Holographics International

Selling Holography: Who, Where & Why?
Nancy Gorglione: Homage to California
Imperial College: Blazing a Trail

Autumn 1987 Number 1
Price £3 (UK)
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The International Magazine of Holography

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EDITORIAL

Welcome to Holographics International! We have worked long and hard to produce this first issue and we hope you enjoy it. Firstly, however, I would like to tell you a little bit about Hi and the people who work on it.

Editorial Policy

Holographics International was set up partially due to the fact that there did not seem to be a publication whose sole concern was holography and which was set up for its own sake, ie. was not set up as an appendage to some other organization or body. As journalists, we take our magazine and the industry it serves seriously. We have no axe to grind (nor holograms to sell). We will report on the industry as accurately and objectively as we can.

Hi is privately owned and does not answer to anyone. My feeling has always been that the ownership of a publication has a tangible effect on its content, and if the owners have a stake in the industry, then it is almost inevitable that conflicts of interest will arise. In these situations, the newspaper almost always loses.

Another feature of the existing holographic press is that holographers, who produce and sell holograms, are allowed to criticise other holographers in the same market. In the small and competitive art market, the effect of a damning critical article can not only seriously undermine the reviewee but, in certain circumstances, could benefit the reviewer. This, as far as I am concerned, is an unacceptable situation.

In saying this, there are great difficulties involved in finding individuals who are qualified to review holographic art but who are not "art" holographers themselves. We have not cracked this one yet and therefore there is no "critical" review in this issue. We would rather have a hole in the content than risk damaging a holographers reputation because of some rival's prejudice. Hopefully we will be able to solve this problem shortly.

Another area where thought is required is in the acceptance of advertisements. One of the aims of the magazine is to promote the holographic industry outwith itself and we cannot do this successfully if we present poor quality holograms in the magazine. We have, therefore, told potential advertisers that we must be allowed to see the holograms which they wish to include before accepting the advertisement. I take great pleasure in saying that, as yet, we have not had to turn any holograms down, but we will certainly do so in future if necessary.

The two main planks of our policy are, therefore, the prevention of conflicts-of-interests situations taking place and improving the image of the holographic industry in the eyes of the people who might want to use it. In general this means getting non-holographers to write the bulk of the copy (except in the cases of "Lab Notes" and "Literature Review" where this is obviously inappropriate). Where we do have holographers writing in non-technical sections, there will be a limitation on the scope and subject matter of their articles, they will be edited (where necessary) and the author's background will be presented in order to allow the reader deeper insight into why they wrote the article. We will not claim that such articles are objective.

In this issue there has only been one such author, Nancy Gorglione. We thank her for the work she has put in and for taking an interest in the magazine.

Holographics International aims to look at all applications of display holography in every country. We know that this is a vast area to cover, but we will be as comprehensive as we can.

Campaigns

There are two issues on which I feel this magazine should take a strong stand. Firstly, the issue of cliquéness within the holographic industry is not a trivial one. There is too much infighting and backstabbing amongst warring factions and this is having an effect on the way potential users of holography perceive the industry.

Another question which deserves some attention is that of professionalism. There are many who feel that there are too many "artistic temperaments" in holography who are either unwilling or unable to deliver contracts on time. This barrier to industry growth must be overcome. Holographics International cannot promote the industry if it refuses to promote itself by providing an efficient, quality service to customers.

Letters

We would be more than delighted to receive letters (as caustic or sycophantic as you like) on our handling of any subject or issue. Suggestions for further articles and further information on subjects already discussed are equally welcome. In future issues, the Editorial will be restricted to a column at most, the rest of this page being devoted to your letters.

Press Releases

Please send us as much information about your work or your company's work as often as possible. The more we know, the more we can write. We are interested in all applications of holography and all of the ins and outs of the holographic world. Put us on your mailing list or phone us when you're doing, or know of someone who is doing, something interesting.

The Staff

The staff of Holographics International is a rather nebulous entity, but there are a few individuals who I would count amongst my "regular staff".

Martin Taylor, Deputy Editor, has a BSc in Physics and an MSc in Nuclear Technology, both from Imperial College, London. At different times he is responsible for all aspects of magazine production and promotion.

Dr Kaveh Bazargan, of the Applied Optics Group at Imperial College, is consultant editor. In this capacity he advises Hi on all technical matters and writes for the technical sections of the magazine.

Duncan Young is doing the MA in holography at the Royal College of Art, his first degree having been in fine arts. As cartoonist for Hi he will hopefully help holographers to take themselves less seriously.

Pippa Salmon is studying Physics at Imperial College. She has been involved with writing and editing since her arrival at college. Her contributions will generally be business and commercial features.

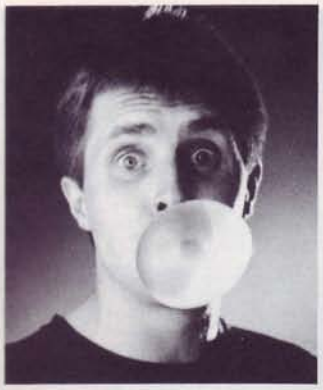
My name is Sunny Bains and I am the editor and publisher of Holographics International. I also study Physics at Imperial College and have been involved in writing and journalism for some time. I saw my first hologram at the Ontario Science Centre in Canada, and have been obsessed with holography ever since. It is my job to run the magazine, and to take the flak if I get it wrong.

Imperial College

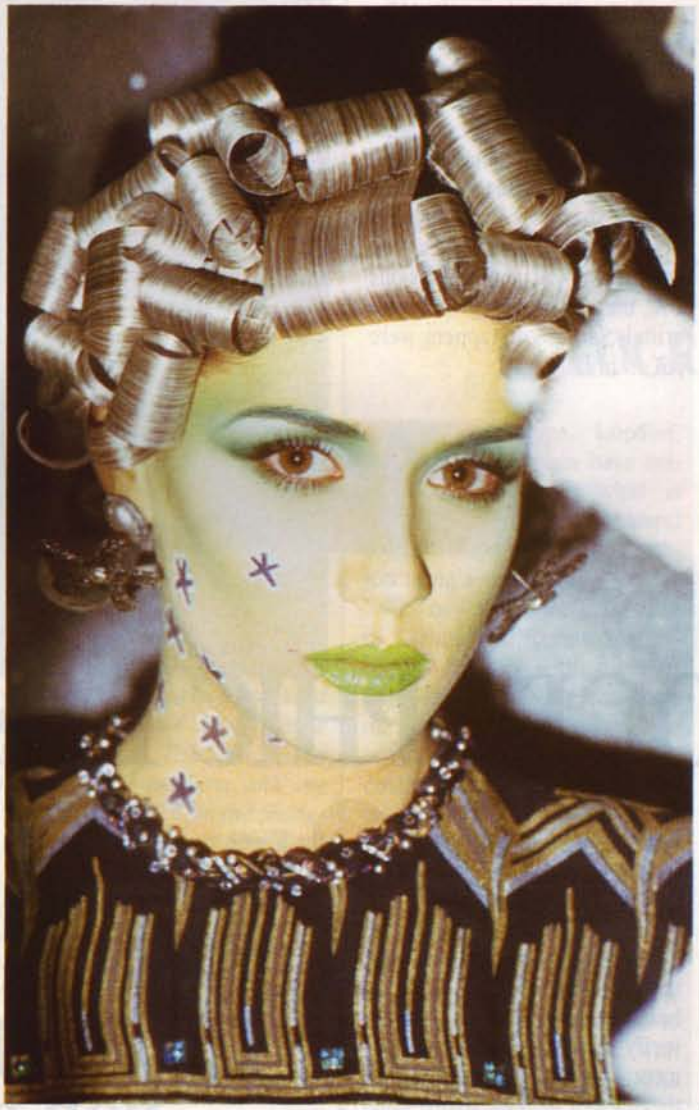
Readers may notice that 80% of the regular staff have or have had some connection with Imperial College, and that we have focused on IC in this issue. We felt that it would be hypocritical of us not to start off with the place that we all know best, but we will be travelling around finding out as much as we can about other places so that in future we can write about them with as much authority.

Subscriptions

This is the point at which I point you towards the back page and ask you to send us money. At £12, $20 US, per year we feel that Holographics International is good value. You will not get another free copy! From now on you have to pay. We think we're worth it.



HOLOGRAPHY COMES TO HAUTE COUTURE



Zandra Rhodes, the famous British clothing designer is using holograms to display her wares. Two 50x60cm white light transmission holograms by Patrick Boyd, who is studying holography at the Royal College of Art, went on display in her shop in Grafton Street, London on October 5th.

Patrick, who was interested in the use of holography in fashion, approached Zandra Rhodes through a friend in March. They went ahead with the shoot in April at the Royal College of Art with two models and made four pulsed portraits, one of each model in each of their two £2000 dresses.

Zandra is said to be very happy with Patrick's work and a trial hanging of the holograms in the shop went well. It is hoped that the holograms will attract customers in the Christmas party season ahead.

The models' hair was styled by Eugene of Trevor Sorbie in London, the make-up was by Phyllis Cohen, and the photographs were taken by Tobi Corney. The frames were by Andrew Logan.

Patrick Boyd says his next ambition is to produce an embossed holographic cover for a fashion magazine, though he has no specific plans to do this as yet.

DOUBLE VISION

Pilkington, a British company who manufacture glass products, will soon be marketing holographic contact lenses.

The lenses are bifocal, allowing people who would normally need, say, reading and driving glasses to have the benefit of both at once. This is achieved by having two zone plates etched on the surface of the contact lens. Each presents an image to the brain depending on how the cornea is focused. The more blurred image will be ignored by the brain.

The idea for the lenses came after work on "head up" displays for aircraft. The contact lenses require the same properties of the hologram that the display does, ie. with both the user must be able to see more than one image, allowing the user to choose which image is most useful.

The contact lenses will cost about £250, $400 US per pair.

HOLODISK

Advanced Dimensional Displays, based in Van Nuys in the United States, has developed a holographic stereogram called the "Holodisk" which projects an image on top of a flat plane. The hologram is top lit and as the disc turns, the object also moves.

The first hologram of this type was produced one year ago and since then ADD have been experimenting with the new form to test its limitations and to see which images are most effective. The idea for the hologram started evolving in 1985.

The 360 degree stereogram has one frame per degree, and though higher ratios have been tried the resulting holograms tend to be more noisy. The experimental images included holograms of computer generated images, of an aircraft shooting into space, and one of a woman called "Lovely Rita".

Kevin Rankin of ADD explained people who had little association with holography liked the holodisks very much as they are much closer to the "Star Wars" hologram of Princess Leia than other types of hologram have been.

Interest in these products has been expressed by various toy companies and it is expected that they will find their way into American shops by Christmas 1988.

A patent for the "Holodisk" is pending.

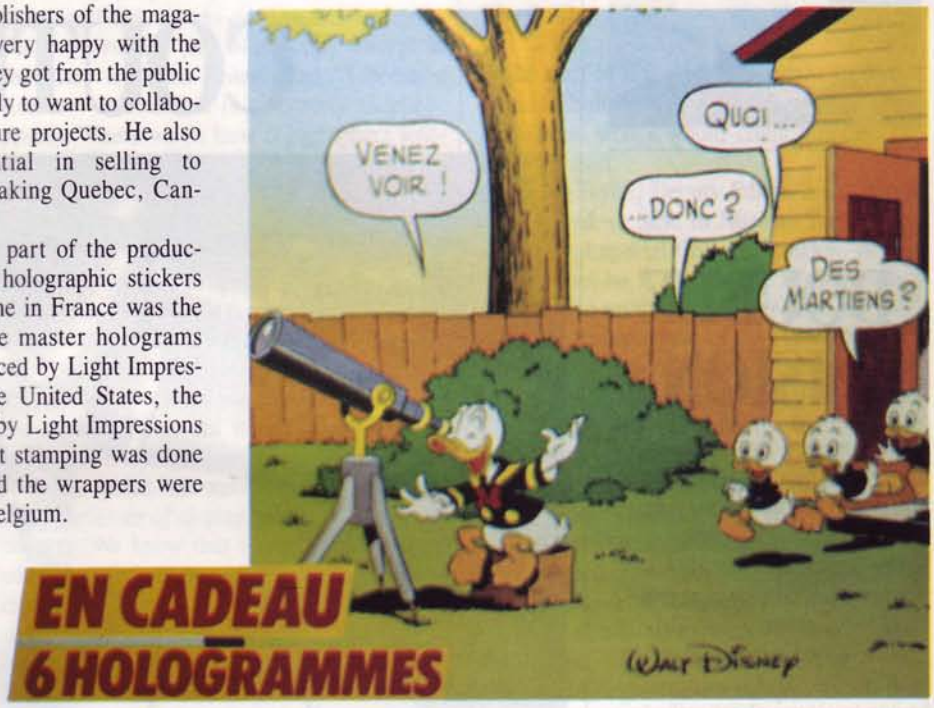
HOLOGRAPHIC COMIC BOOK: A FRENCH FIRST

Holographic International, a French company based in Paris and not connected with this publication, brought holography to a mass market when it produced holograms to be sold in conjunction with the Mickey Mouse magazine.

The magazine was published on March 10th of this year and included in its inner pages a set of holographic stickers and a sticker book. A total of six sets of stickers was required to complete the comic which would then be completely holographic.

Four hundred thousand copies of the magazine were sold throughout France, Belgium and Luxembourg. Sets of holographic stickers were then sold in 22 000 shops at FF4 per set. Nicola Baskevich, director of Holographic International, said that the publishers of the magazine were very happy with the response they got from the public and are likely to want to collaborate on future projects. He also sees potential in selling to French-speaking Quebec, Canada.

The only part of the production of the holographic stickers actually done in France was the design. The master holograms were produced by Light Impressions in the United States, the embossing by Light Impressions UK, the hot stamping was done in Italy, and the wrappers were put on in Belgium.



HOLOGRAPHIC FASHION

Marks & Spencer, the well known British clothing chain store, is now selling a range of holographic T-shirts and sweatshirts which bear holograms made by Light Impressions. The hologram theme has proved popular, and new orders have been placed for Spring and Autumn 1988.

Light Impressions has known for some time that it is possible to use embossed holograms on textiles, according to Managing Director John Brown, but it took the involvement of Marks & Spencer to make it work in practice. The company used an application technique devised by Heat-Seal (Textiles) Ltd, which enabled the garments to pass M&S's rigourous machine-wash tests.

Light Impressions is claiming a technological first for the successful application of holograms to fully washable textiles.

The bonding of holograms to clothing will also be useful for the permanent application of brand and designer labels which verify the authenticity of a garment, says Light Impressions, as they cannot be removed.

The holographic garments are M&S's fastest selling boyswear items, according to Frank Wood, the company's Senior Technologist for children's wear. M&S plan to stock them in over 100 stores.

The new ranges for Spring and Autumn 1988 will carry hologram application a stage further onto cotton/acrylic knitwear. They will feature cartoon characters, including Popeye (with a 3D hologram of a spinach tin), the Flintstones, and Disney characters. A range for older children will depict drive-in movies and holograms in the form of cats eyes on dark sweaters.

LEONARDO CALLS FOR PAPERS

Leonardo, the journal of the International Society for the Arts and Sciences, will be publishing a special issue devoted completely to holography in the late summer or early autumn of 1988.

The journal, which is based in Berkeley, California, United States, has chosen Louis Brill, ex-editor of LASER News to be managing editor of the special issue. A call for papers has gone out and artists, engineers and scientists interested in this project have been asked to provide abstracts by December of this year.

Those who wish to contribute should write to ISAST, PO Box 421704, San Francisco, CA 94142, USA.

The Shanghai Institute of Laser Technology in China has produced an He:Ne laser which can supply more than 25mW in its single frequency mode, ie. with infinite coherence length. The laser, called the MS120, is being sold commercially and is shown above with one of its designers. Further information can be obtained from the Shanghai Institute of Laser Technology, 319 Yue Yang Road, Shanghai, China. Telephone +86 21 379650.

MIRAGE GALLERY OPENS

Mirage Holograms of Britain, which recently became incorporated in the United States, opened a new holographic gallery in New York in the first week of October.

The gallery, which is situated in the Herald Centre, Herald Square, presently occupies 1500 square feet and has a permanent exhibition of holograms and a holographic shop. The gallery will also be marketing a pulse portrait service.

Mirage has been trading since early 1986 and specialises in the wholesaling of holograms, on both film and plate. The company have been working on the gallery project since January of this year.

Early in 1988 Mirage intends to open the first of a series of changing exhibitions of collections by holographic artists.

U.S. BANKNOTE SETTLES

US Banknote, which was being sued for breach of patent by International Banknote, the parent company of American Banknote Holographics, has settled the case out of court.

The agreement allows for a federal injunction to be taken out against US Banknote in the United States, preventing the company from breaching the ABN Holographics patent again. The patent refers specifically to the use of holograms for security applications, ie. the prevention of counterfeiting.

Light Impressions, which is also being sued, will not be affected by the US Banknote settlement. ABN Holographics has said that it will be continuing court proceeding against Light Impressions. In turn, Light Impressions has challenged the validity of the patent in question and has said that it will continue to defend the litigation.

NATURAL COLOUR PULSE HOLOGRAM MADE

Imperial College, London, and Ilford, of Britain have collaborated to create what is thought to be the first natural colour hologram of a living object using a single laser.

The new technique makes use of "Stimulated Raman Scattering" to produce a three colour pulse from a single green pulse of laser light. A green pulse is emitted from a frequency-doubled Nd:Yag laser and then passed into a pressurised gas, or "Raman" cell. In the cell, collisions between photons in the laser pulse and the gas molecules cause the wavelength of the pulse to be shifted. In this case the system is set up so that one third of the pulse is shifted to red and one third to blue, with one third remaining green. The pulse which emerges is therefore ideal to produce a multiple pulse hologram.

One of the main difficulties faced by holographers working with real colour is that the only film and plates available to them are either green and blue or red sensitive, and therefore real-colour holograms have had to be made by matching two pieces of film together. However, Ilford has produced an experimental full colour holographic film which it allowed the IC researchers to use for the new system.

The connection between Raman scattering and colour holography was made by Dr Mike Damzen and Dr Kaveh Bazargan in this case, although it is thought that there is a earlier Russian paper which discusses the question. The actual work on the project was done by William McGuigan as part of an MSc in Applied Optics.

The hologram made at IC, which was not of very high quality, was a single beam reflection hologram of a human hand holding a credit card. It is now in the possession if Ilford.

The work was done in the summer of 1986 and the equipment has since been dismantled and redistributed to others in the Applied Optics group. There has been discussion about trying to get research council funding, but as yet no one in the group has found the time to make an application. At least £50,000 would be needed to properly investigate and develop this potential holographic "dream system".

A year has passed since the completion of this project but William McGuigan's results have still never been submitted to be published.

HOLOGRAMS IN SPACE

In July Holos Gallery of San Francisco, United States, completed a project for General Electric of the USA to make a hologram which could eventually be used to guide robots to space shuttles and orbital stations.

The hologram is designed to be viewed by the robot with a special arm equipped with a light source and video camera. The hologram is of a target which allows the robot to get its bearings and find its way to the door control which will let it into the spacecraft. The hologram has to be viewed and illuminated from the same angle, 90 degrees.

Initially Vince Di Biase of Holos Gallery, who helped design the hologram, thought the robot would be confused by the direct reflection of the light source obscuring the target image. General Electric, however, assured him that this would not be a problem and was proved correct: initial tests were very successful.

General Electric was apparently very pleased with the holograms and intend to patent this application of holography.

HOLOGRAPHY INSTITUTE MOVE

The Holography Institute has moved from Emeryville in Northern California, United States, to a more scenic location at Petaluma, outside the city.

The work of the institute is largely educational and includes courses for both children and adults. In April of this year a course was held at their Emeryville laboratory for students of the Berkeley campus of the University of California.

The new site will be more stable vibrationally as well as being less expensive than the city location. The Institute, which is run by Jeffrey Murray and Patty Pink, will now be able to offer residential courses to those interested in practical holography. The new address of the Institute is 423 Wilson Street, Petaluma, California, USA.

LASERSMITH LABELS

Steve Smith of Chicago, United States, now trading under the name "The Lasersmith", has just completed a contract to provide labels for bottles of jewellery cleaner and silver glaze.

Tarn-x, the manufacturer of these products, approached Mr Smith via its packaging company and decided to go ahead with a pilot project although The Lasersmith had never made Mylar holograms for labels before. An initial run of 50 000 labels for each product has been test marketed and Tarn-x has already asked for 100 000 more of each to be made.

The images on the labels show, respectively, a jewellery box overflowing with gold and gems and a silver tea set, each with the name of the product overprinted.

NEW NEWS

The first issue of Holography News described as "The International Business Newsletter of the Holography Industry" was published in September.

The newsletter is edited by Lewis T Kontnik and is produced in Washington DC in the United States. It will be published monthly, and its format of the first issue was six "legal" size pages of text. Holography News will be subscription funded and will cost $295 within the United States.

Further details can be obtained from Holography News, PO Box 9796, Washington DC 20016, USA.

POP PORTRAIT

David Byrne of the pop group Talking Heads and contemporary artist Keith Haring were immortalised holographically at the New York Museum of Holography's laser pulse studio in August.

These holograms will be part of the Museum's current exhibition "The Holographic Instant: Pulsed Laser Holograms" until the exhibition changes on October 23rd. These works were produced with a pulsed laser loaned by the JK Lasers Division of Lumonics Inc and the Museum claims that they are the clearest, brightest form of 3D portraiture.

The studio holographer was Ana Marie Nicholson of Holographics, Long Island City.

ONE WORLD

A hologram, designed and produced in Britain, may help ease hardship in the third world.

The "ActionAid" hologram was designed by Andrew Pepper and produced by Light Fantastic, using Agfa Gevaert Plates and a model by Albatross. All labour and materials were given free of charge, and the proceeds from hologram sales will go towards specific educational and agricultural projects in some of the poorest parts of the world.

The hologram is a white light reflection hologram of a globe inside a skeletal cube. It costs £145 and is available from Light Fantastic Gallery of Holography, 48 South Row, The Market, Covent Garden, London WC2 8HN, UK. Credit card holders can phone 01 836 6423/4 (+44 1 836 6423/4). For more information about ActionAid contact them at Hamlyn House, Archway, London N19 5PS, UK. Telephone 01 281 4101 (+44 1 281 4101).

NEWPORT WORKSTATION

Newport Corporation of the United States has introduced the compact model HC-1034 Holography Workstation designed for use in non-destructive testing and design evaluation.

The compact model is the latest addition to the company's range of holography workstations, and is intended for use where space is limited. Newport describes the system as fast, with high quality holograms being produced in ten seconds of objects up to 18in in diameter. The holograms are viewed with a built-in TV camera.

The workstation features the Newport Thermoplastic Recorder which should ensure "user-friendly" pushbutton operation. It is also completely self-contained as it includes a high-performance honeycomb optical platform and pneumatic vibration isolation system: no special facilities are required.

Other advanced features include console-operated motorised zoom and focus for precision under test. The system price is $50 975.

Further details can be obtained from Rudy Garza, Product Manager for Holography, Newport Corporation, PO Box 8020, Fountain Valley, CA 92728, USA. Tel (+1) 714 963 9811.

CONFERENCE CONTROVERSY

The "Third International Conference on Holography '87", scheduled to be held in Copenhagen, Denmark, this August, was cancelled. The Chairman of the Conference Board of Directors, Dr Teit Rizau, said that the cancellation was due to a municipal strike in Denmark shortly before the conference was due to take place. However, it is thought that few people were planning to attend in any case, because of reservations about the organization of the event.

Many holographers were unhappy that in order to attend the conference they would be required to submit a hologram which would be kept for special exhibitions by the conference organizers. Also, the resignation from the Board of Directors of Dr Tung Jeong, who was troubled about the lack of consultation between the organizers and himself, caused concern about the event. In addition, Dr Nils Abramson of Sweden, whose name was included on the list of Conference Directors, said that he did not give permission for his name to be used in this way.

It is now planned that the conference will be held in Denmark in 1989, with the 1988 conference being held at Lake Forest College in the United States.

HOLOGRAPHY DIRECTORY

A new edition of the Holography Directory, produced by the Museum of Holography in New York, will be published in November.

The publication, which was due to come out in July, is being edited by John Reilly. It will contain the names, addresses and of business interests of holographers around the world. It can be obtained from the Museum of Holography, 11 Mercer Street, New York, NY 10013, USA, at a cost of $50.

CRITICAL PERIOD FOR WAVEFRONT

"Wavefront", the holography journal associated with the North West Coast Holography Society (United States and Canada), will not be published again until June 1988 at the earliest.

The journal, edited by Al Razutis, has lost the funding it received from the Canada Council and has been unable to find any other sources of revenue for the time being. Mr Razutis explained that this was because those in a position to help "Wavefront" had been offended by various critical comments made in the last few issues, especially in a review of the Expotec Show in Montreal, and an article on holography patents.

Mr Razutis will be looking for industrial or other sponsorship in order to resume publishing the magazine in June.

SURVEY

Mass-produced holograms first came into the public eye in the early 1980s, when *American Bank Note Holographics* of the United States began to produce small, embossed holograms for credit card companies. To ABN it was a logical extension of their security printing operation, but it came at the start of an important stage in the development of holography.

Advances in production methods had made holograms relatively cheap and easy to manufacture, particularly where large numbers were required. Because they were very difficult to forge, however, the potential of holograms for use as security markings was quickly recognised.

To prevent counterfeiting, holograms have been applied to machine parts, perfume containers, video tapes and many other items. Bank books, high security bonds, ID cards and passports are also being protected by holograms, and most people regularly carry at least one hologram on a credit or cheque card. Holographic security marks have the added advantage of being easy to check, as well as being inexpensive and almost impossible to counterfeit.

The Holocopier from *Applied Holographics* of Britain is an example of a new generation of hologram production methods. It looks rather like a photocopier and has a microprocessor to guide the operator through the process.

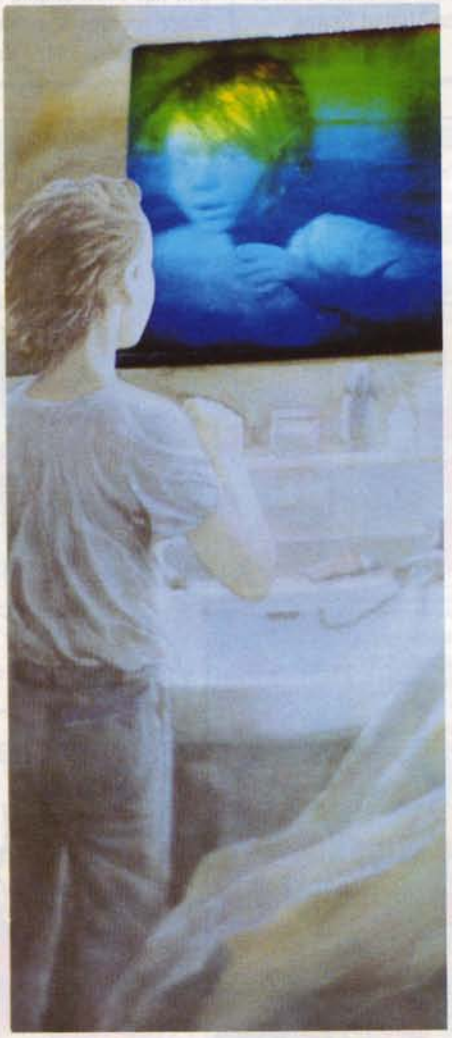
It was originally developed for sale to printers and studios. However, only two of the machines have been sold. Dr Simon Brown of Applied Holographics, explained, "We carefully control the transfer of information", ensuring that the security of hologram production is maintained.

The company uses its Holocopiers to provide a bureau service for its customers at a rate of up to 52 000 reflection or transmission holograms per copier hour. Among the best known projects they did using the Holocopier was a range of fantasy game characters, which were given away with *Nabisco's* Shreddies breakfast cereal earlier this year.

More recently, *Tonka Toys* have launched a line of action toys called "Supernaturals", centred around dual channel holograms. Applied Holographics made holograms which showed the good and bad characters Tonka had designed depending on the angle of illumination. A spokesman from the *Lesley Bishop Company*, which deals with Tonka's Public Relations, described sales as "absolutely amazing". These two projects look set to be the first of many, as holograms can now be produced at the same rate as the rest of the product.

Holograms are used in an increasing number of promotional displays and in packaging, thanks to their remarkable visual impact. Large plate holograms like those often seen in holographic galleries can form the centre of static display stands, as was demonstrated by a striking *Visa* promotion at Frankfurt Airport.

On a smaller scale, holograms can be incorporated into packets and hand-outs such as the German *Estee Lauder* advertising card where the glass part of the product container is replaced by starfoil. A well produced and designed hologram can, significantly improve sales of toiletries, food and similar items.



A scene from 'The Mirrorstone'.

Light Impressions, of the United States and Britain, have produced holograms for several companies, including *Kelloggs*, *Coca-Cola* and *Bassetts*, a confectionery company. These were included with products as free gifts in order to boost sales. Other holograms produced by Light Impressions have been used for products ranging from tote bags for luxury cosmetics to neck hangers for bottles of household cleaning fluid.

"Rainbow" holograms are particularly popular as their attractive range of colours catches the eye. Advertising company *S J Corbett* of the United States used this property of the hologram to attract doctors to a brochure for a new medicine that they were promoting for the pharmaceutical company *Upjohn*.

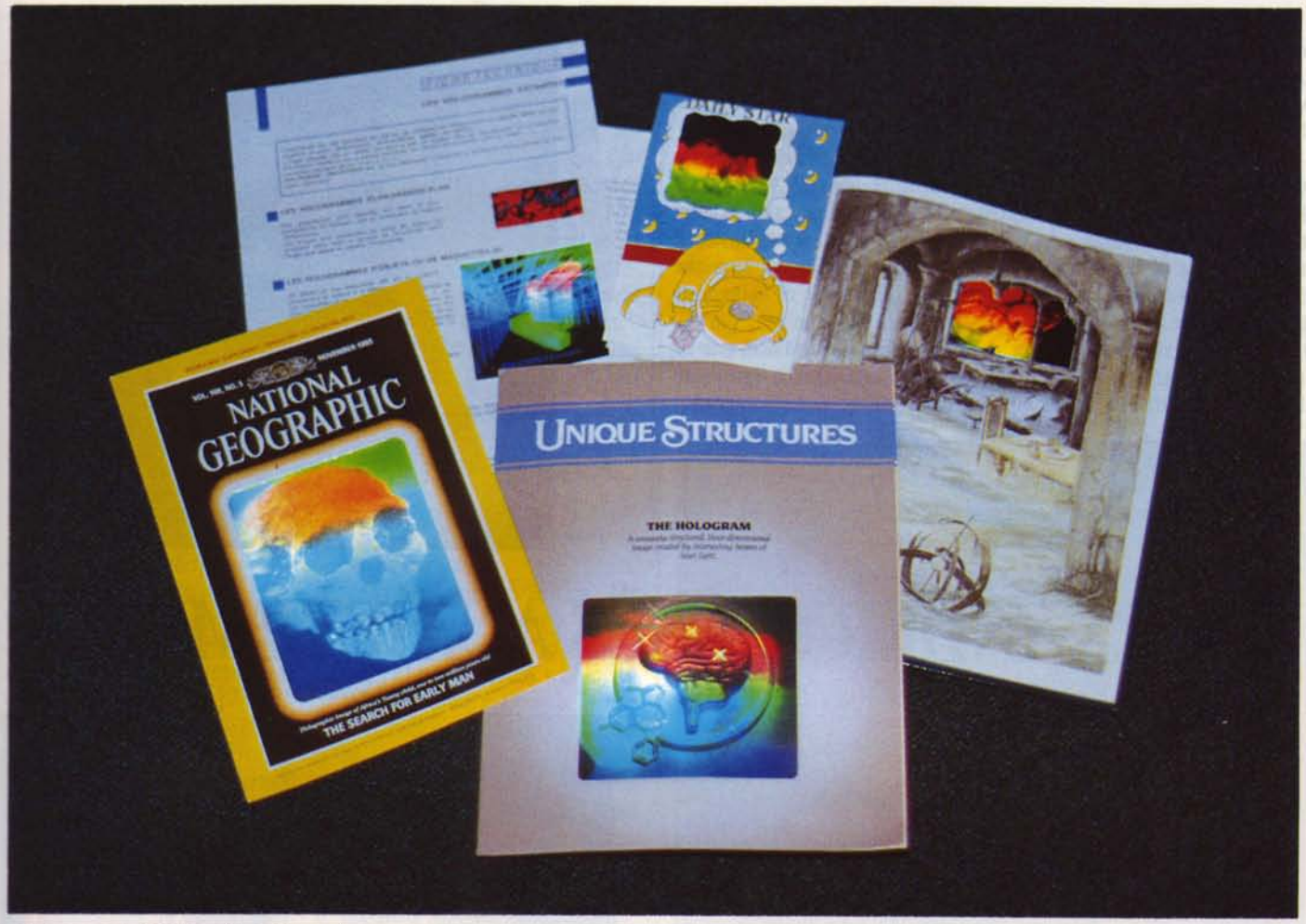
Bill Harrison, in charge of commissioning the hologram, said that they were quite pleased with the work that American Banknote produced for them. However, he does feel that some other holographic companies could improve their service as far as getting things done on time is concerned. Most companies, he said, were more efficient at selling than at providing the service.

Corporate identity can also be promoted using holography, by enclosing holograms in company reports and other literature or by incorporating them into 'executive gifts' featuring the organization's logo. Headed notepaper bearing a hologram has added impact and has been proven to increase response percentages in direct mail campaigns. However, a poor hologram can have the opposite effect.

As it became possible to make thin, cheap holograms, interest was aroused in combining holography and printing. In 1984, *American Bank Note* applied copies of an eagle hologram to the cover of the *National Geographic Society magazine*. The hot stamped rainbow hologram was 1/50 000th of an inch thick.

Since then many publications have carried holograms of increasing sophistication. Hot stamping is used in most cases where holograms are applied to publications in large quantities. As well as the economy of the process, hot stamped holograms integrate with the surrounding surface more successfully than pressure sensitive stick on holograms and they tend to be less shiny.

Holograms have now been used in advertisements in magazines and on the covers of



Holograms in Print: making the grade

numerous books. *Zebra Romance* novels are embellished by embossed holograms which have several interesting features. The main subject of each hologram is a model which appears to be alternately in sunlight and in moonlight, depending on the viewing angle. If viewed from below, as it would be if the book were on a high shelf, the words "A Zebra Romance" are shown.

Black Market, a thriller published by *Hodder & Stoughton* in September, has a cover hologram of a hand grenade against a New York skyline. The run of 100 000 holograms was produced by Light Impressions at their plant at Leatherhead in Britain.

A hologram on the cover of the *Penguin Books* novel, *Stone 588*, shows the diamond which is the subject of the book. The idea of using a hologram on the cover came from Penguin themselves but it was designed and produced in foil by Light Fantastic of Britain.

Penguin publicity agent Humphrey Price remarked that the project had been good value for money, although there were no plans to use a hologram on a book cover in the future unless it were particularly relevant.

Peter Woodd, Managing Director of *Light Fantastic*, described the current processes for applying holograms to paper as "cumbersome", and said that the company was researching more direct methods.

Mr Woodd's company also provided the holograms for the extremely successful children's book *The Mirrorstone*, which incorporated holograms in the illustrations. The book, which was written by Michael Palin, illustrated by Alan Lee and published by *Jonathan Cape*, was joint winner of the 'innovation' section of the 1986 *Smarties* Prize for Children's Books.

Viewing conditions and integration of the holograms with the rest of the illustrations were given very careful consideration by designer Richard Seymour. The result is an example of holograms in books at their best. The seven holograms were precisely positioned by *Blockfoil Ltd* and *Malvern Press* of Britain, who adapted their equipment to improve accuracy. To minimise costs, holograms for different pages were embossed together on the same sheet of foil keeping the cost of the holograms down to about 50p per book.

The general public's continuing fascination with the hologram has also created a growing demand for holographic novelties.

The many holographic galleries and exhibitions which have opened in many large cities usually sell a range of holographic novelties, including embossed stickers, jewellery, key rings, greetings cards, etc. as well as more expensive framed plate holograms. The travelling exhibition touring Canada, *Images in Time and Space* is accompanied by a "holographic boutique", operated by *Global Images* of the United States.

Although large companies such as American Bank Note will normally not consider orders worth less than $25 000, others may accept a minimum run as low as four hundred square small holograms, which would cost about 75 pence each. For larger quantities this would drop substantially.

Some companies have built up a range of stock holograms so that small users can buy off the shelf and avoid the origination costs of a custom-made hologram. Global Images, for example, claims to have one of the best selections, offering a number of different types of hologram including film, dichromate, embossed, stereograms, and computer-generated holograms.

Holography is becoming more and more widely used to promote, to decorate, and to sell. The industry is improving all the time, as professionalism catches up with technical advances and users realise that a good hologram requires a good model.

Pippa Salmon

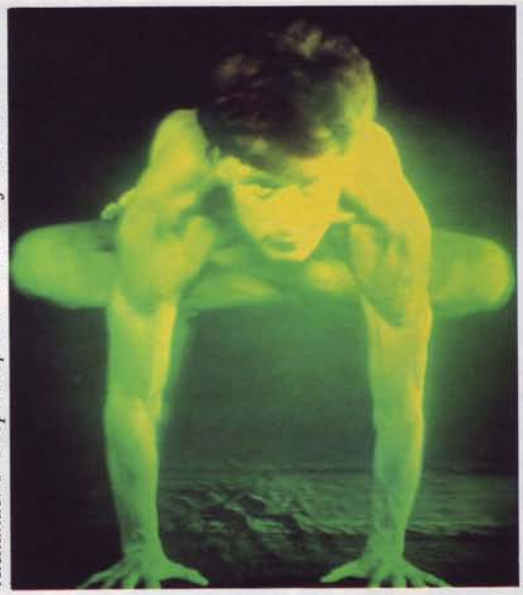
ALEXANDER SENSES ACHIEVEMENT

Alexander, the famous British sculptor and, more recently, holographer, is being featured at the new Power House Museum in Sydney, Australia. The museum commissioned Alexander to make holograms with the theme of "The Senses" which are thought to make up the largest ever commission of display holograms.

The museum is moving to a new building where 30 exhibitions on the history and creativity of Australia will be housed. Alexander's holograms will be placed in the first gallery of the first exhibition on the "Human Experience". As well as the five senses of touch, smell, taste, hearing and sight, the collection includes holograms on the "sixth sense" of intuition or awareness, and the sense of balance or proprioception.

Also this October, Alexander is representing Australia at one of the world's most important exhibitions of modern art, the Sao Paulo Bienale in Brazil. To this exhibition he is taking three holograms: "War into Peace 2"; "Freedom"; and "Final Gestures — Homage to Durer" as well as his second holographic film entitled "The Dream".

The new film, longer and more complex than his first film "Masks" will have it's premiere in Brazil and after that will move on to the Museum of Science and Industry in Los Angeles, United States.



Alexander's 'Proprioception' or sense of balance.

Scene from Alexander's new film 'The Dream'.

Tony Ennos

ENNOS JOINS ULTRAFINE

Ultrafine Technology, a London-based company offering optical inspection and testing systems, is now able to provide advice on the application of holography and related laser techniques to industrial measurement, following the appointment of Tony Ennos as a consultant.

Tony was formerly head of the Holographic Unit at the UK National Physical Laboratory. He will be giving applications advice to companies wishing to use holography for detecting faults in materials and components, as well as providing back-up to users of Ultrafine's holographic camera.

This camera is an ideal low-cost system for companies wishing to start using holographic testing techniques, says Ultrafine. Typical applications include measurement of the deformation of engineering components under stress, vibration analysis, and non-destructive testing.

Contact Ultrafine at 16 Foster Road, Chiswick, London W4 4NY, Britain. Tel 01 995 2303 (+44 1 995 2303).

FRANCIS GOES HUNGARY

Francis Tuffy, a Research Assistant working with holographic stereograms at Kingston Polytechnic in Britain, has been given a grant to work in Budapest, Hungary, for five months from October 1st under the supervision of Professor Greguss of the Applied Biophysics Department at Budapest Technical University.

Mr Tuffy first contacted Prof Greguss after reading some of his research papers, which were primarily concerned with medical applications of holography. They arranged to meet at Prof Greguss' lab where Mr Tuffy was impressed with the standard of the work and the quality of the holograms.

On his return to Britain, Mr Tuffy found out about a British Council scheme to give scholarships to postgraduates wishing to work in Eastern Europe. When approached, Prof Greguss agreed to supervise Mr Tuffy and the British Council agreed to fund him. He is on five months unpaid leave from Kingston Polytechnic until March 1988.

The work he will be doing in Budapest will apply some of Prof Greguss' work with panoramic lens systems to holographic stereography.

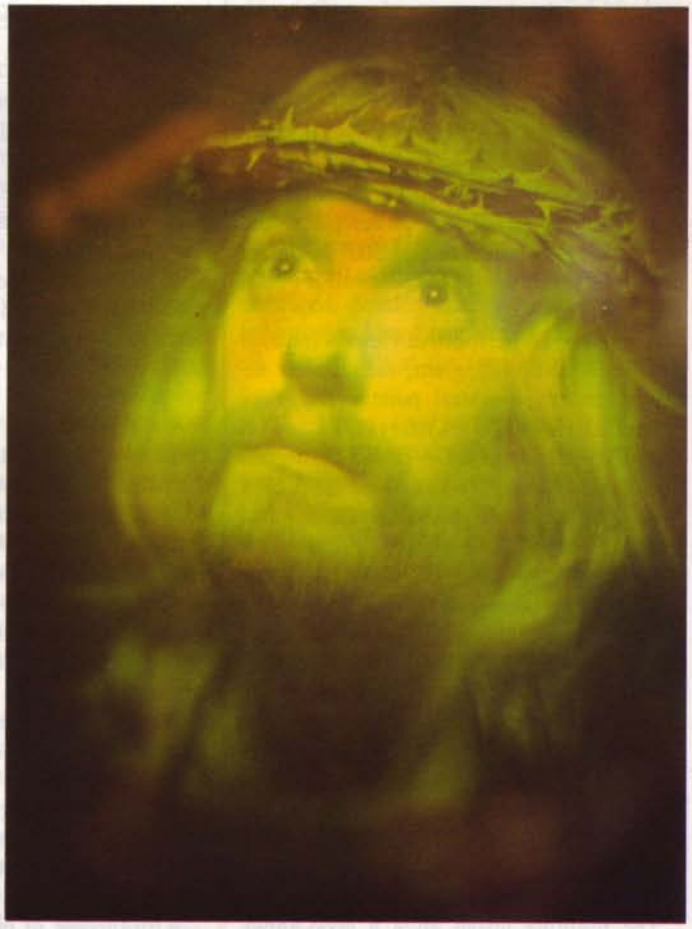
BELL RESOURCES PAULA

Paula Dawson, an Australian holographer known for her work with large objects, has obtained substantial financial backing to continue her work in display holography. It has been speculated that her benefactors may also be planning to set up a holographic research centre in Australia.

Bell Resources, a large Australian company, approached Ms Dawson in June, on the advice of the wife of the Chairman of their board of directors who had seen and appreciated her holographic work. According to Ian Wildy of Bell Resources, Ms Dawson will be given all the equipment she needs to pursue her holographic interests. There is, he says, no set budget, but she will receive whatever equipment she requires within the "limits of common sense".

When asked about the future of the company's involvement in holography, Mr Wildy said they hoped eventually to work in the "wide spectrum of holography", and they were especially interested in doing work in non-destructive testing. Although at the moment "Bell Resources Holographics" consists solely of Paula Dawson, there has already been collaboration between Ms Dawson and researchers at CSIRO, an Australian government research laboratory, including Dr Hariharan and Dr Hegedus.

On the subject of a holographic research centre, Mr Wildy was only prepared to say that this was an option that Bell Resources had open to them.



FLYING THE RED CROSS

Holodesign is a newly launched Swiss laboratory making large run film holograms and custom-made plate pieces, including multiplex works.

It is owned jointly by Geneva-based holographer Pascale Barre, and Simone and Malcolm Ford, who are in Basle. The Fords are possibly the only people wholesaleing holograms to outlets in Switzerland through their company Laserart Ford AG. They market a range of standard stock holograms in distinctive packaging.

Pascale Barre and his fellow holographer Michel Cardinale are flying the flag for holography in French-speaking Switzerland. They have a small retail outlet, Holos Art Galerie, in Geneva. In addition, they have made many custom holograms such as the one of Christ pictured above, for which Pascale himself was the model.

CHAD at CEGB

The production of holograms from computer-generated images could become a useful design aid as a step between perspective drawings on a flat screen and scale models, which are expensive and time-consuming to construct. Pioneering work in this field has been done by a team from Britain's Central Electricity Generating Board (CEGB), but a lack of enthusiasm from the Board's designers means that the extra funding to further develop the idea has not been forthcoming.

Of the various techniques which have been suggested for making holograms of computer output, the CEGB team chose the production of stereograms from a series of perspective drawings as the most likely method. Two demonstration holograms have been made, the first a rainbow hologram of the control room at the Heysham 2 nuclear power plant, and the second a laser-illuminated 360° hologram of the cooling circuit of the Sizewell B nuclear station.

A series of 24 perspective views were used for the Heysham hologram, each a view inwards towards a central point. They were horizontal views at 1.5° intervals around an arc. These drawings were copied onto glass photographic plates, which were held in a special jig to ensure the same relative sizes were maintained.

The master hologram was produced using a 20mW He:Ne laser. The beam was vertically polarized and split in a 15:1 subject:reference ratio. The subject beam was expanded and scattered by a ground glass plate placed against the drawing plate.

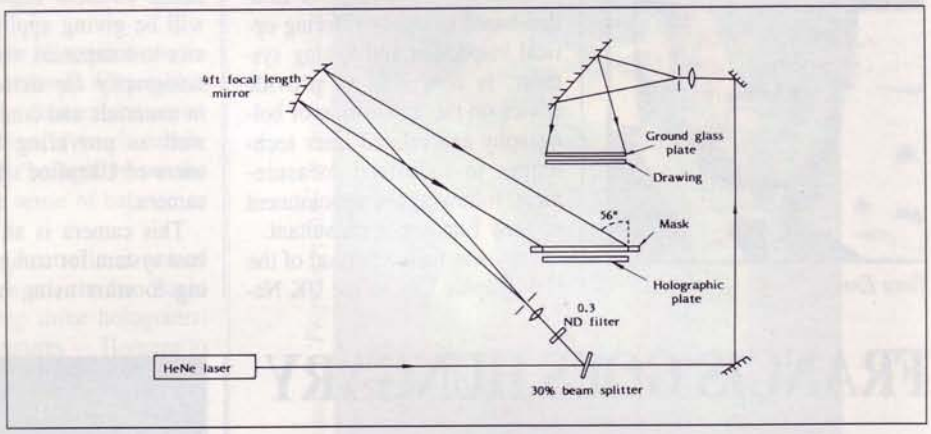
The mask slit on the hologram plate was horizontal and was moved vertically by its own width of 10 mm after each drawing had been exposed. Each strip was given a 50 second exposure, and the hologram was developed to a density of 3-2 and then bleached.

The resulting image gives a good three-dimensional impression, the CEGB team says, although it does rotate as the viewer moves his head from side to side. This is because the drawings were views from points on an arc, while the holographic plate is flat.

The team have made image-plane rainbow copies of the master for viewing in white light.

The more ambitious hologram of the Sizewell cooling circuit was set up as an octogon formed by 250 x 200 mm plates which the viewer can walk around to see the image from all sides.

A total of 224 perspective drawings were made, 28 for each holographic plate. To avoid large jumps in the drawing plane when moving from one holographic plate to the adjacent one, each drawing was rotated to face the centre of the strip to which it was exposed, rather than being held parallel to the holographic plate.



A pulsed ruby laser was used this time, to avoid earlier problems of movement during the exposure, which was reduced to 500µs. The laser was operated at near maximum output at fixed Q, giving pulses of 1.5J. The beam ratio was set at 27:1 reference:subject, and 9 mm slits were exposed to 28 drawings per plate.

A special viewing system had to be set up to illuminate the octagonal set of plates. A 20mW He:Ne laser was used together with a rotating mirror to scan the beam around the octagon. The laser was placed pointing vertically upwards in the centre of the octagon and the mirror was positioned above it in the roof of the display unit.

The team has identified a number of areas where their methods could be improved, but they believe their holograms have demonstrated that the remaining problems can be overcome to enable a useful extension of computer aided design to be developed. They have coined the term computer holographic aided design, or CHAD, to describe the process.

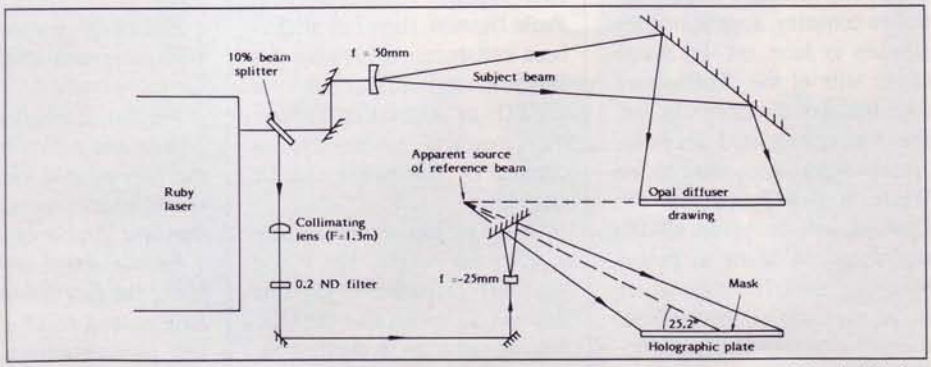
With the use of more sophisticated techniques and equipment they believe that the whole process could be carried out by a single machine linked to a computer. This could produce holograms on film very cheaply in under an hour, and copies in a few minutes.

This would require the use of an alternative method of producing the images of the perspective drawings, such as projecting them onto a screen, using a laser written erasable display, or even more futuristic devices like a liquid crystal display or a magnetic-optical device directly connected to a computer. These latter devices would eliminate the need for an intermediate photographic stage entirely.

The holograms produced have aroused considerable interest whenever they have been displayed, and the CEGB's Generating Design and Construction Division conducted a survey of its staff to find the likely demand for an engineered production unit should it be built. The response, however, was disappointing and the CEGB has now shelved work on the project indefinitely.

It would take about £1 million to develop a working prototype of a machine to produce holograms directly from computer-generated images, Dr. Bryan Tozer, the leader of the research team, believes. He now expects that another company will develop a similar system to that which he envisaged, even though two years ago his team was ahead of everyone else in this field.

This work, done at the CEGB's Marchwood Laboratories in Southampton, is described in a paper presented to the recent conference "Holographic Systems, Components and Applications" held in Cambridge from 10-12 September 1987, entitled "Holographic Display of CAD Output" by I.A. Armour et al.



Martin Taylor

LLOYD CROSS

Lloyd Cross came to holography from a physicist's background. As part of the Willow Brook research lab at the University of Michigan, he had been working with lasers since 1960, and ruby masers before that. Jerry Pethick was a Canadian plastics sculptor with a curiosity about holography. Lloyd made Jerry a hologram, and the rest, as they say, is history.

In 1968 they set up a sand-table in the basement of a building in Ann Arbor, Michigan, and with a krypton laser made 11 x 14in laser transmission holograms.

They devised the sand-box holographic camera together as a solution to the problem of vibration isolation. Fine, washed silica sand filled a large wooden box, mounted on cinderblocks. Partially inflated innertubes sat between the cinderblocks and sandbox, further isolating the system.

Expensive optical mounts were replaced by optics mounted on PVC pipe and placed in the sand. They began making holograms of hitherto unimagined quality. The word got out on campus and Emmet Leith and his colleagues came over to take a look at what they had to admit were the finest holograms they'd seen.

The Vietnam effort found Willow Brook doing serious R&D on laser guided bomb systems. Lloyd made his choice and ended up in Manhattan, first at the NY School of Music, then on to a theatre on Prince St in Soho. Kinetic krypton and He:Ne laser mandallas from sound graced the walls of the small theatres of New York.

From here, Lloyd made his way to golden California, to San Francisco, but first he took a brief stop off in Verde Valley, Arizona, with Peter and Ana Marie Nicholson. Holographic cameras were set up and pulsed holography explored, but Lloyd's mind was on stereograms. Here, among the red rock hills and oak creek canyons, he worked out the basics of multiplex holography.

To understand the impact of Lloyd's teaching in California, the aesthetic and cultural mores of the time, as well as the place itself, must be considered.

California lacks a deeply ingrained culture. The original inhabitants, the Indians, were a comfortable lot who took plentiful food from the land and sea. They were rapidly enslaved and decimated by European settlers. First to arrive were the Spanish, up from Mexico. They controlled trade and determined economic growth until Marshall yelled "gold" in 1848.

In the years after 1848, miners and settlers from the rest of the country and Europe poured in, while the Spanish-Mexican population continued to increase. The railroads imported the Chinese, and additional Oriental folks and Pacific Islanders joined the migration. Today, California is a multi-lingual, diverse and rich ethnic soup with only a brief group history and an easy custom of taking wealth from the ground.

At the time of Lloyd Cross' arrival, San Francisco (the City, as all her lovers call her) was an alive place full of powerful philosophies of life. The Beats with their unwashed poetry had opened things up; the hippies had added their music and space; a personal space where the exploration of consciousness was the norm.

We looked to New York as the centre of the art market of the early seventies. We listened to Andy Warhol, who told us the everyday object was art. The artist as voyeur, the artist as media manipulator, was just being born. Our search for truth had led us to science. We all wondered about technology. Hadn't artists always made art with the technology their contemporary civilizations had produced?

Into this clime came Lloyd Cross and Jerry Pethick. They got their City legs at the Exploratorium, the giant sensory emporium of science started by one of the Oppenheimer brothers, in karmic reparation for Los Alamos and Almagordo, before setting up holographic shop in the Mission district.

Here they rented space at Project One, a rental co-operative warehouse. Four sand-tables were set up, and a shingle proclaiming the School of Holography was hung on the door.

The first student to sign up, $7.50 registration fee in hand, was Lon Moore. Soon Lon, joined by other students, Gary Addams and Fred Unterseher, began teaching holography at the School. The school soon moved a few streets over to a warehouse on Shotwell St. The warehouse had formerly housed a white bread bakery, the smells of which still permeated the air.

Posters about town, a few newspaper articles and a tent at an art fair attracted students to the new school, the author among them. You could sign up for a weekend intensive holography workshop, or meet weekly for the entire sixty dollar six week long course.

The School of Holography during the days of Lloyd Cross was revolutionary in the development of holography. You did not have to be a physicist anymore to make a hologram. The stable table took it out of the physicist's laboratories and into the hands of the people. The holograms were brighter than the physicists' anyway. Expensive lab equipment was shunned; we were taught to explore refuse containers behind industrial parks for our components. People found lasers this way.

Lloyd Cross demonstrating one of his laser scan stars.

If the sand-table was the stabilizing mass in holography, Lloyd's inherent philosophies and enthusiasm were the inspiration. The atmosphere, the vibes, at the School were so intense; holography was what we had all been looking for. Not just holography as the end product; all creative paths to holography were embraced. Suddenly we were artists, using holography. Lloyd taught and encouraged us all. We all felt at the time that history was being made.

Everyone was very intent on making holograms. People wandered in off the street and were accepted. Exotic and wonderful people like Michael Kan were made so at home that they moved into the warehouse. People who had been thought strange all their lives were suddenly not just tolerated but accepted and encouraged. Great thoughts manifested, beautiful holograms and machines were made.

The School grew and larger sections of the warehouse were released. Eventually, as it evolved into the Multiplex Co, it was to cover 15 000ft² of the warehouse. People carved out cubby-holes to live in; under a tie-dyed parachute tent, Lloyd lived and perfected his system of multiplexing stereogram holograms. A business grew, its story worthy of a book.

People spiralled out of the School's labs and into their own basements and warehouses. Lloyd's students went out to spread the message of the whole image. Lloyd moved up the street. He worked out the equations and perfected his idea of an optical quality plexiglas liquid-filled lens. He worked on multiplexed stereogram solar tracking systems. He freelanced, built ever evolving stereogram tension structure cameras in Los Angeles and Japan, consulted in Sweden, and organised exhibitions in Australia.

Lloyd is toying with a new company name, maybe the Cross Holographic Camera Company of America, for the new mini holographic camera he's been thinking about.

Continued on page 29

ON THE ROAD

It's five in the evening on a hot day in early August as we pull out of our driveway in Sonoma County, Northern California. After days on the telephone, appointments have been scheduled with holographers in Southern California, and we are now following the California yellow brick road. The asphalt arteries speed us through the startling landscapes that are the everyday commonplace to Californians. We're off to see the wizards of holography.

We arrive in Los Angeles on the following day. LA originated as a series of neat little suburban towns. These grew in population and size, until today, Los Angeles is a sprawl of merged townships, each with a distinct culture, criss-crossed by freeways.

Our first call is in Van Nuys for a visit to Chris Outwater and Craig Newswanger of Advanced Dimensional Displays.

The first of their two industrial park suites houses their holography laboratory. This currently includes facilities for large format transmission stereograms with full in-house cinema capabilities. Two Newport tables, one 8x12 ft and one 10x16 ft, occupy a large portion of the lab. The smaller table stabilizes the computer controlled camera used to produce the stereogram masters. Copies are made on the larger table.

An optimum assortment of optics are from a variety of sources, including Newport, Jodon and the neighborhood surplus store. ADD has recently switched to the Coherent Innova series of lasers, including two argon lasers with a 5W single mode output, and a krypton with a 1W TEM_{00} output in the red line.

The second suite houses the offices, showroom, and a smaller R&D holographic camera. We are in the second office of this suite, watching Craig Newswanger's holodiscs rotate. An 8in diameter reflection film hologram of "Lovely Rita" slowly undrapes her robe below the shoulder as she rotates through 360 degrees.

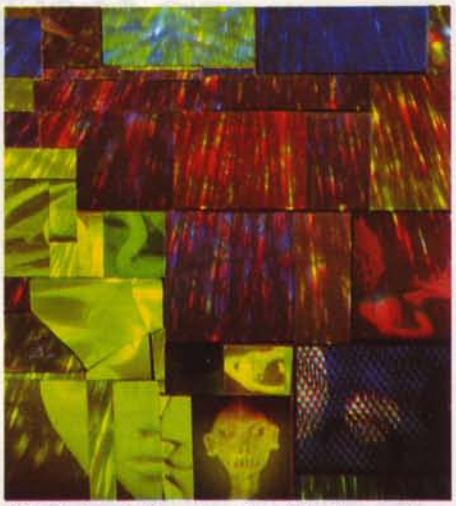
The holodisc rotates on a turntable with the illuminating light above the centre of the hologram. Rita is image-planed half out of the film surface of this reflection stereogram. Computer animation geometric figures convolute and evolve in another Holodisc. Mach 8 jet planes rocket into space in a third.

Craig, 34, Vice President of ADD, is full of enthusiasm about plans for other Holodisc images. The enthusiasm is inspiring to us, as it already has been to Hasbro toy manufactures and other clients. These Holodiscs are the first holograms I've ever seen that approach fulfilling science fiction fed public expectations of the medium.

Christopher Outwater, President of ADD, walks into the office. Chris first read about holography in Scientific American in 1966, when he was 17. He began trying to make holograms in his garage, reading everything he could find about the medium. After nine months of trying, he made his first hologram.

During these garage holographic days and later, Chris worked with Eric von Hamerveld. Chris and Eric eventually wrote a book together, "A New Guide to Practical Holography", published by Pentangle Press of Beverly Hills in 1974.

Chris paid his dues as a holography instructor at the University of California at Los An-



"Yog's First Adventure" multicolour reflection hologram composite by Nancy Gorglione.

ABOUT THE AUTHOR

Nancy Gorglione was a student at Lloyd Cross' school of holography in San Francisco in 1972, before setting up a holography lab in a basement with Lon Moore and Randy James, modestly called "Celestial Holograms".

However, the colourless limitations of holography at that time made the study of Jazz look like more fun, and she did this for the next few years. She made stained glass windows for a living, which lead her to the study of vacuum deposition of thin films. She also directed "Laser Affiliates", whose laser light performances were aimed at the synchronisation of light, sound and motion.

Vacuum deposition and laser light shows led her back to holography, where there was now colour. She taught holography at a couple of Universities, and as a California Artist in Residence.

Now she likes to compose large pictures with reflection holography. These have recently been one-of-a-kind, multicolour reflection hologram composites fashioned of glass plates mounted together. Although she didn't know it at the time, the last ten years have, she says, been a University to learn to make these pictures. Colour relationships within the hologram composites, spatial arrangements and repetition of images are all based on Jazz patterns.

Her husband, Greg Cherry taught himself holography in 1977, reading everything he could find, and experimenting. He was, in his own words, a hobbyist holographer. His background in metals technology and prototype model building for th Californian electronics industry found him making spatial filters, spin coaters, overhead mirror mounts and computer integral machinery for fun.

He set up a table in his garage in Novato, then moved to Sebastopol in part for the underground basement. His hobby of holography began to look like a business as his holograms found buyers.

Now they have a small lab dedicated to reflection copies with a 4x6ft cinderblock with an OEM 30mW He:Ne laser. They painted a steel top on the grid for ease in recording set-ups and eventual computer optics control. Spin coaters, used in triethanolamine colour control, line on a bench in the front of this lab.

The rest of the laboratory was built when they first started living together. They divided the 900ft² basement into a darkroom and master camera room. The concrete camera's isolation table measures 5x9ft. An 18in overhead collimating mirror allows a wide angle of view in the finished holograms. They master with a hybrid small frame Argon laser, and make large reflection copies with a 50mW He:Ne. They are currently developing a third camera to explore large format transmission holograms.

When they married in 1985, they started the Cherry Optical Company.

Current products include three lines of glass plate holograms, open and limited editions, and one-of-a-kind holographic composites. They sponsor touring exhibitions and permanent installations of their holograms.

They recently installed a permanent holographic display at Lawrence hall of Science in Berkely, a museum running a full time children's science educational programme. Their display has examples of 24 different types of holograms with illustrated text. It also includes a working 4x4ft holographic table which they made.

geles Extension from 1972 to 1982. During this time he also worked for Laser Images Inc. Laserium, doing holographic research and making holographic diffraction gratings for laser scanning effects. While at Laser Images he met Craig, an electro-optics engineer.

As holographic consultant for a Walt Disney Enterprises subsidiary, Chris was responsible for a programme to use holograms in various Disney activities. He eventually developed a holographic lab at Disney over a period of five years, which became the mainstay of ADD in 1983.

Currently, Chris and Craig are helped in the darkroom by holography technicians and brothers, Kevin and Rick Rankin.

We move into the next room, a high-ceilinged warehouse that serves as showroom for ADD's rainbow stereograms. These stereograms present a refined evolution of Lloyd Cross' multiplexes, impressive in sizes up to 32x70in. They are clean and bright, with little, if any, visible movement within the vertical slits that compose the holographic movement.

With clients such as Kray Research, Burroughs Corporation, MIT and NASA, ADD's stereograms often include sophisticated computer animation, which lends itself to smoothly animated multicolour motion.

Images reflect the gamut of ADD's clients, from a computer animated Toyota with rotating engine, to a beautifully registered multicolour animated version of a General Electric power plant. Chris and Craig's laser light show background is obvious in the multicolour stereogram "Explosion", composed of fine-edged and swirling laser diffraction patterns.

ADD is gearing up a mass production reflection copy factory, and is involved in a five person partnership which is opening a new holographic gallery in the Los Angeles Museum of Contemporary Art. The first exhibition, scheduled to open in December, will feature commercial and fine art holography from a variety of holographers. Partners include Gary Zellerbach from Holos Gallery in San Francisco.

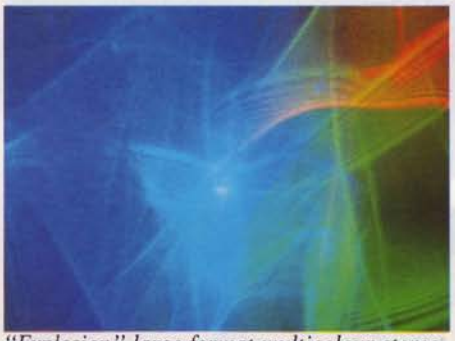
Soon we are moving on to Bob Hess' apartment holographic studio in East Palo Alto. We are in the heart of Silicon Valley, major manufacturing seat for computers, related electronics and integrated circuits. Coherent, Spectra-Physics. Lexel, and Linconix all maintain company headquarters and manufacturing plants here for their laser products.

Inveterate shoppers can find the rare laser or optics bargain at the beckoning surplus stores, giant warehouses with shelves stock full of dusty components and equipment. Bob Hess found a like-new Spectra-Physics 15mW He:Ne laser for $1250 at one such store.

We pass the NASA/Ames Research Moffitt Field giant aircraft hangers and wind tunnels. Bob Hess' apartment is now visible from the freeway. It is part of a beehive complex of brick buildings housing approximately 250 apartments. This provides consistent holographic stability for periods of up to 15 minutes for masters.

His reflection copies have typical exposure time ranges from 1.5 to 7 minutes, with no rejects because of movement. Although the nearby freeway provides an ever-present low drone, the only movement problems are caused by the beat resonance from prop planes which take off and land at the nearby Moffitt Field.

Bob's apartment is a home subservient to its function as a holography lab. The master bedroom/bathroom suite houses his two stable tables and darkroom. Both tables are 4x8 ft, basic refined Lloyd Cross-Holography Handbook cinderblock and treaded rod design.



"Explosion" large format multicolour stereogram by Craig Newswanger of ADD.

One table has ⅜in cold rolled steel top with magnetically mounted optics, while the other has a Newport breadboard top with tapped holes which Bob uses to screw down his optics. An 18in collimating mirror allows Bob a wide angle of view in his finished holograms.

The bathroom shower has been modified to serve as a powerful squirrel fan-powered laminar flow hood. Darkroom trays on modified bathroom countertops hold basic reflection processing chemicals of stock Kodak D-19 developer and Nick Phillips' PBQ bleach. The other bathroom shares shower functions with a triethanolamine resting bed. There is a drill press in the kitchen.

Bob initially taught himself the theories of holography, then took a course, "Measurements in Holography", at the two year Associate Avocational School at Vincennes University, Indiana. He moved to Palo Alto in California in 1981 to be close to a community of holographers, to Holos Gallery and to Spectra-Physics, where he began work three weeks after moving.

Eventually, the success of Bob's stock and custom holography freed him from the job at Spectra-Physics. His company, Point Source Productions, produced thousands of 4x5in image plane reflection holograms in a lucrative contract for the Sharper Image. Currently Point Source Productions copies its stock images "Mask", "Boris", "DeRailleur" and "Eye", which are distributed through Holos Gallery in San Francisco, and Another Dimension in Connecticut.

Back in Northern California, I have an appointment to visit John Kaufman in his Point Reyes holography studio. It is a big jump up a steep hill to John's studio. The house is small with a high ceiling and a view of such space and peace and privacy that I'll tell you no more about it.

After welcome and conversation we remove to the downstairs holographic studio, where everything is consciously placed and arranged in artistic compositions. Old and famous objects, shadow puppets, bones, rocks. The isolation table is a Lloyd Cross variant, 4x6 ft sand-table, with collimating mirrors and a Spectra-Physics 124B 15mW He:Ne laser.

Across from the sand-table, John drapes a piece of black velvet, a fitting backdrop for the scintillating coloured jewels that are displayed one at a time. John seems to work in several basic styles, each of which has produced one or more series of artworks.

His shadowgrams are straight reflection holograms that use diffusion screen lighting. He makes multiple reflection exposures, each with trieth/camera and object change. The resulting holograms are of rich and complex mixed colouration and composition.

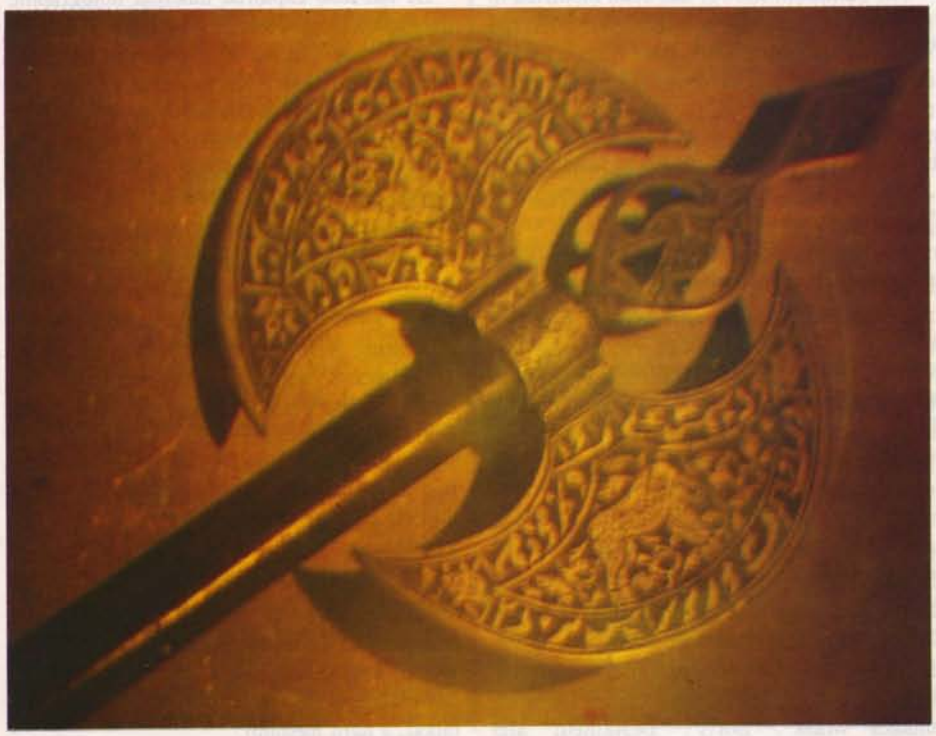
John is perhaps best known for his "Rock" holograms. These multiple exposure image plane reflection holograms make sophisticated play with texture and plane. Through shadowy and specific lighting of certain areas of the rocks during mastering, John is able to produce overlapping and fragmented rock compositions which result in much bold and subtle mixing of colours.

He has also explored inherent holographic movement in his pieces. Through registration of two masters of the same object in the copy, one master of which had movement, John was able to produce interference fringes. In viewing the cop, the two different colour exposures produce a third colour that moves with the fringes.

The various holographic techniques he uses have in common an exceptional exploration of pseudo-colour control in reflection holography, a term that he coined to describe his processing techniques with triethanolamine. This process, with subtle variations, allows the holographer almost a full palate of colours from which to choose.

I'll end this brief tour here for the moment. But what of Lon Moore, Don Broadbent, Eric von Hamerveld, David Schmidt, Sharon McCormick, Anait, Allen Shapiro, Jeff Murray, not to mention Steve Provence, Steve McGrew and Randy James? They are alive and well and California holographers all, worthy subjects of a separate story.

We all continue in holography, once in the blood, a hard medium.



To the left are photographs of an exhibition of holograms of Ukrainian artifacts at the Museum of Holography in Paris. By making holograms of the museum pieces, people around the Soviet Union and the world are able to see the collection without any risk of damage.

Above and to the right are two holograms by holographer John Kaufman whose one man show of recent multi-colour holograms opens in November at Holos Gallery in San Francisco, California. This latest show will be his fifth at Holos, a record for the gallery.

John Kaufman first studied holography back in 1974 with Fred Unterseher and then with Lon Moore in 1975 and 1976. Up until then his medium had been photography. In 1980 he showed his first multi)colour reflection hologram and he has been developing his own colour style ever since.

He is most famous for using pseudocolour, ie. using triethanolamine to swell the plate emulsion. The wider fringes reflect different frequencies of light which we perceive as colour.

The hologram shown above is called "Split Rock" and was created earlier this year. The reddish colouring of the inside edges are intended to give the feeling of a wound.

To the right is a hologram called "Spring Rain". Made in 1986, it is an example of the most skilled use of pseudo-colour.

If you are planning an event or exhibition which you would like to be listed in our next issue (Jan 17th 1988) please send us all the relevant details no later than December 1st 1987.

CALENDAR

October 17th — November 28th 1987
The Interference Fringe Gallery of Toronto, Canada, presents "Big Stuff", a collection of holograms by John Perry. The large-format holograms were produced for large corporate clients — including AT&T, Pontiac and Tonka — at Holographics North in Burlington, Vermont, US. For further information phone (+1) (416) 535 2323.

October 23rd 1987 — February 7 1988
The Museum of Holography in New York, US, is showing an exhibition on "Californian Holography", curated by Nancy Gorglione. The exhibition will include, among others, works by Lloyd Cross, Bob Hess, John Kaufman, ADD, Greg Cherry, and Nancy herself. For opening times etc. phone (+1) (212) 925 0526.

October 25th-30th 1987
The "First International Symposium on Industrial Uses for Holography" will take place in New Mexico State University at Las Cruces. For information contact Larryl K Matthews, NMSU, Mechanical Engineering Department, Box 30001, Las Cruces, NM 88003, US.

November 16th-20th 1987
The "International Symposium on the Technologies for Optics" in Cannes, France, will include a technical programme on "Real Time Processing, Concepts and Technologies". Telephone (+33) 1.45.53.26.67.

November 19th 1987 — February 28th 1988
John Kaufman's fifth one man show is presented at Holos Gallery, San Francisco, US. See Preview. For more information, contact Gary Zellerbach at (+1) (415) 861 0234.

December 5th 1987 — End January 1988
Works of the six artists who participated in the 1986 Fringe Research Artist in Residence Programme are exhibited at the Interference Fringe Hologram Gallery in Toronto Canada. For details phone (+1) (416) 535 2323.

January 10th-15th 1988
"O-E/LASE '88", which will take place in Los Angeles, US, will include sessions on "Computer Generated Holography", "Holographic Optics, Design and Applications", and "Practical Holography III". Phone (+1) (206) 676 3290.

January 31st — February 5th 1988
SPIE present "Medical Imaging II" at Newport Beach, California, US. For information phone (+1) (206) 6763290.

VIGNETTING

One of the most stunning effects in holography is the projection of images in front of the hologram plane. An easy way to produce such an image is to make a conventional off-axis hologram and to look at the pseudoscopic (inside-out) image by flipping the plate through 180 degrees. The image is then seen in front of the hologram. In general, however, we want to produce a normal-parallax or *orthoscopic* image projecting into space. There are two ways of doing this — in one step and in two steps. In the one step case a conventional optical imaging system is used to form a *real* image of the object, which is then used to form the hologram. The imaging system may consist of lenses or mirrors, or a combination of both. Fig. 1 shows a simple arrangement for producing such a hologram. The disadvantage of this technique is that the field of view is usually very small — ie. the image can only be seen from a narrow range of viewing positions, although there are tricks that can be used to improve the result. The more usual way of producing a projected orthoscopic image is to use a two-step technique, via a *master* hologram.

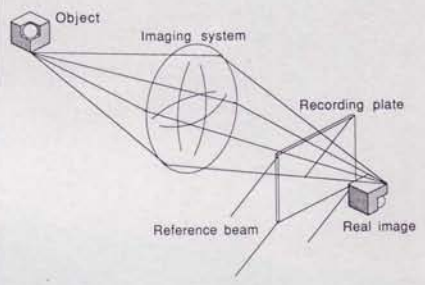


Fig. 1: Producing a one-step projection hologram.

Recording a two-step *projection* hologram

Let's suppose that the master hologram is recorded with a collimated (parallel) overhead reference beam, as shown in Fig. 2a, and that we want our final hologram to be a transmission one. (The discussions below apply equally to reflection transfers.) To make the transfer hologram (H_2), the master (H_1) is illuminated with the *conjugate* of the original reference beam, ie. every ray is reversed in direction. In this case the conjugate beam is another collimated beam (Fig. 2b). The result is an undistorted but pseudoscopic image projected into space. We now place the plate for the transfer hologram so that the projected image lies in between the two plates. A second collimated beam is used to record H_2.

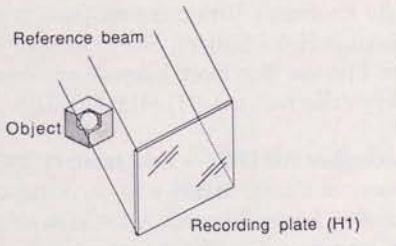


Fig. 2a: Recording a master hologram.

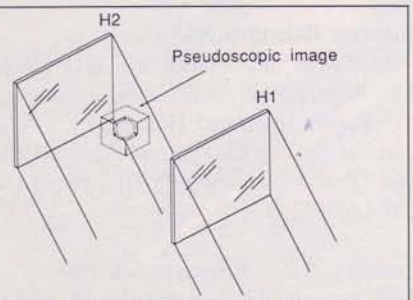


Fig. 2b: Recording a transfer hologram.

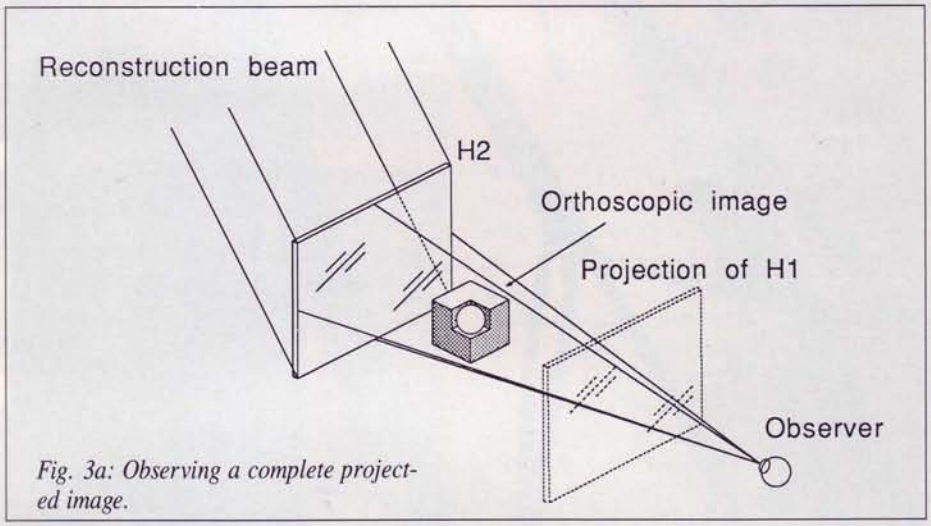


Fig. 3a: Observing a complete projected image.

To view the final hologram, we illuminate H_2 with the conjugate of the second reference beam. For simplicity, let's assume that the final reference beam is from a same laser source. Fig. 3a shows how the final image is observed. The image seems to float in front of the hologram, and if all stages have been completed correctly, the image is sharp and undistorted (and hence realistic). The image reconstructed with this technique is not visible from all angles. Here is the rule that determines whether a point on the image is visible ot not: in order for an image point to be visible, the observer's line of sight (ie. the straight line passing through the eye and the image point) must intercept H_2 as well as the projected image of H_1. Figs 3a and 3b show the image being observed from two different positions. The four lines indicate the field of view available. It is clearer to look at the scene from above and to consider the horizontal field of view — Fig. 4. In Fig. 4a the whole of the image is visible, because the line of sight for each image point intercepts both H_1 and H_2. The shaded area signifies the *viewing zone* or the area in which image points are visible. When the observer moves from the central position — Fig. 4b — the field of view is narrowed and some points in the image lie outside the viewing zone. In our example, two portions of the image have been cut off. More specifically, one portion has been cut off by H_1, the other by H_2. As we shall now see, there is an important difference in the visual perception of the two truncations.

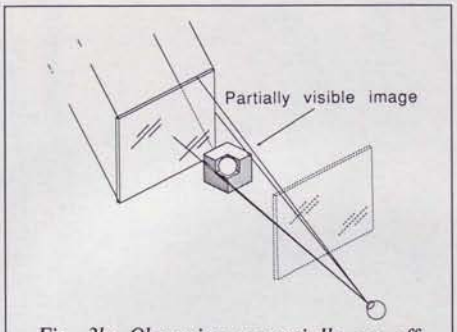


Fig. 3b: Observing a partially cut off projected immage.

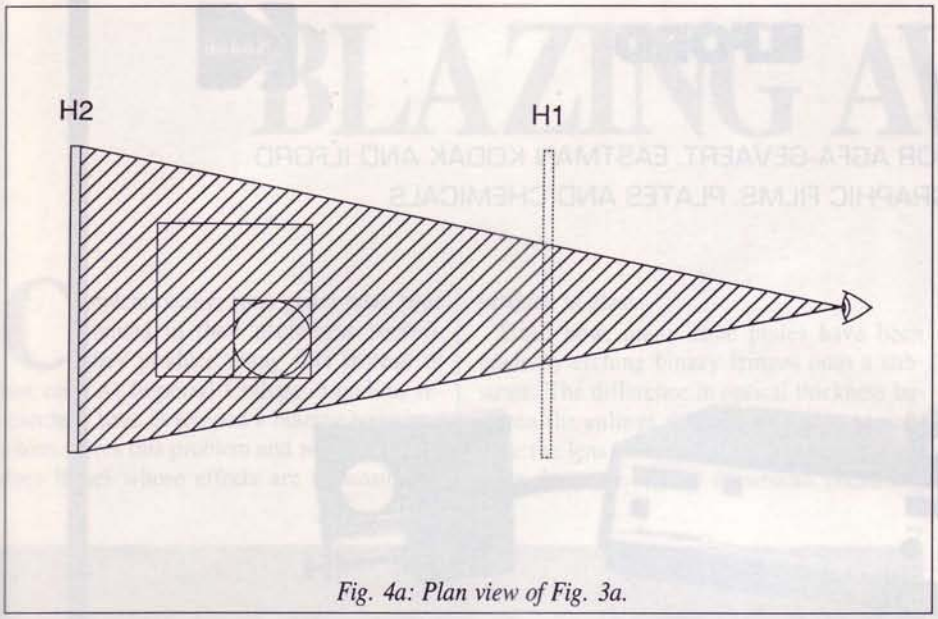


Fig. 4a: Plan view of Fig. 3a.

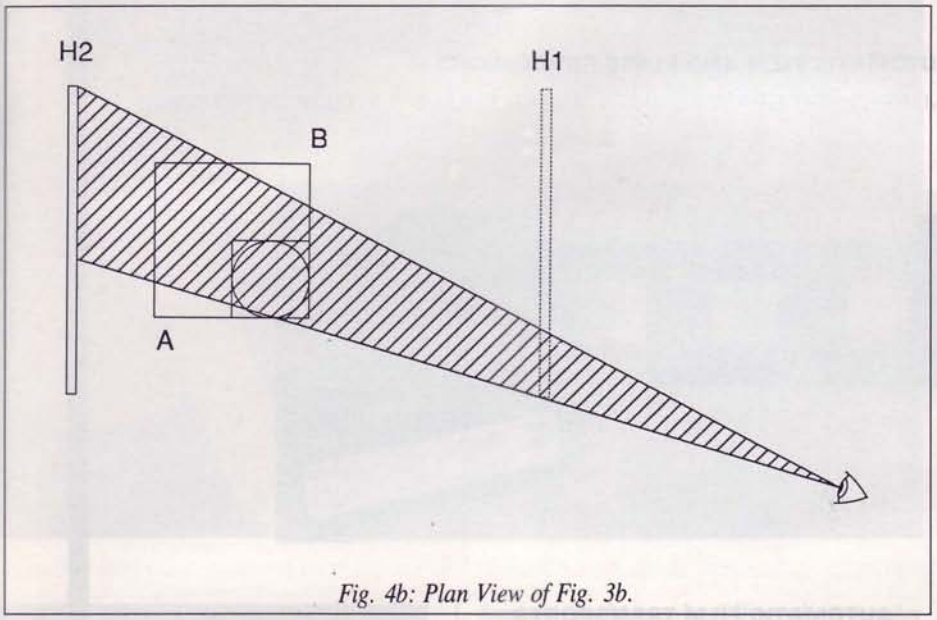


Fig. 4b: Plan View of Fig. 3b.

Vignetting

Let us first look at the left cut-off portion, A. The image is bounded by the edge of the projection of H1. The observer doesn't normally find this effect disconcerting, because it is analogous to an object being viewed through a window in an opaque wall — from certain positions only a portion of the object can be seen. The parallax properties of the two situations is identical, so the brain is happy interpreting such a cut-off. Let's now look at the other cut-off portion (B). This time, the image is bounded by the edge of H¼ which lies behind the image. We can say the image is *vignetted* (not strictly correct, but close enough).

The brain has a hard time interpreting this situation, because it has no analogue in real life — if a window lies behind an object, its edges can't possibly have any effect on the visibility of the object.

When the brain tries to interpret a 3D visual image, it looks for different *depth cues* to work out the relative positions of the parts of the image. Examples of well-known depth cues are *stereopsis* — slight differences in the images as seen by the two eyes, *accommodation* — focusing of the lens on the image point, and *parallax* — changes in the image appearance as the observer moves. It seems that vignetting is a particularly strong depth cue, and can override the other depth cues, particularly if two or more edges of the image are cut off. In other words, a projected image can be perceived to be just behind the hologram plate even when all other cues suggest that it is in front. It is no good trying to convince a casual observer that the image is actually being projected six inches in front — if he (or she) says it's behind the plate, then that's where it is!

So, it seems best to try to avoid vignetting. The permissible volume for a projected image can be ascertained by the construction shown in Fig. 5 — a line is drawn from each corner of H_1 to the opposite corner of H_2. If the image lies within the shaded volume, then it is always cut off by H_1 before H_2 has a chance to get in on the act, therefore the image is never vignetted. In this case the two plates have the same size and therefore the four lines meet at one point in space. Fig. 6 shows the corresponding construction for a rainbow hologram in which case the master is a strip hologram. When making a hologram as described here, it is best to sketch out the set-up all the way to the final hologram, and to make sure that the image always stays within the allowed volume. It is often preferable to work 'backwards', ie. to decide on the exact requirements of the final hologram, and work back to geometries to record H_1 and H_2.

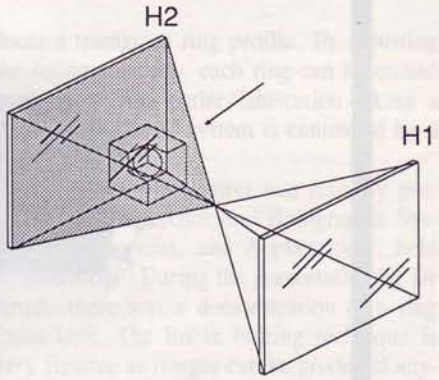


Fig. 5: Permissible volume for the object to avoid vignetting.

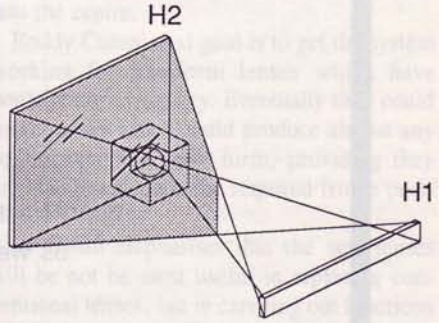


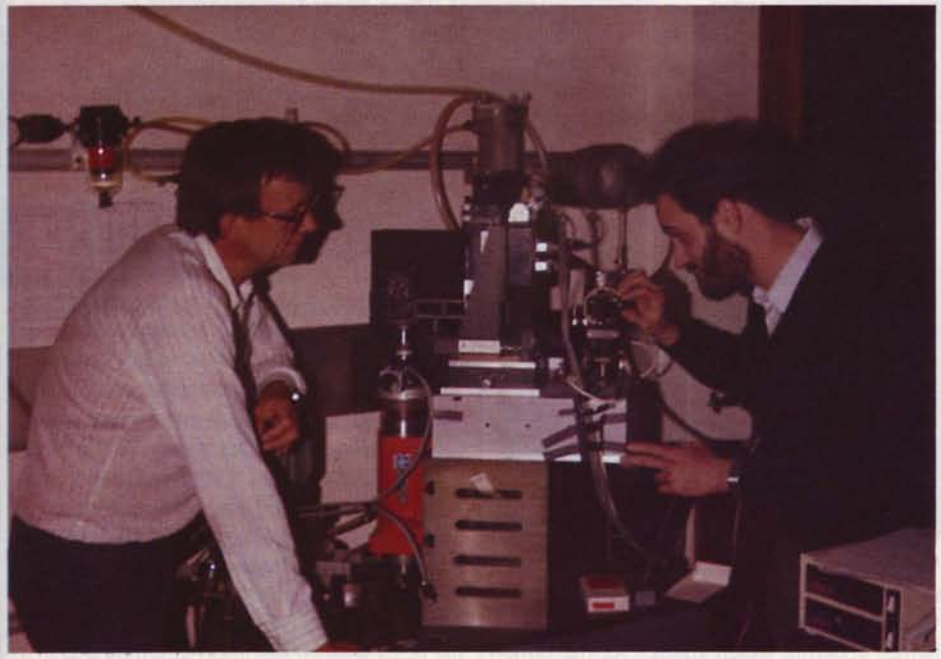
Fig. 6: Permissible volume when recording a rainbow hologram.

Dr Kaveh Bazargan

BLAZING AWAY

Conventionally, zone plates have been limited in their usefulness because they produce many foci instead of just one. At Imperial College, London, researchers have developed a blazing technique which solves this problem and which can produce lenses whose effects are impossible to produce in glass.

Until now, many zone plates have been made by etching binary fringes onto a substrate. The difference in optical thickness between the rulings diffracts the light to produce the lens effect. The binary pattern zone plate, however, has its drawbacks because it does not produce an undiffracted zero order as would be required from a lens, but rather it ideally diffracts about 80% of the incoming light into the first order points.



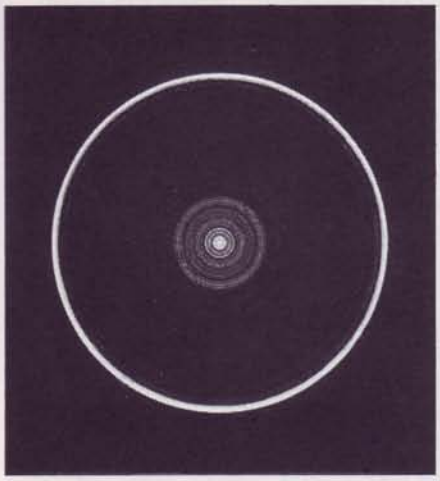


Figure 8: Typical ring focus produced by above element. The ring focus is 5mm in radius, the same as that of the wide ring of the diffractive optical element. The element has zones from 1.5mm to 8.5mm radius. No zones were written within the central region.

Ideally, the profile for the zone plates should not be binary but parabolic (shown). Neil Emerton, who started this project under the supervision of Dr Robin Smith, and Roddy Canas, who took over the project from him a year ago, have approximated this ideal parabolic blaze to a linear one, and have shown that this approximation becomes increasingly accurate as the number of fringes or zones is increased.

In order to etch these zones, the IC system uses razor blades to make a triangular aperture through which a light source shines onto a photoresist which is being rotated on an axis. At positions which correspond to the base of the triangle, the exposure to the light source is longer and therefore more of the photoresist is removed. Closer to the top the exposure decreases and so less of the photoresist is removed. Each such exposure produces a triangular ring profile. By adjusting the set-up correctly, each ring can be etched in this way, the entire fabrication taking a few hours. The IC system is controlled by a microcomputer.

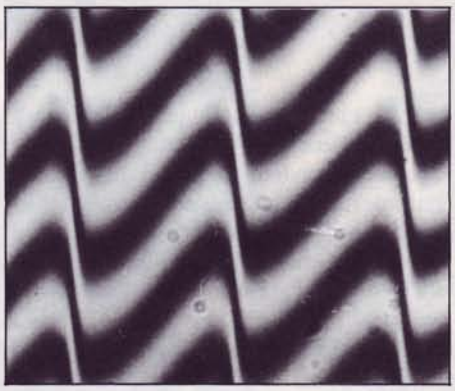


Figure 6: Interference micrograph of a typical blazed element.

A paper on this subject was recently presented to a conference on "Holographic Systems, Components, and Applications", held in Cambridge. During the presentation by Dr Smith, there was a demonstration of a ring focus lens. The linear blazing technique is very flexible as fringes can be produced anywhere on the plate with any thickness. For the ring lens, the widest zone was positioned in a ring at some radius from the centre, with narrowing rings being etched on either side, ie. out towards the edge and in towards the centre. The resulting lens gave the ring focus as shown. Due to limitations of the system, it was not possible to etch zones all the way into the centre.

Roddy Canas' next goal is to get the system working for kinoform lenses which have non)circular symmetry. Eventually they could make lenses which could produce almost any sort of complex wave form, providing they are able to calculate the required fringe position.

Dr Smith emphasises that the new lenses will be not be most useful in replacing conventional lenses, but in carrying out functions which they cannot. They can also be used to test whether complex wave forms from aspheric optics are the complex waveforms which were expected.

Neil Emerton was and Roddy Canas is supported by Science and Engineering CASE Studentships and Pilkington PE Ltd, UK.

Sunny Bains

UNITING THE SLICES

Researchers at Imperial College of Science and Technology, University of London, are applying volumetric multiplexing techniques to medical, astronomical and biological data to produce full parallax dispersion compensated holograms.

The work was inspired by Mr Lawrie Wright of the Royal Sussex County hospital and was initially taken up in 1983 by a private company called "New Holographic Design" (subsequently "Icon Holographics"). Eventually the project moved to Imperial College where it received SERC funding under Professor Chris Dainty.

The project which is currently being led by Mr Stephen Hart, involves the use of CAT, MRI and Electron scans etc, ie two dimensional data, which are holographically laid on top of each other allowing for a gap between the slices. The holograms are produced using a collimated reference beam and are played back using a viewer designed by Dr Kaveh Bazargan.

The viewer compensates for the fact that the different wavelengths in white light will be diffracted by varying degrees when they pass through the hologram, thus causing the colours to spread out. An HOE in the viewer pre)spreads the beam so that the hologram placed on it simply recombines the coloured light to produce a black and white image.

The collimation of the reference beam allows the final hologram to have full, undistorted vertical and horizontal parallax. This is obviously an important feature of a hologram to be used for scientific purposes.

The rig basically consists of a split beam transmission set up with the object beam projecting a slide from a slide projector. As each slice is added, the screen moves to the correct distance from the recording plate, therefore adding the third dimension. The exposures for each slice are ramped to ensure equal brightness. A copy hologram or H2 is taken of the master, using collimated object and reference beams. This is done in order to increase efficiency and can also bring the object image closer to the viewer.

The data which have been processed using this multiplexing technique have been quite diverse, but medical data have so far attracted the most press attention. There has been much talk of multiplex holograms being used by surgeons and other doctors to make diagnoses etc, but at the moment it seems unlikely that this is a role that holography can fill. Holograms would have to compete with computers in this field and, at the moment, computers are much more flexible.

The computer systems which are used at present in conjunction with MRI and CAT scanners are able to give different pictures from different views and different angles of

1.

slice. This can be invaluable to a radiologist who has to first see the data in different ways before deciding which slices give the information he or she needs in the most effective way.

Dr Cox, Consultant Neuro radiologist at the Mordsley Hospital in London, explained that their relative inflexibility made holographic multiplexing techniques unsuitable for diagnostic purposes, especially in neuro surgery. The geometry of the brain was, he said, simple enough so that two dimensional scans

2.

were straightforward to read once one had become practised at it, and the computer facilities which the MRI and other scanners came equipped with allowed easy identification of the relevant slices.

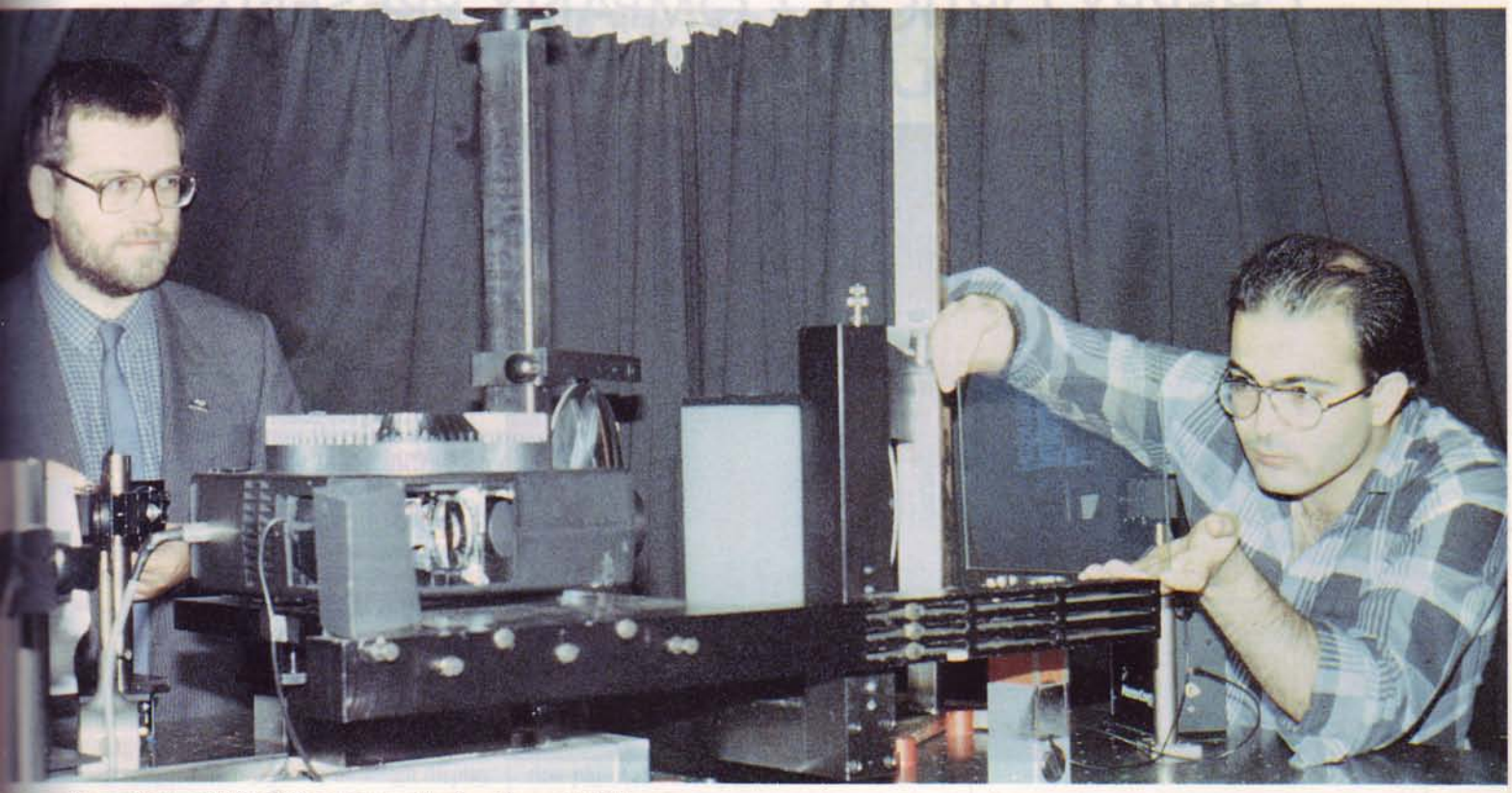
Where he thought volumetric multiplexing might be useful, was as a hard copy medium for communicating MRI or other results to patients, to doctors without access to the computer data, and at conferences. In these cases, the computers would be used to choose the slices which would be used to make the hologram. Dr Cox also felt that holograms might be a good way to compare brain data in research, as holograms can be laid on top of each other to produce two images sharing the same space, but he admitted that cost might be a prohibitive factor in this field.

Heart data, with its geometric complexity, was thought to be a much more likely candidate. Dr Donald Longmore, head of the Magnetic Resonance Unit at the National Heart and Chest Hospital (UK), has a very specific need to view his data in three dimensions, but requires an extra facility which the system at IC has not yet got: colour. Dr Longmore would like to be able to look at a hologram of the heart with all the information on it which he can get from his computers at the moment. The two dimensional pictures that his computers provide contain information about the velocity at which blood flows into or out of the heart, represented by shades of blue and red. If holography could put this information into three dimensions then it could be a powerful diagnostic tool.

Dr Kaveh Bazargan, who has done much work in the field of colour holography, says that the technology to provide just this already exists, it is mostly a question of money for the development of the system. Either multiple laser or raman scattering colour techniques (see news pages) could provide the colour.

Initial experiments with grey scale on the black and white holograms suggest that the medium is sensitive enough to be able to show colour or light intensity differences: vital for the kind of application Dr Longmore is looking for. Resolution also seems more than adequate for the data represented in the holograms.

Another advantage of the IC system is that

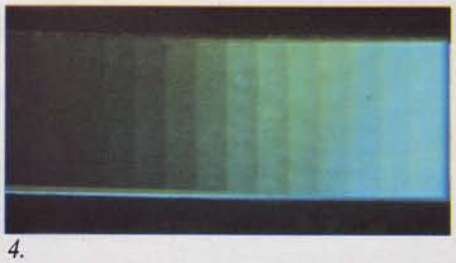


Steven Hart and Kaveh Bazargan on the rig at Imperial College.

Mr Hart is a computer specialist. Given raw data he can enhance images, omitting the unnecessary and accentuating the relevant. Thus every component in the holographic process, including the data, can be optimised to produce the best possible hologram. He has used these image enhancement techniques on astronomical and medical data, clearing away background light and grey matter, respectively, which obscured the desired images.

3.

The main thrust of the work at the moment is to find the upper limit of the system, fine tuning each component and investigating each parameter to make the system work well and reliably. Dr Geraldo Mendes and Amir Kooros have been assisting in this area in order to get the work completed before the SERC grant for this project finishes, and it is due to end in December. It is hoped that, by then, the black and white system will be running smoothly enough for it to be used as a re-



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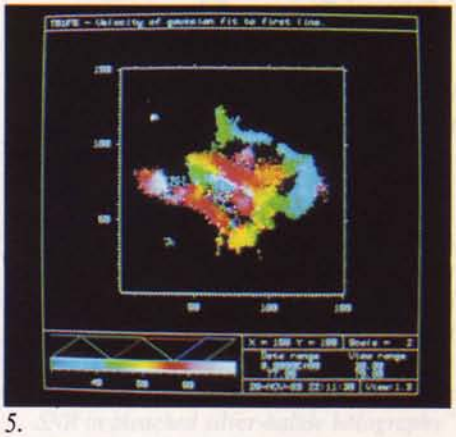
search tool for people at IC and elsewhere. Whether, once it is set up, it will be allowed to remain that way is largely dependent on whether the space and/or the equipment that the system uses are needed by others in the department.

At the same time, Mr Hart is looking to have the project funded elsewhere, possibly by a scanner manufacturer or anyone else enthusiastic enough to do it justice. Although he would like to continue working on the project himself, he feels that the project is important in it's own right and his only priority is to keep the work going.



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1. Skull, ventricles and tumor with fiducial frame. X-Ray CT slices from a GE 8800 scanner at the National Hospital for Nervous Diseases, Britain. Courtesy of Mr David Thomas. Eleven slices were used.

2. Dispersion Compensated Viewer. Dolls' House hologram by Francis Tuffy, Kingston Polytechnic.

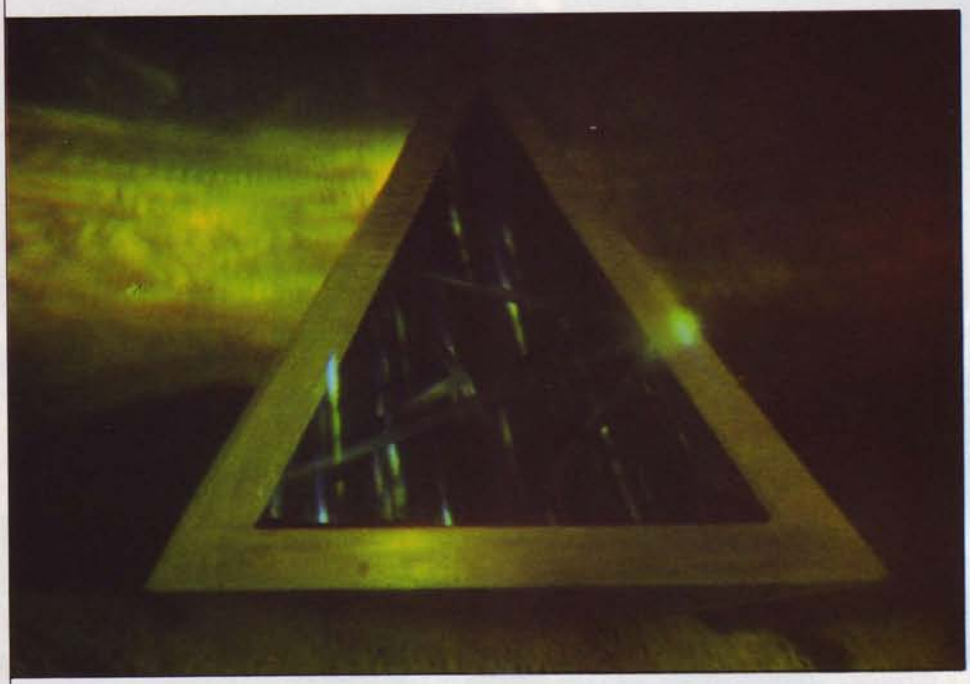
3. Spyrogyra alga, approximately 60 microns in diameter. Here seventeen slices taken using Contoural Scanning Law Microscopy (courtesy of Prof Brakenhoff, University of Amsterdam, The Netherlands) are multiplexed together.

4. Hologram of Agfa-Gevaert standard grey scale step wedge.

5. Colour coded image of gas velocities for the planetary nebula NGC-5189. Raw data for this consist of 150x150 spectra each of 90 points: this is equivalent to 4 Megabytes of information. The data was taken from the ICST/RGO TAURUS instrument on the Anglo-Australian Telescope.

Sunny Bains

CHERRY OPTICAL COMPANY PRESENTS



EGYPTIAN MEMORIES

Multicolor i.p. reflection hologram 8″ × 10″ edition of 25 by

GREGORY W. CHERRY

A superb hologram of a bronze pyramid floating above the desert sands at dusk. A blue ray of light projects from the pyramid.

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BOUQUET

One-of-a-kind Multicolor Reflection Hologram Composite, 33″ × 34″, 1986, by

NANCY GORGLIONE

Cherry Optical Company
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COMPREHENDING CHEMISTRY

Holographic Processing has traditionally involved guesswork, cookery and a bit of luck. This is because there are so many factors affecting the outcome — the concentration of the grains in the emulsion, the effect of the gelatin, the exact type of development taking place (chemical or solution-physical), etc. Over the past few years several excellent chemical formulae have been proposed, many of which have been the result of empirical tests. The understanding of the processes, however, has lagged behind their use by holographers. Until now there has been surprisingly little linking, systematically, changes in the developer content to the diffraction efficiency and the signal to noise ratio of the hologram.

Looking at the recent scientific literature, the work of two groups show great promise of shedding light, at last, on the mysteries of chemical processing in holography. The two groups are that of Hariharan at CSIRO in Sydney, Australia, and the Optics laboratory at the University of Alicante, Spain.

Work at CSIRO

Hariharan and his colleagues have been making important contributions to display holography for many years, although display has always been a sideline for them. Hariharan has a refreshingly down-to-earth approach and has a knack of coming to simple, clear, conclusions. In a recent paper, [1] he examines the effect of the drying procedure on the efficiency of a hologram. It is found that using an alcohol bath before drying can raise the efficiency by some 20%. The conclusion is that the alcohol forms a secondary volume phase hologram by local hardening of the gelatin. The drying stage has been investigated by several authors before, and as the recent results indicate, it is not a trivial stage in the production of holograms.

In another recent publication, [2] the authors systematically vary the concentration of chemicals in a developer and examine the effect on scattering and diffraction efficiency. They report that most developers in use in holography have a solvent action on unexposed silver halide grains, resulting in solution-physical development as well as chemical development. The systematic variation of the developer constituents pinpoints the chemicals which are responsible for the effect. In a further paper [3] the authors look at the delicate balance of the halide concentration in the developing bath. They report that a bleach bath may act as a reversal bleach or as a rehalogenating one, depending on the concentration of the alkali halide.

Work at Alicante

It is well known that the signal-to-noise ratio of bleached transmission holograms generally decreases as the pre-bleach density increases. In 1982 [4,5] the Alicante group reported that by grossly overexposing the hologram, ie. by obtaining pre-bleach densities of 5 or 6, the SNR increases. It seems that no-one had bothered to expose a plate to such densities before. Since that report, several interesting publications have emerged from the group, for example a detailed examination of Hariharan's process of rehalogenation without fixation [6].

More recently, fine-grained photographic emulsions have been manufactured and tested [7,8]. The emulsions obtained are suitable for transmission holography. Some of the results show efficiencies identical to those obtained with commercial Agfa*Gaevert emulsions, although the speeds are much lower. The work shows promise of a better understanding of holographic recording materials, especially when taken in parallel with the work on processing chemistries.

It seems that we are beginning to get an understanding of the complex relationships between photographic recording materials and processing materials. We look forward to more work in this area including, no doubt, future work from these the two groups mentioned.

References

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3. *P Hariharan and C M Chidley, "Rehalogenating bleaches for photographic phase holograms: the influence of halide type and concentration on diffraction efficiency and scattering". To be published in Applied Optics.*
4. *J Oliva, M Pardo and J A Quintana, "High SNR in bleached silver-halide holography" Applied Optics 21, 171 (1982)*
5. *A Fimia, M Pardo and J A Quintana, "Improvement of image quality in bleached holograms" Applied Optics 21, 3412 (1982)*
6. *J J Crespo, A Fimia and J A Quintana, "Fixation-free methods in bleached reflection holography" Applied Optics 25, 1642 (1986)*
7. *A Bonmati, J J Crespo and M Pardo, "Preparation of photographic emulsions for recording transmission holograms" Optica Pura y Applicada 19,19 (1986) — In Spanish.*
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Dr Kaveh Bazargan

Lloyd Cross, continued from page 17

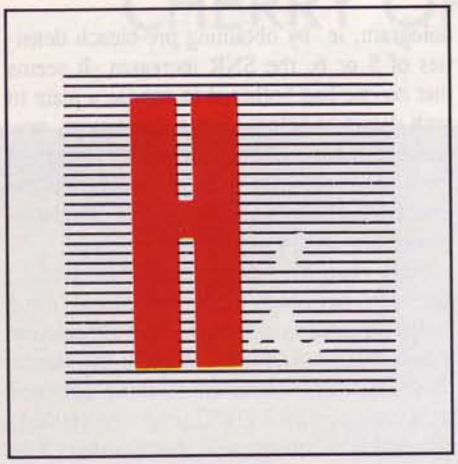
This camera, designed for educational and technical applications comes full circle in design. It is the opposite end of the spectrum form the sand box, no longer relying on the large stabilising mass. This camera, using tension structure design, is, to quote Lloyd: "isotropic in terms of gravity... any vibrations return to the starting point".

Made of stainless steel components, the camera is tunable by computer control or by hand. Two cubic feet in size, it is geared up to expose 4 x 5in plates. Fringes are computer monitored, and the camera tweaks itself in and locks fringes for critical applications.

It is currently in the prototype construction phase. Lloyd, working with his wife, Cecil, and his son, Lloyd Thomas Cross, hopes to introduce production prototypes next year.

Nancy Gorglione

Lloyd Cross with wife Cecil and son Lloyd Thomas, blanketed by laser scan stars.



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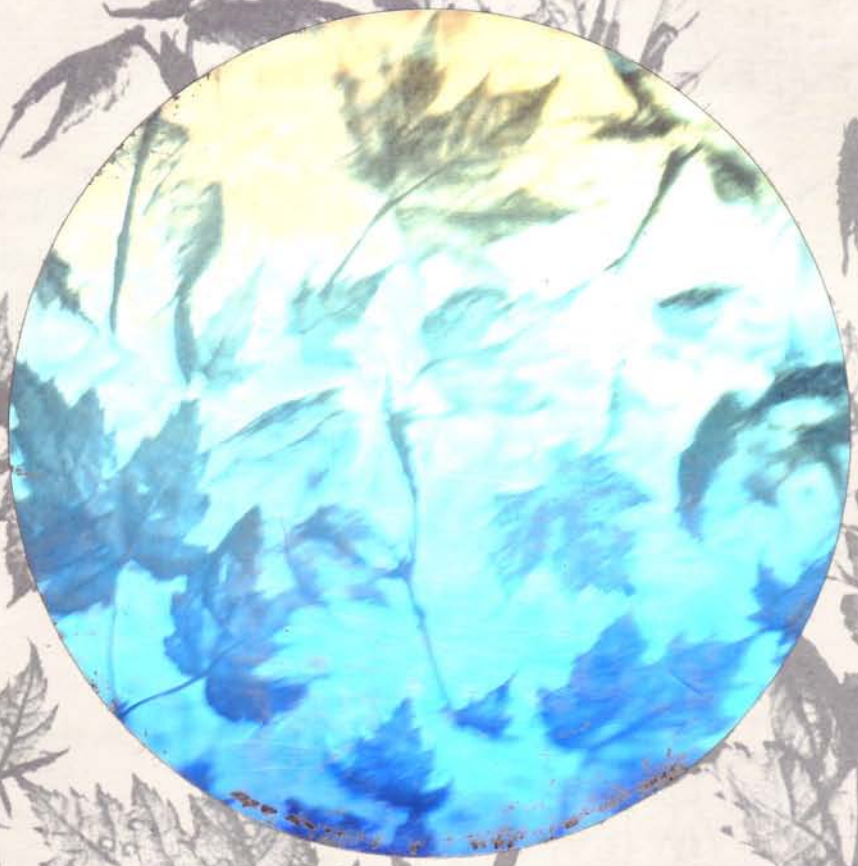

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