FINE ART APPLICATION OF HOLOGRAPHY: THE HISTORICAL SIGNIFICANCE OF LIGHT AND THE HOLOGRAM IN VISUAL PERCEPTION AND ARTISTIC DEPICTION

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RESEARCH FORMAT

THIS PH.D. RESEARCH IS PRESENTED IN TWO PARTS. THE WRITTEN THESIS IS COMPLIMENTARY TO, AND SHOULD BE READ IN CONJUNCTION WITH A VIEWING OF THE SERIES OF HOLOGRAMS DESCRIBED IN THE SECOND SECTION OF THE THESIS. AN EXHIBITION OF THESE WILL BE MOUNTED AS PART OF THE PH.D. SUBMISSION, AND THIS WILL BE VIDEOTAPED TO SUPPORT THE LIBRARY COPY OF THE THESIS. PHOTOGRAPHS OF SOME OF THE HOLOGRAMS ARE REPRODUCED AS FIGURES IN THE THESIS. HOWEVER, PHOTOGRAPHY CAN RARELY DO JUSTICE TO THE HOLOGRAPHIC IMAGE, AND, IF POSSIBLE, READERS SHOULD AVAIL THEMSELVES OF THE VIDEOTAPE IN ORDER TO BE FULLY CONVERSANT WITH MATTERS DISCUSSED IN THE WRITTEN THESIS.

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A B S T R A C T

This research considers the place and potential of holography in Fine Art, and its ability to stand alone alongside other established art mediums.

Building on the authors experience of holography and its origins in the technological revolutions of the mid-20th century, the research process considers the personal involvement in an artistic medium that began as a product of the scientific arena. It reflects on the way holography has almost inevitably been linked to photography arguing that both should be placed within a broader framework of light in art, with individual characteristics that set each of the two apart.

The ways the traditions of light in art have influenced developments in painting, sculpture and the like, are assessed, and it is argued that light itself has recently become a semi-independent medium. This, it is promulgated, points the way forward to suggest a potential place for holography within that tradition.

The second part of the thesis details the personal involvement in the creation of a series of holograms to demonstrate what might be possible in the medium.

The use of only two basic techniques reinforced the belief that too much technology can sometimes divert from the artistic quest; and the series begins by exploring colour variation, achieving tones which are unusual for the medium.

In pursuing the concept of holography as a cladding device and of its ability to contain, cover and reveal layers of visual information, the work culminates by revealing holography's unique ability to overcome the two/three dimensional conundrum, arguably demonstrating its potential to stand alone as a medium in its own right.

However, this possibility, it is suggested, seems to have arrived just as the discipline has lost its tenure within the art world.

I N T R O D U C T I O N

i) Holography as an Art Medium - its History and Potential

This research began as a quest to consider the place of holography in relation to the Fine Arts. As a sub-discipline of the Arts, it only has a history of some three decades of practice, and its future direction therefore seemed open to conjecture.

Because Holography came out of the scientific arena and was first considered primarily in relation to practical applications for the laboratory and industry, the programme of research begins with an overview of technology and art as a means of establishing the greater historical context in which holography might be situated. A brief scan of the material relating to the links between art and technology suggests holography could seem to have those absolute credentials which would see it rightly included alongside those other technological mediums artists are currently involved with. These are outlined in chapter one.

However, to fully explore the potential of holography, it was necessary to make a more detailed evaluation of the discovery of the medium in the late 1940's, and chart its subsequent development. After its discovery, the initial theories were only able to be put into practice some fifteen years later, simply because of the lack of a suitable technology at

the earlier date. However, once laser light had been developed in the early 1960's, the possibilities for holography to become an art medium soon evolved.

By the mid-1970's the art establishment was beginning to explore and recognise holography's potential, and its presence, as an adjunct to and an associate of 'photography', was beginning to be established. Within the next decade, holography, as a sub-discipline of the Arts, seemed to be well on its way, as it was being produced by art students in institutions, displayed in galleries and museums, created by artists in residence, and written up in journals dedicated to the process (see chapter 2 (i)).

This burgeoning interest seemed suddenly to come up hard against the economic monetarist politics of the 1980's, and during the period of this research the discipline had all but vanished from Art Schools and other venues in which it had gained what can only be deemed to be a tentative foothold. (chapter 2 (ii))

In all this, the potential of holography to stretch the boundaries of artistic exploration or expression appeared hardly to have been tested. For there was little evidence to suggest an aesthetic tradition had been developed. In consequence, this research set out to explore this avenue, to ask why this had happened; and to consider whether or not the chance still existed for an aesthetic tradition to develop.

The quest soon suggested that the potential for the development of

an aesthetic tradition seemed to have been prevented by twin factors of economics, and those constraints in the technological processes surrounding the creation of holography; and with evidence to suggest that the projected visions made for holographic technologies were occasionally more to do with science fiction than science fact (see also chapter 2 (ii)). Then again, the success of the computer in art was often posited as a parallel to an anticipated holographic development. Yet circumstances seem to conspire to prevent this, and while the former has continued to expand, holography has all but disappeared from the aesthetic arena.

In the event, this led to a re-evaluation of the question of how to interpret the predominant vision which links holography to photography. For this, it is seems, had beset the medium, and laden it with the existing aesthetic viewpoints which surround and influence events in photography; and not all of which are desirable or easily transferable to holography. Indeed the research suggests holography has the potential for its own aesthetic tradition which is based upon its essential differences to photography; even though both can be said to be able to take separate positions within an aesthetic of 'light in art' (chapter 2 (iv)).

To separate out holography from photography in respect of this aesthetic quest, the medium is considered in relation to the tradition of Light in Art. Because of its intangible nature. it is necessary to explore the history of light. This is achieved by establishing its use as a tradition, by defining the very essence of Light in Art, and by following the processes in which artists across history have used and depicted light

in their deliberations. To establish early examples showing the import of these matters, the search ranges from the prehistory of Cave Paintings to the use of light in Ancient Egypt. Necessarily curtailing the exploration because of the impact light has made on all artistic endeavour throughout art history, the analysis continues in the early 19th century, and focuses on the hypothesis that 'the art of any period reflects the understanding of the subject at that time'. Moving to the end of the century, the influence on the Impressionists of natural and artificial light is explored; although significantly it is noted that this is still a paint medium and not the medium that light itself was soon to become. (chapter 2 (iii) - (iv)).

An exploration of Light in Art in the 20thC, and especially its use by the mid period of the century, suggests that the component parts of modern artificial light (electric, neon, etc) were becoming an established art medium in their own right. The laser, it is argued, is the purest form of these artificial light systems, and thus holography offers the ultimate manipulation of what is now an established and semi-independent medium, and therefore can sit alongside more traditional forms such as painting, sculpture, etc. (chapter 2 (v)).

Having established that holography has the potential to develop an aesthetic tradition, yet all the while recognising this possibility has been curtailed by events, the research moves to the practical phase, where a series of holograms was created as the means of establishing the suitability of the medium to meet the criteria outlined above.

An original aspect in the 'Proposed Plan of Work' to produce a holographic data base as part of the research was overtaken by events, when The Creative Holography Index was published in Germany (ed. Pepper. 1992). This made this aspect of the anticipated programme of study redundant; however, it is anticipated the research will make a significant contribution to the Index.

ii) **The Personal and Practical Application**

Although this research deals directly with holography as a specific medium, and the way that areas within it were pinpointed to highlight its import as a medium in its own right, the fundamental act within the research had to encompass the creative approach to the work. This would see the research work and especially the creation of the holographic work become a personal exploration into an artistic domain. In effect the research process became a matter of accommodation to the specifics originally submitted in the 'Proposed Plan of Work' for the Ph.d., and necessarily included material from the body of knowledge and practice the author had previously acquired. Finally, and most importantly, it had to embrace those seredipidist accidents which are the most crucial aspect of the creative process. In this artistic endeavour, as Duchamp says (Tomkins. 1997), this becomes a matter of 'taking an object out of context and giving it a new thought', so that it becomes almost a metaphoric way of saying the alternative. In essence then, this is a process of adventure, a quest, a working laboratory of possibilities, and not just the realisation.

Argan (1978: 11) sums this up when he says of the work of Paul Klee

and Leonardo da Vinci:

> "In their creative thought both Leonardo and Klee are not so much concerned with the art object, as with the manner in which it is produced. They are concerned not with form as an immutable value but with formation as a process".

Chapter 4 therefore sets the scene for this personal interpretation, by outlining the author's previous research, alongside a review of the technological possibilities which were available. Again the crucial choice was between taking a purely technological route and balancing this against an aesthetic potential which seemed to have been underdeveloped and unexplored. Technology, in itself, seemed not to hold the answer to the quest, and colour control in reflection holography - which is described as being 'the most restrictive issue of the past' - was chosen as a route forward.

The 'Electric Mickey' series thus sought to explore the idea of colour control and to show that the medium could offer an extensive choice in colour variation (chapter 5). The use of everyday objects (an electric plug, the associated cable, and two cut-out circles for the ears) to give metaphoric reference to other objects (in this case the almost universal iconography of Mickey Mouse) was then discovered to have given the medium an opportunity to be successfully incorporated with established genres (assemblage, collage, etc). Moreover, it was found that by sandwiching together more than one hologram which replayed back on different colour wavelengths, a wider range of tones was produced than had previously been thought possible. This edge to the research was further enhanced by realising that in using the shadowgram technique and then not following the

convention of painting the reverse of the hologram, meant that the recorded volumetric space was optically punctured by the circles used to represent the ears. This first series, then, reveals opportunities to further use cladding to explore the object under scrutiny, to consider further aspects of colour control, and perhaps most importantly of all, to highlight the twin realities of a hologram. By this, I mean that its physical reality is a flat piece of acetate encoded with a visual reality of three-dimensional space; and this puncturing of the film and the specific qualities of its presentation demonstrates an admission in the work of the two/three dimensional conundrum or enigma inherent in holography.

It was decided to concentrate on the holes in volumetric space, and to achieve this by reducing content to focus on the hologram as a covering or cladding device. A series of recordings were created in which holographic holes were able to suggest shadows that might have been cast by the strips of masking tape used to fasten the holographic film to the display wall. The ephemerality of the film used and the masking tape come together with the optical holes to create a visual contradiction on many levels (chapter 6).

The research then deliberately set out on a preconceived use of cladding to explore holographic tone in the context of surface colouration. Using up to five sandwiched holograms taped to a photocopied image of Aristotle generated a range of tones which allowed for the introduction of another intensity of colour, using a symbolic blue which serendipidously gave another layer of meaning to the final composition (chapter 7).

This Aristotelian image was followed by another classical reference, and themes which had been established in the practical work were further

extended in an experiment using a white light transmission technique. The positive/negative images found on classical Greek vases provided the inspiration for imagery which developed into a body of work, and which started by the ironic juxtaposition of a cow for the Greek bull, to then incorporate objects (milk bottles and sheets of glass) to clad and give structure and a sculptural presence to what were essentially two-dimensional images in space (chapter 8).

Finally, an attempt was made to incorporate all of the elements in order to make some sort of assessment of the aesthetic possibilities presented in this series of holograms. The 'Light Bulb' series uses a most utilitarian object to make statements about the holographic ability to reveal a unique interpretation of the world and the objects in it. Optically puncturing a holographic recording by using stencils, the holograms therefore contain a visual reality partially obscured. All aspects of the previous body of work were accommodated in this section of the work, with colour, cladding, and an acknowledgement of the surface of the hologram being present. In addition, a new element in the form of a recording of a three-dimensional object was achieved, and produced an interpretation which could not be obtained in any other medium (chapter 9).

The search for an aesthetic potential in holography, it is felt, has been vindicated, and this inevitably returns us to that crucial factor of the self and the research process. The artistic endeavour is always a personal crusade, with options open to the artist to strike off in various directions. This was the case here, with the practical work driven by personal visions as well as the serendipidist accident, in a way that any scientific researcher might well be prevented from following. For it is

always the process and the possibilities and not the realisation that drives the aesthetic quest forward. As Lewis Wolpert (1997: 41) says:

> "Artistic works may have an emotional content that is completely missing in scientific understanding. They also express the personal views and feelings of the artist while scientific ideas are, in the end, free of any emotions that the scientists may have had."

PART ONE - HOLOGRAPHY EXPLORED

CHAPTER ONE

Art and Technology - An Overview

The object of the research described in this thesis is to assess the potential of holography as a fine art medium. Holography is a process which was only recently invented, and is firmly lodged in the technological arena of the second half of the twentieth century. The exploration of its origins, coupled with the consideration of holography as a Fine Art medium constitutes an investigation that necessarily brings together the subjects of art and technology. However, in order to provide the correct historical context in which this research can be established, it is first of all necessary to briefly consider the tradition and link between art and technology as it has existed throughout the ages.

From the earliest cave paintings of the stone age, through to every piece of contemporary art, an interlinking or entwining commonality between art and technology occurs. Welsh (1994: 149) refers to this when he states: "there has always been the presence of technology of some kind in the background of the artistic production". This 'presence' is perhaps most noticeable in the work of certain artists, and Welsh goes on to cite Leonardo da Vinci as being an extraordinary individual who was able to encompass both art and science. And even during periods of history when the concept of the artist as an individual had yet to evolve, the presence of technology is clearly noticeable. For example, in charting the history of the mediaeval world, Heer (1962: 399) refers to Gothic art as being

"heavily preoccupied with technology", and the European Cathedrals from this period remain a tangible reminder of the inexorable link that binds the two subjects together, exhibiting as they do, an array of new technologies that allowed for their monumental scale and style.

Apart from the unpredictable factor of good fortune, an important element in determining the survival of a piece of art lies in the manner in which it was first constructed. Doerner (1973: 316) states that the preservation of the paintings produced by the old masters can be attributed to the high level of craftsmanship employed in their production. In these cases, the technology surrounding the manufacture and application of paint all those centuries ago has helped to ensure that such works are still in existence today. And although Doerner deals exclusively with the art of painting, the reasoning behind his hypothesis means that its relevance can be extended beyond pigments and canvas to encompass all historical works of art.

It is not the purpose to deviate from the original premise of this research as outlined above in the Introduction, and examine in detail the complexities of this technological/artistic interaction across every period of recorded history. It is simply the intention here to take a brief overview of this art and technology link in the context of the era in which holography was born. Even then, by narrowing the focus of the investigation in this way, the proliferation of technological forms and the vast number of art movements that have flourished and influenced events during the twentieth century, means it would be equally impractical to try to

comment on every permutation of an art/technology context which has arisen during the past one hundred years. This overview, therefore, can only touch on some of the significant and perhaps more pertinent examples of this link.

At the end of the nineteenth century a technological revolution was being generated by the increasingly urban-based manufacturing economies of western Europe and North America. Hughes (1993: 15) refers to these events taking place in the context of the formative years of one of the most famous artists of the modern era, when he writes that: "the first twenty five years of the life of the archetypal modern artist, Pablo Picasso - who was born in 1881 - witnessed the foundation of twentieth century technology for peace and war alike". Alongside these developments in maunfacturing, the beginnings of the modern era was also marked by a vast change in scientific thinking that would see the atomic age redefine the natural world.[1]

Within this environment of change, a transformation was also taking place in the visual arts. The Cubist break with those three centuries of convention relating to pictorial space and sculptural form that had come out of the Renaissance was now welded to the incorporation of utilitarian elements into their work.[2] Strips of newspaper, magazines and wallpaper were included and incorporated, thus confirming the general direction of the revolution that was later to become known as the Modernist movement (see Duro and Greenhalgh. 1993: 96-7 and 191-2). Thus, from the early 1900's, the traditional notions of what art should look like and what it

could be made from, were irrevocably altered. In this new aesthetic era, the link between art and technology was no longer to be limited to the issue of skill and workmanship.

The proliferation of new technology during this period influenced extremes of thought within the artistic communities of Europe. In Italy, the Futurist movement rejected the past in favour of the modernity of industrialisation. Central to their ethos was the perceived liberating qualities of speed and power induced by the machine age. Characteristic works of this movement, such as Boccioni's sculpture - 'Unique Forms of Continuity in Space' (1913) - and paintings of moving cars by Balla, made in the same year, express these beliefs in a style that encompassed and further evolved the Cubist principals of pictorial and sculptural space.[3] However, in spite of the influence of sequential photography and a belief that the cinema was the ideal means of expression, the greater majority of Futurist art was still executed using the traditional materials of bronze for sculpture and oil paint on canvas.[4]

The aesthetic of the Russian Constructivist movement was also based on changes brought about by industrialisation, and is especially evident in their sculptural creations. Steel, glass and plastic became commonly used materials in the three-dimensional work of Naum Gabo, who combined these elements of technology with an increasingly abstract style.[5] Gabo, a former engineering student, was a living embodiment of the Constructivist ideology that argued artists should be re-trained as qualified engineers or technicians in order for them to take their place with their fellow workers

in the modern industrial world.[6] Nevertheless, the need for the Bolshevik revolution to promote itself through utilitarian propaganda quickly nullified this tendency towards pure abstraction, and the movement lost some of its leading protagonists when it disintegrated and dispersed.

War and revolution brought an end to a period that has been called "the mechanical paradise" (Hughes. op.cit. 1993: 9-56), and these events forced many artists to reconsider their relationship with an industrialised world that seemed to have delivered a technological hell rather than the anticipated utopia. The Dadaists, for example, lampooned traditional notions of beauty and taste as defined by the militaristic and industrial powers of Europe, using the tactics of shock and unreason to challenge the accepted artistic values. The weapon they used in this quest was in the form of the "ready made", a functional mass-produced object taken out of context and then exhibited as art. In Duchamps's 'Fountain' (1917), which consisted of a porcelain urinal, signed R. Mutt, a product of industrialisation was thus stripped of its functional role and used to create an absurdity.[7] Exhibiting everyday commodities as art in this way meant that the material content of such work was derived from manufacturing sources and processes, rather than being made by the individual artists themselves. Thus the means of production provides the "ready-made" with an explicit technological reference.

Following the Dadaist art of the absurd, this technological link in art seems to permeate almost all of the major art movements of the second half of this century; and the all-pervading influences of mass production

can be easily established. Foster (1989: 80-5), for instance, in a survey of the dialectic between art and commodity, highlights the evolution of this theme, tracing it through Warholian Pop Art and Minimalist experiments - such as the Carl Andre brick sculptures - to serial forms and images, and on through to the post-modern development of an ironic, 'cute commodity' artwork wielded by the likes of Jeff Koons.

At the same time, as manufacturing processes helped to define the individual styles of these movements, other artists were forging a more direct link with technology by adapting the component parts of industrialisation into their work. The seeds of this practice had been sewn in the first decades of the century when a small number of artists had produced works in which mechanical movement played a part. However, it was not until the 1950's and 1960's that the Kinetic Art movement came to the fore. One of the most famous examples of this genre was Jean Tinguely's 'Homage to New York' (1960) - consisting of a machine which destroyed itself at a specially held event.[8] Tinguely built his machine with the assistance of Billy Kulver, a research engineer, who went on to produce collaborative works with other artists. These became known as 'Experiments in Art and Technology', with an E.A.T. organisation founded in 1967. The activities of E.A.T., and the publication of Jonathon Benthall's 'Science and Technology in Art Today' (1972), and Jack Burnham's "The Effects of Science and technology on the Sculpture of this Century" (1968), represent a growing interest by artists and theoreticians alike in the relationships between art and technology.[9]

The potential of this interaction has been given added impetus what Foster (op.cit. 1989: 5) describes as the "informational or post industrial elements in our economy". These elements have brought a transformation to almost every aspect of contemporary life, and the arts are no exception. For, as Kirchman (1990: 34) has observed, the reality is that: "since contemporary culture is being driven by contemporary science and technology, one of the roles of the artist is as 'coloniser' of the technology for artistic ends". Over the last few years, then, the growth in individual and institutional interest in what Clark (1995: 28) calls "the most sudden and extensive broadening of technical possibilities" has had to be incorporated into the artistic process, so that the ubiquitous computer, with its multi-functional abilities can be argued to be, perhaps, the most prominent of a range of micro-dynamic technologies, yet must be joined by photocopiers, video machines and a range of other diverse appliances for the transmission of data and imagery.[10]

It would appear then, that holography - which is a visual medium with clear scientific origins - has the absolute credentials to fit comfortably into this new range of options facing the contemporary artist. However, to begin to understand its true potential as a fine art medium, it is first of all necessary to consider its relatively short historic life to properly assess its place in the order of things.

NOTES AND REFERENCES TO CHAPTER ONE

1. See Gamwell. L. (1980: 6-9).
2. see, Picasso's 'Table with bottle, wine glass and news paper (1912), Braque's 'Guitar and Programme' (1913), and Juan Gris' 'The Man at the Cafe' (1914), as examples of cubist collage: in Varneode K., and Gopnik A., (1990: pp's 22, 48 and 45).
3. For examples, see the exhibition catalogue for 'Futurismo & Futurismi', Venice in 1986, edited by F. Bompiani, pp. 75-81 and 133.
4. See Bragaglia. A.G., (1911: 38-45), and Read. H. (1994: 138).
5. For further reading and examples of Gabo's work, see Hunter S., and Jacobus. J. (1976: 147). For further readings and examples of art work of this period containing the elements of Light and Mechanics, see Neret. G. (1986: 95).
6. See Popper. F. (op.cit. 1993: 12)
7. For examples of other Dadaist work, see Lemoine,Serge (1987). Duchamp's 'Urinal' is reproduced at p. 276.
8. For further reading on Tinguely, his work, and the Technology Movement of this era, see Hunter. S., and Jacobus. J. (op.cit.1976: 264).
9. For further reading on the Experiments in Art and Technology group (E.A.T.), see Bijvoet. M. (1994: 15-35).
10. For readings on Video Art, see Popper F., (op.cit.1993: 54-74); and for readings on Photocopy Art, see Walker. J.A., (1994. 151-4). Further suggestions for reading and examples of Computer Art are given in the notes to Chapter 2.

CHAPTER TWO

A History of Holography

i) Discovery and Development

In this chapter the origins and practical applications of holography are examined. The speculation which has occurred regarding the evolution of holography as a creative means of expression is explored, and a number of factors are considered as to why no real aesthetic tradition has evolved within the medium. The conclusion suggests that the common perception of an historical context in which the medium has been seen has been unhelpful, and an alternative context is proffered for consideration.

In 1947, during attempts to overcome the problems of image clarity in electron microscopy, Dr. Denis Gabor invented a new method of recording the light-waves from an object without having the use of lenses. Gabor deduced that a coherent wave of light which simultaneously illuminated an object and a photographic plate would produce an interference pattern that could be recorded on the plate. Once developed, and placed back into its original position and illuminated by the same source of coherent light, an exact reproduction of the scattered waves would reproduce an image of the object in three-dimensions, as if it was still there. In 1948 he published his findings[1], and called his photographic plates 'holograms'.[2] Further research was then limited because Gabor's discovery, although correct, could not be then satisfactorily put into practice, simply because a pure

enough form of artificial light had yet to be invented.

In 1963, scientists at the University of Michigan working on radar systems, put Gabor's theory to the test with the newly invented laser. Now with a continuous source of coherent light they were able to produce sharp, three-dimensional images on a relatively large scale. Thus, after fifteen years the hologram was reborn out of a curiosity, rather than with any specific functional purpose in mind.

As theory could now be put into practice, and as befitting an invention born of the laboratory and not the art studio, a range of different technical and scientific applications were developed using variations on the new technique. Since then, over the past three decades, it has become an industrial tool, so that at the time this research was underway, holography can be found in diverse locations ranging from the non-destructive testing of machine parts, to use as a security device on videos, on tickets, and on bank and credit cards. Yet the unique way in which holography records visual information has also been recognised as having the potential to be much more than a means of testing for wear and tear, or resisting counterfeiting and fraud.

One of the scientists who first put Gabor's theory into practice described the newly reinvented concept of holography as sounding "wild and improbable" to the layman.[3] These feelings, however, were not just confined to lay perceptions. Professor Kirkpatrick of Stansford University, a pioneer in this field, put rational explanation to one side

when he said that what holography achieved was "almost unbelievable".[4]

These outbursts of incredulity were made in response to a process which owed its existence to a touch of seredipity, and for the first time in the history of image formation it offered the means of producing an exact, three-dimensional visual replication of a subject. Because the process of holography records and reproduces the wave front of light that has been reflected from an object, the resulting holographic image could not be distinguished from the material object. To the viewer it is a visual reality, which, unlike previous three-dimensional viewing systems, does not rely on any sort of trickery to fool the brain into thinking it is looking at volumetric space.[5]

The sense of expectation generated by this new process was expressed by Unterseher, Hansen and Schlesinger (1987: 16) in their short history of the medium:

> "In the next several years, the scientific journals were filled with articles, as numerous laboratories jumped into what was seen as one of the most exciting inventions of this century. Hundreds of patents were issued as the big labs competed to develop everything from holographic television (not yet a reality) to testing aeroplane wings under stress (a practical application of the technique currently used). At the same time, everyone continued to marvel at the magic of nonexistent 3-D scenes appearing out of nowhere from a flat piece of glass".

The 'magic' of the hologram meant that whilst science used the medium

as a practical toy and dreamt of future applications, it was not long before the process was being displayed outside the discrete confines of the research laboratory. As early as 1968 the Swedish physicist Hans Wilhelmsson was advocating this new scientific technique might be of possible use to artists (1968. 161-9). And by the middle of the 1970's a state funded Museum of Holography had opened in New York. Other similar establishments in Europe, America and Russia followed. Major holographic exhibitions were also being staged, with *Britain's Royal Academy of Arts* making the unprecedented decision to stage two different shows of holography within a twelve month period. In his introduction to the 1978 catalogue for the 'Light Fantastic 2' show, Sir Hugh Casson - the then President of the Royal Academy - explained that this second exhibition was necessary because, "The speed of inventive development in this field is so rapid, (and) its contribution to art so potentially rewarding". Within ten years, support for the inherent creative possibilities of the medium had grown at a considerable pace.

In the 1980's, as holography began its third decade of practice, the move towards promoting the medium as a nascent visual force continued on all fronts. A number of books were published on the subject, all of which were written in a populist style, and defined optical and holographic theory in lay terms. For example, in the introduction to 'The Hologram Book', the authors state: "we believe that there are many people such as students, artists, photographers, hobbyists and others who want a satisfying explanation of holography" (Kasper and Feller. 1985: 8). A number of such publications went beyond mere explanation to encourage their

readers to build their own studios and make the their own holograms. A typical example, 'Holograms: How to Make and Display Them', contains everything from chemical recipes for processing, to plans for making your own optics, and suggestions for further reading and courses for the enthusiast to attend. Everything is here for the budding D.I.Y. holographer; and the book concludes by urging the "amateur" to become involved with the medium, stressing that "the techniques are not difficult and the results rewarding" (Saxby. 1980: 140).

Nor did individual enthusiasts have to work alone with their holographic manuals. Support and advice was available from the Royal Photographic Society, whose members met on a regular basis to produce their own newsletter entitled 'Real Image'. However, the majority of International journals featuring holography were produced at various locations throughout the U.S.A. The most popularly recognised of these was Holosphere, which was published quarterly by the Museum of Holography in New York.

At the same time as these publications provided a network of ideas and support for indiviudal enthusiasts, the visual nature of the medium was being seen as a commodity that could enhance the business potential for a number of organisations. Photographic companies were also producing a range of film and plates for an expanding holographic market. Commercial holography studios brought their three-dimensional images into the market place and introduced the hologram as an affordable commodity just like other more established mediums. Thus, holography began to move out of the confines of galleries and museums and into the everyday experience.

Despite this proliferation, the only way artists or designers in the U.K. could make a hologram was either by building their own studio, or paying for the private classes on offer from the commercial companies. This situation changed in the early 1980's when the first holographic studios to be established within art departments were opened at London's Goldsmiths College of Art, at Salisbury College of Art, and at Liverpool Polytechnic. These initial and somewhat tentative steps were soon to be overshadowed by the Royal College of Art in London, which opened its own suite of holographic studios in 1986 at a cost of half a million pounds.[6]

Within a quarter of a century, then, holography had developed from a scientific curiosity into a multi-functional tool, a market product and a department in one of Britain's most predigious art education establishments. The R.C.A. had invested in a medium which apparently looked set to continue its evolutionary transformation: but things were about to change.

ii) Disappearance from the Aesthetic Arena

By 1997 all of the holographic courses available in U.K. art education establishments had closed. And this trend had not just been confined to this country; for by the early 1990's, the Museum of Holography in New York had closed its doors, with the subsequent loss of its attendant 'artist in residence' scheme, and the demise of its magazine, Holosphere. Within a decade, the intense curiosity which surrounded this genre and had pointed to the possibility of holography being infinitely

explorable as a creative visual medium, appeared to have vanished.

The demise of these centres of institutional interest has provided this enquiry with difficulties, for research which sets out to examine the possibilities of holography as a Fine Art medium must be aware of any aesthetic tradition that may already exist within the medium, if for no other reason than to validify the investigation. And without the existence of any centralised point of reference now, the search for any continuous line in the history of artistic participation in the medium has been made all the more formidable.

In comparing the respective aesthetic histories of the likes of photography, film, video and computing against that of holography, Rene Paul Barilleaux says: "in the late 1970's and early 1980's, holography's history was still largely an oral tradition, with less formal written documentation than these other media" (1992: 417). This lack of historical data has also been noted by the British artist, Margaret Benyon, who states that: "there is little serious writing about art in holography.... Holographic journals print exhibition reviews and articles about art in holography, but these are often superficial (1992: 415). Benyon also argues that art critics have a sceptical view of holography as a creative visual medium, suggesting that one of the reasons for this lies within mixed holography shows where work by commercial companies and scientists has masqueraded as art. Her claim that these low opinions are often formed by commentators with no idea that the work they were reviewing was not made by artists, is a contentious point. However, it does bring

to the fore the important issue of authenticity, and the need to be able to distinguish between different categories of holographic work.

The significance of this becomes even more apparent when the history is more closely examined. During the 1970's, holography had moved out of the laboratory and into a more public arena, where, in Britain, it was exhibited twice in one year at the Royal Academy of Arts. It would be an easy mistake to assume that this association suggested that the oldest art institution in the country was exhibiting holograms which could truly be classed as art. However, the mere presence of R.A. patronage means there exists the potential for this point to be overlooked, and it should be noted that the holograms in both shows were actually made at the Department of Physics at Loughborough University by a private company. The subject matter of the holograms shown ranged from objects, such as a free standing tap, a packet of cigarettes, an ashtray, and a cup and saucer on a table, to the slightly more fantastic robots and model spacecraft from the film Star Wars.

That the straightforward replication of such mundane imagery was exhibited as art in a major cultural institution might be argued to be some sort of perverse aesthetic joke. Yet Chris Titterington of the Victoria and Albert Museum, suggested (1992: 3-4) that such early work should not even be labelled as kitsch, because it was executed by scientists and technicians who had little or no understanding of the cultural rules which have grown to surround and govern the production and exhibition of art.

iii) The Aesthetic Quest

An understanding of the procedures involved in this cultural classification is therefore necessary when the history of holography is more closely scrutinised. However, such an awareness does not provide an answer to the central question of this part of the research; and which asks, is there an aesthetic tradition within the medium of holography?

To try and answer this, another question must first of all be resolved. In the face of Barilleaux (op.cit. 1992: 417) and Benyon's (op.cit. 1992: 415) comments about the lack of written historical data on the subject of holography and art, we must ask where should such a search for evidence of an aesthetic tradition begin? A likely source would appear to be with the arts journal 'Leonardo', where the Swedish physicist, Hans Wilhelmsson, first proposed the possible use of holography by artists (op.cit. 1968: 161-9). A literature search in libaries at Liverpool John Moores University (formerly the Liverpool Polytechnic) and the Royal College of Art, for instance, has revealed that 'Leonardo' was the only such publication to feature articles about holography on a regular basis. And it may seem befitting that a journal published on behalf of the Society for the Arts, Sciences and Technology, should have covered the subject. However, the question remains as to how helpful this coverage has been in revealing any sort of aesthetic tradition evolving within the medium?

With hardly any other written material on the subject, Leonardo's texts written by practitioners in holography are of singular import.

Margaret Benyon's unique career as an artist who has worked with holography for over twenty-five years can be traced in three volumes of the magazine,[7], while two issues (Vol. 22. Nos.3/4. 1989, and Vol. 25. No.5. 1992)) were dedicated solely to the subject, and contain a number of "Personal Accounts" by different practitioners. These serve to show a range of ways in which the aesthetic potential of the medium has been explored; and their findings will be of particular relevance in illuminating the practical part of this research.

However, it must be remembered these 'personal accounts' are the subjective writings of only a handful of individuals world-wide, and whose only commonality is derived from working in the same medium. And though they could well have provided the basis for an evolutionary academic tradition, all the evidence suggests there have been too few practitioners for this to have happened.

The network of support-structures developed by those working within the medium (see Benyon. op.cit.1992: 414) has been criticised by Titterington (op.cit. 1992: 6) for producing a "holographic ghetto" which has shielded its residents from having to involve the medium in the main-stream of art. Benyon, on the other hand, argues the art establishment is biased against holography (op.cit. 1992. 413), and although this remains a contentious issue, its relevance to this research has been eclipsed by the events that have taken place since these comments were made.

The last edition of 'Leonardo' solely dedicated to holography was in

1992, entitled 'Archives of Holography'; which has a certain poignancy in the light of what was to happen. Since then, the most striking aspect of holography's continued presence in the magazine is in a handful of articles about the medium, none of which deal specifically with its use in Fine Art. The fall-off in interest in the only arts journal to regularly feature the medium runs parallel to the decline of holography in the country's art education establishments. It is of particular relevance then to ask why holography, having established a tentative foothold, has disappeared from the aesthetic arena; and to assess what effect this might have had on this research and projected course of study?

In his discourse "Technology and the (Trans)Formation of Culture", Philip Hayward suggests that: "the range of potential applications of advanced technologies is necessarily beyond the precise intentionality of its designers and manufactures" (1994: 6). Holography's evolutionary path has followed this pattern, but only to a certain extent. Its initial impact as a potential art medium has not been sustained, and it would appear that even Titterington's "holographic ghetto" (op.cit. 1992: 6) has rapidly decreased in size over the last five years.

In seeking the root cause of this demise, it is appropriate to consider P. J. Kavanagh's observation on the underlying force that shapes much decision making, and which argues "there's an economic root to most things (1985: 123). Economics does play a significant part in holography's demise within the aesthetic arena, and this is intrinsically linked to the technological hardware needed to make holograms. Jon

Mitton, who, in 1992, was one of the last students to graduate from the R.C.A. with an M.A. in holography, has since tried to continue to work in the medium. He reflected:

> "I've only had one holographic commission since leaving, and was only able to complete that by renting the Royal College's facilities at a cut-price rate before they closed down. Although I have some holographic plates, they remain redundant without a studio, which would cost too much for me to set up on my own. Commercial studios are just too expensive to hire, and as a member of a collaborative art group we are more inclined to invest in technology that we can all make use of. Even though it would be nice to have a holographic studio we don't have the money it would cost to set up and maintain, it would be impossible to justify its existence".
>
> (personal communication)

The economics which Mitton describes as being such a contributory factor have been of crucial import; for example, the price of a box of one hundred pieces of Agfa-Gevaert, 10 x 8 inch holographic film in 1997 is £609.88, and when this is compared to a box of Agfa's signum colour photographic paper (at £34.82),[8] the difference in price is an obvious factor. Then again, film is only one part of the holographic process, for coupled to this is the need for a laser, for precision optical components, for chemicals for processing, and a vibration isolation table. Price is a prohibitive factor, which makes Saxby's plea for the "amateur" (op.cit. 1980: 14) to become involved in holography in the same way they have with photography, all the more unrealistic.

The demise of holography at the R.C.A. can also be linked to the

politics of monetarist free-market economics. The unit at the College was given its own departmental target and was then required to run at a profit after its first year, and be virtually self-funding after that.[9] As Rod Murray, head of the unit from 1990-95) recalls:

> "By the time I arrived, running costs were far outstripping the money that was being brought in by commissions and summer schools. Unrealistic projections had been made about the units earning capabilities, and unrealistic conditions were imposed upon it which meant that I spent most of my time having to try and generate income for the unit. The cost of maintaining equipment, combined with the continual increase in (the cost of) materials meant that the College had to keep bailing the unit out. In the end it became too much of a liability to survive in an era of economic accountability".
>
> (personal communication)

Apart from this financial burden the factor of technical innovation has contributed to the dramatic rise and fall of art holography; on which the catalogue of the 1978 'Light Fantastic 2' exhibition, said:

> "Those who saw last year's Light Fantastic exhibition will see that the limitations of holography are being removed... Holoco (the company who'd made the holograms at Loughborough mentioned above) hope that by the end of 1978 they will have produced some true full-colour holograms, and that before the end of 1984 it will be common place to have holograms in the same we we have photographs in our homes today".
>
> (Boyle. 1978: 1)

This optimism matches the popular belief prevalent in the 1970's and '80's, which was based on a faith in the continued ability of the craft of holography to progress and improve. Again, the critic Edward Lucie-Smith,

who described holographic portraiture as having an "ectoplasmic quality", then reassuringly tells us that: "no doubt this will vanish with technical improvements in the future" (1980: 116). And one of the boldest assumptions for holography comes from Lloyd Cross, who had been responsible for a number of technical innovations within the holographic industry. During the 1980's, he foresaw "the development of holographic projection techniques for 3-D movies", and suggested holography would supersede the photograph: "It will deliver better colour than photography, better resolution than projected video, and it will integrate into other systems" (Walton. 1982: 66).

Holography is not alone in this over-optimistic futurology and similar forecasts have occurred in the history of computer generated imagery (see Jones. 1990: 29; and Mallary. 1969: 33). Such overwhelmingly optimistic predictions can perhaps be attributed to the popular and cross-cultural belief that science and technology will continue to improve upon what has already been acheived (see Hayward. op.cit. 1994: 2-3). However, this is where the evolutionary similarities between the two mediums end. Stallabras (1994: 16) warns of the 'gung-ho ethos' that often exists in texts on computer art, although it would be hard to ignore the growing presence of the computer within the arts community. In a 1990 issue of Art Journal devoted to computer art, the editor remarks on an unusual optimism in the contributors, which is largely based on the perception of the flexibility of the computer as a universal tool. Again, within the last decade, 'Leonardo' has become increasingly dominated by articles on the different uses of computer technology in the production of visual

imagery, and a number of established art journals[10], without any technological agenda, have also given coverage to this medium. This optimism is in stark contrast to the position of holography which has failed to develop as the optimistic forecasts had predicted.

However, it would be wrong to suggest holography has not evolved technically since Gabor made his first holograms in the late 1940's. There have been innovations, and in Practical Holography (Saxby: 1988) there is information on how to produce twelve different types of hologram, with technical variations on each. Despite this, the basic techniques have not radically changed, and holography remains bound to its equipment, which includes a laser, various pieces of optical equipment, a vibration isolation table in a suitably stable environment, and film or plates and chemicals for processing the holograms. This limits the activity to the confines of a specifically equipped studio space, and to create even a simple hologram requires many hours of work, all the while operating within a margin of error dictated by only half a wavelength of light; and as techniques get more complicated, the amount of time needed to maintain accuracy increases. Each image has to be laboriously produced, and although any number of images can be taken from a master hologram once it is produced (in the same way that a photographic print can be taken from a negative) the care required to work within the margin of error makes this as slow a process as that required to produce a one-off hologram. Such a slight margin of error also means there is a need to eliminate any movement within the component parts used to create a hologram, and this applies to any imagery used as subject matter, which has to be inanimate and held in a

totally static position while the hologram is being exposed. Only a pulsed laser can be used to record living things or moving objects, and a fully equipped pulsed studio can cost around £100,000 to set up. In effect this puts this sort of technology out of the financial reach of most practitioners.

Even then, the pulsed laser has not been able to fulfil all the prophecies made about the medium. Technical limitations may be the reason, yet this has not constrained the concept of holography from being taken into the realm of fiction; with some highly convincing Hollywood fantasies spawning a host of visual inaccuracies[11], and the popular press still consistently lauding the possibilities of holographic television and cinema.[12] The reality of the situation is more prosaic, and Paula Dawson the Australian artist has pointed out: "the concept of what a hologram is far outstrips the actuality" (Coyle, in Hayward (ed). op.cit. 1994: 85).

The exception to this lack of any significant form of technical innovation lies with the embossed hologram, which can integrate computer generated imagery or strips of film footage to produce animated holograms, which can then be mass-produced. The flexibility and durable nature of this holographic technique derives from the way an image is hot stamped onto foil, and ensures it has become a commercially viable product.[13] Munday Spatial Imaging is one of the U.K.'s leading holographic companies, and its founder clearly believes that the future belongs to the embossed hologram, when he argues that:

> "We are reluctant to accept one-off commissions any more because of the amount of trouble there is involved in having to rearrange the studios. The system we have developed for producing images that will eventually become embossed holograms can be set up and left alone".
>
> (personal communication)

Holography thus remains sidelined in the popular contemporary view which already sees a digitally based merger happening between photography, video and computer generated imagery (see Willis. 1994: 197-208). The advantages of digitisation are many and its implications far reaching; for:

> "Unlike silver-based photographic film, the digital image does not consume scarce, non-renewable resources. It does not require a time consuming development process. It can be stored compactly, accessed by computer, manipulated freely and transmitted to remote locations"
>
> (Mitchell. 1992: 19)

For holography to become part of this merger then, would require some fundamental changes, for in the past fifty years it has largely been dependent on the use of increasingly expensive silver based emulsions. The embossing process, however, does not necessarily have to rely on this, and uses photo resists instead. This process, if combined with the development of film made from photo thermoplastics or photo polymers, could provide holography with the means of being allowed access to the melting pot with the other visual mediums.[14] Unfortunately such films have not been produced on a commercial basis during the course of this research.

For all of the advantages of the embossing process, it is the high

production costs that, once again, makes the whole thing inaccessible to most artists and practitioners. And though a print run may produce a series of holograms costing a matter of pence rather than pounds, this has to be off-set against the expense of producing the initial master from which copies are eventually produced. Current prices for this process range from between three and five thousand pounds for even a simple image; and the high cost prohibits any non-commercial work from being carried out. However, embossing remains of special significance, simply because it provides a means of mass-producing holograms, to the extent that these have become a ubiquitous feature in every-day life. And it is this presence which has kept holography from disappearing altogether from the public arena.

Prohibitive costs and technical limitations have thus had devastating consequences, and because of these factors the two questions Speer (1989) asked, as to "who will be holography's Pablo Picasso or Alfred Stieglitz", and "who will guide the field into new areas of expression through content and form?" both remain unanswered. Moreover, it means that for the foreseeable future, at least, Titterington's "holographic ghetto" (op.cit. 1996: 6) will never easily acquire the population necessary to make an impact on the contemporary art world. This situation is all the more exasperating because these problems cannot be resolved here by this one piece of research. And they will remain a stumbling block which inevitably restricts the depth of any exploration into holography as a creative visual medium.[15] However, having highlighted these problems, it is important to look at an aspect of the medium which, it is argued, this

research project can actively participate in.

iv) Links to an Established Tradition

A relatively new visual medium such as holography presents the artist with a dilemma, simply because of the lack of any aesthetic tradition. There are, of course, advantages and disadvantages to this. Being a young medium means anyone wishing to explore holography is unburdened by the weight of historical reference, in the way that a novice painter would be. Yet to work in isolation without regard to any aesthetic tradition would be tantamount to burying one's head in the sand. And the need to create analogies which link different visual experiences remains strong, for as Naipaul suggests: "Perhaps there is no pure or primal gift of vision. Perhaps vision can only be tutored, and (this) depends on an ability to compare one thing with another" (1994: 76).

This is further expanded on by Speer (op.cit. 1989: 299) who argues art appreciation is based on visual literacy, and that this process is usually introduced into the educational system in the form of art history; where students are given the opportunity to study the cultural and aesthetic changes in the history of painting and sculpture. The question then is, where does holography fit into this equation? And in order to answer this, it is necessary to see if there has been an earlier attempt to place holography within an historical tradition. And if this has happened, to then carry out a critical exploration of this tradition to ascertain if

it has any validity.

Ever since holography moved out of the laboratory and into the more public arena it has been linked with photography. One of the earliest descriptions of the process, which dates back to the early 1960's, was entitled "Lenseless Photography".[16] This pairing has often taken the form of an association or adoption by already established photographic institutions. In the early 1980's, and under patronage of the Royal Photographic Society, a holographic group was formed. The headquarters of the Society, in Bath, also has played host to holographic exhibitions, and the same is true of the Photographers Gallery in London. In 1987, the Victoria Albert Museum staged Towards the Bigger Picture, an exhibition of contemporary photography which also featured a number of holograms. During the middle of this decade, holography also became a regular subject in the pages of the British Journal of Photography, with a diverse selection of articles ranging from "Ilford's New Holographic Emulsions" (1985: 1286-7), to "Establishing a routine holographic service in a department of medical illustration" (1986: 865). Unlike the articles in Leonardo mentioned above, however, these rarely had an art content, and were concerned with technical applications.

The holographic facilities at the Royal College of Art were also governed by this analogy and were made part of the Photography department. Students studying for the M.A. in holography had their ethos decided by a staff whose experience lay in photography. Speer (op.cit. 1989. 299-306) supports this coupling, suggesting students of holography should study the stereoscopic formats of the past in order to learn from their mistakes and failures. Collectively such examples have formed a link to bring together

the mediums of photography and holography. The question is whether or not this association provides the correct context for the hologram?

Walter Benjamin's (1977: 219-53) perspective places photography in a pivotal position to collapse the 'aura of the original', and means that "many look back on the photography of this century and agree that no other cultural phenomenon has had such importance since the invention of printing (Gips. 1990: 233). Photography is also significant because it is a product of the modern industrial age, and for this reason was always a distinct possiblity that a link would be made between it and any new visual medium which derives from a similar technological background. It is hardly surprising, then, to find that such comparisons have been made about computer art and photography (see Stallabrass. op.cit. 1994: 15). However, this shared commonality does not provide grounds enough to proclaim the existence of an aesthetically valid tradition, and the question still remains as to whether this pairing offers the correct context in which holography should be viewed?

Both photography and holography are methods of recording various intensities of light onto photosensitive materials, with arguably the most common use being to create records of objects. Titterington (op.cit. 1992: 8) offers an explanation, suggesting that for many the attraction and satisfaction which is to be derived from both photography and holography belongs in their immediacy and "indexical nature". Both mediums do provide a means of replication, yet it is the make-up of a holographic

image that renders it distinct from almost anything else.[17]

A photograph is created by taking the light reflected off some subject which is three-dimensional in its physical make-up, and then reducing it to two-dimensions. The completed image bears no physical resemblence to the original subject, and the already established psychological process of deciphering an array of tones on a flat surface (see Gombrich. 1989: 29-54) is a necessary requirement for this representation to be effective. Holography is intrinsically different from this, because it provides the means by which the physical reality of light can be made visible.

Zec highlights the unique way in which this phenomemon uses the subject of light: "Holography gives absolute priority to light in a new way as opposed to the referential relation to reality. Therefore holographic space no longer is related to the obvious visual, material and spatial order of things" (1989: 429). Popper (1993: 37-8) corroborates this definition, describing a hologram as being "not only a product or tool, but a statement of specific effects based on the autonomous structure of its medium, light". He also stresses the need to ignore the dependence upon the photographic paradigm in order to create a historically legitimate aesthetic for holography. It therefore would appear that comparisons between the two can only be taken so far.

The way in which light is used in photography and holography may be a fundamental difference that separates them. However, at the same time,

light is such an intrinsic part of each medium that it places both in the much bigger tradition of light in art. It is my belief that it is through this perspective that the correct context for holography can thus be established. But in order to achieve this, it is necessary to define the boundaries of this particular tradition, and once this is completed to then follow an historical survey to locate the true position of holography.

NOTES AND REFERENCES TO CHAPTER TWO

1. see 'Holography: A New Scientific Technique of Possible Use to Artists', by Hans Wilhelmsson, in Leonardo, (1968) Vol. 1. pp. 161-9.
2. Rebecca Coyle (1994: 65) writes "the word hologram derives from the Greek, 'holos' - whole, and 'gramma' - message.
   In her notes (p. 85), she gives a more extensive definition, taking reference from the Shorter Oxford English Dictionary (rev.ed. 1978), which defines Holography "as 'writing wholly by one's own hand' (p. 975), the prefix holo from the Greek as 'whole, entire' (p. 975) the suffix -gram from the Greek as something written, letter (of the alphabet) (p.878) and -graph as 'the Greek termination was chiefly used in the sense 'written', whence autograph, holograph, photograph, etc; sometimes in the active sense 'that writes' (p. 881)..."
3. See D. McNair, 'How to Make Hologram', (1983: 248).
4. See Hans Wilhelmsson (op.cit. 1968: 163).
5. See Graham Saxby, 'Practical Holography' (1988: 6). Saxby remind us that a hologram can record an object which in every respect replicates the object, with full parallax.
6. See Lewis Blackwell, 'Dark Room Dramatics', in Creative Review, (Feb. 1987: 18).
7. See Margaret Benyon:
   - 'Holography as an Art Medium', in Leonardo,(1973. Vol. 6. pp. 1-9.)
   - and, 'On the Second Decade of Holography as Art and My Recent Holograms', in Leonardo, (1982. Vol.15. No.2. 89-95).
   - and, 'Cosmetic Series 1986-7: A Personal Account', in Leonardo, (1989. Vol. 22. Nos. 3 & 4. pp 307-12).
8. These prices were quoted by Agfa Gavaert in September 1996 (personal communication).
9. See Blackwell (op.cit. 1987: 18).
10. Articles on Computer Art can be found in established Art Journals, such as:
    i) 'Art and Design' (1994. Vol.9. 11-12. Nov.- Dec.) had the whole edition given over to Computer Art, under the title 'Art and Technology'.

ii) 'Art Journal' (1990. Vol. 49. No.3) which devoted a whole issue to the subject.

11. Three popular films from the 1990's which feature fantastical portrayals of holography, are:
    (i) Dark Man - 1990
    (ii) Total Recall - 1990.
    (iii) Batman Forever - 1995.
    Perhaps the best known T.V. example of the fantasic use of holography occurs in the character of 'Rimmer' in the BBC series 'Red Dwarf'.
12. See 'Focus: The Magazine of Discovery', Sept. 1996, in which a Communications Supplement (p. 8) claims "Holographic TV systems are now under development for the home".
13. The process involved in producing the embossed hologram on the cover of the National Geographic Magazine, Vol. 165. No.3. March 1984, is described (pp 372-3).
14. For further information and a more detailed explanation of these terms, see Saxby (op.cit. 1988: 273-80).
15. In addition to these political and monetarist influences, one aspect which may well have influenced events relates to the fact that at a provincial university, such as Liverpool John Moores, the making of holograms was always a sequential matter, in that only one hologram could be made at a time. Unlike sculpture, for example, where a studio might see four, five or more artists working at one time in clay, or stone, in metal of some sort, or with the detritus filched from a builders skip, only one student could ever be involved at one time in making a hologram. This singularity in the materials used in creating a hologram contrasts with the multi-layered nature of most other mediums; and this together with the sequential aspect meant the teaching of the subject was always going to come up against the move to a modular system where a number of students had to complete a holographic image in a pre-set period of time. The teacher/pupil ratio was also impacted by this sequential factor and created a one to one relationship of such extremes that it stood in contradistinction to the demands made on the educational processes of the day.
16. The term 'Lenseless Photography' as a way of describing holography,

was coined for a press release by the Optical Society in 1963. (see McNair. op.cit. 1983: 248).

17. The analogy between holography and photography is further undermined by the fact that any photograph of a hologram always reduces its three-dimensional aspect to a two-dimensional representation. Saxby (op.cit. 1988: 304-11) devotes a chapter to this problem, stating that: "Making successful photographs of holograms is not particularly easy". This point seems especially relevant in relation to the reasons for the disappearance of holography from Art Education, for: "Without photographs and slides, it is doubtful whether the discipline of Art History could have developed" (Duro and Greenhalgh: 1993: 226).

CHAPTER THREE

Holography in Terms of the Tradition of Light in Art

i) Introduction

This chapter focuses on the tradition of light in art, and the problems of defining this all-encompassing and often intangible construct. Using an hypothesis which acts as a means of circumnavigating these problems, the history of this tradition is charted from ancient to modern. And the suitability of holography being placed at the head of this tradition is discussed.

ii) Light in Art defined

To properly consider the tradition of light in art, it is necessary to define the term. Hills (1987: 4) points to the fact that this aspect of art appreciation has not always been the primary concern of those who've chosen to translate visual language into the written word: "One of the reasons why art historians have preferred to emphasise perspective rather than light as the foundation of the Renaissance achievement is that the scope of perspective is more easily defined. Light is at once universal and elusive". Hills further expands on this problem, suggesting the reason for this tendency is because of the "bewildering duality of light as agent and object of vision".

In order to make sense of this phenomenon, the practice of coupling

the non-material nature of light with the tangible reality has often been used. So that "light in terms of painting" and "light in terms of architecture" are more specifically familiar definitional titles than any overall tradition of light in art. Within each of the former definitions different sub-divisions have be created, and a number of publications have been devoted to these subjects.[1] However, to set out to consider each different area in turn would take up more time and space than is possible in this context, and it is the intention here to consider the tradition of light in art by proposing a straightforward hypothesis, which holds that:

> 'The art of any era reflects the age in which it was produced. It will therefore hold clues to the understanding of the subject of light at that particular period. By searching for these clues, which are not always immediately apparent, the history of light in terms of visual production comes to the fore'.

iii) Historic Examples of Light in Art

An early example of the often elusive subject of light in art lies in the prehistoric cave paintings at Lascaux in France and Altimira in Spain, which range from 10,000 to 30,000 years in age. These markings are important for two reasons. Firstly, they have come to represent the cornerstone on which scholars have constructed the history of art. Secondly they emphasise the multi-functional role of light that Hills (ibid: 4) points to; a matter which is often overlooked in the rush to an interpretation of this subject. And although historians tend now to consider these cave paintings in categories such as 'art for arts sake', or as sympathetic magic, or as symbols of religion and totemism (see Young.

1974: 535-7; and Ucko and Rosenfeld. 1967), it is the often unspoken and unacknowledged nature of their interdependency on the primacy of light which will be emphasised here.

These depictions of horses, bison, auroch, deer and other ruminants are interspersed with scenes of the hunters themselves engaged in the chase, and were carried out deep in the interior of the caves, in an environment which would normally have been one of total darkness, and hidden from the outside world. That these had a propitiatory purpose to make the efforts of these hunter-gatherers more efficacious is only a possibility. However, it is certain these early men relied on artificial light from simple oil lamps which allowed them to invade these interiors and create their masterpieces (see Wells. 1975: 15). Indeed, the fact they have been hidden has preserved them for us today, for they would surely have weathered and vanished had they been exposed to natural light. In these caves, then, the subject of light probably played some sort of dual role. Firstly it had a practical function of allowing the blackness to be lit to allow the animals to be depicted in what may well have been some sort of sacred ceremony. Secondly - and we can only guess at the true meaning - this was perhaps the first example of interior illumination in the spiritual sense, with the isolation from natural light and a reliance on the naked flame maintaining these sights as magical domains for successive generations of stone-age hunter-gatherers.

Whenever humans gathered to form early societies, the inexorable link between light and the inexplicable would always be easily made. Daily

events such as the coming of daylight and the regular patterns of changing light in the skies must have provided comfort in the form of reliable references. Moreover, the need to express awe and satisfy wonderment seems to have also been a recurrent theme. Speculation today suggests the stone monuments of the neolithic age which appear throughout the world were used for religious intercession, by taking the measurement and prediction of the movements of the sun and stars to symbolise this interaction. The sun, as a symbol or object, has always influenced artifacts. It is the provider of warmth and light, and has been the inspiration for some of the greatest monuments of the ancient world:

> "The merciless African sun certainly caused the (ancient) Egyptian architects to choose massive and utterly simple shapes for their pyramids and palaces. Enormous flat walls and huge round columns are their main feature, whilst simple cornices produce one straight and heavy shadow to outline the silhouette of these simple buildings against the sky. On these huge granite surfaces we find only the thin and finely engraved lines of the hieroglyphics, which would be invisible in the absence of harsh Egyptian sunshine".
>
> (Kalff. 1971: 5)

These domiant North African structures may have been influenced by the intensity of natural light, but they are also statements of a belief in an afterlife which included representations of the sun as an expression of religious experience. Between 2723 and 2563 B.C., the Egyptians created colossal pyramids as tombs for their divine royalty in the glare of their sun gods, Ra and the less austere Autun. The dominance of the sun in Egyptian life ensured these idols became supreme dieties in a panoply of

gods. And in this Egyptian display of precision-building, the external light source was passed through channels in the massive bulk of the interior to illuminate the centrally located burial chambers at what were probably deemed to be propitious moments. The simple but effective shape of this monument was ultimately reinforced and accentuated in a smoothly sided edifice topped off and tipped in electrum, a mix of gold and silver that would interact and reflect the intensity of the sun.

These examples of picture making by early hominids and the one remaining example of the seven ancient 'wonders of the world', give some indication of the role light has played in the construction of art works. And as time progressed and different technologies and different mediums were developed, these have diversified. However, in order to prevent the account becoming a massive trawl through the influences of light across the annals of art history, as in the Byzantine and Renaissance ages, it is necessary to move swiftly through time and recommence the story in a more recent setting.

iv) The Nineteenth Century

By picking up the theme in the second half of the nineteenth century, the setting for the modern tradition of light in art can be more easily established, for Impressionism was a classic reaction in paint to changing views concerning the subject of light. The traditional roles of recording and story telling which painting had enjoyed for so long, were, by the 1850's, under threat from the new discipline of photography. Astonishing images could be recorded by exposing paper soaked in silver chloride to

light, and at once the process became immensely popular.[2] Painting, on the other hand, had become somewhat hide-bound by academic rules (see Gombrich. 1993: 406), with convention dictating how students tackle the subject of light in painting. The dominant subject matter of the day lay in an idealised vision of nature, and although there were exceptions to this rule,[3] it was in the new branches of science that the most exciting and often dangerous research experiments on the subject of light in art took place:

> "Although we are talking about scientists, what is in question here is the discovery of the "visionary" capacities of the body, and we miss the significance of this research if we don't recall some of its strange intensity and exhileration. For what was often involved was the experience of staring directly into the sun, of sunlight searing onto the body, palpably disturbing it into a proliferation of incandescent colour. Three of the most celebrated students of vision of this period went blind or permanently damaged their eyesight by repeatedly staring at the sun: David Brewster, who invented the kaleidoscope and steroscope; Joseph Plateau, who studied the so-called persistence of vision; and Gustav Fechner, one of the founders of modern quantative psychology".
>
> (Crary. 1988: 34)

During the last four decades of the nineteenth century, the effect of the new technological discoveries pertaining to light began to be manifest in the visual arts. In terms of painting this meant working at those effects of light and colour which ran counter to previously accepted convention. The new ethos (later to be called impressionism) advocated painting from direct observation in order to convey the changes of light

and atmosphere in any one particular scene. Famous examples include Monet's series of paintings on a single subject (the Gare St Lazare. 1876-8, the Haystacks. 1890-2, the Poplars 1890-2, and Rouen Cathedral)[3]. And in a brief period of time the handful of painters who made up this short-lived movement were responsible for a body of work destined to overwhelmingly raise our awareness of light. Their observations, which at the time appeared ludicrous to many, become so effective that they have now become part of our general awareness.[4] These innovative philosphies of the Impressionists brought painting into line with contemporary investigations into light, and this was assisted and inspired by the latest techological developments of the day:

> "Impressionism saw no reason to struggle with the traditional painting materials promulgated by the Academy, embracing instead the powerful colours of the spectrum that the new science promised to deliver" (Bomford et al. 1990: 51).

The products as well as the philosophies of the increasingly industrial western world were to play a crucial role in the development of this new art movement. The artists palette, for example, had been expanded across the nineteenth century by the development of new pigments, and an increasing access to new colours was to have a huge impact on the techniques of painting. A most celebrated aspect of the Impressionist movement lay in the way its artists opted to paint 'en plain air' in order to capture the effects of light on landscape with immediacy. Auguste Renoir later said, this relatively untried practice was made yet more feasible thanks to further technological developments: "Without paints in

tubes, there would have been no Cezanne, no Monet, no Sisley or Pissaro, nothing of what journalists were later to call Impressionism" (Bomford et al. ibid: 41). Impressionism thus benefited from, and was directly influenced by the technology and events of its time, and it is a convenient starting point to use as the beginning of the modern concept of light in art. Nevertheless, it remains a movement primarily identified with changes in the discipline of painting, and has not been seen to herald an evolution into new areas of the visual arts in general.

v)Twentieth Century Light in Art

As the twentieth century dawned, well-established and comfortable definitions surrounding the Fine Arts were about to be inexorably changed. This coincided with a greater understanding of the subject and of light itself, and the invention of more sophisticated forms of artificial illumination. Light was transformed from being something which was merely associated with other mediums to a point where it became an autonomous material in its own right.

Clues to this impending change can be found in Impressionist works, such as Manet's 'La Bar aux Folies-Begeres (1882), and Renoir's 'Moulin de la Gallette' (1876).[6] In these paintings of urban life, artificial light which now prolonged the leisure time of Paris is clearly depicted. The hours of darkness were becoming increasingly illuminated, for gas lighting had been introduced into Europe in the early eighteen-hundreds; although its primacy as a source of illumination was to last for less than a century. Thomas Edison's filament light bulb was to supercede the gas

mantle, and the race to provide the world with artificial light was evenually won by electricity. Once again the provision of light - this time on an enormous scale - was to substantially change values, and electric light was included in the work of a small number of European artists as early as the 1920's (see Popper. op.cit. 1993: 12-3); although it would be after the second world war, in the United States, that the evolution of "literal light" blossomed as an art material (Perreault, in Hess and Ashbery. 1971: 133).

By the middle of the twentieth century, artistic interest had focused on the imagery and products of popular culture, and further undermined the high/low distinction which had previously surrounded the subject of art. The rapid evolution of different forms of electric illumination had turned light into an affordable commodity of mass consumption, available like any other perceived essential ingredient of modern living. It seems fitting, then, that in the USA in the largest free-market economy in the world, the irony of exhibiting commercial lighting devices devoid of any orthodox aesthetic value should be recognised by artists. Neon signs featuring words, messages and symbols became a regular sight in fashionable art galleries. And this particular form of lighting, so closely associated with advertising, was made even more famous by Bruce Nauman, whose work in neon continues to explore and present a complex range of philosophical ideas.[7]

Artificial light thus took its place alongside the more established materials in the Fine Arts, and with the move towards a more minimal

presentation, its properties were further explored. Dan Flavin's installations made from columns of fluorescent tubes are some of the most famous examples of a host of work which epitomises a late 1960's pre-occupation which sought purity through the reduction of narrative.[8] The quest was taken a stage further by James Turrel who started using fluorescent tubes and moved on to create work using high intensity zenon projected light. Turrel's installations are similar to those of Flavin, in the sense that they are deliberately constructed to engulf the spectator, so forcing a redefinition of the space they occupy. However, Turrel hides the source of his illumination, and in so doing, places all the emphasis on the division of space by using light rather than physical materials.[9]

Within a brief period, then, artists have gone from working with lighting appliances normally associated with the domestic market, to using forms of light designed for use in an entertainment or industrial capacity. Out of this latter category has come the laser, which produces a unique source of light consisting of a single wavelength. This ability to isolate, control and reproduce the individual wavelengths of light making up the visible part of the electromagnetic spectrum embodies our present near-total understanding of the physical make-up and behaviour of this subject.

In their search for more refined forms of artificial light, a handful of artists, including Turrel, have chosen to work with lasers. With its intense linear quality, laser light has proved to be the perfect

device for drawing in space with precise accuracy; and for the past thirty years it has been used in a host of different environments, from gallery installations to large scale open air projects. The spectacular nature of these latter works and its increasing use in outdoor commercial events to create monumental drawings in space, means the distinction between art and entertainment can appear to be blurred. Despite this, artists such as Rockne Krebs, Dani Karavan and Horst Baumann have continued to explore the aesthetics of laser light on an environmental and urban scale (see Popper. op.cit. 1993: 29-36).

During the second half of this century, light itself has become an independent subject for artists to work with. A short, but nevertheless unique tradition has thus been established, and the evidence points to the fact that this relatively new independence manifests itself in subtle ways in the guise of the laser-dependent process of holography. We can therefore return to Popper's definition of a hologram (op.cit. 1993: 38) being "a statement of specific effects based on an autonomous structure of its medium, light". And though these 'specific effects' can vary, from recordings of objects to diffraction gratings,[10] they are all examples of a process which takes the manipulation of light to new levels.

Thus the role of light throughout the history of art is clearly revealed by pursuing a dialectic investigation. And it is the conviction of this research that the finite control of light present in holography, gives this medium absolute credentials to allow it to be placed at a leading edge in the tradition of light in art. However, this position can

only be properly claimed if it can be proven holography is a more than suitable Fine Art medium. And to this end it is necessary to consider the practical side of this investigation and show how the series of holograms making up that part of the research project fulfils this criteria.

NOTES AND REFERENCES TO CHAPTER THREE

1. For examples of the coupling of light with some other facet of the creative process, see:
   i) Painters of Light - The World of Impressionism, Roberts. K., (1978).
   ii) 'The Metaphysics of Light', in The Illustrated History of Architecture. Nuttgens. P., (1983).
   iii) Three Little Books About Paint: No.1. Light., (Exhibition catalogue). (ed). Harrison. M.
2. See, Gernsheim. H & A., (1971: 36-52).
3. See, The Paintings of J.M.W. Turner., Butlin. M., and Joll. E. (1977). and Constable and his World., Gadney. R. (1976), where the depictions of nature were not seen to follow convention until long after the two artists had produced their work.
4. House J. (1986) has good reproductions of Monet's 'Haystacks' (plates 136, 163, 247, 252 and 253); his 'Poplars' (plates 137, 209, 233 and 255); and his 'Rouen Cathedral' series (plates 138, 163, 164, 240 and 267).
5. See, Clark. K., (1987: 204).
6. See Richardson. J. (1967, plate 45) for the Manet; and Pach. W. (1975: 54) for a reproduction of the Renoir painting.
7. For further reading and examples of Bruce Nauman's work, see catalogue for Whitechapel Gallery exhibition (1986), and Butterfield. J., (1993)
8. For further reading and examples of Flavin's work, see 'Dan Flavin: Fiat Lux', by W.S. Wilson, in Hess. T.B. and Ashbery. J. (eds), (1971: 139-49), and 'Tall Cornered Fluorescent Light', Exhibition catalogue, Pace Wildenstein (1993).
9. For further reading and examples of James Turrel's work, see catalogue for Hayward Gallery exhibition, 'Air Mass', (S.Bank Centre. 1993); and Butterfield. J., (op.cit. 1993).
10. A holographic diffraction grating is a hologram formed by the interference of two or more beams of pure, undiffused laser light. The processed hologram will act as a prism and split the white light (used to reconstruct it) into spectral colours.

PART TWO: THE PRACTICAL WORK

CHAPTER FOUR

Introduction - The Personal Involvement

The final phase of this research centres on the construction of a series of experimental holographic artwork. Through this, theory will be put into practice and the outcome can then be judged to assess whether or not the results suggest that holography can, indeed, be placed at the head of the tradition of light in art. The construction of the exhibited holography therefore constitutes a personal investigation into the medium, and for this reason, at this stage, it is important to detail the involvement of the author as artist.

As an undergraduate Fine Art student at Liverpool Polytechnic (1983-86) the opportunity arose to make a number of holograms in the studio which had just been developed within the department. With the aid of hindsight, it can be seen that the existence of this unique facility was the direct result of the upsurge of interest in holography in the arts during the late 1970's and early 1980's (which is described above). Having no previous experience of laser and optical technology, the allure of being able to create perfect reproductions of objects in three-dimensions was the main attraction of the medium to the new undergraduate; and, at first, the processes involved in producing holograms seemed to be utterly mysterious.

In 1985, the Royal College of Art announced the opening of its holog-

graphic studios. The author was accepted to study for an M.A. in Holography (1986-88) and found the differences between these two institutions was enormous. At Liverpool the equipment had been minimal, and was often home made, while the work undertaken was often experimental in the sense that it was usually the first time many of the holographic techniques which are now regarded as standard practice had ever been attempted. For a novice holographer, the R.C.A. was initially an overwhelming experience. Having to get used to working with new and expensive equipment, coupled with an emphasis which placed technique over content, as well as the prevailing and underlying political pressure to prove the worth of holography in as short a time as possible, did not make this the ideal environment for any deep philosophical reflection or artistic contemplation.

Charting the history of holography now for this research process, has been most significant and enlightening, in that it has greatly helped the author establish a more objective vision of the medium, and of its apparent disappearance from the aesthetic arena. As as already been mentioned above, the technical ceiling which holography had reached, and the high costs of the medium, seemed to suggest that for the forseeable future it will probably remain a marginal area for artists to be involved with. Yet however frustrating this might be, it did not invalidate this investigation, and the question of how and in what direction the practical phase of the research should move had now to be resolved.

The answer came partly from the investigation of the tradition of light in art (chapter 3 above), as well as from the environment in which

the majority of the practical work of completing the series of holograms was to be undertaken. Firstly the investigation into the tradition of light in art had revealed the difficulties in highlighting the almost intangible nature of this subject. For even though light has become an independent subject in the second half of this century, it is a medium that poses its own particular problems. As the artist James Turrel explains in relation to his own work with light: "There is no critical vocabulary attached to the works of light and space - which further complicates the matter" (Turrel in Butterfield. 1993: 72). This problem of light and language has also come to the fore in holography, with Coyle (op.cit. 1994: 68) suggesting it has hampered the ability of practitioners to adequately describe their work, and of critics to properly appraise it. Such problems will undoubtedly persist if the concept of holography as "a statement of specific effects based upon an autonomous structure of its medium, light (Popper. op.cit. 1993: 38) is not properly thought through. As already mentioned, these 'specific effects' can vary, and it became apparent that this factor could provide the means by which the practical phase of this research could escape the possibility of becoming tongue-tied by those metaphysical connotations inherent within this definition.

Just as the subject of light in art is often coupled with tangible reality (light in terms of painting, etc), so a decision had to be made about how and in what form the investigation here into holographic light would actually manifest itself. At this point the second factor, the environment in which most of the practical work of this research was to be

undertaken, began to influence events.

Funding for the research allowed the latest holographic systems then being used in the U.K. to be assessed on a first hand basis. During this period the commercial studios of Munday Spatial Imaging, and the Royal College of Art complex were visited, and their computer generated stereogram and pulsed laser multiplex systems were studied. Both could be seen to offer new and intriguing possibilities. The computer-generated process can create three-dimensional images of objects which have never physically existed, whilst the multiplex process can produce animated holograms using a series of photographic images as a source. However, charting the history of the discipline had clearly highlighted the fact that the very latest advances in holographic technology might not always necessarily provide the best means of investigating holography as a fine art medium. It was obvious that any aesthetic inquiry could well become unduly shackled by the amount of technology these processes involve, and it was important for the research to maintain control over the hardware involved in the holographic production. With the aesthetic potential of holography remaining relatively unexplored, it became apparent that technology in itself was not necessarily the answer, in that even the most basic of techniques could be used to provide clues in the quest for the resolution of this most elusive of constructs. And the very concept of achieving some aesthetic progress with the minimum of technology was an attractive idea.

Utilising multiplex and computer generated techniques would also mean

that most of the practical work for the project research would have to be executed outside the confines of the Liverpool John Moores University. At this time the same holographic studio in which the author had first made his holograms a decade earlier (then the Liverpool Polytechnic) was still housed within the Fine Art department in the University; and with the dawning realisation that already established techniques could provide the key to this programme of study, there seemed no need to look elsewhere.

Before the holograms could be made, however, it was necessary to make a number of changes in the studio in view of the limited resources it contained. And although the unit had then been running for some ten years, the restrictions in higher educational funding as well as temporal constraints meant that the production and completion of the work was always likely to be problematic. Yet, if the studio was to provide a suitable base for the practical work, then the restrictions of the past had to be overcome, and the opportunity was at hand to do this. By January 1993 enough new and refurbished equipment was available to test most of the existing holographic techniques, and the question of which area of this practical phase of the research should first be approached was answered by pinpointing what had been the most crucially restrictive issue of the past.

Up to this point the option of colour control in reflection holography had not been available to those who had previously worked in the studio. The amount of time and technology needed to try and generate natural colour in holography (see Saxby. op.cit. 1988:61-7) meant that this was not a viable proposition, even with the funding that this research had

generated. However, other less costly techniques do exist and these create a much wider range of colours than the monochromatic red which is produced by an untreated holographic plate or film and a helium neon laser. The creation of holograms which replayed back on different wavelengths of light, it was hoped, would produce a broader palette and offer a greater choice. What remained to be seen, therefore, was whether or not this could be achieved within the context of the studio where this practical phase of the research would be undertaken.

As the parameters of the first part of the investigation were now defined, attention turned to the formal considerations of the first piece of practical work. Having been without any holographic facilities for a number of years, the author was keen to pick up the threads of his previous investigations into the medium, and it therefore became necessary to pause and reflect on the direction of this previous work.

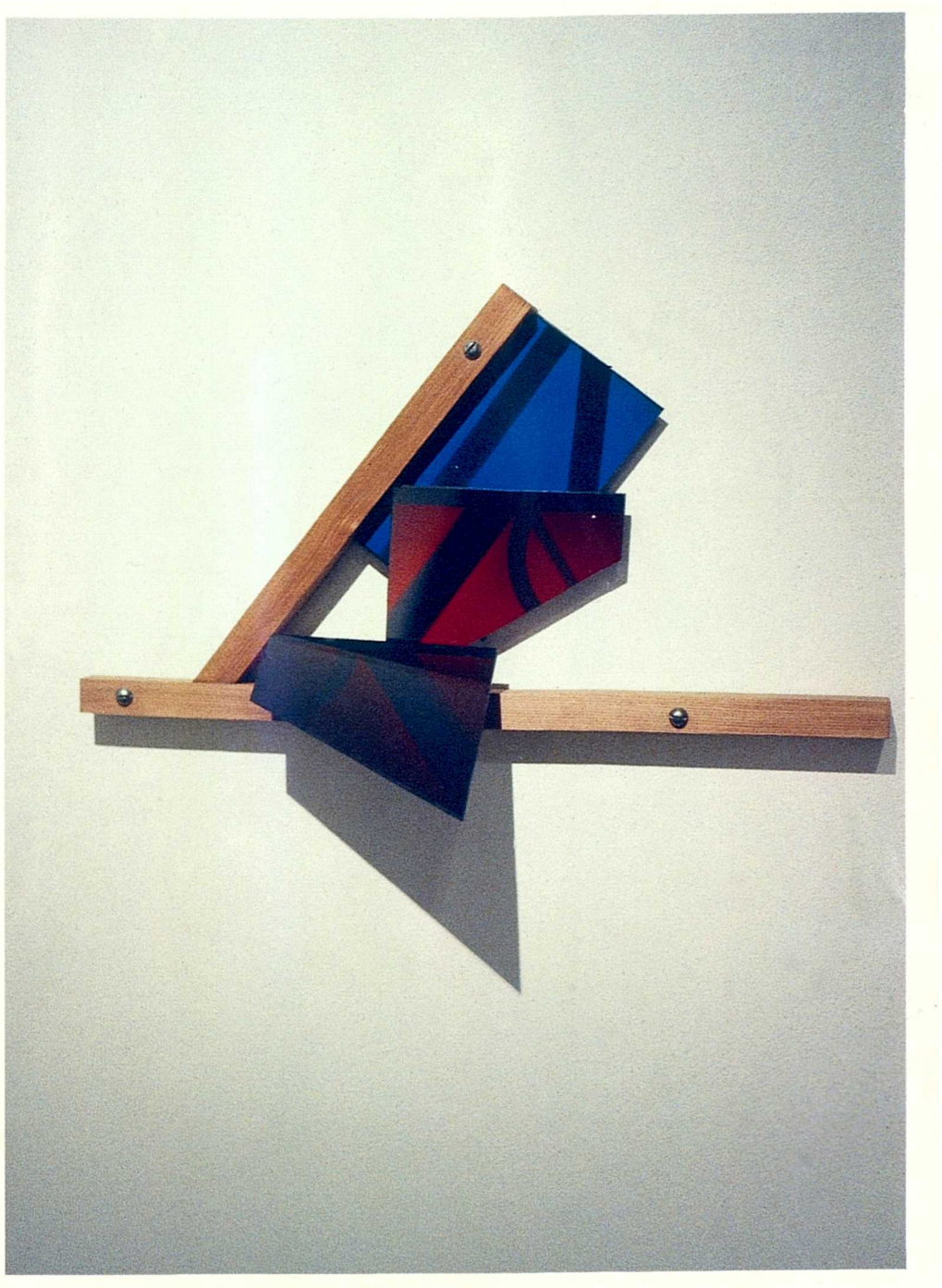
As an M.A. student at the R.C.A., the author had made a series of small, wall-based constructions from pieces of holographic plate and wood. These had explored the nature of real and holographic shadows, with much of the imagery based on the geometry used in making holograms. These reflected a growing understanding of the process of making holograms, but it was only after properly exhibiting the work that it was noticed how effective they were in emphasising the relationship that exists between the viewer, the hologram and the spotlight which illuminates it. Real shadows were visible at every angle, while the holographic imagery only existed for

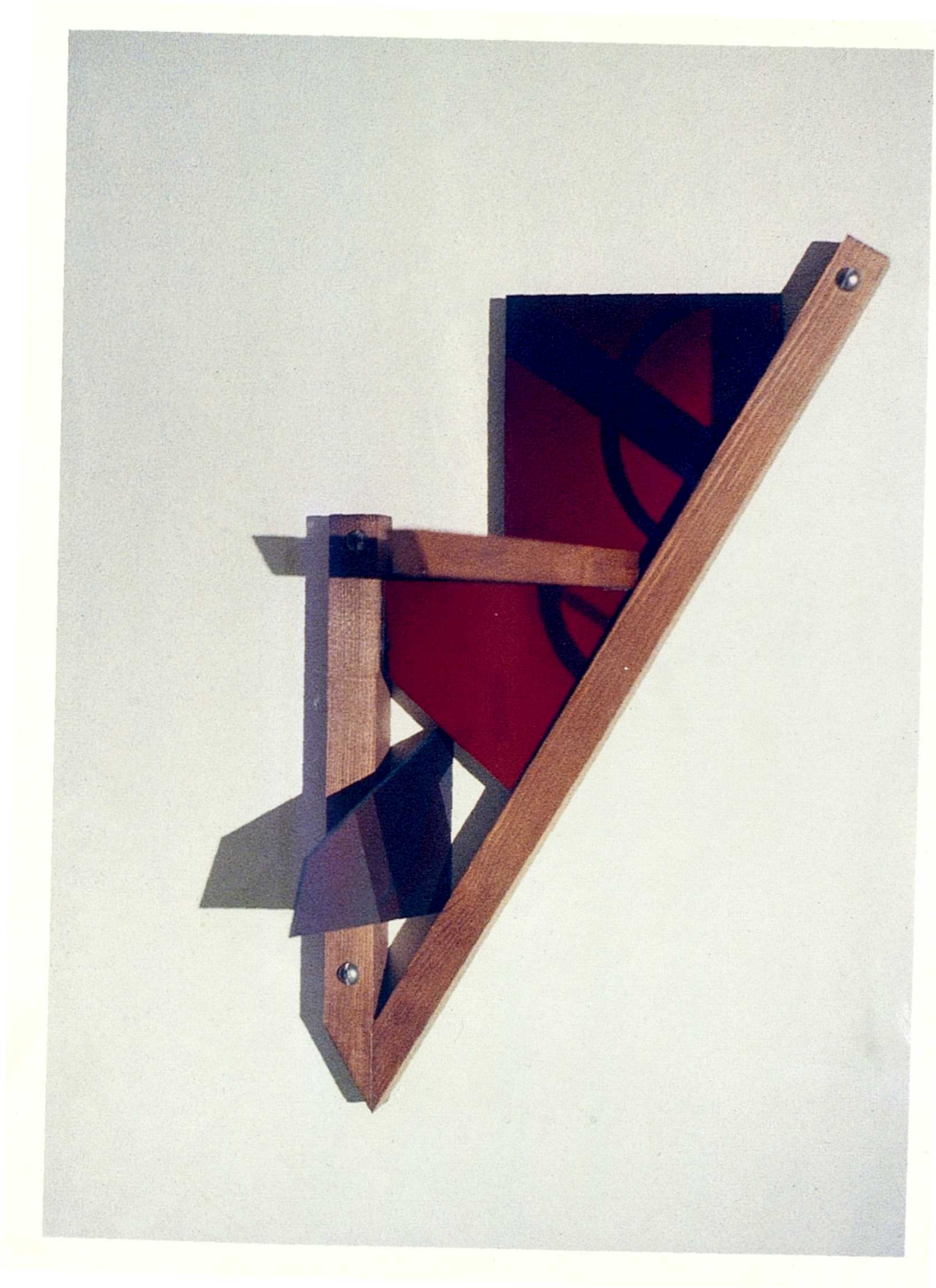
the viewer when he or she stood directly in front of the construction, underneath the spotlight that was responsible for bringing the composition to life (see Fig. 1).

Having taken stock of the understanding gained during the research investigation for the M.A., it was decided to move forwards by looking beyond the geometry of holography for inspiration. The Electric Mickey series, which constitutes the first practical work of this research, thus continues an exploration of this relationship between the viewer, the hologram and the spotlight, and does this by pursuing a greater range of imagery. It also provides a suitable basis from which an investigation into colour-control in reflection holography could begin. Having defined the parameters for the first phase of this practical part of the research, then, it was now time to give due consideration to the aesthetics of this first piece of work.

F I G U R E O N E

Photographs of two Holograms created as part of the author's M.A. degree course at the Royal College of Art, London, 1988





CHAPTER FIVE

Holographic Colour - The Electric Mickey Series

The initial idea and inspiration for the compostional structure of the Electric Mickey series comprised of two different elements, and used a spotlight which was set to illuminate its own electric socket plug, with a hologram of two circles behind the plug. The electric cable connecting the spot light to the plug is deliberately not concealed. Once illuminated, two dark circles appear on either side of the plug, and transform the image into a permutation of the popular and internationally known Mickey Mouse emblem. Conceived as a wall mounted presentation, the amalgamation of the physical and aesthetic in this concept suggested at this stage a potential in reflection holography to be the perfect vehicle for an exploration into colour control; for it was anticipated variation throughout the series would come in the form of holographic colour.

The concept for this idea had evolved from my past work and from the research into the role which light had played throughout the history of art. This had emphasised the importance of electricity as the source of inspiration in many of todays visual imaging systems. Electric Mickey is therefore a celebration of this, and the surreal and humourous prospect of a plug with ears seemed an appropriate representation of the magic that the projected light of the cinema or flickering tube of the television can induce. The prospect of recording three-dimensional space onto a flat surface was also sympathetic to the visual paradox that exists within

Mickey's peculiar ears, for:

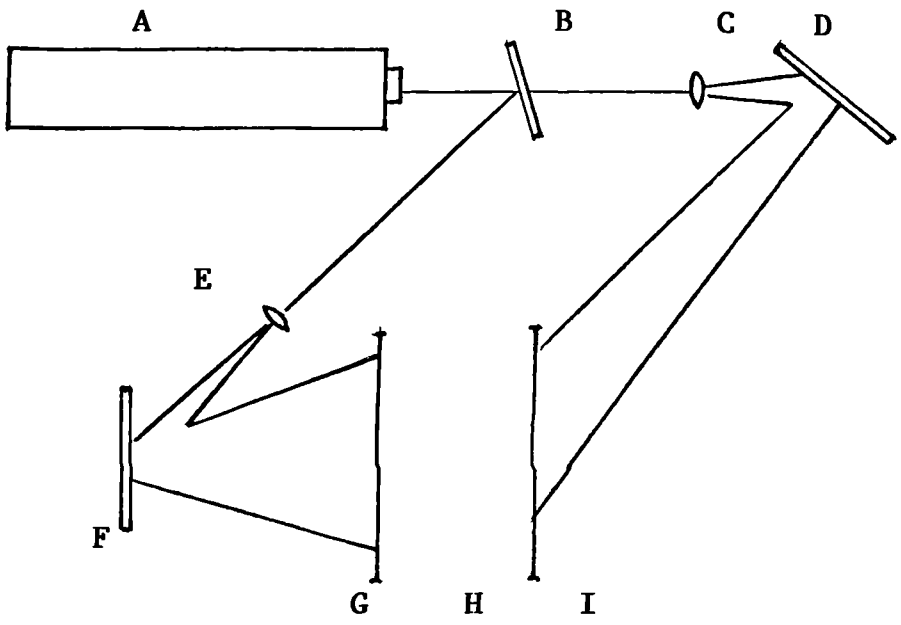
> "His ears are two solid black circles, no matter the angle he holds his head. Three-dimensional images of Mickey Mouse - toy dolls or the papier-mache heads the grotesque Disneyland Mickey's wear - make us uneasy, since the ears inevitably exist sideways as well as frontally. These ears belong not to three-dimensional space but to an ideal realm of notation, of symbolisation, of cartoon resilience and indestructability".
>
> (Updike, in 'Introduction'. Yoe & Yoe. 1991)

Electric Mickey was thus designed to be an affectionate homage to the potency of the moving image, and now with the basic framework of the composition decided upon, it was time to consider what sort of reflection holograms would be best suited to display this particular work.

At the centre of the compostion the illuminated plug and the shadow it cast would provide a strong image. The holographic ears would then have to be equally bold in order to compete with these real elements, and to maintain a sense of visual harmony. With this in mind it was decided to use one-step, white-light shadowgrams for this particular work. This previously established technique (see Saxby. op.cit. 1988: 156) fulfilled the holographic requirements of the Electric Mickey composition because of the unique way it records a volume of space. A shadowgram records a volume of space which has been defined by two beams of laser light, one of which falls directly onto the hologram, whilst the other illuminates a sheet of frosted glass which is placed or situated a number or centimetres behind the hologram (fig. 2). The resulting interference pattern caused by these

F I G U R E T W O

Plan View of Optical Set-Up for One-Step Shadowgrams



KEY

A	LASER
B	BEAM SPLITTER (set on a 50/50 ratio)
C	SPATIAL FILTER
D	MIRROR
E	SPATIAL FILTER
F	MIRROR
G	GROUND GLASS SCREEN
H	VOLUME OF SPACE IN WHICH OBJECT(S)/ART WORK CAN BE PLACED
I	FILM HOLDER

two beams records the volume of space between the hologram and the frosted glass. Because the second beam back-lights this volume of space, the resulting holographic image appears to have an internal light source which manifests itself in the form of vivid colour. Thus space becomes colour, and the volume of this space can only be properly understood when an object is brought into the proceedings. Almost any object can be placed into the space between the hologram and the frosted glass prior to exposure, although they will not be recorded in the conventional sense. This technique records the volume of space around the object, but not the object itself. The light falling on the object should not be strong enough to record any of its surface detail, so that in the final hologram a three-dimensional black hole appears where the object once was. This shadowgram technique would, it was realised, not only provide the intensity of colour needed for the final composition, but would also record the two holes to provide an equally bold set of ears.

Retaining the identifying contradiction of Mickey's ears was essential; therefore two-dimensional circles were used, rather than three-dimensional spheres. In this instance, the black holes would appear as flat holes which would float in space.

The most commonly used method of creating a variation of colours in reflection holography is by pre-swelling or 'hypersensitizing' the holographic emulsion in a mixture of Triethanolamine and water, before exposing it to laser light. The requirements of this particular technique are well documented,[1] and I saw no reason to deviate from this procedure.

However, before this could begin, a decision had to be made about what sort of holographic material should be used in the Electric Mickey composition.

There are two options when it comes to making holograms. Either holographic film or glass plates can be use. The theoretical definitions of Popper (op.cit. 1993: 38), and Zec (op.cit. 1989: 429) rightly highlight the fact that a holographic image is made up of light; and yet a holographic image is also reliant on the millions of pieces of silver suspended in the gelatin based emulsion which is coated onto acetate or glass. Having worked previously with holographic plates which were cut and shaped after the image was recorded had emphasised this dual reality of holograms. In this instance they became a screen onto which visual information was recorded, and were also pieces of glass which could be manipulated in much the same way as could any ordinary piece of glass. The dependency of a holographic image on the information encoded in its emulsion, and which in turn is attached to the surface of another material, means that due consideration must be given to this other material if it is to become part of a composition which is made up of a number of different elements.

The importance placed on this decision in this research is in stark contrast to the norm, for in all of the available literature on those who've worked with holography, there is no reference to this particular consideration having been made. With the Electric Mickey series, then, the decision to use film was based entirely on the aesthetics of the composition. In particular, it was the compositional reference to animation and its link with celluloid which proved to be the compelling

motivation in influencing this choice. The resulting hologram would also have to be flexible enough to be manipulated after the image was recorded; and it had to be attached to a wall to have a hole cut in its centre to allow the plug to also be fixed onto the wall. Holographic plates are three millimetres thick, cannot easily be drilled, and have to be attached to a flat surface with the aid of mirror plates or a frame. In contrast this composition called for the final hologram to be bare, in the sense that its edges were to remain clearly visible and not hidden behind any framing device. Film was therefore the only option; and all that remained was to start producing the holograms.

The prospect of shooting the holograms posed few problems. What did have to be resolved, however, was to sort out what chemistry should be used to process them. Professional opinion differs on this subject,[2] for unlike the ready-made photographic developers which can be bought 'off the shelf', holographic chemistry has to be produced by the individual. It was my belief that an investigation into different theories would prove wasteful, and possibly side-track the intentions of the research; and so I elimated this potential problem by employing the same chemistry I'd used at the R.C.A., which had provided excellent results (see Technical Appendix). I therefore had only to apply the experience of working with holographic plates to the process of working with film.

Of course working with film inevitably posed its own particular problems, for its success requires much more time and attention be spent on every aspect of the holographic process. The majority of holographic

techniques favour the use of plates because they provide a greater degree of stability, and can easily be pre-swelled at a relatively quick pace to enable the exploration of holographic colour. The exact opposite is true of film, for after the pre-swelling stage the flexibility of its acetate base means that it cannot be dried with a simple hair dryer - a standard procedure used on plates. Instead, the film has to be squeegeed to get rid of excess moisture and then hung up to dry in a safe darkroom environment. Then, once it has sufficiently dried, the film has to be attached to a clean piece of glass by index-matching with turpentine; and the glass with the film fixed to it has then to be placed into a plate holder so that the process of recording the holographic image can begin.

Having established an optical set up for creating shadowgrams, the two discs that would become Mickey's ears were put into position, and the first sheets of film were pre-swelled. This part of the process took much longer than anticipated. Triethanolamine is a clear, viscous solution which is somewhat difficult to dissolve in water. Pre-swelling solutions have to be properly mixed so that when the holographic emulsion is squeegeed dry there are no streaks left behind, for these would eventually result in areas of the hologram replaying back on different wavelengths. This technique also makes holographic emulsions much more sensitive than untreated ones, which is beneficial because it reduces exposure times - even though safe-light levels in the darkroom have to be reduced if the emulsion is not to become fogged before the hologram is made. The guide-lines for pre-swelling holograpms only provide a basic framework of rules,[3] and this process is also dependent on such variables as being able to

maintain a constant room temperature, a matter which in this research situation I had little control over. Thus, through a process of trial and error it became standard practice to pre-swell two sheets of film at the end of the day, and let them dry overnight to be used the following morning. It quickly became axiomatic then, that the creation of different colours in reflection holography requires a great deal of forethought, much experiment, and some initial failure.

The results of the procedure could only be assessed once the hologram was developed, washed and properly dried. After these different stages were complete, the appearance of the final image would give the first indication as to how successful the process had been and if the required colour had been attained. In order to speed up the procedure, the two 'ear' discs were left in their original position once the optical set-up was seen to create the right results; and with a fixed holographic composition in place, the quest for colour variation could then begin.

After a period of time the holograms being created replayed back on different wavelengths. Different colours were easier or more difficult to produce depending on the size of their particular wavelength. A much greater variation of green and red was possible because of the relative size of their wavelength. However, orange and yellow, and blue (which can easily slip into non-visible ultra violet) were much more problematic because of their relatively small wavelengths. Once a particular colour had been produced the component parts of its pre-swelling solution was recorded so that this particular hue could be reproduced in the future (see

Technical Appendix). Through practice the number of streaks and marks resulting from lack of care during the pre-swelling and squeegeeing processes began to be eliminated from the film.

Within the space of several weeks, a number of differently coloured holograms containing Mickey's ears had been produced. The excitement generated by the colour variations possible was matched by a growing recognition of the value that speed and variation in the use of film allowed in assembling the range of the Electric Mickey compositions.

As the holograms were produced they were taped to the wall for inspection, for at the time this was the quickest and easiest way to view the work in progress. Having previously painted the studio walls white, the holograms could only be properly seen, however, if they were taped to a piece of black card fixed to that wall. It is standard practice to paint the back of a reflection hologram black in order to help protect the emulsion and increase the brightness of the image.[4] In the preliminary of the Electric Mickey series it had been decided to follow this advice. However, as the holograms were taped to the wall it became obvious that this work would not be following the conventional notions for displaying holographic work.

Margaret Benyon's 'Cosmetic Series', 1986-7, (see Leonardo. 1989: Vol. 22, Nos. 3/4: 307-12) had shown that painting the back of reflection holograms was not a necessity. In this work, Benyon had created a number of holographic portraits and then set them against paintings of the same

subject. By doing this, the holographic image gave way to the painted one as the viewer walked past the composition. A similar variation in the employment of a background in the Electric Mickey compositions began to emerge as the hologrpahic film was taped to the wall for inspection.

In these holograms, Mickey's ears appeared as black holes; and viewing the hologram revealed that you could see through these holes to whatever was behind. As I'd always painted the back of any reflection hologram I'd previously made this effect was particularly surprising. And so, instead of painting the back of the hologram, which would effectively block the holes, it was decided they should be left clear and a background be introduced into the composition. The inclusion of another and more permanent element behind the hologram would thus be in direct contrast to the more ephemeral nature of the holographic image itself, which appears and disappears at the flick of a switch or as the viewer walks past the piece. As well as being a representation of the phenomenon of Mickey's ears and a vehicle for light to manifest itself as colour, the holographic element in Electric Mickey now became a screen which had been optically pierced to reveal yet another surface.

The question of what to put behind the holograms now became a matter of some importance. As a matter of initial convenience a piece of black paper was used, and this was followed by sliding different pieces of grey and white paper between the hologram and this background sheet. As well as experimenting with tone, different coloured sheets of paper were also

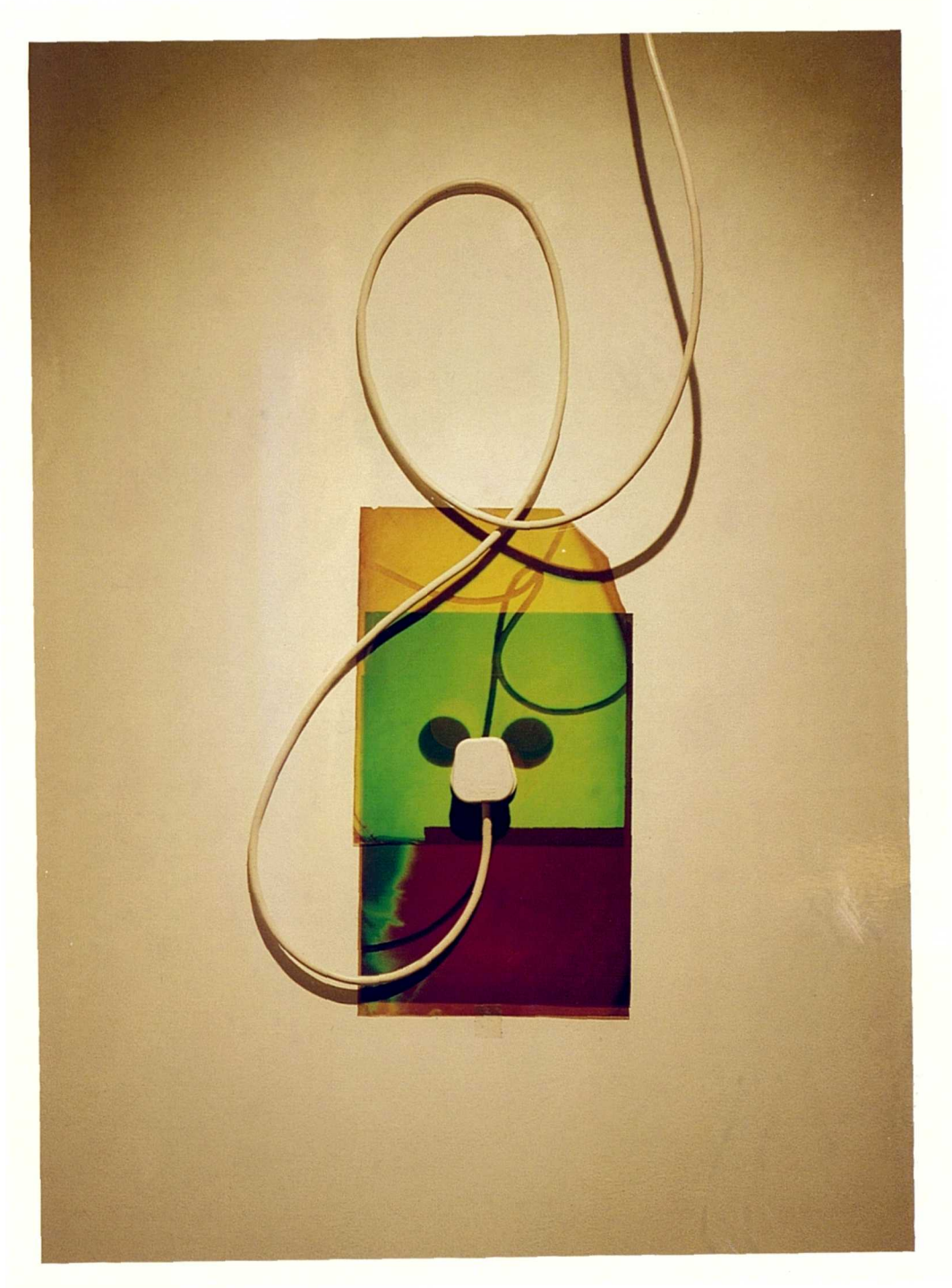
introduced behind the various holographic colours being produced. None of the combinations provided a definitive solution, but as a number of holograms were produced the repetition of the imagery involved led to a final decision as to what to use as a background.

In creating multiple holograms of the same image, the analogy betwen this and the process of printing began to grow. At this stage the sheets of holographic film remained in the standard 10 x 8 inch format, and with Mickey's ears left in the same position for each exposure, the only variation obtained was in their colour. However, despite the similarities to printed material, the fact remained that these holograms were produced by hand, using a time-consuming process which contained a huge number of variables - and each of which could effect the outcome of the image. This generated an inherent contradiction in the analogy with the printed image, and this was further exploited by using photocopies of Mickey's ears as a background to the holograms. These flat images, arguably the most ubiquitous form of mechanical reproduction, are cheap, can be produced almost instantly in a standardized size, can provide a suitably dark background, and are almost the opposite in terms of production values to the holograms. Yet the irony of this contradiction was deliberately heightened by the inclusion of the photocopies, for they maintained the theme of serial imagery which had already been established.

Once several holograms had been made and the other elements of the composition had been assembled, all that remained was to begin to put the Electric Mickey series together to form a cohesive piece of work (Fig. 3).

FIGURE THREE

Photograph of one of the holographic compositions created in the 'Electric Mickey' series



However, rather than bring the artwork to a definitive conclusion, these first Electric Mickey compositions were to mark the end of one stage and set the scene for the beginnng of the next.

Although I have generally found it necessary to try and pre-visualise holographic work by making sketches and drawings, the infinite subtleties and surprises that becomes apparent once the spotlight is switched on to illuminate a piece of work cannot be anticipated or accounted for in advance. Having reached the stage of turning a sketched concept into a piece of work, it was no real surprise then to find the first Electric Mickey presented a number of unexpected possibilities. An immediate response was to re-arrange its component parts, not because of any dissatisfaction with the piece, but because of the number of potential alternatives it presented. It had been the intention from the inception of the idea to have the Electric Mickey composition form the basis for a series; and by moving the electric cable that interrupted the spotlight and cast shadows over not only the hologram but the plug and the photocopy, it became obvious that this series could demonstrate a keen mixture of repetition and infinite variety at one and the same time.[5]

As several holograms had already been made, and the rest of the component parts were easily accessible, a number of Electric Mickey's were quickly put together. Every assemblage provided different opportunities for exploration; however two elements remained static throughout, and the holographic and photocopied ears maintained the concept of a fixed and repeated imagery; while everything else around the ears had the potential

to be altered. This even extended to the electric plug, which, although it remained in the same place, could be rotated to any position within 360 degrees. The photocopied backgrounds also had the potential to be expanded or reduced, while the electric cable cast its own shadows across the whole of the central elements of the composition, and out beyond its defined boundaries. Exhibiting this embryonic version of the Electric Mickey series in the gallery of the Myrtle Street building at the Liverpool John Moores University emphasised the fact that the architecture of a building would also cause a dramatic variation in the composition. In this instance the shadows cast by the cable were considerably enlarged because of the increased height of the ceiling and lights. Previously the work had only been displayed in the low ceilinged holographic studio, and this new variation on scale was both exciting and daunting at the same time, so that in order not to become side-tracked too far from the original intention of this work it was necessary to maintain a standardised format for another compositional element.

Using only A4 photocopies of the ears reduced the variation in each composition and helped to emphasise the colour variation of the holograms, which was still the main objective in this body of the work. The Electric Mickey series, it was felt, was enhanced by the strength of the holographic colour it uses, and this in turn was framed by its mono-chrome surround. Introducing other colour variations was considered; however when tested its presence created a compositional imbalance because of the unique intensity of holographic colour. Therefore, it was left to the holograms to provide a luminous jewel-like centrepiece to the composition, and this,

on its own - with that garish quality Titterington notes can be so off-putting (op.cit. 1992: 6) - comfortably fits in with the other ephemeral and populist imagery that the work both uses and encompasses.

Another form of holographic variation was also found to be possible, because of the decision to work with film as opposed to glass. Up to this point the size of the holograms so far produced had remained the same, measuring the standard 10 x 8 inches. However, when the image of the ears was recorded just above the central point of the hologram, with the film in a portrait (upright) position, this allowed much of the hologram to be reduced without interfering with the recorded image. Cutting down the holograms would inevitably reduce their colour content, although when this was first tested their impact remained strong because of the monochrome surround. And because the holograms were created on film, their shape could be very quickly altered with the aid of a guillotine, with an immediacy that far outweighed and diminished the many difficulties which had been encountered during their time-consuming production.

Variation thus centred on the holographic element of composition, in the form of colour and shape. Film also offered an unequalled sense of sponaneity, and ideas generated by using a cut and paste style were developed. The freedom that the use of film now afforded at this stage was in stark contrast to the constraints experienced previously in making holograms, for then the process had followed a rigid set of rules and required infinite amounts of pre-planning. It thus became important to try to reflect this new sense of fluidity and freedom, and to extend on the

possibilities that it offered. With this in mind, it was decided that the holograms should be held in position by strips of masking tape to indicate the non-permanence of each compostion.

The combination of the tape, the unprotected film, the photocopy and the electric plug created a very fragile composition, which, it was deemed was entirely appropriate in circumstances where the inspiration had been derived from the intangible qualities of projected light. However, this fragility, coupled to the act of cutting down the size of many of the holograms produced its own set of problems. As a consequence of all this experimentation, the stock produced for the series had become somewhat depleted; and though they were not actually being destroyed, the act of guillotining them had inexorably reduced their numbers, so that further holograms had to be created.

In these it was discovered that new holograms could be produced which extended on this theme of variation, by the simple expediency of introducing lengths of the same electrical flex used in the final composition. Now the physical reality of the cable could exist side by side with its holograpahic reality. Not only that; for having now replenished the stock of holograms, and by continuing the process of compositional experimentation, it became apparent that the colour variation which could be achieved might also be extended. By sandwiching together two holograms which replayed on different wavelengths, it was possible to considerably increase the number of hues that could be produced; although it was noted that this technique did create a slightly more subdued colour.

Once again, it was the use of film rather than glass plate that proved pivotal in expanding the boundaries of this research, allowing, as it did, a new form of colour mixing to inadvertently be born.

At the same time as this discovery was made, it also became increasingly apparent that if this series of holographic production was not brought to a conclusion, then this one project could well swallow up all the research time and funding. Many possibilities remained to be explored within the Electric Mickey series, and yet the original objective of this first piece of practical work had been achieved. In the circumstances, a period of reflection was needed before further work could commence on the next phase of the research.

Summary to the Electric Mickey series

From the outset of this practical phase to the research, the need to increase the range of holographic colour was identified as being crucial to the idea of providing an expansion in artistic choice. Achieving this has to be viewed in the correct context, for established techniques used here to create colour variation in reflection holography were occurring in a studio environment where previously the issue of colour control had not even been an option. A mixture of experience and persistence was all that was needed to show that even when film is used, colour control in reflection holography is possible. This dramatic increase of choice represents a significant development in terms of technique; yet even as the holograms were produced other aspects relating to the identity of the

medium began to become apparent.

One major innovation in this work came from the identification and recognition of the two realities present in a hologram, which sees it existing as a screen of encoded visual information and also as a simple piece of acetate or glass. In highlighting and not hiding this fact, the composition of the Electric Mickey series had evolved to specifically point to this duality. In attempting to show that holography is a suitable Fine Art medium, the honesty in this presentation is an important factor, for it removes any preconceived notions that may still surround the medium.

It is important to be aware of the historical traditions of your working practice, and in the case of the Electric Mickey series, the methodology of construction fits into the already established definitions of collage and assemblage (see Elderfield. 1992: Preface). Whether or not this series of work will ever be labelled with one of these terms is immaterial; what is significant is that Electric Mickey contains many of the characteristics inherent in these two forms of art; and successfully introduces the element of holography into this genre. Choosing to work with film played a significant part in this, as the freedom and movement it afforded meant that the creative process did not finish at the production of the holographic image.

The use of an already established holographic technique also produced an unexpected surprise, because the holograms did not have their emulsion protected in the usual manner. Thus, Mickey's ears appeared as holes that

pierced the hologram, allowing any background to become clearly visible and to become part of the artistic construction. Thus, as well as producing holographic space, the hologram also created another spatial dimension by revealing the space behind it. This effect has similarities to the slashed canvases produced by the artist, Lucio Fontana; although it was achieved wthout having to physically cut or tear the holograms. Fontana's actions were a rejection of the flat surface of the canvas (see Ferrier and Le Pinchion. 1990: 446), and the optical perforations caused by the non-presence of Mickey's ears further emphasised the inherent paradox that exists in a two-dimensional plane which contains a recording of a three-dimensional space.

NOTES AND REFERENCES TO CHAPTER FIVE

1. See Saxby (op.cit. 1988: 264-7), and Technical Appendix to this thesis.
2. See Saxby (op.cit. 1988: 68-75, and 264-7).
3. See Saxby (op.cit. 1988: 264-7), and Unterseher, Hansen and Schlesinger (op.cit. 1987: 175).
4. See Saxby (op.cit. 1988: 93).
5. The relationship between an 'infinite variety' of effects and the interpretation of actual results, was re-emphasised when, after a period, the compositions were re-assessed and it was suddenly brought to the fore that the electric cable snaking from the plug to the spot-light could easily be intepreted as imaging the spikey tail of the actual cartoon mouse; thus adding yet another dimension which had not previously been considered.

CHAPTER SIX

Tape Compositions - The Creation of Optical Holes

The direction in which the practical aspect of this research would now take was inexorably influence by the findings made during the production of the Electric Mickey series. Although the choice of working with film had proven to be time consuming in terms of creating colour variation, the speed and flexibility it offered after the holographic process was complete had been a revelation. Ideas could be quickly tested and changed, creating an unusual momentum in the development of the Electric Mickey compositions. This ability to explore variation had resulted in no single definitive Mickey composition being produced; and it also meant that any future work did not necessarily have to be conceived and executed as a definitive art work. One direct result of this fluidity of choice was that many of the holograms produced from this point in the research might not appear to easily fit into any of the four main bodies of work which are identified here by their respective titles. This new working practice allowed the holograms to be used in a more abstract way as an exploration of ideas, many of which do not necessarily amount to a completed work. Therefore, it will be necessary to exhibit these holographic sketches in such a way that they are viewed in the context in which they were made.

The Electric Mickey series, which had become a major body of work by this time, had brought a number of issues to the fore that seemed to demand

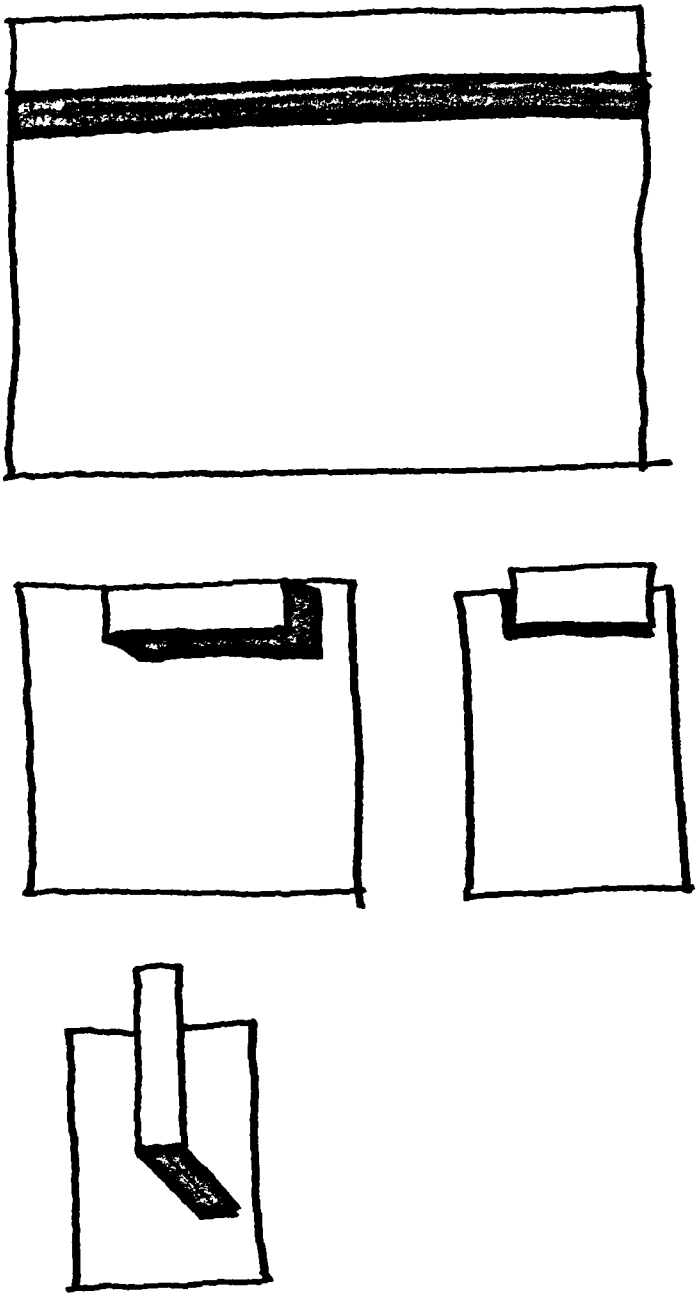
further exploration. And so in order to maintain the sense of momentum which had been generated, it was decided to temporarily abandon the theme of colour variation and focus upon the suject of image content using the shadowgram technique.

The image content of a shadowgram is open to interpretation because it is the space around the subject that is recorded, rather than the subject itself. A subject maybe familiar enough to be recognised by the hole it creates in space. In the Electric Mickey series, the holographic image of the two circles were given a specific meaning when the real plug was put into the correct position, when they then and only then, became recognisable as Mickey's famous features. Without the plug the ears return to being simply two circles, which are open to wide intepretation. The plug therefore plays a crucial role in defining the overall image. However, the task facing the viewer is made more complex by the fact that the circles also act as holes which penetrate the surface of the hologram. Their role had thus become multi-functional because they defied any one definition. This intriguing point led to the production of further shadowgrams which also rely on the presence of a real object to give a specific meaning.

During the creation of the Electric Mickey series, the act of securing the holograms with tape had proven to be a key point in helping to shape the cut and paste style of the compositions. Its use was seen to be of such significance that as well as serving a functional role, this method of securing the film was to become the main focus for the next set of

FIGURE FOUR

Sketchbook drawing for proposed 'Tape Composition' Hologram



As the number of images were produced, it became apparent that the holographic film had a tendency to curl slightly, because it was only held in position on the wall by the one piece of tape needed to create the illusion of the shadow. And it was realised that if the film could not be held taught to the same extent that it had been when the hologram was exposed to laser light, then the resulting curling effect produced an unacceptable level of image distortion. This particular result was disheartening. However, the fact tht the holograms had been produced relatively quickly meant that too much time was not lost in exploring this failed idea. And although the idea of tape compositions was abandoned, the theme of using holograms as a screen which can cover as well as reveal whatever lay behind them had once again been stressed. In the work that followed on from these compositions, this idea was to be developed further.

CHAPTER SEVEN

Aristotle's Eye - Colour Extremes and the Holographic Hole

The production of holograms containing both positive and negative space, coupled with the reduction of the image content which had been an intrinsic part of the 'tape compositions' led to the idea of creating areas of pure holographic colour. In this instance the negative space would have no illusory or symbolic connotations, and would act only as a means of shaping the colour within the 10 x 8 inch format of the film. After two such holograms had been made (using the shadowgram technique), the idea was generated of creating areas of colour specifically designed to cover an image that could be placed beneath the holograms. Once again the idea came to the fore of using holograms as a screen that would cover as well as reveal what lay behind. During the Electric Mickey series, the concept of incorporating backgrounds for the holograms had evolved once these had been made and the compositions were being put together. Covering a specific image with holographic colour would reverse this process, for the image would have to be selected before the holograms were made. Thus it was first of all necessary to find a suitable image to experiment with.

Having now structured the basic premise for this new piece of work, it was decided to use an enlarged photocopy of a photograph of a bust of Aristotle as the base image for the composition. The relevance of this choice stems from the 15th century preference and vogue for monochrome, an

influence that has been so strongly imbued that by now it is difficult to keep in mind the fact that ancient Greek sculpture originally was coloured (see Hauser. 1992: 82). In addition to its loss of colour, this particular bust of Aristotle had been through many changes in its lifetime; with the photographic image, for example, being a Roman copy of a Greek original, with a restored nose.[1] In this instance the depiction of Aristotle was about to be transformed again, but this time with a photocopy and holograms which would create a contemporary re-incarnation of an ancient image.

It was also felt that the concept was imbued with the same sense of irony that pervaded the Electric Mickey series, but in this case this was created by the way in which a three-dimensional marble bust, which had survived for over twenty centuries, was now reduced to a flat photographic image; and which in turn had been flattened even further by the process of photocopying. This image of Aristotle was therefore as ephemeral now as the surface colouration which had once adorned it, and no less so than in the modern form which was about to be created for it by the holographic process. Rendering the profile of the philosopher in the form of a photocopy thus provided a suitable monochrome base onto wwhich the holograms could be overlayed, and also maintained a link in terms of continuity with those used in the Electric Mickey series.

Aside from the further exploration of using holograms as screens that can cover and reveal, this work also allowed the research the opportunity to further explore the subject of colour in reflection holography. Work completed as part of the Electric Mickey series had shown that colour

variation could be achieved in the environment of the studio in Myrtle Street. However, these compositions had been consciously designed to maximise the effect of the vibrant nature of holographic colour. Now, at this stage in the research, the garishness of holographic colour was considered to be a potential problem. Titterington (op.cit. 1992: 6), says of this aspect of holography, that it is something "I will never get used to". And so, although colour variation represented a breakthrough in terms of choice, the issue of its garishness could well have become a restrictive one; and this, it seemed, might possibly dictate a limitation to its further potential as a Fine Art medium.

Though the production of natural colour in holography seemed to have been ruled out, the idea of sandwiching together different holograms during the Electric Mickey series had created a new range of tones with an impact which was far more subtle than individual recordings replayed back on a single wavelength. And so, by pursuing this process of colour mixing, it was believed it might be possible to create a much more deliberate range of tones, and that these would be less overpowering than those produced by individual holograms. If this could be achieved, then this would help rectify one of the major problems the intensity of colour in reflection holography poses.

The image of Aristotle was therefore to act as a recognisable container onto which the holographic colour was to be superimposed; and the next consideration to be addressed was to decide where this colour should be applied. One possible answer came out of the author's own

experience as a small child when visiting a local art gallery, where the monochrome statues and busts had appeared particularly unnerving because of their blank eyes. It therefore seemed appropriate that these still strong memories could well act as a catalyst for this piece of work, and it was decided to concentrate the holographic colour around the eye area of the Aristotelian image.

The final design would superimpose holographic colour around the eye area in an oval shape, but not on the eyeball itself, which would remain uncovered. Oblong lengths would radiate away from the eyeball, dividing the oval into quarters, and creat two distinct conceptual areas of colour within the design.

Two stencils were cut from black paper to create the oval quarters and the oblongs. These mimicked the contours of the face (which was a profile view), so that the colour within the 10 x 8 inch framework of the holographic film would appear to fit exactly around the eye area. In order to establish a sense of surface, the stencils were fastened to the other side of the sheets of glass be used to fix the film while the hologram was exposed. This would limit the depth in the holograms, so the colour would only be 4 millimetres (the thickness of the glass) off the surface of the image it covered. Again the shadowgram technique would be used for this piece of work.

The intention in this piece of work was to create colour that in terms of intensity, was the opposite to that achieved in the Electric

Mickey series. And to attain this goal it was decided to attempt to achieve a range of tones in a way which could not be produced by holograms that replayed back on a single wavelength. It had already been noted that colour mixing created by sandwiching together different holograms seemed to create a much more subdued range of tones, and so this technique was selected for further exploration.

A final decision had to be made about the specific range of colour which would be created to cover the image of Aristotle, and after much consideration 'white' was chosen for the oval shape, with 'brown' for the oblongs. This process of colour selection was speeded up because the correct formulae for swelling holographic emulsion had already been identified and tested. A blue hologram over a yellow one would, it was believed, create the desired white for the oval, and a red over a green hologram it was argued would produce the brown for the oblongs. At this stage these possibilities of colour combination and the tones they would produce were still largely at the stage of being theoretical assumptions. The discovery of this technique during the Electric Mickey series had allowed some experimentation to take place. However, the task of creating such a specific set of tones to superimpose over the image of Aristotle would take the research into uncharted territory.

The composition had been specifically designed so the holographic colour would be contained within film, rather than glass plates; for having to sandwich four holograms together and then attach them to a photocopy would be impractical if glass plates were utilised. As in the

Electric Mickey series, the decision to use film meant that the process of pre-swelling the holograms for this composition would require a great deal of time and preparation. However, the blemishes or streaks experienced during the pre-swelling of the Electric Mickey holograms could not be tolerated in this piece of work, for the creation of clean areas of unbroken colour was an absolute requirement. And so extra attention would have to be taken when squeegeeing the film to ensure that the emulsion dried evenly.

Once the first blue hologram had been made and overlayed onto the image of Aristotle, the analogy between this and the process of printing again came to the fore. Andy Warhol's silkscreen portraits of 20th century celebrities had been constructed using photographic base images onto which areas of colour were later applied.[2] And now this image of Aristotle seemed to clearly mirror this concept, but with holography instead of ink providing the source of colour. Yet however strong this analogy appeared, the time-consuming nature of the various aspects involved in producing the desired holographic colour suggested that in this instance the Aristotle composition would probably be a one-off piece rather than developing into a series of work.

The care and attention invested in creating such an exact set of tones meant holographic production went ahead at a particularly slow pace. In the final composition, five different holograms were used instead of the proposed four, and these had taken weeks to prepare. Swelling the film so it would replay back within the middle of the wavelength of a particular

colour (approximately 450 nanometres for blue, and 575 nanometres for yellow) produced the best results for successful colour mixing. In the case of the proposed brown oblongs, the combination of red over green produced a rather dull brown, and so a further orange hologram was added (beneath the two) to create a more dynamic tone. To further restate the impermanent nature of surface colouration, clear tape was used to attach the hologams to the image of Aristotle.

Once the work was positioned onto a wall and viewed from a distance, it became apparent that although the holograms contained negative areas that should read as holes, the volume of the five sheets of film which were sandwiched together meant that through these areas the image of Aristotle was now being slightly obscured. Inserting repeated sections of the base copy between the holograms rectified this problem, and in so doing, helped further to establish more overlapping planes of two-dimensional information into the composition.[3]

Viewing the composition from a distance also brought to the fore an unexpected discovery about the holographic colour. The creation of a subdued set of tones had been achieved, and during the conception of this work it had been presumed that single areas of brown and white would be produced. This did happen, although the combination of sandwiched holograms also created a range of tones that became visible when the composition was viewed from different heights. After further examination it became apparent this shift in colour resulted from each hologram replaying the light that falls onto it at a slightly different angle. The

advantage of this unexpected shifting colour emphasised the compositional intention of a seemingly arbitrary colour scheme being imposed upon a fixed subject. At the same time, the ephemeral natue of surface colouration provided justification for the choice of the image of Aristotle, and the final result fulfilled the original aims by clearly showing the holographic elements to be a cladding device.[4] Despite their prominence in the composition, the colours so far produced had, as yet, no deliberate significance, and the achievement of a range of more subtle tones was no more than a continuation of extending the holographic palette. However, the success of having produced these effectively subdued colours was to alter the final outcome of the work.

The composition of the Electric Mickey series had been deliberately designed so that its holographic colour was surrounded by monochrome. This had been done to emphasise the colour; and because its intensity had made it difficult to successfully introduce any other form of colour into the framework, while, at the same time striving to maintain a compositional balance. With a more subdued range of tones it was felt that the perceived dictatorial consequences of holographic colour had been lessened, and, in this instance, that it might be possible to successfuly accommodate another element of colour into the composition.

With the holographic colour centred around the eye area of Aristotle, and the image itself in profile, the gaze of the philosopher seemed to point to how and where another element of colour could be introduced. The profile edge of Aristotle was mounted onto a sheet of Kingfisher blue

paper, chosen for its symbolic significance in that it represented the vivid colour of the Mediterranean sea and sky; a vista which the original bust of the philosopher may well have looked upon. Viewed in isolation, the tone of the paper is intense. However, once in position, the colour of the paper and that of the holograms balance to create an harmonious composition, with the blue element providing an ambiguous sense of space for the Aristotelian eye to stare into (Fig. 5).

As the two-dimensional/three-dimensional visual conundrum was central to this work, it was decided to mount the final composition at a single point, allowing the bottom edge of the work to curl outwards and cast a shadow. Fastening the composition this way also highlighted its inherent fragility. Thus the analogy between this and a continually changing reading of images and artifacts from ancient civilisations was brought to the fore; and this had always been a sub-text to the work.

Summary

The primary objective in pursuing this piece of work had been to further establish the use of holography as a cladding device, and to explore previously uncharted areas of colour control. To achieve these aims it was decided to create a much more pre-defined composition than had previously been attempted. This decision reflects the fact that the research had reached a stage when the results of past work had been assimilated, and this inculcated knowledge allowed for a much higher degree of pre-planning to be included.

FIGURE FIVE

Photograph of the 'Aristotle's Eye' holographic composition

In this instance the holographic cladding contained areas of flat colour specifically designed to cover the area around the eye of the base image of the profile of Aristotle. The problems of clarity caused by the density of sandwiching five holograms together had been resolved without undermining the objective of using the holograms as a cladding device.

Colour was the agent which was to be used to conceal areas of the base image, and its production and the ensuing results was to dominate this piece of work. The intention had been to produce a specific range of tone, although sandwiching different holograms had resulted in an unexpected but not unwelcome colour shift. Expanding the holographic palette, and the successful accommodation of another coloured element into the composition in the form of the sense of blue space can therefore be argued to represent significant advances for this research.

However, as the holograms were being made, it also became apparent that the length of time required to complete this process could well become a restrictive factor. There would not be the time or the resources to maintain this level of colour production throughout the remaining period of the research. And this sobering fact led to the conclusion that now this level of tonal control had been achieved, its future employment would have to be a carefully considered option, and might only be used when the aesthetic requirements of a piece of work demanded it. Through the creation of this work, and the understanding that was derived during its production, it was now felt that colour control in relation to reflection holography had been thoroughly explored.

NOTES AND REFERENCES TO CHAPTER SEVEN

1. The marble bust of Aristotle, from which the photograph was taken is housed in the Kunsthistorisches Museum in Vienna. See The New Encyclopedia Brittanica (1993: Vol. 14. 56).
2. see the catalogue for Andy Warhol: A Retrospective, (ed). K. McShine, (1989: 302-4).
3. Because of the growing body of holograms produced at this juncture, it was necessary to create a gallery within the confines of the studio. This was equipped with the lighting necessary to display holograms, and this allowed for finished compositions to be displayed and the results of the work in progress to be more accurately assessed. Because real and illusory shadows were integral to the visual argument being conducted in the research programme, the base colour of the walls was painted white for emphasis. Previous to this the studio had been painted black, and again the subjective personal equation came to fore, as it is my belief that this had a negative effect on the working environment and practice.
4. It is felt necessary at this point to define the term 'Holography as a cladding device'. By this I mean "the use of holography to specifically cover and partially obscure a designated image". In the Greek Cows series (chapter eight) it is the holograms that are clad, sandwiched by the physical presence of milk bottles in front and behind the hologram, and by the shadows these cast onto the surface of the hologram.

CHAPTER EIGHT

Greek Cows: Transmission Holography and the Three Dimensional Environment

At this point the one-step shadowgram technique had fulfilled the necessary requirements in work created for this research, and had also generated the added advantage of producing results at a relatively quick pace. So far this aspect of the technique had assisted in the creation of a substantial number of holograms, a feat which would been impossible if more time consuming two-step techniques had been employed. The large number of holograms thus produced allowed for a greater amount of experimentation to take place than might otherwise have been the case. Spare pieces of film (the results of testing or mistakes) provided an ideal source for this process; and the sense of spontaneity this generated had become an integral part of this programme of study.

To take the research further it was considered necessary to move away from the realm of reflection holography and explore the other main area of this medium, in transmission holography. At the Royal College of Art, a transmission technique had been observed which mirrored the reflection based shadowgram in a number of ways. The major difference of the technique (apart from the fact that it will produce white light transmission holograms) is that it records the volume of space directly in front of the hologram, and was conceived as a means of creating master holograms of two-dimensional information. As is the case with most holographic techniques, the reference beam is designed to hit the unexposed

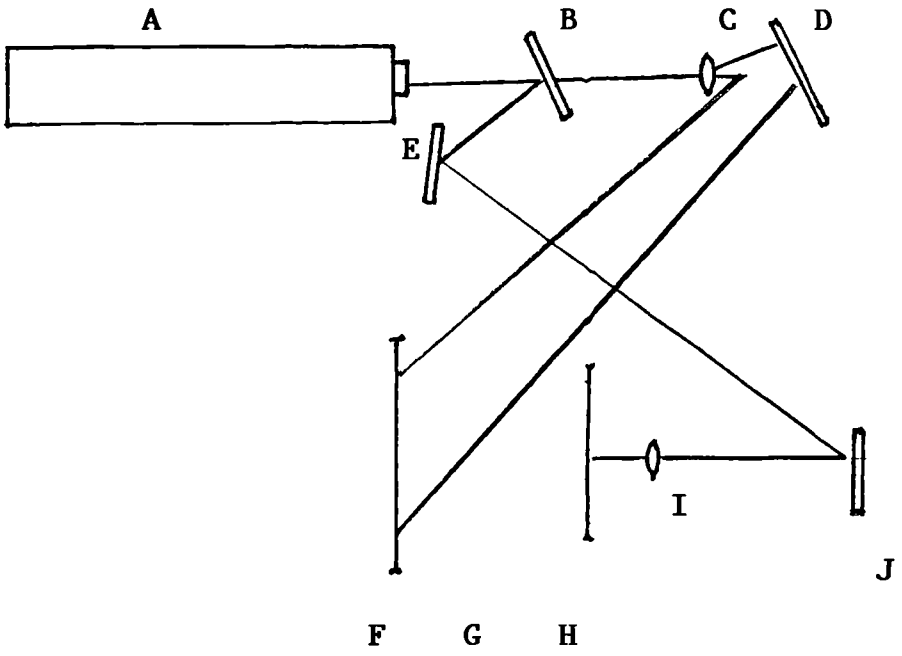
film at an angle of 37 to 45 degrees. This means that the two-dimensional information has to be far enough away from the hologram if it is not to interfere with the reference beam and cast a shadow onto the surface of the hologram (Fig. 6). During the R.C.A. visit, it had been pointed out this technique could also produce one-step white light holograms that would record a limited depth, although the perceived problem of interfering with the reference beam and the resulting shadow meant this option had not been explored. Having already produced a series of work which had deliberately created positive and negative areas with reflection holography, the permutations in this technique now appeared to possess a number of qualities that would further the quest and take it into the realms of transmission holography.

The aim of testing the technique was to observe the results produced and assess their relevance to the ongoing theme of creating positive and negative areas within the surface of holograms. Moreover, there was no reason to suppose this testing should not create an image that would hold some significance to this theme; and a suitable subject was now suggested by research into the origins of this practice.

The Greek vase painters of the sixth century B.C. had produced some of the earliest and most famous examples of visual cryptograms (see Gombrich. op.cit. 1989: 35). These rely on the capacity of the viewer to read images created in negative formats. In this research, reference to this form of decoration was made by adopting the classic motif of a Greek bull, although in this insance - and following on from and sustaining the

F I G U R E S I X

Plan View of Optical Set-Up for One-Step, White Light Transmission Hologram



KEY

A	LASER
B	BEAM SPLITTER (Set on a 50/50 ratio)
C	SPATIAL FILTER
D	MIRROR
E	MIRROR
F	FILM HOLDER
G	VOLUME OF SPACE IN WHICH ARTWORK WAS PLACED
H	GROUND GLASS SCREEN
I	SLIT OPTIC
J	MIRROR

sense of irony beginning in the Electric Mickey series and which worked through the Aristotelian compositions - a change in gender produced a final image of a stylised cow. Positive and negative copies of this image were made on sheets of acetate, to be used in the production of two one-step white light holograms.

After the first hologram was created, the immediate concern was to assess the effect of the first stencil (the positive) on the clarity of the image. In the areas exposed to laser light, the hologram split the beam of the reconstructing spotlight into different colours of the spectrum. As the stencil had been positioned directly over the film, a clearly defined image of a two-dimensional spectral cow appeared on the surface of the hologram. Meanwhile, the unexposed areas of the film remained clear and did not interfere with the reconstruction beam.

In order to assess the outcome of moving the image off the surface of the hologram, this procedure was repeated with the stencil positioned so it was approximately one centimetre away from the surface of the film. As in the first Greek Cow test, another two distinct areas were created on the surface of *the hologram, one exposed, the other unexposed. This exposed* area also contained a recording of the positive area of the stencil as it had stood in front of the film plane. But because of the angle of the reference beam and the space between the stencil and the hologram, this second cow was out of alignment with the surface image, and was therefore only partly visible. In the spirit of this research, this aspect of the technique had produced interesting results; and these, it was felt,

warranted further investigation. However, further consideration had to be given to see if this testing could evolve into a more substantial body of work which would continue the exploration of issues already raised during the course of this whole programme of study.

These tests had retained the use of surface narrative through the two-dimensional stencil of a stylised cow, as well as accentuating the hologram as a screen containing areas and layers of visual information. With these holograms now carrying over so many of the characteristics and devices from the previous work, what remained to be established was whether or not the theme of holography as a cladding agent could be maintained.

The method of reconstructing the image in a white light transmission hologram, which requires the beam of a spotlight to pass through it, began to suggest a new variation on the concept of cladding was possible. At first the holograms were taped onto a sheet of glass whose bottom edge was sunk into a plinth for rigidity. A spotlight was then directed onto it and the image of the cow(s) became visible. Because this procedure requires a great deal of floor space, the plinth was placed in the centre of the studio so that the holograms could be assessed. At this point it was noted the reconstructing beam could be interrupted in much the same way as the spotlight had been in the Electric Mickey series. In this instance the interruption produced a different effect, because the holograms were standing in space and not attached to the wall. Placing an opaque object behind the holograms cast a shadow which left a pronounced negative space through the image, and this fell onto the surface of the plinth. The

image could be partially or totally obscured by the shadow, depending on the size of the object and its position. Thus, by viewing the images in space a new dimension had been introduced to the practice, by using the holograms as the recipient of a form of cladding.

A decision now had to be made about what form this cladding would take, and to avoid obscuring the holographic image the possibilities of using some sort of transparent material began to grow. This was aided by an abundance of glass and glass objects which almost inadvertantly had been collected in the holography studio. Using four empty milk bottles to sandwich the holograms not only fulfilled the practical requirements of this concept, but added another humorous element into the composition. The shape of the bottle behind the hologram served to break up the light, producing a mottled surface on the image. The bottle which had been placed in front held the film in place and maintained the effect of surrounding the hologram with a three-dimensional physical presence. This new development showed sufficient potential to evolve into a number of substantial new works, and this warranted the production of more of these white light transmission holograms.

The resolution was achieved by employing a wall of double rows of milk bottles. Set on a plinth, this free-standing structure received a degree of aesthetic and physical stability from sheets of clear glass upon which each layer of bottles was stacked. Between the bottles, holograms containing images produced by both the positive and negative stencils were positioned. These had been cropped to fit within the framework of

FIGURE SEVEN

Two photographs of the compositions created in the 'Greek Cows' series

Moving from two-dimensions to three had not necessitated abandonment of the established method of construction developed throughout the practical stages of this research. Nor was the inherent flexibility of the cut and paste style lost in this new work. Because the holograms were supported by the bottles, which in turn were free standing, there was an infinite variation implied by the extension in numbers of identical component parts. However, the final configuration had to take account of the size of the proposed gallery area, as well as the strain on time and resources required to make holograms and assemble the necessary supporting structure.

Summary

This phase of the research had begun with the intention of expanding the concept of positive and negative areas within a white light transmission hologram. On assessing the results of this testing it became apparent the holgrams, and the way in which they were viewed, would provide enough scope for a substantial work to develop. Such a methodology differed from that used previously, because the holograms were the starting point from which the final composition evolved. During this process, the objectives of the work expanded to encompass and add a new perspective to the recurring themes of cladding, and the concept of holograms as screens containing visual information. As in the previous work, the make-up of this composition invokes the genres of collage and assemblage through the amalgamation of different images, materials and found objects.

The most innovative aspect of this work was in the way in which it incorporates holography into a sculptural three-dimensional environment. And although it had been designed with one preferred viewpoint in mind, and with flat imagery, the physical presence of the bottles and the manner in which the holograms were displayed combined to emphasise the sculptural impact of the composition. In the context of this whole body of research, it is important to stress that this work showed holography can successfully be integrated into a sculptural format; and that this further underlines its suitability as a Fine Art medium.

CHAPTER NINE

Light Bulbs: the Conjunction of all the Elements under Investigation

The final configuration in the Greek Cows work had evolved from a curiosity to create positive and negative space with a white light transmission technique. This methodology was different from the previous work, but was nonetheless successful; and in its wake a similar sense of inquisitiveness generated a desire to assess the consequences of expanding this holographic investigation to include a three-dimensional form. The decision to use the same holographic technique was based on the theoretical assumption that a three-dimensional form would be recorded, if the object was placed in the volume of space between the hologram and the ground glass screen. At this point it remained unclear as to whether there would be enough light falling onto the form for any surface detail to be recorded, and in this respect the transmission technique appeared to share a close affinity to the shadowgram. Creating the images of the Greek Cows had proved that any interruption in the reference beam would cast a shadow onto the surface of the hologram, leaving this area unexposed. Because of the direction of the reference beam, any interruption occurring off the surface of the hologram would cast a shadow at an angle. It was anticipated that through this technique a recording could be made of a three-dimensional form in space that at the same time would create a two-dimensional image of itself on the surface of the hologram.

This desire had been triggerred by three factors, firstly the

sculptural aspect of the previous work served as a reminder that, so far, none of the holograms produced during this research contained recordings of three-dimensional forms. Secondly, there were no prerequisites surrounding this subject, and the exclusive use of flat imagery had only come about because it was considered the best way fulfilling the requirements of each piece of work. However, the means of recording objects in a three-dimensional format had been central to the discovery and subsequent evolution of holography, and it was felt that this point oculd not be ignored. Finally, the third factor centred on the author's first encounters with the medium - an event of such import it is necessary to give a brief summary of the experience to give some indication as to why the urge to push the medium to new horizons infused this research.

I first saw holograms in 1982, and all were recordings of three-dimensional objects. The feelings of utter amazement that these induced is still a very vivid memory. A year later, an opportunity arose for me to make some holograms, and I was driven on in the face of a process that appeared to be utterly incomprehensible, by the allure of replicating a three-dimensional object in the form of a holographic recording. Despite exploring other issues with the medium, the ability to record three-dimensional form has remained central to my thinking and artistic deliberations.

Introducing a three-dimensional form into this research, I believed, would create a new perspective on the theme of cladding, as the shadow from the object would be cast onto the surface of the film. In this instance

it was calculated that the act of covering the film to create two different images would take place during the holographic process. The next step was to select a three-dimensional form for this experiment.

Once again the abundance of glass objects in the holography studio provided a suitable source in this selection, and a light bulb was chosen because of its unique and recognisable form. The bulb was glued onto a piece of glass and this was then placed in position in front of the film holder. All that remained to be done was to make the hologram.

Once the hologram had been exposed and developed, the results of this test were assessed. There had been enough light falling onto the surface of the bulb to record its surface detail, and the shadow that it cast on the surface of the hologram meant that two opposite images of the same object exist on the same piece of film. Because of the distance here between the object and the film and the angle of the reference beam, the shadow or hole partly obscured the recording of the bulb. The position in which the bulb was glued to the piece of glass meant that only the crown of the bulb was visible. This viewpoint did not show the distinct shape of the bulb to its best advantage, and so its position was changed and another test made. In this, the recording of the bulb was more recognisable. And although the bulb was frosted, enough light had passed through it to cause a small amount of constructive interference to take place within the area of its shadow. This effect was not apparent in the area cast by its metal bayonet fitting.

The most important aspect of this testing was that it served to re-emphasise Popper's interpretation (op.cit. 1993: 38) of holography being "a statement of specific effects based upon an autonomous structure of its medium, light". The combination of the recording of a three-dimensional object, and the two-dimensional hole on the surface of the film pointed to the fact that in holography the physical rules of the material world do not apply. In this instance, the shadow cast by the bulb had punctured the surface of the film, partly obscuring its own presence in the finished hologram. The flat hole cut into the recording of the bulb effectively altered its form, and it was felt this warranted further investigation.

It was decided that the best way of heightening the two-dimensional/ three-dimensional conundrum that this testing had posed, would be through the introduction of linear shadows. Thus a line would appear to cut through form. However, this would not be possible using the white light transmission technique, as the object would always cast a shadow of itself. It was important to retain the light bult as the object, for its physical structure does not normally allow for its form to be altered; and so a different holographic technique had to be used.

Reverting back to the shadowgram technique meant the shadows cast onto the surface of the hologram would be independent of the light bulb. This was possible because the object would be behind the hologram and not in front of it, as was the case in the transmission technique. It was calculated that if a sheet of glass with vertical lines drawn onto it was placed in the path of the reference beam, the resulting shadows cast onto

the surface of the film would appear as lines cutting through the recroding of the bulb in the finished hologram. A series of trials proved that the shadowgram technique was capable of recording the surface detail of the bulb if it was positioned as close to the film as possible.

Testing began, and the previous observations and calculations were confirmed. The three-dimensional recording of the bulb was sliced through by vertical lines of unexposed film. As in the previous work using the shadowgram technique, the lines allowed whatever was behind the hologram to be seen, and the need for the inclusion of a background into the composition began to grow in importance. A number of holograms were produced so that options relating to the background could be explored simultaneously. Spraying the back of the holograms would fill in the lines and negate their role as the means by which a separate background could be observed. Leaving the holograms unprotected indicated how they could further the theme of holography being used to cover and reveal layers of visual information. Sheets of glass on which exact proportional drawings of the bulb had been made, were recorded using the shadowgram technique. By positioning these behind the recordings of the three-dimensional bulb, it was anticipated the image of the drawn bulb would be visible through the lines of the covering hologram, and further emphasise a paradox of line and form in the composition.

The desire to assess the results of the lines on the recording of the three-dimensional bulb as quickly as possible, meant these holograms had not been pre-swelled; and they replayed back on the red wavelength.

To create a contrast to this, it was decided to pre-swell the film which recorded the drawings.

Once the two holograms were sandwiched together, it became apparent in terms of the amount of light replayed, that the underneath one was more efficient in recording the three-dimensional bulb which covered it. This disparity in brightness (a result of the pre-swelling) meant the recording of the drawn bulb - a vibrant yellow/green - overpowered the composition. Moreover, the variation in the optical effect of the singular line of the drawn bulb contrasted with the multiple cutting lines dissecting the holographic image, and created an inconsistency which played a part in generating a visual imbalance in the work. As a result a number of compositional variations were tried, but all proved unsatisfactory. Having reached an impass, it was therefore decided to stop holographic production, and reassess the aesthetic implications of what this experimentation revealed.

The inability to achieve compositional harmony, it is suggested, had not undermined the importance of the central theme of this part in the practical work, which centred on the ability to alter three-dimensional from through the use of shadows cast by two-dimensional stencils. Cutting through the holographic bulb had been deemed a fitting way to demonstrate this, simply because it represented an act which would be impossible to achieve with a real bulb. This process seemed to offer a visual interpretation of the literary proverb that 'the pen is mightier than the sword', in that the lines proved an effective way of reiterating the notion

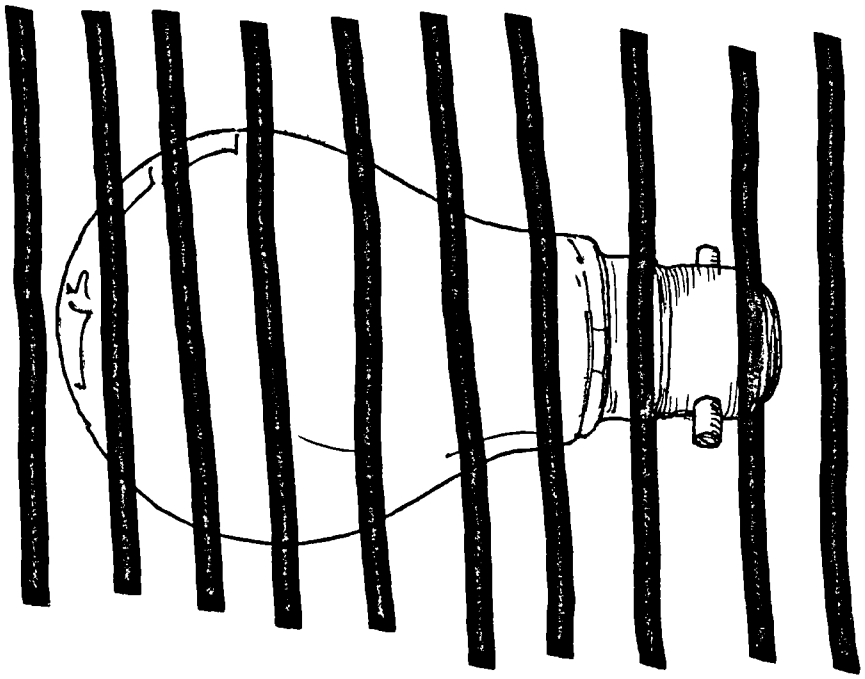
of holograms being screens of visual information which can be pierced in a non-physical way to reveal further layers of data. However, they had not only cut through the recording of the bulb, but went on into the space that surrounded the bulb. Consequently, the linear strips of unexposed film emphasised the overall surface of the hologram to such an extent that the visual impact of cutting through the bulb was reduced (fig. 8).

After further consideration it was decided a more effective way to alter holographic form would be to create a stencil that would puncture a hole through the centre of an object without interfering with its outer edges. Limiting the hole in this way would accentuate its impact in creating a new interpretation of an object, and create a focal point to the composition. Previously the holograms had recorded all of the bulb and the volume of spce in which it was positioned. And because the shadowgram technique had been used, this volume of space appeared as a single colour. On its own, this colour had no perceivable depth, and the only indication of the space came from the presence of the bulb. This characteristic suggested the inclusion of another stencil to evenly crop the space around the bulb would generate an impression of a two-dimensional line around the outer edge of the three-dimensional form. Thus the area of exposed hologram would contain two opposites, in form and line.

In order to achieve this, two stencils mirroring the shape of the bulb were cut and stuck onto a sheet of glass. This was positioned in front of the plate holder so the stencil was aligned with the bulb. Two sheets of film were pre-swelled to replay back on the orange and blue

FIGURE EIGHT

Sketchbook drawing for stencilled lines idea for hologram in the 'Lightbulb' series



wavelengths respectively. In the resulting holographic recordings the theoretical conjecture which had led to their creation was born out. The smaller stencil created a hole in the shape of a bulb in the recording of the three-dimensional bulb; while the outer stencil, again in the shape of a bulb, allowed only the outer edge of the real bulb and a line of space around the form to be recorded. This combination of a linear representation of an object and the partial recording of the actual object therefore created a unique composition within a single hologram (Fig. 9).

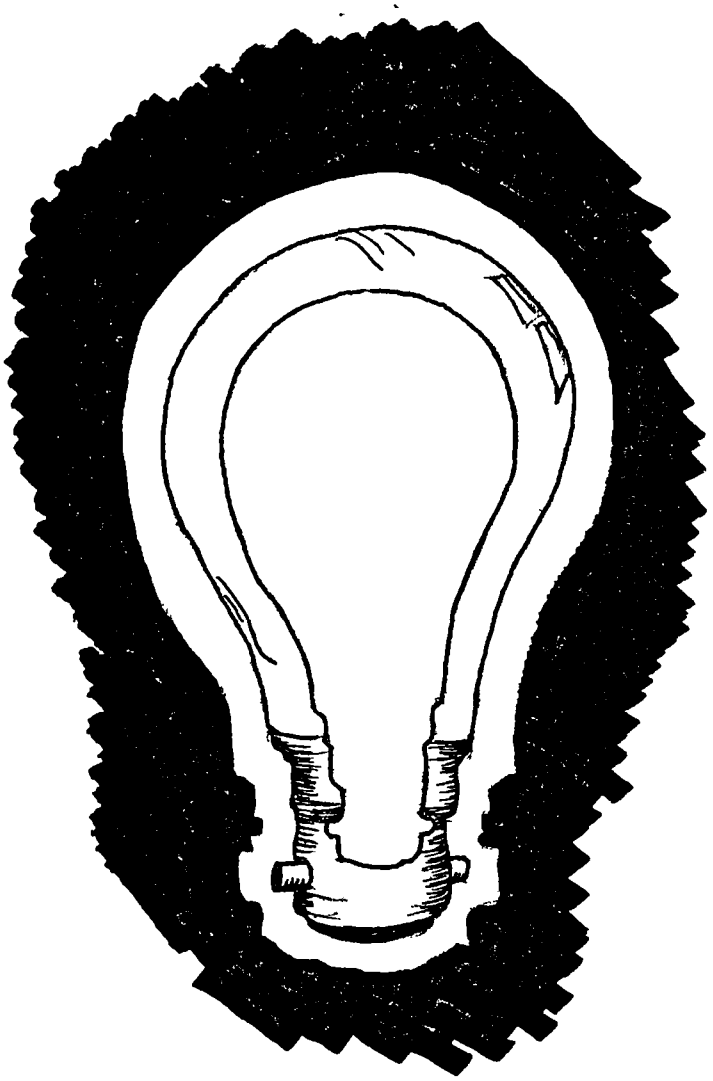
The hole produced by the stencils meant a large area of the holographic emulsion remained unexposed, leaving it transparent. This once again brought the issue of the inclusion of the background to the fore. However, the inability to find the correct combination of sandwiched holograms in the previous testing pointed to problems this could involve. In order to avoid these, it was decided the linear/form combination in the two holograms could best be accentuated if they were backed by holograms of a single colour, but on a differnent wavelength to their own. And because the holograms of the holed bulb had been pre-swelled, their intensity of colour was equal to those used as backgrounds.

Summary

The starting point for this section of the work derived from the results of an experiment suggesting it would be possible to alter a recording of holographic three-dimensional form with two-dimensions. Thereafter, the primary aim of the work was centred on creating an

FIGURE NINE

Sketchbook drawing of 'holed' bulb idea for hologram in the 'Lightbulb' series



interpretation of an object that could not be achieved using any medium other than holography. This was accomplished by recording only part of a light bulb, and the ultimate realisation of this concept served to re-iterate the definition of holography as being a medium composed of light. Whilst providing this means of altering form and volumetric space, the holes produced by the stencil also accentuated the holographic enigma of a two-dimensional surface. In these compositions the twin realities of a hologram had been heightened to exist alongside each other. Central to this paradox is the role played by the holographic emulsion, and the information it does, or (in this case) does not contain.

These light bulb compositions - the final work in this practical part of the research - represented a culmination of all that had been learnt during this period. The experience gained manifested itself in the way in which the final configuaration of the bulb was arrived at. Calculation based on the results of experimentation had played a more prominent role in forming a working methodology than it had previously done. And because the holed bulbs contain the recurring themes of colour, the hologram as a screen contains both visual information which can be optically punctured, and holography as cladding. It was therefore unnecessary to include any other non-holographic elements into the work.

The wealth of holography specifically designed (or evolved) to test out and finally stand as a complete portfolio of those ideas generated during the practical part of this research clearly demonstrates that holography can successfully be incorporated with other mediums, and can fit

into already established aesthetic genres. It is thererefore fitting - in terms of the ambition of the research - that this last piece of work should be marked by results that deal exclusively with the potential of holography to reveal a unique interpretation of the world.

CONCLUSION

The intention of this research was to investigate the suitability of holography as a Fine Art medium. To achieve this it was necessary first to review the history of holography and site it within the broader framework, relating to its technological origins and their links to the artistic process. The constant overlap between art and technology was explored to reveal how these have occurred across time, from prehistoric cave paintings to the current use of computers in art. In the event, the analysis seemed to suggest holography was well placed and had credentials to support its claim to be included in the tradition of art and technology.

A review of the history of the medium reveals a brief lifespan; from its discovery in the late 1940's and development in the early 1960's, to a tentative installation in the Art School curriculum in the 1980's, and its subsequent demise and disappearance from that same venue in the 1990's. This rise and fall in the world of Art education was paralleled in the wider artistic domain, with what turned out to be a forelorn anticipation of the medium becoming more popularist and even available to the hobbyist. The analysis shows this unfulfilled promise occurred largely because of restrictions imposed by the constraining technological processes needed to achieve results in the medium; and because of some wilder speculations about its evolutionary possibilities that have yet to become a reality.

Technological constraints were matters lying outside the premise of this enquiry and were unable to be resolved in this research programme.

The aesthetic quest was therefore the obvious place in which to situate the research, in order to offer an alternative viewpoint. And though the discipline seemed to have accepted those links which had already seen it allied to the photographic process, it was felt that however understandable these might be, they were not really helpful. Indeed, it could be argued their presence was actually restrictive. In the event, it was believed the medium could stand alone, and not necessarily be specifically linked with photography. To this end the enquiry sought to further the aesthetic quest by positioning holography in terms of the tradition of Light in Art.

It was also felt holography offered the ultimate in the manipulation of light, a medium which has become an established and a semi-independent form in its own right, sitting, as it does, alongside the more traditional genres. Light in Art, it was posited, has always been an intangible matter, with definitional problems that have tended to be sidestepped within the discipline. Thus a definition was sought, and this, it was argued, revealed that 'light in art always reflects the understandings of the subject and its technological possibilities at that specific point in history'. To illustrate this, a broad based exploration of the historical interaction of light in art was made, concluding with an exploration of its specific locus in the 20th Century, and specifically tracing the evolution and subsequent use of artificial sources of illumination.

Having thus positioned holography in historic and aesthetic terms, the second part of the research consisted of the creation of five series

of holograms, and these will be exhibited to support and illuminate the arguments put forward in this written account.

The first piece of work in "The Electric Mickey" series set out to explore the the creation of colour variation in reflection holography, and to resolve those problems contained within the definition of holography as 'offering an ultimate potential to manipulate light'. Here, the personal nature of the artistic quest carried the research forward along certain lines, and was determined not only by individual artistic preferences, but also by the locus of the research and the specificities of the technology available at that site. This latter aspect once again highlighted the inherent problem of using cutting-edge techniques. For these, it is argued, may well suggest a potential, yet the history of the discipline indicates their presence can never guarantee they will necessarily generate the desired aesthetic result.

The tonal variation achieved in this first series was greater than expected because of the way film was used, and because of ways in which the norms of holographic display were extended. Holes in the holographic image and the sandwiching together of holographic films added extra dimensions, suggesting further experimentation was possible in the manipulation of volumetric space and in the use of cladding as a means of exploring the image under scrutiny. What is described as the inherent holographic conundrum is explored across all five series; and this divines and examines the paradox of recording and presenting what simultaneously appears to be two/three dimensional imagery. Ultimately this culminated

in the introduction of recordings of objects to demonstrate that holography is able to offer a unique interpretation in the combination of light, and of form, and of space. This, it is argued, presents a new aesthetic potential which could well be considered to be the factor which allows the medium to stand alone in in its own right.

Perhaps most significantly, only two established techniques were used to push this aesthetic quest to the point where such success was possible. The shadowgram and white light transmission procedures used here are relatively simple when compared to the full range of holographic processes; yet in this locus these two basic techniques were quite able to present a range of possibilities, which allowed for a fluency of expression and generated results that clearly suggested an aesthetic potential. The irony, however, was that just as this possibility was being established, so the demise charted above became the reality, and the studio in which the majority of the work had been created was closed down.

Holography, it seems, is therefore hoist by its own peculiar petard. For it would appear from the research presented here that the medium has the ability to form an aesthetic domain in its own right, but at the time of writing has regretfully few opportunities in which to demonstrate this potential.

This may not always be the case however, and it is hoped that the findings of this research will prove to be a springboard for future

investigation. On a personal level, the author would like to develop the techniques used in the practical part of this study in order to explore the human body. The importance of the human form throughout the history of art makes the prospect of being able to optically carve through flesh and bone all the more tantalizing. Perhaps this would be the ultimate demonstration of the ability of holography to provide us with unique visual interpretations of form and space.

To realise this proposition would require the use of a pulsed laser, and is an indication of the author's present confidence in working with holography. This has only been achieved because of the thorough examination of the medium which has taken place during this research. By carefully pin-pointing a set of fundamental aesthetic requirements and developing these through the practical work, a rare insight has been born. Thus the intitial standpoint of rejecting the 'cutting edge' aspects of holographic technology has been reversed, and the author is now able to envisage usage without fear of compromising aesthetic values.

The constraints on space and time that regulated this research have not allowed for an exploration of all the avenues of interest that have been uncovered. Charting the role of light in art throughout the ages, for example, was a particularly fascinating activity, and one which the author is keen to expand upon in the future. Within this one area then, there lies the foundation for a major work that would offer a fresh perspective on the visual history of the human race.

Such potential is at the heart of this conclusion, and helps to illustrate the point that this research should not be viewed as something which is only of import to those interested in holography. Most of all it is hoped that the success of the methodology employed in this investigation can be of some help to other artists. This could be particularly relevant to those who would wish to explore the visual and technological mediums that abound today.

Holography as a medium appears to be sleeping, and the author does not know exactly where, as an artist, he will go next. However, because of this research, whichever direction is chosen, it will be pursued with a new degree of confidence.

TECHNICAL APPENDIX

There are two fundamental requirements needed to make a hologram of the sort presented in this piece of research. These are:

i) STABLILITY

This is essential, because working within a margin of error of a wavelength of light requires a degree of stability within all the component parts during the recording process, in order to ensure there is no movement outside the parameters of that wavelength.

ii) CONSTRUCTIVE INTERFERENENCE

To create an interference pattern on the holographic film that will be successful, both beam lengths from the beam splitter to the film holder must be equal (see Figs. 2 & 6).

Although these fundamentals apply to the series of work presented here, there is specific and detailed information available on all established holographic techniques and possible variations on these techniques in Saxby (1988), and in Unteseher, Hansen and Schlesinger (1987). Both volumes contain long bibliographies on other technical resource material. And yet within all these accounts on the ways of making holograms, there are discrepancies and shades of difference.

It therefore seems suitable to list the specificities employed here in making the holograms for this research. This techical knowledge, however, also represents an accumulated and inculcated body of information acquired by the artist/author across a decade of practice that may well demonstrate a variation on other instructions found elsewhere.

iii) PRE-SWELLING

The first information relates to the pre-swelling technique used to create colour variation in the 'Electric Mickey' series, chapter 5.

In this instance the holographic film was pre-swelled in a mixture of water and various perecentages of triethanolamine:

10 mgm triethanolamine - to 100 mgm of water = yellow
12 mgm triethanolamine - to 100 mgm of water = green
18 mgm triethanolamine - to 100 mgm of water = blue

The film should be pre-swelled for three mintutes in any of these particular solutions, with the emulsion facing up. All of the film should be covered by the solution. After three minutes it should be removed, and squeegeed with a rubber blade to remove excess moisture, and then hung to air dry.

By varying the percentage of triethanolamine by a few milligrams - each side of the above quantities - it is possible to create variations on a single tone.

iv) DEVELOPING AND PROCESSING

A) The chemistry used in processing the reflection holograms is as follows:

Two solutions (part A and part B) are mixed together just prior to processing taking place

Part A. Pyrogallol - 10 grams to 1 litre of water.
Part B. Sodium Carbonate - 60 grams to 1 litre of water.

100 milligrams of solutions A and B, together, is sufficient to develop one piece of 10 x 8 inch film.

The hologram should be placed in the mixed solution with the emulsion side facing upwards in the tray. All the film should be covered by the solution. The hologram should turn 90 per cent dark within three minutes, and should then be taken out of the mixture and washed under cold running water for two minutes. It must then be placed in a tray of liquid bleach (see below for constituents) until it clears, and then washed again under cold running water for a further three minutes. The hologram can then be squeegeed (as above), and dried with a hair dryer, taking care not to allow the heat to buckle the film. Alternatively, it can be air dried, but this will take a commensurately longer time.

The Bleach is made up as follows:

30 grams Ferric sulphate
30 grams Ethylene diaminetra - acetic acid disodium salt (EDTA)
30 grams Potassium bromide
30 grams Sodium hydrogen sulphate
per litre of water.

The developer cannot be re-used and should be disposed of as soon as processing has taken place. A tray of bleach - approx. 500 mgms - can be used again, although it too should be disposed of after a days use.

B) The chemistry used in processing the Transmission holograms is as follows:

Into one litre of water, add:
20 grams Sodium Sulphite
60 grams Sodium Carbonate
8 grams Quinol (hydroquinone)
1 gram Phenidine

This solution or mix can be re-used throughout the period of a working day.

The film (again emulsion side up) should be placed in the developer for three minutes until it turns 40 per cent dark. It should then be removed and washed under cold running water for two minutes. Following this it should be bleached in the same mix as that outlined above for the reflection holography process, and following the same procedures.

v) LASER

A 25 milliwatt helium neon laser was used to create all the holograms in this research.

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