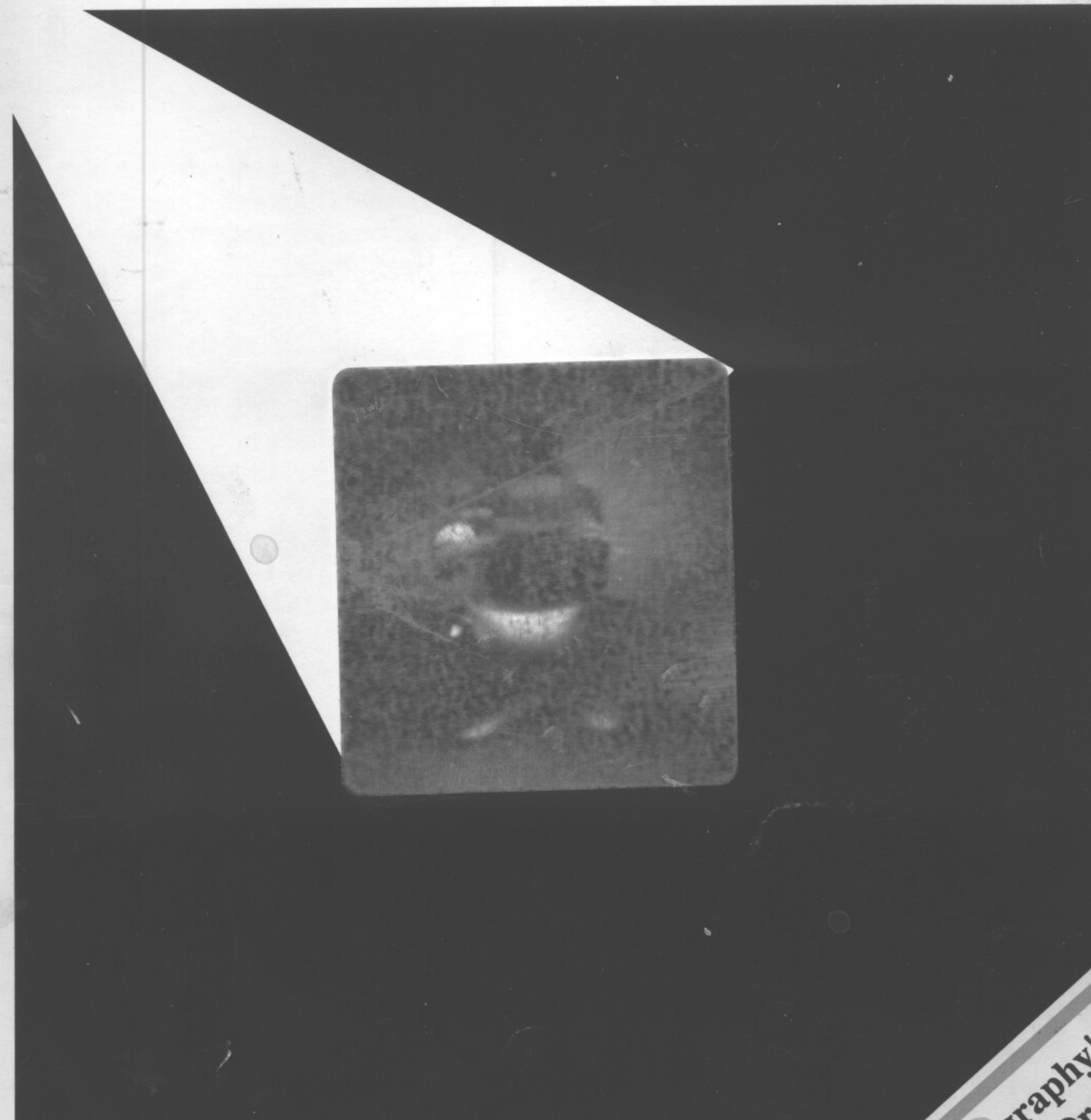
1990-91 directory issue

midwest engineer

News Magazine of the Western Society of Engineers



Holography's Field of Dreams

midwest engineer

Vol. 43, No. 1 1990-91

Nils Pedersen .... Editor
David S. Clark .... Business Mgr.
Y. Eugene Yamamoto .... Chairman, Publication Committee

SOCIETY OFFICERS

Y. Eugene Yamamoto .... President
Donald L. Lane .... 1st Vice President
Norman Weber .... 2nd Vice President and Asst. Secretary
F. D. Hurd .... Treasurer
David S. Clark .... Executive Director

TRUSTEES

Frank J. Breitsameter .... Jon Hagstrom
Joseph C. Broz .... John N. LaPlante
Linda C. Byus .... Walter D. Linzing
Raymond J. Criddle .... Darsey J. Moore
Donald E. Eckmann .... Steven J. Parrish
Frederick J. Emmett, Jr. .... Cordell Reed

PAST PRESIDENTS

Joseph F. Luby .... Lawrence W. Johnson

SUSTAINING COMPANY MEMBERS AND THEIR REPRESENTATIVES

Alvord, Burdick & Howson
William H. Richaradson

AT&T
Michael D. Windle

CBI Industries
Jon Hagstrom

Commonwealth Edison Company
William H. Dunbar, Jr.

DeLeuw, Cather & Company
Gene M. Randich

Fluor Daniel
Ronald L. Green

General Electric Company
Charles Castine

Harza Engineering Co.
David R. Baier

HDR Engineering Inc.
Walter D. Linzing

IBM Corp.
Rishi Madabusi

Illinois Bell Telephone Company
Joseph F. Luby

Lester B. Knight & Associates
Charles G. Rummel

MIDCON CORP.
John L. Pelletier

Motorola, Inc.
Larry Puhl

Northern Telecom Inc.
William N. Kashul

Packer Engineering Associates, Inc.
Donald H. Sandell

Sargent & Lundy
William A. Chittenden

United Engineers & Constructors
William T. Comerford

STS Consultants, Ltd.
John P. Gnaedinger

Westinghouse Electric Corporation
Donald L. Lane

MIDWEST ENGINEER (ISSN-0026-3370) is published monthly except June, July and August by the Western Society of Engineers at 176 W. Adams St., Chicago, Il 60603. Second Class Postage Paid at Chicago, Ill. Postmaster: Send address changes to address above. Telephone 372-3760. Single copy, $3.75, annual Directory, $10.00; annual subscription, $15.00. including annual Directory; foreign subscription, $20.00. The Society does not assume responsibility for products, statements and opinions in articles, papers, and discussions appearing herein.

the cover

The embossed hologram on the cover was created by The Lasersmith, Inc. By moving it in the light at the correct angle, the ball appears to be in front of the mitt. For the best results, avoid flourescent light. Use sunlight or strong single filament bulb greater than 100 watts. **See cover story on pages 60-71.**

in this issue

A message from W.S.E. President Y. Eugene Yamamoto 3
W.S.E. Officers 4
W.S.E. Trustees 5
W.S.E. Past Presidents 6
W.S.E. Honorary Members 7
W.S.E. Life Members 8
W.S.E. Sustaining Company Members 9
W.S.E. Awards 10-13
W.S.E. Headquarters Staff and Executive Directors 13
W.S.E. 1990-91 Committees 14-16
W.S.E.1990-91 Divisions 17-19
Membership Application 20
W.S.E. Constitution 21-26
W.S.E. Membership Directory Section .... section pages 1-19
W.S.E. Business Affiliation of Members .... section pages 20-24
Chicago Area Engineering Societies 51
Midwest Engineering Schools 52-53
Review of W.S.E. 1989-90 Programs 54-58
Cover Feature-Holography 60-71
Midwest Engineer Index-1989-90, compiled by John Moore 72-73
Professional Directory 74-75
Advertising Index 76

cover story

holography grows up, engineers put it to use

Business, Industry, Research, Arts increase their participation in this field

Holography is becoming an important engineering tool as well as a potential force in architecture, electronics, medicine, computer science, advertising, physics, manufacturing and the arts.

Some of the world's best holographic work is going on in the greater Chicago area, which is home to the largest number of working holographers in the country.

Once thought of as just a way to produce interesting and dramatic three-dimensional (solid) images for viewing entertainment, it has evolved into a multi-faceted phenomenon.

A hologram is a thin sheet of material, which when lighted properly, projects a three-dimensional picture which appears to be many inches or feet inside the hologram or floating in air several inches or feet in front of it or both.

Holography is derived from the word elements holo (whole or entire) from the Greek holos and graph (drawn or written) from the Greek graphos. It was discovered in 1947 by Hungarian-born Dennis Gabor who presented it in 1948 and was awarded a Nobel prize for it in 1971. He devised the concept while trying to improve the electron microscope.

Nothing much was done with it until 1960 when the Laser was introduced. The laser provided the light coherence needed to make a hologram. Light waves have peaks (crests) and valleys (troughs). Lasers keep these peaks and valleys marching in step. In holography opposing peaks cancel each other out while compatible ones reinforce each other. You need lasers to produce holograms, but you don't need them to display images from the holograms.

In 1963, two University of Michigan researchers, Emmet N. Leith and Juris Upatnieks used the laser to bring holography into practical use.

A hologram is made by aiming a laser beam at a beam-splitter mirror. One split beam heads for the object, bounces off and hits the film or emulsion-coated plate. The other, called the reference beam, is expanded by another mirror and goes around the object to the plate. The two beams interfere causing an interference pattern on the film which when developed becomes a hologram. The reference beam (laser or other type) is then used to illuminate the hologram which produces the image. This system can be expanded with additional lasers, mirrors and various materials to enhance the results. Multiple exposures can be used on one hologram for various effects such as movement or changes of expression.

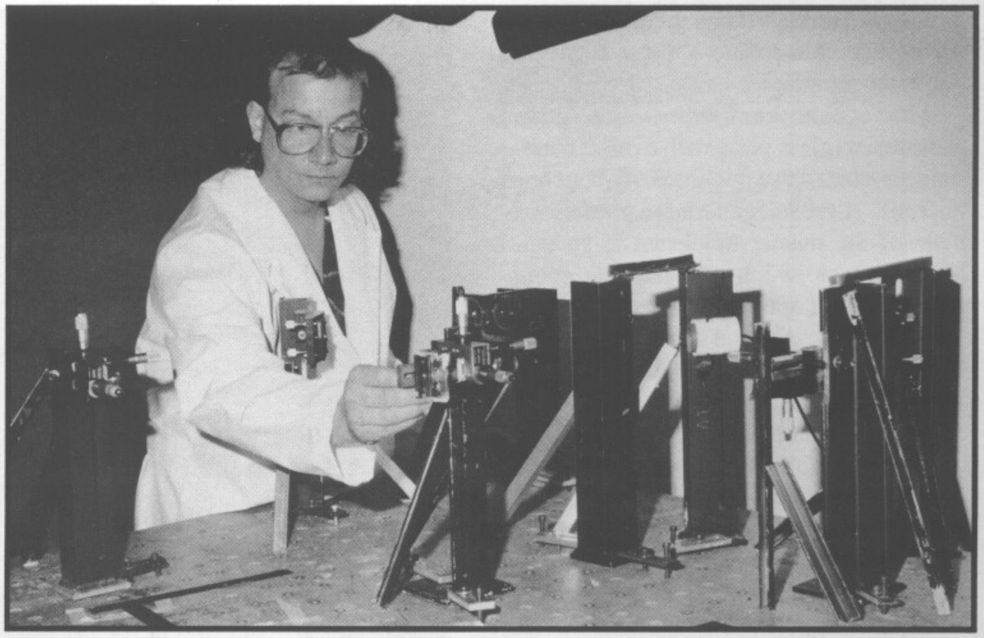
In effect, the hologram visually reconstructs the object by capturing and producing the light wave fronts reflected by the object.

Holograms can be transmission where light flows through the hologram or reflective where it bounces off it.

Because the slightest movement can defeat the creation of a hologram, and unwanted light can reduce the quality, most of the work is done in a dark laboratory on a non-vibration table, recording small, inanimate objects. The use of ultra expensive ultra-high speed pulse lasers and other techniques, however, make it possible to make holograms of people and larger objects.

Steven Smith, president of The Lasersmith, Inc., in Chicago is a commercial creator of holograms including the one on our cover. He says a typical holographic system consists of four items:

- A dark room with both minimized air flow and sufficient sound proofing to restrict the flow of sound waves (both serve to depreciate that quality or ability to produce holograms).
- An isolation table, that serves to eliminate external ground or environmental vibrations from entering the holographic camera system. This table, of various construction styles (concrete, steel or sand box), is suspended on air-filled inner-tubes and serves as the working area for all the optical elements required to produce a hologram.
- Optical elements that are used to move and mold the coherent light into a usable tool.



Steve Smith of the Lasersmith, Inc., tunes the optics on a holography system.

Smith maintains that the rainbow embossed hologram has the greatest commercial use today. "Embossing brought mass production to holography."

Embossed holography creates a printable platen or rotary surface through pres-

Steve Smith aligns the film holder for the focused image rainbow hologram sure, says Smith. "It is a relief etching of the holographic image embossed into a polyester substrate.

"Most of them are recorded on a positive photoresist (glass plate with a resist material spin-coated to a thickness of about one micron). A second generation photoresist plate of the master hologram is an embossed image which can generate about 20,000 lines of optical etching or printable relief per inch. A metal shim is then made from the photoresist in a three-part process -- placement of a conductive layer, thickening of the conductive layer to allow growing of duplicate shims, and electron forming of duplicate metal masters."

Smith notes that 100 third generation metal masters for printing can be made from one hologram. "Tens of millions of embossed holograms have been made from one original. We recently had 3,000,000 labels made from one original for Sears Corp."

The two main formats for embossed holography are mylar, two mil in thickness with a 3M transfer adhesive backing (see our cover) which works like a pressure sensitive label, and hot stamping foil which is embossed on 1/4 to 1/2 mil foil and lies flush on a page.

Embossed holography has been used on credit cards, business cards, T-shirts, money, membership cards, stock certificates, labels, coupons, book illustrations, point of purchase displays, awards, toys, badges, annual reports, brochures, greeting cards, publication tip-ins, magazine covers and garment tags.

Lasersmith is one of only five or six labs in the country doing commercial work in this area.

"A fair amount of our effort goes beyond the commercial end of our business. We use profits to keep us on the leading edge through research."

An example of this research is a method with patent pending that Lasersmith used to record the full color hologram on our cover. It is a hybrid, still camera/holography system which creates a holographic stereogram.

Forty conventional 35mm cameras are anchored on a rail, each on a precise rotating device pointing to the subject at a different angle at the required distance. In this case, the ball was thrown and the player and ball were recorded before the ball hit the mitt. When light hits the hologram, the ball appears to be in the air in front of the hologram. A small computer serves as a logic circuit to trigger all the cameras electronically. The results are played through a holographic system. A similar hologram could be obtained by using a pulse laser which costs more than twice as much as the camera rig but the color would not be as true.

"This is a way for us to leave the studio and go into the real world using holography which is in its early stages with still photography, in its advanced stage. We are working on a way to advance this concept with electronics."

Rudolph Guzik, president, Imaging Technology Consultants, checks vacuum plenum on large format film holder during setup of non-destructive test

Another Lasersmith innovation with patent pending and about to be commercialized is injection molded replicated holograms. "This is a breakthrough that could enable us to make 50,000 holographic lenses in a few days. The other product uses for it are too numerous to list. In this case, holography is built into the part during the plastic injection molding. It is also a way to prevent counterfeiting."

It begins with creation of an embossed hologram which is etched in a bath of nickel. A few generations later, it is a plate which is put into the injection molding machine for one-step production of each complete part.

Lasersmith also has made the largest fixed 3-color multi-image corporate display in the world and has created the first computer generated embossed hologram.

"Until now, we have limited our production to making masters which other companies use to manufacture the holograms, but we plan to enter the manufacturing end in the near future."

Rudolph P. Guzik, president and founder of the Chicago Chapter of Society of Photo-Optical Instrumentation Engineers (SPIE) and president of Imaging Technology Consultants, in Chicago, states that holography in movies, television or amphitheater productions is a long way off. "The practical technology for that is not even in sight as yet although the theoretical methods have been discussed since the early 70s. It is more likely that a variation of stereography or a hybrid will be the most practical approach."

Guzik taught holography 15 years ago and has maintained an active interest in practical applications. Some of the important items coming out of holographic research now, according to Guzik are new materials, optical computing, Fourier Transform optics, holographic optical elements, neural networks, optical storage, binary optics, computer generated holograms, circuit-board and IC testing and microlithographic methods.

The most exciting advances are being generated with a complex of new tools, says Guzik. They include electro-optics, new photo-active materials, electronic imaging and computers, fiber optics and electron microscopy. "There is a whole new world of opportunities for holography and it is difficult to project where is will

The World Turns to GE for Gas Turbine Value.

GE Delivers.

Gas turbine value is measured in terms of performance and reliability. GE performance and reliability are unsurpassed – offering new levels of efficiency, flexibility and availability.

GE offers the widest range of gas turbines available – from aeroderivatives to heavy-duty models, from 20 MW to 212 MW. Among them are machines for all applications, including utility, industrial, combined-cycle and cogeneration, cyclic and baseload duty.

Each new GE machine is, in large measure, the product of thousands of unit-years of operation. This accumulated experience is continually applied to advancing GE technology to achieve superior performance in every new generation of machines.

GE continues to lead the way in gas turbine value – the result of a dynamic combination of technological advances, talented and dedicated people, sophisticated manufacturing facilities and our commitment to serving your power generation needs now and in the future.

Get the full story on the world's broadest gas turbine line. Contact your local GE Sales Engineer or call (518) 438-6500.

GE Industrial & Power Systems Sales

lead, but like the holographic lens in store check-out scanners, holography will become a common element in systems used everyday by ordinary people."

"Holographic interferometry in non-destructive testing is one of the most widespread practical uses." You can take holographic pictures of objects as they are tested with heat, stress, compression, bending, twisting, pulling and vibration. The holograms can be superimposed over the object to note the differences. Interference fringe patterns on the hologram can be analyzed to determine differences.

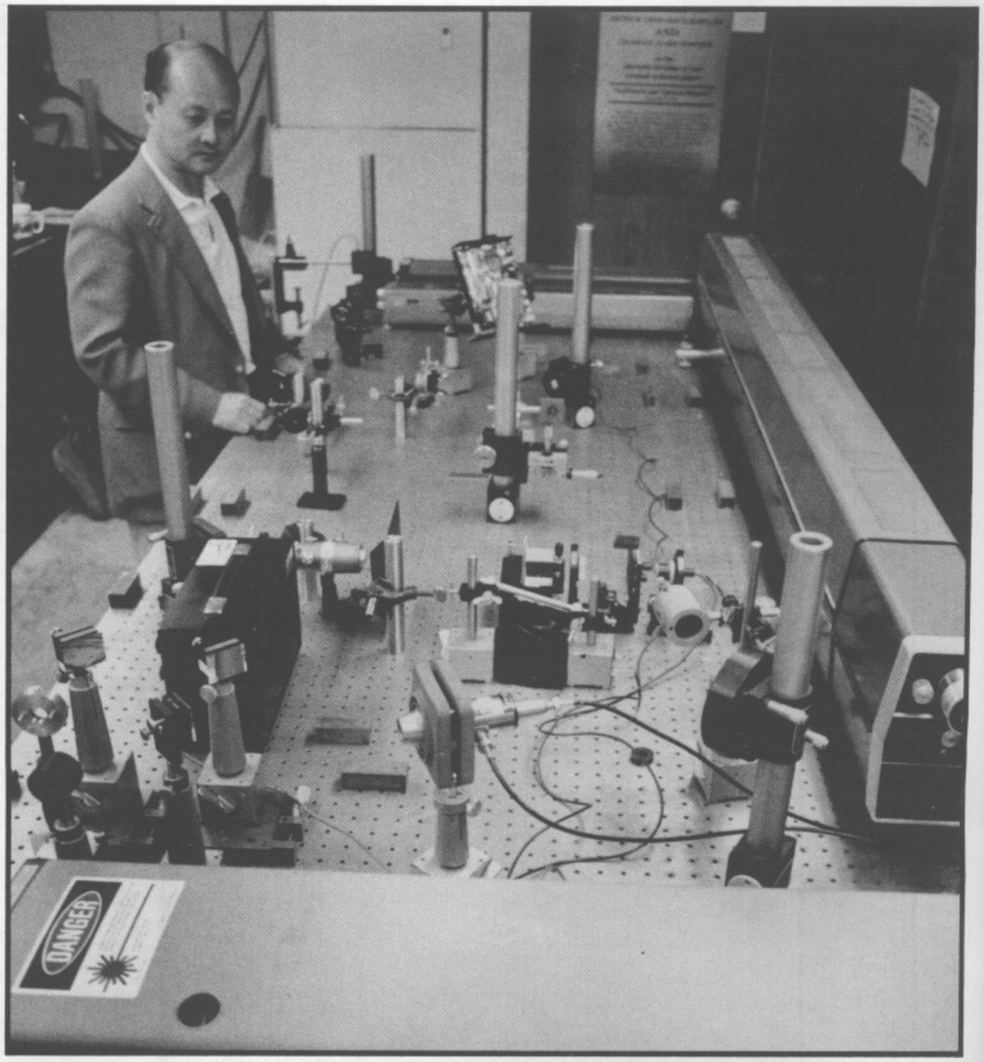
"Because it is impossible in most cases to prevent movement which can distort the test results, the geometry of the playback can be changed to compensate. Angles can be changed, bending can be separated from twisting, compression can be separated from bending and so on. You are dealing with wavelength interferences where 1/1000 of an inch is out of the ball park -- you must be under 1/10,000 of an inch to see it clearly. You can tell the engineer exactly when something begins to distort under stress and why. Airplane tires, violins, tanks, concrete and many other items are tested this way."

Vibration mechanics can be studied now using electronic holographic interferometry, also called speckled interferometry, which is based on extracting information from the changes in the electronic image, according to Guzik. "An engineer can take a package to the job with the video, laser and optics built in and watch the vibration patterns as they occur on the screen. There are a number of these units on the market. It's actually auto-interferometry."

Guzik's firm, Imaging Technology Consultants, provides assistance in engineering physics, optics and imaging science.

The following examples of problem-solving projects using holographic non-destructive testing were undertaken by Guzik's firm:

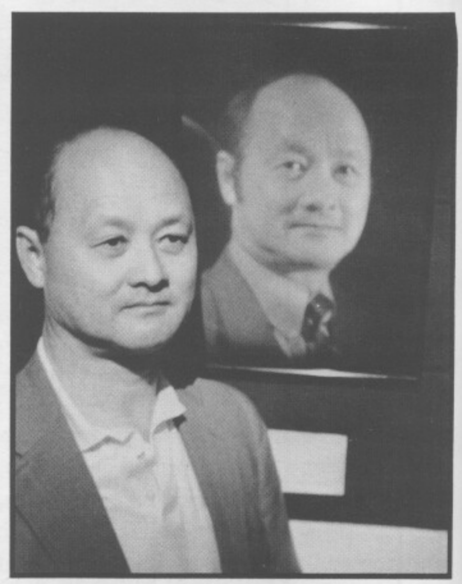
- An ink fountain casting used on a commercial offset press was deforming in such a way that it was hard to properly adjust the ink. They built a special fixture to hold the unit during the holographic testing. Interferometry showed the casting was not distorted but rather there was shifting and release in the machine mount for the unit. Because the motions involved were subtle and complex, holography was used to follow incremental changes as pressures occurred.



Dr. Tung H. Jeong of Lake Forest College, uses five lasers on vibration-free table in research setup for true color holograms and holographic elements.

- Another offset press test showed how a lever-driven linkage failed to apply the expected pressure between the elements that were being moved. It was a large unit so it required a setup in the printing environment. It was discovered that there were a series of contributions to the relaxation of contact points. Sideframes were bowed and mounting pins were bending. A bearing that held the linkage was shifting in its mount. An unanticipated torsion in a cross member also was found.

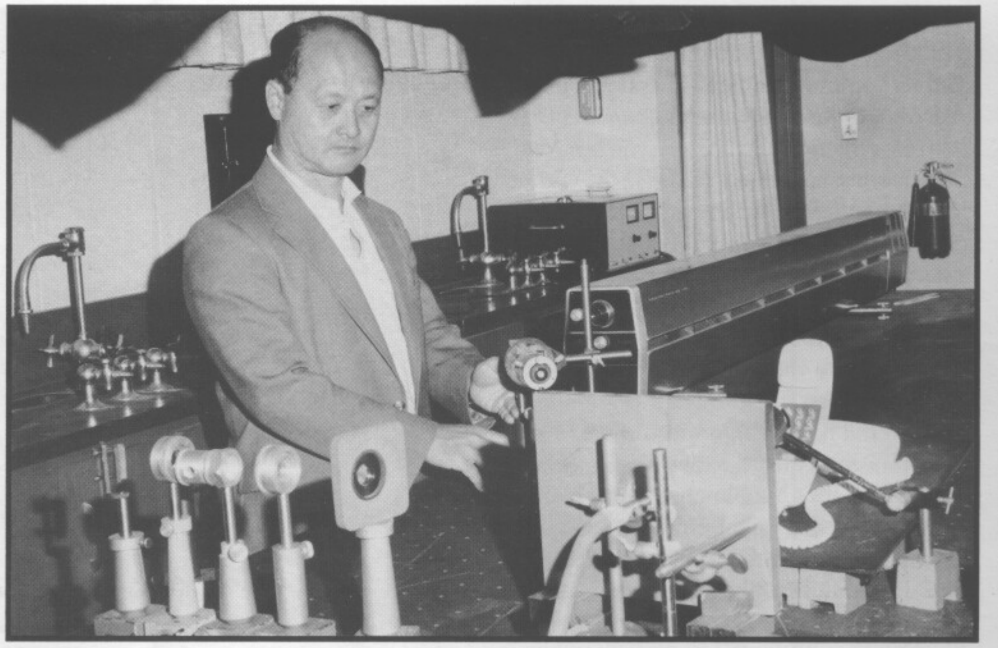
Dr. Tung H. Jeong, director of the Center for Photonics Studies at Lake Forest College and president of Integraf, a company for consultation and worldwide distribution of holographic materials, is the grand old man of holography in the Chi-



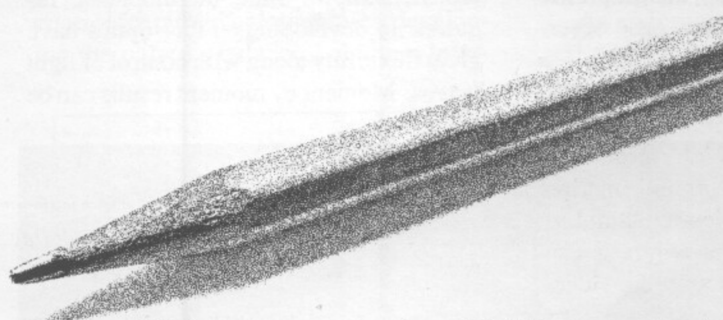
Dr. Jeong poses by holographic portrait recorded by Northwestern University Prof. Hans Bjelkhagen.

cago area. He holds patents for numerous holographic inventions including the basic 360 degree cylindrical hologram where the people or objects appear to be revolving in space inside a transparent cylinder resembling a lamp shade.

He began his research in holography in 1966 at Lake Forest College and is an internationally-known expert and teacher. He has been director of the summer holographic workshops since 1971. Scientists and others come in from all over the world for the hands on workshops in July which are divided into beginning and advanced holography. The 3rd International Symposium on Display Holography was hosted by Lake Forest College in 1988. The liberal arts school has just completed construction of a $4 million science building to expand the teaching and research of holography and other subjects. There are no classrooms in the building -- all the



Dr. Jeong with teaching situation setup to make holograms of phone at right.



Write Down Precisely How Much Electricity You'll Need On July 10, 2010.

In 1970, as we planned the final construction phase of what's now one of the world's most modern electrical generating systems, peak power demand here in northern Illinois totalled a little over 10 million kilowatts. Yet at its completion in 1988, that demand was already 74% higher.

Critics of the program maintained that such enormous levels wouldn't be seen until the 21st century. They were wrong by nearly two decades.

Correctly evaluating the needs of a northern Illinois population the size of 20 Pittsburghs 20 years in advance is, as you'd expect, no simple task. But it's one which is crucial to maintain the lifestyle and business environment that make northern Illinois a prosperous and productive place to live.

So, while some parts of the country are experiencing blackouts and brownouts, there's comfort in knowing that here we'll have reliable electricity, in abundant supply, well into the 1990's. Just like we planned.

Commonwealth Edison
We're There When You Need Us.

learning is in research labs.

"Holography is extremely useful in education because it is very teachable and it involves every aspect of fundamental optics," Jeong states.

The holography laboratories at the school have been self-sustaining through research sponsored by firms who have problems to be solved. "We have one of the most complete holography labs around. It doesn't pay for most firms to buy their own equipment and hire experts when we have everything already here," Jeong says.

One notable example was the use of holography in neutrino experiments in Fermilab's 15 foot bubble chamber which is used to observe subatomic particles. A team of international scientists made feasibility studies at the school before the project began at Fermilab. The experiments are explained later in this story. Most of the other projects involve holographic interferometric non-destructive testing and holographic optical elements (HOE).

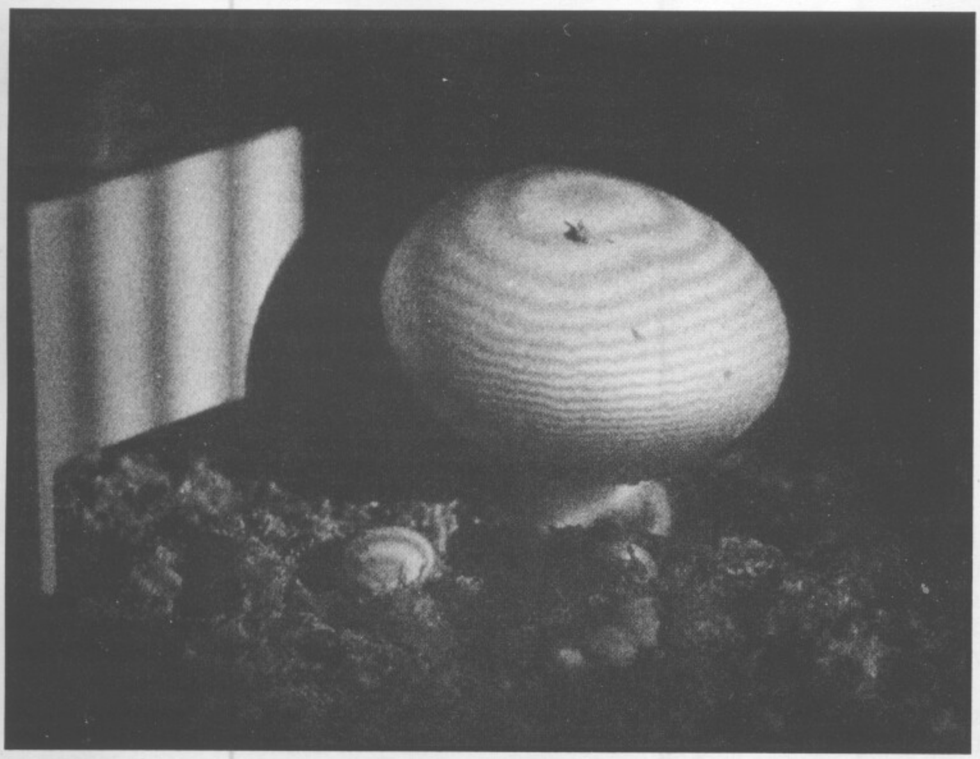
Working with students, Jeong has combined the use of fiber optics, thermoplastic and holography to make real-time observations of the growth of mushrooms -- a feat which can be useful in science, indus-

In this hologram in Dr. Jeong's collection from Richmond Holographic Studios, Ltd. Boy George's hands project into the air.

try, and non-destructive testing. As a replacement for film, thermoplastic requires no developing. Fiber optics have great flexibility along with control of light waves. Moment by moment results can be

The Chicago Chapter of SPIE in conjunction with the Optical Society of Chicago is holding SPIE's "Optical Engineering Midwest" Conference, September 27-28 in the Ramada Hotel O'Hare, Rosemont, IL Call (312) 784-6119 for further information. The meeting will have a one-day table top exhibit and two days of sessions on Holography and Applications, Biomedical Applications, Lasers and Electro-Optics, Optical Engineering, Electronic Imaging, Optical Engineering in the 90s and Neural Networks. Tutorials on related technology are also available with discounts for group enrollment.

viewed showing differences between a fixed time and the present. A mushroom moves as it grows and this movement can be subtracted from the growth by recording an unmoving object next to it. Some



Dr. Jeong's hologram of an onion. Holography records moment by moment growth of the onion.

"Masks" in Dr. Jeong's collection comes from Kiev Holographic Laboratories in USSR. A magnifying glass floats in front magnifying the masks.

of the many advantages of fiber optics are the elimination of mirrors, lenses, half-wave plates and pinholes, miniaturized system, easy to illuminate hard-to-reach areas, ease of moving object beam and easy combination of light from many lasers.

Jeong's lab is testing a new photopolymer which is sensitive to all colors, requires no developing, comes in sheets with arbitrary thickness and can be stored for a year. Full color 3-D images are formed as the polymer is exposed resulting in a permanent hologram.

Jeong notes that a million dollar holography machine at Insystem, Inc., San Jose, California, inspects silicon wafers during integrated-circuit manufacture. A hologram is made of a perfect wafer and through comparison of each wafer coming through, differences (defects) are found. A filter is the key element. If no light from the wafer being tested passes through the filter, it is perfect. If light passes through, exact locations of the defects are recorded on a hologram and shown through a video system.

Jeong reports that optical computing with holography as its centerpiece is a hot item for research now because of its spectacular potential. "You can make free-space interconnects to hook up one process to another. Two arrays of 1000 x 1000 processors would take one million million (10^{12}) wires to connect. You would have a cubic meter of solid copper. But with holography, you can have four million bits on one square millimeter of film with four million interconnects crossing without touching. You're handling light instead of wires so you're not wasting energy through heat."

Some other important applications for holography noted by Jeong include:

- Holographic optical elements (HOE) which perform the same functions as lenses, mirrors and gratings. HOE can combine functions not possible with conventional optical elements including bifocal contact lenses, compact disc players and universal product code scanning.
- Head-up display (HUD) holographic visors in military and commercial aircraft allows the pilot to watch a distant target while data is relayed through the unit.
- Holographic microfiche for high density information storage can be duplicated more economically and hold 50 times more information than conventional microfiche and it is impervious to scratches and dirt.
- Light-in-flight measurements can be made using picosecond and fentosecond lasers, recording stop-action 3-D pictures of light wavefronts.
- Phase conjugation where holograms are recorded instantly on crystals and a "pump beam" projects the real image precisely back on the object. The "time-reversed object beam can be 10,000 times more intense than the original. This has applications from star wars to optical circuit components.

Dr. Hans I. Bjelkhagen, associate professor of biomedical engineering at Northwestern University, uses holography to study human tissue, subatomic particles and interferometry non-destructive testing.

Bjelkhagen began his research career at the Royal Institute of Technology in Stockholm, Sweden and has worked for the European Organization for Nuclear Research, Geneva, Switzerland and at Fermilab in Batavia, Illinois. He introduced fringe control for pulsed holography by developing the pulsed sandwich hologram interferometry. Bjelkhagen also developed dental holography, in particular, in vivo (within the living organism) measurements on the functional dynamics of human teeth and prostadonatic appliances using a pulsed ruby laser system; a laser instrument for measuring tooth movements and tooth mobility; a clinically applicable laser luminescence method for the early detection of dental carries, and a method for imaging of chest motion due to heart action by holographic interferometry. He is partner in a Swedish firm which has developed new chemistry for reflection - Denisyuk holograms as well as portrait holography.

Bjelkhagen and colleagues at Northwestern are using holography to take an "optical biopsy." "We hope that by using holography in vivo, we will increase our understanding of the etiology and pathology of Crohn's diseases, colitis, proctitis and several forms of cancer. The system, called endoholography or endoscopic holography combines endoscopy and holography. Most of our work, so far, centers on the colon."

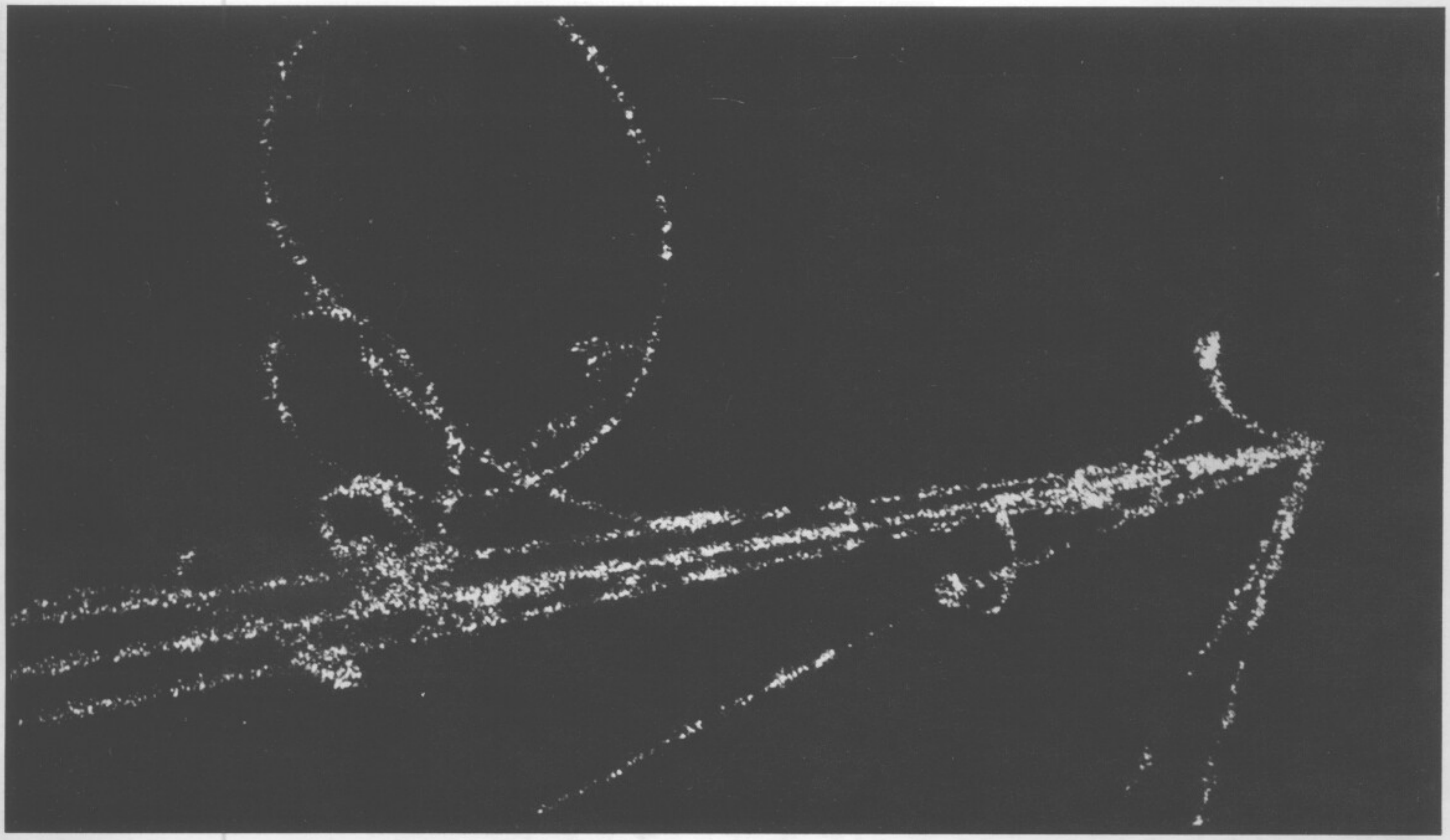
An endoscope uses a single-mode optical fiber for illumination. Single-beam

Webster's Definition of Engineering:
"A science by which the properties of matter and the sources of energy in nature are made useful to man."

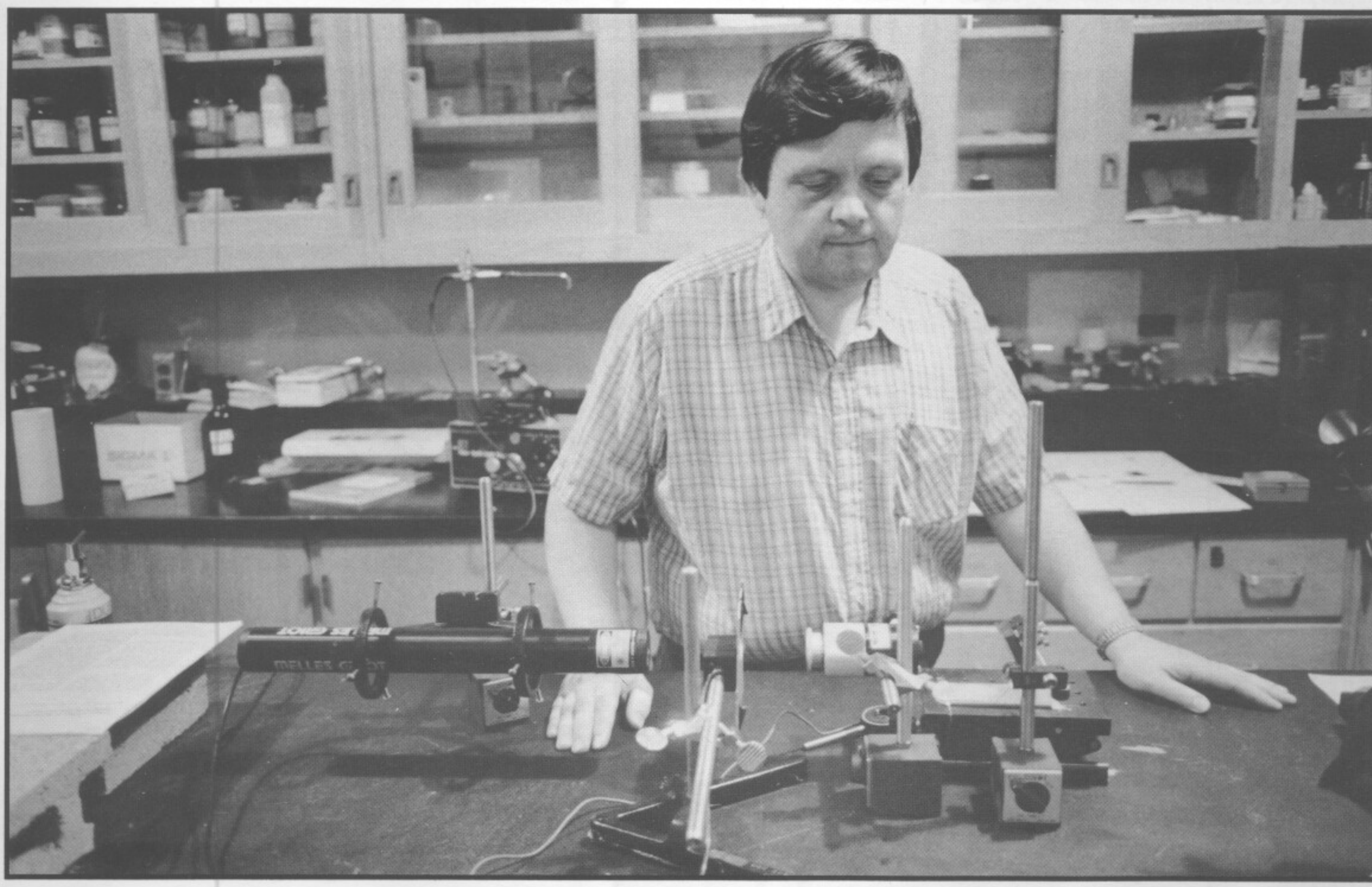
MidCon Corp. buys, sells and transports natural gas throughout the United States.
Our engineers help get the job done.

We Salute
THE WESTERN SOCIETY of ENGINEERS

MIDCON CORP.
A SUBSIDIARY OF OCCIDENTAL PETROLEUM CORPORATION



Subatomic particles are observed holographically through the trail of bubbles they make in Fermilab's 15 - foot bubble chamber.



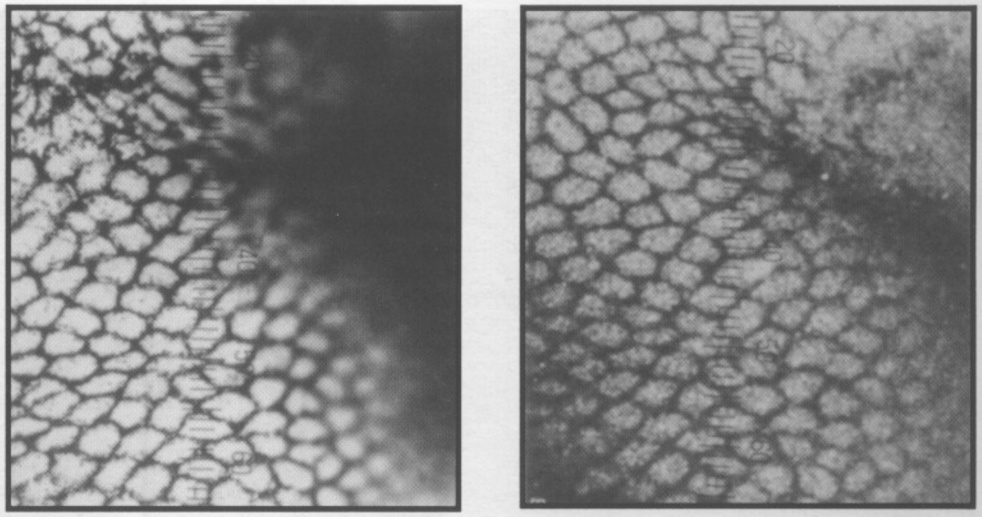
Northwestern University Prof. Hans Bjelkhagen sets up system for resolution tests in a holographic endoscope project.

reflection holograms are recorded in contact with the tissue at the distal end of the endoscope. The holograms are then studied under a microscope.

The holoendoscope is assembled in three parts, a film holding cartridge, a diaphragm and light baffle section, and an optical fiber-holding configuration. It is adjustable by sliding the three tubes over each other.

"The holographic images are of much higher resolution than those of conventional endoscopy." says Bjelkhagen. "More flexible versions of this system will allow access to other parts of the body."

Working with Northwestern students and colleagues, Bjelkhagen measures the entire crack-opening profile in concrete or



Left, tissue sample seen through microscope and right, holographic image of same sample seen through microscope.

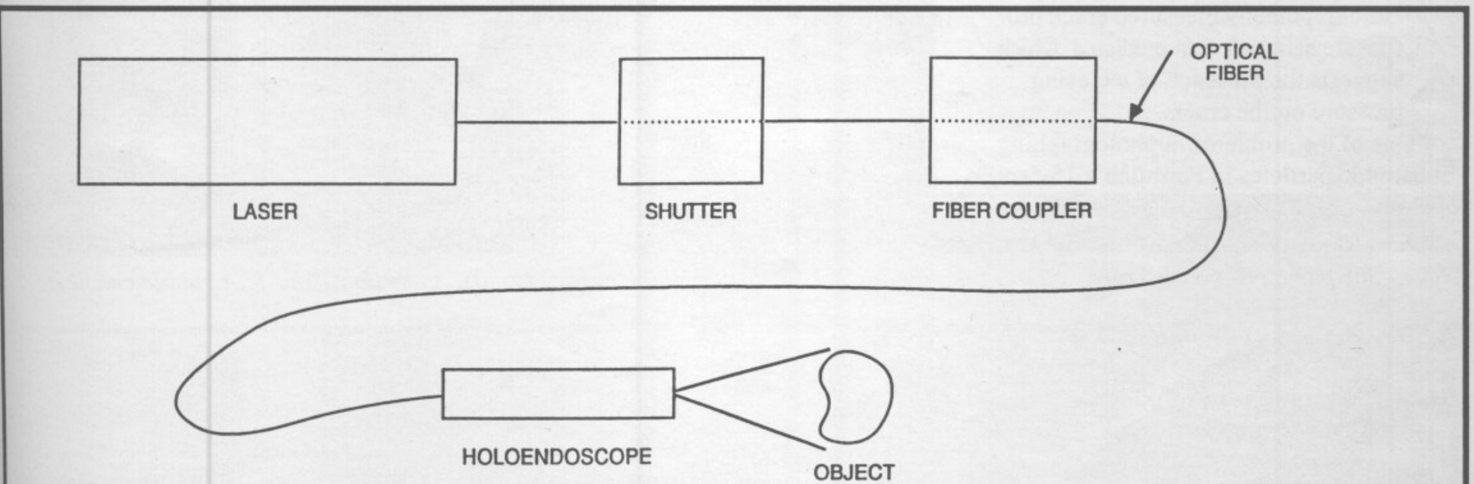


Diagram of a typical endoholographic system.

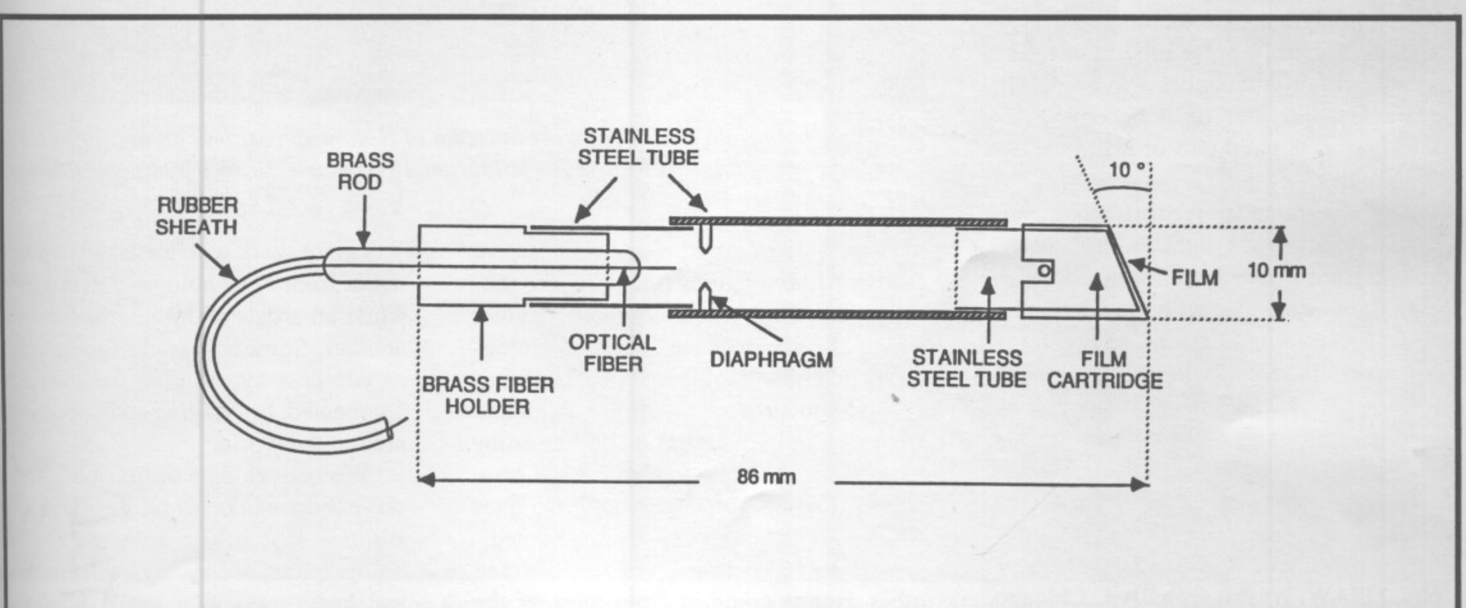


Diagram of a holendoscope.

mortar which was previously impossible to do.

The process uses interferometry with a sandwich hologram. Two holograms of the concrete in two different states of displacement are glued together. By rotating the sandwich around a specific axis, the effect of rigid-body motion is eliminated. Rigid-body motion obscures fringe patterns and renders the interferogram useless.

Some of the findings so far are:

- Holographic interferometry can be used to measure crack profiles to an accuracy of 1.4×10^{-5} inches.
- Displacement of cracks in mortar appears to be concentrated at the crack tip.
- Holographically measured crack profiles are narrower than predicted which suggests the presence of a closing pressure on the crack.

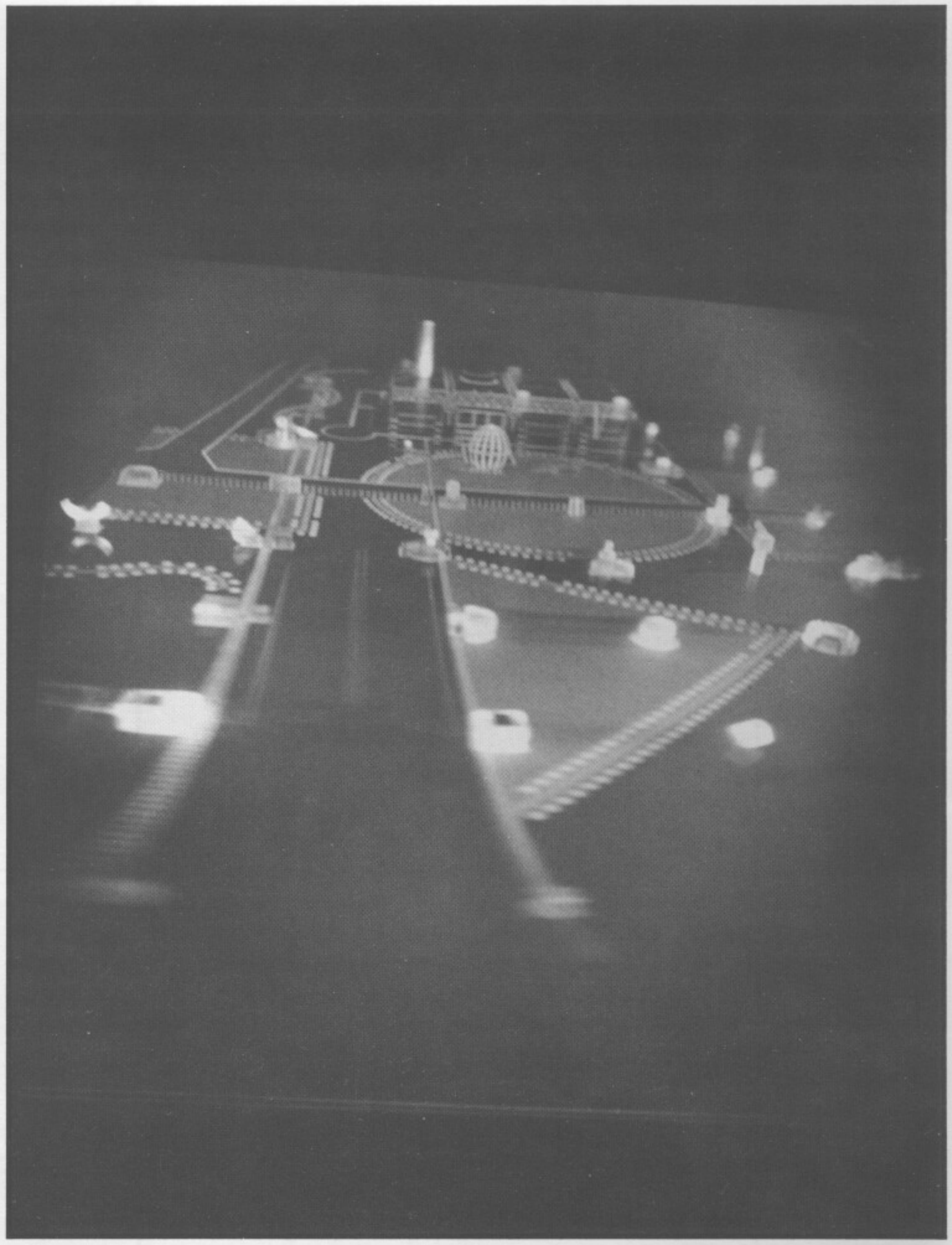
"One of the problems in photographing subatomic particles in Fermilab's 15-foot Bubble Chamber is the difficulty of focusing on particles traveling at ultra short distances at ultra high speeds," says Bjelkhagen. "You have to focus at a short-lived dot in 15 feet of space at the right moment. A particle decays in times of order of 10^{-13} seconds traveling a few millimeters. But a hologram gives you sharp focus of everything in the chamber."

Charged particles travel through a liquid in a superheated condition leaving a track of tiny bubbles which are simultaneously photographed and holographed.

In the system, a pulse ruby laser fires a beam through a chamber window. The beam is split, part of it becoming the reference beam and part of it illuminates the bubbles.

The holograms are reconstructed using a continuous wave light at ruby wavelength from a dye laser, pumped by an argon-ion laser. The output from the dye laser is transmitted through an optical fiber which illuminates the hologram. Different areas of the bubble chamber volume are then studied with a telephoto lens and TV camera looking through the hologram.

Display holograms of all descriptions, at least 150 in four galleries, can be viewed by the public at the Museum of Holography, 1134 W. Washington Blvd., Chicago, from 12:30 p.m. to 5 p.m. Wednesday through Sunday. Founded by Executive Director Loren Billings in 1976, the museum is part of the Holographic Center which also includes the School of Holography and holographic research facilities.



This huge hologram exhibited in the museum of Holography shows an architectural use. Part of the scene floats in front of the hologram. From Paris, France by Jacque Bousignue, it is called "Parc De La Villette."

"So far this year, we've given about 250 lectures to school groups. Children enjoy the exhibit and they understand the principles of holography, especially the ones who studied computers," Billings noted.

Billings says busloads of students and other groups come in from most of the midwest states as well as from the suburbs.

A giant shark with teeth barred projects out in front of its hologram in one gallery while an artists' exhibition is featured in another. Some holograms appear to move as you pass by. A permanent display is augmented by visiting exhibitions from around the world.

"We believe part of our job is to preserve these works for future generations," Billings says. The museum also sells holographic jewelry, toys, calculators and watches.

The center conducts workshops and lectures on its own premises or away for organizations.

"The museum has worked with the University of Illinois, Northwestern University, The Society of Photographic Scientists and Engineers and numerous schools. We have mounted major exhibitions of holographic works at the Chicago International Arts Exposition, the University of Chicago, the University of Illinois at Chicago, the Long Beach Museum of Art, the Buffalo Museum of Art, the Frankling Institute, and Siggraph, the world's biggest computer conference. Our works have also been exhibited in the Museum Fur Holographie in Cologne, the Musee de L'Holographie in Paris, the Paris Air Show, and in Munich, Strassburg, Budapest and Sweden.

"To date, some 800 students have received instruction in holography and other allied subjects-optics, photochemistry, interferometric holography, pulsed holography, and the physics of light. Three separate and fully equipped labs are devoted to class usefrom the beginning introductory level to the most advanced. The teaching staff is headed by individuals who have done pioneering work in holography and who enjoy nationally recognized reputations in the fields of optics and photochemistry. Our advisory board is composed of scientists and scholars of international standing.

"We are now able to take computer generated animations and transfer them into three dimensional holograms, which we feel will be a landmark breakthrough uniting artistic imagination and high technology.

"We have done pioneering work in the field of embossed holography for several years."

support your organization by advertising in the midwest engineer

Dr. Ted R. Niemiec, director of education for the Holographic Center and Museum of Holography, stands near a display of smaller holograms.