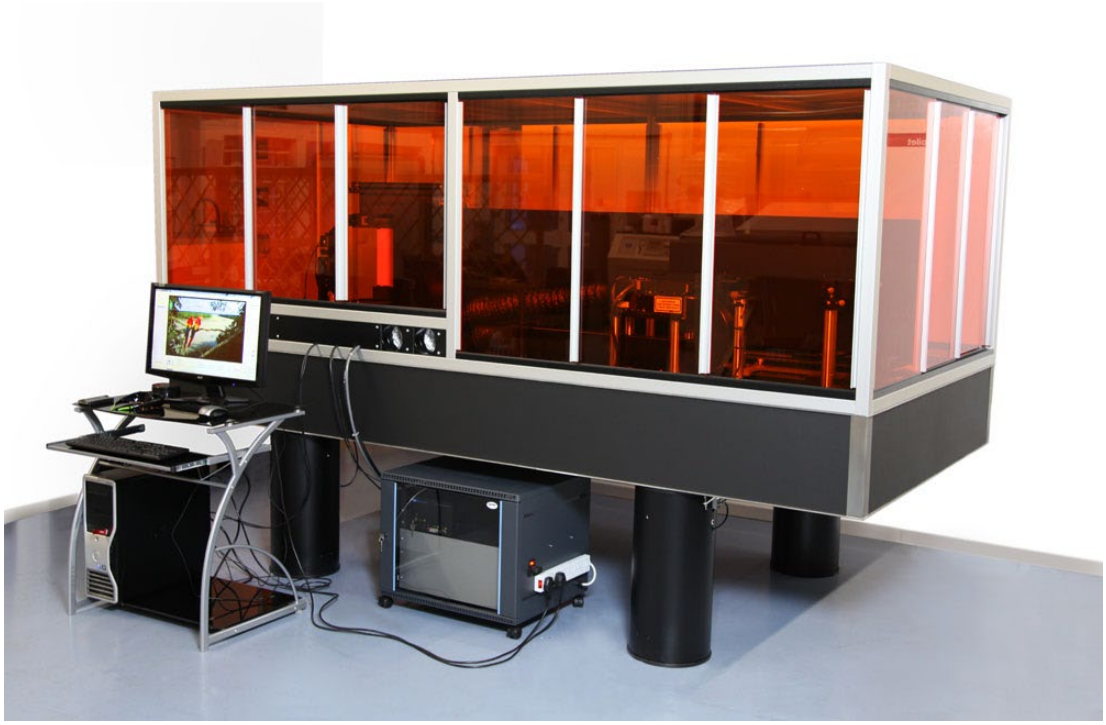
DI-HO - The World's First Digital Holographic Stereogram Printer

by Rob Munday



The DI-HO 2 system, 2012

After creating the world's first microcomputer-generated holographic stereogram, with the help of Nick Phillips at Loughborough University (see *Computer Holograms and Amiga Bird* by Rob Munday), I became increasingly interested in building my own holographic stereogram mastering system, one that would allow me to create holograms and holographic artworks independently.

A germ of an idea took hold in 1989, the year the first commercially available LCD video projector - the Epson VPJ-700- was launched. This new technology employed polysilicon TFT active-matrix LCD panels to display still and moving images, which were then projected through an optical system onto a screen. I began to wonder whether an LCD panel could replace photographic film as the image source for recording a holographic stereogram. If it could, then the possibility emerged of building the world's first fully computer-automated, digital holographic stereogram printer.

I became determined to design and build such a system, but progress was painfully slow. I was working full-time at the Royal College of Art during the day and spent most nights making holograms at home, often working into the early hours. Between 1989 and 1991, I filled notebooks with designs, calculations, beam paths and optical layouts. By 1991, it had become clear that the only way to succeed was to resign from the Royal College and commit myself fully to the project.

There was another powerful incentive: I was already spending almost every night completing holographic projects, such as the King's Helmets for the Tower of London, in the studio I had built in the living room of my tiny semi-detached house at 39 Pyrcroft Road, Chertsey, Surrey, KT16 9HT. Five hours of sleep had become a luxury. I had always wanted to run my own creative holography studio, and after six years at the Royal College, I finally handed in my notice.

Soon after leaving, I was fortunate to rent the former premises of SCIEMECHS Ltd., the engineering company owned and operated by Mr. and Mrs. Lovelock. SCIEMECHS was legendary in the UK holography community for producing the world's finest spatial filters and mirror mounts—equipment that, even today, has never been surpassed. After Mr. Lovelock sadly passed away, his wife, Jean Lovelock, invited me to take over the workshop: a large, well-equipped space in her back garden at 8 Wheatash Road, Addlestone, KT15 2ER, just a few hundred metres from my own home.

My first holographic stereogram mastering system

Soon after moving in, I began building my first holographic stereogram mastering system, believed to be only the second such system ever designed and constructed in the UK, the first being that of Prof. Nick Phillips in Loughborough University. My initial plan was to create a prototype that used a 35 mm slide projector, specifically a Kodak Carousel, to project images from standard 35 mm transparencies. This approach allowed me to validate the camera design, the optical components, the motion-control mechanisms, and the control software, written by me in AMOS BASIC on a Commodore Amiga, before attempting the far more ambitious step of integrating an LCD screen as the image source.

A Kodak carousel slide projector

The system was designed around several key criteria:

1. **Compact footprint:** It had to fit entirely on an 8 × 4 ft (240 × 120 cm) optical isolation table.

2. **Compatibility with short-coherence blue lasers:** The system had to be able to use a short coherence length blue laser for the exposure of photoresist plates, and thus the reference and object beam lengths needed to be as close to equal as possible.

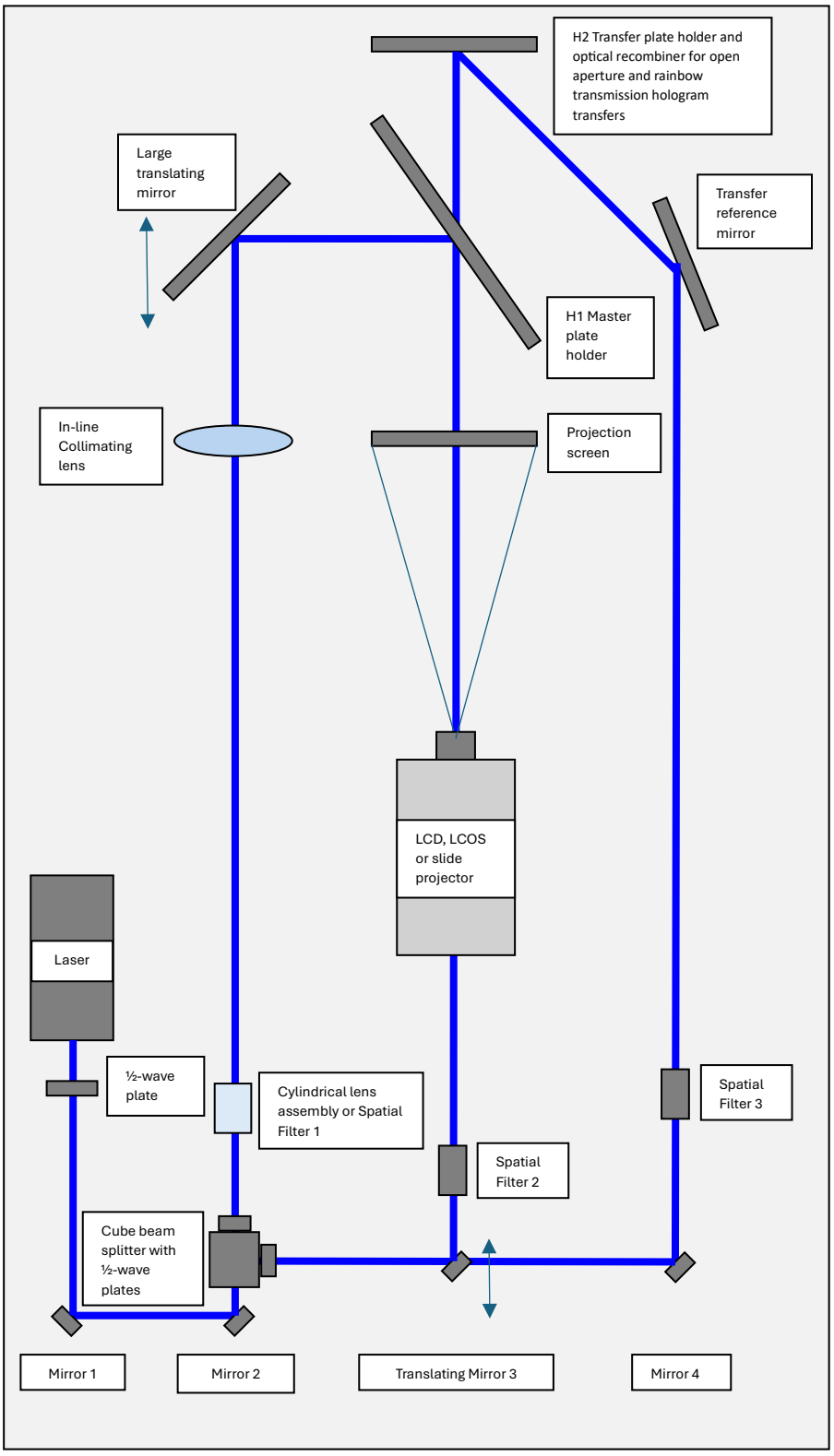
3. **Integrated H1 and H2 capability:** Both the H1 mastering camera and the H2 transfer camera (for open-aperture and rainbow transmission hologram transfers) had to be accommodated on the same table, with a mechanism that allowed quick, reliable switching between the two modes.

4. **Achromatic-angle geometry:** The master plate holder, together with its translating slit mask, had to be positioned at the achromatic angle to ensure optimal colour registration in the final transfer hologram.

5. **Flexible reference-beam options:** The system needed to offer a choice between a single open-aperture master reference beam, delivered via a spatial filter, and a translating slit reference beam generated by a cylindrical-lens pair. The cylindrical-lens pair enabled a variable slit width.

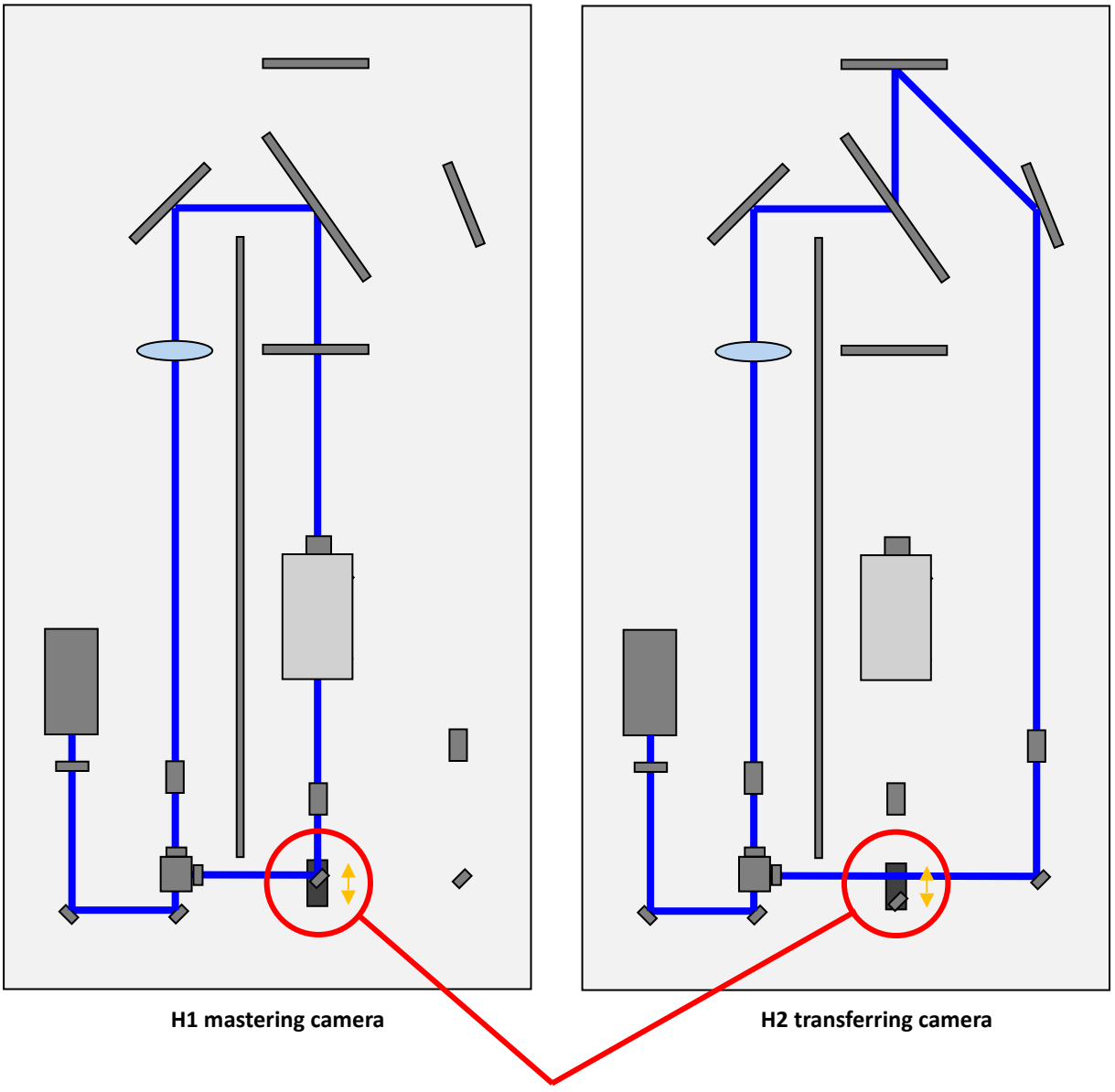
6. **Reduced optical distortions:** The system needed to reduce all optical distortions, particularly noticeable in holographic stereograms due to the flat nature of the subject being recorded, by use of an in-line collimating lens rather than an off-axis collimating mirror.

My design:



Integrated mastering and transferring cameras

The optical assemblies, referred to as the H1 and H2 cameras, required for both mastering and transferring, were permanently installed on the DIHO table. They were designed so that switching between mastering and transferring required only a single, simple adjustment: sliding a small mirror into its alternate position. In the configuration shown below, the path lengths for the mastering camera are equal, while the transferring camera has slightly unequal reference and object beam lengths. If required, the transfer reference beam can be matched to the object-beam length by redirecting it through two additional mirrors. In practice, this slight inequality proved inconsequential when using modern blue lasers with sufficient coherence lengths.



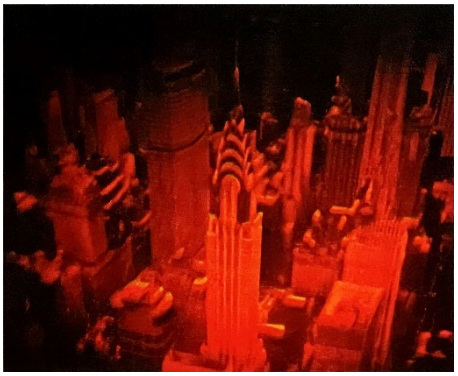
H1 mastering camera

H2 transferring camera

Small sliding mirror used to switch quickly and easily between cameras.

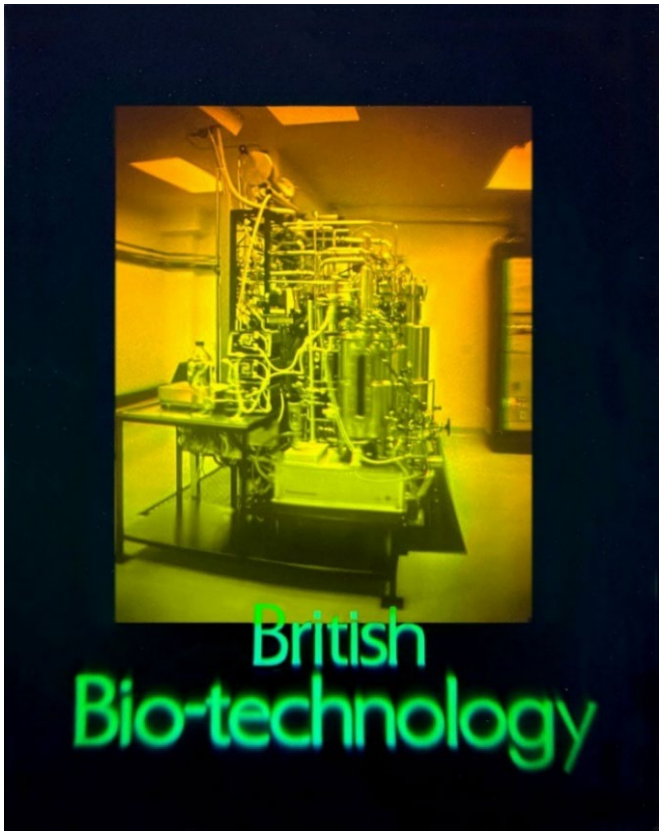
Unfortunately, no photographs were taken of the first system I built at 8 Wheatash Road. This early prototype used a Kodak Carousel slide projector, modified with a hole cut into the back to allow an expanded laser beam from a 50 mW helium–neon laser to pass through and illuminate the 35 mm transparencies. Despite its improvised nature, the system proved remarkably effective, and many reflection/volume holographic stereograms were produced with it during the summer and latter half of 1991, including:

Manhattan, 1991, by David Burder/Rob Munday



A 4” x 5” glass plate and film reflection holographic stereogram, created from photographs taken by David Burder FRPS from a helicopter, and as featured in all editions of the book Practical Holography by Graham Saxby, and in the book, The Prime Illusion – Modern Holography in the Age of Digital Media by Dr. Martin J. Richardson.

British Biotechnology, 1991, by Rob Munday



A 40 x 30 cm glass plate, two-colour reflection hologram containing a holographic stereogram of a system for creating an AIDS immunotherapeutic vaccine, designed, shot, and created by me, with a two-level graphic logo overlaying the stereogram and in front of the image-plane. It was the first commissioned holographic stereogram produced using my first film-based, analogue stereogram mastering system. The hologram was unveiled by The Right Honourable, now Lord Peter Lilley to commemorate this world-leading facility based in Oxford, UK.

Greek Artifact, 1991.

A 10” x8” glass plate holographic stereogram, created from a stereographic sequence recorded in Greece and sent to me in London.

The Øresund Bridge by Rob Munday

Mona Vinci and Mona Lisa by Jeffrey Robb

Design of the DI-HO (Digital Input – Holographic Output) system - the world's first fully computer-automated, digital holographic stereogram printer

The world's first LCD video projector, the *Epson VPJ-700*, was launched in 1989. It was followed almost immediately by Sharp's first LCD projector, the Sharp XV-100, also released in 1989. In 1991, Sharp introduced the XG range of professional LCD video projectors, the first of which was the *Sharp XG 3800E/U*. The *XG 3800E/U* was a groundbreaking product and among the earliest LCD video projectors designed for use in classrooms, conference rooms, and training suites. It employed three 3.6-inch TFT LCD panels (RGB), each specified with a native VGA resolution of 640 × 480 pixels (307,200 pixels) and a contrast ratio of 100:1. In reality, the panels contained 640 × 512 pixels (327,680 pixels), providing additional rows for electronic masking and alignment.

The Sharp XG 3800E/U video projector

Not knowing where to obtain OEM LCD panels with a suitable controller, I decided to buy a commercial projector, take it apart, and rebuild my own projector for holographic use. At around £4,000 new, however, it was far beyond my budget. Fortunately, a friend in the events industry, Niel Erwin, formerly a roadie for the rock band *The Who*, managed to find a second-hand unit for me for around £2,000.

It was not a simple matter to reverse-engineer the projector. Once the cover was removed, a dense tangle of cables, circuit boards, power supplies and optical components lay before me. Fortunately, I found a willing and exceptionally talented electrical engineer, Steve Fleetham of Micro Technical Services, to help. It wasn't long before the projector lay in pieces and the essential electronics had been identified and extracted. A purpose-built DI-HO LCD projection unit was then designed and constructed using the Sharp components. Steve charged £4,950 per unit for this work.

On the very day I had planned to replace the film/slide projection unit with my new LCD projection unit and conduct the first ever 'digital' hologram tests, a coincidence occurred. An MIT student, Eric Krantz, working within the Spatial Imaging Group under Dr Stephen Benton, happened to visit and kindly offered to assist. *N.B. Holography News later reported this as a collaboration, which was incorrect; see below.*

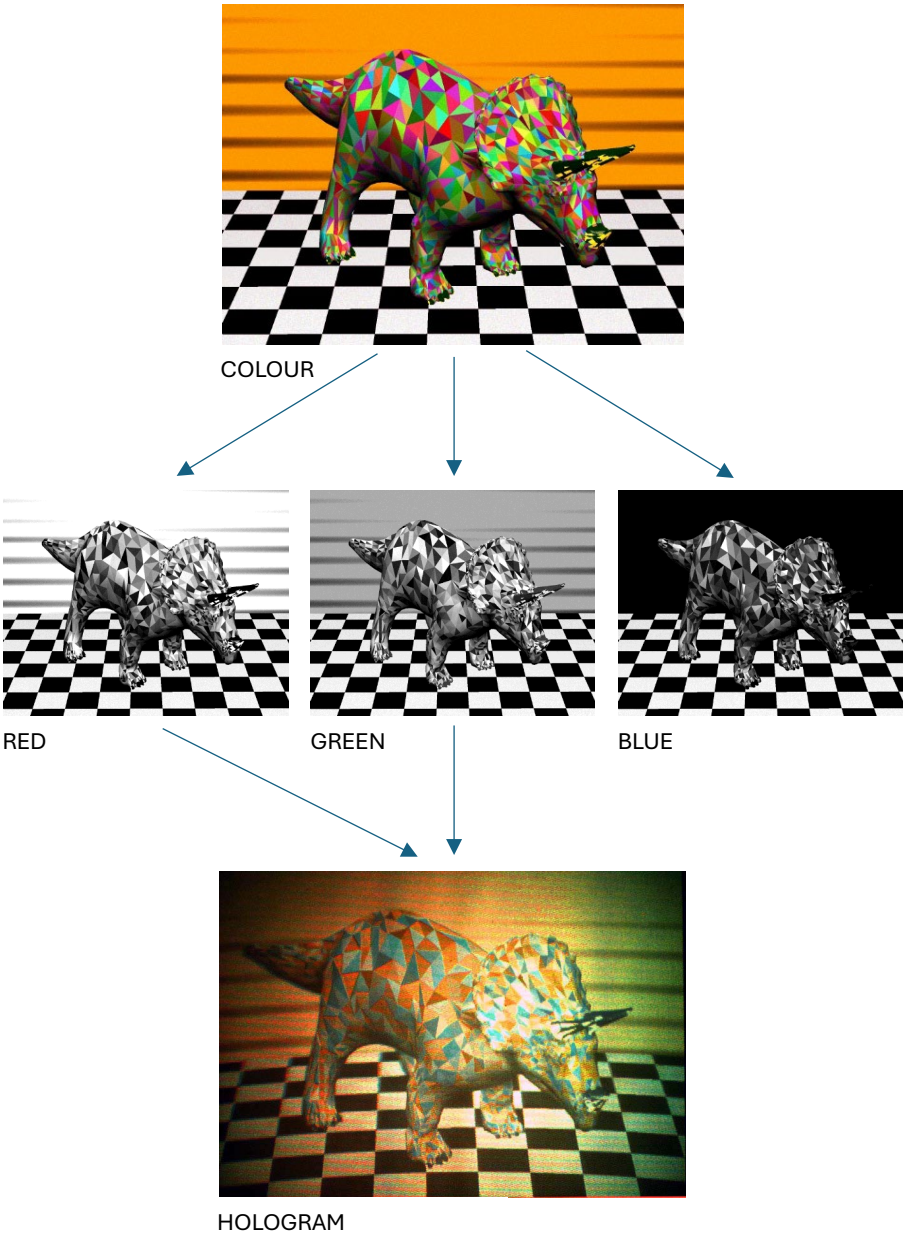
The world's first digital reflection holographic stereogram, early 1992

The projectors were duly swapped, and the first tests were carried out using a sequence of stereographic images that I had computer-generated a few days earlier with *Imagine* by Impulse, Inc., the most widely used Amiga 3D modelling and animation program of the 1990s. The full-colour image sequence depicted a toy Triceratops dinosaur with mirrored horns standing on a chequerboard floor. Software I had written in AMOS BASIC, published by Europress/Mandarin Software for the Amiga, and named *DI-HO Control* was used to automatically colour-separate the frames. AMOS BASIC was one of the most iconic pieces of Amiga software ever created, enabling users to fully exploit the machine's revolutionary graphics and animation capabilities.

In the case of mastering reflection (open-aperture) holograms, a spatial filter was used to expand the beam onto a large, static reference-beam mirror, illuminating and exposing the entire H1 master plate. Three H1 master plates were required — one for the red channel, one for the green, and one for the blue. Each plate was placed manually into the holder, one at a time, behind the slit mechanism. After loading the plate, for example for the red separation, the Holomation software was instructed to automatically record all 70 frames onto the plate by extracting the red channel from each full-colour frame in sequence, displaying the colour-separated frame on the LCD screen, projecting it onto the ground-glass screen, and recording the result through the translating slit aperture.

In the case of the *Triceratops* hologram, although three H1 masters were recorded - red, green and blue - only the red and green masters were used to create the final work. This was due to time and cost constraints, and a two-colour hologram was considered sufficient to demonstrate that the system functioned correctly for this first digitally created hologram. The final two-colour hologram was made using a reflection hologram transfer camera and studio, still based in my living room at home.

Triceratops by Rob Munday became the first-ever computer-rendered and digitally produced 3D hologram - a holographic stereogram.



Volume 6 No 6, July/August 1992

Munday's High-Res LCD Stereograms

Robert Munday of Munday Spatial Imaging has developed a technique to shoot holograms up to size 8" x 10" direct from a modified high resolution LCD screen.

Displaying computer-driven imagery on the LCD screen has the advantage that the colour separations and discrete image elements are always in perfect register, so the system is suited to shooting colour stereograms as well as producing artwork for 2D and 2D3D holograms. Several places are experimenting with LCD screens for hologram artwork visualisation (see, for example, HN Vol 5 No 10).

Munday uses an Amiga 3000 graphics workstation with software that he has written to control and manipulate the imaging. Images can be input from sources such as a scanner and video, or originated on the computer. The software allows planar separations of 2D images or combinations of images, for example to create a 2D3D hologram of separately input pictures and logos. These can also be combined with a 3D stereogram.

Munday's demonstration piece, a collaboration with Eric Krantz, an MIT graduate, is a 7½" x 9" multi-colour reflection hologram of a computer-generated toy triceratops dinosaur on a tiled surface. The colours are strong and in register, with an image depth of about 6". It comprises 70 slits of which two contain the hologram credits. Munday told **Holography News** that the number of slits can be increased to achieve the resolution required.

Mastering Service and Tech Transfer

Munday is now offering to produce holograms from disks or images supplied from customers. He can accept images stored using almost any image file format on Amiga, Mac or PC formatted 3½" disks and deliver white-light viewable reflection or transmission holograms. He also hopes to supply laser masters to embossing or silver halide manufacturers.

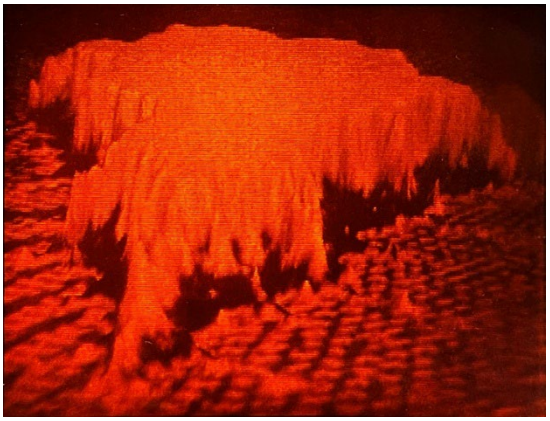
Munday's suite of computer, software and LCD screen gives flexibility in image manipulation and impressive holographic results. Recognising that he cannot supply the anticipated demand, he is open to technology transfer arrangements. HN

Contact: Munday Spatial Imaging, 39 Pyrcroft Rd, Chertsey, Surrey, KT16 9HT, England; phone & fax+44 932 564899,

N.B. On the day that I had planned to swap the film/slide projection unit with my new LCD projection unit and conduct the first tests, and by a complete coincidence, an MIT student named Eric Krantz, working within the Spatial Imaging Group under Dr. Stephen Benton came to visit, and kindly assisted me. Please note, however, that Holography News incorrectly reported this as a collaboration, see left.

Several other reflection holographic stereograms were made using this now digital system, including:

Mandelbrot Mountain by Rob Munday, 1992.



Mobius Strip by Graham Tunnidene

Water Drop by Jeffrey Robb

The world's first surface-relief 'rainbow' embossed digital holographic stereograms, late 1992

It was evident that the commercial potential of this new mastering technology lay in producing full-colour, three-dimensional and/or animated surface-relief 'rainbow' holograms that could be mass-replicated by embossing. Later that year, I therefore replaced my 633 nm helium–neon laser, used for exposing red-sensitive silver-halide plates, with a 442 nm helium–cadmium laser, enabling me to expose both blue-sensitive silver-halide plates (H1s) and photoresist plates (H2s). My aim was to create the first digitally produced, transmission 'rainbow' surface-relief embossed holograms. Sally-Anne Bennett (now Sally Carver), then a senior holographer at Light Impressions Europe in Leatherhead, Surrey, generously supplied the photoresist plates.

Z

The first was an opportunity to design and create the world's first digitally produced embossed hologram - a project for which I had complete creative freedom. Named Z, and although the hologram was subsequently provided to a London-based company called Z Publishing, it was primarily and more importantly Spatial Imaging's first sample FDI-HO digital embossed hologram.

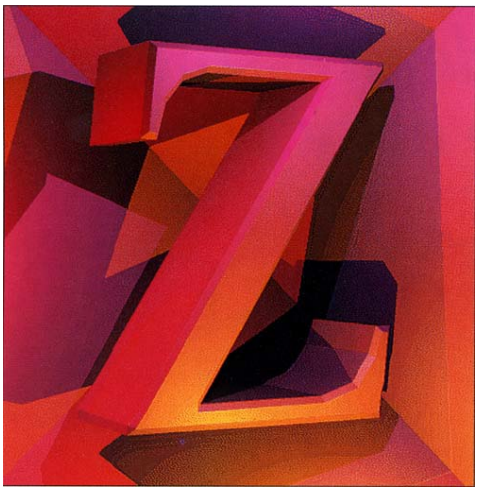
Using my Amiga computer and Imagine software, I generated a 3D stereographic sequence featuring the letter *Z* suspended inside a pyramid, illuminated by multiple coloured light sources from different angles to create a play of overlapping shadows. The choice of the letter *Z* was also fitting: in mathematics, geometry, and computer-modelling programs, the depth axis is conventionally denoted the *Z-axis*, making it an apt symbol for the world's first digitally produced embossed hologram whose very purpose was to convey depth.

For rainbow-hologram H1 masters, a cylindrical-lens assembly was used to generate a narrow slit of light, which was reflected from a large translating reference-beam mirror onto the H1 master plate. By moving the mirror back and forth, the slit-shaped reference beam was scanned across the plate to the precise positions required for the red, green, and blue exposures. All three colour separations were therefore recorded onto a single H1 master plate, and the entire sequence of exposures was carried out automatically, without any user intervention.

John Wiltshire, Applied Holographics' senior holographer, had generously agreed that his company would shim and emboss the hologram for me. After successfully exposing the photoresist transfer plate, I drove to meet John at Applied's facility in Braxted Park, Essex, and to deliver the hologram. On seeing it, he expressed genuine surprise and astonishment, refusing at first to believe that it had not been made from a real physical object.

The hologram was duly shimmed and embossed, and I received a single roll containing some 200–300 copies.

Z by Rob Munday became the first-ever computer-rendered and digitally produced 3D transmission rainbow, surface-relief embossed hologram / holographic stereogram and another landmark in the transition from analogue to digital holography.



'Z' by Rob Munday became the first-ever computer rendered and digitally produced 3D transmission rainbow, surface-relief, embossed hologram / holographic stereogram.

SBU

The second hologram was commissioned by Strongberg Universal (SBU), a music events-management, ticketing, and promotions company, via IC Holographic. SBU required a hologram to authenticate tickets and passes for music events, including Madonna's VIP backstage passes for her two 1993 Wembley Stadium concerts.

The design brief was straightforward: to present SBU's ace-of-spades logo in 3D holographic form. Two versions were produced — one with a static background and another with an animated background. Chris Levine, IC Holographics' designer, marketer, and part-owner, supplied the background graphic, while I created the ace-of-spades model and rendered the stereographic image sequence using my Amiga 3000 computer and Imagine software. I then produced both the H1 master hologram and the H2 photoresist transfer hologram using the DI-HO system. The completed photoresist plate was subsequently sent to Applied Holographics for replication.

Volume 7 No 1, February 1993 **Holography News**

New Techniques & Products

Munday Masters First LCD-Originated Embossed Stereogram

iC Holographic, Munday Spatial Imaging (MSI) and Applied Holographics have produced what is probably the first embossed 3D hologram from a master stereogram shot direct from an LCD screen. The three-colour hologram is a 3cm-diameter disc of what Chris Levine of iC describes as 'a representation' of the client's ace of clubs logo. There are two versions, one with a static background, the other with an animated background. The client, Strongberg Universal (SBU), will use the former on promotional literature, while the animated hologram will be used to identify genuine tickets for SBU's promotional events. The company is an image-maker with drinks and rock music clients, among others.

iC did the design of the hologram, then the artwork, on a Macintosh computer disk, was read by Munday's DI-HO (Digital Input-Holographic Output) Amiga system (see HN Vol 6 No 6). The artwork was then enhanced and converted for the stereogram output, then automatically displayed frame by frame in three colour-separations on the LCD screen. Each frame was captured to the H1 on Agfa silver halide film using a HeCd laser supplied by UK Optical Supplies. Applied then made the photoresist H2 and embossed the initial order of 12,000 holograms.

Rob Munday of MSI reports that he is now developing the second generation DI-HO system to take advantage of Amiga's powerful 4000 computer. This will be able to take images from Kodak's Photo CD as the original artwork for the stereograms, and will feature a new 640 x 480 pixel LCD.

MSI/iC to Collaborate More

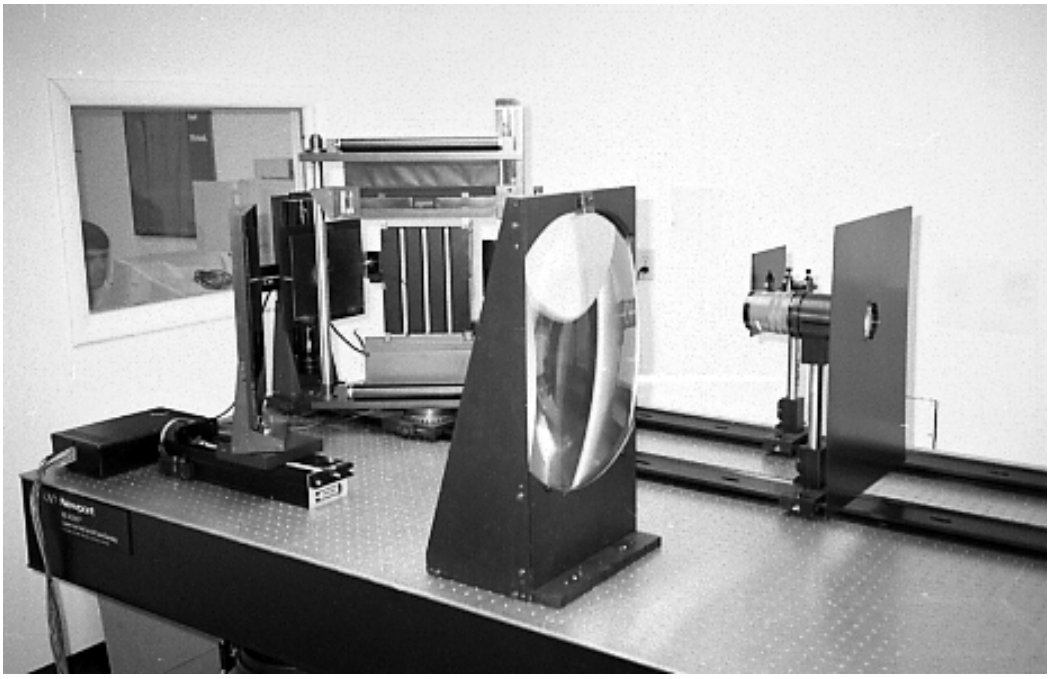
The SBU hologram is the latest in a series of collaborations between iC and MSI, although previous works have been silver halide holograms. They report that they enjoy a close working relationship with a synergy of creative and technical skills, so they are exploring a closer business relationship particularly to exploit the DI-HO system. HN

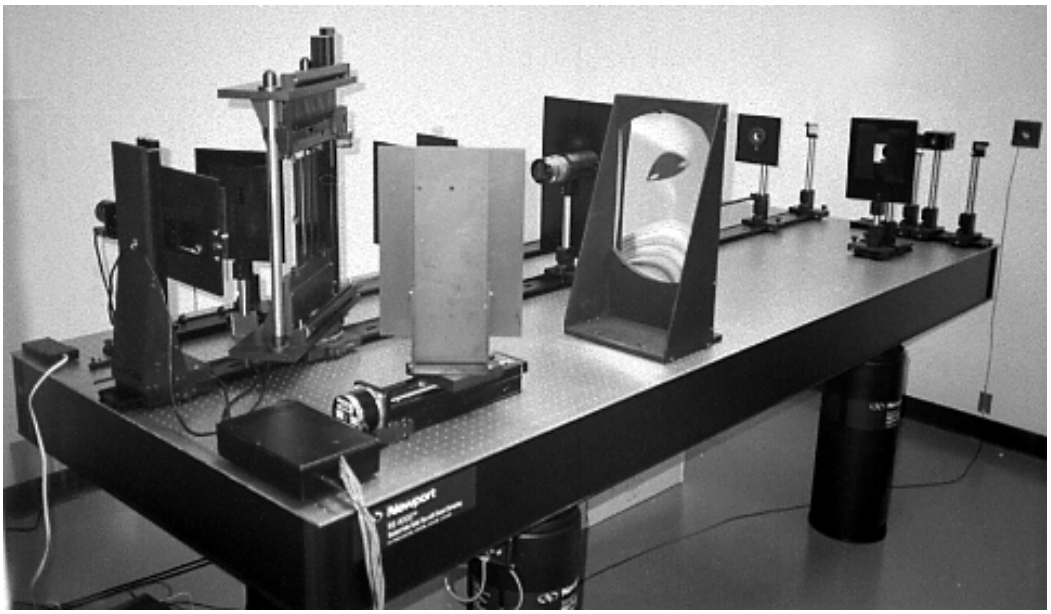
Contacts: iC Holographics, 3/4 Mallow St, London EC1Y 8RQ, England; phone +44 71 490 4030, fax 490 2693. Munday Spatial Imaging, 39 Pyrcroft Road, Chertsey, Surrey, KT16 9HT, England; phone/fax +44 932 564899. Applied Holographics PLC, 40 Phoenix Road, Crowther Industrial Estate, District 3, Washington, Tyne & Wear, NE38 0AD, England; phone +44 91 417 5434, fax 416 3292.

Please note: Unfortunately, as is often the case, there are some mistakes in the article above. Firstly, the hologram was not the first LCD-originated embossed stereogram, the Z hologram was, but it was the first commercially 'commissioned' hologram of this type. Secondly, IC Holographic only provided the background image, and lastly, Applied Holographics did not make the photoresist H2, this was made by me using the DI-HO system and then sent to Applied Holographics for shimming and production.

Below is a photograph of me controlling the system from the computer, just outside of the DI-HO studio. Also below are two photographs taken of the DI-HO system purchased from me in 1996, and installed at the company Novavision Inc, of Bowling Green, Ohio, USA. I can be seen controlling the system from the other side of the viewing window.

Rob Munday controlling his DI-HO (Digital Input – Holographic Output) holographic stereogram mastering system. He is pictured in front of his Commodore Amiga 3000 system holding a Kodak Photo CD. To the right are CD ROM drives and SyQuest removable hard-disk cartridge drives. On the monitor to the left can be seen my image Mandelbrot Mountain, a digitally produced full colour 3D stereogram of a mountain scene in the shape of a Mandelbrot fractal which was computer generated using the unique fractal landscape generating program VistaPro by Virtual Reality Laboratories.





Two views of a DI-HO system. This one was sold to the company Novavision Inc, Bowling Green, Ohio, USA

The DI-HO Video Linear Rail

In 1992, I also designed and built my first video linear rail system. I believe that it was the first linear rail stereographic sequence recording system to utilise a translating 'shift' video camera, or a video camera at all.

The system as based on a two-meter-long rail with a belt driven carriage that was powered by a large stepper motor, sitting upon two large studio tripods. On top of the carriage was a specially designed video camera module, comprising a smaller stepper motor driven, ball-screw, linear stage which translated a small CCD machine vision video camera behind a static lens connected together with sliding bellows to prevent light ingress. The entire video camera module was fixed to a tilting mechanism to enable vertical alignment with the scene being recorded.

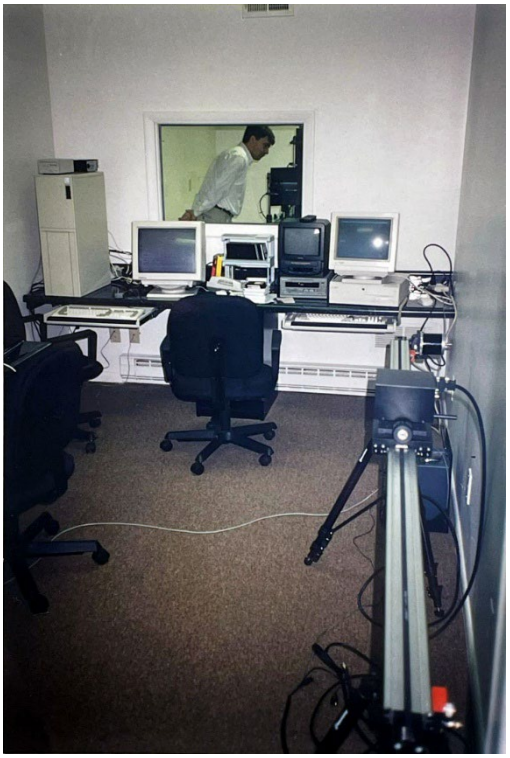
To remove keystone/perspective distortion, I chose to use a ‘shift camera’ behind a static lens rather than the more conventional ‘shift lens’ in front of a static camera, as this enabled a simpler and more accurate positioning of the lens to record viewpoints with exact and equal spacings. In the early 1990s, with limited computer power, this was the best technique to use.

The rail was controlled using a Cambridge Computer Z88, first launched in 1987. This was the first lightweight, battery-powered, notebook-style computer, and the first computer to be released by Clive Sinclair, after he had sold his Sinclair brand to Amstrad. What’s more, it had an RS232 serial port, enabling the control of external devices. I wrote the software to control the systems motors and camera using the computer’s built in BBC BASIC programming language.

A Cambridge Computer Z88

The DI-HO video linear rail system was sold to companies that purchased a DI-HO system, as a complimentary input device, capable of shooting video sequences of real-life scenes.

Few photographs exist; however, one can be seen in the picture below, taken in the premises of Novavision, Bowling Green, Ohio, USA, who purchased a DI-HO system in 1996. The camera system is seen on the right-hand side, in the DI-HO control room. Through the window, also shown in the previous picture, one can seem me examining the DI-HO system.



Holomation software

The software to control the DI-HO system, christened Holomation, was written my me using the programming language AMOS BASIC, published by Europress / Mandarin Software for the Amiga computer. AMOS BASIC was one of the most iconic pieces of Amiga software ever created, enabling Amiga users to fully utilise the Amiga's revolutionary graphics and animation capabilities.

For Holomation, this power was essential. It allowed me to manipulate sequences of images, write routines for image registration and colour separation, and automate the creation of 2D–3D holograms by shifting multiple graphic elements laterally according to the rules of stereographic depth.

As a result, the DI-HO also became the first mastering system capable of generating a stereographic image sequence on the fly, producing each frame in real time as it was being recorded onto the H1 master hologram. This technical breakthrough made it possible to manufacture full-colour, multi-planar, 2D–3D holographic stereograms with unprecedented speed.

The technique took full advantage of the Amiga's Blitter Objects (BOBs), software-drawn objects using the Amiga's *blitter* to copy pixel data into the playfield bitmap and designed for easy game creation. It enabled the holographer to select a background and then overlay any number of full-colour graphic/image elements. For the background and each image element, a depth position could be entered relative to the image-plane. A negative position placed the element behind the image-plane, and a positive position placed it in front. Using the rules of stereography, the software then automatically calculated the left and right movement needed for each image element, automatically moving them all to the correct positions for each frame in real time, to produce the desired perceived depth.

One of the first, made in 1993, was a small promotional embossed hologram for Bass Brewery. The same sequence was also used for a DI-HO promotional hologram. The image elements, designed by Chris Levine of IC Holographic, see below, were taken from the model elements used for a prior 43 x 32cm multi-colour reflection hologram commission.

The first digitally created 2D-3D DI-HO hologram, produced as a promotion hologram

The role of IC Holographic Ltd.

From a very early stage, the full power and potential of the DI-HO system was recognised by Chris Levine, a commercial hologram designer/marketer, and part owner of the company IC Holographic Ltd. Chris Levine keenly offered to collaborate with and become a non-exclusive distributor for Spatial Imaging, particularly for DI-HO hologram commissions. This led to the commissioning of several DI-HO holograms between 1992 and 1996, including a number of holograms for music album covers. Of those commissioned by IC Holographic, many were designed by Chris Levine, with design input from Rob Munday, and Spatial Imaging's new employee, Jeffrey Robb. Some, however, such as the 'moviegrams' for the bands Queen, Boyzone, and Wet West Wet, were designed and created by me.

This mutually beneficial relationship was reflected in a DI-HO promotional leaflet, designed by my employee Jeffrey Robb and produced in 1994. Chris Levine of IC Holographics contributed the DI-HO logo, using a small 'i' in **DiHO**, to echo his own iC Holographic brand, and a 'chevron' to signify the flow from digital input to holographic output.

At this same time my sole tradership, Munday Spatial Imaging, became incorporated as Spatial Imaging Ltd. and required a new logo. I chose to also use the chevron symbol, within a circle, as the logo of Spatial Imaging, which represented my goal to move the holographic medium forward, both creatively and technically. Spatial Imaging also agreed that IC Holographic could act for Spatial Imaging to non-exclusively promote this new and exciting form of holography in the design and advertising industry and handle inquiries for commissioned DI-HO holograms.

As time went by, however, Chris Levine began to increasingly exaggerate his input, often claiming in the press to be the sole creative designer of the output from my DI-HO system, and even inferring that the technology belonged to him or IC Holographic. Chris Levine/IC Holographic also unilaterally decided to rename and trademark the 'Moviegram', a special variant of a DI-HO hologram, invented by me in 1993, as a 'Holomovie'. Four such articles, all initiated by Chris Levine/IC Holographic are shown below.

Hotshots

trends The hologram has come a long way since its beginnings in plastic rings and naff postcards. The future of this two-dimensional sleight of eye is the Holomovie: a fully-animated, colour hologram capable of holding four seconds of film footage on metal foil. Designed by Chris Levine at iC Holographic (0171 240 6767), and commissioned by Queen Productions, the first **Holomovie** stars Freddie Mercury, eerily brought back to life to grace a 20-CD boxed-set, 'Ultimate Queen'. The original silver nickel master can be seen at the Museum of the Moving Image from Fri 15.

BARRY HOMES

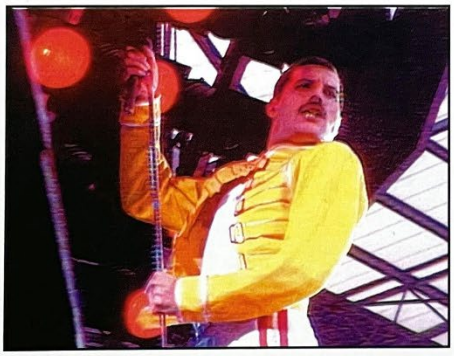
In the first, above, published in *TIME OUT magazine, 1995*, it can be seen that IC Holographic referred to the 'Moviegram', which had been designed and created by me for the rock band Queen, as a 'Holomovie', that had been designed by Chris Levine, and that it was the first 'Holomovie', all of which were false claims. See my account of this project below.

NEW PARTNER FOR APPLIED

Applied Holographics has appointed the leading hologram designer iC Holographics as its first agent and distributor in the UK. This agreement brings together the design expertise of iC and the production capabilities of Applied to form a partnership of great strength and consolidates a close relationship of several years' standing which has set new standards in the industry.

iC will be focussing on the development of promotional opportunities in the entertainment and CD industries, where it has already established itself as the leading holographic design studio with commissions for such artists as Pink Floyd, David Bowie, Queen, Simply Red, Wet Wet Wet and many others. iC has also been closely involved in the creative imaging design of the holographic CD process from the early stages of development and has produced some of the first 3-D i.D library designs now available.

Based in London's Soho, iC is ideally located to develop awareness for its work within the creative arts scene, and its in-house computer design systems are particularly appropriate for the short lead times required in the music industry. These systems include one of the latest developments in mastering technology - DIHO. This creates Holomovies with up to four seconds of full colour animation directly from video footage and computer graphics, and through the new partnership the technique is now available to Applied's own client base.



The application of creative flair to holograms is becoming ever more critical with advancing technology and a rapid increase in both the demand for holography and the expectations made of it. The expertise of iC represents an invaluable addition to Applied's own design facilities - creating a combined resource which is unparalled in the industry.

For examples and further information on Holomovies, please contact ourselves or iC Holographics. Their details are (Tel) +44 171 240 6767; (Fax) +44 171 240 6788; (E-mail 100413.3406 @ compuserve.com)

MARVEL-LOUS

The second article, above, published in *Vision magazine, 1995*, infers that the DI-HO system itself was an 'in-house system' of IC Holographic/Chris Levine.

FOLIO

HOLOGRAPHY

Hey, trippy, man. Or wot? These stills are from a holographic 'film' for a CD compilation album of retro house music called *Sound Dimensions*. Of course, you don't get the full effect here in good ol' 2-D, but you can imagine... The film was created by holographic designer **Chris Levine** and technical developer **Rob Munday** at design studio **eye'see!** It derives from 2-D video footage and was created using their pioneering DiHO or Digital Input-Holographic Output system.

Levine shot the video in a conventional photographic studio, using lighting to give the close-to-the-edge feel of a club. The video images were downloaded frame by frame on to a liquid crystal display (LCD) screen and a laser was projected through the LCD, recording a hologram on a glass plate coated with light sensitive emulsion. This created a physical relief pattern which was used as a master hologram. A nickel imprint was taken of this and when stripped away, a negative holographic impression was left on the metal. This can be used for embossing on to plastic, foil or, as in this case, incorporated into the injection moulding of a compact disc.

The holographic film is created by incorporating a sequence of 60-100 images or frames of animation, which can be viewed from left to right. The same process can be used to create 3-D film, except that the original footage will have to be shot in 3-D by bouncing lasers off actual sculpted models on to a plate. Munday developed the kit to produce static holograms or holographic film digitally by stripping down off-the-shelf equipment and rebuilding it. Eye'see! is patenting the system. It has already used the digital process for a holographic CD for the **B52s**, as well as a static holographic sticker for **Pink Floyd** on tour. It is now working on various projects for the records and games industries, as well as drinks manufacturers. The technology could also be used as a device against counterfeiting. 'And I am excited by the whole idea of linking sound to holographic images,' adds Levine.

12

The third article, above, published in *Creative Technology Magazine, 1995*, describes the DI-HO as both Chris Levine and Rob Munday's system, and goes on to say that IC Holographics 'is patenting the system'! Again, both misleading and false statements.

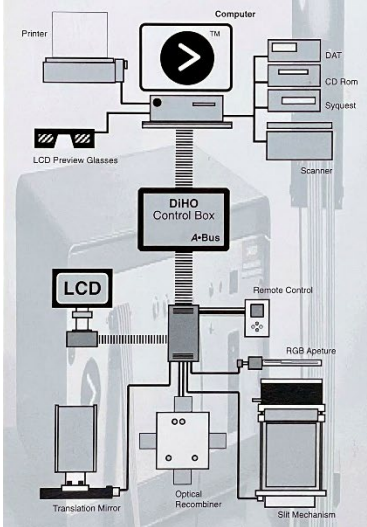
Earlier this year, he was finally persuaded to put together *Hypervisual 1* (planned to tour in '98), the first solo exhibition featuring the full scope of his creative vision. It also offered the chance for two technological gurus, Robert Munday and Howard Batchen – Levine's key collaborators – to reveal a few tricks of the holographic trade.

A fourth article, left, published in the *Oasis - Was There Then Exhibition programme 1997*, described me as one of Chris Levine's technical collaborators.

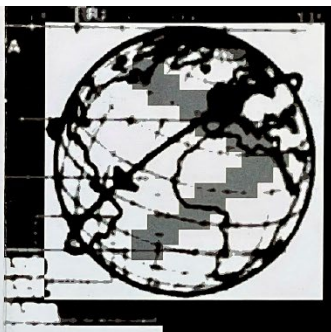
Both Chris Levine and his secretary frequently referred to my creative holography studio, then in Addlestone, Surrey, as his studio, in meetings with clients. Largely for this reason, Spatial Imaging's and my relationship with Chris Levine was relatively short lived and was dissolved by me/Spatial Imaging in 1997.

DI-HO promotional leaflet, 1994.

DiHO® / System Configuration



- Full Colour
- Animated
- 2D/3D
- Easily Visible
- Cost Effective
- Simple to Operate



di>ho™ Sales Information

Technology Transfer

Munday Spatial Imaging
39 Pyrcroft Road
Chertsey Surrey KT16 9HT
Tel / Fax: 0932 564899

Mastering

iC Holographic ltd
8 Flitcroft St
London WC2 H8DJ
Tel: 0171 240 6767 Fax: 0171 240 6768

Digital input
> Holographic Output

di>ho™

DiHO® / Digital input
> Holographic Output

DiHO® is a revolutionary concept in hologram mastering pioneered and developed at **Munday Spatial Imaging** in England.

Using the latest in LCD technology combined with advanced computer imaging, it is now possible to master holograms direct from digital input such as video and computer graphics to create visual results that are unlike anything seen to date in the field of commercial holography.

DiHO® is based on the holographic stereogram process which uses a set of stereographic images of an object or scene as input. These digital images are manipulated and downloaded into the system using dedicated **Holomation®** software which then controls the mastering automatically ensuring optimum results everytime.

Masters are shot using **DiHO®** from which copies can be reproduced in a wide range of formats including embossed, injection moulded, DCG, photopolymer and Silver Halide holograms.

DiHO® truly represents the next generation of holographic imaging and **is available now!**

DiHO® / Mastering Services

- **DiHO®** mastering services are available to client end users and hologram manufacturers alike.
- Masters can be produced to specifications compatible with most manufacturing requirements.
- Photoresist, Photopolymer, Silver Halide and DCG formats are supported.
- Artwork can be supplied by the client as video / film, flat artwork, computer graphics, or can be created to commission.
- 2D/3D and Stereograms, animated and in full colour!

input > Computer Graphics

input > Video or Film

input > Flat Artwork 2D/3D

di>ho™

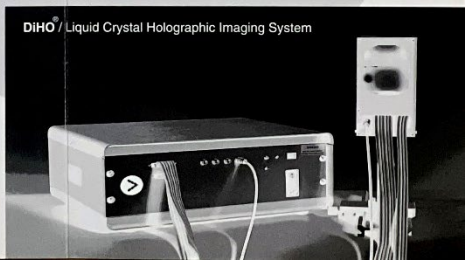
DiHO® / Technology Transfer

DiHO® technology is available to hologram manufacturers worldwide who require efficient in house mastering using the latest cost effective holographic production methods.

A variety of packages are offered to suit most commercial needs and **DiHO®** can be installed and fully operational with suprising ease.

- **DiHO®** components are engineered to the highest standards and are fully guaranteed.
- Full training and technical support service.
- Complete start-up systems, or upgrade your exsisting holographic origination facilities.
- Free upgrades of **Holomation®** software.
- Further details on request.

DiHO® / Liquid Crystal Holographic Imaging System



DI-HO ‘Moviegram’ holograms designed and produced by Rob Munday for music album covers, 1994-1996.

Mike Oldfield - Hibernaculum, 1994

In 1994, I was commissioned to design and produce the world’s first digitally generated, full-colour, animated CD album cover hologram for the British multi-instrumentalist and composer Mike Oldfield, best known for his landmark 1973 album Tubular Bells, which launched Virgin Records.

The commission came from Altered Images Ltd., the company behind the celebrated Magic Eye random-dot stereograms that captivated audiences worldwide.

The video for the single was provided by them, and I selected a suitable two-second sequence. To realise the hologram, I then employed the DI-HO (Digital Input – Holographic Output) system to create a full-colour and animated holographic stereogram. I named this unique type of hologram, a *Moviegram*.

DI-HO commissions that Spatial Imaging gained from IC Holographic included the following:

Queen - The Ultimate Collection, 1995

In 1995, Spatial Imaging was commissioned to create a digitally produced, full colour, animated 2D hologram, which I had christened a 'moviegram' the previous year, for the band Queen. The hologram was commissioned by IC Holographic, a London based hologram design and marketing agency.

The hologram adorned '*Queen – The Ultimate Collection*', a 26" square, wall mountable cabinet which included 20 CD's, featuring all 18 studio and live albums released up to that point. The set was released on 13 November 1995 and was limited to just 15,000 sets worldwide. The front door of the set has Royal blue felt, including placeholders for two CD's, the Queen crest, moving gold coloured Freddie Mercury hologram and the limited-edition number. The inside features placeholders for the remaining 18 CDs on maroon felt, a booklet, and a Queen crest buckle to hold it in place.

I utilised my unique DI-HO (Digital Input – Holographic Output) system, that I had designed and built between 1989 – 1991, to create the hologram. The DI-HO system was the world's first computer-automated 3D digital holographic stereogram recording system.

My DI-HO system enabled me to create the hologram directly from a suitable digital video sequence. I procured an analogue video tape of Queen's legendary Queen 'Live at Wembley Stadium' concert on July 12, 1986, Queen's final tour with Freddie Mercury. I carefully stepped through the video to find an exciting, dynamic two-second, fifty frame sequence from which to make the hologram and came upon a sequence of Freddie Mercury performing in his iconic yellow buckled jacket with white trousers, now one of the most recognized stage costumes in rock history. The clip comes from the end of the first song, One Vision, which Queen performed at their second concert, approximately 5 minutes into the film.

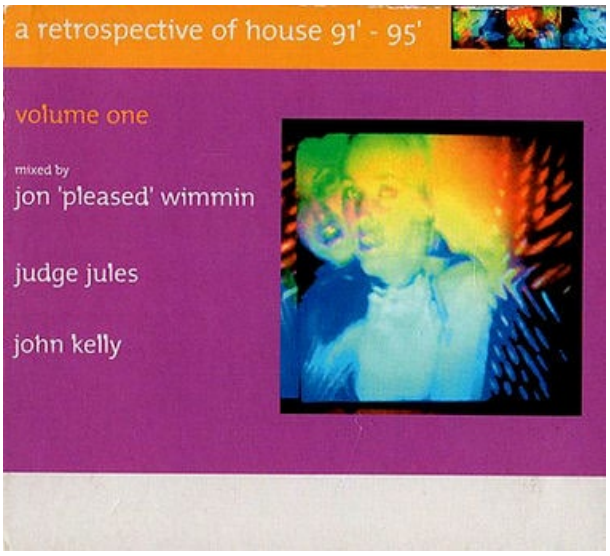
Once I had chosen the sequence, I digitised it using a Matrix video digitiser, one of the first generation of video digitisers for microcomputers, on a Commodore Amiga 4000 computer. I ultimately used 46 frames with the first and end frames repeated to aid the horizontal animation effect. The result was this VGA 640 x 512-pixel resolution sequence.

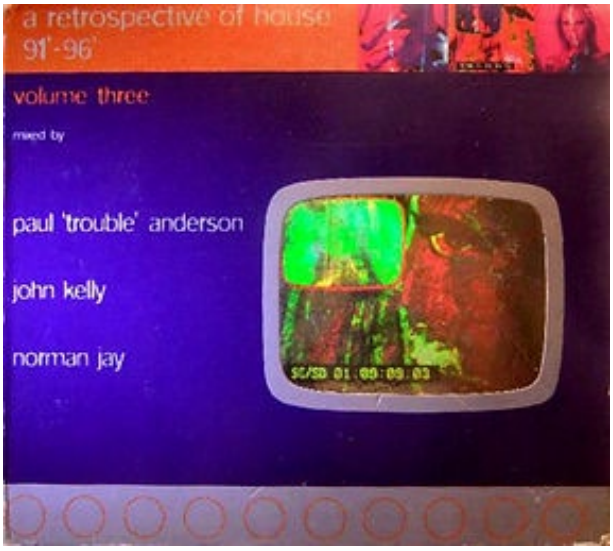
After much post processing to clean up, sharpen, and saturate each frame of the sequence, needed for hologram mastering, I then created a silver-halide master transmission hologram, followed by a photoresist ‘rainbow’ image-planed transfer hologram using my DI-HO system.

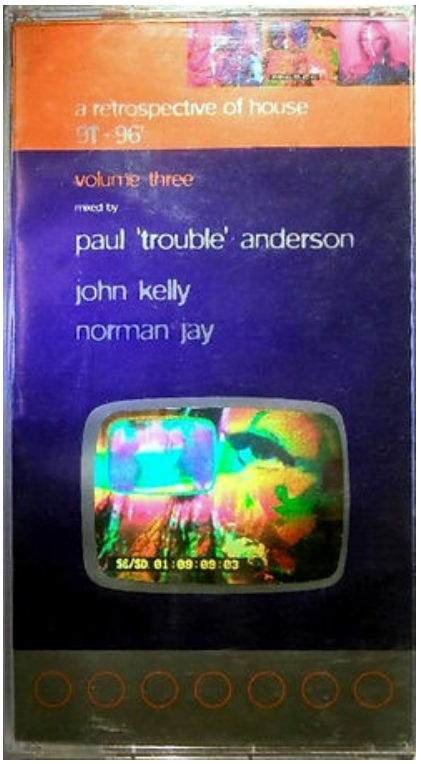
The photoresist transfer hologram was then sent to Applied Holographics Plc for replication by embossing onto gold coloured PET film. The adhesive backed PET film holograms were then die cut and applied to the product.

Unfortunately, no credits were given to me/Spatial Imaging on the product or in any discographies for my design and creation of this historic hologram.

A Retrospective of House ’91-96’ - Volume One, Two, and Three, 1995

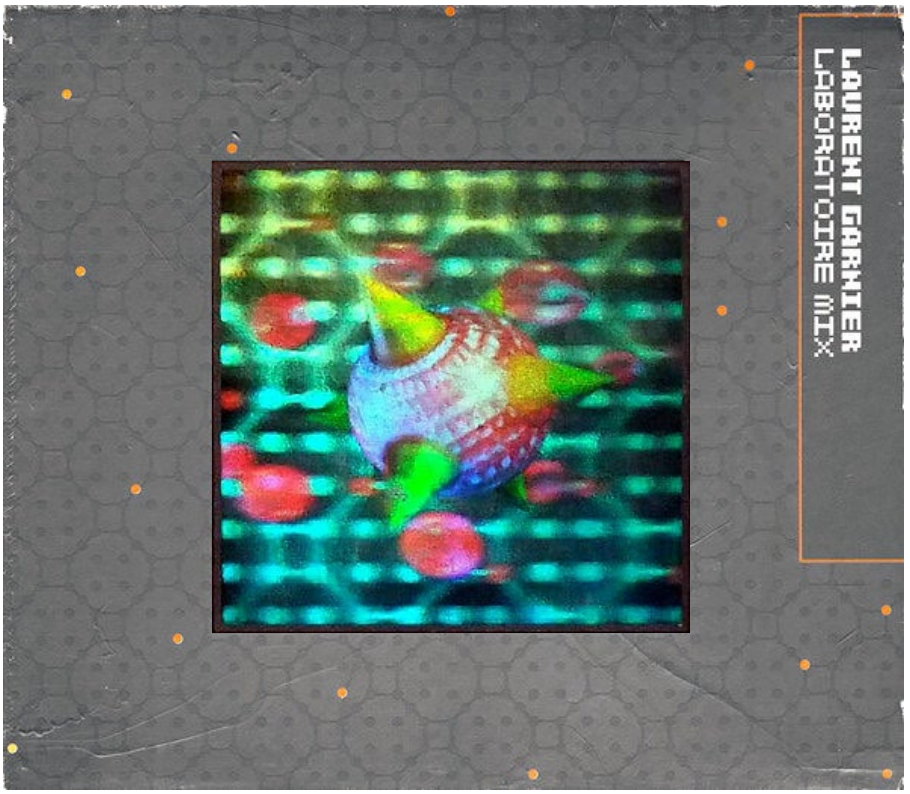






Boyzone – Father And Son, 1995

Laurent Garnier - Laboratoire Mix, 1996



Spatial Imaging's DI-HO holographic stereograms 1992 – 1997

Over a five-year period, from 1992 - 1997, Spatial Imaging mastered more than one DI-HO hologram per week, totalling some 250 - 300 DI-HO projects. The majority of these holograms were designed by Jeffrey Robb, acting as Spatial Imaginx`g's designer, and later Creative Director.

The revenue from the DI-HO system paid Munday Spatial Imaging's, and later, Spatial Imaging Ltd.'s., overheads, and kept the company afloat during these years. Below is a selection of holograms made using the system during this time:

India Tiger – stock-image embossed 2D-3D hologram.

A 2D-3D hologram with an animated tiger roaring made using 2D-3D Maker.

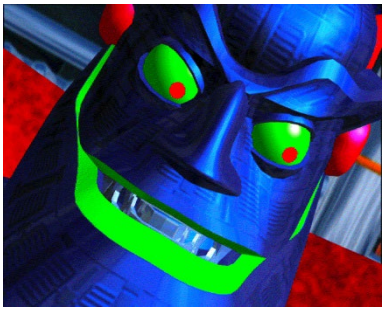
Taj Mahal – stock-image embossed 3D hologram.

A 3D holographic stereogram sequence shot my Rob Munday whilst on holiday in India.

Reboot – commissioned embossed 'moviegram' holograms

Three animated 'Moviegrams' commissioned by Mainframe Entertainment (later known as Mainframe Studios), of Vancouver, Canada, for ReBoot promotional items.

ReBoot (1994), a children's television series, was the first-ever entirely computer-generated television series. This was a landmark moment in animation history and positioned Mainframe Entertainment as a pioneer in the field.

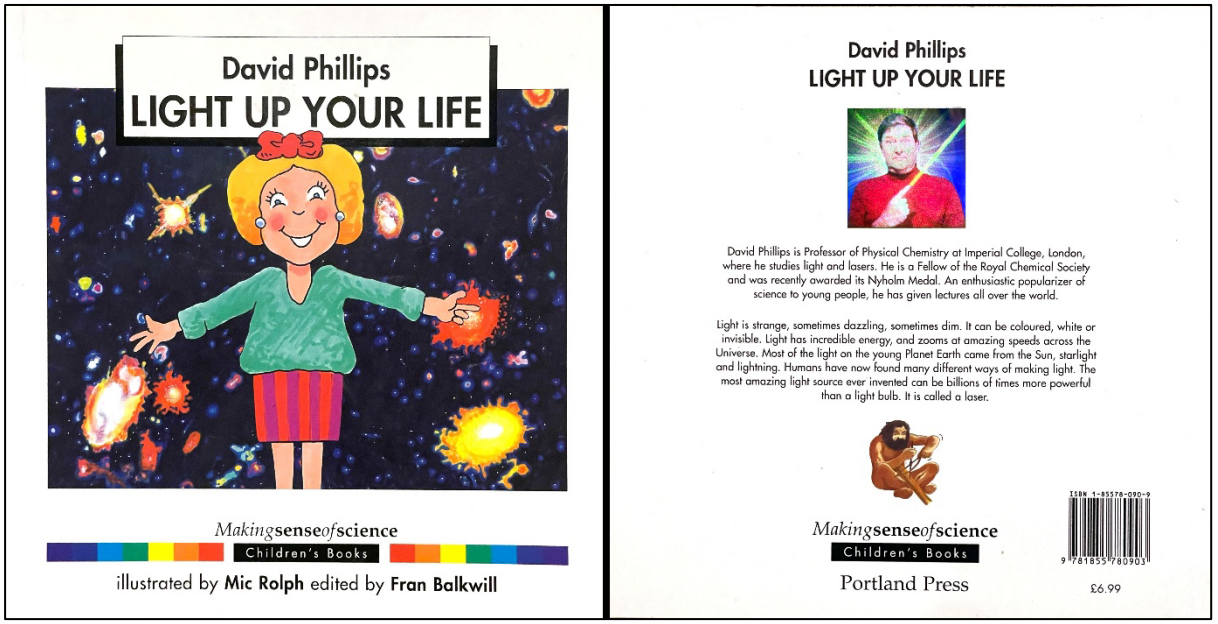




N.B. By coincidence, Ian Pearson, the founder and owner of Mainframe Entertainment, was a fellow student in the same year and on the same BA(Hons.) degree course, Scientific and Technical Graphics as me and a friend. After the first year of the four-year course, Ian Peason approach me to ask for my advice. He had been offered a full-time position in London at one of the first commercial computer-graphics facilities, Molinare, and asked me if he should accept the offer, rather than finish his degree. I advised that he should finish his degree and work for them afterwards. He refused to take my advice, and within a year had created the world's first computer generated music video, for the song Money for Nothing by Dire Straits. He never looked back. I lost touch with him in the 1980's and, as far as I know, he never found out that I had created the holograms for his landmark TV series.

Light Up Your Life book – commissioned embossed 3D/animated hologram

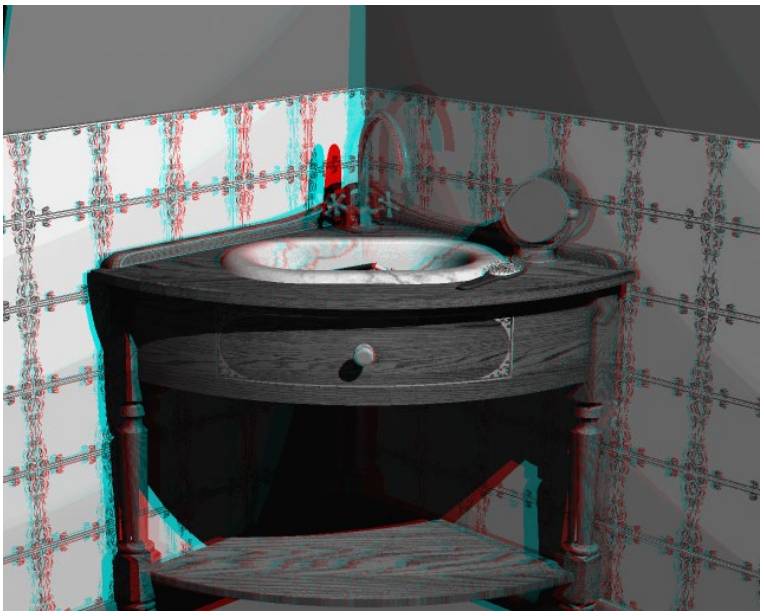
In 1997, Spatial Imaging was commissioned by the author, David Phillips, to shoot and create a full colour, 3D and animated portrait of himself, for his book *Light Up Your Life*, a children's science book about light in his *Making Sence of Science* series. The portrait was shot using my first video linear rail recording system, the video digitised, and a laser beam and background added to the sequence using Amiga computer graphics.





The Amiga Format competition and Victorian Sink – a competition winning entry, 1993.

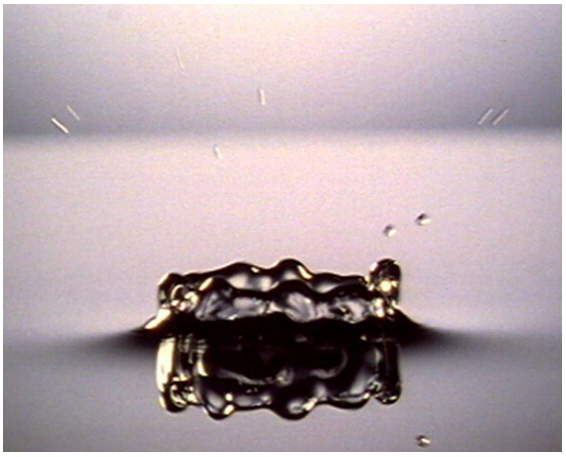
In 1993, Spatial Imaging worked with Amiga Format Magazine to run a competition for the best computer-generated stereographic sequence created using an Amiga computer. The winner received a hologram made using his images. Twenty-five entries were received and the winner was Victorian Sink by Anthony Nutley.

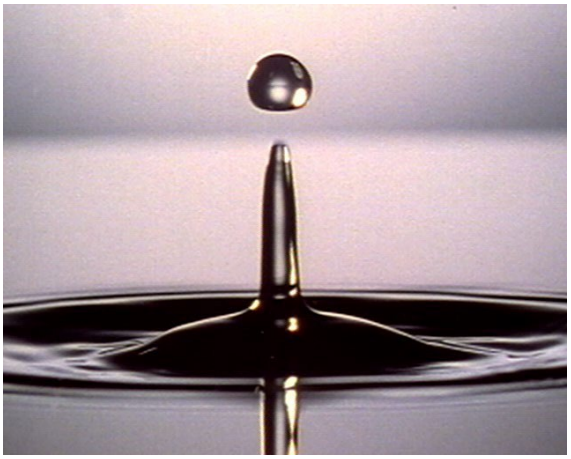


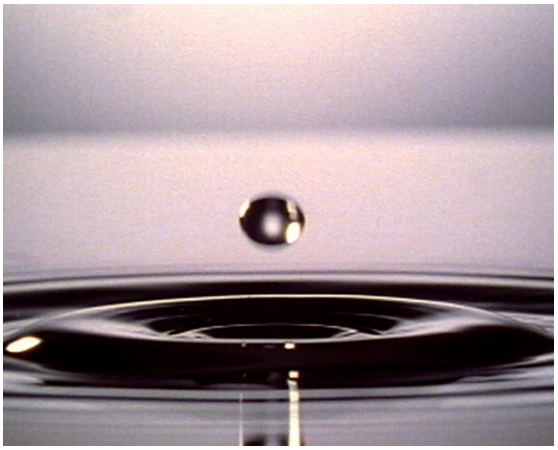
Water Drop by Jeffrey Robb, 199X, - artwork, 5 x 4 inch reflection hologram, and embossed hologram stock images.

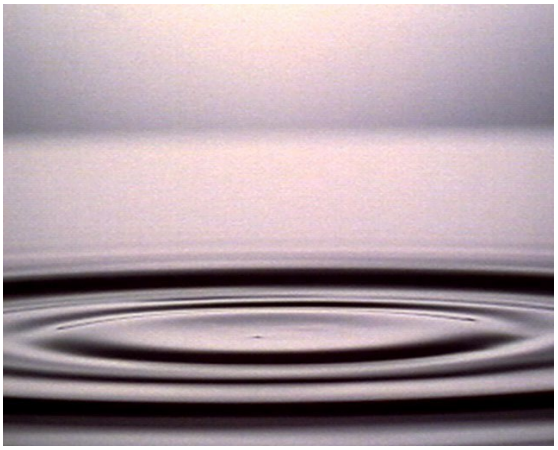
Prior to graduating from the Royal College of Art and joining me at Munday Spatial Imaging, Jeffrey Robb created an animated holographic stereogram of a water drop, as part of his MA(RCA) in Holography. The stereogram was originally made in Loughborough University by Prof Nick Phillips using a holographic stereogram mastering system funded by the Computers in the Primary and Secondary Education (CITE) government program and was made using film footage procured from the film library of Oxford Scientific Films. The mastering system was made available to RCA students to use.

After joining my company, Jeffrey Robb agreed to use the same film footage to create further animated 'moviegram' holographic stereograms using the DI-HO system. Both reflection hologram and embossed hologram stock images were created. The former was later mass reproduced and sold by the company Laza Holograms, as a film reflection hologram.







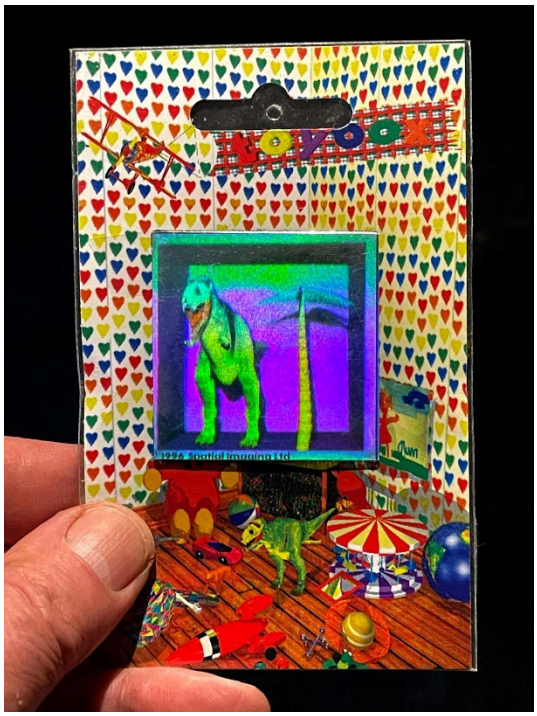


Lego – commissioned embossed 3D brand protection hologram.

Toybox

In 1996, I had the idea to create the first holographic Christmas advent calendar. The idea was to position computer-generated holographic toy boxes, each containing a full-colour animated toy scene, behind real cardboard doors. I thus set out to design and computer generate twenty-four such toy boxes using my Amiga computer and Imagine 2.0 software. After generating nine toyboxes I made the decision to create nine holograms, optically recombined using the DI-HO optical recombination system in a 3 x 3 array. It was the first time that the DI-HO optical recombination system was employed. Nine H1 master holograms were first exposed using the DI-HO by my relative new employee and trainee holographer, now holographic artist, Inaki Beguiristain. Once exposed and developed, the H1 master holograms were placed back into the plateholder and a transfer made from each one, one by one, onto the transfer plate. The transfer plate was moved each time so as to tile the holograms in a 3 x 3 grid. Embossed, self-adhesive holograms were subsequently made.

The first nine toy boxes



Whist there were not enough toy boxes to make a Christmas advent calendar, the image proved to be extremely successful. Many hundreds of full-sized stickers were sold, and each individual toy box was used for many different types of gift products, from fringe magnets to pill boxes, and key rings to greeting's cards.

The second seven toy boxes. The final two of a city scene show two channels of one toy box.

Even though twenty-four were never made, nor a Christmas advent calendar produced, this hologram became the most famous and successful of all the holograms created using the DI-HO system.

EyeBytes

In 1995, Jeffrey Robb and I decided to create a range of commercial stock-image embossed holograms, that could be sold for use on a variety consumer products, such as toys, fridge magnets, and greetings cards. Jeffrey Robb devised the name EyeBytes, and over 24 were created, both animated and 3D, and from video footage and computer-generated images.

Many were made from video footage shot using my first video-linear rail system, which I designed and built in 1992. They system utilised a shift video camera behind a static lens to prevent keystone distortion. By todays standards, the camera, a machine vision camera with a composite video signal output, had an extremely low VGA resolution of only 640 × 512 pixels, and noise levels and colour saturation left a lot to be desired. Two to three shoots were held at a friend's photography studio in Camden, London, to record the various live action images.

EyeBytes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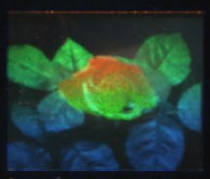
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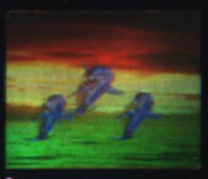
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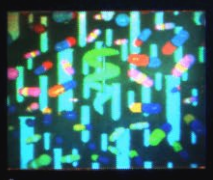
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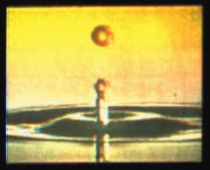
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Products that used EyeByte holograms included ‘Moments’ greetings cards, and Laza Holograms fridge magnets. Many thousands were sold. Also, many were purchased for promotional applications, for example, my hologram of the Taj Mahal was used for Indian restaurant menus. For a period of time the EyeByte range was licenced to XXXXXX, in Germany.

Pink Floyd's The Division Bell album - the one that got away.

In January 1994, a call came in from the hologram design and marketing agency IC Holographic to tell me that there was an opportunity to shoot and create a DI-HO 3D holographic stereogram for a world first holographic CD music album, not for the cover of the album, but for the CD itself. Whilst several holographic CD singles had been produced prior to this, they featured only simple 'dot-matrix' diffraction patterns and graphic images in the inner and/or outer mirror band (IMB/OMB). No holographic CD album had ever been made, nor any CD on which the entire reverse side was holographic, nor any that incorporated a 3D/stereographic image. The CD would be a first in all three respects.

The album was to be Pink Floyd's seminal 1994 release *The Division Bell*, and the CD was to be manufactured using a new technique called E2E (Edge to Edge), invented by Nigel Abraham of Applied Holographics and developed and utilised by Nimbus Records in collaboration with Applied Holographics under the joint-venture company 3dCD LLC.

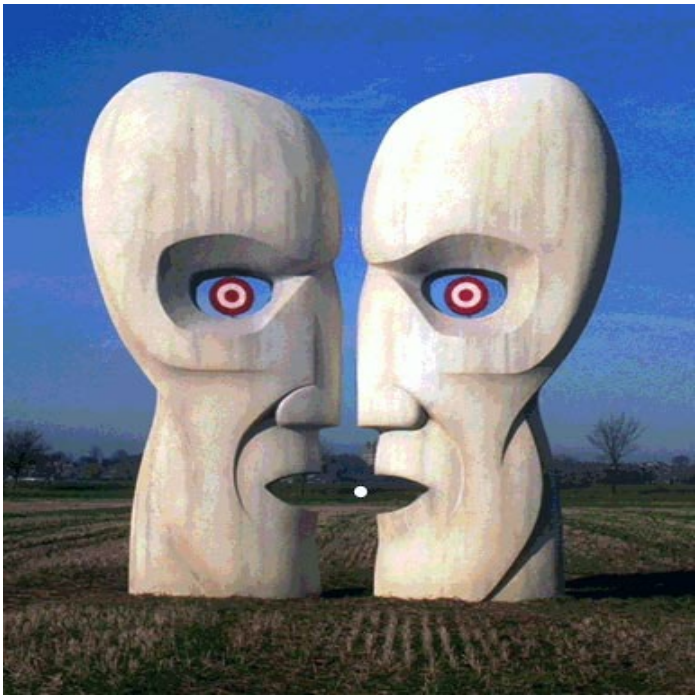
On a cold late January day in 1994, I drove to a field in Cambridgeshire, not far from my ancestral home village of Wicken, to shoot two giant polystyrene heads. The heads in question had been devised by artist/sculpture Keith Breeden, constructed by John Robertson, and positioned by the legendary Pink Floyd artist Storm Thorgerson to create the iconic album cover.

Varius official photographs of the heads used for the album.

I set up my linear rail system on two tripods in the muddy field in front of the heads, aligning everything so that Ely Cathedral, visible on the horizon, sat slightly higher that the mouths of the two sculptures, and in which an animated lighting effect would be added by me using the Amiga program Deluxe Paint, published by Electronic Arts, in post-production.
With nothing moving except the clouds, and no electrical supply anywhere nearby, I opted to use my 35mm Nikon film camera and operated the rail manually. I had marked the rail in increments, stepping the camera along and exposing each frame in turn. Eighty frames were taken in total.
We broke for lunch and dined at the 15th-century pub The Maid's Head in Wicken, where my great-uncle, the last working peat digger of the fenlands and a local celebrity, was given a free pint of beer every day from the age of eighty until he died, some years prior to the shoot, at the age of ninety-four.

When I returned home, the film was sent for processing, the frames digitised, and a Kodak Photo CD delivered. Eager to create the hologram, I recorded the H1 master in early February and had already produced a small test photoresist transfer when another call came through: Nimbus Records would not be able to complete the development of their new E2E technique in time, and so it would not be possible to create the first holographic CD album using my stereographic image. The launch date had been brought forward to 28 March 1994, leaving only six weeks — far too little time to complete what would have been a unique, historic, and technically ambitious holographic edition. And so, very sadly, my DI-HO 3D holographic version of this now-iconic image and album cover was never used.

The E2E technique was subsequently used to produce a holographic album entitled *The Life of Chris Gaines (1999)*, for the singer Garth Brooks, one of the most successful and influential country music artists in history, and was the only album ever made with the process before the rights were sold exclusively to Microsoft for use for software discs.



Frame 35 from the 80-frame DI-HO sequence that was used to create the H1 master and transfer hologram for the 1994 Pink Floyd 'The Division Bel' holographic album, showing one of four lights that alternated back and forth between the mouths of the heads as the hologram was titled.

Below is the central frame from my original 80-frame stereographic image sequence, together with an anaglyph version.

The original central frame from the stereographic image sequence shot by Rob Munday for Pink Floyd's iconic 1994 album The Division Bell.

An anaglyph image made using the same original stereographic image sequence shot by Rob Munday for Pink Floyd's iconic 1994 album The Division Bell.

Technology transfer of DI-HO systems.

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Munday Markets DI-HO System

Munday Spatial Imaging (MSI) has started to market its DI-HO® (**D**igital **I**nput-**H**olographic **O**utput) stereogram design and origination system. One of the first to be sold was installed at Qingdao Haisite Computer Laser Mastering Centre - see story this issue.

Munday first showed holograms made with this system two years ago (see HN Vol 6 No 6), but has spent two years refining the computer software, the system controls and the optical system to create a user-friendly hologram for making holograms. The concept has been to create a system that can be used by a graphics designer rather than a specialist holographer. Probably, however, the market will be hologram mastering studios that will accept computer artwork files from designers. Robert Munday claims a lead of several years over competing systems in the level of image manipulation, stereogram specification, LCD technology and exposure control offered by the system. A paper about it will be presented at the International Symposium on Display Holography at Lake Forest.

***Holomation* Program**

The basic DI-HO system comprises a fully-integrated computer image holographic stereogram mastering and transfer system, with all the software, optics, plate holders and control systems required (see diagram). It will accept input images from virtually any digital source, outputting them in perfect registration to the liquid crystal display (LCD) for the hologram master exposure.

The *Holomation* software included provides comprehensive features including automated exposure of both full colour masters and full colour transfers, with control of an optical recombiner to gang-up images. It calculates and controls the stereogram exposure angles, RGB slit positions and all exposure variables. It can be tailored to work with continuous wave or pulse lasers, or to control a linear rail photographic recording system or an electron microscope stage.

The Holomation program also offers the facility to

Continued on page 7

INSIDE:

APA: Source for Computed HOEs

Minnesota optical development company APA Optics, Inc (NASDAQ: APAT) has produced its results for the third quarter of fiscal '94, ending December 31st 1993. They show revenues of $500,369, a 19% drop on the same quarter in the previous year. The loss for the period was $136,706, a slight improvement on the previous year third quarter, thanks to improved operating costs. Annual turnover is heading towards $2.1-$2.2M.

APA's major field of operation is custom produced computer-generated binary holograms, which often replace assemblies using several conventional optical elements. The company works with e-beam written systems which make a photomask from a computer-designed and generated pattern. The mask is then used as a master for a holographic optical element.

Brian Cohn, Optical Systems Engineer, explained that typically APA uses an e-beam machine to scribe grating though the mask into photoresist which is transferred into chrome, to produce an amplitude grating. An active ion etching process then transfers this into a phase relief pattern and generates a binary amplitude grating using some proprietary methods and several masks.

Supplies Floptical Optics

One of APA's commercial developments was the binary optical element used by the Iomega Corporation for the holographic optical tracking technology in flop-

Continued on page 2

Equipment

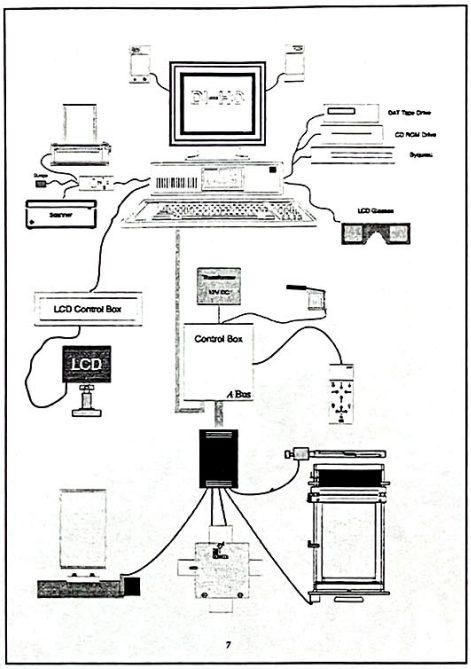
DI-HO System - *cont'd from P1*

view a simulation of the hologram in a full colour stereoscopic version using LCD shuttered stereo viewing spectacles. This reveals the perceived depth and parallax effects, allowing any changes to be made before the hologram has been exposed.

An Amiga 1200 computer (an Amiga 4000 in the Enhanced DI-HO system - see below) controls all aspects of master and transfer hologram exposure on the specially designed holographic camera. The images are separated into red, green and blue colour separations in 256 grey levels then output in sequence to a specially-designed 640x480 pixel high resolution LCD for laser-exposure onto the hologram master.

The only handling required during the process is to place the plate in the plateholder for the master exposure, to chemically process it and to replace it for the transfer configuration. The transfer can be done in a spread-beam single exposure or a slit multiple exposure, depending on the power and coherence length of the laser.

The optional optical recombiner calculates the number and position of multiple images on a plate and controls the translations stages and exposures accordingly.



Schematic of the DI-HI® Procedure

Enhanced System.

The basic system will work with pre-created computer or graphics images. The 'Enhanced DI-HO' system includes an Amiga 4000 graphics computer for the creation of the original artwork. This will accept practically any form of image input, as well as allowing origination using standard graphics programs.

MSI is also offering a linear rail recording system for the imaging of scenes from life or the real world. This can be configured for a video, 35mm still or cine camera, which travels along the rail under computer control, making exposures at predetermined intervals. These images can be scanned or frame-captured.

The price of a DI-HO system varies between £65,000-£120,000 (±$100,000-$335,000), depending on the configuration required. MSI will quote to each customer's specification, to include installation, training and hardware/software updates. (The optical table and laser are not included.) The price for the rail system is £15-20,000. HN

Contact: Munday Spatial Imaging, 9 Pyrcroft Road, Chertsey, Surrey, KT 16 9HT, England; phone/fax +44 0932 564899.

HoloPak to Sell Jaeger

In spite of the recent appointment of main board member Wayne Parker to be responsible for Jaeger Graphic Technologies (JGT) (see HN Vol 8 no 2), New Jersey company HoloPak Technologies Inc has now decided to sell JGT. The company's official statement cites operating losses at JGT, the continued uncertainty of the European economies, and the existence of better opportunities within its existing business as the basis for the decision. HoloPak's Marketing Director Mark Wootner told **Holography News** that there is simply too much competition in the European hot-stamping foils market for an American company to make much impression, especially operating on current exchange rates. Wootner confirmed that the company remains active in the European holography markets, working with several European companies. HN

Contact: HoloPak Technologies, PO Box 538, East Brunswick, NJ 08816, USA; phone +1 908-238-1800, fax 238 7936.

Five DI-HO systems were sold as technology transfers.

1. 1994 - Haisite Mastering, Qingdao, China.
2. 1995 - Spatial Holodynamics, Mumbai, India.
3. 1996 - Novavision Inc., Bowling Green, Ohio, USA. This system as later sold to Light Fantastic-Opsec, Shepshed, UK.
4. 2011 - G. Libert Innovative Microscopy Centre, Daugavpils University, Daugavpils, Latvia.

In addition to these systems, three holographic stereogram mastering systems were later built by private holographers under the guidance of Rob Munday and using parts and software from Rob Munday's original DI-HO system.

1. Mathew Shrieber (artist-holographer), Miami, USA.
2. Jeffrey Wyle (commercial holographer), Miami, USA.
3. Patick Boyd (artist-holographer), UK

Limitations of the DI-HO system, and the reasons for its demise.

Two step holographic stereograms are essentially holograms of ground glass diffusion screens, onto which a series of images are projected. The interference pattern created by this arrangement is complex and often shallow. 1990's embossing/replication techniques relied upon hard embossing, which forced this surface relief interference pattern into a layer of lacquer coated PET film using heat and pressure. This process was not conducive to embossing complex holographic interference patterns, and hence the resulting embossed holograms would often lack brightness and colour saturation.

The use of a ground glass diffusion projection screen also caused an effect called 'search lighting', meaning that the intensity of the transmitted light through the screen, and hence the brightness of the projected image, was greater on the optical axis. The effect of this was that holograms appeared brighter when viewing from head on, and dimmed when viewing from an angle.

The DI-HO system utilised one of the world's first TFT LCD (thin film transistor liquid crystal display) screens, and hence the resolution and contrast were low by today's standards. This led to low a relatively poor colour saturation in the holograms, as compared to holograms made from models of from high-contrast lithographic films, as in the case of conventional 2D-3D holograms.

The DI-HO was a two-step system, requiring an H1 master hologram to me made first, followed by an H2 transfer hologram.

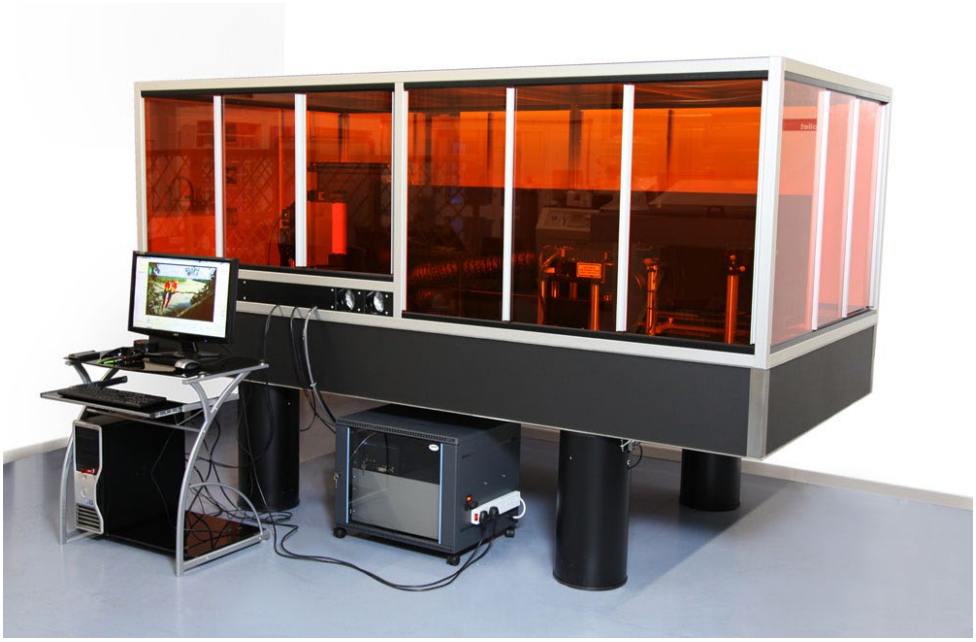
In 1994, the SIMAIN system, designed and built by pioneering American holographer Kenneth Haynes of American Banknote, was completed, and an origination service offered. This was the first one-step holographic stereogram mastering system. Due to the nature of this system, the above four limitations of the DI-HO system were no longer present, and many companies preferred the quality of SIMIAN holograms over those produced by the DI-HO system. The SIMIAN system itself was not for sale.

Lastly, the use of and interest in commercial 3D holograms and holographic stereograms, for everything but security and authentication applications, began to wane in the late 1990's. Commissions for them died off, and Spatial Imaging moved into the field of security and authentication holography utilising my Lightgate 1270 'dot matrix' hologram mastering system, that I invented in December 1996.

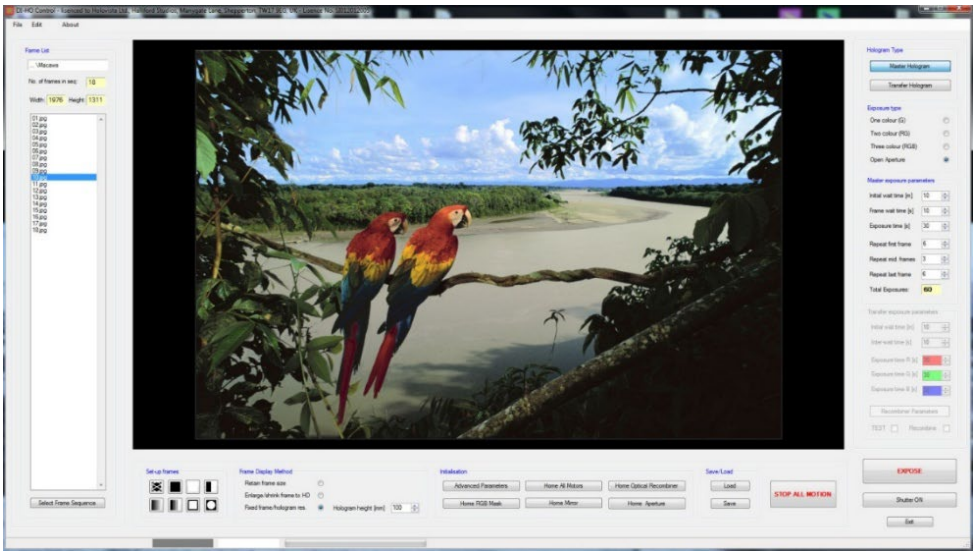
DI-HO 2

In 2012, 21 years after building the original DI-HO system, Spatial Imaging was surprised to receive an order for one, from the research company XXXX, based at Daugavpils University, Daugavpils, Latvia. It gave me an unexpected opportunity to redesign and build a new DI-HO system using the very latest optical components of the time.

The system utilised a 1920 x 1080-pixel HD reflective LCOS micro-display, made by the company HOLOEYE Photonics AG, a 300mw CVI Melles Griot single frequency diode-pumped solid-state blue laser at 457 nm, and a new software interface was written by me in VB.Net called DI-HO Control 2.



DI-HO 2



DI-HO Control 2

World First Claims

The claim that the DI-HO system was the world's first computer-automated digital holographic stereogram printer needs to be explained in a little more detail.

The first-ever computer-generated hologram, defined as a hologram that has been made using a computer calculated interference pattern, was first made by Byron Brown, a student working under Adolf W. Lohmann at IBM in 1964. The hologram itself however was not made digitally. It was created by first drawing the computer-generated interference pattern onto paper using a California Computer Products (CalComp) pen plotter. The plotted image was then photographed and reduced onto silver halide film, both analogue processes. The silver-halide film copy served as the hologram.

Dot-matrix holograms were first made in 1984 by inventor Frank Davis who built and sold the first commercially available system for making dot-matrix holograms, the Davis Light Machine, to K Laser in Taiwan in 1991. Dot matrix holograms are sometimes referred to as digital holograms as they are made using a digital computer image and comprise of an array of diffractive pixels. Each pixel in the hologram represents a pixel in the original computer image, however, in the case of early dot-matrix systems, the hologram was only designed to create a diffractive pattern, sometimes called a 'kinetic' hologram. These systems could not create 3D/stereographic images. Please note, the author designed the first dot-matrix system that was capable of creating wide-angle, full colour 3D stereographic images in 1996, and won the International Manufacturers Association Award for Excellence for Best New Technique for it in the year 2000.

In The Netherlands, holographer Walter Spierings of the Dutch Holographic Laboratory B.V. had built a holographic stereogram printer that could make full colour holographic stereograms in 1989 but using analogue film stereographic sequences.

The DI-HO system, therefore, was the world's first computer-automated digital hologram / holographic stereogram printer that was designed to make holograms / holographic stereograms directly from computer generated images displayed on an electronic/digital/solid state SLM liquid crystal display (LDC). It was also the world's first commercially available computer-automated digital holographic stereogram printer. Not only that but full colour and/or animated DI-HO holographic stereograms could be made and is thus the best candidate for 'world's first digital hologram printer'.

The DI-HO system utilised a two-step process, one step to expose the H1 master hologram, and a second step to expose the image-planed transfer hologram. Later 'one-step', directly written, digital holographic stereogram printers were developed, the first being the horizontal parallax only Simian system developed by Keneth Haines between 1992-1993, and introduced commercially in 1994. This was followed by Michael Klug, Mark Holzbach, and Alejandro Ferdman's one-step, full parallax, Zebra Imaging stereogram system in 1996, and then the Geola UAB's system in the late 1990's.

It must be borne in mind, however, that none of these systems were 'fully' digital. In other words, the holographic interference pattern itself was created in an analogue fashion using laser interference. Fully digital holograms, whereby the interference pattern itself was directly written in a digital manner, were first made by Toppan, Japan, in 1997 using an electron-beam lithography system, and commercially available, fully digital mastering systems that used light first appeared in 2013 from 4 Pico Litho B.V. in The Netherlands.

My mistake at the time, and being a creative holographer/artist, was not to publicise the system in the scientific press, and so a later system, designed and built by Walter Spierrings of XXXXXX is sometimes described as the world's first digital hologram printer due to a paper that he presented at the XXXXX symposium in XXXX.

The first article to be published about the DI-HO, however, came in the July/August 1992 issue of Holography News, and several authoritative books on the history of holography, two of which are shown below, have since described the DI-HO system and my digital holograms as having been the first.

FIGURE 21.11 The post stamp with two-channel hologram from two different viewing angles. The stamp was issued in Australia in 1999 to celebrate the Millennium shift. This stamp was also available as a personalized stamp and the depicted stamp is personalized by Hans Bjelkhagen. The holograms for the stamps were produced by Applied Holographics Plc in cooperation with Avon Graphics. The stamps were printed by SNP Ausprint. (Courtesy of Hans Bjelkhagen.)

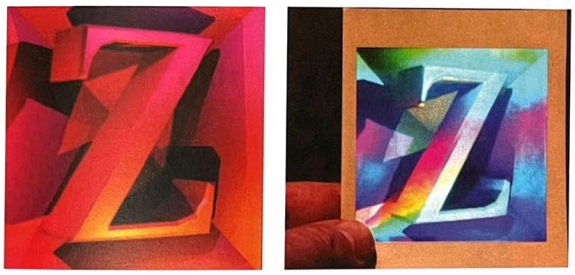


FIGURE 21.18 "Z" by Rob Munday, 1992. This was probably the world's first digitally produced embossed holographic stereogram. (Courtesy of Rob Munday, who also took the photographs.)

(a) (b) (c)

FIGURE 21.22 Embossed 28 × 38 mm hologram produced by OAO NPO "Krypten" from DWDH original made by Geola Digital, uab—views from left, center and right (a–c). (Photograph by Laura Zacharovaitė.)

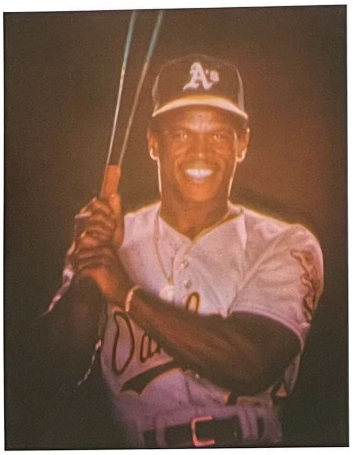


FIGURE 1.45 The first three-colour (multiple photo-generated holography) reflection holographic stereogram of US baseball star Ricky Henderson. (Courtesy of W. Spierings, 1991. Dutch Holographic Company B.V.)

onto a diffusion screen. Three separate H_1 transmission master holograms were produced using red, green and blue lasers. Each master was then transferred, one at a time, to a full-colour reflection H_2 on fine-grain silver halide emulsions. Spierings began working on the MPGH technique after being inspired by Steve Benton's work at MIT in the mid-1980s on computer-generated stereograms. At about the same time that Walter Spierings introduced his MPGH colour reflection holograms, another holographer, Rob Munday in the United Kingdom, was working on a similar (H_1/H_2) technique but with an important difference—this was the first of the digital stereogram systems. In 1991 Munday developed a system that he called the DI-HO (Digital Input–Holographic Output) to record H_1 holographic master stereograms and H_2 transfers using a modified high-resolution LCD screen. He used the Commodore Amiga 3000 Graphics Workstation with software that he had written himself named *Holomation*. The system could accept image input from sources such as a scanner or video as well as computer-generated artwork. The software also allowed for the planar separation of 2D graphic images which could then be combined with a 3D stereogram. Holograms up to a size 8" × 10" could be made with the system in both reflection and transmission format. Munday's first demonstration hologram was made in collaboration with MIT graduate Eric Krantz in 1992. It was a 7 ½" × 9" multi-colour H_2 reflection hologram of a *triceratops* dinosaur on a tiled surface (see Figure 1.46) made using multiple H_1's produced from digital data (the *triceratops* was a computer-generated 3D model). The H_1's were based on 70 slits, but Munday's technique allowed the number of slits to be increased to achieve better resolution if required.

Later in 1992 Munday also produced an embossed colour hologram called 'Z' using the above technique. The DI-HO system was used to record the stereogram frame by frame in three colour separations with each 'strip' colour separation contained on a single achromatic angled H_1 plate. The H_1 hologram was recorded on Agfa silver halide material using a Helium Cadmium laser. Munday then transferred the image to a surface relief photoresist H_2 before commissioning Applied Holographics plc to emboss the hologram. By the late 1990s, digital cameras and LCDs had largely replaced the old analogue techniques, giving birth to digital holographic printing.

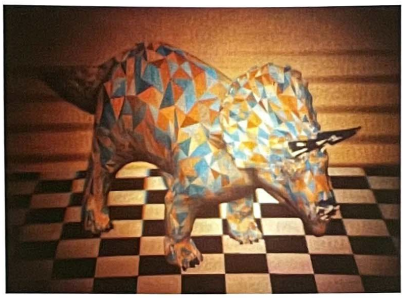


FIGURE 1.46 *Triceratops* hologram (courtesy of R. Munday).

A sketch of an idea, one step digital rainbow holograms.

It is perhaps worth mentioning that, also in the spring of 1987, an RCA holography unit student by the name of Mathew Andrews asked me to design a holographic camera with which he could make one-step rainbow holograms. The camera I devised incorporated a large curved piece of frosted aluminium, acting as a diffuser for a line of laser light. This acted as an object beam, such that when exposed, the resultant hologram would be a rainbow hologram with a simple field of colour. Then, by making multiple exposures through a series of graphic films, laid in contact with the plate, and by raising or lowering the line of laser light on the diffuser, a multiple colour 2D, one-step rainbow hologram could be made.

This sparked a new idea, which I hastily wrote down on a scrap of paper whilst on the beach in St Tropez on holiday that summer. I must have deemed it important, as I even signed and dated the sketch.

The sketch

In short, I had realised that if one could modulate the line of laser light along its length, both in intensity and in position, using the aforementioned single-step, rainbow hologram camera design, and expose very small areas of the hologram, i.e., pixels, one by one, then it would be possible to create a one-step 3D 'digital holographic stereogram.

I returned to the college in 1987, determined to build such a system, but, once more time, was against me.

In the late 1980s and early 1990s, both Kenneth Haynes and Steve McGrew filed a series of patents which described one-step holographic stereogram printing systems that utilised analogue film strips to provide the image data, but no systems were built at this time.

I finally started to build my one-step digital stereogram system in 1992, at my studio in Wheatash Road, Chertsey, Surrey, with the help of an employee, the holographer and artist Paul Newman. A large XY motion platform was built, capable of moving a pixel aperture across a 50 x 60cm area, a holographic diffuser was made, and I began negotiating the production of a custom ferro-electric LCD screen with which to modulate the line of laser light/viewing zones. Once more, however, commercial projects took precedence, and the system was never completed.

Ken Haynes finally built his own operational LCD based working system, the Simian System, in 1994 and began making the first commercially available one-step digital holographic stereograms.

If I had published my idea when I had thought of it in 1987, and also completed building my system in 1992, I would have been credited for the world's first one-step digital holographic stereogram system and holograms. This one escaped me.