NOISE, ARTEFACT & THE UNCANNY IN LARGE SCALE DIGITAL PHOTOGRAPHIC PRACTICE

CHARLES RICHARD KRIEL

Doctor of Philosophy

UNIVERSITY OF THE ARTS, LONDON

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ABSTRACT: "Noise, Artefact & the Uncanny in Large Scale Digital Photographic Practice"

By Charles Kriel

This dissertation explores the question: why, when encountering the products of many new technologies delivering information via a new media, do I often experience a feeling of disquiet or estrangement? I use the example of laser-photographic printing to explore the issue through a program of practice-based research. The outcome of this line of enquiry includes an original contribution via three series of large-format digital photographic works: *Presenting "The Amazing Kriels," Home At Last,* and *Pure.*

In this thesis, which supports the main body of the research, that is, the practice-based research, I will briefly review the case for artefact as noise within photographic printing, articulate a significant difference between the artefact levels of traditional analogue and Lambda prints, present original dialogical evidence for estrangement in the latter, and identify it via readings of Sigmund Freud's "The Uncanny" and McLuhan's "The Gadget Lover," as a function of the *uncanny.* I will propose an original rewriting of McLuhan's ideas of "hot" and "cool" media, as well as the cycles of irritation/mediation/repression within McLuhan's media theory as a direction for future research, and relate them to a shift from large-scale analogue photographic printing to Lambda printing.

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Dedicated to Richard Lowell Kriel and to the memory of Flossie Schoetke

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INTRODUCTION

This dissertation asks and attempts to answer the fundamental question: why, when encountering the products of many new technologies which deal with information delivery via a new media, do we often experience a feeling of disquiet or estrangement? It uses the example of laser-photographic printing, and specifically Durst Lambda prints, to explore and illustrate the issue.

In this thesis, I will briefly review the case for artefact as noise within photographic printing, articulate a significant difference between the artefact levels of traditional analogue and Lambda prints, present original dialogical evidence for an estrangement of the viewer in the latter, and identify it via readings of Sigmund Freud's *The Uncanny* and McLuhan's *The Gadget Lover*, as a function of the *unheimlich*. I will propose an original rewriting of McLuhan's ideas of "hot" and "cool" media, as well as the cycles of irritation/mediation/repression within McLuhan's media theory, and relate them to a shift from large-scale analogue photographic printing to Lambda printing.

DEFINITION OF TERMS

Much confusion and ambiguity arises around certain terms used within this thesis. "Noise" and "artefact" have been particularly subject to vagaries of interpretation in a variety of literature; for the purpose of clarity, the following definitions should be applied within the context of this dissertation's arguments:

Signal and Noise

It is worth noting that a broad range of definitions of noise could be applied to the subject matter contained within this thesis. *The Manual of Photography* defines *image noise* as "...essentially the unwanted fluctuations of light intensity over the area of the image," and discusses graininess (a subjective quantification) and granularity (a more scientific term) as the principal sources of noise within a photographic image. These definitions work well with the intent of this thesis, however it is worth noting an overall definition outside imaging. As outlined in [US] Federal Standard 1037C, *Glossary of Telecommunications Terms*, published by the National Communications System: Technology and Standards Division, which grows from information theory definitions created by CD Shannon (see below), noise is an undesired disturbance within a frequency band of interest; the summation of unwanted or disturbing energy introduced into a communications system from man-made and natural sources (Federal Standard 1037C, 1996). *The Manual of Photography* corroborates this definition, with the addition of an appropriate and contrasting definition of signal, and signal-to-noise ratio:

> *In communication theory the signal-to-noise ratio (S/N) is the ratio of the information carrying signal to the noise that tends to obscure that signal. In the case of images, the signal is some measure of the amplitude, or contrast, of the wanted image structure. The noise is the equivalent measure of the unwanted, usually random, superimposed fluctuations* (Jacobson, Attridge, Ray, Axford 2000, pp.413-422).

Information

Contrary to many standard definitions, but in keeping with discussions revolving around information capacity vis-à-vis information content, within this thesis *information* is treated as *all* the data received in a channel of communication, both noise and signal.

Artefact

For the purposes of this thesis, *artefact* and *noise* are nearly interchangeable definitions, with a slight weighting of the definition of artefact toward unintentional evidence of a man-made process.

Interpolation

Interpolation is the estimation of a value of a function or a series between two known values. Within this thesis, it is also interpreted as *the creation of speculative information.* Although this could be interpreted easily as the creation of *noise* in an information channel, within this work it is heavily weighted toward the *clarification of signal via mathematical speculation on image content.*

Graininess and Granularity

Graininess is "the sensation of non-uniformity in the image produced in the consciousness of the observer when the image is viewed ... a subjective quantity." Graininess is a clear function of the enlargement of the fluctuations in microdensity (or granularity – an objective term) in a negative, and is largely an effect encountered when viewing a photographic print (Jacobson, Attridge, Ray, Axford 2000, pp.415-416).

Repression

One of the more basic concepts of psychoanalytic dialogics, repression is the process where thoughts and memories are expelled from the conscious into the unconscious. Freud distinguished between primal repression – "a 'mythical' forgetting of something that was never conscious to begin with, an originary 'psychical act' by which the unconscious is first constituted" – and secondary repression – "concrete acts of repression whereby some idea or perception that was once conscious is expelled from the conscious." Secondary repression always involves the return of the repressed, and indeed, they are essentially one. Jacques Lacan saw primary repression as a structural feature of language (in our case, mediation) itself, indicative of the impossibility of completion in significance (Evans 1996, p.165).

Fear of Castration – confronting the lack of necessity of a function of the unconscious following mediation

Freud's castration complex was introduced in 1908, and argues that on the moment of discovery of genital differences between the sexes, the assumption is that the female's penis has been cut off, which results in an array of distresses related to the father, mother and threats in general. Subject to a great deal of scrutiny, and a largely misunderstood theory within Freud's doctrine, the castration complex in the context of this dissertation is used metaphorically only to represent the human organism under stress (Evans 1996, pp.21-23).[1]

Thanatos

The death drive is fundamental to the doctrine of Freud. Linked to the suicidal complex, the oedipal phase and narcissism, Freud's concept of the death instinct describes a nostalgia for a lost harmony, a desire to return to the preoedipal fusion with the mother. Freud tied the death drive to biology, but in our context, we will refer to Lacan's ever-evolving takes on the matter. Lacan situated the death drive firmly in the symbolic, the realm of language, symbol and signification, as a question of culture rather than nature. Lacan asserted that every drive is virtually a death drive, because every drive pursues its own end, every drive is tied to repetition, and every drive attempts to enter the realm of excess *jouissance* where enjoyment is experienced as suffering (Evans 1996, pp.32-33).

Jouissance

A strictly Lacanian term with no direct English equivalent, *jouissance* is roughly translated as "enjoyment", but with a sexual connotation and an in-built prohibition: there is a classic opposition between *jouissance* and pleasure. *Jouissance* is the suffering of too much pleasure, at which point it becomes pain, and in this sense is exemplified by the paradoxical satisfaction that the analysand derives from his symptoms – Freud's "primary gain from illness." Lacan claims:

> Jouissance *is forbidden to him who speaks.*[2]

Set firmly in the symbolic, or the signifying realm of language, *jouissance* is tied to the castration complex, desires for a primordial state, and therefore incest taboo, making it forbidden. This very forbidden nature paradoxically is the drive toward a transgression of what is already impossible; *jouissance* is "the path towards death" (Evans 1996, pp.91-92).

Estrangement, or The Uncanny

For the purposes of this dissertation, the terms "estrangement" (or a sense or experience thereof) and "the uncanny" will be interchangeable, and will not take into account either

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[1] As, in fact, all Freud's theories are treated here; an exegesis of a century of dialectical psychoanalytic theory is beyond the reach or ambitions of this thesis.

Hegel's (1807) notions of estrangement, nor those of Marx (1844), each of which carry political/social and universal overtones. As outlined later in this thesis, the uncanny (*unheimlich*) is the return of the repressed familiar, creating a feeling of disquiet, estrangement and "anxious ambiguity." Foster (1993, p.7), in a brief overview of Freud's theory, outlines the primary effects: 1) ambiguity between the real and imagined; 2) confusion between the animate and the inanimate; and 3) an "eclipse of the referential by the symbolic" or an overtaking of the signified by the signifier.[3] Freud (1919, p.368) comments on the uncanniness of female genitals for male subjects:

> *This* unheimlich *place, however, is the entrance to the former* heim *of all human beings, to the place where everyone dwelt once upon a time and in the beginning. There is a humorous saying: "Love is homesickness"; and whenever a man dreams of a place or a country and says to himself, still in the dream, "this place is familiar to me, I have been there before," we may interpret the place as being his mother's genitals or her body (see* Home At Last*). In this case, too, the* unheimlich *is what was once* heimisch, *homelike, familiar; the prefix "*un*" is the token of repression.*

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[2] In our case, this can be read as "...him who *mediates*" or "...him who *signifies.*"

[3] Freud's theories long predate Jean Baudrillard's (1983) notion of second order simulacra, which articulates the condition whereby reality is judged by it's simulation – that is, the signified is overtaken by the signifier.

CHAPTER OUTLINES

The chapter "Artefacts of Analogue Photographic Imaging" will review granularity within photographic imaging, and particularly photographic enlargement.

"Digital Prints" will review relevant highlights of the transition from analogue photography to digital imaging practices, as well as explore Durst Lambda laser photographic printing technology.

"Photographic Materiality" will introduce the first series of the practical research, *Presenting "The Amazing Kriels,"* and explore introduced granularity in digital imaging. It will also review the work of Mariko Mori and Andreas Gursky, both practitioners of large-scale photographic imaging. We will find similarities between the practical work of this dissertation and the works of Mori and Gursky, and will explore the materiality of photography in relation to the "surface" of the image, including a review of the early theoretical work of William Crawford in exploring the meaning of the surface of the image via traditional printmaking. Finally, a case will be made for the viewer looking "through" the material surface of a print (either traditional or photographic) in order to "see" the print's subject.

"Media, Language and Analysis – a Psychonanalytic Approach" introduces the next practical portion of the research, the photographic series *Home at Last.* McLuhan's theory of psychical autoamputation is outlined, and its relevance to the introduction of new forms of media explored. His theory of "Hot and Cool" media is reviewed and revised, based on a dialectical analysis. Finally, the uncanny is introduced and fused with these theories of McLuhan to answer the essential questions of this research.

"Conclusions: Redefining the Practical Research, In Theory and In Practice" reevaluates the practical research based on the theoretical research, and presents a summation of the theoretical research.

"Revising McLuhan and *Pure*" proposes future directions for theoretical research, and the possibility of revising McLuhan's theories of the drive to technological revision. Directions for practical research are introduced via the photographic series *Pure*.

Appendices A and B contain technical information related to photographic imaging and artefacts.

METHODOLOGY AND LITERATURE REVIEW

METHODOLOGY

The methodological approach to this research grew organically from a simple model of practical research leading to practice, from which theoretical questions were drawn. These questions, in synthesis with both practical research and the products of practice, led to theoretical conclusions. These conclusions, in synthesis with the above, led to further research in both the practical and theoretical realms, which in turn were re-synthesised to arrive at fresh conclusions and outcomes (see Figure 1).

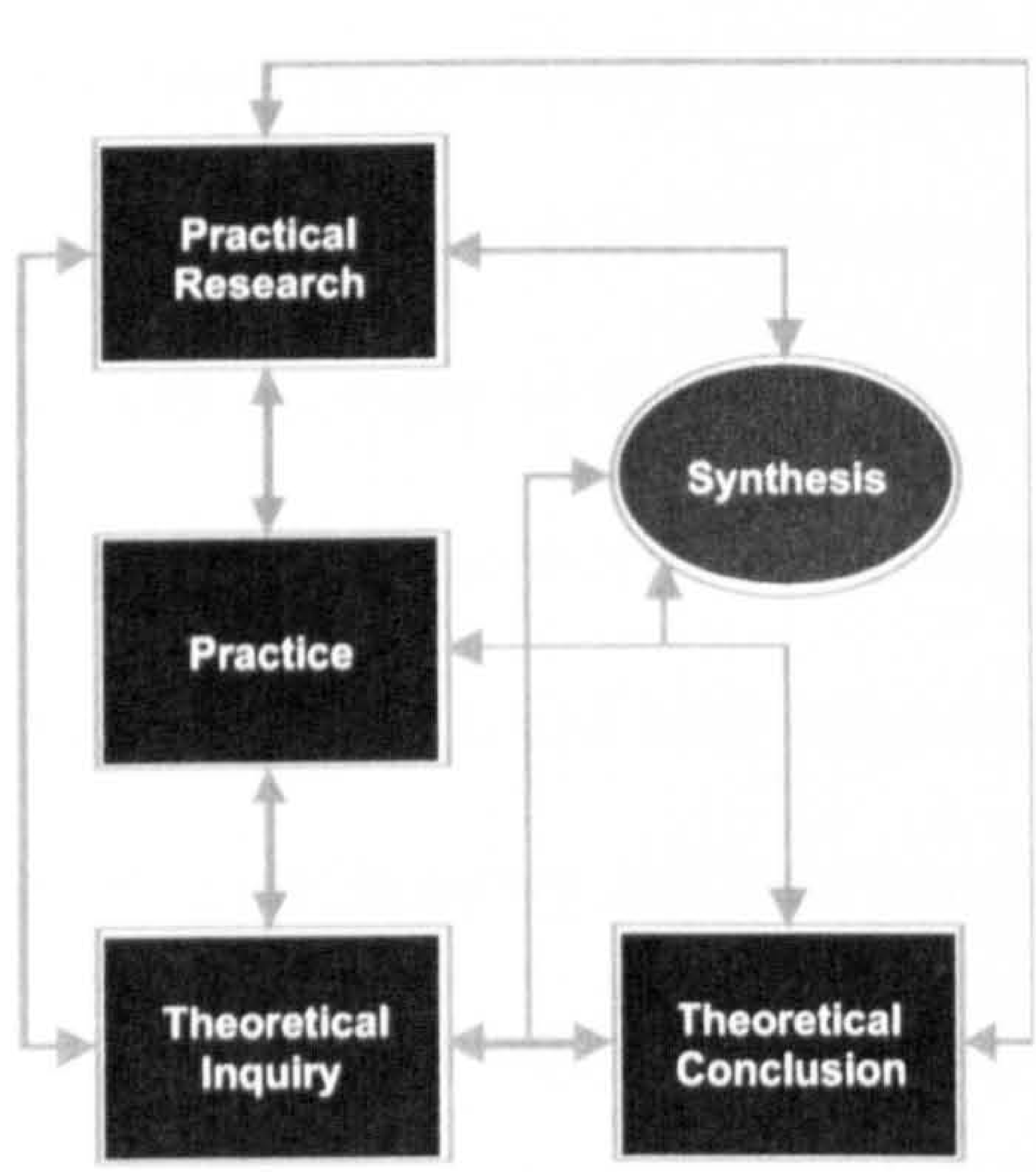

Figure 1 Methodology

The steady stream of both abstract and intuitive ideas which flow between theoretical research and the creation of visual art as research lends itself to the flow of ideas from any one point in the research to any other point in the research. It is within this framework that the research should be evaluated.

The evidence within this dissertation is based on personal practice, and a dialectical attempt to define an art theory. It is not an attempt at a cognitive theory of image reception, nor is it a scientific analysis of image reception. There exist ample and better opportunities within the fields of social science, psychology, cognitive science and the science of imaging to develop a science of image reception based on the psychological effects of noise on the viewer, and I would encourage any reader of this dissertation who has the interest to work in that direction. This dissertation operates within the realm of creating a new aesthetic theory based on research and resulting conclusions gained from observation, personal practice, and a philosophical enquiry into the results of a combination of the two.

LITERATURE REVIEW

The central question addressed by this research is: "Why, at the time of this writing, would the viewer be confronted with a feeling of estrangement when encountering a large-format laser photographic print?" This research attempts to answer that question via practical research focusing on the large-format laser photographic print, which is central to the question. The research makes an original contribution to both the contemporary practical visual arts dialogue as well as the theoretical dialogue surrounding the evaluation of the reception of imagery, the latter via an original synthesis of Sigmund Freud's (1919) essay *The Uncanny* and Marshall McLuhan's (1964) essay *The Gadget Lover*, as well as the latter's theory of hot and cool media.

The original theoretical conclusion reached is unique, as is the practical work itself, and while many of the constituent elements of the synthesis, both practical and theoretical, have been addressed, the synthesis itself of Freud, McLuhan, *The Uncanny*, *The Gadget Lover*, and the laser photographic print is singular at this writing.

The works of Sigmund Freud in defining the concept of the uncanny, and of McLuhan in examining (indeed, in nominating the process of) auto-amputation, are the essential constituent elements of this synthesis. They are discussed throughout.

Hal Foster wrote extensively about Surrealism's relationship to the uncanny, and specifically about photography and the uncanny in much of Hans Belmar's work. Breton's contemporary, Belmar's work is most frequently cited in contemporary visual arts practice and histories as the predecessor to Cindy Sherman's work with dolls. In *Compulsive Beauty,* Foster (1993, pp.7-17) argues that the provocation of the uncanny is the quintessential technique of surrealism. He provides a philosophical and aesthetic underpinning for the surrealist movement, against a backdrop of Freudian psychology. However, Foster makes no reference to the surface of the photographic print, or to granularity.

Dr. Hans Selye (1956), in his pioneering work *The Stress of Life* created the seminal text on stress, health, and physical and psychological disorder. McLuhan (1964, pp.41-47) refers extensively to Selye's work in *The Gadget Lover*, however, neither Selye's nor McLuhan's writings function as art critical texts, nor do they explore the relationships between auto-amputation (McLuhan's term, though often attributed to Selye by way of *Understanding Media: the Extensions of Man*) and the uncanny.

William M. Ivins (1953), former Curator of Prints for the Metropolitan Museum of Art in New York, published the highly influential book *Prints and Visual Communication.* In it, he outlined the case for a language of the print finding its source at the material surface of the actual object. Although he discusses photography, his reference to photography is as-a-whole linguistically, and does not make the same fine distinctions between photographic methods and materials that are made for printmaking materials and practices. His work is discussed later in the dissertation.

William Crawford (1979), in *The Keepers of Light – A History & Working Guide to Early Photographic Processes*, builds on the work of Ivins by claiming a material language to photography, and distinguishing between the language of one photographic process and another. His book, however, is largely a technical how-to manual, and his overall analysis of the reception of the photographic image, based on its materiality, is limited.

Jacques Attali's (1985) work, *Noise: The Political Economy of Music*, received a great deal of attention within the art critical dialogue at the inception of this research, however, as his work deals principally with music's prescient nature – it's ability to represent society at all levels – it bears little if any application to this research.

Claude Shannon's (1948, pp.379-423, pp.623-656) work laid the foundation not only for contemporary computing, but for the field of information theory. His seminal paper "Mathematical Theory of Communication" was the first paper to address concepts of entropy, signal-to-noise ratios, and information theory. His work was largely scientific and dealt with the technical and theoretical communication of information, and not a psychological analysis.

Edwin Land's (1986, pp.3078-3080) research into human vision made an enormous contribution to photography in general, but in the context of this research, his work "An Alternative Technique for the Computation of the Designator in the Retinex Theory of Color Vision,"[4] is particularly instructive. Here he demonstrates the adaptability not only of the human mechanism, but also of vision. Land's work, however, deals specifically with the

[4] This article builds on Land (1959) but also harmonises these works with certain findings of the neurophysiology of vision.

scientific aspects of human colour vision (and elsewhere, of light and photosensitivity in general), and is for the most part beyond the parameters of this research.

Several other articles are cited within this research which either demonstrate adaptability of the human mechanism, or make inroads into an exploration of human vision on the cognitive level. They include: Adelson & Moyshon (1982); Barlow (1972); Bennet & Malek (2000), Bridgeman (1993); Campbell & Robson (1968); Richardson & Webster (1996); Wallach (1948), Weiskrantz, Warrington, Sanders & Marshall (1974); Zhou & Baker (1993); and Colborn (1999). All, however, as above, are more in the field of cognitive research, and lie outside the parameters of this research. They are, however, referenced within this dissertation for the interested reader or researcher.

The Manual of Photography (Jacobson, Attridge, Ray, Axford 2000) also synthesises information theory with photographic practice, particularly in relation to signal-to-noise ratios, etc., and contains extensive exegeses on every technical aspect of the photographic process. The definitive reference book of the science and techniques of photography, as well as the reference of record, *The Manual of Photography* also introduces, as a technology, laser photographic printing processes into the technical record of photography.

Outside fields of academic writing, certain other works form an essential part of the "literature" in this practical research. It would be remiss to include works from Information Theory, Cognitive Science, Psychology, Media Theory, etc., and to exclude the authors of certain essential tools and algorithms which make the practice of the work possible. Indeed, the conception of this research would not be possible without the program Adobe PhotoShop, which, over the past decade or so, has radically altered perceptions of what photography is, and of what it is capable. The algorithmic addition of noise to a photograph, algorithmic upward image scaling, image smoothing, sharpening, etc., all find their base in practice within the parameters of PhotoShop. Originally written as a hobby program called Display by

Thomas Knoll, and used by his artist-brother and soon-to-be partner John Knoll at Industrial Light and Magic, PhotoShop was released in an 0.87 iteration as Barneyscan XP. Under a distribution arrangement with Adobe, PhotoShop saw a 1.0 release in 1990 (it is currently in version 7.0.1). Although digital imaging and photography seem ubiquitous to most users, it is worth noting that the first Macintosh II colour-capable computer was introduced in 1987, PhotoShop is barely a dozen years old, and true large-scale continuous tone digital photographic printing has been practised commercially for little more than five years, therefore the conceptual relevance of a program like PhotoShop, and the work of its author, to this research should not be underestimated (Schewe 2000).

Dr. F. Kenton Musgrave, PhD's (1993) dissertation, "Methods for Realistic Landscape Imaging" is the seminal text on the subject, and lay the groundwork for the series *Home At Last*. Musgrave was the first to accomplish realistic 3D landscape modelling, and did so without the aid of user-friendly software (indeed, Dr. Musgrave presented a realistic computer modelled landscape series as part of his dissertation) (Kitchens & Gavenda 2000, pp. 6-7). Musgrave's research concerned itself with the execution of this work, technically, and not with a psychological analysis, nor with printing methods. His work as a practitioner of 3D modelling of landscapes is, in the opinion of this researcher, without peer.

The works of Mariko Mori, Andreas Gursky, John Cage and Christian Marclay, and their impact on the practical portion of this research are both acknowledged and discussed in the dissertation.

Roy Lichtenstein thoroughly explored the constituent elements creating the "surface" of an image via his paintings (and later, his sculpture) of comics panels and other objects. Although Lichtenstein's work is often thought of as being about comics, the key element of his thought was about reproduction, the needs for humanity to render objects into imagery, and the methods used to go about this process (Ratcliff 2002). In evidence, as one well-known story goes, Lichtenstein showed art dealer Leo Castelli his Benday/comics paintings in 1961. Castelli immediately accepted them. A few weeks later, Andy Warhol showed his own comics to Castelli (Lichtenstein and Warhol did not know one another). Castelli did not accept the Warhol paintings. Warhol's were constituted of expressive brush-strokes. Lichtenstein's, on the other hand, had been painted via a series of Benday dots. Pre-empted, and realizing the key issue in Lichtenstein's paintings was his reproduction of the process of reproduction, Warhol quit painting comics (Hendrickson 2000). With reference to this dissertation, Lichtenstein was concerned with the *introduction* of reproduction noise to the image, rather than the removal of said noise.

Sigmar Polke also famously explored the introduction of noise to imagery, as well as the nature of printmaking, throughout his career (although, again, he was concerned with the introduction of printing noise rather than the erasure of it). His Raster Drawings are perhaps most pertinent. To quote Rubinstein (1999) in his review of Polke's work at the Museum of Modern Art:

> *"Contemporaneously with his intentionally clumsy ballpoint-pen drawings, Polke was also creating the "Raster Drawings," a very different type of work which foregrounded the issue of mechanical reproduction. At MOMA, the earliest "Raster" drawing (in German, Raster is a printing term that refers to the halftone screen of a photoengraved image, as well as to a TV screen) was a portrait of Lee Harvey Oswald. In order to create this work, Polke had counted (with the aid of a magnifying glass) the number of dots in a newspaper photo of the assassin. Then, resourceful almost to the point of comedy, he inked the tip of a pencil eraser and printed each dot individually to produce an enlarged, deliberately imperfect version of the original halftone image.*

The landscape works of the artist Claude Lorraine bear a tangential relationship to this dissertation and program of exploration (Lorraine painted landscapes and made prints; I have made 3D computer models of landscapes as photographic prints). Lorraine was born at the beginning of the 17^{th} century (1604 or 1605) in the French Duchy of Lorraine. His paintings concerned themselves with direct observations of light, and the idealised landscape (BBC 2003). Lorraine's works have been hugely influential up to today, and have been documented thoroughly in art history, the work of other painters, and in literature. An example of the power of his influence can be found by example in Dostoyevsky's (1953) lengthy and reverential description of Lorraine's *Acis and Galatea* (1657) in *The Devils*. Lorraine's work, however, did not concern itself with photography, the photographic surface, granularity or graininess, large-format photographic printing, Freud's notion of the uncanny, 3D computer modelling or the Durst Lambda printer.

Susan Collins recent work with landscapes bears some relationship to the landscape work within this book, as it too uses 3D modelling of landscapes, however, again, it bears little relationship to the essential aims of this research. Nonetheless, her contribution to the contemporary dialogue of visual art should not go without note.

ARTEFACTS OF ANALOGUE PHOTOGRAPHIC IMAGING

GRAIN

In 1840, Edgar Allan Poe attempted to describe the qualities of "photographic drawing[5]":

> *If we examine a work of ordinary art by means of a powerful microscope, all traces of resemblance to nature will disappear – but the closest scrutiny of the photographic drawing discloses only a more absolute truth, more perfect identity of aspect with the thing represented* (Coke 1961).

By "ordinary art", Poe surely was speaking of drawing and it's extensions – painting and printmaking – as well as speaking at a time when verisimilitude was privileged in the visual arts. The mar on the face of the simulation of reality within these practices, both in Poe's time and ours, remains largely the same and based in each medium's materiality: the coarseness of paper in a drawing emphasised by alternating bits of leaded and unleaded areas across the surface; brushmarks and canvas texture in a painting; and etching lines in a print. These are among the material markers which tell us in which medium a representation is rendered. They

[5] By "photographic drawing", Poe, in fact, was referring to the daguerreotype. The two terms, in America at the time, were interchangeable.

are the material artefacts of an intended purpose, simultaneously defining a method of realisation, and delineating a path toward a failure of intention.

To describe photography in the first decades of its practice, however, was to describe a new technology for the production of images of reality, and the description of any new technology is sure to be bound up in the language and by the standards of the technology that preceded it. As McLuhan (1964, p.288) put it, "The old belief that everybody really saw in perspective, but only Renaissance painters had learned how to paint it, is erroneous." Poe "saw" a "more absolute truth" in photographic imaging via the language through which he read drawn images. In hindsight, it's quite clear there is more to the "more" than the "absolute truth." What we in fact see when we look at a photograph through a microscope, or even a magnifying glass, is not just the image being rendered but also the constituent elements of that image. Just as Poe saw strokes and marks and lines in drawing, in photography we see grain.

A photographic negative is made up of black silver spread across a clear film base, in ratio to the amount of light to which the film emulsion was exposed prior to processing. These grains of silver are more or less the same size as the grains of silver halide from which both they and the emulsion were made.

If a photograph of a grey card were made, the print would, to the naked eye appear as a continuous tone grey field. The constituent elements of the image are generally too small to be seen under normal observation. On closer examination, however, we would see that the tonal field was made up of clumps of black metallic silver, called "photographic grain." Unevenly distributed across the photographic page, these grains *in general* do not touch,[6] but because an emulsion typically contains many "layers" of grains, a random, irregular pattern is

[6] They may, in fact, *be* clumped together, however, due to irregularities in manufacturing processes.

formed that is much more apparent to the eye, and is particularly enhanced when the image is enlarged, even by a factor of three or four times (Horder ed. 1971, pp.216-218).

This overall condition is referred to as the "graininess" or "granularity" of an image, depending respectively on whether the image is discussed aesthetically or scientifically. It is not only an effect that can be observed and measured according to the enlargement size of the print or the distance one must stand from the print before its "grainy" appearance disappears. It can also be measured instrumentally and formulaically.

It is rare for granularity to be observable to the naked eye in a negative, however it can be measured (see Appendix A). When an image is described as "grainy," the reference is usually to the print. However, printing papers are typically manufactured using an emulsion of fine granularity, therefore the perceived graininess of a print is in fact the granularity of the negative, projected and enlarged onto the print.[7]

Although clearly measurable via sensitometry and densitometry, and largely based on characteristics of emulsion, density, contrast, and gamma, to the human eye the main determining factor in the graininess of a print is the degree to which the print has been enlarged. A 36x24 mm negative, no matter how tightly packed its silver elements, once enlarged 100 times will produce a vastly grainy print. The ability to measure granularity scientifically, however, gives us a much less ambiguous language within which to discuss the "mealy" quality of a greatly enlarged print. By measuring granularity electronically, and determining a print's quality according to the photographic efficiency of the emulsion in transmitting image data to the eye, we begin to be able to think about the surface of a photograph in terms beyond Poe's "traces of resemblance to nature." We can, in fact, begin to discuss granularity on the level of "signal-to-noise" ratios and information theory:

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[7] At micro-densitometer levels, however, the granularity of the print emulsion itself can be measured.

Granularity has the same properties as the "noise" in a wireless receiver; i.e. it obscures the intelligibility of the signal. In order for a signal to be clear – and this can only be stated within given probability limits – it must exceed the noise the more the greater the certainty required that the signal is genuine (Kraszna-Krausz ed. 1961, p.718).

NOISE

The need for greater analysis of detailed photographic information, particularly in relation to scientific and surveillance photography, has given rise to the need for more exacting means of determining photographic efficiency as well as the tools necessary to achieve these measurements. Borrowing from technologies used to evaluate electrical communication and information transmission, photography in general and medical photography in particular, have adopted Fourier analysis of complex waveforms as a standard tool in determining photographic negative and print quality. Results of determinations of quality are often expressed in terms of signal-to-noise ratio. In this context, "granularity" as it is spoken of conventionally (by the photographer vis-à-vis the scientist) is turned on its head, and, in an image of average density, the grains themselves become *signal,* while the even white space of the paper beneath the emulsion is termed *noise.* The overall image area, in this discussion, would be considered an information channel.

The grains themselves – the elements of silver on paper – are the constituent elements of the signal. The more tightly packed and evenly distributed they are, given a photograph of average density, the more information we receive about the image reproduced. The more white space we see between them, given that same image, the more noise transmitted in the information channel. Overall, the ratio of signal-to-noise must be high enough that the viewer of the image can determine the original photographed subject despite the elements of noise inherently contained in the print of the enlarged negative.

While measurements of granularity, density, gamma and contrast are useful in determining the resolving power of a particular film or paper based on the packing density of silver halides in its emulsion, a discussion of signal-to-noise comparisons within photographic visual images reveals a number of other aspects of the photographic recording process which introduce artefacts into the final image. Among these are lens aberrations, Newton Rings and reciprocity law failure. These are thoroughly discussed in other literature, and within this dissertation in Appendix A, however they remain particularly relevant to the overall conclusions of this dissertation, as they are artefact-inducing phenomenon that are eliminated in the print enlargement process when utilising laser-photographic printing technologies, discussed below.

DIGITAL PRINTS

A DIGITAL APPROACH TO IMAGING

In the previous chapter, we've discussed how images are encoded photographically in an emulsion based on the effect of a variety of light rays' impact on silver solutions. Digital imaging encodes pictures based on a different model – the impact of light rays on sensors. These sensors, in concert with data processing circuitry, convert the energy of light rays into binary information sequences stored on electromagnetic or optical media, or a combination of the two.

BINARY CODING

At a fundamental level, information is stored digitally based on a binary model stating that all information can be broken down into a string of 1's and 0's – a base of ON's and OFF's or YES's and NO's. In 1679, German mathematician Gottfried Wilhelm von Leibnitz conceived a system of image encoding, representing information as binary numbers which would subsequently be represented by a series of spherical pellets in a machine controlled by a rudimentary form of punched cards. His system of describing all calculations as a binary series was comprehensive, and the forerunner of today's digital methods (Dyson 1997, p.37).

A single binary number is referred to as a bit, and a series of 8 bits is a byte; in the ASCII system of alphanumerical coding, the letter "e" is represented thus:

01100101[8]

Contemporary systems extend beyond 8-bit encoding, with 128-bit encoding not uncommon in large-scaled information servers.

Groups of binary data are combined to describe picture elements (pixels) in contemporary digital imaging. To represent a black and white image in the photographic sense, that is a full range of densities mapped across a print surface, each pixel is described as one of typically 256 shades or levels of grey, rather than either black or white. Digital colour images of photographic quality are made up of three virtual "channels" (red, green and blue) in much the same way layers of emulsion are stacked to create colour. Each channel's pixel densities are represented as one of typically 256 shades of red, green or blue,[9] and the three layers

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[8] An early presentation of my research at a seminar at Central Saint Martins College of Art and Design – London Institute was nearly "hijacked" by an attendee who insisted my discussion of the perception of digital photographic imagery be rooted in a discussion of the binary. It was my opinion at the time, and remains my opinion, that I have never knowingly met anyone who has actually seen pure binary computer code on their screen (it is, in fact, almost impossible in contemporary computer systems), and I likely never shall – this despite having been involved in the "computing community" since 1986. Byte-level code is a rare encounter even for many programmers, but machine-code (binary level code) is usually encountered in contemporary computing via the most fundamental level of port control applications in robotics, or EPROM programming, and is certainly not encountered in most contemporary arts institutions.

To labour a point, my one encounter with typing a series of binary information into a computer came when I was programming a string of binary actions into a serial port controlled relay system – ON's and OFF's to control solenoids embedded in a band of stuffed robotic squirrels. In point of fact, although I was typing 1's and 0's, it was at the ASCII level – I was typing *symbolic* bits in byte language for the C program I had written, which were subsequently converted by the computer back into bits to control relays – an impressive illusion for the observer or programmer, but hardly an encounter with bit-level code.

Machines operate and store information at bit-level. Several layers of byte-level code are placed over the bit-level language. Graphical User Interfaces are layered over the top of *byte*-level language as a metaphor for the computer *user*. The observer of a digital photograph has no encounter whatsoever with binary data storage in the way the observer of an analogue photograph encounters silver-based data storage, and it is discussed within this thesis as background only, in aid of understanding for the reader unfamiliar with the inner workings of computer language and data storage.

[9] This, in an 8-bit per channel colour file, which yields a 24-bit depth image. 16-bit per channel files (producing a 48-bit depth image) are common at the professional level of digital photographic printing and scanning, and each

together yield an RGB colour image,[10] which, at high enough resolution, appears as a continuous tone colour image, often with greater resolution than that which can be recorded on an analogue film base. That is to say, an image authored on photographic film and scanned digitally at a high resolution will represent a broader colour range and more levels of density, and will contain pixels smaller than the representative analogue grain of the photographic print. Images of 100 megabyte or more are common.[11]

IMAGE ACQUISITION

Images in digital photography can be acquired in several ways: via photographic print and film scanning, digital camera, or by rendering an image entirely "in computer" (3D modelling, for example). Although digital image acquisition, its methods and problems of artefacts and noise, are outside the scope of this thesis, it is useful to review some points, and they are outlined in Appendix A. Most importantly, digital printing is metaphorically the reverse of the process of digital image acquisition, and scanning in particular.

DIGITAL PRINTING

There are several methods for creating prints from a digital image file stored in a computer, and almost anyone who uses a computer will have used a printer at some point, whether to create text documents or more complex graphic images. Our concern in this thesis is with printing the photographic image digitally, which means working from bit-mapped images

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pixel in each channel is represented as one of 65,536 levels of density for the corresponding colour. The relatively new extended e-sRGB colour space, as defined by PIMA document 7667 (2001) calls for three user-defined levels of colour precision: 10-, 12-, and 16-bit per channel colour space.

[10] RGB is the standard for digital photographic practice. In the print industry, a CMYK (cyan, magenta, yellow and black) file would be more common.

rather than vector-based text and graphics languages like Hewlett Packard's Printer Command Language (PCL) or Adobe's Postscript; our primary concern is with large-scale digital prints that exceed the capability of traditional analogue photographic enlargement. At this writing, only one technology surpasses emulsion/light-based printing: laser-photo printing – and for large-scale laser-photo prints only the Durst Lambda series of printers is able to surpass enlarger-based printing (see below).

Noise is at the root of my proposition concerning large-scale prints and the uncanny, and it is worth noting that a "print of poor quality" is another way of nominating "a visual signal occluded by a noisy information channel." As with our extensive review of photographic enlargement and the problems of granularity and other lens/emulsion-based artefacts, a review of less-refined digital printing methods and their problems is contained in Appendix A, including another laser-based printing method – electrostatic printing – followed by inkjet prints, of which "Iris" prints were long considered the premium choice of visual artists.[12]

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[11] The practical portion of this dissertation contains many images rendered at over 350 megabyte.

[12] The well-known IrisGPrint Giclee has, at this writing, been discontinued, and it would appear that Iris has gone off the large-scale digital printing market, although they still manufacture smaller format "proofing" systems. Iris (or Giclee) prints were often favoured by artists working with computers and photography. However, because they were, at heart, inkjet printers, they were incapable of continuous tone printing, and were subject to banding and rainbow effects – a level of noise that placed Iris prints far below the quality of the large-scale analogue photograph.

Cymbolic Sciences LightJet printer uses a similar technology to the Durst Lambda laser photo printer. However, the Lambda prints on a continuous roll, 52" wide. Rolls are up to 150 ft. in length. The LightJet printer loads photographic paper in sheets inside a drum, limiting print size to 30" on the longest dimension, and is not really capable of large-format printing. The LightJet has been discontinued.

At this writing, the Pictography 4000 digital colour printer is widely considered the best dye sublimation printer available for digital photographic reproduction, and offers exceptional quality. However, print size is limited to A3. Fuji also manufactures the FujiProof Extra, a dye sublimation proofing system, but, like the LightJet, print size is limited to 30".

For these reasons, Iris prints, dye sublimation, and LightJet prints will not be considered within this thesis. However, a general discussion of laser printing technology (both electrostatic and laser photo printing) as well as inkjet printing are included for background and comparison.

ENLARGING IMAGES

When a photographic negative is enlarged onto a positive print, upward scaling occurs on an optical basis. Light is passed through the transparent negative, and the image contained therein is magnified and focused onto a flat sheet of photographic paper by a compound lens (discussed in Appendix A). The resolution of a digital file is quoted in dots per inch (dpi), and although "virtual", these files have an analogue, real-world XY dimension. A 36x24mm image scanned at 2400 dpi, when printed without alteration, will print at 36x24mm – 3400x2264 pixels. To enlarge the image, the computer must perform a multiplication of the number of pixels, and write the new pixels in a new file. An enlargement of ten times would yield an image 34,000x22,640 pixels, however, each 10x10 area of pixels would be identical in colour and density, yielding a pixelated image. To compensate for this, interpolation algorithms are used in combination with sharpening algorithms[13] to create new speculative information to place in the nine-pixel space between the original pixels, smoothing the transition from pixel to pixel, now that that transition is more apparent in the enlarged image (see Appendix A). One side effect of this combination of upward image interpolation, smoothing and sharpening is the obscuring or suppression of original image granularity, were the original image authored on film (again, see Appendix A). This effect is essential to the overall effect of Durst Lambda laser-photographic printing, and its ability to create enlargements without granularity.[14]

[13] Readers familiar with both digital and analogue photographic practices will recognise, for example, Adobe Photoshop's "Unsharp Masking" algorithms as a digital simulation of a traditional analogue photographic process, used frequently in the motion picture industry (see Appendix A).

[14] Durst employs a set of proprietary algorithms for image interpolation and sharpening.

LASER PHOTOGRAPHIC PRINTING

Laser photographic printing is based on a process introduced by Durst Phototechnik A.g. (Durst) in 1994 with the release of the Durst Lambda 130 Large Format Digital Laser Imager (Lambda), which Durst (1999) refers to as the first "Large Format Direct to Photographic Media Output Device" on the market (see Figure 2).

Lambda is unquestionably the industry standard, with no effective competition in the large format photographic output market. Although inkjet and electrostatic technologies are still used for large format printing, their use tends to be limited to applications where image quality is subordinate to the demands of outdoor display (billboards and fly-posters), massive print runs, economics, or lack of ready access to Lambda technologies (the Lambda is unavailable in North Korea, Cuba, Iran, Iraq and Libya due to political sanctions (Durst 1999b), and broadly unavailable outside markets with highly developed economies and market-led advanced imaging requirements).

Where four inks are combined in inkjet printing to either directly reproduce one of four (or more) colours,[15] and simulate via dithering, screens, etc., a broader but limited range of colours, Lambda printers utilise a combination of light from a red, blue and green laser to create a final light output of any one of 68 billion discreet colours, utilising a 36-bit colour registry system. The final output medium is a variation on traditional analogue-optical photographic paper, rather than paper designed for absorption of inks, making Lambda printers capable of reproducing not only continuous tonal ranges, but ranges of tone and density that far exceed ink- and toner-based printing technologies. The precision of the Lambda laser-exposure system is such that an apparent resolution of 4,000 dpi is standard.

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[15] As discussed in Appendix A, true colour reproduction is limited to the number of inks in an inkjet printer, with most inkjets capable of four true colours, many capable of six or six plus black, and very few capable of as many as a dozen. All other colour reproduction is simulated via dithering or screens.

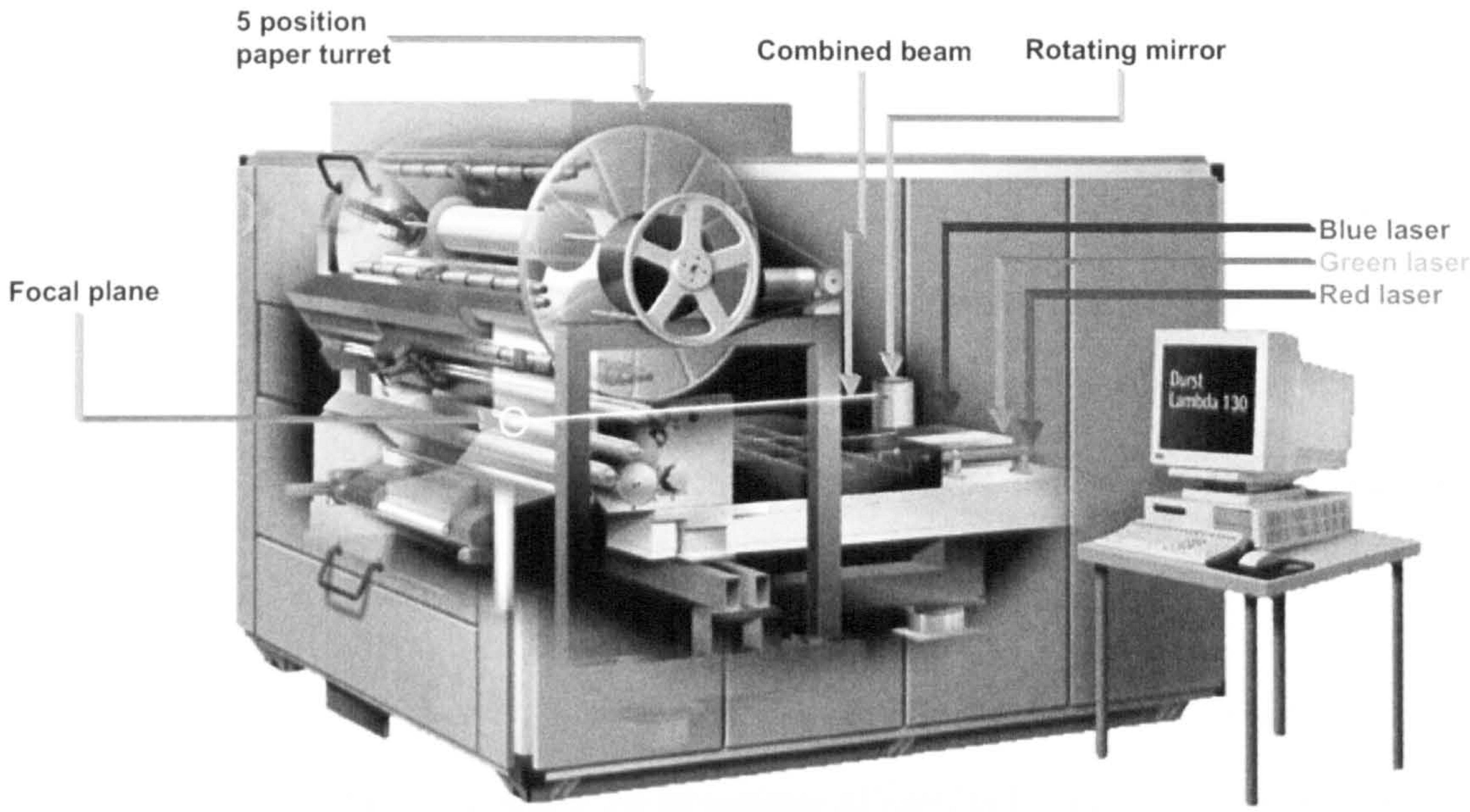

Figure 2 Durst Lambda 130

A variety of photographic paper and film media are manufactured specifically for use with the Lambda printer. It is worth noting that, within circles of photographic print makers and photographers, the standard of measure for print quality is often cited as the Ilfochrome print (formerly Cibachrome) for tonal range, brightness and overall print quality – and that Ilfochrome is one of the many papers manufactured specifically for use on Lambda printers. Durst, a business partner of Kodak, recommends KODAK PROFESSIONAL Digital III (Digital III) papers for use on Lambda printers, and indeed, the print quality of this combination is such that it has made a substantial contribution to Lambda dominating the "Large Format Direct to Photographic Media Output" market.

Digital III papers have been specifically designed for the short exposure times required by Lambda printers. A second-generation paper designed strictly for digital exposure, Digital III has also been engineered to minimise image flare around sharp-edged graphic input like text – an imaging requirement of many commercial printers. This increases overall image fidelity across all applications, and lessens noise in critical output. Digital III paper is also noted as having an equivalently broad tonal range to standard optical photographic papers (Kodak 1999).[16]

Commercial printing also often requires fields of a single colour, sometimes with text overlay. Because of the broad colour range of the Lambda single beam exposure system, the use of photographic print media, and the combination's continuous tonal qualities, colour fields no longer have to be screened or dithered. Nor are they limited to a narrow range of ink colours should solid colour be required.

The Lambda's superiority in print quality is not limited to comparisons with inkjet and electrostatic printing, however, and it has demonstrated itself to have clear quality advantages over both traditional optical photographic printing processes, as well as hybrid optical-digital methods. Prior to large format laser photographic printing, rather than writing a digital image file direct to final output media (in this case, photographic paper), an internegative or inter-transparency process was required. Film recorders would be used to write digital image data onto a transparent analogue optical data storage medium which would then be enlarged using traditional optical printing techniques. This process not only degraded image quality, for a number of reasons not least of which was generational image quality loss, it also still created film grain magnification in the final output print.

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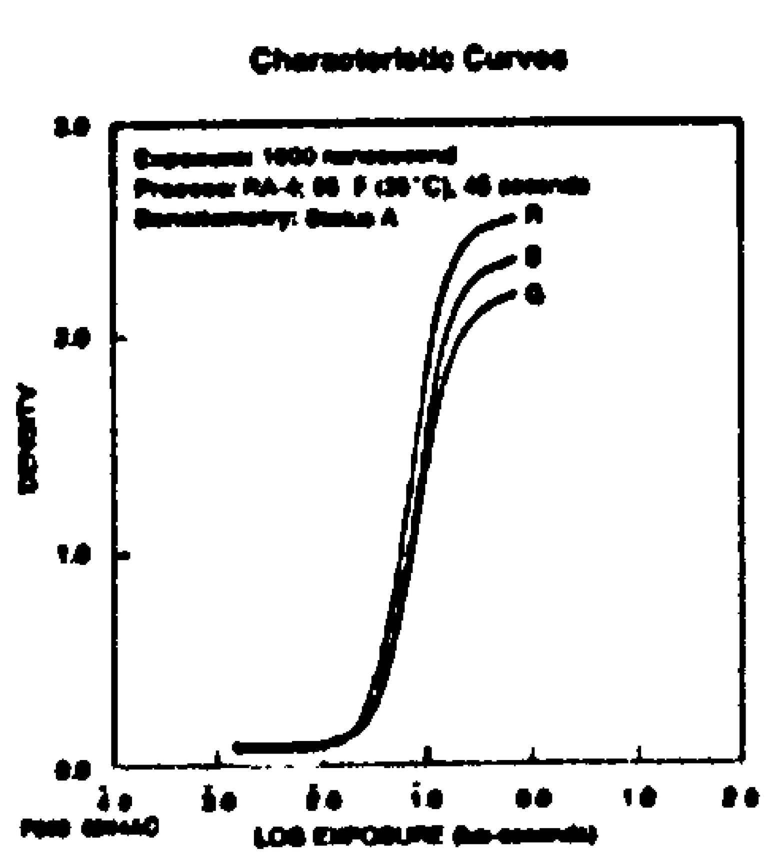

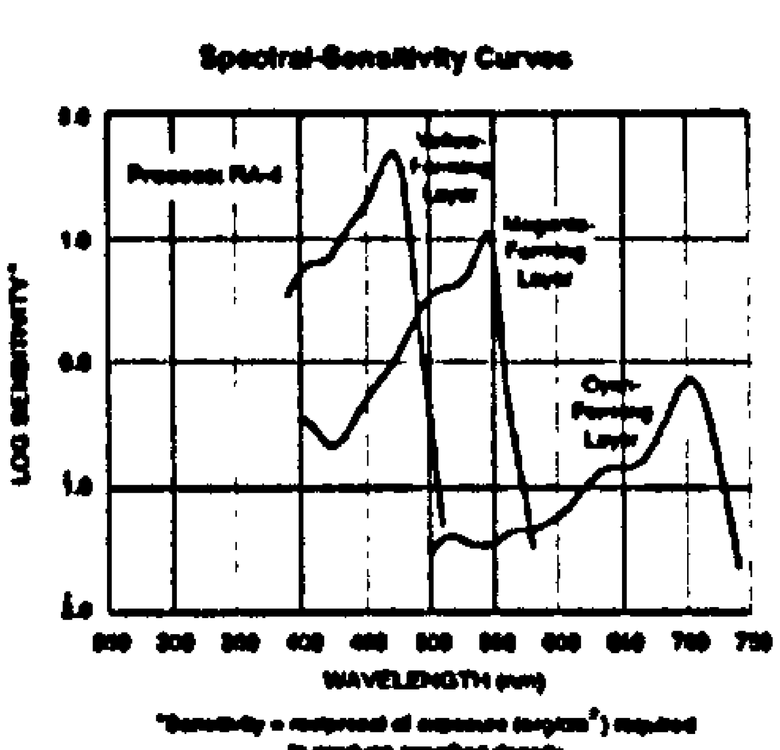

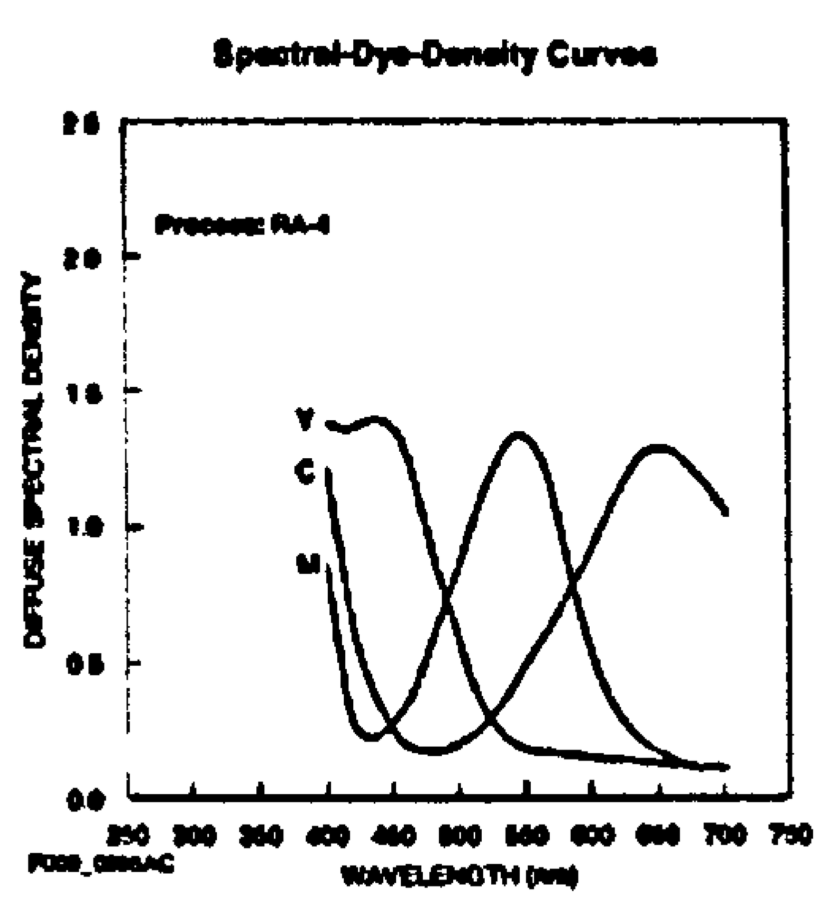

The use of an inter-media process limited control over density in the print. Although densities could be optimised within the computer file in a way that allowed gamma shifts to leave blacks and whites unaffected by overall density changes, the optical printing process would require a second overall density adjustment which would, by the very nature of density manipulation via filtration, affect levels in pure blacks and whites. Inter-media processes also left the photographic print subject to reciprocity law failure when large format prints were the goal. Because image enlargement in the Lambda system is a digital process of upscaling, distance between the light source and photographic media remains constant, as do light levels, eliminating any reciprocity law-related effects. Further, by eliminating an inter-media print step there is no negative or negative carrier, and therefore no possibility for the creation of Newton Ring artefacts.

Large format printing is a key issue within this dissertation, and it should be noted that the Lambda printer has few print size limitations. The Lambda can accommodate paper up to 50 inches on it's shortest dimension, and prints on the vertical dimension along a patented continuous roll-to-roll exposing system, with photographic paper selected from any one of five rolls in a multi-roll turret (see Figure 3). This continuous roll-to-roll system, perhaps more than any other technical factor, contributed to the demise of early competing laser photo print systems which utilised in-drum exposure systems, limiting print size to 50 x 50 inches (see Figure 4). Kodak Digital III papers are available in rolls up to 50x1,968 in. (164 feet). Although a highly unusual aspect ratio, 50x1,968 in. would be the theoretical print size limitation. The Lambda, however, allows digital tiling of an image, so by printing in panels, print size is theoretically limitless, although computer file sizes vs. media file capacity would, in this case, be a real-world issue.

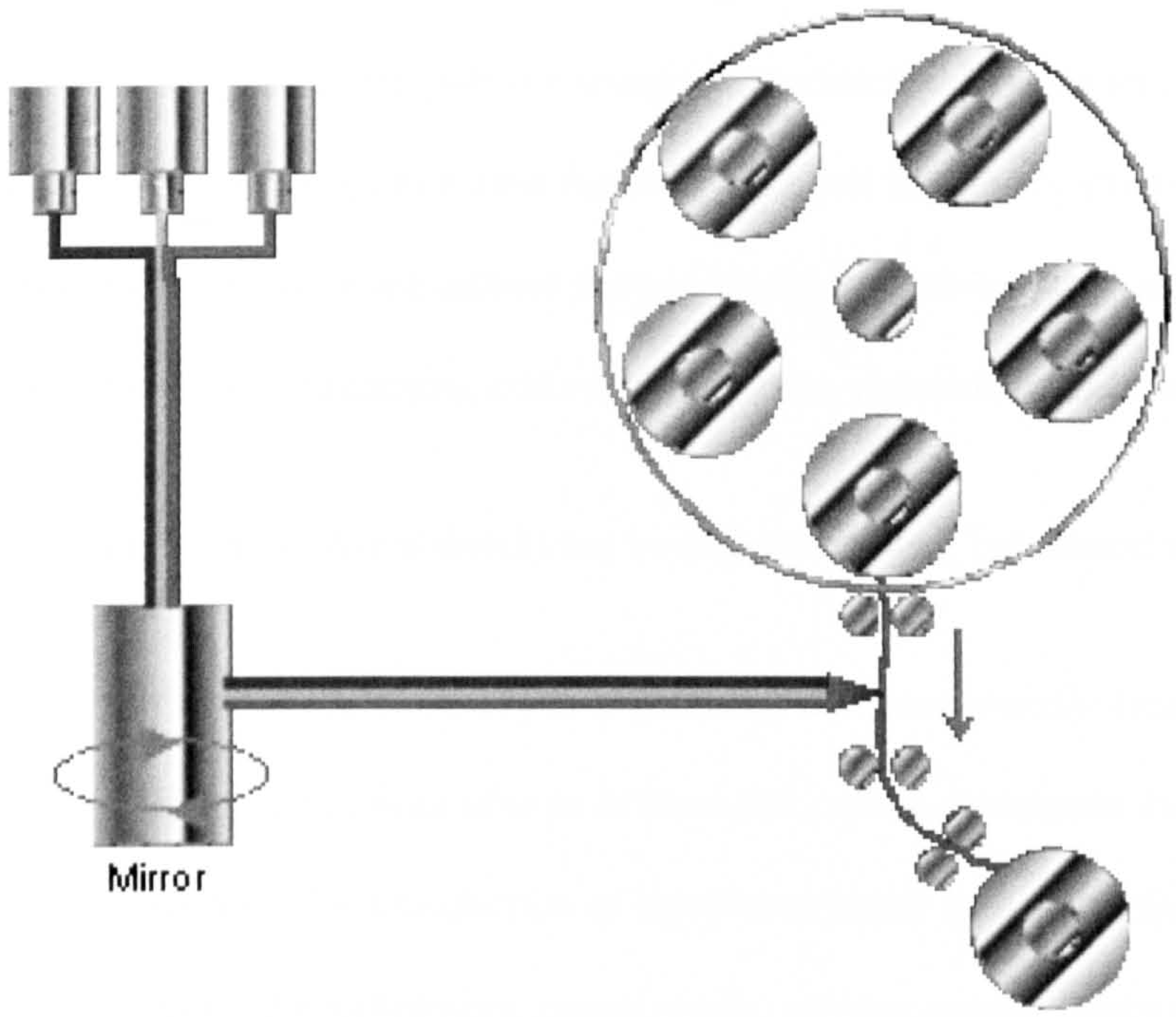

Figure 3 Continuous roll to roll exposure system

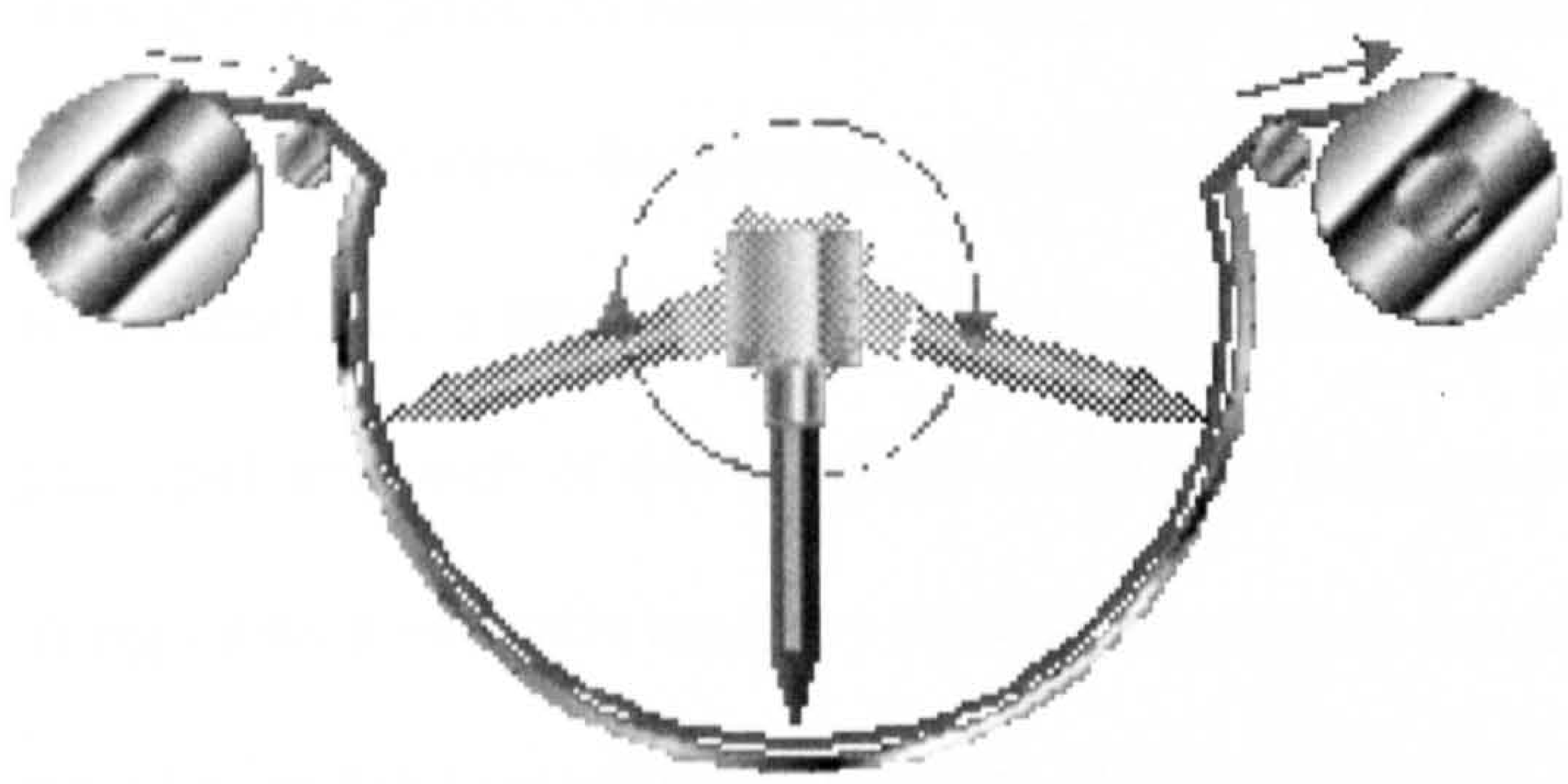

Figure 4 In-drum exposure system

CONCLUSIONS

The most significant advance in print quality relative to our discussion is the Lambda print system's elimination of photographic grain in large format prints. As shown earlier, traditional optical photographic print systems enlarge granular elements in storage media when negatives or transparencies are magnified optically onto photographic print film. The Lambda system of interpolative image enlargement side-steps this issue, not only eliminating an enlargement of grain within the final print, but frequently smoothing out granular elements from the original image capture storage media (negative or transparency film), whilst simultaneously sharpening and enhancing edge elements in the final image.

The significance of this should not be underestimated, but should also be stated simply:

> *Prior to digital laser photo printing, no commercially available large format imaging process has been able to achieve full colour continuous tone image representation without the introduction of significant levels of noise visible to the eye, whether in the form of brushstrokes, pencil marks, etching marks, image grain, image screens, colour dithering, or some other artefact inducing imaging method.*

This is not to state that noise does not exist in a Lambda or Lambda-equivalent laser photographic print. As outlined in Appendix A, the opportunities to introduce artefacts into the imaging process, from capture through to final print, are vast. However, the Lambda print is so significant a step forward in imaging technology, I would assert, and it is one of the principal proposals of this exegesis of noise in photographic imaging, that the improvements in signal-to-noise ratio made by laser photographic printing processes are so significant as to exist beyond the visual language of the lay viewer *at this writing*, and has introduced a significant shift in the psychological process of evaluating two dimensional imagery, as we shall see in the following chapters.

PHOTOGRAPHIC MATERIALITY

This dissertation forms a part of a larger, practice-based research program that explores the question of how our response to large-scale photographic prints fundamentally changes when visible granularity is no longer part of the image, and how this understanding can be used to both introduce a new field of inquiry in aesthetic photographic (and, indeed, media) theory and to inform the practices of working artists and photographers. The initial question, what is happening psychologically for the viewer that is so different with this new method of printing – large format Lambda printing – came initially from viewer reactions to prints from a series of my own work: the photographic installation *Presenting "The Amazing Kriels."*

RALPH BLACKWELL AND "THE AMAZING KRIELS"

I was born into a family of circus and carnival performers in the United States. For two generations "The Amazing Kriels," as they were called, travelled throughout North America with a variety of circuses, tent theatre shows,[17] and carnivals.[18] Keen self-promoters, they

[17] Tent theatre shows were a form of travelling vaudeville, playing to essentially small-town audiences where proper theatres did not exist. Tent theatre became irrelevant as an entertainment medium with the introduction of television stations and cinemas in most of the US's small towns.

often had themselves photographed both formally and informally for the press. When the last performing Kriel, my grandmother Lois Kriel, died in 1990, I inherited her collection of these photographs, as well as dozens of personal photographs of the Kriel family.

In a period in the critical art dialogue concerning photography where, generally, an emphasis is placed on the banality of the image and aesthetic preference tends toward the "uninflected," these were particularly timely images to have been given. There was an immediate resonance concerning the abnormality of the normal family for most people to whom I showed many of the snapshots (the fantasy figuration of one's own "family" in fragmented and nomadic "post-Modern" America is a research subject ripe for the picking). Running away from your own family to live with a circus family has an appeal to many children (and adults); to be confronted with the image of that very fantasy, in the form of family snapshots, realises visually that flight of fancy. That the image one encounters might be, say, a snapshot of the family posing on the lawn outside their house, as families often do, but all wearing gold sequinned costumes, only adds to the odd constructed-ness of these largely unconstructed[19] images (see Figure 5, Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10).

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[18] "Carnival" is an Americanism for "fun fair", often takes the form of a "county fair", and bears no relationship to the European colonial Catholic idea of "Carnival", which in the US would be referred to as "Mardi Gras" or "Fat Tuesday" ("Pancake Day" in the UK).

[19] Unconstructed, that is, in relation to the photographer's intent, which was likely to take a family photo, not to create a visual commentary on the culture of the American family via an image of a subcultural relationship.

Figure 5 from *Presenting "The Amazing Kriels"* series (60 x 48 in)

Figure 6 from *Presenting "The Amazing Kriels"* series (60 x 48 in)

Figure 7 from *Presenting "The Amazing Kriels"* series (60 x 48 in)

Figure 8 from *Presenting "The Amazing Kriels"* series (60 x 48 in)

Figure 9 from *Presenting "The Amazing Kriels"* series (60 x 48 in)

Figure 10 from *Presenting "The Amazing Kriels"* series (48 x 97 in)

In short, these pictures, to most people, are strange photos of a strange family.

Most of them were taken by Ralph Blackwell, who died in the 1970's.[20] In the context of my own works, however, they were considered photographic appropriations, with a great deal of recropping, image reconstruction, and photographic collage applied to the final products.

A broadly skilled performer, Ralph Blackwell travelled on Billy Choate's Bisbee's Comedians tent theatre in the 1940's and 1950's. After that, he often travelled with Dick Kriel (my father) on various carnival and stage show ventures across the US. A ventriloquist, juggler, actor, lasso specialist and saxophonist, Blackwell was also a talented photographer. From appearances I believe Blackwell shot mostly medium-format black and white negative stock, and it is known he kept a small darkroom in his trailer where he produced prints.[21] Blackwell's photographs were exceptionally well-composed and technically well-exposed for a hobby photographer working with manual cameras and enlargers. His photographs

[20] From a personal interview with Judith Richards, who travelled with the Kriels from the late 1950's through the late 1960's.

possessed that sense of "the decisive moment" so often spoken of in the photography of the middle half of the last century, and I am confident that if his archives exist somewhere, they are ripe for exploitation by some bright young curator.

Sadly, Lois Kriel was nowhere near as accomplished an archivist as Blackwell was a photographer. Grown senile, narcoleptic, and unhygienic from a lifetime living as a "gypsy,"[22] her preferred vessels for storage of her family photographs were a white patent leather purse and a cardboard shoe box, both of which contained, oddly, quite a lot of untubed toothpaste and the remains of stillborn kittens which she often misplaced.[23] Although I say I inherited these photographs, in truth I recovered them from her home shortly before her death in hospital. This recovery was to be the beginning of a long process of restoration, reconstruction and recontextualisation of the images bit by bit over the course of many years.

In Lois' home, I found about 200 images, almost all of which were small prints, under 10x8 inches, but also many very small contact prints from medium format films. Although the prints themselves, in their original condition, were of good quality, by 1990 they were in very poor condition. Most were creased. Many were stuck together. Almost all were coated by a patina of mildew, toothpaste, dried blood and fur.

My original intention was to simply restore this mess of a collection of photographs, printing the new versions at roughly the same size as they were originally printed. Photographic restoration can be a lengthy process, however, which was exacerbated by a need to devote time to a broader art practice. Fortunately, in 1996 I was awarded an artist's grant from the London Arts Board, and in 1997 an artist's residency with the Artec Arts and Technology

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[21] "Trailer" is an Americanism for "caravan."

[22] It should be noted here that "Gypsy" is considered a racist term by the Romany peoples to whom the term is so often carelessly applied, and that its use within this dissertation is in the context of the broader definition of "gypsy" as a wandering performer.

Agency, then located in the Islington area of London. These gave me both a measured period of time (one year) to restore the photographs and to develop a larger piece of work for the internet, using the photographs as the principal images. At that point, my priority became the restoration of the images for dissemination over the internet.

My intention, at the start of the project, was to scan the images and "touch them up" in Adobe PhotoShop, of which in 1996 I had a basic working knowledge.

The project took somewhat longer than a year to accomplish, but also provided the fundamental training needed to work effectively with digital images. By the end of the project, I had learned to scan and manipulate (or restore) a photograph at low resolution, and prepare it for dissemination on the internet. Although I had no intention at the time of printing the images large format, even at that stage "noise" had become an issue. Files need to be very small to download over the internet efficiently. To do this, compression algorithms are used to eliminate "redundant" information in the image file. Many algorithms first process the image, introducing redundancies by limiting the tonal range of areas of the photograph, and then proceed to eliminate pixel duplication within the image. These are called "lossy" compression schemes, because they introduce a "loss of quality," degrading the overall image quality of the photograph.

With the online project, "quality" of imagery vs. image file size was the main issue in dealing with noise. The issue of noise and image quality came up again, but in a very different way, shortly after the project was completed in 1998 when I was asked to mount a solo exhibition of these images at the gallery of Tomato Design in Soho, London. The Tomato Gallery, which also served as the reception area for a clique of many of London's leading graphics and advertising agencies, as well as the home of the massively influential band Underworld, is

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[23] Lois Kriel, to her credit, was America's foremost trainer of housecats, and had the only known housecat act in the country during her lifetime. In her dotage, however, she became the proverbial "old woman living in an

decorated in what might be called "warehouse chic" – rough-hewn brick walls, exposed pipes and ductwork, revealed structural girders and large windows. Far from the "white cube" of normal galleries, the Tomato Gallery demands a bold statement from artists exhibiting there, and after examining the space it became obvious the simplest solution to this issue would be to print my manipulated photographs as large as possible. The images, having before been technically designed for efficiency, would now have to be designed for scale, with the maximum amount of image information possible contained in both the computer image files and the final prints.

PRESENTING "THE AMAZING KRIELS"

The restoration process was begun again from scratch. Images were rescanned at high resolutions for larger output. It was at this point in the production of *Presenting "The Amazing Kriels"* that photographic grain first became an issue in the context of my practise. Although the original damaged prints certainly contained visible grain, this had largely been obscured in the initial restorations by low resolution scans for the internet. Scanning now for large scale prints, the new digital resolutions were typically high to the point of revealing the photographic grain in the print when magnified on the screen for editing. That is to say, the pixel resolutions of the digitally stored scanned images were higher than the granular resolutions of the prints being scanned. This was an interesting effect and worth noting, but once restoration began by working on the scanned high resolution file, "effect" became "issue."

apartment with a hundred cats." This is as close an explanation of the animal remains as I can come up with.

THE INTRODUCTION OF NOISE INTO THE EDITED IMAGE

Digital restoration of analogue authored photographs, involving "digital airbrushing," the repair of scratches and dust spots, etc., has become a common practice, to the point where the standard Adobe PhotoShop software package, in its most recent iteration and as of this writing, now includes a "Healing Brush" tool for the repair of visible damage contained in the image. A common issue when restoring these photos, and particularly when they have been authored using fast films with a high relative granularity, is the introduction of a wave-like pattern of granularity where bits of the image have been duplicated successively in order to obscure a neighbouring image-defect.

Appendix B contains a basic explanation of the effect, in the context of a fascinating account of how this can create real-world issues of enormous consequence (see Appendix B, 18 Dec 1996 excerpt from reporter's transcript Superior Court of the State of California for the County of Los Angeles, testimony from the case Sharon Rufo, et al, n/a, Plaintiffs vs. Orenthal James Simpson,[24] et al, Defendants, Hon. Hiroshi Fujisaki presiding).

What is fundamentally important to us in this transcript is that any "virtually airbrushed" or "cut and paste" digital manipulation of a scanned photograph interrupts the random nature of the pattern of grain that spreads across the image. If, for instance and in the case of images from *Presenting "The Amazing Kriels,"* there was significant damage to a section of a photograph representing the left leg of an acrobat, it would be possible to pick up tonal areas of the right leg, and place them over the damaged area of the left leg. Then, in detailed areas around the "paste" from the right leg to the left leg, small areas of the left leg could be duplicated and moved within the outer borders of the left leg to provide an even tonality. What also happens, however, is a repetition of the granular patterns within the area of the left leg that has been duplicated. Were it to be duplicated several times, a wave-like pattern of granularity would occur, disturbing the overall random granularity of the image and revealing the edit that had occurred in the image (see Figure 11).

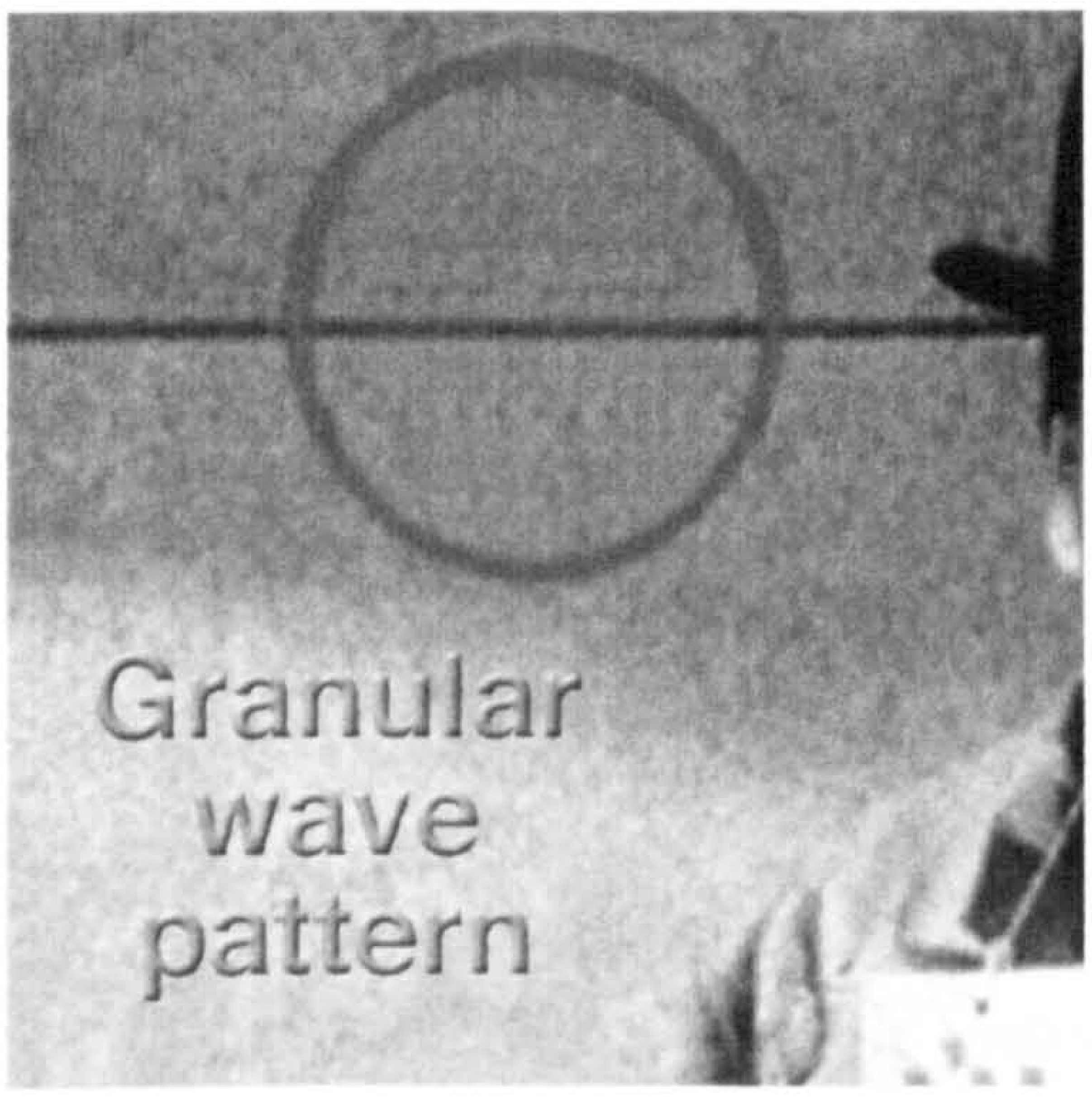

Figure 11 Granular wave pattern

There are several techniques which are used to repair this, and typically, a combination of techniques is used. One, as pointed out by the somewhat less than expert witness in the Simpson trial, is to blur the image, thus blurring out the overall "graininess" of the photograph, and therefore obscuring any irregularities in the pattern of the image's granularity, but also eliminating any trace of granularity within the image whatsoever. Were a man's life on the line, for better or for worse, this would hardly do. To do the job convincingly, after the blurring a random pattern of digital "noise" would need to be applied to the image, algorithmically. This, generally, and certainly at the time I was working on this section of the research, meant certain pixels within the image were randomly "whited out," simulating grain.[25] Then, once again, an overall blurring is applied to the image, increasing the verisimilitude of the granular effect.

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[24] O.J. Simpson, American football and film star, on trial for the murder of his wife and her alleged lover.

[25] Film grain algorithms and plug-ins are now more sophisticated, with many digital video makers using these algorithms to simulate all the artefacts of film (scratches, dust, grain, irregularities of frame-to-frame exposure, removal of frame interleaving, addition of frame jitter, etc.), thereby concealing the authoring of their imagery via video.

This effect can be further enhanced by then "writing" the digital image out to film, as was a common practice in the mid- to late-nineties, particularly in the United States, where the process costs on average less than 5% of what it costs in London. My initial experiments with restoring the images from *Presenting "The Amazing Kriels"* and then printing them large format started here. Images would be saved to CD-ROM, then sent to a laboratory in Colorado, where they would be written to 5x4 film stock. I would then have those 5x4s printed and delivered back to the UK. Unfortunately, any prints over about 20x16 were far from satisfactory, which would normally not be the case when printing from 5x4 negative stock. However the introduction of a significantly higher gamma in the negative, as well as the introduction of digital artefact, confounded by the redoubling of granularity made the prospect of printing these negatives 48" on their shortest dimension an inadequate solution. The optical enlargement of digital artefact was particularly troubling. After repeating the experiments with labs in Seattle, Washington, D.C., and London, it was clear I would need to find another solution.

At this point in my work I took the images to be printed at a large format "output" house which used the Lambda series of printers.[26] To my eye, the quality of the prints was remarkable, and far beyond that which I had observed in earlier experiments where I sent data files to a film recorder to have the images imprinted on 5x4 negative, and then printed large format via analogue lens-based enlargers.

Over the course of several months, I managed about 35 prints. These I would casually mount and hang around the walls of my Brick Lane studio, taking the time to "live with them" in order to better understand the work.[27] After several months of looking at these images (and to

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[26] Rebranded "Digichrome" prints by the local output house, No Limit (Farringdon, London). As Durst places no restrictions on the branding of print output from its Lambda series of printers, Lambda prints are, confusingly, referred to by a variety of names, depending on the printer.

[27] It has, of late, become a regular practice for me to request as part of my contract for exhibition that I be allowed to spend the night in the gallery after installing the work. This gives me an opportunity to "live with" the work

reiterate a point, they were images of my family), I began to believe that my relationship to them, as images, was significantly different than my relationship to any of the other prints of previous works in my studio. It felt as though they were strange, or disturbing, and somehow distancing. Obviously this could well have been a result of the images' content, being from another time and place as well as being my family. However, when a visit from a studio colleague, the artist Nicholas May, resulted in an evaluation of the images as being "hermetic" or "sealed off" I thought perhaps there was something more to it than the content of the images alone. What more, I had no idea what the answer might be.

Left puzzled and challenged, I was at a loss within myself to come up with an answer for this effect, until, fortunately, new solo exhibitions by the artists Andreas Gursky and Mariko Mori were held in London at about the same time.

MARIKO MORI

Mariko Mori is a Japanese artist, in her mid-thirties at this writing, who has studied in Japan, New York, and London – specifically at the Chelsea College of Art, London Institute (Cluett 1997). Her work is refreshingly diverse, from 3D video through installation sculptures and video installations, but most notably for this dissertation large scale digital photographs, with a heavy emphasis on 3D computer modelling and PhotoShop image manipulation. Lithely dancing through critical territories of nationality, religion, pop culture iconography, and gender, Mori arguably escapes classification of her work specifically within any of these discourses, playfully creating touching works of personal identity in the overall context of a mass media cultural environment of pigeon-holed brand-labelled personality types (see Figure 12, Figure 13, Figure 14, Figure 15, and Figure 16).

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itself in the context of the gallery, and gain a more intuitive understanding of the "hanging," as well as allowing

Figure 12 Mariko Mori, *Birth of a Star*, 1996 (72 x 48 in)

me time to make changes. I frequently spend the night in my studio, and find my best understanding of my work often comes on waking and seeing it there.

Figure 13 Mariko Mori, *Burning Desire*, 1998 (480 x 960 in – five panels, each 480 x 48 in)

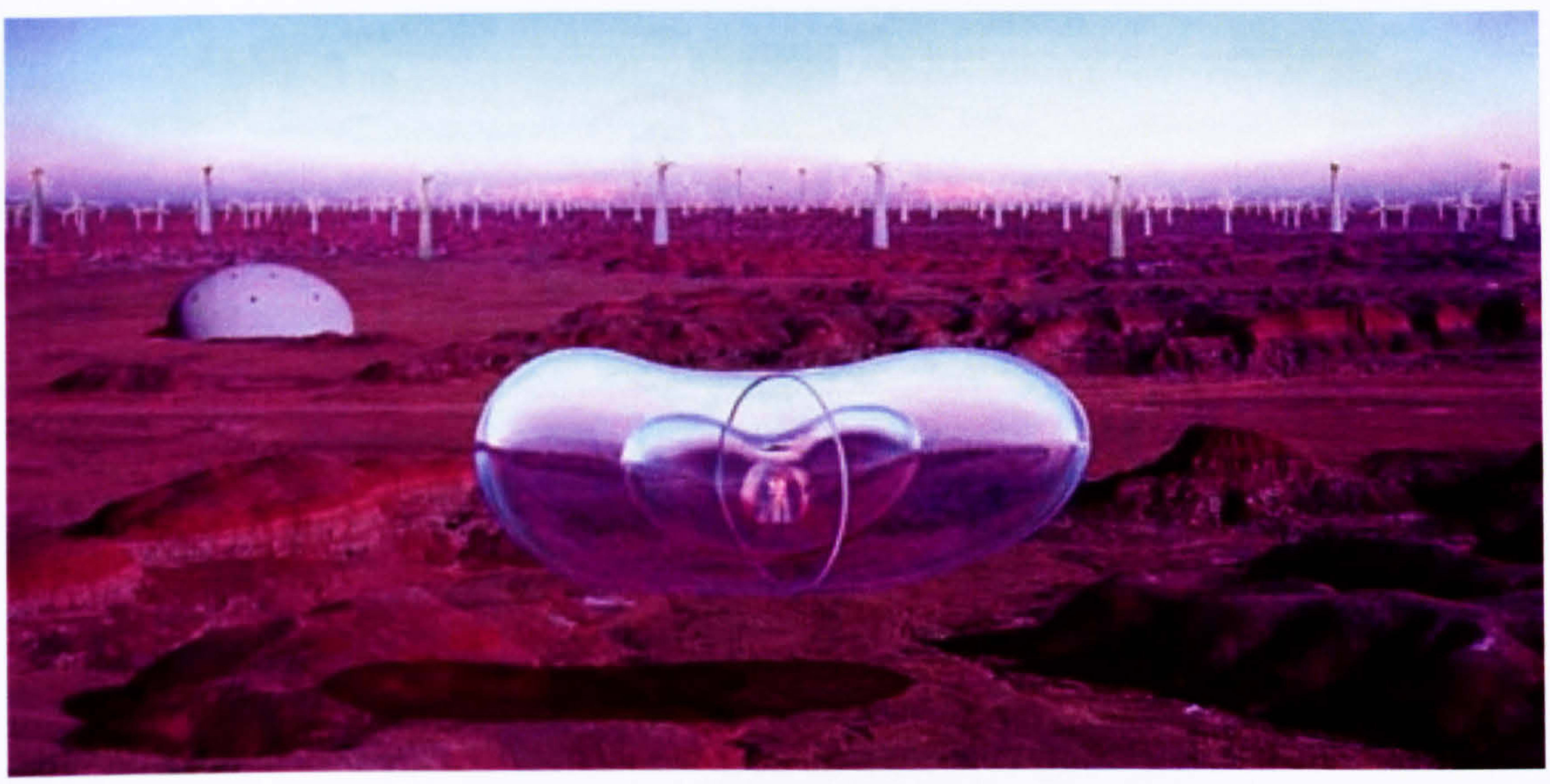

Figure 14 Mariko Mori, *Entropy of Love*, 1996 (480 x 960 in – five panels, each 480 x 48 in)

Figure 15 Mariko Mori, *Mirror of Water*, 1998 (480 x 960 in – five panels, each 480 x 48 in)

Figure 16 Mariko Mori, *Pureland*, 1998 (480 x 960 in – five panels, each 480 x 48 in)

Mori's works are of monolithic scale, with extraordinary attention to the detail of image production, and up-to-the-minute fabrication techniques for display. In *Burning Desire* (see Figure 13), for example, Mori splits the landscape-format image into five vertical panels of

48x120" for a total dimension of 10 x 20 ft. (Wolf 1998).[28] Mori uses the Durst Lambda printer extensively. As Artist-in-Residence with Fuji Japan, Mori had regular access to two Lambda printers using, one could safely assume, Fuji photographic papers.

ANDREAS GURSKY

Born in Leipzig in 1955, Andreas Gursky began his career by studying at the prestigious Düsseldorf Kunstakademie under conceptual photographers Bernd and Hilla Becher. Often compared with Casper David Friedrich, a German landscape painter whose perennial popularity is once again on the European rise, Gursky focuses on the landscapes of contemporary life. Factory interiors, merchant banking trading floors, hotel atriums and commercial display windows have all been the subject of Gursky's work (see Figure 17, Figure 18, Figure 19, Figure 20, and Figure 21).

[28] Note that 48" is the largest horizontal dimension of which the Durst Lambda printer is capable. To quote the influential and highly-respected British artist and pedagogue John Hilliard (1996), "When students ask me how large they should print their photographs, I tell them 'as large as you can afford.'"

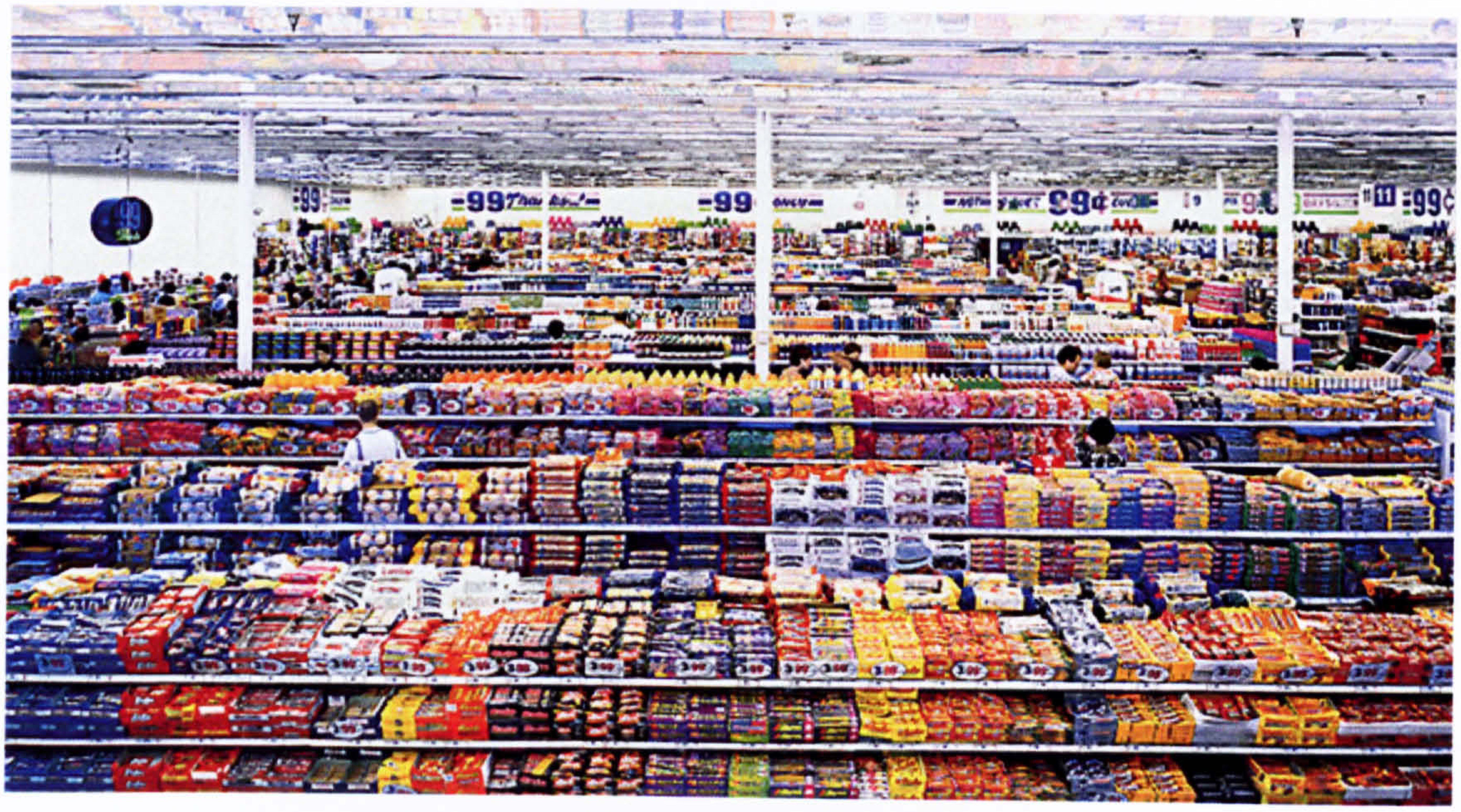

Figure 17 Andreas Gursky, *99 Cent*, 1999 (81 1/2 x 132 in)

Figure 18 Andreas Gursky, *Mayday IV*, 2000 (81 3/4 x 200 in)

Figure 19 Andreas Gursky, *Paris, Montparnasse*, 1993 (81 3/4 x 157 1/4 in)

Figure 20 Andreas Gursky, *Tokyo Stock Exchange*, 1990 (74 x 84 9/16 in)

Figure 21 Andreas Gursky, *Shanghai*, 2000 (119 5/16 x 81 1/2 in)

Many of Gursky's images are heavily computer-based, originally authored on film, then transferred to digital files and output via Durst Lambda printers.[29] Gursky worked extensively

[29] It should be noted here that establishing the printing source of an artist's work can be an arduous task. A quick search over the internet will show identical works by either Gursky or Mori identified variously as C-Type prints, Chromogenic Prints, Laser Photo Prints, and, oddly, Cibachrome, which, despite the reality of a Cibachrome or Ilfochrome print being a print made from positive transparency, has come to be grouped with prints made from negatives. It would appear that all of these labels are variously applied to a category of photographs defined in art workers' minds as "great big colour photos." Indeed, a quick telephone interview with two members of staff specialising in photographic print typing at Sotheby's London revealed the institution made no distinction between

with ZKM Karlsruhe (Centre for New Media), whose focus is on digital imaging, telematics, and the use of technologies in the visual and performative arts (Bielicki 1997).

REACTIONS AND SIMILARITIES

The differences between Mori's and Gursky's works are vast. However, there are strong similarities, particularly for two exhibitions in the same gallery, spaced so close together chronologically. Both use digital techniques extensively. Both sets of work were photographically based,[30] and contain at least one analogue source (although Mori's work also contains a great deal of 3D computer modelling). But the most impressive aspect of their similarities was one of scale (both artists were printing, typically, 48" on the shortest dimension of their works) and sensation: the presence of a quiet sense of estrangement, as in the *Presenting "The Amazing Kriels"* series.

The three series of work could scarcely have been more different in approach and content: two in colour, one black and white; one computer-modelled, one computer-manipulated, one faithfully computer-restored; one futuristic with spiritual and science-fiction overtones, one architectural and documentary with images of masses at work and play, one nostalgic with heavy references to the past and family. Yet, again, my reactions to the prints of all three artists ranged from "sealed off" through "creating a feeling of estrangement."

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prints produced via analogue enlargement methods and laser-photographic printing methods. Further, in a call to Victoria Miro Gallery, who represent Gursky in the UK, an attempt to initiate a discussion of print types drew both hesitation and, finally, a blank.

[30] As were many exhibitions throughout Europe and the United States at the time, photography having finally come into its own within the fine arts world.

This is confirmed by opinions expressed in casual interviews with other artists, and in more recent reviews available to the general public. Frantiska and Tim Gilman-Sevcik (2003), the noted Czech curators, have characterised much of Mori's photographic oeuvre as "distant [and] introverted" (it is worth noting that in the wealth of writing concerning Mori's work, shockingly little of it addresses the material nature of her highly digital practice).

Edward Leffingwell (2001), commenting on Gursky's work, noted:

> *Gursky's hermetic, almost lifeless multilevel hotel atriums astonish, draw in and then repel the viewer with the manipulated clarity of their resolution. In works such as* Atlanta *(1996),* Times Square *(1997) and* Shanghai *(2000), the broad, apparently seamless perspective of the atrium is the result of the digital marriage of two separate views, which permits the photograph to contain more information than would otherwise be possible and allows greater clarity in an enlarged image.*

Indeed, one of the principal points shared by the images of Gursky, Mori and myself are that they are not only large-scale photographic prints, but also contain considerably more visual information, due to printing at an extremely high resolution.

To quote Margaret Sundell (2000) in *ArtForum*:

> *[I]n the early '90s, Gursky started to doctor his pictures digitally.... As a result, his images his images retain crystalline definition, minuscule grain, and a high-gloss sheen.... The colors, though lushly saturated, are too metallic. He forces us to confront the presence of a technology that, although apparent, remains incomprehensible.... Gursky leaves his viewers with two options: either persist in trying to figure out how the images are made and get bogged down in an obfuscating technology; or abandon the effort entirely and submit to a pleasurable ... cognitive drift across the surface of his "allover" compositions.*

Or, as Katy Siegel (2001) says:

> *Gursky makes photographs that are at once superhuman and all too human: images that see more than we can see, in better focus, with more density of detail.*

I would later find that Gursky, although remarkably cagey in the latter part of his career about discussing his techniques and concerns, has been noted in earlier work to possess a deep concern for the surface of his photographic prints. Again, quoting Siegel (2001):

> *Because of its anonymous, industrial quality, the Kunsthalle carpet in Dusseldort (*Untitled I, *1993) makes a particularly good subject: Not only could this particular allover stretch of carpet extend infinitely, it could easily by any number of identical carpets in various public buildings. Like Gerhard Richter's gray paintings, the image presents a deadpan all-things-being-equal face. Above all, it reminds us of the photographic emulsion itself, blown up; in a double irony, the photograph is itself composed of those grains of silver.... The scale and structure of the photograph's constituent material elements and the material elements of its subject converge.*

This concern would prove enlightening to my process of research at a far later stage.

Further investigation at that time uncovered a profound similarity between the three series of images, which ultimately would lend a credence to Leffingwell's comments on Gursky: most were large scale and most were printed using Durst Lambda laser photographic printers. Could such different images printed via a similar method share a quality so distinct as to render them all subject to creating a feeling of estrangement in the viewer, and if so, how? What was the underlying issue in Durst Lambda prints?

A quick look at the company's literature for the Lambda printer exposed what was common to all of the prints beyond their use of the Lambda – and indeed this was something that had been mentioned to me earlier by the output house making my Lambda prints – Durst makes it a point of pride to remind customers that large format Lambda prints reveal no discernible granularity (Durst 1999b).[31] If this lack of granular artefact is enough to give many images of many different subjects with many different aesthetic styles a similar character, then it is clearly possible to propose: first, that these prints share an overall linguistic component within the syntax of photography; second, that that language is spoken with the accent of photographic materiality; and finally, that the phrases spoken in that language with that accent have the effect on the viewer of creating a sensation of estrangement and discomfort.

MATERIALITY INTO MEANING

For 30 years, from 1916 to 1946, William M. Ivins (1953) was Curator of Prints for the Metropolitan Museum of Art in New York. In 1953 he published the highly influential book *Prints and Visual Communication.* Ivins covered a broad range of topics within this specific volume, and suggested many ideas fairly new to the evaluation of prints both in contemporary art and in transmission of scientific data over the centuries.

Ivins' main purpose seems to be to outline critical differences between drawn (vis-à-vis textual) methods of printmaking: woodcut, etching, wood engraving, metal engraving, etc. Overriding this concern, however, is Ivins' point that via prints, man was able to describe his environment, in broad terms of classification and in the more narrow terms of scientific description, more accurately than in words; that prints, effectively, launched a revolution allowing authors and artists to *illustrate* rather than *describe* concepts using "exactly repeatable pictorial statements." The body of contemporary human knowledge is more or less, in Ivins' estimation, dependent on the invention of reproducible drawing.

[31] In fact, this was the first clue in typing the print technology used by Mori and Gursky for many of the prints in their exhibitions.

Ivins' second major point though is that accuracy in reproduction of prints was fairly arbitrary. Not only did the physical makers of prints (not always the same people as the engravers of plates) often have little familiarity with the subject they were reproducing, but the engravers themselves often copied engravings from other engravers, and knew no more of their subject matter than the workers pulling the prints.

To complicate this even further, different cultures (say 16th c. German vs. 16th c. Italian) placed different emphasis on different styles of engraving; a German metal engraving of "The Fall" would look vastly different from an Italian metal engraving concerning the same subject – not just because engravers had their own individual style, but also because they were working within the context of a larger national and cultural style. As if that were not enough, the basic effect produced by engraving in metal, where fine lines and crosshatching were easily achieved, was vastly different than the basic effect available to the artist cutting in wood, which required deeper cuts and whose substrate could not bear intricate line.

Fundamentally, a chaos of style overrides the analysis of prints, but that chaos can be ordered through an understanding that the "surface" of a print, that is the meaning imbued in an image by depth, intricacy, and density of line, has a syntax, and that the elements of this linear syntax come together to form a statement within the overall language that is "printmaking."

Prints and Visual Communication had at least one more broad idea: photography did not have a syntax. Ivins (1953), who devoted several chapters to photography, saw the photograph as a form of printmaking, and as such, a solution to the above problem. Photographic reproduction was revolutionary, no doubt, for it allowed an image to be precisely repeated without resorting to line; photography overcame linear syntax to establish a more thorough and less culturally inflected visual communication.

WILLIAM CRAWFORD

The Keepers of Light – A History & Working Guide to Early Photographic Processes, by William Crawford (1979), in its initial chapters takes a different perspective. Crawford, although highly indebted to Ivins and appreciative of what was owed, nonetheless saw Ivins' statements about photography in the same light as the reader of this dissertation might begin to see the statements by Poe quoted earlier in this thesis. To repeat:

> *If we examine a work of ordinary art by means of a powerful microscope, all traces of resemblance to nature will disappear—but the closest scrutiny of the photographic drawing discloses only a more absolute truth, more perfect identity of aspect with the thing represented* (Coke 1961).

Crawford felt that Ivins, perhaps as we see Poe, in a reverie of the revolution of knowledge and information transmission that photography created, had overlooked a simple fact of photography: it, too, had a syntax embedded in its materiality. But Crawford's emphasis was not on the fine points of line – indeed, Ivins had pointed out that photography was, more or less, without line. Nor was Crawford's point, as is mine, concerned with grain; while not overlooking the idea that all photographic prints are created from halide-based emulsions on paper, he prefers to centre his arguments on paper-making methods and the fine points of different photographic printing methods: gum prints vs. platinum prints, for instance.

What Walker did offer, however, was to say simply this: a gum print of one image means and says something different about its subject than a platinum print of the same image; Ivins is so concerned with the temporary suspension of credulity required to see a subject through the lines of an engraved print that he fails to see that viewers of a photograph must *also* look *through* a photographic printing method in order to see the subject of a photograph. Essentially, photographic prints have a syntax, over and above that of the products of traditional printmaking, and Ivins' linear syntax is not sufficient to cover that of the photographic print.

Crawford's focus in *The Keepers of Light* is on the photograph itself, with very little emphasis placed on the perspective of the viewer. A thorough technical "how-to" makes up most of the book, and never does Crawford question whether the viewer is experiencing a conscious or unconscious reading of photographic syntax, whether an understanding of that syntax is innate or learned, or what, precisely, those syntactical elements might mean to the unconscious mind of both the viewer and the maker of the photographic print.

LOOKING THROUGH THE PRINT

The idea of reading a subject *through* the material nature of its representation is as essential to this dissertation as the idea of the syntax of that same materiality.

This dissertation is concerned with two fundamental approaches to a theory of how we look *through* the granular artefacts of a photographic image to see the subject represented: one of a lack of syntactical understanding, and one of the unconscious repression of our awareness of the existence of extraneous image information.

Marshall McLuhan pointed out in 1964 that "new technologies are always used to do old tasks ... until some driving force causes them to be used in new ways."[32] In a manner of speaking, McLuhan is saying here that until a new language is developed for a new technological (read: mediated) form, then that new form will continue to "speak" and be "read" in the language of the form that preceded it. Motion pictures, when invented, were little more than containers for the work of the theatrical stage, and did not escape the stiffness of the proscenium until a pre-classical filmic language was created.

Often, when a new medium is introduced, its value is judged primarily by the way it alters access to and distribution of existing material. It is only later that people realize that the horizons of effective communication have been pushed back, and that they can now present ideas in ways that were not previously possible (Fraser 1999).

Each new media form contains the medium that preceded it until it comes into its own via the creation of a discreet language. McLuhan writes eloquently of this throughout his body of work, but easy examples include the use of stripped down laptops, initially, as deliverers of the "electronic book" (3G PDAs, with their hyper-linked, multimedia documents are obviously a better use of the technology, with more linguistic "integrity"); film as a container for the theatre and its language of the proscenium, prior to the development of a classical filmic language; or video as a container of the filmic language, before the gestures of infinite portability, tape stock, and ability to shoot in otherwise impossible circumstances worked their way into the gestural language of video-making.

But also, without a developed language to examine a new form, it is impossible at worst, and inconvenient at best, to measure the new form's defects unscientifically.[33] For example, before the introduction of the audio CD, vinyl LPs created via the then-new Direct-to-Disc Mastering techniques sounded ... amazing! The casual listener, or even the audiophile, had little innate language to discuss experientially the limitations in signal-to-noise ratios for this new media. Although it was possible to speak empirically about "noise" levels in relation to vinyl surface artefacts and in comparison to "hiss" noise levels from tape, it was not possible to speak from experience about the complete absence of these artefacts in and from recorded

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[32] From email correspondence between Dr. Alistair Fraser and Eric McLuhan, Marshall McLuhan's son, kindly provided by Dr. Fraser.

[33] As Paul Virilio (1986) has pointed out, the invention of any new technology is also the invention of the accidents of that technology – for which one must also develop a sophisticated language (for a more visual commentary, see also Virilio 2002, available online). The invention of the automobile brings about the invention of the automobile accident, which, once understood thoroughly, brings about the invention of 3-point seatbelt systems, air bags, crush spaces, and further, the festishisation of "old school" automobile accidents, as seen in J.G. Ballard's (1984) novel "Crash" and the subsequent film version by David Cronenberg (1986).

media[34] – CDs were not being produced for the consuming public at that time. To hear a disc-based recording sans surface noise was outside the experience of almost any layman.

When CDs were introduced, of course, we all understood how poor Direct-to-Disc recordings really were. Comprehension of this new language of a lack of discernible physical surface artefact came quickly, and shortly thereafter, surface noise from LPs became a fetishised and aestheticised phrase for artistic creation – most notably in the works of turntablist/composer Christian Marclay (1985),[35] but also within the popular cultural product of hip-hop groups throughout the music industry.[36] We all knew what scratches on vinyl sounded like, we just needed to hear them through their absence to develop a complex language around them.

In personal correspondence with Dr. Alistair Fraser concerning McLuhan and his theories, he related the following story, which further illustrates the point:

> *I am reminded of the experience of the radio industry when the first satellite communications were used on air as a way of [acquiring] reports from reporters in the field. The quality of the sound was so good the listeners believed that they must be faked: recorded in the local studio. So, the broadcasters added noise to the signals to give the ambience and authenticity of the older radio transmissions. The need for that passed as the public became familiar with the quality of the new medium*
>
> (Fraser 2002).

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[34] Vis-à-vis noise introduced during amplification.

[35] *Record Without a Cover* is the most notable of these. Being precisely what it says on its absent box (a "silent" record unprotected by a record sleeve, and with only a guiding groove cut into its surface), *RWAC* was released coverless, and would sit in record bins of record shops gathering dust, scratches and fingerprints until someone bought it and took it home. The sound of the collected physical material artefacts became as much a part of the sound of the composition as did the noise of shifting bottoms in John Cage's (1986) well-worn but highly influential 1952 work, *4'33"*.

An exhaustive discography of Marclay's works has been created by Patrice Roussel, and is available at http://www.northwestern.edu/jazz/artists/marclay.christian/discog.html.

[36] Herein, we potentially have a classic Lacanian obsession with the obstacle (surface scratches on vinyl) to that which we desire (audio clarity), thus creating a fetishisation of the obstacle over the original object. To borrow an

In the same way, we are aware of grain yet lack a viewer's aesthetic language of granularity to comprehend and discuss internally its absence.[37] When grain is made an issue – either from the unintentional enlargement of grain in an overly enlarged photograph, or via the war-horse of creating a sense of "nostalgia," "timelessness" or "gritty realism" through the aesthetic use of grain – we certainly comprehend that it is there. Yet we spend most of our time unconsciously looking *through* grain to see an image, unconscious of its presence or absence, in the same way we have no constant awareness of reflectance in a window when peering outside a café from within – we usually just see the pedestrians, and only notice the artefacts of the window if we consciously look for them. We have, fundamentally and unconsciously, repressed our sensory awareness of artefact in order to decrypt and understand signal.

The mechanism for human visual understanding *is* adaptable. In one example of this, Edwin Land (1986), in "An Alternative Technique for the Computation of the Designator in the Retinex Theory of Color Vision," pointed out that human colour perception (often referred to as human colour constancy) is based not on the colour of light reflected from the surface of an object, but rather on a calculation performed by the human visual system based on the colour of reflected light from an object combined with the colour of light from the scene's illuminant. In film photography, the difference in colour temperature between an outdoor "natural light" illuminant and an indoor "tungsten light" illuminant is sufficient to require photographers to change films or filters or a combination of both to render the subject of the photograph in "natural colours." Our eyes do this on-the-fly, in real time, calculating reflected luminance levels across three colour channels, then comparing them to a calculation of illuminant channel levels, determining perception of colour.[38]

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example from Slavoj Žižek (1992, pp.107-122), it is like the young man gone to pick up his date at her parents' house who becomes more interested in his conversation with the father than in the girl dressing upstairs.

[37] Which is not to say we lack a technical language for grain; from the discussion in Appendix A of noise and artefact in analogue photographic processes it is abundantly clear that this area has a strong technical language for discussion within a specialist's dialogue.

[38] Land questioned whether this calculation occurred in the retina or the cortex – thus "Retinex Theory."

Two examples based on personal experience I often give of the adaptability of the human visual system and our ability to overlook signal-blocking artefact are those of looking through a window containing reflectance, and switching from glasses to contact lenses; I experienced both of these at about the same time in my research as when first realising the disquieting effects of removing grain from a large scale image. The first example is the more common. Seated in a café looking out onto the street at pedestrians walking by, we see the sidewalk, the street, the vehicles, the pedestrians, the details of expressions on passing faces. And we hear the muted noise of traffic outside the café. What we also see are reflections in the window we are looking through, although generally we are unaware of them. It is an unconscious awareness, and as such, we unconsciously block the reflectance. If light coming through the window were an encrypted carrier of information (and in fact it is), it has been encrypted upon reflecting off the subject we see – say, a pedestrian. Passing through the window, artefact or noise is added to the signal when the reflectance of the window becomes a part of the information channel. Light then reaches our eyes, and the information is decrypted. Part of the process of decryption is separating out signal from noise. Our object is to see the pedestrian. We unconsciously repress our conscious awareness of the artefact that is the window's reflectance. We suppress the noise. We see the pedestrian clearly.

Walk into the BBC's Television Centre in White City in the west part of London, however, and casually looking through the window is a different experience altogether. A huge atrium reception room greets the visitor to the building. Revolving doors and oversized thick-panelled glass form the entire street-side wall of the atrium. Light streams in to naturally illuminate the room. Not unlike a very large café – but in this case there are two differences: the glass is so thick you cannot hear the traffic going by outside over the interior ambient sounds of the room; and the glass is nearly completely non-reflecting.[39]

[39] BBC Television Centre was severely damaged by a terrorist attack during the writing of this dissertation (BBC News 2001). Once repair is complete, the effect described here may no longer occur.

It is a very strange experience the first time you spend any time in this room. You know the traffic is outside because you can see it, but you cannot hear it at all. Logically, this would lead you to believe there was a very thick glass between you and the traffic, and in fact there is, but your normal evidence for the glass – that is, reflectance – is absent, and you find yourself, in a slightly disquieting moment, seeking out the edges of the glass; the architectural reinforcements holding the huge sheets in place. You are looking for any evidence of the thing that causes this strange quiet surrounding you even though you are only metres from a busy four-lane city traffic conduit. Reflectance in windows, in general, has become noticeable precisely because of the immediate absence of reflection in the glass of the BBC Television Centre atrium. Our unconscious function of suppressing the existence of or repressing our conscious awareness of reflectance in window glass has been mediated off onto the anti-reflective technology of the glass used in constructing the atrium. Our individual organism's functioning adaptation for removing noise from signal when looking through a window glass has been turned around by a technological mediation, forcing a second adaptation onto us. And, indeed, we do adapt. During my research, I worked for the BBC and visited Television Centre often. After a couple of weeks, only in the context of my research did I ever again think about the strange thick invisible wall that hermetically seals the interior world of the BBC.[40]

The second example is that of switching from wearing glasses to contact lenses. Beginning to wear glasses at an early age, and continuing to wear them almost constantly until the age of 35 I had become accustomed to having my vision boxed-in; large bars of plastic blocked my peripheral vision when I wore glasses. At 35, and shortly after the start of my research, I switched to contact lenses. Modern contact lenses are light, thin, flexible, gas permeated, and nearly unnoticeable once in the eye. However, for the first week after switching from glasses

[40] The effect we are describing here is by its very nature transitional and part of an overall cycle, as we shall see later in this thesis.

to contacts, I suffered serious vertigo. Why would this be the case? I asked my optician, who said that the circumstance was so common as to be nearly universal; it takes time to readapt to once again possessing peripheral vision without distortion. In other words, it takes a while to get used to having normal vision. It also takes time for an individual to adjust to **not** having their periphery obscured by a plastic frame around their eye. They haven't thought about or been consciously aware, on a moment-to-moment basis, of the blockage. They've repressed their conscious awareness of the presence of noise in the signal of their vision. Their unconscious repression of the noise of the plastic frame of the glasses has now been mediated onto contact lens technology. As they first adapted to having frames surround their lenses and having a part of their vision blocked, they must now adapt again to having clear unobscured peripheral vision.

These are personal but highly illustrative examples. There is also abundant clinical evidence of adaptability within the realm of a cognitive perspective on the human visual mechanism (see Adelson & Moyshon (1982); Barlow (1972); Bennet & Malek (2000); Bridgeman (1993); Campbell & Robson (1968); Richardson & Webster (1996); Wallach (1948); Weiskrantz, Warrington, Sanders & Marshall (1974); Zhou & Baker (1993); and Colborn (1999) for just a few examples). Further, within linguistic study, psychologist Jennifer Freyd (1983) has argued that some of our cognitive processes have become adapted to the demands of "shareability", a function which would demand constant update, not generation to generation, but moment to moment within a single organism's lifetime. Working out from Freyd's study, evolutionary psychologist Geoffrey Miller (2001, p.366) suggests that:

> *...we may tend to perceive some naturally continuous phenomena in discrete ways, just because it is easier to give verbal labels to discrete categories than to points on fuzzy continua. Applied to verbal courtship, Freyd's shareability idea suggests that sexual selection may have made human mental processes well adapted for producing*

romantically attractive language, not just effective survival behaviour.

Given the speed of constant changes in language, cultural backdrop, verbal fashion, cross-cultural mating signals transmitted via popular global media, and acceptability levels of sexual promiscuity from decade to decade, it becomes easy to see not only that the human mechanism is adaptable – clearly in terms of linguistic reception and transmission, whether verbal or visual – but also to see the pace at which that adaptability function can operate across an entire (for our overall case, visual) culture.

However, these are only a background against which perception of human vision and image comprehension is to be understood, and against which to demonstrate the existence of visual adaptability at a cognitive rather than psychological level. None of these leading examples stand to give an explanation of the effect outlined previously – that is that which is created for the viewer when encountering a large scale grain-free Lambda photographic print. Cognitive science is still a hugely diverse field, without anything approaching a "grand unified theory" yet to be discovered; leading theoretical perspectives regarding a psychology of vision still tend to look more toward the art theoretical than the scientific (see Luuk 1980), as, indeed, does this dissertation.

MEDIA, LANGUAGE AND ANALYSIS –

A PSYCHONANALYTIC APPROACH

HOME AT LAST

Noting at this point in the continuum of the research that the one thing to go on in establishing a cause for a sense of estrangement from a large scale Lambda print was a significant reduction if not total elimination of grain, the next practical step in the research was to create images that eliminated visible granularity on every level. When working from Blackwell's images for the *Presenting "The Amazing Kriels"* series, a fuzzy, overly-enlarged pattern of grain was still present, although it had taken on more the tenor of a surface tonality than an overall granularity. What once were spaces of non-image information between granular image elements had now become smoothed out through the process of upward scale interpolation. However, because of the extreme small size of some of the original prints, as well as the age and (poor) quality of granularity in the originals, an odd mottled noise quality existed across the surface of the large-scale prints. Not quite grain, not quite photographic noise, the mottling of tonality nonetheless formed a sort of smoothed digital noise on the images.

The *Home At Last* series was designed to get around this. *Home At Last* was also influenced heavily by the abundance of landscape photography making the rounds of European galleries in the late 1990's. Owing in part to the Düsseldorf Kunstakademie lectures of conceptual photographers Bernd and Hilla Becher, the banal landscape had become a "hot visual topic" in the art world to the point of finally permeating the popular culture press. Intentionally banal and uninflected landscape photographs could be easily had in nearly every fashion and fashionable art magazine of the moment. This also seemed to fit the emotional topic I wished to approach. However, it was critical to me that my work approach the dialogue from an original direction.. Finally, the work needed to reflect the state of my research at the moment, and lead me to new findings. Thus, I decided it must be photography, be free from any traditional analogue photographic artefacts, and be printed large scale on Lambda printers.

I found the answer in 3D modelling (see Figure 22, Figure 24, Figure 25, Figure 23 and Figure 26).

Figure 22 Charles Kriel, from *Home At Last* series (48 x 64 in)

Figure 23 Charles Kriel, from *Home At Last* series (48 x 97 in)

Figure 24 Charles Kriel, from *Home At Last* series (48 x 64 in)

Figure 25 Charles Kriel, from *Home At Last* series (48 x 68 in)

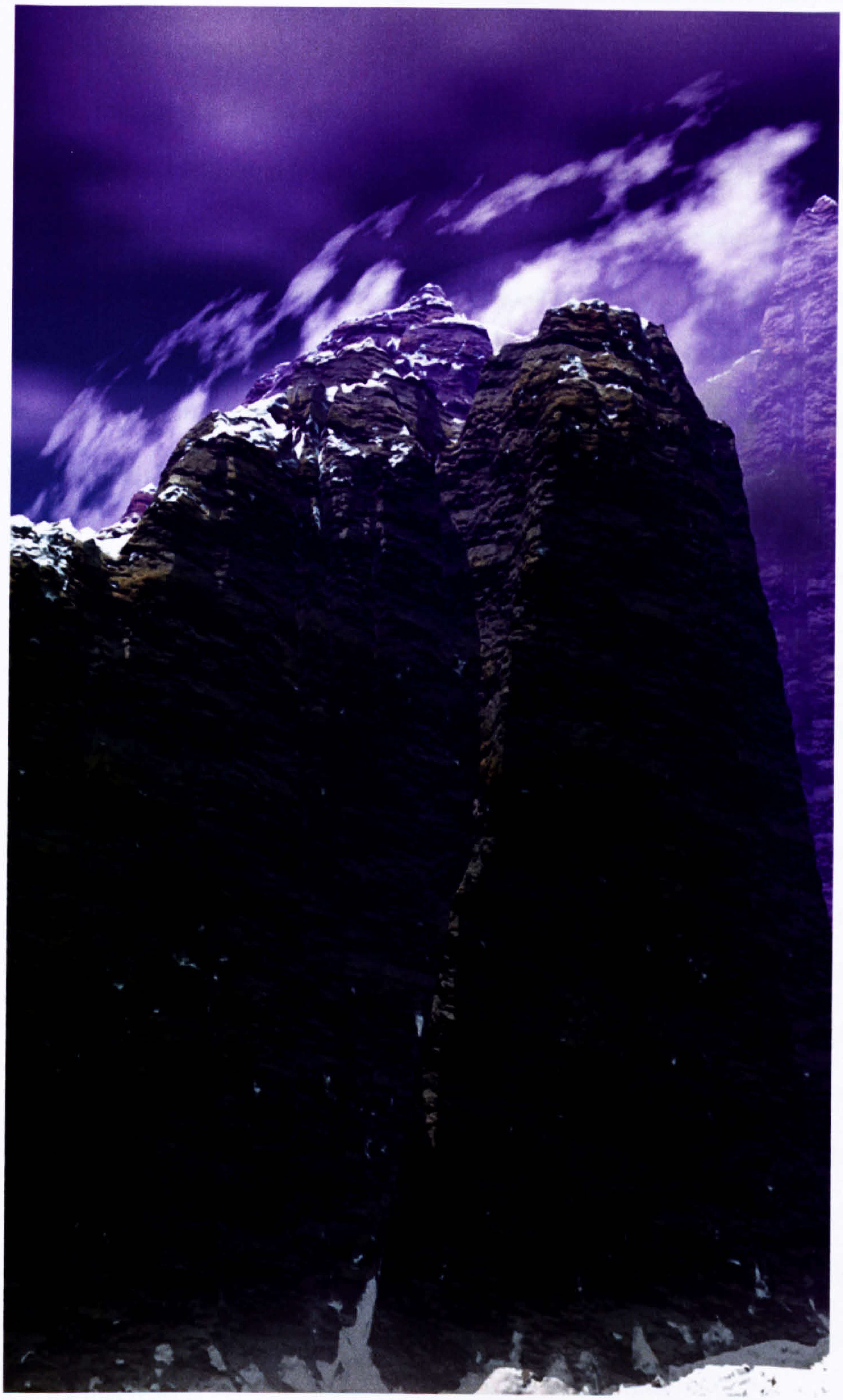

Figure 26 Charles Kriel, from *Home At Last* series (80 x 48 in)

An examination of the fundamentals of 3D computer modelling is outside the parameters of this research, however, 3D modelling technology has advanced considerably over the past decade. This is particularly true in still imagery, and the modelling of natural scenes. Raytracing, a technology that traces every ray of light in a scene, from illuminant through reflectance and refraction to the eye, has made the use of more natural materials a simple though time-consuming process. Also, the specific introduction of volumetric material algorithms, which allow variables in the internal density of an object to be based on the algorithmic properties of materials applied to the object, has allowed for more realistic modelling of difficult objects such as water, clouds, haze and atmospheres. This seemed the perfect medium for the *Home At Last* series.

I set several parameters for myself in producing the work, some technical, some aesthetic:

All work would be raytraced and use volumetric materials. Raytracing is one of several methods for producing two-dimensional views of three-dimensionally modelled scenes, as are Scanline and Z-buffer rendering. Raytracing differs in that it mimics actual physical effects associated with the propagation of light, and was chosen for its superior quality. Volumetric materials have the quality of displaying images of volume data, which is to say, they communicate the appearance of an object according to the three-dimensional volume of the space occupied by the object, rather than attempting to communicate the object's surface. Light will pass through a cloud, for example. Volumetric material modelling takes this into account during the raytracing process, and not only communicates information about how the light passes through the cloud, but also about what happens to the light once it has passed through the cloud and reached other objects. Again, this is a superior method of three-dimensional modelling and was selected for that reason.

All the works would be printed at 48" on the shortest dimension, and printed on Lambda printers. The 48" dimension was preferable as it is the largest paper width the Lambda can accommodate. By making this the shortest dimension of the images, the prints would achieve the largest size possible without tiling. To accomplish this, obviously, budgets would be beyond the reach of the funding for my PhD. Also, it was very important that I had the opportunity to examine the works and ask for reprints if any defects existed or changes needed to be made – only adding to the budget requirements. Finally, it was critical that the machines upon which the prints were made were accurately calibrated, with fresh processing chemicals, and printed by the best print technicians available – all of this to insure minimal introduction of artefacts. I approached Durst, the manufacturers of the Lambda series, at their headquarters in Bressanone-Brixen, Italy, and they agreed to support my research by allowing me to do all of my printing in their research lab. This gave me access to a great deal of practical information and many images from different photographers printed on the Lambda series of printers, as well as access to what are possibly the best calibrated Lambda printers in the world.

The images would not be modelled on any existing landscape, but rather on my imagination, allowing a stronger emotional content and more opportunity for sublimation. When I made the first one (see Figure 22), I realised to my astonishment I didn't really know what a mountain looked like, nor the sky. This did not seem a hindrance in any way, although it encouraged me to make a study of skyscapes as well as natural mountain scenes. Because Durst Phototechnik A.g. is located in a mountain ski resort in the historically Austrian part of Italy at the base of the Dolomites, I was able to learn, over the course of the year I worked on *Home At Last*, the physical qualities of a mountain. Over that summer, I also arranged to live in nearby Venice (home of the closest reasonably-priced air destination from London), which is known for its beautiful skies, and indeed this was instructive in my "natural history" self-education.

Verisimilitude would be privileged in the modelling of the mountains. I also chose to use the aesthetic model of the classic mountain scene postcard photograph, with its emphasis on rich colour and "golden mean" composition. This somehow seemed appropriate in an ironic sense, as the Durst company, still family-owned, was founded on the invention of the "cluster pack" lens, manufactured and sold to 19th c. postcard printing businesses in nearby ski resorts.

None of the images would contain any signs of life within them. It was essential, in my mind, that the landscapes be bereft of any of the warmth one associates with the landscape postcards previously mentioned. Also, the visual cost to the realism of the images would be considerable, given the relatively poor state of technology for rendering natural trees, plants, and grasslands.

The landscapes would show no traces of the existence of human life, either. No footprints, buildings, etc. The phrase ran through my mind, as a mantra in the creation of the work, "unmolested beauty is essentially banal." Banality, but from a different perspective than the Becher-esque dialogue, was critical to the work.

The images would be rendered at the highest possible resolution. There were considerable limits to this. The computers available as part of my research were limited to three PIII 450 MHz PCs with limited RAM, and a G3 266 MHz Mac PowerBook, on which most of the images were modelled. The goal was to develop images that were around 100 Mbytes. On machines of this speed, some renders took as long as three weeks, and in retrospect, the images needn't have been rendered at such high resolution (von Aufschnaiter 1999). However, at the time it was important to the research to insure no artefacts made their way into the images.

The rendered images would be touched up in PhotoShop at the highest resolutions. This was to insure that no hard lines along vertices gave the images the appearance of having been 3D modelled.

Two of the images were exhibited several times, both casually and formally, but most notably in two exhibitions in London galleries and one at the British Council Gallery in Prague, Czech Republic.

As expected by this point, regardless of setting, gallery, hanging, etc., a repeat of my earlier experiences of a hermetic sense about the work was present. Even more interestingly, the sense of disquiet was compounded by a moment of vibration between "looking at a photograph" and not knowing what one was looking at in *Home At Last.* Many of the images do indeed look like photographs in content, but formally look somehow different.

What I did have, at this point, was substantial case for proposing that grain-free photographic prints had the potential to create a feeling of disquiet in the viewer unaccustomed to seeing photography in that form; that this sense of disquiet was probably related to the mediation of the unconscious function of noise suppression/repression onto new and unfamiliar technologies; and that the effect was reproducible from one series of work to the next. What I also had was the beginning of an idea of why this might be happening; an idea gathered on a return trip from the Dolomites and brought about by rereading the classic work of communications theory, Marshall McLuhan's *Understanding Media, the extensions of man,* as well as his intended update on the text, *The Laws of Media.*

PSYCHICAL AUTOAMPUTATION

Marshall McLuhan (1964) stated his case succinctly in the title of his work *Understanding Media, the Extensions of Man.* McLuhan felt that man had extended his perception, his senses, and thereby his consciousness, through media. In his essay *The Gadget Lover, Narcissus as Narcosis* (1964, pp.41-47), he states that the need for extensions of man arose from the superstimulation of psychical and physical pressures on the body and the nervous system; all extensions of man are to be considered media. In his brilliant summation of a life's work in media theory, *Laws of Media* (McLuhan & McLuhan 1988) written with his son Dr. Eric McLuhan, the elder McLuhan quotes extensively from a broad range of literature to back his case:

> (McLuhan & McLuhan 1988, p.374) *The effect of stimulations, external or internal, is to break up the unison of action of some part or the whole of the brain. A speculative suggestion is that the disturbance in some way breaks the unity of the actual pattern that has been previously built up in the brain. The brain then selects those features from the input that tend to repair the model and to return the cells to their regular synchronous beating. I cannot pretend to be able to develop this idea of models in our brain in detail, but it has great possibilities in showing how we tend to fit ourselves to the world and the world to ourselves. In some way the brain initiates sequences of actions that tend to return it to its rhythmic pattern, this return being the act of consummation, or completion. If the first action performed fails to do this, fails that is to stop the original disturbance, then other sequences may be tried. The brain runs through its rules one after another, matching the input with its various models until somehow unison is achieved. This may perhaps only be after strenuous, varied and prolonged searching. During this random activity further connexions and action patterns are formed and they in turn will determine future sequences.*
>
> -- *J. Z. Young* (1951, pp.67-68) [41]

> (McLuhan & McLuhan 1988, pp.374-375) *Today man has developed extensions for practically everything he used to do with his body. The evolution of weapons begins with the teeth and the fist and ends with the atom bomb. Clothes and houses are*

[41] McLuhan fails to include what is Young's arguably greatest and most pertinent quote (Brockman 1996), "Man creates tools and is moulded by his use of them."

extensions of man's biological temperature-control mechanisms. Furniture takes the place of squatting and sitting on the ground. Power tools, glasses, TV, telephones, and books which carry the voice across both time and space are examples of material extensions. Money is a way of extending and storing labor. Our transportation networks now do what we used to do with our feet and backs. In fact, all man-made material things can be treated as extensions of what man once did with his body or some specialized part of his body.

-- E. T. Hall (1959, pp.56-57)

And, interestingly:

(McLuhan & McLuhan 1988, p.377) *The human body is the magazine of inventions, the patent office where are the models from which every hint was taken. All the tools and engines on earth are only extensions of its limbs and senses. One definition of man is "an intelligence served by organs."*

-- Ralph Waldo Emerson (1870, p.151)[42]

The mediation of human functions grows out of accelerated pressures, stresses and irritants to the human nervous system, and spurs the invention of new extensions. For example, the need to move greater burdens across longer distances creates a stress on the man who must bear the load. In response, he is spurred on by his own "irritation" to invent the wheel, a mediation of the functions of feet and back. The irritant of myopia, brought on by increased looking at close distances (read: reading) spurs man to invent glasses, a mediation of the function of the cornea. The fleshy padding around the calcaneus is well-equipped for absorbing the shock of running through a field; that same padding is *ill*-equipped for barefoot daily jogging through

[42] Emerson may have taken this definition from Louis de Bonald (1796), *Théorie de Pouvoir Politique et Religieux* (Moulinie 1979).

the concrete jungle. The added "irritation" of harder surfaces spurs the invention of the air trainer. However, the design of the air-enhanced trainer is not simply the invention of an arbitrary device to absorb shock in the body. It is a mimetic signifier of the reaction to impact of the fleshy heels of the foot. Further, these air-shock systems act as amplifications of the isolated function of the human heel during impact. The function of the heel has been mediated.

There is, however, a cost to pay for these mediations. McLuhan calls it "auto-amputation," and relates it to the stress brought on by an amplification of the mediated function onto the new "extension of man." Quoting A. T. W. Simeons (1960) from *Man's Presumptuous Brain* (pg. 43):

> (McLuhan & McLuhan 1988, pp.375-376) *But when, about half a million years ago, man began very slowly to embark upon the road to cultural advance, an entirely new situation arose. The use of implements and the control of fire introduced artifacts of which the cortex could avail itself for purposes of living. These artefacts* [sic] *had no relationship whatever to the organization of the body and could, therefore, not be integrated into the functioning of the brain stem.*
>
> *The brain-stem's great body-regulating centre, the diencephalon, continued to function just as if the artifacts* [sic] *were non-existent. But as the diencephalon is also the organ in which instincts are generated, the earliest humans found themselves faced with a very old problem in a new garb. Their instinctive behaviour ceased to be appropriate in the new situations which the cortex created by using artifacts [sic]. Just as in the pre-mammalian reptiles the new environment in the trees rendered many ancient reflexes pointless, the new artificial environment which man began to build for himself at the dawn of culture made many of his animal reflexes useless.*

A counter-irritant is added to the equation in the human psyche when a natural function is extended onto a mediated form. To cope with our auto-amputation of a human function, we create a discrete numbness in reference to the function. In the case of the wheel, McLuhan (1964, pp.42) declares the stimulus for its invention to be the "pressure of new burdens resulting from the acceleration of exchange by written and monetary media." To cope with this, the function of the feet in rotation (walking) is both mediated and amplified onto the wheel. The amplification is made bearable to the central nervous system by unconsciously numbing awareness of the function of the feet – a repression of perception. The irritant to the psyche is auto-amputated and amplified via mediation, which in turn creates a counter-irritant, dealt with via a repression of perception.

Anyone who can remember the first experience of walking or jogging in air-enhanced trainers is familiar with the strange extra spring added to your gait. There is something amplified via this mediation, but there is also something missing. Impact on the heel. The runner can be more bold with their gait than ever before. Further, the runner's grip on the track is more firm and their contact with the pavement more stable. The actual role of the entire foot in running has been radically altered simply by slipping on a pair of trainers, and the body must act differently from this point forward whenever running. How then, psychically, does the runner negotiate this change in the role of the foot and heel during the mimesis of the unenhanced action and function of the foot and heel? How does the runner "keep it down" and avoid psychological and physical confusion between running barefoot and running with trainers?

To explain, McLuhan referred to the work of medical researchers Hans Selye and Adolphe Jonas who held that "all extensions of ourselves, in sickness or in health, are attempts to maintain [psychical] equilibrium. They regard any extensions of ourselves as 'auto-amputation,' and they find that the auto-amputative power or strategy is resorted to by the body when the perceptual power cannot locate or avoid a cause of irritation." To be clear: the air-enhanced trainer is a response to the irritation created by running on hard surfaces. A function of the body is amputated from the body and placed on the trainer. In turn, however, the trainer "brings about a new intensity of action by its amplification of a separate or isolated function" – shock absorption by the human heel.

The irritation of the psychic amplification of the isolated function of the shock-absorptive action of the human heel, fetishised through the trainer, must now be borne. McLuhan maintains that such amplification is borne by the nervous system only through repression of perception, or an unconsciously self-induced numbness.

➔ Irritant	leads to
➔ Auto-amputation	and
➔ Amplification	via
➔ Mediation	which creates as side-effect
➔ Counter-irritant	coped with via
➔ Unconscious repression of conscious perception[43]	or "numbness"

➔ Additional external social pressures then create a new irritant...

McLuhan (1964, p.46) is clear on what takes us from the sixth phase of this "cycle" back to the initial "irritant" step:

> *Socially, it is the accumulation of group pressures and irritations that prompt invention and innovation as counter-irritants.*

Social and group pressures prompt new invention, creating an ongoing cycle of technological innovation which McLuhan (1964, p.45) claims places man in the position of being the "sex organs of the machine world."

Are we not missing something here, though? McLuhan, in the middle phases of his cycle of technological reproduction, points to the internalisation of external mediations – which in and of themselves are psychically sourced internally – then dramatically shifts to a strictly external pressure to complete the cycle. *Social* pressure creates an irritant. We counter this irritant through innovation of media forms, then face *internal* pressure at an amputation of a part of our own psyche, then forcefully numb ourselves to our self-amputation. At which point we succumb to social pressure once again.

It is almost superfluous to say that, in the realm of psychological poetics, the initial irritant is self-sourced, and McLuhan's "moon-milking" of the psychological and social appears overly-constructed. Is it not possible, in fact, that the unconscious repression of conscious perception is itself the irritant that spurs further innovation? And were that the case, what spurred on the initial innovation within a mediating cycle?

→ Irritant	leads to
→ Auto-amputation	and
→ Amplification	via
→ Mediation	which creates as side-effect
→ Counter-irritant	coped with via
→ Unconscious repression of conscious perception	which is a new...
→ Irritant	

To examine this proposal, we must first examine the fundamentals of the notion of repression, it's knock-on effects, as well as another essential notion of McLuhan's theory of media – media "hot" and "cool."

[43] McLuhan uses the term "numbness."

"HOT" AND "COOL" MEDIA

McLuhan most famous dictums concerned "hot" and "cool" media. This...

> *...referred to the different sensory effects associated with media of higher or lower definition. "Hot" media ... are more full of information and allow less involvement of the user; "cool" media ... are less full of information and allow much greater sensory participation by the user* (McLuhan & Zingrone eds. 1995, p.3).

The more information (according to McLuhan's model), or higher a resolution within a media form, the "hotter" it becomes. Television, although filled with an almost infinite variety of content, as a material medium was classed considerably "cooler" than film. With very few lines of horizontal resolution, the small screen against the wall of the living room demanded viewers be pulled in. Film, McLuhan felt, was much higher resolution with considerably more information, pushing the viewer away.

The concepts of "hot" and "cool" media are probably amongst McLuhan's most confusing, perhaps because they lack a critical conceptual element. In McLuhan's estimation, cinema is hotter than television – that is, less involving. Comic books are cooler than photography – more captivating. This is counter-intuitive; personal experience would seem to instinctively speak otherwise, and perhaps therein lies the source of confusion.[44]

The essential flaw with a conception of high resolution media as less involving than low resolution media seems to lie in the idea that high resolution media provides more information — that is to say, McLuhan equates "information" with "signal." He is never quite clear in separating his terms, creating a great deal of confusion.

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[44] This confusion is entertainingly, and more than a little accurately, documented in Woody Allen's (1977) classic film, *Annie Hall*, in which McLuhan himself makes a cameo appearance.

Within information theory, noisy, low resolution, lossy media, contrary to McLuhan's estimations, contain an equal amount of information to hot media, but a significant part of that information is artefact or noise.

Noise cannot be separated from signal in terms of one being information and one being non-information. Although noise and signal are separate entities, noise and signal are both information. This is a basic concept of information theory, and has been well-covered across myriad publications on the subject. Considered in this way, if we return to a photographic model, a 6'x4' print enlarged through traditional analogue optical printing contains the same amount of information as a 6'x4' Lambda digital laser-photo print. However, the analogue print contains a great deal of *non-image* information. Some of its information is image (for the most part, and in an image of average density overall, the granular elements) and some of it the white space between enlarged granular elements. In the Lambda print (practically and to the eye) all of the information in the print is image information – it is all signal. Were we to cut out equivalent sections of each print and scan them digitally, the uncompressed digital file sizes would be identical. The white spaces between the grains of the analogue print would still need to be registered according to density and colour. They contain the same amount of information.

Noise is that information which is extraneous to signal, but it is all information.

In McLuhan's configuration, the Lambda print would be "hot" media and the analogue print "cool" media *only* if the Lambda print could be said to contain more information than the analogue print. In that case, we would naturally be less involved (according to a "hot"/"cool" media paradigm) with the Lambda print, and that would seem to satisfy the basic question being asked within this dissertation – why are we estranged from Lambda prints when we are initially introduced to them. Because, in fact, the Lambda print contains more signal and less artefact than the analogue print, but an equal amount of information, McLuhan's idea simply does not work.

There is, however, a case to make for the Lambda print as the "hotter" version of large format photographic printing, but only if we augment McLuhan's premise thus:

> *"Hot" media are signal rich; "cool" media are artefact or noise rich. Both allow equal sensory participation by the user, however, in "hot" media that participation is weighted toward conscious participation; in "cool" media, a significant portion of participation is taken up by the function of separating information into signal and artefact, consciously engaging with signal, and unconsciously repressing noise. "Cool" media only* seems *to involve us more – in fact, participation in the information is equal but divided.*

This need to unconsciously repress our awareness of artefact or noise is the second irritant in the cycle of engagement with mediation. It is also possibly the impetus that drives technological innovation. Most media eventually move from "cool" to "hot" as we are constantly driven to decrease artefact. We are, therefore, confronted with a "heating up" of a media each time a significant leap is made in the transmission of signal over noise. Each time this happens, we are left less irritated. However, our unconscious is left with less to do, and this is the meta-irritant of any motion toward an increase of signal over noise. This, in itself, creates a new sense of disquiet, for we are confronted by our own unconscious function's irrelevance in the face of a *mediation* of its function. We have previously unconsciously adapted to the presence of noise, and now must again adapt – this time to the absence of noise. Faced with the confusing irrelevance of our own desire to inject meaning, understanding and signal into a noisy information channel, once that channel is filled in by technology, that is to say, *once our function of noise repression has been mediated onto algorithms performing upscale image interpolation functions, and we are confronted by that mediation,* we are also confronted by our own unconscious function of repression by means of its very absence. Where we have unconsciously speculated the content of signal, were there signal in place of the noise we are seeing, algorithms now speculate this content, aiding clarity. That which we have repressed has been powerfully returned to us by its very absence – and we experience what Freud (1919) called the "*unheimlich,*" or the "uncanny."

THE UNCANNY

The uncanny (*unheimlich*) is the return of the repressed familiar, creating a feeling of disquiet, estrangement and "anxious ambiguity." Foster (1993, p.7), in a brief overview of Freud's theory, outlines the primary effects: 1) ambiguity between the real and imagined; 2) confusion between the animate and the inanimate; and 3) an "eclipse of the referential by the symbolic" or an overtaking of the signified by the signifier.[45] Freud (1919, p.368) comments on the uncanniness of female genitals for male subjects:

> *This* unheimlich *place, however, is the entrance to the former* heim *of all human beings, to the place where everyone dwelt once upon a time and in the beginning. There is a humorous saying: "Love is homesickness"; and whenever a man dreams of a place or a country and says to himself, still in the dream, "this place is familiar to me, I have been there before," we may interpret the place as being his mother's genitals or her body (see* Home At Last*). In this case, too, the* unheimlich *is what was once* heimisch, *homelike, familiar; the prefix* "un" *is the token of repression.*

The repetition compulsion, that is, the tendency of the subject to expose himself cyclically to distressing situations, and its inextricable link with the death drive, combined with their interweaving of Freud's castration complex are the fundamental avatars of the uncanny.

[45] Freud's theories long predate Jean Baudrillard's (1983) notion of second order simulacra, which articulates the condition whereby reality is judged by it's simulation – that is, the signified is overtaken by the signifier.

A thorough explanation of Freud's concepts of repression, castration fears, death drive (*Thanatos*), repetition compulsion and *jouissance* are hardly needed within this thesis. They have been well-covered elsewhere. None of these terms, however, are absolute, as can be seen when accessing the debates contained within specialist psychoanalytic and art theoretical literature. Therefore, a brief overview of each is given earlier in this thesis, with an emphasis on those points significant to the argument, and a reference to the way they are defined within the context of this thesis and its arguments.

CONCLUSIONS:

REDEFINING THE PRACTICAL RESEARCH,

IN THEORY AND IN PRACTICE

In this dissertation, I have reviewed the case for artefact within photographic printing, articulated a significant difference between the artefact levels of analogue and Lambda prints, presented original dialogical evidence for an estrangement of the viewer in the latter, and identified that, via a reading of Freud, as a function of the *uncanny*. I've proposed an original rewriting of McLuhan's ideas of "hot" and "cool" media, as well as the cycles of irritation/mediation/repression within media theory, and related them to a shift from large scale analogue photographic printing to Lambda printing. An original theory of the drive toward the heating of cool media, and an original reading of mediation in general has also been proposed.

This has been illustrated via the example of an examination of Lambda laser photographic large scale prints.

At this stage in the overall research, it is necessary to re-evaluate by example the practical research on the basis of the new reading of photographic materiality.

PRESENTING "THE AMAZING KRIELS"

The photographs from *Presenting "The Amazing Kriels"* started in analogue form. On old film stocks printed on less technically advanced paper than what is available today, the original small prints exhibited high degrees of granularity when magnified, with a great deal of noise in the information channel. When printed large via Lambda printers, much of the grain was retained, although "smoothed out" to a degree. The smoothing was sufficient to approach the quality that induces a sense of the uncanny, yet still, grain was part of the language of these images.

A revised look at the images, in context of the conclusions reached via the theoretical research gives a more thorough understanding of what happens in the images, and why the uncanny is still a part of them, despite their retention of a certain granular quality.

As stated much earlier in the thesis, the resolution of the scans used for printing was sufficiently high as to begin not only to represent tonalities within the overall image, but also to represent the tonalities of noise contained within the original prints – which is to say, not only was image/signal information scanned, so was grain/noise information.

The grain of the original prints – or more specifically the non-image information between the granular elements – was broken down in the scanning, upward image interpolation, and Lambda printing processes to become image information for what is fundamentally a new image signifying both subject matter and noise in the original prints. The representation of the content of the photographs was mediated from the granular elements onto the picture elements (pixels). So, too, was the noise. The functions of grain were mediated onto the pixels, but so was the grain itself. Within this context, a contemporary naturally "grainy" photograph (*any* naturally grainy photograph) characterised by limits of technology and overly large analogue printing becomes *impossible* without resorting to signification. Granularity, because of the advance in printing technology that the Lambda printer represents, has now become a linguistic/aesthetic/semiotic choice made by the photographer. When it is possible to print at (theoretically) any size without visible granularity, the presence of grain (or print surface noise of any kind, including screens, inkjet dithering, etc.) must always be attributed to a gestural choice made by the artist.

This throws the grainy photograph into a new position of significance. Are grainy photographs now to be considered ironic? Are they nostalgic attempts to recapture something lost? Have they become kitsch and in "poor photographic taste?"

It is useful as well to understand that Lambda prints and traditional analogue prints share the same formal problems – they both attempt to represent the subject in a literal way, despite whatever stylisation might arise. Camera-based photography still occurs in the moment, and images are still made via light falling from a scene onto a recording media, whether film or photosensor array coupled with digital storage media. Whatever manipulations occur afterwards do not change the source of origin or this constituent similarity. Yet language has now shifted. Once we become acutely aware of granularity via its mediation onto pixels, "secondary revision" has occurred. The image content itself previously had little or nothing to do with granularity, and the grains were only constituent elements taken unconsciously. At this point, however, our "noise" sensor has been taken by surprise, duped out of its role by its lack of necessity, and any granularity within the image has ceased to be a constituent element and now becomes part of the image itself. The constituent elements of the photograph – message and noise – have cohered by virtue of their shared mediation onto pixels to become part of the overall image. Where before in imagery we were blinded by the appearance of the organic unity of granular elements – they existed only to conceal their own reason for existence – we are now confronted by the unity of the old noise with the old subject to create a larger totality of meaning in the new mediated form.

Signifier has become signified. This renders *all* of the constituent elements of the new photographic print suspect, including the subject. If even an analogue granular element is now a photographic gesture, nothing is what it seemed and all has become interpretation. The ground of the established, familiar signification has opened up, and we find ourselves in a realm of total (and anxious) ambiguity – the realm of the uncanny.

"HOME AT LAST"

> *The more we find ourselves in total ambiguity, not knowing where "reality" ends and "hallucination" (i.e. desire) begins, the more menacing this domain appears. Incomparably more threatening than the savage cries of the enemy is his calm and cold gaze.... What is crucial here is this inversion by means of which silence begins to function as the most horrifying menace, where the appearance of a cold indifference promises the most passionate pleasures – in short, where the prohibition against passing over into action opens up the space of a hallucinatory desire that, once set off, cannot be satisfied by any "reality" whatsoever* (Žižek 1991, p.90).

It cannot be ignored that *Presenting "The Amazing Kriels"* was a photographic installation whose subjects were members of my family, captured in a time and a place where it is impossible for me to return. It is not just the issue of returning to America, to Alabama, to the 1960's and '70's, returning to take a place beneath the protective gaze of my family. It is not only an issue of returning to a place that no longer exists; tent theatres and carnivals as they were once known have vanished and the American circus is now a corporate space. The neighbourhood one would once call home was at it's origin nothing more than an ever–shifting configuration of tents and trailers – homes whose physical relationship to one another changed as they were moved hundreds of miles in a single night to reside as sub–community to a larger and different community each week.

Home, within *Presenting "The Amazing Kriels,"* is forever forbidden, forever sought, and impossible. *Home At Last* is the amplification of the anxious ambiguity of this work. Ever vibrating between what is real and what is fiction, *Home At Last* amplifies the space where everything becomes suspect without resorting to the use of the more literal version of signifier as signified represented by mediating granular elements. Three-dimensional models played on the photographic plane for veracity but with overt overtones of the lie, *Home At Last* first convinces, then arouses the suspicion of the viewer who notes the false veracity of the images, the lie which tells the truth. It is Foster's "anxious ambiguity." Foster, in a brief overview of Freud's theory, outlines the primary effects of the *unheimlich*: 1) ambiguity between the real and imagined; 2) confusion between the animate and the inanimate; and 3) an "eclipse of the referential by the symbolic" or an overtaking of the signified by the signifier (Foster 1993, p.7). Viewers see too much, see what they are supposed not to notice, see both surplus and lack in the same frame. The surplus knowledge contained within the image where everything becomes signal – all is message – amplifies both the subject's and the viewer's desires, and "points to a deceptive surface beneath which swarms an undergrowth of perverse and obscene implications, the domain of what is *prohibited*" (Žižek 1991, p.90).

In previous iterations of large-scale photographic imaging, one of the constituent elements of the print – that is, photographic grain – was an irritant to be dealt with. As discussed previously, viewers must unconsciously repress their awareness of the image's granularity in order to the see the subject of the image. Now that that unconscious function of repression has been mediated onto the algorithms of the Durst Lambda printer, the viewer is confronted by the lack of necessity of their own unconscious function. When that which is repressed is returned to us – and to reiterate, it is here returned to us via a sudden confrontation with repression's absent function – then the viewer enters the realm of the uncanny. That which is repressed and then returned to us becomes uncanny in effect, thus the feeling of estrangement when encountering the large-scale photographic print without granularity. This is a transitory (or temporarily transitional) effect. At some point over the course of time, the viewer becomes comfortable with this new high resolution media and is no longer thrown into a state of disquiet by the abundance of signal over noise in the high resolution information channel of the Lambda print. However, in the state of transition from a low resolution media to a high resolution media, the relatively noise-less transmission of information evokes the uncanny.

Where is this *home* reached *at last* within these images? Or better, what is this forbidden and impossible home? In the realm of the uncanny, it is in an attempt to deny the language of signification – where is the gesture of grain, brushstroke, noise, banal dialogue or vertices? *Home at Last* attempts to deny signification – to what mountain, what home, what existence does the series owe its reference. Of what picture element is it composed? Yet it fails, just as all efforts to achieve the impossibly forbidden are sure to. In surface, content, meaning, intention and constituent element – *Home At Last* is a drive to the impossible, capitulated onto the image.

This dissertation's stated goal is to address the question: why, when encountering the products of many new technologies which deal with information delivery via a new media, do we often experience a feeling of disquiet or estrangement? It has used the example of laser-photographic printing, and specifically Durst Lambda prints, to explore and illustrate the issue. The exploration has been principally one of practice-based research, with a strong theoretical element.

In the course of this research, three series of large-scale photographic works were created. The first (*Presenting "The Amazing Kriels"*) explored the issue of the removal of noise both via digital retouching of analogue-based photographic imagery and through massive digital upward interpolation onto laser-photographic prints. Through the creation of this work, and through subsequent theoretical research comparing the works to the works of other artists, it was established that the use of digital interpolation to increase scale smoothes granular elements within the final large-scale photographic print. It was also surmised that this phenomenon had a significant effect in the creation of a sense of estrangement from the imagery. It was also concluded through subsequent research that this estrangement bore an equivalence to Freud's notion of the uncanny.

Estrangement has been defined in many ways throughout the course of philosophy, psychology, and art history and theory. In most discourses on estrangement, three definitions arise: those of Hegel, Marx and Freud. For Marx (1844), alienation and estrangement are interchangeable terms, are indicative of a process of isolation from a natural or social context, and typically have to do with the transfer to another party of something that is one's own. Hegel (1807) adopted this definition, expanding on it to include the process of separation of the products of society from their origins. Although both these definitions of estrangement were reviewed in the course of the research, they were deemed inappropriate to the course of the research (the case could be made that much of McLuhan's project exploring auto-amputation is based on Hegel – something I would firmly disagree with as this would be to ignore the sources – Selye and Jonas – which McLuhan himself cites). As has been pointed out in more publications than can be enumerated, one of Marx's great failures was his inability to personalize the universal; something Hegel shared. Indeed, Žižek's entire project, the synthesis of Marx and Lacan via Hegelian methods, has done much to revive Marx's historical fortunes, as he has indeed personalised what Marx created in the universal. As this exploration had everything to do with personal reactions to and feelings of estrangement from a group of artworks, it was deemed that Freud's estrangement/alienation via an evocation of the uncanny would be the more appropriate framework to work within, and this researcher believes it has born fruit.

The second series of practical work (*Home At Last*) explored the research question through the creation of images with a high degree of verisimilitude, yet that were originally authored via three-dimensional computer modelling, eliminating visible granular content. Although the option of authoring via digital photography was considered and researched, it was deemed inappropriate to the research, as digital photography at this writing is still of insufficient quality to compete with professional analogue photographic materials. This second series of work took the whole of the research practice into the metaphorical realm of eliminating the "ground" of the large-scale photographic print – that is to say, eliminating its granular physicality. As a rigorous step in the midst of a practical/theoretical program of research this represented a significant step toward achieving an outcome to the initial research goal. It also allowed for considerable practical feedback to the theoretical exploration, where Freud and McLuhan were then synthesised. This synthesis and its conclusions, but even more to the point, the two bodies of practical work, constitute the research outcomes of this dissertation in answer to the initial research question.

Pure, the third series, and the suggested revision of McLuhan's theories, represent a suggestion of future work, both for myself and other researchers.

REVISING MCLUHAN AND *PURE*

From this point, future research could move in almost any direction. However, works and readings contained within the main body of this research have suggested new directions for both practical and theoretical research to come. While the work of the theoretical research could be picked up by almost any researcher with an interest in the topic, as could a program of thorough sociological and psychological (vis-à-vis psychoanalytic) research confirming the estrangement of the viewer in the face of increased signal in an information channel, the personal work is precisely that, and can only serve as a touchstone for an artist wishing to extend the work already made.

THE POSSIBILITY OF REVISING MCLUHAN

One other possible direction of future research based on the theoretical portion of this research would be an original reading based on a fusion of McLuhan, Freud and Lacan in order to further extend the cyclical process of mediation, repression and irritation.

All extensions of man are media. Whether clothing, spacecraft, cooking utensils, signification or language – internally spoken or externally referenced – all extensions are media; and all media follow an essential cycle of Irritant, Auto-amputation-Amplification-Mediation, Counter-irritant, and Numbness/Repression. McLuhan claims that the drive to greater technology, to a "hotting up" of already mediated forms, is due to additional outside pressures on what is essentially an internal process of psychical adaptation. This thesis proposes, among other points, that in fact if all adaptive drives within the cycle of mediational development and subsequent adjustment to that mediation are internal, then the entire framework should be kept thus, sans the originating adaptive drive. An internal drive for the creation of "hotter" media, which requires an additional psychical adjustment and the beginning of another circuit of the cycle, must exist.

This leaves the question of why. The cost of any adaptation, whether generational within a species, or personal within the life of a single organism, is unquestionably high. McLuhan's theories of irritant/counter-irritant/auto-amputation/numbness bear this out.[46] What is the drive that asks us to repeat, again and again, the cycle of psychological adjustment to "hotter" forms of media – the cycle of irritant-estrangement-irritant, ad infinitum?

This thesis proposes that the answer lies within Freud's primal fantasies – seduction, castration, the primal scene, but most important for our context, the fantasy of intrauterine existence. The intrauterine fantasy is deeply tied with "a desire to return to the pre-oedipal fusion with the mother." It is existence pre-language. It is pre- mediation and signification. Whether the first experience of a mediation of a function of the organism lies at birth, at Lacan's mirror stage or at any other possible point in the developing psychology of a human is debated widely and is beyond this text, but it can be assumed for argument that there is, in fact, a primordial point within consciousness before mediation of any of the organism's functions – particularly communication. Mediation is forced upon the organism as surely as the being first seeks sustenance and needs to communicate this. It is a moment of suffering and birth of desire doomed to repetition throughout the life of the individual, born both of

[46] Ample evidence also exists within the field of evolutionary theory – see Miller (2001).

external pressures of extrauterine survival and internal adjustments to an immediate need to grasp the language of the scream. It is the birth of the initial irritant – the first situation of distress. Successful communication of distress – a mediation of desire into infantile language – leads to a momentary satisfaction of desire, and it is a cycle to be repeated throughout the lifetime of the child. It is a desire to return to a state of pre-signification that can only leave[47] the psyche at the point of secondary revision – analysis; it will, in fact, find repetition even there.

"Repetition is fundamentally the insistence of speech," according to Lacan (1993, p.242), and marks the return of a drive to *jouissance*, an excess of enjoyment bound to return even as it drives toward death. This excess is ever doomed to entropy, ever marked to transgress the limits of other drives and fall into the realm of Thanatic will.

As new irritants are introduced throughout different stages of life, new strategies are developed to mediate solutions to these moments of disquiet off onto the various extensions of man, and self-amputate them from the function of the organism itself. Each new self-amputation leads to an amplification of expression, reach, sight, and sense, but each amplification leads to a counter-irritant as the individual must psychically adjust to a fundamental shift of role in relation to the mediated solution to the irritant. This adjustment is performed via an unconscious repression of the conscious perception of the adjustment – and one cycle of adaptation, satisfaction, and solving of *dis*ease and *dis*quiet is accomplished. In McLuhan's world, this *should* be enough. Compelled however to repeat this cycle and to repeat all cycles which metaphorically take the individual from primordial state through expression of desire through the moment of excess *jouissance*, the compulsion to create a new state of irritation arises and manifests itself in a heating up of mediated forms embodying repetition, will-to-death and castration – not McLuhan's societal and monetary pressures.

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[47] In fact, it never leaves.

In the context of reading signal information consciously and noise information unconsciously, this mediation is as well heated up, and an uncanny doubling of effect occurs. Unconscious repression of the existence of noise in the information channel is mediated off onto the technology of digital upward image scaling and smoothing effects, and we are confronted by the new lack of necessity for the existence of our unconscious repression – a threat of castration of psychical function. That which we have repressed is returned to us, and we are overcome by a sense of the uncanny – a disquiet forcing us away from the image. This uncanny confrontation with our own now-obsolescent function of repression is, in addition, *self*-castrative. The "evil eye" of Freud's *unheimlich*, our own desire is mirrored back to us, stares out at us from the grain–free image we are examining, and not only threatens a part of our psyche with castration, but further compels us through the cycle of ever-heating media, moving us even closer to an additional auto-castration of human function; we are invited, again, to quell a sense of *dis*ease and irritation by mediating yet another function off onto technology, as we seek to retread the cycle of mediation to the moment of *jouissance*. It is a cycle never satisfied – there is no return to the primordial, pre-linguistic state before mediation:

> (Lacan 1977, p.319) *The prohibition of* jouissance [the pleasure principle] *is inherent in the symbolic structure of language, which is why "*jouissance *is forbidden to him who speaks."*

This is the cost of numbness and repression after auto-amputation/self-castration: the process of adaptation is in itself as self-generative as technology; man becomes the genitalia not only for technology/media/language, but for his own drive to *jouissance* and ultimately death. The death drive is, in this case, not the drive to self-destruction as an end, but self-destruction as a move toward excess pleasure through escape from language, mediation and the symbolic – it is the death drive as both intrauterine fantasy and desire to reach beyond mediation, subverting secondary revision, seeking the forbidden impossible painful pleasure of *jouissance.*

This would be the proposed foundation of a new and original theory for the process of mediation and technological innovation, the reading of new forms of media, as well as significant improvements in established media forms, based on the materiality of mediation and a psychological reading thereof. It could be illustrated via the example of an examination of Lambda laser photographic large scale prints, or perhaps any technological innovation.

PURE

The realm of sexual desire is writ large over the practical work of the main body of this dissertation. Rereadings of the earlier images created as part of the research based on theories developed later in the work show a consistent conscious (and oddly unconscious) effort to reflect the content in the form – to marry the uncanny subject to the uncanny container.

In *Presenting "The Amazing Kriels,"* analogue photos were used which still contained granular elements, but also contained human elements. *Home At Last* attempted to deny both. Where might it be possible to embrace both the human and the camera-based elements, still work within the realm of the uncanny and *jouissance*, represent *each* original contribution within the theoretical research, and amplify the realm of the dialogically sexual and psychological beyond mere dialectics? *Pure*, a body of work created during the research, is work that speculates theoretically on the above questions; although quite complete in form, it is a presentation of work that is, with regard to the above questions, in progress.

Pure wishes to do the impossible – to reach the intrauterine fantasy as reality, to exist pre-signification, to embody in image *jouissance*. For *Pure*, if my reading of the cycle of mediation were to be rooted in a sense of the uncanny, which Freud located in desires for intrauterine primordial existence, then it is my opinion that the natural extensions of this research would reflect in content what they tried to achieve formally.

Pure began with film-based photographic images. They have then been scanned at high resolution. The images have then had their colours amplified to take the image beyond a "realistic" depiction. Within my readings of a cognitive approach to human vision, edge–detection as a means of identifying objects is frequently a central issue. In this context, the images in *Pure* have their outlines blurred to the point beyond recognition. The images have then been abstracted to various degrees in an attempt to reach beyond signification. Without question, they contain no noise elements (according to the logic of this dissertation). To date they have been printed on Lambda printers.

The constituent elements might be interpreted as a series of pornographic photographs, shot under the same lighting conditions as most male-targeted pornography, and from similar angles, but they go beyond this. Žižek (1991, pp.110-111) pointed out the inherent failure of pornography in and of itself to represent the impossible transgressive:

> *The unattainable/forbidden object approached but never reached by the "normal" love story – the sexual act – exists only as concealed ... as soon as we "show it" ... instead of the sublime Thing, we are stuck with vulgar, groaning fornication.... The fantasy ideal of a perfect work of pornography would be ... the balance between narration and explicit depiction of the sexual act.*

In my "intention" the images would attempt to embody *jouissance*, not represent or signify sexuality – an impossibility from the outset – therefore the process and desire to create the imagery became as fundamental theoretically to the work as the prints themselves (see Figure 27, Figure 28, Figure 29, Figure 30, Figure 31, Figure 32, Figure 33, Figure 34 and Figure 35).

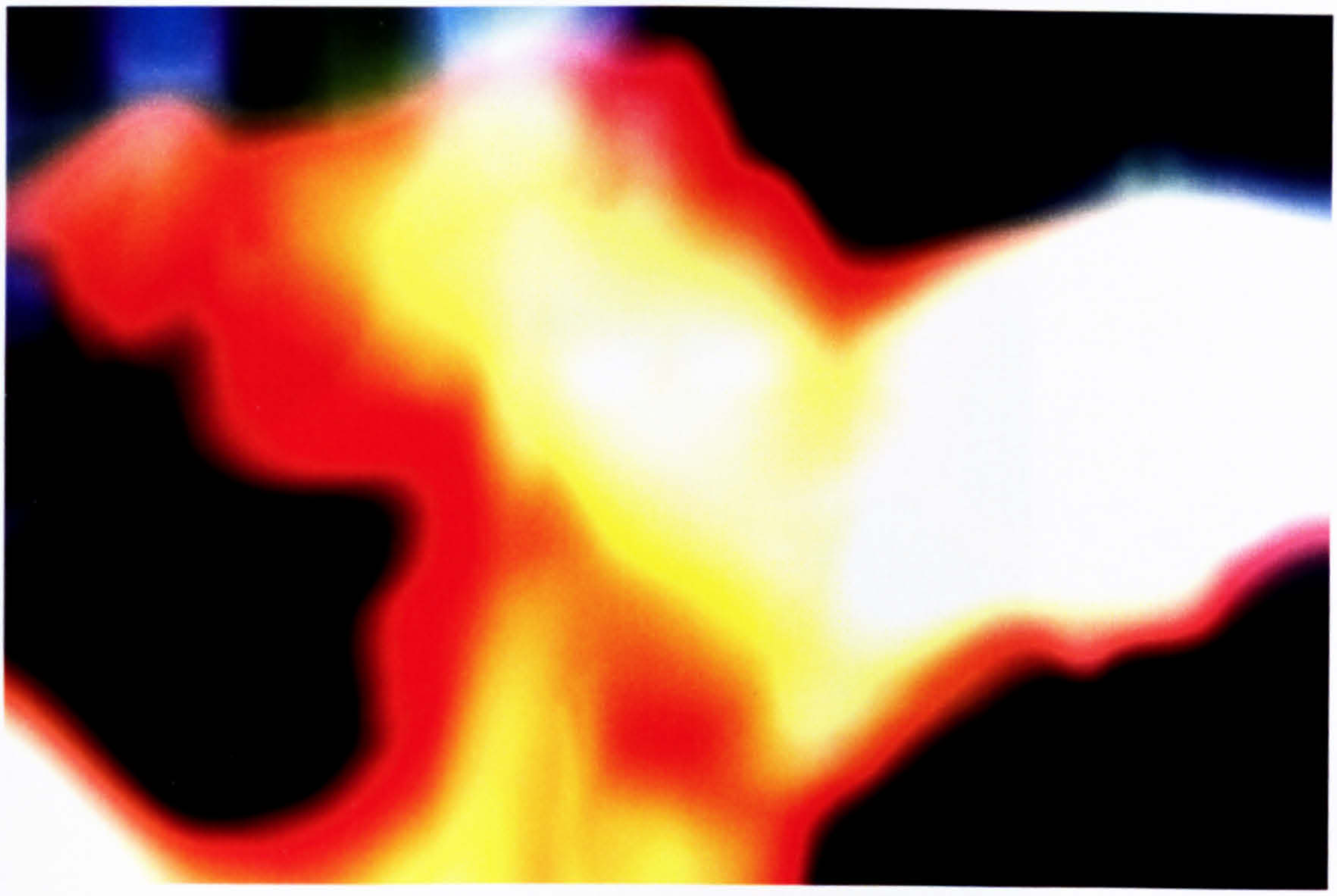

Figure 27 Charles Kriel, from *Pure* series (48 x 73 in.)

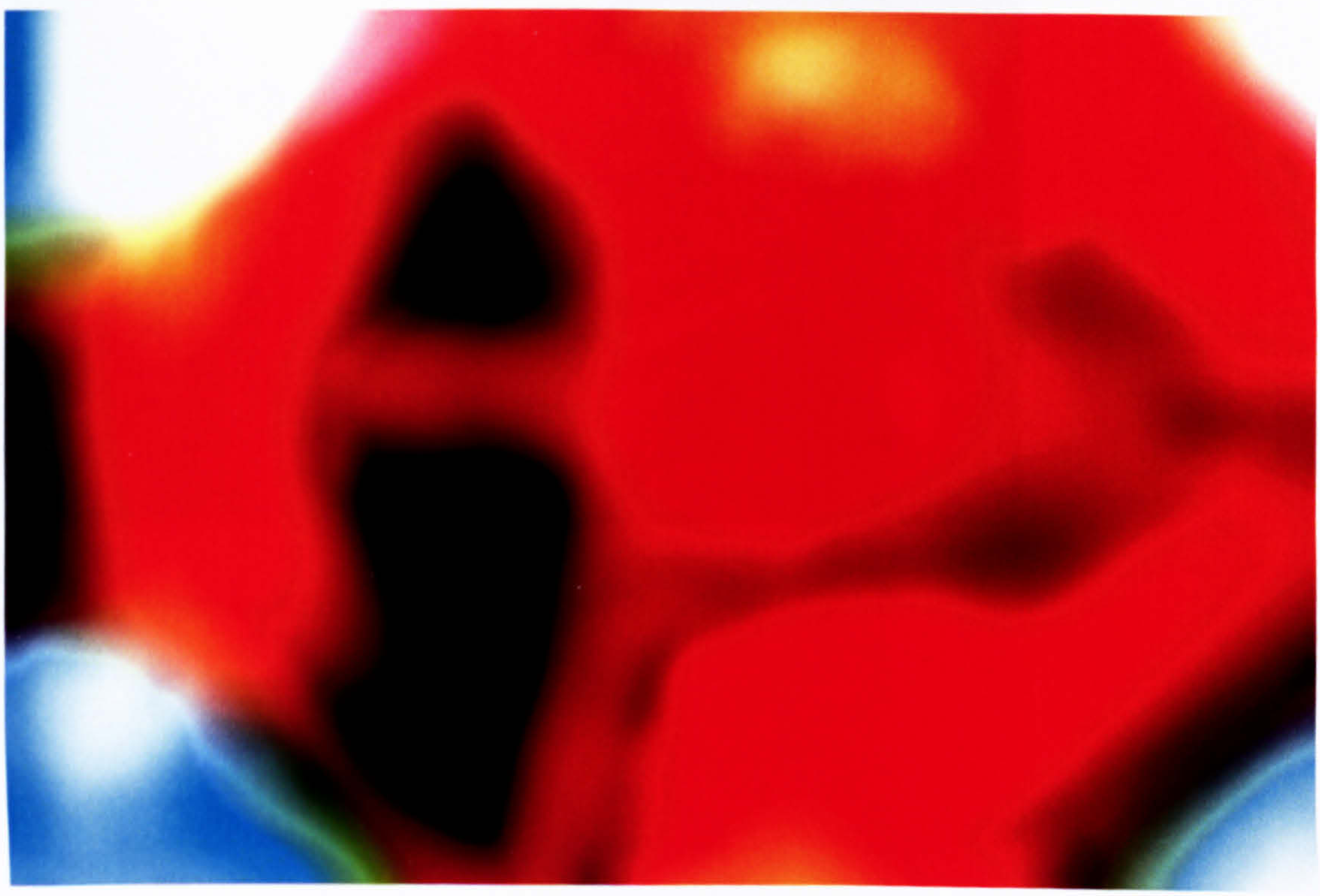

Figure 28 Charles Kriel, from *Pure* series (48 x 73 in)

Figure 29 Charles Kriel, from *Pure* series (75 x 48 in)

Figure 30 Charles Kriel, from *Pure* series (48 x 54 in)

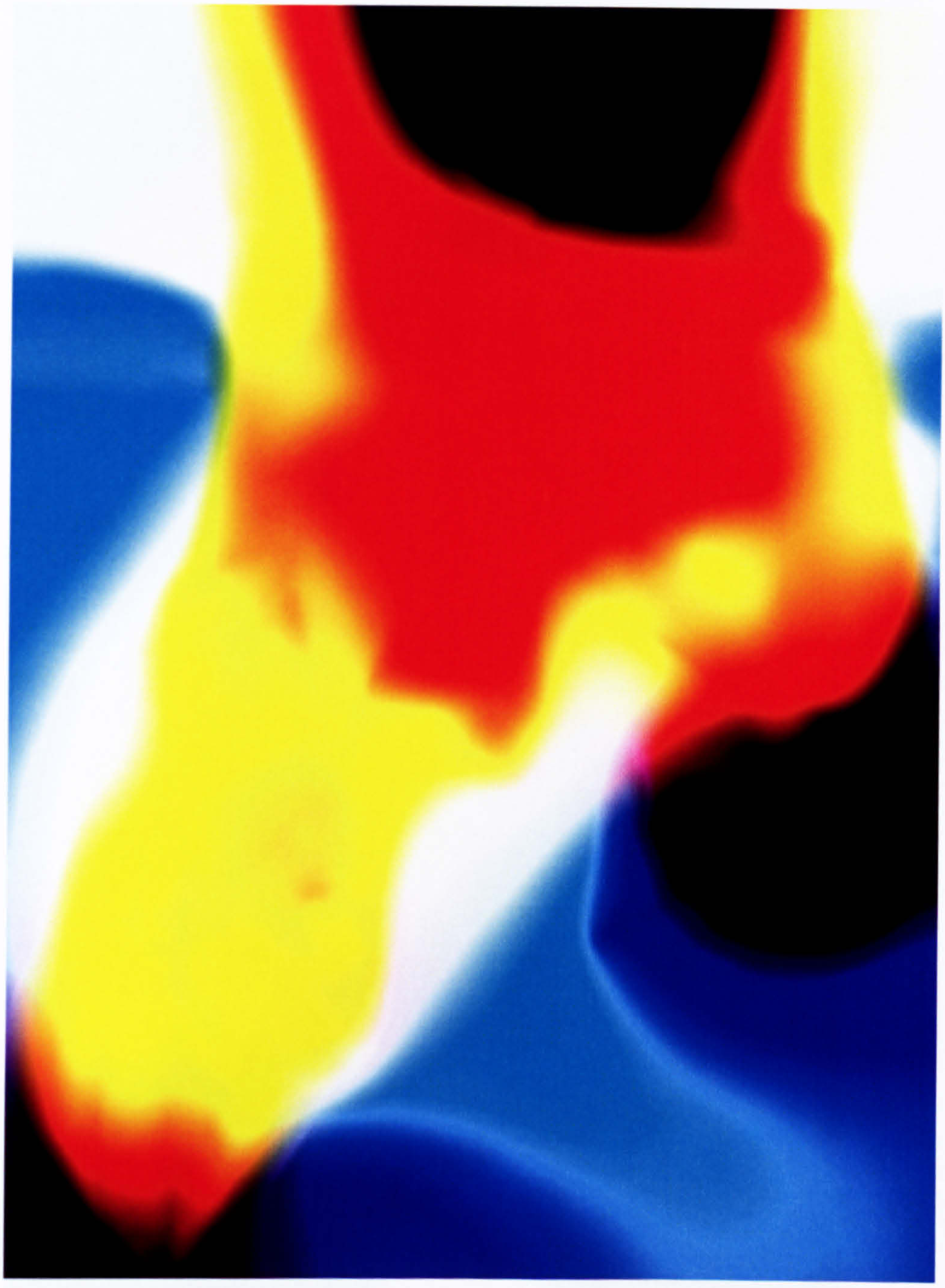

Figure 31 Charles Kriel, from *Pure* series (65 x 48 in)

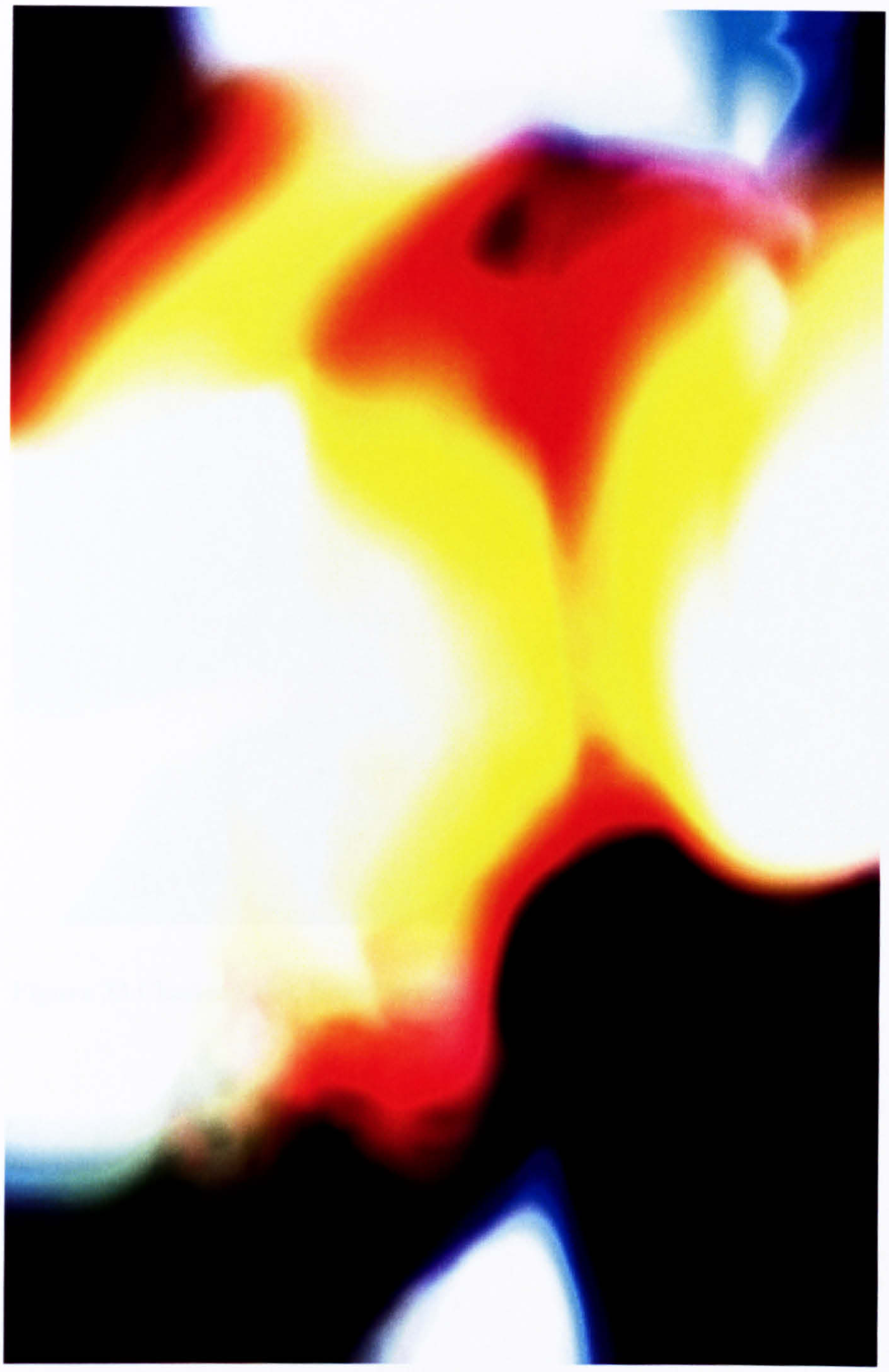

Figure 32 Charles Kriel, from *Pure* series (74 x 48 in)

Figure 33 Charles Kriel, from *Pure* series (48 x 58 in)

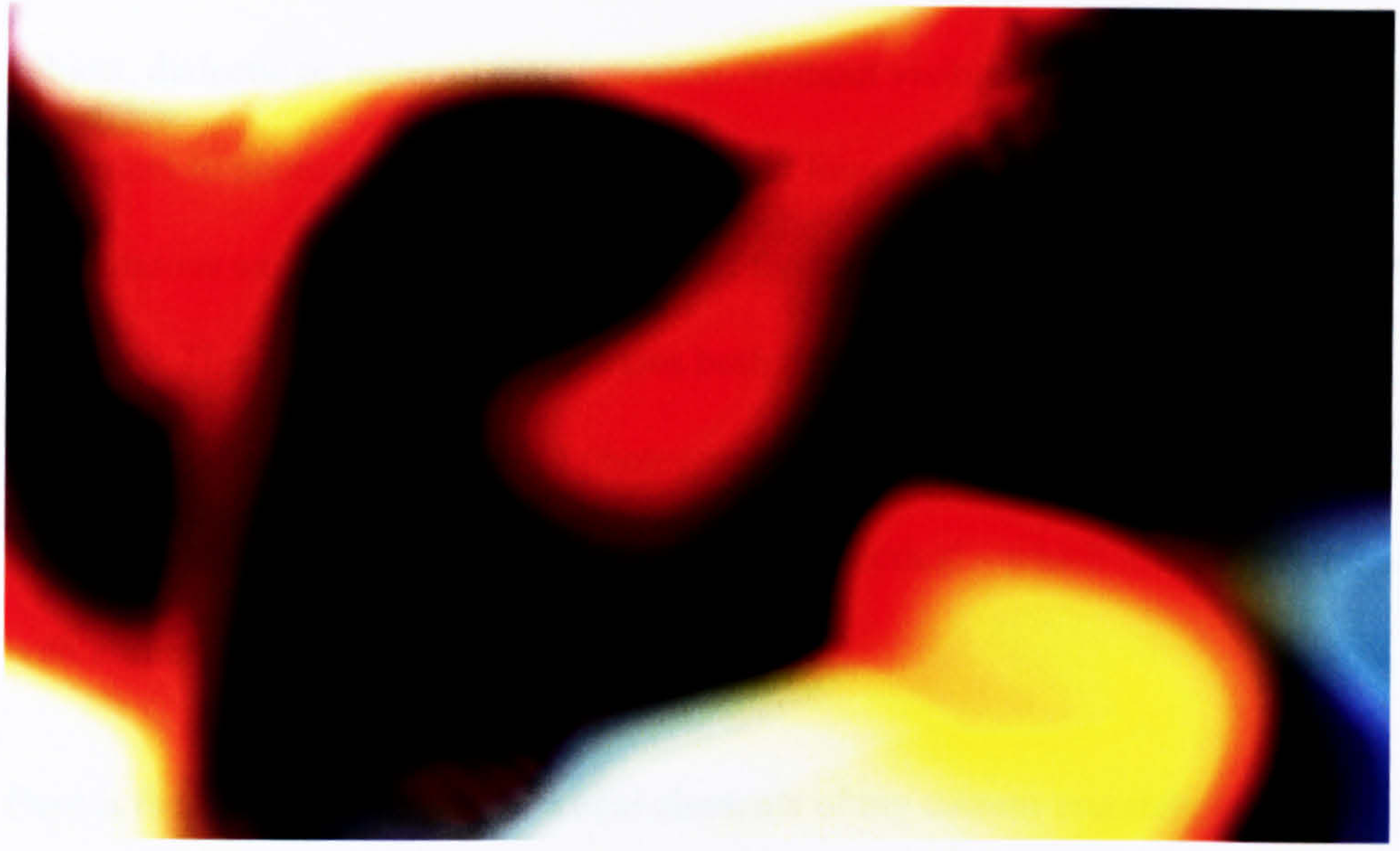

Figure 34 Charles Kriel, from *Pure* series (48 x 80 in)

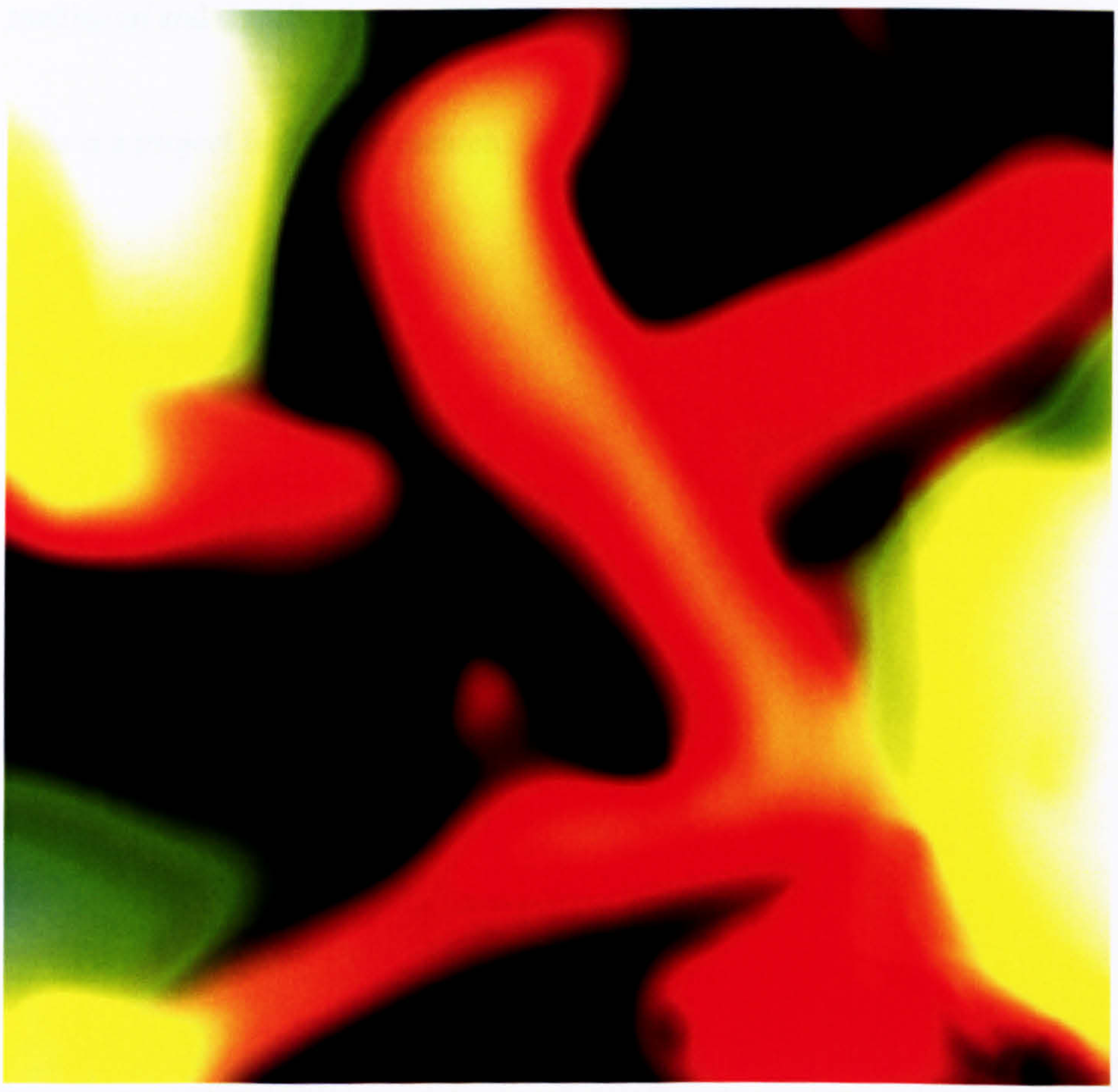

Figure 35 Charles Kriel, from *Pure* series (48 x 49 in)

Pure may be the space where we no longer know what we are looking at, either in terms of subject, dialectic or material manifestation. Without visible constitutive elements, without references to photographic materiality, without lines and edges of figuration, *Pure* may be pure anxious ambiguity: the embodiment of the thrust to reach an order before mediation or language. This embodiment transgresses both the signified and "signifier status" of grain and noise as privileged fundaments of photography, reaching a point of appearance of organic unity. The elements – psychological, material, dialectical – which make the thing would be both absent *and* the thing itself.

Pure is the summation of the practical elements of my current research, taking the theoretical concerns into a speculative realm that calls for a new reading of photography – and media in general – based on an ever-shifting materiality, and from there our psychical relationship to mediation and signification.

This is a project for future research.

APPENDIX A

The potential sources of noise in analogue and digital photography and printing are well documented throughout the lay and scientific literature of the subject. This section is included, however, for the interested reader. Sources of information should be considered broadly as the whole of this material is largely duplicated within the larger body of photographic literary canon.

GRANULARITY

A micro-densitometer coupled to a voltmeter is the most basic tool of measurement for grain within an image. A photometer designed to measure photographic densities, a densitometer takes readings of light levels either reflected off photographic prints or projected through photographic film. Selwyn, in 1935, defined the formula for measuring granularity via the use of densitometry. If the diameter (d) of a variable aperture densitometer is known, then density readings taken at different points will vary, and in an increasing ratio opposite the narrowness of the aperture. This alone indicates the unevenness of distribution of granular image elements within the photograph. A larger aperture reading would, in general, be close to the average of several small aperture readings, and several larger aperture readings would follow a bell-curved Gaussian distribution, determined by the spread σ. 68% of all measured values will lie in the range 2σ, with 99.9% within the range of 6σ. The relationship between σ for average density and d is:

$$\sigma \times d = \text{constant.}$$

The constant is granularity (Kraszna-Krausz ed. 1969, pp.717-718).

It is rare for granularity to be observable to the naked eye in a negative but as we see above, it can be measured. When an image is described as "grainy," it is usually the print that is being referred to. However, printing papers are usually composed with much finer grained emulsions, therefore the perceived graininess of a print is in fact the granularity of the negative, projected and enlarged onto the print.[48] Despite this, granularity can be measured in print emulsions, although measurement is complicated by the print density reflecting that of the negative density – the print, effectively, mirrors the negative. Contrast is the better determining factor. The Goldberg condition states that the average "good photograph," in terms of technical print quality, can be determined as:

$$\gamma \,\text{neg} \times \gamma \,\text{pos} = 1.5$$

One may determine the print granularity by dividing the negative granularity by γ neg.

Gamma is used in photography to measure contrast reproduced in a photographic negative – the ratio of contrast in a negative compared to contrast in the original photographed subject would be measured in gamma. Gamma helps photographers determine how materials will respond to exposure variations: low gamma materials produce low density changes for low variations in exposure; high gamma materials produce high density changes for low exposure changes.

[48] At micro-densitometer levels, however, the granularity of the print emulsion itself can be measured.

Technically, gamma is the slope of the straight line portion of the characteristic curve of a photographic emulsion, measured sensitometrically. For D (density) and E (exposure):

$$\gamma = D/\log E$$

Using a negative film with a gamma of 1, and a print paper of a similar rating, the full tonal range of the original subject would be reproduced in the print. Under the Goldberg condition,[49] the exact condition for tonal verisimilitude from subject to print would be derived when (Kraszna-Krausz ed. 1969, pp.691-693):

$$\gamma \text{neg} \times \gamma \text{pos} = 1$$

NOISE

The need for greater analysis of detailed photographic information, particularly in relation to astronomy and aerial "monitoring" technologies, has given rise to the need for more exacting means of determining photographic efficiency as well the tools necessary to achieve these measurements. Borrowing from technologies used to evaluate electrical communication and information transmission, photography in general and medical photography in particular, have adopted Fourier analysis of complex waveforms as a standard tool in determining photographic negative and print quality. Results of determinations of quality are often expressed in terms of signal-to-noise ratios.

Fourier analysis states that real world transmissions of information (signals) can be approximated by a sum of sinusoids (sine waves). These are illustrated along a two

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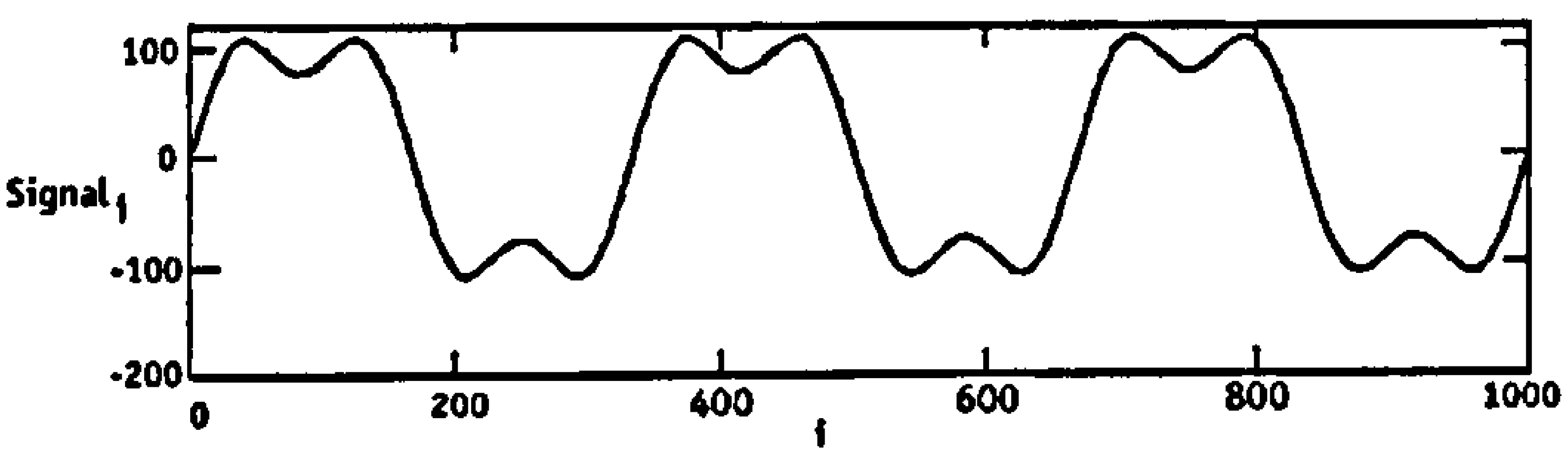
[49] The discrepancy here, between 1 and 1.5, is a measure of the distance between photographic practice and photographic science. While from a technical perspective, the rendering of exact tonal reproduction is ideal, in most cases photographers will choose printing papers based on the comparison of the full tonal range they wish to

dimensional graph. The more sinusoids in the sums, the better the reproduction of the signal. Through Fourier analysis, a signal-to-noise ratio can be determined.



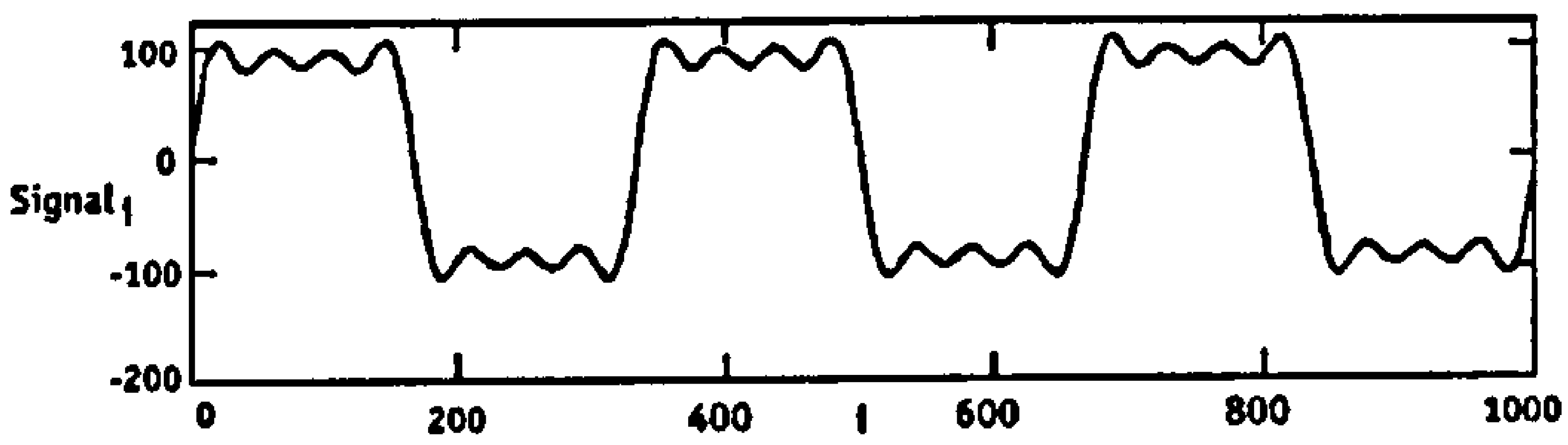


Figure 36 Fourier transform

Fourier analysis resolves a waveform – of which the electrical signal produced by a densitometer reading across the surface of a negative is an example – into a series of sinusoids of varying amplitude and frequency (Krantz 1994). In the analysis of electrical signals, the sinusoid are drawn across a time line. In the first graph of Figure 36, we see the sum of two sine waves with amplitudes chosen to approximate a 3Hz square wave across a millisecond timebase. The first sinusoid has a frequency of 3Hz, the second 9Hz.[50] The second graph is similar to the first, but adds a 15Hz sine wave and a 21Hz sine wave – clearly a better approximation (MT Group 2003).

However, in the measurement of visual information, the temporal base of audio and electrical signal measurement is replaced by a spatial scale.

reproduce and the tonal range of the negative – the attempt being to utilise the maximum range of the paper, rather than accurately reproduce the tonal range of the subject.

[50] For simplicity of explanation, the sinusoids in these two illustrations are harmonics of the 3 Hz base wave.

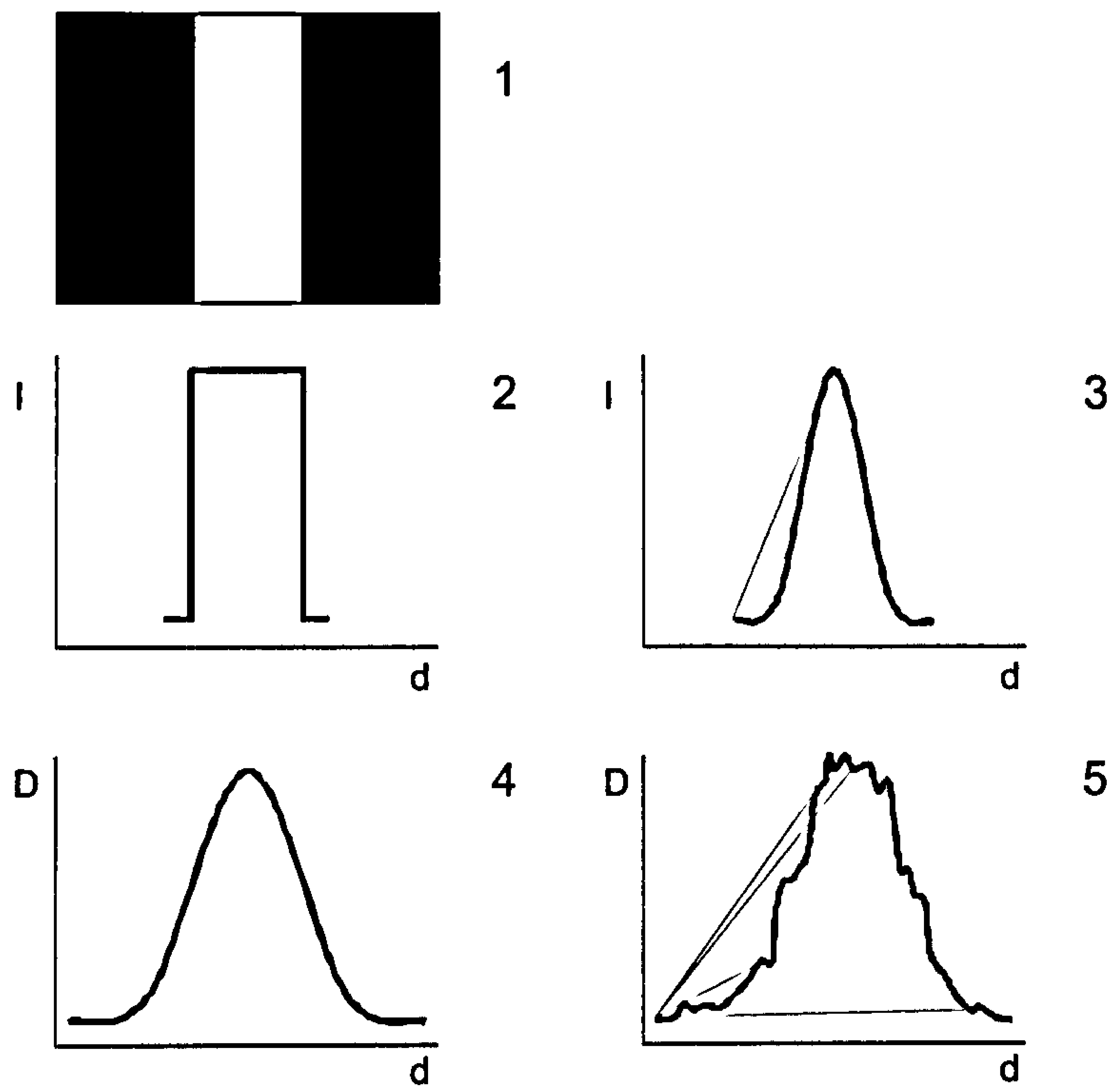


Figure 37 Wave representations of black and white tonal bands

In Figure 37, illustration 1 shows a white band across a black colour field, and illustration 2 plots light intensity (I) against our spatial dimension, distance (d), using a square wave. Illustration 3 demonstrates the spread of the photographic graphing of the image that might be caused by "noise" in the visual "signal" created by lens aberrations, Newton Rings, etc. In illustration 4 we see a further spread, created by mapping image density (D) against distance across the photographic print, and finally in illustration 5, a more accurate graphing of the reality of the density output, once photographic granularity adds noise to the curve (Kraszna-Krausz ed. 1969, p.777-778).

Via Fourier analysis, and within the context of image granularity, we could, theoretically, determine the number of sinusoids required for an accurate photographic depiction of illustration 1, where each grain of silver, each imaging element, would be represented by a single sine wave. The more sinusoids packed across a graphed distance, the more accurate the depiction of the image in question. However, the complexity of illustration 5 reflects the complexity of density representation when the white spaces of paper between the clumps of image elements are introduced. In this sense, "granularity" as it is spoken of conventionally is turned on its head, and the grains themselves become signal, with the even white space of the paper beneath being termed noise, and represented by peaks within the sine wave.

The grains themselves – the elements of silver on the paper – are the constituent elements of the signal; the peaks in the sine wave of illustration 5. The more tightly packed and evenly distributed they are, the more information we receive about the image being reproduced. The more white space we see between them, the more noise we receive. Overall, the ratio of signal-to-noise must be high enough that the viewer of the image can determine the original photographed subject, despite the elements of noise inherently contained in the print of the enlarged negative.

NOISE OUTSIDE OF GRAIN

While measurements of granularity, density, gamma and contrast are useful in determining the resolving power of a particular film or paper, based on the packing density of silver halides in its emulsion, a discussion of signal-to-noise comparisons within photographic visual images reveals a number of other aspects of the photographic recording process which introduce artefacts into the final image. Among them are lens aberrations, Newton Rings and reciprocity failure.

LENS ABERRATION

The lens is one of the essential components in transmitting light from subject to film, as well as film to printing paper, and therefore one of the more crucial elements in achieving accuracy of resolution in producing a final print. In general, a perfect lens would render a sharp-edged dot as a dot, and a straight line as straight. In practice, however, a dot at some level of magnification and inspection always becomes a fuzzy-edged patch of density, and a straight line always reveals a certain curvature. Several types of aberration are common to the photographic process – chromatic aberration, spherical aberration, coma, astigmatism, curvature of field, transverse chromatic aberration, distortion and flare.[51]

Chromatic aberration. When lights passes through a prism, the rays deviate inconsistently, with greater deviation at the blue end of the spectrum. A lens, which focuses rather than deviates light rays, nonetheless focuses them on different planes, with blue rays focusing closer to the lens plane than red rays. Although the human eye is most sensitive to colours in the green range, many photographic emulsions are more sensitive to blue light, and upon close examination, what would otherwise appear at first glance to be a sharply focused image is in fact blurry in the lower range of the colour spectrum. This is correctable by creating compound lens systems which could correct for chromatic aberration, but those systems in themselves introduce aberrations of other sorts, leaving the design of most lens systems compromised. This effect is most notable at low *f* stops.

Spherical aberration. Spherical aberration, on the other hand, becomes more pronounced with larger lens apertures. Light passing through the centre of a lens comes to focus on a certain plane. However, light passing through the edges of a lens focus on planes in front of or behind the light focussed from the lens' axis. In converging lenses, an image is never fully focussed across the axial range of the lens. In a simple diverging lens, rays sourced off-axis are bent outward in a manner that suggests their origin as the point-of-focus for rays passing through the axis of the lens.

[51] As this thesis is concerned principally with photographic prints, a discussion of the resolving power of lenses in cameras is outside the scope of this research.

The effects of spherical and chromatic aberration are most pronounced in the centre of a negative or print on the axis of the light passing through the lens, although they are registered across the whole of the image from rays sourced across the whole of the subject. Some aberrations effect only light off the axis of the field of view: coma, astigmatism, curvature of field and distortion.

Coma. A coma patch is a spherical aberration of an oblique group of light rays, rendered on the imaging plane in the shape of a teardrop or comet, with the wider distributed patch referred to as the coma flare. A first order coma contains one flare, with the length from light point to end of flare registering around three times the total width of the aberrant flare. Higher order comas may have more than one flare however, and the general complexity of comatic aberration, particularly pronounced in lenses with a wide field of view, makes them largely unpredictable. It can, however, generally be said that a proportional relationship exists between the size of the coma flare and the distance of the light point from the lens axis, and that this is proportional to the square of the lens aperture (Kraszna-Krausz ed. 1969, pp.3-7).

Astigmatism. Astigmatic aberration results when a lens is incapable of rendering an off-axis point of light as a point, and instead registers it as short lines, the length and direction of which are dependent upon the focal plane.

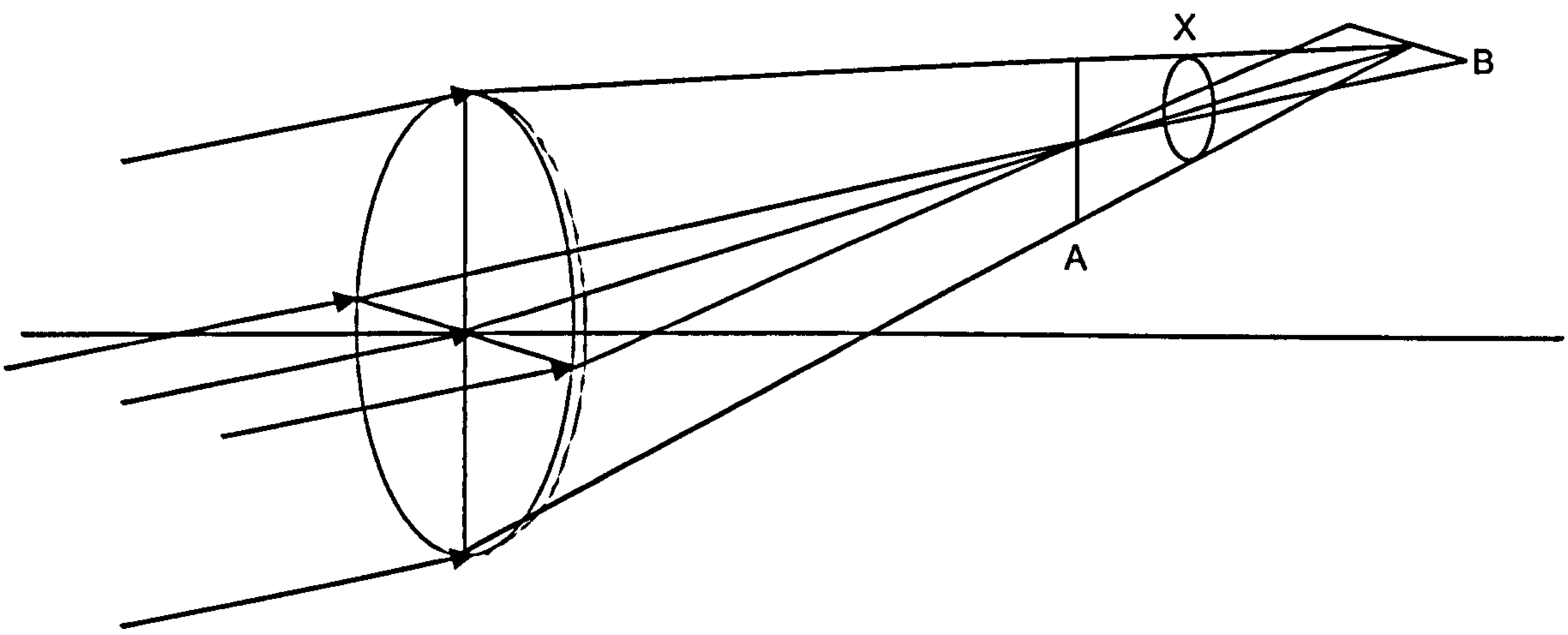


Figure 38 Astigmatic aberration

In Figure 38, light enters an irregularly shaped lens suffering from astigmatic aberration, whose distance halved from focal axis to lens edge differs vertically and horizontally. Light rays focussed across the vertical axis come to focus at focal plane B, while rays transmitted across the horizontal axis focus at focal plane A. At focal plane B, the horizontal rays from the light point appear as a horizontal line, as do vertical rays on focal plane A. The best resolution point is focal plane X, where the light point's sharpness is compromised both vertically and horizontally. The desired image of the point is unattainable.

Curvature of field. A curved lens, uncorrected for curvature of field, is unable to sharply focus an image across a flat field. It is normal, for instance, for a converging lens to focus off-axis light rays at a point closer to the lens than light entering directly through the lens axis. Therefore, the ideal focus plane for a lens marred by curvature of field is a curved imaging plane. Field curvature increases the further the ray enters the lens from the axis, and cannot be corrected by adjusting the aperture of the lens.

Transverse chromatic aberration. Independent of axial chromatic aberrations, transverse chromatic aberration is often more simply referred to as colour magnification error, but is also referred to as lateral chromatic aberration. An aberration which occurs only away from the centre of the lens' field of coverage, it effectively changes the focal length of the lens depending on the colour of light rays being transmitted, and creates a "colour edge" outlining the subject.

Distortion. When off-axis light rays pass through an aperture placed a distance in front of or behind a lens, they will be prevented from passing through the lens centre. This produces not an error of focus, but rather a distortion of the image based on varying magnifications across the image plane. Distortion comes in two forms, barrel distortion and pincushion distortion, and results from the aperture being either in front of or behind the lens, respectively (Langford 1972, pp.19-21).

Flare. At each glass/air surface in a lens, approximately 5% of the light is reflected, with 95% transmitted. To compound this, the reflected light will, in turn, have 5% of it's brightness reflected again at each glass/air surface. Reflected twice (or at any even multiple), the light is capable of reaching the film plane and reducing the overall contrast of the image. Lens flare factor can be loosely calculated by dividing the tonal range of the subject by the tonal range of the resulting image, and can be corrected by coating the lens elements.

Lens aberration is particularly pronounced in the enlargement process. The magnification of the image, flatness of the overall picture plane, and range of light transmitted compound to create a complex environment of light transmission. As a result, enlarger lenses are more often than not compromised, with the lens designer having to accept a degree of astigmatism and spherical aberration in exchange for continuous focus across a variety of apertures (Kraszna-Krausz ed. 1969, p.6). Lens aberration is the first of a variety of noise-inducing elements more pronounced in the darkroom (and subsequently the photographic print) than in the camera (and the negative).

Reciprocity Law Failure. The Bunsen Roscoe Law of Photochemical Equivalence states:

$$\text{Exposure} = \text{Intensity} \times \text{Time}$$

This is also known as Reciprocity Law, and in theory should remain constant. In practice, certain emulsions are more sensitive to certain intensities of light. Low light intensities over long periods of time and high light intensities over short periods of time create Low Intensity Reciprocity Law Failure and High Intensity Reciprocity Law Failure, respectively (Kraszna-Krausz ed. 1969, p.1252). High Intensity RLF results when many electrons are released from the light source too rapidly for slower moving silver ions, resulting in a large number of *deposits* of silver atoms in the emulsion, each too small to form a catalyst for development. Low Intensity RLF results when electrons are released too slowly from the light source. These electrons form silver atoms individually, which are unstable and tend to emit their acquired electrons and revert back to silver ion, invisible after development in the print. Langford has developed a highly original metaphor to explain reciprocity law failure:

> *Reciprocity law failure can perhaps be likened to filling a narrow necked bottle with water, in a very dry climate. If the volume of water is applied all at once, as from a bucket, much will fail even to enter the bottle. If on the other hand it is fed in drip by drip very slowly, a high proportion of water will be lost by evaporation. The optimum filling rate is the one by which all the water enters the bottle, but in a period short enough to minimise evaporation* (Langford 1972, p.167).

In real-world photographic practice, reciprocity law failure is typically encountered when making large prints, and up to three times the normal expected exposure according to the Bunsen Roscoe Law of Photochemical Equivalence is often required. RLF introduces another level of noise into the channel of information transmission from the negative to the positive print.

Newton Rings. The formation of Newton Rings on a print are exclusively an artefact of image projection. When light passes through two transparent surfaces which are not in full and evenly distributed contact, and the distance between those two surfaces is equal to, or a harmonic of, the wavelength of the light source, then concentric bands of coloured light will form on the projected surface, i.e. the print. This often happens when a negative is placed on a piece of glass for projection – usually required for larger format negatives. Heat from the light source can cause the negative to bow away from the glass. This can be resolved in several ways: if a negative is small enough, a glassless carrier is used; the negative may be sealed against the glass with a layer of liquid glycerine, pressing out air pockets between the negative and glass; or etched glass can be used in the carrier. The effect of Newton Rings as a source of noise in image projection is so consistent it is often used to check for irregularities of curvature in optical components (Kraszna-Krausz ed. 1969, p.1004).

ENCODING VISUAL DATA

An 8-bit string of ASCII code is one means of encoding, symbolically, the letter "e." It does not, however, approach the complexity required to represent the letter "e" visually. To do this, something akin to a Fourier analysis of the two dimensional visual space occupied by the densities of the letter's form against a background field must be executed, and the peaks and troughs of densities represented as binary data across a given visual space. For example, we could represent a black and white version of a 3mm letter "e" at a standard imaging resolution of 600 dpi using 4,900 bits of information. That is to say, 4,900 analyses of image density would be read across the surface of the 3mm letter "e," converted into black's and white's (1's and 0's), encoded electromagnetically in the computer, and mapped across a digital area (see Figure 39) (Conway 1999). The process is call bit-mapping, with each element referred to as a picture element, or pixel. In this case, the pixels are described according to resolution, dynamic range (black or white), and pixel size.

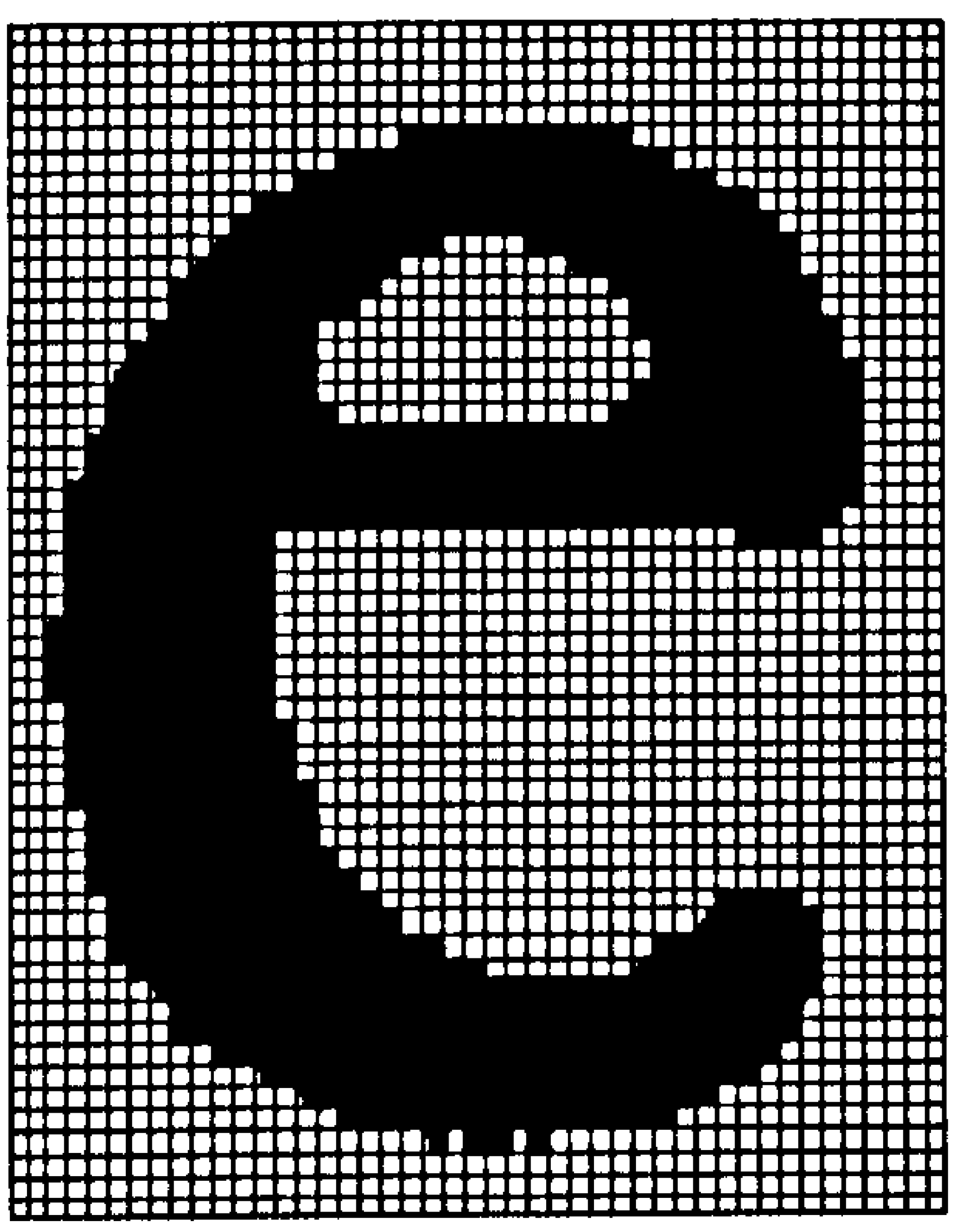


Figure 39 Bitmap illustration of the letter "e"

To represent a black and white image in the photographic sense, that is a full range of densities mapped across a print surface, each pixel is described as one of 256 shades or levels of grey, rather than either black or white. Digital colour images of photographic quality are made up of three virtual "channels" (red, green and blue) in much the same way layers of emulsion are stacked to create colour. Each channel's pixel densities are represented as one of 256 shades of red, green or blue,[52] and the three layers together yield an RGB colour image,[53] which, at high enough resolution, appears as a continuous tone colour image, often with greater resolution than that which can be recorded on an analogue film base. That is to say, an image made from a photographic print scanned digitally at a high resolution will represent a broader colour range and more levels of density, and will contain pixels smaller than the representative analogue grain of the photographic print. Images of 100 megabyte or more are common.[54]

IMAGE ACQUISITION

Images in digital photography can be acquired in several ways: via photographic print and film scanning, digital camera, or rendering an image entirely in-computer (3D modelling, for example). Although digital image acquisition, how it is accomplished and problems of artefacts and noise, are outside the scope of this thesis, it is useful to understand the basics, as digital printing is fundamentally the reverse of the process of digital image acquisition, and scanning in particular.

Most film, print and document scanners in use by artists and photographers at this writing are flatbed scanners, which utilise an array of Charge Couple Devices (CCD) (see Figure 40) to acquire image data, which is then transmitted to the computer for storage, editing and

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[52] In an 8-bit per channel colour file, which yields a 24-bit depth image. 16-bit per channel files (producing a 48-bit depth image) are common at the professional level of digital photographic printing and scanning, and each pixel in each channel will be represented as one of 65,536 levels of density for the corresponding colour. The relatively new extended e-sRGB colour space, as defined by PIMA document 7667 (2001) calls for three user-defined levels of colour precision: 10-, 12-, and 16-bit per channel colour space.

[53] RGB is the standard for digital photographic practice. In the print industry, a CMYK (cyan, magenta, yellow and black) file would be more common.

printing. At the top end of scanning technology, drum scanners are more common. Rather than CCD, drum scanners use photomultiplier tube (PMT) technology. A document is mounted around a glass cylinder, which in turn is spun around a beam splitter (for more on the use of beam splitters in scanning, see the discussion of flatbed scanners below), which separates light reflected from the scanned document into red, green and blue colour channels via light filtration. Each pass of the scanned document is then read by the photomultiplier tube and converted into an electrical signal. This signal is then converted into binary data and recombined into a digital version of the scanned image.

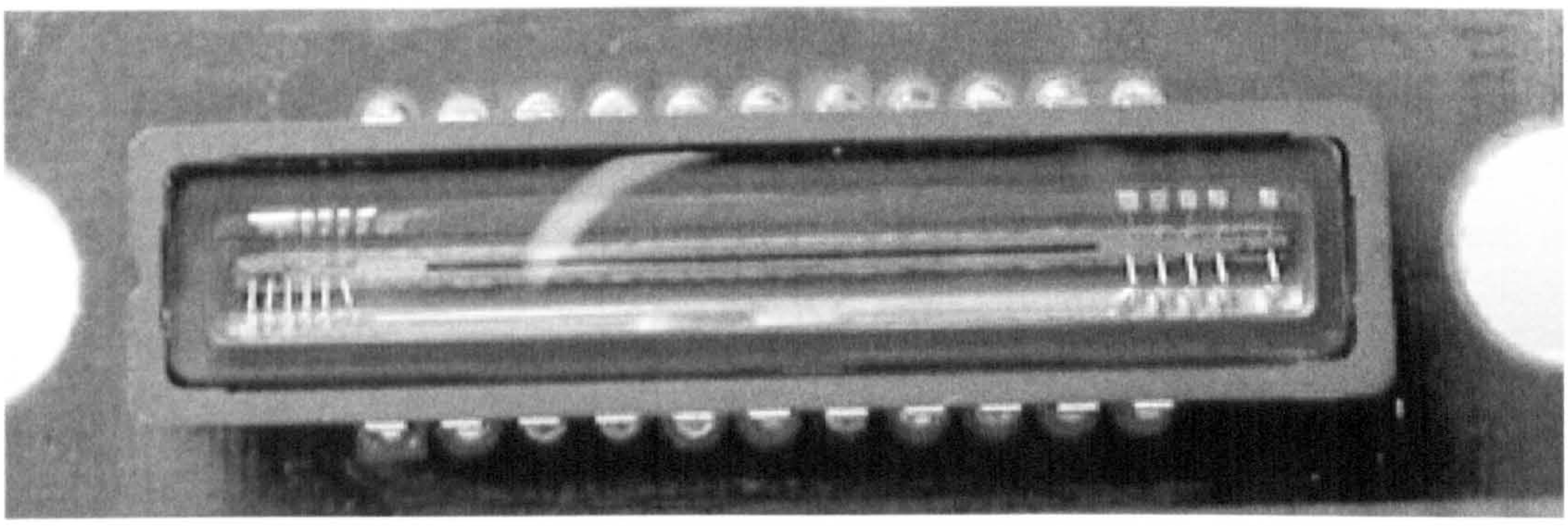

Figure 40 CCD element

Rather than a single light sensor, the CCD-based flatbed typically contains thousands of light sensitive diodes in an array, and constructed as a single microchip. Resolution of the image is determined by the number of individual diodes, called photosensors,. in the CCD array. Each photosensor is capable of converting photons (light) into a stream of electrons (electrical charge). The electrical charge from each diode is read by a transistor, which in turn converts the information into binary data, and as above, sends it to the computer for editing, storage and printing via a TWAIN[55] software interface.

[54] The practical portion of this dissertation contains many images rendered at over 350 megabyte.

[55] An acronym for nothing – short for "Never the TWAIN shall meet".

The document, when scanned is lit by either a cold cathode fluorescent lamp (CCFL) or a xenon lamp. The scan head, typically comprising an array of mirrors reflecting light from the document through a lens and then a filter onto the CCD array, is moved across the document by a stepper motor, which is capable of moving the head in small increments, or steps. The image is read "row-by-row" at the resolution of the stepper motor, rather than all at once, as with analogue still photography.

As with photographic emulsions, the light must be read as three separate colours – red, green and blue. Photosensors are sensitive to luminance, not a combination of luminance and colour. Digital cameras have CCD matrixes, rather than arrays, and the more expensive of them typically have three CCDs, one for each primary colour. Inexpensive photosensor matrixes using only a single CCD will alternate photosensor colour sensitivity – one red, one green, one red, one green, etc., with even numbered rows containing one green, one blue, one green, one blue. The total number of photosensors is thus divided 50% green, 25% red and 25% blue in what is called a Bayer filter pattern. Because the human eye is not equally sensitive to all colours, it is necessary to record more green information in order to produce an image which appears to the viewer as "true colour" (Jacobson, Attridge, Ray, Axford 2000, pp.120-121).

DIGITAL PRINTING

There are several methods for creating prints from a digital image file stored in a computer, and almost anyone who uses a computer will have used a printer at some point, whether to create text documents or for more complex graphic images. Our concern in this thesis is with printing the photographic image digitally, which means working from bit-mapped images rather than vector-based text and graphics languages like Hewlett Packard's Printer Command Language (PCL) or Adobe's Postscript; our primary concern is with large-scale digital prints that exceed the capability of traditional analogue photographic enlargement. At this writing, only one technology surpasses emulsion/light-based printing: laser-photo printing – and for large-scale laser-photo prints only the Durst Lambda series of printers is able to surpass enlarger-based printing (see below).

Noise is at the root of my proposition concerning large-scale prints and the uncanny, and it is worth noting that a "print of poor quality" is another way of nominating "a visual message occluded by a noisy signal." Given our extensive review of photographic enlargement and the problems of granularity and other lens/emulsion-based artefacts, a review of less-refined digital printing methods and their problems is in order, starting with another laser-based photographic printing method – electrostatic printing – followed by inkjet prints, of which "Iris" prints were long considered the premium choice of visual artists.

ELECTROSTATIC PRINTING

Electrostatic printers are more commonly known as laser jet printers, and have become the de facto method of printing for commercial office-based business. The process is based on several exchanges of static electricity, with the final image heat-sealed into the paper.

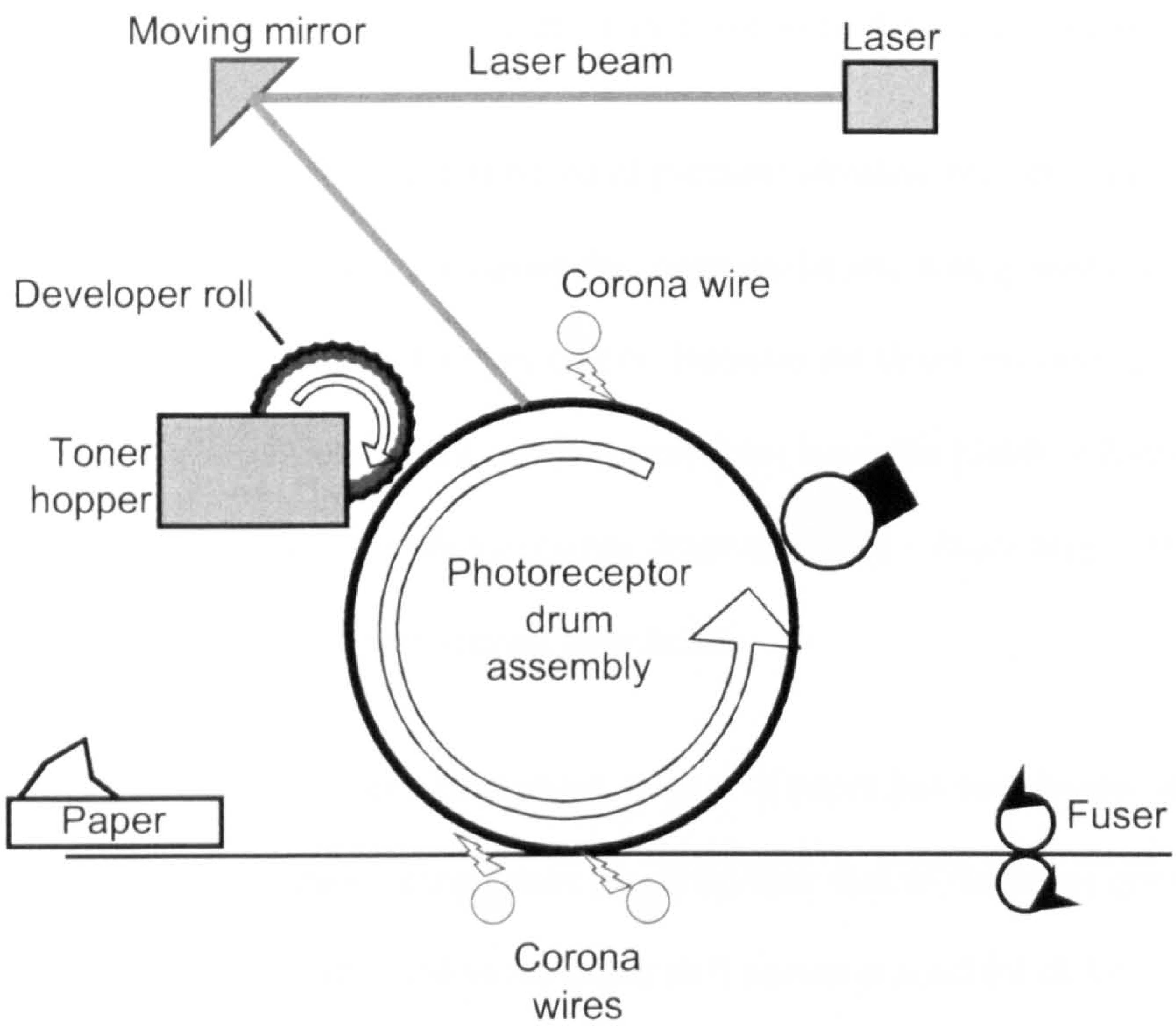

Figure 41 Laser printer

Image data is sent from the computer, typically in practice as a vector-based file, but as businesses become more creative with their presentations and documents, often as a bit-map. The data is read by the printer, and once the image has been calculated by the printer and assembled in the printer's memory, a positive electrostatic charge is passed from the corona wires onto the photoreceptor drum assembly, which is composed of a highly photoconductive material (see Figure 41). This charge, because of the assembly's photoconductivity, can be discharged by light photons.

Just as a scanner acquires an image line-by-line, the laser beam is moved across the drum assembly, "writing" the image data line by line, discharging areas that should receive image density. Meanwhile, a metal developer roller is passed through the toner hopper, which is filled with negatively charged magnetic beads. In the toner hopper, toner particles have been given a positive electrostatic charge. They are attracted by their dissimilar charge to the magnetic beads, which in turn attach themselves to the metal developer roller.

These toner particles are composed of pigment blended into irregularly-sized plastic particles. The metal developer roller passes the magnetic beads, with positively charged toner particles, over the photoreceptor drum assembly. Because the drum has been given a stronger negative charge than the metal beads, the toner particles leave the beads and attach themselves to the discharged areas of the photoreceptor drum assembly – those areas earlier discharged by the photons emitted by the scanning laser beam.

As this process has been happening, a sheet of paper has been loaded into the printer and given an electrostatic charge more powerful than that of the drum assembly. The toner particles are then attracted to the paper as it passes around the drum. At this point, the paper is rolled off the drum, typically face-up, and the toner particles are held onto the paper by charge and gravity. The final stage of printing is to seal the particles into the paper. Because the particles are composed principally of plastic, a quartz tube lamp inside the printer is able to melt the plastic particles, fusing the pigment they contain into the heated paper, giving electrostatic prints a strong durability.

This is, of course, for a monochrome print. For laser colour prints, the process is quadrupled, with the paper taking four consecutive rolls around a cyan, magenta, yellow and black toned drum assembly.

Although electrostatic printing is durable, inexpensive, and very quick, large-scale printers are prohibitively expensive (most laser printers print at a maximum of A3), and rarely print at a resolution higher than 600 dpi (for comparison, a Durst Lambda printer has a perceived equivalent resolution of 4,000 dpi) (Durst 1999a). Also, because each of those dots must be either cyan, magenta, yellow or black, without variable densities, a colour-toned screen must be developed for the print – far below anything approaching photographic quality (Hawkes & Wilson 1998).

INKJET PRINTING

Inkjet printing is the most popular method of digital printing in practice at this writing. Costs for hardware are low, and quality/cost ratio is relatively high. Although not capable of the quality of even a grainy photograph due to an inability to accurately print continuous-tone images, quality is sufficient to satisfy most consumer's imaging demands, contributing to the printers' popularity.

Inkjet printers do what they say on the box, spray ink onto paper, and come in two varieties: thermal bubble (more commonly known as bubble jet), and piezo-electric (referred to ubiquitously as inkjet printing, this technology is patented by Epson, the commercial and arguably qualitative leaders in the field of inkjet printing).

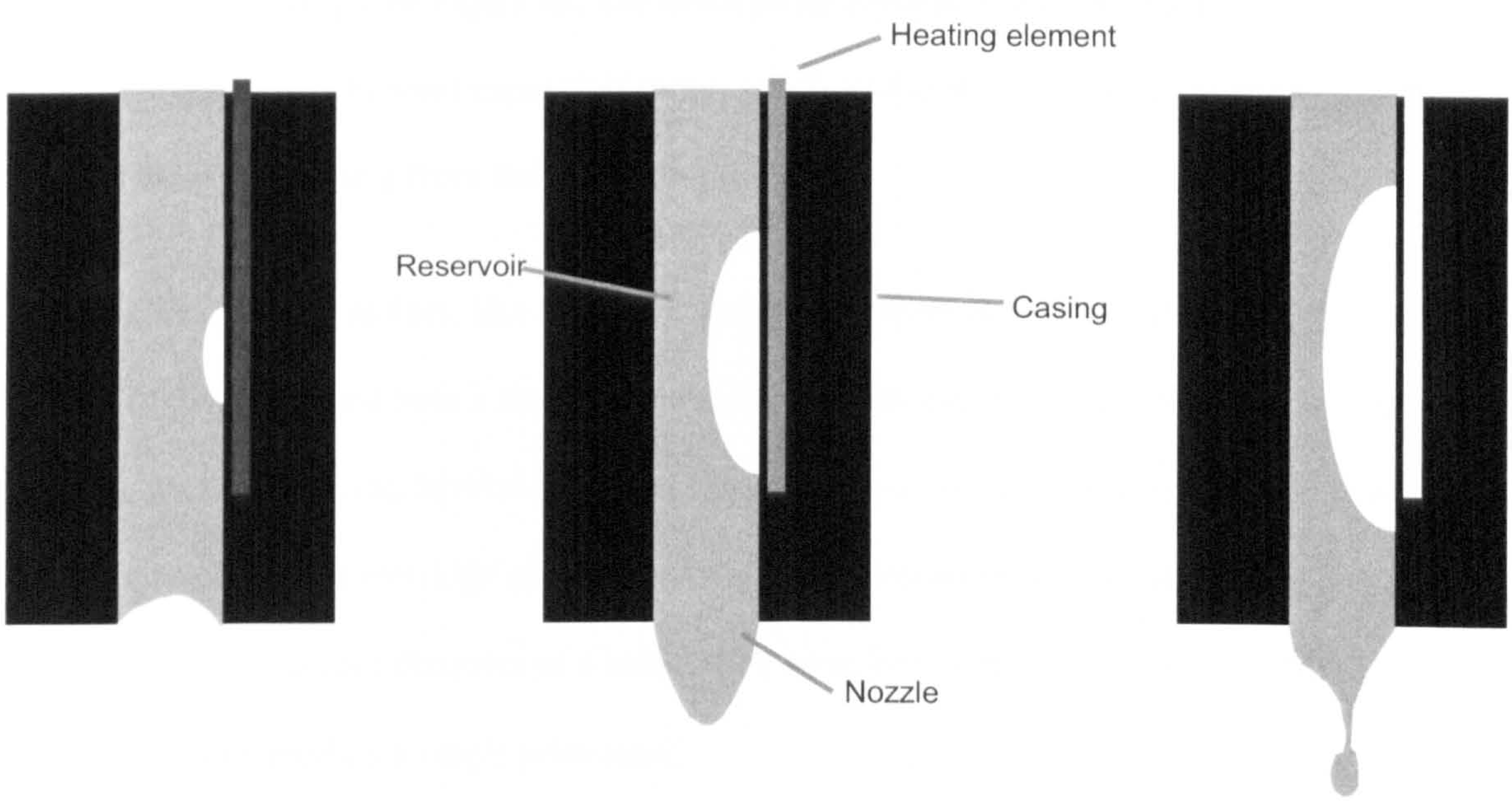

Figure 42 Bubble jet print head

Bubble jet printers, as shown in Figure 42, operate on heat and pressure. Small electronic resistors, in the casing of each jet nozzle, heat and vaporise a portion of ink contained in the ink reservoir, creating a bubble. As the bubble expands, ink is forced from the end of the nozzle and sprayed onto the paper. Once the resistors cool again, a vacuum is created within the reservoir, drawing ink back into the nozzle casing.

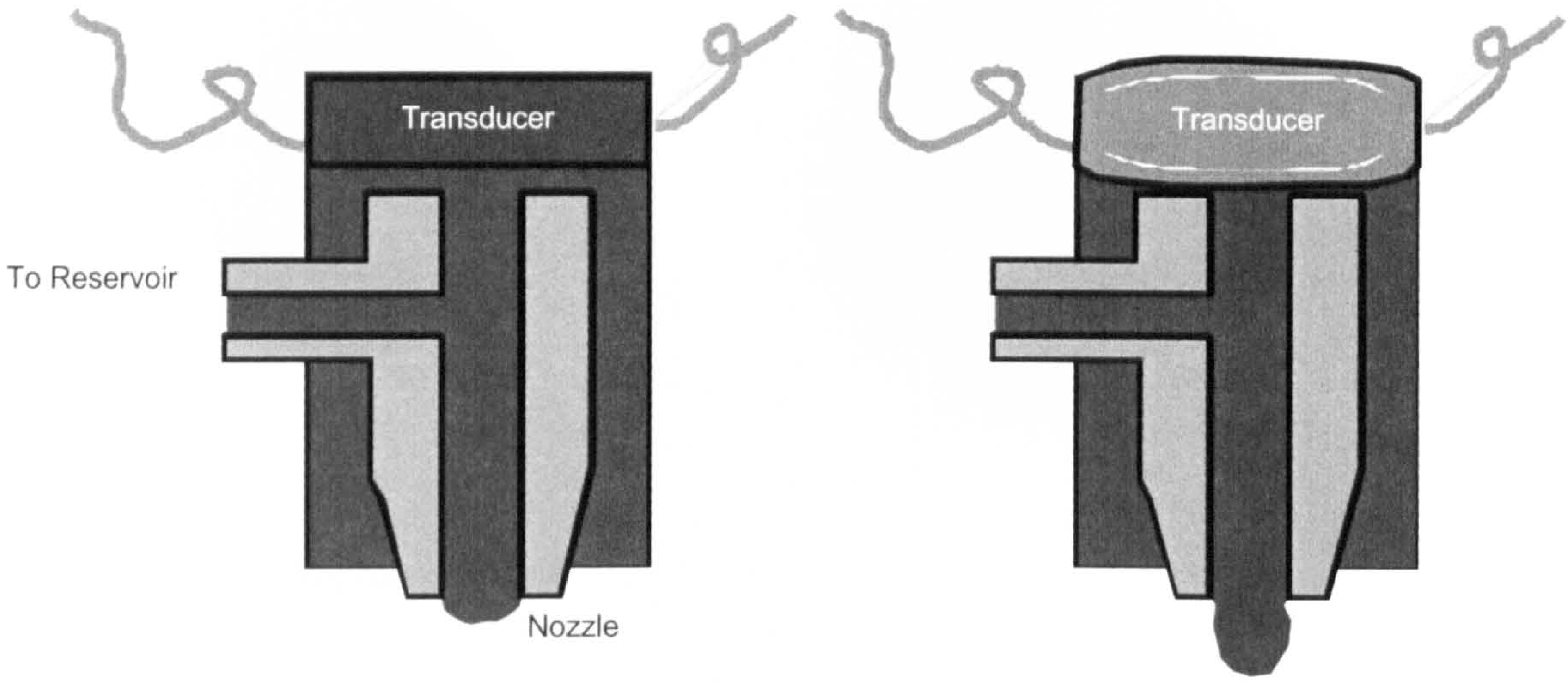

Figure 43 Piezo-electric print head

Piezo-electric printing (see Figure 43) use small piezo crystals to vibrate droplets of ink out of the nozzle cartridge. Outward expansion sprays ink from the nozzle, inward retraction pulls ink into the nozzle casing from the ink reservoir.

In both cases, stepper motors, like those in scanners, transport the print heads across the surface of the paper, and both x and y resolution are determined by the precision of the motor and transport mechanism. Several passes will be made over the same area by different print heads (each colour ink cartridge often contains its own disposable print head), allowing ink droplets smaller than the diameter of a human hair to be fired onto the paper. Hundreds of nozzles are contained on a single print head.

Colour ink-jet printers vary widely in resolution and colour capability. At the low end, monochrome printers achieve a resolution of 300 dpi with a single black ink cartridge. Mid-range consumer "photo" inkjet printers operate at a resolution as high as 2,880 dpi, and will have a minimum of four ink colours, and often six and upwards. At the high end, the now discontinued IrisGPrint Giclee was capable of near photographic quality over a large format.

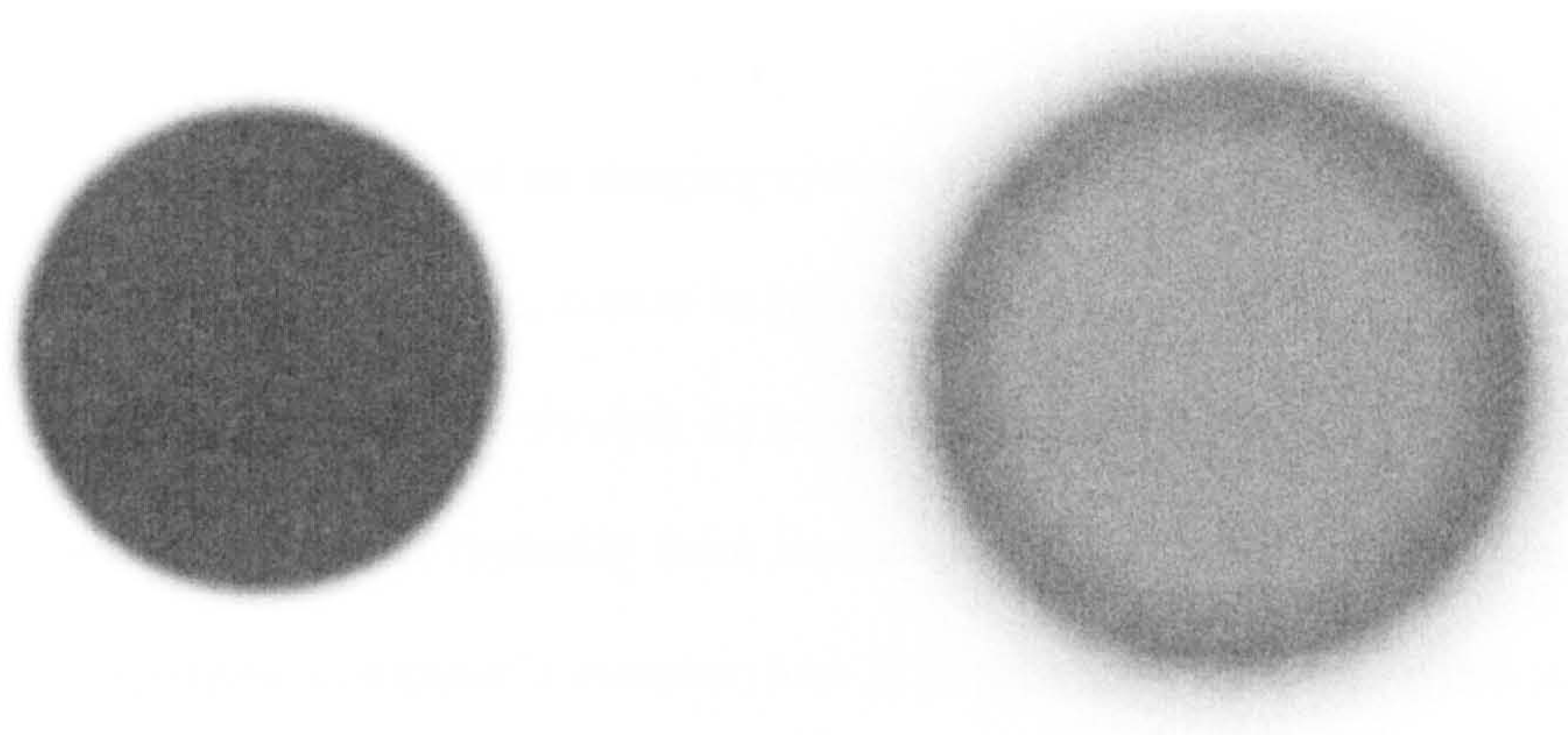

Figure 44 Inkjet droplet spread

Media quality is one of the principal determining factors in inkjet print quality. As with photographic print media, paper brightness determines the breadth of tonal range. With inkjets, absorption – that is to say, the degree to which the paper absorbs and spreads a droplet of ink – determines the overall sharpness and resolution of an image (see Figure 44). High absorption causes spreading of ink, unevenness of saturation, and a loss of sharpness. Low absorption allows higher x and y resolutions to be achieved, as control is more precise.

Although results are impressive for such an inexpensive technology, inkjet prints still can't manage true continuous-tone printing, and are therefore unable to render subtle colour shifts without considerable noise in the print. Despite perceived (see below) resolution as high as 2,400 dpi in Iris Prints, and real-world resolutions of 2,880 dpi with Epson inkjet printers, results are still far below those of traditionally enlarged prints. Despite this, inkjet printing remains the print medium of choice, noise and all, for one-off non-photographic enlargements for the consuming public.

PERCEIVED RESOLUTION

Resolution, taken as the ability of an imaging system to acquire or display clearly distinguishable details of an image, comes in two varieties: 1) spatial resolution (the clarity of a single image, often expressed in xy dpi); 2) temporal resolution (the clarity of a moving image or object – as in video), typically from frame-to-frame, but also often expressed as the refresh rate of a graphic computer's monitor; and 3) perceived resolution, which is the apparent resolution of a display from the observer's point of view.

Blakemore and Campbell (1969) showed that our visual system performs the rough equivalent of a Fourier analysis when viewing spatial data and Ginsberg (1978) published data which showed that visual perception is based on analyses of images in octave wide bands. All spatial frequencies within the octave appear to be the same and part of an overall curve (see Figure 45), the result being that perceived resolutions are often much higher than real-world spatial resolution in machine imaging.

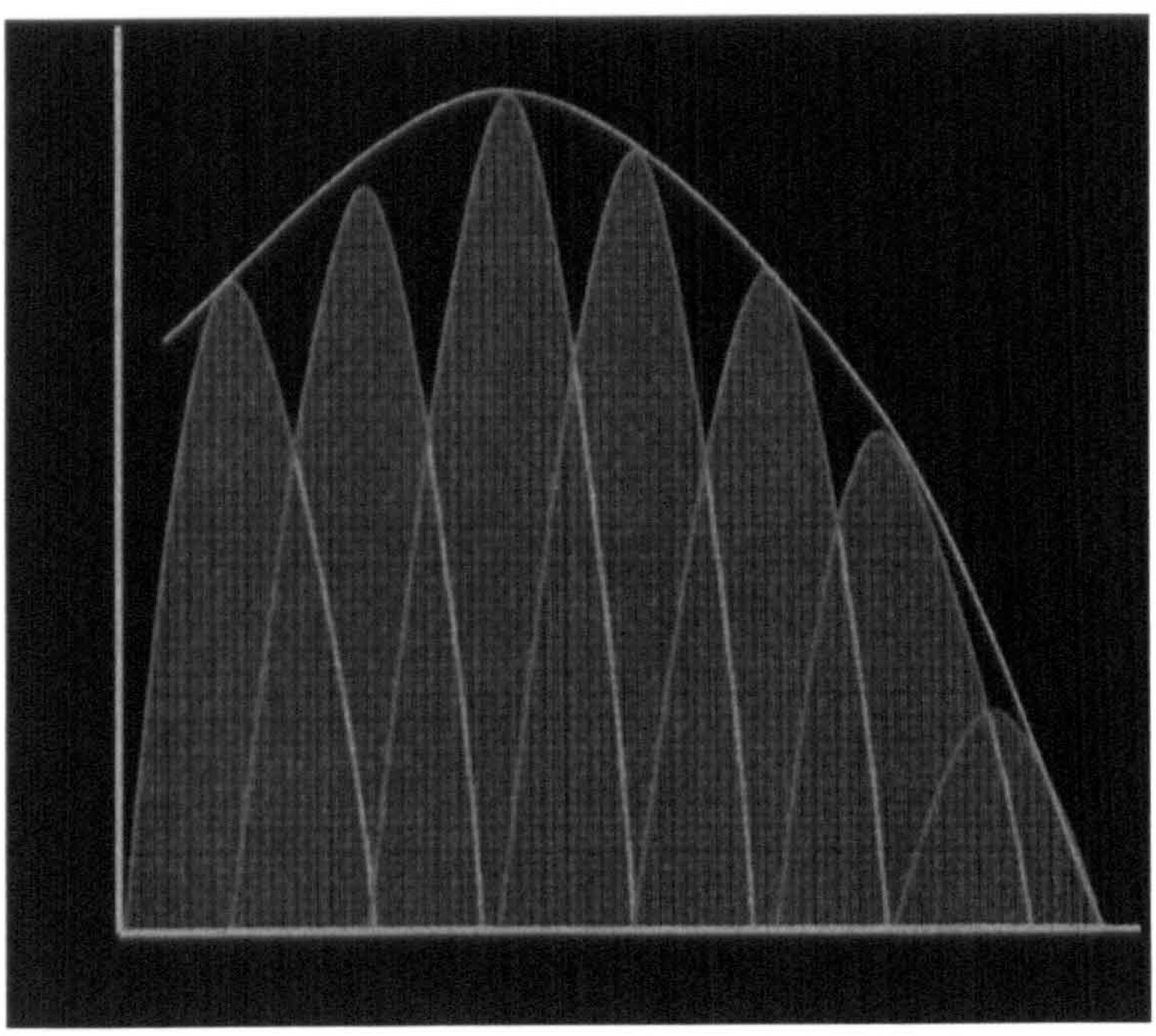

Figure 45 Spatial frequency represented by waves

IMAGE INTERPOLATION – ENLARGING IMAGES

When a photographic negative is enlarged onto a positive print, upward scaling happens on an optical basis. Light is passed through the transparent negative, and the image contained therein is magnified and focused onto a flat sheet of photographic paper by a compound lens. The resolution of a digital file is quoted in dots per inch (dpi), and although "virtual," these files have an analogue, real-world xy dimension. A 36x24mm image scanned at 2400 dpi, when printed without alteration, will print at 36x24mm – 3400 x 2264 pixels. To enlarge the image, the computer must perform a multiplication of the number of pixels, and write the new pixels in a new file. An enlargement of ten times would yield an image 34,000x22,640 pixels, however, each 10x10 area of pixels would be identical in colour and density, yielding a pixelated image. To compensate for this, interpolation algorithms are used to create new information to place in the nine-pixel space between the original pixels, smoothing the transition from pixel to pixel, now that that transition is more apparent in the enlarged image.

There are several approaches to scaled-up interpolation of data in general, and imaging data in particular, and within each category of approach, there are many classifications of algorithm.[56] To name but a few:

Nearest Neighbour Interpolation, outlined in the example above, where the new pixels are assigned the value of the original pixel in the nearest original lattice point;

Bilinear Interpolation interpolates linearly between the four closest lattice points;

Bicubic Interpolation is by far the most common interpolation method used in imaging applications. This method uses a non-linear average of 16 pixels surrounding the source pixel;

Data Adaptive Directional Interpolation is based on the idea that image interpolation works best when it is done along image edges, rather than across them, and begins with the calculation of likelihood that a pixel belongs to an edge based on a pre-given set of directional values (Li & Orchard 2000)(Kimmel 1999).

There are several other methods, such as Lanzcos, Mitchell, Cubic B-Spline, Wavelet Based Scale Interpolation, Table Interpolations, etc., and the prevailing direction of research and commercial product seems to be toward edge-based interpolation methods (Muresan & Parks 2000). Our principal conversation concerns interpolation methods put in practice in large-scale laser photo printing. The proprietary algorithms implemented by Durst in the Lambda series of laser photo printers are trade and company secrets, and will not be examined in this thesis. However, the most commonly practised method for image enlargement at this writing is a combination of bicubic interpolation with unsharp masking.[57] Durst does utilise a combination of spatial interpolation and sharpening (von Aufschnaiter 1999). Overall methods of each are discussed for illustration below.

SPATIAL INTERPOLATION

When an image is upscaled, the overriding question is what to do with the new spaces in the target image that fall off the raster of the original pixels. To begin, let's consider an upscaling in one dimension – a temporal interpolation.

If we chose to expand a signal by a factor of 2, where signal = f, time = t, and the resulting signal = g, then:

---

[56] Algorithms are necessary when the pixel in the target image does not lie on the raster of a pixel from the source image. To scale a 4x4 image to 8x8 is so straightforward the math can be done in one's head. 4x4 to 5x5, however, is a different issue.

$$g(t) = f(t/2)$$

The signal, via a digitisation derived from Fourier analysis, will be sampled at even integer values of t,[58] comprising the raster. The problem arises that in the target signal (g), we have no idea of the values that will lie on the odd integers – the in-between values. We cannot construct a perfect reconstruction of f at this sample rate (ideally, we would conduct a continuous reconstruction of f to arrive at g, something that rarely happens in time-based wave analysis), but to be fairly accurate, we should "know" that no value of t lay above the Nyquist frequency, and that the wave were a regular periodic wave without periodic frequency variations.[59] Taking those conditions *a priori* we can see from the example below how we would arrive at non-raster values of g.

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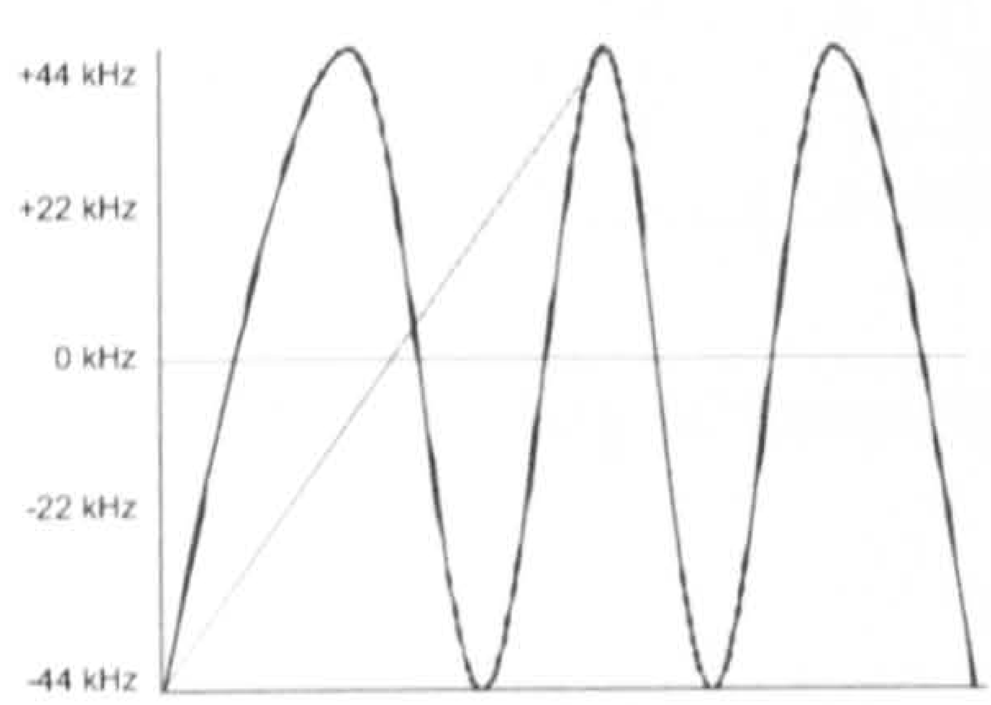
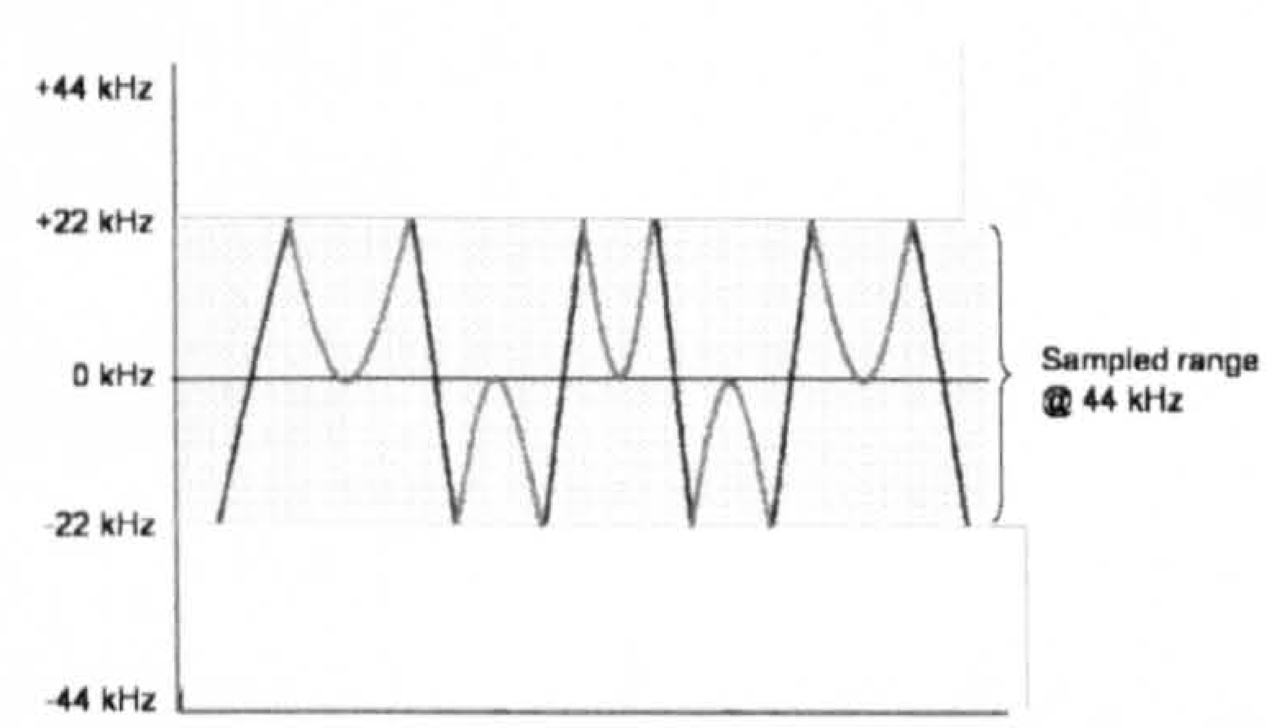
[57] Although not quite a misnomer, unsharp masking is in fact a method of increasing the apparent sharpness of an image.

[58] For this example only. The raster values, in this case the even integers, are determined by the sampling frequency, and may fall anywhere, provided they are uniform.

[59] Where a sampling range is equivalent to the frequency of a sampled wave, the Nyquist frequency is $x/2$, where x represents the highest value of f. Any frequency registering above the Nyquist frequency would be folded over onto itself in an effect called aliasing.



Footnote Figure 1



Footnote Figure 2

In Footnote Figure 1, we see a relatively regular 44 kHz sine wave. However, it has a full dynamic range of 88 kHz – 44 kHz above a base of zero, and 44 kHz below. If we were to sample this wave at a range of 44 kHz, we would get something like what we see in Footnote Figure 2 – with all values above and below ±22 kHz, folded over onto themselves. This effect is called aliasing, and 22 kHz, in this example, would be the Nyquist frequency. Aliasing is one of the major sources of noise in conversion of analogue data into digital form, whether for imaging or audio (for more detailed information, see Jacobson, Attridge, Ray, Axford 2000, p.409).

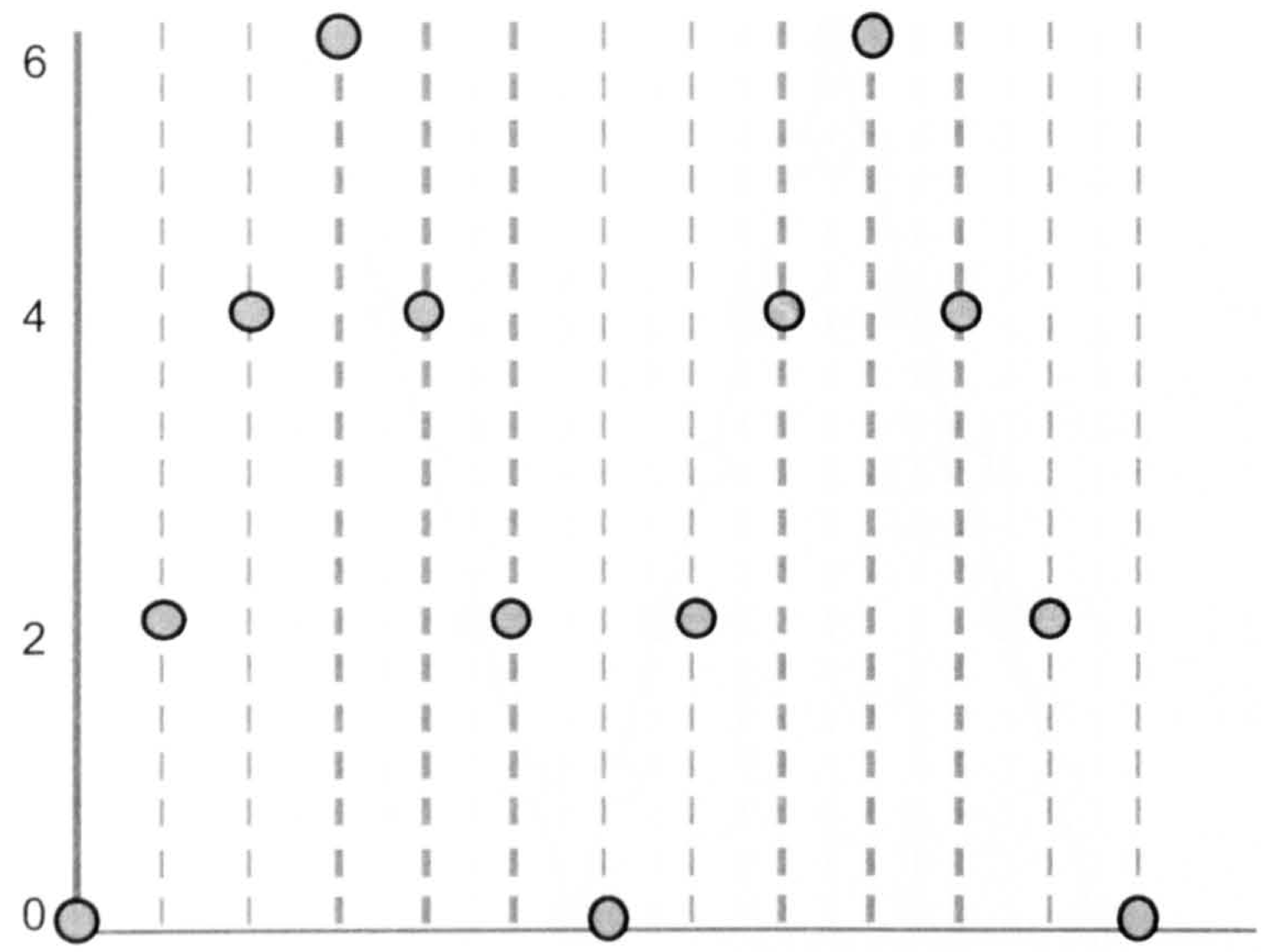


Figure 46 Simple triangle wave

In Figure 46, we have a simple triangle wave sampled at regular intervals, deriving values of 0, 2, 4, 6, 4, 2, 0, 2, 4, 6, 4, 2, 0 – an array that gives a rough indication of *f*. To arrive at *g*, we would first double *t*, to arrive at something like Figure 47.

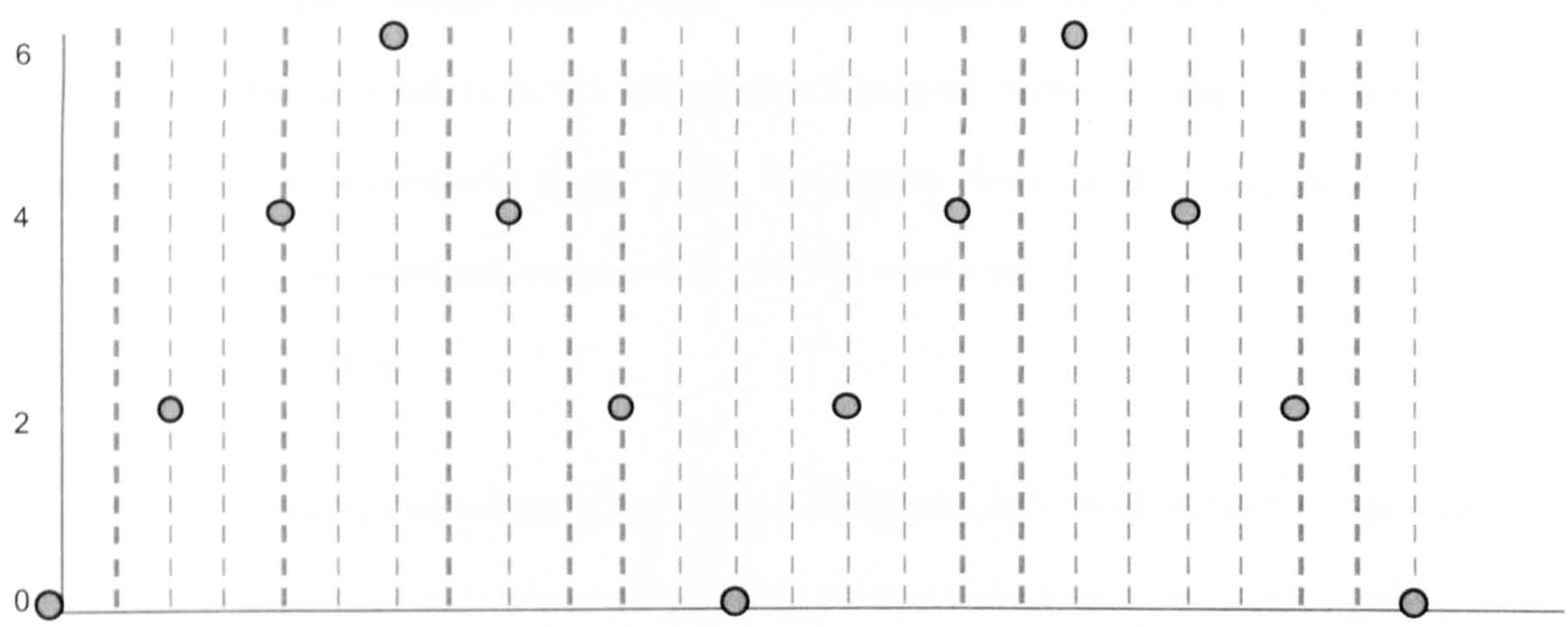


Figure 47 Doubling of sample rate of simple triangle wave

To derive values for the odd-numbered integers on the new scale of *g*, we would have needed to have doubled our sample rate of *f* (see Figure 48).

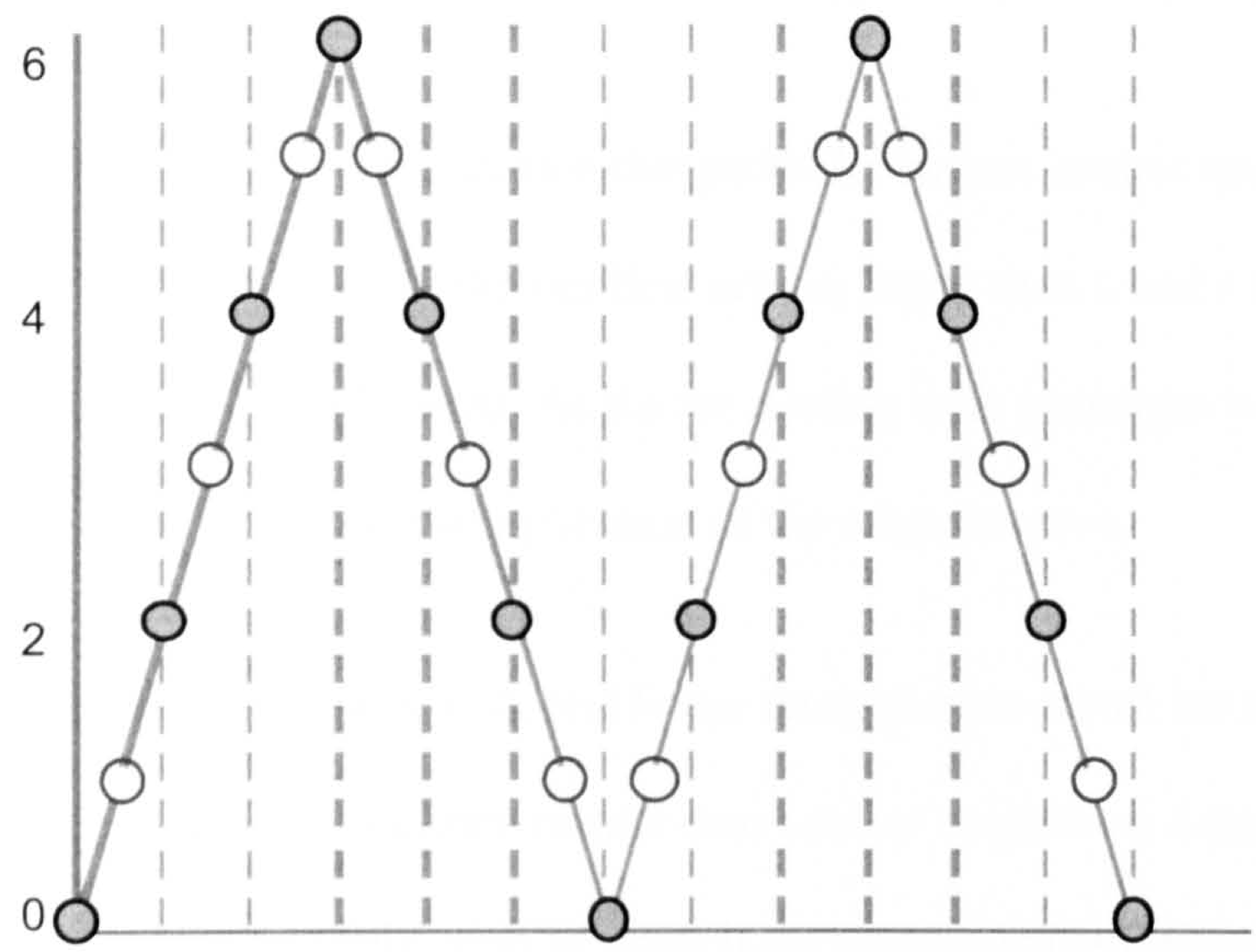


Figure 48 Doubling of sample rate of simple triangle wave, with interpolation

However, having sampled the triangle wave at even numbered integer points on the array, and given the values we have derived, to construct points on the odd numbered integers, we may either duplicate each of the values we have measured on the even numbered integer points onto the odd numbered integer points (called "nearest neighbour" or "pixel replication"), or we can interpolate new values for the odd numbered integer points by taking the average of two consecutive even numbered integer points on the array. For a regular triangular wave sampled at points on peaks and troughs, this would provide a perfect reconstruction of a temporal range of values.

To derive values using nearest neighbour when doubling the time component of a wave, new points on our target time scale where are placed at 1.5 times the time point on our original wave (to treble the wave, new points would be placed at 1.33 and 1.67). This gives us an array of values: 0, 0, 2, 2, 4, 4, 6, 6, 4, 4, 2, 2, 0, 0, 2, 2, 4, 4, 6, 6, 4, 4, 2, 2, 0, 0.

A simple form of interpolation would work quite differently. Here, we would draw a line through the sampled points, and calculate new samples at points lying halfway in between. In equation form this would be:

$$f(t) = s \times f(floor(t)) + (1\text{-}s) \times f(ceil(t))$$

where *floor* is the function that picks the largest integer smaller than t and *ceil* is the "ceiling" function that picks the smallest integer larger than t, and s is $t\text{–}floor(t)$ – the distance between t and the sample point. As we are dealing with a triangle wave, this is linear interpolation, and renders a perfect multiplication of the original wave.

So far, this works well, and linear interpolation seems the better option of the two, however, it *can* yield less accurate results than nearest neighbour, depending on the wave sampled and the intended multiplication of time. If we were to triple the lengths of the wave, the results for linear interpolation would be as in Figure 49, and for nearest neighbour as in Figure 50.

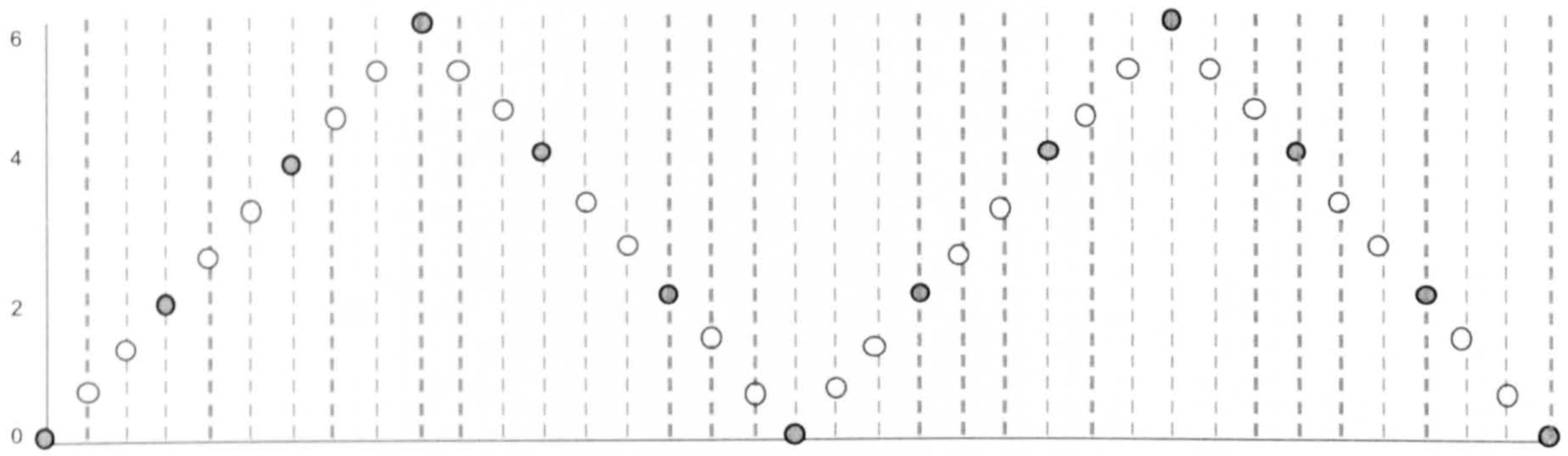


Figure 49 Trebling of sample rate of simple triangle wave, with linear interpolation

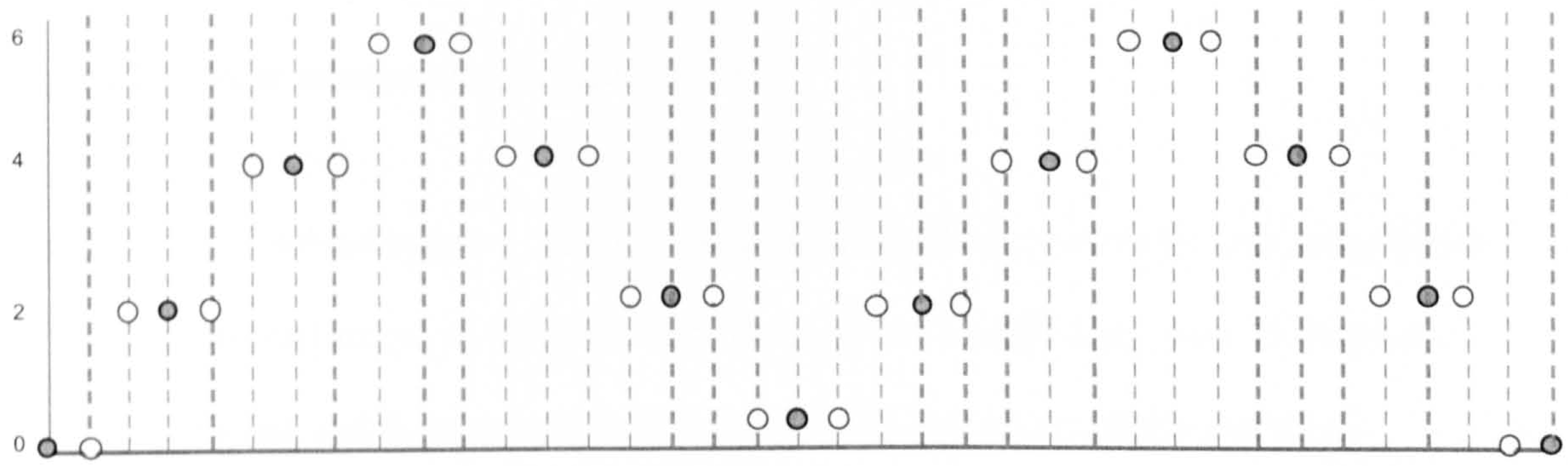


Figure 50 Trebling of sample rate of simple triangle wave, with nearest neighbour interpolation

We are assuming, however, that we have sampled a triangle wave – in point of fact we could have been sampling **any** wave, and the accuracy of our results changes dramatically. If, for instance, our original wave had been a square wave, with values of 0, 0, 1, 1, 0, 0, 1, 1, 0 and 0, and we chose to treble it, nearest neighbour would yield the more accurate result (see Figure 51), while linear interpolation would overly smooth the wave (see Figure 52).

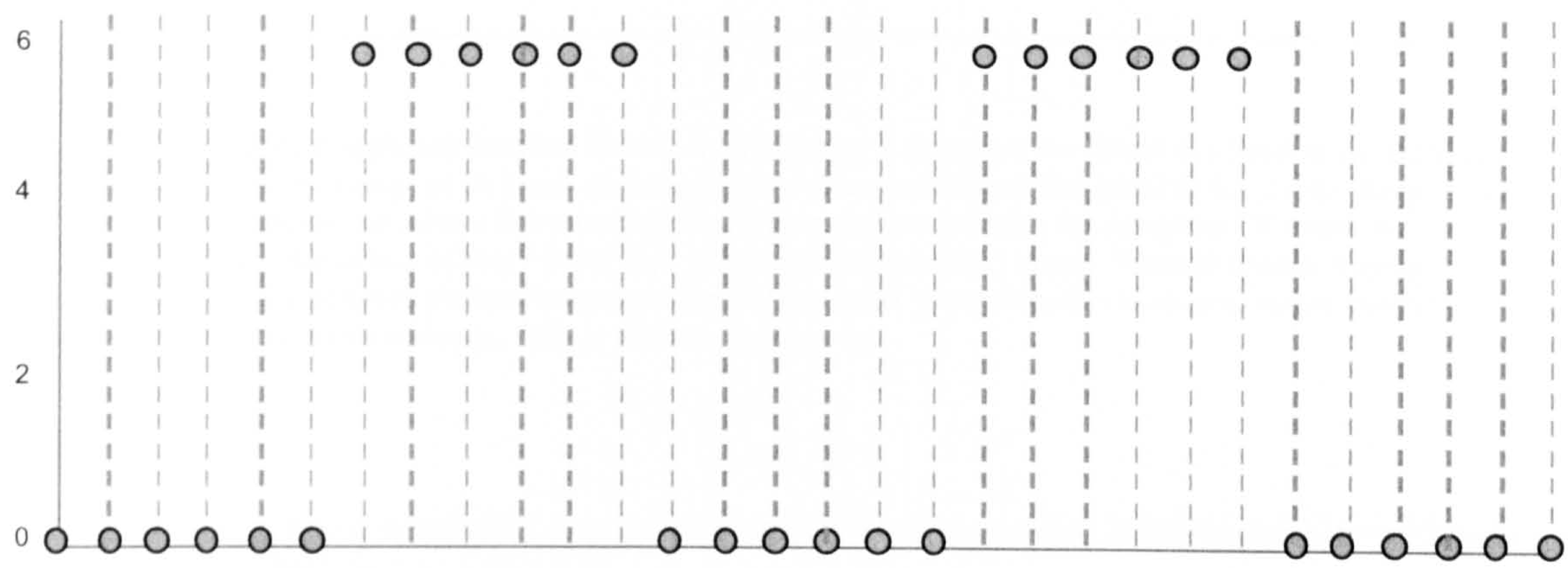


Figure 51 Nearest neighbour interpolation of square wave

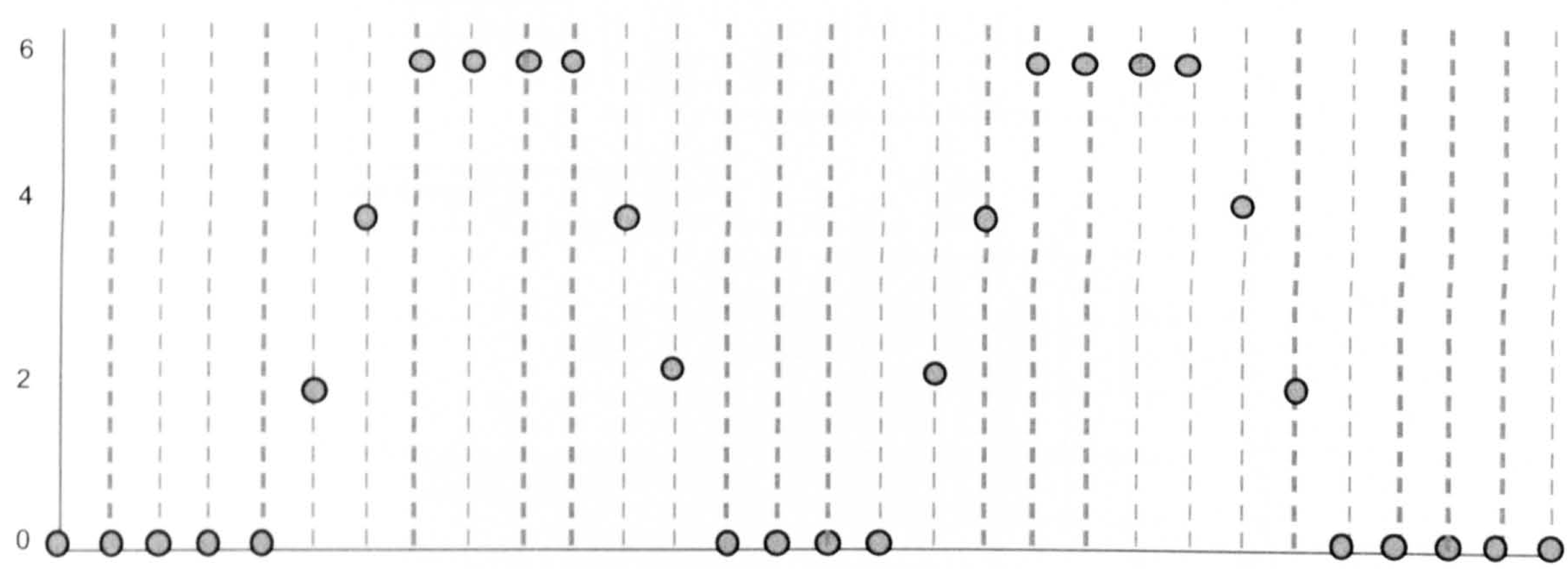


Figure 52 Linear interpolation of square wave

This problem is solved by more complex interpolation methods, such as bicubic interpolation in two-dimensional arrays. In bicubic interpolation, the 16 nearest neighbours of the source pixel are sampled, and the target pixels are derived utilising bicubic rather than linear waveforms (*Programming in Java Advanced Imaging* 1999).[60]

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[60] A breakdown of the formulas utilised in bicubic interpolation are beyond the scope of this thesis. A brief account is given by Paul Bourke in "*Bicubic Interpolation for Image Scaling,*" http://astronomy.swin.edu.au/pbourke/colour/bicubic/, quoted here:

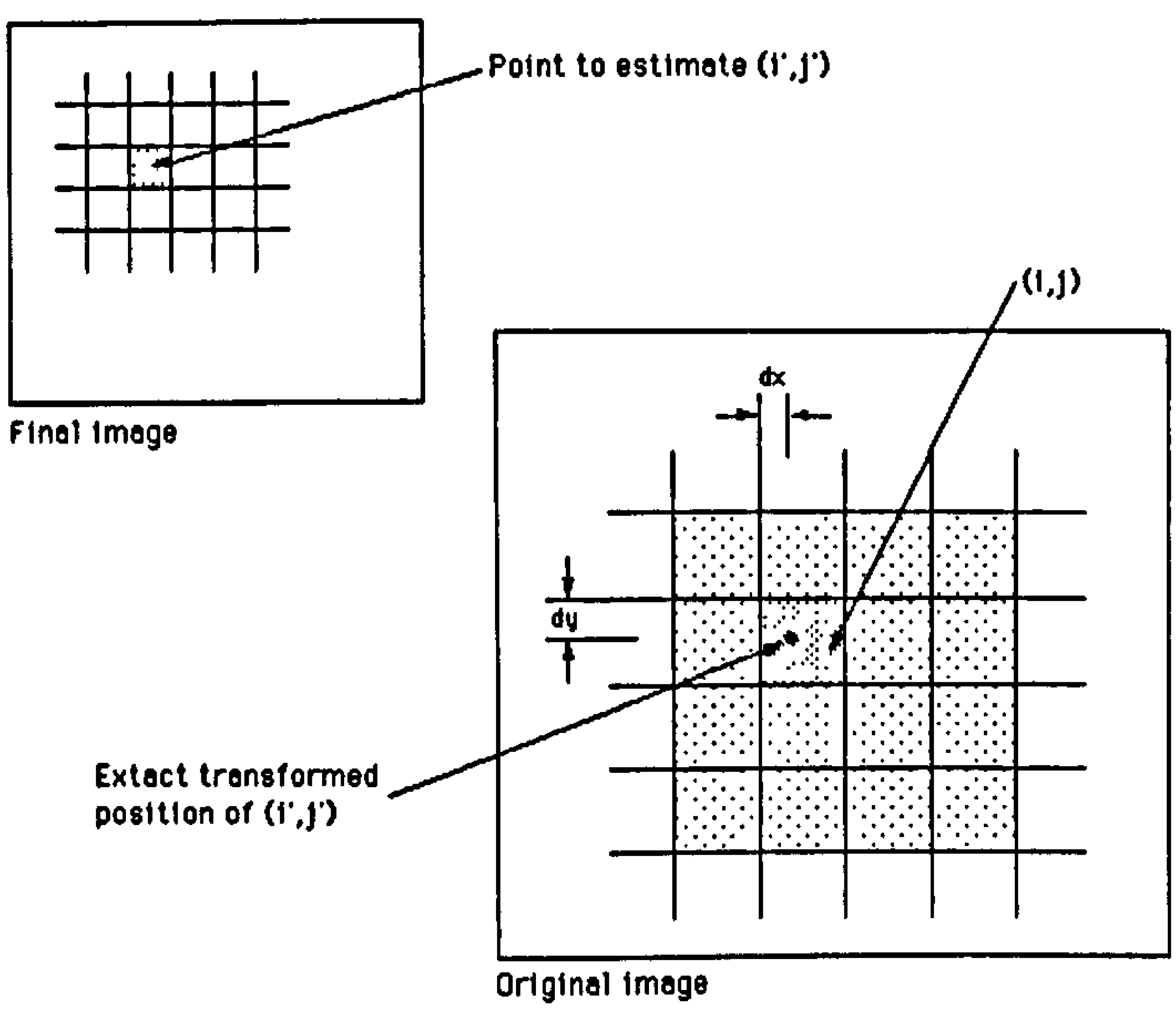
To upscale in two dimensions, required for image enlargement, interpolation must be estimated for x and y. If, in a given two dimensional array, we sampled each pixel in a 2x2 image, we would find values for A, B, C and D (see Figure 53).

"The standard approach is called bicubic interpolation, it estimates the colour at a pixel in the destination image by an average of 16 pixels surrounding the closest corresponding pixel in the source image.... The diagram below introduces the conventions and nomenclature used in the equations. We wish to determine the colour of every point (i',j') in the final (destination) image. There is a linear scaling relationship between the two images, in general a point (i',j') corresponds to an non integer position in the original (source) image. This is position is given by:

$$x = i\, w' / w$$

$$y = j\, h' / h$$

The nearest pixel coordinate (i,j) is the integer part of x and y, dx and dy in the diagram is the difference between these, dx = x - i, dy = y - j.



The formulae below give the interpolated value, it is applied to each of the red, green, and blue components. The m and n summation span a 4x4 grid around the pixel (i,j).

$$F(i,j) = \sum_{m=-1}^{2} \sum_{n=-1}^{2} F(i' + m, j' + n)\, R(m - dx)\, R(dy - n)$$

The cubic weighting function R(x) is given below.

A	B
C	D

Figure 53 2x2 pixel array

Were we to increase the size of the image by a factor of 2, we would then need to find values for *e*, *g*, *h*, *i*, *k*, etc. (see Figure 54).

A	*e*	B	*f*
g	*h*	*i*	*j*
C	*k*	D	*l*
m	*n*	*o*	*p*

Figure 54 4x4 pixel array

Under this model, in two dimensions, linear interpolation now becomes *bi*linear interpolation, and *e* would be the average of A and B. Similarly *g* is the average of A and C. To derive *h*, we would average all our given values in our source image:

$$(A+B+C+D)/4 = h$$

$$R(x) = \frac{1}{6}\left[P(x+2)^3 - 4P(x+1)^3 + 6P(x)^3 - 4P(x-1)^3 \right]$$

$$P(x) = \begin{cases} x & x > 0 \\ 0 & x \leq 0 \end{cases}$$ ”

UNSHARP MASKING

As we saw in Figure 52, one by-product of upscaling an image via interpolation is a general smoothing of the image – an introduction of noise to the signal. New information about the source image cannot be created by filtration or interpolation into the target image from the source image. Once the source image has been acquired, via scanning, digital photography or some other source, the data in the computer file is all one has. However, as we have seen, it is possible to filter, interpolate and even enhance the appearance of an image via algorithms. The general smoothing introduced into an image on upscaling – and by smoothing, in this case we mean the overall softening of edge information – can be counteracted via sharpening mechanisms, the most common of which is unsharp masking.

Unsharp masking was originally an analogue photographic process used to enhance information concerning the edges of film-based images. A laborious process, unsharp masking involved making a blurred, inverted film mask of the original image which would then be contact printed in register with the original. This would "automatically" burn and dodge the original image, holding the detail of the image's highlights while increasing contrast and detail in the shadows.

In digital image processing for photographs, the most common method of unsharp masking is to implement the useful, if somewhat brutish "Unsharp Mask" algorithm in Adobe PhotoShop, typically reserved for attempting to regain sharpness lost in the scanning process. Unsharp masking is best performed manually, and in the digital realm is performed via five standard PhotoShop processes:

Duplicating the original image;

Blurring (or smoothing) the duplicate;

Reducing the brightness and contrast of the duplicate;

Subtracting the blurred duplicate from the original; and

Adding the resulting (edge) image to the original.

In equation form, an edge image $n(x, y)$ is produced from the source image $f(x, y)$:

$$n(x, y) = f(x, y) - f_{smooth}(x, y)$$

where $f_{smooth}(x, y)$ is a smoothed version of $f(x, y)$.

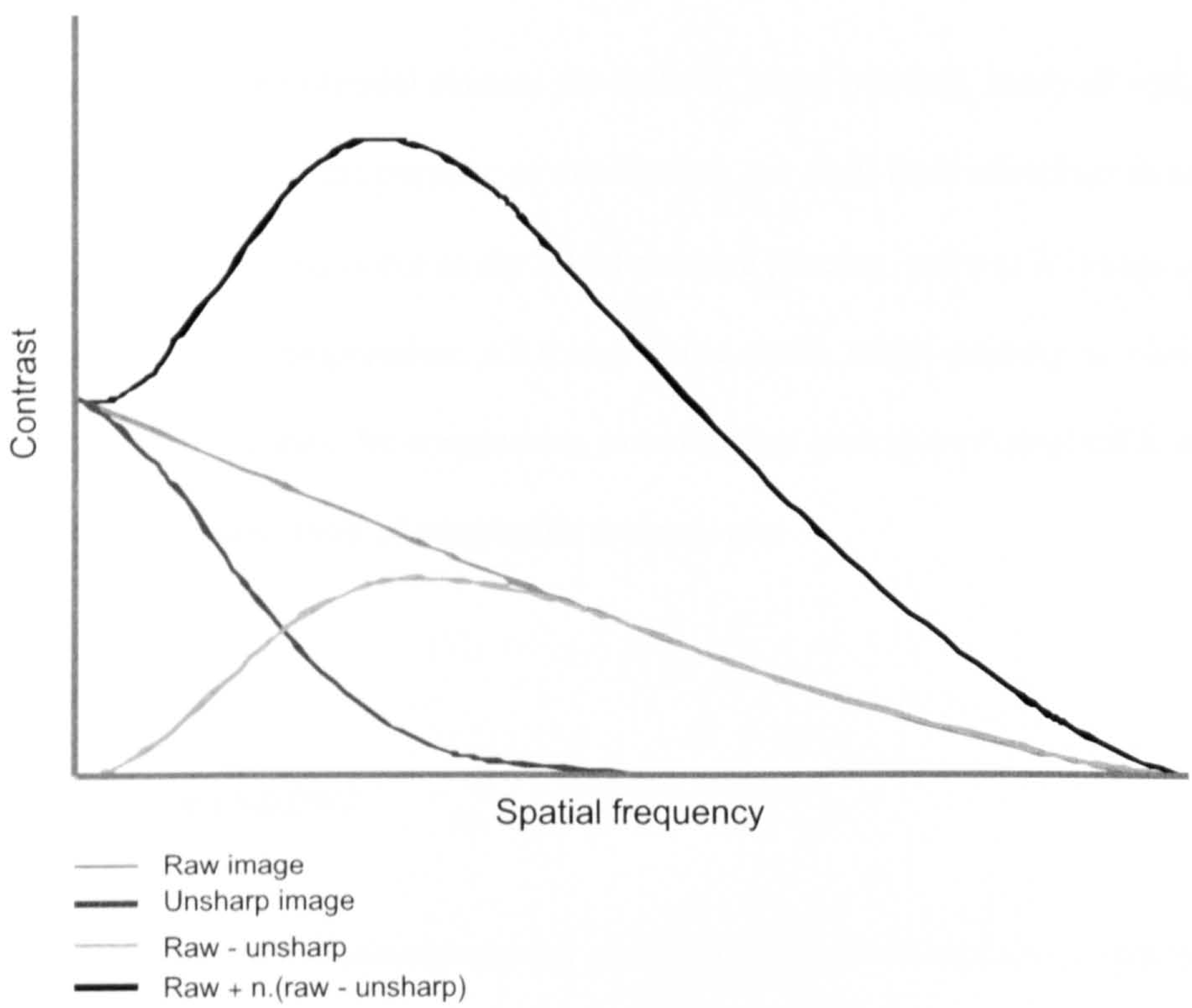


Figure 55 Unsharp masking graph

In Figure 55, the low-pass or unsharp image, created by blurring, is subtracted from the original raw image, resulting in the raw – unsharp image (note how, for much of the arc, it is inversely proportional to the unsharp image). This yields the details, or highpass, or edge representation of the raw source image.

This iteration of the image is then added to the original source image as:

$$f_{sharp}(x, y) = f(x, y) + k \times n(x, y)$$

where k is a scaling constant with larger numbers increasing the amount of apparent sharpening, and f_{sharp} is the final, target image (Fisher, Perkins, Walker & Wolfart 2000) (Lodriguss 1997) (Legault 1999).

SOURCES OF NOISE IN INKJET PRINTING

There are several potential sources for noise in inkjet printing, many of which have been outlined above. For the purpose of this section, we shall limit ourselves to sources of noise and print defects that occur in the inkjet printing process, and not in image capture, manipulation or compression. All things being equal, inkjet printing is, fundamentally, a noisy, messy business by comparison to traditional analogue photographic printing, much less printing with new laser photographic technologies.

COLOUR BANDING

The fundamental difference between an inkjet print and an analogue photographic print is the issue of printing gradations of continuous tonal ranges from the original image (continuous tone). As with traditional CMYK printing, inkjet prints are limited to a specific number of tones and colours, whether printing with a simple four-ink process, or even the more sophisticated six-ink processes marketed by Epson. Often referred to derisively as "pseudo-continuous tone printing" (vis-à-vis "true continuous tone" photographic printing), inkjet printing is fundamentally incapable of printing true colour gradations in certain tonal ranges.

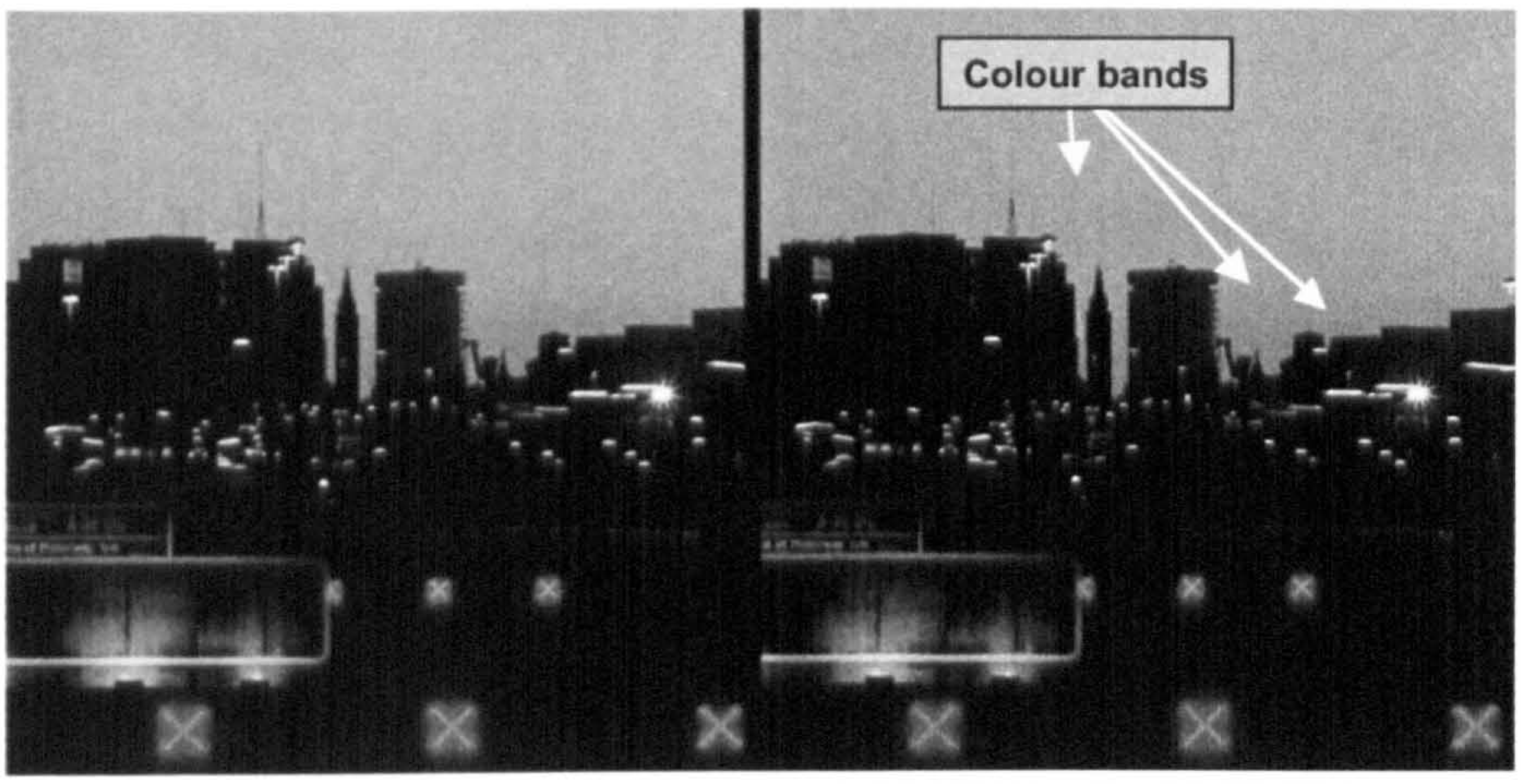


Figure 56 Colour banding

In the above photograph of the Birmingham skyline (see Figure 56), the effect of colour banding has been exaggerated for illustration.[61] In more sophisticated print systems, dithering is often used to offset the effects of colour banding (see Figure 57). Dithering places a variety of coloured pixels close together to create the effect of a colour the printer is not capable of reproducing. Varying the number of ink droplets used to create a region of colour gradation, all with the same density, is the strategy employed by Hewlett-Packard in the HP DeskJet 850C, and other printers. More logically, Polaroid and Epson employ different ink droplet densities to create a varying range of colour. Despite the success and sophistication of many different schemes, colour banding is still visible, even to the naked eye, in the inkjet print.

[61] The very limitations of print technology make it nearly impossible to illustrate accurate samples of print types, short of printing this dissertation via laser photographic prints, which are capable of displaying the noise information of other print technologies as image information. Therefore, in the above example, the right-hand version of the photograph has been reduced to 256 colours without dithering. Although an exaggeration, it is typical image quality for many, if not most, inkjet printers.

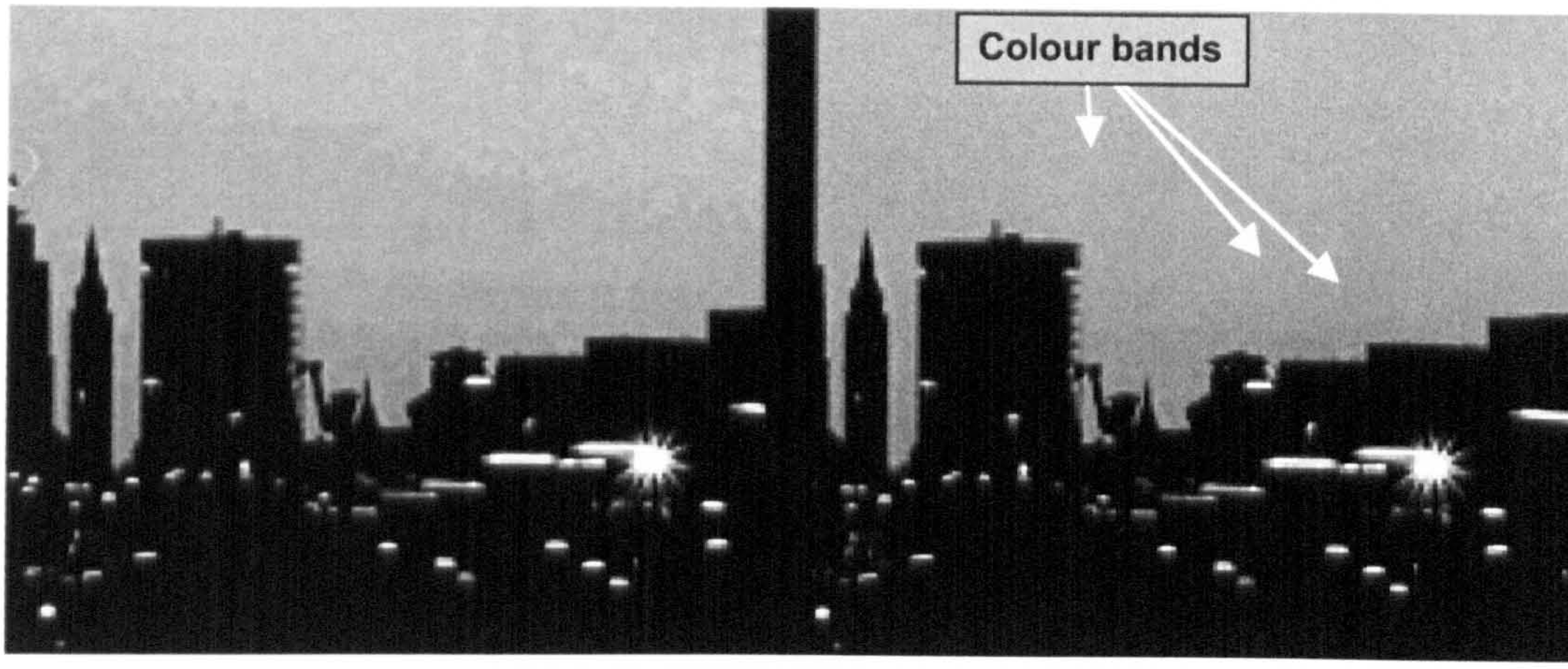


Figure 57 Colour banding with dithering

INK DROPLET SPREAD

The spreading and penetration characteristics of ink droplets into inkjet printing papers is another major determinant of inkjet noise. Feathering, colour bleeding and puddling are the three major defects related to ink droplet spread.

Feathering is the lateral absorption of ink droplets into the printing paper, and is quantified in dot gain. The effect is one of irregular edges around the dot – where individual paper fibre colouring is often visible – and inconsistent ink and colour density across the diameter of the droplet once absorbed into the paper.

Colour bleeding occurs when one colour droplet invades the colour region of a contiguous droplet, again causing irregular jagged fibre colouring and edges. This is one of the principal causes of colour banding, in that irregular edges are created between areas of colour.

Puddling occurs when ink droplets fuse on the surface of the paper before drying, and results in image spread and irregular edges. This problem often occurs during printer errors, during overprinting (printing an area more than once to increase density , smoothness of gradation and image fidelity), or when the substrate of the paper has low absorption or has become saturated with inks.

The degree of spread that occurs when an ink droplet hits the target paper depends on many factors, both in the ink and delivery system (surface tension, viscosity, droplet impact energy, and droplet delivery time) and in the molecular makeup of the paper (surface energy, surface topography, electrostatic charge, pre-deposited drops).

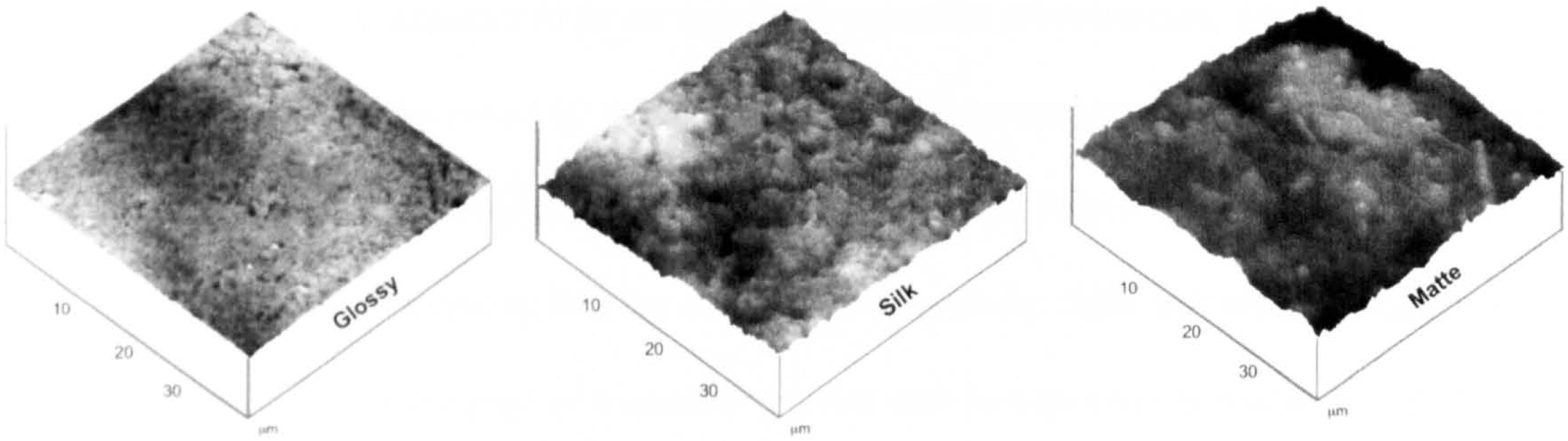


Figure 58 Surface roughness of printing paper (von Bahr, Kizling, Zhmud & Tiberg 2001)

The effect of surface roughness of the printing paper also has a significant effect on the spread of ink droplets Matte paper is far more porous than either silk or glossy papers, and therefore initially absorbs inks much faster, yielding less spread. However, it has been shown that over time (measured in microseconds), precisely because matte paper is more porous, inks in matte substrate are more susceptible to sub-surface flow within the paper, and the initial droplet integrity achieved is lost.

The surface tension of the droplet (and, therefore, the level of surfactant in the droplet), the lifetime characteristics of the droplet, and kinetic energy of the droplet all have a significant effect on the spread of the ink once it hits paper. Indeed, the effect is increased the smaller the droplets used. An Institute for Surface Chemistry report from late 2001 demonstrates the severity of the situation in a discussion concerning pure liquid absorption into the surface of paper:

*When an equilibrated drop hits the surface, its kinetic energy is redistributed in a number of ways. A part of the energy is dissipated as heat, a part is transformed into the surface energy of expanding solid/liquid and liquid/vapour interfaces, and finally, a part is preserved in the form of kinetic energy of liquid flow. If the action of gravity is important, the potential energy of the drop should also be taken into consideration. Furthermore, unless the surface has been prewetted, heat evolution due to solvation and heat consumption due to evaporation may take place.... Thus, even the spreading of pure liquids appears to be an extremely complex phenomenon, which is fundamentally governed by the global laws of conservation of mass, momentum, and energy.... Summarizing the aforesaid, one can see that there exist several different dynamic regimes characterizing drop spreading under different limiting conditions. Therefore, a wide range of transient regimes can be expected in practice.... [G]iven the complexity of the spreading phenomena in **pure** liquids, one might expect [an]* ***even more hopeless*** *situation with complex solutions* (von Bahr, Kizling, Zhmud & Tiberg 2001).

SATELLITE DROPLETS

Even more severe than the problem of droplet spread on the surface of the printing material is the issue of rogue, artefact droplets, often called satellite droplets. These occur completely outside the digital calculation of colour and density by printing software, the chemical formulas for molecular drop composition, atomic estimations of kinetic energy within inkjet droplets, and the absorption rate of printing papers. They exist strictly as an artefact of the inkjet droplet delivery technology.

As was seen in Figure 42 and Figure 43, ink is drawn from a reservoir and delivered to the surface of the paper as ink droplets via a nozzle; either by a piezo-electric transducer acting as a pump, or by the "boiling" of ink in the nozzle of the jet, pumping it onto the paper via the increase and decrease in size of a bubble inside the nozzle. Figure 59 uses the example of bubble jet technology to illustrate the fluid dynamic effect of satellite droplets. After the break-off of surface tension which creates the ink droplet, additional droplets are created behind the larger droplet intended for the paper.

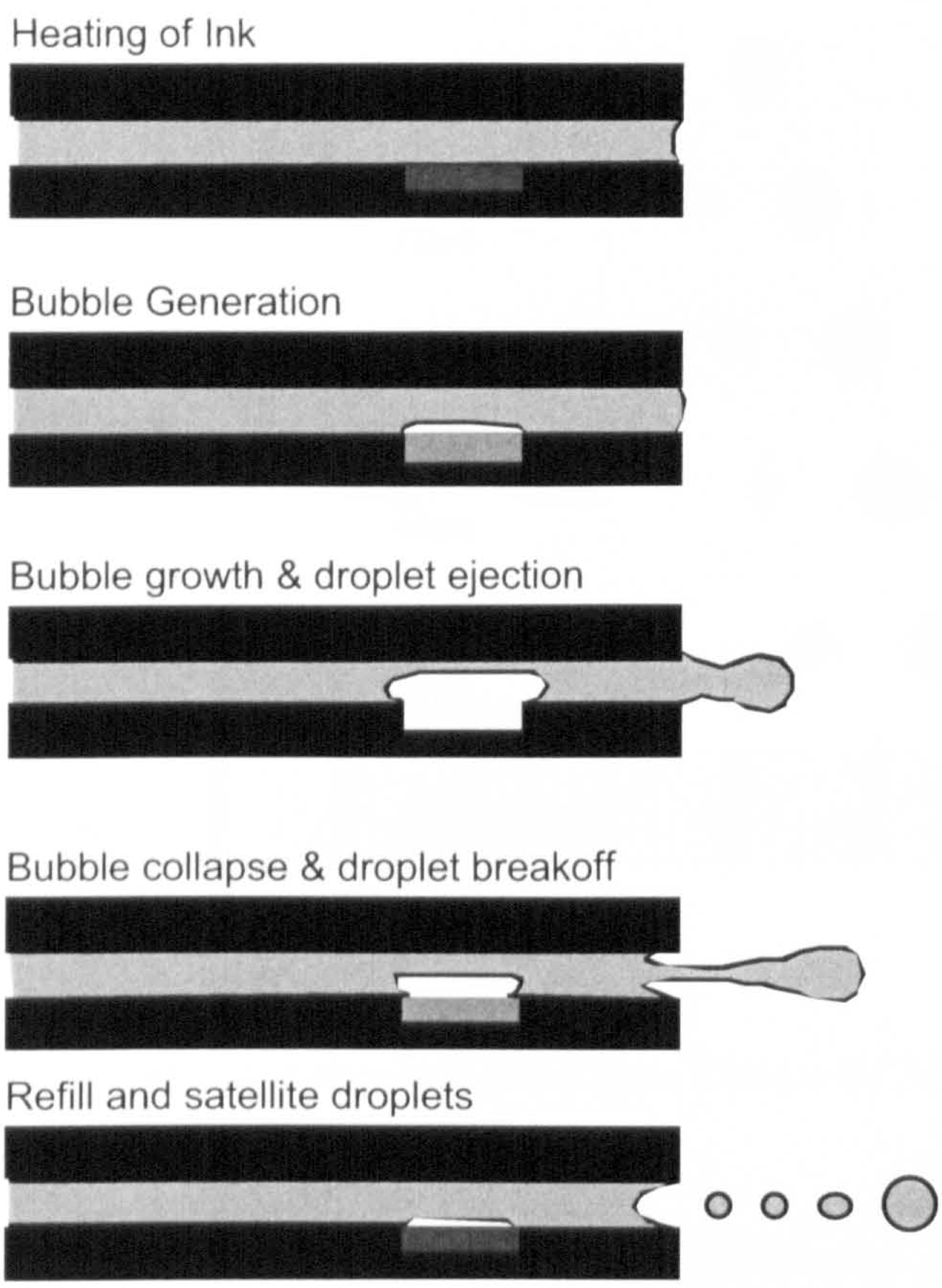


Figure 59 Inkjet satellite droplets

Initially, it would appear that these droplets would cause oversaturation of ink in certain areas, creating puddling. However, microphotographic evaluations performed by Chen, Chen and Chang (1997) demonstrate these droplets are created at intense speed, but far too slowly and without sufficient directed force for them to reach the paper at the same location as the principal droplet (see Figure 60). Indeed, the force of their expulsion for the nozzle is such that they fall across a different curve than the principal droplets, as well (see Figure 61). The result is an overall softening of hard edges as well as colour fields, and an inaccuracy of shape, colour and density.

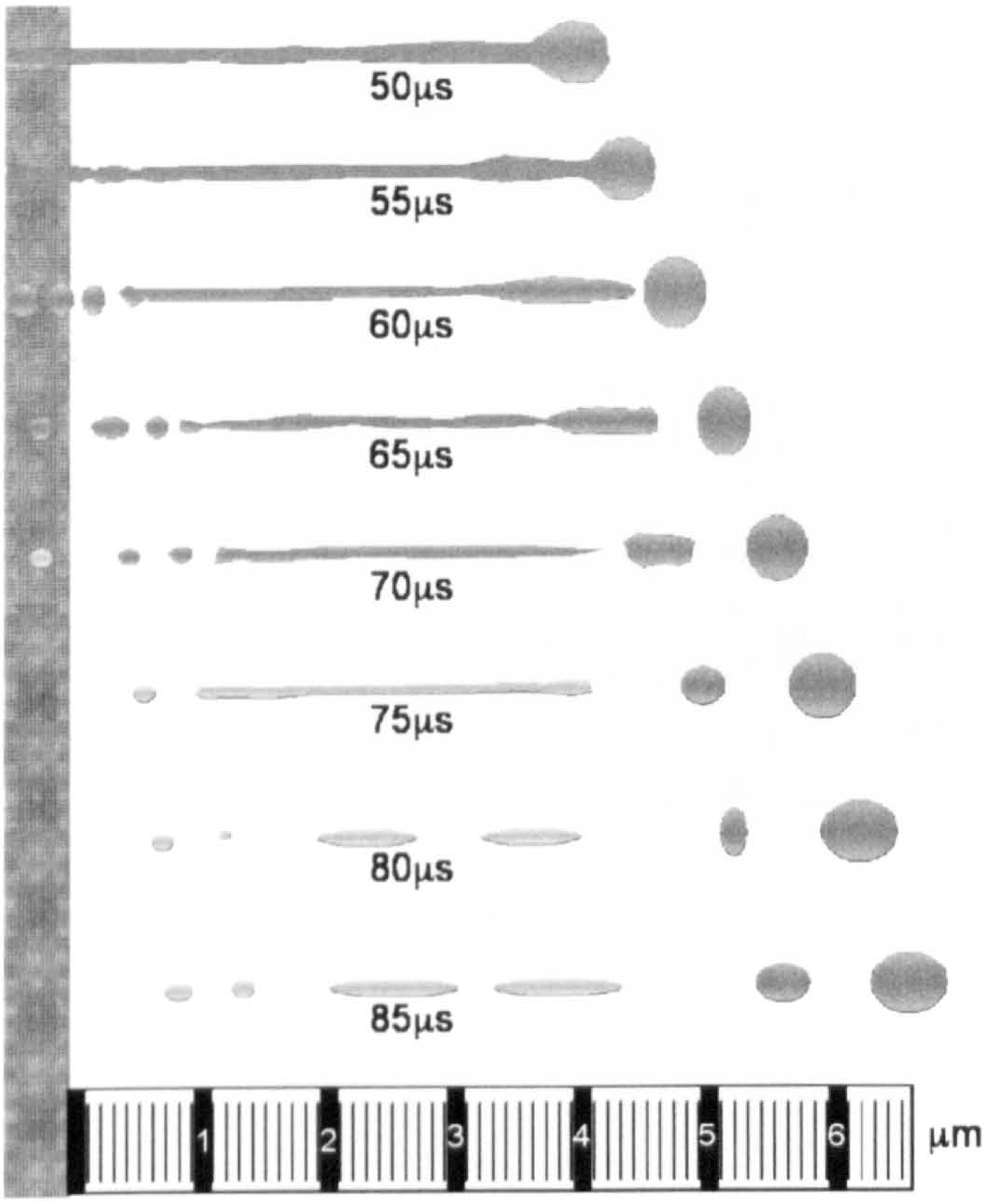


Figure 60 Inkjet droplets (after Chen, Chen and Chang 1997)

As Figure 62 shows, one result of the combination of satellite droplets (indicated by grey areas) and principal droplets (indicated by black areas) nearly resembles the inverse of comatic aberration outlined earlier. The illustration, which demonstrates a fine black line composed of two rows of micro droplets, is compromised two small rows of satellite droplets at uneven angles, and of uneven size and density. Further, over-saturation can be created in areas where satellite and principal droplets overlap, causing further spreading and banding than estimated by the printer design team. Small information areas are created with tails trailing out in the direction of the printer head's movement or training the paper's progress through the printer's paper advancing system.

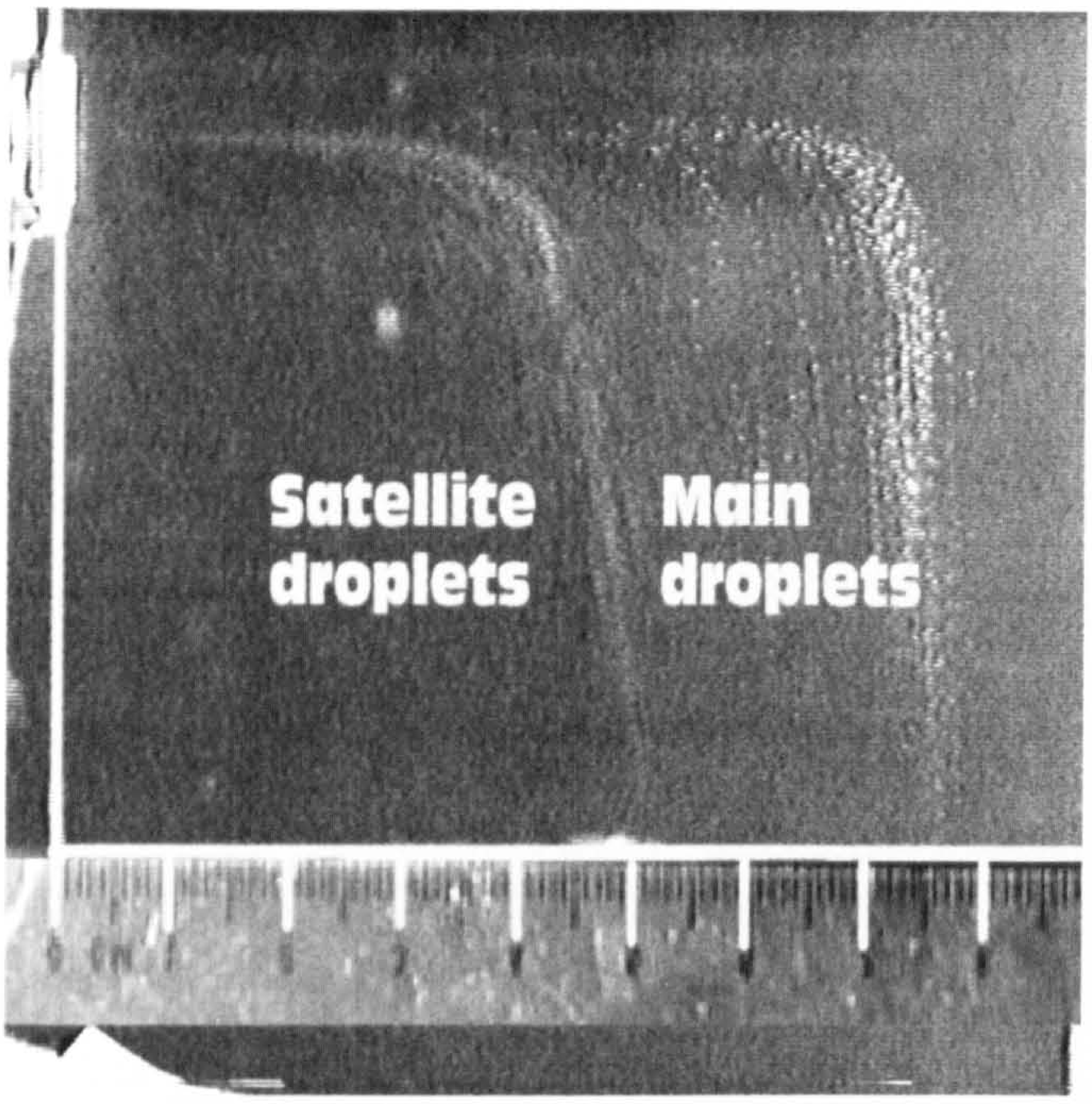


Figure 61 Inkjet droplets (after Chen, Chen and Chang 1997)

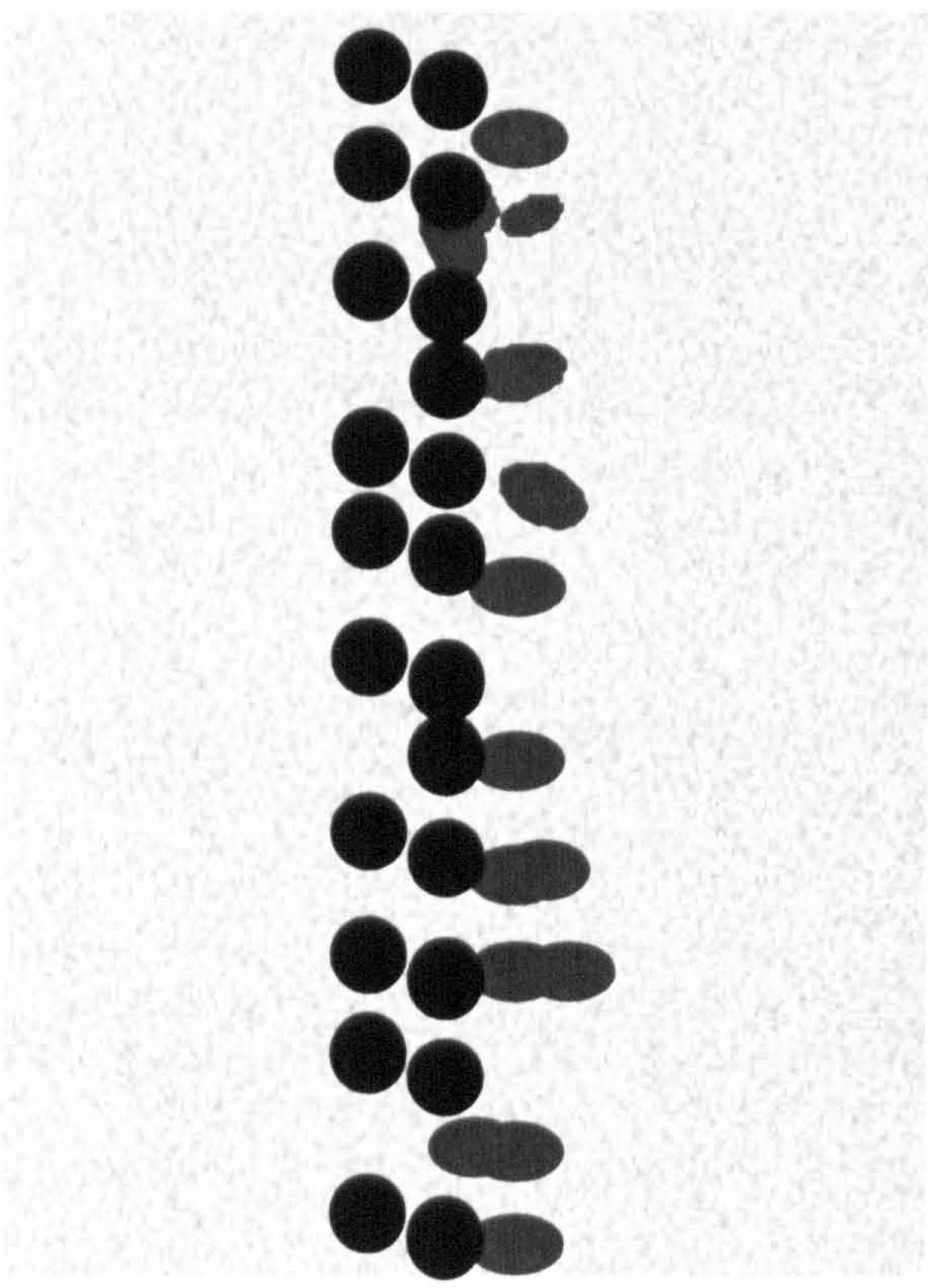


Figure 62 Inkjet droplets (after Chen, Chen and Chang 1997)

NOISE SUPPRESSION

Noise cannot be separated from a signal, but it can be suppressed. Astrophotography papers have been consistently referenced in this dissertation, as the need to suppress noise in photography is particularly acute within this field. Often when a photograph is taken of distant stars, it can be very difficult to discern white elements between granular picture elements from stars themselves. In Figure 63, we can see an example where grain and noise can be a real problem in critical identification of the subject.

Figure 63 Image noise in astrophotography (Mellinger 1998)

In instances like this, and indeed, in all instances of excessive noise, be it noise from image capture, analogue photographic printmaking, or digital printing, there are generally two options for the suppression of noise and grain; one spatial and one temporal. By temporal, we mean that if all other given elements in a series of images are identical, and the only variation between them is that of the noise content, then an analysis of each image will yield arrays of pixel values which can then be averaged, effectively suppressing the noise content of one averaged image. This, however, is at the cost of overall contrast and tonal range to the image.

The second option – the spatial option – usually involves one form of blurring or another, at a huge cost in overall sharpness to the image. Gaussian blurring is the most commonly used of these, however the results can be an introduction of noise in the sense of a loss of clarity that far exceeds the noise levels existent within the image prior to attempting to suppress granularity. In addition, there is a loss of overall contrast and tonal range (see Figure 64).

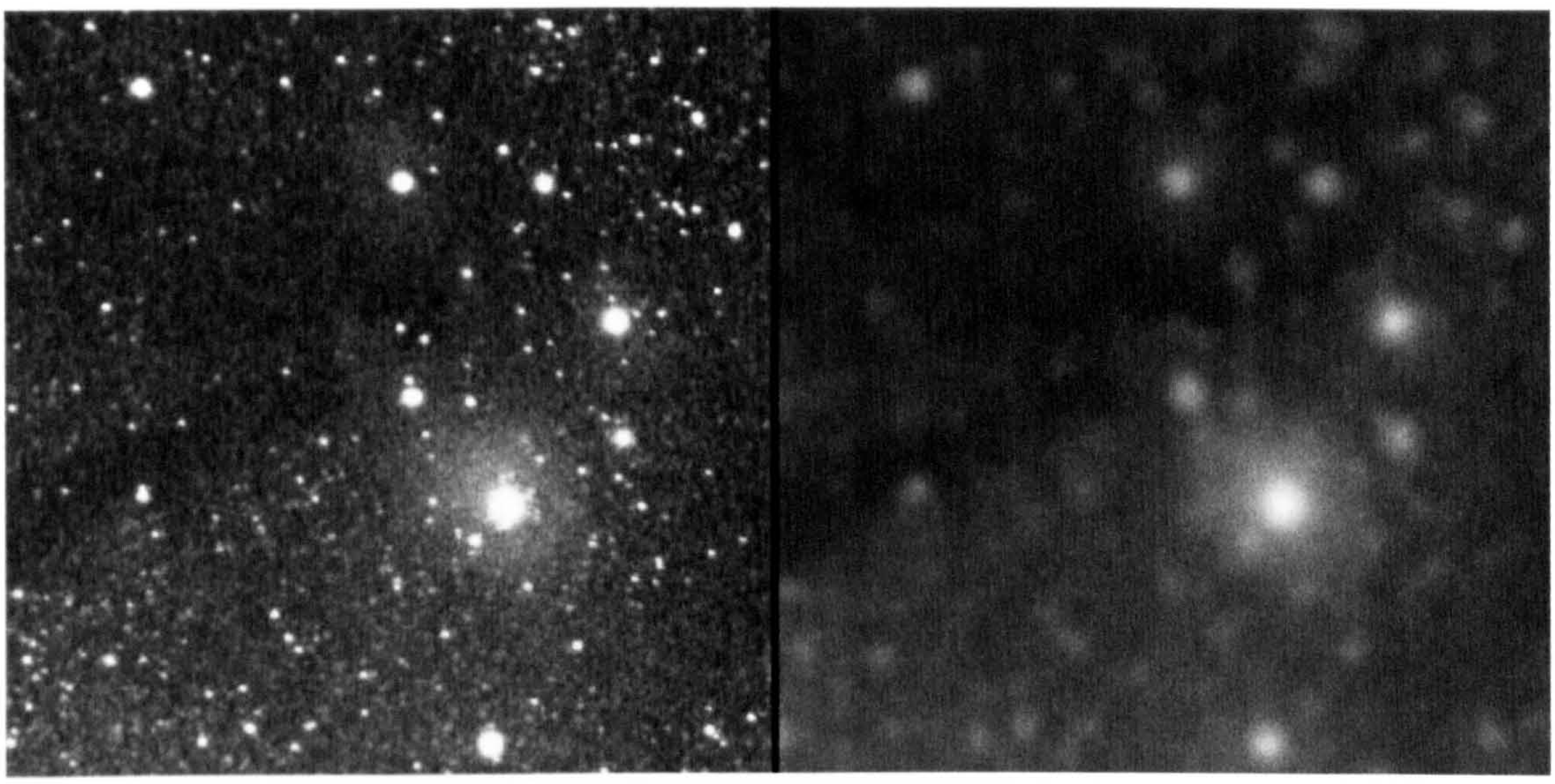


Figure 64 Image noise in astrophotography, with Gaussian blur (Mellinger 1998)

However, by modifying the Gaussian blur via a pass filter, we are able to maintain some highlights while still suppressing certain amounts of noise – still, it should be noted, at the cost of overall contrast and tonal range. In principal this works similarly to unsharp masking in combination with an overall blur.

A matrix of pixels[62] is analysed for values, and then averaged. In the case of a 3x3 matrix, the average across the 9 pixels would be assigned to pixel 5, counting left to right, top to bottom. The entire grid is then shifted one pixel to the right, and the convolution is repeated. This

[62] The size of this matrix varies from algorithm to algorithm.

overall blurring yields an overall suppression of granular noise within the photograph, but tends to blur out highlights, as in the Gaussian blurring example above (see Figure 64).[63]

To maintain highlights, it is possible to filter the averaging system, where, for instance, any pixel having a luminosity more than 30 points above the average luminosity will maintain it's value. These pixel points would be the stars. Neither would they be blurred, nor would their place within the overall tonal range of the image decrease.

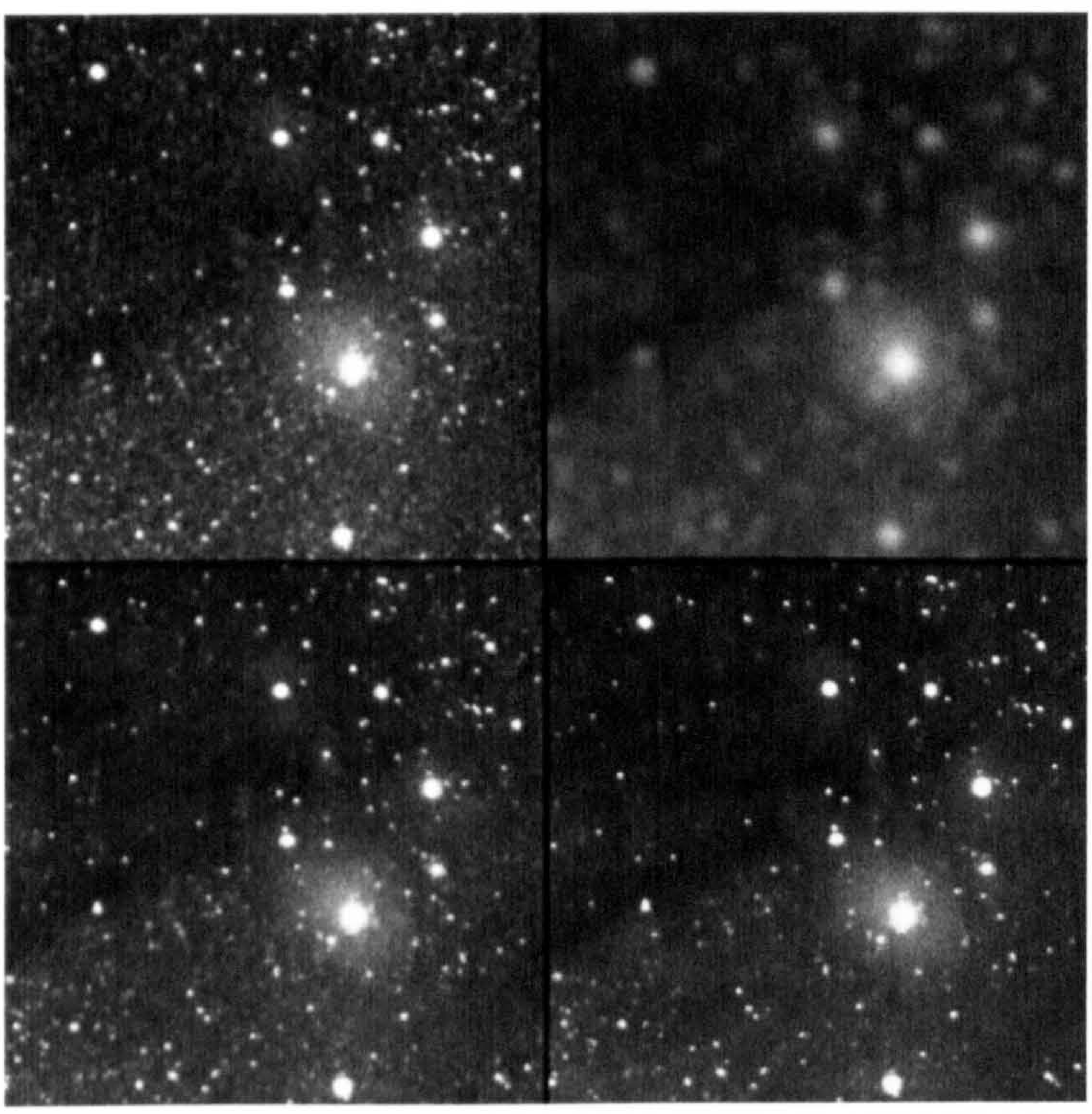


Figure 65 Image noise in astrophotography with unsharp masking (Mellinger 1998)

Figure 65 shows our original astrophotograph in the upper-left hand corner, with Gaussian blur applied in the upper right. A convolution with a high-pass filtration of 20 (across three

[63] In Gaussian blurring, the weighting of each pixel for averaging decreases in an inverse ratio to proximity to the centre pixel.

channels),[64] is shown in the lower left, and the original image convoluted with a high-pass filtration of 40 in the lower right (Mellinger 1998).

This type of noise suppression is effective and standard practice in astronomical photography. However, it is far less effective in day-to-day practice, where combinations of algorithms for image enlargement, grain suppression and unsharp masking are typically applied.

[64] Of a possible luminance range of 256, across three channels: red, green and blue.

APPENDIX B

REPORTER'S DAILY TRANSCRIPT
DECEMBER 18, 1996

SUPERIOR COURT OF THE STATE OF CALIFORNIA FOR THE COUNTY OF LOS ANGELES

SHARON RUFO, ET AL., N/A, PLAINTIFFS,

VS.

ORENTHAL JAMES SIMPSON[65]*, ET AL., DEFENDANTS*

DEPARTMENT NO. WEQ
HON. HIROSHI FUJISAKI, JUDGE
(REGINA D. CHAVEZ, OFFICIAL REPORTER)

MR. LEONARD (SOLICITOR): Now, you can retake the stand at this point.

(The witness complies.)

Q. (BY MR. LEONARD) If you don't do a perfect job, are there often indicia or indicators of this type of manipulation that are apparent on the original – on what – on the photograph of the negative, are they – are there?

ROBERT GRODEN (WITNESS): If it's not done right, yes. It's easily detectable.

Q. Okay.

Let me direct your attention specifically to this air-brushing method.

What would be – what would you look for, in general terms, to determine whether there has been any air-brushing-type manipulation to a photographic image?

A: The image, instead of being continuous grain – or, for instance if you look at a hand, it's not just one solid color; they're subtle. There's changes; there's shadows.

Normally, in an air-brushing situation, you're dealing with a flat background. If you try to use it in something where there's a great deal of detail, the detail will simply be there.

[65] O.J. Simpson, American football hero, on trial for the murders of his estranged wife and her lover.

If you examine what purports to be an original photograph, using that technique, what you would detect is a plain background without the detail, or an irregular, unnatural edge.

Q. And with that regard to the registration or proper positioning of the various elements in a photograph, what would you look for to determine whether that exists?

In other words, when you're looking at a photograph and you want to look for out-of-registration elements, what do you look for?

A. Well, you would inspect, again, depending on the method used and the type of indicator that might be there. You would end up with examining the edges from where one element would come in contact with another element. For instance if we were to use a matte insert technique, if the matte were off slightly from the sizing or were off – or the positioning were off, even by a fraction of a millimeter, you would end up with an odd-colored edge, meaning that didn't belong, something that would be – it would look somewhat like a halo, something of that nature. Either that, or it would be a dark line.

In other words, if matte were too small, as opposed to being too large, you'd end up with an irregular density.

Q. Now, is there another wholly different type of method used to utilize to create a composite or alterated – excuse me – altered photographic images, that involves computer technology?

A. Yes. There is –

The technique of digitization has been refined again and again and again and again, through the last decade or so. And it is totally different than everything else we've got here.

What we have here are mechanical or photographic or art-type techniques. In a computer, in what they call the digital domain, what you're doing is, you are not manipulating a photographic or physical entity; what you're doing is, you're manipulating elements or picture elements that are known as pixels within the original picture.

And –

Q. You know, would it be helpful – sorry to interrupt you – would it be helpful if you go down and actually draw what you're talking about with pixels and so forth?

MR. GELBLUM (SOLICITOR): Your Honor, I object without typing it up. I'd like an offer of proof –

MR. LEONARD: Sure.

MR. GELBLUM: – at side bar.

(The following proceeding were held at the bench, with the reporter.)

THE COURT: What's your offer of proof on digitizing?

MR. LEONARD: I want to – what I want to demonstrate is that, if you use the state-of-the-art digital equipment and you do the proper cover-up, if you will, techniques, you – it's very difficult to discern.

THE COURT: Is that his opinion that's what was done in this case?

MR. LEONARD: He doesn't know.

No – look –

MR. GELDBLUM: I asked him in his deposition. He didn't mention that.

THE COURT: Wait a minute.

MR. LEONARD: Wait a minute. Okay.

You can combine all of these techniques if you want to. For instance, if you – if you digitally manipulate a photograph and you don't see something, like you – like you can air-brush it or use some other technique, the point is, it's extremely difficult to – to discern digital manipulation. That's all I'm going to *elicit from him. That – that these techniques can be combined. These –*

THE COURT: Let me ask you.

MR. LEONARD: No here –

THE COURT: May I ask you a question –

MR. LEONARD: Yes, of course.

THE COURT: – please.

What is it exactly that this witness is going to testify to with regards to –

MR. LEONARD: He is going to say –

THE COURT: – on [item] 1930?

MR. LEONARD: I'm sorry.

THE COURT: Is it 1930.

MR. LEONARD: He's going to say there are several indicators of it, that the picture has been manipulated. There's a whole list of them. For instance –

THE COURT: he's not going to be able to testify as to how it was done?

MR. LEONARD: No. And he can –

THE COURT: Then I'll – excuse me. You know, if you let me talk, we'll get through this a lot faster.

He is going to say there's something wrong with the picture; is that right?

MR. LEONARD: Um-hum.

THE COURT: All of those techniques are various techniques that he knows of, and can alter the picture, but he doesn't know which one affected it?

MR. LEONARD: He sees indications of air-brushing. He also sees the fact that the – that the – that the – as he's described here, that there's some indication that elements are out of register which are an indicator of matte technique.

THE COURT: Is he going to testify that there are some elements of digitizing?

MR. LEONARD: No. He's going to say that you can't – you can't tell whether it's been digitized, if it's – it's one point that – that it's a very sophisticated technique. All right? And can I – I'll explain it to you.

He's going to say it's a very sophisticated technique, and that you can – you can rephotograph the digitally created image with, for instance, with a type of film that has a rather large grain, and it masks the pixelization. The way you can determine whether a photograph has been digitally manipulated is because it has a very distinctive – I'll call it grain structure. It's really pixels.

THE COURT: Is he going to testify that that exists, too?

MR. LEONARD: What?

THE COURT: is he testifying that that exists in this photograph?

MR. LEONARD: You can't tell whether it exists.

THE COURT: Then I'll sustain the objection as to that aspect.

MR. LEONARD: Can I – one more. Can I make one more point?

THE COURT: Sure.

MR. LEONARD: One more point.

There's evidence that this – that the photograph – that what was represented to us as being an original negative is a duplicate negative, if – that it's out of register. There's a couple different points.

There's no legitimate reason for what was represented to us in the original negative to be a duplicate negative. That is, there's very strong circumstantial evidence that it's been – it's been tampered with.

And my point is that, if there – if there were more than one method – for instance, if there was masking, if there was air-brushing, and underneath all of that, there had been an original digital manipulation, if it's done right, you wouldn't be able to see the original digital manipulation.

It's like, we've got a murder case going here with circumstantial evidence. There's circumstantial evidence that the photograph has been altered in two of these ways.

And the photograph also went – went to Paris or London and back on a Concord.

MR. BAKER: London.

MR. LEONARD: That's pretty unusual. That came out in Scull's deposition. There's some – there's a lot – there's a lot of circumstances surrounding the photograph that are unusual.

The guy claims he lost his camera and his camera was rebought –

THE COURT: Just stay –

MR. LEONARD: All I'm trying to argue is that there are circumstantial indicators that this – beyond the actual looking at the photograph or where it lines up with the others on the contact sheet, which indicated – indicate that it was duplicated, or at least there's a suspicious break in the chain of custody.

THE COURT: See if I understand your argument.

Your argument is that his testimony is going – and some other evidence, or some evidence is going to show that these are duplicate negatives.

MR. LEONARD: This is a duplicate negative.

THE COURT: And that – that is an element that you contend is supportive of an opinion that it's been tampered with?

MR. LEONARD: Yeah. That's a reason, yes.

THE COURT: If you just let me talk, we'd get through this real fast.

And that you'd like to ask him about the digitizing, because that is one of the methods that can be used to alter it.

But this witness could not establish that, in fact, was the one that was used, only that it can – that could have been used, and he would not be able to know.

MR. LEONARD: No. But it's extremely difficult, if not impossible, as their expert has admitted, if it's done right, in the proper –

THE COURT: So your main contention is that, if you feel there's sufficient evidence in which this witness can say that there are elements to support an argument that it was altered, because there was a duplicate negative, and that part of the altering could be by various methods, including digitizing?

MR. LEONARD: Exactly.

THE COURT: But he can't say that is the case here or not?

MR. LEONARD: He can't with regard to the –

THE COURT: Okay. Overruled.

MR. GELBLUM: Your Honor, may I be heard?

THE COURT: No. I think –

(The following proceeding were held in open court, in the presence of the jury.)

Q. (BY MR. LEONARD) If you would, step down there.

When we had the time out there, we were talking about digital manipulation, and you used pixelization and so forth.

First of all, can you just illustrate for us, sort of basic elements of a digitalized [sic] photograph?

A. It's extremely simple ... in its most simple form, the entire screen of a digitized picture contains a series of items known as pixels, or picture elements.

Picture elements are exactly rectangular, be they square or elongated, into a rectangular form. And each one of ... represents a single pixel or picture element.

The total digital picture is made up exclusively of digital elements known as pixels.

Each one of these is assigned a value in color and density, color being, or course, the – it's very obvious what it is; density being from something known as demin [sic] which is very thin or light or clear or white, to demax [sic], which is dark gray, charcoal black, very dense.

Each of these elements becomes part of the overall picture.

The number of pixels determines the resolution of the overall picture. A lot of home computers will use 300 to 600, maybe as many as 800 dots or pixels per inch as its resolution.

Professional machines will go as high as 3,000 per inch or greater, so you get a far more photographic field to the end result. So for those of you who may have home computers, if you deal with – with program like Photo Shop [sic] or things of that nature, you know that when you look at the picture, it seems very choppy; they have things called jaggies.

Jaggies is, if you have a diagonal line that interferes and goes through the middle of a pixel, the computer has to arbitrarily decide whether it goes to this side or this side of it. And instead of getting a straight line, you end up with a slightly lightning shape or jagged line.

In ultra-high resolution situations of 3,000 lines or pixels per inch or better, you don't get the jaggies for two reasons: Number one, programs of that nature and sophistication, like computers, have programs that eliminate the jaggies and tend to smooth them out. The other situation, which is the obvious one thing I was trying to get to, is when you have many other things, they become less apparent tot he eye, and you need a microscope to detect them.

Q. Now, if you created a digitally manipulated photograph, and you wanted to hide that fact for whatever reason, is there a method you've just told us that it can – it's – you can discern these distinctive geometric pixel-like – or pixels, rather, by – under a microscope, correct?

A. In most cases, yes.

Q. If you were going to digitally manipulate a photograph, and you wanted to hide that fact so that someone looking at the – what purports to be the original negative, after the fact, can't tell that you digitally manipulated it, what could you do?

A. There are various steps you could do, one of which would be to throw it slightly out of focus, so that the edges would blur. There would no longer be sharp edges on the pixels.

Of course, if you'd use the maximum resolution, you could get it in the first place.

Q. Well, by that, you mean you'd use that, what you describe as high tech, 3,000 pixels-per-inch-type machinery?

A. That's correct.

And then you'd throw it slightly out of focus, or you would use what's known as a dithering effect.

A dithering effect is part of a program that is included in things like Photo Shop, where they tend to average out edges or elements of each pixel, so it would disappear or be much less apparent.

Another way of dealing with it would be to create a high-resolution print and then rephotograph it on a piece of film, like 400 ASA film, or something that's very grain, and if the grain is larger than the pixels, they'll disappear, they'll be covered up.

Q. Just – just go over that – that point again. Let me make sure I understand.

You would create a high-resolution digital print using the more sophisticated machinery, so that you would have 3,000 pixels per inch, let. Say.

MR. GELBLUM: Objection. Asked and answered. No reason to go over it again.

THE COURT: Overruled.

Q. (BY MR. LEONARD) And then at that point, you would then take another photograph of that digitally created image; is that right?

A. That's correct.

Q. And you would take the photograph with a – what you said was a grainy film.

What do you mean by that?

A. Grain is an element of photographic film. The slower the film – and this is a general rule – the slower the film, 50 ASA, 32 ASA, 75, 100. Slower film have finer grain, much finer grain. What you're left with is – let me demonstrate.

This arbitrary shape here is a piece of photographic grain, let's say. What you've got on film is a carrier, which is an acetate type of situation, variety of plastic of sorts. And what you've got is a coating on what's known as the emulsion side. And the emulsion side of the film has just a whole bunch like this.

Now, the slower the film, the finer the grain. In other words, it's less apparent. If you look at an 8 by 10 or 11 by 14 blow-up of a fine-grain print, it's very hard to see the grain.

But if you use a fast film, as you would – say a sporting event, and you need to freeze the action, you need to be able to use a higher shutter speed, you use a faster film.

Well, the down side of the faster film is, it has much larger grain. And when you blow it up, it appears very grainy. It's as if you're looking through a screen or a mask.

Q. Well, explain the relationship between the – the larger grain and the pixels and to the extent, if any, that – that might mask the underlying pixels.

A. Well, the nature of the grain itself, outside of being larger, also has a granular element to it. And if you are – if you're showing a granular element over an already slightly blurred pixel area, it will mask it completely; you won't be able to detect it or see it.

Another situation is, if you were to print it nonphotographically, say in a magazine, using lithographing dots, the lithographing dots would be larger than the pixels, and they would totally mask it, as well.

MR. LEONARD: Now, you can retake your seat.

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