The story of my Lightgate 1270 dot-matrix hologram mastering system

By Rob Munday, 2026

The Lightgate B system, 2004.

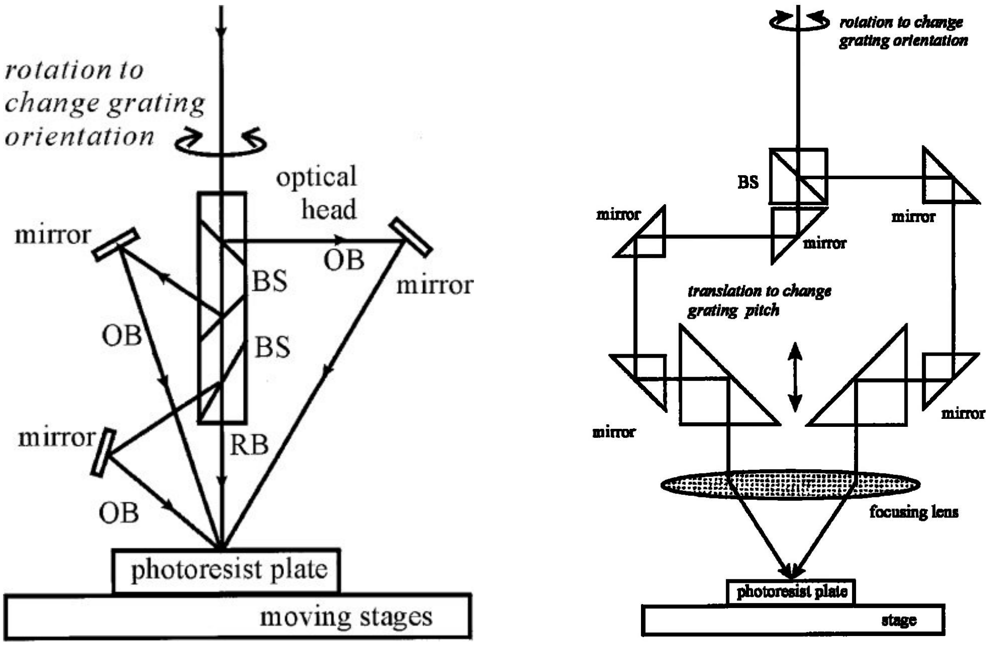
On the evening of Boxing Day, 26 December 1996, while relaxing in the bath at my home, Roseville, Free Prae Road, Chertsey, Surrey KT16 8DX, I experienced a eureka moment that would shape the technical side of my holographic career and drive the business of my company, Spatial Imaging Ltd., for the next thirty years.

I had been tasked by Walter Clarke, a Canadian Irish investor, and owner of Global Images Inc. to design and build a 'dot matrix' hologram mastering system. Walter had previously purchased two of my DI-HO digital holographic stereogram mastering systems for his security hologram companies in China and India, but he had recognised the potential and advantages of dot-matrix technology for security-hologram origination.

In 1996, only four dot-matrix mastering systems were known to exist, and of those four, only one was available to purchase commercially. The earliest, the Light Machine, was developed by Frank Davis in 1988, with later technical input from Kenneth (Ken) Harris of Dimensional Arts Inc. The second and third were proprietary systems developed by Craig Newswanger for Applied Holographics plc in 1990, and Fujio Iwata for Toppan in 1994. The fourth was produced by C. K. Lee at National Taiwan University in 1995/96, later commercialised as the Sparkle system by Ahead Optoelectronics, Inc. In 1996, only the Light Machine was commercially available, however.

Little is known about the Toppan system, however, both the Dimensional Arts and Applied Holographics systems were relatively slow and produced only low-resolution holograms, limiting them to making simple diffractive patterns. C.K. Lee's system offered a somewhat higher speed and resolution, but it did not become commercially available until 1998. Only the Light Machine, however, could be purchased at the time and yet was incapable of making advanced security holograms and digital stereograms. As discussed in more detail below, both the Light Machine and the later Sparkle system relied on an assemblage of cumbersome optical components to split and then recombine the interfering beams, whereas Craig Newswanger's system used a spinning diffraction-grating/lens assembly.

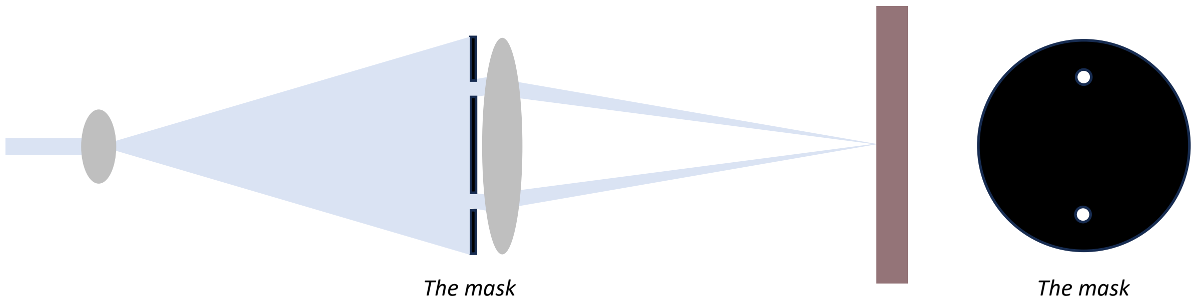
For comparison, below are diagrams of the optical configurations for the Light Machine and the later Sparkle system. As can be seen, these systems comprised of a multitude of glass beamsplitters (BS) and mirrors, to split and then recombine pairs of beams. In the case of the Light Machine, only three object beams (OB) were arranged at different angles relative to the reference beam (RB) to allow for the selection of only three grating spatial frequencies (colours). The entire assembly of optics for both systems then needed to rotate, stop and settle before recording each diffractive pixel, resulting in ungainly, difficult to align, and slow machines.



Left: A diagram of the optically complex 1989 Light Machine by Dimensional Arts Inc.
Right: A diagram of the even more complex 1995 C. K. Lee / Sparkle system by Ahead Optoelectronics, Inc.

Keen to avoid replicating any of the existing technologies, I spent several weeks trying to invent an alternative approach. Then, on 26 December, as I relaxed in the bath, an idea struck me - so simple that I was convinced there must be a reason it couldn't work. By the next morning, having failed to think of one, I cut my Christmas holiday short and went over to my studio at 8 Wheatash Road, Addlestone, Surrey, to test the idea.

The concept couldn't have been simpler: make two holes in a thin piece of cardboard and place it in a diverging laser beam. The mask would block all but the light passing through the two apertures, creating two spatially separated beams of light. A single lens placed in front could then bring those beams to a common, overlapping focal point. At that intersection, the beams would interfere, and the resulting interference pattern could be recorded as a diffractive pixel.



The Lightgate optical principle.

Arriving at the studio, I realised that I could use my DI-HO system's optical recombiner to translate a photoresist plate in X and Y directions, so I quickly wrote a simple software routine on my Amiga computer to step it in very small, pixel sized increments between exposures. I then set up the optical components seen in the diagram above, an expanding lens to diverge the beam, a thin piece of cardboard with two holes, and a large lens to reconverge and focus the resulting pair of beams onto the photoresist plate. With excitement I exposed a small single-angle patch of diffractive pixels, roughly 2 mm square.

At that time, the highest-resolution, and indeed the only commercially available system in the world was the Dimensional Arts Light Machine, with a resolution of only 100-200 diffractive pixels per inch and a speed of only 1-2 exposures per second. After developing my very first test, and seeing bright rainbow colours diffract from its surface, I placed it under the microscope and, to my utter surprise and amazement, discovered a near-perfect dot-matrix hologram with a resolution of 1,270 dpi - some six to twelve times higher resolution than the Light Machine. What's more, and with further testing, a speed of 20 pixels per second was ultimately achieved, 10-20 times faster than the competition.

The rest is history. The idea worked, no one else had conceived it, and that single eureka moment resulted in fastest and highest-resolution dot-matrix hologram mastering system, the bestselling dot-matrix hologram mastering system ever built, and the first dot matrix system to be able to make complex security holograms, spawning a whole new security hologram industry worldwide. Walter Clark suggested the name Lightgate, and I added 1270 to reflect its resolution, thus the *Lightgate 1270,* later to be renamed the Lightgate B, was born.

It is often quoted that the simplest ideas are the best ideas, and this simple idea earned millions of pounds Stirling in revenue for Spatial Imaging Ltd. over subsequent years.

Significant advantages of this optical configuration included:

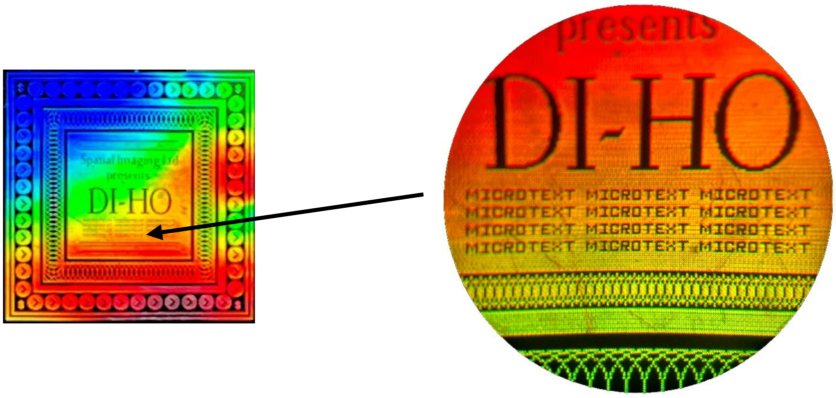
- The two interfering beams are two parts of a single beam, and thus always have identical path lengths, enabling the use of very short coherence length lasers.

- The two interfering beams are two parts of a single beam and thus are in perfect alignment, each with the other, with their focal points always perfectly overlaid.

- There are no moving optical components, and thus nothing to cause instability in the two interfering laser beams.

- The only moving part is a simple, lightweight mask (later two masks) which can be rotated at high speed, thus significantly decreasing the time to record a dot-matrix hologram.

- The compact size of the optical system enables it to be placed within an open-frame XY table and underneath the photoresist plate being exposed. This, in turn, provides for a highly stable system, prevents dust from falling onto the photosensitive surface, shields the photosensitive surface from ambient light, and enables simple visual alignment (focussing) of the combined focal point to the photosensitive surface.

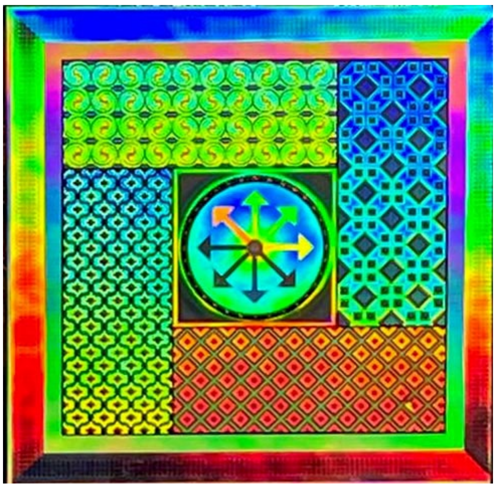


The second hologram test made on the 28th of December 1996.
Thought to be the first dot-matrix hologram to record microtext. The microtext is just 100um high.

Having now proven the system, the next step was to build a simple mechanical system to rotate the mask, and hence the two interfering beams to any angle. This was simple enough. I made a more rigid mask, this time from a thin sheet of aluminium, drilled two 1mm diameter holes in it, and mounted it in such a way that it could be rotated with a belt driven stepper motor under computer control. It was at this point that my Lightgate Control software program was born. The program needed to rotate the mask, and hence the two interfering beams, in accordance with the grey level of the pixel in the computer image (or bitmap) being recorded – see below for a full explanation of the dot matrix principle.

This simple technique, whereby the grating orientation, or angle of diffraction, is rotated for each diffractive pixel, creates a moving colour effect as the hologram is tilted, and so I termed this kind of dot-matrix hologram a 'kinetic' hologram.

Having written the software, I then created the first embossed kinetic hologram to be made using a high-resolution Lightgate dot-matrix system, see below:

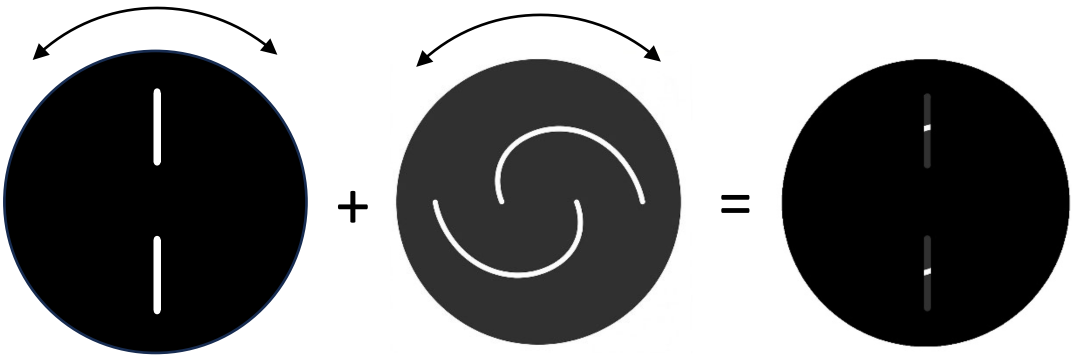


The first 'kinetic' dot-matrix hologram made using a Lightgate in early January 1997.

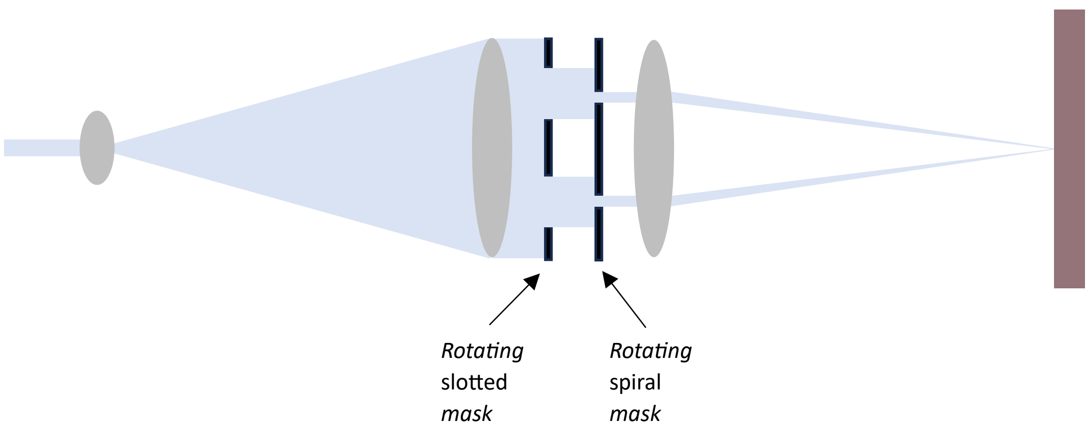
The next significant development followed very quickly in early January 1997. Whilst it was now possible to create high-resolution, single frequency (single colour) kinetic holograms, the final challenge was to invent a way to additionally move the two beams closer together or further apart, i.e. change the angle between them. By doing so, it would then be possible to also change the spatial frequency (relative colour) of each diffractive pixel on the fly.

Not only that, but by being able to continuously change both the grating orientation and the grating spatial frequency at the same time, it would be possible to diffract the light from any given pixel in the hologram though any angle and thus to any point in space. This would ultimately lead me to develop several highly sophisticated optical features including the first dot-matrix covert laser projected hidden images and the first dot-matrix full colour, wide-angle holographic stereograms, which won a coveted International Hologram Manufacturers 'award of excellence' in the year 2000 – see *LPI* and *3Digital* below.

It occurred to me that, if I used a pair of masks next to each other, one with two slotted apertures and one with two spiral apertures, used in tandem, two beams could be created with any orientation and spacing between them. The slotted mask would select the orientation of the resultant diffraction grating and the spiral mask would select the spatial frequency.



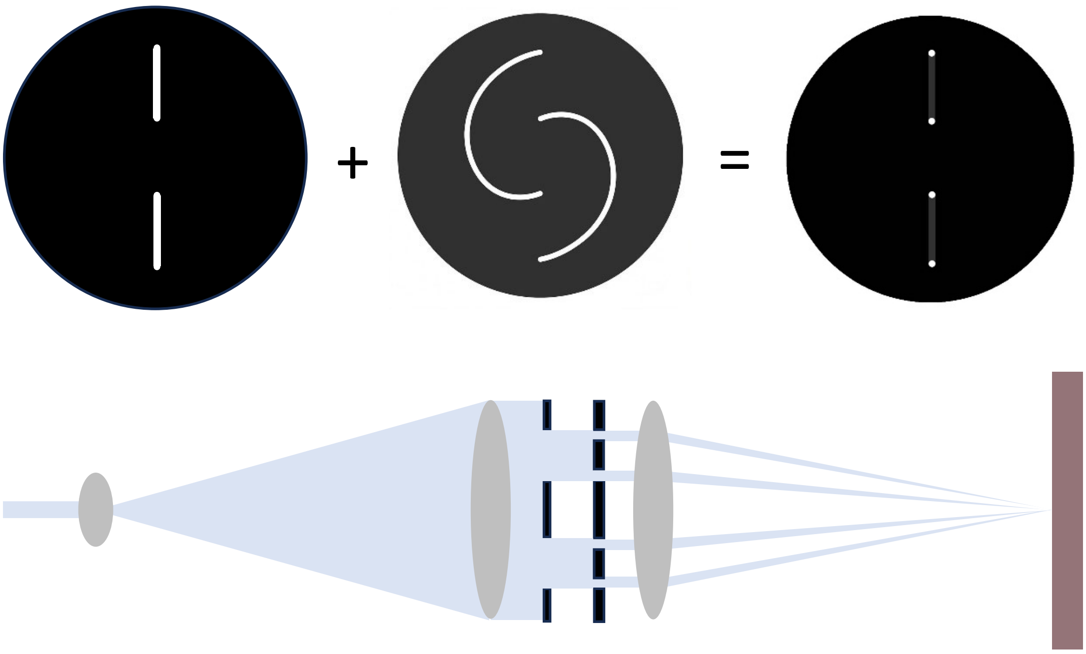
Twin masks for the selection of both grating orientation and grating spatial frequency on the fly.



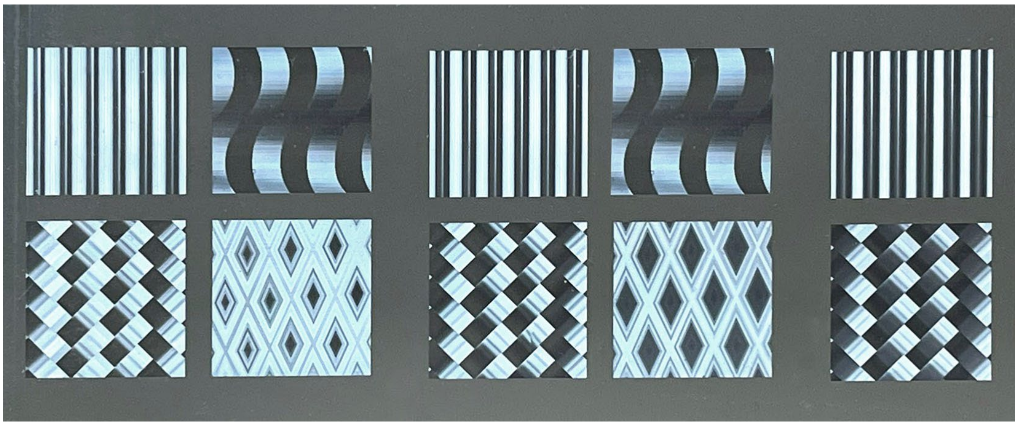
The final optical configuration for the Lightgate 1270, and Lightgate B series.

*A brand authentication hologram for Disney made using the Lightgate B system, comprising of kinetic, guilloche, laser projected covert hidden image, and full colour 3D holographic stereogram optical features. The latter feature, christened 3Digital, won the **IHMA 'New Holographic Technique' award in 2000.***

Whilst designing the two masks that controlled both grating orientation and spatial frequency, I realised there was one final, significant possibility. By arranging the apertures on each mask so that, at a single position, they overlapped to generate four beams of laser light rather than two, all four beams would interfere to form six mixed-frequency gratings, producing an achromatic, or white, diffractive pixel. The ability to create achromatic pixels was exclusive to the Lightgate system and a unique selling point, enabling the creation of achromatic kinetic patterns, achromatic 3D stereograms, mixed white and coloured elements, and many other exclusive security features.



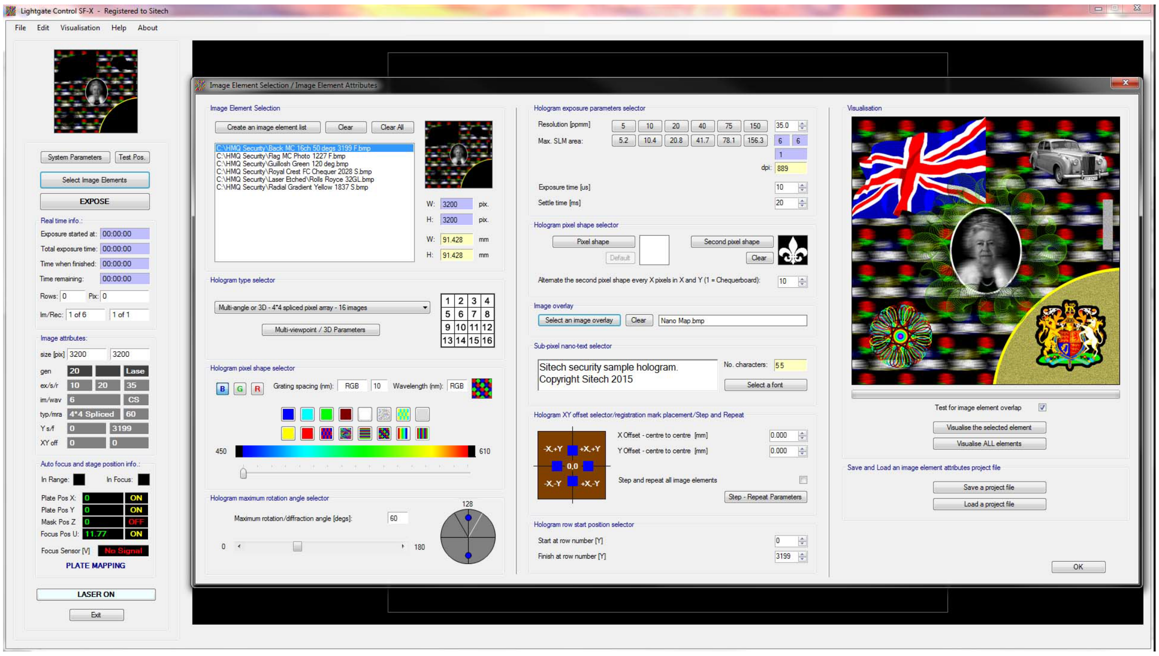
A mask configuration that produces four beams for the creation of achromatic - white diffractive pixels.



Achromatic kinetic diffractive patterns made using the Lightgate four-beam technique.
One application was the simulation of carbon-fibre effect.

Originally named the Lightgate 1270, and later the Lightgate B, the Lightgate system was also the world's first fully computer-automated, light-based mastering platform capable of producing sophisticated security holograms and wide-angle 3D stereograms with parallax, surpassing traditional techniques. Crucially, its exceptionally user-friendly but sophisticated design and recording software, *Lightgate Control*, allowed operators with little or even no holography experience to create complex holograms at the touch of a button for the very first time.

Lightgate Control, the software I began developing in 1996, enabled the assembly, composition, and visualisation of complex multi-element holograms and automated their exposure, including full optical recombination. Eventually ported to VB.net, it was continuously enhanced for almost three decades and was the most capable hologram-mastering software available on any platform until the arrival of *PicoHLD* for the 4Pico B.V. PicoMaster system in 2022.



Lightgate Control, circa. 2018.

Between 1996 and 2006, over forty Lightgate 1270 (Lightgate B) systems were sold worldwide, an exceptional penetration for what was, at the time, a relatively small holography industry.

In 1996, only a handful of large companies dominated the security hologram market, but the cost-effective, simple-to-operate, computer-automated Lightgate system enabled many smaller firms and start-ups, particularly in the Far East and Asia, not only to compete, but to produce superior, next-generation security holograms. The Lightgate 1270 system was instrumental in the rapid expansion of the security hologram sector during the late 1990s and early 2000s, a period in which it grew into a billion-dollar industry.

The platform then evolved through successive generations of what have been more recently termed 'interference lithography' systems - Lightgate S - an ultra-fast system, Lightgate P – the world's first large format dot-matrix mastering system for packaging applications, Lightgate X, Lightgate P-UV, Lightgate D, and recently the Lightgate U system, introduced in 2025.

Billions of holograms have been produced from Lightgate-originated master holograms, including for some of the world's largest security hologram projects. Even today, three decades after its invention, original Lightgate systems remain in active use for security hologram mastering. The Lightgate 1270 and its successors sustained my companies, Spatial Imaging Ltd. and Sitech Ltd., funded artistic work such as my holographic portraiture, supported Spatial Imaging's lenticular division, 3D Print, and provided long-term employment for several staff for over twenty years.

Lightgate dot-matrix holograms for the UEFA EURO 2000 Football Championships, used on all merchandise.

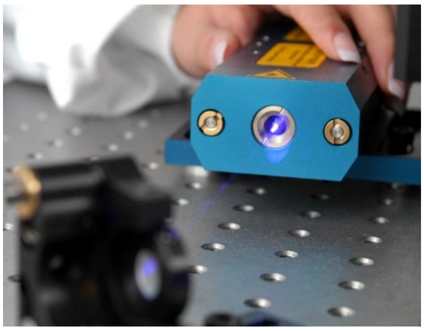
The Lightgate system was followed by the KineMax system, developed by Pawel Stepien of Polish Holography Systems. The KineMax employed an equally innovative but fundamentally different digital mastering technology called '*image matrix'*, and became the leading system from the mid-2000's until it too was surpassed by the truly groundbreaking PicoMaster platform, a single-beam, direct-write lithography (SB-DWL) system developed in 2013 by the Dutch company 4Pico B.V. (now Raith Laser Systems B.V.), and exclusively distributed worldwide by Spatial Imaging.

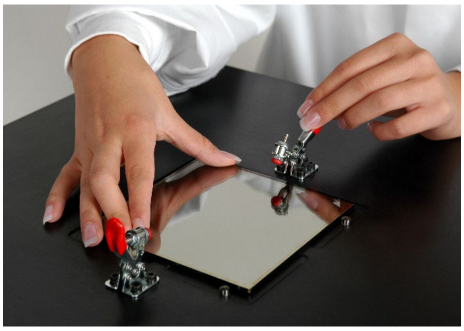
Whilst other systems have come and gone, such as the accomplished but commercially unsuccessful Sparkle system from Ahead Optoelectronics, Inc, a more refined and capable version of the Light Machine system; the Firefly system from Combustión Ingenieros S.A.S., modelled on the KineMax system; and various systems produced in China and India that replicated existing technologies, three light-based digital security hologram mastering platforms have dominated the market over the past thirty years: first, the Lightgate dot-matrix system; second, the KineMax image-matrix system; and third, the PicoMaster SB-DWL system.

My eureka moment, however, and the Lightgate system that followed, proved pivotal. It set in motion a transformation of the security hologram industry and reshaped its capabilities and competitive landscape.

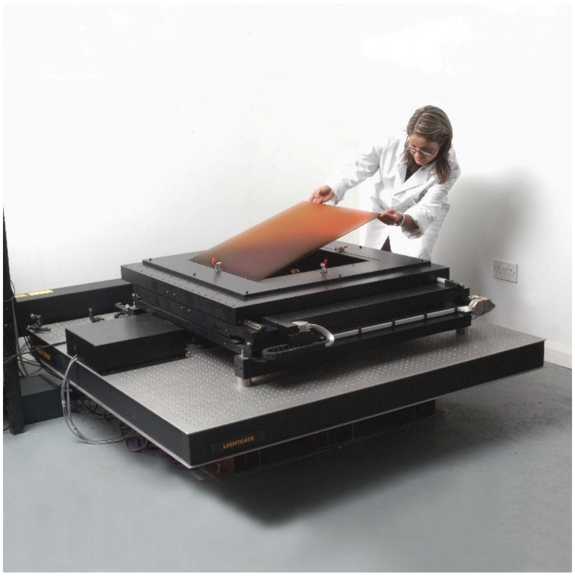
Images of the Lightgate system.

The Lightgate System, 1997, utilising a Helium Cadmium laser.





Left: The Lightgate B System, 2004, utilising a 405nm Diode laser. Right, Loading a photoresist plate.



Left: Lightgate P1 large-format system, 2004, won the ***IHMA 'New Holographic Technique' and 'BEST OF THE YEAR' awards in 2005.*** *Right: Large format dot-matrix hologram shown by Spatial Imaging holographer Olivier Pitavy.*