The Government of the Eye: Light Technology, Liberalism and the Victorian City, 1840-1900

A thesis submitted to the University of Manchester for the degree of PhD in the Faculty of Arts in June 2002 by Christopher James Otter, Department of History.

Contents

Abstract of thesis submitted by **Christopher James Otter** for the degree of **PhD** and entitled **'The Government of the Eye: Light Technology, Liberalism and the Victorian City, 1840-1900,'** in **June 2002**.

Recent scholarship on liberalism in the nineteenth century has made several suggestive observations about the relationship between civil conduct, vision and the material form of the city. My thesis, "The Government of the Eye: Light Technology, Liberalism and the Victorian City 1840-1900," takes this relationship as its focus, arguing that the construction of infrastructures designed to modify sensory, bodily and practical conduct was integral to the liberal project in Britain. I concentrate on infrastructure designed to foreground the visual over other senses. Much of my dissertation examines gas and electric lighting as two technologies ostensibly designed to augment urban vision. Electricity, I argue, by producing purer light, that is, light without noxious chemicals, heat, dirt and smell, generated environmental conditions which facilitated both clear vision and healthy bodies. This whiter light was vital for urban practices such as policing, attentive work, study, and leisure. I also examine an array of other technologies designed to embed and make durable conditions of maximum vision without other sensory interference. These include soundproofing techniques, for example wood and asphalt paving, and deodorisation projects, as well as more palpably visual technologies like glazing, smoke-abatement and street-widening. All these diverse engineering schemes, I argue, produced a city within which smells, touch and sound were deliberately occluded, and vision enhanced. This enabled the city to become a place where society could observe and police itself, in a fashion which was essentially liberal. Furthermore, increasing the amount of pure light in the city was another tool through which healthy bodies could be maintained. A civil and healthy city was one fit to be economically productive. Finally, I examine these technologies as material entities: their lamp-posts, meters, fuses, and wires, as well as the labour required to build, and the upkeep to maintain, their functioning. By delegating so much agency to these networks, liberal government introduced new sources of contingency and anxiety. Blackouts, electrocution, and accidents all form part of the cultural phenomenology of our modern, liberal, electric epoch.

Declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification from this or any other university or institute of learning.

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For my mum and dad,
my gran,
and Tina.

Introduction: Writing a Political History of Visual Technology

Urban infrastructure – gas, electricity, water, sewerage – is profoundly political. During the nineteenth century, such technologies were increasingly mobilised and manipulated in order to govern massive urban populations. Giant networks of pipes, wires and drains were constructed, by the state, municipal bodies, and private companies. These infrastructures, through which modern cities were literally engineered into existence, targeted a population which in the earlier part of the century had been a source of political unease and moral concern. Drains and sewers would liberate the bodies of the poor from the filthy habits to which they had succumbed; gaslight and slum demolition would expunge the darkness which spawned vice and demoralisation. Dirt and darkness were the conjoined targets of a pervasive environmental campaign: government sought to strategically expunge them in the name of order, decency and reason.

These values, familiar from the writings of Edwin Chadwick, Samuel Smiles, Octavia Hill and Charles Booth were hegemonic in the Victorian era, when the mantra of respectability reverberated from many pulpits. Cleanliness and light were the agents of physical and moral improvement of the masses. Improvement was itself equated with self-discipline and independence, themselves associated with freedom. This thesis examines how technology became indispensable to this project to provide the population with the means to practice freedom. One way in which this freedom could be manufactured and made durable was through the calculated deployment of vast infrastructural networks, in and through which power, quite literally, flowed. Equipping people with the power to be clean, healthy and mobile was to provide them with the physiological basis for self-government: there would be no need to rely on workhouses, alms or philanthropy, while the ensuing liberty could be exercised in more positive ways, for example voting and learning.

These technologies, distributing water, energy and information, have quite literally enabled us to become who we are. The water and food that cleanses and nourished me is monitored and measured to achieve these ends: I know the precise material constitution of everything I allow into the depths of my body, simply by scrutinising the information on the packet. The gas heating my house and the electricity powering my refrigerator keep my body, and my cheese, milk and salad, at an optimum temperature. Without my telephone and email, I would remain isolated, starved of information. My practical agency and its constraints are ineluctably intertwined with the fate of an inconceivably massive machine order traversing the globe. Agency, ability, selfhood, in other words, transcend the meagre capacities of our organs, bones, brains and muscles. We share our collective existence and fate with technologies and infrastructures. We owe the very form of our being to roads, wires, pipes, drains, factories, laboratories and machines, just as this agglomeration of networks owes its form to us.

This thesis offers a political history of a set of technologies which, during the nineteenth century, and particularly its final quarter, were calculated to expand the scope and accuracy of the human capacity to *see*. Street-widening and attempts to purge the atmosphere of smoke were as integral to this project as gas and electric light: they were, in their differing ways and according to different rationalities, designed to create and maintain certain levels of *visual agency*. These levels of agency were themselves necessitated by a manifest demand for light: to allow factories to run all night, to facilitate transportation systems, for policing and less formal strategies through which society literally became visible to itself. Mobilising and enhancing vision, therefore, was essential to a liberal order within which each subject was to be freed to maximise their capacity for motion, attention and productivity.

Perhaps an example might be helpful here. Writing an introduction on a laptop involves a whole series of technological mediations enabling me to see with ease and lucidity. Clear, legible and focused text is produced by a liquid crystal display on the flat rectangle positioned before me. I refer to notes illuminated by a powerful electric desk lamp. Without my spectacles, which have been designed precisely to correct the idiosyncrasies unique to my particular eyeballs, the squinting and straining would have long been unbearable. Three technologies just for this simple act of seeing: crystals, glass, electricity and lenses (organic or otherwise) configured, without a moment's conscious reflection on my part, while the serious business, the brain-work, of producing a coherent argument can continue unhindered. No candles or ink for me! Ocular agency, therefore, is a result of a specific level of technology. It also gives me my identity: as a graduate student, an occasionally reluctant member of the information age, a reader of books in bed. This identity, cerebral, self-motivated, industrious, is both technologically framed and essentially liberal. I govern myself, but only with the help of an assortment of tools.

A history of agency and its technological framing, therefore, is a particular kind of history of the body. This sort of history is ontological and phenomenological, concerned with how our basic experiences and abilities have been modified, or even produced, by entering into new relations with technological systems. This assumes the body's viscid stubbornness and materiality. There are limits to what the body can and cannot do: there is thus a visceral horizon for the play of ideas, language and representations. The discovery and measurement of these limits, for example, those of the eye itself, were integral to the design of many of the light technologies depicted in this thesis.

These technologies, the agency they made possible and the kind of society they helped to bring into being, are the subject of this work. It is by no means a comprehensive history of nineteenth-century visual technology and culture. By analysing gas and electric light and their systems of distribution, as well as glazing, public inspection, abattoir design, photometry and pavements, I aim to provide a series of studies of what might be termed *mundane perception*: everyday technologies and the tiny shifts in perception they enabled. That said, this thesis does not provide a typology of light technology, or a cultural history of light, for which readers should look elsewhere.[1] Similarly, it does not provide a history of the development of the lighting and utility industries.[2] Likewise, there are many aspects of nineteenth-century visual culture that I

[1] Such studies are provided by, for example, Brian Bowers, *Lengthening the Day: A History of Lighting Technology* (Oxford: Oxford University Press, 1998), William O'Dea, *A Social History of Lighting* (London: Routledge and Paul, 1958), Wolfgang Schivelbusch, *Disenchanted Night: The Industrialisation of Light in the Nineteenth Century* (Oxford: Berg, 1988), Andreas Blühm and Louise Lippincott, *Light! The Industrial Age 1750-1900: Art and Science, Technology and Society* (Amsterdam: Thames and Hudson, 2000).
[2] See Thomas Hughes, *Networks of Power; Electrification and Western Society 1880-1930* (London: Johns Hopkins University Press, 1983), I.C.R. Byatt, *The British Electrical Industry 1875-1914: The Economic Returns to a New Industry* (Oxford: Clarendon, 1979), Leslie Hannah, *Electricity Before Nationalisation: A*

ignore. I have not addressed photography or cinema, for example, and provide only limited discussion of consumption or spectacle: these topics have a massive historiography which has informed parts of this work, although I am shifting focus away from the perhaps over-familiar world of shopping and display, glitter and dazzle, flâneurs and prostitutes, the liminal and marginal.[3] There is also no place for discussion of light in the visual arts, philosophy or literature, and little analysis of the powerful symbolic role of light, especially in representations of race.[4] The focus here is largely on material structures and systems and how their engineering formed part of wider strategies of government. Consequently, I will be keen to align my analyses with larger

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Study of the Development of the Electricity Supply in Britain to 1948 (London: MacMillan, 1979). Brian Bowers. *A History of Electric Light and Power* (Stevenage: Peter Peregrinus, 1982).

[3] On photography, see John Tagg, *The Burden of Representation: Essays on Photographies and Histories* (Minneapolis: University of Minnesota Press, 1993), S. Lalvani, *Photography, Vision and the Production of Modern Bodies* (Albany, N.Y.: State University of New York Press, 1996). For cinema, see John Orr, *Cinema and Modernity* (Cambridge: Polity Press, 1993), Linda Williams, ed., *Viewing Positions: Ways of Seeing Film* (New Brunswick, N.J.: Rutgers University Press, 1995), Judith Mayne, *Cinema and Spectatorship* (London: Routledge, 1993), J. Comolli, "Machines of the Visible," in T. De Lauretis and S. Heath, eds., *The Cinematic Apparatus* (New York: St. Martin's Press, 1980). For shopping and consumerism, see Geoffrey Crossick and Serge Jaumain, *Cathedrals of Consumption: The European Department Store 1850-1939* (Aldershot: Athgate, 1999), T. Richards, *The Commodity Culture of Victorian England: Advertising and Spectacle 1851-1914* (London: Verso, 1991). On spectacle, see Jonathan Crary, "Spectacle, Attention, Counter-Memory," *October* 50, 1989, Judith Walkowitz, *City of Dreadful Delight: Narratives of Sexual Danger in Late Nineteenth-Century London* (London: Virago, 1992), Vanessa Schwartz, *Spectacular Realities: Early Mass Culture in Fin-de-Siècle France* (Berkeley: University of California Press, 1998). A useful collection of essays on the flâneur is Keith Tester, ed., *The Flâneur* (London: Routledge, 1994): see also Elizabeth Wilson, *The Sphinx in the City: Urban Life, the Control of Disorder and Women* (London: Virago, 1991), Susan Buck-Morss, "The Flâneur, the Sandwichman and the Whore: The Politics of Loitering," *New German Critique* 39, 1986, and Vanessa Schwartz, "Walter Benjamin for Historians," *American Historical Review* 106:5, 2001: this literature owes much to renewed interest in the work of Walter Benjamin. For an eighteenth-century comparison, Penny Corfield, "Walking the City Streets: The Urban Odyssey in Eighteenth-Century England," *Journal of Urban History*, 16:2, 1990. On prostitution, see Judith Walkowitz, *Prostitution and Victorian Society: Women, Class and the State* (Cambridge: Cambridge University Press, 1980), Mary Spongberg, *Feminizing Venereal Disease: The Body and the Prostitute in Nineteenth-Century Medical Discourse* (Basingstoke: MacMillan, 1997)

[4] On vision and light in modernity, see Martin Jay, "Scopic Regimes of Modernity," in Scott Lash and Jonathan Friedman, eds., *Modernity and Identity* (Oxford: Blackwell, 1992). For impressionism, see T.J. Clark, *The Painting of Modern Life: Paris in the Art of Manet and His Followers* (Princeton: Princeton University Press, 1999), while for later developments in modernism, see Rosalind Krauss, *The Optical Unconscious* (London: MIT Press, 1993). For the importance of light, particularly as metaphor, in philosophy and literature, see Hans Blumenberg, "Light as a Metaphor For Truth," in David Levin, ed., *Modernity and the Hegemony of Vision* (London: University of California Press, 1993), Arthur Zajonc, *Catching the Light: The Entwined History of Light and Mind* (New York: Bantam Books, 1993), Cathryn Vasseleu, *Textures of Light: Vision and Touch in Levinas, Irigaray and Merleau-Ponty* (London: Routledge, 1998), Raymond Williams, *The Country and the City* (London: Chatto and Windus, 1973), Carol Christ and John O'Jordan, eds., *Victorian Literature and the Victorian Visual Imagination* (London: University of California Press, 1995). For race, see Richard Dyer, *White* (London: Routledge, 1997), Mariana Valverde, "The Dialectic of the Familiar and the Unfamiliar: 'The Jungle' in Early Slum Travel Writing," *Sociology* 30:3, 1996.

narratives of the role of the visual in modern thought and practice.[5] Vision has often been spoken about as the 'master sense' of modernity.[6] If this kind of general phrase is to retain any validity, we must try to anchor it in the material conditions within which kinds of sensory experience were made possible. In other words, I am looking at the reconfiguration of vision in everyday urban life and the role that technologies which have become totally ubiquitous have played in this.

Infrastructure, as a material technology of rule, is beginning to receive the attention of historians.[7] Christopher Hamlin's recent analysis of Chadwick's pipes and drains is exemplary. In particular, he emphasises the way in which their very form was intended to generate and perpetuate a self-governing sewerage network that would produce clean, healthy bodies able to dynamically pursue economic activity. Literally embedding the miasmatic notion that disease was spread by dirt, and not hatched in subjects physically enervated by arduous toil and inadequate nutrition, was one strategy by which the freedom of the economic sphere, and an attendant set of moral alibis, could be produced and naturalised. The 'hydraulic city', that vast web of cylinders flushing away our waste, implanted the sacred Victorian creed of cleanliness without the 'hand' of government in any way touching the bodies of the governed.[8] This was a liberal technology aiming at securing a liberal order.

This thesis is divided into two halves, each of three chapters. The first half, "Organisation", explores the relationship between liberalism as a mode of rule and infrastructures facilitating lucidity of perception within the city. The first chapter provides a theoretical overview of a set of themes running through both the following chapters on organisation and the second half of the thesis. The liberal order is the starting-point of my argument. I begin by outlining the idea of governmentality, which

[5] Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (London: MIT Press, 1990), Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (London: Tavistock, 1970), Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* (London: University of California Press, 1994).
[6] David Levin, ed, *Modernity and the Hegemony of Vision*, introduction, Christoph Asendorf, *Batteries of Life: On the History of Things and Their Perception in Modernity* (London: University of California Press, 1993).
[7] See, for example, C. Mukerji, *Territorial Ambitions and the Gardens of Versailles* (Cambridge, 1997); C. Hamlin, *Public Health and Social Justice in the Age of Chadwick: Britain 1800-1854* (Cambridge, 1998).
[8] See T. Osborne, "Security, Vitality and Drains," in Andrew Barry, Thomas Osborne and Nikolas Rose, eds., *Foucault and Political Reason: Liberalism, Neo-Liberalism and Rationalities of Government* (London: UCL Press, 1996).

derives from a late lecture by Foucault and has been developed by sociologists to describe all strategies aiming at modifying the conduct of others.[9] The liberal variety of governmentality, simply put, refers to all techniques designed to generate freedom, or self-rule, in others. This technical, strategic notion of liberalism is obviously very different from more formally political or coherently ideological accounts.[10] For my purposes, it offers a way of analysing infrastructure as a critical tool of government, which forms the basis of the first half of the first chapter. The bodies of the governed were the targets of these systems, and this necessitates a discussion of how the body itself was understood in modernity. For simplicity's sake, I emphasise three facets of this 'modern body': its inner temporality, its innate limits, and its fundamental norms.[11] These norms, for example of temperature, respiration, and energy, could be perverted or secured by environments: this connection between scientifically-established norms, technology and government is integral to the argument that follows. Freedom and bodily normality were intimately connected within an environment which humans were increasingly modifying, consciously or otherwise. In doing so, an increasing number of objects and machines were being employed to do things for us. Here, I introduce the idea of 'material agency' as developed by Andrew Pickering: although we have deployed the objects, and calculated how to use them, the agency they possess is not ours.[12] This means that government in the modern period, which came to rely so much on technology, became increasingly nonsubjective, and that scientific knowledge, which in modernity claims to be able to unearth the truth of matter, was called upon to measure the qualities of the materials out of which cities were built. In the course of this discussion, the terms 'modern' and 'modernity' have been introduced perhaps rather uncritically, and the fourth part of the first chapter attempts a working definition of them. Following, among others, Bruno Latour, I argue that modernity is a particular way of ordering and organising the world, into, for example, nature and culture, body and

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[9] Michel Foucault, "Governmentality," in in Graham Burchell, Colin Gordon and Peter Miller, eds., *The Foucault Effect: Studies in Governmentality* (London: Harvester, 1991).
[10] See, for example, Parry, *The Rise and Fall of Liberal Government in Victorian Britain* (London: Yale University Press, 1993), Richard Arneston, ed., *Liberalism*, 3 volumes (Aldershot: Edward Elgar Publishing, 1992).
[11] There is a vast literature on the 'modern body.' A useful introduction is Catherine Gallagher and Tom Laqueur, eds. *The Making of the Modern Body: Sexuality and Society in the Nineteenth Century* (London: University of California Press, 1987).
[12] Andrew Pickering, *The Mangle of Practice: Time, Agency and Science* (London: University of Chicago Press, 1995).

mind, or subject and object.[13] I offer a couple of examples of places where these distinctions germinated, notably in modern scientific practice.

The second half of the first chapter looks more specifically at what kind of subjectivity was consistent with liberal forms of rule, how this was 'modern', and what sort of sensory dimension there was to this relationship. The liberal subject, I argue, was a subject of energy, self-discipline, restraint, thrift and reason: this was very often evoked in terms of watchfulness, both of the self and of others. This visual aspect to liberal subjectivity is expanded through a discussion of civility, public observation and discipline: the use of the senses is very much seen as a practice specific to an evolving sphere of civil society. However, civility was not a social constant: indeed, the majority of the population were frequently depicted as behaving in distinctly uncivil ways. Here, I discuss the sensory order of the poor, where noise and smell was seen as overriding the polite, distant spectatorship through which civility was practiced. This suggests that there was a profoundly sensual dimension to the way social difference was not just imagined, but tangibly, actively felt. This difference was very often evoked in terms of a distinction between those with a 'normal' set of sensory responses to the world, and those who were essentially 'desensitised'. The latter tolerated things the former found unbearable or disgusting, very often because their environment precluded any other response. Lacking discernment of the physical world around them, they failed equally to form revulsion towards immoral practices. There was thus an explicit link between environment, the senses and morality. The chapter concludes by returning to the theme of infrastructure, and argues that technologies such as toilets, separate bedrooms, and deodorisation mechanisms were seen as tactics of resensitisation.[14] This resensitisation was to be formed through an architecture within which the individual was encouraged to develop a sense of privacy and shame.

Chapter two introduces the concept of light, which binds the remaining five chapters. I begin by describing the various ways in which light was regarded as essential to the government of the modern city. It was vital to enable visual connection, social observation and imitation: it was second only to clean water as a natural agent of health

[13] Bruno Latour, *We Have Never Been Modern* (London: Harvester, 1993).
[14] The relationship between these techniques of individuation and the modern self are examined by Tom Crook, "Building Society: Body, City and Home 1830-1914" (forthcoming PhD thesis).

and deodorisation: it was essential to industry and transportation. The administration of light within the city, for these combined purposes of civilisation, vitality, productivity and motion, became integral to projects of urban improvement. I explore this through the study of two model towns proposed in the Victorian era, James Silk Buckingham's *Victoria* (1849) and Benjamin Ward Richardson's *Hygeia* (1875). Both cities, I suggest, had the eradication of darkness as a central aim, for the reasons already outlined. This enables me to develop the concept of *oligoptica*, the notion of a city being a collection of small arenas where vision is freely practiced by all. The contrasts between this liberal visual order and the more familiar, disciplinary panopticon, are highlighted: both systems of vision, I argue, tend to co-exist within the city.

But model cities remain just that, and the rest of the chapter looks at attempts to concretely engineer lighter, airier spaces within existing cities, which had often grown with only minimal regulation of building. The role of the municipal engineer is addressed here, as is some of the legislation facilitating the closure of cellar-dwellings and the improvement of streets. I then examine three material techniques designed to foreground clear vision and minimise interference with the other senses: smoke abatement, glazing and soundproof paving. By moving from the drawing-boards of utopians to the practical activities of engineers, horses and workmen, the act of assembling a liberal city starts to seem considerably less rational and organised. The final part of the chapter, which offers a case study of the widening of the Manchester thoroughfare of Deansgate in the 1870s and 1880s, continues this theme, emphasising contingent events such as strikes, bad weather and accidents, all of which interfered with this massive and expensive project. The chapter closes by emphasising the role of maintenance and inspection in producing anything approaching durable change to urban infrastructure. I also suggest that the rather straightforward notion of embedding the dominance of the visual becomes complicated by analysis of smoke abatement, which palpably failed to cure the atmosphere of soot and smoke, for reasons, which were equally consistent with freedom.

In chapter 3, I look at the kinds of visual economies produced within the city over the course of the nineteenth century. If government was operating through increasingly complicated networks in order to achieve its aim of civilising and nurturing the population whose energies drove the economy, then the smooth functioning of these infrastructures necessitated an expansion of agencies of inspection. I discuss the nature of inspection, its growing ubiquity and the critical role of standardised, systematic measurement of environmental norms. Following this, I examine the logistics of inspection by looking at the activities of the Alkali inspectorate in the 1860s and 1870s, before describing the activities of the Medical Officer of Health, the Public Analyst and the Nuisance Inspector. The practical systems through which each of these figures scrutinised, measured and tabulated the minutiae of the city's life, I argue, constructed a living, evolving corpus of knowledge through which efficient intervention in the urban fabric could take place. The city, in other words, was opened up to the eye of government, which exposed pipes and privies, meat and milk, chimneys and lodging-houses to the routine act of inspection in the name of minimum standards of environment.

Yet this field of inspection did not spatially coincide with the realm open to polite, public observation. Here, I look at various ways in which aspects of urban life were privatised, withdrawn from vision and castigated as obscene. This amounted to a profound concern with the demoralising effects of natural functions being open to view, something associated by reformers with the spatial of the courts and alleys of the poor. Defecation, nudity, sex and death were practices upon which the eyes should not linger: they were, however, basic and irreducible organic mechanisms. Violent, obscene organic activity, in other words, was removed from the public sphere as much as possible: again, this is a process consistent with my definition of modernity. The visceral and turbulent aspects of bodily existence were to take place secretly, in bedrooms, toilets, hospitals. To illustrate this point, I use the example of the slaughterhouse, and attempts to replace it with a system of public abattoirs. The slaughterhouse was, I argue, neither fully private nor fully public, frequently exposing the sights and sounds of death to onlookers whose frequent fascination epitomised demoralisation. The abattoir, by contrast, was wholly secluded from the public, a space where a quick, silent and unseen death-stroke was substituted for the protracted, animated struggles of the slaughterhouse. Such a movement can be seen as further evidence of an attempt to materially recraft the city as a space where civil sights prevailed for a public possessing a deep, embedded sense of horror.

Parallel to this was a concerted effort to introduce placid, harmonic and morally-instructive displays of nature into urban areas seen as devoid of elevating spectacle. Parks, open spaces, zoos, flowerbeds and gardens were, with varying degrees of success, constructed across the period for the purpose of presenting an image of nature as benign and responding to human care. The example I use here is that of the public aquarium. As well as displaying piscine life through calculated use of glass and light, these great tanks, which became common in the 1870s, also demonstrated how environmental management could secure the welfare of our fellow beings. Nature was thus held up as logical order inseparable from a milieu, an order which humans could both see and imitate. The use of private aquaria was promoted as a technology through which individuals could awaken a sense of empathy with so-called lesser creatures, and develop environmental sensibility. The judicious administration of water, air and light could foster life.

The second half of this thesis, "Illumination", concentrates in more detail on technologies designed to light the city. Chapter 4 begins by briefly delineating the major developments in the scientific studies of light and vision in the nineteenth century. The wave theory of light, and the new emphasis on the physiology of seeing, provided an epistemological framework within which the appraisal and calibration of new optical technologies, particularly sources of artificial light, took place. The relentless investigation of the physiological conditions under which normal vision took place shows how the Cartesian model of the subject began to be complicated. The remainder of the chapter addresses this measurement of light. Following chapter three, I emphasise the importance of meters and laboratory science in the practical calculation of environmental conditions within the city, conditions that were, moreover, putatively tuned to the norms of the body. However, as the convoluted tale of photometry shows, any attempt to introduce an unambiguous standard measurement of light, and particularly of its perception, was almost impossible. Nonetheless, the steady production, circulation and publication of average levels of illumination is another aspect of the way in which environmental conditions became increasingly quantified and normalised. Legal light levels were upheld in laboratories where other urban truths, such as the chemical composition of foodstuffs, were assembled.

The various technologies designed to calculate light, particularly photometry and spectroscopy, provide a point of access to the complicated history of light technology in the final decades of the century. The final two chapters deal with this period. Chapter five examines the kinds of visual agency associated with early electric lighting systems. These systems, it bears pointing out, came in many different forms: arc lights and electric candles were as important in the 1880s as incandescent light. Electric light, I argue, promised to produce a visual field within which accurate colour perception at distance could take place, something which explains its early use in lighthouses, docks and railway stations. It was thus able to activate certain physiological capacities of the human ocular system which other forms of light sometimes, or always, failed to do. Having provided a sketch of this visual field, I examine the kinds of subjectivity this field made possible. Following the work of Jonathan Crary, I argue that both attention and distraction were integral to the remaking of the modern observer.[15] The ability to concentrate, especially at work, and to be seduced and beguiled, especially while enjoying the new leisure activities of the city, could both be secured by electric light systems. Particularly important here was the manipulability and focus of electric light, enabling more nuanced tuning of illumination and visual practice, which improved the ocular abilities of, for example, surgeons and watchmakers. Finally, electric light was promoted and experienced as an explicitly sanitary technology, as vital to the production of wholesome atmosphere as sewers and drains. Chemical analysis was brought to bear to uphold the claims that the electric light did nothing to impair the air of rooms, unlike all other forms of light. Electricity, I argue, was able to produce light without creating sound or smell. It thus formed part of a complex of technologies within which the body, as well as the ocular apparatus, could function in a normal way. However, this was only achieved in certain locations, where fragile collections of equipment were maintained in functional order by knowledgeable electricians. The final section of chapter five rectifies any insidious Whiggery by looking at a series of failed electric light technologies, and ways in which the gas industry responded to the competition. The regenerative gas burner and the gasmantle were both designed to produce a purer light without upsetting the chemical balance of the air or the physical condition of the room.

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[15] Jonathan Crary, *Suspensions of Perception: Attention, Spectacle and Modern Culture* (London: MIT Press, 1999).

Light technology, in other words, must be examined as infrastructures targeting the whole environment and not simply human eyes. Their systemic aspects must also be addressed, and this is the subject of the final chapter. The early electric light installations in factories, wharves, harbours and stations, were small-scale, designed for specific industrial purposes. Likewise, the few houses lit electrically were those of enthusiasts like William Preece, the electrical engineer and telephonist, or Octavius Coope, the brewer. This chapter looks at the material elements necessary to build larger electric systems, from lamp-posts and metering systems to the miles of cables, conduits and manholes needed to make its delivery durable and predictable. Discussing the subterranean world emphasises how strategies designed to impact on the conduct and agency of the population were literally engineered into existence by modifying the earth itself. The condition of this underground world, already full of gaspipes, water mains and telegraph wires, is discussed, along with the kinds of accidents and anxieties accompanying different material systems. Gas had long been associated with poison and explosion, but electricity brought with it a set of reconfigured fears, notably around powerful, imperceptible currents, which led to the discontinuation of overhead wire systems and the careful management of alternating current.

The chapter concludes with a case study of the electrification of the City of London in the early 1890s. This scheme illustrates many of the themes echoed throughout the thesis. For example, I emphasise the protracted experiments and deliberations over thirteen years, prior to the construction of the system itself. The logistical complexity, material contingency and sheer labour involved are discussed, as well as the persistent problems of fog and accidents.

Government, therefore, came to involve the recruitment and deployment of vast material resources. This thesis attempts to examine this strategy, and shows how taking infrastructure seriously perhaps entails rethinking some of our theories about how government works. A few tentative suggestions are offered in a brief conclusion, which also suggests how further research might extend these analyses.

Part One

Organisation

How a sensory world is dismantled, resynthesised and represented is inseparable from the problem of how a world of objects, individuals and social relations organises itself.
(Crary, 1999)

Travelling around the world along the highways of civilisation, it becomes obvious that the material world is largely built by, and for, seeing.
(Luckiesch, 1940)

1: Organising Freedom: The Body, the Senses and Urban Infrastructure, 1840-1900

This chapter is divided into two sections. The first introduces a series of themes which will be elaborated throughout the thesis: liberal governmentality, the body, material agency and modernity. Consequently, it in no way pretends to provide anything more than an outline of what I mean by these terms and why they are central to my project of examining light technology's politico-social agency. Copious footnotes are provided to direct readers to more detailed analyses. The second section examines the relationship between liberal subjectivity and the senses. Vision, I argue, became the master sense of modernity due to its technical, and phenomenological, capacity to realise forms of practical action upon which the exercise of freedom came to hinge. *Practising perception* became critical to one's display of freedom, the performance of which did not spring autochthonously from the mind, soul or will, but was secured materially by the relations bodies entered into with spaces, infrastructures, and atmospheres. Thus urban reconstruction can be envisaged as an attempt to manufacture the conditions under which humans could physically exercise the self-government upon which the practice of freedom relied.

This chapter functions as a kind of glossary, providing a map of the terrain which the remaining five chapters will cover in more detail.

Governing Humans and Nonhumans: Freedom, Materiality and Modernity

In order to analyse the role of material infrastructures in organising modern freedom, I will introduce two bodies of theory. The first, the Foucauldian analytics of governmentality, shifts focus from politicians, institutions and states to a more humble, heterogeneous array of rationalities and techniques aiming to organise spaces and populations for particular purposes. The second, actor-network theory and its variations, genuinely attempts to treat all elements of this organisation, human or nonhuman, as actors, whose conjoined and relational agency is essential to the survival and durability of any arrangement. Both approaches have problems, and there are significant points of friction between them, especially over the question of materiality. I will signal some of these concerns in advance, but the thesis is a whole can be taken as a sustained rumination on the possibilities and drawbacks of each.

Liberal Governmentality

The term 'governmentality' has been defined as:

> *All* endeavours to shape, guide, direct the conduct of others, whether these be the crew of a ship, the members of a household, the employees of a boss, the children of a family or the inhabitants of a territory. (Emphasis mine)[1]

Foucault pithily summed up this redefined, highly general conception of government as "*the power to affect in all its aspects*."[2] There have been several admirable sociological studies of governmentality, which have delineated genealogies of its mutations, all of which have elaborated the genesis of a historically-specific mode of *liberal governmentality*, emergent in Britain from the mid-eighteenth century onwards.[3] Historical analyses of governmentality are also being written.[4] I will begin by sketching the salient features of this form of government as defined in these works, before indicating its specific advantages and disadvantages as a tool for analysing technology.

The first aspect of liberal governmentality is the centrality of *freedom* as the dominant value through which rule over others has been practised: "what is universal in the modern world is the centrality of freedom as a good."[5] Government has become

[1] Nikolas Rose, *Powers of Freedom* (Cambridge: Cambridge University Press, 1999); 3.
[2] Cited in Gilles Deleuze, *Foucault* (Minneapolis: University of Minnesota Press, 1988), 76; italics in Deleuze.
[3] See, for example, Rose, *Powers of Freedom*, Mitchell Dean, *Governmentality Power and Rule in Modern Society* (London: SAGE, 1999), Colin Gordon, "Governmental Rationality: An Introduction," in Burchell, Gordon and Miller, eds., *The Foucault Effect*.
[4] Gyan Prakash, *Science and the Imagination of Modern India*, (Princeton: Princeton University Press, 1999); Patrick Joyce, *The Rule of Freedom* (forthcoming: Verso, 2002).
[5] Charles Taylor, *Sources of the Self: The Making of Modern Identity* (Cambridge: Cambridge University Press, 1989), 395.

organised around the concept of freedom, rather than, say, blood, loyalty or bondage. The control of others, therefore, involves conceiving of them as inherently free: "it involves a form of power over others that is made operable through the liberties of those over whom it is exercised."[6] Thus freedom is very much a historical product of multiple strategies through which political subjectivity has been fashioned. As an organising mode of rule, freedom emerged as a precarious solution to the problem of autonomous domains, economic, biological and social, which had specific limits, logics, even laws. These were immanent to the domain in question; consequently they existed independently of direct government, whose role was to maintain the conditions within which autonomous functioning operated. The contradictions constitutive of this formulation gave liberal government its power and perennial anxiety.

The most important of these domains is the economy. Earlier forms of government, such as cameralism, had targeted economic processes while remaining within an organising framework of sovereign and household. Through the work of Adam Smith and Thomas Malthus in particular, the economy emerged as a dynamic realm, with its own logic (the 'invisible hand') which, because temporally emergent through the collective, unpredictable action of economic agents, was necessarily opaque. Unbending rule or Procrustian diktat would be counter-productive, limiting the freedom through which new products and markets developed. By the early nineteenth century, the security of this dense, autonomous realm had become the overriding concern of government, epitomised by the ascendancy of laissez-faire and political economy.[7]

Freedom of trade, the untrammelled circulation of labour, money and commodities, relied upon a strong and productive labour force, the measurement of which generated a second new object of liberal government, the population. Rationalities of government, argued Foucault, became "situated and exercised at the level of life, the species, the race, and the large-scale phenomena of population," leading to an obsession with sex, health, and disease.[8] Population, with its capacities and limits, became an abiding object of analysis: like the economy, the fact that it possessed laws was itself largely

[6] Dean, *Governmentality*, 47.
[7] See, for example, Mary Poovey, *Making a Social Body: British Cultural Formation 1830-1864* (Princeton: Princeton University Press, 1999), chapter 2.
[8] Michel Foucault, *The History of Sexuality Volume One: The Will to Knowledge* (Harmondsworth: Penguin, 1990), 137.

unquestioned, yet acknowledged to be both epistemologically and strategically beyond the reach of government. Censuses and investigations attempted to chart its immanent trends of growth and decline, life-expectancy and birth-rates.

Between this population and the economic activity sustaining it, emerged a third domain, that of society, which, by the early nineteenth century, was recognised as an specific object, a complex, opaque sphere, with regularities only discernable at the level of the totality. This discovery was "only possible because of this bio-politics of the population,"[9] which created the conditions of existence of a society:

> Made up of the concrete exchanges of the economy, of the lives, infirmities, frailties and death of individuals, of the occupations, customs, habits, patterns of family life and modes of communication, of the quest by the population for subsistence, and of the ensuingdistribution of wealth.[10]

Society itself could not be directly manipulated by government, yet intervention of various kinds would become necessary to prevent the damaging impact of the free market on gestating social variables, for example crime.[11] The 'sanitary idea' of Chadwick, for example, has been convincingly depicted as a political solution designed to secure both the freedom of the market and that of the health of the population, in the interests of social morality: I will return to this theme at various points throughout this chapter.[12] Less dogmatic and more heterogeneous were the many strategies, embodied in housing and public health legislation, codes of building and the like, designed to fight physical degeneration and moral turpitude across the period 1850-1900. Society, as a whole, was becoming, in halting, agonistic fashion, "a target of state intervention – what has been called 'the social'."[13] From these bits and pieces, something with the consistency and coherence of 'social policy' would be assembled.

Agonistic is an important adjective here, for liberal governmentality is typified by continual questioning of the appropriate extent to which tampering with the conditions under which these domains existed was justified. "The enduring puzzle of liberalism," was "the conundrum of how to establish a viable boundary between the objects of

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[9] Dean, *Governmentality*, 113.
[10] *Ibid.*, 126.
[11] See, for example, Jacques Donzelot, "The Promotion of the Social," in M.Gane and T.Johnson, eds., *Foucault's New Domains* (London: Routledge, 1993)
[12] Christopher Hamlin, *Public Health and Social Justice in the Age of Chadwick.* (Cambridge: C.U. Press, 1998)
[13] Paul Rabinow. *French Modern: Norms and Forms of the Social Environment* (London: MIT Press, 1989), 15. See also Donzelot, "The Promotion of the Social," and *The Policing of Families* (London: Hutchinson, 1980).

necessary state action and those of necessary state inaction.[14] Mill, for example, argued that "no subject has been more keenly contested in the present age" as the question "of the limits of the province of government."[15] The fundamental tensions between society and economy have been a fertile source of political debate for the best part of two centuries.

This thesis, however, will not address the writings of political theorists. Why, then, do I take liberal governmentality as my starting-point? Because the aim of liberal forms of government is to secure as far as possible physical and mental forms of conduct consistent with a free and prosperous circulation of money and goods, a healthy population and a contented, pacific social order. Furthermore, as highlighted in the opening quote, this theory allows *any* strategy designed to produce durable changes in conduct to be addressed as governmental, including "apparently humble and mundane mechanisms which appear to make it possible to govern," such as the infrastructures which will concern me here, and those entrusted with their construction and maintenance: engineers, plumbers, electricians.[16] "Each one of us," declared an engineer in 1880, "is responsible, so far as his power of control goes...for the proper conduct of life in harmony with known laws."[17] These figures, along with doctors, nuisance inspectors, analysts, planners and any number of others, are human relays, enabling government to function over enormous distances, fusing science and politics into a fearsome organisational alloy. The practical and technical aspects of rule, rather than its intellectual or philosophical coherence, are the objects of governmental analysis. This leads, among other things, to a critique of the distinction between the macro- and microphysics of power. Rather than the state existing as a macro-actor orchestrating government, it appears to exist in a condition of perennial becoming, immanent and emergent through endlessly mutating techniques of rule.

The governmentality literature thus opens up vast areas of legitimate study for the political historian. However, it is not without flaws, some of which I have no room to

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[14] Colin Gordon, "Governmental Rationality," 18.
[15] J.S. Mill, *The Principles of Political Economy, with Some of their Applications to Social Philosophy* (London: Longmans, 1929), 941.
[16] Miller and Rose, "Governing Economic Life," in Gane and Johnson, eds., *Foucault's New Domains*, 82.
[17] Edward Philbrick, "Sanitary Engineering," *The Plumber and Sanitary Engineer*, III, March 1, 1880, 127.

discuss.[18] The main problem in using this body of theory to address technology is its palpably intellectualist or discursive character, that leads, I think, to the denigration of materiality. Thus, we find arguments such as those of Rose, who claims to produce an empirical study by looking at "moment(s) when thought tries to realise itself in the real," a real defined confusingly as "composed in the work of thought itself."[19] Likewise, Dean advocates a "materialism (that) must be concerned with thought."[20] Technology, architecture and engineering can thus appear as materialisations of a guiding rationality existing prior to, and apart from, these manifestations, a position that has been criticised from many angles.[21] Reality appears primarily *negative*, as defined largely in terms of its "obstruction to rule."[22] Government, then, can assume something of a programmatic character, the activity of minds moulding matter as they fancy. This critique will take shape throughout the thesis; by acknowledging the agency of objects, we expand our notion of politics to become something like "the management, diplomacy, combination, and negotiation of human and nonhuman entities."[23] Only by abandoning some of its modern epistemological premises, I will argue, can governmentality truly come to account for the staggeringly intricate webs and networks through which our world coheres.

Another important area of concern surrounds the term 'liberal', the meanings of which are discussed at the start of the second section. If we are to talk of a specific mode of governmentality predicated on freedom, we must acknowledge the demonstrably illiberal forms of rule with which it co-existed. Disciplinary institutions, panoptic spaces, astonishing inequality, and acts of compulsion remind us that governing is an irreducibly heterogeneous, even contradictory act, which no theory can hope to contain, a point made recently by Mariana Valverde.[24] This focus on heterogeneity necessitates abandoning an overly sociological, formal approach in favour of one addressing the historical and material arrangement of technologies and rationalities of rule. The illiberal within the liberal also draws attention to the *imaginary* force of the latter; it has survived

[18] An example is the potential confusion between the political and the governmental. See Barry Hindess, "Politics and Governmentality," *Economy and Society*, 26: 2, 1997.
[19] Rose, *Powers of Freedom*, 55.
[20] Dean, *Governmentality*, 30.
[21] For example, Chandra Mukerji, *Territorial Ambitions*, chapter 7.
[22] Frank Pearce and Mariana Valverde, "Introduction," *Economy and Society*, 25:3, 1996, 307.
[23] Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies* (London: Harvard University Press, 1999), 290.
[24] Mariana Valverde, "Despotism and Ethical Liberal Governance," *Economy and Society*, 25:3, 1996.

as an ordering principle of politics with unrivalled success throughout the last two centuries in the face of tangible reminders of its failure.[25]

These criticisms are not exhaustive, and will hopefully become clearer as this section, and the thesis as a whole, develops.

Organism and Infrastructure

The bodies forming a population were the fundamental agents through which wealth was generated: securing their physical vitality was imperative, yet this basic act necessitated preserving the freedom of the market. This dialectic between laissez-faire and health would generate a cascade of evanescent syntheses, from the Speenhamland system, through 'less eligibility', to pensions, insurance and unemployment benefit. This vector of development, in other words, lead to the invention of the social. Governmentality, here, is operational at the organic plane itself, displaying "a concern for the population and its optimisation (in terms of wealth, health, happiness, prosperity, efficiency)" which has been termed *biopolitics*, the intimate connection between the health of the individual, the size and condition of the population and the strength of the state.[26] "The bodily strength of the individuals of the working class," argued Chadwick, "constitutes the chief strength of the nation."[27] Underpopulation, for example, had been equated with political weakness in Prussia following the end of the Seven Years' War in 1763. Malthus would soon indicate the limits of any notion of indefinite organic expansion, both of the individual and the population, tracing the circumference within which political economy would be trapped for the next hundred years. The worker's body became an object of anxious analysis; its posture, training, diet and vital processes subject to scientific scrutiny.[28] By 1900, the biopolitical impulse had opened up

[25] See Peter Wagner, *A Sociology of Modernity: Liberty and Discipline* (London: Routledge, 1994)
[26] Dean, *Governmentality*, 20.
[27] Chadwick, *Report on the Sanitary Condition of the Labouring Population of Great Britain* (Edinburgh: Edinburgh University Press, 1965), 252.
[28] See, for example, Anson Rabinbach, *The Human Motor* (Berkeley: University of California Press, 1992).

concerns like degeneration, the paradigmatic pathology of urbanisation and industrialisation. This phenomenon signalled concern that national health and strength were being enervated by the very economic processes designed to nurture them, a condition with potentially grave political repercussions:

> It has now got into a condition in which it cannot be left...This mighty mob of famished, diseased, and filthy helots is getting dangerous, physically, morally, politically dangerous. The barriers that have kept it back are rotten and giving way, and it may do the State a mischief if it be not looked to in time.[29]

Sims was certainly being polemical, but he emphasised the genuine anxiety that the bodies of the poor would rebel if misgoverned. The organic plenum upon which government rested was diseased and rotting.

The body, argued Foucault, has been "invested" with technological power throughout the last two centuries.[30] What exactly does this mean? In factories, schools, homes and public spaces, machines, tools, and energy of all kinds has been utilised to shape the abilities of human bodies to labour, learn, and move. This process has been calculated using physiological, physical and chemical knowledge of the organic and inorganic matter and the circulation of energy within and between them. Vitalism, the doctrine that a life-force existed which was irreducible to mere physical and chemical processes, certainly waned across the century, although we should beware regarding this as a total victory for materialism. Nonetheless, we may state, with due respect to historians of biology, that a more empirical, quantitative and materialistic physiology dominated the period 1850-1900.[31] "The human body and the industrial machine," were, for Helmholtz, perhaps the century's greatest physicist, "both motors that converted energy into mechanical work."[32] The universe of organic and inorganic matter was held to operate according to a single set of physico-chemical laws. The configuration of, among other things, thermodynamic theory, positivism, experimental biology (facilitated by the liberation of the cadaver instigated by the 1832 Anatomy Act), photography and statistics, extracted knowledge from the body which was then utilised to technologically

[29] George Sims, *How the Poor Live; and Horrible London* (London: Garland, 1984), 44.
[30] Foucault, *The History of Sexuality Volume One*, 139, 152. See also Jonathan Crary and Sanford Kwinter (eds.) *Incorporations* (New York: Zone, 1992); and Michel Feher, with Romona Naddaff and Nadin Tazi, ed. *Zone: Fragments for a History of the Human Body*, 3 vols. (New York: Zone, 1989).
[31] See William Coleman, *Biology in the Nineteenth Century: Problems of Form, Function and Transformation* (Cambridge: Cambridge University Press, 1977), for a comprehensive discussion of these, and many more, questions.
[32] Rabinbach, *The Human Motor*, 2.

frame it within conditions designed to maximise its aptitudes. The body was thus a force to be rationally moulded, to be coaxed and cajoled rather than dominated, something I will return to in more detail in chapter four.

I will merely point out three aspects of this reconfigured physiological knowledge. First, the issue of *time*. Nineteenth-century biology can be distinguished from eighteenth-century natural history precisely by this concern with temporality and change. Darwinianism marks less of a break here than Cuvier, at least in the Foucauldian schema, but the centrality of growth, change and decay in the theory of natural selection was essential to this reconceptualisation of the body.[33] Second, there was the question of the *limit*. Pre-Malthusian thought, for example, still utilised a conception of infinity: animals might be bred to the point of immortality, while population might increase boundlessly.[34] Nineteenth-century physiology held that the body had limited capacities; it had thresholds beyond which its optimal functioning (breathing, energy, movement, even intellection) broke down. It was a field of forces, resisting the reckless administration of force. Vital circuitry was opaque, a domain of its own: another limit to government had been unearthed. Finally, there was the *norm*. Measuring physiological capabilities revealed regularities, which, like emergent social 'facts', were distributed along a continuum. Pathology, as Broussais argued, was calculable in terms of its deviation from a mean state of organic normality.[35] The norm functioned as a hinge linking the biological and the social; "the word became indispensable because it created a way to be 'objective' about human beings."[36] The norms of the body and the norms of society seamlessly coincided; one could not foster one without framing the other, a connection of vital significance for the epistemologies underpinning infrastructural reform.

Calculation, therefore, revealed regularities existing at the level of population or society: *rates* or *laws* could only be discerned by analysing the totality. These trends, moreover, were thoroughly historical: rates grew or fell, and their curves produced the unfurling

[33] Michel Foucault, *The Order of Things*, 263-280.
[34] Godwin and Condorcet were the principal targets of Malthus's attack. See *An Essay on the Principle of Population: And a Summary View of the Principle of Population* (Harmondsworth: Penguin, 1970), VIII-XV. See also, Catherine Gallagher, "The Body vs. the Social Body in the Works of Thomas Malthus and Henry Mayhew," in Catherine Gallagher and Thomas Laqueur, eds., *The Making of the Modern Body*, 87
[35] Georges Canguilhem, *The Normal and the Pathological* (New York: Zone, 1989)
[36] Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990), 160

indices of national health particularly associated with statistical societies. Scientists, meanwhile, relentlessly monitored anatomical capacities with tachistiscopes, optometers, calorimeters, ergographs and other devices. As gauges of the biological and moral condition of the social body, they were environmental barometers, for the organism, as every Darwinian knows, flourishes only to the extent that a degree of harmony is forged with its surroundings. The normal state indicated this harmony: physical or moral pathology, irrespective of questions of personal guilt, were environmentally determined for everyone involved in public health throughout the period. This environmentalism opened a space for legitimate governmental interference to the extent that the body had norms which must be nurtured in order for it to achieve operational levels. Intervention in areas like sanitation, nutrition and ventilation was justified by an environmental rationality, which ceded a framing agency to the milieu within which organic activity occurred. The expertise of scientists, engineers, and doctors was channelled into this orchestration of vitality, a move which has been described as the "'biologisation' of politics."[37]

The germination of this environmental rationality of government is evident in areas like sumptuary law, and later, eighteenth-century police concerns over streets and building.[38] In the nineteenth century, there was an explosion of legislation and construction calculated to create an environment conducive to physical normality, and thus moral rectitude. "The proper work of a sanitary authority," declared *The Builder* in 1874, "is to make morality of the people possible by laying for it the foundation of health, without which it cannot exist."[39] Architecture and engineering would provide something like a material *a priori* for a healthy population, generating an environment within which the possibility of normal development would be maximised. A healthy subject would rationally choose to be moral under such circumstances. Government would create the conditions within which this choice would be made possible, which entailed intervention at the level of milieu.

A good physique required clean water, pure air, adequate light, an appropriate temperature and unadulterated food. Air, for example, would be an abiding

[37] Rabinbach, *The Human Motor*, 207.
[38] Dean, *Governmentality*, 91. Alan Hunt, "Governing the City: Liberalism and Early Modern Modes of Governance," in Barry et al. *Foucault and Political Reason*.
[39] *The Builder*, XXXII, December 12, 1874, 1024.

environmental concern. Polluted and stagnant air, trapped in courts and factories, was blamed for maladies ranging from constipation to childhood scrofula. The free circulation of clean air was essential for warding off physical, and moral, pathology: "give us a profusion of fresh air. Ventilate! Ventilate! Ventilate!" intoned one architect.[40] "Ill-ventilated dwellings and schools," argued another, "contribute the first elements of disease." He continued, expressing a formula repeated across the period: "architects, by the construction of healthy dwellings, schools and workshops, may thus effect a great and beneficial change in the physical condition of the working population."[41] Streets, parks, trees, yards, windows, skylights, ducts, extracting shafts, grilles, vents and purifiers, were all martialled and co-ordinated in this war against stagnation. Under Model By-laws drawn up by the Local Government Board in 1877, all rooms on all storeys abutting open space were legally obliged to have a window for the purposes of ventilation. Factory Acts included clauses, typically permissive, aimed at securing the circulation of air necessary to remove the clouds of grit and dust generated by industrial production, as well as to cool the atmosphere. Heat was blamed for igniting the passions, and acting on the body in more permanent ways. Furnaces and lack of ventilation led to conditions which "act(ed) upon the organisation like the tropical sun, and puberty is developed before age and education have matured the moral sentiments."[42] Body temperature (ninety-eight degrees Fahrenheit) was a norm which environment must secure: otherwise, the savage, irrational habits of equatorial tribes would be biologically reproduced in Bolton and Bradford.[43]

The recognition of the pathologies generated by environment was integral to the project of Chadwick, especially manifest in the General Board of Health, established in 1848. The Board itself was somewhat ephemeral: but the need for technical systems, particularly hydraulic ones, to durably implant new physical norms permeated England during the following decades. This solution blamed material arrangements, not economic ones, for social and moral problems, placing an infrastructural wedge between

[40] W. Forrest Salmon, "Some Observations on the Ventilation of Buildings," *British Architect*, XXI, February 15, 1884, 80.
[41] B.H. Thwaite, "Hygiene Applied to Dwellings," *The Plumber and Sanitary Engineer*, II, July 15, 1879, 247.
[42] M. Leon Faucher, *Manchester in 1844: Its Present Condition and Future Prospects* (Manchester: Heywood, 1844) 46.
[43] Lakeman, for example, devotes a whole chapter to the issue of ventilation in *Health in the Workshop* (London: William Clowes and Sons Ltd., 1884).

the two domains. It promoted one sort of freedom, freedom from decomposing matter, rather than numerous other freedoms (freedom from hunger, cold, or poverty, for example.) Health would become the engineer's responsibility: the industrialist was free to do as he wished. Liberty itself, as Hamlin argues, was specifically yoked to health: "one could only be free to act if one were fit to act."[44] The huge systems of sewers and drains perforating cities after 1850 therefore implanted certain sets of social relations. Local authorities would build, maintain, inspect and operate sanitary systems while the population would keep itself physically clean. Vice and sin could not then be blamed on the authorities; they were moral acts for which the individual could be held responsible, the result of a perverse use of freedom. The network thus freed "a space for vital normativity through a minimum standardisation of the environment," which in turn freed a moral space, within which reason could evolve.[45]

I will return to this relationship between sewerage and morality at the end of the chapter. Suffice to say here that infrastructure formed one axis through which the idea of the social as a sphere of regulation emerged. Water, light, transport, food, air, sewerage, and heat were all, slowly and following different logics, seen as areas that individuals, however morally diligent, could not actively secure. Liberty was becoming anchored in a socially-secured field of vital intervention, which targeted the body through the networks through which it derived its strength. The proliferation of these networks, mundane and ubiquitous as they would become, was doubtless historically extraordinary. By 1863, for example, there were nearly 22,000 miles of telegraph wire in Britain: by 1873, Manchester alone had 1004 miles of gasmains. The Thirlmere aqueduct, which opened in 1895, delivered Cumbrian rainwater across ninety-three miles of undulating dales. The agency of Lancastrian workers was made possible by the co-ordinated circulation of water, gas, dung, air, electricity, information, warmth, milk, urine, trams, and meat. Their action made spectra of human action possible. What on earth can it mean to say such a thing?

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[44] Hamlin, *Public Health and Social Justice in the Age of Chadwick*, 68.
[45] Tom Osborne, "Security, Vitality and Drains: Liberalism and Power in the Nineteenth Century," in Barry et al eds. *Foucault and Political Reason*, 116.

Material Agency and Durability

"To ask how governing works," argues Dean, "is to ask how we are formed as various types of agents with particular capacities and possibilities of action."[46] Human agency itself has a history, one inseparable from techniques which have been mobilised to make possible, channel or restrict action in a world which "is continually *doing things*, things that bear upon us…as forces upon material beings."[47] Scientists and engineers have, over the last couple of centuries, acted as the latest historical figures endeavouring to coax the forces of a refractory universe to act for and with us. Andrew Pickering makes this point cogently:

> Scientists, as human agents, manoeuvre in a field of material agency, constructing machines that…capture, seduce, download, recruit, enrol, or materialise that agency, taming it and domesticating it, putting it at our service, often in the accomplishment of tasks that are simply beyond the capacities of naked human minds and bodies, individually or collectively.[48]

Bending and shaping matter into configurations equipping us with new capacities, physical or mental, entails acknowledging the mutual involvement of the human and nonhuman in any action. This *symmetrical* approach is fundamental to work in science studies, such as actor-network theory, which have tried, often in the face of tiresome opposition, to overcome the polarity between the natural and the social sciences, in which facts are held to be either entirely independent of, or utterly dependent upon, human beings.[49] Agency is a collective performance, whether it be the hungry crow cracking a recalcitrant nut on my balcony, or the emailed draft of this chapter appearing in my supervisor's mailbox. The conjoined act depends neither on the bird or its breakfast, or the student or his computer, but the aligned performance of both.[50]

These chains of agency are thus performative: action is their defining characteristic rather than, say, truth.[51] Furthermore, they are thoroughly heterogeneous: people, texts,

[46] Dean, *Governmentality*, 29.
[47] Andrew Pickering, *The Mangle of Practice*, 6.
[48] *Ibid.*, 7.
[49] See, for example, the exchanges between Bruno Latour and Michel Callon, and Yeates and Collins in Andrew Pickering, ed., *Science as Practice and Culture* (Chicago: University of Chicago Press, 1992)
[50] For lengthier examples, see Pickering on the bubble chamber in *The Mangle of Practice*, chapter 2, and Latour's account of firearms in *Pandora's Hope*, 176-182.
[51] Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Milton Keynes: Open University Press, 1987), Pickering *The Mangle of Practice*, chapter 1, Hacking, "The Self-Vindication of the Laboratory Sciences" in Pickering (ed) *Science as Practice and Culture*.

animals, buildings, and machines, for example, combine to make "network(s) of heterogeneous material arrangements."[52] This performative, relational approach is characteristic of what became known as actor-network theory.[53] Agency, here, is absolutely relative and dispersed. This includes material agency as much as human, since the efficacy of, say, a road surface depends as much on climate and traffic as it does on any intrinsic set of properties, and this could *never be otherwise*. Any act, therefore, cannot be imputed to a single 'mind' or a single 'object', as intentionality is diffused through social networks, and frequently 'mangled' in practice. Little wonder that governmentality analyses, like actor-network theory have drawn attention to "non-subjective intentionality."[54] Humans are here not programmers, materialising their ideas, but enmeshed from the start in a world of agency, a world which historians must take seriously. Non-subjective intentionality necessarily involves the agency of nonhumans; which is to say that the collective, coterminous action of humans and nonhumans should be the basis of governmental analyses.

Mobilising the world is something occurring in real time, and is always threatened by contingency. Sanitary engineers, for example, quickly found that a standard sewerage system had to be modified by knowledge of local geological and geographical conditions: they discovered the world couldn't be programmed, that it had to be worked with, not against: "brute contingency, sheer chance emerging in time, is integral to practice."[55] Chance could only be tamed statistically, by calculating the probabilities of accidents, while insurance schemes accepted both the inevitability of risk in an age of increasing technical density and its social nature. Local authorities, industrialists and businessmen were thus absolved of blame through legislation which volubly betrayed the "nonsubjective" nature of intention and agency in the industrial epoch.[56] In return however, maintaining the material frameworks within which people lived and worked

[52] John Law, "Introduction," *A Sociology of Monsters: Essays on Power, Technology and Domination* (London: Routledge, 1991), 16.

[53] John Law, "After ANT: Complexity, Naming and Topology," in Law and John Hassard, eds., *Actor Network Theory and After* (Oxford: Blackwell, 1999). See also Michel Callon, "Society in the Making," in Wiebe Bijker, Thomas Hughes and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (London: MIT Press, 1987).

[54] Dean, *Governmentality*, 22: John Law, in *Organising Modernity* (Oxford: Blackwell, 1994), uses the same phrase, 96.

[55] Pickering, *The Mangle of Practice*, 209.

[56] On chance and risk, see Ian Hacking, *The Taming of Chance*, Beck, *Risk Society: Towards a New Modernity* (London: Sage, 1992), Anthony Giddens, *The Consequences of Modernity* (Cambridge: Polity Press, 1990).

increased in importance. This is visible in numerous areas; for example, the genesis of building regulations, the omnipresence of inspection and the rise of the repairman. Instruments, texts, eyes and hands were all deployed to preserve an order designed to foster the minimum conditions necessary for a normal population, economy and society.

Durability emerged as the key criterion of infrastructure, a durability that was relational, as Law observes: "it is not that some materials are more durable than others…Rather, it is that some network configurations generate effects which, so long as everything else is equal, last longer than others."[57] Relational durability is hardly a novel concept, dreamt up by contemporary theorists, as this quote from *The Builder* demonstrates: "the durability of any material…depends not only on its own inherent properties, but *principally on the agencies to which it is opposed*."[58] Weather, vibration, accidents, pollution and vandalism – all states of matter and all kinds of agency – had to be counteracted to fight entropy. Testing materials became an obsession; only the slow grind of time could prove the worth of a durable assemblage. Over the century, a kit of resilient parts emerged - iron, plate-glass, concrete, marble, granite, tin, asphalt, zinc, encaustic tiles – sturdy bones and tough skin for a reinforced city.

Chapters two and six develop this theme of durability by analysing how new elements, such as hardwood pavements, wires, glass and insulation, were incorporated into urban networks in order to fortify them. Through this, certain kinds of human practice and agency (transport, light, heat) could be entrenched and potentially made permanent. The more successful this project became, of course, the less repair it needed, with the result that it could disappear from consciousness and sight, much as street surfaces, fuses and cables do. This leaves us with a phenomenologically-comprehensible notion of our autonomy from such networks, an autonomy which has been massively influential in ordering modernity.

[57] Law, *Organising Modernity*, 103.
[58] *The Builder*, June 26, 1875, 569. Emphasis added.

Modernity

The distinction between modern and premodern is itself an effect of the powerful drive towards order which distinguishes modernity.[59] What I wish to outline here is not a comprehensive theory of modernity but a particular anthropology of modernity focusing on particular epistemologies and practices emergent from the seventeenth century onwards in dispersed locations.[60] These styles of thought, in differing ways, cemented a set of distinctions and dualisms, which underpinned liberal strategies of rule.

The opaque, autonomous realms about which liberal government agonised - economy, population, nature - were slowly disaggregated through practical techniques as diverse as political economy, laboratory science, Cartesian philosophy, anatomy and anthropology.[61] Modernity can be characterised as the process whereby particular distinctions between autonomous domains are forged through practices and techniques designed to secure their permanence. These distinctions, as fundamental as those between mind and body, nature and society, or fact and opinion, are held to divide the moderns from the premoderns, for whom the world, with its cosmologies, cults and superstitions, was hopelessly tangled. The "late-medieval world view," for example, has been depicted as one mixing ancient lore and impregnable religious truths, the linking of which "made for fertility and richness in ideas, but also for confusion."[62] We are modern, this argument runs, because reason enables us to cut through the obfuscating thickets of culture or religion and see the world *as it really is*. This is the argument advanced by Bruno Latour.[63] However, despite the claim that science provides unmediated access to ultimate molecular truth, doubt refused to disappear. Kant's noumena and its Lockean forerunner, Boyle's moot causes, Smith's invisible hand,

[59] Z. Bauman, *Modernity and Ambivalence* (Oxford: Polity, 1991)
[60] The literature on modernity is voluble. Key works include Hans Blumenberg, *Legitimacy of the Modern Age* (London: MIT, 1983), Lash and Friedman, eds., *Modernity and Identity*, Foucault, *The Order of Things*, Taylor, *Sources of the Self*, Niklas Luhmann, *Observations on Modernity* (Stanford: Stanford University Press, 1998), Stephen Toulmin, *Cosmopolis: The Hidden Agenda of Modernity* (Chicago: University of Chicago Press, 1990), Latour, *We Have Never Been Modern*, Peter Wagner, *A Sociology of Modernity: Liberty and Discipline* (London: Routledge, 1994), Bernard Yack, *The Fetishism of Modernities: Epochal Self-Consciousness in Contemporary Society* (Notre Dame, Indiana: University of Notre Dame University Press, 1997), Giddens, *The Consequences of Modernity*, and Law, *Organising Modernity*.
[61] See Poovey, *Making a Social Body*.
[62] Hall, *The Revolution in Science, 1500-1750* (Harlow: Longman, 1983), 5.
[63] Bruno Latour, *We Have Never Been Modern*.

Newton's unknowable gravity - all acknowledged the limits of human comprehension. This framework is seductively analogous to that structuring liberal arts of rule, but I do not mean to suggest that these very different thinkers in any way directly influenced nineteenth century doctors and architects. I do think, however, that a set of presuppositions about how the world operates had become *common sense* by the nineteenth century; for example, the notion that we have a mind and a body and that the latter is inferior and requires government from the former. The discourse of sanitary reform is ordered around this principle. I will now provide a couple of examples of moments when modern thought emerged.

The distinction between body and mind was made most clearly by Descartes:

> I knew that I was a substance the whole essence or nature of which is to think, and that for its existence there is no need of any place, nor does it depend on any material thing; so that this 'I', that is to say, the mind by which I am what I am, is entirely distinct from body...even if body were not, the soul would not cease to be what it is.[64]

The human, in this conception, is absolutely bifurcated. The mind, critically, has "no extension or location in space": it is utterly severed from the rest of the world, becoming effectively "an island of awareness in a vast sea of insensate matter."[65] The mind is a non-place; thought occurs here in timeless disembodied stasis, in "a single inner space in which bodily and perceptual sensations...mathematical truths, the idea of God, moods of depression, and all of the rest of what we now call 'mental' were objects of quasi-observation."[66] The visual metaphor is important, and will be developed in the second part of this chapter, but there is a deep, almost Augustinian mistrust of the body evident here, built around the total identity of soul and mind. As well as being capable of contemplating the infinite (later, this becomes the sublime), the soul is that ichor which gives human bodies life. Animals, plants, rocks and seas are soulless and are thus dead; any motion they betray is machinic. This marks a huge shift from classical and medieval notions of the living earth; as is evident in, say, early modern mining treatises, the notion of earth as benevolent mother has been replaced by an image of earth as infinite resource to be plundered or merely investigated. Nature is merely *res extensa*, passive, inert.[67]

[64] Rene Descartes, *Discourse on Method* (London: Everyman, 1984), 26.
[65] Drew Leder, *The Absent Body* (Chicago: University of Chicago Press, 1990), 108, 8.
[66] Richard Rorty, *Philosophy and the Mirror of Nature* (Oxford: Blackwell, 1980), 50.
[67] See Carolyn Merchant, *The Death of Nature: Women, Ecology and the Scientific Revolution* (New York: Harper Collins, 1990), Hans Blumenberg, *Legitimacy of the Modern Age*.

Human and nonhuman, subject and object, and mind and body were consequently positioned on radically different ontological planes. The body receives a fleeting kiss of life from the soul; otherwise it is merely part of the plenum of dead matter constituting the world. This view has proved extraordinarily successful: one reason is cultural and material: we have, simply put, built a world on the premises of there being a body and a mind: we live a very 'disembodied' lifestyle, we eschew contact and keep our distance. The body, as phenomenologists have suggested, has "intrinsic tendencies towards self-concealment" which have been culturally furthered in the West by processes as diverse as literacy, individuation, and mass leisure.[68] Much of the body remains sunk in obscurity, largely insensate – the lungs, liver and brain, for example, are almost totally devoid of the capacity to feel. These tendencies of the flesh towards numbness have been accentuated by processes of individuation and withdrawal examined in the second part of this chapter. The active brain-inert matter distinction, it will be apparent, is evident in the governmentality literature as well. Suffice to say here that the body which liberal modes of rule targeted and invested, as an object to be known and a machine with laws, limits and regularities, is a modern body, one which exists apart from a mind, and that this distinction has been increasingly built into our world, practice and language ever since.[69]

Another site where modern distinctions were forged was the laboratory. In their classic analysis of the debate between Boyle and Hobbes, Shapin and Schaffer show how the former, through his advocation of experimental science at the Royal Society, rigorously separated the study of nature (which was scientific and apolitical) from that of society: "the study of nature occupied a quite different space from the study of men and their affairs: objects and subjects would not and could not be treated as part of the same philosophical enterprise."[70] In the laboratory, one produced and acknowledged facts and eschewed opinions. God, for example, might be, and for Boyle, probably was, responsible for natural order, but scientists would leave such questions to theologians. Here is one occasion where God begins to be first bracketed (as later in Kant) and then

[68] Leder, *The Absent Body*, 3.
[69] An excellent study of this is provided by Timothy Mitchell, *Colonising Egypt* (Cambridge: Cambridge University Press, 1988).
[70] Simon Shapin and Stephen Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life* (Princeton: Princeton University Press, 1985), 337.

crossed out altogether as an animating, transcendental force.[71] Nature, meanwhile, is dead and objective, although continually threatening to socially erupt as madness, untamed sexuality and wildness, all of which retained their female coding despite the devivifying of the world.[72] The desire to liberate what is human and mental from what is natural and bodily is integral to liberal strategies of government.

This depiction of modernity is, admittedly, schematic; what I hope to have provided is a sketch of certain intellectual and practical trends in Europe which have suggestive connections to the sorts of governmental techniques discussed in later chapters. The human and the natural are severed: we make society, but not nature, and, in science, we have the key to its truth. In fact, as Latour argues, this modern order actually mixes such putatively pure realms into hybrids so remarkable, that the society-nature split is ultimately revealed as an ephemeral invention: where could we locate robots, clones and ozone holes? But if the true order of the world has eluded us, what, then, is left to distinguish modernity? Firstly, the ordering impulse itself, which, as a discourse and practice, has radically altered Western thought and politics. Secondly, the length, complexity and hybridity of the networks we use to govern have demonstrably escalated; in a cosmological universe, where everything has its place and is intimately connected to everything else, change is unsettling. For the moderns, what is natural can be mobilised at will, for connections forged have no cosmological significance whatsoever.

The length of networks and liberal rule are also intimately connected: because the latter is committed to preserving the autonomy of domains, while still shaping them, translation mechanisms are imperative.[73] The body's strength must be fostered while its freedom is respected; translating 'national' interest into subjective interest is vital. Gas and electricity meters, for example, translate worries about wasted energy into concerns about the household budget. Translation is a way to enrol others in the development of a network while respecting their freedom. It enables action at greater and greater

[71] Latour, *We Have Never Been Modern*, 32-5. See also Marcel Gauchet, *The Disenchantment of the World: A Political History of Religion* (Princeton: Princeton University Press, 1997).
[72] Merchant, *The Death of Nature*, chapter 5.
[73] Rose, *Powers of Freedom*, 48-9. See also Latour, *Science in Action*, 107-32.

distances, and, because of its reliance on so many others, is an "imperfect mechanism," always threatening to unravel.[74]

The length and technical density of governmental networks grew exponentially across the nineteenth century. Systems of water and gas allowed increasing numbers of people to be free be clean, healthy and warm without any order or compulsion to do so. A clean, healthy and warm body (as opposed to a scabrous, encrusted, painful or shivering one) can then phenomenally *recede*, embedding mentalisation in fleshly experience itself. The body's normality, we might say, is inversely proportional to the extent to which it exerts demands on the self and requires attention. Infrastructures securing this normality thus promote the dominance of the mental. They order our experience, practically reinforcing the distinction that there is an *I* up here, in here, enskulled, which can autonomously groom, nurture and command the organic *it* from which it can never escape. This is neither a 'social construct' nor brute reality: it is a product of the body's own tendencies meshing with discourses articulating the distinction and architectures and spaces designed to be lived in by a being in which the mind organises the body.[75] Neither modernity nor liberalism could function without phenomenological validation of their premises.

Two caveats are necessary here. First, Latour greatly underemphasizes the self-critical nature of much modern thought. Many strains of opposition to the purity of modernity can be located: romanticism and hermeneutics, for example.[76] Secondly, scientific thought and practice, itself highly reflexive, would challenge and dismantle several aspects of modernity as I have defined it. The self-grounding cogito of Descartes, for example, would be replaced by a more physiologically-mediated notion of experience, central to my analysis of vision in chapters four and five. The moderns, thus, adopted a more critical stance towards their own 'critical stance' than Latour gives them credit for, which accounts for the enormous historical changes within modernity.[77] However, few scientists went as far as Richet and argued that intellection was fundamentally chemical. The mind was not dethroned by thermodynamics any more than it would be by

[74] Rose, *Powers of Freedom*, 50.
[75] Leder refers to this body-culture-space ensemble as a 'phenomenological vector', *The Absent Body*, 150-3. See also Henri Lefebvre, *The Production of Space* (Oxford: Blackwell, 1991).
[76] See, for example, Charles Taylor, *Sources of the Self*, Stephen Toulmin, *Cosmopolis*.
[77] The 'critical stance' is Latour's term for the modern drive to separate all hybrids into pure forms.

phenomenology. This was important, because the mind-body distinction in particular was integral to the practice of liberal government: the body could be made the target of infrastructures designed to equip its user with a mind fit for reason.

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Subjectivity and the Senses: How Vision Became Integral to Liberalism

The liberal subject was thoroughly modern, consisting of a body and a mind. If a normal body could be secured by standardised environment, the mind could be freed from its visceral shackles. There was a normalisation of the mind at work here too; a normal subject governed the baser passions and functions through the judicious deployment of reason. Practising freedom, displaying one's control of the self, itself relied upon a certain reconfiguration of the senses, the conduits linking the body and mind. This section will endeavour to explain what this means, and why it was so integral to the question of government.

The Liberal Subject and Vision

Subjectivity is historically mutable and multiple; by utilising a term like 'the liberal subject', I refer to a kind of subjectivity built around the concept of freedom. There were many subjects who remained unfree, and within the same individual, conflicting subjectivities collided; I am not suggesting there was monolithic kind of personhood shared by everyone in Victorian Britain. But a particular set of habits, traits and practices, emergent in both political theory and practical government, became associated with freedom, and this became, to a certain extent, normative across the period.

Perhaps most important here was a specific form of self-government promoted relentlessly throughout the nineteenth century. Samuel Smiles was one of many zealots of self-help, for whom the self was an object upon which one should work, a relationship existing fundamentally apart from institutions or central government: "where men are subjected to over-guidance and over-government, the inevitable tendency is to render them comparatively helpless."[78] Self-scrutiny itself has a long history, traced by Foucault and Weber among others.[79] Habitual self-discipline entailed nurturing restraint, of the passions, appetites and desires. A lower self, irreducibly bodily, was to be governed by the cerebral higher self. Self-mastery and independence thus presupposed one another, and their combination produced the ability to govern others, particularly one's family. There was thus always an "irreducible despotism in the heart of the paradigmatic liberal subject's relation to himself."[80] One's own discipline gave one the freedom to discipline those incapable of forming a similar relation with the self: women, children, criminals, the old, the ill, lunatics, drunkards, barbarians.

This liberal subject can be characterised as *cultural* and *cerebral*: its non-liberal other remained a prisoner of the body and its blind, natural drives. Mill argued that "the English are farther from a state of nature than any other people, a product of civilisation and discipline."[81] This was used to justify illiberal modes of rule, over the colonies, of which Mill approved, and, domestically, over women and the poor, about which he was more ambivalent.[82] Critically, this was underpinned by the unquestioned assumption that the mind had to dominate and control the potentially wayward body in order to produce the self-discipline necessary to be entrusted with freedom. Freedom, in short, was predicated on reason, which itself was predicated on the modern cult of the mind, which had carved out an inner space which one was encouraged to cultivate through mechanics' institutes, public libraries, and self-help guides. Nonconformity and temperance played their role here; a brain addled by gin was reduced to an organ like all others, a slave to base desire. The mind was the motor of the middle classes; in work, and play, it drove their activities.[83]

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[78] Samuel Smiles, *Self-Help: With Illustrations of Conduct and Perseverance*, 1. See also Patrick Joyce, *Democratic Subjects: The Self and the Social in Nineteenth-Century England* (Cambridge, Cambridge University Press, 1994).

[79] Foucault, *The History of Sexuality Volume One*, Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (London: Allen and Unwin, 1976).

[80] Valverde, "Despotism and Ethical Liberal Governance," 359.

[81] J.S.Mill, *The Subjection of Women* (Arlington Heights, Ill.: AHM Publishing Corporation, 1980), 66.

[82] See Mill, *Considerations on Representative Government* (London: Longmans, Green, Reader and Dyer, 1882) For the question of race and liberalism, see Richard Dyer, *White*. For the gendered nature of liberalism, see Carole Pateman, *The Sexual Contract* (Cambridge: Polity, 1988).

[83] Simon Gunn quotes a Victorian surgeon who argued: "we are of the middle class, and in the individual labours of our day our minds play a more leading part than either our mouths or our

Other aspects of this subjectivity could also be discussed: energy, thrift, diligence, perseverance, and disinterest. All were rational practices conducted by a self-disciplined individual, the public exercise of which amounted to *civility*, something which became axiomatic to liberal forms of rule. Civility has been defined as "the capacity of the self to exercise restraints upon its passions and affections in order to enter into moral intercourse with others."[84] If one was willing to conduct oneself civilly, then one was free, for example, to enter museums or libraries, or attend concerts or lectures. Consequently, gesture, deportment and behaviour became critical targets of government: one was invited to present oneself in way consistent with norms of civility, elaborated in prolix byelaws:

> Every person who in this Cemetery shall smoke, conduct himself in a noisy, disorderly, or unseemly manner, or shall be intoxicated, or gamble, or play any game, or use improper or indecent language, or trespass upon or refuse to quit any portion of the ground when called upon to do so, or shall take any dog into the Cemetery, or damage or destroy any tree, shrub, plant, monument, memorial, grave, or any other property within the Cemetery, or shall interrupt any religious service, or obstruct any officer or servant of the Corporation in the execution of his duty, shall for each and every offence be liable to a penalty not exceeding the penalty hereinafter mentioned.[85]

In short, one must fulfil minimum criteria of conduct to move through city's public spaces, criteria which included silence, propriety, sobriety and cleanliness. A tramp cannot be a liberal subject. A madman cannot vote. Suffrage, wrote Mill, was "accessible to all who are in the normal condition of a human being."[86] For an elaboration of what this norm was, one did not need books. It was displayed on the streets of the city every day, for society to *see*.

Modes of government, argues Rose, "make new kinds of experience possible, produce new modes of perception."[87] Liberal governmentality was a profoundly visual technique of rule: if the subject's freedom was the foundation of government, then civil conduct displayed both the subject's right to freedom and the validity of freedom as a form of political power.[88] Moreover, this social speculum did not take the form of monocular scrutiny of a total field, but the mutual examination of society by itself. Everyone was

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muscles." *The Public Culture of the Victorian Middle Class: Ritual and Authority in the English Industrial City*, (Manchester: Manchester University Press, 2000) 77-8.

[84] Rose, *Powers of Freedom*, 44.

[85] Manchester City Council, *Proceedings*, 1874-5, 349-50

[86] Mill, *Considerations on Representative Government*, 70.

[87] Rose, *Powers of Freedom*, 32.

[88] This point is made at greater length by Pasquale Pasquino, "Michel Foucault: The Will to Knowledge," Gane and Johnson, eds., *Foucault's New Domains*.

encouraged to act as a policeman, in a "self-monitoring of looks in which the subject and object positions were exchanged," the technical and morphological aspects of which form central themes of this thesis.[89] The city was a stage, with society as both actor and audience: there was no God judging the actions of his puppets.

The same was true of the subject's visual relation with himself.[90] There were no angels casting censorious glances from some celestial perch upon one's misbehaviour, merely a society, a family, and a self before which to be ashamed.[91] Shame is a highly visual emotion: one was encouraged to inspect one's conduct and expunge anything which could inspire shame. In addition to being a policeman, one must also be a judge:

> I divide myself, as it were, into two persons; and that I, the examiner and judge, represent a different character from that other I, the person whose conduct is examined into and judged of. The first is the spectator...The second is the agent, the person whom I properly call myself, and of whose conduct, under the character of a spectator, I was endeavouring to form some opinion.[92]

Adam Smith admirably depicts the spectatorial subject: vision is the sense through which one is invited to conceptualise the relation one has with the self. The logic is eminently Cartesian: consciousness and perception are static, and completely divorced from motion. Descartes regarded vision as the conduit connecting mind and world: "all the management of our lives depends on the senses...and that of sight is the most comprehensive and noble of these."[93] Descartes had absorbed a long tradition of ocularcentric writing, but the basic evidence of his body reinforced this. The eyes provide us with a vast range of information deceptively instantaneously and covering a remarkable distance: "vision secures that standing back from the aggressiveness of the world which frees for observation and opens a horizon for elective attention."[94] Vision facilitates distance-perception, and a static point from which one can survey worldly flux, which in turn cements the phenomenological self-evidence of the object-subject opposition. Moreover, we exercise a degree of volition vis-à-vis vision in a way we do not for hearing or smell: I can choose to close my eyes if something disgusts me. The sense that we control our distant relation to a world separate from ourselves through the

89 Tony Bennett, "The Exhibitionary Complex," *New Formations* 4, 1988, 82.
90 I use the male form throughout because of the gendered nature of the liberal subject.
91 Erasmus, for example, talks of how "angels are always present, and nothing is more welcome to them in a boy than modesty, the companion and guardian of decency." *On Civility in Boys*, 1530, cited in Elias, *The Civilising Process* (Oxford: Blackwell, 1991) 110.
92 Adam Smith, *Theory of Moral Sentiments*; cited in Rose, *Powers of Freedom*, 41
93 Descartes, *Discourse on Method*, 65. Cited in Jay, *Downcast Eyes*, 71.
94 Hans Jonas, "The Nobility of Sight," in *The Phenomenon of Life: Toward a Philosophical Biology* (London: University of Chicago Press, 1966), 148.

exercise of the eyes has come to seem commonsensical because of the conjoined mobilisation of senses, culture and space. This has produced a form of modern 'visuality'.

Before progressing with this argument, I will briefly clarify exactly what I mean by 'visuality', for it often used in a somewhat slapdash way. It refers to the embodied act of seeing itself: all activities, voluntary, conscious or otherwise, of the eyes, optical cortex and brain, which produce sight. However, since no vision takes place in a vacuum, this definition must be expanded. We rarely simply see, but usually synthesise our perceptions from a variety of other sources, especially hearing, taste, smell and touch. Vision is part of a *sensorium*, meaning "the entire sensory apparatus taken as an operational complex."[95] The relationship between the senses, or their relative uses and importance, varies historically along with politics, culture and spaces: the senses can be reconfigured, in other words. All discourses relating to the senses in total thus form part of visuality. This includes codes of conduct: an injunction to be quiet impacts on the hierarchy of the senses. The senses were educated through practices such as music, art, and gastronomy.[96] The arts of love entailed a nuanced choreography of glances and gazes. Doctors informed their patients about the care of the senses; one should, perhaps, avoid harsh sunshine and smoking to help one's eyesight. Certain things were not to be seen; blinds were customarily drawn when funeral processions passed. An extraordinarily diverse array of texts, habits, practices and lore formed a knotted, complicated discourse of perception. Finally, all physical and spatial factors are vital. Light, heat, air and humidity all alter visual conditions, while buildings, with their walls and openings, inevitably create specific visual arrangements, which, with the complex discourses relating to the senses, are palpably historical, as John Rajchmann has argued:

> Who sees what or whom and where are integral features of the visual thinking of a period and not an independent fact about its contexts. And this visual thought is rooted in a specific sort of 'material existence.'[97]

The modern, Western idea of there being five senses, with vision usually the most important, has become so naturalised that it is worth emphasising that not all cultures so

[95] Walter Ong, "The Shifting Sensorium," in David Howes, ed., *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses* (London: University of Toronto Press, 1991), 28.
[96] W. Cave Thomas, *Symmetrical Education*: reviewed in *The Builder*, XXXV, October 13, 1877, 1041.
[97] John Rajchmann, "Foucault's Art of Seeing," *October* 44, 1988, 92.

conceive the body's relation to the world. Some tribes recognise only two senses; some scientists in the West have recognised as many as seventeen.[98] Other cultures and times have perceived perception in radically different ways: the Moi, for example, equate the ear with reason, while our location of the seat of experience in the head would seem odd to the Greeks, who placed it in the chest, or the Aquarana of the Amazon, who position it in the heart.[99] The moderns regarded perception as something we do, from a mind in a head inside a body, to reach out to a world. This *exteroperception* is itself only one axis along which we feel: visceral sensations (interoperception) and balancing ones (proprioception) have usually been ignored.[100] Modernity, in short, necessitated a reconfigured sensorium, for which the reordered collective would appear natural and timeless.

Modernity and Perception

Given the relative malleability of the human sensorium, we are eminently justified in asking why it is that a particular set of perceptual practices and discourses have developed in the West over the last two or three centuries. Here, I will provide a summary of the vast literature on modernity and perception, before addressing three historical processes through which the visual capacities of the subject have been developed: the civilising process, public observation, and disciplinary individualism.

"Modernity," writes Jonathan Crary, "is inseparable from on the one hand a remaking of the observer, and on the other a proliferation of circulating signs and objects whose effects coincide with their visuality."[101] The literature on modernity and perception has very often addressed the dominance of vision as the master sense through which bodies, languages and objects have been practically connected.[102] This can, however, lead to rather reductive conclusions, for example: "interaction in the big city is characterised by

[98] Howes, ed., *The Varieties of Sensory Experience*, Robert Rivlin and Karen Gravelle, "The Seventeen Senses," in *Deciphering the Senses: The Expanding World of Human Perception*. (New York: Simon and Schuster, 1984). See also Lyall Watson, *Jacobsen's Organ and the Remarkable Nature of Smell* (London: Penguin, 1999).

[99] Howes, ed., *The Varieties of Sensory Experience*.

[100] The terms were developed by Charles Sherrington, in *The Integrative Action of the Nervous System*, (London: Archibald Constable and Co., 1906), lecture IX, "The Physiological Position and Dominance of the Brain."

[101] Crary, *Techniques of the Observer*, 11.

[102] See, for example, Levin, ed., *Modernity and the Hegemony of Vision*.

consistent visualisation and the retreat of verbal and tactile components; it does not admit of contacts other than visual ones devoid of touch."[103] The dominance of the eye, of distance, interiority and stasis, formed part of the formation of a section of society who considered themselves, and were considered, respectable, which provides clues to the relationship between the senses, government and the way society was imagined.

The tilting of the sensorium toward the visual pole is often held to begin with Renaissance developments of printing and perspective.[104] Advances in empirical and positivist science, and geometry, coupled with technological inventions such as the telescope and microscope, created an irresistible trend towards quantification. Maps, books, clocks and meters permeated English society, forging powerful connections between visual practices and truth.[105] Measurement and its recording was the backbone of scientific, economic and governmental practices; from double-entry book-keeping to social investigation, food analysis to urban planning, the chart, map and table assumed decisive salience.[106] In the city, spaces of leisure and instruction, museums, zoos, art galleries and the like, invited people to visually imbibe an order held up to be seen, while squares, streets and parks were constructed, often with questionable success, to create conditions giving subjects appealing vantage-points from which to survey the world. Through and between cities, transport was circulating with increasing rapidity, divorcing the observer from the landscape, producing what has been termed "panoramic perception," a visual mode associated with the assimilation of a distant, rolling screen.[107] People were invited to be tourists, entailing "a much greater sensitivity to visual elements of townscape than is normally found in everyday life."[108] Within urban spaces, leisure practices were increasingly organised around a phalanx of visual technologies,

[103] Asendorf, *Batteries of Life*, 94.
[104] Walter Ong, *The Presence of the Word: Some Prologomena for Cultural and Religious History* (New Haven, Conn.: Yale University Press, 1967), on perspective, see Jay, *Downcast Eyes*, 51-60, John Berger, *Ways of Seeing* (Harmondsworth: Penguin, 1972), Norman Bryson, *Vision and Painting: the Logic of the Gaze* (London: MacMillan, 1983).
[105] Examples can be found in Steven Shapin, *A Social History of Truth* (London: University of California Press, 1994), D. Lowe, *History of Bourgeois Perception* (Brighton: Harvester, 1982), John May and Nigel Thrift (eds.), *Timespace: Geographies of Temporality* (London: Routledge, 2001); A. Debus, *Man and Nature in the Renaissance* (Cambridge: Cambridge University Press, 1988).
[106] See, for example, Mary Poovey, *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society* (London: University of Chicago Press, 1988).
[107] Wolfgang Schivelbusch, *The Railway Journey: The Industrialisation and Perception of Time and Space* (Leamington Spa: Berg, 1986), 193.
[108] John Urry, *Consuming Places*, 132-3: cited in Lynda Nead, *Victorian Babylon: People, Streets and Images in Nineteenth-Century London* (London: Yale University Press, 2000), 60.

phenakistiscopes, Faraday wheels, zooetropes and stereoscopes, which paralleled the practical relationship between vision and consumption emerging elsewhere in department stores and exhibitions.[109]

The eye was not merely, as Ruskin and Gladstone opined, the portal to the soul, and hence truth: it was the interface through which a subject became a consumer, traveller, worker and moral agent. Consequently, maximising its fragile capacities was imperative. Spectacles, wrote Dionysius Lardner, "are incontestably the most universally useful gift which optical science has conferred on mankind."[110] Functional contact lenses were developed in 1887; night-blindness, strabismus, myopia, and colour-blindness were investigated and tested; a rabbit's eye was unsuccessfully transplanted into a human eye socket in 1887.[111] Although we should beware succumbing to full-blown ocularphilia, the eye's centrality to nineteenth-century civilisation is indisputable.

This equation between vision and civilisation was noted by Freud, who famously argued that when humans began to walk erect, sight became, physically, spiritually and metaphorically, 'higher' than smell, the function of which "was taken over by visual excitations, which, in contrast to the intermittent olfactory stimuli, were able to maintain a permanent effect."[112] More sociologically, Elias connected civilisation with the development of observation and distance in his study of the civilising process. By analysing conduct manuals from medieval times to the nineteenth century, he shows how the senses were gradually reshaped around social practices which came to be equated with civility. Noise, and touch, for example, became increasingly prohibited in polite social circles as people were encouraged to observe a distant world from a private interior: "in order to be really 'courteous' by the standards of *civilité*, one was to some extent obliged to observe, to look about oneself and pay attention to people and their motives."[113] This withdrawal into the self in polite circles slowly engendered an "invisible wall of affects between one body and another, repelling and separating,"

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[109] Crary, *Techniques of the Observer*, Mitchell, *Colonising Egypt*, Crossick and Jaumain, eds., *Cathedrals of Consumption: The European Department Store, 1850-1939*.
[110] Lardner, *The Museum of Science and Art*, 1855; cited in Asa Briggs, *Victorian Things* (London: Batsford, 1988), 103.
[111] The attempt was described in *Archives of Ophthalmology*, XVI, 1887, 47, 182.
[112] Sigmund Freud, "Civilisation and its Discontents," *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, XXI (London: Hogarth, 1961) 99.
[113] Elias, *The Civilising Process*, 67.

bringing with it repugnance at vulgarity and potential shame about one's own conduct.[114] The body, maligned by Descartes, became the locus of shame and disgust: civility, therefore, was inseparable from dominance of the mind, and the eye became the organ through which the polite could examine one another for signs of decorum or indiscretion. The body was ephemeral and subject to change and decay: it could never provide one with an enduring, permanent sense of self like the mind.

"The history of sensibilities," noted Alain Corbin, "is based on the study of variations in thresholds of tolerance."[115] These changing civil norms, neither irreversible nor socially homogeneous, are central to any study of the senses: conduct manuals, laws and treatises enable the historian to approach shifts at the level of discourse, which, while not allowing us to directly access a practical world, tell us much about the constraints placed around practice in the name of civil conduct. Intolerance of certain sights rose, while intolerance of many sounds and nearly all smells leapt accordingly.[116] One had to present oneself in such a way as not to generate intolerance in others. Certain sets of gestures and movements, and a detailed, practical lexicon of social comprehension, had to be learnt. The nobleman, and later the respectable citizen, "must learn to adjust his gestures exactly to the different ranks and standing of the people at court, to measure his language exactly, and even to control his eyes exactly."[117] By the nineteenth century, being in public, especially in the city, involved the use of a shifting, sometimes intangible, set of rules for displaying the self and decoding the acts of others.

This code was cast in explicitly visual terms. One displayed one's command of civil conduct while one's own eyes formed part of the social mirror in which others saw their selves reflected. Appearances, therefore, were vital: the sartorial and the physiognomic merged into a single surface of meaning, which could be decoded via a nuanced knowledge of social types. "Decoding," observed Richard Sennett;

> means you take a detail of behaviour as a symbol for an entire character state. Just as, say, the colour of a scarf or the number of buttons undone on a blouse may symbolise a woman's looseness, so small details of appearance or manner can symbolise a political stance.[118]

[114] *Ibid*, 60.
[115] Alain Corbin, *Village Bells: Sound and Meaning in the Nineteenth-Century French Countryside* (London: MacMillan, 1999), 298.
[116] Alain Corbin, *The Foul and the Fragrant: Odour and the French Social Imagination* (Leamington Spa: Berg, 1986).
[117] Elias, *The Civilising Process*, 182.
[118] Richard Sennett, *The Fall of Public Man* (New York: Norton, 1992), 238.

Novels, newspapers, caricatures, cartoons, and, increasingly, photographs provided the public with such taxonomies. Complex and ironic connections between detail and character were forged, as in this description in a Manchester bohemian paper from 1876:

> He (i.e. the reader) might perchance observe a lady who passed through the perils and pleasures of some thirty-five summers, and whose appearance gives outward and visible tokens that she belongs to the strong-minded, women's rights class...Two attenuated curls, which fall droopingly and willow-like about her neck and shoulders, form the sole concession to a modern feminine love of finery.[119]

The reader was helped by an analogy to Mrs Jellyby from *Bleak House*. One was to be trained to be a detective of character. "First," wrote Carlyle, "*Man is a Spirit*, and bound by invisible bonds to *All Men*; Secondly...*he wears Clothes*, which are the visual emblems of that fact...Society...is founded upon Cloth."[120] Darwin argued that facial muscles involuntarily revealed character and states of being, which were also displayed through unwilled processes such as blushing, the baring of teeth and the racing of the heart.[121] One moulded one's self in private, fully aware that in public, the interpretation of one's appearance, because socialised, was beyond one's conscious control.

Consequently, public existence only became bearable through a process of withdrawal behind a mask which was semiotically co-extensive with the self. Passivity indicated self-government: "public behaviour was a matter of observation, of passive participation, of a certain kind of voyeurism."[122] Reserve and silence, said Simmel, were characteristic of metropolitan subjectivity.[123] Moreover, the exhibition of quiet, sober conduct was a vital strategy through which the social order was shown, particularly through promenades and parades: "the voluntarism of the parade and its public visibility served in this conduct as an ideal of the self-regulating urban community that policed itself through its own inherent rules of conduct."[124] The practice of silence furthered the salience of vision: just as darkness was held to augment hearing, so quiet enabled conditions favourable to ocular inspection to be fostered. "The institutionalisation of silence," it has been stated, "assure(s) the durability of power."[125]

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[119] "Manchester Ladies," *City Lantern*, III, December 29, 1876, 106.
[120] Thomas Carlyle, *Sartor Resartus* (Oxford: Oxford University Press, 1987), 48.
[121] Charles Darwin, *The Expression of Emotion in Man and Animals* (London: University of Chicago Press, 1965).
[122] Sennett, *The Fall of Public Man*, 27.
[123] Georg Simmel, "The Metropolis and Mental Life," in Richard Sennett, ed., *Classic Essays on the Culture of Cities* (Englewood Cliffs: Prentice-Hall, 1969).
[124] Gunn, *The Public Culture of the Victorian Middle Class*, 188.
[125] Jacques Attali, *Noise: The Political Economy of Music* (Manchester: Manchester University Press, 1985), 8.

Self-government, through which liberal rule functioned, thus required a society rendered visible to itself as a group of ordered, orderly individuals. This visual morphology was the framework literally giving shape to the public sphere, within which one displayed one's right to freedom through practising civility. This self-regulatory principle, as suggested earlier, co-existed with more coercive visual technologies designed to forcibly instil discipline: prisons, penitentiaries, workhouses. If one failed to display self-discipline: if one was drunk and disorderly, or loud and offensive, or created a nuisance, in short, if one was guilty of *misconduct*, one would be denied one's freedom to inhabit the public realm. Prison and the public sphere are both spaces equally traversed by lines of sight; prison, however, renders the relation between subject and society asymmetrical by fixing the former permanently in a field of vision. Developments in architectures of surveillance, including the panopticon, were, unsurprisingly, pioneered in colonial environments, where the erratic habits of native populations denied them the right to a public sphere.

The panopticon, the cylinder of cellular spaces permanently visible from a central minaret, was designed to force the criminal to search his soul in a flood of light. It institutionalised "an inspecting gaze, a gaze which each individual under its weight will end by interiorising to the point where he is his own overseer."[126] The restless and undisciplined body of the delinquent is immobilised: the self turns inwards. The body can be transcended by compelling the mind to search itself in isolation and silence. Where education, imitation and training have failed, the panopticon forces restraint and civility. In fact, as Foucault argues, the number of non-judicial institutions resembling the panopticon indicates the degree to which the prison-nonprison opposition is part of the ideology of the prison itself. Libraries, schools, factories and hospitals often utilised aspects of this spatial configuration: "whenever one is dealing with a multiplicity of individuals on whom a task or a particular form of behaviour may be imposed, the panoptic schema may be imposed."[127] But other schemas could be used to cultivate forms of conduct: the panopticon is by no means the only architectural template of liberal governmentality. Indeed, the frozen body impaled on a ray of light is hardly

[126] Michel Foucault, "The Eye of Power," in Colin Gordon, ed., *Power/Knowledge: Selected Interviews and Other Writings 1972/77* (Brighton: Harvester Press, 1980), 155.
[127] Michel Foucault, *Discipline and Punish: The Birth of the Prison* (Harmondsworth: Penguin, 1991), 205

consistent with liberalism, which demanded less cumbersome and more flexible modalities of surveillance, something which I will develop further in chapter two.

It was indeed a long way from the bleak and monotonous spaces of discipline to the polite world of the square or shopping arcade. Both were spaces where the senses were to be used, freely or otherwise, in specific fashions: the agency of walls, glass and light were used to frame the possibilities of visual conduct. Both were also constructed, it could be argued, with some form of government in mind, for the respectable and the criminal. But the bulk of people in nineteenth-century cities were neither respectable nor criminal, neither fashionable nor delinquent, and it is to these that I now turn.

Practising Perception: Space and the Senses

To write a history of the senses is to write a history of practices and spaces. It also involves writing a history of how social groups perceived themselves and others, which, in the case of the nineteenth century, has an intimate relation to questions of freedom: because self-government required sensibility, refinement and reserve, those palpably lacking these qualities displayed an inability to escape the body. The exercise of reason and perspicacity were precluded by animality and baseness.

Civil society emerged, from the late seventeenth century, in a landscape designed to make possible mutual observation, individuation, and silence. A certain kind of public space, deodorised, well-lit and paved, cleansed and open, was constructed, sporadically, across the eighteenth century, a process gathering pace in the nineteenth.[128] The visual practices I have associated with liberalism only made sense a setting of squares and parks, museums and clubs. By the 1850s, the club, for example, had become a key space where men of social standing went to sit silently, reading and smoking, sunk in upholstery.[129] In theatres and concert-halls, drapery and padding absorbed unnecessary reverberation; whispering and the hiss of gaslights could begin to sound irritating. The balcony and the plate-glass window became favourite spots for observation, removed from dust and clatter. Such perceptual practices were not limited to the world of

[128] Miles Ogborne describes several such locations in *Spaces of Modernity: London's Geographies 1680-1780* (London: Guildford Press, 1998).
[129] See Gunn, *The Public Culture of the Victorian Middle Class.*

pleasure: the stock-exchange, for example, was also a space in which noisy behaviour would upset this subtle sensory arrangement:

> A collection of gentlemen, with thoughtful, intelligent faces, who converse with each other in laconic whispers, supply the defects of words by nods and signs, move noiselessly from one part of the room to another, guided as if by some hidden instinct to the precise person in the crowd with whom they have business to transact.[130]

This array of individuals produced a gestural and physiognomic semiotics hinging upon silence. Civic wealth required a tranquil cocoon in which to gestate.

This nexus of wealth, leisure and civility amounts to a culture of sense: a collective and practical mode of interacting with the people and objects "of our intimately, or extimately, technologised world...and what they (do) to and with hand, eye and skin."[131] This 'cultural phenomenology' was performed in a public sphere designed with a set of perceptual practices in mind. The display of self-control, particularly apparent in civic parades and promenades, was important here: bodily discipline was a demonstration of the legitimacy of middle-class authority. In short, social distinctions became manifest and permanent through such public observations: to practice silence and train the eye was to "validat(e)...one set of social practices over against others."[132] This validation led observers from their familiar haunts, stock-exchanges and clubs, to the city's courts and slums where a very different culture of sense had developed.

The trope of the unknown city, the *terra incognita*, is ubiquitous in Victorian novels, newspapers and social investigation: this volubility betrays a desire to know the city and map its every nuance, a totalising project driving writers as diverse as Sala and Chadwick, Dickens and Charles Booth, as well as artists and photographers. This garrulous discourse mobilised a semiotic system that will be familiar to most readers, one which has been ably documented by historians.[133] All I wish to mention here is the sensory dimension of this discourse. Almost without exception, those who investigated the slums expressed their disorientation about the absence of visual logic in the spaces they found, and their repulsion at the affronts felt to the other senses, particularly of smell and touch. Andrew Mearns described his entry into the slum zone thus:

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[130] B.Love, *The Handbook of Manchester* (Manchester: Love and Barton,1842), 233.
[131] Stephen Connor, "Cultural Phenomenology," *Critical Quarterly*, 42:1, 200, 4-5.
[132] Peter Stallybrass and Allon White, *The Politics and Poetics of Transgression* (Ithaca, N.Y.: Cornell University Press, 1986), 197.
[133] For example, Walkowitz, *City of Dreadful Delight.*

> You have to *grope* your way along *dark* and filthy passages swarming with vermin. Then, if you are not driven back by the intolerable *stench*, you may gain admittance to the dens in which these thousands of beings who belong, as much as you, to the race for whom Christ died, *herd* together. (Emphasis added)[134]

Many similar examples could be given, all doubtless tinged with the same titillating Gothic fascination. What is vital is the culture of sense that viscerally impacts on the respectable observer. In fact, 'observer' seems inappropriate here as Mearns depicts himself reduced to reliance on his hands, heroically overcoming the noxious effluvium. The discourse produced records a shift in the threshold of tolerance, which is articulated in the spaces of the city where it confronts its negation: "in the slum, the bourgeois spectator surveyed and classified *his own antithesis*."[135] The advancing threshold of tolerance through which such a relationship was articulated was consciously evoked by anyone discussing or describing the slums: as the Mayor of Manchester argued in 1883: "wickedness, ugliness, dirtiness offend us more than they used to do."[136] To make the poor visible inevitably involved the reciprocal evocation of one's civility, itself usually expressed through in terms of a clash of cultures of sense.

This clash was usually couched in terms of differences in tolerance and delicacy. Slum dwellers found the disgusting bearable; they were *desensitised*. The environment - dark, hot, stagnant, malodorous and dirty - inured them to things which decent citizens had learnt to not simply regard as intolerable but actually feel impinging upon themselves as pathologically vile. This was most pungently evoked through the sense of smell. Slum zones, often contiguous to wharves and factories, and frequently peppered with dungheaps, stank. Glue-factories, knackers'-yards, tallow melters, haddock-smokers, gasworks and jam factories disgorged a promiscuous cocktail of smells, against which the sensoria of the refined revolted. Following the construction of a gasworks in Bow, one writer argued that "there is now, I believe, no place in Her Majesty's dominions more avoided by persons of sensitive organs than Bow Common."[137] Sensibility could not be cultivated in such an ambience, as one chemist stated: "all delicacy of perception is lost to those who are constantly subjected to the influence of noxious smells and

[134] W. Preston, *The Bitter Cry of Outcast London* (Leicester: Leicester University Press, 1970), 58.
[135] Stallybrass and White, *The Politics and Poetics of Transgression*, 128.
[136] Cited in Redford, *The History of Local Government in Manchester*, II (London: Longmans Green, 1939), 207.
[137] T.B.Simpson, *Gas-Works: The Evils Inseparable from their Existence in Populous Places, and the Necessity of Removing them from the Metropolis* (London: William Freedman,1866), 13.

flavours."[138] "The sense of smell," complained Chadwick, "appears often to be obliterated in the labourer by his employment."[139] Absence of adequate sanitation habituated the very poor to dirt; taken together, slum air was "insufferably offensive to strangers."[140]

Social distinctions were experienced through other sensory media. In *Morbid Effects of the Deficiency of Food*, Howard declared that the poor:

> Lose all relish for plain nutritious food, and their appetites can be stimulated only be something savoury and piquant...By this mode of life, too, the digestive organs become impaired: and the function of digestion is so feebly and imperfectly performed, that even much less nutritive matter is extracted.[141]

Spices, salt and vinegar masked the putrefying fish and meat sold by street vendors, while lack of domestic refrigeration led to meat becoming "rapidly tainted," while leather became "covered with a green mould, even in one night."[142] Thus arose the "passion for stupefying herbs and roots" observed by Mayhew.[143] Alcohol served as a multipurpose desensitiser for the poor; "drink dulls the senses and reduces them to the level of the brutes they must be to live in such sties."[144] Manual work coarsened and toughened the skin: proximity and intimacy damaged the capacity to feel in a nuanced way. Moreover, the silence discernable in the club was palpably absent in most urban streets; dogs, costermongers, street musicians, bells, and shouting created a cacophonous melange of sound which affronted those requiring concentration. Differences in levels of tolerance corresponded to social differences, a point made clear in *The Lancet* in 1877: street musicians, the publication argued, were:

> To a very large extent supported by persons not contributing to the rates, whose occupations are of an entirely manual character, and who are not, therefore, disturbed by sounds which defraud the thinker of a portion of his working time, and are simply destructive to the nervous invalid.[145]

One could not work on one's mind in such an atmosphere, ran the logic of this discourse; only the truly embodied, labourers, long accustomed to industrial noise and bawdy banter, could withstand it. Swearing simply compounded the problem: "look

[138] H.C.Bartlett, "The Chemistry of Dirt," *British Architect*, X, October 18, 1878, 152.
[139] Chadwick, *Report on the Sanitary Condition of the Labouring Population*, 297.
[140] Hector Gavin, *Sanitary Ramblings, Being Sketches and Illustrations of Bethnal Green: A Type of the Condition of the Metropolis and Other Large Towns* (London: Churchill, 1848), 69.
[141] Howard, *Morbid Effects of the Deficiency of Food*, cited in Love, *The Handbook of Manchester*, 118.
[142] Gavin, *Sanitary Ramblings*, 47.
[143] Henry Mayhew, *London Labour and the London Poor*, I, 2, cited in Stallybrass and White, *The Politics and Poetics of Transgression*, 128.
[144] Sims, *How the Poor Live*, 21.
[145] "The Tyranny of Street Music," *The Lancet*, May 19, 1877, I, 737.

particularly at the little children...Listen to them if you want your very soul harrowed with the vilest, filthiest language that disgrace(s) humanity."[146]

Desensitisation, in short, corresponded to a collapse of visual dominance. Darkness, narrowness and the dense packing of bodies precluded distance. The connection between this and the phenomenon of the crowd was made explicit by Le Bon. Within a crowd, he argued, an individual, however cultivated, becomes "a barbarian – that is, a creature acting by instinct...the faculty of observation and the critical spirit possessed by each of them individually is destroyed."[147] The result was a sensorium prey to illusion and misjudgement, as well as one devoid of discernment: "the vilest practices are looked upon with the most matter-of-fact indifference."[148]

The slum generated physical conditions largely precluding individuality, inwardness, distance, reserve: in short, the specific mode of visuality I have associated with liberal subjectivity. Crowding and physical proximity stunted delicacy and discernment, as the Medical Officer of Health for Glasgow observed in 1882:

> It is almost too horrible to express in naked, uncompromising language the jostling of birth and death, and the functions of life which must be the daily experience of such houses...We go confidently in search of delicacy and refinement, and high-toned morality, amid physical circumstances which are equally inimical to those finer growths and efflorescences of the moral nature of man.[149]

"Few girls," another writer argued, "can grow up to virtue in such dens; few boys can have such houses and not become thieves and vagabonds."[150] Proximity bred promiscuity; immorality begot animality. "In the wynds of Glasgow, as well as Manchester, children are to be seen reduced to a purely animal existence, and without even a name."[151] The poorest sections of society also formed associations with nature which were antithetical to the modern, distanced and controlled relationships established in laboratories and zoos. Donkeys and pigs shared cellar-dwellings; while fleas and rats infested slums. Charles Booth contrasted the orderly street, with its trees and flowerpots, with housing in which he found women "with matted hair...whose clothing is stiff with

[146] "Deansgate Redeemed," *The Free Lance*, IV, May 8, 1869, 145.
[147] Gustave Le Bon, *The Crowd* (New Brunswick, N.J.: Transaction Publishers, 1995), 52, 63.
[148] Preston, *The Bitter Cry of Outcast London*, 61.
[149] James B. Russell, "Homes of the City Poor," *The Sanitary Engineer*, V, January 5, 1882, 120.
[150] "Inner Life of the Poor," *The Plumber and Sanitary Engineer*, II, December 1878, 11.
[151] Faucher, *Manchester in 1844*, 79-80.

accumulations of...dirt, their underclothing, if they have any at all, swarming with vermin."[152]

The image of writhing animality underscored the animality of the human body, naked, caked in filth, bearer of disease. It lacks the clean, sculpted edges of the classical body, and instead merges and mingles with its surroundings. It is *grotesque*, "multiple, bulging...protuberant and incomplete...never closed off from either its social or ecosystemic context. The classical body on the other hand keeps its distance."[153] Two kinds of body: one too natural, swarming and plural; one cultural, individuated. Two sensoria: one typified by a mingling of smell, taste and touch; one where the senses of distance, and vision in particular, have transcended those of intimacy. Two urban morphologies: slum and square. This powerful set of oppositions structured the logic the social imaginary; this, in its turn, informed the strategy of liberal governmentality.

Society, it will be apparent, could easily be imagined as divided along lines of disgust and intolerance, distinctions which were felt, smelt and heard. Alain Corbin has spoken of the "visceral depths to which the nineteenth-century conflicts reached."[154] I take the term 'social imaginary' to mean, very simply, the how individuals imagined their relation to social groups within a totality, something which obviously involves how distinctions and hierarchies are thought.[155] Like Corbin and Joyce, I am obviously suggesting that something more than the relationship one had with capital was involved here, a more bodily and perceptual awareness: "it would be futile to analyse social tensions and conflicts without accounting for the very different kinds of sensibilities that decisively influence them."[156] The sensibility and conduct of the self-governing, individuated subject for whom stench, blood, noise and smoke was anathema conflicted with that of a more embodied, less discerning, desensitised kind of person, a person, moreover, without the refinement and discernment necessary to be civil. This was vital to the question of government. If environment and infrastructure could be reconfigured so as to make privacy, distance, visual dominance, self-consciousness, and individuality

[152] Charles Booth, *Life and Labour of the People of London. First Series: Poverty: Streets and Population Classified* (London: MacMillan & Co., 1902), 64.
[153] Stallybrass and White, *The Politics and Poetics of Transgression*, 9, 22.
[154] Corbin, *The Foul and the Fragrant*, 232.
[155] The most developed theory of the social imaginary is that of Cornelius Castoriadis, *The Imaginary Institution of Society* (Cambridge: Polity, 1986).
[156] Corbin, *The Foul and the Fragrant*, 5.

possible, then the population could be given the opportunity, without compulsion, to improve itself. In so doing, it would behave rationally and normally in choosing civility above uncouthness, and could then be free to enter museums, and take nightschool classes, and the cycle of improvement would gain momentum, fired by the autonomous activity of a morally-responsible individual provided with certain environmental minima. It would be easier to justify various kinds of illiberal compulsion towards the few who remained obdurately wedded to drink or violence. Another modern distinction would be drawn more clearly.

Infrastructure and Modifying Perception

Infrastructure, in the modern world, targets both a body and a mind, aiming to embed physiological and moral norms. The former involves securing the natural capacities of the body, while the latter frames the conditions under which a rational relation to the self and the social can be made possible. Both are risky techniques, since the pathological is inherent within them: deviance, as a social fact visible in prisons, asylums, and hospitals, testifies to that. But if environments were normal, then the ensuing distribution of the civil and uncivil would merely disclose the topology of natural difference, of morality and aptitude, manifesting the open hierarchy of liberal society. To illustrate these points, I will return to the example of sewerage and toilets.

The Health of Towns Report of 1840 chose to focus on the moral impact of urban conditions on the poor. Heavily influenced by Chadwick, sanitation played a critical role in its recommendations, which included a general sewage act and the creation of Boards of Health. Swelling populations of workers were usually equipped with communal privies and cesspools, while drinking-water was gathered from any number of sources, including rainwater butts, public pumps and rivers into which waste was invariably dumped. The lurid descriptions of such facilities need not be repeated here; what I wish to indicate is that this protracted rumination on excrement indicates the anxiety about both the health of the poor and their *indifference* to their environment. Sanitary improvement aimed at the durable improvement of both; it was thus a governmental technology designed to make possible self-governing citizens. By the 1870s, dilapidated middens and shattered pipes were widely identified as incompatible with the physical and moral conditions necessary for civil life. Inspecting Chesterfield in 1872, *The Builder* pointed out that the geographical advantages of the town's location (natural spring water, good ventilation and rainfall) were being perverted by a failure to both construct a satisfactory sanitary system and maintain it in a functional condition. "It is our duty…to speak in sharp tones of condemnation upon certain of the sanitary arrangements, slovenly propensities, and dirt habits exhibited in sundry parts," argued the publication, before talking of privies "filthy and abominable, and a disgrace in a country boasting of civilisation."[157]

In Manchester, the appointment of John Leigh as MOH in 1868, and the subsequent reorganisation of the city's public health arrangements, led to a renewed council effort to entrench and maintain improved sanitary conditions. In 1874, Leigh announced this fact, and described how the water and excrement were effectively separated by the new arrangement:

> More than 4,000 of the horrid cesspools which infected the air of Manchester and filled its courts and back streets with fever cases, have been emptied out, the underlying black and saturated soil removed, and the cavities filled up level with the courts, streets and passages. All communication between the new closets and drains has been closed, so nothing can find its way from the closets to the sewer system.[158]

The details of the sanitary system are less important than the drive to hermetically seal waste from water, something which will be encountered again, with blood, in chapter three. This material ordering process, so characteristic of modernity, aimed at adjusting thresholds of tolerance. One should drink only pure water, and find anything else disgusting. Similar problematisations of bread and milk can be seen at around the same period: taste, purity and indifference were politically linked by a drive to cultivate a sense of refinement in the poor, which itself involved sensory reconfiguration.

The stench of the poor disgusted the respectable: the poor had to learn to find themselves disgusting. Cleanliness, argued Reynolds, had become "our greatest class symbol."[159] The use of soap, whitewash and disinfectant, as has been well documented, increased dramatically between 1840 and 1900; by cleansing oneself and one's surroundings, one would become aware of the stench of others, and in doing so, would develop a sense of awareness of individuality and self-respect. Remedies for domestic smells proliferated:

[157] "Chesterfield and its Black Spots," *The Builder*, XXX, February 17, 1872, 188.
[158] Manchester City Council, *Proceedings*, April 1, 1874, 205.
[159] Reynolds, *A Poor Man's House*, cited in Anthony Wohl, *Endangered Lives: Public Health in Victorian Britain* (London: Dent, 1983), 76.

carbolic acid, mustard powder, coffee, and eucalyptus, for example, were utilised for deodorisers and ozonisers.[160] Coupled with ventilation, sunlight, soap and water, aromatic vapours could arouse and make durable intolerance of what was distasteful, uncivil or downright abhorrent. The poor's ability to transcend their tolerance of squalor, in other words their resensitisation, was thus wired to permanent improvement of environment, as Leigh argued:

> Cleanliness produces self-respect; with purer air and clean surroundings, the mind is less depressed, and seeks less the excitement of drink. I should expect that greater temperance would follow greater cleanliness – that higher mental cultivation would be sought.[161]

Self-respect and self-disgust, like liberty and discipline, presuppose each other. Changing self-perceptions could occur through many different means. When *The Builder* produced a report condemning sanitary arrangements in Hackney Wick in 1873, the local newspaper replied:

> The necessity of seeing ourselves 'as others see us' is being forced upon us in a remarkable manner. Our contemporary, the 'Builder', has sought out in our midst and held up to our gaze a grim array of terrible facts.[162]

The attempt to turn the city into a kind of social speculum will be explored at the beginning of the next chapter. Durable shifts in tolerance were remarked upon by outside observers as unequivocally civilising. When, in 1868-9, a series of privies and ashpits were rebuilt in an area off Rochdale Road in Manchester, the council noted:

> Perhaps the most interesting and important information obtained was from the occupants of the houses, some of whom stated, that whereas before the alterations were made they never opened the windows of the back bedrooms at all, in consequence of the stench that came into the rooms from the privies and ashpits below, they now opened them daily and got the rooms ventilated; and that, though from habit they had become almost unconscious of the somewhat less noisome atmosphere in the rooms below, yet that since the alterations at the backs of the houses had been made, they had become aware of a disagreeable foecal smell in the houses of neighbours and friends.[163]

It is through such quantum shifts in sensibility that a civil population of discerning individuals would be formed.

The foul and the fetid, we should not need reminding, was a wily foe, diaphanous and dispersed, resisting the pursuit of sanitarians. Nonetheless, the historian is justified in seeing this enormous project to limit smell and waste to private toilets, pipes and sewage

[160] W. Eassie, "Sanitary Architecture IX – Deodorisation of Drains," *The Sanitary Record*, II, February 13, 1875, 111: "A Domestic Deodoriser," *ibid*, VI, June 29, 1877, 410: "Rimmel's Aromatic Vaporiser," *ibid*, VIII, February 15, 1878, 112. See also "Disinfecting and Deodorising Compounds," in Alexander Blyth, *A Dictionary of Hygiene and Public Health* (London: Charles Griffin & Co, 1876), 191.
[161] Manchester City Council, *Proceedings*, 1875-6, 372.
[162] "Homes in Hackney Wick," *The Builder*, XXXI, December 20, 1873, 1033.
[163] Manchester City Council, *Proceedings*, 1868-9, 272.

works as integral to any understanding of the sensibilities and emotions at work in modern society. Doubtless the drive to rigorously separate waste and city can be seen in terms of a repressive hypothesis, as several writers have argued.[164] The private realm would become the space where one grooms oneself, and "does the things that would disgust others if they were to be witnessed."[165] The 1844 Metropolitan Building Act, for example, stated that "every privy (was) to have a door for privacy."[166] Public toilets, too, enabled one to urinate and defecate without fear of being seen. These processes were facilitated by the increasingly widespread use of locks, not to mention such "exceedingly ingenious" inventions as the 'engaged' bolt, patented by Harrison in 1885.[167] The private produced an architecture of individuation and reserve, a place where delicacy and disgust could be fostered.

So why is this *liberal*? Hopefully, the connection between infrastructure, the body and the political subject will be reasonably clear by now. Sewerage and water systems, if properly inspected and maintained, could begin to make durable environmental conditions within which subtle shifts in the relation one had to one's body and society could occur. One became conscious of the body as something to be cleaned, to be presented to society; one developed feelings of shame and introspective anxiety. Without changing the phenomenal form of the city, the discourses aiming at improvement could not hope to succeed, for they would, quite literally, fail to make sense. Discourse and space had to be aligned to make improvement something one could practically exercise upon the self. As the mundane example of a few houses in a northern street makes clear, sensibility could be aroused to one's environment by engineering, doubtless a sensibility encouraged by inspectors with their questions. Self-awareness, self-rule, individuation, intellection, vision and intolerance were all co-productions of networks, bodies, senses, and discourses. One gained in freedom by learning to see the world as a nuanced set of environments: freedom to move about the city was one's reward. By mastering a set of practical and perceptual techniques, one could enter libraries, museums and art galleries. But failure to do so limited one's

[164] William Miller, *Anatomy of Disgust* (London: Harvard University Press, 1997), Dominique Laporte, *History of Shit* (London: MIT Press, 2000).
[165] Miller, *Anatomy of Disgust*, 177.
[166] Cited in Harper, *Victorian Building Regulations: Summary Tables of the Principal Building Acts and Model By-laws 1840-1914* (London: Mansell, 1985), 20.
[167] *British Architect*, XXIV, September 4, 1885, 103.

movement. The frowns of the civil were as forbidding as truncheons and closed doors. Civility was not an obligation, but actively eschewing it amounted to a reckless choice.

Freedom, in short, was exercised in a public world designed for mutual self-inspection, which entailed capturing and taming enormous levels of material agency. The capacity to conduct oneself civilly was the mark of freedom; it was exercised in a public realm studded with the eyes of society. This was a world needing light. The urban symbiosis of freedom and light is the subject of the next chapter.

2: Oligoptic Engineering: Light and the Liberal City

Light, as both environmental agent and symbol, was integral to the 'improvement' of the city and its population in the nineteenth century. This chapter begins by outlining the various ways that light became integral to the project of liberal urban government. I then discuss how improvement and light became inseparable in projects to demolish slums and widen streets. Through addressing various model towns and improvement schemes, I will develop the concept of oligoptica, a liberal visual arrangement, which contrasts with the more disciplinary panopticon. Municipal engineering thus had as one of its aims the opening of urban space to the collective inspection by and of its citizens. The remainder of the chapter investigates a series of technologies designed to make this visual economy normal, natural and durable: smoke abatement, glazing, soundproof paving and street widening. In moving from the high pulpit of 'theories' and 'projects' to the messy practicalities of building and engineering, government appears as a rather contingent, haphazard, even shambolic affair. The final example of the Deansgate improvement in Manchester shows how little logical 'improvement' was achieved despite vast organisation and expenditure. Light, then, was integral to the drive to improve the city's moral, physical and economic health, but this drive, or desire, which structured so much Victorian rhetoric and action, must never be confused with the piecemeal, frustrating process of materially reconfiguring the city. In fact, tracing this history of mundane material reconstruction leaves us impressed at how much was achieved.

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Light and Urban Improvement

The Desire for Light

The problem of urban darkness, of unknown masses lurking "secluded from superior inspection and common observation" persisted across the century. This quote is from Chadwick, but it could have come from Charles Booth.[1] In this era of censuses and statistics, such seclusion was an obstacle to the collation of knowledge, and hence to progress. More practically, it posed the problem of order. Without "superior inspection," the city's dark recesses became breeding-grounds of crime. In 1800, C.G. Stonestreet had argued that crime zones could be reformed by a combination of street and inspection:

> By carrying through the midst of it a free and open street with buildings suitable for the industrious and reputable orders of the people, (this) would let in that *Eye* and observation which would effectively break up their combinations.[2]

Street improvement carried this disciplinary impetus throughout the century. The court, the alley and the cul-de-sac were edges where official knowledge of the city appeared to abruptly terminate; in these shadowy realms, disorder and disease fermented. Lord Aberdare, addressing the Congress of the Social Science Association in 1875, expressed this equation:

> Narrow streets, close courts, ill-ventilated and crowded houses generate disease, disease poverty, and poverty but too often produces crime. Evil communications corrupt good manners; and evil associations are inevitable in these resorts of the miserable, the vicious, the drunkard and the criminal. Foul air depresses, depression craves its stimulants, and stimulants beget drunkenness and its long train of curses. Crime is promoted by security and detection from punishment and the difficulties of the detection and the facilities for escape are multiplied in these Alsatias which are found in all our towns.[3]

During political unease in the 1820s and 30s, police were frequently frustrated by the tangles of streets into which rioters vanished: likewise, the courts off Whitechapel provided a ghoulish foil for the activities of Jack the Ripper.

[1] Edwin Chadwick, *Report* (1842 edition), 243. Cited in Stallybrass and White, *The Politics and Poetics of Transgression*, 126.
[2] C.G. Stonestreet, *Domestic Union, or London as it Should Be*, 1800. Cited in Cannadine and Reader, ed., *Exploring the Urban Past: Essays in Urban History by H.J. Dyos* (Cambridge: Cambridge University Press, 1982), 149.
[3] Lord Aberdare, "Social Science in Brighton," *The Builder*, XXXIII, October 9, 1875, 901.

Illuminating these dismal realms, then, would facilitate the collection of knowledge and the functioning of power. The social investigator and the policeman would extend the eye of power into the city's depths. This formulation, through which a monocular state eye suffuses the irrational terrain wrought by untrammelled urban expansion, reminds us that disciplinary urges persisted. Yet to regard the 'opening' of the city to light and vision as purely the imposition of central power is clearly simplistic and conflicts with the simultaneous liberalising impulse delineated earlier.

The problem of social seclusion was usually seen less as one of official policing than one of intercourse and imitation. Cities, it was argued, had physically developed so as to visually segregate social groups from one another. Engels provided the abiding image of this:

> Every great city has one or more slums, where the working class is crowded together....in general, a separate territory has been assigned to it, where, *removed from the sight of the happier classes*, it may struggle along as it can.[4]

This arrangement was particularly pronounced in modern industrial cities. Contrasting this form with that of the pre-industrial town, in this case Carlisle, one surveyor argued: "it must have been an advantage for the inhabitants, as they would be in touch and sight of all that passed through the city, or had business in it."[5] As every available space was crammed with workers' housing, this ability of the citizenry to monitor itself was materially precluded. The ensuing problematic was frequently posed in two ways. First, like Engels, it was argued that the "happier classes" were protected from "everything which might affront the eye and nerves," a process clearly cementing shifts in levels of tolerance.[6] Second, it meant that the working population were denied the opportunity to view and mimic their betters.

This principle of imitation informed many schemes for improvement of domestic and public space:

> Human nature is ambitious and imitative. Most people like to appear as well as their neighbours. If the latter live in dirt and disorder, they are content to do the same, But clear

[4] Engels, *The Condition of the Working Classes in England* (Oxford: Oxford University Press, 1993), 39, emphasis added.

[5] H. McKie, "Lanes, Courts and Back Streets in Old Cities and Towns, Exemplified by Those in Carlisle," Association of Municipal and Sanitary Surveyors and Engineers, *Proceedings*, XIV, July 12, 1888, 300-1.

[6] Engels, *The Condition of the Working Classes in England*, 59.

> away one dwelling and make it clean and tidy, and at once competition is created, which stimulates the tenants of other houses to bring about like improvements.[7]

Denied the opportunity to observe the behaviour of their superiors, inhabitants of courts and culs-de-sac had no chance to improve, as Octavia Hill informed the Select Committee on Artisans' Dwellings in 1882: "a great deal of the deprivation of these courts is because no public opinion reaches them."[8] Rather, children grew up with no other visual examplar than the immoral acts of those around them. The idea that urban form had generated a socially damaging and divisive visual economy was made explicit in this statement from the 1838 Select Committee established to discuss plans for metropolitan street improvement:

> There were districts of London through which no great thoroughfares passed, and which were wholly occupied by a dense population composed of the lowest class of persons who being entirely secluded from the observation and influence of better educated neighbours, exhibited a state of moral degradation deeply to be deplored. It was suggested that this lamentable state of affairs would be remedied whenever the great streams of public intercourse could be made to pass through the districts in question. It was also justly contended that the moral condition of the poorer occupants would necessarily be improved by communication with more respectable inhabitants, and that the introduction at the same time of improved habits and a freer circulation of air would tend materially to extirpate those prevalent diseases which not only ravaged the poorer districts in question, but were also dangerous to the adjacent localities.[9]

Street reconstruction, therefore, was promoted as a technology of moral improvement, one targeting the visuality of the lower classes. By providing the opportunity to observe moral rectitude and purpose, they would be freely invited to improve their habits, which themselves would augment the moral and physical condition of the city. As ever in Victorian England, morality and bodily health were inseparable.

Sunlight was a critical weapon in the war against disease. The "dark narrow streets and grimly-looking back lanes, into which the sunshine seldom penetrates," were forcing-houses of disease as well as crime.[10] "A material, as well as a *moral* and *mental*, etiolation or blanching occurs," observed Forbes Winslow, "when the stimulus of light is withdrawn."[11] This view was echoed by Florence Nightingale:

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[7] "Elevating the Poor in Their Homes," *The Plumber and Sanitary Engineer*, II, September 15, 1879, 327.

[8] Cited in Gareth Stedman Jones, *Outcast London: A Study in the Relationship Between Classes in Victorian Society* (Oxford: Clarendon Press, 1971), 180.

[9] Cited in Percy Edwards, *History of London Street Improvements 1855-1897* (London: P.S.King, 1898), 10.

[10] "Improvement of Artisans' Dwellings in Manchester and Salford," *British Architect*, XIV, July 23, 1880, 37.

[11] Forbes Winslow, *Light: Its Influence on Life and Health* (London: Longmans, Green, Reader and Dyer, 1867), 5.

> Where is the shady side of deep valleys, there is cretinism. Where are cellars and the unsunned sides of narrow streets, there is the degeneracy and weakliness of the human race, mind and body equally degenerating. Put the pale withering plant and human being into the sun, and, if not too far gone, each will recover health and spirit.[12]

Absence of sunlight was blamed for scrofula, anaemia, pthisis, retarded growth, chlorosis and rickets. It was a classic environmental nuisance: a stunter or devitaliser rather than a killer, producing a "big army of pale, dull, pinched, backward, underweight and catarrhal children."[13]

Sunshine, for some, was an almost universal agent of vitality, a dehumidifier, deodorant and disinfectant. Thermodynamic theory and practical sanitary strategies spoke as one on this:

> No living creature, and scarce any vegetable growth of higher order than a fungus, can thrive without it. It is the foundation of all our vital energies and powers, as well as the material origin of all mechanical force of whatever description on the face of the earth – excepting, perhaps, the tides, earthquakes and volcanoes, of which mankind makes very little use.[14]

Unsurprisingly, architects and engineers endeavoured to deliver more light to houses, hospitals and schools. This was not to overwhelm the delicate eyes of workers and children with light: a balance, in keeping with the liberal anxiety about limits, must be kept. "The aim of the architect," wrote Carl Pfeiffer, "must be…to arrange his buildings that they will supply a sufficiency of light and heat, and yet keep both light and heat under perfect control."[15] In schools and factories, this calculated distribution of benevolent rays was seen as facilitating thermodynamic conversion of sunlight into brainwaves:

> Physical light actually becomes transmuted into mental and moral light and vigour– an example of the transmutation of energy that should command the attention of schoolmasters and school boards.[16]

The deployment of glass as both sanitary and visual technology is explored in greater detail later in this chapter.

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[12] Florence Nightingale, *Notes on Nursing: What it is, and What it is Not* (London: Churchill Livingstone, 1980), 71.
[13] Katherine Gamgee, *The Artificial Light Treatment of Children in Rickets, Anaemia and Malnutrition* (London: H.K. Lewis & Co, 1927). This treatment involved groups of naked rachitic children, clad only in unwieldy goggles, being placed in cages and exposed to ultraviolet light.
[14] "A Plea for Sunshine," *The Plumber and Sanitary Engineer*, II, May 1879, 162. An identical formula can be found in John Tyndall, *Heat Considered as a Mode of Motion* (London: Longman, 1863), 431-2.
[15] Carl Pfeiffer, "Light: Its Sanitary Influence and Importance in Building," *The Builder*, XXXV, July 21, 1877, 731.
[16] D.F. Lincoln, "Sanitary School Construction," *The Plumber and Sanitary Engineer*, II, November 1, 1879, 391.

Morality and vitality were conjoined aims of this drive to capture and channel solar agency for humanity's benefit. Transport networks, commerce and leisure practices, too, required calculated quantities of light in order to expand and function more efficiently. Artificial light, as will be seen later, enabled factories to operate all night. This issue of calculation was vital, for the nineteenth century city was subject to measurement on a hitherto unseen scale. Levels of light itself, as will be seen in chapter four, were examined and computed in obsessive detail. Similarly, the amount of light admitted into buildings was hotly debated. The body required certain levels of light to remain healthy: architecture must, therefore, aim to admit this into human habitations. "In this climate," wrote one architect, "adequate light will not be secured with less than 1 ft^2 of window surface to about 100 to 125 ft^3 of the contents of the room."[17] Building laws enshrined this calculus of light, while lighting-up times were measured and published at an increasing rate. Street construction itself was subject to complex estimates regarding the distribution of sunlight across the day, leading to the conclusion that a street following a line east to west was "a street of extremes, cold in winter, hot in summer. The diagonal street is very much better off."[18] Urban design had to mediate the unyielding actions of the elements to foster a healthy population.

There was, moreover, a germinating demand that a certain basic quantity of light was the right of all. The abolition of cellar-dwellings and adoption of new legal minima of air and window space is tangible evidence of this. Still, these trends should not be confused with a miraculous obliteration of darkness. Sims, for example, complained that "the law says that no child shall grow up without reading, writing and arithmetic; but the law does nothing that children may have air, and light, and shelter."[19] The law of Ancient Light, dating from 1189, had been reworked in 1832; it stated that if one had enjoyed a quantity of natural light for twenty years, "the right thereto shall be deemed absolute and indefeasible."[20] In an age where building was being undertaken at a greater rate than in previous centuries, there were an escalating number of cases where the liberty to build and the liberty to enjoy light clashed. The law itself was fiendishly intricate;

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[17] D. Galton, "Some of the Sanitary Aspects of House Construction," *The Builder*, XXXI, August 23, 1873, 669.
[18] H. Triggs, *Town Planning: Past, Present and Possible* (London: Methuen, 1909), 253
[19] Sims, *How the Poor Live*, 106.
[20] Cited in B. Fletcher, *Light and Air: A Text-Book for Architects and Surveyors* (London: B.T. Batsford, 1879), 6.

measurement was notoriously difficult, with competing methods and equations merely adding to the legal complexities. Nonetheless, one architect commented in 1877 that:

> In many important and complicated cases we shall...have cause to congratulate ourselves, in the interest of the public health, that the law, instead of looking with natural jealousy upon the enforcement of a servitude, now leans to the right of light in preference to the right of building.[21]

The historian would be wise to avoid generalisations here; nonetheless, the right of the individual to a reasonable quantity of light, by which to work and in which to be healthy, was being forcefully promoted in the courtroom as well as the hospital and council chamber.

Practical improvements and more utopian schemes all integrated light into their design. The following section examines the phenomenon of 'improvement' and, via analysing model towns and cities devised in the nineteenth century, develops the conception of oligoptica, the visual schema of the liberal city.

Improvement, Model Cities and Oligoptica

The administration of sunlight, for the purposes of civil observation, policing, health, cleanliness, and commerce, never amounted to a co-ordinated programme. But in plans to widen streets, demolish slums, and construct gardens, parks and squares we can trace intentional efforts by municipal authorities to diminish levels of darkness. Improvement schemes, of course, were no nineteenth century invention: schemes by Wren and Spranger, among others, show that a desire to consciously organise and enhance the metropolis predated industrial capitalism.[22] However, the kinds of improvement discussed in this and the next chapter were responses to the unprecedented, and largely unplanned, urban expansion characterising the later eighteenth and early nineteenth centuries.

These zones of sprawling housing in Manchester were described definitively by Kay in 1832:

[21] F.H. Hummel, "Ancient Lights," *The Architect*, July 28, 1877, 40.
[22] Ogborne, *Spaces of Modernity*, chapter 2.

> The greatest portion of these districts, especially of those situated beyond Great Ancoats-street, are of very recent origin; and from the want of proper police regulations are untraversed by common sewers. The houses are ill soughed, often ill ventilated, unprovided with privies, and, in consequence, the streets, which are narrow, unpaved, and worn into deep ruts, became the common receptacles of mud, refuse and disgusting ordure.[23]

Kay described a town largely devoid of building regulations or laws. De Tocqueville, visiting Manchester, observed that there was "no trace of the slow continuous action of government."[24] Older cities had administrative apparatuses more capable of managing this prodigious growth. Liverpool, for example, passed its first Improvement Act in 1786; a second, in 1826, facilitated street widening. The development of local government in industrial towns can be seen as a response to this need for organisation. In Manchester, an Improvement Committee was formed in 1828. Two years later, regulations stated that streets were to be no narrower than 24 feet.[25]

Improvement Acts gradually raised this minimum width across the century. As will be seen later, these attempts to rationalise urban space were circumvented in so many ways that to view their cumulative effect as that of a 'political rationality' reconfiguring the real is misguided. The city was not easily bent into new shapes, and plans hatched by committees and surveyors were constantly redrawn to accommodate this, so much so that no guiding rationality in and of itself existed outside practical acts of material construction. Nevertheless, however reworked, compromised or sometimes ignored, changing legal thresholds trace a calculus of desired improvements, a drive to smooth, straighten and widen urban thoroughfares, and to orchestrate the minutiae of the street. The 1844 Manchester Improvement Act, for example, stated that the Council could request the removal of "any Porch, Shed, projecting Window, Step, Cellar, Cellar Door or Window, Sign, Sign Post, Sign Iron, Showboard, Window Shutter, Wall, Gate, or Fence, or any other Obstruction or Projection," if it interfered with passage.[26] The liberal nature of this act should be observed. Manchester was not to be forcibly smoothed: rather, a series of predictably messy and protracted confrontations between council and tenant would take place. The ambivalences of liberty, as in cases of light and air, generated opposing logics. If council legislation interfered with the freedom to build, it could easily be argued that it was:

[23] James Kay, *The Moral and Physical Condition of the Working Classes in Manchester, 1832* (London: Frank Cass & Co. 1970), 27.
[24] De Tocqueville, *Journeys to England and Ireland* (London: Faber and Faber, 1958), 105.
[25] Redford, *History of Local Government in Manchester*, II, 152.
[26] *Manchester Municipal Code*, II, 58-9.

> an attempt to prevent the improper liberties of the human subject; for what right...has any man to form streets, construct houses, and crowd them with human beings, so as to deteriorate health and shorten life because he finds it profitable to do so?[27]

The centrality of liberty to government, and its contradictions, is apparent in such routine, agonistic, flexing of municipal muscle.

It was estimated that between 1865 and 1915, some twenty-five million pounds was spent on widening British streets.[28] Whatever the figure, this draws attention to the accumulation of piecemeal reforms that left cities substantially altered. There was no Haussmannisation of English cities, but they were hardly left to develop haphazardly. As in Napoleon's Paris, tactics of street improvement formed part of a wider strategy of slum demolition, policy evident from the 1830s. Prior to this, several London improvements, notably Regent Street, had consciously skirted poor districts in order to draw more effective boundaries between them and more respectable areas, as Nash admitted in 1812:

> The whole Communication from Charing Cross to Oxford Street will be a boundary and complete separation between the Streets and Squares occupied by the Nobility and Gentry, and the narrow Streets and meaner houses occupied by mechanics and the trading part of the community.[29]

This principle appears to have gradually disappeared thereafter. Reviewing metropolitan improvements over the second half of the century, Percy Edwards argued that:

> Sometimes a line for a new street, though not as short as an alternative route, would commend itself, owing to the fact that by adopting the longer line light and air would be admitted into crowded areas not intersected by the shorter route, and where light and air would be most desirable.[30]

A similar principle informed the construction of squares. When the location for Albert Square in Manchester was decided in 1863, the council declared that its object had been the "securing (of) an open space in the centre of the city, which whilst adding materially to its general appearance will improve the sanitary condition of the district."[31]

Demolition of slum areas was one thing: reconstruction quite another. Administrative delays and the failure of private capital to fund the construction of new dwellings,

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[27] William Davidson, cited by Chadwick, *Report on the Sanitary Condition of the Labouring Population of Great Britain*, 216.

[28] H.R. Aldridge, *The Case for Town Planning*, 1915, cited in Ashworth, *The Genesis of Modern British Town Planning: A Study in Economic and Social History of the Nineteenth and Twentieth Centuries* (London: Routledge and Kegan Paul, 1954), 170.

[29] *Parliamentary Papers*, 1812, first report, 89, cited in Cannadine and Reader, eds., *Exploring the Urban Past: Essays in Urban History by H.J.Dyos*, 82.

[30] Percy Edwards, *History of London Street Improvements*, 163.

[31] Manchester City Council, *Proceedings*, March 4, 1863. Cited in Redford, *The History of Local Government in Manchester*, I, 272.

coupled with the miscalculated notion that suburbanisation would ease land congestion, meant legislation to improve housing frequently had exacerbated overcrowding.[32] However, over the course of the period, we can distinguish a pronounced tendency for the replacement of "cellular and promiscuous" domestic arrangements by "open and encapsulated" ones.[33] The former configuration is that of the court: a cluster of cramped dwellings linked to the rest of the city by a narrowest passageway. These houses shared facilities (water pumps, toilets) and their only open space was the court itself. Consequently, "they live their lives before each other's eyes, and their joys and sorrows are the common property of the entire community."[34] By contrast, byelaw housing erected after 1850 had enclosed facilities and private backyards. Houses were constructed along parallel sides of streets connecting openly to other urban thoroughfares, the inhabitants of which were, by implication, invited to view them. One was implicitly expected to present one's house for public inspection (scrubbed doorsteps and pristine lace curtains may have an origin here) while simultaneously using the privacy afforded by the house to care for one's self and family. Likewise, model tenement blocks, with, for example, attendants overseeing communal stairwells, made possible a collective policing of morals predicated upon an unambiguous distinction between public and private:

> In addition…to the great decrease in the rate of mortality and disease which was noticed in these model dwellings, the check given to immorality and crime formed an appreciable benefit, as the supervision carried on effectually cleared the building of all persons of bad character.[35]

Model dwellings, built by councils or private philanthropic trusts, aspired to govern the habits and conduct of workers in ways that could verge on the paternal. Indeed, the very notion of such a conscious architecture of control could be seen as implying reliance or dependency, or else, as in early French *cités ouvrièrs*, generating resistance to what was perceived as excessive discipline. This illiberal tendency perhaps explains why model tenements and, indeed, communities, were generally rare and unsuccessful. Larger schemes, such as that of Owen at Lanark, had failed due to a combination of

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[32] An account of the 1868 and 1874 Artisans' and Labourers' Dwellings Acts is provided by Stedman Jones, *Outcast London*.

[33] Martin Daunton, "Public Place and Private Space: The Victorian City and the Working-Class Household," in Fraser and Sutcliffe, eds., *The Pursuit of Urban History* (London: Edward Arnold, 1983), 214-5.

[34] George Sims, *Horrible London*, 144.

[35] C. Gatliff, "Improved Dwellings and their Beneficial Effects," *The Builder*, XXXIII, February 27, 1875, 181.

impracticability and suspicions of socialism. Later projects, at Saltaire, Bourneville and Port Sunlight, were usually of limited size, and financed and designed by opulent and altruistic industrialists, who invariably banned alcohol, planted trees and encouraged rational recreation.[36]

Others preferred to plan whole cities. Inspired by Campanella's *City of the Sun* (1602) and Andreä's *Christianopolis* (1619), the Christian community had several adherents, among them Minter Morgan, whose planned commonwealth was designed along passionately anti-laissez-faire lines.[37] Along with the Ohio Rappites, whose community similarly eschewed alcohol, Morgan's work inspired James Silk Buckingham, M.P. for Sheffield, who published his plan for *Victoria* in 1849. This city, one mile square with a population of ten thousand, was an environmental diagram proposed as an explicit solution to the problem of governing industrial society. "Would it not be possible," asked Buckingham, "to remodel society, by systematic association, on a better plan than the present?"[38] Noxious trades were to be located around the perimeter of the town, while parks and washhouses catered for the sanitary needs of its people. A 300-feet tall octagonal tower, capped with a spire and an electric light (a remarkably rare commodity in 1849) was the centrepiece of the community. Of particular significance to my own concerns here is the overt equation of architecture, visibility and conduct. Better men, Buckingham argued, were produced in conditions where their actions were on open display to all – his model city enshrined this functionalist architecture with quixotic clarity:

> From the entire absence of all wynds, courts and blind alleys, or culs-de-sac, there would be no secret and obscure haunts for the retirement of the filthy and the immoral from the public eye – and for the indulgence of that morose defiance of public decency which such secret haunts generate in their inhabitants.[39]

The morality of the public would be produced within an architecture precluding obscene or criminal conduct. Yet, as Buckingham's atavars remind us, this was no liberal space: alcohol and tobacco were strictly forbidden, while labour laws were to be scrupulously controlled. Moreover, the uniform imposition of such a centralised scheme found few adherents in the halcyon days of British industry.

[36] For more details on these see Ashworth, *The Genesis of Modern British Town Planning*.
[37] See John Carey (ed.) *The Faber Book of Utopias* (London: Faber, 1999), for more details on such schemes.
[38] James Silk Buckingham, *National Evils and Practical Remedies, With a Plan of a Model Town* (London: Peter Jackson, 1849), 107.
[39] *Ibid*, 193.

Benjamin Ward Richardson, physician and founder of the *Sanitary Review*, delineated his scheme for a "City of Health and Comfort", *Hygeia*, at the Brighton Social Science Congress in 1875. Its form had much in common with that of *Victoria*. Abattoirs and factories were removed to the perimeter of the settlement, while ample leisure facilities tempted the poor away from alcohol. Yet in other ways, the arrangement seems to suggest an emergent notion of the welfare town, less disciplinary and more liberal. Alcohol was not explicitly banned: rather, few people drink because of the shame they would feel: "a man seen intoxicated would be so avoided by the whole community that he would have no place to remain."[40] In keeping with liberal ideas, the people have been trusted with freedom, which they have used judiciously and collectively to enact a public display of sobriety which is imitated by all. The sanitary dimension was more pronounced in *Hygeia*, which took its name from the daughter of Esculapius, the Greek father of medicine. Unlike Buckingham's city, this was a machine for securing health. Each house had its own water and gas supply; wide streets, "filled with sunlight," hid a subway system.[41] This scheme shows us how an ideal sanitary community was thought.

Despite Richardson's insistence that "there was no reason why the details should not at once be considered, with a view to their practical application," and rumours of a site being purchased on the Sussex coast for its construction, *Hygeia* remained the work of a draughtsman rather than a builder.[42] Constructing such a town was an act of intervention, in both the housing market and the flow of labour and capital, which was dismissed as "communistic" by *The Sanitary Record*, which continued:

> Many of the results enumerated by Dr. Richardson can be obtained by other means at a much less pecuniary cost to the rich, and with a greatly diminished loss of liberty and self-respect to the poor.[43]

While his plans gathered dust on his drawing board, Richardson returned to his other projects, among them abstinence, anaesthetics and bicycling.

It is thus an anachronism to speak of 'urban planning' as such in the nineteenth century. Isolated voices, like Mearns, who argued that "without State interference nothing

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[40] B.W. Richardson, "A Model City of Health and Comfort," *The Builder*, XXXIII, October 16, 1875, 924.
[41] *Ibid*, 924.
[42] B.W. Richardson, "Health Improvements in Great Cities," *The Builder*, XXXV, January 13, 1877, 33.
[43] *The Sanitary Record*, V, October 7, 1876, 238.

effectual can be accomplished on any large scale," would grow in prominence, leading to governmental strategies that were more socially interventionist.[44] The modest and permissive 1909 Town Planning Act was one example of this. Nevertheless, *Hygeia*, along with the manifold, piecemeal schemes to improve streets and housing, demonstrated the salience of environmentalism among urban reformers as they sought to balance welfare and freedom. Rabinow has investigated French plans that display this concern more graphically. Tony Garnier's *Cité Industrielle*, for example, is depicted as "a grid of intelligibility, this time for modern welfare society." He also calls this plan "an urban parallel to Bentham's panopticon."[45]

By this, Rabinow does not mean to argue that the *Cité Industrielle* (or *Hygeia* for that matter) is an abstract type, a sort of mental summary of a period's visual thought about the welfare of its citizens. It is, rather, a *diagram of power*: a concrete, transposable model for solving the perennial problem of how to govern a population. A diagram of power functions as both a cartogram, or representation of "the distribution of the power to affect and the power to be affected," *and* as a very real machine for achieving these effects.[46] The panopticon, alluded to above, must thus be seen as entirely immanent to the social field within which it functions. But there is potentially no limit to the practical schemas that can be designed to govern populations. What, then, are the characteristics of this 'urban panopticon'? Some clues are provided by Deleuze, who argues that the panopticon is ideally suited only for "the pure function of imposing a particular taste or conduct on a multiplicity of individuals, provided simply that the multiplicity is small in number and the space limited and confined."[47] In addition to the small size, it also generates "a brutal dissymmetry of vision," in which the eye that permanently gazes is hidden from the bodies upon which its inspection focuses, a position which has been described provocatively as "creat(ing) a semblance of God."[48]

The panoptic schema, with its walls, immobility, asymmetry, and God-view, is palpably unlike the spaces discussed thus far. Rather than enclosing, fixing, locking, stratifying and dominating, the liberal city, with its parks and wide streets, and private houses with

[44] Preston, *The Bitter Cry of Outcast London*, 69
[45] Rabinow, *French Modern*, 12.
[46] Deleuze, *Foucault*, 73.
[47] *Ibid*, 72.
[48] Jacques-Alain Miller, "Jeremy Bentham's Panoptic Device," *October*, 41, 1987, 4, 5.

bathrooms and toilets, is a space of calculated freedom, open and risky. There is no overview of this space, which exists phenomenologically as a myriad of microspaces, within which free subjects circulate and interact. Total knowledge of this activity, in keeping with liberal thought, is impossible. This multiplicity has been termed *oligoptic* by Latour.[49] I propose to use this term in contradistinction to and conjunction with the panopticon in order to characterise the kinds of spaces discussed in this and following chapters. What are the differences between the panopticon and oligoptica? First, one is singular and one plural. The panopticon provides the total, permanent overview of a space and its occupants, while the city's oligoptic spaces (parks, museums, squares, offices, libraries), taken cumulatively, never amount to a totality: they always remain local, jumbled, mediated. Second, there is symmetry. Unlike in the panopticon, the viewed can always return the glance, because all are viewers and viewed: the God's eye vantage-point does not allow anyone this privilege: the arrangement is thoroughly social, in other words. There is no 'eye of power'; rather, there are many eyes all seeing a slice of society. Third, therefore, this is a space of many, chaotic and unpredictable lines of sight, as opposed to the formal, radial configuration in Bentham's device. Fourth, whereas in the panopticon, one is trapped in a "cruel, ingenious cage," in oligoptic space one is free to move and look as one wishes.[50] Finally, the panopticon is a space depriving the fixed subject of privacy, while oligoptica, local points where the few see the few, function as the outside of a deeply private realm within which one's appearance in the mirror of the oligoptic social is created. Thus, the freedom to view in public is paralleled by a freedom to withdraw from view if one so chooses.

These two visual arrangements should not be seen as opposites, however, as some have suggested.[51] Both, as Deleuze suggests, only really handle small groups of people. More importantly, both aim to create a subject who internalises the social norms necessary to act freely, as outlined in chapter one. Both, therefore, target the mind through placing the body in a particular relation with other bodies in space. The oligoptic principle, as will be obvious, is the visual morphology of a liberal society, a schema to freely produce

[49] Latour, "On Recalling ANT," in Law and Hassard, eds., *Actor-Network Theory and After*, 18. See also Latour and Emilie Hernant, *Paris Ville Invisible* (Paris: Institut Synthélabo Pour le Progrès de la Connaissance, 1998).
[50] Foucault, *Discipline and Punish*, 205.
[51] S. Jensen, "Knowing in Action," http://www.lok.cbs.dk/departments/mpp/lok/publikationer/ssj-know.pdf.

self-governing and restrained subjects. This can be found in museums, as Tony Bennett writes:

> As micro-worlds rendered constantly visible to themselves, expositions realised some of the ideals of the panopticon in transforming the crowd into a constantly surveyed, self-watching, self-regulating, and, as the historical record suggests, consistently orderly public – a society watching over itself.[52]

The actual economy of gazes is of less interest here than the concerted attempt to create spaces within which this could be realised, which is a project demonstrable by examination of the history of municipal building. Open spaces, it was often maintained, would effectively be regulated by the public itself, rather than the police:

> It may be asked what security have we that these places, if thrown open, would not be taken possession of by dirty roughs, who would destroy the gardens and be a nuisance to the neighbourhood? In answer, I would point to Leicester Square, which is often thronged by the working people. The best defence of property is publicity; no shutters baffle the burglar like the unguarded windows and the 'bull's eye,' and a square without railings would always be under the eye of the police.[53]

Freedom, then, involved the working population's self-organisation and self-discipline. Such fragile liberty was obviously, indeed, freely, open to abuse. At Embden Street School, in Greenhays, Manchester, the yard was opened in 1884 as a public playground. Here, publicity merely led to the place becoming "the resort of idle fellows, mere 'toughs' who *assume the right of the public* and exercise it by coarse violence, insult and even personal attack."[54] The space was closed to the public shortly afterwards, because a "consistently orderly public" failed to organise itself. Freedom's limits and weaknesses are apparent in such prosaic plans and their abandonment.

Consequently, Victorian institutions tended to combine elements of the panoptic and the oligoptic. Libraries, schools, hospitals and museums employed varying degrees of each. Bethnal Green Museum, for example, was described thus: "the main approach, through the western entrance, leads into the central hall, which commands almost a complete view of the whole of the building."[55] Any official, therefore, could assume a *nearly total* view of the free comportment of the visitors: local hierarchies existed within the putatively free space. This was the age of attendants, porters, overseers and inspectors: gatehouses, booths and desks, rather than towers, were their dominions. The decline of the corridor in school design forms part of the same trend; to allow one better view of a space of self-controlled, rather than shackled, bodies: "the school just opened has a

[52] Tony Bennett, "The Exhibitionary Complex," 81.
[53] M.J. Vernon, "On Public Parks and Gardens," *The Sanitary Record*, IX, November 22, 1878, 322.
[54] Cited in Redford, *History of Local Government in Manchester*, III, 153, emphasis added.
[55] "The Bethnal Green Museum," *The Builder*, XXX, May 18, 1872, 380.

central hall, but is polygon in form, with the classrooms so arranged round it that they radiate from the eye of the headmaster when at his own desk."[56] The panoptic and the oligoptic, therefore, were often complementary techniques for regulating conduct, the one constraining and dominating, the other freeing and levelling. Perhaps this best expresses the visual and organisational tensions of liberalism.

Between 1850 and 1900, such spaces fell increasingly under municipal control. This process is the subject of the next section.

Municipal Engineering

The history of the development of Victorian local government has been authoritatively charted elsewhere.[57] What is relevant here is local authorities' increasing power to administer infrastructures designed to produce conditions within which healthy, rational, liberal subjects could be secured. This was an important shift from the eighteenth century, when there was a marked reliance of the locality on the centre; matters as mundane as street lighting required explicit parliamentary permission, a situation exacerbated by the closed nature of many corporations. The 1835 Municipal Corporations Act led to an enormous reorganisation of local administration. Old self-appointing commissions were abolished and replaced by more liberal bodies, elective, representative and, to some extent, accountable to the public. With this liberalisation of administration came new powers to ease the passage of legislation: from 1845, Parliament began passing 'clauses' acts, sets of model laws which local governments could quickly adopt. Municipalities thus came to embody the concept of self-help: "the principle of self-government is found to be the only principle which a large and dense urban population, like that of Manchester, can be satisfactorily governed."[58]

The growing ability of local government to borrow from central government, coupled with a series of other financial arrangements, facilitated municipal funding of

[56] The school in question was that at Huntsman's Gardens, Sheffield. *British Architect*, XXII, August 29, 1884, 105.
[57] D.Fraser, ed., *Municipal Reform and the Victorian City* (Leicester: Leicester University Press, 1982); D.Fraser, *Urban Politics in Victorian England: The Structure of Politics in Victorian Cities* (Leicester Leicester University Press, 1976).
[58] L. Faucher, *Manchester in 1844*, xii.

institutions and infrastructures. In Manchester, three parks were opened in 1846, while in 1851 the corporation bought the gasworks from the police commissioners, and passed an Improvement Act. The following year, the city founded a public library. What we see is the emergence, by no means even or unproblematic, of civic government as the motor of environmental reform. Infrastructures, it was recognised, were a legitimate object of governmental interference, as William Farr argued:

> Over the supply of water – the sewerage – the burial places – the width of streets – the removal of public nuisances – the poor have no command...and it is precisely upon these points that the Government can interfere with most advantage.[59]

The municipality would become perhaps the most important agency in this technical mobilisation. "A powerful local government cannot, it is true, make employment plentiful, bread cheap, or spirits dear; but it is in its power to give...these blessings of water, air and cleanliness."[60] Much of the legislation was permissive: for example, the 1848 Public Health Act stated that Local Boards of Health could be established if the death rate reached twenty-three per thousand, but, consistent with liberal ideas, there was no sense of compulsion. Likewise, the 1870 Tramways Act allowed local authorities to purchase private tram systems on favourable terms after twenty-one years of operation. Thus municipalities were given the opportunity to freely avail themselves of services and infrastructures, but only if they wished. Glasgow, for example, soon ran its gasworks, established public washing facilities, built model dwellings and bought the city tram network. Under Chamberlain's leadership, the compass of Birmingham city council greatly expanded: the 'civic gospel' fused nonconformity and environmental management in equal measure. Figures like Gomme, as Clerk of the London County Council in the 1890s, implemented a kind of municipal utilitarianism, arguing that individuals perform best under conditions of minimal government, yet require certain basic services to be provided for them (water, light, transport, education).[61]

Municipal provision of particular services, therefore, was one technical way in which the everyday idea of a specifically social set of problems appeared before the public. The activities of workmen disrupting traffic to mend water pipes or gas mains became a routine sight, a mundane and forgettable act of governmental intervention to secure overall urban harmony. The inspection of housing, reading of gasmeters and reporting of

[59] "Fifth Annual Report of the Registrar-General," 1843, cited in Wohl, *Endangered Lives*, 144.
[60] George Clark, inspecting Briston in 1850, cited in Hamlin, *Public Health and Social Justice in the Age of Chadwick*, 296-7.
[61] For more on this see Winter, *London's Teeming Streets* (London: Routledge, 1993), chapter 11.

infectious diseases transported urban government inside the private realm, while the vaccination and food adulteration acts transported it effectively inside the bodies of the governed. Many found this inimical to the principles of political economy and self-help: the principle of "the more you do for people the more they expect you to do" has remained an axiom for many since Victorian times.[62] But a growing number saw in this cautious principle of intervention a more nuanced and socialised conception of freedom:

> If sanitary science, unknown to our medieval ancestors, has taught the modern Englishman that the safety of his own well-ordered castle is dependent upon his neighbour's being also set in order, surely the most radical opponent of paternal government will concede that freedom must be qualified by the moral and physical rights of the neighbour.[63]

Gradually, the city became an analytical, governable object in its own right. Its environment as a totality could be justifiably acted upon by government in order to nurture the health and morality of its population. The activities of statistical societies in the earlier part of the century laid the epistemological foundations of this: relative incidences of disease and crime enabled the physico-moral topography of cities to be mapped. It was a long way from this avalanche of numbers to full-blown modernist city planning, but the increasingly dense webs of urban inspection, calculation and intervention added governmental weight to the knowledge produced by statisticians and investigators. Municipalities began appointing experts to monitor specific aspects of urban life: medical officers of health, surveyors, architects, engineers, electricians, analysts. These ensuing networks, as will be seen in the next chapter, provided a powerful practical base for the epistemologies upon which governing came to rest.

For municipal governments, therefore, the urban milieu was an object to be measured, analysed and improved. The biological conception of milieu, "a foreign environment that caused living beings to change and adapt" implied that natural bodies' norms emerged temporally, relationally and contingently.[64] The city, therefore, was a social milieu that could retard or secure the organic norms necessary for a healthy and productive workforce. Calculating and recording these environmental norms, as suggested in chapter one, became integral to the government of the city. Liberal arts of rule, therefore, partook of the positivism of the sciences.

62 Honeyman, "State Aid and Dwellings for the Poor," *British Architect*, XXIII, April 2, 1885, 325.
63 Lewis Angel, "The Sanitary and Constructive Supervision of Dwellings," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, VII, July 7, 1881, 106.
64 Rabinow, *French Modern*, 31.

Environmentalism dominated sanitary and medical thought across the century: medical officers of health, like Leigh, espoused it with a regularity betraying common sense:

> Long observation and much intercourse with the labouring classes have convinced us that the more we improve their surroundings, the more we shall improve them morally and socially, as well as raise their standard of health, and diminish the excessive mortality that has long prevailed in our city.[65]

As Hamlin has argued, this equation, so dear to Chadwick, implied the adoption of "physiological and moral universalism," the principle that there was no ultimate biological difference between classes.[66] Social difference was less biological than environmental: to think environmentally about the city, therefore, was to think socially. To intervene in questions of housing, water, gas, and transportation was to intervene in a social domain existing outside the free market. Builders, plumbers, surveyors and engineers played an axiomatic role in building this realm of social intervention.

The practices of these figures tell historians much about the heterogeneity and messiness of government. Addressing the Association of Municipal and Sanitary Engineers and Surveyors in 1876, Acland, Regius Professor of Medicine at Oxford, described the practices of a surveyor thus:

> The surveyor of the present may be called to advise on anything, from the form and cost of an earthenware syphon-trap, to the calculation for work to be done by engines, which are to supply half a million of persons with water, safe to be sipped in wine-glasses, and delivered in quantities adequate to cleanse the largest and foulest of factories; to be responsible for the construction of sanitary mechanisms...to act also as Inspector of Nuisances, he is to have knowledge of what is dangerous to the public weal in respect of any and all nuisances; of all filth producing agencies; of soundness and unsoundness of food; of occasions of epidemics and contagions. He is to be able to carry out all measures for prevention of infectious diseases advised by the medical authority; he is faithfully to observe and execute all lawful orders of the Local Government Board which may be hereafter issued.[67]

The engineer, in other words, was as concerned with the frailties of human tissue as with the brute strength of iron, a point made by Fleeming Jenkin, Professor of Engineering at the University of Edinburgh:

> In respect to domestic sanitation, the business of the engineer and that of the medical man overlap; for while it is the duty of the engineer to learn from the doctor what conditions are necessary to secure health, the engineer may, nevertheless, claim in his turn the privilege of assisting in the warfare against disease, by using his professional skill to determine what mechanical and constructive arrangements to secure these conditions.[68]

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[65] Manchester City Council, *Proceedings*, June 9, 1868, 277-8.
[66] Hamlin, *Public Health and Social Justice in the Age of Chadwick*, 66-7.
[67] Acland, "The Relation of Modern Engineering to Public Health and Local Government," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, III, February 18, 1876, 161.
[68] Fleeming Jenkin, "On Sanitary Inspection," *The Sanitary Record*, VIII, April 19, 1878, 241.

Engineering vitality was always to be concerned with the freedom of the individual: "coercion, even if attempted, will in the end retard progress." It was also predicated on the collective health of society, searching for "the most economical means for providing a healthy home for every man, rich and poor, according to his wants, his place and his condition."[69]

In order to normalise and free the individual for the good of society, there needed to be not only agreement on what environmental norms were, but also legislation to introduce some level of standardisation; "uniformity in building law, as far as practicable, is essential."[70] The liberty of local authorities and builders had, many surveyors argued, led to a baffling diversity of laws and codes which thwarted the project to provide healthy homes and clean streets. "How can the conditions under which man and property live and exist," moaned one surveyor in 1884, "possibly vary so much as to produce 170 different sets of laws on the same subject in two different counties?"[71] In Oldham, the minimum thickness of walls was nine inches, while in Manchester, it was four-and-a-half. Tightening and standardising building codes was itself another aspect of the socialisation and nationalisation of environmental norms. Only certain local variables, notably climate and occupation, ought to inflect these levels. Rationalising such practices, again, was harder to achieve, something I will return to in the next chapter.

The majority of this thesis focuses on public spaces, particularly streets. Nonetheless, it is perhaps worth briefly addressing a couple of ways in which building laws were tightened so as to produce certain calculated minimum standards of private environment. Unlike in the eighteenth century, when it was a problem limited to isolated places on the fringes of society, like prisons and ships, overcrowding became recognised as among the worst of urban ills: "it is a well-established law that, other things being equal, the insalubrity of a place increases with the density of its population."[72] Quantifying levels of density became an obsession of sanitarian: from these figures, the amount of air available for each individual could be computed. William Guy found rooms so crowded

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[69] Acland, "The Relation of Modern Engineering to Public Health and Local Government," 166, 168-9.
[70] E.B. Ellice-Clark, "The Supervision of Private Building by Public Authority," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, X, March 15, 1884, 100.
[71] *Ibid*, 84.
[72] "London Statistics," *The Builder*, XXXI, May 10, 1873, 370.

that each individual had a mere 56 ft^3 of air each.[73] This contrasted with legal attempts to provide a minimum quantity of air: the 1866 Sanitary Act had, for example, defined overcrowding both quantitatively, in terms of air space, and generally, in terms of nuisance. But in common with other laws, legal thresholds of airspace varied greatly across the country and between institutions. Prisons, common lodging houses, hospitals and Poor Law sick wards had bewilderingly differing levels; the Barrack Improvement Commission of 1861 recommended a meagre 100 ft^3 per bed, while some recommendations for hospitals went as high as 2000 ft^3. Unusual habitations, like barges, remained somewhat beyond the reach of the law: cramped sleeping-quarters, reportedly, did not seem to unduly harm the health of the inhabitants. Children's rooms could be smaller, owing to their lower lung capacity. A certain chunk of domestic atmosphere was the right of all, which in turn generated council antipathy to uneven or oddly-shaped spaces. Screens and projections were assailed, as were "unnecessary angles or corners, beaded skirtings, moulded cornices" and other architectural frippery interfering with smooth measurement and cleanliness.[74]

Council intervention in building clearly entailed the production of private spaces amenable to inspection and measurement. It also involved the abolition of houses devoid of the requisite quantity of light. Cellar dwellings had been highlighted as particularly damaging to human life in the 1844-5 Royal Commission on the State of Large Towns and Populous Districts. In Liverpool, between 35,000 to 40,000 people were reputed by Duncan to live in cellars. During winter months, they would frequently be filled with stagnant water. The atmospheric conditions of some of these spaces was indicated by reports like these:

> When the door...was closed both light and air were excluded...On one occasion Dr. Duncan had to grope his way, at noon day, into a house in Thomas-street; on a candle being lighted the patient was discovered on a heap of straw in one corner of the room, whilst in an opposite corner a donkey was comfortably established.[75]

Following his appointment as Medical Officer of Health, Leigh battled to close cellars in Manchester. "So numerous were the inhabited cellars in Manchester," he proclaimed, "that it might well have been considered a city of cave dwellers."[76] Between 1868 and 1872, some 2,400 were closed by the newly-formed Health Committee: in 1874, only

[73] Blyth, *A Dictionary of Hygiene and Public Health*, 293.
[74] "Improved Dwellings for the Poor," *British Architect*, XX, November 9, 1883, 215.
[75] Joseph Boule, *British Architect*, XI, April 11, 1879, 155.
[76] Manchester City Council, *Proceedings*, January 5, 1870, 100.

108 remained. The darkest, gloomiest realms of the poor were tangibly being eradicated, evidence of palpable, if undoubtedly modest, shifts in environmental norms.

The remainder of this chapter explores several more mundane, ubiquitous technical schemes to engineer durable environmental shifts.

Urban Reconstruction and Public Vision

Oligoptic engineering, then, was a project administered locally, by engineers, surveyors and modest technicians often working for council committees battling with each other for a share of municipal funds. Grappling with a recalcitrant environment, in rain and cold, with fragile tools, spindly workmen and limping horses, often in the face of public opposition, the practice of urban reconstruction was so terminally problematic as to never function in anything like a programmatic way. Governing through infrastructures was a perennially unstable, incomplete process, relying on the conjoined agency of many bodies, human or otherwise, and many objects. If there is a logic to this process, a general strategy towards framing the population in a more standardised environment, within which minimal conditions of health will produce bodies fit to bear the responsibilities of freedom, then this logic exists within the networks within which it becomes manifest and mangled. This is vital, for it suggests that we cannot understand governmentality as an abstract, immaterial rationality.

The following examination of smoke, glass, pavements and streets hopes to begin to elucidate this critical point.

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The Air and Surface of the City: Smoke, Glass and Pavements

The murky, smoky atmosphere of the Victorian city was no Dickensian invention. The 'smoke nuisance' persistently compromised vision and health throughout the period, from Michel Angelo Taylor's 1819 parliamemtary anti-smoke campaign to the formation of the Coal Smoke Abatement League of Great Britain in 1905. "The evil of smoke," lamented *The Times* in 1845, "has reached a most intolerable height."[77] Domestic and industrial chimneys spewing forth an opaque chemical cloud were blamed; in the narrow alleys and cramped courts of the poor this merely further darkened the atmosphere. This penumbral skein clinging to the city obliterated conditions of clear perception: during a particularly infamous fog in 1879, Russell found that "it was not possible during a greater part of the day to see across a narrow street." He "measured the distance at which objects became visible, and found it to be four and a half yards."[78] In Manchester, Leigh reported that coal-smoke "forms a constant dark canopy over the town, and causes an ever-present murkiness in the streets."[79]

Given the enduring, albeit waning, Chadwickian obsession with pythogenesis and miasma, this umbrageous cocktail of soot, dung, grit, and industrial vapour inevitably became associated with illness. In this mephitic atmosphere, nature struggled: "vegetation is stunted and unhealthy, and threatens to disappear altogether from the face of the land."[80] During the 1879 fog which afflicted London, "many of the fat cattle exhibited at the great show at Islington died of suffocation." Smoke, it was argued, depressed the systems of the weak and poor, "lowering the vital energy."[81] Leigh argued that "the solid particles constantly floating in the atmosphere from the factory chimneys and other sources, keep up a constant irritation in the air tubes, producing ultimately chronic bronchitis and emphysema of the lungs."[82] Natural air was being distorted and polluted by social miscontrol. Industrial pollutants imperceptibly penetrated the skin and organs of workers; tests on deceased miners and factory labourers revealed "a perfectly dense black network" of bituminious particles coating the lungs, gradually generating ulceration and cavities.[83] Organism and milieu were clearly not harmonised, which itself impacted back upon the delicacy of perception of these men, perverting their sensibility by clogging the body's viscid core. Microscopic shards of matter posed a profound

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[77] Cited in E. Ashby and M. Anderson, *The Politics of Clean Air* (Oxford: Clarendon, 1981), 11.
[78] R. Russell, *London Fogs* (London: Edward Stanford, 1880), 22, 25.
[79] John Leigh, *Coal-Smoke: Report to the Health and Nuisance Committees of the Corporation of Manchester* (Manchester: John Haywood, 1883), 4.
[80] *The Lancet*, July 18, 1874, II, 94.
[81] Russell, *London Fogs*, 22, 29.
[82] John Leigh, Manchester City Council, *Proceedings*, 1868, 179.
[83] H.L. Bartlett, "The Chemistry of Dirt," *The British Architect*, X, 29 August 1878, 152-3.

threat to health and public vision. The moral consequences too, were apparent. Smoke, Russell concluded, "defeats attempts at cleanliness and neatness even among the most scrupulous of the poor."[84] Fragments of insoluble soot and smoke promiscuously insinuated themselves into the domestic realm, "cover[ing] every article of furniture, darken[ing] and spoil[ing] all drapery, curtains, carpets, table-covers &c." In Manchester, gloves, it was claimed, were the only way to prevent hands from blackening.[85]

Across the period, a series of laws and technologies were devised to counter the smoke nuisance. Local Improvement Acts often included 'smoke clauses', stipulating that industries would utilise smoke-consuming furnaces. Alkali Acts of 1863, 1874 and 1881 tackled the problem of hydrochloric acid, calculating a maximum legal level of impurity (0.2 grains of alkali per cubic foot), thus aiming to produce certain measurable truths about the tolerability of air. Aside from new developments in calibration and laboratory analysis, an abundance of smoke-abatement devices were patented after 1850, including Juke's furnace, Erskine's firebars and Whittaker's mechanical stoker, which, according to the *British Architect* enabled "almost as complete combustion as possible".[86] In addition, stoves and grates promising better combustion proliferated. Many of these designs tempted manufacturers with promises of improved efficiency and profit, and exhibitions of such devices were common, notably those at South Kensington (1881-2) and Manchester (1882). Mechanical stokers and automatic firers were, it seems, relatively successful, but many such contraptions failed, often because they reduced smoke while compromising the smooth running of engines. As *The Engineer* admitted in 1896, the steelmen of Sheffield, a notoriously smoky city, would have reduced smoke levels long ago if was profitable and productive to do so.[87] Charting the shift in legal thresholds of impurity provides one way of assessing changing perceptions and levels of pollution, but there is little doubt that these shifting perceptions must be balanced against the persistence of the smoke problem across the century. The various acts had actually proved easy to evade, and industries often relocated to areas beyond the remit of such legislation. Their basically liberal premises – lack of compulsion, small penalties, emphasis on 'best practicable means', hesitancy about enforced inspection – and limited

[84] Russell, *London Fogs*, 33.
[85] Leigh, *Coal-Smoke*, 5.
[86] *British Architect*, XII, December 19, 1879, 242.
[87] "Smoke Prevention," *The Engineer*, LXXVIII, July 24, 1896, 90.

extent had plainly failed to tangibly improve the atmosphere of cities. London fogs, argued a rueful Shaw-Lefebvre, First Commissioner of Works, in 1881, "were of denser and of longer duration than formerly, even invading the summer months."[88] Reality, it must be concluded, refused to be programmed, and liberal principles themselves were part of the problem.

The primacy of the visual was embedded more substantially through the growth and development of the glazing industry. Glass was, of course, an ancient invention: archaeological evidence suggests it was in use at least four millennia ago.[89] But it was with the late eighteenth-century introduction of sheet-glass (crown glass produced in a cylinder and then flattened) that the glazing of relatively large areas became technically feasible.[90] The major arena of experimentation with this enlarged building medium was the glasshouse. Harnessing lightwaves by means of precise use of glass enabled James Loudon, glasshouse-making magnifico, to declare in the 1820s that man was developing a "proud… command over nature."[91] Loudon was referring especially to 'ridge and furrow' glazing, which involved scrupulous pleating of glass to deflect maximum sunlight onto rows of vegetables. His optimism was boundless: "there is hardly any limit," he suggested, "to the extent to which this type of light might be carried,"[92] and he conjured up visions of "artificial climate" and vast vitreous canopies over cities. Something of this hubris can be seen in the projects of the most famous Victorian glass architect, Joseph Paxton, who, apart from building the Crystal Palace, built many winter gardens and glasshouses, and even proposed an eleven-mile Crystal Girdle around London.

The cost of glass was greatly reduced by the repeal of excise duties (1845), and this inspired the enormous growth in the industry after 1850. Particularly notable was the development of plateglass, which, wrote *The Builder* in 1870, "far surpasses in transparency and elegance the small panes formerly used."[93] These qualities of plateglass were due to its being more even than sheet-glass, as a result of improved

[88] "Smoke Abatement," *Nature*, XXIII, January 13, 1881.
[89] Ronald Douglas and Susan Frank, *A History of Glassmaking* (Henley-on-Thames: Foulis, 1972).
[90] For a taxonomy of Victorian glass, see *The Builder*, XXXI, January 25, 1873, 69-70.
[91] James Loudon, *Remarks on the Construction of Hothouses* (London: J.Taylor, 1817), 2.
[92] Loudon, *Encyclopaedia of Gardening*, quoted in Hix, *The Glass House* (Cambridge: MIT Press, 1981), 29.
[93] *The Builder*, XXXI, January 25, 1873, 70.

techniques of production. Although it was acknowledged that "no type of glass" was "perfectly transparent," the greenish-blue tint of the best plateglass "has no deleterious effect whatsoever, the majority of persons being entirely unaware of its presence."[94] In addition, as tests revealed, it was materially more durable, and consequently, greater areas could be spanned with enhanced clarity. Thus, in the 1860s and 1870s, there was an efflorescence of glass building, with arcades, markets and winter gardens being much in vogue. Leeds Corn Exchange, with its hulking glass roof, is a fine example of this. The glass was also strong enough to support human weight; consequently, deck lighting flourished, refracting the sun's rays into basements and cellars.

The opulence of early Victorian vegetables and the exotic plant life displayed at places like Kew Gardens provided undeniable evidence of the salubrious qualities of glass, which repelled damaging radiation while admitting light necessary for photosynthesis. Human beings, it followed, would also thrive in a lighter climate. "The sun's rays impart a healthy and invigorating quality to the air, and stimulate the vitality of human beings as they do that of plants," observed John Haywood in 1873; he consequently advocated increasing the window-area of houses and orienting them as much as possible to the south-east to ensure greater periods of sunlight.[95] Others recommended glass roofing to admit sunlight into cramped garrets and attics.[96] The aspect of hospitals and asylums was similarly addressed. But it would be wrong to see this as an attempt to admit as much light into as many spaces as possible. Too much glass and injudicious fenestration could overheat rooms – at the Manchester Industrial Exhibition in the summer of 1880, a huge plateglass roof forced the temperature up to 110° Fahrenheit at times.[97] Likewise, winter cold could be magnified by glass, leading to freezing schoolrooms. Hence the deployment of shuttering, mullions and transoms and technical developments such as ground glass and double-glazing.[98] The physical and chemical properties of glass all contributed to admit a specific configuration of waves into buildings, as Carl Pfeiffer acknowledged in 1877: "every different kind of glass may change the relationship

[94] W. Rosenhain, *Glass Manufacture* (London: Archibald Constable and Co., 1908), 32, 34.
[95] John Haywood, "On Health and Comfort in House-Building," *The Builder*, XXXI, August 23, 1873, 669.
[96] See, for example, W. Laschelles, "Glass Roofs For London," *ibid.*, XXXIV, December 16, 1876, 1226.
[97] *British Architect*, XIV, September 10, 1880, 115.
[98] *The Builder*, XXXI, November 8, 1873, 881.

between the luminous, calorific and chemical rays, even as the prism – to which all glass is more or less alike – changes it."[99]

Complex and non-linear prismatics notwithstanding, this enhanced use and embryonic science of glass contributed to a material embedding of new visual norms. The clarity of visual conditions generated by plateglass struck observers forcibly. 'We can see objects through it without distortion or obstruction of any kind,' observed Aston Webb, favourably comparing it to older forms of sheet-glass.[100] These accurate visual conditions were analogous to the acuity and definition experienced by early viewers of electric light. The glass display cabinet, providing such limpidity, enabled shoppers and museum-goers to inspect clothes and exhibits without being able to touch. Plateglass also formed an ample barrier against soundwaves. Thus, silent meditation was encouraged, both inside public spaces and into the public from the private. It is in the accumulation of such prosaic material practices that shifts in the relations between the senses can be located. This hidden voyeurism was encouraged by some of the more eccentric visual technologies invented, for example platinum-coated glass, which was "transparent to the persons inside the room, but opaque to those in the street as long as there is no light inside."[101] Such vitreous trickery could produce a private realm physically divorced, yet optically connected, to the world without.

New glazing techniques, therefore, suggested that certain visual economies could be created, by controlling who could see whom and when, partitioning and isolating without hiding. In hospitals, for example, a cellular, yet transparent, architecture avoided "the unpleasantness often felt in associating with strangers," yet enabled a kind of oligoptic monitoring to function, as "the patients would also, to a certain extent, watch each other when awake."[102] Again, elements of the panoptic and oligoptic were fused in such an arrangement. Glazed hospitals could also be kept cleaner, their surfaces smooth and strong, and corners illuminated. School doors often had upper portions glazed to

[99] *The Architect*, July 21, 1877, 29.
[100] *British Architect*, X, December 6, 1878, 221.
[101] *Ibid.*, XI, May 16, 1879, 210.
[102] Henry Greenaway, "Hospital Construction," *The Builder*, XXX, June 29, 1872, 505.

allow taller teachers to observe pupils' activities through them, and careful deployment of interior glass became indispensable to workhouse and asylum design.[103]

This calculated transparency, however, had obvious limits. Some schools and hospitals may have taken advantage of technological developments and advances in calculation, but many did not. Natural lighting of schoolrooms, complained *The Sanitary Record* in 1879, "almost universally depends on accidental circumstances."[104] This situation was hindered by Education department rules which insisted on full light hitting the faces of both children and teachers, an arrangement universally condemned among architects as fatiguing to the eyes. Similarly, the conditions of lucidity about which Webb enthused were restricted to cabinets, shops and wealthy housing. In 1908, one glazing expert concluded that "for the glazing of ordinary windows, sheets are often employed which produce the most disturbing, and sometimes the most ludicrous, distortions of objects through them." The public's toleration of this situation he found most puzzling.[105] Again, strategies of administered lucidity only succeeded in sharpening contrasts between sensual environments, rather than replacing one set of perceptual conditions with another.

Outside such institutions, however, the sensual environment was even harder to control. In the medical and architectural press, the problem of urban noise was identified as having reached acute proportions by the 186os and 70s. Street music disturbed horses, students and worshippers: a rather ambiguous law was passed against it in 1865.[106] But they formed only one aspect of a perpetual stream of aural irritants: bells, buzzers, cartwheels, whistles, steam trumpets, dogs and costermongers all jeopardised the possibility of silent, reflective conduct. This cacophany, it was argued, added "to the amount of nervous disturbance now so rapidly on the increase."[107] Furthermore, street surfaces themselves were being blamed for the level of both daytime and nocturnal noise along major thoroughfares. The Strand, for example, gained a reputation for being "the

[103] For a good example of the use of glass within Prestwich Union Workhouse, see *ibid*, August 17, XXX, 1872, 645.
[104] *The Sanitary Record*, X, March 21, 1879, 204.
[105] Rosenhain, *Glass Manufacture*, 149.
[106] See John Picker, "The Soundproof Study: Victorian Professionals, Work Space and Urban Noise," *Victorian Studies*, 42:3, 1999/2000.
[107] "London Noise," *The Sanitary Record*, V, October 28, 1876, 277.

most intolerably noisy thoroughfare in the metropolis."[108] Another writer concurred: "for continued noise, concentrated noise, we must contend that that of the Strand is unique, and without rival." The insufferable clatter, it was argued, was a result of the street surface: "the way is paved from Exeter Hall to Temple Bar with granite boulders."[109] Such inelastic, plangent materials could, it was argued, generate nervousness and insomnia, triggering, in turn, "indulgence in alcohol" to combat the annoyance: again, a perversion of the natural norms under which the human organism flourished threatened to engender socially pathological habits.[110]

Consequently, paving surfaces were tested for their acoustic qualities – along with durability and tread, silence became the major prerequisite for a good road. By the 1870s, Macadam had fallen out of favour – it was slippery, painful for horses, and noisy: "an expensive nuisance." Granite sets had generally replaced it in city centres. Outlining the 'Manchester System' of street construction, Royle argued that the great asset of granite was its robustness. Welsh granite was, he suggested, practically "everlasting."[111] But there were problems with it – the asphalt in between the blocks could erode, creating chasms in which water stagnated and over which horses stumbled. Further, this unevenness accentuated the clatter of vehicles passing along the street, which led to moves to experiment with new surfaces, as one engineer admitted: "probably the desirability of decreasing the noise caused by the vibration of vehicles has had more influence than anything else in attempts to supersede the hard granite."[112] Thus a whole series of new materials, including rubber, metal and even glass, were examined to ascertain their ability to create less irritating conditions, within which the kinds of visual practices associated with respectable conduct could be made durable. The two most important of these were asphalt and wood. By 1873, *The Lancet* was referring to the "battle of the pavements;" over the next twenty years, extended trials took place across London, as well as in provincial cities.[113]

[108] "Needless Noise," *The Lancet*, September 23, 1876, II, 440.
[109] "The Strand: And Some Items Noteworthy in it," *The Builder*, XXXV, May 19, 1877, 502.
[110] "Noiseless Pavements," *The Sanitary Record*, IV, February 6, 1875, 98-9.
[111] H. Royle, "Street Pavements as Adopted in the City of Manchester," in *British Architect*, VI, July 21, 1876, 35.
[112] E.B. Ellice-Clark, "On the Construction and Maintenance of Public Highways," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, III, July 6, 1876, 68.
[113] "Noiseless Pavements," *The Lancet*, December 13, 1873, II, 849.

The use of asphalt paving dates back to at least 1838, but the first large-scale experiment in Britain was that in Threadneedle Street in 1869. Reporting on trials of the surface in 1875, *The Builder* enthused about the "feeling almost of elasticity to the tread of the foot, and...great non-conductivity of vibration or of sound...(T)he noise of...wheels is suppressed, and only a clack of the horses' shoes is heard."[114] Institutions requiring silence were immediately interested in the new surface. For example, the architects Mills and Murgatroyd of the Royal Exchange in Manchester wrote to the Council in 1871 expressing a desire for repaving outside the building, as "it is important that it should be as far from noise as possible."[115] The silent code of gesture and signal so important to trading required as hushed an ambience as possible, and limiting road noise was central to this. Following inspection of trial pavements in London, York Street in Manchester was laid with asphalt early in 1872, the Val de Travers Company providing the surface. The tests, however, proved a failure. A Council inspector was entrusted with the role of recording daily events on the street, and he reported a miserable litany of accidents – "at 3pm a horse attached to a lorry fell to its knees."[116] Battered by the incorrigible Manchester drizzle, the asphalt quickly became treacherously slippery, and an army of men had to constantly sprinkle it with sawdust. After eighteen months, the surface was removed and replaced with granite. Royle concluded that the surface was incompatible with the inclement Lancastrian weather. Tests in London, too, revealed problems of excessive hardness. The highway engineer Allnutt stated that it was "at times dangerous to walk on. It is like walking on ice...A few days ago a little girl was killed at the Plumstead Board School by falling from a see-saw on asphalte pavement."[117] Moreover, the rising commercial value of coal tar was leading to declining quality of asphalt. The particular frictional qualities of the substance did, however, make it ideal for skating, and the 'rinkomania' of the 1870s provided temporary commercial solace for companies who had over-invested in the early part of the decade.[118]

Wooden pavements, too, were lauded for their ability to deaden sound. Like asphalt, the surface was developed earlier in the century, and many woods, including hemlock, mahogany and eucalyptus, had been used, leading to the City being "traversed, from east

[114] *The Builder*, XXXIII, July 3, 1875, 596.
[115] Manchester Paving, Sewering and Highways Committee, *Minutes*, August 16, 1871, 46.
[116] *ibid*, March 13, 1872, 142.
[117] H. Allnutt, *Wood Pavement as Carried Out on Kensington High Road, Chelsea &c.* (London: E. and F. Spon, 1880), 15-16.
[118] *City Lantern*, II, January 7, 1876, 113.

to west, by an unbroken line of wood paving" by 1892.[119] In addition, it found use in encircling specific institutions requiring silence. Hospitals were often provided with such pavements, owing to the deleterious effects of the clamour of traffic on patients. "The boon which will be thus secured to sufferers in...hospital in the shape of increased quiet will necessarily be of incalculable value."[120] The streets around St Mary's Hospital in Manchester were relaid in 1877, after Thomas Radford complained that "the patients have suffered very much from the noise" of the old road.[121] Similarly, clubs campaigned for girdles of soundproof paving. The Union Club in Manchester complained in 1879 that:

> the bedrooms in the Club are much used by members and the noise of the stone pavement is very disturbing. The Reading and Writing rooms front towards Mosley Street and the Committee feel that wood pavement would be a great boon to large numbers of members daily using the rooms during the busiest hours of the day.[122]

Unfortunately for members, the Council declined the request, arguing that the street was already being relaid with granite. But other institutions were more fortunate; for example, Manchester Grammar School was girdled with wooden paths in 1882.[123] Wooden blocks were also often fitted along with new tramlines.

However, the fashion for wood pavements was short. Although quiet, they unfortunately gained a reputation for harbouring water and dung between blocks and foundations. The health risk was palpable.[124] In hot weather, clouds of offensive particles, stinking and opaque, were released from these clammy crypts. Wood pavements, in short, could not durably produce the environmental conditions appropriate for civil sensibility. As *The Engineer* indicated in 1894, once creosote protection wore away, there was "little or nothing to prevent the fibres and pores of the wood from becoming saturated with rain water and other far more noxious liquids." They became uneven and pitted. Wooden pavements were blamed for the particular virulence of an epidemic in New Orleans in 1879. In narrow, dark streets, "the pestilential agents at work encounter little or nothing to interfere with their septic activity," a situation, which compared unfavourably with asphalt, the "very constitution of which," the article concluded, was antiseptic.[125] Isolated areas of London (Paddington, for example) retained faith in hard woods,

[119] "Wood and Asphalt Paving," *The Engineer*, LXXIV, May 20, 1892, 435.
[120] "Silent Paving," *The Lancet*, August 21, 1875, II, 297.
[121] Manchester Paving, Sewering and Highways Committee, *Minutes*, October 3, 1877, 73.
[122] *ibid*, April 21, 1879, 228.
[123] *ibid*, May 24, 1882, 380.
[124] "Wood Pavement," *The Lancet*, September 30, 1882, II, 549.
[125] "Street Paving and Hygiene," *The Engineer*, LXXIV, December 28, 1894, 573-4.

especially eucalyptus, while American cities continued sporadic laying of wood pavements during the first two decades of the twentieth century, but use of the surface fell into terminal decline thereafter.[126]

Asphalt, after its rather uncertain start, gained in popularity. In Manchester, for example, a mere 968 square yards had been laid for the trial pavement, and it was soon pointed out that "no trial can give a fair result unless a considerable area is paved."[127] Larger trials slowly cemented asphalt's reputation as a reasonably cheap, generally durable, moderately quiet surface. It would be reductive in the extreme to regard its success as purely due to its generation of silent, clean streets – the availability of cheaper materials and the development of the automobile are of at least equal significance. Victorian cities, by 1880, had a variety of street surfaces, all grappling with the manifold requirements of urban life. But asphalt and, to a lesser degree, wood pavements, were technologies designed to generate silent traffic. They created potential archipelagos of silence, areas of civic life materially designed to minimise noise.

Oligoptic engineering, therefore, was a project mired from the start in a world of pulsing material agency, slowly securing little spaces fit for reserved conduct while elsewhere running up against the interminable frustrations of obdurate matter, limited money and a public jealously guarding its liberties. I will close this chapter with an example which demonstrates this point: the widening of the main Manchester thoroughfare of Deansgate from 1869 to 1880.

Widening Deansgate

The huge volume of street improvement across the nineteenth century involved the mobilisation of all the forces I have outlined above – new building materials, surveying techniques, quantification, the law, inspection, taxes and loans. Constructing new and wider streets was undertaken for many reasons: to improve circulation and the mobility

[126] A. Blanchard and H. Drowne, *Text-book on Highway Engineering* (New York: John Wiley and Sons, 1913), 503-529.
[127] E.B. Ellice-Clark, "Asphalt and its Application to Street Paving," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, V, July 31, 1879, 51.

of traffic, to flatten insanitary property and destroy fevernests, as well as the engineering of civil spaces.

Engineering civility involved embedding, in the very stones of the city, the salience of the visual. Narrow streets and culs-de-sac, as emphasised earlier, were associated with the baser, animal senses of smell and touch; they were hotbeds of vice, crime, vermin and sickness. Public inspection, the freer play of light and improved mobility were the objectives of improvement. Traffic has moral purpose, a direction and aim. The loiterer and idler, by contrast, are directionless – their aimless gaze fixed on the pockets of the wealthy or the figures of women, their bodily density an obstruction. A wider street, with wider footpaths, provides the material possibility of urban motility, and less excuse for pointless dalliance. The businessman, argued the *Free Lance* in 1868, was not in the street for pleasure; "he never saunters or swerves – he goes along rapidly, as if he mean(s) business."[128] Consequently, the street was seldom planned as an arena for flâneurs – the gaze of the pedestrian should be focused straight ahead, or perhaps shop-windows. Other urban attractions, providing more wholesome ocular pursuits, like the staging of nature examined in the next chapter, tended to be constructed away from streets themselves. This perhaps explains the rather half-hearted attempts to introduce urban promenades, of which the Thames Embankment (1864-9) is perhaps the best example. Along with the drive to facilitate circulation was a corresponding movement to curtail the physical dangers of the street, by, for example, drawing a more rigorous and permanent distinction between street and pedestrian pavement. Smoother, wider streets were also more easily cleaned. Clean streets presented an example of civic diligence to the public: "a good scavenger is a practical teacher of that cleanliness which is next to godliness; and if the streets were well kept, the crowds who frequent them would read excellent plain sermons in the stones."[129] In addition, the Towns Improvement Clauses Act of 1847 stipulated that all streets should be named and all houses numbered. The self-governing, mobile subject could not function without such little technologies to smooth and guide urban mobility.

[128] *Free Lance*, III, July 25, 1868, 235.
[129] John Liddle, "The Morality of Street Cleaning," *The Sanitary Record*, VIII, February 8, 1878, 87.

Nonetheless, the most basic method of producing a lighter street across the century was to either widen existing thoroughfares, or build new ones, a process manifested by the shifting legal minima of street width. Manchester, as mentioned earlier, passed an act decreeing that no new street was to be less than twenty-four feet wide in 1828, a figure that had increased to thirty feet by 1841. In 1851, the borough council took over the building and control of the city's highways, and founded the Paving, Sewering and Highways Committee to oversee them. Predictably, however, widening streets was always compromised by the nature of the city itself. Thus streets built before regulation existed throughout the century: Marr found some under ten feet wide in 1904, when main streets, legally, were supposed to be fifty-six feet wide.[130] The existence of railway viaducts meant it was physically impossible to widen many streets. Byelaws were easily evaded, and, as suggested earlier, often complicated and confused. In 1849, the exasperated Board of Health, when asked about local law in London, responded that:

> Even single streets are divided, often longitudinally, and paved and cleansed at different times under different jurisdictions. In the parish of St. Pancras...there are no less than 16 separate paving boards, acting under 29 Acts of Parliament.[131]

Inter-committee squabbling was endemic, with money the inevitable obstacle to harmony. In London, for example, while the more centralised Metropolitan Board of Works built the streets, the many vestries and district boards actually paved them. Compulsory powers were hard to implement, and usually involved huge amounts of compensation. In addition, landowners often proved reluctant to sell land for improvement: the Duke of Northumberland's obstinate refusal to sell his London land delayed until his death the Avenue to which his name was bequeathed. To speak of political rationalities as schematic entities existing above this chaotic mass of obstacles is to take reality as excessively programmable. In spite of the undoubted role of plans, maps and measurements, much of the 'improvement' undertaken in cities consciously took into account the inevitability of compromise, delay and failure. In other words, any 'rationality' was immanent to practice and hence mediated and transformed by it. Many of the titans of the late Victorian city, including John Barry, Charles Booth, and the entire staff at *The Builder*, all complained explicitly about the lack of power to achieve anything approximating to civic planning. The city was already an unimaginably vast

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[130] Marr, *Housing Conditions in Manchester and Salford* (Manchester: Sherratt and Hughes, 1904), 49. For street widths, see Manchester City Council, *Proceedings*, 1907-8, 46-7.

[131] "Sanitary Consolidation," *Quarterly Review*, 88, 1850, 455. Cited in Ruth Hodgkinson (ed.) *Public Health in the Victorian Age. Debates on the Issue from Nineteenth-Century Critical Journals*, I. (Farnborough, Hants.: Gregg, 1973).

entity, a sprawling mass of buildings, railways, and roads. Any intervention on its very fabric had to work with, rather than against, its enduring material structure, patterns of landholding and vested interests. It is against these basic facts that we should assess the undoubtedly massive mobilisation of resources required to reconstruct the city as a site of liberal civility and vision.

The creation of effective organs of local government undoubtedly increased the ambit of byelaws and planning restrictions. But Councils, as in the case of Manchester, found themselves perennially responding to the legacy of the early, unregulated urban growth – the new inspectorates' reports constantly drew attention to these vast tracts of housing which required urgent improvement to bring them up to newer minimum standards of space and hygiene. Mancunian slum districts surrounding Deansgate, the ancient thoroughfare extending from Knott Mill in the south to Victoria station and the cathedral in the north, became major sites of anxiety. Leigh had identified the areas to the west of lower Deansgate in 1851 as a hotbed of cholera.[132] In his inaugural report as MOH, he argued that the sanitary state of the district had, if anything, deteriorated. Deansgate's reputation as a centre of disease was inseparable from its form – warrens of narrow alleys led off the street into a maze of courts. Looking back at the area in 1897, Robert Faulkner recalled the "labyrinthine network from which even the initiated shrunk aghast."[133] Air stagnated in these blind alleys and tiny yards, and the concentrated "evils of a polluted city atmosphere" of the area attracted the attention of *The Builder* in 1866.[134] Deansgate itself was palpably too narrow to function as a major urban artery:

> after making allowance for width, there is no street in Manchester that has so much traffic as Deansgate…It is a street in which not only thousands walk, but also hundreds stand; and the footpath is so narrow that one-half of its passengers are driven into the road.[135]

When the fair was held at Knott Mill, the street became impassable. In addition, the crowded nature of the thoroughfare prevented rapid locomotion: it became a place of stasis and loitering. The corners around the Wood Street slums were "marked by lounging ruffians."[136] Caminada, reviewing his career as a Manchester detective, recalled these slums as "the rendezvous of thieves…a very hot-bed of social iniquity and

[132] Leigh and N.Gardiner, *A History of the Cholera in Manchester* (Manchester: Sims and Dinham, 1850).
[133] "Vanished Deansgate," *Manchester City News*, April 24, 1897.
[134] *The Builder*, XXIV, February 17, 1866, 171.
[135] *Sphinx*, January 16, 1869, 202.
[136] *Ibid*, 203.

vice."[137] Prostitution and beerhouses proliferated, and a series of particularly squalid slaughterhouses nestled in between them. The area, in short, was the very antithesis of civil urban topography: vision was foreclosed by its tangled streets, and every kind of social and biological pathology flourished in its dark corners. It was thus little wonder that, as the inspection and tabulation of the city grew, it became shorthand for the ills of Manchester, and that its reconstruction was to be the largest Mancunian civic improvement of the period. A stanza from a poem in the *Manchester Critic* epitomised the disgust the area inspired, and the optimism the improvement scheme inspired:

Deansgate! Dirty, dusty
Dark, degraded and depraved,
With thy purlieus rank and fusty,
Who would wish to have you saved?[138]

The first improvement plan for the street was produced as early as 1863.[139] In 1867, it was announced that the whole of Deansgate from Victoria Bridge in the north to Knott Mill in the south was to be widened to "a uniform length of twenty yards."[140] The First Improvement Bill, giving the council powers of compulsory purchase, passed into law on 12 July 1869, and covered the area from Victoria Bridge to John Dalton Street.[141] The Second Act, passed in 1875, extended this to Knott Mill. The revised frontage of premises had been fixed in 1865, when the City Surveyor, John Lynde, planted a line of iron pegs from which the width of the street could be exactly gauged.[142]

But its inception until its putative completion in 1880, the implementation of the scheme proved a costly and at times hapless endeavour. Only the south side of the street was significantly affected, and this immediately drew derision from local publications, who argued that the worst slum areas would be untouched as a result. Furthermore, actually compelling property owners to leave proved difficult; even when, as in the case of John Barton, they were apparently willing to do so:

137 J. Caminada, *Twenty-five Years of Detective Life* (Manchester: John Heywood, 1895), 16.
138 "Farewell, Deansgate!" *Manchester Critic*, August 30, 1873.
139 Manchester City Council, *Proceedings*, December 3, 1866, 206.
140 *Ibid*, 1867-8, 408-9.
141 Axon, *Annals of Manchester* (Manchester: Heywood, 1886), 319.
142 Manchester City Council Improvement Committee, *Minutes*, X, May 22, 1865, 125.

> Great delay has occurred first in getting the old buildings down, second in preparing for and getting the new buildings up so far, the difficulty being in obtaining iron in time for its place in the building.[143]

Supply depended on larger networks of quarrying, smelting and mining, all of which were subject to the vagaries of nature and weather, and the cooperation of workforces. Any delays inevitably left other work incomplete: thus Deansgate became increasingly impassable as building work decelerated. It rapidly became a rather bleak, bare space, with half-built properties, empty shops and demolished frontages giving "an appearance to the street which is very prejudicial," according to one businessman in 1870.[144]

The first improvement was, according to the *Manchester City News*, nearing completion in March 1873.[145] However, the publication remained rather coy about the precise meaning of 'completion', as much property had yet to be built, and the new pavements were not fully laid. Indeed, the irregularity of flagstones was causing accidents, which, along with injuries caused by falling hoardings, was generating a burgeoning compensation bill. Plans for tramlines along Deansgate also complicated matters, as the necessity of trams' turning threatened to render the widening useless. By 1875, the improvement had cost over £500,000, and was far from finished. Although one newspaper argued that "in the way of improvement it is the most important work which the Corporation has undertaken," the street still had a ramshackle appearance, with flags being laid to the north, and land being acquired for the second improvement in the south.[146] Leigh suggested in 1878 that the sanitary character of the neighbourhood was improving – "wide streets and palatial warehouses occupy the sites where, some years ago, fever dens were found," a comment which should be taken sceptically given his later reports.[147] The Watch Committee was routinely turning down licences for the sale of alcohol in an effort to improve the moral character of the area.

But problems persisted. Many of the city's carpenters and joiners went on strike in 1877, delaying building work. Severe weather in 1879 hampered construction. During this period, newspapers like the *Manchester Critic* regularly derided the improvement as a "disgrace," claiming that the façade-like nature of the street was being reinforced. The

[143] John Barton, cited in *ibid.*, XI, September 30, 1872, 275.
[144] Jewsbury Hulse, cited in *ibid*, XI, July 25, 1870, 132.
[145] *Manchester City News*, March 1, 1873.
[146] *Manchester Critic*, September 3, 1875.
[147] Manchester City Council, *Proceedings*, July 10, 1878, 269.

reconstruction was "hollow and deceptive," with unchanged moral and sanitary mire merely disguised by the new frontages.[148] The *City Jackdaw* was even more forthright in 1879, describing the array of dubious characters flooding the street on a Saturday night.[149]

Talbot, the deputy town clerk, declared the improvement finished on 26 January 1880:

> The widening of this important thoroughfare having been completed, the Improvement Committee are prepared to sell their surplus lands in Deansgate, which comprise excellent sites for warehouses, shops and other premises, in plots to suit purchasers.[150]

This appeared rather questionable given that the pavements were not fully laid until October 1880, and land was still being acquired at the lower end of the street as late as November 1882.[151] Further, businesses appeared reluctant to buy the land, especially towards Knott Mill, so the street was still described as a "wilderness" in 1881.[152] Thus, the street was patently failing to become a glittering social and economic focal point, and the Council found itself pressed with requests to erect property itself in order to attract business. The second improvement was petering out rather dismally: reviewing the condition of Manchester streets in 1886, the *British Architect* carped, "there appears to be little tendency to extend the improvement beyond John Dalton Street."[153]

The sense of architectural incompleteness was worsened when inspectors and journalists reported that the moral and sanitary condition of Deansgate remained unimproved. Visiting Bradley's Yard, a court running off Wood Street, Reverend Charles Wilkinson found the houses "in the last stage of delapidation."[154] This was precisely the kind of ramshackle, unhealthy area the improvement was intended to demolish, yet at precisely the time that Talbot was announcing the project's completion, it appeared as intolerably foul as ever. The north side of the street remained largely unaltered, and Leigh, producing a long report on the condition of the area in 1881, found his earlier optimism disappearing. Despite the demolition of 1,260 houses, almost entirely to the south of the thoroughfare, the mortality rate of the Deansgate sanitary districts remained the worst in

[148] *Manchester Critic*, October 19, 1877, 151-2.
[149] *City Jackdaw*, January 24, 1879, 86.
[150] Manchester City Council Improvement Committee, *Minutes*, XIII, January 26, 1880, p245.
[151] Manchester City Council Paving, Sewering and Highways Committee, *Minutes*, October, 13 1880, and Manchester City Council Improvement Committee, *Minutes*, XIV, November 27, 1882, p118.
[152] *Manchester City News*, March 26, 1881.
[153] *British Architect*, XXVI, August 19, 1886, 133.
[154] *Ibid*, XIV, July 23, 1880, 55.

the city. Some passages were still a mere 2 feet 2 inches wide, he complained, adding that the topography of the region was still materially unsuited to health and hygiene:

> There are still a large number of courts and passages in this district. A large number of the streets are narrower than is now required by the byelaw of the Council of the city of Manchester, 1868. The passages that do exist are very narrow and the spaces between the backs of the houses is small and insufficient.[155]

Thus, the improvement cannot be said to have greatly 'improved' Deansgate when set against the quantified and calculated standards the city used to assess its own being. Undertaking a vast, ambitious scheme over a period of at least fifteen years proved the street's material resistance to attempts to craft it into a civilised space. Given that over half Manchester's improvement budget of the 1870s was spent on the project, the only conclusion that can be reached is the extraordinarily messy, convoluted nature of improvement. By the 1890s, however, writers seemed to have forgotten the laborious nature of establishing even the most fragile reconfiguration of urban space. This act of blackboxing became written into the city's narrative of modernisation. "The Act," recalled the *Manchester Guardian*, "cleared away the old rookeries…and broke up the black spots which lay within an arrow's flight of the gilded chambers of the Town Hall."[156] Analysis of urban improvement must not forget the enormous, costly, prolonged physical effort through which the material basis for such pompous rhetoric was produced. The ensuing improvement was not simply the realisation of a dominant, guiding programme, reconfiguring space as dictated by master planners. Rather, it was the mangled, contingent result of hundreds of encounters between council and tenant, workman and brick, accountant and treasurer. Nearly one million pounds was expended mobilising builders, flagstones, ironwork, sewerage, surveyors, carpenters and horses, and paying disgruntled property owners and injured pedestrians, to modestly widen the city's central thoroughfare and leave its reputation as a weeping sore on the city's raddled physiognomy unaltered. The shallow foundations of slum dwellings still left them anchored in the earth, and their flimsy walls remained a refractory foil in the face of an army of Council improvers. What was the solution to the ills of Deansgate? More inspection, more plans, more figures, more reports. Simon and Inman's 1935 text, *The Rebuilding of Manchester*, closes with a chapter entitled "The Urgent Need for a Plan."[157] The urban engineering projects of the later Victorian period never amounted to

[155] Manchester City Council, *Proceedings*, January 1, 1881, 417.
[156] *Manchester Guardian*, June 28, 1890.
[157] Simon and Inman, *The Rebuilding of Manchester* (Manchester: Longman, 1935), 81.

'planning' as such, and for all the growth of networks of inspection and circuits of vision, the city's form proved obdurate and difficult to change.

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The examples of smoke abatement, glazing, paving and street widening all show how municipal engineers attempted to craft space, in a fashion calculated to engender environmental and sensory conditions through which the free circulation, exchange and observation of citizens could be enhanced. To some extent, it has upheld the idea that the city was a site where civilisation could be assembled, displayed and normalised. But what also emerges are several issues surrounding the contingencies of material arrangements and networks that made physically producing a totally civil, liberal, socially-transparent city an impossible mission. As emphasised, what emerged was perhaps a more differentiated set of environments and attitudes towards them, ones which loosely mapped onto, and underpinned, more traditional class distinctions.

Firstly, we cannot ignore the issue of maintenance. The civil city is always a work in progress. It is never assembled; it is always being maintained, inspected, improved. This laborious process of upkeep is easily forgotten. London's streets, for example, needed around ten million pounds annually to maintain them by the 1870s.[158] Manchester's Paving, Sewering and Highways commission lists the quite extraordinary array of workers, animals and objects required to keep the city's streets workably clean, clear and even. From horses, their harnesses, feed and carts to oils, bricks, chippings, tar and disinfectant, their records reveal the immense labour to prevent the entropic disintegration of frail material circuits.[159]

Secondly, the question of contingency is critical. The durability of material systems, besides depending upon upkeep, also relied upon increasingly calibrated, predictable, qualities of matter. But the kind of durability needed for street surfaces could not be tested in a laboratory: rather, quasi-laboratory conditions themselves had to be created in

[158] "London's Roads and the Cost of Them," *The Builder*, XXXIII, July 31, 1875, 678.
[159] See, for example, Manchester City Council Paving, Sewering and Highways Committee, *Minutes*, 22 August 1877, 19.

the street, for example by the laborious inspection mentioned earlier.[160] The problems of wood pavements become took several years of experiment to become obvious. Similarly, the series of problems befalling the Deansgate improvement – strikes, bad weather, shortage of materials, tenants' delays – were not apparent in advance and no long-term 'programme' could have predicted them. Moreover, the greater their size and the more heterogeneous and complex their morphology, the more dangerous these infrastructures potentially became. Gas networks, as shall be seen in chapter six, were particularly prone to accidents, which destroyed inorganic and organic matter with equal force. Walking through plateglass could kill, while thick smogs could leave pedestrians totally disorientated, with sometimes-fatal results.[161] The accident, from minor electrocution to major explosion, revealed the ultimate frailty of the networks of modernity, a point taken further in chapter six.

Thirdly, there is the question of visuality itself. I have argued that liberalism as a technique of rule hinged upon public visibilities and the materialities underpinning them. But as the case of smoke abatement suggests, something more than brute material resistance and contingency complicates this. An environment conducive to civility involved sewerage, deodorisation and silence. Yet a palpable film of industrial effluence was as much a part of the urban experience in 1900 as it was in 1840. Industry, aside from its economic importance, was also of course a bourgeois virtue, and models of the town emphasising this predate the rise of the industrial city.[162] Thus arose the "doctrine of black smoke and good business being inseparable."[163] It has been argued by Alain Corbin that, at the precise historical juncture when the public proximity of ordure, stench, noise and bodies was fast disappearing below the horizon of tolerability, industry managed to represent itself as, if not exactly salubrious, more tolerable than other practices raising sensory problems in civil society.[164] Further, domestic fires were not legally regulated until the 1956 Clean Air Act: the private realm was left free to pollute the public, Thus, compared to dungheaps and blood, smoke was less easily removed

[160] Latour makes a similar argument in *The Pasteurisation of France* (London: Harvard University Press, 1988).
[161] E.H. Baldock, for example, died after inadvertently walking through plateglass – see *The Builder*, XXXIII, 28 August 1875, 785.
[162] This 'filthy city', depicted by Mandeville in *The Fable of the Bees* is analysed by M. Ogborne, *Spaces of Modernity*.
[163] "The Atmosphere of Great Towns," *The Engineer*, LXXVIII, May 15, 1896, 496.
[164] Corbin, "Public Opinion, Policy and Industrial Pollution in the Pre-Haussmann Town," in *Time, Desire and Horror: Towards a History of the Senses* (Cambridge: Polity Press, 1995).

from the urban stage. This points towards a hierarchy of intolerability, which complicates both my rather heuristic notions of visual environment and the kinds of socio-sensory imaginaries they entail.

A brief final point: my examples all prove that hospitals, exchanges, schools and the like found it easier to implement these visual strategies. This should not surprise us. Perhaps the decline of the public sphere, so beautifully charted by Richard Sennett, has as one of its more distant, intangible causes the palpable impossibility, and, as he would have it, the undesirability, of fully realising a world of administered sensory conditions. In the Victorian period, however, the quest to manage public spaces within which physically normal and morally civil subjects could exist continued undaunted. This public realm hinged on the mutual inspection by and of its citizens: just as important to the functioning of the city, however, were the endless, everyday rounds of inspection, measurement and analysis by civic officials, a point developed in the next chapter.

3: The Inspection of the City: Measurement, Obscenity and Display

Anxiety about vision in the Victorian city developed in two directions. Firstly, there was the fear of structures decaying and breaking down when not exposed to the normalising eye of government. These structures were not simply social ones in the traditional sense: if social order came to rely increasingly on a set of nonhuman technologies to secure its civility, then these networks themselves required constant scrutiny and upkeep. Secondly, if civility was intimately bound up with raised thresholds of tolerance, then it became imperative to preclude certain sights from public vision altogether. From clampdowns on bull-baiting to the erection of public urinals, urban authorities battled to eradicate corrupting spectacles from everyday urban life, and replace them with more elevating and instructive ones. This complementary, and very modern, strategy, of maximum inspection of objects, and more nuanced, compromised observation of organic processes, is explored in this chapter.

Networks of Inspection

Modest though technological innovations like asphalt and plateglass were, when agglomerated, they amounted to a battery of techniques to build civil public and domestic spaces – quiet, salubrious, deodorised arenas of unfettered vision. But, once new streets, houses, parks, drains, and sewers were constructed, they could not merely be allowed to corrode and collapse. If liberal governmentality, the organisation of freedom, was a based upon a political dream of a self-regulating order of subjects, then the objects holding this order together required constant observation, fact-gathering and maintenance:

> Originally sound design and construction will not permanently secure the object aimed at. Pipes corrode and break, joints give way with time; moreover, when alterations are made, defective work is not infrequently introduced. Hence, periodical inspection is absolutely necessary to safety.[1]

[1] "On Sanitary Inspection," *The Sanitary Record*, VIII, April 19, 1878, 241.

This involved, in turn, making public inspection as a normal routine of urban life. Governmental agencies, therefore, had to both develop systems of permanent monitoring, and present these as consistent with a liberal ethos of rule which granted each citizen freedom from intrusion. Thus it was that governmental inspection developed awkwardly. Nonetheless, although often resisted and contested, by the final quarter of the century, the infrastructures and networks upon which the civil city had come to depend were exposed to regular and official observation, producing a gestating sense of accountability among, for example, providers of food, water, and gas.

Earlier attempts to inspect and monitor the conditions of the poor were usually philanthropic, particularly those influenced by the evangelistic emphasis on helping one's neighbour, a position consistent with the decline of the Calvinistic ethos. Such groups can be traced back into the eighteenth century, and they operated and multiplied across the century. Particularly notable here was the development of women's groups.[2] Bible-women, for example, delivered religious tracts and advice on household management from 1857. Other groups gave more practical resources to combat the ills of the age. In the 1870s, the Manchester Ladies' Sanitary Association administered carbolic acid and whitewash to slum residents, while the Wood Street Mission began its proselytising and rescuing of slum children in 1869. More familiar is the work of Octavia Hill, who recommended that responsible women take over courts and train the inhabitants in morally respectable conduct. Hill's system encouraged the familiar set of traits I have associated with liberal subjectivity: "self-control, energy, prudence, and industry."[3] The ensuing relationship between tenant and landlady, therefore, was hardly one of dependence; Hill was as determined to fight pauperism and instil self-help as Chadwick.

Parallel to these developments was the cautious germination of a more regular, institutionalised, and ultimately masculine, set of governmental apparatuses designed to observe and record the physical and moral conditions of the population. The idea of centralised monitoring, advanced by Chadwick in the 1840s, met with much resistance; the General Board of Health established in 1848 was sufficiently resented to force its early

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[2] See Prochaska, *Women and Philanthropy in Nineteenth-Century England* (Oxford: Clarendon, 1980).

[3] Octavia Hill, "Four Years' Management of a London Court," first published in *MacMillan's Magazine*, 1869. Reprinted in Robert Whelan, ed., *Octavia Hill and the Social Housing Debate* (London: The IEA Health and Welfare Unit, 1998), 63.

demise. But the 'sanitary idea' of its architect, and its insistence on orchestrated inspection was gradually cemented in practice over the following three decades. This inspection was itself more localised and devolved, adopting a less confrontational role than Chadwick's inspectorate had done. These inspectors rapidly found that the promotion of a uniform system of sanitation entailed a far greater concession to local conditions than was anticipated, something which extended as far as requiring translators to comprehend accents.[4] The ensuing compromise, evident between 1860 and 1890, involves elements of the approaches of both Hill and Chadwick: the intimate knowledge of the former, and the desire for system of the latter. In 1872, for example, Leigh reported that Nuisance inspectors, when visiting the courts and passages of the poor, were "to endeavour to place (themselves) in friendly relationship with the inhabitants."[5] A more comprehensive and effective apparatus of health, sanitary and nuisance inspection was coming into being, regularly inspecting, for example, slaughterhouses, sewers, gaspipes, lodging-houses and insanitary property. Although the legislation they wielded tended to be adoptive, the act of inspection itself, and the idea of minimal environmental standards that it upheld, was becoming, if not liked, then at least grudgingly accepted.

What, exactly, was the role of these inspectors? They were key relays in what Latour has called "action at a distance;" the ability of any set of governors, liberal or otherwise, to influence "unfamiliar events, places and people."[6] They functioned as observers and recorders of the urban fabric, checking the condition of pipes and pavements, tabulating the amount of smoke and flow of sewage, monitoring the airspace of rooms and the salubrity of wallpaper, taking samples of meat, milk and water. In doing so, these mundane figures literally brought elements of the city back to the offices from which it was governed. They thus accelerated the amount of information circulating purposefully from all corners of the city back to those, like Leigh, upon whom the burden of government had been placed. For example, information on the number and location of defective cesspools and the death-rate from various infectious diseases in different wards of the city could be correlated to produce a powerful argument for expenditure on a new sewage system. The information itself had been slowly and often painfully correlated by a team of observers. Unlike schemes like Hill's, this was an emergent bureaucratic machine

[4] See Hamlin, *Public Health and Social Justice in the Age of Chadwick*, chapter 9.
[5] Manchester City Council, *Proceedings*, April 8, 1872, 147.
[6] Latour, *Science in Action*, 223.

grappling with the messy contingencies of city life. It made the threat of inspection a permanent one and instilled, in theory at least, self-monitoring and correction. It also made routine the inspection of areas of city life usually hidden from view; cesspools, drains, slaughterhouses. All such inspectors checked for both illegality and salubrity, or what were slowly coming to be seen as minimal standards of environment. Rather than deriving their authority from moral or religious maxims, as Hill and others did, these teams of inspectors operated through norms and rules which had been scientifically established. This science, as will be suggested, was hardly abstract, but deeply mired in the mundane complexities of urban life, but it became increasingly important to the government of the city.

Calculating Intolerance

The task of the inspector, than, was to observe, measure and record. Central to this task was the accurate calibration of states and dimensions of matter. As in the case of atmospheric pollution, this entailed the invention and circulation of a proliferating number of instruments. An instrument has been described as "any set-up, no matter what its size, nature and cost, that provides a visual display of any sort in a scientific text."[7] Given their reliance on statistics, tables and numbers of all kinds, council documents and proceedings were scientific texts: their truths and suasive capacities were anchored in empirical data and consecrated techniques for ordering it. Instruments are thus "immutable mobiles", producing a common reading under differing sets of conditions, a reading which itself becomes an immutable mobile.[8] From complex machines like the photometers discussed later in chapter four, to the simplest ruler or measure, instruments are portable gauges of truth-production.

Measurement of distance and volume was critical to urban government, be it the width of roads, the volume of rooms, the area of window-space or the size of backyards, all of which gradually became subject to a legal minima of length and volume. Yards and inches, therefore, had to be standardised, to ensure that all the yards measured within a city were identical, and that a yard in Carlisle, say, was equivalent to a yard in Penzance. From the Weights and Measures Act of 1824, there was an ongoing Parliamentary attempt

[7] *Ibid*, 68.
[8] *Ibid*, chapter 6.

to standardise measurements, something which was acknowledged as increasingly imperative following the destruction, during the fire of 1834, of standards kept in the Commons. From 1855, copies of the pound and yard imperial standards were held at the Royal Mint, the Royal Society and the Royal Observatory, in addition to the Houses of Parliament. The imperial yard, for example, was composed of gunmetal and required testing every ten years for evidence of distortion. Standards were always to be tested at a temperature of 62° Fahrenheit. Concurrently, an inspectorate developed, checking the correspondence between primary standards and those utilised in factories and markets. Secondary standards were kept by the Board of Trade, which assumed control of them after 1865; they became the particular concern of the Warden of the Standards, who kept them safe in a fireproof room. Local authorities were obliged to provide examples for use by surveyors, builders and tradespeople from 1824, but this law was reiterated in 1878, indicating the persistence of unknown numbers of idiosyncratic local metrological units.[9] It was recommended that these standard measurements be placed "in the care of corporate bodies in large cities, and should be accessible for the use of the public," and be periodically tested and, if necessary, renewed.[10] Manchester City Council received a set of new standards, for the measurement of feet, inches, parts of inches, decimal grain weights, fluid ounces and standard avoirdupois grain weights, in 1879. The mathematical truths of urban space were thus anchored, theoretically, by a chain stretching from a battered, puckered inspector's measuring-rod right up to official standards preserved in revered sovereign institutions. Nonetheless, this circulating chain of reference was acknowledged by many to be defective, something upon which proselytisers for decimalisation capitalised:

> It is all very well to say that a pint contains 4 gills, or 34.66 inches, and to have a beautifully made vessel, containing exactly a pint, carefully preserved at Westminster or Somerset House; but this is very little good when we remember that out of every hundred bottles of wine or beer sold as if they were pint bottles, ninety-nine do not hold a pint at all![11]

Thus, once a normal level of domestic air-space, commercial volume or atmospheric purity had been scientifically established and legally consecrated, networks of calibration were necessary to monitor and maintain such standards. The value of these norms was

[9] For more details on the history of metrology, see Ronald Zupko, *Revolution in Measurement: Western European Weights and Measures Since the Age of Science* (Philadelphia: American Philosophical Society, 1990).
[10] *The Architect*, September 8, 1877, 130.
[11] H. Arnold-Foster, *The Coming of the Kilogram: A Plea for the Adoption of the Metric System of Weights and Measures* (London: Cassell and Company, 1900), 40.

often disputed, but that they existed and could be scientifically established was generally not. Thus, the standards of pure air decreed by the Alkali Acts, for example, only made sense within a system of routine examination of the emissions of factories producing, say, sodium bicarbonate. The passage of the first Alkali Act, therefore, was accompanied by legislation allowing inspectors to enter property. This army of inspection was organised under the control of Robert Angus Smith, who between May and December 1864 organized around 1000 inspections of works. But this centrally-directed inspectorate for a specific industrial emission was something of an exception, albeit a significant one which grew in importance. Salt and cement works, for example, were to be thus inspected following the 1881 Alkali &c. Works Regulation Bill. Most supervision was undertaken at a more local level. Smoke from other factories, for example, was generally surveyed by municipal authorities, as instructed under the 1858 Sanitary Act. In Manchester, Inspector Hurst of the Smoke sub-committee occupied himself in 1867-8 scrupulously watching the emissions from a total of 1,707 chimneys.[12] Periods of black, white and no smoke were recorded, as at the Govan Ironworks, Glasgow, in 1877: "the hour at which the observations were taken was from 11.52 to 12.52, and the results were 44 minutes black, 14 light, and two minutes no smoke."[13] Prosecutions could then be founded upon factories' transgression of temporal limits, as well as others involving relative impurity or volume of discharge.

Domestic spaces were similarly opened up to the habitual observation of council inspectors. Ashpits and privies were, by the 1890s, legally obliged to be a minimum of 6 feet from dwellings and 100 feet from water pipes in Manchester.[14] Byelaws established in the 1860s decreed that every room in a new dwelling in the city should be 9 feet high, with an aggregate window area of 10 ft^2.[15] Similar laws, as indicated in chapter two, developed for air space and street widths. The production of such spatial truths was not achieved via some putative imposition of an abstract scientific idea, but was ground out by engineers, builders and inspectors with fragile instruments, measuring the areas of windows or the widths of alleyways, irrespective of weather or the welcome offered them by residents. Their equipment, which included techniques of recording, enabled data (and, indeed,

[12] Manchester City Council, *Proceedings*, 1867-8, 375.
[13] "Smoke Nuisance," *The Sanitary Record*, VI, January 6, 1877, 12.
[14] *Manchester Municipal Code*, II, 690. The requirement for ashpits and privies to be at least 6 feet from houses is found in the 1877 Local Government Board Model By-laws. The figures were different for London.
[15] Manchester City Council, *Proceedings*, March 6, 1867, 108.

samples of such things as soil, milk and urine) to circulate with varying degrees of efficiency from remote corners of the city to the laboratories, offices and courtrooms, where facts piled up and their averages were calculated and appraised. Thus, networks of monitoring and inspection functioned by harmonising the activities of inspectors and their instruments and recording systems, and councillors and their graphs and tables. The reported facts in their thousands were made stable in the form of tabulated data, which, when combined, provided the foundation for governmental action. The practice of inspection, therefore, produced the raw morass of information ripe for processing. The durability and permanence of these sometimes threadbare conduits of data flow maintained the knowability of the city: the practical epistemology through which government operated was an ongoing labour generated through inspection. To the extent that government sought to frame environmental conditions within which organic normality could be achieved, inspectors and surveyors with their devices of quantification acted as conduits of mundane reason, upon which the maintenance of normality came to hinge.

Once again, we should be cautious. The undoubted proliferation of networks of inspection and calculation, and the ensuing acceleration of the circulation of information should not be equated with an abstract programme or rationality existing in a separate realm from its surgical and tactical application to 'reality' any more than the project to reconfigure urban space into a stage fit for civility. The practicalities of watching, measuring and documenting the minutiae of urban processes reminds us of the untidiness of governmental techniques. Following the passage of the first Alkali Act, Smith bemoaned the logistical problems of transporting cumbersome measuring equipment between factories, many of which were located some distance from railway stations. The problems were even more acute when measuring the effluence from factories whose condensers had been constructed at the pinnacle of smokestacks. Writing of an array of chimneys lining the banks of the Tyne, Smith complained of:

> The difficulty of mounting to the summit, and when there of working calmly at a height of 125 feet on a platform slenderly railed under a strong wind and even rain. One may occasionally stand for an hour under these conditions...and as a rule it may be said that inspectors who are not equal to sailors in climbing cannot make examinations at the summit of the towers.[16]

[16] R. Smith, "Annual Report for 1864," cited in Ashby and Anderson, *The Politics of Clean Air*, 19-20.

Inspection was always an embodied practice: an obvious point perhaps, but one worth making. In such conditions, the 'truth' was hardly something analytical, mental and rational but whatever set of inscriptions managed to maintain their legibility, crumpled and rain-sodden, from the gruelling, tedious act of observation and transportation.

In addition, recalcitrant factory owners often preferred to make conditions as arduous as possible for inspectors, as the *Sanitary Record* acknowledged in 1877:

> The difficulties in the way of obtaining even proximately correct information of this kind are in many districts almost insurmountable, the manufacturers in localities in which noxious vapours most abound being presumably the least disposed to furnish statistical statements.[17]

Tradesmen, when confronted by council inspectors, frequently behaved obstructively, or even violently: their defence, inevitably, was their liberty. Powers of inspection undoubtedly grew in the latter half of the century, but this was still legally complicated. The proliferation of inspection may have been perceived as an infringement of privacy by some, but for those aiming to coordinate the collation of urban knowledge, the meagre resources at their disposal were viewed with dismay. One MOH complained in 1879: "I would ask how, with the enormous district which I personally have to serve, it is possible for me to make these inspections."[18] Likewise, measurement itself was complicated by different sets of professional conventions and systems, as well as an array of local metrological peculiarities that obstinately endured attempts at rationalisation. Carpenters and joiners, for example, utilised different sets of measurements, so councils had to translate between differing metric idioms in order to produce standard measurements.[19] The vagaries of these practical indices, with their battens, loads, and squares, need not unduly detain us here.

The movement for smoke abatement, as suggested in the previous chapter, testifies more to the development of an orchestrated strategy for clearer air than palpable, statistically-proven evidence of its achievement. This orchestration, like the campaign for purer water, generated the institutionalisation of sampling and laboratory testing. Likewise, the quality and chemical composition of foodstuffs came under increasing scrutiny across the century. Food and drink had for centuries been the target of some form of governmental regulation: Edward the Confessor employed ale tasters to thwart adulterers of beer, while King John

[17] "Noxious Vapours," *The Sanitary Record*, VI, June 8, 1877, 384.
[18] "Systematic Inspection," *ibid*, X, May 2, 1879, 286.
[19] Alfred Beaton, *Beaton's Pocket Technical Guide: Measurer and Estimator for the Building Trades* (London: Lockwood and Co, 1872), 64.

attempted to control the cost and size of loaves through assizes. Sovereign efforts to moderate the nation's nourishment, however, were isolated, sporadic and often symbolic: Engels recorded a case of twenty-six "rancid hams" being publicly burnt in Bolton.[20] Like the bodies of ancien regime bandits and regicides, tainted meat was branded and marked.

As the vital consequences of industrialisation unfolded, the correlation between bad diet and physical decrepitude inevitably attracted investigation, as in Howard's 1839 text *An Enquiry into the Morbid Effects of the Deficiency of Food.* Aside from the intimate correspondence between diet and health, concerns were also raised about how food, particularly milk and meat, was produced, processed, distributed and stored. The industrialisation of food production itself made possible increasing chemical subterfuge at the point of manufacture. From the 1850s onwards, doctors and chemists regularly warned of the dangers to health posed by food impurity and adulteration. Critical here was a campaign waged by *The Lancet* between 1851 and 1854, headed by Hassall, which led first to a Select Committee on adulteration, and finally to the 1860 Adulteration of Food Act. The Food and Drink Act of 1875 extended and codified earlier acts, providing a more precise definition of maximum levels of permitted impurity. Later acts, like the 1887 Act for the better Prevention of the Fraudulent Sale of Margarine, firmly defined the legal purity of specific products. Again, establishing 'purity' involved the active sampling, transportation, and laboratory testing of food. Slowly, through the institutionalisation of analysis, food and drink would become routinely exposed to scientific scrutiny. Where once royal tasters' discretion and judgement separated good from bad, scientific trials produced visual evidence of the material composition of foodstuffs. The sense of taste was easily duped by the adulterer's chicanery: legal provision of labels would gradually tilt the phenomenology of eating towards the pole of vision.

Legislation also encouraged the development of local apparatuses to permanently test the quality of food. The 1860 Act allowed authorities to appoint analysts, but since they could only examine food as a consequence of an official complaint, it made little impact. This was altered by an act of 1872 enabling routine analysis to legally take place. In Manchester, the formation of a regular apparatus of food monitoring began in 1873, when the council first appointed a Public Analyst, Charles Escourt. He shared the Council's

[20] Engels, *The Condition of the Working Classes in England*, 81.

laboratory at Gaythorn gasworks, with Leigh. A year later, the Society of Public Analysts was founded, along with its journal, *The Analyst*. This society was empowered to adopt its own standards of purity: from 1880, for example, vinegar had to contain a minimum of three per cent acetic acid. Escourt and his cohorts compiled and delivered detailed reports to the council of the results of extensive sampling of milk, bread, fish and meat. These reports quantified and publicised levels of impurity, especially of milk, producing a neat figure, which could be tabulated over time to calculate long-term trends in food safety and quality. Nationwide, these slender networks produced between 15,000 and 18,000 results per year between 1875 and 1880. Around seventeen to eighteen per cent of all samples proved to be adulterated, according to the various legal norms in existence; an average distribution of impurity was established, which could then be driven down. When published, the figures were often seized upon by a popular press keen to expose fraudulent vendors – for example, the *Free Lance* regaled its readers in 1875 with a litany of metals found in children's sweets: "the three chrome yellows, or chromates of lead, red-lead; white, or carbonate of lead; vermilion, or bisulpheret (sic) of mercury; the three Brunswick greens; veritar, or carbonate of copper; and emerald green, Scheele's green, or arsenate of copper."[21] Despite such lurid reports, the concern here was generally less about poisoning than irritation and basic levels of nutrition.[22] For example, bread was frequently found to be impregnated with alum, which blocked digestion. Everyday aches and pains, it was hoped, would be minimised by carefully isolating rogue substances, like arsenic, while a framework was set in place within which shopkeepers or wholesale dealers were invited to be more accountable to their customers. From Escourt's laboratory, and other similar urban centres of calculation, the truth of matter was being produced and circulated.

However, these local statistical centres hardly amounted to a smooth publicity machine. One expert complained in 1887 that "the only reliable results of food adulteration have, until recently, been confined to purely scientific journals."[23] Legislation had itself proved extremely problematic: 'normal' milk, for example, organically varied according to the type, health and diet of the cow producing it. The established test for milk involved measuring its specific gravity; yet Hassall was forced to admit that "the specific gravity

[21] *Free Lance*, X, May 21, 1875, p162.
[22] We can observe a shift here from titles such as Accum's *A Treatise on Adulterations of Food and Culinary Poisons* (London: Longmans and Co, 1820), to books like Hassall's, which were more concerned with falsification and irritation.
[23] J. P. Battershall, *Food Adulteration and its Detection* (New York: E. & F. Spon, 1887), 2.

varies even among samples of good milk."[24] Proving intentional adulteration was also intrinsically troublesome. Most difficult, however, were the series of problems with the analysis itself. The contingencies and errors of nineteenth century laboratory science are perhaps nowhere more evident than in early food analysis cases, where defence and prosecution frequently came up with wildly divergent results. Condemning "the bungling of public analysts," *The Sanitary Record* reported several such cases in 1874, including one in Edgware where the prosecution had traced 45 grains of alum in a bread sample, while the defence found none.[25] "Who is to decide," complained *The Lancet*, "when chemical experts perform analyses with such widely varying results?"[26] Calls for a central laboratory to analyse the analysts received a predictably frosty response from the Society of Public Analysts, who complained that "it would supersede the skilled work of an analyst."[27]

Analysis would continue to be undertaken at a local level, in laboratories, which, like that at Gaythorn, were frequently shared by several men, the most important of which was the Medical Officer of Health. These figures, as suggested in chapter two, were truly heterogeneous inspectors, with responsibilities for pollution, sewerage, epidemics, housing, noxious vapours and adulteration. They were perhaps the most important calibrator of urban environmental conditions, scientist-detectives endlessly pursuing the insanitary and the putrid, as Manchester City Council pointed out in listing the variegated nature of his role:

> Much of the work done would be of a scientific character, and an extensive knowledge of chemistry and of natural philosophy, in addition to ordinary medical knowledge, must be possessed by the Officer of Health.[28]

Analysing rainfall and testing levels of illumination were just two of these tasks. Over the following two decades, the qualifications required by MOsH were formalised, a process facilitated by the founding of the Sanitary Institute of London in 1876, which provided diplomas. In 1888, for example, it was decided that a diploma in sanitary science was a

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[24] Frederick Filby, *A History of Food Adulteration and Analysis* (London: George Allen and Unwin, 1934), 200.
[25] "Public Analysts and Private Adulterators (II)," *The Sanitary Record*, I, July 35, 1874, 66.
[26] *The Lancet*, May 2, 1874, I, 613.
[27] "Public Analysts," *The Sanitary Record*, I, August 8, 1874, 108.
[28] Manchester City Council, *Proceedings*, August 15, 1867, 266.

necessary qualification for any Medical Officer of Health presiding over a district with a population greater than 50,000. Several admirable studies of these men exist.[29]

What is notable here is the great expansion of the numbers of inspectors and officials whose ubiquitous activities greatly enhanced the scope and efficacy of the MOH. Leigh became responsible for a coordinated battalion of men whose tasks became increasingly tuned to specific urban ills. For example, in 1869 and 1870, Manchester City Council appointed official disinfectors and whitewashers, the former to spray the houses of the hospitalised with chlorine, and the latter to scrape away any wallpaper, incinerate it in the Council furnace in New Allen Street and then coat the walls with caustic soda and whitewash. Some of these walls, it was revealed, had been covered in as many as fifteen layers of pestiferous paper.[30] The relationship between certain forms of decoration and ill-health had become a notable concern; lead, antimony and arsenic were all found in paint, while the chemical composition of wallpaper was perhaps of less concern than its tendency to harbour moisture in air pockets or conceal patches of dirt.[31] While no council could appoint chemists or analysts to routinely sample and test the material with which the poor embellished their homes, disinfectors and whitewashers, unskilled men with a simple brief, could prevent the potential lingering of dangerous clusters of germs and filth. Urban governance entailed the growth of such humble routines aiming to secure environmental minima: the working classes were free to develop an abiding taste for wallpaper.

A larger and more significant set of local inspectors were charged with the task of monitoring, reporting and regulating nuisances. The legal term 'nuisance' dates back to at least Tudor times: but it was defined in the 1846 Nuisances Removal Act very broadly, as anything unwholesome, insanitary, filthy or foul which interfered with the health and movement of the urban population. A series of further acts, of 1855, 1860 and 1863, widened this definition still further so as to include industrial smoke, polluted rivers, slaughtering of animals and street refuse. In Manchester, as in other cities, the council established a Nuisance Committee to monitor these offences. There were specific

[29] For example, W.M. Frazer, *Duncan of Liverpool: Being an Account of Dr. W.H. Duncan, Medical Officer of Health for Liverpool, 1847*-63 (London: Hamish Hamilton Medical Books, 1947), which describes the career of Britain's first MOH; Royston Lambert, *Sir John Simon, 1816-1904; and English Social Administration* (London: MacGibbon and Kee, 1963)
[30] Manchester City Council, *Proceedings*, April 8, 1872, 135-9.
[31] See, for example, H.C. Bartlett, "Poisonous and Non-Poisonous Paints and Wall Papers," *The Sanitary Record*, VI, January 6, 1877, 12.

inspectors, for example, for smoke and rivers, while for the general inspection of sanitary conditions and illegalities, there were six inspectors for six districts. In 1870, the old Nuisance Committee of Manchester was radically reorganised, with the number of these general inspectors increased to nineteen. Like the MOH, with whom they collaborated closely, they had a wide and eclectic remit, locating them somewhere between health inspection and police – indeed, many of their cases were later referred to such committees. The broad spectrum of urban irritants with which these inspectors dealt inevitably led to clashes with other officials and legal ambiguities; rather than addressing crime or disease per se, they reported practically anything that could be said to inhibit, or interfere with subjects' freedom to move and breathe. 97,618 visits to the homes of the poor took place in 1870: 3,239 resulted in a verdict of a 'dirty house'. Municipal levels of domestic salubrity hinged on such statistics. The conditions of streets were regularly examined: for example, any "projections and encroachments" beyond building lines were penalised, usually with warnings or small fines. In 1870, 186 notices were served to citizens of Manchester for this offence.[32] Public urinals were scrutinised and sprinkled with carbolic acid. Loitering, street games, smoking chimneys, swearing, playing shinty, wheeling barrows on footpaths, spitting, kite-flying, short sun-blinds and roaming dogs were similarly reported, tabulated, quantified and the culprits apprehended and penalised. Supplying analysts with regular samples of foodstuffs was another of their tasks. Nuisance inspectors were also enlisted in the endemic battle against smoke; in 1876, Manchester's inspectors were instructed to report any instances of black smoke billowing from a chimney for more than three minutes out of thirty.

The minutiae of urban life were slowly being exposed to a more systematic routine of council inspection. Lodging-houses "in which persons of the poorer class are received for short periods, and although strangers to one another, are allowed to inhabit one common room," were particularly singled out for inspections, which took place at night.[33] Men and women were to be strictly segregated, rooms ventilated and lime-whited, and, in an attempt to curtail overcrowding, each resident legally entitled to 500ft^2 of air-space. When the Great Britain Sanitary Institute began holding examinations for inspectors, competence at the calculation of the size of rooms was explicitly demanded. In 1881, question three of the paper asked: "describe the method of measuring the available air space in rooms. How

[32] Manchester City Council, *Proceedings*, September 21, 1871, 382.
[33] *Ibid*, June 25, 1873, 320-1.

much air space is desirable? How much should be insisted on?"[34] Many inspectors were drawn from the building trade, where familiarity with the pragmatics of urban mensuration had been generated. All had to keep permanent records of the results of their odysseys through the dour hinterlands of the city. Inspectors were thus to be armed with the requisite practical skills to uphold the shifting legal minima deemed consistent with liberty, vitality and civility, the implementation of which was inevitably hindered by money, limited resources, space, obstinacy, mistakes and human inertia.

Manchester's Nuisance Committee was abolished in 1890, and split into separate Sanitary and Cleaning Committees. Along with the police, the MOH, and separate posts like the Public Analyst, it had slowly made the idea of public inspection tolerable. By exposing the streets, yards, shops, factories, pubs and lodging-houses to regular inspection, and recording the conditions of walls and windows, and the habits of men and animals, consecrated levels of decency were, doggedly and hesitantly, established. This entailed removal and prohibition of certain practices and spectacles which were regarded as fundamentally inconsistent with civilised conduct: death, defecation and sex. Natural and inescapable, these primal processes of the human, and animal, body were subject to a moral anxiety which was frequently invoked in visual terms. Urban inspection, therefore, formed part of a ceaseless quest to locate and expunge all vestiges of visual corruption from the public realm, which was to be a space in which the spectre of raw nature was erased.

Machinating Nature: Public Abattoirs, Aquaria and the Engineering of Sensibility

Nuisance inspectors patrolled and reinforced the lines dividing civil from uncivil, public from private, tolerable from intolerable, lines which both legal and material reorganisation had also attempted to make less ambiguous. Opening the city up to official as well as less organised forms of visual interrogation thus functioned as a central technique through which new norms of decency were embedded. The kinds of material reform of the urban

[34] "Inspectors of Nuisances," *The Sanitary Engineer*, IV, August 15, 1881, 425.

fabric depicted in chapter two were vital to this project. The Deansgate Improvement, for example, had as one of its aims the eradication of the spectacle of vice: alcoholism, prostitution and violence, pathologised and vilified, could be limited by creating a public architecture where pockets of darkness were expunged. Inspection, as suggested, tackled less ostentatiously 'criminal' activities, many of which were explicitly seen as affronts to the senses and motion of the civil subject. Public houses without urinals, for example, led inevitably to the spectacle of men urinating in the street. Cocks crowing through the night drove nervous clerks to the brink of despair; the sound, "loud, piercing and intermittent," was seen as "the enemy of slumber essentially."[35] Dogs roaming the streets interfered with the smooth progress of carts and cabs. Inspection, therefore, formed one axis of a wider modern project to organise nature.

Dickens's much-quoted observation of Coketown, that nature was "bricked out"[36] of a polluted, penumbral realm of concrete and iron has perhaps unduly influenced perspectives on the relationship between nature and the Victorian city. In fact, urban areas teemed with nonhuman life; we find pigs and donkeys ensconced in houses, packs of dogs, cat colonies, effloresing pigeon and rat populations, legions of horses providing the locomotive basis of the city's commerce and transport, insects infesting walls, beds and bodies, eels in water mains, giant frogs lurking in street hydrants. The problem for Victorian urban government was not to remove nature, but to create legitimate spaces for it, to make it a permanent yet unobtrusive resource for nourishment, physical vitality, moral elevation and motion. Animals had to enter into sets of well-defined relations with humans, to become pets, meat, forces of locomotion or zoological examples, a process entailing careful construction of spaces for nature within the city. These spaces were vital to both feeding and transporting urban populations, but here, I wish to concentrate on what such organisation of nature tells us about evolving shifts in norms of sensibility and their visual elaboration, and what this can tell historians about governing liberal cities. To elucidate these points, I will focus on two institutions: the abattoir and the public aquarium.

Central to the problem of nature was the problem of vision. 'Coketown' was full of nature, and natural processes, but their chaotic proliferation frequently confronted the senses with

[35] "Cock-Crowing," *The Sanitary Record*, III, July 24, 1875, 61.
[36] Charles Dickens, *Hard Times*, 54.

the immediacy of crawling, viscid life. Howling dogs and creeping lice assailed ears and skin. The stench of dogs could, it was claimed, reach such proportions that young girls fainted.[37] Pets, by contrast, are soft to stroke, purr benignly, and don't stink. More problematic was the sight of cruelty and slaughter, which, when juxtaposed with the absence of humanising sights of flowers and trees, engendered an environment of indifference and tolerance of natural spectacles or processes which respectable people found distressing or repugnant. Thus the management of nature within the city was regarded as critical to generating a sense of decency and humanity among the poor.

Indifference, as argued in chapter one, was the outward sign of desensitisation and lack of civility. When this indifference shaded into outright brutality, concerns were magnified. The equation of social disconnection, corruption, desensitisation and physico-moral pathology structured much of the discourse of urban improvement across the period, especially informing the pervasive environmentalism of sanitarians, architects, and evangelicals. Removing corrupting, degrading and demoralising sights from the urban environment - nudity, death, blood, sexual practices, bestial disorder, and defecation - could produce a realm of the obscene, while fecund, bountiful life was staged in zoos, parks, gardens and museums for the moral improvement of the public. Public abattoirs and aquaria are instances of this attempt to lower thresholds of tolerance and reconfigure norms around an engineered nature, which became both moral exemplar and foul font of all corruption. Their morphology facilitated a certain relationship between the senses, emotions and space.

Vision, Slaughter and the Architecture of Demoralisation

Decency was almost impossible in the dense, communal spaces of the poor. Natural bodily functions were socially performed in spaces precluding privacy. Open to familial and even public view were pain, death, defecation and nudity, which generated tolerance and indifference. In his 1840 volume, *The Philosophy of Marriage*, Ryan observed how "scarcely any street can be passed through without meeting some storehouse of obscenity."[38] Moaned George Sims: "poor artisans' children grow up with every form of

[37] "Prosecution of a Dog Fancier," *The Sanitary Record*, V, September 23, 1876, 204.
[38] Michael Ryan, *The Philosophy of Marriage*, 146. Quoted in Elizabeth Wilson, *Sphinx in the City*, 39.

crime and vice practiced openly before their eyes."[39] This led to the poor becoming "so used to discomfort that they do not look upon a corpse in the room they live, and eat, and sleep in as anything very objectionable."[40]

The city's animal population created equally acute visual problems. At fairs and circuses, for example, promiscuous mingling of animals and humans in bawdy, bodily carnival undercut the order regarded as necessary for the function of civil cities. From 1871, following the Fairs Act, Corporations moved rapidly to close these sites of disorder, as they had over practices such as cockfighting, bear-baiting and prize-fighting. In truth, fairs had long been in decline. Knott Mill Fair, held yearly at the southern end of Deansgate, had become regarded as a menace to urbanity, a vestige of a pagan past, ill-disciplined and coarse, a throwback to the days of Merrie England. It was closed in 1876, forming another aspect of the improvement of the thoroughfare and its environs.[41] Such demotic spaces were being replaced by rational, controlled, public leisure areas – tennis-courts, skating-rinks, parks and libraries. Public displays of cruelty, like those of teeming life, were slowly being eradicated: anti-vivisection and vegetarianism flourished. To gratuitously revel in the agony of a tormented beast was to eschew one's human soul. Lord Erskine, while unsuccessfully promoting his Cruelty to Animals Bill in 1809, forcefully argued that "these unmanly and disgusting outrages are most frequently perpetrated by the basest and most worthless; incapable, for the most part, of any reproof which can reach the mind."[42] The supreme display of desensitisation was to palpably show one's incapacity for sympathy. Discourses of sensibility and reform of practices combined to generate what Alain Corbin has referred to as a "revolt of being" among the bourgeoisie, for whom thresholds of disgust and sensibility were being slowly redrawn.[43] Even obscene waxworks were suppressed.[44] Subtle shifts in attitudes focused the attention of reformers upon recalcitrant spaces of the city, as Stallybrass and White argue:

> The reformation of the senses *produced*, as a necessary corollary, new thresholds of shame, embarrassment and disgust. And in the nineteenth century, these thresholds were articulated

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[39] G. Sims, *Horrible London*, 115.
[40] *Ibid*, *How the Poor Live*, 60.
[41] Three other Manchester fairs were all abolished in the same year.
[42] Cited in James Turner, *Reckoning With the Beast: Animals, Pain and Humanity in the Victorian Mind* (London: Johns Hopkins University Press, 1983), 22.
[43] A. Corbin, "The Blood of Paris," *Time, Desire and Horror*, 178.
[44] For example, "The Police and the 'Tableaux Vivants'," *City Lantern*, III, December 8, 1876, 85.

> above all through specific *contents* – the slum, the sewer, the nomad, the savage, the rat – which, in turn, remapped the body.[45]

The slaughterhouse should be added to this list. A realm of violence, pain, screams and horror, it was a critical space where such redrawn thresholds of sensibility were articulated and materialised. Prior the 1870s, slaughterhouses were almost invariably small private establishments; converted houses, shops or stables nestling in courts and alleys off main thoroughfares. Observed Dudfield, Medical Officer of Health for Kensington, of his vestry's slaughterhouses in 1873: "With one or two exceptions, the buildings do not appear to have been erected with reference to the special purpose for which they are used, and hence many of them are wholly unsuitable."[46] Such spaces intermingled with local houses, shops and streets. Ventilation and light were often lacking, while water-supply could be fitful, resulting in conditions as squalid as these reported from the City in 1876:

> In a general state of disrepair; the roofs dilapidated, the flooring uneven and broken, the side walls filthy and bloodstained, the drainage defective and sluggish, the water-supply inadequate and badly-placed. Accumulations of dung, offal and blood were general…nothing short of entire reconstruction of these premises will satisfy the requirements of sanitary science.[47]

This was not an arrangement lending itself to easy monitoring: "under existing circumstances a systematic examination of animals is impossible."[48] These filthy, dark and disconnected enclaves of horror offended sensibility in other ways. Animals were frequently forced, in public view, through narrow streets and even shops en route to their deaths. "Few things can be more objectionable," wrote Dudfield in 1876, "than the driving of terrified animals through shops and dwellings."[49] The proximity of butchery to domestic and commercial space, combined with lack of drainage and storage, created conditions confronting urban dwellers with violence and cruelty. Describing slaughterhouses off Deansgate in 1869, one writer complained, "out of the slaughter-houses in them comes the bleating of the bleeding calves."[50] Concerned London citizens wrote to *The Builder* in 1874 complaining that they "meet the blood and offal as they are being conveyed across the footpath to the carts which come for them."[51] Aside from the sanitary implications, this display of pain and blood was palpably demoralising and

[45] P. Stallybrass and A. White, *The Politics and Poetics of Transgression*, 148.
[46] Dudfield, "London Slaughterhouses," *British Medical Journal*, November 1, 1873, II, 522.
[47] "The City Slaughter-House and the Proposed By-Laws," *The Sanitary Record*, July 8, V, 1876, 21.
[48] "City Slaughterhouses," *ibid*, I, July 11, 1874, 23.
[49] T. Dudfield, *London Slaughter-Houses and Cow Sheds* (London: W.H. & L. Collingridge, 1876), 9.
[50] *Sphinx*, January 16, 1869, 203.
[51] A letter from 'Two Citizens' in *The Builder*, XXXII, July 25, 1874, 624.

desensitising. "There is a moral taint surrounding these places," observed the Manchester Butchers' Guardian Association in 1869.[52] The slaughterhouse was insufficiently private: it revealed barbarity at the core of civilisation, producing a corrupting and desensitising spectacle:

> In some localities it became almost a pastime for young children of both sexes to frequent the slaughter-houses, and witness the death-struggles of the butchers' victims. This familiarity with scenes of blood was justly considered as having an immoral influence.[53]

Sympathy and care could never be nurtured in a world where the evidence of pain oozed out of every crevice. Humans, many argued, were not intrinsically or infinitely good: as one polemicist for humane treatment of animals put it, they have "but a limited supply of sympathy which is rapidly reduced in volume, and sometimes entirely dried up, by an extended use, or a persistent repetition" of cruelty.[54] Like hangmen, slaughtermen and butchers were the pariahs of society, whose activities "must absolutely and necessarily brutalise, degrade, and demoralise the men whom we doom to this trade."[55]

The development of a system of public abattoirs in Manchester and other provincial cities was the culmination of a protracted campaign to shroud the degrading display of death in urbane silence and obfuscating cement. In London, concerns over the trade first found legal sanction in the 1844 Metropolitan Buildings Act, which gave noxious trades, including butchery, thirty years to improve conditions compromising health and morality. These included provisions to move slaughtering to no less than 40 feet from streets, or 50 feet from houses.[56] Slowly, urban form and sensory intolerance were being legally aligned. From 1851 all new slaughterhouses in London required a licence. Yet in 1874, when metropolitan butchery was obliged to distance itself from more wholesome activities, sanitarians reported that many slaughterhouses were "screened from public view by canvas only, or not at all," and often took place in the same building as inhabited lodgings.[57] These kinds of premises were too small and isolated to be touched by comprehensive rebuilding regulations. Following the resistance of the powerful metropolitan butchery trade, the 1874 London Slaughterhouse Act allowed older premises to remain open, providing they were more scrupulous about practice. Regulation eleven of

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[52] Manchester City Council, *Proceedings*, January 15, 1869, 291.
[53] A. Darbyshire, "On Public Abattoirs," *The Builder*, XXXIII, February 6, 1875, 113.
[54] Josiah Oldfield, *The Evils of Butchery* (London: William Reeves, 1895), 12.
[55] *Ibid*, 13.
[56] "Slaughter-Houses in the Metropolis," *The Builder*, XXX, August 17, 1872, 643.
[57] "London Private Slaughter-Houses," *The Sanitary Record*, I, December 19, 1874, 436.

this act stated unconditionally that "no slaughtering may be done within public view."[58] In the same year, a system of public abattoirs was built in Copenhagen Fields in the City, and 284 London slaughterhouses were abolished over the following two years.[59] However, the persistence of insanitary metropolitan slaughterhouses was commonly acknowledged, and for many was tied explicitly to formal questions of administration, as *The Lancet* concluded in 1874: "until the whole metropolis is brought under municipal government there is little hope of any others being established than those belonging to the City."[60]

In provincial cities, less powerful and refractory butchers were more easily persuaded of the benefits of central abattoirs. Manchester's complex of abattoirs and markets, for example, was completed between 1870 and 1873. These spaces were machines for humane and salubrious killing. Pain, for example, was alleviated by swifter, scientifically-established techniques. There had even been claims that "excessive fatigue, terror, panic, or rage, deranges (animals') functions and the nutrition of their tissues, not only diminishing the quantity but affecting the quality of their flesh."[61] Likewise, animals denied water and ventilation, when slaughtered, were held to yield "dry, sapless and blackened flesh."[62] Traditional techniques of slaughter were criticised as unduly cruel. Poleaxing, for example, frequently required five or six blows to kill an animal. Methods involving stabbing and throat-slitting were regarded as equally barbaric. Experiments were conducting with carbonic acid (administered via masks or in chambers), guillotines and dynamite. In 1883, the London Model Abattoir Society proposed the use of electricity. As I will show in chapter six, electricity's efficiency as a death-device would reconfigure urban anxieties in the later 1880s and 1890s.

The abattoir was a large, internally differentiated space sealed from the world without, yet open to perennial council inspection, which distinguished it from the typical city slaughterhouse: "the contrast between a properly constructed abattoir and the existing slaughter-houses cannot fail to impress."[63] Any city butcher could bring animals there to

[58] "Metropolitan Board of Works Regulations for Slaughter-Houses," *Ibid*, I, November 14, 1874, 346.
[59] "Slaughter-Houses and Offensive Trades," *The Lancet*, September 13, 1876, II, 440.
[60] "London Slaughterhouses," *ibid*, July 11, 1874, I, 57.
[61] "Cruelty and its Pathological Effects," *Ibid*, March 8, 1873, I, 354.
[62] Oldfield, *The Evils of Butchery*, 27.
[63] "A Report by MOH and Borough Engineer of South Shields upon City and Borough Abattoirs," *The Sanitary Record*, V, August 5, 1876, 92.

be systematically laired, killed, refrigerated and stored: "the lair being entered by the cattle intended for slaughter at the back, and the meat, when dressed and ready for human food, passing out at the front for the purposes of commerce."[64] Lairing and slaughter were divided: "the buildings have been designed so that animals being taken into them never see the slaughtering till they are taken to be slaughtered."[65] The unnecessary fear inspired in animals by being "witnesses to the slaughter of their companions" was removed by this further separation of death from life.[66] The dreadful, nightmarish netherland between life and death was abolished: until the instant of death, animals' life was respected. Cowsheds were to be ventilated and louvred. Like humans, the amount of respirable air necessary for vital normativity was calculated and materially enshrined in building regulations. Dudfield, for example, argued that "the allowance of space for each cow shall not be less than 800 cubic feet."[67] The epoch of the norm had a bovine dimension.

Thus the public abattoir was a technology for both occluding pain and cruelty, and ordering nature and society: flesh was drained, chilled and stored, blood and offal "placed in impervious, covered, moveable receptacles, constructed of galvanised iron or other non-absorbent material, and removed from the premises without delay," followed by a thorough circulation of water.[68] The abattoir was a death-machine: socially useful meat was separated from abject waste, while each was materially sealed from the urban sanitary network by systematic deployment of tile, asphalt, iron, brick and concrete: "no offal or manure is allowed to pass into the sewers."[69] Larger ones were rational, machinated citadels of death: the Parisian abattoirs, built in the 1860s, contained 311 slaughterhouses when fully built, and included pavilions for "roasting pigs in gas…the cleansing of offal, the triperies, the blood store, the extraction of albumen and animal oil, the preparation of calves' heads and sheep's feet, &c."[70] The process of making animal into meat, oil and glue was effaced, eradicated from urban vision and consciousness, blackboxed. This secret space, where life was silently erased, cemented a cryptic space of the obscene and reinforced the decency of cleansed, bloodless public space.

[64] Darbyshire, "On Public Abattoirs," *The Builder*, XXXIII, February 6, 1875, 113.
[65] M. McKie, "Carlisle Public Slaughter-Houses," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, XIV, June 23, 1888, 257.
[66] "London Private Slaughter-Houses," *The Sanitary Record*, I, December 19, 1874, 436.
[67] Dudfield, *London Slaughter-Houses and Cow-Sheds*, 20
[68] "Preventing Slaughter-House Nuisances," *The Sanitary Engineer*, IV, September 1, 1881, 451.
[69] Dudfield, "Slaughter-Houses of the Future," *The Sanitary Record*, II, June 5, 1875, 365.
[70] "The Congress of French Architects," *The Builder*, XLVIII, June 13, 1885, 829.

Displaying Nature

The creation of public abattoirs was thus one aspect of the engineering of privacy, whereby natural processes could be shielded from public eyes. As has been shown in earlier chapters, in innumerable urban locations, promiscuous communal areas and dense pockets of human activity were slowly replaced by more unambiguously public and private space. Natural processes of death, sleep, washing, defecation and procreation were all situated within a more consciously differentiated private architecture. Parallel to this was a movement, gathering in pace across the century, to protect green, open spaces from the rapacious expansion of cities. From small local groups like the Manchester Society for the Preservation of Ancient Footpaths, dating from 1826, to potent organisations like the Commons Preservation Society, founded in 1865, there was mounting concern about the need for air and greenery within towns. This movement bore legislative fruit, for example in the 1877 Metropolitan Open Spaces Act, which enabled authorities to acquire land in the capital for the explicit purposes of recreation. More wide-ranging powers, to acquire land as well as preserve it, were attained by the National Trust, founded in 1895.[71]

But nature was also deployed in the creation of public spaces devoted to pleasurable gazing, consumption and observation. Parks, arboreta, gardens, orchards and flowerbeds were engineered to manufacture beautifying displays of fecund order. As well as infusing urban atmospheres with vital oxygen, verdant spaces were lauded for their elevating effects on desensitised urban masses. "The humanising effects of beautiful scenery upon the hearts and minds of men can scarcely be exaggerated."[72] Asylums, hospitals and sanatoria positioned patients to face sunlight and greenery: "The inmate of an asylum ward cannot have scenery too beautiful or surroundings too bright, seeing that he has nothing to look upon from day to day all the year round, and perhaps all his life long."[73] The Kyrle Society, founded by Octavia Hill and her sister Miranda in 1875, distributed flowers to the poor to awaken sensitivity to nature. In Salford, Hyacinth bulbs were distributed to residents; the resulting flowers, if they thrived in the rainy Mancunian

[71] For more details, see Robin Feddon, *The Continuing Purpose: A History of the National Trust, its Aims and Work* (London: Longmans, 1968).
[72] *Free Lance*, IV, January 23, 1869, 25.
[73] William Dawes, reviewing the current state of asylum architecture in the *British Architect*, XIII, 5 March, 1880, 127.

climate, were be brought to subsequent exhibitions and judged.[74] The practice of tending to flowers in plants in window boxes and individual pots was encouraged. The nurturing of life, even on such a small scale, had moral, visual and environmental connotations; admiring the fruits of one's labour encouraged a sense of achievement and self-respect, while the plant itself actively oxidised the atmosphere of the house or court in which it germinated and flowered.

The zoo was a larger-scale exhibition of natural order. Menageries, which date back to at least the time of the Egyptian pharoahs and in Britain to the reign of Henry I, who built one at Woodstock, were invariably ostentatious displays of purely royal or imperial power. While it would be naïve in the extreme not to acknowledge similar pretensions at work in the modern zoo, the differences are important. Regent's Park Zoological Gardens, established in 1828, set out to distance itself from such sites, in terms of size and permanence. Furthermore, the gardens were established with scientific knowledge in mind: collections of animals could be observed and measured. Provincial zoos grew in number: in Manchester, the zoological gardens, which contained elephants and polar bears, were founded in 1842.[75]

The natural world was exhibited for the edification and elevation of society: the two realms were neatly aligned and separated by the act of observation. This is particularly evident in the case of public aquaria. Unlike the zoo, with its long history, the aquarium was regarded as "peculiarly modern."[76] The first true public aquarium was the fish-house established in the Zoological Gardens at Regent's Park in 1853, and many were constructed after 1870, most notably at the Crystal Palace, Brighton, Liverpool, and the Royal Aquarium in Westminster. Manchester's Aquarium, which opened in Alexandra Park in 1874, had an elaborate Italian Gothic frontage, giving the building an "ecclesiastical appearance; it might be taken for a giant temple, erected for some popular preacher."[77]

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[74] "Flowers for the Poor," *The Builder*, XXXI, March 29, 1873, 253.
[75] B. Love, *The Handbook of Manchester*, 1842, 273-4. For more details on zoos, see Vicki Croke, *The Modern Ark. The Story of Zoos: Past, Present and Future* (New York: Scribner, 1997).
[76] J. Taylor, *The Aquarium: Its Inhabitants, Structure and Management* (London: W.H. Allen and Co., 1884), 5.
[77] "The Manchester Aquarium," *The Builder*, XXXII, February 28, 1874, 174

Behind this imposing facade was a tuned machine for producing and maintaining the environmental conditions apposite for piscine life. Marine and littoral climes were replicated by 200,000 gallons of Blackpool seawater, circulating through subterranean cisterns. Fresh water tanks housed river and lacustrine fish, "by means of which it is hoped that the most delicate of fresh-water fish may be kept for an indefinite period in full health and vigour."[78] The water itself was only one of many environmental elements brought into harmonious juxtaposition. Plant life was required to replenish aquatic oxygen, as the naturalist Philip Gosse wrote in 1853:

> My notion was that as plants in a healthy state are known to give out oxygen, and to assimilate carbon, and animals on the other hand consume oxygen and throw off carbonic acid, the balance between the two might be ascertained by experiment, and thus the great circular course of nature, the mutual dependence of organic life, be imitated on a small scale.[79]

Like air for terrestrial creatures, water "must be kept in constant circulation day and night."[80] A relatively low temperature had to be maintained, between 40 and 65 degrees Fahrenheit. Like humans and cows, piscine creatures had calculable environmental norms facilitating their growth and health. Maintaining these norms required adequate ventilation or judicious administration of ice cubes: "the water in the Aquarium should always be cold to the hand."[81]

Viewing conditions were calculated and managed. Light, wrote one aquarium engineer;

> Is all important, for to enable the contents of the show-tanks to be properly seen, it is absolutely necessary that the hall or corridor in which the spectators are should be much shaded, and that nearly all the light it receives should come through the water in the tanks.[82]

In such conditions, fish naturally gravitated to the tank's darker perimeter, and closer to the visitors. The features and colours of fish were particularly pronounced if highlighted against a dark, inclined backdrop. Thick plateglass was used for the viewing surface. Tanks, also, should not be excessively broad, which placed excessive lateral strain on the glass: at the Crystal Palace aquarium, huge tanks shattered, leading to the adoption of structurally-reinforcing iron mullions.

The ensuing arrangement, with freshwater, coastal and marine fish assigned separate areas, produced a viewing effect modelled on that of familiar urban visual practices, as

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78 *Ibid*, 174.

79 Philip Gosse, *A Naturalist's Rambles on the Devonshire Coast* (London: John Van Voorst, 1853), 228-9.

80 C. Driver, "Aquaria and their Construction," *The Builder*, XXXIV, March 11, 1876, 243.

81 W. Hughes, *On the Principles and Management of the Marine Aquarium* (London: John Van Voorst, 1875), 27.

82 C. Driver, "Aquaria and their Construction," *The Builder*, XXXIV, March 4, 1876, 213.

The Builder reported before the opening of the Manchester Aquarium: "the animals which these tanks will contain are seen not only through glass frontage, but in precisely the same way as the contents of the glass cases in our museums are."[83] The underwater world was established as a taxonomic display, organised for considered inspection. Less obviously, this act of ontological encasing, in glass, light and water, permanently held nature at a distance from humanity, just like the abattoir. The glass case positioned nature under permanent observation, a legitimate and edifying position within the modern collective. Physiological quandaries relating to fish and marine reptiles could be solved:

> Until quite recently, the living inhabitants of the sea have been practically inaccessible to the inquirer, and to place a multitude of them in a position in which all their actions can be observed, and in which, whenever necessary, they may be captured for closer examination, cannot fail to lead to the clearing up of many uncertainties and to the acquisition of much new and important information.[84]

At Manchester, for example, the ontogenesis of the herring's young was observed and recorded for the first time. In the wake of the publication of *The Origin of Species*, it was suggested that large aquaria were necessary so that "the study of the embryology and larval conditions of the lower animals could be more easily followed." The aquarium thus became a kind of "zoological station for the observation of the life-histories of marine animals analogous to astronomical observatories or stations."[85]

Consequently, the aquarium was one of many technologies making possible the dominance of vision: fish could be effortlessly examined from every angle without the viewer encountering their rank odour or scaly bodies. By establishing and making durable visual distance, crowds could be educated in the pleasures of silent contemplation, attention and interest, as Henry Humphries argued:

> By lifting even the mere border of that green curtain of the ocean, or by awaiting its unveilings, as the retiring tide bears back its folds, a host of wonders will be revealed, sufficient to rouse the most torpid mind of the most inactive idler.[86]

The unfocused, listless ogling of the seaside lounger, he continued, acquired visual training and edification through contact with staged, socialised nature. Observing natural harmony, it followed, could awaken issues of sensibility and compassion; keeping one's own aquarium, like gardening or growing flowers, could:

> Imperceptibly touch…those feelings of humanity towards the lower animals which have hitherto been too much neglected...Anything which can neutralise this tendency to cruelty, or

[83] "The Manchester Aquarium," *The Builder*, XXXII, February 28, 1874, 174.
[84] "The Brighton Aquarium," *The Lancet*, August 17, 1872, II, 238.
[85] J. Taylor, *The Aquarium*, 2.
[86] Henry Humphries, *Ocean Gardens: The History of the Marine Aquarium* (London, 1879) 7-8.

> develop a more tender regard for the lower organised of our fellow creatures, becomes a means of moral education.[87]

It could also instil environmental sensibility: viewing, or, even better, managing, the organic symbiosis at play in giant fishtanks familiarised one with basic principles of sanitary engineering:

> The Sanitarian may take a lesson from the Marine Aquarium, for the principles which govern it – the mutual dependence of animal and vegetable life – are the principles which govern our existence: they are continually in operation within us and around us. The keeper of an Aquarium cannot be otherwise than a sanitarian, and to a certain extent a physiologist, for if he is to manage his aquarium efficiently, he is bound to notice most particularly the elementary principles of Sanitary Science – namely, that the animals he has undertaken to maintain in an artificial state of existence can only be so maintainedby preserving them in a cleanly habitation of sufficient cubic space, and by supplying them with pure air, pure water, pure and varied food, by maintaining as far as possible a uniform degree of temperature. The Aquariist will carry these principles into the arrangement of his own dwelling, and they will influence his conduct whenever he is called upon to discharge analogous duties for the benefit of the community.[88]

What one learned from playing god with a few fish, one could use in the government of one's own life. To keep an aquarium was to learn the practice of environmentalism. As well as interest, education, and compassion, atmospheric awareness could all be fostered by this calculated exhibition of natural order. The aquarium thus joins institutions like the public museum and zoo in creating "a set of cultural technologies concerned to organise a voluntarily self-regulating citizenry."[89] The observing crowd, concluded Hughes, could operate on different levels: the "unlettered" gazed in "wonder and curiosity," while the "cultivated" studied "details of structure and affinities and analogies."[90]

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The construction of abattoirs and aquaria, then, formed two modest aspects of a huge, glacial engineering project through which modern realms of private and public were created. A play of the socially invisible and the socially visible was set in motion. The unseen, obscene space of death and the open, civilising display of life materially organised collective sensibilities: they provided a morphology within which the manifold Victorian discourses of improvement could literally *make sense*. Their construction can thus provide us with fragments of a physical archaeology of modern norms of sensibility and emotional tolerance. The regulated public was given a decent world to observe: council inspectors

[87] J. Taylor, *The Aquarium*, 24-5.
[88] W. Hughes, *On the Principles and Management of the Marine Aquarium*, 48-9.
[89] T. Bennett, "The Exhibitionary Complex," 76.
[90] W. Hughes, *On the Principles and Management of the Marine Aquarium*, 52.

would regulate the norms of this world, prying into the sewers and slaughterhouses where the organic endured in a noxious and frightening state.

Private practices, rites of passage, become increasingly intimate through this architecture of individuation, just as public space, however fleetingly, was given over to the pleasures of looking, a city and a society perpetually displayed to itself. Liberal governmentality, as I have argued, worked through the creation of architectures, infrastructures, spaces securing respectable, considered observation. Crowds are manageable if atomised into masses of introspective minds. But modern modes of rule have organised far more than human populations. Aside from ordering lifeless matter into infrastructural configurations fit to sustain us, these governmental strategies have also been anxious to organise nature, whose disgusting and wholesome aspects were increasingly brought into sharp relief by such technologies. Modern government aspires not to just to control humans, but animals too.

Control, of course, has its limits: cows and fish, like factory workers and schoolchildren, had physiological limitations which wise and judicious government sought to respect. By maintaining cows in a state of vital normality until the point of death, more nutritious, tastier meat was produced: by providing fish with adequate light, air and water, they would prosper and beautify their tanks. Learning to exploit bodily the norms of the body revealed through calculation was necessary for optimum functioning. The second half of this thesis concentrates on light technology and the body, beginning with an analysis of how new forms of knowledge about vision, light and their measurement created a framework within which novel technologies could be tested.

Part Two

Illumination

I live in the midst of technical *delegates*; I am folded into nonhumans.
(Latour, 1999)

We must adapt the illumination to the requirements of vision and not compel vision to accommodate itself to unsuitable illumination.
(Clewell, 1913)

4: Calculating Light: Vision, Physiology and Photometry

From deodorisation to silent pavements, glazing to the staging of fecund nature, street-widening to public inspection, urban government aimed at normalising the sensory spaces of the city to manufacture a civilising *topoi*, a pattern at once material, human, atmospheric and discursive, through which healthy, rational, civil, productive subjects could be secured. As was evident, this project was essentially liberal in that it was predicated on the idea that there existed a normal body, which had to be worked through and with, rather than upon, which had its own economies, laws and drives, which were irreducibly visceral and largely opaque, as well as a social realm, composed of its own regularities and resistances, which could be framed and guided by judicious environmental management. Forever agonistic and self-critical, liberal governmentality inevitably found itself generating an incessant stream of data, out of which the perfect tuning of the never quite normal body with its technical environments remained tantalisingly out of reach.

Here, I begin by making the argument that scientific knowledge of light and vision, however contested, mangled and contradictory, became vital in the vast nineteenth-century expansion of light technology. The historian cannot account for the insinuation of these new systems into the interstices of an already crowded technosocial realm without examining how understanding of the nature of light, physiological seeing, and the material means of generating it were revolutionised across the century. This radical reworking of ideas of light and perception enabled vision, and techniques stimulating it, to be monitored, metered, calculated, and predicted via laboratory experiment and a panoply of tools of measurement (photometers, spectroscopes, bolometers, illuminometers, polariscopes, radiometers, thermopiles, chromoptometers). These knowledges, of the bodily-ocular-technical assemblage and its calculable performance, meant that new light technologies were usually subjected to a battery of tests to determine their capacity to stimulate or dampen a wide array of effects (visual, auditory, olfactory, physiological, neural, respiratory) in a normal body. This chapter closes with discussion of early laboratories dedicated to this kind of calculation: as in the brief analysis of food analysis in the previous chapter, it will suggest that nineteenth-century science was a scrappy and frequently inconclusive affair, but one that rapidly became essential to government.

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Entropy, Electromagnetism and Ether: Nineteenth-Century Theories of Light

"A wave-theory of light," intoned Oliver Lodge in a lecture to the Ashmolean Society in 1889, "is quite certainly true."[1] The nineteenth century began with Newtonian physics still in the ascendancy: light rays, it was generally accepted, were composed of tiny bodies moving in streams. The prevalence of this corpuscular theory was such that when Lavoisier devised his first list of elements, he placed light at the head of the list. But the researches of Young and Fresnel shattered this Newtonian consensus by 1830, destroying the ideas of both corpuscles of light, and the rays they formed; light came to be defined as essentially "a regular sequence of spreading disturbances in a universally present medium…termed the ether."[2] This is not the place for a history of this particular scientific idea: rather, it must simply be asserted that, until the emergence of quantum theory in the early twentieth century, there was practical consensus on its veracity. Light was not a substance: as the physicist Sprague explained in 1894: "light is not a *thing*, but the *perception of an action*. The light is in the eye itself."[3] Waves of varying dimensions, but identical speeds, radiated across vast tracts of interstellar darkness, some of which the

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[1] Oliver Lodge, "The Luminiferous Ether and the Modern Theory of Light," reprinted in *The Ether of Space* (London: Harper, 1909), 1.

[2] Jed Buchwald, *The Rise of the Wave Theory of Light: Optical Theory and Experiment in the Early Nineteenth Century* (London: University of Chicago Press, 1989), xiii. For the work of Young and Fresnel see *ibid.*, Park *The Fire Within the Eye: A Historical Essay on the Nature and Meaning of Light* (Princeton: Princeton University Press, 1997), chapter 8, Sidney Perkowitz, *Empire of Light: A History of Discovery in Science and Art* (New York: Henry Holt, 1996), chapters 3 and 4 and Zajonc, *Catching the Light*, chapter 5.

[3] J. Sprague, "Electricity and Light," *The Electrician*, XIII, May 17, 1884, 7. The final remark indicates the distance of this anti-substantialist position from that of Aristotle, whose theories of light were prevalent until the age of Galileo, Newton and Kepler. For Greek theories of light see Park, *op cit*, chapters 1-3. Aristotle thought light was an accidental quality; otherwise, he argued, rays would collide.

human eye happened to discern and process. Light, moreover, did not travel from point to point, as classical theories of vision had supposed; the critical point is that the physical action of this universe of ceaselessly oscillating waves appeared to have a purely accidental, tangential relationship with human eyes.

Thomas Young, in his research on the wavelengths of light, deduced that the visible spectrum occupied wavelengths of between 39,180 (red) and 59,750 (blue) per inch, a range astonishingly small compared, for example, to sound. William Herschel (1800) and Johann Ritter (1801) detected infrared and ultraviolet rays respectively, demonstrating that our eyes perceive a mere fraction of a far broader spectrum of waves. When William Hyde Wollaston peered through a tiny slit with a prism to scrutinise a sunbeam in 1802, he discovered a set of mysterious, vertical black lines, which were later named after Fraunhofer, who repeated the experiment with more reliable equipment in 1814. In 1836, Brewster discovered a different pattern of lines displayed by sunlight as it passed through laughing gas; by doing so the possibility of the science of spectroscopy can be said to have been created.[4] By telescopically analysing spectra produced by incandescing substances, Bunsen and Kirchhoff concluded that each element emitted its own unique distribution of lines. Solar rays, they suggested, corresponded to those of no known element; the existence of Helium was inferred from these cryptic spectral traces. Spectroscopy thus enabled scientists "to determine, with as great a degree of certainty as appertains to any conclusions in physical science, the chemical composition of the sun and far distant fixed stars."[5] Sir Henry Roscoe enthused about the manifold uses of this technique for identifying the material constitution of substances; the detection of, for example, adulterated wine and impure precious metals both benefited from the technique, which became a potent weapon in the battle against counterfeit substances. By 1885, spectroscopic analysis could "detect a thousandth part of a grain of the red colouring matter in a blood stain." Spectroscopy thus became a "more and more trusted and valuable means of research in medico-legal investigations."[6] In 1871, the *British Medical Journal* reported the case of a murderer arrested as a consequence of a spectroscopic test, although

[4] David Brewster, "Observations on the Lines of the Solar Spectrum," *Philosophical Magazine*, VIII, 1836.
[5] Henry Roscoe, *Spectrum Analysis: Six Lectures Delivered in 1868 Before the Society of Apothecaries of London* (London: MacMillan & Co., 1885), 2.
[6] *Ibid.*, 197.

it remained sceptical about whether human blood could be distinguished from animal.[7] Translating light's striated script remains an elemental technique through which scientists acquire cosmic information. Alfred Wallace, composing his paean to the century's scientific triumphs, concluded that through spectrum analysis, "we have acquired what are really the equivalents of new senses, which give us knowledge that before seemed absolutely and for ever unattainable by man."[8]

More sobering were the implications of the second law of thermodynamics, first stated by Carnot, "the Mozart of Physics," in his 1824 paper, *Reflections on the Motive Power of Heat*, although the term 'entropy' seems to date from considerably later.[9] Carnot illustrated it with the example of the steam engine; gradually, the temperature of the boiler and the condenser become equal, leaving an identical amount of energy but in a more chaotic state: "the system becomes less and less able to do work as it becomes more and more disorganised. One way to think of entropy is as a measure of this disorganisation."[10] But a theory that had industrial origins (the word 'thermodynamic' derives from a type of engine) soon had cosmic ramifications. William Thomson's *On a Universal Tendency in Nature to the Dissipation of Mechanical Energy* (1852) stated that the steam engine's urge to disorder was a manmade, industrial synecdoche of the languid galactic drift towards heat death, the state of frozen equilibrium which is, we are told, the inevitable fate of the universe. "Our sun," observed Helmholtz in 1871, "is a body that gradually expends its immanent store of heat and thus will some day be extinguished."[11] Although, as Myers has shown, prophets of entropic decay and thermodynamics often found space for a prime mover transcending even this chilling extinction, the death of light and the cosmos was obviously legible as a physical analogue of the death of God.[12] As vitalism declined as a viable physiological theory, "the human organism (was)...brought absolutely within the

[7] *British Medical Journal*, May 27, 1871, I, 561.
[8] Alfred Wallace, *The Wonderful Century. Its Successes and Its Failures* (Toronto: G.N. Morang, 1898), 41.
[9] Steven Toulmin and June Goodfield, *The Architecture of Matter* (London: Hutchinson, 1962), 260. The term seems to have been coined by Clausius in 1865. See Rabinbach, *The Human Motor*, 47.
[10] Greg Myers, "Nineteenth-Century Popularisations of Thermodynamics and the Rhetoric of Social Prophecy," in P. Brantlinger (ed), *Energy and Entropy: Science and Culture in Victorian Britain* (Bloomington: Indiana University Press, 1989).
[11] From a lecture in Cologne. Cited in Dolf Sternberger, *Panorama of the Nineteenth Century* (Oxford: Blackwell, 1977), 132.
[12] Myers, "Nineteenth-Century Popularisations of Thermodynamics." Tyndall, for example, illustrated the law of energy conservation by arguing "the flux of power is eternally the same," which essentially "generalises the aphorism of Solomon, that there is nothing new under the sun," (from Ecclesiastes 1:9) *Heat Considered as a Mode of Motion*, 434.

action of the law of the conservation of energy" with the consequence that eternity was an absolute contradiction of the laws of nature.[13]

John Tyndall, whose *Heat as a Mode of Motion* (1855) popularised the law of the conservation of energy, also argued that light and heat, as Kepler had suggested, were identical. They were, moreover, *electrical*; light was "nothing more than electrical energy in the form of white heat."[14] That light was an intrinsically electrical phenomenon emerged through the work of Faraday and Maxwell.[15] "Light," declared Hertz in 1889, "is in its essence an electrical phenomenon," and, by implication, "the domain of electricity extends over the whole of nature."[16] Maxwell, by demonstrating that electricity and light travel at the same speed, would provide a forceful arguments for advocates of electric light, like Preece, who confidently asserted that electricity was "naturally the proper source of artificial illumination."[17] Yet simultaneously, as Crary has cogently argued, the physics of light and the physiology of seeing were becoming increasingly sundered; "as light came began to be conceived as an electromagnetic phenomenon it had less and less to do with the realm of the visible and with the description of human vision."[18]

The calculation of the velocity of light was yet another example of the irruption of temporality into modern thought. For Greek and medieval thinkers, light travelled at infinite speed. Kepler argued that since light was insubstantial, it encountered no friction and thus there was no limit to its rapidity: Descartes agreed. That light had a speed, however, was already being posited by scientists like Rømer and Huygens, who estimate the figure at 144,000 miles per second. Determining the exact value of the speed of light caused much scientific squabbling between English, French and German physicists across the period, particularly those, like Maxwell, who needed a value within a particular range

[13] "Electricity and Physiology," *The Electrician*, XI, August 18, 1883, 320.
[14] Killingworth Hedges, lecture at the R.I.B.A. Reprinted in *British Architect*, XXI, February 22, 1884, 91.
[15] See, for example, Morus, *Frankenstein's Children: Electricity, Exhibition and Experiment in Early Nineteenth-Century London* (Princeton: Princeton University Press, 1998), Zajonc, *Catching the Light*, chapter 6.
[16] M. Hertz, "The Identity of Light and Electricity," in *The Electrician*, XXIV, November 15, 1889, 32-3.
[17] William Preece, "The Sanitary Aspects of Electric Lighting," in *ibid*, XXV, August 29, 1890, 462.
[18] Crary, *Techniques of the Observer*, 88.

to vindicate a set of equations.[19] This deferral at the physical heart of seeing, between object-as-lit and object-as-seen, which would later be joined by physiological theories of delay, was to render the idea of self-present perception troublesome by the time of Bergson and James, and again suggested different speeds and modalities of wave transmission both within and without the body.

For all the modernising iconoclasm of the wave theory, electromagnetism and entropy, one central aspect of the ancient theory of light remained: ether. From Aristotle to Descartes, empty space was considered a logical impossibility. Light, it was argued, required a medium through which to pass. Newton described the ether thus: "a certain most subtle spirit which pervades and hides hid in all gross bodies."[20] This 'aetherial medium' was equally pivotal in electromagnetic field theory, pioneered by Faraday and Maxwell. Oliver Lodge observed in 1880 that "we are absolutely certain that light is a periodic disturbance in some medium, periodic both in space and time."[21] Ether, one physicist argued in 1894; "…almost represent(s)…the underlying essence of all things – the *substance* of metaphysics, endowed by mathematicians with all the properties of an elastic solid, possessing none of the attributes of matter itself…"[22] Yet by this time, the contradictions within the notion of ether were glaringly apparent. Ether had to be solid, because it remained entirely still, owing to the transverse actions of light waves, *and* liquid, to materially facilitate the orbits of stellar bodies. This question of ether's elasticity, suggests Ian Hacking, became "*the* problem of cosmology" around the time of Lodge, Hertz and Preece.[23] Elaborate experiments, like that conducted in 1887 by Michelson and Morley to detect ether wind, failed to produce positive evidence for its existence. Lodge, as Chair of Physics at University College, Liverpool and later president of the Physical Society, grew increasingly convinced that the ether's universal omnipresence held out the possibility of telepathy and even communication with the dead. He took the ghostly blurs and smears on photographs as tangible evidence of the invisible workings of the elusive medium.[24] Others gravitated in the opposite direction. Poincaré seriously questioned its

[19] Simon Schaffer, "Accurate Measurement is an English Science," in Norton Wise (ed), *Values of Precision* (Princeton: Princeton University Press, 1995).
[20] Isaac Newton, *Principia*, 547. Quoted in Park, *The Fire Within The Eye*, 270.
[21] Oliver Lodge, "The Relation Between Electricity and Light," in *Nature*, XXIV, 27 Jan 1881, 303.
[22] Sprague, "Electricity and Light," *The Electrician*, XIII, May 17, 1884, 7.
[23] Hacking, *The Taming of Chance*, 155.
[24] See, for example, his texts *The Ether of Space* and *Ether and Reality: A Series of Discourses on the Many Functions of the Ether of Space* (London: Hodder and Stoughton, 1925)

existence in his 1902 paper, *Science and Hypothesis*, which also appears to have been the first tentative formulation of a principle of relativity; Einstein rid physics of the troublesome concept shortly thereafter.

A Semi-Governable Organ: Physiological Optics and the Limits of Perception

In *The Order of Things*, Foucault argued that the modern period is marked by the invention of 'man': all knowledge became rooted in biological, temporal conditions, which irreducibly mediated perception and consciousness:

> (The study of) perception, sensorial mechanisms, neuro-motor diagrams, and the articulation common to things and the organism…led to the discovery that knowledge has anatomo-physiological conditions, that it is formed gradually within the structures of the body, that it may have a privileged place within it, but that its forms cannot be dissociated from its peculiar functioning.[25]

This epistemic rupture is certainly apparent in optical science. Classical, Cartesian views of perception had maintained a Platonic disdain for the messiness of sensory experience. Its privileged figure for the visual process was the camera obscura. Literally a 'darkened chamber', this apparatus was connected to the outside world by a tiny aperture, through which light streamed, producing a perfect, inverted image of the world outside on the dark wall at the back of the chamber. This visual diagram, it has been suggested, "affected the scientific imagination so greatly that by the seventeenth century it had become *the* model for the eye."[26] It was a potent and ubiquitous tool of analogy for the activity of the mind too, perhaps most famously described by Locke:

> For, methinks, the *Understanding* is not much unlike a closet wholly shut from light, with only some little openings left, to let in external visible Resemblances, or *Ideas* of things without; would the pictures coming into such a dark room but stay there, and lie so orderly as to be found upon occasion, it would very much resemble the Understanding of a Man, in reference to all objects of sight, and the *Ideas* of them.[27]

Locke's mechanistic approach to the senses lent itself to such a metaphor.[28] Light and mind were joined through a schema simultaneously immediate (nothing interposes to

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[25] Foucault, *The Order of Things*, 319.
[26] Zajonc, *Catching the Light*, 30.
[27] John Locke, *An Essay Concerning Human Understanding* (Oxford: Oxford University Press, 1975), 162-3.
[28] For more on Locke's position, and those of Descartes, Berkeley, Hume and Kant, see Gary Hatfield, *The Natural and the Normative: Theories of Spatial Perception from Kant to Helmholtz* (London: MIT Press, 1990), chapter 2.

distort the arrow of light) and distant (the mind is separated, split off from the world). The camera obscura was an inherently idealist and Cartesian position.

The opening decades of the nineteenth century saw the insinuation of ocular physiology into this schema: between 1810 and 1840, the emergence of this position "effectively broke with a classical regime of visuality and grounded the truth of vision in the density and materiality of the body."[29] Organic opacity and uncertainty poured through this yawning fissure in the Cartesian optical diagram. The subsequent history of visuality, argues Crary, follows two imbricated, mutually inflecting, vectors. Firstly, the foundational freedom, resistance and strangeness of the body, which would draw plaudits from Romantics, Modernists and later phenomenologists (Goethe, Seurat, Cézanne, Merleau-Ponty). Secondly, the endless production of knowledge about the byzantine neural and sensual processes through which vision emerged, a knowledge having as its locus the capturing, framing, calculating and disciplining of the body. Modern perception ultimately fails to correspond to either extreme of this continuum. What I wish to suggest is that the attempt to *govern* through vision is marked by a similar opening into the vertiginous paradoxes and doublings of viscid freedom: on the one hand, the very irreducibility of ocular performance is taken as a foundation of attempts to govern through the free body and its wayward economies. The living body cannot be an epidermal screen upon which power writes its script; rather, it is a force to be operated through, a formula entailing capacities and limits rather than infinitude. Yet this listless quest to quantify these capabilities (ocular, kinetic, muscular) entails situating bodies within increasingly taut webs of observation and calculation, which enframe the networks modern beings trace from home, to work, to play. The resulting subject is neither fully free nor entirely disciplined, but constantly comes into being in an urban environment built to attract, enlist and sustain its diverse capacities. Light technology must be assessed as one of the manifold techniques involved in this mammoth reconfiguration of our world.

In keeping with the development of the sciences of man, physiological optics entailed making the eye itself an object of knowledge. The structure and composition of the retina was relentlessly investigated. The anatomist Gottfried Trevianus first identified retinal receptors in the 1830s. Two basic kinds were recognized: cones, sensitive to colour, and

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[29] Crary, *Suspensions of Perception*, 11-12. See also Jay, *Downcast Eyes*, chapter 4.

rods, around a thousand times more numerous, which respond to light. The former are densely concentrated in the macula lutea (or yellow spot), at the centre which is a small dip, the fovea centralis, wholly composed of cones, a site of pure, clear colour vision. The further one moves from this spot, the more rods come to predominate, until at the limits of ocular perception we discern only light. Thus, the eye was seen to be composed of a patchwork of varying capacities. It had a topography amenable to delicate analysis: the fovea, for example, was estimated to be 0.5 mm in diameter. Researchers like Wilhelm Wundt, with his distinction between blickfeld and blickpunkt (overall retinal field and fleeting area of focus), or Pierre Janet, with annular zones of differential clarity, made much of this. As the eye was opened to the inspection and measurement of scientists, its organisation remained enigmatic, resisting epistemic capture.[30]

The eye appeared to resist absolute control by either a stable "inner" subject or the force of "external" discipline. At the level of practice, technologies designed to facilitate lucidity of perception had to cede accept visceral obstinacy. Illuminating engineers like Blondel would be acutely aware of these frustrating, irreducible organic tendencies inherent in vision. Simply filling streets with glaring arclights, he argued, was useless, for it failed to take into account the "diaphragmation" of the eye; the pupils' automatic expansion and contraction according to light levels: "an object may...appear one to sixteen times more luminous...according to the opening of the pupil."[31] Moreover, the ocular apparatus possessed an ability to tone down contrasts; this was "an actual, physiological process in the visual substance, and not...an error of judgement."[32] No perfect form, no *eidolon*, existed apart from the physiological system, which decomposed and processed it for vision. The eye, effused Preece, "adapt(s)...itself with wonderful rapidity to change of light."[33] The challenge for the engineer was to tune technology and body together.

These visceral resistances of the eye undermined ideas of lucidity and interiority. Entoptic phenomena were important here: blood vessels in and behind the pupil, specks of dust intransigently lodged in the conjuctiva. Like the detritus collecting in the whorls of the ear,

[30] A detailed summary of fin-de-sieçle ocular theory, especially emphasising the differential and nuanced topography of the retinal surface, is W.H.R. Rivers, "Vision," in E.A. Schäfer, *Text-book of Physiology*, II (London: Young J. Pentland, 1900), 1026-1148.
[31] A. Blondel, "Street Lighting by Arc Lamps," *The Electrician*, XXXVI, November 15, 1895, 90.
[32] *The Psychological Review*, II, 1895, 324.
[33] Institute of Civil Engineers, *Proceedings*, CX, 26 April 1892, 55.

or bits of food wedged in between teeth, attention was drawn to the peculiar coatings of the body that belonged neither to a distant world of objects, nor an intimate collection of private organs. The eyes, moreover, were delicate and required care. Manuals were published which provided guidelines for the correct angles at which one should read books or peer through microscopes; desks were designed to force reluctant and slouching children's bodies into a more physiologically-correct position.[34] The transparent portal onto an outside so central to the Cartesian world now acquired a problematic, fragile, and fleshy thickness, folds and furls, scuffed bodily edges. The modern split between mind and body was certainly being complicated: this critique, as suggested in chapter one, warns us to beware overplaying it, although the basic duality was hardly threatened as the dominant common-sense ontology throughout the period.

The classical model was also disturbed by the early nineteenth-century location of the blind spot, the point connecting the optic nerve to the retina. Located close to the fovea centralis, this further disrupted the smooth visual field. Still more significant were investigations into binocular disparity. Whereas the camera obscura, with its single pinhole, was predicated upon monocular vision, the physiological model acknowledged the inevitable disjunction between the viewpoints of two embodied orbs bisected by the nasal bridge. Crossing at the chiasma, optic nerves from each eye somehow synthesised their differential information into a composite image. In 1833, Wheatstone measured 'binocular parallax', the physiological geometry of difference within vision itself; as well as its scientific uses, this knowledge also cleared the way for his development of the stereoscope. This device, hugely popular in mid-century, invited viewers to closely scrutinise a field of receding and apparently unrelated pictorial planes and literally watch visual synthesis occur. Science and mass culture were part of the same machinic reconfiguration of vision.[35]

If the spatiality of the classical optical schema was unravelling, then its temporality and stasis was being altogether annihilated. The fixed eye, gazing out upon a world always already there to be seen, was replaced by the perpetually moving eye(s), unhinged, jumping from point to point, never arresting visual flux. Javel defined this restless optical

[34] See, for example, Browning, *How to Use our Eyes and Preserve Them by the Aid of Spectacles* (London: Chatto and Windus, 1883).
[35] Crary, *Techniques of the Observer*, 117-126.

kinesis as 'saccadic motion' in 1878, after the French for 'jerk'. Vision was irreducibly temporal. Just as lightwaves had a definite speed in ethereal space, so too did waves within the neural spaces of the body. The speed of nervous transmission was calculated by Helmholtz in 1850. It was later defined by the electrotherapist Steavenson as "a molecular disturbance propagated along the nerve in the form of a wave the length of eighteen millimetres, and possessing a velocity of twenty-eight metres per second."[36] All human action and perception was thus subject to lag and deferral, registered in the afterimages integral to the aesthetics of Goethe and Turner. Presence was shot through with difference, a realisation at the heart of laboratory experiment and visual practice well before the invention of cinema. In the 1880s, it was calculated that showing picture frames at a rate of sixteen per second produced the ocular effect of continuous motion.[37] Crary describes this discovery of visual delay as the "*historical* obliteration of the possibility of thinking the possibility of presence in perception."[38] In addition, the eye itself was recognised to change as the body grew older:

> In infancy and childhood, the (conjunctival) vessels are so small and few that, except at the inner and outer canthus, there are hardly any visible to a casual observer; and the sclerotic has, in consequence, a uniformly white and glistening aspect. As age advances, the conjunctival vessels become larger and more noticeable, especially in persons much disposed to the weather; so that a considerable degree of redness of conjunctiva may exist without constituting a disease.[39]

The laboratory, as well as the surgery, became a key site for the monitoring and measurement of the visual capacities of the subject. In the 1820s, Purkinje produced crude figures for the duration of pupil dilation, and rates of ocular fatigue. The modernising of vision was relentlessly quantifying, a ruthless investigation of optical aptitudes, means and thresholds, particularly apparent in the development of psychophysics in the 1850s. Most closely associated with Gustav Fechner, this discipline was predicated on the calibrated administration of stimuli, and the measurement of response. Fechner's Law, a logarithmic curve plotting stimulus against sensation, became a standard tool for experiment into physical perception and judgement. Individually tested, sensations appeared to increase at a slower rate than stimuli: collectively plotted, response levels revealed the familiar,

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[36] W. Steavenson, "Electricity, and its Manner of Working in the Treatment of Disease," *The Electrician*, XIV, March 28, 1885, 408.
[37] Stephen Kern, *The Culture of Time and Space* (Cambridge, Mass.: Harvard University Press, 1883), 82.
[38] Crary, *Suspensions of Perception*, 4.
[39] James Dixon, *A Guide to the Practical Study of Diseases of the Eye* (London: John Churchill, 1866), 32.

sinuous form of a bell curve. Animal neuro-optical apparatus behaved similarly: in 1873, McKendrick and Dewar performed tests on the visual organs of frogs, which:

> Showed that the moment light impinged on the retina the electro-motive force rose, and that there was also an increase in electro-motive force when the light was withdrawn...the authors showed that the experimental results agreed very closely with Fechner's psycho-physical law.[40]

Light's optical action, it seemed, was electric, unconscious and distributed statistically. Devices like the spymograph, which recorded human pulsebeats and the rhythms of birds' wings, revealed natural physiological patterns beyond the eye's reach.

Critically, ocular facility was being organised around instruments and systems, like the tachistiscope of the 1880s, whose machinated punctuality was replicated in both industrial and recreational practices. Sensation was fast becoming an "effect or set of effects that were technologically produced and were used to describe a subject who was compatible with these technical conditions."[41] The collective agency of bodies and machines was constantly produced, revised, readjusted. The tuning of light, eye and machine produced an endless murmur of figures, which reproduced the same liberal paradox identified above. The free capacities of the eye generated only statistical truths, relative to a normal, *social eye*, with which the *individual eye* largely failed to coincide. Liberal government of the eye found itself bifurcated at root: forever swerving between these two kinds of eye. The measurement of illumination, upon which so many debates about light technology were based, revealed this problem most acutely.

An Impossible Science: Photometry and Modernity's Double Vision

Calculating light's brightness and character was integral to the visual reconfiguration of urban space, and the comparison and assessment of technologies of perception. Measuring the eye's responses to types, colours, directions and levels of illumination was a vital part of the phalanx of techniques around and through which the optical capabilities of the

[40] J. McKendrick and J. Dewar, "Physiological Observations on the Action of Light," *British Medical Journal*, May 10, 1873, I, 543.
[41] Crary, *Suspensions of Perception*, 27.

modern subject were appraised and calibrated. Spectroscopy, as examined above, was one of many tools contrived to gauge light: the annals of electrical engineering are filled with complicated, cumbersome machines to produce quantitative knowledge about the nature of light, among them radiometers, polariscopes, bolometers, thermopiles, chronoptometers.[42]

However, the photometer was the main tool through which light was measured throughout the period.[43] The term "photometry" was coined by Johann Lambert in the eighteenth century: the first extensive researches were published by the French scientist Bouger, between 1729 and 1760. The photometer is a device enabling comparison of the brightness of two sources of light, and the two simplest, most ubiquitous designs were those of Bunsen and Rumford. The former entailed positioning two lights on either side of a sheet of paper upon which a grease-spot was applied. By adjusting the position of the light sources until the spot became invisible, it became possible to calculate their relative brightness by using what was known as the inverse-square law, developed by Kepler, which stated that the brightness of an illuminated area diminishes at a fixed ratio as one moves away from it. A light casting the same illumination as another, but from twice the distance, is four times as bright.[44] Rumford's system utilised the same equation, but compared the shadows cast by two lamps or candles. By 1900 there were a bewildering array of photometers, involving complex configurations of prisms, wedges, discs and screens.[45] Trotter described photometric equipment thus:

> By a photometer, a gas-engineer means an assemblage of apparatus of different kinds, including meters, pressure-gauges, thermometers, balance, and other accessories, a remarkable feature of the collection being a great elaboration of cabinet-work and velvet curtains.[46]

[42] The polariscope was a tool to compare the spectra of two different light sources (see, for example, *The Sanitary Engineer*, V, March 23, 1882, 341), while bolometry operated on the principle that light being analogous to heat, the magnitude of the latter was an index of the former. See Silvanius Thompson, "Experiments in Bolometry," *The Electrician*, XI, October 6, 1883, 491.

[43] Sometimes, scholars appear to have underestimated its ubiquity. In his otherwise exemplary study, *Nineteenth-Century Scientific Instruments* (Berkeley: University of California Press, 1983), Gerard Turner ignores the photometer altogether.

[44] The inverse-square law is explained in greater detail in Park, *The Fire Within the Eye*, 161-2.

[45] A taxonomy is provided in J.A. Fleming, *A Handbook For the Electrical Laboratory*, Two Volumes, (London: The 'Electrician' Printing and Publishing Company, 1901) 264-301. Particularly vexing was the issue of colour photometry: see E. Nichols and W. Franklin, "A Spectro-Photometric Comparison of Sources of Artificial Illumination," *American Journal of Science*, XXXVIII, August 1899. For more information on photometer design, see Robert Bud and Deborah Warner, eds., *Instruments of Science: A Historical Encyclopaedia* (London: Science Museum, 1998), 456-8.

[46] A.P. Trotter, "The Distribution and Measurement of Illumination," Institute of Civil Engineers, *Minutes*, CX, 10 May 1892, 94.

This assemblage, which also included a human operator, required laborious fiddling and tinkering to function smoothly, but was pivotal in the production of truths about light in the nineteenth-century city. Assessing these truths became integral to urban government's project to monitor the performance of the infrastructures designed to frame a civil population. Photometers were included in the Weights and Measures Acts of 1878 and 1889 as "measuring instruments used in trade."[47] Nonetheless, there was almost universal recognition among scientists that photometry, and the measurement of light in general, was in a confused state. The magazine Industries complained in 1892 that photometry was "one of the most backward branches of measurement."[48] *The Electrician* depicted the science as "immature and defective" two years later.[49] Louis Bell moaned that "of all the physical constants none are in so unsatisfactory a state as those pertaining to illumination."[50] Yet standardised measurement remained essential for the illuminating industries, as well as for the public and private spaces needing their environments visually monitored and modified: all new light sources (oil and candles as well as gas and electricity) and many existing public lights were continually monitored and tested against standards.

The primary unit of measurement was the standard candle: composed of a mixture of spermaceti and wax, adopted as the Parliamentary standard of comparison in 1852, defined as weighing 1200 grains avoirdupois (one-sixth of a pound), and burning at 120 grains per hour.[51] Its physical inconsistencies were notorious. The committee appointed to examine photometric standards by the Board of Trade in 1879 reported that candles lacked a carefully defined chemical composition, were frequently impregnated with other materials, and had wildly varying wicks.[52] The candle, observed exasperated photometrists, was no more scientific a unit than the old 'barleycorn'.[53] No predictable, 'normal' candle could be said to exist. Each candle had its own unique materiality: "the

[47] *The Engineer*, August 28, LXXII, 1891, 174.
[48] Quoted in *The Electrician*, XXIX, June 17, 1892, 170.
[49] *Ibid*, XXXIII, September 28, 1894, 632.
[50] Louis Bell, *The Art of Illumination* (New York: McGraw, 1902), 313.
[51] France and Germany utilised different standards, the carcel oil lamp and the Hefner paraffin candle respectively. *Ibid*., 316.
[52] "Photometric Standards," *The Sanitary Engineer*, V, December 1, 1881, 10.
[53] James Barr and Charles Phillips, "The Brightness of Light: Its Nature and Measurement," *The Electrician*, XXXII, March 9, 1894, 524. There were three barleycorns to an inch, a measurement defined in statute in 1324.

hardness of the sperm and the compactness of the wick are elements which vary in every different lot of candles."[54] "No one," wrote *The Engineer*, "can foretell what candle-power a given sperm candle will produce."[55] Indeed, techniques of chemical refinement were arguably robbing candles of certain illuminating properties at the precise moment when increasingly potent arclights required measurement.

Nonetheless, ease of manufacture, habit, portability, simplicity and, most importantly, the law, all combined to keep this "antiquated and ill-defined unit" in use, despite repeated attempts to replace it.[56] By the time of the British Association Committee report on standards of white light in 1885, the pentane standard, devised by Vernon Harcourt, had emerged as the most promising alternative: "a unit of light which is practical in construction and adjustment, (possessing) extreme accuracy."[57] The Metropolitan Board of Works was urged to adopt it in 1887, in order to produce more reliable statistics relating to London's light levels. However, doubts were raised about the level of skill required to operate and adjust the flame, and the influence of different atmospheres on the lamp was a further problem. In 1887, a committee on photometric measurement ran so low on funds as to be unable to pursue further tests. In 1895 the Photometric Standards Committee was still pressing for the adoption of the burner; it became legally recognised, alongside the candle, shortly after.[58] Candles, observed Fleming, were "falling into disuse as a practical standard."[59] Moreover, more standards had emerged. The Violle platinum standard, first adopted in France at the 1884 Paris Congress of Electricians, was defined thus:

> The light emitted by one centimetre squared of platinum at a certain temperature, defined by the ration of two amounts of radiation – one being the whole radiation emitted by the platinum, and the other being that portion which is passed through a certain absorbing medium.[60]

The obvious problem with the platinum standard was its expense and the level of laboratory skill required to maintain the incandescing metal at absolutely constant temperature. German physicists failed to reproduce it. The 1888 Committee on the Standards of Light did not consider it a practical standard. Although experiments at the

[54] *The Plumber and Sanitary Engineer*, III, October 15, 1880, 445.
[55] "Standards of Light," *The Electrician*, XXVI, February 13, 1891, 129.
[56] *Ibid.*, XXXVII, October 2, 1896, 731.
[57] *Ibid.*, XVII, October 15, 1886, 481.
[58] Fleming, *A Handbook for the Electrical Laboratory*, 262-3.
[59] *Ibid.*, 238.
[60] O. Lummer and F. Kurlbaum, "The Search for a Unit of Light," *The Electrician*, XXXIV, November 9, 1894, 37.

Davy-Faraday laboratory would demonstrate its worth, it was unlikely to be utilised anywhere beyond a national level.[61]

This lack of portability meant that the circulating chain of metrological reference linking local testing to national and legal levels frequently became strained. Fleming, in his long discussion of photometric laboratory conditions, argued that the Violle standard should operate at a national level, alongside the one-candle pentane lamp; local, working standards could be measured against them. In reality, the mobilisation of many mediators was necessary to shuttle the truths of light from factory floor to local laboratory, gasworks to National Physical Laboratory, and hence record the various levels of light evident in the city. The candle, for all its instrumental irregularity, was the closest the illuminating industry had to an "immutable mobile" for most of the period.

It also retained its use as the basic unit of light, despite efforts to replace it with *lumen*, which, with *lux* (illumination), was mooted as an elegant epithet for absolute light. Like the nomenclature of other units, they ebbed in and out of favour, before being decisively revived following the 1896 Geneva Congress. Speaking at the 1889 Paris Electrical Congress, Preece proposed the lux as the unit of illumination, defined as the light cast by one French carcel lamp over one metre. It should, he argued, replace the obsolete term 'foot-candle', which had been used from around 1866.[62] The distinction between absolute light and illumination, continued Preece, had proved another problem inhibiting practical photometry: "the measure of the illumination of a surface, as far as intensity is concerned, is quite independent of the source of light itself."[63] Photometry, it will be recalled, began as a technique to compare the intrinsic brilliance of a light source in and of itself, not the level of illumination. This latter value was, argued Preece, the only one that mattered: arclights possessed high levels of absolute radiance, but their light was often distributed poorly. Nobody saw by looking directly at such sharp points of light. "No attempt," wrote *The Electrician* in 1890, "appears to have been made until recently to measure illumination."[64] Preece, along with Trotter, was responsible for pioneering instruments to achieve this. The latter engineer, in 1892, produced a series of illumination curves for

[61] Royal Society, *Proceedings*, XLV, 1899, 469.
[62] Alexander Pelham Trotter, *Illumination: Its Distribution and Measurement* (London: MacMillan, 1911), 15.
[63] W. Preece, "The Measure of Illumination," *The Electrician*, XXIII, September 13, 1889, 478.
[64] "Measurements of Illumination," *Ibid*, XXV, August 15, 1890, 412.

London streets, including Whitehall, measurements requiring instruments of greater mobility and durability. He also continued to advocate the foot-candle, arguing that "as the heights of lamp-posts and the widths of streets are measured in feet," it was more apposite.[65] A typical example of the new device was described by Sir David Salamons in 1893, who emphasised its compactness: it "packs up into a sling case barely larger than those used for field glasses…It may also be employed for rapidly comparing the light in one or more places far apart, which is frequently a great convenience."[66] Similar instruments were soon being called 'illuminometers' – their size and weight, combined with robust design, enabled knowledge of the urban environment to circulate and accumulate with greater rapidity, articulating the city's atmospheric being. As Latour has argued:

> The history of technoscience is in a large part the history of all the little inventions made along the networks to accelerate the mobilisation of traces, or to enhance their faithfulness, combination and cohesion, so as to make action at a distance possible.[67]

However, as Latour also argues, this acceleration is often a punctured, syncopated process. Many problems emerged as illumination photometry tried to turn the glimmering mosaic of civic surfaces into a coherent script from which the relative distribution of urban radiance could be discerned. Functional machinery, coherent scientific units, dependable laboratories and disciplined inspectors all had to be co-produced and wound into a dense knot of agency. Practical measurement was thus "interactively stabilised" by a biotechnical tuning process with no predetermined outcome.[68] Thus, the angle at which measurements were taken became a significant problem; "the light falling on a unit area of pavement…is directly proportional to the angle at which it falls."[69] Equations were produced, tested and modified. One result was the distribution curve, developed by Trotter, which plotted contours of rings and ellipses corresponding to levels of light intensity varying according to the distance from lampposts. This representational system was graphical and statistical. Another problem which was practically emergent was that extremely intense lights, particularly arclights fitted in stations and docks, were so powerful that they had to be moved an "inconveniently great" distance from standard

[65] Alexander Pelham Trotter, "The Distribution and Measurement of Illumination," Institute of Civil Engineers, *Minutes*, CX, May 10, 1892, 71. The terms 'foot-candle' and 'candle-foot' were interchangeable.
[66] "A New Form of Portable Photometer," *The Electrician*, XXXI, May 12, 1893, 43.
[67] Latour, *Science in Action*, 254.
[68] Pickering, *The Mangle of Practice*, 69-70.
[69] H. Robinson, in *The Electrician*, XXVII, July 10, 1891, 261.

candles in order to produce a photometric reading.[70] This led to the development of mediating machines to mechanically diminish the brightness of the arc, and corresponding equations to compute the ratio.

Material resistance spawned new forms of apparatus, but it also engendered new bodily practices. The visceral, physical act of manipulating and adjusting sensitive photometric equipment was frequently stressed:

> After very little practice, it is not difficult to make the two lights vary until (the difference) is *hardly sensible*. The muscular sense of moving the lever enables its mean position to be found, or the alternate motion may be continued for a couple of seconds, while the observer looks at the scale and estimates the middle position. (Emphasis added)[71]

The regimented, controlled bodily practice, and the trained sense of ocular discernment emerged along with the functioning of the technical assemblage and the corresponding set of inscriptions. Photometry, like all scientific practice, was "a temporally emergent, autochthonous discipline of human agency."[72] This intrusion of the body and its vagaries compromised, for some, the integrity of illumination measurement:

> A very little experience will convince the experimenter that the results depend upon the *general state of the eye*, the personal equation of observer, practice, preconceived notions of relative intensities, and other factors so variable that the result is little better than guesswork. (Emphasis added)[73]

But there was no way of purging the machine of its organic, sensual elements. Photometric calculations relied upon the fallible, individual eye to judge when the lights appeared to even out. Thus, biotechnical apparatus articulated a kind of double vision. On the one hand there were "the sometimes ludicrous difference of results obtained by independent observers in *individual cases*." (Emphasis added)[74] On the other, it was "difficult to imagine that anything else can be a substitute for the human eye in testing the relative value of two lights for visual purposes."[75] Measuring light necessitated viewing light, which threaded an ineluctable ocular subjectivity and slippage through the tightest calculation. Physiology compromised photometric endeavour, yet was the locus of its calculating quest. The physical arrangement of the apparatus materialised something of this ambivalence, being fundamentally monocular (many observers having eyes of rather different capacities) and attempting to fix the point of observation, thus arresting an eye

[70] *Ibid*, XII, December 29, 1883, 146.
[71] Trotter, "The Distribution and Measurement of Illumination," Institute of Civil Engineers, *Minutes*, CX, 10 May 1892, 99.
[72] Pickering, *The Mangle of Practice*, 108.
[73] Bell, *The Art of Illumination*, 331.
[74] T. Seymour Hawker, "Hawker's Sine Photometer," *The Electrician*, XIII, July 26, 1884, 253.
[75] Fleming, *A Handbook for the Electrical Laboratory*, 287.

which obstinately resisted stasis.[76] Binocular inspection was recommended as a way of equalising the effects of differential vision existing within the observer.[77]

These quandaries produced a bifurcation of vision, between photometric results and their subjective effects, a chasm unbreachable by a notion of normal, average vision, beyond which individual optical eccentricities forever lurked. The endless testing of subjective capacities produced a notion of normal perception and its environmental media which would become increasingly vital to the project of governing through the eye. The term 'emmetropic' was coined to define "an eye of perfectly normal refractive power, in which the parallel rays passing from objects meet in a focus *upon* the retina," in contradistinction to myopic or hypermetropic states, which referred to particular sizes of eyeball which did not guide the rays to such a perfect point.[78] Normal vision, consequently, involved no ocular exertion; the emmetropic eyeball was an orbit of perfect data transmission:

> Normal vision exists when, firstly, each eye is so constructed that a sharp and exact image of the object toward which the eye is directed; is formed upon the proper sentient layer of its retina; and when, secondly, a correct appreciation of the form, position, colour and most of the physical qualities of the object so depicted is conveyed to the mind.[79]

The normal eye was further defined as capable, for example, of discerning 165 colour tones and 572 brightnesses.[80] Its constituent parts (cornea, pupil) had average sizes; as an assemblage, it responded to diminishing levels of light in a chromatically predictable way: "a person with normal vision passes through a stage of red-blindness, as the intensity is diminished before he arrives at absolutely monochromatic vision."[81] The actions of this eye were always defined in accordance with average distribution patterns and experiments. Lights themselves varied and flickered, so calculations to produce "mean spherical density" and other such figures would be developed.[82] Normal vision was thus the coincidence of average eyes with an averagely-lit environment: hardly 'natural', but hardly entirely arbitrary either. It was simply an association which *held.* A normal eye saw a certain set of objects clearly under specific conditions, which were measurable, and the resulting association's stability was a founding truth through which aptitudes and deviances could be ascertained: eye-tests for train-drivers, riflemen and sailors, for

[76] This criticism was made by the surgeon and brain researcher Broca in *The Electrician*, XXXIII, October 26, 1894, 754.
[77] *The Engineer*, LXXVIII, June 19, 1896, 610.
[78] Dixon, *A Guide to the Practical Study of Diseases of the Eye*, 5.
[79] Thomas Longmore, *The Optical Manual* (London: W. Clowes & Son, 1885), 2.
[80] *The Psychological Review*, II, 1895, 324.
[81] W. Abney, *Colour Vision* (London: Sampson Law, Marston and Co., 1895), 104.
[82] J.M. Bryant and H.C. Hale, *Street Lighting* (Urbana, Ill.: University of Illinois, 1911), 17.

example, were epistemologically anchored in this premise and its practical arrangements. This biotechnical abstraction sat uneasily alongside what we can term individual vision, the temporally-emergent act of seeing by two body-borne, blotched, bloody elliptoids of jelly swivelling in bony orbits in spaces striated with sporadic effulgence and formless penumbra. Those calculating light either tried increasingly to either accommodate the body and eye, or to efface them, but the problem remained – it is utterly integral to any articulation of agency. "A photometer may declare that the average illumination is high, but the eye is the sole judge in these matters, and refuses to be satisfied."[83] Brilliant light might produce high photometric readings, but this was no guarantee that the eye was discerning urban space with perspicacity. Blondel, whose labyrinthine equations to define forms of brightness testify to the increasing imbrication of mathematico-technical control with physiological indeterminacy and freedom, concluded that the psychophysiological density of subjective response "may make simple physical measurements simply illusory."[84] Normative perceptual capacities functioned as a simulacrum of a fully predictable sensory response:

> The more the senses are revealed to be inconsistent, conditioned by the body, prey to the threat of distraction and nonproductivity, the more a normative individual is defined in terms of objective and statistical attentional capacities that facilitate the subject's functional compatibility within institutional and technological environments.[85]

Such social regularities paradoxically displayed the machinated aptitudes of a population whose agency was entirely mediated by machines. Boutroux and Durkheim concocted sociological analysis from this problematic: regularities (physical, moral) existed at a social level, not an individual one.

Debates about illumination reveal this concern with the statistical. In urban, industrial and leisure spaces, the calculation of mean light levels required for an average eye to perform at a level facilitating agency followed the collective path, and the laws of light aimed at a similarly statistical, social level. Individual eyes, with different colour perceptions, lens diameters, pupil dilation speeds, brightness thresholds and rates of fatigue were the evasive targets of this framework, which the government of the eye hoped to mobilise. Tuning photometers to produce compatible readings became a critical attempt to anchor the truth of light beyond the eyes and in a machinic architecture of glass and metal.

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[83] W. Sumpner, "The Diffusion of Light," *The Electrician*, XXX, February 3, 1893, 381.
[84] *Ibid*, XXXVI, November 15, 1895, 90.
[85] Crary, *Suspensions of Perception*, 287.

The Public Laboratory: Photometric Inspection and Legal Thresholds of Light

The laboratory's salience as a social space devoted to the production of truth has been the subject of many studies.[86] As in the case of food analysis, all I wish to emphasise here is the equation between laboratory and epistemic authority, and the vital importance that this played in manufacturing and maintaining specific truths upon which key aspects of urban government came to rely. The origins of this authority have been convincingly located in the social landscape of the Restoration, where the laboratory, according to Shapin and Schaffer, became a special space where experiments on nature were performed, and facts established. Taking their cue from Galileo and especially Francis Bacon, experimenters at the Royal Society laid the foundations of modern scientific method. "If one wanted to produce authenticated knowledge – matters of fact – one had to come to this space and to work in it with others."[87] This space, devoted to interrogating and articulating nonhumans (air, cannonball trajectories, bacteria, foodstuffs, poisons), has, as argued earlier, been seen as a paradigmatic moment in the founding and maintaining of the modern cleavage between society and nature. This modern settlement, Shapin and Schaffer contend, was fundamentally political, a solution to the problem of knowledge by building a consecrated space in which experimental philosophers performed according to formal rules of method and more tacit codes of conduct.[88] "To entertain...doubts about our science is to question the constitution of our society," they conclude.[89] Facts about the physical nature of our world palpably exist, but they must be seen, measured and verified (in other words, made) in this space before they can circulate in the social world outside its doors. In the words of

[86] See Stephen Shapin and Simon Schaffer, *Leviathan and the Air-Pump*, for the classic sociological account of the importance of the laboratory in the later seventeenth century. For a more anthropological reading, see Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton: Princeton University Press, 1986); and Latour's *Science in Action*. For more performatively-inflected analyses, see Latour, *Pandora's Hope* and Pickering *The Mangle of Practice*. Also useful are Pickering (ed), *Science as Practice and Culture*, Morus, *Frankenstein's Children*, Shapin, *A Social History of Truth*, Law, *Organizing Modernity*.
[87] Shapin and Schaffer, *Leviathan and the Air-Pump*, 39.
[88] This latter aspect of the scientist's practice is explored by Shapin in *A Social History of Truth*.
[89] Shapin and Schaffer, *Leviathan and the Air-Pump*, 343.

Bacon, when interrogated in the laboratory, "nature betrays her secrets more fully…than when in enjoyment of her liberty."[90] Establishing the truth about anything nonhuman, which in terms of nineteenth century local government meant anything from the performance of gaslamps to the chemistry of smoke, involved a detour through the laboratory.

Although the laboratory shared this epistemological hegemony with other spaces, including museums and even public houses, its credibility was becoming more entrenched by the 1880s and 1890s, as increasing numbers were established in universities, technical colleges, factories, and gasworks.[91] Many of these were used to analyse and measure anything that civic authorities required; in Manchester, light and food were both analysed at the laboratory at the Gaythorn gasworks. Specialist laboratories were also becoming more common, for purposes as diverse as psychological testing and industrial research.[92] Pressure mounted in the 1880s for a national laboratory to measure electricity, so as to "provide the means for legally determining the correctness of the instrumental appliances by which it is sold."[93] The Board of Trade established this at 8 Richmond Terrace, London, to verify and determine standards and instruments, and to train observers in the skilled operation and accuracy required when manipulating equipment. Indeed, training electrical inspectors was regarded as at least as important as the building of laboratories themselves: "the appearance of this new functionary will be like the dawn of a new species."[94] The Electrical Standardising, Testing and Training Institution, constructed shortly afterwards, included "a suite of private testing rooms, where for a truly moderate fee anyone can pursue original or other forms of experimental work under the most favourable conditions."[95]

Fleming, who designed the laboratories at University College, London, described the methods necessary to perfect their formal efficacy. The laboratory was a space of

[90] Bacon, cited in Merchant, *The Death of Nature*, 172.
[91] See Graeme Gooday, "The Premisses of Premises: Spatial Issues in the Historical Construction of Laboratory Credibility," in Crosbie Smith and Jon Agar (eds.), *Making Space for Science* (Basingstoke: MacMillan, 1998).
[92] William James established a small psychological laboratory at Harvard in 1876, while General Electric built its first industrial research laboratory in 1900.
[93] Major Cardew, "The Electrical Standardising Laboratory," *The Electrician*, XXV, May 30, 1890, 90. The periodical itself, rather surprisingly, opposed the institution at first as too expensive, citing a similar French institution's profligate construction as proof.
[94] *Ibid*, 91.
[95] *Ibid*, XXXIII, June 14, 1895, 216.

pronounced and materially contrived silence, necessitating thick walls and solid foundations to physically cocoon them against the vibrations and noise of city life. Light also should be excluded when necessary, with "blinds made of black American oilcloth or some materials impervious to light."[96] This was especially important for photometric galleries, which required jet-black walls, and carefully maintained atmospheric conditions. These environmental oases were the spaces where the level of urban light was measured. The legal level, at which an average lamp should burn, was fixed at sixteen candles under the 1860 Metropolitan Gas Act and the 1871 Gasworks Clauses Act, having previously been twelve. Shifting norms of luminous tolerance can be discerned through this legal change. Gas was also tested for pollutants. Leigh, as MOH for Manchester, made tests of the city's gaslight "almost daily", producing annual reports proclaiming its average strength.[97] This level was, for example, 20.32 standard candles in 1870-1, but only 18.53 in 1874-5. These average figures publicly pronounced how light the city was, and whether it was getting lighter or darker. In London, where private firms provided gas, the Metropolitan Board of Works subjected its power to constant scrutiny to ensure it never fell below the legal average. This level itself was open to revision: the Board of Trade appointed a committee to look into possible alteration in 1891.

The daily measurements themselves were usually averages: in Manchester, the MOH would perform ten one-minute photometric observations, before and after which he would weigh the candles to monitor their rate of combustion.[98] The photometers at Gaythorn themselves were subject, by the 1890s, to four annual examinations, after which they were usually adjusted against a mediating standard. In 1891, it was declared that any photometer utilised to measure the candescent quality of gas could be examined and certified by the Board of Trade. Likewise, commercially produced arc and incandescent lamps were invariably tested in photometric galleries to ascertain whether, on average, they corresponded to the maker's criteria.

The levels of light provided for the normal eye in both public and private was thus subjected to relentless calculation. However, this quantifying process was subject to the inevitable emergence of practical resistances of eye, light and machine. Thus, when the

[96] Fleming, *A Handbook for the Electrical Laboratory*, 10.
[97] Manchester City Council, *Proceedings*, 1867, 312.
[98] *Manchester Municipal Code* II, 443.

laboratory reading of the light level of an average Manchester gaslight was seen to be falling, it did not necessarily follow that the light itself was dimmer. The photometers, or the candles, or the eyes of observers, could all be held to blame: all, as I have shown, were acknowledged to be fallible. In 1891, Williams, the senior chemist for Manchester City Council, reported that he had "been to the Owens College and examined the apparatus employed there for the determination of the illuminating power of the Manchester gas and found it to be defective."[99] In 1883, the Metropolitan Gas Referees pointed out "a persistent difference between the return of the illuminating power of the gas from the testing place at Clapham and the testings of the same gas at Kennington, where it is stored," a difference blamed on photometric apparatus.[100] The vagaries of individual observation could also produce curious results, as *The Sanitary Engineer* reported in 1881:

> Two gas examiners of London obtained 16.5 candles and 19 candles, respectively, as the illuminating power of the same sample of gas, using the same photometer, and candles from one packet. This variation is considerable, and shows a difference in treatment...far to (sic) great for trained observers working under a common superintendent.[101]

In short, although urban light levels were quantified to an unprecedented extent in the last two decades of the nineteenth century, it must be concluded that the reliability of the figures was itself subject to constant anxiety. This was particularly so given the palpable differences between gaslight produced in laboratories and that actually illuminating streets and homes, as Preece acknowledged to the Streets Committee of the Commissioners of Sewers of the City of London in 1885:

> The gas lamps in the City are supposed to give an illuminating power of fourteen candles, when burning five cubic feet of gas per hour, and they do so when burning steadily and regularly in the laboratory, but when placed in the street lamps the supply of gas becomes irregular through age and dirt in the burner; the flame flickers about through imperfect combustion and through draughts, the lanterns become dim and the glass, therefore, obstructive, and the result given is only ten candles instead of fourteen.[102]

Interminable problems with apparatus could thus render legal minimum light levels something of a dead letter; but what is worth pointing out is that the techniques of atmospheric governance and calibration and the engineering of civil visual environments entailed the attempt to replicate the perfection of laboratory conditions in key sites across the city. Any innovation which could make the translation from laboratory to less controlled spaces more immune to these warpings would always arouse interest.

[99] Manchester City Council Gas Committee, *Minutes*, XXIII, December 16, 1891, 23.
[100] *The Electrician*, X, July 14, 1883, 212.
[101] "Photometric Standards," *The Sanitary Engineer*, V, December 1, 1881, 10.
[102] William Preece, "Report on Electric Lighting in the City," *The Electrician*, XV, April 25, 1885, 497. The legal minimum light level for the City seems to have been two candles fewer than that for the rest of London.

This shift from laboratory to the city as a whole was a necessary trajectory for any new technology. The following chapter examines various light technologies developed between 1870 and 1900, and how they fared on this onerous voyage across the new world of photometry and physiological vision in a gestating liberal state demanding pellucid, noiseless, defumigated space and self-governing, industrious, attentive, healthy subjects.

5: Technologies of Perception: Electricity, Gas and the Changing Parameters of Visual Agency

The introduction and dissemination of electric light technology must be analysed in terms of the general political concern for a clear, clean, healthy environment, and the rise of laboratory science, photometry, quantification and municipal engineering; in other words, the context outlined in the first four chapters. This chapter examines numerous new light technologies employed in the city in the final decades of the nineteenth century. Rather than provide a typology of these systems, I begin by emphasising three specific aspects of vision that were particularly necessary to both urban and wider state organisation: colour, distance and detail. Accurate chromatic discernment, the ability to detect and project light over longer distances, and legibility and physical recognition were essential to many practices, from factory production and policing to transportation, military activity, shopping, and theatre-going. Rather than electric light miraculously dispelling Dickensian gloom, its early successes resulted from an ability to generate and maintain, in certain locations, specific forms of visual agency which were essential to a liberal order. It allowed people to move a bit faster, and compare colours, read or judge distances with a little more accuracy.

The development of arc and incandescent light, however, did not merely involve the eyes of the governed. The entire body, its capacities to work, move and breathe, was implicated in this reconfiguration of visual practice. The second section of this chapter looks at the kinds of bodily agency that new illuminating technology could realise. Here, I look at issues of attention, distraction and health. Liberal practices of government aimed to realise these capacities in different locations across the city: concentration at work, fascination and seduction when consuming, wholesome air at home. These abilities, it was argued, were promoted or retarded by the environmental conditions acting in a series of ways upon the stubborn, viscid bodies of the population. Water, air and food facilitated certain levels of cleanliness, strength and organic harmony. Light in its turn would realise particular kinds of agency. These kinds of practices, it must always be remembered, were conjoined products of a body and a machine. The stabilisation of the performance of both was emphasised in chapter one: at points in this chapter I refer to this as a process of 'biotechnical tuning'. This means the mutual interaction of, say, a worker and an arclight so as to produce a harmonised, purposeful activity; say, the ability to discern colours at night.

However, given that the criteria for what calculating and assessing attentive, accurate, healthy vision were themselves in a state of perpetual flux, it should not surprise us that the ultimate triumph of electric light, and the collective redistribution of humans and nonhumans which it helps to hold together, was a convoluted and messy process, stretching well beyond 1910. Inferring any straightforward vector of development from this will always correctly lead to accusations of reductionism. Thus this chapter concludes by looking at a series of electric light systems which failed: electric candles, arclights, and a particularly unusual scheme of piped distribution. These systems failed neither for purely social reasons nor for purely technical ones. Rather, the particular biotechnical agencies and bodily perceptions they made possible fitted neither the social nor the technical requirements of the evolving modern order, which demanded particular ocular capacities, environmental conditions, speeds, attentive abilities, and colour discernments. Moreover, newer forms of gaslight, like Welsbach's mantle and Wenham's regenerative burner, promised similar visual conditions at a cheaper rate than incandescent light. Explaining their rise to prominence entails making a similar argument to that about incandescence: that securing specific forms of agency consistent with liberal ideas of productivity, morality and health were the only real criteria that mattered. Their ultimate decline and failure falls beyond the chronological sweep of my thesis, but the reasons were, I conclude, ultimately as much environmental as economic or perceptual, supporting my thesis that light cannot be analysed as a purely visual-optical technique.

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Making a Visual Field: Colour, Distance and Detail

In this section, I will delineate some of the lighting conditions that electric light could produce in public; a visual field whose salient features were the accurate replication of daytime colours, the enhanced distance at which clarity of ocular perception was discernable, and the distinguishing of detail. The ensuing conditions of vision were always a local achievement, requiring material durability, maintenance and inspection: nonetheless, by suggesting the kinds of agencies and practices this made possible, I hope to show the evolving connection between technological systems, perception and subjectivity, one developed later in this chapter.

Colour

However clumsy and fallible the equipment involved in the complex process of calculating light, it was integral to all attempts to promote and compare new light technologies. The spectroscope, for example, was marshalled by engineers and scientists to compute the chromatic character of various forms of artificial light. Those promoting electric light, like Paget Higgs, claimed that the spectroscope provided irrefutable evidence for the superiority of the new technology. Gaslight produced spectra dominated by red, orange and yellow. Little light was produced from the hotter part, which was the material reason for the light's yellowness; it was simply too cool to generate wavelengths of all frequencies necessary for a human eye to see as it did by daylight. "It is impossible to add the indigo and violet, and this is the cause of (gaslight's) inferiority. The electric light is more complex."[1] Others concurred: "as far as mere colour is concerned…the electric light approaches nearer to the sun than does the gas-flame."[2]

This judgement was reinforced by optical experiment. Weber's chronoptometer was utilised by Herman Kohn in 1880 in a series of statistical tests to gauge the eye's performance at discerning colours by gas, electric and sunlight. This device, consisting of a succession of coloured discs pinned to black velvet, was used to test the colour perception of "fifty eyes"; the average results, although crude and varying, seemed to demonstrate the physiological effects of the hotter light:

> Electric light always improves the colour perception when compared with gaslight, on an average the perception of red from two to six times, the perception of green from two to seven

[1] Paget Higgs, *The Electric Light and Its Practical Applications* (London: E. & F. Spon, 1879), 5.
[2] W. Pickering, "Concerning the Gas-flame, Electric and Solar Spectra, and their Effect on the Eye," *Nature*, XXVI, February 9, 1882, 341.

> times, the perception of blue from one and a-half to two times, the perception of yellow from two to five times.[3]

The compass of this statistical sweep demonstrated the vagaries of subjective perception, as well as those of the chronoptometrical technique itself: for some experiments, "even the longest room in the physiological laboratory in which I carried on my experiments...was not long enough to determine the limits of perception." This entailed opening the laboratory doors and using an adjacent corridor, at which point, "owing to the great distances, the conversations had to be carried on in a loud voice."[4] This rather comic episode gives the historian some indication of the scrappy, mangled nature of optical experiment.

Nonetheless, spectroscopic data was becoming vital epistemological ballast for any assertion about the quality of artificial light. Gaslight had long been associated with light of a somewhat sulphurous hue: "we have difficulty by artificial light in illustrating the exact colours, as the gaslight being yellow, it imparts a yellowness to some colours and takes it out of others."[5] Throughout this chapter, I will underline the importance of avoiding monolithic notions of light technology; arc lights could be bluish and flickering, while rare earth alloys used in gasmantles could generate a whiter beam. Nevertheless, private experiments and public installations seemed to suggest that electric light technology could genuinely expand the temporal range of daylight, rather than merely puncture the night with patches of a "garish lustre."[6]

The ability of electric illuminants to duplicate the solar spectrum led to its early deployment in factories producing coloured goods. A report from the *Warehouseman and Drapers' Trade Journal* of 1882 was typical:

> The general employment of electric light for indoor purposes is much to be desired on several accounts. It is a matter of common observation that colours cannot be properly selected by gas or candlelight. Not merely do blues and greens get mixed up, but almost every tint and shade is altered by the yellow of the lamps and candles, and it is one of the great advantages of electric light that it *enables us to see colours as they really are.*[7]

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[3] H. Kohn, "Comparative Determinations of the Acuteness of Vision and the Perception of Colours by Day-light, Gas-light and Electric Light," *Archives of Ophthalmology*, IX, 1880, 60.
[4] *Ibid*, 62.
[5] S. Chandley, "The Combination of Colours," a speech read before the St. Helen's Literary Society. Printed in *The Builder*, XXXI, January 18, 1873, 40.
[6] Edgar Allen Poe, "The Man in the Crowd," in *The Fall of the House of Usher and Other Writings* (Harmondsworth: Penguin, 1986), 183.
[7] Quoted in *The Electrician*, VIII, May 13, 1882, 418 (emphasis added).

This new light, therefore, reproduced the polychromatic milieux within which a normal eye operated during daylight. Rather than squinting through bilious gloom, workers could now confidently match colours at night. This quickly cemented new visual expectations: "we doubt if we could get along now," reported one mill owner, "if we were to return to the old gas lighting."[8] The same technologies reproducing daylight perception in factories could be manipulated to assist in the creation of environments conducive to the public arenas of pleasure and consumption familiar from the literature of modernity. In 1879, Hepworth enthused about the Jablochkoff candles illuminating the *Magasins de Louvre* in Paris: "here ladies can buy their silks without any regard as to what a tint may look like in daylight; for daylight is here manufactured for them by the aid of Gramme and Jablochkoff."[9]

By 1880, the *British Architect* was reporting that "nearly all the large drapery establishments" of New York were utilising electric light, a critical reason for which was lack of environmental damage.[10] Like clothing, the colours of food were highlighted by electric illumination. Grocers and butchers were also displaying an interest in electricity. Following the experimental lighting of the City in 1881, an observer reported that "costermongers' goods show off to perfection."[11] For chill rooms the light was evidently environmentally apposite. The occasionally steely rays of electric lamps could give meat a livid pallor. Butchers at Smithfield market fitted gold leaf reflectors to revivify its appearance: a case of electric light imitating gas, without the heat.[12] Shopping at night had become an experience of manifold light-spaces, from coruscating naphtha flames to pure white electric light. Cabinets and window displays "developed mainly by the stimulus of electric lighting."[13] Choosing clothes by gaslight became a faux pas, as evinced by Mr Pooter, asinine protagonist of George and Weedon Grossmith's *Diary of a Nobody*:

> Bye-the-bye, I will never choose another cloth pattern at night. I ordered a new suit of dittos for the garden at Edwards', and chose the pattern by gaslight, and they seemed to be a quiet pepper-and-salt mixture with white stripes down. They came home this morning, and, to my horror, I found it was quite a flash-looking suit. There was a lot of green with bright yellow-coloured stripes…I tried on the coat, and was annoyed to find Carrie giggling.[14]

[8] *Ibid.*, VIII, January 14, 1882, 136.
[9] T.C. Hepworth, *The Electric Light: Its Past History and Present Position* (London: Routledge, 1879), 82.
[10] *British Architect*, XIV, October 29, 1880, 201.
[11] *The Electrician*, VI, April 9, 1881, 262.
[12] *The Engineer*, LXXIV, November 18, 1892, 431.
[13] Louis Bell, *The Art of Illumination*, 275.
[14] George and Weedon Grossmith, *Diary of a Nobody* (Harmondsworth: Penguin, 1965), 183.

The concentration and agglomeration of light in city centres made the streets potentially "a glassed-in stage on which an advertising show was presented."[15] While Schivelbusch sometimes appears intoxicated by the rhetoric of Benjamin his point has validity, albeit at a local level. The development of flashing lights (1882), skywriting (1895) and neon (1907) gave entrepreneurs a sophisticated paintbox with which to daub their names and emblems across the night. This was especially evident in the United States, with the development of the 'Great White Way', the extravagantly-illuminated main commercial street. Floodlighting was used to stage monuments and public buildings after dark: the architecture critic Thomas Mawson argued that the effects could be "strikingly beautiful."[16] The urban nightscape emerged as a collage of illumination, the physiological effects of which could be arresting:

> One evening last summer we took an evening stroll and soon found ourselves stepping from the dimly lighted...side streets into a broad main thoroughfare illuminated by fourteen amp arcs under large ground-glass globes. The contrast between the two methods was most striking...Why was there such a warmth and such an exhilarating effect?[17]

Illumination became a leisure attraction in itself. Blackpool lit its piers, promenade and the Prince of Wales's theatre by arclight in 1879, and two years later *The Electrician* commented that "the electric light is fast coming into favour as one of the attractions that should be possessed by seaside resorts."[18] The same journal eagerly reported on the amount of leisure pursuits that were taking advantage of electricity. Hull F.C. hosted a football match beneath arclight as early as 1893.[19]

Looking back from 1911, Bryant and Hale observed how merchants had insisted on ever-increasing, photometrically-verified quantities of light flooding the nocturnal city: "it is claimed justly that the best lighted streets attract the crowds."[20] But this seemingly indiscriminate amplification of light had enemies; architects in London, for example, began complaining to the city council about the extent of illuminated advertising.[21] Further, claims made by electric light promoters should not disguise the fact that the new technology did not brighten a hitherto Stygian world. Gaslight had been axiomatic in the

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[15] Schivelbusch, *Disenchanted Night*, 146.
[16] T. Mawson, *Civic Art: Studies in Town Planning, Parks, Boulevards and Open Spaces* (London: B.T. Batsford, 1911), 138.
[17] *The Electrician*, XXVII, October 25, 1891, 851.
[18] *Ibid.*, VII, July 9, 1881, 114.
[19] *Ibid.*, XXX, February 17, 1893, 462.
[20] Bryant and Hale, *Street Lighting*, 40.
[21] See Nye, *Electrifying America: Social Meanings of a New Technology* (London: MIT Press, 1990), 49.

expansion of nocturnal activities, both industrial and commercial: a physical environment and set of optical expectations had evolved along with the particular illuminant.

Thus, merely equipping established spaces of nocturnal activity with electric light often created a series of chromatic and aesthetic problems. Nowhere was this more evident than in the theatre. Filament lamps may have notably cooled auditoria, but they also distorted the colours of scenery and made cosmetics appear ashen and ghoulish. "The effect of electric light on stage scenery is very far from satisfactory," admitted *The Builder* in 1882.[22] The internal decoration of houses had also evolved symbiotically with candles, oil and gas light: again, white rays of incandescent lamps produced displeasing effects. Electric light would ultimately lead to the development of more subdued colour-schemes. Certainly light technology's nature as an environmental technology, meant that new spatial, decorative and chromatic norms necessarily evolved with it.

One final point: art galleries frequently adopted electric light in order to avoid damage to paintings. Eulogies abounded to the resultant perceptual conditions. A reporter at the Central Exchange Art Gallery, Newcastle-upon-Tyne, stated in 1882 that "every shade of colour was brought out with marvellous distinctness," but this was not shared by every observer.[23] Pictures displayed at the Union League Club House in New York, claimed the *Scientific American*, "appear...to the observer as (they) did to the artist when (they) left his easel."[24] This strategically made the rather erroneous assumption that all paintings were made by and to be viewed by daylight. Rembrandt, for one, painted several canvases by candlelight, and intended some of them to be seen thus.[25] The electric glare may have left them soot-free, but it probably robbed them of their ideal viewing conditions.

Distance

Creating a sense of distance between bodies, as argued in chapter one, was an essential aspect of liberal rule: the experience of private space and individuality enabled a practical space of self-government and stasis to be maintained amid the teeming morass of urban

[22] *The Builder*, XL, January 7, 1882, 10.
[23] *The Electrician*, VIII, March 25, 1882, 297.
[24] Quoted in *ibid.*, VII, May 21, 1881, 4.
[25] O'Dea, *A Social History of Lighting*, 9.

life. Museums, aquaria, and art galleries as well as individuated domestic architectures, all made possible a visual environment which enabled a decorous distance to be upheld. Light technology as much as wide streets and slum clearance functioned as a material condition of its possibility, by allowing accuracy of perception across greater tracts of space. As both searchlight (concentrated focus on a point) and beacon (concentrated point on which to focus), electric light systems found use as technologies enabling distant vision.

Throughout history, the military has been swift to exploit, and fund, technological innovation. Electric technologies were from their inception utilised and developed by armies and navies: telegraphy, for example, forever altered systems of communication between and among regiments. Electric light, both as technology of detection and communication, had an equally significant effect on the nature of battle. Prior to the invention of arcs and, more importantly, portable generators with reliable cables, paraffin lamps were generally used in warfare. The potency of these lamps should not be underestimated, but their relatively limited illuminating capacity and flicker meant that war, like surgery, tended to halt at night. It was, simply put, impossible to know with accuracy just where, and who, the enemy was. This shadowy, mottled, imprecise field of vision was transformed by new arclight systems, which were first used in earnest, for signalling and illumination, by both sides, during the Franco-Prussian war (1870-1). The light had the ability to pick out detail and colour at distances well beyond the conventional range, facilitating the nocturnal identification and location of enemy manoeuvres. The importance of recognition was highlighted by this report from the Argentinian navy in 1882:

> We have used the light for signal purposes, first hoisting our flags and throwing the light upon them, and then turning the light on the other ships and observing their flags. Of course the light would be useless for the purpose were we not able to absolutely distinguish colours by it. We are laying six miles off the shore, and at a house two miles inland it is possible to read small print by our light. At first, the people thought it was a new kind of comet, and predicted another revolution.[26]

Without such televisual technologies, the scale and scope of modern warfare would have been impossible. Electric light found many arenas of use by virtue of this capacity to enhance the scope of accurate, or simply functional, vision. Mangin Projectors, pioneered by the French military, were clamped to the pinnacle of the Eiffel Tower soon after its construction; experiments showed that animals and humans could be discerned at 10-

[26] The report was from the ironclad *Alicante Brown*, quoted in *The Electrician*, VIII, April 29, 1882, 387.

11,000 metres distance. When combined with increasingly durable and mobile plant, armies' temporal and spatial scope could expand. Tests with searchlights in 1892 showed that new portable dynamos could function flawlessly in "ankle-deep" mud.[27]

Light technology, therefore, formed part of a set of techniques aiming to maximise the accuracy of soldiers' perception. This included recognition of insignia and illumination of enemy positions, as well as the training precise use of the rifle. Optical specialists were utilised by the army in order to generate in soldiers "the power of *judging distance*," without which:

> A soldier cannot use his rifle correctly...The acquirement (sic) of the art of *judging distance* is effected by causing the men under instruction to note the apparent size and aspect of soldiers placed at certain distances, to observe and familiarise themselves with the appearance of different parts of the figure, limbs, accoutrements, and dress of the men, and to make comparisons between them and the appearances of the same soldiers and objects at various other distances.[28]

This was less a science built on calculation than on repetitive training, habitually associating particular configurations of eye, hand and rifle with a particular distance.

By the mid-1880s, the engineer Maier was observing that electric light was "indispensable" for naval operations.[29] Its potent beam could illuminate enemy coasts and ports, project coherent signals, help avoid collisions, and identify torpedo boats: in 1894, Germany repainted its entire submarine fleet bluish-grey, considered the least detectable colour by arc. Beams and searchlights themselves could extend over increasing ranges; one light at the 1893 World's Fair, it was claimed, was visible sixty miles away on clear nights.[30] Even so, the suggestion in *Nature* that lifeforms on Mars could be contacted by the simultaneous flashing of the lights of all the world's fleets was perhaps somewhat optimistic.[31] A project to light ocean routes from Europe to America with ten gargantuan lightstations anchored to the seabed attracted derision.[32]

Rather than illuminating objects at a distance, signalling entails communicating flashes and colours rapidly and accurately. As late as 1852, there had been no legal system of naval lighting, but, from that date, ships were obliged to use green lights to mark the

[27] *The Engineer*, LXXIII, March 25, 1892, 252.
[28] Longmore, *The Optical Manual*, 10, italics original.
[29] J. Maier, *Arc and Glow Lamps* (London: Whitaker and Co., 1886), 350.
[30] *The Engineer*, April 7, LXXV, 1893, 293.
[31] Reported in *The Electrician*, XXIX, September 16, 1892, 526.
[32] "A Far Fetched Idea," *ibid*, XVII, July 9, 1886, 163.

starboard bow, and red for the port.[33] Very few people, it was argued, could fail to distinguish them.[34] Yet the growing speeds at which ships were travelling, combined with the Board of Trade's rather simple testing procedure for colourblindness, ensured that concern remained. Nonetheless, the reliance of transportation systems on signalling increased relentlessly. The arclight, with its projecting capacity, was quickly employed for beacon and communication purposes. The most obvious example of this was the lighthouse. Arclights were deployed at the South Foreland lighthouse in 1858, and by 1871, photometric analysis at Sauter Point showed that its beam had a maximum intensity of 700,000 candles.[35] By 1893, the French electrical engineer André Blondel claimed that his flashing lighthouse beam could reach a prodigious eighty-five miles, a figure he contrasted with English designs which he claimed revolved too fast, resulting in "gushes" which dazzled rather than securely indicated.[36] This had led to electrical experiments at Dungeness being discontinued in 1874: "the full glare of the electric light at a low elevation was found to be dazzling and bewildering, so much so that it was impossible to judge accurately of the ship's distance from the shore."[37] Pure intensity without crafted direction was not enough: better reflectors would be developed to focus and direct these giant beams. The proliferation of lighthouses and buoys also necessitated greater distinction between lights, and a whole array of techniques to break, flash, revolve or give colour to beams to enable precise navigation of perilous coastlines. The comprehension of these clear, unambiguous signals was helped by telemetric devices designed to judge distances: the fallibility of the eye again required mechanical solutions: "it is well known that the distance of any object at sea, and more especially the distance of a light, cannot be estimated by the eye with any approach to accuracy."[38] Once again, ocular agency was a compound result of the interaction of man and machine.

Fog, as discussed earlier, menaced urban as well as maritime vision. Recalling the 'Great Fog' of 1813-14, *The Builder* reminded readers of pedestrians drowning in the Thames, or

[33] Thomas H. Bickston, *Colour Blindness and Defective Eyesight in Officers and Sailors of the Mercantile Marine* (Edinburgh: James Thin, 1890), 1-2.
[34] *The Engineer*, XXVII, August 16, 1895, 166.
[35] J.M. Douglas, "Electric Lighting Applied to Lighthouse Illumination," *British Architect*, XI, March 21, 1879, 133.
[36] *The Electrician*, XXXI, September 1, 1893, 478.
[37] E. Edwards, *Our Seamarks. A Plain Account of the Lighthouses, Lightships, Beacons, Buoys, And Fog-Signals Maintained on our Coasts for the Guidance of Mariners* (London: Longmans, Green and Co., 1884), 56.
[38] Archibald Barr and William Stroud, *Telemeters or Range-Finders for Naval and Other Purposes* (London: Institute of Mechanical Engineers, 1896), 56.

finding their way through the city by touching walls and buildings. Unnecessary deaths, the publication complained, were still caused by fog, referring to a lamentable accident involving a warehouseman in the city.[39] More generally, descending curtains of fog occluded urban visibility and frequently suspended motion and circulation. In January 1870, for example, the leaden gloom in Manchester forced the majority of the city's transport to stop.[40] The gas supply was strained to breaking-point by the sudden onset of fogs, and the light itself was simply incapable of indicating position at sufficient distance for the safety of the public to be guaranteed. On "dark and foggy days," the Council heard, "business had to be suspended, and workpeople dismissed, for want of the requisite supply of gas."[41] By contrast, the generation of electricity was "especially suitable for sudden demands," such as fogs.[42]

Thus, the security of circuits of communication and transportation, so vital to the dynamics of the liberal city, was augmented by electricity. In an age where the normative operation of the city, the market, and the social was inseparable from kinetics and permanent circulation, electric light networks could be seen to facilitate this autonomous functioning.[43] The acceleration of information, goods, traffic, money and people was made possible by a series of material techniques: street widening, new vehicles, smoother road surfaces, more durable rails. Electric light played a particularly critical role here. Darkness, smoke and fog leave the circulation of people, money and goods, from and through which such vast entities as 'capitalist society' are assembled, suspended and frozen. Penetrating light, creating safe conditions of visibility, liberates and lubricates these circuits. The expanding range and reach of vision is liberal in the sense that dispersed and free subjects, rather than the state, are utilising it. Prior to the development of effective onboard dynamos, traffic through the Suez Canal, for example, was forced to halt at night. Lighting ships electrically enabled them "to pass through it at night, instead of coming to anchor, as at present." By 1888, vessels equipped with the new light had cut

[39] "London and its Fogs," *The Builder*, XXXII, December 20, 1874, 1014, 1021.
[40] *Shadow*, January 15, 1870.
[41] Manchester City Council, *Proceedings*, 1870-1, 153.
[42] *The Engineer*, LXXIV, December 23, 1892, 562.
[43] For the significance of motion, see Wolfgang Schivelbusch, *The Railway Journey*, Paul Virilio, *Speed and Politics: An Essay in Dromology* (New York: Semiotext, 1977). For communication and connection, see Andrew Barry, "Lines of Communication and Networks of Rule," in Osborne et al., *Foucault and Political Reason*.

their average time of passage from 38 hours to 22 and a half.[44] The free flow of the global market was thus made that bit freer, more natural, more liberal.

The ability to safely detect and judge the position of distant objects thus enabled a hitherto impossible degree of nocturnal speed. Automobile travel at night is unthinkable without electric light, as Bryant and Hale observed in 1911: "with the advent of the automobile and other swiftly moving vehicles, the distinctness with which objects may be seen must be improved, so that the danger may easily be avoided."[45] Ten years later, Trotter commented on how new forms of electric light enabled road traffic to move "at a pace which a few years ago would have been condemned as reckless and furious."[46] The distance at which one could accurately detect moving objects determined the velocity at which one could safely and practically travel, and visual and bodily habits evolved accordingly.

Detail

"In the high Victorian era," argued Sennett, "people believed that their clothes and speech disclosed their personalities."[47] This environment of public disclosure of detail, as argued in chapter one, required a certain set of material conditions, including, obviously, a certain level of light to facilitate the reading of signs. Foucault, it is worth remembering, defined discipline as a "political anatomy of detail," a mobilisation of visual technologies designed to secure the scrutiny of the entire surface of the body politic.[48] The liberalisation of government did not lead to a loosening of this obsession with detail: rather, such scrutiny, and its careful recording, was delegated to civil society in general.

The collective act of self-inspection was forced into temporary abeyance when visual conditions precluded its establishment. As Schivelbusch argues, prior to the later nineteenth century, street lighting as we know it barely existed; oil and gas simply were not sufficiently manipulable or potent to produce and sustain an amount of light able to sufficiently stimulate the eye to be able to monitor detail. The idea of constant

[44] *The Electrician*, VIII, January 7, 1882, 114, and XXIV, November 29, 1889, 82.
[45] Bryant and Hale, *Street Lighting*, 21.
[46] A.P. Trotter, *The Elements of Illuminating Engineering* (London: Sir Isaac Pitman and Sons Ltd., 1921), 93.
[47] Sennett, *The Fall of Public Man*, 25.
[48] Michel Foucault, *Discipline and Punish*, 139.

streetlighting was alien to most towns, which often turned off what little lighting they had after midnight or during full moons: "a town is often left in complete darkness for nights together," observed Newbigging and Fewtrell in 1878.[49] Four years earlier, *The Builder* had moaned that "little or no effort has yet been made to improve the *lighting* up of London's streets by night."[50] Early demonstrations of electric light had proved rather unsatisfactory, as Higgs admitted in 1879: "such experiments have only succeeded in blinding the bypassers, and projecting long shadows behind them."[51] These problems with arc lighting will be explored later in this chapter.

The emergence of electric streetlighting was thus a protracted, haphazard affair. Laboratory testing revealed that optical acuity could be increased by whiter electric light, owing to its engagement of more retinal cones at a greater distance. Thus, electricity promised to play a role in fulfilling Helmholtz's dictum that sensory pleasantness corresponded "to the conditions that are most favourable to perceiving the outer world, that permit the finest discrimination and observation."[52] Photometric testing in both laboratory and street was, as shown in chapter four, used to establish norms and thresholds of lighting for specific practices. For street lighting, there was inevitably disagreement over the precise photometric quantities requisite for particular streets. Illumination, argued Trotter in 1892, "begins to be useful when it is comparable with moonlight," the value of which he estimated at one-thirty-sixth of a foot-candle.[53] According to Bryant and Hale, the form and aptitudes of the eye itself was itself an evolutionary response to the need to see by moonlight. This ability was not achieved without fatigue; they estimated the maximum power of moonlight at one-fifth of a foot-candle. However, according to photometric tests, the amount of light acting upon the eye in some streets fell to an "almost unmeasurable quantity," which led to "uncertainty in discerning objects."[54] Similarly, Trotter found it almost impossible to take photometric readings in some streets, where colour and detail were only discernable very close to lamp-posts.[55]

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[49] Newbigging and Fewtrell, *King's Treatise on the Manufacture of Gas* II, (London: W.B. King, 1878), 275. For the early history of gaslighting, see Brian Bowers, *Lengthening the Day*.
[50] *The Builder*, XXXII, June 20, 1874, 521, emphasis original.
[51] Higgs, *The Electric Light*, 6.
[52] Cited in Dolf Sternberger, *Panorama of the Nineteenth Century*, 173-4.
[53] Trotter quoted in *The Electrician*, XXIX, May 13, 1892, 32. Bell, *The Art of Illumination*, 254-7.
[54] Bryant and Hale, *Street Lighting*, 22.
[55] Trotter, *Illumination: Its Direction and Management*. (1911?), 262.

Calculating light meant not only measuring distance and colour-recognition, but also detail, or "distinguishing power," frequently equated with reading distance.[56] In 1891, a writer for *The Electrician* observed that in Piccadilly, the gaslamps failed to provide conditions approaching general legibility. Rather, they merely faintly plotted the route ahead, serving as "buoys", which were fine for maritime traffic, but hardly appropriate for urban centres. "The illumination *as* illumination, for the purpose of reading a newspaper or finding a fallen sixpence, is of the feeblest kind."[57] Street lighting by electricity, it was argued, enabled this ease of legibility to be generated. When St Petersburg's Nevskii Prospekt was lit by arclight in 1883, a writer commented, "in every point of Nevskii it was possible to read easily."[58] Blondel defined the minimum conditions of public lighting as "good sensation of light, so that (observers) are able to read printed matter at the foot of a lamp-post" in 1895.[59] This was palpably not being achieved by gaslight, as the London *Gazette* began utilising tinted green paper to enable it to "be read in comfort in a bad light" two years previously.[60]

In spaces where reading was either required for safety or desired for comfort, electric lights, usually small and incandescent, were deployed with increasing regularity. Pullman electrically lit some of its cars as early as 1881, while omnibus inspectors were equipped with tiny lamps to check tickets.[61] From the 1870s, the practice of fixing street nameplates to public lamps became more common. The St James and St John vestry, Clerkenwell, for example, passed a resolution in 1874 to place street names on lamp-posts "in embossed ruby letters on ground glass at the back," which would "act as a direction for people in search of streets in neighbourhoods with which they are unacquainted."[62] Thus the free circulation of traffic and pedestrians could be secured by materially increasing the volume and legibility of signs on the city's surface. This trend for the precise illumination of vital surfaces can be detected elsewhere: inspectors required portable lamps or torches to gain visual access to pipes, wires and meters, while an array of delicate instruments, among them the laryngoscope and the esophascope, enabled surgeons to scrutinize concealed cavities and tissues within the body.

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[56] James Barr and Charles Phillips in *The Electrician*, XXII, March 9, 1894, 525.
[57] *Ibid.*, XXVII, July 3, 1891, 241, emphasis original.
[58] Quoted in J. Coopersmith, *The Electrification of Russia* (Ithaca, N.Y.: Cornell University Press, 1992), 48.
[59] Blondel, "Street Lighting by Arc Lamps," *The Electrician*, XXVI, November 15, 1895, 90.
[60] *Ibid.*, XXX, February 3, 1893, 379.
[61] *Ibid.*, XXVIII, February 5, 1892, 342.
[62] *The Builder*, XXXII, October 24, 1874, 897.

Producing enhanced, directed, detailed nocturnal vision was, of course, a vital aspect of urban policing. During the reign of George I, argued *The Builder*, householders were obliged to suspend lights outside their homes until eleven p.m. only, after which "highwaymen continually rode into the streets…and perpetrated the most open outrages with impunity."[63] The police themselves often owned, ran and controlled the city's lights in the earlier nineteenth century: in Manchester, for example, the corporation bought the gasworks from the police in 1843. Gaslight had itself become regarded as "a powerful auxiliary agent in the prevention and detection of crime" long before this date.[64] When gaslight was suspended, due to strikes, systemic faults or the policy of only lighting the streets during certain times, there was often a perceived rise in crime, as was the case in Sunderland in 1875:

> The chief constable of the borough informed the magistrates that in consequence of the corporation issuing orders that no lamps were to be lighted during the summer months, the streets and houses were decidedly unsafe, as his limited number of men were unable to prevent burglaries, robberies and assaults, owing to the darkness, and the identification of offenders was impossible.[65]

Likewise, "robberies and assaults" were described as "frequent" during the failure of the New York electric system in 1889.[66] Miscreants found extinguishing or tampering with lamps were fined, usually between one and two shillings.[67] This seldom carried the old political connotations of lantern smashing, given the fact that assailing a whole system was difficult for rioters. Nonetheless, Scotland Yard had fitted its own plant for electric light by 1891, in case strike or accident plunged it into darkness.

On the street itself, electric light, if well-fitted and properly-maintained, promised to produce a field of localised detail. *The Electrician* reported excitedly on incidents whereby criminals were caught as a direct consequence of new light technology. Following an incident whereby a hansom cab driver ran over and severely injured a pedestrian, the electric light led to the unsuspecting offender's capture:

> A police constable…pursued him for a short distance, and, facing the station, where the electric light brightly illuminates the street, was able to take the number of the offending vehicle. Cabby has consequently been summoned – much to his surprise and much, we hope, to the education

[63] *Ibid.*, XXXIII, July 24, 1875, 652.
[64] Newbigging and Fewtrell, *King's Treatise* I, 69.
[65] *The Builder*, XXXIII, June 12, 1875, 539.
[66] *The Electrician*, XXIV, November 8, 1889, 18.
[67] E.g. Manchester City Council, *Proceedings*, 1876-7, 401.

of his brethren, whose reckless careers would be speedily checked were electric lighting more general.[68]

Caminada, in his entertaining memoirs on his detective career, pointed out the utility of lamps for arresting criminals, in this case a base coiner, one of his many bête-noires:

> When he arrived opposite the Commercial Hotel, in Henderson Street, I saw him take something out from his pocket and examine it under a lamp. While he was thus engaged I walked up and arrested him.[69]

Constant, bright light, judiciously arranged and competently maintained, could thus produce the visual conditions apposite for the functioning of liberal realms at night: commerce, leisure, circulation, speed, and security. But these patchy networks of augmented perceptual environments required, once again, huge labour and material mobilisation to successfully function. The next section of this chapter examines the kinds of subjective agency that such visual technologies could embed.

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Attention, Silence and Salubrity: Electric Light as Environmental Technology

Electric light was promoted, by Edison and others, as a technology of perception in the broadest sense:

> The (incandescent) light is designed to serve precisely the same purposes in domestic use as gaslight. It requires no shade, no screen of ground glass to modify its intensity, but can be gazed at without dazzling the eyes. The amount of light is equal to that given by the gas-jets in common use; but the light is steadier, and consequently less trying to the eyes. It is also a purer light than gas, being white, while gaslight is yellow. Further, the electric light does not vitiate the surrounding atmosphere by consuming its oxygen, as gaslights do, and discharge into it the products of combustion. The heat emitted by the lamp is found to be only one-fifteenth of that emitted by a gaslight of equal illuminating power: the glass bulb remains cool enough to be handled. Of course, there are no poisonous or inflammable gases to escape, and the danger of fire is reduced to nil, with a consequent reduction in the rate of insurance.[70]

Not simply modifying vision, the light acted upon the other senses, as well as purifying the atmosphere from which the lungs drew their breath. This section explores the development of electric light as an environmental technology designed to produce, in

[68] *The Electrician*, VI, January 1, 1881, 73.
[69] Jerome Caminada, *Twenty-Five Years of Detective Life*, 99.
[70] Thomas Edison, writing in the *North American Review*: cited in "Mr Edison to the Rescue," *British Architect*, XIV, October 22, 1880, 189.

controlled spaces, the conditions within which a normal body could see, breathe, move and live with freedom and comfort. Consequently, we can view systems of light production as integral to the assembling of subjects able to function as producers and consumers, in a wholesome urban milieu. Building a civil, visual environment, within which this subject could be fostered, was the aim of all promoters of light technology.

The Productive Eye: Attention, Clarity and Control

In modernity, the "means of perception" were continually reconstructed in order to bring about the productive and consumptive capacities of the population in accordance with new techniques of manufacture and leisure.[71] Writing in 1908, Pillsbury argued that "nearly every trade and profession has given its members a mind adapted to receiving impressions that would not be received by the great mass of men."[72] The measurement and assessment of artificial light used in the workplace formed one critical axis along which this reconfiguration of physiological capacities developed. Not only was the solar spectrum more accurately simulated by new forms of electrical illumination, but the brightness of the lights, when properly focused, promised to generate the lucidity required for tasks requiring prolonged periods of attention, like drafting, reading, lacemaking and printing. By the early twentieth century, electric corporations and illuminating engineers, building on these experiments, were performing detailed tests to calculate the precise amount of white electric light required for any number of productive tasks. Minimum urban street lighting, argued Trotter in 1921, should be between 0.01 and 0.25 foot-candles. He produced figures for any various tasks: 4-5 foot-candles for weaving coloured goods, 10-15 for surgery, 15-20 for watchmaking.[73]

According to the *Halifax Courier* in 1880, a worker, when asked, said he preferred electric light "because it enabled him to see work better that required his close attention."[74] Capturing and maintaining physiological and ocular agency in, say, the silk and dying industries, made possible the securing of an attentive, productive subject. The environmental effects of electric light, its lack of heat, dirt and hiss, also augmented these

[71] Crary, *Suspensions of Perception*, 13.
[72] Walter Pillsbury, *Attention* (London: Swan, 1908), 40.
[73] Trotter, *The Elements of Illuminating Engineering*, 76.
[74] Quoted in *The Electrician*, IV, March 6, 1880, 183.

conditions of productive concentration and attention to be generated. The latter was defined in 1909 by the psychologist Titchener in stark terms as identical with "sensible clearness."[75] This clarity applied, according to the emphasis of the psychologist, to both internal states of consciousness and external conditions under which an act of perception took place. Consequently, we can speak with a degree of caution of the slow incorporation of questions of visual environment into wider discourses of psychology, which themselves would become increasingly vital to workplace organisation. Eyestrain in particular was regarded as inimical to accurate, industrious seeing; below certain calculable thresholds of illumination, the eye reached its limits of dilation, lost focus, blinked rapidly, and became strained: "it is curious how little control there is over the absolute direction of the eye when the light has almost disappeared."[76] This optical pressure, it was argued, was "largely avoided if the entire working surface is liberally illuminated."[77] Trials of electric light soon demonstrated physical easing of the visual act: "it is possible to read and to write for many hours by such a light without experiencing the least fatigue."[78] However, attention was not limited to facilitating ocular agency: alongside perceptual questions sat wider physiological ones of fatigue, posture and co-ordination. Attention itself, argued Pillsbury:

> rests upon the attitude of the man's body, the direction of his eyes, and other bodily signs...As a whole then it seems that the physiological effects of the attention are as widespread as they well could be.[79]

Brighter, whiter light could avoid the hunched, squinting nocturnal deportment that led to headaches, eyestrain, backache and bad posture. Attention was a biotechnical effect traversing the body from lens and retina to nerves and muscles.

Illuminating engineering was the name of this technique of visual management: "the art of directing (candle-)power for the use and convenience of man."[80] There were, it was acknowledged, two basic modalities: general and local lighting. The former operated through diffusion, which invited the material analogy with clouds:

> When the sky is clouded, the sunlight pierces the clouds as through a ground glass, and the whole sky is like an immense illuminated ceiling, radiating light from every point and in all directions. The objects illuminated diffuse in their turn the light which they receive, so that there

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[75] Edward Titchener, *Lectures on the Elementary Psychology of Feeling and Attention* (New York: MacMillan, 1908) 173.
[76] W. Abney, *Colour Vision.*, 114.
[77] Clewell, *Factory Lighting* (London: McGraw-Hill, 1913), 103.
[78] W. Preece, "The Sanitary Effects of Electric Lighting," *The Electrician*, XXV, August 29, 1890, 464.
[79] Pillsbury, *Attention*, 12, 25.
[80] Trotter, *Illumination: Its Distribution and Management*, 1.

> is an intercrossing of rays, producing the effect of a *mean amount of light* everywhere. This is *general illumination*. (First emphasis mine)[81]

Nature, it is worth emphasising, is itself statistical: normal light is natural. This diffusion could be achieved through ground glass ceilings or globes, or "big funnel-shaped covers" to throw light onto the ceiling.[82] Local lighting utilised directed, concentrated foci: necessary for billiards, surgery and lacemaking.

Examples of these visual management techniques could doubtless be multiplied. Although they worked through and with the body's fragile economies, they palpably allowed increased control and discipline. Human abilities to discern objects were reconfigured in the same radiant zones that facilitated better intersubjective monitoring. Supervision, that combination of the panoptic and oligoptic, could be exercised over wider spaces, with greater discernment: even the necessity of hanging arclights higher left larger wedges of airspace through which to literally oversee the shopfloor. New York State began introducing electric light into many of its institutions for precisely this reason in the later 1880s.[83] The light also reduced fire risks, valuable for protecting property and human life alike. Exeter asylum, which opened in 1886, was the first such building consciously designed to be lit electrically.[84] Concentration of illumination was considered essential in focusing the concentration of schoolchildren.[85]

But it would be misleading to conclude that illuminating engineering entailed an agglomeration of an arrogant, dominating light, its devious and nefarious ruses divesting us of our freedom.[86] This pessimistic perspective ignores the mutual imbrication of human and nonhuman in any collective act. New light technologies redistributed both human and nonhuman agencies: they are biotechniques, not omnidirectional power effects raining upon pure human being from a cold realm of metal. The individual's control over light was a case in point. Switching gas on and off entailed time-consuming use of stopcocks and taps, while "the moment the (electric) light is required, it can be had."[87] Putting out

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81 Higgs, *The Electric Light and its Practical Applications*, 6.
82 W. Sumpner, "The Diffusion of Light," *The Electrician*, XXX, February 3, 1893, 382.
83 *Ibid.*, XXIII, September 27, 1889, 534.
84 *British Architect*, XXIV, August 21, 1885, 183. See also J. Taylor, *Hospital and Asylum Architecture in England: Building for Health Care* (London: Mansell, 1991), 147-8.
85 Bell, *The Art of Illumination*, 235.
86 A perspective taken, for example, by Hans Blumenberg, "Light as a Metaphor for Truth," in Levin, ed., *Modernity and the Hegemony of Vision*.
87 Robert Hammond, *The Electric Light in Our Homes: Popularly Explained and Illustrated* (London: Warne, 1884), 92.

one gaslight could result in a simultaneous rush of light through others, while with electric light, "not only could all the lamps in a room be simultaneously extinguished without putting out those in another, but...each individual lamp...was under perfect control by means of a small plug switch, placed conveniently near it."[88] This ease of use extended to the simplicity with which bulbs could be changed and the portability of the light, further freeing the capacities of humans to see with clarity and comfort. Switches and valves themselves were consciously constructed with the optical architecture of humans in mind:

> Although the eye is very sensitive to sudden changes of light...if you make the change sufficiently slowly you allow the pupil time to expand and contract, and the change is not noticed very well. Therefore, instead of turning this valve rapidly, it is turned by a slow screw, so that it takes at least a minute to make a change of light equal to one candle-power.[89]

A simple steel helix tuned the speed at which illumination levels shifted to the natural economy of the pupil, mobilising the body's natural capacities.

Increasing amounts of brighter, more physiotechnically tuned, light were integral to the tactics of enhanced productivity. In these specially-maintained archipelagos of managed illumination, attention and discernment could be, within its physiological parameters, stimulated and prolonged. "Unimportant as it may look at first glance," reported Bolling and Lowe on the iron trade in 1881, electric light "adds to (factories')...productive power, for by means thereof many operations may now be carried on irrespective of day and night, all of which enable an increased production to take place."[90] The importance of electric light to the clothing industry was emphasised during debates over revisions to the 1882 Electric Lighting Act. The electrical engineer James Shoolbred, for example, observed that in "cotton, wool and silk weaving, and corn and dye works, and lace and hosiery," the new light technology had improved efficiency and visual acuity.[91] An industrial milieu of measured, managed attention was slowly being formed. Reported *The Electrician* in 1881; "rather more work is done at night than in the daytime, because of the lower temperature, and because the workmen are not so distracted by passing sights and sounds."[92] By depicting electric light as a technology of profit, able to thwart night's encroachment, promoters could translate it into the interests of manufacturers, exploiting what could be termed the polyvalence of the light's agency, exemplified in Edison's

[88] William Thomson in *The Electrician*, VII, May 21, 1881, 3.
[89] J. Gordon, "The Development of Electric Lighting," read before the Society of Arts. Quoted in *ibid*, XI, July 23, 1883, 139-40.
[90] In *ibid*, VII, August 6, 1881, 178.
[91] Select Committee on the 1882 Electric Light Act, *Report*, 1886, 275.
[92] *The Electrician*, VII, October 1, 1881, 305.

description of his lamp. Edison felt that electric light might be capable of permanently eradicating night, overcoming the need for sleep.[93] The luminiferous reach of arclight facilitated distant vision at night, allowing quarrying, fishing and harvesting to continue after dusk; as a beacon, it was deployed in tunnels and along canals. Finally, the efficiency of electricity, and its lack of smoke, added to its industrial allure.

The human capacity for work, and the environmental, machinic, conditions of commodity production, were both coproduced in a slowly mutating environment, within which optimum capacities of both forever remained elusive. This is the jagged vector along which liberal environmental government wended its agonistic way.

The Salience of the Visual: Domesticity, Silence and Seduction

The same technologies mobilised to capture the attentive agency of workers were also deployed to produce a shimmering array of distraction-effects at the heart of the pullulating world of urban nocturnal leisure. States of fascination, attraction and luminous seduction were generated alongside states of concentration and attention in ways that force historians to acknowledge the conjoined industrial and mass cultural origins of modern perception:

> Modern distraction was *not* a disruption of stable or 'natural' kinds of sustained, value-laden perception that had existed for centuries but was an *effect*, and in many cases a constituent element, of the many attempts to produce attentiveness in human subjects.[94]

Manifold centres of visual allure (glass cases erupting with the glittering bounty of international commerce, floodlighting, clock faces, signs, stage effects) all vied for attention; the effect was a decomposition of arrested focus into distraction, a vertiginous surrender to the saccadic.

Electric light was thus one of a diverse range of perceptual technologies which disassembled and reconstituted visuality itself. This involved a certain retraining of the eye, of visual expectations, muscular actions and habits. Arclight's brightness imparted a disarming flatness to objects, which, when combined with sharp, long shadows and more sterile colours, could disorientate viewers. Form, depth and volume seemed weirdly

[93] Nye, *Electrifying America*, 147.
[94] Crary, *Suspensions of Perception*, 49.

skewed, which "made a nonsense of the ancient art of sciagraphy."[95] This delicate architectural distribution of shadows was imperilled by the abrasive intrusion of the new light. Arclight, argued the gas engineer Sugg in 1882, produced "intensely black and excessively broad shadows."[96] As illuminating engineering developed, these effects were countered by diffusing techniques: globes, glass ceilings, directed light, calculated degrees of reflection. However, there was always the danger of annihilating shadow completely. Lighting objects from all angles robbed them of depth; the "eye vainly struggles to select the wanted degree of relief," leading to lack of perspective, physiological over-compensation, and eyestrain.[97] Calculated illumination entailed negotiating both the irreducible processes of the body and the less intransigent, but hardly plastic, set of optical, physical and psychological routines through which everyday seeing took place.

This perceptual reconfiguration and techniques of light management necessarily co-evolved, generating a complicated, unpredictable series of human resistances and habitual accommodations. Bell recommended avoiding general illumination in the home, as it "deadens shadows (and) blurs contrasts."[98] Lampshades were darkened: lighter wallpapers came into vogue. Reflection ratios were measured and plotted: reflecting capacities varied from 82% for white blotting paper, to 0.4% for the black velvet used to envelope photometric experiments.[99] New decorative and architectural forms became possible: Tiffany lampshades, open planning. The psychophysics of seeing had to be correspondingly tuned. Eyes were accustomed to seeing yellow at night, "and a whiter light being introduced, appeared to be blue. The Americans did not call it blue at all. When they had been accustomed to them the imaginary blueness rapidly disappeared."[100] The rosy glow of gas retained something of the hearth; electric light, scientific and abstract, provided no such simulation.

Nonetheless, the domestic world would be gradually reconfigured around electricity. The murk, dirt and stench of the slum zones were targeted by sanitarians as vital objects of reform. Cleansing and draining, administering soap and water, was integral to this, as was

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95 Reyner Banham, *The Architecture of the Well-Tempered Environment* (London: The Architectural Press, 1969), 44.
96 William Sugg, *Gas as an Illuminating Agent Compared with Electricity* (London: Walter King, 1882), 19.
97 Bell, *The Art of Illumination*, 16.
98 *Ibid.*, 185.
99 *The Electrician*, XXX, February 3, 1893, 381.
100 W. Preece, Institute of Civil Engineers, *Minutes*, CX, May 10, 1892, 142.

whitening: "our English homes should be the embodiment of brightness."[101] Domestic illumination could generate and perpetuate brightness and comfort:

> In these days it may be said that, whatever the rank in life, the brightest and best portion of our lives is spent in the evening hours, when the cares of the day can be set aside, and all the comfort within our reach is thoroughly enjoyed.[102]

Comfort and relaxation, Hammond suggested, were secured by electric light. Aside from its salubrious and sensory qualities, the ability to delicately manipulate the light facilitated the enhancement of domestic environmental differentiation. Particular domestic spaces, it had long been argued, should have different levels of light: staircases and halls should be light, dining rooms should be bathed in soft radiance, bedrooms warm and inviting, billiard tables brilliantly highlighted.[103] This partitioning of visual spaces was largely confined to wealthier groups, but by 1900, was clearly expanding in its social reach. Hammond and Coope both boasted of the control that electricity brought to their domestic economy, Preece could leave the electric lighting of his daughter's dolls' house "effectively under the child's control."[104] Electricity in the kitchen began to be deployed for more than lighting: electric cookers, coffee-grinders, irons, knife-sharpeners, and washing machines promised to domesticate practices which were previously carried out in public.[105] Technology thus further cemented the practical distinction between public and private realms, and the gendering implicit in this. When combined with the segregating and individuating agency of wiring and switches, electricity clearly was a technology providing the material possibility of separate, introspective, self-governing subjects.

This partitioning of tuned environments, this fixing, framing *and* freeing of visual agency, was reproduced across the urban landscape. Theatres were among the first institutions to avail themselves of electric light: the Savoy adopted it in 1881. Aside from the atmospheric effects of removing burning gasjets from auditoria, electric light's pliability inaugurated a new epoch in stage effects. Rheostats, glazing and switches allowed light to be flashed, dimmed, coloured and directed with hitherto unimaginable sophistication. Dubosq, for example, created apparatus to spotlight a figure through his or her every peregrination; "this point can be enlarged or contracted at pleasure by the movements of a

[101] *Manchester Magazine*, I, May 1879, 35. The quote refers to the activities of the Mission of Women.
[102] Robert Hammond, *The Electric Light in our Homes*, 75.
[103] G. Aitcheson, "Coloured Decorations," *The Builder*, XXXI, March 29, 1873, 273; E. Roberts, "Hints on House Building," *ibid*, XXX, February 24, 1872, 141.
[104] *British Architect*, XXIV, September 18, 1885, 123.
[105] *The Electrician*, XXXIII, June 22, 1894, 208. Nye, *op cit*, 384.

special diaphragm which limits the field of lighting."[106] Landmarks were increasingly illuminated. When the clock face of the Houses of Parliament was lit electrically in 1880, *The Electrician* commented that "the contrast with the face looking towards Great George-Street, which is still lit by gas, is very striking. The electric-lit face has a silvery-white appearance, whilst the gas-lit face has a dark dingy red tinge."[107] The Prince's Tennis Club in Knightsbridge installed electric light designed to illuminate the courts "in such a manner that no shadow will be thrown on the ball during play."[108] Frontages of department stores and hotels became surfaces devoted to mass illumination. The First Avenue Hotel in New York was described as a "fairy palace" in 1884.[109] International exhibitions represented the pinnacle of this ostentatious display. 2,500 electric lights were displayed at the 1881 Paris Electrical Exhibition, generating a hyperbolic response in the English architectural press: "the nave of the Palais de l'Industrie was lighted up on Saturday by more than 200 lamps of great power. The effect was marvellous, and will long be remembered by those who witnessed it."[110]

But the ability of the new light system to realise conditions enabling one to be private in public was perhaps its most telling practical advantage. When the reading room at the South Kensington museum was equipped with arclight in 1880, the light was "steady and of good colour."[111] Free libraries were able to extend their opening hours when a durable system had been introduced. The British Museum employed electric light in its reading room from October 1879, which enabled scholars to remain at their labours until six o'clock. Despite a host of problems with the carbons, including hiss, flicker and occasional fragmentation of the carbons, the trustees of the Museum agreed to its permanent adoption in February 1880. The following winter, the building found itself in the position of being able to keep the library and its adjoining rooms open until seven, while having to close the rest of the museum three hours earlier. New arclights had been fitted, making the lucubrations of students easier: "there is now none of that disagreeable

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[106] E. Algave and J. Boulard, *The Electric Light: Its History, Production and Applications* (New York: D. Appleton, 1884), 411.
[107] *The Electrician*, VI, December 25, 1880, 61.
[108] *Ibid*, XXIII, October 4, 1889, 541.
[109] Hammond, *The Electric Light in our Homes*, 170.
[110] *British Architect*, XVI, September 2, 1881, 441. Also see Keith Beauchamp, *Exhibiting Electricity* (London: Institute of Electrical Engineers, 1997), for a review of nineteenth century electrical exhibitions.
[111] *The Electrician*, V, September 4, 1880, 183. An earlier arclight experiment was discontinued after the carbons began to buzz, causing distraction.

hissing and painful blinking that detracted from the service of the former lamps." Something of the experience of these perceptual conditions can be gleaned from the following report:

> The silent manner in which the light seems to glide into existence in a moment, and illuminate the prevailing dusk as if by magic, is very beautiful, and convinces even the most sceptical that for libraries, museums and picture galleries, or, indeed, any place where the silence should be undisturbed in any way, the electric light is that to be preferred.[112]

By 1890, the majority of the Museum's rooms were open until ten at night. These lamps produced light alone; they materially maintained the *salience of the visual.* Incandescent lamps were silent, while arclights, if the carbons were pure and correctly spaced, behaved similarly.[113] Gaslight, however, could emit a sibilant gush, a "hot hissing sound."[114] This noise was magnified when adjusting the light at the stopcock, which sometimes caused it to flare and whistle "most distractingly," drawing attention to the light itself, rather than the spaces and surfaces it illuminated.[115] Moreover, the complex effects of smoke, vapour, and heat upon the air currents in rooms could produce an atmosphere of curiously layered densities. "In electricity," wrote John Slater, "the architect would probably find a valuable acoustic ally."[116] According to Tyndall, the diminished oxygen levels in gaslit rooms had strange auditory effects. Delicacy of sonic transmission, as well as silence, could be augmented by electric light.

Gaslight tangibly impinged on the entire body. Its fumes caused headaches and sore throats. All light sources based around combustion inevitably smelt, and produced heat. The drop in temperature was among the most striking effects of electric light. At an 1885 meeting of the Royal Institute of British Architects:

> The large gas-burner, which usually makes the room almost unbearable, was removed, and a ring of thirty-six Swan incandescent lamps was arranged round the base of the dome...The effect was very pleasing, and the difference in temperature from that which ordinarily prevails was most marked.[117]

Balls, dances and theatres became notoriously hot as the gas burned beyond midnight. Similarly, the palpable coolness made possible by removing gaslight facilitated enhanced productivity and health in factories and offices. Following the installation of electric light

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[112] "The Electric Light," *ibid*, V, November 13, 1880, 306.
[113] A. White, "The Silent Electric Arc," in *ibid*, XIV, November 29, 1884, 56.
[114] Zola, *The Ladies' Paradise* (Oxford: Oxford University Press, 1995), 319.
[115] J. Willis, *Hints to Trustees of Chapel Property and Chapel Keepers' Manual*, 1884, 17. Cited in Bowers, *Lengthening the Day*, 50.
[116] J. Slater, "Electric Lighting Applied to Buildings," *The Electrician*, VI, April 30, 1881, 305.
[117] *The Builder*, XLVIII, June 13, 1885, 825.

at the offices of the *Irish Times* in 1884, the "thermometer rarely mark(ed) higher than seventy degrees during the night...the sick list has all but disappeared."[118] Electric light promised to produce light without modifying the atmosphere, providing a more normalised habitat through controlled temperature and clean air, and promising to free the pure physical act of seeing from unwanted sensory interference. Our daily experience of air has been irrevocably changed by the eradication of the fumes and smoke associated with combustible illuminants. If Haussmann's Paris was a city where the bourgeoisie was free to pursue visual delights, then this new light form was a technology able to materially cement this. Moreover, if Bazalgette's London was a city where the respectable classes were washed and watered by ceaseless hydraulic circulation, then electricity promised to foster health and cleanliness. Electric light was thus an infrastructure making materially possible both the autonomy of vision and the healthy body, swaddled in immaculate air.

Atmospheric Government: Electric Light as Sanitary Technology

In 1890, William Preece declared:

> The electric light is unquestionably the light of the future when electrical energy is generally distributed through our towns, and its supply is continuous...everybody will take to it, not alone for its beauty, but because it is, above all, a source of health and comfort."[119]

Light technology, like similar systems of drainage and sewerage, was an enframing mechanism of environmental mediation. It targeted the whole of the organism, not simply perception. As well as producing a speckled, peppery visual field, gaslight could damage the eyes. It flickered, said Hammond, "every tenth part of a second," nearly the speed at which the illusion of constant motion was produced:

> While the constant fluctuation of a gas-flame keeps the retina of the eye in a constant varying vibration, the uniform volume of light received from an electric lamp makes it more comfortable and less dangerous to the eyes than any other form of illuminant known.[120]

Electric light was consequently promoted as a technology able, temporarily, to arrest optical instability, and avoid visual injury. Writhing flames of gas or oil strained and hurt the eyes; "persons accustomed to read or work long by (candle)...lights have their eyes injured; and this injury is not so much from the light itself as from its fluctuation."[121] Bell warned that "a flickering gaslight...strains the eye seriously and is likely to cause

[118] J. Angelo Fahie, "Electric Lighting From a Sanitary Point of View," *The Electrician*, XIII, October 18, 1884, 522

[119] William Preece, "The Sanitary Aspects of Electric Lighting," *ibid.*, XXV, August 29, 1890, 466.

[120] Hammond, *The Electric Light in our Homes*, 87.

[121] Thomas Peckston, *A Practical Treatise on Gas Lighting* (London: Hebert, 1841), 7.

temporary, even if not permanent injury."[122] Incandescent electric light was, by contrast, "a stable and unchanging point of light," glowing at a precise temperature, a steadiness enhanced by improved dynamos.[123] Sealed in its vacuum, the filament also maintained the lachrymosity of the eye; gaslight's heat "dries the eyes, the lids, the forehead, and temples."[124] Opticians went as far as to recommend tinted spectacles to obviate "the scorching heat of the gas light."[125] Under electric light, eyes were freed to weep. Arid corneas triggered "pain and headache."[126] This desiccation of the eye's liquid economy added to fears of growing strabismus, eyestrain and myopia:

> Of the growing prevalence of defective eyesight, especially of myopia, nobody, we imagine, will entertain any doubt...There is no denying the fact that the general tendency is to create and perpetuate a blind race, who left to themselves might have preserved their eyesight, and under *less artificial conditions* might recover its full enjoyment ... Everything that tends to establish a higher standard of illumination...is calculated to improve the nation's eyesight. (Emphasis added)[127]

Electric light was a technique of environmental normalisation, capable of maintaining an even, natural temperature. Even arclight carbons, which produced some heat, did not "sensibly affect the surrounding air," producing cooler spaces more conducive to the chilled emotions of the respectable: hot air, long associated with factory work, was sybaritic.[128] Lower temperatures were only one of a plexus of atmospheric effects. Gaslight, candles and oil lamps all emitted light "by robbing the air of its life-giving quality."[129] Estimates showed that every cubic foot of gas, required between five and six cubic feet of air in which to burn. Ventilation flues were devised to feed the ravenous flames, but frequently the only option was to open windows, leading to uncomfortable draughts. Gaslight at dances left the brain "in a morbid state," leading to headaches and insomnia.[130] Schoolchildren wilted in arid, stuffy classrooms:

> At this time of year towards 3.30 we must light up for an hour; the air is already vitiated, and brains begin to be fagged as a consequence. All at once seventy gas jets at least are alight, and each at a low computation consumes as much oxygen as six persons; the equivalent of *420 more*

[122] Bell, *The Art of Illumination*, 13
[123] J. Slater, "Progress in Electric Lighting," presented to the R.I.B.A. *British Architect*, XXVII, May 19, 1882, 238.
[124] W. Pickering, "Concerning the Gas-Flame, Electric and Solar Spectra," *Nature*, XXVI, February 9, 1882, 341.
[125] Charles Long, *Spectacles: When to Wear and How to Use Them* (London: Bland and Long, 1855), 19.
[126] Professor Cohn, "Electric Light and the Eye," *The Lancet*, September 18, 1886, II, 544.
[127] Oakley, "The Electric Light and Eyesight," *The Electrician*, XVII, October 1, 1886, 430-1.
[128] T. Hepworth, *The Electric Light: Its Present Position and Future Prospects*, 41.
[129] Hammond, "Municipal Electricity Works," *The Builder*, LXV, August 19, 1893, 138
[130] Hammond, *The Electric Light in our Homes*, 50

> people is crowded in whose breath – well, we will not say what they breathe out, chemists will tell us that.[131]

Chemists were indeed loquacious on this subject. Carbonic acid, released by the burning of charcoal particles in coal-gas, was "very hurtful to animal life, even when largely diluted with air; it acts as a narcotic poison."[132] It was omnipresent in air: "a normal atmosphere contains 4.5 volumes of CO_2 in 10,000 of air."[133] Chemists established a "boundary line between pure and impure air" at 10 parts per then thousand.[134] Poor ventilation and gas lighting were frequently found to generate an atmosphere transgressing this limit. The chemist Charles Tidy found thirty-six parts in bedrooms, and estimated that a batswing burner released 4,300 cubic inches of the acid per hour, one-third as much as an average cow. Tests in 1879 showed that "inferior coal-gas commonly contains as much as twenty per cent of carbonic oxide. The result of the inhalation of this gas is to render the blood corpuscles useless."[135] Soot spewed forth, caking ceilings. The presence of sulphuretted hydrogen, "a colourless gas, having the odour of putrid eggs…most offensive when…a mere trace is present," was legally limited to a putatively imperceptible quantity: it was removed from gas prior to commercial use by passing it through hydrated peroxide of iron.[136] But its odour lingered around cracked piping, and, its effects on the body were described by Thomas Beames:

> The brown, earth-like complexion of some, and their sunken eyes, with the dark areolæ around them, tell you that the sulphuretted hydrogen of the atmosphere in which they live has been absorbed into the blood.[137]

Water vapour combined with sulphurous acid to form oil of vitriol, demonstrable with litmus paper. The stench of gasworks was notorious: the Fulham and Chelsea works sent sulphur and hydrocarbon compounds, ammoniacal gas and soot snaking across the Thames. The gas it produced for streetlights and homes was "so foul and offensive as to cause headaches, sickness and pain to the eyes."[138]

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131 Thomas Ryder, "Electric Lighting of Schools," *The Electrician*, XXII, December 14, 1888, 173.
132 Robert Bridges, *Fownes' Manual of Chemistry: Theoretical and Practical* (Philadelphia: Henry C. Lea, 1878), 162.
133 Charles Tidy, *Handbook of Modern Chemistry: Inorganic and Organic* (London: J. and A. Churchill, 1878), 101.
134 The figure was established by Pettenkofer; *ibid*, 102.
135 B. Thwaite, "Hygiene Applied to Dwellings," *British Architect*, XI, January 10, 1879, 17.
136 Bridges, *Fownes' Manual of Chemistry*, 200.
137 Thomas Beames, *The Rookeries of London: Past, Present and Prospective* (London: T. Bosworth, 1852), 85.
138 T.B. Simpson, *Gas-Works: The Evils Inseparable from their Existence in Populous Places* 33.

The environment within which the healthy body could be generated was impossible in air so vitiated, malodorous and poisoned. "What child," asked *The Builder* in 1876, "can be expected to develop into a well-grown man, who is nursed in an atmosphere not of oxygen, but of sulphuretted hydrogen?"[139] This position unquestionably marks a major shift in the threshold of tolerance, and this modified sanitary sensibility formed a major axis along which debates about light technology moved. Under gaslight, children grew ill; workers became "blanched and sickly."[140] Electric light, besides making possible new visual modalities, produced tangible improvements in health:

> That the electric light is a powerful element of health is evidenced by the fact that those who use it not only feel all the better for its introduction, but their appetite increases, and their sleep improves, and the visits of the doctor are reduced in frequency.[141]

Purifying the air inside factories, offices and warehouses increased productivity: by reproducing the natural conditions in which the body had evolved to function, the health and organic economy of the population could be nurtured and freed.

This sanitary dimension of electric light cannot be overstated. The introduction of the new technology into factories, hospitals, schools, and prisons occurred at a time when electricity was regarded as an almost metaphysical essence of being as well as a force of radiant vitality. Cerebral, neurological and optical activity were established as fundamentally electrical, while applications of electricity to the body were being attempted to cure aneurysm, neuralgia, writer's cramp, facial palsy, hemiplegia, cataracts, gout, locomotor ataxy and tooth decay.[142] The first primitive electrocardiogram was produced in 1878, and a child was reportedly brought back to life for two days after electricity was applied to the chest and back.[143] Probably apocryphal, this story suggests something of the fascination with the equation of electricity and life that pervaded the final two decades of the century. Electricity could retard the formation of cream, positively stimulate yeast cultures and incubate eggs. From at least 1845, currents passed through the ground reputedly enhanced the growth of crops.[144] Its white light could be adopted to grow fruit, vegetables and flowers: tests in 1880 showed that "electric light was clearly sufficiently powerful to form chlorophyll and its derivatives...Fruit, excelling both in

[139] "Cleansing the Atmosphere," *The Builder*, XXXIV, May 6, 1876, 433.
[140] F.W. Griffin, in *The Electrician*, X, April 15, 1883, 347.
[141] Preece, "The Sanitary Aspects of Electric Lighting," *ibid*, XXV, August 29, 1890, 464.
[142] See, for example, R.M. Simon, *Medical Electricity* (Birmingham: Hall and English, 1880).
[143] *The Lancet*, August 16, 1884, II, 307. For more detail on the history of the use of electricity in surgery and medicine, see Margaret Rowbottom and Charles Susskind, *Electricity and Medicine: History of their Interaction* (London: San Francisco Press, 1984).
[144] *The Electrician*, XI, September 15, 1883, 411.

sweetness and aroma, and flowers of great brightness, may be grown without solar aid."[145] Other experiments produced conflicting results, including a batch of inedible Scandinavian celery, but that electric light was a more salubrious and vital form of radiance was not contradicted.[146] No plant could feign the formation of chlorophyll, or dissemble its size or colour: the proof produced by the "meaningful behaviour of nonhumans" was integral to modern experimental practice.[147]

This testimony of mute objects, especially valuable or decorative ones, was critical to those aiming to prove the environmental worth of electric lighting. Tales of ruined books and corroded paintings abounded: in 1887, investigations into the effects of gaslight upon the volumes in Birmingham free library revealed the extent of this material damage:

> Leather exposed to the foul air in which gas had been burning for 1,077 hours was seriously deteriorated, for the extent to which it would stretch was reduced from ten per cent to five per cent, while the strain it would bear was reduced in the ratio of 35 to 17, or about two to one.[148]

Likewise, sulphur compounds at the free library in Leeds were reported to have almost completely destroyed bindings.[149] In 1859, a Commission reported on the impact of gaslight upon the delicate tints and pigments of the nation's paintings: sulphuretted hydrogen, it was found, blackened any paint with a white lead base, while acids gnawed away at the surfaces and frames. Unless perfect ventilation could be secured, gaslight was inadmissible in such spaces of silent contemplation. Opening art galleries after dark only became possible when electric light had become functional; the South Kensington museum, where electric light was introduced in 1881, operated as a kind of laboratory here, in which its preservative effects could be monitored and measured. Gaslight was also shown to discolour paper; experiments showed "slight degradation of tone" after a mere 240 hours beneath a flame, while a 144 candle-power arclight left the paper pure after 552 hours.[150] Clothing, curtains and wallpaper became sooty and faded.

Cleanliness, whiteness and purity had become the dream of a conjoined medical, architectural and social environmentalism. Like cesspools and middens, wynds and courts,

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[145] C.W. Siemens, "On the Influence of Electric Light Upon Vegetation, and on Certain Physical Principles Involved," *ibid*, V, March 13, 1880, 200-2.
[146] Killingworth Hedges, *Useful Information on Electric Lighting* (London: E. and F.N. Spon, 1882), 127.
[147] Latour, *We Have Never Been Modern*, 24.
[148] "Gas in Libraries," *The Electrician*, XI, September 23, 1883, 419
[149] Hammond, *The Electric Light in our Homes*, 51.
[150] *The Electrician*, XXIX, September 9, 1892, 504.

cellars and garrets, gaslight had become regarded, in medical and engineering circles at least, as inimical to the civilising, sanitary spaces necessary to harbour a healthy nation:

> While many people would not hesitate to spend a hundred pounds in re-arranging the drains of a house prefer a gas burner to a pair of candles in their bedrooms, we can hardly expect that statistics about products of combustion will have much effect.[151]

Electric light, clean and pure, had palpably supra-visual effects. Besides enabling the eye to see more 'naturally', it provided a salubrious, cool, airy atmosphere. This was, in short, a critical part of a naturalised milieu within which the fitness of the population could be secured. The expert relays responsible for guaranteeing this were, as highlighted in chapter two, the municipal engineers, those heterogeneous environmental manipulators responsible for tuning healthy bodies and liberal cities. By the final decade of the nineteenth century, electrification had fallen within the province of these titans of oligoptic engineering:

> The chief duties of municipal engineers have been to improve sanitary matters, to remove vegetables and decaying matter from water, and by a proper system of drainage to remove all dangers from health (sic). But the duties of a municipal engineer will not be complete until he takes in hand the electric light...Gas burnt in a bedchamber is as bad as bad water and bad smells.[152]

White, brilliant and wholesome, championed by the vanguard of environmental and sanitary reform, electric light was surely to sweep aside its sickly competitors and establish itself as the dominant lightform. This position is outlined even in so impressive a work of cultural history as Schivelbusch's *Disenchanted Night*: electricity is an "apotheosis", a spectacular invention revolutionising light and vision.[153] The final section offers a corrective both to this and the asymmetrical narrative I have thus far provided.

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[151] "Electric Light and Health," *ibid.*, XXIV, February 5, 1890, 486.

[152] W. Preece, "On the Relative Merit and Cost of Gas and Electricity for Lighting Purposes," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, XVII, June 27, 1891, 231.

[153] Schivelbusch, *Disenchanted Night*, 50

The Lights of Folly: Electric Candles, Piped Light and the Rejuvenation of Gaslight

Thus far I have used the expression 'electric light' to refer to any illuminant driven by electricity: if my analysis has been at all nuanced, it has been to distinguish arclight from incandescent. Here, I examine a series of electric light systems, including arclight and the Jablochkoff candle, which failed to become durable perceptual infrastructures. This leads into the broader question of the temporality of the development of electric light technology. I aim to provide a longer-term history here, emphasising the sheer diversity of illuminating projects across the century, as well as the contingency involved in their success. Gaslight, like electric light, has often been presented as a monolithic technology, rather than a bewildering array of burners, operating in, and producing, social milieux and biotechnical agency. I close this chapter with the history of gasmantles and regenerative burners, both of which were designed specifically to counter the charge that gaslight was dim, dirty and unhealthy. At various points en route, the failure of infrastructure at a network level, rather than at the point of perception, will be referred to, which should ease the reader into the knotted world of wires and pipes laying in wait in the final chapter.

Abandoned Illumination: Arclight, Jablochkoff Candles and the Longer History of Electric Light

"Historians of systems," Thomas Hughes reminds us "need among their number not only Charles Darwins but also Edward Gibbons."[154] Viewing Edison's development of a working system of incandescent light as an apotheosis is to impose a reassuring, retrospective teleology in place of the strikingly complicated world of late nineteenth-century technologies of perception. We conflate the outcome of a massively convoluted history with its causes, and see in the mere germ of a technology all the parts that will become dominant. This essentially genetic, or entelechic, view of technology utilises what

[154] Thomas Hughes, in Bijker, Hughes and Pinch (eds), *The Social Construction of Technological Systems*, 56.

Latour calls "the diffusion model": the essence of Edison's light (its whiteness, its cleanness) was materialised at Menlo Park in 1878 and flourished unmangled as it expands through the hands of intermediaries.[155] To avoid this explicit Whiggery, and respect the plurality and contingency of technological history, historians must adopt notions of translation, mediation, and biotechnical agency. Technologies do not diffuse, changeless, through a society: they are translated into others' interests (a clean light becomes an efficient light, a bright light becomes a safe light) in countless transformatory acts of mediation. Agency becomes distributed across an assemblage consisting of metal, heat, eyes, flesh, passions and light, the manifold intermeshings of which produce a technosocial order. This model actually makes the durability and blackboxing of incandescent light appear an even more extraordinary achievement, since not only technology, but also society, economy and politics are ineluctably embroiled in its every move. But the durability is not the achievement of Edison, the pure human, the filament, the pure object, or modern society, the pure social. It is an ongoing, never absolutely stable, hybrid achievement. The technologies outlined below failed to achieve dominance because their technosocial associations were too weak; their fissile bonds frayed and snapped for many reasons.

Electric light was not invented in 1878 by Edison. The fundamental principles of both arc and incandescent light were demonstrated by Humphrey Davy, making it approximately as old as gaslight. This underlines the fact that systemic elements, especially the dynamo, were essential for realising a durable network. The early history of electric lighting is obscure: we find references to King's experiments with incandescence in 1845, and Staite's arclight demonstrations at, among other places, the National Gallery and on Hungerford Bridge in London between 1847 and 1853.[156] Henry Mayhew reputedly lectured by an arc light in 1853 that he had designed himself.[157] Lacassagne and Thiers produced an arclight floating in mercury in 1855; others produced combustible filament lamps, among them Werdermann and Hedges.[158] Geissler tubes, phosphorescing light in glass cylinder, were also available commercially by 1878.[159] Consequently numerous electric lighting systems were in an experimental stage in 1878, of which the incandescent

155 Latour, *Science in Action*, 132-140.
156 See Bowers, *Lengthening the Day*, 66-7.
157 C. Mackechnie Jarvis, *Papers on the History of Electrical Engineering* (Manchester: Journal of the Institution of Electrical Engineers, 1955).
158 Hedges, *Useful Information on Electric Lighting*, 42.
159 Hepworth, *The Electric Light: Its Past History and Present Position*, 109.

light was simply one. In 1879, Hepworth, predicting the future of electric lighting, found many systems promising, but of incandescent lamps, he observed; "they represent a system which, I think, will never lead to any practical result."[160] Arclights and electric candles commanded the majority of attention in the early 1880s.

The failure of these systems only makes sense if we take into account the context of a liberal visual environment co-acting with the bodies and spaces of the modern city. Early arclights, however bright, were notoriously prone to fluctuation: the electrodes between which the arc shone burnt at different ratios: "an unsteady or flickering light has an ill effect on the sight, and electric lighting on the *arc* system is open to this objection."[161] Such irregularity was "irritating to the worker," and elaborate clockwork counterbalances were invented to combat it, further encrusting already baroque technology.[162] Hammond found the blinking glare of arclight "absolutely unfit for home use."[163] Failing to cement biotechnical conditions fit for attentive work, the arclamp also created anxiety in medical circles. In 1879, several American manufacturers abandoned experiments, "owing to the intermittent character of the light used, which injuriously affects the optic nerves of the workmen, interfering with a steady gaze."[164] The physiological consequences were explored in the following years. *The Lancet* reported in 1882 that:

> The vibratile impulses of the electric force is obviously stronger than the delicate terminal elements of the optic nerve in the retina can bear without injury...the electric light is too hard; it needs to be softened.[165]

Reports from Kronstadt in 1880 suggested that the number of eye diseases had risen sharply since the introduction of arclight.[166] Its unmediated rays reportedly induced "electric sunstroke" in 1888, evidenced by "reddening and tumefaction of the skin...desquamation, congestion of the conjunctiva ...(and) visual objects having a yellow appearance."[167] Workers reported the development of freckles under arclight's remorseless glare. This typical early description of arclight is taken from the *British Architect* in 1881:

> The light resembles an intense glare, rather than anything else. It has not even the softness of moonlight to recommend it. Then again it seems to lack concentration. Evidently there is need

[160] *Ibid*, 107.
[161] Fahie, "Electric Lighting From a Sanitary Point of View," *The Electrician*, XIII, October 18, 1884, 521.
[162] Preece, "The Electric Light at the Paris Exhibition," *ibid.*, VIII, December 24, 1881, 91.
[163] Hammond, *The Electric Light in Our Homes*, 80
[164] *The Plumber and Sanitary Engineer*, II, April 1879, 127.
[165] *The Lancet*, November 11, 1882, II, 815.
[166] *The Sanitary Engineer*, IV, December 1, 1880, 4.
[167] *The Lancet*, January 14, 1888, I, 99.

of some alterations (sic) before anything like a general adoption of electricity for public lighting.[168]

The panoply of techniques devised to tame, mute, direct and reflect light obviously assisted in establishing visual environments more tuned to the demands of the modern state. However, these mediating techniques could make the situation worse; at the British Museum, a screen of topaz-coloured glass designed to remove excessive violet rays left readers immersed in "jaundiced" light, giving them a "cadaverous appearance."[169] In 1881, electric light was thus almost universally derided as "ghastly and unpleasant" even in so supportive a publication as *The Electrician*.[170] Rose, orange and yellow globes were used to attune eyes and brains to the steely rays of the light, but, as Hedges acknowledged, "the colour unfortunately turns out to be one of the greatest objections against the general use of the light from the voltaic arc for interiors."[171]

Arclight had to be mediated, its intermittent functioning modified by unwieldy machinery. It was also suspected of surreptitiously producing environmental damage. Tests at the Royal Society showed "very conclusively that as high as twelve or fifteen grains of nitreous oxide per hour were produced by many of the electric lamps," the smoke being perceptibly red.[172] There were even reports of electric arcs yellowing paper.[173] Compounding this were technical difficulties interrupting the maintenance of silence. If electrodes were positioned too closely, diminished in potential, or ran on weak current, they produced "a disagreeable hissing sound."[174] The correct distance between carbons generated convoluted debate. The arc, it appeared, had little leeway: too short (below 0.1 inches) and it invariably hissed, while if above 5 millimetres, it produced a "flaring arc, which consumes the upper carbon very quickly."[175] The arclight engineer thus aimed at a tiny space to avoid creating flicker or noise. Attentive conditions materially hinged on this slender gap. Additionally, composition of the carbons themselves caused concern. Early carbons were simply sawn from graphite cylinders; they flickered enormously and sometimes stopped functioning altogether. Later ones were specially made, from fire coke

[168] *British Architect*, XV, April 8, 1881, 182.
[169] *The Electrician*, V, November 13, 1880, 306.
[170] *Ibid*, VII, October 15, 1881, 338.
[171] Hedges, *Useful Information on Electric Lighting*, 77.
[172] *The Sanitary Engineer*, IV, December 1, 1880, 4.
[173] *The Electrician*, XIX, April 1, 1887, 453.
[174] A. White, "The Silent Electric Arc," *ibid.*, XIV, November 19, 1884, 56.
[175] A. Blondel, "Street Lighting by Arc Lamps," *ibid.*, XXXVI, April 3, 1896, 757.

or pure graphite; "a good carbon should ring hollow when struck, and should be perfectly similar in diameter throughout its entire length. Straightness is also very desirable."[176] But irrespective of the perfection of electrode geometry, the arc was a light generated, like candles, through the disintegration of a medium. Soft carbons would discharge splinters and sparks which could be dangerous. Replacing them when spent involved labour, or elaborate equipment.

Arclamps achieved their agency precariously; the scientist harnessed and configured many elements to produce an intricate, durable mechanism. Carbons, spacing, potential, and disintegration ratios all had to act harmoniously; and even then the light's uses were limited to railway stations, lighthouses, streets and docks. That its prodigious power was so frugally used reminds us that obliterating night was only desirable in certain special environments. Across the period, we find schemes to light whole cities: Napoleon, for example, reputedly desired a set of gargantuan towers to light Paris "so that *no* shadows will remain."[177] This desire for total transparency was repugnant to a liberal order cohering through more subtle and capillary circuits of power, ones respecting the freedom and privacy of the individual, as *The Electrician* suggested in 1880: "to light a whole city with a huge electrical sun is a great scientific achievement; but it is not the sort of light that anybody wants."[178] Tower lighting in American cities was adopted; the light produced concentric rings of light, leaving most streets crepuscular and grey. In Detroit, for example, seventy-two arcs were mounted 150 feet in the air, an experiment which lasted for thirty years.[179] The failure of giant arc lamp projects tells us much about limits: the limits of ocular capabilities, the limits of light technology in terms of distance, intensity, direction, focus and steadiness, and the limits of a liberal society keen to operate through the natural capacities of its population and not through one dominant, monocular, omniscient power. Liberal illumination was not so arrogant or spectacular.

Technological failure, then, is explicable in terms of, but irreducible to, the bodies and the sociopolitical orders between which it mediates. It fails because the collective cannot stand it. This saves us from patronising those who attempted to produce technologies which strike us as eccentric, or irrational. Reason, it is worth saying, is what we

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[176] Hedges, *Useful Information on Electric Lighting*, 25.
[177] Quoted in Schivelbusch, *Disenchanted Night*, 123.
[178] *The Electrician*, IV, May 7, 1880, 325.
[179] Schivelbusch, *Disenchanted Night*, 126-7.

retrospectively call the logic of that which knits together our collectives. Thus the Spanish duo of Molera and Cebrian should not be dismissed as cranks. In August 1879 they demonstrated their system of electrical division "by optical contrivance." Like many engineers, they were struggling with the ongoing problem of dividing electric current. Rather than manipulating electric current, they argued that by ensconcing the "most powerful source of light" available in a prismatic chamber, the light could be piped "in several beams of parallel rays, without the smallest stray ray of light being lost." Reflectors could then be positioned to intercept beams and channel them into specific positions. Mains and distributors could serve whole cities; "a net of properly branched out pipes will put into communication every room of the building with the service pipe."[180] Four giant arclights encased in glass could light the whole of San Francisco. Rather than the light bearing down from above, it would snake through subterranean cylinders.

It would be easy to view this scheme as the work of Catalan mavericks, but early demonstrations of their system were apparently hugely successful. The *Mining and Scientific Press* reported effusively in November 1879 that one arclight of 4,000-candle power had been used by Molera and Cebrian to light a building in San Francisco and "the quality of the light was equal to that of pure diffused daylight." Moreover, "the dispersing lenses and reflectors are arranged inside the building so as to illuminate every part without any obscure corners."[181] In 1880, the pair were overseeing further experiments in Barcelona, according to the *Crónica de Catalana*. A private house was lit with pipes and prisms in Barcelona, and in the same city, an Electric Company formed to implement their invention.[182] Thereafter, at least in the English engineering press, there is only silence. Barcelona and San Francisco both adopted electric light without piping it beneath their streets. The material problems with the scheme were obvious; it was enormously expensive and required extensive upkeep. Yet, in keeping with the symmetrical argument I am using, it also failed because of its disciplinary, illiberal and almost panoptic nature:

> For all large institutions like colleges, libraries, hospitals and asylums, factories, barracks, prisons, and other public establishments, our system, besides totally preventing fires, has the great advantage that the light can never be meddled with by the inmates of the institution, but *it is under the direct control of only one supervising officer*. (Emphasis added)[183]

[180] Molera and Cebrian, "Practical Divisibility of the Electric Light," *The Electrician*, III, August 2, 1879, 128-9.
[181] Quoted in *ibid*, IV, November 22, 1879, 3.
[182] *Ibid*, IV, November 29, 1879, 13; and IV, February 28, 1880, 169.
[183] Molera and Cebrian, "Practical Divisibility of the Electric Light," *ibid.*, III, August 2, 1879, 131.

This kind of visual architectonics was certainly possible: indeed, prisons and asylums illiberally confiscate from their inmates the right to control their own light. But elsewhere, the ability to regulate one's own light was promoted as a vital principle of freedom. One supervising officer controlling all the lights in an institution, or even a city, smacked of the kind of centralised observation or state interference quite incompatible with the idea of a self-governing collective. Liberal systems cohered through a diffuse social optic that such centralised perceptual systems inhibited.

Devised by the Russian engineer Paul Jablochkoff in 1876, the candle bearing his name has a marginally longer history. It was "composed of two carbons placed side by side with a slip of insulating substance between them, which burns away with the carbon exactly in the same way as the wax of a wax candle is consumed with the wick."[184] Originally, the insulating substance was composed of Plaster of Paris or kaolin, but by 1882, its makers had perfected a combination of baryta and lime for this purpose.[185] Other electric candles, those of Wyld and Jamin, dispensed with this alkaline filling altogether and deployed electromagnets to keep the carbons separate. Thus, the carbons burned down at an equal rate, avoiding some of the problems bedevilling arclight. Further, the technical simplicity of the lamp suggested a great advance over arclight. A candle usually burned away in ninety minutes, but four or five could be placed in one lamp; when one burned down, another could be lit without complex machinery. "In this respect alone," argued Hepworth, "it represents a most important advance in the domain of electric lighting."[186] He effused about the display of Jablochkoff candles at the Rue de l'Opera and the Hippodrome in Paris: "the glitter and the general effect of the spectacle were altogether beyond description," while those at the Exposition at the Champ du Mars drew admiring crowds.[187] In London, gas shares underwent a "temporary panic," and the candles were installed at several sites, most prominently along the Thames Embankment and Waterloo Bridge, where sixty of them burned from 1878-1884.[188]

The period of this installation effectively demarcates the brief history of the Jablochkoff candle in Britain, although forty were displayed at the 1886 Liverpool Jubilee

[184] "The Electric 'Candle'," *The Builder*, XXXV, June 30, 1877, 677
[185] Baryta (barium oxide) was an alkali earth which could withstand high temperatures.
[186] Hepworth, *The Electric Light: Its Past History and Present Position*, 79.
[187] *Ibid*, 82, 83.
[188] *The Plumber and Sanitary Engineer*, I, February, 1878, 44.

Exhibition.[189] The failure of the candle, again, is irreducible to purely technical, physiological or social factors. Although the lamps were very bright (photometric experiment established their luminescence at 380 candle-power), there were problems with its direction. The actual area of illumination was disproportionately small compared to the intrinsic radiance, as was demonstrated by Shoolbred in1879.[190] Bazalgette reported that the Embankment he designed was not as effectively lit as it might be, as "the projection of the light from the Jablochkoff candle is rather upwards."[191] The visual impact of this bright light radiating towards the sky was described as "dazing (and) weird…with its deep shadows. There is something irritating in the electric light, and the effect, if it were universally applied, must be…to have some disastrous effect on the nerves."[192] The incandescing carbons occasionally sent showers of sparks onto the Embankment, while over time, it became clear that the lights often extinguished themselves over the course of a night. Six Jablochkoff lamps displayed at Westgate-on-Sea in 1878-9 had to be changed every hour, and even then, lights occasionally went out. "Nothing will prevent the necessity of an attendant having to visit the lamps every four or five hours to insert fresh candles," concluded the electricians responsible. Despairing of the intermittent nature of the illumination, they argued that the electric candle system was "surrounded by so many practical difficulties, that no amount of improvement is ever likely to fit it for general adoption."[193] In comparison with steadier, more malleable forms of light, the once-promising technology began to suffer. Wrote Preece in 1881, "I am afraid the exhibition in Paris has sounded the knell of all forms of candle, as well as those of the Werdermann type."[194] The Jablochkoff Electric Light and Power Company found itself forced to lower prices to the point where it began to veer towards insolvency. In 1883, it lost out to the Swan-Edison Company over the contract to light the Strand vestry in a rather squalid affair in which the Board of Trade appeared to overturn the vestry's desire to adopt the Jablochkoff system, and by October of that year they were bankrupt. Despite claims by company members that they had a "magnificent future," shareholders

[189] K. Beauchamp, *Exhibiting Electricity*, 145.
[190] J. Shoolbred, "Electric Lighting, and its Application to Public Illumination by Municipal and Other Bodies," Association of Municipal and Sanitary Engineers and Surveyors, *Minutes*, VI, July 31, 1879, 15-18.
[191] *Ibid*, June 7, 1879, 31.
[192] "Illumination by Electricity," Association of Municipal and Sanitary Engineers and Surveyors, *Minutes*, VIII, June 29, 1882, 185.
[193] W.H. Bennett and William A. Valon. *Report on Electric Lighting on the Jablochkoff System at Weston-on-Sea* (London: Clayton and Co., 1879), 8, 15.
[194] Preece, in *The Electrician*, VIII, December 24, 1881, 91. The Werdermann light was a small arclamp.

and consumers were losing faith with the light.[195] The lights were removed from the Embankment, and by early 1885, London's premier promenade was once more illuminated by gas.

This reversion to gas reminds us of the non-linear, unpredictable nature of technological politics during the 1880s, a period when there was simply no fixed pattern of light adoption, which in turn suggests the patchy, diffuse nature of electric light's tortuous expansion. Local politics, cost, and the material vagaries of the technology combined with legislative shackles to make every act of translation a leviathan feat. Corporations, often run by men with strong interests in the local gasworks, were reluctant to establish anything themselves that might compete with these mighty concerns. Private initiative led to wild speculation, but less practical result, especially after the Electric Lighting Act of1882, when contracts were legally limited in scope and extent due to what *The Electrician* termed "the fanatical dread of monopoly."[196] Combined with lack of practical skills and limited resources, the result was predictable: a string of ephemeral projects. The Victoria Station in Manchester, for example, tried arclight for a year, abandoning it 1882. "On several occasions," lamented one writer, "the station has been left in darkness when trains have arrived, and the unsteadiness of the light has been very great."[197] Street and dock lighting in Liverpool proved "unsatisfactory": the Corporation discontinued its operation in 1882.[198] Even such vaunted projects as the Holborn Viaduct station were lifeless and empty by 1885; Ferranti's great Deptford station closed after fires and blackouts. Little wonder, then, that the *Journal of Sanitary Improvement* concluded in 1886 that "electric lighting, as a business independent of the trade in apparatus, *does not at this time exist in Great Britain*."[199]

Technical problems, vested interests, economics, the failure to harmonise body and light, fear of infringements of liberty: all these and many other factors help to explain the messy contingencies of the attempts to secure perception in the 1880s. However, no account

[195] *Ibid*, XI, October 13, 1883, 526. This meeting appeared somewhat acrimonious, with one shareholder suggesting that "all they had got was this long wooden shed and the supply of imported Jablochkoff candles."
[196] *Ibid*, XII, March 15, 1884, 459.
[197] *Ibid*, VIII, March 18, 1882, 281.
[198] *British Architect*, XVII, January 27, 1882, 41.
[199] *Journal of Sanitary Improvement*, January 5, 1886. Cited in Hickenlooper, *Edison's Incandescent Electric Lights*, 49.

would be complete without examining how other light technologies responded to the impact of electricity.

The Revolution in Gaslight 1885-1900

The central argument of this chapter has been that light technologies were axiomatic in making possible and maintaining a liberal visual environment; that is, space within which a normal body could naturally see, move, breathe and live. Governing through such environments enabled bodies to be free to rationally and responsibly act. Incandescent light, rather than electric light per se, eventually became our illuminant of choice precisely because of its ability to produce environments within which the agency of modern subjects, to attentively work, pleasurably consume and salubriously live, could be maximised. However, this gigantic, languid shift in environmental norms, reconfiguring the experience of the whole human organism rather than the ocular apparatus alone, was contested and differential. By this I mean firstly that the epistemic frameworks through which light sources were assessed were sufficiently protean to permit promoters of gaslight to scientifically oppose the triumphal statistics of electricians. Secondly, the rise of illuminating engineering made possible, as Trotter's figures show, an increasingly nuanced and tuned environmental sensibility: specific rooms, practices, and spaces all required their own particular arrangement of light. Within this intricate pattern, older forms of light, themselves technologically mutating, found many niches.

Promoters of gaslight, for example, argued that imitating sunlight itself was not the illuminating engineer's aim: one should try to replicate morning daylight, diffused through clouds. Noonday sun was too blue and bright; we shut blinds and draw curtains to protect eyesight from its astringency. Spectrum analysis was thus be used *against* those urging the adoption of arclight.[200] Gaslight often persisted not because of a blithe disregard for science among civic corporations, but precisely because the subtleties of spectroscopy facilitated the distinction between sunlight and daylight to be mobilised against arclight. Similarly, photometry, as in the case of the Jablochkoff candle, could be turned against electricity: Sugg, for example, spoke of "nominally much more powerful electric lights

[200] E.g. W. Sugg, *The Application of Gas to the Lighting of Open Spaces and Large Buildings* (London: Walter King, 1882), 10-13.

(which) do not light the ground better than gas-lamps."[201] Other environmental facets of electric light were contested: heat from gaslight, Trotter argued, was appreciated by factory workers in the winter.[202] The air currents it generated had long been utilised by builders to assist in ventilation: when removed, it was suggested, temperatures could actually rise. Following the adoption of electric light, the Savoy Theatre was reported to "frequently (stand) at the tropical figure of 84 degrees."[203]

Gaslight was not, it must be asserted, any less 'scientific' than electric light: gas engineers used the same methods and instruments to assess and promote their lights, which, especially the improved ones were developed as a reaction to the emergence of technically-feasible electric light systems. Gas stocks plummeted in the last years of the 1870s, yet by 1882, doubtless inspired by the government's timorous legislation, gaslights, pipes, and purification methods were undergoing transformation: "improved burners, rivalling the electric light in brilliancy, greet our eyes as we pass along our principal thoroughfares."[204] In 1889, Slater reported that the development of electric light had stimulated radical improvements in other lightforms:

> The introduction of any new illuminant has two effects: first, it makes the public want more light, and second, it puts the purveyors of the old on their mettle, and immediately they set to work to improve the old forms of burners...there can be no doubt that we now get a far higher value of gas which we burn than was the case ten years ago.[205]

In 1894, *The Engineer* commented that although the electric light was "a competing force," this did "not prove that it (would) conquer the whole domain."[206] Seventy years later, the last gaslamp in the city of Manchester, in Aden Street, Ardwick was finally extinguished. A small ceremony marked its demise. The gradual introduction of incandescent light into germinating biotechnical environments was one transformation of illumination among many during the latter years of the nineteenth century.

Perhaps the most significant invention here was the gasmantle, devised in the early 1880s and perfected by Auer von Welsbach in Vienna in 1886. The mantle, a cone of cotton fabric infused with oxides of rare earth metals, then purified and stiffened, produced light

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[201] *Ibid*, 9.
[202] Trotter, *The Elements of Illuminating Engineering*, 31.
[203] C. Sellars, speaking at a Northern Gas Managers' Association meeting, *British Architect*, XVIII, October 13, 1882, 486.
[204] C. Siemens, "The Future of Lighting and Heating," *The Builder*, XLIII, September 9, 1882, 348.
[205] J. Slater, "Artificial Illumination," *ibid.*, XXII, February 9, 1889, 106.
[206] *The Engineer*, LXXVI, March 4, 1894, 376.

of demonstrable whiteness. It was sufficiently bright to bear photometric comparison with both electric and gas lights, and sufficiently manipulable to imitate the yellowish glare of gaslight:

> It is asserted that the light emitted is, at a distance, hardly distinguishable from a twenty-candle incandescent electric lamp, and by a modification of the composition of the impregnating liquid a yellower light is obtained, resembling that of the best gas-lights, but much more brilliant.[207]

The gasmantle's long-term failure merits more detailed explanation than I can give it. Arriving at a time when electric light was struggling to gain even a moderate foothold in British towns, the gasmantle's brilliance, and ease of technical adoption (it required no new network or capital) assured its widespread use. In 1906 it could be confidently asserted that "the once-doomed gas-burner has, thanks to Welsbach's mantle, in many instances replaced the incandescent electric lamps that were to doom it."[208] Its slow demise can be explained environmentally. The mantle still drained oxygen from the air, and there was "no ground for believing that the products are less objectionable in kind than with a common burner: that most noxious impurity, sulphur, duly appears as its ordinary product of combustion, sulphur dioxide."[209] The carapace of incandescing fibres oxidised while burning: consequently the framework required occasional renewal to prevent shards of hot matter escaping. The light needed more attention than incandescent electric light, and was also less resistant to the unpredictable physical and atmospheric conditions of the street: "even for side streets gas will find itself hard pressed whenever municipalities supply their own current, unless the durability of the incandescent mantle, when exposed to the vicissitudes of an outdoor life, is markedly improved."[210] In addition, the light was accused of an unsteadiness that made it unsuitable for work requiring concentration.

The second major development in gaslight was the regenerative burner, developed from the late 1870s. This principle used the vitiated air produced by gas burners to reheat the flame, before being piped away. The 1885 Inventions Exhibition featured a series of these lamps, among them the Wenham lamp, the most commercially successful form of light: after admiring them, one commentator concluded that "the purveyors of the electric (light) will need to do something much better and cheaper to compete with any one of these

[207] "Gas-lighting by Incandescence," *The Builder*, LI, September 18, 1886, 436.
[208] Archibald Williams, *How it Works: Dealing in Simple Language with Steam, Electricity, Light, Heat, Sound, Hydraulics, Optics, Etc* (London: Thomas Nelson, 1906), 409.
[209] "Incandescent Gas Lighting," *The Engineer*, LXXVIII, April 3, 1896, 348.
[210] *The Electrician*, XXXV, October 25, 1895, 851.

lamps."[211] Regenerative lamps were considerably cheaper than large sunburners, which had also dealt with the products of combustion by piping them out of rooms.[212] Combined with rising use of extract grilles, these lamps promised to reduce environmental damage. Yet the sulphurous products of combustion remained; they were merely released into the outside atmosphere rather than the room itself, while the lights themselves burned with the same ochreous glow as other gasburners. The ocular agency and environmental composition it generated were in keeping with the atmospheric trends of the time, but potentially less white and clean than those promised by incandescent electric systems. A similar tendency can be seen in the wider gas industry itself, where quality of gas itself was subject to increasingly stringent legal limitations; gas engineers such as Hunt argued that the level of sulphur compounds permitted in coal-gas were so low as to be imperceptible.[213] Additionally, many techniques for purifying gas had become available. Less carboniferous gases, it was proved, produced less polluted light; one Liverpool company was patenting metal gas by the early 1880s.[214] Use of coal-lime in the production process prevented some of the more offensive gases being produced during the gas purification process.[215]

However, the glut of devices and techniques to improve the quality of gaslight, along with the efflorescence of new lighting technologies of all kinds, should not obscure the frequently dismal level of light in English towns. In 1880, for example, half of all houses in Southampton had no gaslight at all.[216] Despite amplified testing of both gas and the light it produced, complaints about its quality persisted and arguably intensified, perhaps further evidence of perceptible, if gradual, changes in thresholds of tolerance. Sometimes, disappointing, technically flawed electric installations still compared favourably to gloomy gas, as at Hull in 1882, where observers were moved to comment on the wretched quality of all modern lightforms, despite the burgeoning number of them.[217] Thus it is no surprise to find examples of towns abandoning gaslight in favour of oil lamps, even after 1880. In Chesterfield, when the corporation and the local gas company quarrelled over prices in 1881, the latter cut off the supply. The corporation retorted by lighting the old oil

[211] "At the Inventions Exhibition," *British Architect*, XXIII, June 26, 1885, 306.
[212] *Ibid*, XIV, December 24, 1880, 275.
[213] Hunt, *The Construction of Gas-Works* (London: Institution of Civil Engineers, 1894), 19.
[214] *British Architect*, XXI, February 22, 1884, 89.
[215] J. Wanklyn, "Need Gas-Making be a Public Nuisance?" *ibid.*, XXIV, July 3, 1885, 9.
[216] *Journal of Gas Lighting*, XXXVI, September 21, 1880.
[217] *British Architect*, XVIII, December 22, 1882, 607.

lamps. In Wimbledon, a similar dispute led to a permanent abandonment of gaslight in 1882. Three years later, it was reported that the paraffin lamps provided better and cheaper light, and that the public was entirely satisfied.[218] Flat wicks and Mitraileuse burners made the lights apparently less prone to meteorological influence than electric light, and the design of the reservoirs cunningly cast no shadow.[219] At a meeting of the North British Gas Managers at Perth in 1890, oil was described as a "more active competitor" to gas than electricity.[220] New brands of oil lamp employed fluted wick holders to augment air currents, the result being whiter flames. Oil lamps also retained a certain charm in fashionable shopping areas, while candles were still recommended for bedside reading by Trotter in 1921.[221]

Delineating all but the most facile and reductive patterns on the history of illumination between 1880 and 1900 is thus an exercise of dubious worth. In these twenty years, the term 'electric light' itself encompasses a set of very different technologies, from powerful, dazzling arclights to steady incandescent light, while these illuminants entered a technosocial world crammed full of a bewildering, mutating array of other light systems. The messy, haphazard implementation of electric light technologies thus echoes similar projects to introduce wider streets, quieter pavements, orchestrated inspectorates and smoke abatement. All such technologies aimed to produce and maintain liberal visual environments; all such surroundings impacted on bodily practice in a series of unpredictable ways. The demand for light, as many observers commented, was rising; we should not confuse the demand, and the hyperbole of certain writers, with the actuality. "The principal streets (of London) are lighted (sic) in a manner which astonishes the foreigner and incites the American to contemptuous scorn," wrote *The Engineer* of the Embankment lighting ten years after the its electric candles burned their last.[222] For electric light to become established as the source of liberal illumination, the physical patchiness of early experiments had to be overcome. Irrespective of its power as a light source, without the laborious construction of systemic elements, the wires, subways, meters, plugs, fuses, insulation, dynamos, switchboards, transformers and manholes, it

[218] W. Crimp, "An Experiment in Street Lighting," *ibid.*, XXIV, August 28, 1885, 98.
[219] *Ibid*, and C. Cooper, "Progress in Oil Lighting at Wimbledon," Association of Municipal and Sanitary Engineers and Surveyors, *Proceedings*, XV, September 28, 1889, 21.
[220] "Gas Companies and Electric Supply," *The Electrician*, XXV, August 1, 1890, 338.
[221] Trotter, *The Elements of Illuminating Engineering*, 26.
[222] *The Engineer*, LXXVII, August 2, 1895, 112.

would have remained a mere beacon. The final chapter examines electric light as material infrastructure, secretly securing perception beneath the city's chaotic streets.

6: Securing Perception: The Management and Distribution of Electricity

The ability of electric light, when properly arranged and managed, to produce local areas where daytime colours were replicated and detailed perception could occur at distance, led to an efflorescence of experiments. Most experiments of the 1880s were, like those referred to in the final part of the previous chapter, isolated and private, powered by plant assembled on the premises. The majority of these were ephemeral, and their tangible failure damaged electricity's reputation as the illuminant of the future. However, alongside these projects were attempts to supply more general urban areas with electricity. No account of electric light is complete without analysing the protracted and complicated process of building these networks.

Britain's first electricity station established for general supply was built at Godalming in Surrey in 1881: its water-driven plant was installed by Seimens and Robert Hammond, the prominent advocate of electric light, oversaw the construction. London's first station was constructed at Holborn Viaduct in 1882, to supply the General Post Office, and a series of shops and hotels. Both stations were abandoned within a few years, due to both financial and technical problems, and by 1885, there was growing despair at the prospects for central stations, as this speech by the President of the Society of Engineers makes clear:

> Nothing that has yet been done in the way of lighting streets or isolated establishments by means of machinery on or near the premises can claim to amount to a distribution of electricity, which to be practical must be effected from distant stations, and with the same facility as gas or water.[1]

In 1888, the Grosvenor Gallery station in London was perhaps the only central station fulfilling this dictum, powering 34,000 lamps via overhead cables. The revised Electric Lighting Act of that year, together with a gradual economic upturn, provided an improved climate for municipal undertakings: by 1900, most towns of reasonable size had electricity stations, usually under municipal control. These systems had, however, developed without national orchestration and standardisation, the result being a diverse array of local networks.

[1] Charles Ganton, "The Distribution of Electrical Energy by Secondary Generators," *The Builder*, XLVIII, April 18, 1885, 565-6.

The legal and municipal developments however, will not feature heavily in the pages that follow: I would refer readers elsewhere for details.[2] Several technical aspects of the development of electricity networks will also be addressed only in passing, notably the dynamo and the transformer, both of which were essential to the genesis of durable and large-scale distribution systems.[3] This chapter concentrates on the infrastructure beyond the plant itself: street-lighting and calculated illumination, domestic lighting and metering, and the elements of electricity networks, cable, conduit and manhole. The gradual emergence of these mundane technologies, their inspection and maintenance, and their growth, inevitably entailed the unpredictable surfacing of a series of problems relating to the management of networks. The proliferation of subterranean passages, and the general absence of subways, generated interminable issues of conflict, between companies and utilities, and between different physical systems themselves. This leads to a discussion of danger and its control. The chapter concludes with a study of the electrification of the City of London, a protracted affair that illustrates many of the points germane to this thesis, particularly the inordinate mangling to which any scheme to rationalise space and practice is subject.

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The Street: Lamp-posts and Distribution

The lamppost itself was the oldest and most established part of the illumination system; but the new light itself brought problems of distribution and management. "The mistake about (arc lighting) is that its brightness is assumed to be a measure of its illuminating power," warned *The Electrician* during the experimental days of electric lighting in the

[2] The classic work remains Hughes, *Networks of Power*. See also Hannah, *Electricity Before Nationalisation: A Study of the Development of the Electricity Supply in Britain to 1948*.
[3] For the dynamo, see Percy Dunsheath, *A History of Electrical Engineering* (London: Faber and Faber, 1962), 99-122. For the transformer, see J. Fleming, *The Alternate Transformer in Theory and Practice.* (London: Benn, 1889).

early 1880s.[4] Tower lighting, as mentioned in chapter five, exemplified this, frequently producing rings of intense light, separated by murkier, umbrageous zones, an effect replicated on a smaller scale wherever naked arcs were deployed. Arcs had to be tamed, directed and softened, to generate a relatively even light. Experience from lighthouse design could be used in cities. Blondel referred to the ideal as cones of light projected from standards enabling "a passenger, or an object that moves along a line joining two lanterns (to) remain illuminated in the most consistent manner possible."[5] Louis Bell, too, underlined the problems of harshly differentiated streetlighting: "all open arcs have the common weakness of giving more light than is necessary near the pole and too little far away from it."[6]

One method of achieving relative homogeneity was to establish a calculus of streetlight distribution. Blondel recommended positioning standards along the street's axial line, at a distance apart of not less than the width of the street. If there were no chains across the street, or no central reservation (both seldom seen in English cities) then a zigzag arrangement had to be adopted, which he regarded as considerably inferior. The aim was to minimise absolute contrast along the horizontal plane while preserving mean illumination. In the Rue Royale in Paris, Blondel's photometer recorded a mean horizontal value of 3.4 lux, a predictably high figure for this maestro of illumination.[7] Elevation was equally critical: illuminating engineers experimented with an array of heights, concluding that there was an apposite range within which lanterns should be fixed. If positioned too high, light could be obscured by formations of mist, haze or smoke. Alternately, if located too low, the lamps could dazzle pedestrians. Trotter, after many years of calculations and observations, suggested that "modern lamps should be placed not lower than eleven feet six inches from the ground in order to put them above the range of vision and reduce glare."[8] More often than not, as at the experimental lighting of the Thames Embankment, engineers had to operate according to a less exact set of calculations, and play off the possibility of glare against that of under-illumination. They slowly found out in practice what was feasible and what was not.

[4] *The Electrician*, VI, May 7, 1881, 325.
[5] Blondel, "Street Lighting by Arc Lamps," *ibid.*, XXXVI, November 8, 1895, 39-40.
[6] Bell, *The Art of Illumination*, 252.
[7] Blondel, "Street Lighting by Arc Lamps," *The Electrician*, XXXVI, November 8, 42.
[8] Trotter, *The Elements of Illuminating Engineering*, 97.

Perfectly uniform illumination, even if technically practicable, was, argued Blondel, actually undesirable. Were this to be achieved, he argued, the visual habits of pedestrians, accustomed to using lights as markers of distance as well as detail, would be destabilised:

> We should then have sources of light which would appear more brilliant at a distance than close to. This fact would completely upset the public, who would no longer be able to appreciate distance or understand the enfeeblement of the globe when looked at closely.[9]

This was a consequence of irradiation, an automatic physiological response of the eye, which makes bright objects appear larger due to the stimulation of an increased surface of nerve endings.[10] Once again, illuminating engineers recognised the vagaries of subjective perception when planning the arrangement of light. Likewise, Webber argued in 1894 that completely even illumination was "less convenient than occasional well-lighted spaces separated by darker portions."[11] Those entrusted with the illumination of cities, therefore, had to strike a median point between a beacon system, based around intense pools of light, and general illumination, modelled on daylight. The myriad centres of light needed in the street, in other words, meant that it was physiologically, as well as technologically, impossible to completely reproduce solar effulgence.

Along with this calculated positioning of lamps and poles, developing arts of reflection and diffraction could be used to direct light towards the street. Inspecting arclights at the 1881 Paris Exposition, Trotter observed that vast amounts of light projected skywards, disappearing into the void of night. Reflectors of various dimensions and shapes were developed, becoming a standard part of the urban illumination kit. The usual kind was white, or blue, enamelled sheet iron, fashioned into a hood: silvered glass deteriorated when exposed to the heat of the arc, while metal rapidly oxidised. Non-reflecting hoods were also adopted on urban streets to prevent rays straying into upstairs bedrooms. Specially manufactured glasses were devised to break, dampen and direct beams. Opal globes, for example, softened shadow, while ground glass deflected beams beneath the lamp, which often remained penumbral, owing to the interposition of the carbon apparatus between light and ground. Ribbed holophane globes diffused and softened the often astringent arclight, and relied on a complex set of calculations: merely "corrugating" glass made it "less effective."[12] Like the distances between lamp-posts, reflectors were designed

[9] Blondel, "Street Lighting by Arc Lamps," *The Electrician*, XXXVI, November 8, 39.
[10] Trotter, *The Elements of Illuminating Engineering*, 12.
[11] *The Electrician*, XXXII, February 23, 1894, 455.
[12] For Trotter's assessment of the 1881 lights, see Brian Bowers, *Lengthening the Day*, 145-6. For the manipulation of globes and diffusing glass, see Blondel, "Public Lighting by Arc

to accommodate the physical act of seeing. Dioptric reflectors, which directed light rays along a horizontal plane, had the effect of spreading illumination over a wider area. Such light, argued Preece, actually appeared brighter than it was. "Hence it is," he argued, "that when the eye alone estimates the value of the dioptric lantern it is deceived."[13] *Deception* in this case appeared to exist only in respect to Preece's own complicated photometric readings: these experiments again reveal the divergence between the subjective and machinic comprehension of light.

Blondel's central aisles and straight thoroughfares, necessary to produce his relatively even illumination, were more a feature of Parisian streets than London ones. Thus the Embankment could be lit relatively easily, but the crooked, tangled streets of the City were almost incalculably complex, as the elaborate array of photometric curves plotted by Preece and Trotter suggest. But illuminating engineers seldom appear to have attempted to move seamlessly from laboratory to street: rather, the byzantine, irregular roadplans of the city were taken as a given, and practice evolved accordingly. There does not seem to have been any rationality operative outside these pragmatic encounters with the particular spaces to be lit: illumination remained a worldly, practical exercise. The rather jumbled facades along streets themselves unevenly reflected light, while street surfaces themselves created other difficulties. Asphalt and macadam required more light to generate contrast than, say, lighter brick, while often undulating, puckered road surfaces further hampered attempts to fashion horizontal planes of light. Electric light was itself often regarded as inappropriate for narrow and outlying streets: when Cockermouth was electrically lit in 1881, the majority of the town remained illuminated by oil lamps because its narrowness and irregularity made them technically, and socially, more appropriate.[14] Indeed, when delineating how a city should have a hierarchy of lightzones, Bryant and Hale regarded suburbs as needing calculated dimness.[15] In short, the idea of nineteenth-century streets and squares lit by cubes of shimmering, identical, crystalline light is deeply misleading. Illuminating engineers themselves disapproved of the idea, for social and physiological, as well as technical, reasons.

Lamps," *The Electrician*, XXXV, April 17, 1896, 820-2, and *ibid*, XXXV, April 24, 1896, 853-5. For the effects of corrugated glass, in Glasgow, see *The Engineer*, LXXV, November 3, 1893, 422.

[13] William Preece, "Report on Electric Lighting in the City," *The Electrician*, XIV, April 18, 1885, 481.

[14] *Ibid.*, VII, August 13, 1881, 194.

[15] Bryant and Hale, *Street Lighting*, p58.

The practice of urban illumination, then, was never a pure, abstract science. Lamps, brackets and standards, as themselves part of the urban landscape, were prone to accidents, vandalism and wear. Vehicles on congested routes regularly hit, scraped and damaged them: *The Builder* referred to the "spectral looks" of lamp standards on Blackfriars Bridge after they had been grazed by traffic.[16] According to the City Commissioners of Sewers in 1877, "hundreds were broken every year."[17] In addition, street architecture had to resist less calamitous collision, damp and numerous other irritants. Hartmann's paint, said *The Engineer* in 1895, was specially selected for decorating London's lamp-posts because of its "durability and appearance".[18] This reminds us that lamps had to be seen by day as well as by night, and critics were frequently uncomplimentary about the appearance of standards. Contemporary lamp standards were often compared unfavourably to those of the previous century, which were more fanciful and crafted than the ubiquitous standards of Victorian times. London's were regarded by one journalist as possessing an "ineffable ugliness," while *The Electrician* bemoaned the condition of the lamps lining Regent Street: "several of the lamps have been there for considerably over half a century. They were in a wretched state of dilapidation, and a disgrace to the parish."[19] Posts themselves were usually made of iron or strong woods: telegraph posts, for example, were generally made from Norwegian pine, through which creosote permeated admirably.[20]

As indicated in the previous chapter, one of the main aims of those producing large-scale urban networks was to minimise the amount of human interference required in its operation. Carbons, ultimately, required regular attention; they had to be "trimmed every day, i.e. the electrodes must be replaced."[21] Consequently, arclights needed regular access for maintenance, while not providing an opportunity for vandalism. Thus Webber devised the following scheme to ensure the security of urban lights: stepladders were, "for obvious reasons," forbidden, as they would provide easy access to vulnerable carbons. Instead, he recommended:

[16] *The Builder*, XXX, November 30, 1872.
[17] "The Ownership of Street Lamps," *The Sanitary Record*, VII, September 14, 1877, 177.
[18] *The Engineer*, LXXVII, September 13, 1895, 266.
[19] *The Builder*, XXX, February 17, 1872, 122; *The Electrician*, XV, October 30, 1885, 464.
[20] "Telegraph Posts," *ibid*, XIV, March 7, 1885, 343.
[21] Bryant and Hale, *Street Lighting*, 6.

> Alternate side holes in the shaft, which are not conspicuous, and in having six or eight portable steps of light steel, which can be securely hooked into the holes he ascends, and taken out by the trimmer as he comes down the pole.[22]

For large city lights, however, trimming could be a difficult task. Like alkali inspectors, those entrusted with the role of trimming carbons often found themselves facing arduous conditions:

> Each lamp required two men in ordinary weather, and these trim fiom fifty to sixty lamps, according to the district. In high winds, however, it takes in some very exposed places as many as five or six men to hold on to ropes lashed to different parts of the ladder to keep it from being blown over. The ladders…have to be practically rebuilt after six or nine months' use. Some good method of lowering the lamps, so as to enable them to be trimmed from the ground, is badly needed.[23]

Seldom can the muddled processes and struggles which literally held urban systems together have been more graphically depicted. Arc lamps always required maintenance, just like candles, Argand burners, Jablochkoff candles, gasjets and mantles. The minimal human maintenance required for incandescent light is unquestionably one factor in its ultimate triumph. A 100-volt bulb was reported to have run for 11,561¾ hours in 1890 without requiring any human contact whatsoever: this autonomous incandescence was a vital aspect of the putatively self-regulating nature of liberal infrastructure.[24]

Domestic Lighting: Fuses, Wires and Meters

Domesticity and privacy were secured by making the house the locus of a proliferating number of energy networks, circulating, distributing and removing the flows through which civilisation has become assembled. The house's "image of immobility would…be replaced by an image of a complex of mobilities, a nexus of in and out conduits."[25] Still and silent, entrenched against the hectic circuits of modernity, the domestic realm was produced by rapid and potent forces deployed to stabilise privacy. These forces had to be mediated and translated to make them meek and polite enough for the parlour and bedroom. The private experience of electricity was to be one of switches, hidden wires and meters; soft and civilised equipment to augment comfort.

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[22] *The Electrician*, XXXII, March 2, 1894, 485.
[23] S.E. Feddon, "Street Lighting by Electricity," *The Engineer*, LXXX, July 9, 1897, 47.
[24] *The Electrician*, XXVIII, December 26, 1891, 188.
[25] Lefebvre, *The Production of Space*, 93.

The fuse was integral to both safety and the ideal of the self-regulating system. Early observers of electric systems were impressed with the fact that fuses protected house and family alike from short-circuits and surges of current. The low resistance of aluminium alloys made them ideal for fuses, which were required wherever conductors were reduced in size. They were always located as close as possible to the point of entry to private residences, to shield the domestic realm from sudden torrents of current: they provided a physical defence against the contingencies of pulsing, industrial, public energy. However, like meters and insulation, these tiny cut-outs were prone to failure, as Bathurst acknowledged: "cases have occurred where the protecting fuses on a circuit did not 'blow' before electrolysis promoted a dangerous arc which had burnt a hole in the tube and presented a serious fire risk."[26] The Technical Advisor of the Fire Office had to approve of all fuse designs. The positioning of fuses was also monitored: "they should never be placed under floors, inside roofs, or behind wainscoting, or skirting-boards, or in wood cupboards."[27] Indeed, although the interment of unsightly wire went on apace in the last decade of the century, good electrical practice became associated with provision for accessibility and easy inspection. "All good wire," observed Bathurst, "should be accessible, (and)...always open to the inspection of owner or wireman." This was to ensure that "the inspector can use his *eyes*, and have no need to trust to his *ears* for inspection."[28] Subsurface wires, argued Atkinson, "should be protected against injury and their position clearly indicated."[29] Another prominent electrician argued that internal wires should be positioned over decorations and then painted the same colour.[30]

Incandescent lights, opal globes, reflectors, lampshades and switches combined to give one control over one's light, while fuses and wiring, if competently fitted, secured the circuit against overload. The switch, argued Hammond, allowed light one to have light the moment it was required, without taper or match, which was further evidence of its safety.[31] By the late 1880s, switches were commonly made of porcelain, and a series of different mechanisms were available.[32] Glowlamps were easy to change: the bayonet cap

[26] Bathurst, "The Electric Wiring Question," *The Electrician*, XXXVI, December 6, 1895, 200.
[27] H. Leaf, *The Internal Wiring of Buildings* (London: Archibald Constable and Co., 1899), 144.
[28] Bathurst, "The Electric Wiring Question," *The Electrician*, XXXVI, December 6, 1895, 200.
[29] P. Atkinson, *The Elements of Electric Lighting* (New York : D. Van Nostrand Co., 1897), 275.
[30] Killingworth Hedges, *British Architect*, XXI, February 22, 1884, 92.
[31] Hammond, *The Electric Light in Our Homes*, 92.
[32] Brian Bowers, *A History of Electric Light and Power*, chapter 13.

was invented as early as 1884. Sockets, designed with small shutters to avoid both accidental shocks and accumulation of dirt, were also coming into common use along with the filament lamp.

The final part of the domestic illumination assemblage was the meter, a vital technology of individuation and self-government. Early gas supply was unmetered: customers simply paid a flat rate for the right to burn as much or as little gas as they wished. The introduction of private meters acted as a means of disciplining and rationalising the use of energy by providing the means for consumers to monitor their use:

> By the consumer burning by meter, attending to the height of the flame of his burners, and not keeping them lighted longer than he may find necessary, he will soon find that a considerable saving of expense will be the consequence, on comparing what he may have to pay by meter, with what he might have been in the habit of paying for his gas when he burnt it by contract.[33]

One was encouraged to regularly read one's meter, to calculate one's consumption of light and heat, to budget and think ahead: wanton draining of urban energy supplies could be checked by translating municipal concerns into the everyday, private idiom of thrift. Nonetheless, such a technique of rationalisation ran into inevitable material problems. The Sales of Gas Act of 1859 defined the cubic foot as the legal standard for the measurement and purchase of gas, yet, as one expert on metering pointed out, gas was:

> An aeriform body, invisible, highly elastic, varying in volume with every barometric change, very complex in its chemical constitution, affected by every change in temperature, liable to condensation, and to be absorbed by water, of which it is also an absorbent.[34]

One particular cubic foot of gas, in other words, was not necessarily equivalent to another in terms of composition or density. The eccentricities of metering mechanisms themselves added to these problems: in 1882, the *British Architect* reported the case of a meter which had recorded five times the actual quantity of gas used.[35] This situation was exacerbated by inscrutability of readout:

> The great percentage of dissatisfaction with gas consumers is with parties who look at the meter as a kind of *automaton*, and the officer who takes its index as a *conjurer*, who can and does make it say whatever he chooses.[36]

Even the *Journal of Gas Lighting* admitted that "the majority of gas consumers are unable to tell by an examination of the meter, how much gas has been consumed."[37]

Consequently, a whole series of men were employed to mediate between councils and

[33] Thomas Peckston, *A Practical Treatise on Gas-Lighting*, 378.
[34] Glover, *On National Standards of Gas Measurement and Gas Meters* (London: W. Trounce, 1866), 3.
[35] *British Architect*, XVIII, September 22, 1882, 452.
[36] A. Wood, *A Guide to Gas Lighting* (Lewes: George P. Bacon, 1872), 30.
[37] *Journal of Gas Lighting*, XXXVI, August 10, 1880, 221.

customers: Manchester appointed a whole Gas Meter Sub-Committee, equipped with a corpus of instruments and an official Gas Meter Inspector. Tacitly admitting the vagaries of both meters and supply, gas users were explicitly advised to regularly monitor the readout, "as so doing they will be able to detect any waste of gas caused by escapes or extravagant consumption."[38] The rise of ornamental meters, positioned openly in halls and stairwells rather than languishing forgotten in cellars, helped this periodic act of domestic measurement. Customers dissatisfied with the readout could summon the inspector to test the functioning of the meter, by paying a fee refundable if the equipment was found to be faulty.

The inelastic and theoretically more quantifiable properties of electricity might suggest that effective metering would be technically easier than with gas, but it proved at least as difficult. Domestic supply of electricity was unfeasible without reliable means by which consumers could be charged: one engineer spoke of the "urgent necessity for a good meter" in 1883.[39] But, as Algave and Boulard admitted, the "devising of a practical electric meter is not without difficulty," a problem compounded by the fact that in the absence of a real market, electrical engineers were unlikely to receive financial reward for such a challenging undertaking.[40] One of the central problems with electricity meters was the question of what to charge: consequently, meters measuring both amps and watts were developed. Wattmeters were becoming most popular by the early twentieth century.[41] But a set of technical difficulties persisted. The machines themselves had to be durable; their internal mechanisms had to resist routine wear, as well as the innocent attention of insects, often attracted by its warmth, and less blameless tampering by users. This latter practice was clearly a problem: customers found to have damaged, abstracted energy from, or altered the index of any meter, were liable to a five-pound fine.[42] With the rise of prepayment (or penny-in-the-slot) meters, some users deviously siphoned off the current to avoid paying, and special circuits were devised to preclude such practices. Meters had also to be clearly legible: guides to decoding the rows of dials were published: "the chief

[38] *Manchester Municipal Code*, III, 424.
[39] C. Vernon Boys, "On Meters for Power and Electricity," *The Electrician*, XI, June 16, 1883, 110.
[40] Algave and Boulard, *The Electric Light*, 363.
[41] A comprehensive breakdown of metering systems and their history was provided by G.H.W. Gerhardi, *Electricity Meters: Their Construction and Management* (London: Benn Brothers, 1917).
[42] Clause 38 of the 1882 Electric Lighting Act. See Manchester City Council Gas Committee, *Minutes*, June 19, 1894, 64.

advantage of direct-reading is that it allows the consumer to see how much he is using, and this gives him confidence."[43]

By 1900, it was becoming common practice to fit the meter between five and six feet high on walls, to further aid clear and habitual reading. In larger households, meters recording temporal fluctuations of supply were sometimes fitted, to deter servants or attendants from secretly wasting electricity. The introduction of two-rate meters encouraged the use of electricity at periods when stations traditionally produced less energy: customers were invited to harmonise their use with these periods and so contribute to overall municipal efficiency. The prepayment meter was another technology making possible particular practices and relations:

> Its use in flats is gradually becoming more extended, and in furnished apartments, where the consumers are chiefly nomadic, it relieves the proprietor of all responsibility as regards the consumption, over which he has practically no control.[44]

Providing that there was some visual indication when another coin was needed, a reliable prepayment meter made one's supply of electricity entirely one's own responsibility. One was free to be as frugal or profligate as one desired: the management of domestic space was becoming, slowly, a rational act of self-government.

The Network of Energy Distribution

The delivery of a safe, reliable and predictable supply of electricity was achieved through the construction of durable mains. There were three key elements of this system: conduit, cable and manhole, which were required to resist corrosion and wear, and allow easy management, inspection and repair:

> While the other features may be accessories thereto, the employment of smooth, strong conduits, accessible ducts for distribution of the current, first-class insulation, constant expert attention to details, and thorough organisation in every department, are essential to the production of a successful underground system.[45]

Many systems of distribution developed. Edison, for example, preferred to inter wires in tubes, each around twenty feet long, fused together into chains. Owing to expense, wood was more commonly adopted, but, as in similar experiments on the street's surface, the

[43] James Swinburne, "Electrical Measuring Instruments," Institute of Civil Engineers, *Minutes of Proceedings*, CX, April 26, 1892, 20.
[44] Gerhardi, *Electricity Meters*, 231.
[45] "New York Subways," *The Electrician*, XXIV, March 21, 1890, 503.

material's lack of durability necessitated much repair. Indeed, it was argued that "the acid coming from the wood itself contributes to the process of disintegration and decay," which entailed the development of pipes "hermetically sealed from such agencies as destroy gutta-percha, indiarubber, or anything else that is of the vegetable kingdom."[46] New material strategies were devised to ensure the permanence of cable networks: china, glass and jute impregnated with oil were all used. By 1890, there were so many competing methods that it was admitted that "there may never be quite the same uniformity in the methods of distributing electricity that has come to be the case with water and gas."[47]

The war against corrosion and system deterioration, then, generated many pragmatic solutions, among them the development of new types of pipes. Using pipes in urban areas usually necessitated the laying of extra clay, owing to the softening and deterioration of soil from leaking water, gas and ordure. Likewise, lead pipes, often regarded as the most durable, could sink and fracture in subterranean earth enfeebled and liquefied by the perpetual escapes from other systems. Rain and waste working its way through porous or badly-drained road surfaces added to this terrestrial evisceration. Designers of systems thus needed to take into account the interaction between the earth and the conduit. Failure to do so could lead to serious accidents: "in some cases the water mains have broken and filled the conduits with water, producing washouts and caving in of street pavements."[48] The pragmatic arts of network-building developed as a set of responses to such mundane calamities. Writing of Crompton's system of concrete conduits in South Kensington, Addenbrooke seemed happy to find only one point on the network perforated by water: "here it simply requires a few quarts to be baled out once a week."[49] The proliferation of ill-maintained pipes slowly corroding beneath leaky streets led, in extreme cases, to autocatalysis. In 1895, an enquiry by the Royal Society, the Institution of Electrical Engineers and the Electrical Advisor to the Board of Trade concluded that decomposed salts "chiefly derived from the soil" produced small residues of alkali metals, which in turn generated sparks, igniting any coal-gas which had drifted into conduits from its pipes.[50] Condensation within tubes could generate short-circuits, which required laborious repair. Bitumen's qualities lent themselves admirably to condensation prevention, while

[46] David Brooks, "Underground Conductors," *ibid.*, XXIV, November 29, 1889, 86.
[47] "Underground Systems of Distributing Electricity," *ibid.*, XXIV, February 28, 1890, 423.
[48] Brooks, "Underground Conductors," *ibid.*, XXIV, November 29, 1889, 86.
[49] G.L. Addenbrooke, "Underground Mains IV," *ibid*, XXIV, February 7, 1890, 342.
[50] *The Engineer*, LXXVII, April 12, 1895, 306.

having the rare bonus of "disagree(ing) with a rat's digestive machinery."[51] Deep burial was also desirable, to protect casing from stray pickaxe blows, tremors from steamrollers and the everyday effects of heavy traffic. The Imperial Gas Company, for example, reported leaks of up to ten per cent due to road vibration in the outskirts of London.[52]

Conductors themselves were, it was advised, to be no less than 98% copper, which, after silver, had long been established as the best electrical conductor.[53] Wire, it must be pointed out, was no modern invention: there are Biblical references to it, and wires have been unearthed by archaeologists excavating in Thrace, Scandinavia and Pompeii.[54] Such wires were used for decorative and medical purposes. In addition to cable casing, the wires required insulation, which came in equally diverse forms: vitreous or lithic (for example, porcelain), oily or organic (wax, gutta-percha), and even gaseous (air itself).[55] At his ambitious, doomed plant at Deptford, Ferranti adopted a combination of brown paper and shellac.[56] Vulcanised rubber was perhaps the commonest insulator, but it was accepted that "no insulated wire has yet been produced which in itself can successfully resist the deteriorating influences present in mortar or plaster."[57] Board of Trade Regulations recognised this, by permitting a maximum current leakage of one-thousandth of the highest current borne by the wire. Cheap and poorly-applied insulation was continually blamed for accidents and spasmodic fusing: tests in 1889 indicated that the durability of wires at maximum current varied alarmingly, from a mere forty hours to 895.[58]

These figures emphasised what all electrical engineers knew well: that maintenance was absolutely necessary to the delivery of illumination:

> Every lighting system suffers deterioration as the time of service goes on, and unless careful attention is given to renewal and repair, and to other factors involved in maintaining highly efficient service, the lighting equipment will decrease in effectiveness.[59]

Domestic wires, even when strategically camouflaged for decorative effect, were relatively easy to inspect. Considerably more problematic was the monitoring, testing and

[51] Bathurst, "The Electric Wiring Question," *The Electrician*, XXXVI, December 6, 1895, 201.
[52] H. Jones, *The Construction of Gasworks* (London: William Clowes and Son, 1875), 39.
[53] H. Leaf, *The Internal Wiring of Buildings*, 86
[54] Blake-Coleman, *Copper Wire and Electrical Conductors: The Shaping of a Technology* (Reading: Harwood, 1992), chapter one.
[55] See Black, *The History of Electric Wires and Cables* (London: Peter Peregrinus, 1983), especially 37-84.
[56] "The Art of Insulation," *The Electrician*, XXIV, December 27, 1889, 192.
[57] Bathurst, "The Electric Wiring Question," *The Electrician*, XXXVI, December 6, 1895, 200.
[58] "A Simple Method of Testing Wire Insulation," *ibid*, XXIV, November 15, 1889.
[59] Clewell, *Factory Lighting*, 46.

repair of subterranean wires: "underground conductors are the things which need the closest observation and scrutiny in all their details, though, unfortunately, they are by no means easy to observe and scrutinise."[60] The manhole was the main portal to the subsurface world, providing physical and visual access. Manholes were commonly used to lay cables, lubricated with soap and drawn in through funnels to prevent abrasion of the casing: as much as half a mile of cable could be deposited at once, through several manholes. Crompton's system used manholes as connection points between two conduits. Generally, manholes were located at all junction points, and then every 150 feet or so along the street, "so that taps may be made from the mains for services in the buildings along which they run."[61] Workmen could use these sturdy orifices to test wires using any number of techniques. They were constructed to be only openable "by means of a special appliance," in order to deter vandals and vagrants. Nonetheless, the abundance of underground networks was making the task of localising faults harder. At the Municipal Electrical Association in 1897, Quin argued that "the mileage of cable laid under streets has increased rapidly within these last four years, and more especially does this show itself in the area and complexity of distribution networks," which "renders more difficult the task of (fault's) localisation."[62]

The proliferation of underground circuits and networks led to renewed calls for integrated urban subway systems. The first proposal for the systematic establishment of metropolitan subways dates from 1817, but with the foundation of the Metropolitan Board of Works in 1855, the idea was taken more seriously. Bazalgette was involved in the design of the first planned subway built in London, between Cranbourne Street and Covent Garden in 1855. But in common with other attempts to standardise metropolitan building practice, a Bill to introduce subways across London was scuppered in 1864 by the opposition of private companies, who objected to the great expense of relaying mains. Fourteen years later, the gas engineers Newbigging and Fewtrell argued that "subways, underground passages or tunnels…are, we believe, destined, sooner or later, to be constructed beneath the busy thoroughfares of all populous cities."[63] But, with the exception of coordinated municipal endeavours like the Holborn Viaduct and the Embankment, gas mains, sewers, telegraph

[60] G.L. Addenbrooke, "Underground Mains," *The Electrician*, XXIV, January 17, 1890, 261.
[61] L.A. Ferguson, *Electrical Engineering in Modern Central Stations* (Madison, Wis.: Engineering Bulletin of the University of Wisconsin), 1896, 244.
[62] R.C. Quin, "The Localisation of Faults in Underground Mains," *The Engineer*, LXXX, July 16, 1897, 52.
[63] Newbigging and Fewtrell, *King's Treatise* II, 394.

cables, drains and wires continued to vie for limited space beneath the streets of London and other cities. Sometimes as many as twenty gas mains converged beneath one thoroughfare: in 1875, it was estimated that the length of underground pipes exceeded that of roads by four times.[64] Such figures remained estimates for the simple reason that the vast subterranean networks were so large and unmapped as to be unknowable. The cryptic nature of the electricity system was admitted by *The Electrician* in 1890. There had been no new plan of sewers, the publication argued, for twenty years, which meant any attempt to accurately depict the position of conduits was impossible:

> Supply companies use the Ordnance maps as a rule, but the position of the conductors can only be approximately given on them, on account of their small scale and the numerous alterations which have been made since the date of the survey...we should be glad to know if sketches are regularly made of the bowels of the streets either by the contractors or by the local authorities.[65]

The underground world through which perception and cleanliness were secured was shrouded in a certain degree of mystery. The easiest places to lay wires were along railway cuttings or bridges, but these were exceptions in crowded city centres. Electrical engineers were forced beneath the streets, where their delicate circuits inevitably collided with other networks.

Ideally, cables were to be laid beneath foot-pavements, to avoid interrupting traffic, but this frequently proved impossible. One report of 1890 described how engineers found the entirely unpredictable locations of foundations and cellars in London so irksome that they were forced to turn into the road, where water and gas pipes made progress difficult. When a small part of a sewer was removed to accommodate a conductor, the company in question quickly found themselves hauled before the Board of Trade.[66] But it was with gas systems that electric networks most frequently collided. Gas mains, it had long been acknowledged, leaked routinely, and electricians regularly found evidence of gas in their culverts, conduits, and manholes. The Kensington and Knightsbridge Company reported in 1895 that in Queen's Gate Gardens they "find such a copious discharge of gas in this district that they have to raise the corners of their boxes every day," a situation producing nausea and illness among servants sleeping in adjacent basements.[67] Occasionally, accumulated gas could force off covers of manholes. Securing perception, in other words, brought with it new dangers, necessitating new forms of inspection, control and repair.

[64] "Light in London," (III) *The Builder*, XXXIII, November 13, 1875, 1009.
[65] *The Electrician*, XXIX, July 15, 1892, 269.
[66] *Ibid.*, XXV, October 17, 1890, 665.
[67] *Ibid.*, XXIV, February 15, 1895, 458.

The Danger of Gas: Leakage, Poison and Explosions

The voluminous, permanent leakage of gasmains had been long known: in 1858, it was estimated that perhaps one-fifth of all manufactured gas found its way out of the network at some point.[68] This image of a rotten, porous system, like that of the smoky, dirty lamps which it supplied, was emphasised by all those emphasising the sanitary advantages of its rival:

> The day will probably arrive when, before this very Association, a paper will be read on the iniquity of the nineteenth century in permitting the distribution, by constantly leaking pipes, under the public streets, of such a frightfully noxious thing as coal gas.[69]

Soil visibly blackened around gasmains; if one inserted a metallic cylinder into this ground, gas might escape through it, and, in some areas, "a match applied to the hole will light a...flame."[70] Energies powering the city could not be contained by their technologies of transmission. Iron pipes were themselves permeated by gas, due to what *The Journal of Gas Lighting* enigmatically referred to as "osmotic action," but the majority of leaks resulted from fractured pipes or improperly-extinguished lamps.[71] Many kinds of materials had been used for pipe-construction, including wood, asphalt and tile, and ball-and-socket joints enabled chains of pipes to be laid underwater. These were more malleable and durable than early gaspipes, which were often simply made from old gunbarrels. Yet gas continued to leak alarmingly, insinuating itself indiscriminately into sewers, basements and wells as well as electricity conduits.

The effluvia of gasworks was a routine part of urban experience. When Samuel Clegg first purified gas in London, the stench was reported to have "extended over the whole neighbourhood."[72] One gas engineer admitted that "the odour of coal-gas, when once known, is not likely to be mistaken for any other," which enabled the easy location of leaks.[73] This latter point appears rather questionable, given the almost routine way in which gas silently struck, especially at night. In one week in 1873, *The Builder* reported

[68] Newbigging and Fewtrell, *King's Treatise* II, 331.
[69] Robert Hammond, "Municipal Electricity Works," *The Builder*, LXV, August 19, 1893, 138.
[70] *The Electrician*, XXXIV, February 15, 1895, 458.
[71] *Journal of Gas Lighting*, XXVI, November 2, 1880, 683.
[72] Zerah Colburn, *The Gas-Works of London* (London: E. & F. Spon, 1865), 48.
[73] J. Rutter, *Advantages of Gas* (London: Walter King, 1883), 12.

that seven people had been killed in separate gas escapes.[74] Houses unconnected to the network were also affected: in 1880, a sleeping Glasgow woman was suffocated after a main running beneath her cellar fractured and disgorged gas throughout her home. One did not need to inhabit a machinated house to have one's life irrevocably modified by the networks securing perception. Cryptic flows of poison throbbed beneath the ground. The psychological effect of this environment has been discussed elsewhere.[75] Here, it is perhaps sufficient to make the point that infrastructures could kill, and this act must be acknowledged as part of the reconfiguration of the parameters of agency in the modern world: new forms of life and new forms of death evolved together.

House, street and work were sites were locations where a remote risk of accident was ever-present. All new technologies inspire some degree of anxiety about safety: Wood recalled a time "when the horrified lamplighters of Westminster Bridge refused to light the lamps."[76] Coal-gas was "not only inflammable, but explosive; that is, it takes fire suddenly and expands so forcibly that it will break windows, burst open doors, and throw down walls."[77] The sheer volume of gas upon which the hungry city feasted was visibly evident in the increasingly capacious gasholders in which it was stored. By 1865, London's gasholders were dwarfing St Paul's Cathedral, while the development of telescopic holders, and the abandonment of trussed or girdered rooves "led the way for (their) almost indefinite expansion." By 1894, the South Metropolitan reservoir could hold twelve million cubic feet of gas.[78]

The languid rise and fall of these gloomy, rusting pistons formed part of the daily rhythm of the industrialised metropolis. When accidents occurred, they were frightening events: the Nine Elms gasometer disaster in south-east London on October 31, 1865 was perhaps the most notorious. An explosion in the meter-house punctured the skin of the tank,

[74] *The Builder*, XXXI, December 6, 1873, 963.
[75] Schivelbusch provides a materialist analysis in *The Railway Journey*, arguing that the experience of living within a machinated world ultimately industrialises consciousness itself, a position perhaps echoing some of the mechanistic thinking of modernity itself. He talks of "a new psychic layer that obscures the old fears and lets them lapse into oblivion," (130) a position which arguably reifies the psyche. The history of consciousness, and its relationship with technology, falls well beyond the ambit of this thesis. See also Christoph Asendorf, *Batteries of Life*.
[76] Wood, *A Guide to Gas-Lighting*, 7.
[77] Rutter, *Advantages of Gas*, 14.
[78] C. Hunt, *The Construction of Gas-Works*, 25, 34. See also Lynda Nead, *Victorian Babylon*, 92-4.

forcing out a jet of gas which caught fire. Nine men died, and the charred, skeletal frames of the gasholders became an emblem for those wishing to banish gasworks from cities. Thomas Bartlett Simpson, former owner of Cremorne Gardens, quickly published a pamphlet condemning not only the company in question, but the whole practice of situating gasworks within cities:

> We now find ourselves encircled by about twenty of these dreadful magazines of discomfort, sickness and peril; converting thousands of tons of coal into coke and gas every day, necessarily accompanied by poisonous emanations, and an 'unavoidable accident,' at any one of which may, in the busy hours of day, or in the stillness of night, lay a neighbourhood in ruins, and bury its inhabitants beneath them.[79]

The Times referred to every gasholder as a potential powderkeg, while *The Telegraph* opined that the worst aspect of the disaster was that it had been completely unpredictable. Its effects, argued the strident Simpson, were akin to those of a "hurricane;" the disaster was "as unexpected as it was awful".[80] Less spectacular gasometer explosions were more frequent; 30,000 cubic feet of gas was released when one at Congleton erupted in 1879.[81] Further, the sheer size and potential flammability of these colossal casks made them targets for terrorism. In 1891, the gasholders at Dawsholm, Glasgow, suddenly exploded:

> The phenomenon being accompanied by a loud rumbling noise and strong vibration, distinctly felt in the western portions of Glasgow. The crowns of the holders were next violently torn open, and a second later the ironwork of both structures crashed down – almost simultaneously – to the bottom of the tanks, the whole catastrophe occupying only a few seconds. Fortunately there was little or no wind at the time, and the huge volumes of ignited gas expended their heat in the upper air without doing further damage than setting fire to some haystacks in the vicinity and slightly scorching a valve man who happened to be near the holders.

The incident was firmly blamed on the planting of explosives on the top of one of the holders, an act blamed on "the same class of miscreants" who had perpetrated a similar attack on another Glaswegian gasworks a few years earlier.[82]

Street explosions were more common, ranging from relatively minor incidents like that responsible for wrecking the first London traffic light in 1868, to more disturbing, unpredictable and seemingly inexplicable incidents. In 1873, an iron pillar supporting four gaslamps in Retford was "completely wrenched from its hold, and flung down with such force that the surrounding buildings were completely shaken to their foundations."[83] Routine maintenance could also provoke disaster. When mains were relaid along

[79] Thomas Bartlett Simpson, *Gas-Works: The Evils Inseparable from their Existence in Populous Places*, 9
[80] Quoted in *ibid.*, 13, and 24.
[81] *British Architect*, XII, September 5, 1879, 95.
[82] *The Engineer*, LXXI, February 6, 1891, 112.
[83] "A Startling Occurrence," *The Builder*, XXX, September 21, 1872, 753.

Tottenham Court Road in 1880, a workman foolishly lit a match to check for gas, causing an explosion which ruptured 100 yards of roadway, catapulting paving stones into houses and triggering a series of six further explosions at various points along the main. "The aspect of the houses," commented one observer surveying the debris, "could only be likened to that which would follow a bombardment."[84] Still more regular were incidents where escaped gas was detonated in private houses, often by similar acts to that of the workman above. The building press assumed a wry ennui when depicting such incidents:

> A short but effective search for a gas leakage was made by an individual at West Hartlepool last Saturday. Between himself and the candle a nice little job of restoring the front of the house to its normal condition has been created for the builders.[85]

Inevitably, the new relationships between body and technology which typify modernity were always subject to human, as well as material, fallibility. Self-discipline and control of one's machinated milieu were closely aligned: hence, the kinds of social distinctions outlined in chapter one had a technical dimension demonstrated in the routine practice of environmental management. A report to Manchester City Council's Watch Committee in 1876 makes this point:

> It is impossible however to obtain in every household the necessary amount of care and intelligence to deal with such lamps, and this applies specially (sic) to those of the lower classes in which dangerous low flash mineral oils are often kept in open vessels...oil at the present legalised flashpoint is capable of giving off vapour at the temperature in most rooms sufficient to produce an explosive mixture...It is unreasonable to suppose that the lower classes generally understand the conditions and danger of explosion due to faulty construction, or imperfectly fitting wicks, together with the employment of oils of low flash points such as those at present in use in England.[86]

The poor, the report indicates, were seen as being unable to properly operate environmental technologies, and this failure leads to accidents. Animals, in particular, were blamed for upsetting lamps: cats and dogs had no place around technologies designed for humans.

Electricity contrasted with such puddles of oil smouldering unattended in chipped saucers; by securing permanent environmental modification via a self-regulating set of networks, it promised to free the subject from anxiety and danger. "Properly and scientifically employed," said one electrician, "electricity afforded a means of communication which could be rendered absolutely and perfectly safe."[87] The production and management of safety is the subject of the next section.

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[84] *Journal of Gas Lighting*, XXXVI, July 13, 1880, 63.
[85] *British Architect*, XIII, February 6, 1880, 70.
[86] Manchester City Council Watch Committee, *Minutes*, XXIII, June 4, 1896, 245.
[87] Thomas Bolan, writing in *The Builder*, XLII, May 13, 1882, 597.

Electricity and the Management of Safety

Electricity's safety was, it will be recalled, among the many advantages described by Edison. Unfortunately for him and others, like Hammond, installing electricity systems involved immersing oneself in a world of complicated contingency, of corroding wires, faulty filaments, forgetful consumers, and sleepy workmen. Some of the problems with these pioneer installations have already been discussed: intermittent supply, poorly-focused beams, and defective carbons. Here, I will examine the specific set of dangers and anxieties that crystallised around electricity in the early years of its practical history, and the responses this provoked.

"Perhaps nothing has ever had so much expected of it than that intangible, invisible, terrible, tractable and intractable something called electricity," wrote Hepworth.[88] Clean and quiet, electricity was the paradigmatic modern energy source, yet this impalpability inspired disquiet. Gas forever exceeded its networks, and poisoned and corroded, but it was relatively conspicuous to the senses, through hiss and smell. As such, accidents were frequently seen to be the result of recklessness and indiscipline, while the consumer of electricity was vulnerable to shock in "the utter absence of any intimation of the deadly power lying in ambush."[89] Human eyes and ears could not detect electron streams. "We are endowed with no special senses, by which we can detect the presence of electricity or magnetism," observed *The Builder*; "there is, then, no cause for wonderment that most approach the subject as one of a shadowy nature, if not altogether shrouded in mystery."[90] This again reminds us how the reorganisation of the senses was no easy process. To become accustomed to power sources that did not impinge on the nose was not to immediately feel free to concentrate and breathe. Early electric light installations, then, rather than simply eliding fears, tended to replace a series of comprehended fears with newer, more enigmatic ones. Thus Hammond reported that, following the installation of circuitry in his house, his servant had been unable to sleep, fearing that the house would

[88] Hepworth, *The Electric Light: Its Past History and Present Position*, xi.
[89] *Journal of Gas Lighting*, XXXVI, Oct 26, 1880, p642.
[90] *The Builder*, LVIII, June 28, 1890.

explode.[91] Similarly, one of Brighton's Councillors protested against the introduction of plant into the centre of the resort:

> He protested against the whole of the electric lighting works being placed in the centre of the town, as he was afraid that, if anything happened and the whole thing burst up, the inhabitants of his particular ward might be sent where they would never be seen again.[92]

These kinds of reactions, it was acknowledged, were due to the "untechnical" nature of the public. Preece, as President of the Institution of Electrical Engineers, argued that in the absence of general technical education, it was not unexpected that people felt disturbed and frightened by having "a natural force of enormous intensity" circulating around their homes.[93] *The Lancet* went further, suggesting that irrespective of one's electrical knowledge, there was "at least some grounds for the uneasiness which one of its critics has expressed at the idea of '2,500 volts grumbling in the cellar'."[94] Moreover, there was no eliding the industrial processes at work producing electricity. Like railways and gasworks, electricity stations were transparently industrial, overhung with steam, and generating noise as well as energy. In 1885, the Gloucester Crescent station in London was reported to be creating "tremendous vibration and noise," which made it "almost unbearable on the part of those living in the immediate locality."[95] The new light, it seemed, could entail irksome noise as well as disturbing silence.

Irritation and nervousness were compounded by the very public problems attending early electricity installations. Blackouts and interruptions frequently brought electrically-lit parts of towns to a standstill: all the transformers at the Deptford station burnt out in 1890, leaving the supply disconnected for three months. More common were minor interruptions, as in the City in 1881, when the supply simply stopped, without warning or explanation, for several hours.[96] The kinds of network interference already examined formed only one aspect of a series of accidents, from minor irritants to serious injury. Contact between wires and damp surfaces were themselves frequently blamed for electric shocks or dangerous cross arcs, which could generate fires. When material networks left to their own devices, unpredicted chemical reactions could take place, as shown with alkaline salts. Similar problems could occur with dissolving zinc in batteries, or sparks triggering

[91] Hammond, *The Electric Light in Our Homes*, 71.
[92] *The Electrician*, XXXIV, March 1, 1895, 553.
[93] *The Engineer*, LXXIII, February 17, 1892, 148.
[94] *The Lancet*, May 4, 1889, I, 907.
[95] *Ibid.*, November 13, 1885, II, 208.
[96] *The Electrician*, VI, May 14, 1881, 335.

the fusion of oxygen and nitrogen into "strong and corrosive acids."[97] More disturbing were occasional, unexplained explosions occurring without warning: as the electrical engineer Rankin Kennedy admitted in 1902, these remained an enigma:

> The subject of explosions in underground electric systems has never been properly investigated. Many of the cases have been somewhat mysterious. What actually did explode and what fired the explosive has in most cases only been a matter of conjecture.[98]

This lingering mystery, twenty-five years after the emergence of electric light as a practical system, demonstrates that claims of perfect safety remained something of a fantasy, one consistent with the epistemologies associated with modernity. Perfect, predictable management of physical systems was impossible, because, in real time, matter always has the capacity to perform peculiar acts. To recognise contingency as a fundamental property of all infrastructures was, again, to accept the inevitability of a risk that was not merely social, but sociotechnical: a product of the networks binding our world. Electricity had laws, expressed in elegant equations, yet this graceful conceptual architecture could never capture the movement and activity of the world of electrons.[99] The noumenal realm of the physical world would remain elusive: electrophysics would be carried to the quark and beyond by this frustrating attempt to achieve epistemological closure.[100]

Of course, the arcane world of the particle was never a major public concern. More prominent was the issue of the potentially lethal new energy coursing around the city. Contemporaneous with electricity's rise to prominence in surgery and physiology were growing suspicions of its lethal dangers. In 1869, these were demonstrated by Richardson, who applied the circuit to animals:

> Sheep and other animals were killed by the statical discharge, and the cause of death was shown to be the expansion of gaseous parts of the blood and tissues by which organic lesions of the most extensive kind were induced.

The electrophysiologist D'Arsonval established 500 volts as an approximate threshold, beyond which death, and below which stunning, would result.[101] These tests were used *en route* to devising a series of techniques for electrically stimulating the human body, especially autoconduction, but they palpably showed electricity's ability to both stimulate

[97] *British Architect*, XI, January 17, 1879, 30.
[98] Rankin Kennedy, *Electrical Installations Electrical Installations of Electric Light, Power, Traction and Industrial Electrical Machinery* IV, (London: Blackwood, Le Bas and Co., 1902), IV, 231.
[99] See, for example, J.J. Thomson, *Electricity and Matter* (Westminster: Constable, 1904).
[100] See, for example, Andrew Pickering, *Constructing Quarks: A Sociological History of Particle Physics* (Edinburgh: Edinburgh University Press, 1984).
[101] *The Lancet*, July 2, 1887, II, 32.

and threaten human life, and the disarmingly small gap dividing life from death.[102] Death itself, it was established, resulted from heart failure rather than, as D'Arsonval had maintained, respiratory breakdown.[103] Currents below this limit were admissible into homes, but not without misgivings: accidental electrocutions were reported from at least 1881, and electrical fatalities were frequently reported, including those of Lord Salisbury's gardener and a man at the 1885 Health Exhibition who, rather ironically, died after touching a dynamo.[104] *L'Electrician* suggested electrical cremation in 1881, which would absolutely calcinate any corpse by strapping it into a bodice of platinum wire.[105] The possibility of instant, silent death was itself manifest from 1883, when the *Medical Press* spoke fearfully of "the surreptitious use of the electrical current for the purposes of secret murder."[106] The possibility of electricity, so quantifiable, sleek and malleable, being used to deliberately deliver silent, industrial death, became actualised when the state of New York voted to replace hanging with the electric chair in 1888. During debates in the Assembly, commissioners had spoken coolly of electricity as being "the most potent agent for destroying human life."[107] The 'death chair' was designed by, among others, Arthur Kennelly, former director of Edison's team of electricians. Kemmler was the first man executed by electrocution in 1890. Hangman and noose were replaced with scientist, switch and circuit; if execution is administered by an assemblage of conjoined human-object agency, with electric death, the agency has tilted somewhat in the favour of the nonhuman. Could human guilt be assuaged by this sinister assemblage? *The Lancet* was unconvinced, pointing to the fact that Kemmler took nine minutes to expire. But his body, when finally lifeless, was immediately handed over to medical science: it had been "silently and invisibly absorb(ed) into a scientific and technological system."[108]

The administration of death through the force that could vitalise the body and the city pointed to the necessity of minimising its contiguity to the human realm at anything approximating high voltage. Thus transformer stations and high-tension lines became

[102] For D'Arsonval and his various experiments, see Rowbottom and Susskind, *Electricity and Medicine*, 120-140.
[103] Thomas Oliver and Robert Bolam, *On the Cause of Death by Electric Shock* (London: British Medical Association, 1898), 5.
[104] Hammond, *The Electric Light in Our Homes*, 57, and *The Lancet*, March 7, 1885, I, 440.
[105] Quoted in *The Electrician*, VII, September 24, 1881, 289.
[106] Quoted in *ibid.*, X, February 3, 1883, 276.
[107] Quoted in *ibid.*, XX, February 3, 1888, 326.
[108] Tim Armstrong, *Modernism, Technology and the Body: A Cultural History* (Cambridge: Cambridge University Press, 1998), 34. See also Hughes, *Networks of Power*, 107-109.

particular zones of danger, where workmen had to operate machinery with discipline, or die. "There are dozens of metallic portions of the apparatus," wrote *The Engineer* of substation equipment in 1894, "to touch which with the point of the finger means certain and sudden death."[109] Material accommodations to this could be made; including coating with ebonite, thick gloves or developing tubes which glowed at high voltage, so "everybody would know that to touch the mains means certain death, or at least injury for life."[110] Ultimately, there was no way of absolutely keeping lethal wire and fragile organism apart, and periodic electrocutions have remained part of the darker narrative of civil engineering ever since.

Public anxiety about electric death crystallised around the issue of overhead wires. The conduit system that became dominant in the 1890s was not typical in the embryonic years of the industry. Early wiring was placed above ground: when the House of Commons was electrically-lit for the first time in 1883, the wires were simply laid along the floors of the corridors.[111] Some public installations similarly positioned wires openly across streets, but much the most common approach was to suspend wires from poles, in similar fashion to telegraph and telephone wires. Hammond, for example, erected fifteen miles of bare overhead cables to supply various systems in the early 1880s. The mass of wires accruing above the streets of cities generated public concern: *The Electrician* spoke of the "inordinate multiplication of overhead wires," particularly telephone ones, in 1883.[112] The accumulation of such wires, it was claimed, was to blame for interference with transmission: Preece reported in 1886 that high-tension electrical wires disturbed telephones "within a distance of three thousand feet."[113] Private companies were held to blame for this "nuisance (which) must very soon become unbearable...the wires and cables are now rapidly shutting out daylight and destroying what little beauty is still left."[114] Despite a Select Committee reporting that the danger from this wickerwork of wire was "greatly exaggerated," accidents resulting from falling wires proliferated.[115] Warehouses destroyed by fire and electrocuted horses were used as evidence in claims that

[109] "Electric Lighting Station Accidents," *The Engineer*, LXXVI, January 26, 1894, 73.
[110] *The Builder*, LXVI, January 27, 1894, 65.
[111] *British Architect*, XIX, April 6, 1883, 166.
[112] "Overhead Wires Again," *The Electrician*, XI, November 3, 1883, 588.
[113] Select Committee on the 1882 Electric Lighting Act, *Hansard*, 1886, 219.
[114] "Overhead Wires," *The Electrician*, XII, January 26, 1884, 253.
[115] "Report of the Overhead Wires Committee," cited in *ibid.*, XV, May 15, 1885, 11.

a serious new urban nuisance was growing. In periods of snowfall or gales, poles were regularly blown down, leaving a dangerous tangle of ugly wires.

The emergence of highly potent alternating currents eventually triggered decisive action. Direct current was economically unsuited to supplying large areas, owing to the prohibitive cost of thick copper wires: John Slater estimated that the maximum area of supply from one station was one square mile. High-tension line, by contrast, enabled large currents to be transported for long distances across very fine wires, and then reduced at transformer stations. This was not an issue when supplying small areas; Edison's famous Pearl Street station was positioned at the epicentre of downtown New York. For anything beyond an institution or urban hub, however, stronger current was required. The diffuse demography of Torquay and Cardiff, for example, necessitated alternating-current systems, which itself catalysed public concern. As *The Engineer* argued, "the objection to high-tension currents consists principally in the danger to life and property which unprotected cables having such currents are likely to cause."[116] And, despite the development of enhanced insulation and other safety devices, burying cables underground appeared the most logical solution.

Events in New York were again critical. By 1886, the state had 14,556 miles of overhead cables, and New York City itself had a considerably higher concentration of them than London. The impending execution of Kemmler, coupled with the notorious antics of Harold Brown, who publicly killed dogs, calves and horses to demonstrate the iniquities of alternating current, triggered a febrile reaction. In one week in January 1890, 154 miles of cable were felled, while watching crowds applauded:

> The busiest thoroughfares of the city have been alive with gangs of men actively engaged in cutting down and removing poles and wires, and a further result is that the streets have once more been reduced to darkness...As might be expected, the darkness of the streets has been very much of an impediment to shopping at night, and the consequence is that the streets have been crowded to suffocation, and dangerously, during the daytime.[117]

The impact of reports of this "axeman's crusade" was immediate. Glasgow Corporation, for example, decided to dismantle its three and a half miles of overhead wire. The public, argued the *Engineering Magazine* in 1891, was "possessed with a horror of high-tension circuits."[118]

[116] *The Engineer*, LXXIV, July 27, 1894, 90.
[117] *The Electrician*, XXIV, January 3, 1890, 226.
[118] *Engineering Magazine*, I, 1891, 262.

Parallel with such dramatic measures were a series of legislative moves to curb the pullulation of such fearsome aerial fretwork. Test cases in the 1880s proved that private companies erecting them without local authority consent were guilty of trespassing; the air above the street was as much a part of it as its surface or subterranean passages. Codification of this followed: the 1890 Public Health Act, for example, included clauses empowering authorities to make regulations to protect the public from such wires. Suspended cables could only be constructed with the permission of the Board of Trade, and, to prevent the sometimes slapdash workmanship of earlier erections, precise codes were produced to govern the material configuration of wires, and subject them to the kinds of urban calculus explored in chapter three. Under the 1891 London Overhead Wires Act, an absolute limit of 140 feet between poles was established, while the angle at which wires crossed streets was to be no less than sixty degrees. Supports were to hold no more than twenty wires, be of "durable material", and be marked so that inspectors could ascertain who owned it. Every wire, the Act continued, "together with its supports and all structural posts belonging to or connected with it, shall be duly and efficiently supervised by the Company to which it belongs."[119]

The Board of Trade's revised Regulations for Ensuring the Safety of the Public of 1896 covered the whole country, and further secured electric circuits against accident or overloading. They provided, for example, explicit figures covering the maximum leakage in a public circuit, and the maximum working current in any conductor. This calculus was designed to ensure the harmonious interaction of all elements of the circuit:

> The maximum working current in any conductor shall not be sufficient to raise the temperature of the conductor or any part thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering.

Overhead wires were strictly regulated. Supports had to be "properly stayed against force due to wind pressure, changes in direction of the line, or unequal lengths of span," and must be no lower than eighteen feet high, or thirty feet if crossing a road (metropolitan minima were slightly higher). Aerial lines had to enter consumer's premises at a point "which is not accessible to any person without the use of a ladder or other special appliance."[120]

[119] Quoted in *The Electrician*, XXVIII, December 11, 1891, 149-50.
[120] Quoted in *ibid.*, XXXVI, February 7, 1896, 133-134.

Electricity was to become something experienced only at specified, controlled points of access and contact. Expelled to the netherworld of the city, electric cables would silently and secretly shuttle their electrons from station to home or work, where, tamed and domesticated, light and power could be harnessed for the purposes of attention, consumption or production. Building an infrastructure to secure visual and bodily agency was, therefore, a process emergent within the gestating structure of the city itself: resistances, like those surrounding overhead wires, became apparent and necessitated accommodation. In doing so, contingencies were not negated, but minimised, and the ensuing distribution of energy could be applied to its increasing number of uses, from surgery to execution. This distribution, along with structures supplying gas and water, acted to frame the capacities of subjects: to see, breathe, move and work. Such technologies were governmental in that they aimed to shape and guide the conduct of subjects. This governmentality was liberal in that these subjects had a basic bodily and moral freedom which environmental modification could promote: it was also social, in that it targeted the population as a whole and recognised that urban environment was beyond the reasonable power of the individual to control. In short, government increasingly became concerned with questions of protection, in the form of legislation defining how the physical and technical world of the city was to be most productively arranged so as to secure the health of bodies on the one hand, and the flow of capital and labour on the other. This practical carving out of this sociotechnical domain may have involved the use of reason, but it does not necessarily amount to the product of a rationality. The concluding section of this chapter, I hope, demonstrates this.

Lighting London: Electrifying the City 1878-1900

Hughes's emphasis on the relative technical 'backwardness' of the metropolis in 1900 compared to American and German cities is certainly correct.[121] Likewise, his conclusion that the political organisation of London and cautious legislation retarded the development of electrification has much to commend it. These factors will be emphasised in the

[121] Hughes, *Networks of Power*, 227-261.

following account of the electrification of the City of London, but, in keeping with the analysis throughout, technical factors and material contingency, as well as social elements, will be used to explain the particular trajectory this took. This hopefully rids any analysis of some of the normative assumptions of Hughes's work. The development of a durable electrical network was an unspectacular, and frequently messy process: it was neither the smooth imposition of an abstract rationality, nor beset with titanic accidents and mishaps. The real, in other words, was neither easily programmable, nor perenially obstinate.

The City of London, 673 acres in size and long the financial hub of the empire, was an administrative anomaly even in the arcane world of the capital, with the City Corporation still protected by a mass of charters, some of which had been in force since medieval times.[122] Despite the institution of the Metropolitan Board of Works, government of the City's sanitation, gas, paving and lighting remained in the hands of the City Commissioners of Sewers and various committees, at least until 1897, when its duties were divided between the Court of Common Council and the newly-formed Public Health Department. The need for light was obviously great, and unlike other schemes to light cities, the call was overwhelmingly for street and business lighting, both by night, and day, owing to the "not infrequent, and sometimes quite unexpected, fogs which envelop the City in darkness, even at mid-day."[123]

Consequently, the City was host to a whole series of experimental demonstrations of electric light. In November 1878, sixteen Jablochkoff candles were displayed on the Holborn Viaduct, while a larger-scale experiment took place with arclight in 1880. The Edison Company illuminated the same viaduct with ninety-two filament bulbs in 1882. These projects proved ephemeral, due to the usual problems of capital, legislative caution and defective equipment, but they also revealed several problems specific to lighting the City itself. The crowded, narrow, winding streets, and irregular buildings, tended "to make the task of lighting with a medium giving intense and sharply-defined shadows one of considerable difficulty."[124] In common with similar schemes across London, there were

[122] See David Owen, *The Government of Victorian London 1855-1889: The Metropolitan Board of Works, the Vestries and the City Corporation* (London: The Belknap Press, 1982), 226-259.
[123] "Electric Lighting in the City of London," *The Electrician*, XXVI, February 13, 1891, 455.
[124] "Electric Lighting For the City of London," *ibid*, April 2, 1881, 244.

reports of systemic breakdown, and the need for gaslights to be lit to prevent chaos.[125] Although the Anglo-Brush Company continued to light a portion of the city, the logistical, technical and organisational problems thwarted efforts to introduce the new illuminant into the most important economic space in the country. Preece argued in 1882 that "he knew of no branch of engineering where more forethought was necessary in order to calculate all the contingencies likely to be met with than with a system designed to illuminate a large city like London."[126] Distribution through the dense and narrow streets, locating lamps for optimum illumination, and building supply stations were all immensely complicated tactical issues, and the internecine squabblings of the various committees and vestries required much patience. In 1887, for example, the Brush Company's scheme ran up against the hostility of the vestry of St George the Martyr, which objected to mains being run beneath a mere fifty yards of its roads. In 1889, there were experiments with oil lamps. The antiquated administration of the city, commented *The Electrician*, "appeared to be struggling against the introduction of the electric light into their sacred precincts, as though it were some pestilence."[127]

Nonetheless, after thirty-nine separate reports spanning the 1880s, the authorities did take steps to invite tenders for electric lighting after 1889. The city was split into three provisional areas, and two companies, the Brush and the Laing, Wharton and Down, were entrusted with the supply (they were united under the City of London Electric Light Company shortly after). A specially inscribed commemorative junction box was built into the side of the Mansion House on January 5, 1891, and the first systematic scheme to light the City was underway. By June, 25 arclights were lighting Queen Victoria Street, supplied from the temporary station at Bankside. Despite one frugal City administrator arguing that electric light was "equivalent to using perfumed water to turn a mill," the majority of the main streets were lit by arclight by the end of 1892.[128] Thirteen miles of main thoroughfares were lit electrically by March 1895, by which time the company was supplying nearly 5,000 customers, as well as institutions as diverse as St Paul's cathedral and the local infirmary.

[125] *Nature*, XXIV, May 5, 1881, 17.
[126] "Electric Lighting in the City," *The Electrician*, X, November 25, 1882, 29.
[127] *Ibid*, August 22, 1890, 423.
[128] "The City Lighting," *ibid*, XV, November 25, 1892, 84.

Once the particular political shackles peculiar to the City had been loosened, however, construction was a laborious task. The engineer entrusted with the building, Webber, admitted afterwards that planning the precise position of the conduits was barely possible, because "outside the Postal Telegraph and the City Engineer's office there was no one who could form any accurate idea of the condition of things below the surface of the City streets."[129] The scheme involved supplying alternating current from the two stations, at Bankside and Wool Quay (the latter being eventually dismantled) and then stepping the current down at a series of twenty-two transformer stations dotted throughout the area of supply. Finding suitable open spaces, particularly at affordable prices, sometimes proved impossible: the company was forced, for example, to apply to the vestry of St Benetfink for permission to build a station in a churchyard. The vestry concurred, but only after an annual fee towards church services was extracted in return. "In excavating," Webber recalled, "large quantities of human bones were met with, which had all to be transported carefully for extra-mural re-burial."[130]

Encounters with skeletons of dead Londoners were exceptional: more common were the negotiations with the already complex systems of pipes filling the streets beneath the city: "the occupation of the subsoil by sewers and subways, by the systems of gas, water and telegraphs, is entirely exceptional."[131] While subways did exist in certain parts of the city, they proved impossible to use, owing to the absence of suitable openings for running cables into houses: consequently, conduits were necessary. Webber originally intended using iron piping from the generating stations to the transformers, and bitumen concrete casing for the lower-current circuits. Eventually, he was forced to make a series of pragmatic choices owing to the logistical horrors he discovered beneath the streets. Although formally bound to maintain a minimum distance of six inches between his pipes and pre-existing ones, Webber found himself compelled to bend iron and bitumen tubes into complicated shapes to thread them through the knotted mass of telegraphy tubes, gas pipes and water mains:

[129] C.E.Webber, "Some Notes on the Electric Lighting of the City of London," paper read before the Institute of Civil Engineers, February 8, 1894, printed in *ibid*, XXXII, February 23, 1894, 447.
[130] *Ibid*, 453.
[131] *Ibid*, XXXII, February 16, 1894, 424.

> In many cases, such as in King William-street, so contracted was the space that several ways which were actually necessary had to be omitted and taken another way, and occasionally a deviation under the roadway was obligatory.[132]

Between December 1891 and July 1892, 271 miles of mains were laid in this sometimes-tortuous fashion, a quantity which threatened to drain the supply of iron pipes. Similarly, the design of manholes was mangled by the corrupted and machinated City subsoil:

> These boxes were made as large as possible, which is not saying much; I aimed at making them large and deep enough for a man to get entirely inside, but this was rarely possible. Owing to the obstruction underground, they are of every conceivable size and shape.[133]

Future acts of routine inspection would be forced to negotiate such unknown, indescribable holes.

Positioning the lamps, too, was a process involving pragmatic negotiation with the material configuration of the streets and the tastes of the public. Early arcs were often mounted on scaffolding, to enable engineers to experiment to find the best height: Trotter made photometric recordings in the City in 1891.[134] They were described as "eye-sores, with their peg-like excrescences," and many were later removed.[135] Less ugly standards were erected in due course, with holes cut into the sides to enable men to ascend them to trim the carbons. Again, fixing the posts proved troublesome, owing to the impossibility of predicting in advance the subterranean conditions. Wall brackets were employed in the narrower streets. After a series of experiments involving ground, opal and ribbed glass, the latter was adopted as best suited to deflect light downwards for the benefit of pedestrians and horses. In smaller streets, the engineers had intended to simply adopt the old gas-standards as they were abandoned, but the persistence of stagnant gas within them rendered them dangerous, although there were many reports of them being lit, either by "mischievous people passing on omnibuses," or pedestrians concerned about an electric cut-out.[136] By 1894, these standards were being demolished as obstructions, under the dangerous structure clauses of the Metropolitan Building Act.[137]

These material contingencies, which simply emerged unannounced during the real-time practice of network-building, inevitably slowed work down. Planned completion dates came and went; however, "it was impossible for the work to be done any quicker, or the

[132] *Ibid*, XXXII, February 23, 1894, 449.
[133] *Ibid*, 450.
[134] Trotter, *Illumination: Its Distribution and Measurement*, 253.
[135] "Lamp Posts For Oxford," *The Electrician*, XXIX, October 28, 1892, 696.
[136] "The City Lighting, " *Ibid*, XXX, December 9, 1892, 148.
[137] *The Builder*, LXVI, January 27, 1894, 77.

whole traffic of the City would be stopped."[138] Movement was already greatly constricted "by having 100 yards of footway 'up' in nearly thirty places at one time."[139] The weather further frustrated efforts: in January 1894, a frozen main burst at Hampton, leading to the Fire Brigade being called to pump water from the Thames to maintain the supply. During these early years, supply itself was hardly continuous, and the *City Press* in particular complained of the "intermittent and unreliable supply," drawing attention to the Mayor's dissatisfaction with the distribution to the Mansion House.[140] The predicable array of short-circuits and accidents proved infuriating, particularly during times of fog, when "darkness rivalling that of midnight" could completely suspend activity.[141] Telephonic communication with the Dock Committee was established so that fog might be conquered, but this proved chimeric as always.

In November 1894, there was an accident, modest and ultimately hardly traumatic, which illustrates the contingencies and unpredictability surrounding the everyday functioning of technology which today barely registers in our consciousness. A horse drawing a Brougham carriage received a severe electric shock while passing along a portion of wood paving on Cannon Street. The driver, while watching the horse groaning, twitching and dying, himself received a shock, immediately after which there were two simultaneous explosions in junction boxes, throwing up the road and a series of kerbstones. Several other pedestrians received shocks. None of them were killed, but the testimony of a postman gives some indication of the pain and fright of this kind of street accident:

> He felt as though sparks were going through every part of his body. He had one foot on the plate of the manhole and another on the pavement. He was drawn towards the pavement, but not thrown down. He had two shocks, one on the lid and one on the flagstone, as his feet went down one after the other. When he got both feet clear of the cover he did not feel any further shock. He got away and went on to deliver a parcel at Walbrook. He was just getting on to the pavement outside witness's shop, and a gentleman was asking him if he was hurt, when the street box at the corner of Walbrook blew up, knocking him across the road and against the 'Cannon' public house. A piece of stone struck him on the finger, and a piece of iron stuff came down on his toe. His mouth was full of concrete. He went off then – he had had enough of it…He was still sensible of ill effects from the shock.[142]

The accident, it transpired, was the result of a short circuit forming when wires were crossed: in his report, Major Cardew found the City of London Electric Lighting Company

[138] "The City Lighting," *The Electrician*, XXVIII, March 11, 1892, 480.
[139] Webber, "Some Notes on the Electric Lighting of the City of London," *ibid.*, XXXII, March 2, 1894, 482.
[140] Cited in "The City Lighting," *ibid.*, XXX, March 24, 1893, 590.
[141] "The City Lighting," *ibid.*, XXIX, September 16, 1892, 545.
[142] Board of Trade Enquiry, cited in "The Cannon-Street Accident," *ibid.*, XXXIV, November 23, 1894, 106.

guilty of fitting inappropriate fuses, and accused one company member of "blow(ing) up the public."[143] The enquiry revealed the extent of concern about the accident: electrical practice would have to learn to manage these dangers.

One response was the employment of twelve men to check the street-boxes which were now a ubiquitous aspect of the streetscape. A City electrical inspector, Voysey, had been appointed in 1893, and his duties were slowly expanding to preclude, through regular and routine monitoring of networks, the kind of little calamities described above. Like the position of the lamps and the direction of the mains, the network of inspection fashioned to battle against decay and accident was a response to the practical problems of network-building. When illustrating his report on the project to electrify the heart of London, Webber showed plans and maps, but admitted that they were of little use when actually building the system proper. This illustrates once again how the language of rationality can obfuscate our comprehension of how techniques of rule were implemented. Engineers and electricians, like surgeons and policemen, were not theorists adhering to a masterplan, but pragmatists engaged in a fight to seduce the material world into working with them.

Like the Deansgate improvement, electrifying the City was an enormous labour: many accidents and delays held up the work, and these bottlenecks came in many forms. Manchester and London were cities full of roadworks, scaffolding and misfiring technology. Yet even the most casual comparison must acknowledge that the latter appears to have been rather more successful, at least in terms of achieving its desired ends. Light, increasingly permanent and predictable, was delivered into the frequently penumbral webs of streets connecting the fiscal bastions of the British Empire. The streets themselves remained narrow and clotted. There remains the question of the quality of light. What chromatic finery danced upon the retinas of city gents and costermongers? Approaching Queen Victoria Street from Cheapside shortly after the inauguration of the light in July 1891, a reporter from *The Electrician* described the effulgence as "very good, but not particularly remarkable."[144] A temporary supply producing light from lanterns dangling from scaffolding produced a modest, unspectacular improvement: through the multiplication, embedding and maintenance of such laborious, protracted processes our modern ocular agency would be made possible and durable.

[143] *Ibid*, 107.
[144] "Electric Lighting in the City," *ibid.*, XXVII, July 3, 1891.

Conclusion: Vision and Beyond: Towards a Phenomenology of Modernity

This thesis began by introducing the Foucauldian analysis of governmentality, and ended with an electrical engineer struggling to assemble a small substation in a graveyard, and a horse writhing in agony while an explosion filled a postman's mouth with concrete. This might seem to suggest that I have moved from a theoretical to an empirical register, or shifted scale from macro- to microanalysis. But as I have suggested at various points throughout the six chapters, it has been one of my aims to avoid such clear and, dare I say, modern, distinctions. Perhaps it is sensible here to return to the themes with which I opened the first chapter, and see what, if anything, the ensuing discussion of streets, glass, smoke, inspection, abattoirs, aquaria, photometry, light bulbs, gasmantles, wire and pipes has shown.

Liberal governmentality is clearly an enormously productive method of analysing any number of techniques through which forms of conduct premised on freedom were promoted in the nineteenth century. Builders, architects, engineers, electricians, analysts, inspectors, sanitarians and Medical Officers of Health frequently regarded their role, however modestly and humbly, as being ineluctably linked to the pragmatics of realising a healthy, moral and productive population. The evolution of norms, of, for example, air space, nutrition, illumination, and window size, provides evidence of an efflorescing number of calculations, ones which were, moreover, made with relation to bodies which were to be liberated from damaging environment and noxious atmosphere. Yet all such techniques, as I have shown, were subject to contingencies, delays and accidents. In practice, schemes to encourage cleanliness, promote clear vision, facilitate speed and monitor pollution, were all exposed to the vagaries of a material world never fully under human control, humans never fully under mental control, and, for that matter, rationalities never transparently logical or predictable. At any given point in time, an electricity network or a transportation system relies on so many nonhuman elements that it is hardly the expression or implementation of a pure rationality. Government premised on freedom can clearly be said to exist, but it was not a purely human or mental endeavour, and as such, analysis of it must eschew excessively discursive, mentalistic aspects. Modern society has not just been made by us and we do not totally control it.

This is partly because, as indicated, 'we' do not fully control 'ourselves'. The body's obduracy and limitations circumscribe what can and cannot be achieved in the way of organising and governing. In my analysis, this was perhaps most evident in the case of the eye and light technology. There are very real, stubborn limits to vision. The eye's automatic activities of, for example, diaphragmation, had to be worked through by all engineers hoping to cajole the ocular apparatus to perceive its environment in new ways by new technologies. These visceral capacities help explain why some strategies to govern through eyes succeeded, while others failed. Arclight, for example, produced very impressive readings on photometers, but its sharp and bluish rays were irritating to the eye for all but large engineering and industrial practices. The ease with which seeing took place, therefore, functioned as a very practical measure of technological success: normality, in other words, was never purely a cultural or social creation, but does have a phenomenological foundation, which sets organic boundaries to the possibilities of experience. The body, as the basis for, but not the final determinant of, this experience, must be addressed by governmental analyses just as it was addressed by most of those whose conscious aim was to 'govern' in the nineteenth century.

As indicated in the introduction, governing through the calculated use of infrastructure necessitates harnessing and mobilising the power of vast quantities of resources. Infrastructure was particularly vital to liberal forms of rule, which were operative in an environment dramatically modified by human action: technologies delivering light, water and air were required to reverse the pathologising effects of this abnormal urban environment and equip subjects with the physiological capacities for self-government. Infrastructure also allowed general, and more central, concerns with efficiency, vitality and productivity to be translated into particular, local and private ones, such as saving money, comfort and decency. Translation was essential to a liberal order valuing the delegation and localisation of power. Yet any account of this vast growth of networks, through which such devolved chains of power proliferated, must address their material agency, which was harnessed by humans, for humans, without ever being human. It seems to me that some of the governmentality literature treats the material world as something which only irrupts into the consciousness of planners when it resists attempts to act upon it. Otherwise, it appears to possess a kind of plasticity enabling it to be crafted into the fantastic shapes consistent with forms of rationality. This position, which treats the physical world around us as something either unflinchingly obstinate or completely protean, is not consistent with the practical strategies of building explored throughout this thesis. Inorganic matter, like the bodies of humans and animals, had limits and norms which engineers sought to respect. Materiality, in other words, was integral to the pragmatic activities of network-building and not something which planners preferred to pretend could be willed into submission by the superior powers of the mind. Rational plans, material structures and physiological processes should all be treated with equal weight when discussing the technical aspects of government.

The fourth part of my introduction attempted to locate the ensuing discussion of building and technology within the wider development of modernity, understood as a particular ordering project. The world of wires and roads, of pulsating energies and acceleration, was premised on an inert material world that functioned as a "standing reserve" for a human world existing ontologically apart from it.[1] The modern world was broken in two: nature could, according to Francis Bacon, be tortured like a witch, stretched, flayed, disembowelled and forced, without the possibility of remorse or God's wrath, into whatever shapes we liked. The limits were only human ingenuity and matter's actual properties: the earth and its resources were not to be respected and there was no divine order to be unsettled. In this sense, the obsession with life and the body can be seen as consistent with an immanent society where dead matter must be martialled to force human existence to reach its natural limits, of longevity, strength and productivity. These natural limits, or bodily norms, led to the modern project folding back on itself and confronting the physiological and vital conditions which provide elusive parameters for technosocial mobilisation. The commonsense division of the world into a mind and a body structured sanitary and building discourse across the period, and infrastructures aimed to free the mind from bodily presence and overcome its stinking, scabby, hairy limitations. But there can be no overcoming of the body, and this is truly modern, for we remain embodied and organic processes cannot be escaped. Perhaps this is why death is so hidden and silent in the modern world: the pretence of a continuum of life is the visible surface of a society which denies its own affinity with nature. I don't think I have

[1] This point, and expression, was made by Martin Heidegger, "The Question Concerning Technology," in *The Question Concerning Technology and Other Essays* (London: Harper and Row, 1977).

ever seen an animal die, which would have been a common experience for rural and urban people until the final part of the nineteenth century.

The epistemology and phenomenology of modernity pointed in different directions. The former saw the world in dualisms, the latter as messy and muddled. Order was always undercut by experience, but the ordering project only drew strength from its failures. The struggle to transcend bodily limitations in the absolutely certain knowledge that this was impossible, gave modern science and engineering its restless and inventive energy. The deployment of networks, of gas, electricity, heat, air, and water aimed to equip human bodies with the agency to be healthy and free. Bodies were to reach natural capacities themselves changing along with the milieux within which existence was secured. In this sense, liberalism was committed to the literal engineering of modern society, with its dreams of infinite progress and sobering consciousness of the chimerical nature of such ideas. In developing thus, government entailed the management and monitoring of far more than human populations.

It is the impact of this huge deployment of networks on the basic bodily habits and abilities of people that has interested me. The government of the eye necessitated harmonising techniques of measurement and miles of pipes and wire with the obstinate economy of an optical apparatus at once social and individual. The social eye, as hinted in chapter four, perhaps expresses the epistemology of modernity: it has norms and averages, it has been measured. The individual eye represents the phenomenology of everyday life, always undercutting the totalising premises of socialising technology. Squinting through a tear-stained conjunctival film of dust and blood vessels, men and women readapted their physical habits and mental expectations as much as possible to a world of gasjets, arclamps, contact lenses and plateglass, while their bodies themselves were modified, so intangibly, by the evolving landscape of modernity. But the resistances of both tell us much about the ways in which technological systems have developed.

But the government of the eye could not be solely concerned with seeing: as shown throughout, smells and sounds, postures and practices, air and blood, were subtly transformed and re-experienced. The analysis offered in the previous six chapters represents the beginnings of an outline of a phenomenology of modernity: how the body, in all its visceral depths, as well as skin and senses, has itself changed along with the techniques designed to manage it and the discourses endowing it with basic patterns and logics which give form to the flux of life. This project has to begin by addressing the modest, prosaic and often unthought foundations of existence; seeing, smelling, breathing, eating, hearing, urinating, itching and sweating. This must be done by historically placing the body in the world from which its experience is fused: streets, buses, toilets, kitchens, supermarkets, factories and retail parks. It must also be done by looking at the development of the technologies that frame these practices: food analysis, pavement design, butchery, tyres, shoes, machines, spectacles. To this end, I hope to take my perhaps rather speculative ruminations on the phenomenology of modernity further with future work on food, sound and air. Eating, hearing and breathing are deeply historical practices. Their irreducibly physiological character itself emerges from the bodily interaction with environments designed to impact on the body in specific ways. What seems most natural, therefore, is in fact a product of more than nature. Thus food, sound and air, like light and vision, might begin to appear strange, and history might reveal this strangeness.

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