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Ruling the line: learning to draw in the first age of mechanical reproduction

Frances Robertson

Dissertation submitted for the Degree of Doctor of Philosophy to the Forum for Critical Inquiry

Glasgow School of Art

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Contents

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List of illustrations

Abstract

This dissertation presents a critical study of the development of technical drawing in Britain 1790-1850 in relation to wider visual culture. Technical drawing is often perceived as being an inexpressive, de-natured style and has been largely neglected within art history. Indeed, the images that make up the distinct genre of technical drawing and illustration were produced within distinctive organizational structures such as factory drawing offices and illustrated mass-market publications outside the framework of recognized fine art practices. Nevertheless, I argue that the development of technical drawing and illustration in this period has direct relevance to the discipline of art history, not least because of the rapid growth and spread of this style within wider visual culture.

Using an interdisciplinary approach, I ask how the conditions of production of this style affected its later reception. Particular emphasis will be given to the materiality of production in relation to discursive practices in order to address these questions:
-Why is technical drawing now seen as inexpressive and inartistic?
-How was technical drawing made to seem authoritative with its viewers?

The dissertation moves through three areas, subdivided into pairs of chapters. The first area covers questions that relate to current disciplinary boundaries, and their connections to the cultural politics of the period around 1800. The middle section is concerned with the symbolic and expressive aspects of technical drawing and its characteristic linear markings, and proposes that meaning and expression are read by the viewer as much through an awareness of the embodied practices and the materiality of surfaces and production methods used as much as in the depicted content of the image. The final most substantial section of the dissertation is concerned with the ways in which different groups within engineering hierarchies sought to use drawing skills both as a means of self-presentation and for professional formation in the period to 1850.

The first section, consisting of Chapters 2 and 3, is concerned with art, industry and cultural politics up to and around 1800 in order to question the various narratives and assumptions that formed my starting point. Chapter 2, ‘Civil engineers and Royal Academicians’ examines how accounts of drawing in art and industry in this period have become separated. Chapter 3, ‘Provincials, pupils and print’, expands this framework. While Chapter 2 will question accounts of drawing practice for art and industry in relation to familiar and specific locations of cultural production this chapter by contrast addresses accounts of both production and reception of drawing practices within wider visual culture in the decades around 1800. It poses the question of where else, beyond the Royal Academy or in engineering practices, might one have learnt to draw in Great Britain, and to what end?

Chapters 4 and 5, ‘Fabricating the line’ will ask what aesthetic and symbolic meanings can be taken from styles of mechanical drawing adopted in the first half of the nineteenth century. The argument uses, but also criticises, art historical methods of interpretation based on techniques of visual descriptive analysis and stylistic comparison. Chapter 4, ‘Purity, progress and labour’ examines the meanings that can be attributed to the use of fine uniform ruled lines, and compositional formats of technical drawings on the page, while Chapter 5, ‘Multiplying marks’, examines technical illustrations in print, in order to argue that in the period 1800-*c*.1830 technical drawing and technical illustration developed in tandem to create a visual style that displayed the industrial system to viewers outside the factory.

In my two final chapters 6 and 7 I build on contextual supporting arguments in order to investigate in more detail the social relationships around technical drawing, in the workplace and in professional formation in competition with other occupational groups. I examine questions of professional formation and occupational fragmentation both in relation to elite engineers in Chapter 7 (‘Professional engineers in the world of industrial readers’) and in relation to technical draughtsmen in Chapter 6 (‘Social networks: Artisans, draughtsmen and working relationships’). Draughtsmen comprise a social group that is poorly documented and barely researched in the Britain of this period, in contrast to the scholarship and evidence that relates to the situation in our near industrial neighbour, France. Chapter 6 considers draughtsmen as industrial workers. My findings allow me to argue that the relative invisibility of draughtsmen was not so much the result of their non-elite status, but rather because their status was disputed and problematic. In the first half of the nineteenth century, draughtsmen were squeezed in conflicts about control and autonomy in the workplace, in public anxieties about worker education, and in cultural conflicts about the alleged deficiencies of taste in design for the products of British manufacture.

Chapter 7 complements the discussion of professional fragmentation in engineering in Chapter 6 by discussing the visual practices of elite engineers in the first half of the nineteenth century in relation to professional formation, self-presentation, and authorship, and explores aspects of the tensions involved in engineers’ attempts to gain status by making a claim to special expertise and at the same time of popularising their knowledge and achievements in a milieu of competition with other elite professional groups within a culture of display.

My research demonstrates that in the period to 1850 in Britain, engineers and technical draughtsmen absorbed, selected, and appropriated expressive practices and discourses from fine art in their work and in their self-fashioning as technical artists, and on that basis they developed new and distinctive conventions of composition, mark making and presentation. In training themselves, technical draughtsmen and engineers developed their visual styles through copying from a wide range of examples and conventions. Draughtsmen could thus reflect on their own selections, and create pictures that reflected their own making.

I show that the methods of art history are necessary and relevant in informing the analysis of a topic that is usually confined to histories of technology or science, but these must be integrated with methods and ideas from the history of science and technology. Moving inside the artworld of technical drawing gives a textured account of the ways in which groups of practitioners sought to gain authority by visual means, either with their immediate peers and rivals, or with more general viewers, thus breaking down topic the of ‘technical drawing’ into a much more differentiated field of human activity where visual descriptive analysis begins to have a purchase on issues of the social history of ‘arts and manufactures’ in Britain in the period to 1850. Approaches from the history of technology and science inform my examination of the social and technical negotiations for status in visual production; in addition, two particular topics from the history of science have developed this dissertation towards future research questions I will follow as an art historian interested in visual communications: first, questions about how truth claims have been established and contested through demonstration, and second, in relation to ‘print culture’ how areas of specialist expertise are constructed and presented to general readers.

Chapter 1: Learning to draw in the first age of mechanical reproduction

Introduction

This dissertation is about modes of technical drawing and illustration that developed in Great Britain between the late eighteenth and mid-nineteenth century in relation to the wider visual discourses of that period. It considers the ways in which engineers, draughtsmen and mechanics learnt to draw, their motivations for doing so, and the cultural and social resources they employed. The immediate working contexts of factory drawing offices, mechanics' institutes and illustrated mass-market publications at first glance appear to be outside the framework of recognized fine art networks; equally the mark-making techniques used in these situations differed from those of fine art, with a predominance of regular lines formed with mechanical drawing devices. Nevertheless this dissertation will argue that the development and reception of these technical drawing conventions can and should be placed in relation to the art history of this period; and conversely, that the methods of art history can inform the analysis of a topic that is usually confined to histories of technology or science. Accounts of visual culture at this period that include technical modes of drawing are rare (Klingender and Elton 1968; Kemp 1990; Stafford 1994; Fox 2009); the most comprehensive surveys are to be found in specialist publications, such as *A history of engineering drawing* (Booker 1979) or *The art of the engineer* (Baynes and Pugh 1981), and aimed at an audience interested in the history of technology and engineering rather than the fine arts.

Technical drawings for architecture, civil engineering or for mechanical invention were not a new development at the end of the eighteenth century. Nevertheless, in the period to 1850 conventions of mechanical drawing for industrial factory production rapidly gained a wide currency both in the workplace and through public exhibition and debate. Engineers drew the machines they proposed to their customers. Engineers and managers made drawings to direct workers in the assembly and maintenance of machinery for power generation, and for shaping and making products previously acquired from the domain of artisan craft labour. At the same time similar machine drawings were published in trade catalogues or in newspapers and journals, sometimes accompanied by printed courses of instruction offering to teach the home reader how to develop such drawing skills. By the time of the Great Exhibition of 1851, it could be claimed that mechanical drawings were amongst the most distinctive and widespread visual statements of the 'machine dreams' (Sussman 2000: 197-204) of this period, and raises the question of why the cultural significance of this discourse has been largely neglected by art historians. The common current perception that technical drawing is inexpressive and inartistic does not answer this question, but makes it more puzzling. This dissertation will ask firstly how such current judgements have been shaped, and secondly how did engineers, draughtsmen and artists establish the apparently broad currency and authority of technical images with their audiences in the nineteenth century.

The concept of art history I use is more often termed 'visual studies' (Elkins 2003; Cheetham, Holly and Moxey 2005), derived in part from the work of earlier scholars such as T.J.Clark (1982 [1973]) and Michael Baxandall (1972) who sought to locate the narratives of art within wider cultural histories on the grounds that 'social facts... lead to the development of distinctive visual skills and habits' (Baxandall 1972: 4), in alignment with the cultural studies movement first developed in Britain in the 1950s (Turner 2003: 33-68; Williams 1958; Hall 1980). But while writers such as Clark and Baxandall concentrated their attention on well-known artworks in order to re-interpret the canon, my approach differs in that its objects of study are outside standard ideas of art. This is in accord with the urging of James Elkins, for example in his essay 'Art history and images that are not art' (1995), where he argued that art history should be engaged with 'non-art' examples of 'informational images' in particular with scientific or technical modes of visual communication used in modern western cultures (Elkins 1995: 555). As all images used in public discourse have been constructed through the exercise of visual aesthetic judgement for a conscious rhetorical end, then, claims Elkins, 'any divisions between kinds of images are untenable' (Elkins 1995: 571). Indeed, as technical representations in the period under study enjoyed wide public circulation my research offers an opportunity to examine one aspect of visual culture in the light of Picon's assertion, developed from the standpoint of the history of technology and engineering, that the 'engineer's imagination appears as a component of the social imagination' (Picon 2004: 431).

From art history, the most direct influence on method, as has been implied, comes from writers of the 1970s and onwards who developed new styles of Marxist approach such as T.J. Clark (1982), already noted, or John Barrell (1980), who combined close empirical investigation of limited and defined historical circumstances with careful descriptive analysis of individual artworks; a detailed attack that was developed in reaction to the very broad generalisations of earlier work in this tradition such as Arnold Hauser's four-volume *Social history of art* (Hauser 1999[1962]; Harris 2001: 63-93). Furthermore, the influence of Clark and Barrell on this dissertation is not confined to method, but also acknowledges their subject matter. In works such as *Image of the people : Gustave Courbet and the 1848 revolution* (Clark 1982a) or *The absolute bourgeois: artists and politics in France, 1848-1851* (Clark 1982b), Clark discussed how artists attempted to engage with new anonymous mass audiences for art within the conditions of capitalist urban society from the mid nineteenth century onwards. In *The dark side of the landscape: the rural poor in English painting 1730-1840*, Barrell examined the period of agricultural improvement and land enclosure when the work of artists such as John Constable (1776-1837), according to Barrell, glossed over the conflicts behind the consolidation of power and wealth in the hands of expropriating agricultural magnates. Both Clark and Barrell have thus addressed aspects of the social formation of the 'artworld' of the nineteenth century with particular attention to what was excluded or made invisible, with 'what prevents representations as much as what allows it' (Clark 1982a: 15). Barrell's work is relevant because he considers the social and political conditions by which the landscape genre, previously considered to be of lesser status, gained importance in central cultural institutions such as the Royal Academy exhibitions towards the end of the eighteenth century. Barrell's description of the construction through representation of a mythical pastoral English scene does not just remind the reader of the invisible rural poor, but also of the hidden landscapes of industrial and urban development that largely failed to gain a viewing in prestigious fine art exhibitions at the same period (Daniels 1994: 73; Fox 2009: 490-3). Clark, in addressing the struggle for cultural expression in Paris, and the formation of avant-garde artistic communities, contributed unwittingly to what has become a dominant but often formulaic notion of 'modernity' that has become a commonplace in art history as the 'forms of culture in which processes of industrialization and urbanization are conceived as the principal mechanisms of transformation in human experience' (Harrison 1996: 143). Despite the centrality of this concept, however, art historians have been reluctant to apply this notion of 'modernity' to a full range of image production in the nineteenth century; and in neglecting the history of technical representations a very suggestive example of the relationship between 'industry' as subject matter and production process has been ignored. In considering the development of technical drawing, this dissertation will ask how industrialized processes of representation such as mechanical drawing may also have transformed human experience from within the act of image making. So although this dissertation will apply techniques of descriptive visual analysis, derived from art history, to technical representations, it will not be concerned purely with a disembodied formal analysis. 'Image making' is also a process of manufacturing, and my analysis of the symbolic function of materials, methods and processes in technical image production will treat images also as 'things', acknowledging the importance of the materiality of drawings as objects, and the location of actions and skills within the draughtsman's body.

Other key narratives from art history forming the initial backdrop to the research for this dissertation include Dianne Sachko Macleod's account of how middle class art patrons, often industrial entrepreneurs such as Sir Thomas Fairbairn (1823-1891; Macleod 1996: 90), sought to assert a clear and distinct class identity through supporting previously unknown contemporary artists such as the Pre-Raphaelite William Holman Hunt (1827-1910). Importantly Macleod's account placed into British contexts the question of how artists attempted to address new urban commercial markets whilst pursuing the often-contradictory goals of freedom and financial security (Macleod 1996: 1-5). Her research provides details of the fine art world of provincial industrial cities such as Manchester, meshing with descriptions of broader interactions between 'commerce and the liberal arts' in this city indicated by earlier researchers (Fawcett 1974; Harrison 1985: 120-47; Seed 1988: 45-81). Even in London, research by Paula Gillett (1990) into the working lives of painters has demonstrated a level of 'status anxiety' that prompted artists to routinely mount conspicuous displays of the trappings and demeanour of high cultural grandees in the later nineteenth century in order, as she claims, to expunge the 'degrading memory' of their uncertain artisan status up to the late 1840s (Gillett 1990: 10-43). These sociologically focused works give relevant and useful background; in addition they challenge the often too exclusive attention of art history to the centres of elite fine art culture, to the evolution of theory and ideas, or to prestigious (and long established) means of expression such as oil painting. Such methods simply reinforce a closed domain of fine art whose hard shell, as Gillett suggests, had been successfully constructed in part by the artists themselves by the 1880s. Instead, this dissertation will be looking for evidence of porosity in working lives, techniques of representation, and modes of exhibition. Audiences in the first half of the nineteenth century did not develop 'distinctive visual skills and habits' simply through viewing paintings in a gallery, indeed, until the late 1820s such public institutions were not available (Trodd 1994; Duncan 1995). Instead, initiatives to promote the ‘industrialisation of taste’ such as the *Art Union* journal of London, founded in 1837, aimed to provide a ‘steam engine for the manufacture of a love of art’ (King 1985: 1) through changing the mediums of production and the viewing conditions for art. Subscribers acquired a library of steel engraved reproductions of contemporary art along with essays and articles to be consumed in the privacy of home. Although the intended purchasers of this journal were members of the comfortable middle classes, it was also included in the libraries of many mechanics’ institutes (King 1985: 42-5), alongside other journals aimed at much larger audiences of lower social ranking such as the *Penny magazine*, that were already engaged in circulating descriptions and images of art in print from the early 1830s through the medium of wood engraving (Anderson 1991: 83).

Similar means were used to exhibit and circulate technical drawings and illustrations to audiences beyond the factory. Historians of science have discussed the ways in which the ‘exhibitionary text’ of popular science writing in the nineteenth century made use of an established ‘rhetoric of spectacular display’ (Secord 2000: 439). However the history of technical representation in this period has not yet given similar consideration to printed material as a medium for the formation of visual skills and habits, or as an exhibition space despite the wealth of technical imagery in illustrated journals and magazines. In advocating the inclusion of technical illustrations in the history of technical drawing, much recent work in the field of history of the book and in the history of science demonstrating the role of ‘written and printed materials in the constitution of knowledge’ (Johns 1998: 623) has influenced my approach, particularly in the consideration of effects of presentation and ordering of text and graphics on the page (Frasca-Spada and Jardine 2000). In the first half of the nineteenth century, the number of images included in printed texts increased rapidly within the context of further rapid expansion in the volume of printed material in general; in this publishing world, journalists and other writers often developed a self-congratulatory rhetoric linking print with progress (King and Plunkett 2004: 6; Secord 2000: 30). Indeed, current histories of ‘print culture’ in the nineteenth century must continue to engage with remnants of this attitude (Jobling and Crowley 1988; Steinberg 1996) due in part to the continuing influence of William Ivins’ *Prints and Visual Communication* (1992 [1951]); a work in which Ivins celebrated the expansion of printed images in the nineteenth century as a democratic medium for disseminating scientific and technological progress. When Ivins’ book was first published, from the world of print curation and connoisseurship of the 1950s, his recognition of the contexts of science, trade and industry was startling and innovative. But despite the fact that Ivins now appears much more as a closet Victorian, nevertheless his method of reading meaning in images not so much from subject matter but from material aspects of technique and conditions of production has shaped subsequent approaches, including my own. Equally, his pronouncements give testimony to the cultural significance that has been attributed to print in the context of industrial production in the first half of the nineteenth century. For audiences, book prices fell and levels of literacy increased to include a much wider readership (Altick 1957; Finkelstein and McCleery 2005: 113-5); also, according to William St. Clair, readers in the period 1774-1842 enjoyed a distinctive and unusual chance to compare texts, and to become more informed and more critical when copyright control by publishers and authors was weak (St. Clair 2004: 118; 355-6). These historical circumstances inform my discussion of the promotion of technical styles of drawing through print, and suggest that technical illustrations as an aspect of 'print culture' should be placed against other types of image also gaining circulation at that time: works of fine art as already mentioned, graphic journalism through caricature (Fox 1988) and also new styles of visual communication in statistical graphics, with early examples attributed to William Playfair (1759-1823) in 1786 (Tufte 1983; Meadows 1991).

Although I structure my enquiry around questions of art history, asking, for example, what resources went into the development of the styles of technical drawing (in terms of materials, techniques and references to tradition), or what kind of public was being addressed by the producer, I will not be claiming that technical drawing is art. Rather I will examine its marginal status; the ways in which separate discourses of art and non-art were constructed and maintained. Accounts of technical drawing and of the role of representations in histories of science and technology have been equally influential in shaping my work. As in art history, science and technology studies have also adopted a cultural approach in the late twentieth century, for example in publications such as *The social construction of technological systems* (Bijker, Hughes and Pinch 1987). Hence Shapin and Schaffer, for example, proposed three 'technologies' that were used by proponents to support new developments in science: namely material technology, literary technology and social technology (Shapin and Schaffer 1985: 18-25). Other studies directed more specifically to visual culture and the question of how scientific and technical images were negotiated within social networks provided a range of interpretive frameworks (Rudwick 1976; Daston and Galison 1992; Lubar 1995; Baigrie 1996; Jones and Galison 1998), and heralded many full length studies of aspects of visual culture in the nineteenth century (for example Rudwick 1992; Secord 2000; Tucker 2005) that have informed my own work. In addressing the history of technical drawing the approaches I have found most suggestive have been those of material culture studies, of embodied 'gestural knowledge' (Sibum 1995: 76), and of 'useful knowledge'. Material culture approaches can make even the most everyday practices strange, for example in Andrew Warwick's account of how around 1800 working out mathematical problems on paper was not the 'natural' way of doing things that it became later in the nineteenth century; instead normal mathematical practice was enacted through private reading and oral debate (Warwick 2003: 114-51). Equally, a useful framework to address specific question such as: 'where did draughtsmen learn to draw around 1800?' has come from the examination of 'useful arts' or 'useful knowledge' applied to embodied, tacit methods of empirical enquiry and mechanical science in the context of the eighteenth century enlightenment (Mokyr 2002; Smith 2004; Berg 2007; Jacob 2007; Roberts, Schaffer and Dear 2007). The notion of 'useful knowledge' can allow technical drawing to be placed within a continuum of activities embracing hand craft training, model-making, organised social networks and artistic representational practices, as is evident in one of the few 'visual studies' treatments of the objects, drawings and images associated with the useful arts of this period, *The arts of industry in the age of enlightenment* (Fox 2009).

Interdisciplinarity and professional formation

Although it is evident that I agree broadly with Elkins (1995) that all images assert aesthetic values, I do not follow the implied ecumenism of his stance. Instead, in this dissertation I will pay attention to the social and cultural divisions that have been made between different kinds of images. Working in an interdisciplinary way makes such socially determined divisions even more apparent, for the development of technical drawing as a distinct convention can be linked with processes of professional specialisation and academic discipline formation in the first half of the nineteenth century. In particular, the study of how technical drawing diverged from other discourses can contribute to accounts of professionalisation in engineering, especially in Britain. Despite much recent work on the development of engineering professions, for example on the effect of different national circumstances (Buchanan 1989; Lundgren 1990: 33-75; Meikskins and Smith 1996; Picon 2004: 421-36; Chatzis 2007: 193-6), or on the relations between practical and 'academic engineering' (Marsden 1992: 319-346; Marsden 2004: 401-434), there are few accounts that use visual evidence. Three notable exceptions have used close comparisons of drawing discourses to discuss similarities and professional divergences between architects and engineers (Picon 2004; Saint 2007; Gerbino and Johnston 2009). Both occupations, working on similar projects, only gradually began to diverge around the end of the eighteenth century. Indeed, the close relationship, reflecting the 'sibling rivalry' for work and status between architects and engineers (2007) continued through the first half of the nineteenth century, reflected in the launch of publications such as the *Builder* in 1843, or the *Civil engineer and architects' journal* of 1837.

In the nineteenth century engineers were also embroiled with other groups aiming to consolidate their professional and cultural status; on one side with men of science (Morrell 1990: 980-989), on the other with artists and designers. The foundation of the Royal Academy in London in 1768 has often been defined as the first stage in the consolidation of artistic professions in Britain (Hoock 2003: 7), followed by state involvement in the 'civilising rituals' of public museums and galleries from the 1820s onwards (Duncan 1995: 40-1: Trodd 1994: 33), provision of art and design education in the late 1830s (Bell 1963; Bird 1992; Romans 1998), and the development of a civil service bureaucracy to administer all this from around 1850 (Denis 1995; Green 1990; Minihan 1977). Drawings will also be used to discuss specialization and fragmentation of occupations within engineering, for example between elite engineers and draughtsmen; although there are currently several studies of the situation of draughtsmen in France (Day 1987; Edmonson 1987; Alexander 1999) there is little comparable discussion of British circumstances. However, although I pay attention to division and conflict, giving weight to the material, literary and social dimensions that have separated technical modes of drawing from other styles, I will also make use of the unifying concept of an 'artworld' of technical representation that is derived from the work of Howard Becker (1982) or Arthur Danto (1964: 571-84).

Working in an interdisciplinary way forces an examination of these processes of disciplinary separation in the present as well as the past, as professional specialisations continue to inflect current academic approaches on both sides of the art/science divide, enforcing the social and cultural divisions that have been made between kinds of images. Hence in addition to presenting a historical narrative, a second continuing thread in this dissertation will be an ongoing critical examination of the ways in which current discipline boundaries can isolate and exclude areas of study that perhaps should be more integrated (Jordanova 2000: 60). The history of technical drawing has gaps that can be attributed to those divisions, but equally those gaps raise questions about how far interdisciplinary working can stretch. Histories of technology, that include accounts of technical representation, are themselves scattered across disciplines (Nye 2006: 10). In this scattered environment, accounts of the purpose and function of drawing have often been at odds with one another, so that as Katz notes, those who study engineering design processes might find themselves up against 'unwelcome visitors from an alien intellectual universe' like myself with an interest in the aesthetic and cultural dimension of technical drawing and design (Katz 1997: 453-6).

Histories of drawing education

Finally, this dissertation is informed by histories of art and design education and the debates and questions associated with the teaching and practice of drawing for design and industry within the policies of the state, briefly noted above. In particular, a large literature has been generated since the 1960s, following the work of Quentin Bell in *The schools of design* (1963) charting connections between the Select Committee of 1835-36, the founding of the Government Schools of Design from 1837 onwards, the Great Exhibition of 1851, and establishment of the Department of Science and Art in 1853 (Bell 1963; Macdonald 1970; Bird 1992; Brett 1987; Bonython and Burton 2003; Macdonald 1970; Romans 1998 and 2005; Denis 1995). Despite differences in emphasis and interpretation, almost all these writers follow a 'mainstream' narrative (Romans 1995: 1-10; 2005: 13) with little attention being paid to art and design education outside established art schools; in addition, the existence of art and design education before 1837 outside the Royal Academy, has been equally neglected. Furthermore, changes in philosophies of art education at the end of the nineteenth century that were fought through within the public art school establishment (Macdonald 1970; Denis 1995) have also influenced the terms of analysis applied to art schools earlier in the nineteenth century, because many wider generic histories of art education have been constrained by their origins in research carried out within the framework of contemporary public art schools (Hickman 2005: 11), that are the heirs to these nineteenth century manoeuvres.

This is the framework I also operate within, and indeed, despite these reservations, has prompted this research. Art and design institutions have generated and continue to generate an increasing amount of research into drawing practices, particularly since the development of practice-based postgraduate degree programmes (Thistlewood 1992a; Smith and Dean 2009). This environment has simultaneously fed my interest in these topics while also developing awareness that much of this research, either into current drawing practices, or into historical topics, has a tendency to endorse contemporary philosophies of drawing in an internalist manner. The underlying justifications for the practice of drawing in art and design today almost all stress its importance in the creative and subjective development of the practitioner (Cain 2010) and its role sparking 'innovation' in design. The demands of digital design development have also prompted cross-disciplinary research into drawing practice, visual perception and cognition, and conventions of representation (Whale 2006; Duff and Sawdon 2008; Garner 2008; Treib 2008). As already noted, this emphasis on artistic creativity stems from internal battles about the purpose of art education around the turn of the twentieth century when earlier technical and industrial modes of drawing instruction that had previously held sway in schools and colleges were rejected, in part due to the influence of social critics such as John Ruskin (1819-1900 Hewison *ODNB*; Macdonald 1970; Thistlewood 1992b). This dissertation seeks instead to explore other histories of drawing education in the period before 1850 outside art schools, and to take seriously the ideas and values of the actors in the artworld of technical drawing before this reversal in cultural values occurred.

Technical drawing: scope and definitions

As already noted, competing definitions of technical drawing reveal competing standpoints in authors, with frequent splits between those who characterise technical drawing as functional problem-solving and other writers who choose to use artistic or cultural approaches. Such differences can simply be a question of different disciplinary allegiances. So for example, when design history developed as a separate discipline in the late twentieth century, many adherents were reacting against the methods and objects of study of art history, and purposely addressed their attention to everyday objects, or to the marketing and production techniques of industrial manufacture, frequently insisting above all that 'design is not art', and that value judgements or accounts of designers as artists or authors was based on elitist and misleading approaches carried over from the world of connoisseurship (Fallan 2010: 7-8). Such views, apparently hostile to a consideration of drawing and draughtsmanship, have often led design historians to study the marketing and consumption of design or to stress the sheer material intractability of made objects (Meikle 1998: 198). Drawing for design, surface ornamentation and graphic communication, however, are all significant activities in production for design, and design historians have developed new methods and new topics relevant to the study of drawing as a more anonymous practice. For example, research into notions of design training that were debated in the second half of the eighteenth century in relation to the promotion of trade, consumption and artisan education has presented a world of drawing practices in Britain not otherwise acknowledged in other accounts, for example in art history (Forty 1986: 11-28; Styles 1993: 527-54; Saumarez Smith 2000). An account of the development of technical drawing extends this history further.

Meanwhile historians of science and technology, although interested in drawing for design, have been concerned with different aspects again. In more conservative accounts of engineering drawing, the term is defined within narrow functional limits of design and production. The perceived functions of drawing in these accounts recognise sketches or diagrams on paper as part of the design process, where the engineer for example acts through or executes in two dimensions the paths of moving machine parts; other types of drawings that are recognised include scaled and annotated working drawings that act as commands to a workforce for making, shaping and assembly, and finally 'presentation' drawings that were used to record finished machines for future production purposes, to mark a contract with a client or to persuade new customers to take out orders. These definitions are used in the most frequently cited sources on the history of engineering drawing in Britain, Booker (1973), and Baynes and Pugh (1981) and are in accord with long standing and dominant notions of the engineer as creative leader as voiced by Charles Babbage (1791-1871; Swade *ODNB*) in *On the economy of machinery and manufactures*: 'It can never be too strongly impressed upon the minds of those who are devising new machines that to make the most perfect drawings of every part tends essentially both to the success of the trial, and to economy in arriving at the result' (Babbage 1835 [1832]: 262). Later influential developments of this idea in the twentieth century expanded on the role of the engineer as an inspired individual, who used drawing to body forth the distinctively non-verbal 'intellectual component of technology' already conceived within the 'mind's eye' of the engineer (Ferguson 1977; Giedion 1969 [1948]). Although this notion of the engineer as a 'hero of invention' (Macleod 2007), was coming under critical attack in the last decades of the twentieth century, it was still robust enough to be presented as the subject of the 150th anniversary exhibition at the Royal College of Art that aimed to show: 'the perpetual search for excellence that has dominated the lives of our greatest inventors and engineers' (Walker 1987: 23).

More recent writers on engineering, science and technology, as noted above, have theorised technical drawing as a more anonymous social activity in specific cultural environments. Challenging established accounts of the innovative role of drawing in engineering practice, David McGee demonstrated for example that technical drawing for naval architecture (when shipbuilding represented the largest investment projects of the period) through to the mid nineteenth century was not innovative or cost-saving, but on the contrary reinforced deliberately traditional and conservative designs (McGee 1999: 218-20). Meanwhile John K. Brown demolished generalised and abstract explanations of the ways in which engineers use drawing by describing deep national differences between British and American practices from the nineteenth century onwards. British engineers, he argued, developed and maintained an allegiance to aesthetic values, with constant design invention for its own sake, even when it made no economic sense, thus asserting creativity as a 'central professional value' (Brown 2000: 219-23). American engineers by contrast used technical drawing to develop systems of centralised management, production and worker control with an emphasis on the most cost-efficient methods and increasing standardisation of products (Brown 2000: 283). Although my own analysis recognises technical drawings and illustrations as steps on the way to the manufacturing of other products, I will as already noted also consider images as products intended to be consumed in their own right as drawings and prints. While the artworld of drawings defined as functional problem solving in engineering might include engineers, workers under the command of drawings, mechanical theory and techniques of perspective construction in relation to final manufactured outputs, engineering drawings considered as products for circulation in visual culture might also include draughtsmen, engravers, illustrators, drawing machines, print techniques, publishers and readers. So the geographical scope of 'technical drawing', even in Britain, may have different communities within it; while the community of readers may have been more evenly distributed, engineers, draughtsmen and factories were linked to varying local industries and trades.

The time period of this dissertation uses some historical landmarks that are associated with particular approaches to history and visual culture. The end point around the time of the Great Exhibition (1851), and the founding of the Department of Science and Art (1853) features for example in histories of design, display, and 'consumer culture' (Berg and Clifford 1999); as a site of display, the Great Exhibition also serves as the end point of Celina Fox's narrative of the promotion of the 'useful arts' in the period from 1700, *The arts of industry in the age of enlightenment* (2009). The starting point of *c*.1780 has been more directly linked to politically charged notions of industrialisation, such as Hobsbawm's *The age of revolution: Europe 1780-1848* (1962) or E.P. Thompson's *The making of the English working class* (1963) that covers the period 1780-1832. Art historians have used a shifting variety of periodisations, often based on somewhat arbitrary stylistic categories such as 'rococo to revolution' (Levey 1977; subtitled 'major trends' in painting 1700-1830) or 'Victorian' (Treuherz 1993; between *c*.1840-1890). Matthew Craske's attack on such 'stylistic' thinking in art history used a more materialist approach in order to attack Levey (1977) in particular, Craske instead ascribed changes in art in the period 1700-1830 to a socio-economic cause, 'the impact of urbanization' (Craske 1997: 12). As already noted, T.J. Clark (1982a and b), used the years around 1850 as a marker for change in art, acknowledging the effects of capitalist industrial working practices, but with an emphasis on the class struggle of attempted revolution in 1848 and bourgeois consolidation thereafter. Many further historians of art and design have on the other hand used the Great Exhibition as a starting point for narrative. This has been the case particularly in histories of art, design, and technical education. By looking at the period before 1850, I will address an imbalance in historiography of art and design history. The Great Exhibition and the establishment of the Department of Science and Art created a lot of documentation, thus inviting many accounts of the role of technical drawing within the state education system, in industry and in visual culture after 1850 (Harrison and Zeitlin 1985; Summerfield and Evans 1990; Fox and Guagnini 1993; Purbrick 1994; Denis 1995; Cronin 2001; Purbrick 2001; Bonython and Burton 2003). In comparison, the period before 1850 has less supporting detail or debate; fewer voices have shaped perceptions of the period, and these in turn have often served to underwrite accounts of developments in the second half of the nineteenth century.

The images in Figures 1 to 5 in this chapter serve as a first indication of the scope of this study from the last decades of the eighteenth century *c*.1780 through to the mid-nineteenth century. Mechanical drawings, designs and representations of machinery, are at the centre of this study, as used in the production of steam engines and cotton machinery that contributed to the 'self-sustained growth' of industrial capitalist economies that, according to Hobsbawm registered a 'decisive' increase in activity in the 1780s (Hobsbawm 1962: 28). Other types of technical drawing for architectural or civil engineering projects will also be examined, as will other styles and types of drawing used in decorative and fine arts applications. Examples to populate this contextual background range from further back to the mid-eighteenth century, in order to examine the traditions and techniques that contributed to the formation of visual languages used by draughtsmen and engineers. As already noted, this dissertation is partly concerned with the ways in which engineers sought to develop and consolidate professional status within a wider visual culture; one in which many outside commentators such as Babbage (Berg 1980: 339-342; Schaffer 1994: 203-227) also interested themselves by promoting technical drawing as an essential ingredient of industrial civilisation. With these aims, looking at mechanical drawings in relation to other visual discourses will expand our resources for examining how in the early nineteenth century 'the face of industrialisation now appeared concentrated in the machine' (Berg 1980:1).

Figure 1 shows the installation plan for a condensing steam engine designed by Boulton & Watt for a specific site in 1778. The image is built up in pen and ink on cartridge paper, in ruled lines of unvarying thickness. Apart from a few curved lines produced with compasses or draughtsmen's curves, the entire image has been constructed from lines laid in alignment with the horizontal or vertical edges of the paper, or at 45° to this. The image was produced as a 'direct copy' by the traditional methods of pricking guide holes through from an original drawing. These guide points were then used as markers to reconstruct the original step by step, using the same sequence of tools, that, in Richardson's opinion, led to a 'simplified almost childlike representation with little attention to detail and many inaccuracies' (Richardson 1989: 395).

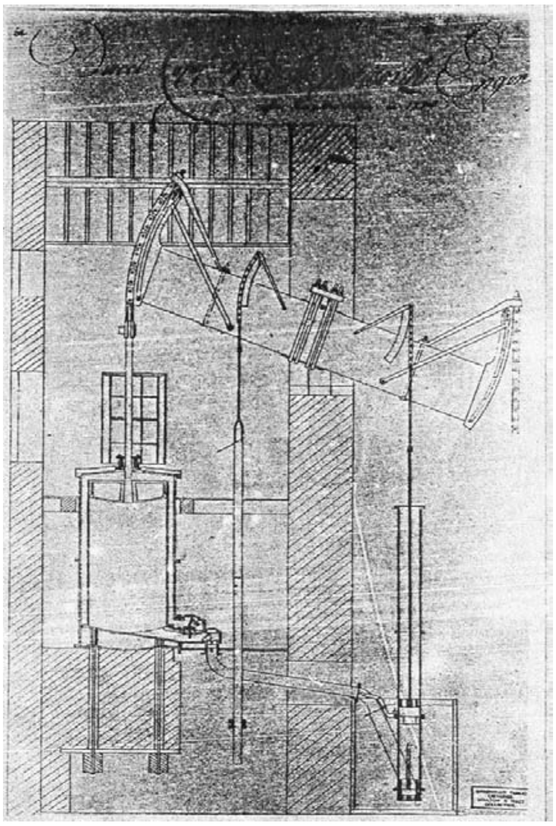


Figure 1: Bedworth engine for Hawkesbury colliery (1778). Boulton & Watt archive, drawings MS 3147/5/625 Birmingham City Council archives and heritage service

In attempting to read this drawing, only a viewer who was familiar with the forms and layout of similar steam pumping engines might be able to decipher it readily. The drawing uses some conventions carried over from architectural drawing, notably in the way in which angled hatched lines are used to denote a section through a solid. However, the conventions used are ambiguous; in the cut-in section of the large boiler in the lower left of the image, the concave half cylinder of its interior space is depicted by blank paper. At the same time the large inclined beam in the upper right hand area of the image is also rendered as blank paper, but here it is intended as a plane surface face-on to the viewer. Although the image is diagrammatic, it retains elements of a naturalistic pictorial view (of a completed engine standing in the customer's engine house) so that the customer, the resident contractor and his workmen have a common reference point to begin the construction and assembly of this device. The drawing is not strictly to scale, nor does it show the small details of construction that made Watt's machine a commercial rival to other engines. To some extent, its perfunctory and unreadable qualities are the result of its being a copy drawing made by laborious methods; the decision to maintain reproducibility in this image overcame other judgements of style. By contrast, the 'presentation' drawing in Figure 2 from 1848 appears at first glance to have banished ambiguity and awkwardness. An initial pencil underdrawing has been completed using fine, evenly inked lines, supplemented with watercolour washes. This drawing uses a standard convention, taken from pictorial representation, where light is assumed to be falling from the top left hand corner and illuminating three-dimensional forms in space. Illusionistic tonal shading and cast shadows are used both to fill out the circular turned forms of the wheels and spindles seen from above, and also to indicate which forms are 'closer' to the viewer, by a rendering of shadow effects to denote where upright forms, not fully displayed, obstruct the light falling onto surfaces standing 'further away'.

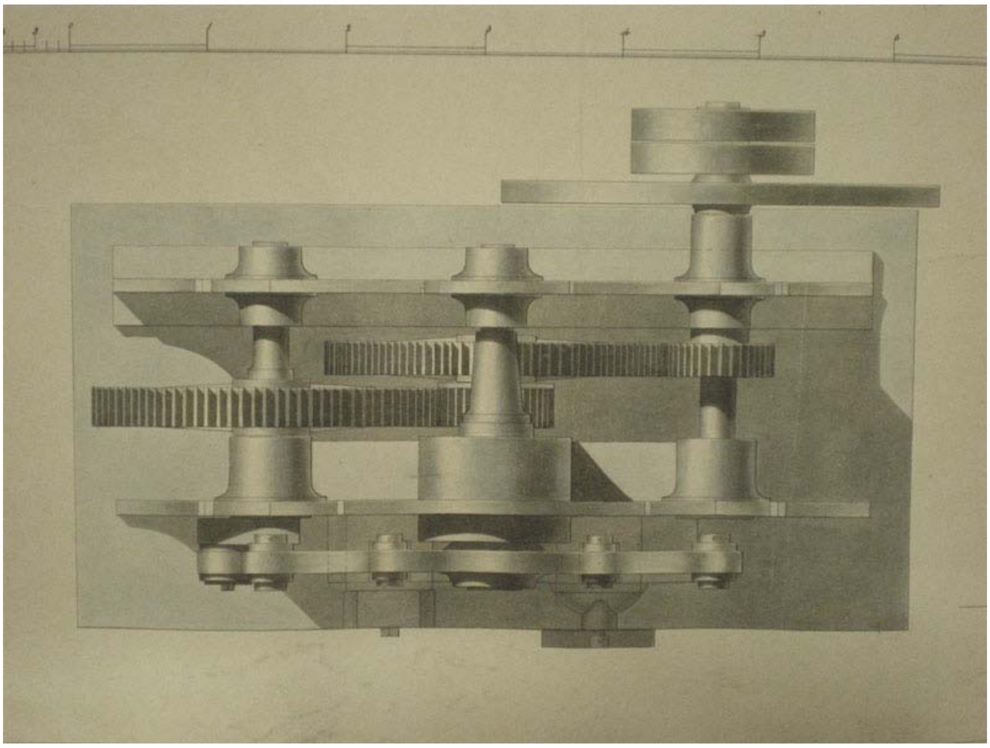


Figure 2: Detail from presentation drawing by E. Barlow (1848), showing top, or plan view of riveting machine. Nasmyth & Gaskell archive, Institute of Mechanical Engineers, London END/14/5/4

Figure 3 shows a working design drawing with sketch qualities; the kind of drawing that is used to support the notion of the engineer as an individual creator bodying forth the conception already held in his 'mind's eye'. This is a pencil drawing, with more hasty indications of tentative placements of elements; several redrawings can be seen. Unlike the two previous examples, this drawing was not intended as a public statement, and it is unusual to find it has been preserved at all (see discussion of sources below). The draughtsman used mechanical aids such as a ruler and compass sweeps for laying in his marks; these two-dimensional marks stand in for three-dimensional operations in the material world. Here the straight lines of extension and lines of rotation produced by rulers and compasses can translate into machine actions such as planing, cutting, rolling, lathe-turning and boring. These equivalences have been very seductive to commentators anxious to urge the direct relationship between drawing and improved industrial production. In addition, the private nature of this drawing, and its sketchy quality, make it attractive to fine art viewers trained to relish the task of re-enacting the cognitive unfolding captured in the sequence of marks (Cain 2010). Although this type of drawing is often given primacy by writers on engineering drawing other than myself, this dissertation, more concerned with public discourses, will instead examine how such drawings have been valued and interpreted.

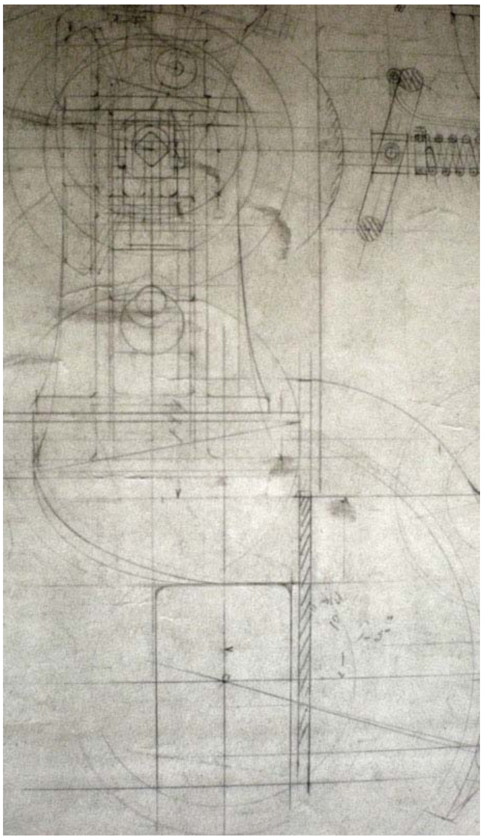


Figure 3: Detail of working sketch, automatic speed regulator Nasmyth & Gaskell archive, Institute of Mechanical Engineers, London END/14/7/1

By contrast, the images shown in Figures 4 and 5 have been selected as examples to demonstrate that technical drawings and illustrations in print are within the same chain of practices. The images in Figure 4 show both copy and original versions of drawings held in the Boulton & Watt archive in Birmingham, while the images in Figure 5 are lithographed reproductions of line drawings of direct acting and oscillating steam engines constructed by Rennie & Co. for naval vessels, printed in the *Artizan* journal. The copy drawing (Figure 4, *left*) acts, as I will argue further in Chapter 2, as the central hinge, as reproducibility was deemed to be an essential quality of technical drawings this had an effect on both function and on appearance.

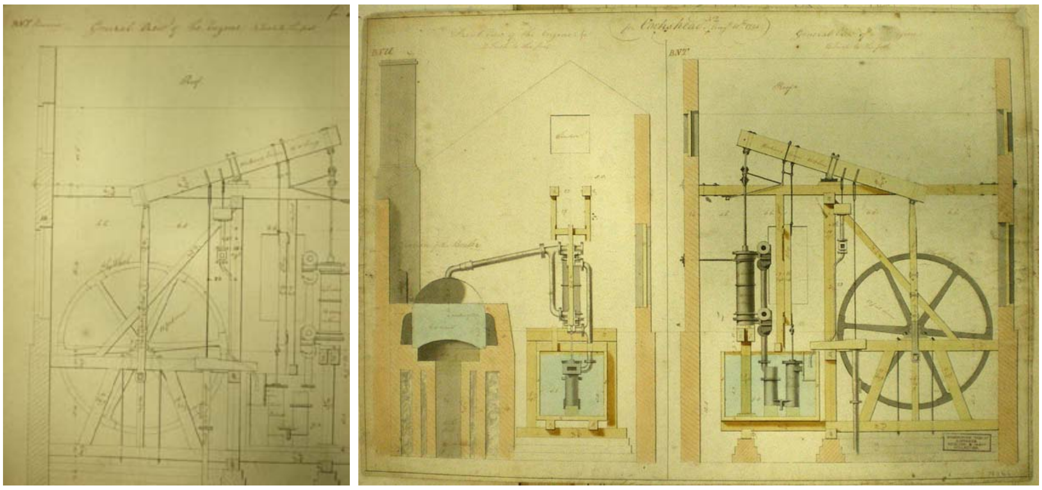


Figure 4: Reverse copy from James Watt's copying machine (*left*) and original (*right*) of Cockshead colliery drawings Boulton & Watt archive Drawings MS 3147/5/246 Birmingham City Council archives and heritage service

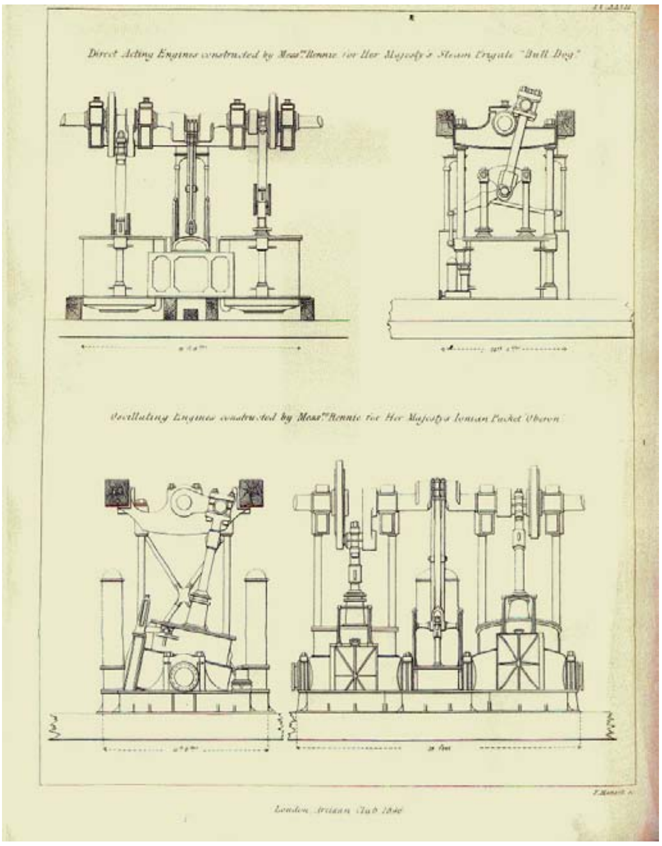


Figure 5: Direct acting and oscillating steam engines by Rennie & Co. *Artizan* 1846

Images of anxiety

The main focus of this dissertation is on mechanical drawings from a period when, as noted, many social groups anxiously debated the 'machinery question'; the political and social changes that the development of mechanised industry and factory working relationships appeared to herald (Berg 1980). The fearful aspect of images of industry has been given a lot of attention by Victorianists (Sussman 2000) and historians of science or technology alike. The celebration of mechanised production for example in

Babbage (1835) or *The philosophy of manufactures* (Ure 1835) has been attacked as demonic fantasies of empty workerless factories, producing an endless stream of commodities through an unstoppable and relentless 'autogenesis' (Edwards 2001: 28). Writers such as Stephen Daniels have developed doom-laden versions of the technological sublime (Nye 1996: xv-xix), in describing how artists and other social commentators in the period around 1800 projected their fears of rapid social change into supernatural, satanic descriptions of the mines, roaring furnaces and steam engines of 'iron Britannia' (Daniels 1994: 70).

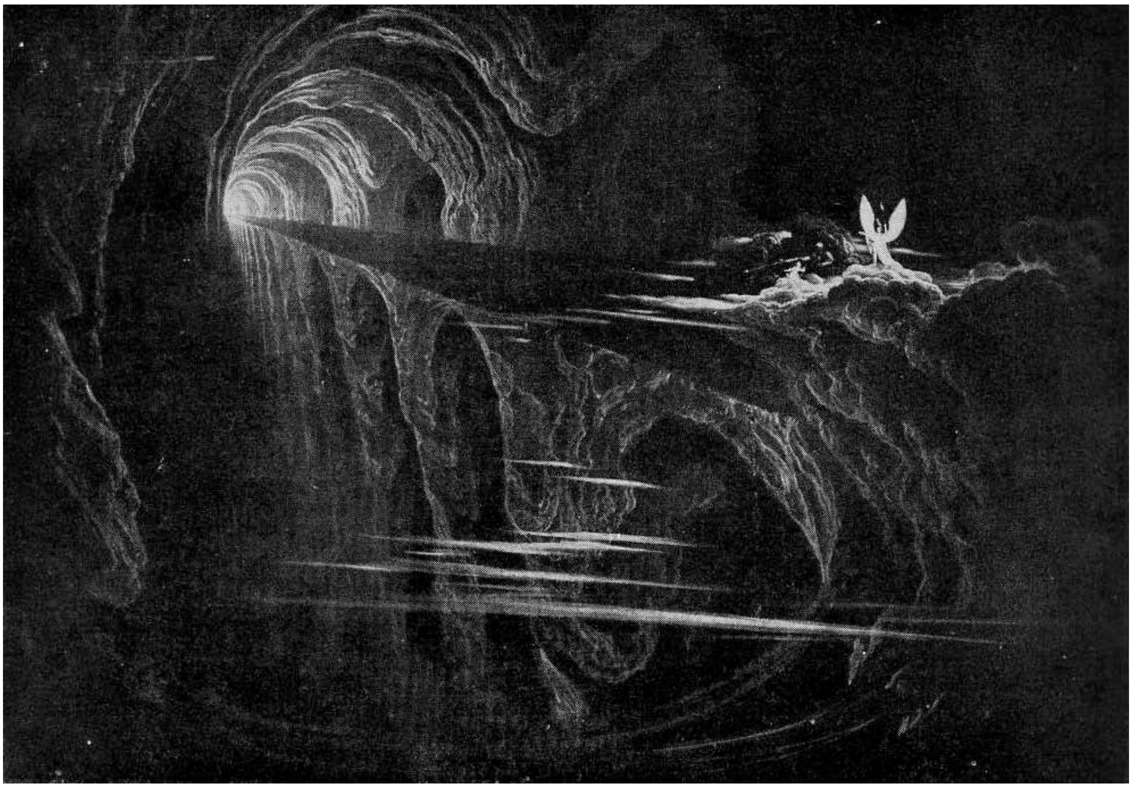


Figure 6: John Martin 'On the brink of chaos' illustration to John Milton *Paradise Lost*, reproduced in Klingender (1972) as Figure 55. Klingender points the reader to a visual comparison with a published image of Marc Isambard Brunel's Thames Tunnel that was opened to the public in 1827, in the same year as Martin's publication (Klingender 1972: 106-7)

In the same vein, John Martin's apocalyptic illustrations to Milton's *Paradise lost* (Figure 6) have also been attributed by Francis Klingender in *Art and the industrial revolution* to a displacement of more immediate earthly concerns. In his interpretation Klingender compared Martin's illustrations of Hell with prints of well-known public construction projects in order to argue that due to disillusionment with previously inflated hopes of scientific progress and political reform 'even the real works of contemporary engineers seemed sinister and fantastic' (Klingender 1972:103).

In Figure 6 the artist John Martin has marshalled his composition around a very distant brightly lit point in space that winks out from a gloomy, swirling vortex of subterranean arches and grottoes. The perspective construction is (literally) underlined very overtly in order to drag the eye constantly to that enigmatic and unreadable bright exit from the depicted scene. The use of very strong contrast creates drama and arouses the attention of the viewer, while the compositional device pricks the eye into ceaseless and restless scanning around the point of light that never yields any information. Other images, dramatic industrial scenes by Joseph Wright of Derby (1734-1797) or Philipp de Loutherbourg (1740-1812) from this period, selected by Klingender in *Art and the industrial revolution* (Klingender 1972) or Fox in *The arts of industry in the age of enlightenment* (Fox 2009) also used similarly dramatic effects of masses of contrasting light and shade and billowing dynamic forms in order to convey energy and a sense of sublime awe in these engagements with the resources of the natural world. Images like this can be interpreted as expressing a state of anxiety that has been displaced into a nameless but perpetual state of agitation. In technical drawings by contrast, for example the drawings of colliery engines shown in Figures 1 and 4 above, orthogonal presentation distributes measured forms systematically across the surface of the page with no single area of focus. The depicted space is extremely shallow and frieze-like; the tone is light and even, allowing the viewer to seize control of the image in a leisurely scrutiny. Information about forms and their relationships have been laid out clearly, and supplemented by written notations. This contrast of style between sublime and the technical representations of similar industrial subjects is marked, and invites interpretation.

Several possible answers, taken from established cultural viewpoints, suggest themselves. It might be said that for engineers and their audiences, the question of aesthetics is inappropriate; more craftily it might be argued that engineers acted as instrumental functionaries for the state, or for capital, attempting to evaporate social concerns under a deliberately bland style. In this dissertation I will discuss and acknowledge variations on these approaches. The first position cannot withstand the question of how without aesthetic judgement one might apply terms such as ‘inexpressive’ at all. And while the second position is more persuasive, recruiting the reader to the task of unmasking the workings of ideology in everyday representation, this approach has now become familiar, even routine. Instead, when I ask why technical drawing is now perceived as inexpressive and inartistic, I will be less concerned with following impersonal processes of the workings of power through representation, but rather with the visual strategies used by mechanics, draughtsmen and engineers in their attempts to construct more complex and shifting markers of social and professional status. In this context artistic expression was an attribute that was overtly deployed or dissimulated according to circumstances. The development of a mode of aesthetic effacement is not the same thing as being inexpressive, it is a considered stance replete with judgements about appearances.

The late eighteenth century was also the period when the Hanoverian regime was intent on ‘forging the nation’. Linda Colley has argued that national identity was invented during this period not by blending the English, Welsh, Irish and Scottish cultures of the formerly separate kingdoms of Britain but by superimposing Britishness over ‘an array of internal differences’ (Colley 1992: 4-5). In Scotland for example, still in process of ‘pacification’ following the Jacobite uprising of 1745, engineers and surveyors were employed by the state for mapping, road building, harbour, canal and planned township projects to bring the Highlands into the orbit of national and Atlantic trade and industry networks (Alfrey and Daniels 1990; Charlesworth 1996; Maudlin 2007). Technical drawings by civil engineers have a clear role in this process, but equally technical drawing for machine production could also in this context be seen as part of a similar drive to create a national identity in industrial discourse, that suppressed those at the cultural margins. In the early nineteenth century Britain was a country that was still culturally organised around local and regional networks; in some regions machine working and factory organisation were not common until well into the second half of the nineteenth century, whereas other areas such as Glasgow, London, Manchester, Leeds, Bolton and Birmingham had substantial steam-driven factory organisations by at least the 1830s or earlier (Berg 1980: 22-4). The millwright and engineer Robertson Buchanan (1769-1816) experienced this patchy geographical distribution of industry as a cultural jungle of strange local dialects: ‘I have experienced considerable difficulty to find precise technical words to express the different parts of Millwork, those being used by Millwrights in different districts being very different from one another’ (Buchanan 1823: 249). Visual communication, he hoped, in textbooks such as his own *Practical essays on millwork and other machinery* (Buchanan 1823) would get over this problem.

Such nation building, described by Colley as a process of excluding outsiders, also implies increased national rivalry. In the late eighteenth century, existing fears of French superiority in the area of invention, design and manufacture were exaggerated and inflamed through journalistic debate and visual polemics (Eaves 1992: xviii; Lubbock 1995: xiii; Rifkin 1988; Simon 2007), matched by a complementary agitation in France (Schama 1989: 189-94; Stewart 2007: 159). After the Revolution of 1789, France also was feared as the origin of ideas of radical republicanism that were as already noted moving artisans to thoughts of equality and protest. Indeed, much as the events and the philosophies of the French Revolution shocked and excited observers across Europe in the period, in the minds of many twentieth-century historians the excitement of the period continued to resonate, amplified by description and analysis, and by the knowledge of subsequent revolutionary upheavals in other places. In the fields of art, design, and architectural theory, the notion of utopianism, conceived as the attempt at moral reform or the reshaping of society through design, has been a powerful concept in interpreting drawings made for architecture, urban planning, and engineering in the eighteenth century (Kaufmann 1953; Tafuri 1979; Picon 1992; Markus 1993; Craske 1997: 229-33; Donnachie 2007). I will discuss the persuasiveness of these ideas about the cultural significance of line marking and line drawing in the early nineteenth century in Chapter 4.

Finally, changes in working practices in Britain also prompted some quite specific fears of class conflict, in particular of the revolutionary threat from radical politics (Desmond 1997; Prothero 1997; Haywood 2004). As already noted, many writers have discussed technical drawing in the light of theories of social control and the threat of social unrest in this period (Foucault 1991 [1975]; Brett 1987; Denis 1995; Purbrick 1998). The inexpressive factual quality attributed to technical drawings, although apparently opposed to sublime or romantic depictions of industry, has thus been imbued with a sinister controlling function by an appeal to theories of the development of objectivity in the nineteenth century as an ideal with hidden political ends; 'the rule of law, not of men' developed, according to Theodore Porter, because it 'lends authority to officials who have very little of their own' (Porter 1995: 74; 8). This notion has been adapted to the description of technical drawing as a means to 'reduce the discretion of both the person drawing the plan and the person reading it' (Alder 1997: 140). However, although these ideas are persuasive, they can be questioned, again on account of the somewhat conspiratorial model of impersonal powers subduing passive victims. Instead evidence from the range of images that survive from the period suggests that technical practitioners used drawings as a weapon for empowerment or even subversion. 'Technical drawings' are not one thing, any more than 'engineering' is one abstract notion, but is a conglomeration of occupations often in conflict for status and recognition, and in this context drawings were a site of disagreement. So, for example, in *A practical treatise on railways*, (Lecount 1839) the author firstly asserted the ideal notion that drawings are a kind of *fiat*: ‘the constructor must have all reasonable access to the drawings... whatever is in the drawings and specifications, must be considered as to be done’ (Lecount 1839: 43). But the same treatise simultaneously undermined the engineer and his drawings, by suggesting it was necessary to bring in another professional actor to question them. A further independent observer and arbitrator ‘without the least reference to the engineers’ should, it was urged, contest the drawings as they were ‘so uncertain, that no two persons can set down and measure a bridge on the plan, &c. without almost invariably differing by several yards’ (Lecount 1839: 51-2).

Considered as the product of a web of individual negotiations, technical drawings and illustrations did not all fall into one formulaic style but occupied a range of expressive positions. If the majority of images in this dissertation avoid satanic or sublime modes, it is because I have chosen instead to explore the ways in which the ‘machine dreams’ of ‘Victorian mechanists’ (Sussman 2000: 197) were constructed, experienced, appropriated and disputed. This is a problematic approach because, as noted, critical unmaskings of the sinister import of technical drawing have been a vehicle for attacking ‘Whiggish’ celebratory notions of technologically-driven ‘progress’ (Jardine 2003; Smith and Marx 1994) that formerly held sway. But although such approaches to technical drawing have helped to develop an awareness of the wider contexts and anxieties associated with this genre, the reductive quality of some interpretations, and the sense of taboo, have become a new orthodoxy. Instead I will ask who aimed to gain power through technical drawing, and what visual means were used to achieve cultural or social authority.

Sources

As already noted, the period before 1850 lacks the quantity of official documentary evidence that has supported accounts of the role of technical drawing within the state education system, in industry and in visual culture in the second half of the nineteenth century. In contrast to the situation in France, for example, where state funding for technical education was in place for both elite engineers and artisan mechanics even before the Revolution of 1789 (Day 1987; Edmonson 1987; Alexander 2008), most official sources in Britain set out to show not achievement but a skills deficit. Notoriously this is the case with the Government Select Committee on Arts and Manufactures of 1835-36, where both witnesses and questioners at these hearings agreed over and again that the arts of design could not develop though lack of drawing skills in the working population. Nonetheless, given the subject matter, this inquiry could not avoid giving varied and detailed evidence, often unwittingly, about a wide range of varied drawing activities in both design and fine arts in Britain, and these have proved to be useful for the present investigation. For day-to-day working practices in engineering, for example from business or office records, there is an equal shortage of detailed information relating to the first half of the century (Cookson 2002: 13), even before reaching down to the level of the drawing office. Equally, many elite engineers, for example through the vehicle of the Institution of Civil Engineers, supported the laissez-faire approach of the state to education and professional pathways (Buchanan 1989: 70-3; 174). Andrew Saint has claimed rather dramatically that 'the spectre of Britain haunts the topic of technical education for architects and engineers' suggesting that a rejection of education by elite engineers and the state is a 'puzzle', when combined with Britain's economic dominance (Saint 2007: 256). A lack of state institutions and 'school culture' in Britain, if that really was the case, need not mean that there was no training or education, but it does mean that information must be assembled from a range of alternative sources.

As noted, in some regions machine working or factory organisation had little or no impact until well into the second half of the nineteenth century, whereas other areas, such as Glasgow, London, Manchester, and Birmingham had substantial steam-driven factory organisations by the 1830s (Berg 1980); this distribution is still reflected to some extent in current archive locations. Large collections of drawings and other business documentation that I have used are in the Boulton & Watt archives (Birmingham City Council Library), the Institution of Civil Engineers, London, the archive of James Nasmyth drawings and correspondence (displaced from Manchester to the Institution of Mechanical Engineers, London), and the collection of John Smeaton drawings kept by the Royal Society, London. As Glasgow was an industrial city, there are archives and library holdings of 'industrial' material associated both with well-known educational and business institutions but also from more everyday sources such as daily newspapers, held in the Mitchell Library (Glasgow City Council), Glasgow University Business Archive, the archives of Glasgow Mechanics' Institution, and Anderson's Institution (Strathclyde University Archives). Prestigious large archives tend to be associated with named 'heroes of invention' (Macleod 2007). These are the locations where most of the remaining drawings are held, such as the Boulton & Watt archive, the Nasmyth & Gaskell archive, or the John Smeaton collection. In all these archives there appear to be too many presentation and general drawings, and too few detail and working drawings. Below the engineers and head draughtsmen whose work has been preserved, a disproportionate number of the drawings made by the mass of 'rank and file' workers have been lost. In part this was due to working practices, as the bulk of drawings executed by junior draughtsmen consisted of elaborating the smaller details of machines in working drawings that were 'sent into the [work] shops' and not returned (Horner 1910-11: 556-7). In addition, not all engineering firms had drawing offices; in Britain, most engineering firms remained as small family-owned businesses with weak occupational structures right through to the twentieth century, whilst of the larger companies that did employ drawing staff, most made machine tools (Smith and Whalley 1996: 43; Cronin 2001: 6-10).

The main primary sources for this dissertation, however, are printed publications. These sources give evidence both about working practices of draughtsmen, engravers, engineers, instrument makers and publishers, as well as the reception and public construction of technical visual discourses. I have used publications of the period such as the *Transactions* of the Society of Arts, Abraham Rees' *Cyclopaedia* (Rees, 1819-20), the *Edinburgh Encyclopaedia* (Brewster 1830), the London *Mechanics Magazine* and *The Glasgow Mechanics' Magazine*. In addition, more recent publications of art and design history or history of technology have also been treated as primary sources on the reception, construction, and revision of notions of 'technical drawing' in visual culture. Finally, through the kind support of Alison Morrison-Low, Curator of the History of Instruments and Photography at the National Museum of Scotland, Edinburgh, I have been able to handle and observe a range of the drawing instruments used by technical draughtsmen in the nineteenth century in order to inform my understanding of the connections and interactions between drawing and print in technical communications.

The structure of the argument

The dissertation moves through three phases, each subdivided into pairs of chapters. The first covers questions that relate to current disciplinary boundaries, and their connections to the cultural politics of the period around 1800. The middle section is concerned with the symbolic and expressive aspects of technical drawing and its characteristic linear markings, and proposes that meaning and expression are read by the viewer as much though an awareness of the embodied practices and the materiality of surfaces and production methods used as much as in the depicted content of the image. The final, and most substantial section of the dissertation, is concerned with the ways in which different groups within engineering hierarchies sought to use drawing skills both as a means of self-presentation and for professional formation in the decades before 1850 (and I will use the word 'formation' deliberately to incorporate the range of meanings understood in French; of apprenticeship, training and education, as well as of more general social forming). The narrative follows a roughly linear structure in terms of chronology, combined with an ABA thematic structure. The central 'symbolic' core, where I consider how the expressive effects of technical drawings could or should be evaluated, sits within a larger framework of specifically 'social' and contextual concerns.

The first section, consisting of Chapters 2 and 3, is concerned with art, industry and cultural politics up to and around 1800 in order to question the various narratives and assumptions that formed my starting point. Chapter 2, 'Civil engineers and Royal Academicians' examines how accounts of drawing in art and industry in this period have become separated. To explore how such separate 'artworlds' have been produced, this chapter looks at the role of archives and institutions and their connection with the development of professional practices and academic discipline formation, focusing on two specific examples: - the archives and histories associated with the engineering firm of Boulton & Watt and the Royal Academy. Both institutions, founded within less than a decade of each other, developed a deliberate philosophy of drawing practice and while they have both generated a substantial body of textual and visual material that separately have attracted a lot of research attention they have not been compared and contrasted before.

Chapter 3, 'Provincials, pupils and print', expands this framework. While Chapter 2 will question accounts of drawing practice for art and industry in relation to familiar and specific locations of cultural production this chapter by contrast addresses accounts of both production and reception of drawing practices within wider visual culture in the decades around 1800. It poses the question of where else, beyond the Royal Academy or in engineering practices, might one have learnt to draw in Great Britain, and to what end? This chapter considers some rival academies in the late eighteenth century whose aims differed from the Royal Academy, and also pays attention to the promotion of drawing styles through print, through into the early nineteenth century.

As noted, the central section that comprises Chapters 4 and 5, 'Fabricating the line' will ask what aesthetic and symbolic meanings can be taken from styles of mechanical drawing adopted in the first half of the nineteenth century. The argument uses, but also criticises, art historical methods of interpretation based on techniques of visual descriptive analysis and stylistic comparison. Chapter 4, 'Purity, progress and labour' examines the meanings that can be attributed to the use of fine uniform ruled lines, and compositional formats of technical drawings on the page. The significance of the distinctive line deployed in technical drawing at this period has frequently attracted a range of charged interpretations, especially in the twentieth century, with the development of academic interest in utopian and revolutionary movements. This chapter will review and challenge both idealist and functional notions of why line making was predominant in technical drawing. By returning to less familiar primary sources of the period it is possible to develop an alternative interpretation that emphasises the physical and intellectual problems of actually 'ruling a line'.

Chapter 5, 'Multiplying marks', examines technical illustrations in print, in order to argue that in the period 1800-*c.*1830 technical drawing and technical illustration developed in tandem to create a visual style that displayed the industrial system to viewers outside the factory. Although technical illustration has often been excluded from accounts of technical drawing, the means by which these genres entered public discourse together at this period suggest that it is misleading to consider one without the other. This chapter considers line drawing in relation to mark-making tools, drawing machines, surfaces, and transfer to print. In continuing the argument of the previous chapter, this chapter will explore some of the material awkwardness involved in transferring and copying from one medium to another. Equally, in discussing the material nature of the processes of technical drawing and illustration this chapter will explore the expressive and aesthetic effects of technical drawing on its audience at the time, both through pictorial values and also through expounding an 'iconography of materials' –that is, through a shared cultural knowledge of the meaning of materials and techniques.

The final, and largest section, considers social networks and working hierarchies in engineering as expressed and negotiated through the medium of technical drawing. Chapter 6, 'Artisans, draughtsmen and working relationships' examines draughtsmen as industrial workers. As implied, this part of the dissertation is the most challenging in terms of finding evidence, but is equally the most worthwhile, as there are few previous accounts that present research into technical draughtsmen in this period in Great Britain. It is, of course, a truism of social and cultural history that the experiences of anonymous workmen are by definition hard to access. However this chapter will also argue that this lack of knowledge comes from the formation of 'draughtsmen' as a social group, when their claims for status brought them into conflict with designers and elite engineers through the medium of drawing. Chapter 7, 'Professional engineers in the world of industrial readers', will discuss the visual practices of elite engineers in the first half of the nineteenth century in relation to questions of professional formation, developing the argument started in the previous chapter, that the range of technological representations developed to assert professional status by engineers did not result in one uniform marker of social distinction, but instead displayed a fracturing of localised groups and sub-groups each vying for respect. This chapter comes closest to the problematic area of the 'heroes of invention' (Macleod 2007); however, this topic should not be avoided, for such narratives were part of the context of professional formation (Lightman 2007) and deserve attention. But while the range of technical representations (such as the design sketch) that have become routinely associated with elite engineers has added to their heroic status of creative genius, other more ephemeral printed material addressed to the non-expert 'world of industrial readers' (Johnson 1852: 196) written by elite engineers has been neglected. Although texts and images addressed to the general reader or aspiring mechanic have most frequently been used to discuss audiences in relation to notions of 'popularisation' (Cooter and Pumfrey 1994: 237-67; Brown et al 2009: 737-52; O'Connor 2009: 333-345; Cantor et al; Lightman 2007: 29-30), this chapter considers the other face of popularisation by asking how such visual and literary practices shaped the professional standing of the authors themselves.

My research demonstrates that engineers and technical draughtsmen absorbed, selected, and appropriated expressive practices and discourses from fine art in their work and in their self-fashioning as technical artists, and on that basis they developed new and distinctive conventions of composition, mark-making, medium and modes of display that were widely disseminated, both to technical working viewers, and then outwards to general readers and viewers through illustrated periodicals and exhibitions. In training themselves, technical draughtsmen and engineers developed their visual styles through copying from a wide range of examples and conventions, with the result that they were able to inhabit and reproduce the motifs and manner of artistic, ornamental and practical styles of drawing. Draughtsmen could reflect on their own selections, and create pictures that reflected their own making. Thus engineers and draughtsmen developed a role as authors and visual technicians, working alongside instrument makers, engravers, and printers.

I show that the methods of art history are necessary and relevant in informing my analysis of a topic that is usually confined to histories of technology or science, but these must be integrated with methods and ideas from the history and science and technology. Moving inside the artworld of technical drawing gives a textured account of the ways in which groups of practitioners sought to gain authority by visual means, either with their immediate peers and rivals, or with more general viewers, thus breaking down the topic of 'technical drawing' into a much more differentiated field of human activity where visual descriptive analysis begins to have a purchase on issues of the social history of 'arts and manufactures' in Britain in the period to 1850. Historians of technology and science have allowed me to examine the social and technical means for negotiating status in visual production; in addition, two particular topics from the history of science have given me a strong basis for future research as an art historian into visual communications; first, questions about how truth claims have been established and contested through demonstration, and second, in relation to 'print culture' how areas of specialist expertise are constructed and presented to general readers.

Chapter 2: Art, industry and cultural politics to 1800: civil engineers and Royal Academicians

This thesis is about the development of technical drawing as a social construction within wider visual culture, a narrative that ought to include some mention of exchanges between artistic and technical genres of drawing. However, it is striking that accounts of visual practice in the period around 1800 in both art history and the history of technology have become separated, with only a few exceptions (Klingender and Elton 1968; Kemp 1990; Stafford 1994; Fox 2009). To explore how such separate 'artworlds' (Becker 1982: 34-9; 145) have been produced, this chapter will look at the role of archives and institutions and their connection with the development of professional practices and academic discipline formation. I focus on two specific examples; the archives and histories associated with the engineering firm of Boulton & Watt and with the Royal Academy. Both institutions, founded within less than a decade of each other, developed explicit documented philosophies of drawing practice and they have both generated substantial bodies of textual and visual material that separately have attracted a lot of research attention but have not been compared and contrasted before. Arguably, this separation is due to disciplinary boundaries, so that, although each discipline has continued to modify its own interpretation of the past, nevertheless the artworld of each discipline still has a limiting effect on the selection of evidence (Jordanova 2000: 60). It is only when working across disciplines that non-communication becomes more apparent. In comparing different accounts of drawing history across disciplines, testing these accounts against each other and also against observed primary evidence, I will ask to what extent one can find agreement and also separation in the philosophies, techniques and styles of drawing practice associated with art as exemplified by the Royal Academy and industry, exemplified by Boulton & Watt.

As noted, civil engineering only gradually became perceived as a separate occupation in the late eighteenth century. In Britain John Smeaton (1724-92 Skempton *ODNB*) adopted the term 'civil engineer' in 1768, and reinforced this again in 1771 by founding the Society of Civil Engineers (Skempton 1981: 4). In histories of engineering, Smeaton's personal status, and the Society of 1771 have been treated as significant events in the period before the foundation of the Institution of Civil Engineers in 1818 (Watson 1988; Buchanan 1989: 37-9; 61-2). But strangely, in histories of technical drawing (as a self-contained micro-genre), Smeaton's drawing practice has attracted less attention until very recently (Fox 2009: 85-101). By contrast, the visual self-presentation of James Watt (1736-1819 Tann *ODNB*), bolstered through the imposingly large Boulton & Watt archive of drawings, is much more well-known.

The Boulton & Watt archive threatens to overshadow other sources because it is very large and seemingly comprehensive with over 1300 portfolios enclosing around 36,000 drawings (Tann 1993; Richardson 1989: 34; Baynes and Pugh 1981: 35). Furthermore, the drawings are only part of a much larger aggregation of material available for public scrutiny in Birmingham (Birmingham City Council Library) or as an online database (Tann 1993). This archive is a good example of the way in which surviving sources encourage researchers to shape their narratives around them (Jordanova 2006: 28-30). Equally, the Boulton & Watt archive has gained extra significance due to a determined campaign of hagiography for James Watt as a 'hero of invention' that began after his death in 1819 (Torrens 1994: 23-34; Miller 2000: 1-24: Marsden 2002: 183-198; Macleod 2007: 91; 181). This chapter will consider the status that has been accorded to James Watt's mechanical drawings from the period of his Boulton & Watt partnership (1775 onwards) in relation to other examples of similar drawing practices, in particular to those of Smeaton. I also survey accounts of academic drawing training and practice in relation to the Royal Academy in London after its foundation in 1768 with particular reference to the incongruities caused by both including and excluding geometrical or architectural drawings.

James Watt: engineering drawing in history and in practice

The Boulton & Watt archive is given significance in histories of technical drawing because Watt's drawing ability has been lauded as a key factor in his success as a 'hero of invention' since at least the mid nineteenth century (Muirhead 1854; Smiles 1865). In addition, many further admiring accounts through to the late twentieth century have pointed to the use of technical drawing as a technique in the managerial transformation of the firm of Boulton & Watt from a small engineering consulting practice in1775 to the planned and centralised Soho Foundry of 1795, often with a rather idealised notion of a smooth and systematic application of factory production methods to machinery production through the medium of drawing (Roll 1930; Rolt 1965; Booker 1979; Baynes and Pugh 1981). So in these narratives, drawing within the Boulton & Watt enterprise is given two functions. Firstly, as a kind of mechanical science, it is described as laying down the accurate construction and assembly of parts that was necessary to get the condensing steam engine to work at all. Secondly, in more managerial terms, it has been seen as a method of manpower control, as a tool of the efficient division of labour in the Soho Foundry. Finally, as a third strand, and with a very close focus on the techniques and appearance of the technical drawings in the Boulton & Watt archive, Richardson (1989) has claimed not only that Watt was one of the first engineers to exploit technical drawing in the ways already described, but that Watt single-handedly invented and laid down many of the conventions that had become standard practice in engineering drawing through to the late twentieth century (Richardson 1989: 227-233). The conventions that Richardson included in his scope were: the use of multi-view drawings on one page, the use of different types of line with fixed meanings, the use of sections, the ways in which dimensions were noted, conventional uses of colour to denote materials (such as yellow for brass), and finally the use of simplified conventional signs for certain complex but standardised parts such as screw threads (Richardson 1989: 1). It must be remembered, however, that the drawings in the Boulton & Watt archive run through to the 1840s, so only the earliest examples from before 1782 can be attributed to Watt himself; after that date other draughtsmen and assistants were taken on to do this work. These questions will be addressed later in this chapter and again in Chapter 6.

The drawing here in Figure 7 shows details of parts to be made for a steam engine:

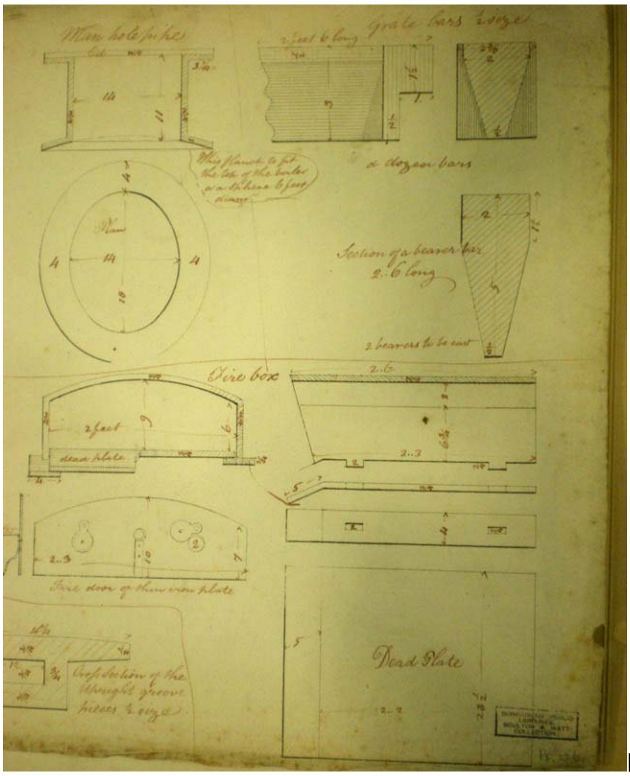


Figure 7: B&W MS 3147/5/246 from Cockshead colliery drawings, damper plate and frame, detail drawing dated 1793

The technical drawing conventions used in this drawing include: unmodulated line produced with pen and ink to denote visible outlines; dotted lines to denote hidden outlines; mechanical controls for the pen such as straight edge, compass and ellipse drawing devices to produce a limited repertoire of straight and conventionally curved marks; the display of sections through structures (denoted by the parallel diagonal marks); references to actual dimensions (denoted by use of scale alongside additional written notation); mixture of image and text; the use of 'true shape' (face-on orthographic projection) to map out the different faces of three-dimensional objects, rather than give a single view in pictorial perspective; multiple views of one object on the same page, and the use of conventionalised cast shadow to denote forms that project towards the viewer. Richardson commented: 'this early drawing contains many present-day practices and conventionalized representation of common components and features. The half section and enlarged detail section in the drawing of the damper plate and frame is very significant in a drawing dated 1793' (Richardson 1989: 367-8).

The Boulton & Watt archive has great diversity of visual material. Although the detailed working drawing in Figure 7, destined for the foreman and metal workers in the workshop, is in accord with a strictly functional notion of technical drawing, other techniques represented in the archive support the argument that a much wider range of uses and audiences for the technical genre must be considered. James Watt produced drawings for print, and also (after 1780) for reproduction by his copying machine. These techniques had an effect on the visual qualities of drawings made for these purposes; indeed, even from the beginning, the laboriously hand duplicated copy of the 1778 Bedworth Engine drawing shown in the introduction (see Figure 1, Chapter 1) appears to assert that drawings should be constructed so they could be easily reproduced. Equally Boulton & Watt produced a printed Instruction Book in 1778 to help in the assembly of condensing steam engines to Watt's designs (Figure 8).

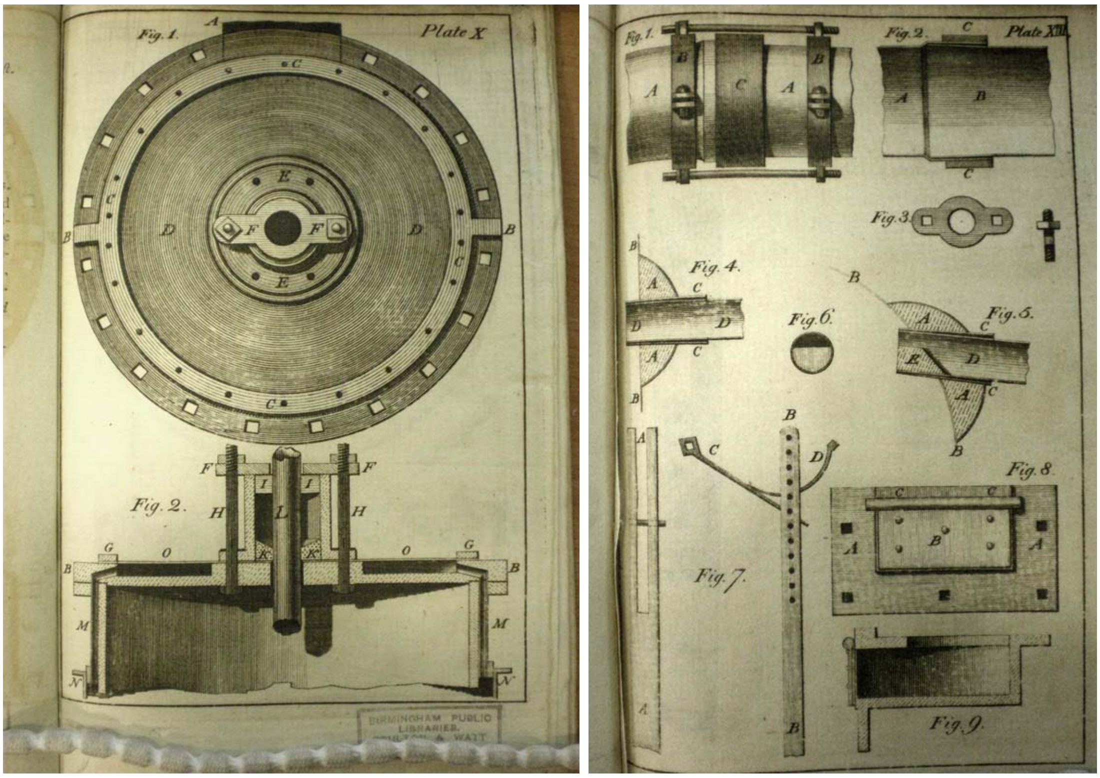
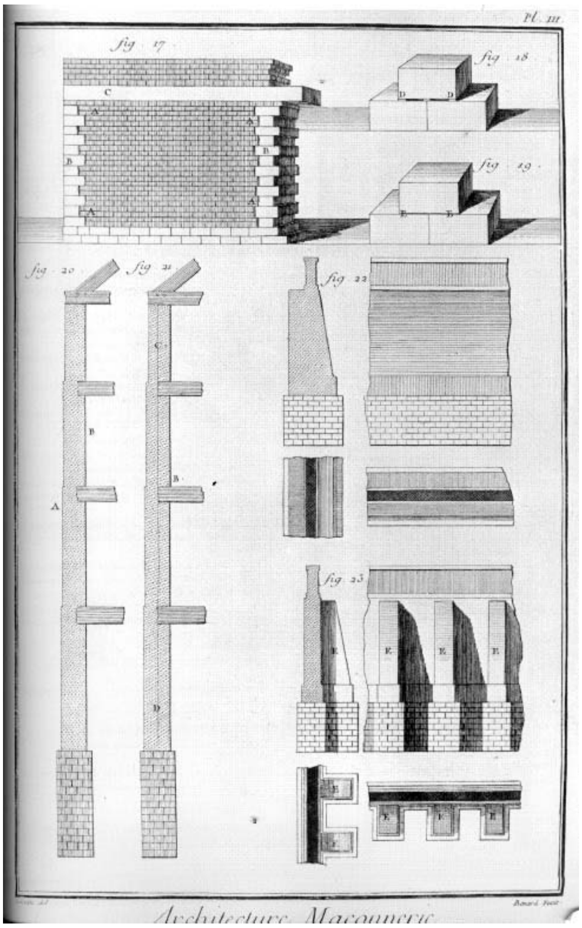


Figure 8: B&W MS 3147/4/326 Watt's Instruction Book 1778. Plates X and XIII, steel engravings after Watt's drawings

This was intended for the use of customers, employees, and subcontractors in the period when Boulton & Watt's main business was as consulting engineers, designing and coordinating the installation of engines to dispersed sites across Britain (Roll 1930; Richardson 1989; Hills 2002). These supplements to the more accepted notion of 'technical drawings' in the archive demonstrate that drawing, copying, and printing were all one continuous practice that embraced not only production and invention, but also audience building in a wider sense. The Instruction Book allowed simultaneous access to the same image across time and distance, in a way that has been noted by celebrants of 'print culture' such as William Ivins (1992), Elizabeth Eisenstein (1979) and Bruno Latour (1986: 12-13). The Instruction Book has various symbolic functions. Some of these fit a narrow definition of technical drawing as a functional instrument of production: it establishes some clear statements about dimensions, configurations, and the order of assembly for a future material object and it is aimed at both contractors and customers. In the same mode, it was intended to enforce control at a distance and to resolve conflicts of interpretation. But equally, it is a public document, and perhaps functions as a sign to a wider audience that Boulton & Watt wished to appear in opposition to anti-modernising secretive craft practices, in line with their policy of inviting visitors to their workshops and publishing newspaper announcements to advance their business (Jones 2009: 71-79). The visual style of the page in Figure 8 can be seen as part of the public image of the company and although it has many visual similarities with the detail drawing in Figure 7, it also shares a visual language derived from architectural and technical illustrations in contemporary encyclopaedias (Figure 9). However, displaying the steam engine as an open secret only continued through the period when the company had the often-uncertain protection of a patent extension on the condensing steam engine to 1800 (Marsden 2002: 94-8). After that date, anxiety about industrial spies and more protectionist notions of business led to the end of such openness (Jones 2009: 79).



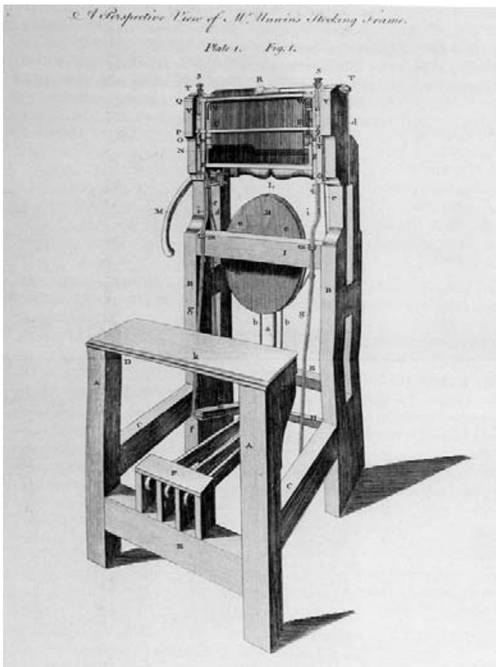


Figure 9: (*left*) Architecture: Masonry, from Denis Diderot and Jean le Rond d'Alembert (editors) *Encyclopedie* 1751-1765 Volume I (Plates): Plate III (1762-3) (*right*) William Bailey (1772) *The advancement of arts, manufactures and commerce* Fox claims that publications like this were driving a move to 'more technical forms of drawing' giving as an example this 'perspective view of Mr. Unwin's Stocking frame', 'devoid of the human presence to work the machine (Fox 2009: 287-289)

The drawing in Figure 10 prepared for Wilkinson's Bradley Forge in 1782 was also designed to nurture Boulton & Watt's public image because this elegant configuration was prepared not as a working drawing but as a 'presentation drawing'. As Richardson notes (1989: 420), Boulton & Watt made extensive use of these prestige drawings throughout the lifetime of the company. Presentation drawings were given to the client, or shown to potential customers as visualisations of a future reality. Both

Richardson and Baynes and Pugh admit presentation drawings to the category of technical drawing, but show a marked reluctance to admit any deviation from utilitarian uses, as for example, when the *Art of the engineer* modestly stated: ‘in some of these marvellously finished drawings there is clearly an element of industrial pride and public relations, but they also served a practical purpose … as reference when a machine needed maintenance or modification’ (Baynes and Pugh 1981: 14-15).

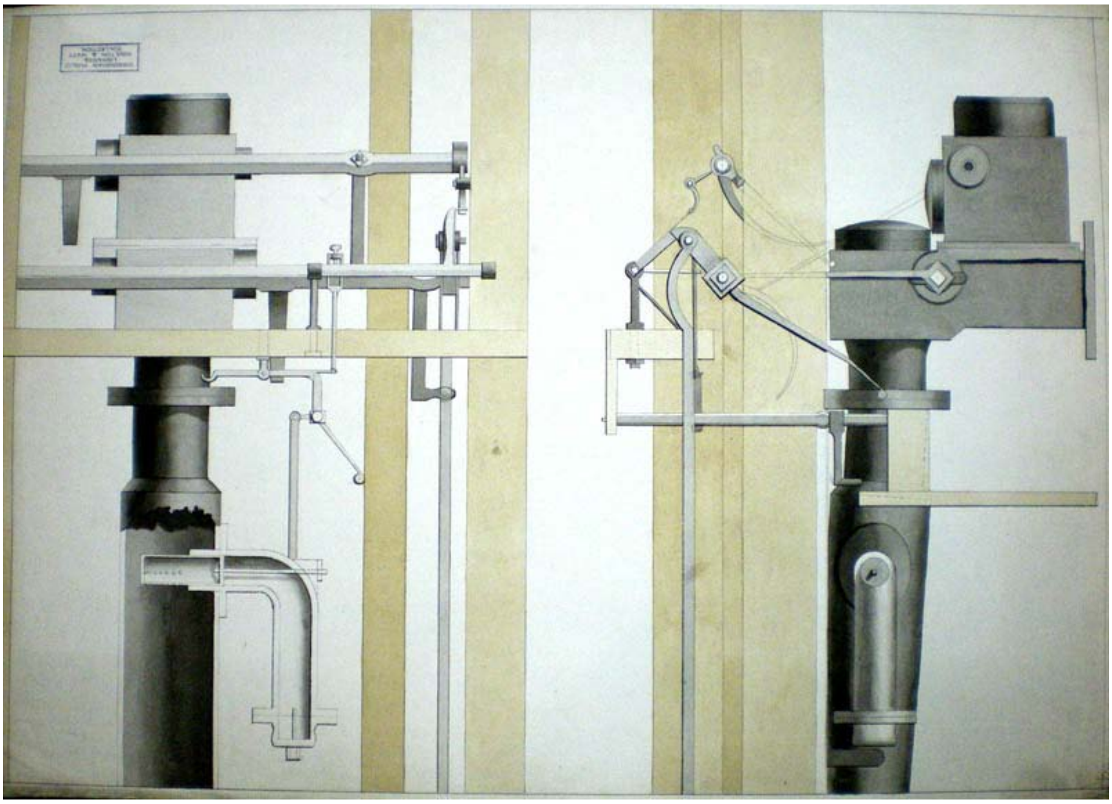


Figure 10: B&W MS 3147/5/239c Wilkinson’s Bradley Forge 1782 pen and wash over pencil underdrawing

In this image, conventional line markings have been carried over from the working drawing style. The drawing has been supplemented with smoothly graded coloured washes to give a quasi-pictorial view that has strong, but localised, areas of three-dimensionality. This addition of watercolour to add strongly illusionistic form to the more schematic line drawing conventions is intended to help the non-engineer to read the future mechanism in both its form and function. In relation to the materials used and the visual qualities of the image, we can also see a clear importation from other visual practices of the late eighteenth century, from architectural drawing and watercolour painting. The question of links between architectural drawing techniques and those of engineering drawing will be addressed later in this and subsequent chapters, while the development of watercolour painting out of observational landscape sketching and surveying activities will be discussed at more length in Chapters 3 and 5.

In the meantime, let us contemplate this ideal machine as it has been delineated. The applied colours have a dual function; they are symbolic, but they are also derived from observation, so they give an appearance of verisimilitude. The paint is applied in washes to give the illusion of light falling from the upper right hand corner, with gentle reflectivity on the cylindrical forms and applied shadows that help to push the projecting forms out towards us. There is even a suggestion of reflected light on the averted left face of the projecting short cylinder in the lower right-hand corner that suddenly superadds the complete apparatus of three-dimensional illusion in this small area of the image. The use of muted colours, unemphatic contrasts, and the softened edge to the shadows creates a calm sense of slightly diffuse light bathing the forms, heightened by their isolation on the white page. The two juxtaposed images present two views of the same mechanism, rotated through 90º, and we can see faint traces of the ruled guidelines that have been used to project and connect the forms across the page. This image explains a complex mechanism, but it also places it passively and obediently under scrutiny in a way that contrasts with its energetic function. The drawing displays the kinematic qualities of the machine but it tells us nothing about other important factors, such as strength, substance, or other qualities of materials. And despite Watt's many experiments on heat (Marsden 2002: 51-55; Miller 2009), none of this is explicit in these technical drawings.

The atmosphere in this image is equally at odds with some verbal descriptions of the steam engine from around the same period, for example, in Rees' *Cyclopaedia* where we read: 'the force of the steam-engine is derived from the property of water to expand itself, in an amazing degree, when heated above the temperature at which it becomes enlarged into steam… in this state the steam will exert a proportionate force or pressure to burst open the sides of the vessel in which it is retained' (Rees 1819 article 'Steam engine' Vol. XXXIV). Equally the *Edinburgh Encyclopaedia* (1830, Vol. 18) article on this subject opens with a striking image from the Marquis of Worcester's 1663 proposal for: 'an admirable and most forcible way to drive up water by fire'. In reading Boulton & Watt's chaste image, should we then conclude that technical draughtsmanship was therefore unconcerned with apt expression, or on the other hand does it show a calculated exercise in the anti-sublime (Nye 1996: xv-xix) in which this engine was carefully presented in order to emphasise that the terrifying forces of nature could be controlled through reason and the works of man? Moreover, if we remember that these engines were successful because of fuel efficiency, underlined by Boulton & Watt's 'unusual payment arrangement' (Roll 1930: 26) in which customers paid one third of the calculated savings in fuel over previous engines, then the frugality and restraint of the image can seem very carefully judged.

In the varied examples of the technical drawings reviewed so far, there are some shared characteristics. There is a self-imposed sparsity of procedure in terms of quality of line, compositional layouts and the use of conventional notation that might lead to the judgement that this style lacks any aesthetic. In contrast to the unpredictable uses of line and composition we might look for in artistic drawings, these technical drawings produce an effect of uniformity and easy comprehensibility. We can see this at work at every level. If we take just a small detail, such as the markings used to indicate a section cut through matter in Figures 1 and 2, the diagonal ruled hatchings deflect prolonged inspection due to what Gombrich (1959: 181) has called the 'etc. principle'. Although these visual characteristics could allow us to interpret technical drawing as an inexpressive and inartistic convention, in context such quietness is rhetorical, a deliberately achieved persuasive and aesthetic effect that had just as important a role in this convention as the functional.

The few examples shown in Figures 7-10 demonstrate some of the variety in the extensive Boulton & Watt collection. Is this enough to support the claim that Watt's use of drawing was innovative and exemplary (Richardson 1989: 227-233), or even, on the basis of priority, that he was the originator of current day engineering drawing practice (Richardson 1989: 149)? Some support comes from Hills who argued that Watt's familiarity with the material operations of drawing instruments infused his thinking both as a mechanical inventor and as a draughtsman. He saw a thread leading from his early working life as an instrument maker in Glasgow when Watt invented a conveniently portable version of a 'perspective machine' around 1765 (Hills 2002: 109-111) that allowed the user to make a rapid transcription of a scene directly from observation in fixed-point perspective. At the end of the 1760s Watt worked as a surveyor and civil engineer and produced observational drawings using the drawing aid he had invented (Hills 2002: 191-293). Furthermore, looking forward again, Hills also suggested (2002: 109) that Watt carried over the action and form of his perspective machine into the parallel motion mechanism he developed for rotative steam engines in the 1780s.

Equally, when Watt joined his business partner Boulton in Birmingham, he entered into an already established culture of drawing for manufacturing (Figure 11) with high cultural affiliations (Quickenden 1980: 274-94; Richardson 1989: 90; Goodison 2009: 31-40) resulting from Matthew Boulton's campaign to obliterate the hitherto poor reputation of Birmingham-made goods until the 1760s. Boulton's strategy had strong reliance on visual communication, recruiting architects such as Robert Adam or William Chambers as designers in order to attract fashionable and wealthy customers (Loggie 2009: 23-30).

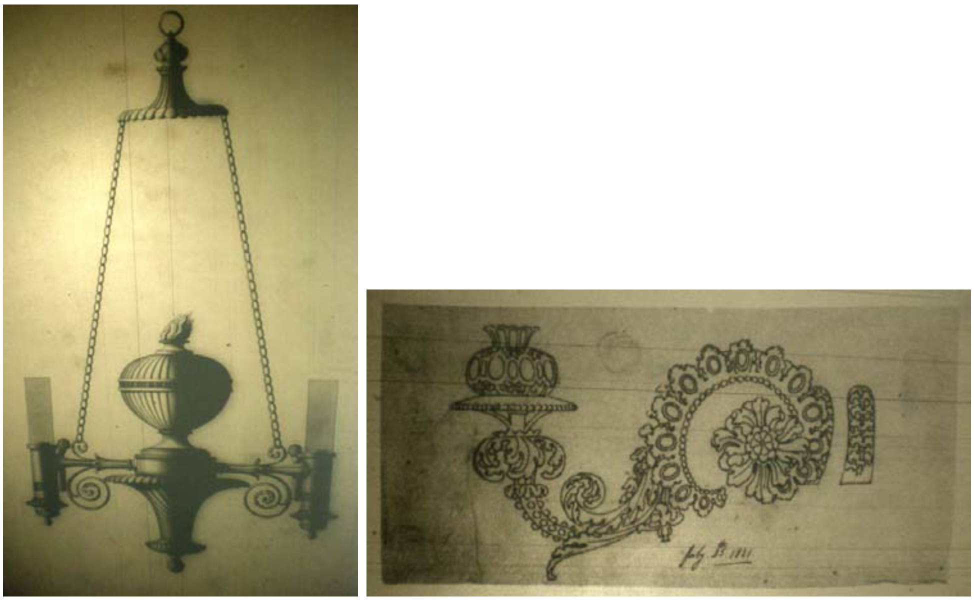


Figure 11: B&W MS3782/21/7 Examples of designs from the Boulton pattern books

Once Boulton & Watt's engineering concern was established in 1775, Watt worked initially as a consultant, so that the only material products changing hands between Boulton & Watt and the customer were drawings, produced by Watt himself until around 1782. Indeed, until that date, Watt had been reluctant to share the drawing work (Richardson 1989: 130). Watt's fears of other draughtsmen had been inflamed in 1777 when William Playfair (1759-1823), briefly hired to help in the drawing office, had failed to meet Watt's exacting standards (Baynes and Pugh 1981: 63; Pollard 1965; Wainer 2005: 21). Pressure of work eventually led to John Southern being employed as Watt's draughtsman in 1782 (Richardson 1989: 130). Later still a drawing office with assistant draughtsmen was established in 1790, designing for both outside contracts and for production at the Soho Manufactory from 1795 onwards (Richardson 1989: 198-220), adding its own substantial share of visual material to the Boulton & Watt archive (the workings of this office, and the aspirations of its draughtsmen will be considered in Chapter 6).

Muirhead's three-volume memoir *The origin and progress of the mechanical inventions of James Watt* included an anecdote about how in 1784 Watt urged a Mrs. Campbell to train her son in drawing if she wanted him to be an engineer (Muirhead 1854 Volume II: 185-8). This advice was given when Watt and Matthew Boulton were educating their own sons, when they imposed on them a varied and demanding programme of drawing that included elements described by Matthew Boulton as: 'fancy, architecture and perspective' (Musson and Robinson 1969: 201-12) as well as mechanical and geometrical drawing. All these different instances of Watt's involvement in drawing throughout his life show that he not only considered drawing to be an important element of engineering work, but that his desire to control a systematic industrial organisation consciously included drawing production.

But although it is certainly true that Watt and his partner Boulton both had a developed interest in drawing and the uses of drawing in industrial production, Richardson's claim for the pre-eminence of Watt is exaggerated. It discounts the partnership with Boulton and Boulton's deliberate and established policy of using visual means to build the high cultural profile of the company. Richardson's emphasis on priority is also too simplistic, as it assumes that technical drawing was one universal system, with just one inventor, whereas there were instead competing networks and schools of practice whose uptake was dependent on specific context, not on chronological order. We have also seen that Watt was increasingly reliant on assistants in the drawing office. Equally, questions of priority are connected with an assumption that the history of any cultural endeavour such as art, science, or technology should be seen as a succession of uniquely inspired individuals. This approach has been under attack for decades, with the cultural status of canonical figures such as James Watt, as already noted, attracting particular critical attention (Macleod 2007). Finally, asserting priority is a diversion from more urgent questions such as how exactly Watt's drawing style was disseminated (this has not been addressed by Richardson or his predecessors).

Other historians of technical drawing describe the emergence of an engineering genre around 1800 with little, if any, reference to Watt. Booker (1979), for example, presented the history of technical drawing as a much more diverse range of differing styles and influences developing in both Britain and France. While he acknowledged the work of James Watt, Booker's attention to the mechanisms of dissemination (such as educational institutions) resulted in his proposing two entirely different 'originators' of technical drawing who used different visual conventions from Watt: Gaspard Monge (1746-1818) in France and William Farish (1759-1837) in Cambridge. Their alternative drawing systems of descriptive geometry and isometric projection will be addressed in later chapters. Celina Fox, who set out to celebrate even-handedly a wide range of 'late eighteenth-century surveyors and engineers [as] the true heirs of Francis Bacon' (Fox 2009: 45) examined the drawings of John Grundy, John Smeaton, and James Watt (Fox 2009: 83-109) in a suite amongst other examples of the work of ironmasters and naval architects of the period. In relation to constructing a history of technical drawing, there are therefore other locations and practitioners to consider, many working before James Watt's time. In particular John Smeaton's work as a draughtsman who contributed to the visual language of technical drawing has not been so clearly acknowledged.

John Smeaton's civil engineering work was based on early studies in water engineering and mill work, by observation in Britain and Holland, through texts such as Belidor's *Architecture hydraulique* (Skempton 1981:12) and through comparative experiments on wind and water power (Skempton 1981: 37-57) as a support to his practice as a consulting engineer. Smeaton's own characterisation of himself as a kind of draughtsman or designer is well-known: 'I receive my propositions of what they are desirous of effecting; work with rule and compass, pen, ink, and paper, and figures, and give them my best advice thereupon', and he rated the importance of drawing highly: 'the rudest drawing will explain Visible things better than many words' (Smith 1981: 219). Equally, and in similar style to James Watt, he equated his performance as a draughtsman as part of his professional self-image: 'I have never trusted my reputation in business out of my own hand… one person therefore brought up in my office is capable of making everything fair, that I am capable of producing and setting in the rough; the labouring oar, is in reality with myself' (Smith 1981: 219-20). As a consulting engineer he wrote about two hundred reports and produced over 1000 drawings, most of which are now in the collection of the Royal Society (Smeaton drawings JS/1-6). Smeaton's importance in relation to the development of technical drawing practices is that at least twenty-six reports (with engraved images) were printed and circulated, as they were schemes for public works that might be submitted to Parliament. The earliest of these printed reports is for the Calder and Hebble Navigation in 1757 (Skempton 1981: 229-30). Smeaton's published drawings and Reports were to become famous and highly sought after by later engineers, in the absence of other textbooks, right through to the 1830s (Chrimes 2003: 39). Furthermore, as I describe in Chapter 7, mediated versions of Smeaton's drawings, often without acknowledgement of source, circulated widely as nineteenth century technical illustrations (Skempton 1981: 244-5).

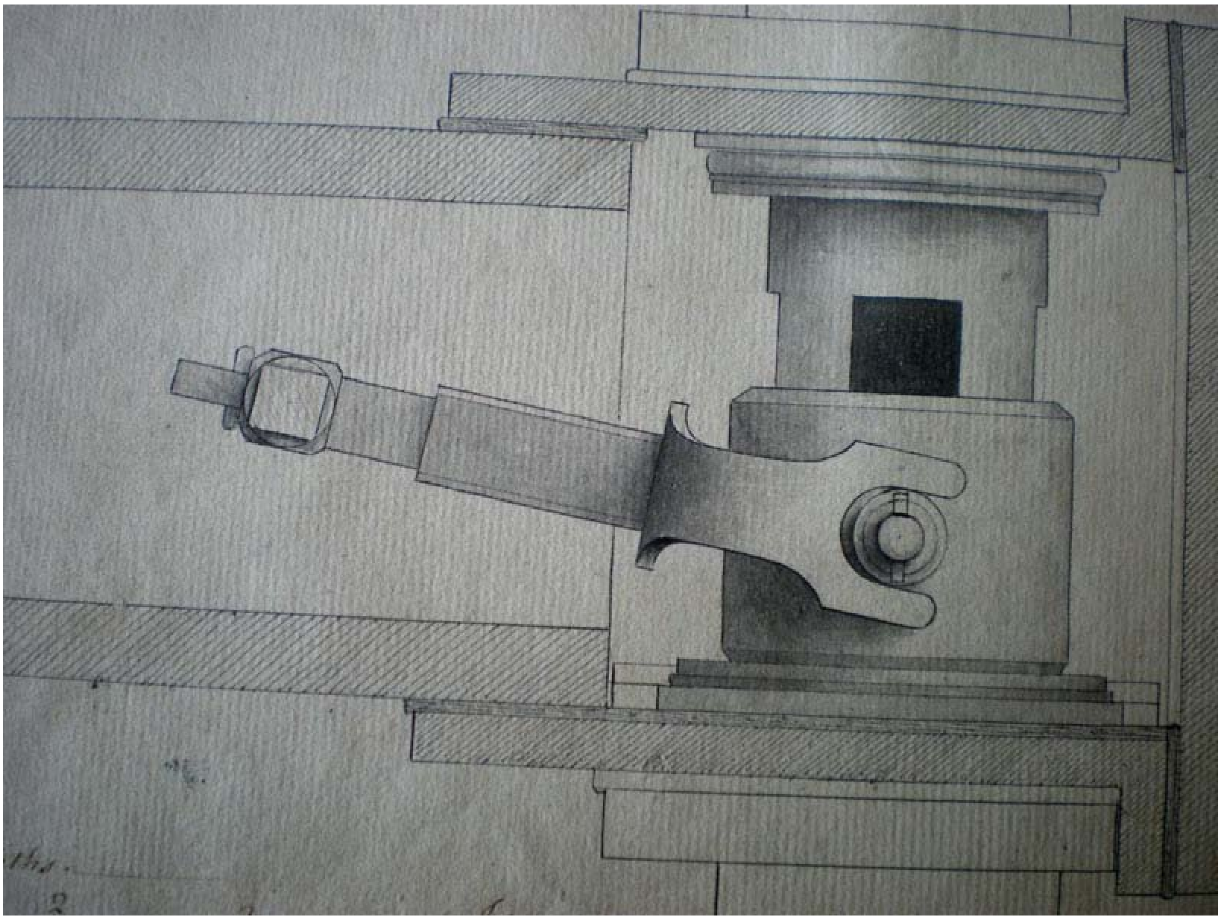


Figure 12: Royal Society Smeaton drawings JS/2/194 detail of Lord Irwin's engine, 1769

Smeaton's drawing of 1769 (Figure 12) is similar to Watt's drawing for Bradley Forge of 1782 (Figure 10), with a lucid linear style embellished with unemphatic graded watercolour washes that create the illusion of solidity through shadow effects. Figure 13 of 1771 (with detail in Figure 14) by contrast has more of a dramatic and even narrative structure, achieved through bolder contrasts. The shadow effects have been applied in a streaky expressive way, and the way in which the shadowed details are framed by plain unembellished rectangular structures emphasises the effect of peering into an aperture at a hidden mechanism. Although both of Smeaton's drawings in Figures 12 and 13 demonstrate the use of mechanical drawing aids (compass, curve and rule) in their appearance, in Figure 13 the spare lines have been set against more stormy and pictorial markings that perhaps serve to announce that the circular sweep of the draughtsman's compass has a direct mechanical relationship with the rotating action of the windmill.

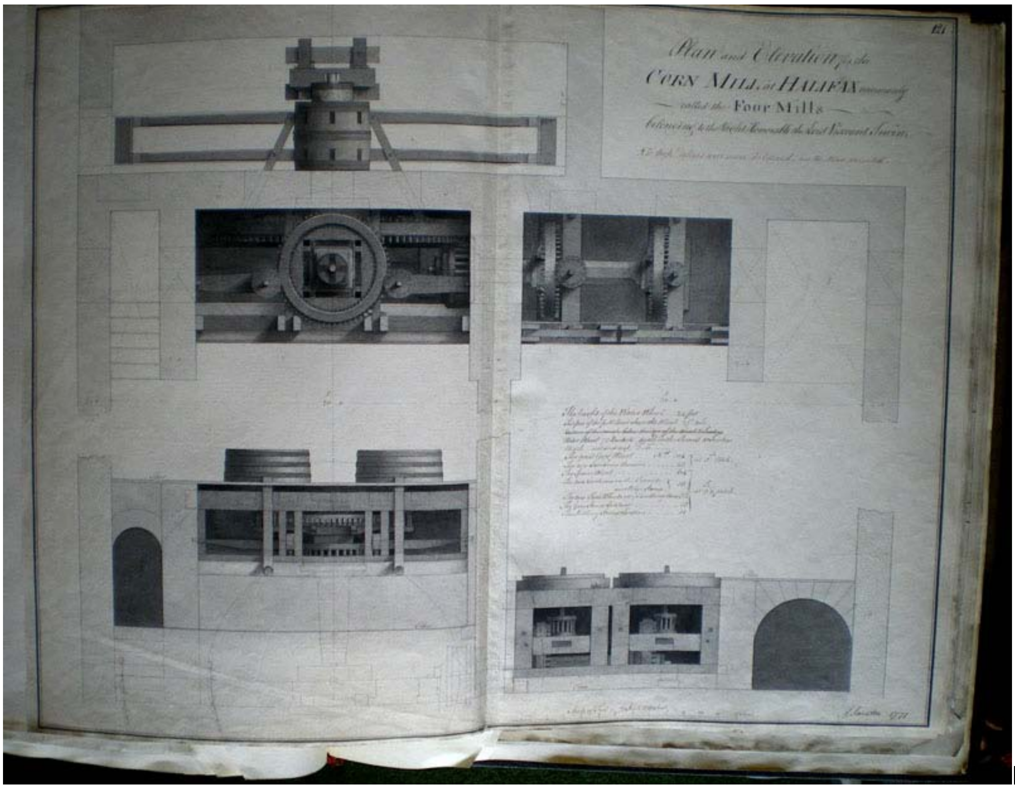


Figure 13: Royal Society Smeaton drawings JS/1/121 Chimney wind mill for the corn mill at Halifax, 1771

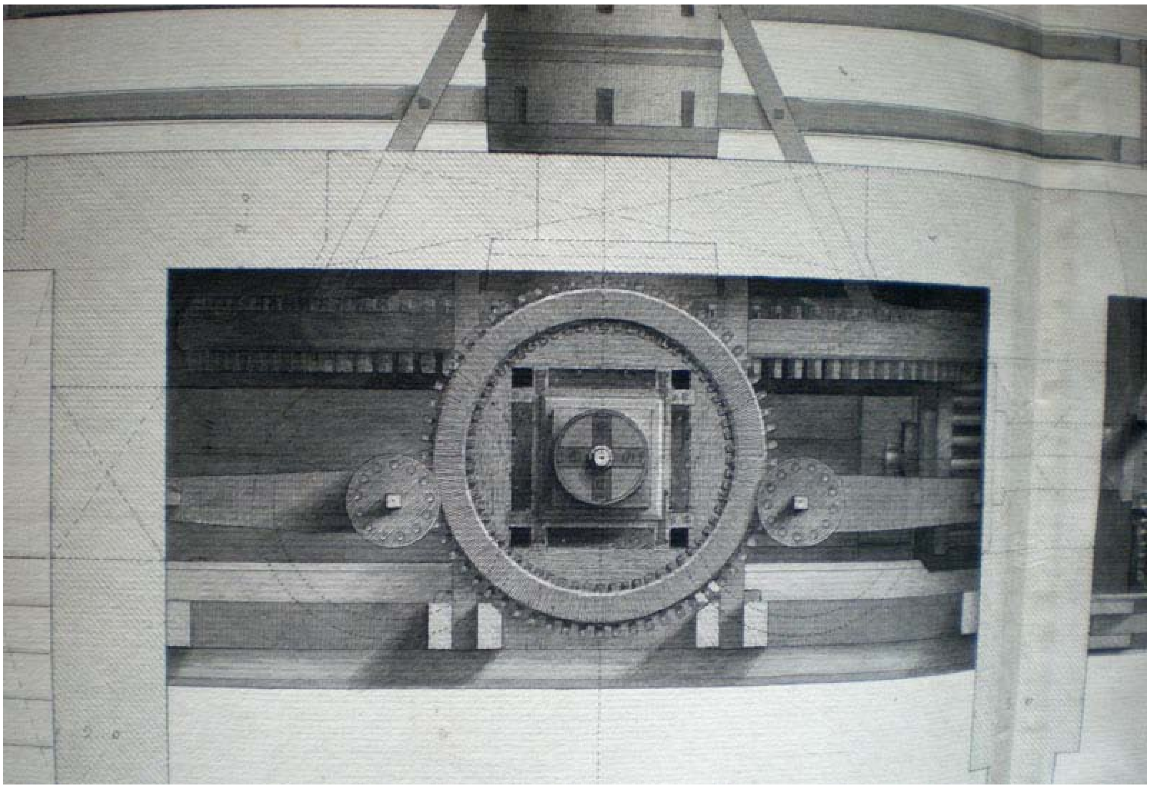


Figure 14: Royal Society Smeaton drawings JS/1/121 detail of figure 13 *above*

Smeaton's drawings were disseminated in his lifetime as engravings in the Reports, and were also re-drawn and re-presented as technical illustrations in nineteenth-century publications, to be discussed in Chapters 5 and 7. For the present, these examples demonstrate that in the decade before the beginning of the Boulton & Watt partnership, Smeaton's drawings made use of the similar range of conventions as those of Watt, but also show some additional expressive strategies. Furthermore, Figure 12, which is most like Watt's presentation drawing of 1784, is the earlier, which might contradict any suggestion that visual sparsity denotes a progressive or modernising tendency.

In summary, the Boulton & Watt archive has many examples of mechanical drawings for engineering. But even in the practice of one person, James Watt, there were different modes of visual presentation for different ends. As will be shown in Chapter 6, those modes expanded again when the company began to take on draughtsmen in its drawing office after 1790. Looking at other sources and examples of drawing for the mechanical arts (Fox 2009), armament production (Alder 1997), naval shipbuilding (McGee 1991) and also, most importantly for architecture (at the end of this chapter), it is also evident that Watt's drawing style did not suddenly spring into being, but developed from a common background. The high visibility of Watt's drawings can in part be attributed to the fashioning of his cultural prominence, to the availability of the archive, or perhaps even more to the availability and elegant appearance of his drawings in reproduction in Baynes and Pugh's handsome publication (Baynes & Pugh 1981: 61-9). In relation to the development of technical drawing, a further question is raised as to why Watt's drawings have been more discussed and reproduced than those of Smeaton. One possibility, that I will return to in Chapter 7, is that Smeaton's drawings are perhaps accorded less 'authenticity' due to an art historical notion of provenance. In comparison to the stability of location, and the cross-referencing available across the Boulton & Watt drawings to the letters, the Drawings day book and other sources in the archive, the Smeaton drawings have a more compromised history.

Finally, before moving to discuss the Royal Academy in London, let us note the effect of the 'artworlds' of the two disciplines that have both studied the drawing practices of this period in very different ways. In the history of technology a reluctance to dwell on the aesthetic appeal of technical drawings has led to a narrow definition of what counts. For example, an essay in 1991 in *Technology and culture* featured a robust attack on nineteenth century European technical drawing practices as demonstrated in textbooks or presentation drawings. The author defined his terms in a way that excluded any aesthetic, rhetorical, or spectacular elements, claiming that any type of drawing ‘incongruous with workshop conditions’ was an ill-gotten hybrid (Belofsky 1991: 23-46). Meanwhile the standard fine art reference text of *Groves’ dictionary of art* simply does not mention any kind of technical drawing at all (Jacoby 1996: 223-230). Nevertheless, as shown, the visual practices of even the archetypal ‘hero of invention’ suggest links to a wider visual culture that will be further confirmed in the second half of this chapter.

Royal academicians: public statements and private practices

The Royal Academy in London provides a location where philosophies of art education and of drawing practice were clearly enunciated. Despite the apparent incongruity of leaping from the Soho Foundry to Somerset House, both locations have significance through their archives and their institutional status where the styles of drawing they promoted fitted in with wider professional and institutional aims. Equally, the practice of drawing was seen as central to the material productions of both establishments. And finally, if the pronouncements and policies of the Academy set out to define high culture, they have also influenced the way in which art history has been written, including associated histories of ‘taste’, art education and of drawing (Bourdieu 1993; Denis and Trodd 2000; Fyfe 2000) in parallel to Boulton & Watt’s importance in the history of technology.

In relation to other European academies of art, the Royal Academy is a latecomer. The French Académie Royale, established in 1648, had served as a model for many similar foundations across Europe and its satellite territories in the New World by the mid-eighteenth century (Wine 1996: 104-5). The foundation date of the Royal Academy in London in 1768 has provided recent art historians, following the methods of cultural studies, with a charged local context, ranging from the politics of culture in late Hanoverian Britain (Hoock 2003: 9-10), to the development of discourses of ‘correct taste’ and the separation of public and private spheres (Barrell 1992; Solkin 1992), or the development of consumer society in the shadow of the industrial revolution (Bermingham and Brewer 1995). But even in this expanded field of art history that embraces a wide view of visual culture, the relationships between technical and artistic conventions of drawing, connected with this institutional framework, have only rarely been juxtaposed.

The Royal Academy was an autonomous society intended to educate and support professional artists under the patronage of George III. The terms of the charter stipulated that Academicians had to be ‘artists by profession at the time of their admission, that is to say, Painters, Sculptors, or Architects’ (Hodgson and Eaton 1905: 345-6). Hoock claims this foundation was the marker of cultural change in Britain, when professional fine art practice began to be defined by opposition to both amateur interest, and to useful or purely decorative arts (Hoock 2003: 7). The Royal Academy was also the location of art education, and through its yearly public exhibitions, of audience formation. All these elements continued to develop as already noted, through the nineteenth century. Even around 1800, although the Royal Academy was ‘autonomous’, former students found it easier to move into official Government posts for artists such as draughtsmen on Admiralty expeditions, engravers to the Mint, or as surveyors (Hoock 2003: 61; 252). In this chapter these references serve to indicate some aspects of ways in which the Royal Academy has become a focus in the artworld of art history. Future chapters will return to questions of the development of state policy for art education, the visual display of culture, and formation of draughtsmen for technical and practical applications.

Some of the educational philosophy of the Academy can be seen in the proposed teaching curriculum. In 1768 four professors were appointed: of anatomy (William Hunter 1718-83: Brock *ODNB*), architecture (Thomas Sandby c.1723-97: Herrmann *ODNB*), painting (Edward Penny 1714-81; Solkin 1993: 199-213) and finally of perspective and geometry (Samuel Wale c.1721-86: Sullivan *ODNB*). The first professor of sculpture, John Flaxman, was not appointed until 1810 (Hodgson and Eaton 1905: 348-9), and some categories of artist were excluded, such as watercolour artists and ornamental artists and designers (Hoock 2003: 32), or in the case of engravers were set apart in a ‘junior corps’ (Fyfe 2000: 108) with no voice in the institution.

In Carl Goldstein’s (1996) account of drawing theory as it was incorporated in the teaching programme, the Royal Academy followed the French academic model. Here drawing was taught in progressive stages with the aim of mastering representation of the human figure. The student began with copying from ‘the flat’ (exact copies, including every mark made in the original, of drawings and prints as in Figure 15), moving to copying plaster casts of antique statues, and then eventually graduating to the life class (Goldstein 1996: 54; Boime 1971: 24-5; Elkins 2001: 16-27).

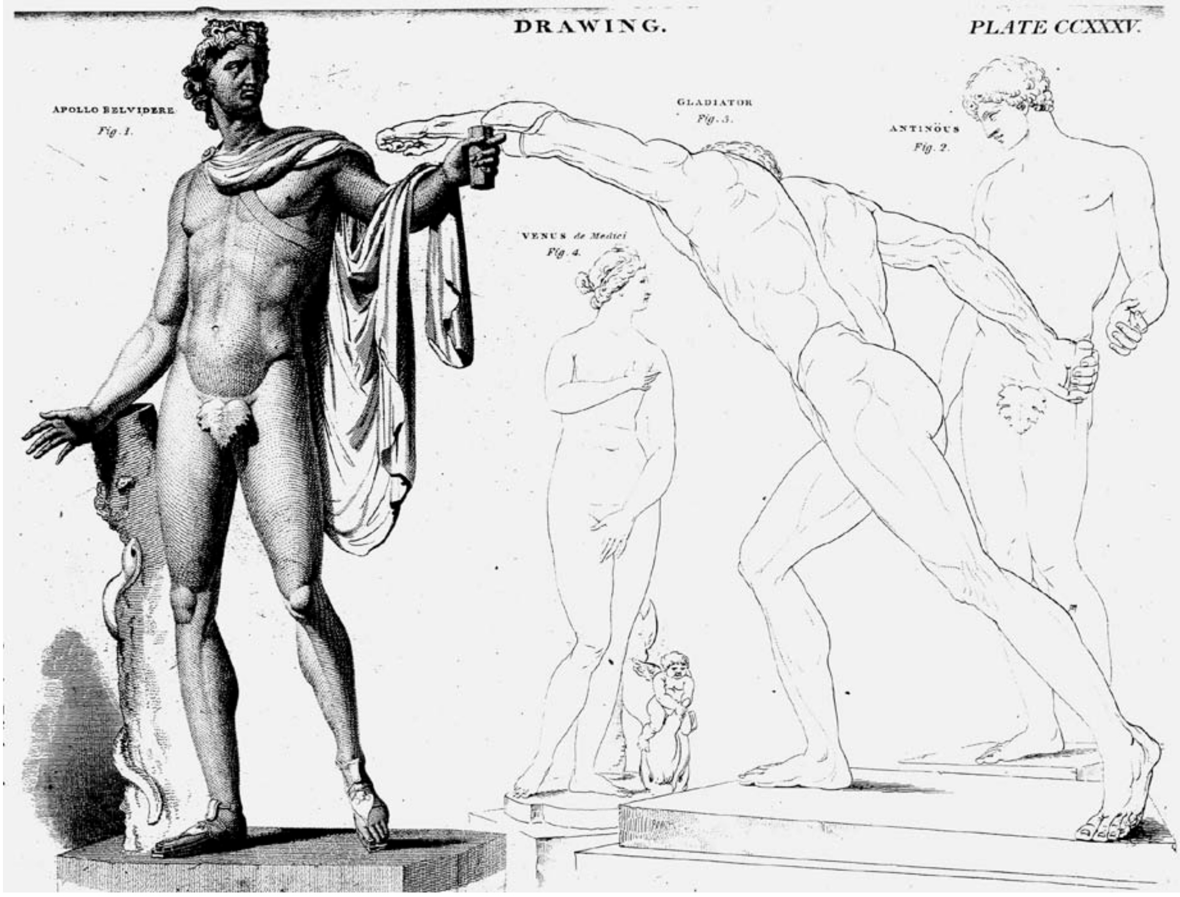


Figure 15: Figures from the antique designed and etched by P. Gibson for the *Edinburgh Encyclopaedia* Plate CCCXXV (1830 Vol. 8: 235)

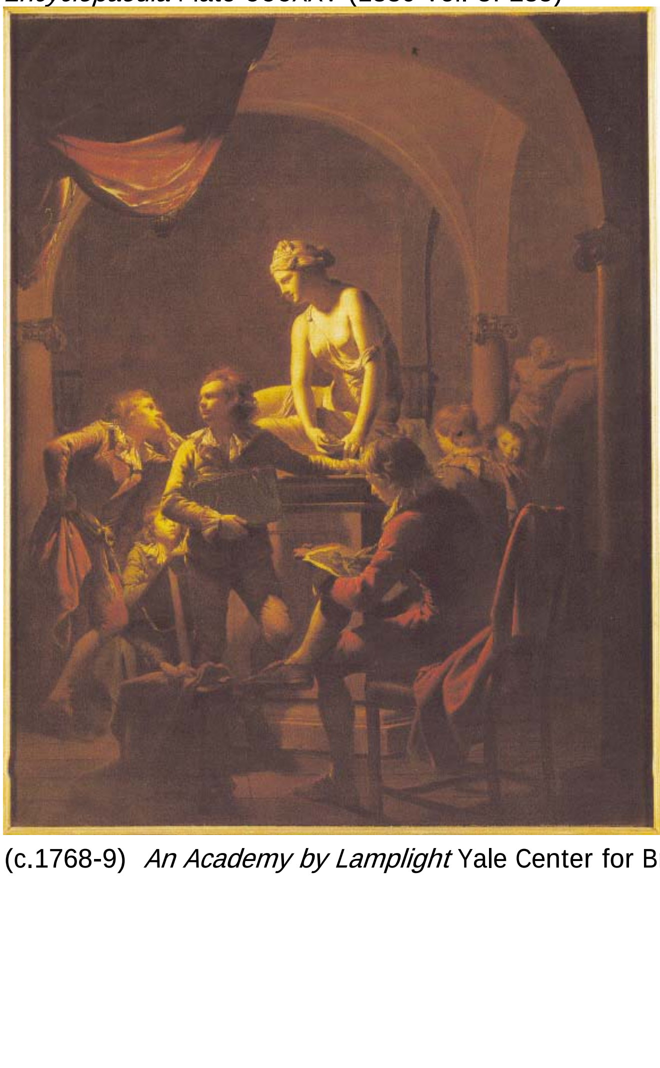


Figure 16: Joseph Wright of Derby (c.1768-9) *An Academy by Lamplight* Yale Center for British Art, Paul Mellon Collection

Despite the staged nature of Figure 16, this painting by Joseph Wright of Derby conveys some of the emotional rationale behind this method of teaching, with students in early adolescence being brought into the orbit of revered classical culture. In the late eighteenth century the limited but common repertoire of technique and subject matter imparted through all European-influenced academies has been described by some scholars as part of Enlightenment 'cosmopolitanism' (Craske 1997: 90-4). Academic technique was largely demonstrated through the production of tonal drawings on paper, and all students followed this two-dimensional programme in the formative stages. Indeed, even at the end of study, sculpture competitions were typically executed in bas-relief. Even when sculpture students made fully three-dimensional figures they used a graded progression from two to three dimensions because the final desired form would be broken down into four faces so that the profile outline could be marked on each outer face of the uncut marble block. Goldstein argues from examples like this that the drawing curriculum and its specific procedures were hence central to the practice and also the philosophy of the art practice as conceived by the Academy. In his opinion, drawing, as a common language, was seen as the basic 'material' of art that elevated the practitioner into a theorist with the result that: 'all questions of materials and procedures were marginalized' (Goldstein 1996: 254). In this manner, a sculptor, an architect, or a painter could each design (that is, make a drawing of) a mural, a medal, or a relief, or a building, leaving the details of execution to skilled workmen.

To augment his account of the role of drawing, Goldstein also pointed to the 'centrality' of Reynolds's *Discourses* on art (Goldstein 1996: 57-8). These texts were public lectures given by the first President of the Royal Academy, Sir Joshua Reynolds (1723-92 Postle *ODNB*) between 1769 and 1790, and available in print from 1797 onwards (Wark 1975: i-iii). In *Discourse I*, Reynolds insisted that an Academy dedicated to the Polite Arts could never flourish if founded on 'merely mercantile considerations'. At the same time, he warned future students against any flashy 'facility in composing', because 'labour is the only price of solid fame'. *Discourse III* of 1770 outlined the principle of 'Beauty, obtained out of general nature, to contradict which is to fall into deformity' – meaning that the artist ought to reduce the variety and particularities of nature to a single ideal or archetypal form that had balance and symmetry. Once the student had grasped a clear idea of this beauty, he ought to 'exhibit distinctly, and with precision, the general forms of things', that in turn would lead to 'a firm and determined outline' that would display 'knowledge of the exact form which every part of nature ought to have'.

Reynolds, a painter, wished to establish a British school of art that would produce History paintings, large-scale elevated public work expressing a tragic or ethical conflict, usually on a theme taken from classical or biblical literature. Solkin has described this as the ambition to create a 'truly civic form of two-dimensional imagery', intended to raise viewers' awareness of shared interests so that they would in theory reflect on how best to promote the general good (Solkin 1993: 3). Hence a subject from Roman history, *Agrippina landing at Brundisium with the ashes of Germanicus*, as exhibited by Benjamin West (1738-1820) in 1768, would, it was hoped, arouse socially-directed sentiments of 'compassion for unhappy virtue' (Solkin 1993: 187-9). To advance the style he felt was most suited for this, Reynolds advocated the reduction of visual expression to clear, discrete elements; partly, as we have seen, through the firm outline rendering of those forms nature 'ought to have', but also through the grandeur of 'distinct and forcible colours' (that is distinct primaries of red, blue and yellow –*Discourse IV*), and also through centring the composition around one principal figure (*Discourse VII*). Even in this brief outline, Reynolds's ideas are very familiar to art history, and Goldstein argues that the 'centrality' of the *Discourses* is confirmed by the fact that, when other academicians such as Barry or Fuseli lectured, their observations were in substantial agreement with them (1996: 57-8). But equally, in the very general abstract terms favoured by Reynolds, his stylistic prescriptions might also seem to apply clearly to technical presentation drawings as shown in the example at Figure 10: clear, ideal forms delineated with firm and determined outline, unambiguous use of discrete colours, and a concentration on one principal focus of interest, suggesting shared aims between styles of technical and fine art representations that were allegedly most separate and distinct.

The centrality of Reynolds's doctrines can be disputed. Official policy is not the same thing as actual practice. If we look at the cohort of founder members (Hutchison 1968: Appendix B), we can see that although more than twenty of the forty founders were painters, only a handful such as Reynolds, Benjamin West, and Edward Penny aspired to history painting, while the remainder worked in a range of genres of lower status in the academic hierarchy, such as those of portrait, landscape, topography, flower-painting, illustration or scenic painting, and extending down to what has been described as the 'artisanal' work of Peter Toms (1728-77) the drapery painter, and

John Baker (1731-1771) coach painter (Hoock 2003: 32). Non-painting academicians, that is sculptors, architects and draughtsmen such as William Chambers (1722-96 Harris *ODNB*), Thomas Sandby, Joseph Wilton (1722-1803), carver of State Coaches, and Samuel Wale, draughtsman and illustrator, incorporated an even greater range of artistic and design procedures into their normal practice. And as the Academy developed, the content of the yearly public exhibitions at Somerset House from 1780 onwards, and the outside activities of academicians, show that Reynolds' aims would never be realised. Artists continued to work at other genres such as portraiture, panorama design, monumental sculpture, and decorative design for craft and industry (Pointon 2001; Bermingham 2001; Yarrington 2001), showing that official programmes could not dictate actual practice, which was various.

Furthermore, the Royal Academy promoted other modes of drawing beyond those derived from academic study in the life room. As noted, one of the first professorships was in perspective and geometrical drawing. This reflects the 'surge' in perspectival theory and practice in eighteenth-century British culture noted by Kemp (1990: 148), and demonstrated by published works such as Brook Taylor's *New principles of linear perspective* (1719) or its successors such as Joshua Kirby's *Dr. Brook Taylor's method of perspective made easy* (1754) or later Thomas Malton's *A compleat treatise on perspective in theory and practice on the true principles of Brook Taylor* (1775; Kemp 1990: 148-54). Thomas Malton (1726-1801 Saunders *ODNB*) aimed his treatise at interested individuals, but he also hoped to exploit the importance given to his subject through the curriculum of the Royal Academy. The majority of examples in Malton's treatise are concerned with pictorial linear perspective: that is, with illusionistic creation of three-dimensional objects and spaces. Plate 34 from Malton's treatise (Figure 17) demonstrates perspective renderings of carriages and machines, that, comments Kemp, 'provides clear demonstrations of the value of perspectival draughtsmanship to those working in the field of applied design and engineering' (Kemp 1990: 156).

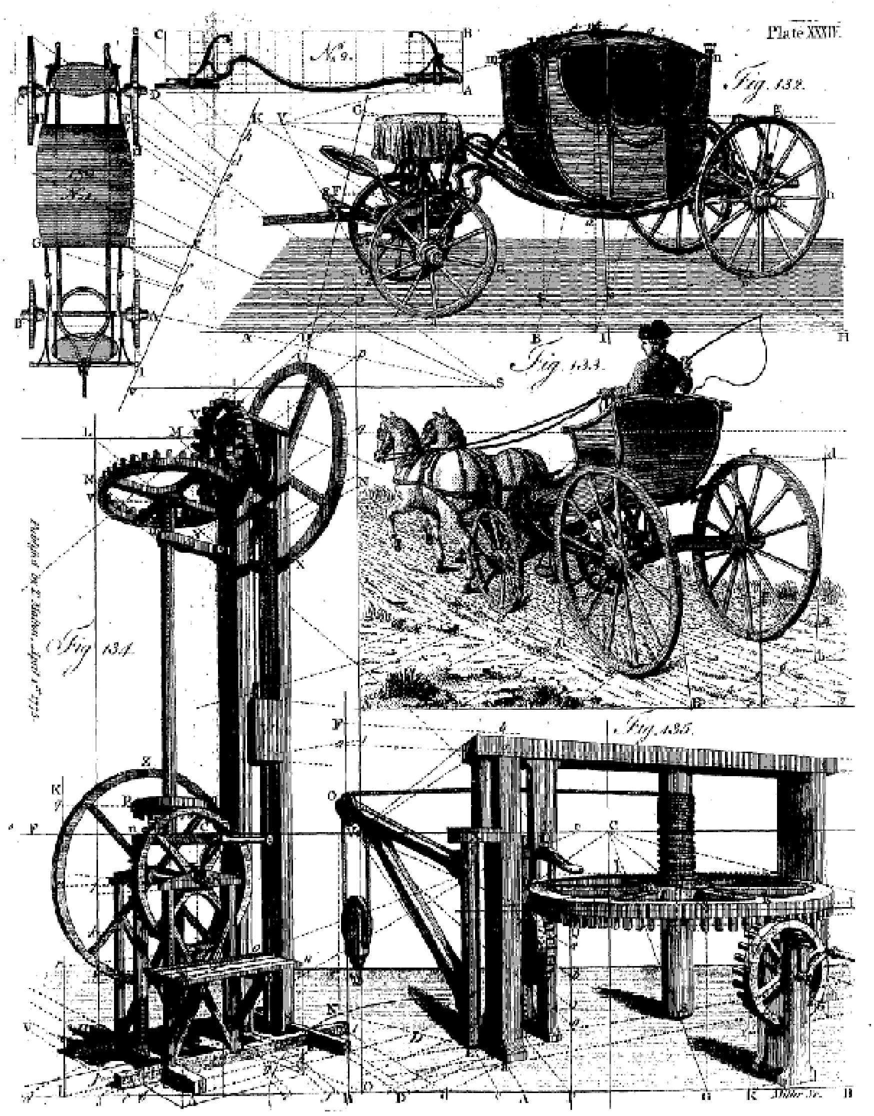


Figure 17: Thomas Malton (1775) A treatise on perspective, in theory and practice: on the principles of Dr. Brooke Taylor... in four books... Plate 34

Kemp's somewhat throwaway comment, in the midst of a discussion of perspective teaching in the orbit of the Royal Academy (Kemp 1990: 154-62) is more significant than it appears, mainly because of what remained unsaid. In relation to the useful arts (described somewhat anachronistically by Kemp as 'applied design and engineering'), the type of pictorial perspective seen in Figure 17 was certainly used around 1800 and through into the nineteenth century in illustrations of machinery (just as it was also used elsewhere to illustrate for example architectural and topographical views). As will be shown in later chapters, this form of perspective was important as one mode of technical drawing in images that promoted and illustrated the mechanical arts, especially through print. But other modes of technical drawing, such as those already seen in the examples of drawings by James Watt, used a different system of parallel orthographic projection. Because *The science of art* was not really concerned with technical drawing practice Kemp did not explore this point. But strangely, he did not relate his discussion to the fine differences of perspective conventions that were used in different factions of the Royal Academy far beyond the work of painters such as J.M. W. Turner (Kemp 1990: 156-62). In particular, examples of architectural drawings from this period use perspective and line drawing conventions in ways that challenge any account that tries to assimilate practice to a single norm.

Architectural drawing: perspectives and allegiances

As already noted, several writers have examined the close links between the working practices of architects and engineers in the late eighteenth century (Picon 2004; Saint 2007; Gerbino and Johnston 2009). As architects were included as Royal Academy members, this suggests that their occupation may have acted as a 'bridge' between techniques and training for industry and fine art. In his account of the ways in which architects and engineers in the eighteenth and nineteenth century were 'muddled up' in 'sibling rivalry' (Saint 2007: 485-8), Andrew Saint has asked how one might separate two practices that have frequently been expressed through similar drawing techniques directed at similar projects. Robert Thorne, who only saw signs of true separation between architects and engineers fairly late, in the mid-nineteenth century after the foundation of the Institute of British Architects in 1834 (Thorne 1991: 53-5), points to late eighteenth century figures such as Robert Mylne or Thomas Telford whose working practices, including drawing, supported the notion of a continuum of practice in this earlier period (Thorne 1991:55-8). One might also cite Sir William Chambers who described his work in 'engineering' terms. Chambers enjoyed high cultural status as a founder member of the Royal Academy, and was also tutor in architecture to George III (Postle *ODNB*). His publication, *A treatise on the decorative part of civil architecture* was almost exclusively concerned with expounding the detailed application of the classical decorative orders to columns, facades or the windows of prestigious buildings. Nevertheless, rousing unfulfilled expectations for the content of his treatise, in his preface he described architecture as the art that: 'builds ships, with ports and piers… forms roads and causeways in marshes and other impracticable places; levels mountains; fills up vallies [sic]; throws bridges over deep and rapid rivers… cuts canals; erects sluices; and conquers every obstacle that nature opposes to her progress' (Chambers 1759: i). Indeed, Chambers's words were echoed in Thomas Tredgold's formulation in the Charter of the Institution of Civil Engineers of 1818 when he described engineering as: 'the art of directing the great sources of power in Nature for the use and convenience of man' (Buchanan 1989: 64). In contrast to such relatively harmonious accounts of common ground between architects and engineers at the end of the eighteenth century, Gerbino and Johnston appear to fix an earlier and distinct date for the separation of architecture and engineering, which they ascribe directly to institutional factors. The foundations of the Royal Academy (1768) and the Society of Civil Engineers (1771), they argue, began a process by which 'the middle ground on which architecture had traditionally stood was slipping away' (Gerbino and Johnston 2009: 131). In short, although they differ from Thorne in choosing events that were almost a century earlier, they agree with him that institutional structures, once established, had a logic of their own in creating separate artworlds for engineers and architects.

Examination of drawing conventions used by architects within the orbit of the Royal Academy show a range of drawing techniques that call into question one single account of 'academic' drawing education while at the same time revealing an unexpected continuum between artistic and engineering styles of drawing. Architects used a wide range of drawing styles and conventions in the late eighteenth century, ranging from watercolour topographical views in pictorial perspective, through to rigorous linear renditions in orthogonal plan-elevation-section views (Lever and Richardson 1984: 18-22). Different styles were chosen for different expressive purposes, to demonstrate allegiances, and to address different audiences. For example, working drawings given to contractors, for example, were made using plan-elevation-section views (Lever and Richardson 1984: 7-8).

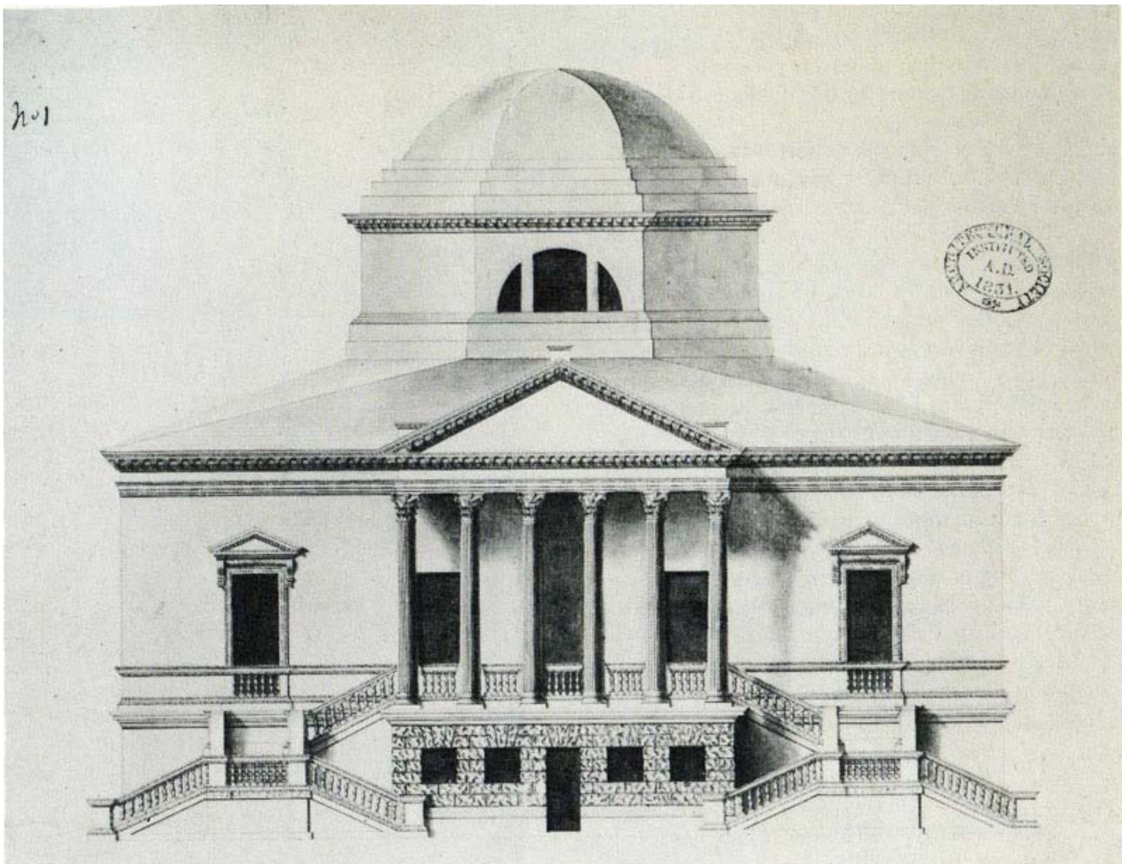


Figure 18: Richard Boyle, 3rd Earl of Burlington (1723) *Design for Chiswick House (front entrance elevation).* Pen and wash, draughtsman Henry Flitcroft (Lever 1984: 54-5)

Moreover, the face-on sparse orthogonal style was not as purely functional as this might imply, for it was also used to demonstrate allegiance with, or knowledge of, prestigious traditions. For example, the design for Chiswick House c.1723 (Figure 18) represented a move in the campaign by Richard Boyle, 3rd Earl of Burlington (1694-1753) to establish a classical architectural style derived from earlier architects that he admired, in particular Palladio, Scamozzi and Inigo Jones. The form of a Palladian villa can be seen in this design, but even as a drawing, it demonstrates its allegiance to Palladio's style of representation in accord with his belief that face-on representation was more accurate and more virtuous. All the same, some details in the drawing of Chiswick House depart from Palladio's self-imposed discipline, as can be seen in the softly-cast shadow effects on the portico area. These shadow marks are borrowed from naturalistic pictorial perspective styles in order to announce to the non-specialist viewer that the portico projects forward (Lever and Richardson 1984: 54-5).


Figure 19: Sir William Chambers (c.1751-2) *Design for a mausoleum in the form of a 'ruined' domed temple with peristyle* Brown pen and ink, grey and pink washes Lever 1984: 61)

By contrast, Figure 19, a design for a mausoleum in the form of a 'ruined' domed temple with peristyle *c.*1751-2 is an example of a drawing that despite its orthogonal face-on presentation is also infused with pictorial and picturesque characteristics. The conceit of presenting the section of a proposed new design as a ruin from the distant past asserts a playful claim that the building does not simply reference the antique style but that it is in some occult manner authentically of that time. Apart from ruled guidelines for vertical and horizontal elements and use of the compass for the dome's curves, the lines are laid in freehand with both jerky and flowing broken marks, adding a sense of naturalistic observation to an as-yet unrealised structure. Finally washed shadows add the pictorial illusion of three-dimensional form. Chambers, the architect, derived this style and the device of the ruin from the French draughtsman Charles Louis Clerisseau (1722-1820) who tutored both Chambers and Robert Adam in drawing when they were in Rome in the 1750s (Lever and Richardson 1984: 60-61).

Chambers's drawing is an example of architectural drawing whose notion of function included expressive and rhetorical aims. At the very end of the eighteenth century and then through to the present day architects would also incorporate pictorial perspective into their presentation of building designs, often to conjure an atmosphere or an environment in an expressive way. In the last few decades of the eighteenth century writers have attributed this to an increased emphasis on feeling in the polite study of architecture (Gerbino and Johnston 2009: 133) or the cult of the picturesque (Savage 2001: 204-5; Worsley 1991: 1). The Royal Academy exhibitions created new and unusual viewing conditions beyond the building site where these different strategies of representation were developed and tested. Savage has claimed that the 'problematic status' of architectural drawings became apparent in this environment, for in contrast to the actual realised works shown by painters and sculptors, architects could only show a visualisation of their idea. In order to make a bold enough statement, architects began to use strategies of juxtaposition and contrast in groups of drawings with the effect that after the first decade of the Royal Academy, the 'traditional series' of plan, elevation, and two sections were rarely shown in exhibition but were reserved for workplace and site use (Savage 2001: 201-3). Specialist artists such as J.M. Gandy or Joseph Bonomi prepared many of the most spectacular exhibition drawings (Worsley 1991:x), and Savage argues that in this context, the term 'draughtsman' came to be used as a word of exclusion by architects who now sought to distance themselves from such work as a means of seeking intellectual stature in the late eighteenth century (Savage 2001: 207)

Equally, architectural drawings had an effect on students at the Royal Academy through their display during lectures. Thomas Sandby's drawing *Design for an idealised bridge, called a 'bridge of magnificence'* (Figure 20, made about 1770) was allegedly most remarkable not for its effect in the Royal Academy exhibitions but rather in its semi-private exhibition to generations of students (Savage 2001: 213).

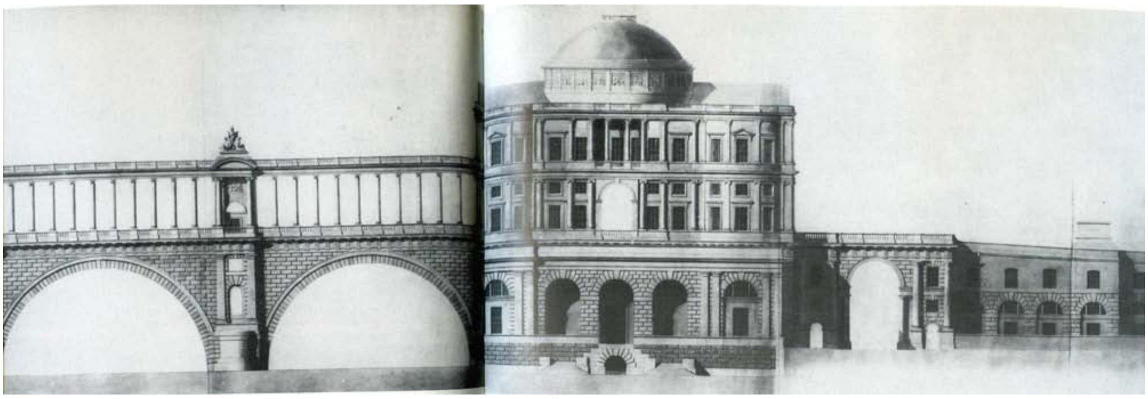


Figure 20: Thomas Sandby (c.1770) *Design for an idealised bridge, called a 'bridge of magnificence'* intended to span the Thames between Somerset House and Lambeth. Pen with blue and ochre washes (Lever 1984: 74-5)

As Professor of Architecture at the Royal Academy from 1768, Sandby delivered annual lectures to the students for almost thirty years from 1770 onwards. This enormous drawing (over five metres in length) was unfolded as an illustration to those lectures, creating a 'powerful impression', according to John Soane's recollections of his student days (Lever and Richardson 1984: 74). Together, these modes of exhibiting drawings within the orbit of the Royal Academy have been described by Savage as a means of developing a 'forum for dramatizing the nobility of architecture as a civic art' (Savage 2001: 213).

Finally architects used drawings as a means of self-advertisement in print, as with the publications of Robert Adam (Figure 21) or Sir William Chambers (see Figure XX, Chapter 6). Such texts did not simply attract clients, however, but were used as exemplars of drawing techniques and decorative details. For example, Chambers' *A treatise on the decorative part of civil architecture* (1759; especially the 'considerably augmented third edition' of 1791), and variants of Brook Taylor's treatise on perspective were among the 'key texts' used in architects' offices by pupils, according to Worsley (1991: 4). Pupils learnt by copying images from these texts, and by copying existing presentation drawings, often doing little else for the first two years of training. These methods (and indeed, the continued use of Chambers as a key text) continued to be perceived as the norm through the 1840s and on to the late 1880s in Britain (The *Builder* 11 March 1848: 130; Spiers 1887: 15). Equally, examples of work by draughtsmen in the firm of Boulton & Watt, to be discussed in Chapter 6 (Figure 80), will demonstrate that copying, for example from Chambers, also carried forward similar practices and cultural references into the visual language of engineering and technical illustration.

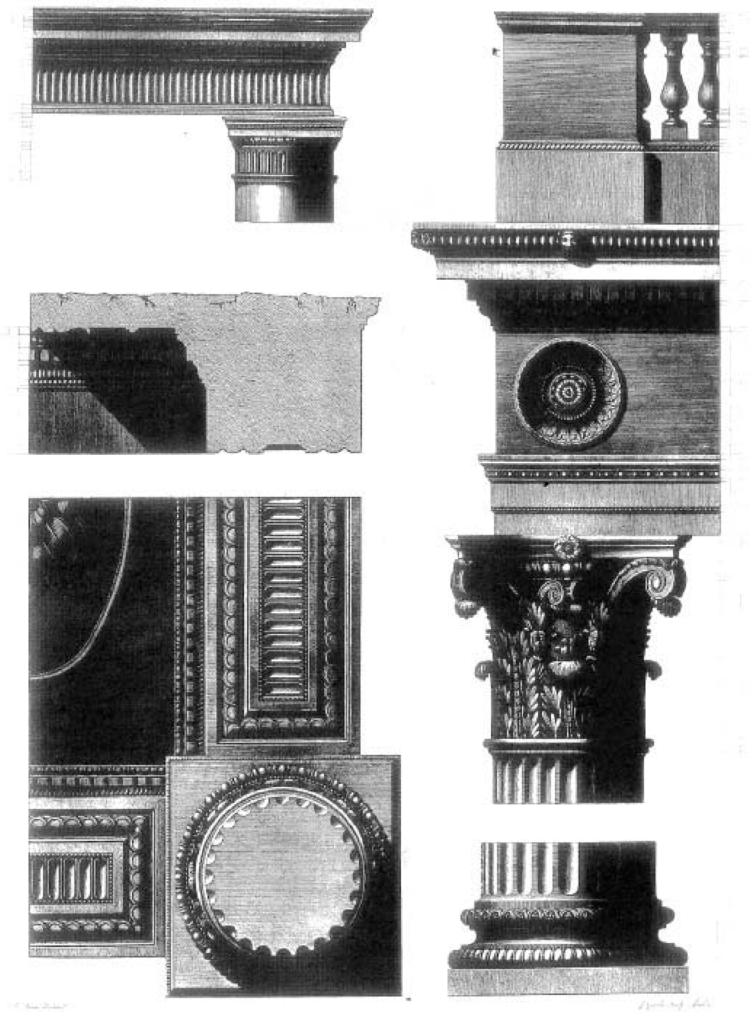


Figure 21: Robert Adam: Details of Luton Park House, Bedfordshire 1767-1775 in *From the works in architecture of Robert and James Adam* Volumes I-III from 1773-1822

Outside the public forums of exhibitions and print, as already noted, the type of working drawings that architects most frequently adopted was the orthographic style of plan-elevation-section views; these were in the majority in everyday practice (Worsley 1991: 23). Although this style has often been described as a utilitarian means of controlling the workforce on site (Lever and Richardson 1984: 7-8; Gerbino and Johnston 2009: 1; 105-9), it also remained the chosen expressive style of self-presentation for many architects. This everyday visual language, deliberately chosen, can be seen in a drawing of 1789 by George Dance (Figure 22) who was elected professor of architecture at the Royal Academy in 1798 after the death of Sandby (Bowdler *ODNB*). The drawings shown here, for the first building in the Gothic idiom in London since Wren's work in the late seventeenth century, display a section view and also details of internal timber construction (Stroud 1971: 157-8).

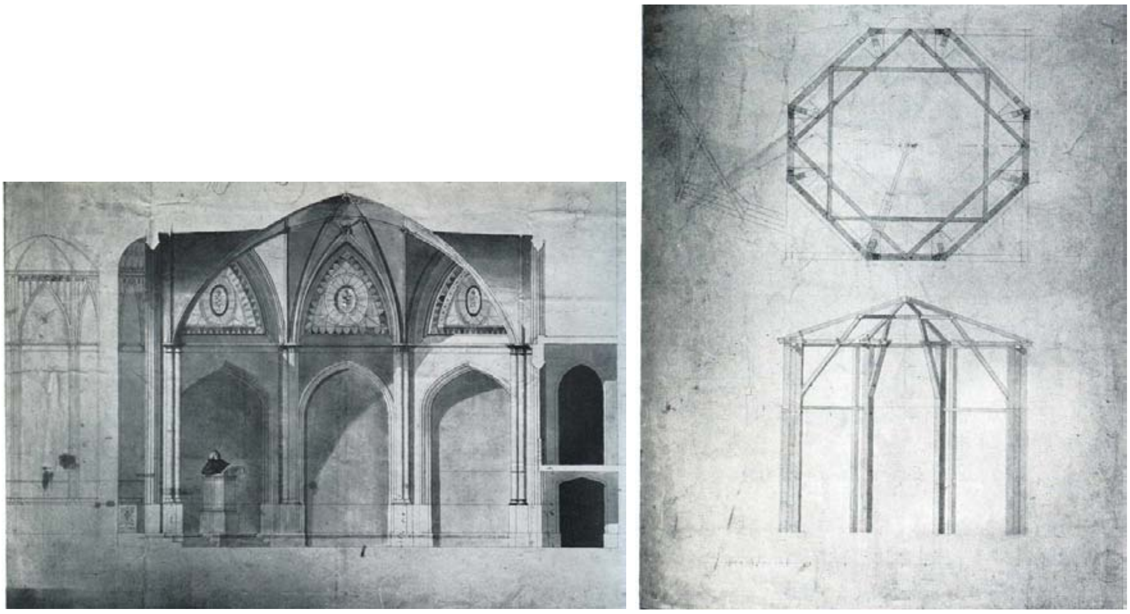


Figure 22: George Dance (1789) *St. Batholomew-the-Less, Smithfield, London (left—section and right—detail of internal timber construction)* (Stroud 1971: 157-8 and plates 52a and b)

Such expressions of everyday architectural drawing practice share similarities with those seen in technical drawings from the Boulton & Watt archive, in detailed project drawings, presentation drawings and publications. Technical draughtsmen used drawing conventions taken from architecture: the orthographic style of plan-section-elevation was the most common approach, but pictorial perspective projections were used as well, frequently in technical illustrations (Booker 1979: 39; Lever and Richardson 1984: 18-22; Evans 1995: 107-21). In terms of expressive markings, there are also many correspondences between architectural and engineering conventions, with the use of fine pen lines above pencilled guides, and watercolour washes used either schematically to denote function or materials, or to lay in shadow projections. Above all, technical and architectural drawing conventions were linked by the use of specific drawing equipment such as drawing boards, parallel rules, and T-squares (Meredith c.1790; Hambly 1988; Richardson 1989). Equipment, argues Becker, fixes the social decisions of an artworld into conventions so that they come to seem entirely natural (Becker 1982: 77). Technical and architectural drawing equipment thus generate certain families of forms both on the drawing paper and then beyond it into three dimensions. For example lines that are strongly oriented to horizontal and vertical axes seem to contain a built-in logic of orthographic projection, and beyond that, into forms that are structured around right-angled forms.

The drawing by Robert Mylne (1734-1811) in Figure 23 demonstrates some aspects of British architectural drawing practice that could indeed appear as a ‘bridge’ to engineering drawings, exploiting a systematic clarification of visual elements for graphic effect. Mylne gained status early in his career through winning the competition to design Blackfriars Bridge in 1759 (his rivals were William Chambers and John Smeaton) and his later work included surveying, architecture and water engineering. In 1770 he joined John Smeaton in founding the Society of Civil Engineers (Woodley *ODNB*). The drawing in Figure 23 is from the previous year, and shows a design for the front elevation of a house.

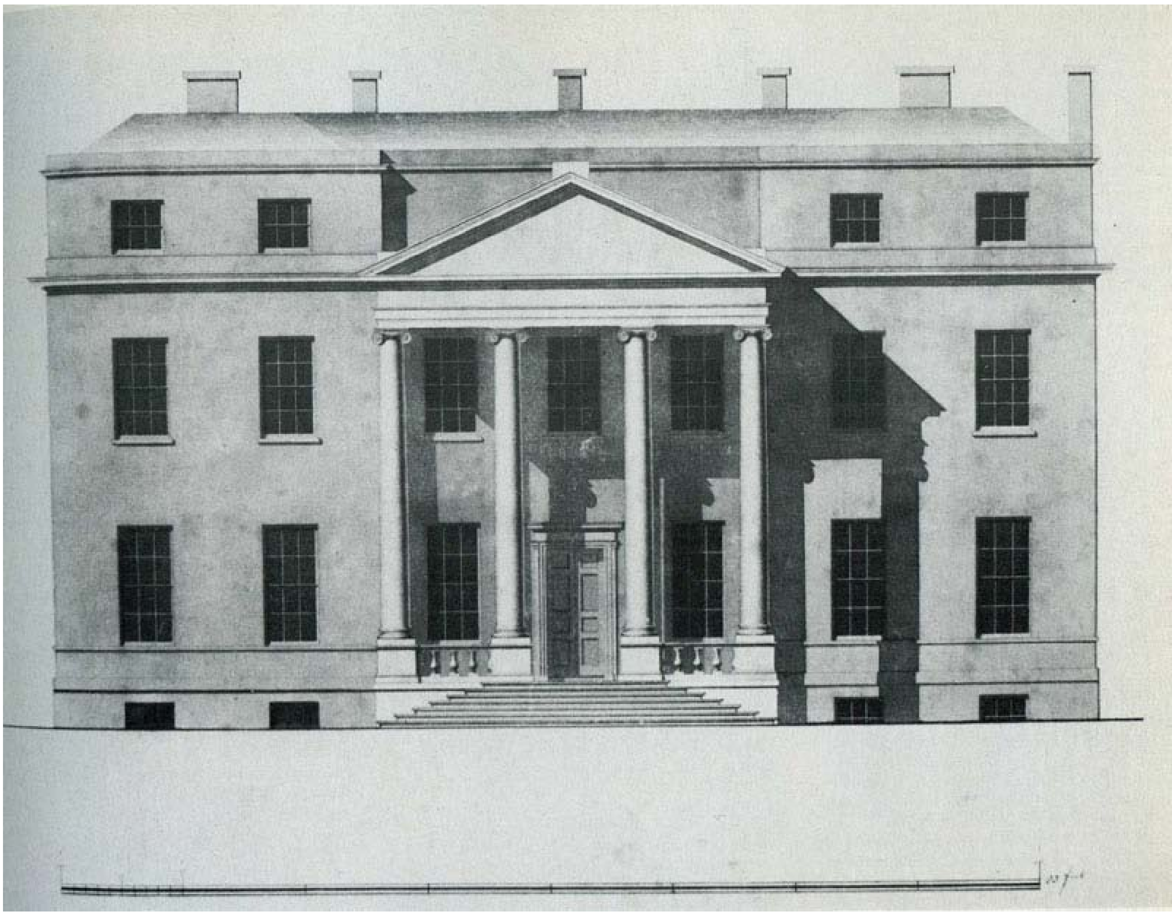


Figure 23: Robert Mylne (c. 1767) *Elevation of principal front of Wormleybury*, Wormley, Hertfordshire Pen with grey and ochre washes (Lever 1984: 64-5)

Mylne has chosen a formal and restrained mode of presentation, with the Palladian technique of an orthogonal view that is similar in effect to Burlington's design for Chiswick House seen in Figure 18. In a similar way, this view is further enlivened with coloured washes and application of shadow that deviates from Palladio's restraint. Mylne's treatment of form through light and shadow, however, is bolder, crisper, and more decisive than that of Burlington and his draughtsman. For example, a careful illusion of reflected light appears uniformly along the extreme right-hand edge of all the columns in the portico. The apparent light source, brighter and less diffuse than in Figure 18, is set at the conventional upper-left hand corner derived from academic drawing practice, but is marked in at a very clear angle of 45° and hence projects an ‘axonometric’ representation of the portico onto the building façade as shadow. Axonometric drawing (Lever 1984: 18-19) is a system of parallel projection, similar in appearance to modes of isometric drawing that will be discussed in Chapter 7. In Figure 23, shading is not simply used to denote the naturalistic appearance of three-dimensional building surrounded by light and air but also, through the neat lined profile of the strongly contrasting shadow, incorporates an additional and separate oblique view of the columns and decorative mouldings of the portico. In effect the shadow is a visual ‘double meaning’ taken from different discourses of representation, but held in place by the effective graphic design on the page. This useful trick, combining elements of the side elevation as a crisply outlined shadow projected onto a frontal view, was often adopted by later draughtsmen for technical presentation drawings.

Mylne’s architectural drawing in this example has very close similarities of treatment to the drawings by James Watt shown in Figure 10, and by John Smeaton in Figure 12. These examples of technical presentation drawings in the neo-classical period by Watt and Smeaton thus show clear allegiances to English interpreters of the Palladian style such as Mylne and Burlington. Having compared drawings of architects and engineers, and considered the networks of drawing practice in this period it is possible to suggest that far from being inexpressive or purely functional, we can see an English Palladian style of neo-classical mechanical aesthetics in technical presentation drawings in the period before 1800. Indeed, this same suggestion, couched in much more negative terms, has already been made from the opposite side of the architectural divide. When Reginald Blomfield (1856-1942 Briggs *ODNB*) the architect and architectural historian looked back in 1912 to the architectural drawing practices that had gone into his own professional formation in the nineteenth century, he reviled the influence of Palladio in England whose adherents had in his opinion spawned a ‘school of mechanical draughtsmen’ whose work had deformed looser and more pictorial traditions of architectural drawing that he found more congenial (Blomfield 1912: 72).

Conclusion

Existing narratives of drawing practice in Britain before 1800 that have been developed separately in histories of technology and art do not address the fact that in terms of actual applications, techniques, and training, there were as many similarities as differences between these two areas. The continuities of practice shown in this chapter also suggest that drawing, whether for art or industry, was the product of interconnected groups of people, and the question of how exactly the working lives of draughtsmen, designers, and engineers were negotiated in individual trajectories will continue to be addressed throughout this dissertation. The challenges raised in this chapter to established narratives and viewpoints have been generated by the simple method of juxtaposing primary evidence and later accounts from a range of sources associated with familiar examples (the archives and histories associated with the engineering firm of Boulton & Watt and with the Royal Academy) that have not previously been compared.

The status accorded to individuals such as James Watt or Joshua Reynolds in accounts of the drawing practices within the two prestigious institutions they are associated with has often obscured more interesting issues such as how, or whether, their ideas and techniques were actually disseminated, and whether they were reflected in actual practice. Further, close descriptive analysis of a range of drawings reveals a diversity of method concealed by the blanket terms ‘technical’ or ‘academic’ when applied to drawing training or techniques. Equally, although the Boulton & Watt collection of drawings extends to the 1840s, well beyond the withdrawal of James Watt from the company, most analysis of the drawings in this archive have been directed towards a description of the practice of one person, James Watt, as an inventor and creative engineer. Looking at other sources and examples of drawing for the mechanical arts and construction, it is also evident that Watt’s drawing style did not suddenly spring into being, but developed from a common background. Equally, drawing practices associated with the Royal Academy were not necessarily separate from those used in manufacture or engineering. The training of painters and sculptors in the life room included designing in ‘the flat’ in a way that shaded towards designing for manufacture, whilst the projects and drawing practices of architects and engineers around 1800 have seemed to several historians such as Saint (2007), Thorne (1991), and Worsley (1991) indistinguishable. Indeed, in analysing the drawing equipment and set-up of ‘architects’ offices’ around 1800, Lever (1991: 59-64) cited the examples of Sir John Soane’s ‘upper drawing office’ c. 1808 and James Watt’s ‘office at Heathfield Hall between 1790-1819, now installed at the Science Museum, London’ with neither explanation for the inclusion of Watt, nor any sense of incongruity.

This chapter has examined at some length the question of uncertainty about the separation of architects and engineers in order to consider their drawing practices as a ‘bridge’ between fine art and technical discourses. Close observation of drawings shows similarities of practice, but also fine differences of approach that display allegiance to different values or social networks. The signs of the development of an abstract and reductive visual language of 'engineering' that I advanced in my comparison of the work of Mylne (Figure 23) with that of Burlington (Figure 18) perhaps supports the 'institutional' explanation offered by Gerbino and Johnston (and also Thorne) for the differentiation of architects and engineers, whereby the members of professional associations police themselves into conformity. To Gerbino and Johnston, the key moment is between 1768 and 1771 and the formation of the Royal Academy and the Society of Civil Engineers (Gerbino and Johnston 2009:131). As noted, Mylne was not a Royal Academician, but instead allied himself with John Smeaton with the Society of Civil Engineers in 1770. However, although the use of visual analysis as applied to Figure 23 could be used to develop the question of professional separation further, my own interest in this analysis lies more in the way in which it demonstrates how some 'technical' visual elements in the late eighteenth century may have been developed from fine art discourses through the informed use of graphic invention, strong expressive composition and allegiance with fashionable and prestigious neo-classical Palladian styles of drawing.

In art history, the foundation of the Royal Academy as a professional association, as a site of public exhibition, and as a teaching institution frequently dominates. But even art historians who have launched critical attacks on the academy, according to Denis and Trodd, have maintained its importance. For example, earlier in the twentieth century, in alignment with notions of the avant-garde or of liberal humanism, a mythical 'Academy' was constructed as a grotesque instigator of formulaic and mechanical work, more recently, in 'new art history terms', the attack has shifted to its ideological role in producing the social structures of 'high culture' (Denis and Trodd 2000: 1). Paradoxically, these attacks have not resulted in a move away from the canon (Fox 2009:7); instead attitudes to fine art still appear naturalised enough to direct attention towards certain objects of study that are considered appropriate to the Royal Academy, for example the construction of 'taste'. Hence, Kemp's account of the 'science of art' presents a progressive narrative of perspective science that is at times as far from actual practice as Reynolds's *Discourses*. Although Kemp has (unusually) re-united material that is often broken up between distinct histories of art or science, he retains an allegiance to academic and elitist ideals, for example describing the great expansion in the volume of literature on perspective in the nineteenth century as a 'paradox' because 'leading artists' had lost interest in this area of expertise (Kemp 1990: 221). To Kemp, the practices and aspirations of the artisans and mechanics of the nineteenth century (who did read the vast literature on perspective) had no cultural significance (Kemp 1990: 227-31), neither apparently did the day-to-day practices of the majority of students who studied at the Royal Academy around 1800 as they also were not mentioned, even though these elements of drawing on the curriculum, perspective and projective geometry, informed the future working lives of former students.

Hoock tells us in passing that Royal Academy students had preference in gaining distinctly practical posts such as Admiralty draughtsmen, engravers, and surveyors to corporations, parishes, schools, hospitals, insurance and dockyard companies (Hoock 2003: 61). As the Royal Academy schools consistently accommodated around 180 students (Bell 1963: 27), this suggests that even in the sixty-year period to 1830, from the several thousand former students that had been trained in a range of drawing skills with artistic and technical applications, many may have sought to gain employment as draughtsmen or designers for practical art or manufacture. However, accounts of drawing education at the Royal Academy focus either on official policy and technique in classes, or on the working practices of the relatively few recognised artists and architects who gained recognition. It has also become apparent that accounts of drawing practices associated with the Royal Academy are not uniform. One might isolate three modes of drawing associated with academic training and practice: the discipline of the life room, perspectival and mathematical drawing, and architectural practice, although writers have often discussed only one type of drawing in isolation, considering only what relates to one specific community of fine art practice such as painting, sculpture or architecture. However, in view of the unresearched question of the diverse future working lives of many Royal Academy students, it seems worthwhile to consider the existence of another and more generalised community of practice in drawing, that of the students.

This chapter has indicated connections between technical and artistic modes of drawing around 1800 through an examination and comparison of familiar accounts previously separated in histories of art and engineering. The methods of art history, with close examination of visual evidence, have been used to examine individual drawings in order to ask what resources were used in forming their style, in terms of materials, techniques and references to tradition, or what kind of public was being addressed by the producer. However, although taking a critical approach, the chapter has remained largely with the output of prestigious individuals in particular locations. I have noted that almost nothing is known about the working lives of many anonymous former Royal Academy students who may have used their drawing skills in various ways not confined to painting, sculpture or architecture, to earn a living. These questions of how one might have earned a living through drawing will be addressed at more length in Chapters 5, 6, and 7. Equally, those students also had demonstrated their drawing skills in order to be admitted to the Academy. As it is apparent from this chapter that both artistic and technical drawing practices already existed before the advent of Boulton & Watt or the Royal Academy, I now turn in the next chapter to ask where else might one have learnt to draw in Great Britain up to 1800, and to what end?

Chapter 3: Art, industry and cultural politics to 1800 and beyond: provincials, pupils and print

The previous chapter questioned accounts of drawing practice for art and industry in relation to familiar and specific locations of cultural production, the Royal Academy in London and the firm of Boulton & Watt. This chapter, by contrast, addresses accounts of both production and reception of drawing practices that were distributed more widely in Britain in the decades around 1800 in order to discover where else, beyond these locations, might one have learnt to draw in Great Britain, and to what end? This chapter will consider rival academies in the late eighteenth century whose aims differed from the Royal Academy, and will also pay attention to the promotion of drawing styles through print, through into the early nineteenth century. First however I will discuss conflicts in histories that deal with the aims and scope of art and design education in late eighteenth century society. In contrast to the Royal Academy, provincial academies, drawing manuals, and organisations such as the Society of Arts often did not make a separation between polite and useful arts, but instead appeared to promote the catch-all philosophy indicated in Charles Taylor's *Artists' repository and drawing magazine*:

The art of DRAWING, as the foundation of all others, claims our first attention... not confined to painters, engravers, embroiderers, &c. professions whose employment evidently depends on it; it is daily practised by the mathematician, engineer, navigator, and others. (Taylor 1784: 52)

The aims of the Edinburgh Trustees' Academy (founded in 1760) and the working lives of masters and students will form the basis for a discussion of further networks of drawing practice and technique in Britain from the mid-eighteenth century, before moving to discuss new models of drawing education developed by the Royal Engineer Department in Chatham, and the Society of Arts, London through the medium of its published *Transactions*. Finally this chapter will also consider the development of drawing education within manuals and other illustrated texts through to the early nineteenth century in order to ask how useful Iliana Bignamini's notion of 'printed academies' is as a challenge to the dominance of established art histories centred on the Royal Academy (Bignamini 1989: 438).

As noted, a substantial literature on drawing education in the past has been generated since the 1960s by historians of art and design education. Most have followed Quentin

Bell and *The schools of design* (Bell 1963) by concentrating on the context and polemics attending the establishment of public art schools from 1837 onwards. This concentration has resulted in earlier practices being treated in a misleading way when they have been discussed at all. Bell's study was not directly about the context of drawing practice around 1800 or the history of the Royal Academy; instead it focuses on the Government Select Committee on Arts and Manufactures of 1835-6 and the subsequent establishment of the Government Schools of Design. However, Bell implied that before 1837 the Royal Academy was the only teaching institution in the country, flawed by its exclusion of the useful arts (Bell 1963: 48-49). Although Bell conceded that other channels for drawing education did exist at that time, he was content simply to report the Select Committee's assertions about the poor standard of drawing skills outside the Academy (Bell 1963: 52-60). Following Bell, Macdonald stated more as an established fact (based on the same partial evidence), that drawing education outside the Academy in the period before 1840 was of 'very low standard' or filled with an 'amateur atmosphere' (Macdonald 1970: 38). More recently Romans (1995; 2005), Thistlewood (1995), Bird (1992), or Denis (1995), while eschewing the high cultural bias of earlier writers in order to examine artisans' education in drawing, have nevertheless remained firmly within the time period of state involvement in art and design education from the mid-nineteenth century onwards. Despite their critiques of earlier scholars, and on the role of public institutions, these later writers appear to be equally constrained by the same disciplinary framework and standard chronology. Design historians, on the other hand, have looked further into the past. As noted in the previous chapter, artists and artisans who provided designs for manufactures were to be excluded from the Royal Academy (Irwin 1991: 220); as a result writers such as Styles (1993), Puetz (1999) or Craske (1999) have now begun to ask where else and how artisans learnt to draw in the period before the establishment of the Government Schools of Design (Puetz 1999: 217-39).

Centralised histories, local practices

In contrast to the approach of wider generic histories, many close-focus local histories of specific art schools present a more inclusive and heterogeneous picture of drawing practice across Britain around 1800. These accounts frequently record without further comment the existence of drawing classes in mechanical and geometrical drawing for artisans. Hence local histories of art schools that were founded as Government Schools of Design after 1837 in industrial cities such as Birmingham (Swift (2004), Liverpool (Willett 1967), Manchester (Archer 1985) and Sheffield (Mackerness 1978) all look back to their cultural origins in the late eighteenth century as amalgamations of private drawing schools, mechanics' institutes, or the 'clubs and economic societies' (Fox 2009: 179-229) that characterised that period. One example would be the Liverpool Society for Promoting Painting and Design (founded in 1783) that staged exhibitions showing established contemporary artists such as Joseph Wright of Derby, Henry Fuseli, and Joshua Reynolds (Morris and Roberts 1998). In turn this initiative prompted a series of further undertakings, such as the Liverpool Academy of Arts in 1810, the Liverpool Royal Institution in 1814 and the School of Design in 1822 (Willett 1967: 10-28). In addition, two further academies, the Dublin School of Design founded in 1742 under the aegis of the Dublin Society for Promoting Husbandry (Bignamini 1989: 443; Turpin 1995: 3-22), and the Edinburgh Trustees' Academy (Brookes 1989) actively recruited a body of artisan students and taught a range of drawing skills that were intended to be applied to both polite and useful arts. Although both academies had the ostensible aim of promoting design for trade and manufactures, the location of both academies in the subject countries of Ireland and Scotland arguably also points to a deeper underlying aim of 'forging the nation' (Great Britain) under Hanoverian rule in the late eighteenth century (Colley 1992; Lenman 2009: 185-206).

Local histories appear more willing to look further into the past in order to admit links with local economies, artisan training and the drawing skills associated with them. Several writers have addressed the question of why there is a discrepancy between wider generic accounts and local detailed histories of education for art and design around 1800. Iliana Bignamini, for example, has argued that conflating the 'academy' with the Royal Academy is far too narrow, and instead has argued that in her opinion a mature institutional system for the arts in Britain including auction houses, museums and the art press (Bignamini 1989: 434-50) was already in existence before the establishment of the Royal Academy in 1768. Indeed, because Bignamini also included a multifarious range of teaching under her umbrella that included travelling private masters, instruction in draughtsmanship at military academies, and not least, 'printed academies' (drawing manuals), then the existence of an art academy in Britain, she asserted, should be reckoned as beginning in the late seventeenth century with works such as Dr. William Salmon's *Polygraphice* of 1672 (Bignamini 1989: 438). Patricia Brookes has suggested that the Trustees' Academy in Edinburgh has not been admitted to broader national histories of art and design education because its utilitarian approach contradicts more recent notions of art as a separate sphere of creative playfulness that now dominate art and design institutions (Brookes 1989: 21-

2; Irwin 1997: 245-7; Macdonald 1970: 269-340). Finally John Swift has addressed the discrepancy between more simplified national accounts of art and design education and the histories of local schools by claiming the baneful influence of a 'centralist view' of art education that uses the notion of a 'vice-like grip of London on all aspects of art teaching' (Swift 2004: 11). He attributes this centralist view to the inertia sustained by established sources, allied with a reluctance to visit regional archives.

Edinburgh Trustees' Academy

The Edinburgh Trustees' Academy was named for and funded by the Board of Trustees for Improving Fisheries and Manufactures in Scotland, and was financed by the assets seized from Jacobites after the 1745 rebellion (Irwin 1975: 90). From the beginning, the Academy aimed to promote skills, particularly drawing, that would support manufactures that the Board of Trustees aimed to foster. Textile trades were particularly favoured in advertisements when the Academy opened: 'for persons of both sexes… [to teach] the art of drawing for the use of manufactures… especially the drawing of patterns for the linen and woollen manufactures'(*Edinburgh Evening Courant* 9 July 1760, quoted in Brookes 1989: 46). Masters of the Academy, for example William Delacour (1700-1767), an applied artist and designer, or in a later generation the painter David Allan (1744-96) also produced patterns for damask design as part of their duties (Brookes 1989: 58; 142-50).

Figure 24: William Delacour c. 1760 Two studies of foliage National Galleries of Scotland D5357 B and C

Examples of the drawing styles favoured for textile design around 1760 can be seen in Figure 24, a study of foliage in the rococo manner by Delacour. This was probably a first drawing towards six designs for linen damask he produced in 1763 for the Board of Manufacturers in the period just before his appointment as master of the Trustees' Academy (Clifford 1999: 216). A later example of drawing associated with the Trustees' Academy, Figure 25 by Alexander Nasmyth (1758-1840 Cooksey *ODNB*), is an elaborate carpet design that his son, the mechanical engineer James Nasmyth (1808-1890), had attributed as an application piece made by his father when he entered the Trustees' Academy as a student in 1774. However, although the drawing is certainly a design for manufacture made with reference to the aims of the Trustees' Academy at some point between 1774 and 1818, Timothy Clifford considers that this drawing was made at a later date, probably for Alexander Nasmyth's third and final unsuccessful attempt to gain the post of principal Master in 1818 (Clifford 1999: 314), although it may have been produced for his two previous applications in 1786 and 1796.

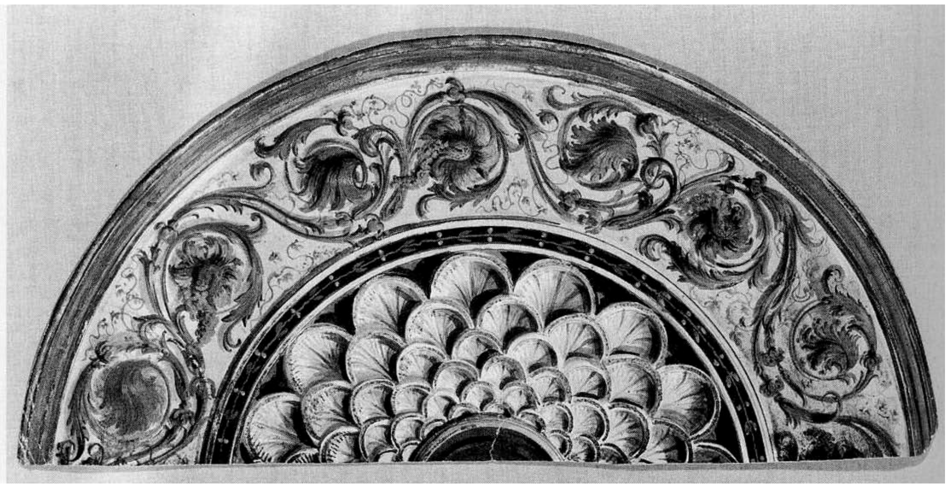


Figure 25: Alexander Nasmyth (c. 1820?) *Design for a carpet* National Galleries of Scotland D 3727/1

In manufacturing, line drawings like this would be used as a basis for further drawing procedures that were specific to different materials. So for woven textiles such as damask or carpets, the line drawings would be treated in a literal manner as a plan; enlarged and transferred to gridded paper by the designer or a pattern-drawer, the continuous line drawing would be reduced to an arrangement of squares, with each square representing one thread, or one knot. For metal work, as might be inferred from the example of one of Matthew Boulton's fancy designs (Figure 11, Chapter 2), the first move towards directing the shaping would be to extract one or more elevations (profiles) from the design.

The cohort of the students in 1760 was made up of apprentices who competed for free places in a school that ran from 3.00 to 7.00pm on three afternoons a week after work. Both boys and girls could apply, and the trades of the students included those of engravers, embroiderers, weavers, metal workers, clock makers and cabinet makers, as well as pupils whose aims were to be painters, sculptors or architects (Brookes 1989: 45; Parker 1984: 125). This range was still in evidence some sixty years later in 1818 when the yearly list of students' trades included engravers, silversmiths, brassfounders, cabinetmakers, masons and upholsterers (Trustees' Academy minutes NG1/1/34: 62). The range of student trades also finds an echo in the candidates that were considered as teachers in the school. As well as looking for skills in ornamental arts, the Trustees' Board considered candidates for the post of Master with mechanical, surveying and engineering knowledge. For example the engineer John Baine, a former student praised by the Board in 1778 for his work as a mechanical draughtsman, was later considered in 1786 as a candidate for the post of Master (Brookes 1989: 103; 128). In 1818 Andrew Wilson (1780-1848), who had been teaching drawing at the Royal Military College in Sandhurst, was appointed as Master in the same competition that rejected Alexander Nasmyth for the third time (Trustees' Academy minutes NG1/1/34: 7). Both of these candidates were prominent landscape painters (Irwin 1975: 240-42) at a time when this genre was gaining in cultural status.

Many different trade apprentices were admitted, and they studied alongside one another. Such an environment may have developed a more distanced and self-aware approach to drawing procedure, in contrast to the perhaps more 'normalising' attitude in a trade apprenticeship where established procedures would have been imparted without comment. As noted, in a trade that shaped materials into three-dimensional objects the next drawing stage might be to move from design drawing to calculating a detailed profile whose form would be inflected by knowledge of the constraints of specific materials (such as glass or pewter). But in the Trustees' Academy drawing classes were held in common. This may have encouraged certain approaches to design that were not so medium specific, especially because changes in production techniques in the last decades of the eighteenth century, such as press moulding and transfer printing in ceramics, or the use of engraved rollers for textile printing, pushed the notion of design drawing towards that of applied surface decoration (Styles 1993: 532-4). But equally, students from different trades, working alongside one another, would have encountered visual evidence that the constraints of different final mediums (such as woodworking or engraving in copper) affected the choice of forms in design drawing. Such exchanges of knowledge do not need to take place consciously, but can happen tacitly, through drawings.

Other modes of drawing associated with the Trustees' academy were, as already implied, observational landscape drawing, landscape composition, mechanical drawing, and also elements of academic fine art training using prints and casts. Landscape drawing, moreover, was enmeshed in several practical applications outside the realm of fine art. The rise of landscape painting in the later eighteenth century in the hierarchy of artistic genres is often attributed to the influence and work of Paul Sandby (1731-1809), brother of Thomas Sandby and fellow founder member of the Royal Academy (Herrmann *ODNB*). This change in status was accompanied by an expansion in meaning, whereby landscape study around 1800 also became associated with picturesque or romantic sensibilities (Parkinson 1998: 9). However, Paul Sandby's earliest landscape work had developed from his original training as a military draughtsman working as a surveyor in 1747-52 during the Hanoverian occupation and pacification of Scotland following the rebellion of 1745 (Parkinson 1999: 9). Such earlier affiliations of earlier landscape representation can still be seen within the working lives of the two landscape painters competing for the post of principal Master of the Trustees' Academy in 1818. Andrew Wilson was chosen as Master because of his connection with the Royal Military College, and in the opinion of the Trustees this demonstrated an ability to teach diverse applications of drawing that they wished to promote (Trustees' Academy minutes NG1/1/34:7). In the unsuccessful candidate, Alexander Nasmyth's professional practice meanwhile aligned him more closely with architecture, civil engineering and mechanical invention, for example in his collaboration with Thomas Telford in the design for the Tongland Bridge near Kirkudbright in 1803-5 (Ruddock 2000: 134-44). In 1818, the Trustees' Board had already been supporting other aspects of training in drawing for the useful arts for at least twenty years, as geometrical drawing classes had been introduced in 1798 (Trustees' Academy minutes NG1/1/26). But as well as appearing to make room for such practical applications of drawing for surveying and construction, the Trustees' Board also decided to start buying plaster casts of figures from the antique in 1798 (Trustees' Academy minutes NG1/1/29: 458) signalling an aspiration to expand the teaching programme to include academic training based on esteem for the classical tradition (Smailes 1991: 128-9; Irwin 1975: 92-6). While few examples of work directly associated with the Trustees' Academy survive, the available records suggest that while drawing skills were evidently seen as vital for the 'improvement of manufactures' (the ostensible purpose of the Academy), there was no systematic approach that favoured for example design drawing directed to each student's trade. Instead, as in the drawing manuals that will be discussed later in this chapter, the approaches were various, and apparently unsystematic.

Brookes has claimed that the Trustees' Academy was 'unique in eighteenth-century Britain' (Brookes 1989: 1), due to the influence of the aesthetic theories of Henry Home, Lord Kames (1696-1782). Kames, the author of *Essays on the principles of morality and natural religion* (1751) had valued 'relative' beauty—that is, directed to some proposed end, more highly than 'intrinsic' beauty—autonomous, or self-contained beauty (Home 1751, cited in Brookes 1989: 22). Kames had been a founder member of the Edinburgh Society for the Encouragement of Arts, Manufactures and Commerce in 1754, and was an influential public figure as an author, lawyer, and prominent agricultural improver (Durie and Handley *ODNB*). Nevertheless I feel that Brookes does overstate her case, for such opinions were not confined to Edinburgh or Scotland. Other academies in Britain wished to promote the useful arts, for example the Foulis Academy in Glasgow (1753-1776), founded by the Foulis brothers, printers who were apparently inspired not so much by their reading of 'principles of morality and natural religion' but by the example of continental trades schools (Gordon 1999: 6; Smith 1999: 9). The school of design in Dublin, with its premiums (money prizes) for fine and applied arts including pattern drawing for linen manufacture, and design for print also quite clearly shared these ideas (Turpin 1995: 13-16). Furthermore, although the Trustees' Academy was set up to improve manufactures, its strategy of bringing together apprentices from trades that would be otherwise separate meant that any drawing programme that was delivered in common could not be strictly directed to one practical end. Similar dilemmas about what to offer when teaching drawing skills can also be seen in military drawing classes and in artisans' drawing manuals in the late eighteenth century. In these environments, unlike the Trustees' Academy where a fine art oriented academic programme began to develop, a clearer emphasis on technical and mechanical drawing skills began to emerge in the nineteenth century.

Drawing for conquest: military drawing and the Royal Engineer Department

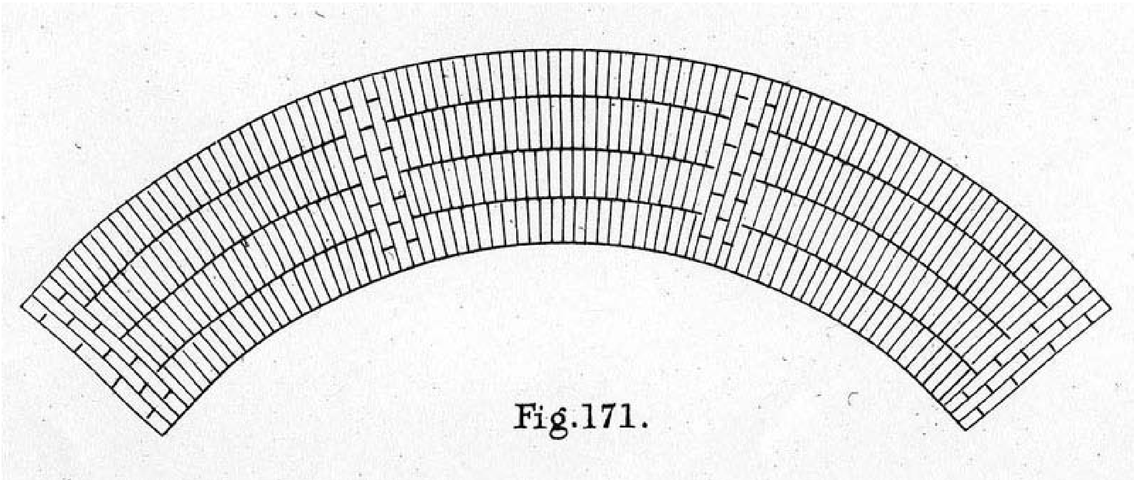
Beyond such 'academies', training for military service encouraged a range of drawing techniques that embraced observational, expressive and academic styles. Drawing was seen as an essential skill for surveying, reconnaissance, construction, and gunnery, and was taught at Government schools such as the Royal Military Academy, Woolwich (founded in 1741), and further colleges at Sandhurst, Addiscombe and Chatham (after 1800). Alleged British inefficiencies in surveying during the French wars of the 1790s and beyond led to an expansion in training with renewed emphasis on drawing skills (Jones 1974: 19-20). But according to Yolande Jones (1974), the intense interest in improving drawing skills in order to advance mapmaking and surveying by the military was not accompanied in Britain by any attempt to develop or impose a uniform system of training or drawing layout until the 1880s, unlike the strict codes used in France or in German-speaking countries from around 1800 onwards.

In Jones's account, the lack of system did not simply apply to map drawing conventions. Officers were trained in a wide range of drawing registers that included mapping, and also in geometrical and mathematical drawing for construction or to calculate trajectories for cannon fire. But equally, classes were given in landscape sketching and even figure drawing, from life and from antique statues, on the well-worn grounds that drawing from the figure is the most difficult task of observational outline drawing one could devise (Jones 1974: 25). As noted, several drawing masters at the military colleges were landscape artists, such as Paul Sandby who taught at Woolwich from 1768-97, William De La Motte (Jones 1974: 20), or Andrew Wilson, who taught at Sandhurst before moving to the Edinburgh Trustees' Academy (Irwin 1975: 240-2). Jones claims that the mixture of registers in military drawing instruction continued well after the 1850s; this she attributes partly to the lack of agreement as to any uniform system for military drawing or mapping, and also to the unpredictable conditions in the field where drawing skills were a rapid means for planning, gathering data, communicating and persuading. This regime of drawing in military academies meant that a large number of men and boys from the middle and upper classes developed a range of drawing skills as a routine part of their education (Bermingham 2000: 83-85); here, according to Anne Bermingham, the habit of making rapid and expressive landscape sketches was adopted not just for strategic observation, but as a means of cultivating personal sensibility and asserting class superiority (Bermingham 2000: 78-83). Just such a combination of expressive landscape sketching and military observation was displayed during the Crimean War in the double page newspaper spread that reproduced panoramic views of the Crimean coastline 'from Eupatoria to Alma, sketched by Lieut. Montagu Reilly, H.M.S. "Retribution"' (*Illustrated London News* 2 December 1854: 568-569).

However, some distinct modes of representation were developed for military use in the late eighteenth century, for example a system of bird's eye panoramic battlefield views designed to display strategic features developed by Paul Sandby for his patron the Duke of Cumberland (Charlesworth 1996: 247-66), or with a similarly high viewpoint, a system of 'military' perspective that adopted an isometric system of projection to display the features of buildings and fortifications (Adams 1813: 465; Perez-Gomez 1997: 248; 274; Kemp 1990: 224). Such land-mapping representational activities were continued by both civil and military agents during the establishment of Hanoverian rule across Britain, during the planning and construction of transport links such as roads and canals, and as a means of recording surveys during the land enclosure movement that benefited already powerful 'improving' landlords (Parkinson 1999: 9; Alfrey and Daniels 1990: 100-1). As already noted, techniques of observing and representing the landscape for territorial and military purposes in the work of Paul Sandby was a significant factor in the later development of landscape painting in Britain in the eighteenth century, initially through the medium of watercolour. Watercolour was used as a highly portable medium, and the way in which the paint is applied (as a transparent wash or glaze, generally on white paper) lent itself to capturing both topographical features and also fleeting atmospheric effects of weather, season, and light on site.

However, by contrast a distinctive style of technical drawing for military use was elaborated and practised in the Royal Engineer Department College at Chatham from1812 onwards, due to the efforts of Sir Charles William Pasley (1780-1861) its first director. Pasley was an energetic organising officer and author with a strong interest in drawing education (Twyman 1990: 60-7). On the basis of observation of the so-called Lancastrian school methods of Andrew Bell and Joseph Lancaster in 1811 (see also Francoeur 1824) that Pasley perceived could be adapted to enable non-commissioned officers to teach themselves and their men to draw, he devised a course of geometry for the engineering schools at Chatham to be assimilated by action and repetition in the same manner as company drills and small-arms exercises (Vetch *ODNB*). In *A complete course of practical geometry* (1822) students worked with a basic drawing kit of compass, flat ruler and right-angled wooden triangle, pencil, pen and ink (Pasley 1822: i-iv). The tasks were worked through progressively, from Part I, Problem 1: 'through a given point, draw a right line parallel to a given right line, by a ruler and compasses' (Pasley 1822: 6-8). By Part IV the students were executing problems in conic sections, for example Problem XIV, 'the two axes of an ellipse being given, find the foci, and describe the curve by means of intersecting arcs' (Pasley 1822: 343-5). The method inculcated learning through geometrical drawing before everything, hence ellipse drawing by means of common mechanical aids from drawing office practice such as 'a couple of nails and string' (Pasley 1822: 348-9) or by trammel (Pasley 1822: 349-54) was only shown at the end of the relevant section. A final section on the principles of plan drawing (Pasley 1822: 563-94) introduced terms such as plan, plane of projection, section, and elevation all conveyed through worked examples. Pasley also developed an *Outline of a course of practical architecture*, first used for Department teaching from 1826; later published for general circulation in 1862 (Pasley 2001 [1862]). In contrast to the abstract geometrical methods of *Practical geometry*, this text gave constant emphasis to actual materials, such as bricks (Pasley 2001: 2-3), limes, cements, and mortars (Pasley 2001: 11-12) alongside close descriptions of contemporary everyday structural techniques (Figure 26).

Figure 26: see second image and caption over page



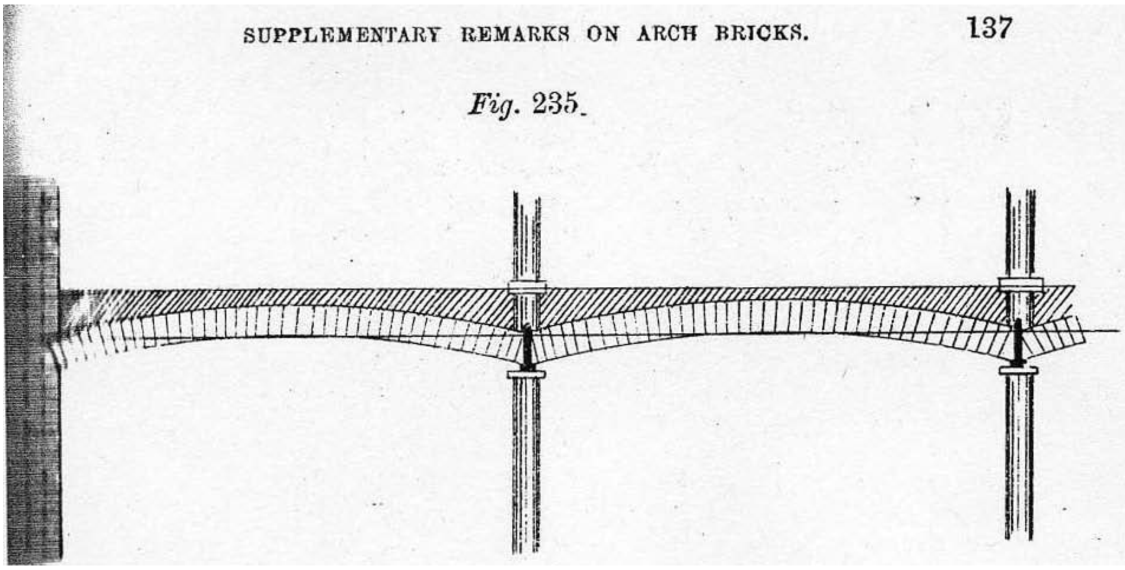


Figure 26: Charles William Pasley (1826) Example of an arch construction worked in brick (Pasley 2001: 84 *top*); Example of shallow brick arches resting on iron girders, from a 'manufactory near Salford' (Pasley 2001: 137 *bottom*). Pasley's text *Outline of a course of practical architecture*, was first produced as a lithographed pamphlet to instruct officers and men from the Royal Engineers in1826; later published in letterpress for general circulation in 1862.

Military drawing for the Royal Engineer Department developed a technical style on the page and a method of mechanical drawing that at first glance appears to enforce crude class separations through disciplining bodies as well as the minds, with regimented drill in geometrical exercises for private soldiers and non-commissioned officers in complete contrast to the range of drawing styles with links to the polite arts and to acts of individual self-expression that their superior officers had encountered during their education. This suggests that in contexts like this, the term 'inartistic' applied to technical drawing also implied a relative lack of agency in practitioners.

Drawing for arts, manufactures and commerce

The Society of Arts of London founded by William Shipley (1715-1803) in 1754 (Allan *ODNB*), functioned in many ways as an alternative academy in accord with the expanded mode proposed by Bignamini (1989: 434-50). Its original name, the Society for the Encouragement of Arts, Manufactures and Commerce, underlines a historical sense of the word 'art' as embracing the work of both artisans and artists (Bennett, Grossberg, Morris and Williams 2005: 6-8). This wider meaning included the technical know-how or laborious craft from which Reynolds had wished to distance himself and the Royal Academy in his *Discourses*. Although the Society of Arts was not a teaching institution with an enrolled body of students, the *Transactions* published from 1783 circulated notices of inventions, useful contrivances and achievements sent in by contributors from across Britain. Through the medium of the *Transactions*, the Society of Arts offered also premiums (money prizes) in chemistry, mechanics, and agriculture as well as in the polite arts. In addition, the Society of Arts building in London was used for public exhibitions, for example in 1760, when one hundred and thirty works by sixty nine artists attracted 20,000 visitors in a fortnight (Fox 2009: 213). The polite arts category had a strongly educational character because prizes were offered to young people, most frequently through a demonstration of progressively acquired drawing skills that followed a sequence familiar from academic programmes. Hence premiums were on offer to applicants under the age of sixteen for outline drawing of a group of human figures from the cast, or for copies of pictures (Society of Arts *Transactions* 1789: 321-2). William Shipley himself had been a drawing master and he continued to run a separate drawing school on Society premises from 1754-61, where he trained several fine artists such as Richard Cosway (Allan *ODNB*; Carline 1968: 55-6; Fox 2009: 208).

Shipley's encouragement of both boys and girls through the wording of the premiums has attracted rather Whiggish praise from historians as a kind of egalitarianism that foreshadows the education policies of our own times (Allan *ODNB*; Carline 1968: 51-2). Although it is true that every drawing premium announcement was directed at both sexes, equality was only offered within strictly defined social ranks. For example, several premiums were offered to the 'sons and daughters of peers and peeresses', or to 'young ladies or gentlemen' (Society of Arts *Transactions* 1789: 308). Lower down the social scale premiums were offered for more specialised modes of drawing such as 'the best perspective drawing [of a machine] by persons of either sex under the age of twenty-one'; for landscape and historical drawings, or for an 'engraving in the line manner' (Society of Arts *Transactions* 1789: 311). These prizes were intended for 'persons professing any branch of the polite arts, or any business dependent on the arts of design, or the sons and daughters of such persons' (Society of Arts *Transactions* 1789: 308-11). In 1795 a rather tetchy note showed it had become necessary to spell out to applicants why these social divisions had been made: 'Honorary Premiums are intended only for such of the Nobility and Gentry as may hereafter become patrons and patronesses of the Arts' (Society of Arts *Transactions* 1795: 77). In this context, attributing the address of premium competitions to both sexes as an early example of current attitudes to art education is misleading. Instead, the conditions of the premiums show a close, even micro-managing, preoccupation with the social and economic conditions that might be considered to encourage 'arts, manufactures, and commerce'.

Close attention paid by the Society of Arts to technique becomes apparent with an increasing range in types of premiums for working artists or designers after 1800. So for example new premiums announced at the turn of the century included prizes for fashionable items suitable for industrial production such as low reliefs in terra cotta (Society of Arts *Transactions* 1799: 308). Drawing for print was also fostered, with a call for examples of engraving on wood ‘capable of being worked by the letter-press’, or for stroke engravings (Society of Arts *Transactions* 1801: 39), for drawing in outline, for chintz patterns for calico printers, or for copper plate patterns for calico printers (Society of Arts *Transactions* 1801: 39). The *Transactions* were illustrated with engravings after drawings that followed a uniform style of presentation, as in Figure 27, a detail taken from a working model lodged with the Society by its inventor and maker Simon Goodrich (Society of Arts *Transactions* 1799: 327-34).

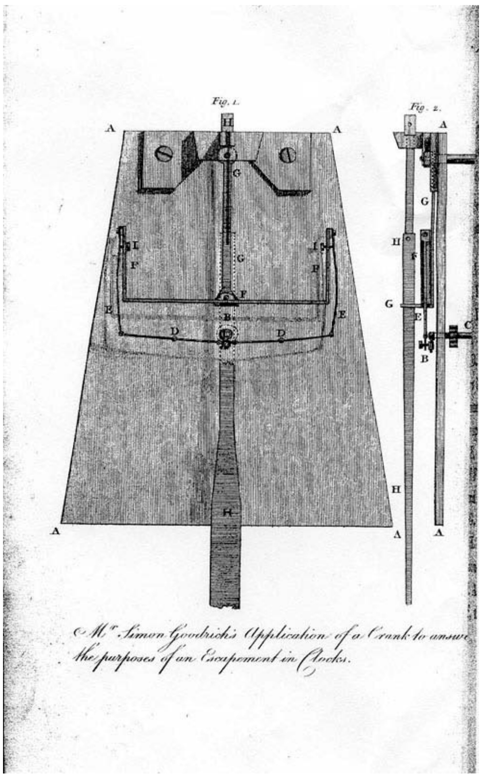


Figure 27: ‘A crank to answer the purposes of an escapement in clocks’ Society of Arts *Transactions* 1799: 327-34

This steel engraving by Wilson Lowry shows the mechanism face on and from the side. In style it is similar to that of Watt’s Instruction Book of 1778 (Figure 8 Chapter 2) with most of the drawing achieved with mechanical aids such as ruler and compass. Unlike in a detailed parts drawing for the workshop (as in Figure 7 Chapter 2) however, the material surface of the object is embellished with ruled lines and cast shadows that are in part a gesture towards a pictorial illusion, but are equally a product of the transfer of a drawing to the medium of steel engraving. The aesthetic is constrained, even produced by the production method. Indeed, the *Transactions* of the Society of Arts are permeated with an awareness of such an interdependence of production. So for example, when the frontispiece to Volume 25 (1807) trumpeted a new medal commissioned by the Society, the illustration gave credit to the five individuals concerned in the business of producing that specific image (Figure 28). Art in the pages of the *Transactions* of the Society of Arts was thus conceived as a network of negotiated commercial relations based on the production of material goods.

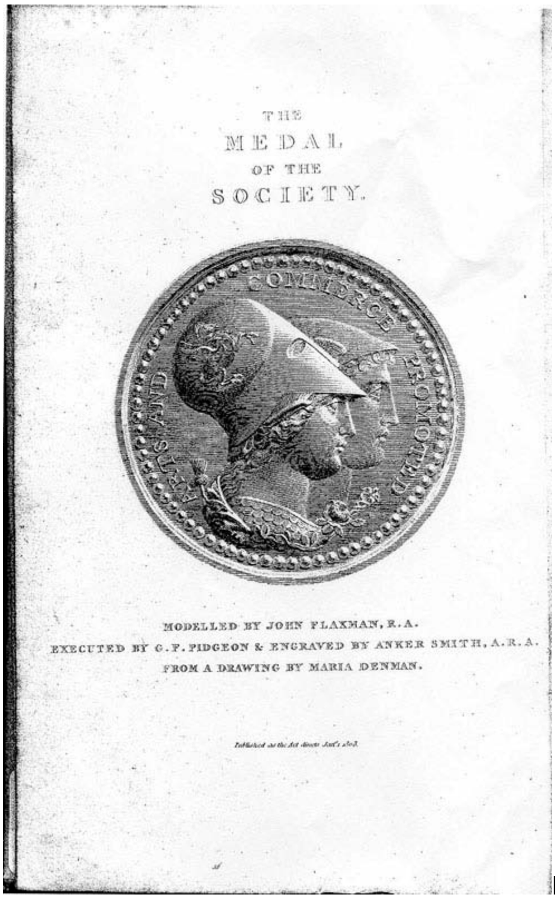


Figure 28: This image of the new medal commissioned by the Society of Arts credits five individuals with its production: modelled by John Flaxman; executed by G.F. Pidgeon; engraved by Anker Smith; drawing by Maria Denman; printed by R. Wilks (on facing page). Society of Arts *Transactions* 1807: frontispiece

By contrast, although the actual practices of the Royal Academy were more varied, the *Discourses* of the Royal Academy functioned as a unilateral declaration that their students and members inhabited a separate sphere from this commercial system. In terms of trades and occupations, it might be tempting to argue that the Royal Academy in effect was creating a new, more modern, professional fine art niche that differed from the inbuilt social relationships between the wealthy amateurs (future patrons) and skilled artisans that made up the Society of Arts' more antiquated notion of the artworld. This analysis would support the argument, noted in Chapter 2, that the institutional formation of the Royal Academy created a key separation between artistic and technical practices around 1770 (Gerbino and Johnston 2009:131). To support this view, one could also note that although the Royal Academy aimed to refine and consolidate fine art practice even further through excluding undesirable categories, the Society of Arts remained more permeable, in offering and awarding premiums in the polite arts to engravers, designers, professional draughtsmen, and mechanical engineers as well as aspiring fine artists. But at the same time, artists and draughtsmen developed new drawing styles and material practices within the Society of Arts. The *Transactions* were used to promote technical drawing with and through new print mediums in a transparent and self-reflexive way (these questions will be developed further in Chapter 5), whilst drawing in print built new audiences. In this light, the social relations within the pages of the *Transactions* could appear anything but antiquated. The way in which the Society of Arts functioned does not simply challenge the idea that the Royal Academy was the only institution concerned with art or drawing education before 1837; rather, it suggests that there was a different model of practice, not centralising like the Royal Academy, but dispersed. At one end the geographical location of the Society was in London, with its attendant repository and exhibitions. But at the other end, its contributors and readers were spread across Britain, with the most active of them submitting drawings, prints and other inventions for the premium competitions. The images were consumed and remastered in the context of a diversity of everyday working lives, beyond centres of polite culture, and which were dependent upon locally varying industries and associated practices. To complete this chapter, I now turn to further printed sources that functioned as resources for learning how to draw (mainly drawing manuals), that were addressed to similarly dispersed readers.

Drawing manuals as 'printed academies'

In her attack on the unique status of the Royal Academy, Bignamini conjured drawing manuals as rival 'printed academies' that were already firmly in existence before 1768 (1989: 483). More guardedly Bicknell and Munro have dismissed the drawing manuals that were available before 1800 by noting frostily that they followed the French academic system, and simply provided a 'series of examples to copy' (Bicknell and Munro 1988: 7). Bignamini's first example, the one on which her claim about the existence of a mature institutional system for training in the arts from the late seventeenth century depended, was William Salmon's *Polygraphice* first published in 1672. However a closer reading of this source shows that although we can find mention of a range of drawing uses in the text, including a very brief listing of three types of 'perspective' in Chapter XXII, the overall constellation of the seven books of the *Polygraphice* takes us back into a world where current schemes of knowledge no longer apply. Certainly Salmon begins in a recognisable fashion by listing drawing instruments and their uses: charcoal, duck feathers for erasing, raven quill pens, rulers, compasses and home-made pastels (Salmon 1685 [1672]: 3-5); but later instructions move beyond formal or functional processes into a verbal elaboration of formulaic emblems. For example, the month of December is to be depicted: 'with a horrid aspect, clad in an irish (*sic*) rug or coarse frieze girt around him; upon his head three or four nightcaps, and over them a Turkish turban, his nose red, his beard hung with icicles, at his back a bundle of holly and ivy, holding in furred mittens a goat' (Salmon 1685: 397). The book finally moves completely away from the 'drawing' or image-making focus promised by the title into chapters on arcanums (chemical and alchemical transformations and operations) and finally into receipts for brewing medicines. While the written text of Salmon's compendium reflects a usage of the word 'arts' that the Society of Arts might have recognised right through into the nineteenth century, it has little information about drawing technique, however the twenty three plate images at the end of the book did support the visual training of the reader in the copy- or pattern-book style, with Plate VI for example (not illustrated here), presenting a medley of eyes, ears, noses and mouths combined rather surrealistically into one busy page. Although Bignamini's rapid reference to *Polygraphice*, unsupported by detailed analysis, cannot support her claim as it stands, nevertheless Bicknell and Munro's dismissal of one stiff academic model in copybooks is equally flawed. There is no doubt that printed imagery did provide an 'academy' for learning to draw before 1800 with a wide range in subject matter and conventions of representation indicated by other researchers (Carline 1968: 32-4; MacGregor 1999: 389-420). Bignamini's most obvious omission in her discussion was perspective treatises (Elkins 1994; Kemp 1990); as already noted in the last chapter, such publications underwent an apparent 'surge' in eighteenth-century British culture (Kemp 1990: 148). Indeed, as noted by Matthew Craske, some of this demand came from artisans who from 1730 onwards set out to 'master design at a pace... to cut as many corners as possible... to enter the world of designing' (Craske 1999: 192).

Craske noted two highly contrasting drawing styles that were gleaned from books by tradesmen aiming to improve their cultural status in order to find a market in expanding luxury retail trades. As well as the relatively severe and restrained style of perspective and geometrical drawing (Craske 1999: 191), Craske also notes the purchase of the 'fantastically frivolous, impractical' rococo style of drawing for design (Figure 29), as disseminated by Thomas Chippendale's *The gentleman and cabinet-maker's director* (1756).

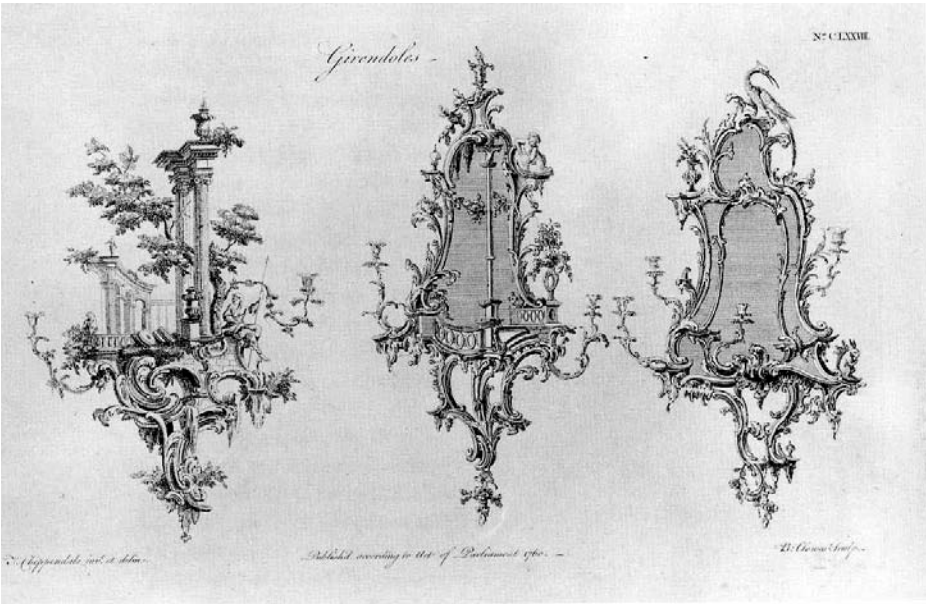


Figure 29: Butler Clowes after Thomas Chippendale 'Girandoles' from *The gentleman and cabinet-maker's director* Plate CLXXVIII

Less ebulliently, Anne Puetz pointed to fear of trade rivalry with France in textile production as the cause of public agitation about the need to train artisans in drawing and design that reached a height around 1750-60 (Puetz 1999: 217-9). Unsurprisingly, the French harboured almost identical fears of British design excellence in the 1750s, resulting in the foundation by Jean-Jacques Bachelier of the Free Drawing School in Paris in 1766 (Leben 2004: 23-7). In Britain, although this was the period when the art schools and academies that have already been discussed were also founded, Puetz reminds us that the greater majority of artisans across Britain did not have access to these, and instead taught themselves to draw using manuals and collections of ornamental motifs such as Robert Sayer's *The ladies' amusement* (1762). Then, to invent new designs, for example to apply to printed textiles, artisans would frequently copy and recombine fragments of such pre-existing elements (Puetz 1999: 221). In relation to the technique of designing through copying, Puetz also cited the 'portable and affordable' (Puetz 1999: 231) *Artist's assistant* series produced by Carington Bowles (1724-93). *The draughtsman's assistant,* (Bowles *c.*1787) was just one of this series, providing a brisk overview of some common subjects and manners of drawing, with copious plate illustrations of human figures, extremely simple perspective constructions, landscapes with buildings and ruins, seascapes and naval battles, and finally many examples of animals and plants.

James Ferguson’s works were equally widely known and disseminated amongst artisans. Ferguson (1710-76 Rothman *ODNB*) was a self-taught lecturer on natural philosophy and inventor of scientific instruments who also sold his teaching through print. His titles included *Lectures on select subjects in mechanics* (1776), and *The art of drawing in perspective made easy* (1775) that ran into multiple editions, frequently listed in catalogues of artisan libraries such as that of Glasgow Anderson’s Institution (Strathclyde University archives OB/10/1/2). In 1805 David Brewster (1781-1868; Morrison-Low and Christie 1984) edited an expanded and annotated edition of *Ferguson’s lectures on select subjects* of 1805, when he observed, perhaps also with an eye on his desired future sales: ‘no book upon the same subject has been so generally widely read, and widely circulated, among all ranks of the community. We perceive it in the workshop of every mechanic’ (Ferguson 1805: i).

Ferguson first earned his living as a draughtsman, designer, and painter of portrait miniatures. He maintained this artistic strand of work alongside lecturing and instrument making until about 1748 (that is, until he was almost forty). Thus when he addressed those readers who would study perspective he imagined: ‘painters and also those who draw landscapes, or figures of machines and engines for books’ (Ferguson 1775: vi). His recommended drawing method proceeded systematically through a building up of complex forms from early simple ‘abstract elementary shapes such as lines, angles, circles, ovals, cylinders’, and then (in order of difficulty) to proceed through fruit, then animals, to human figures. Although the actual tools or mark-making processes are not discussed, his method lent itself to outline drawing with mechanical aids such as ruler or compass in the preliminary stages. The main content of the book gave a clearly presented exposition of simple perspective drawing (Figure 30) using the ‘method point’ that, according to Kemp, was a distinctively British technique in the eighteenth century with particular currency amongst architectural draughtsmen (Kemp 1990: 150).

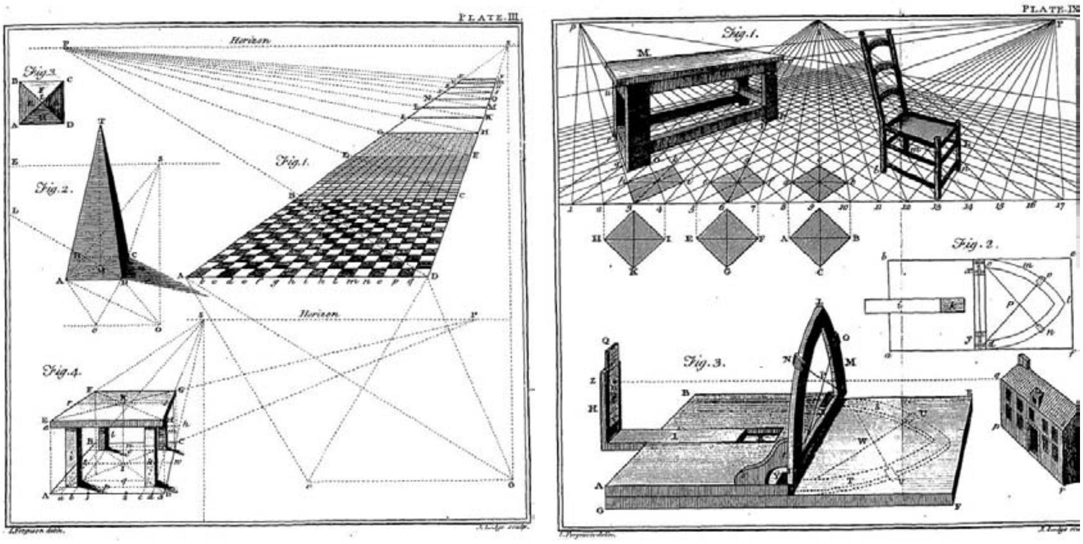


Figure 30: Plate 3 (left) demonstrates ‘how to put a square pavement in perspective’(Ferguson 1775: 41); Plate 9 (right) to represent objects such as ‘an oblong square table in an oblique perspective view’ (Ferguson 1775:) both from *The art of drawing in perspective made easy*

Figure 31 from *Ferguson’s lectures on select subjects* of 1805 shows how by rolling wooden templates together one can mark the path of an epicycloid by scoring with a sharp nail attached to the point. The text and drawing together integrate a demonstration of geometrical drawing and its relation to material shaping and the working of machinery; in Ferguson’s approach to drawing, less emphasis is placed on giving examples to copy,

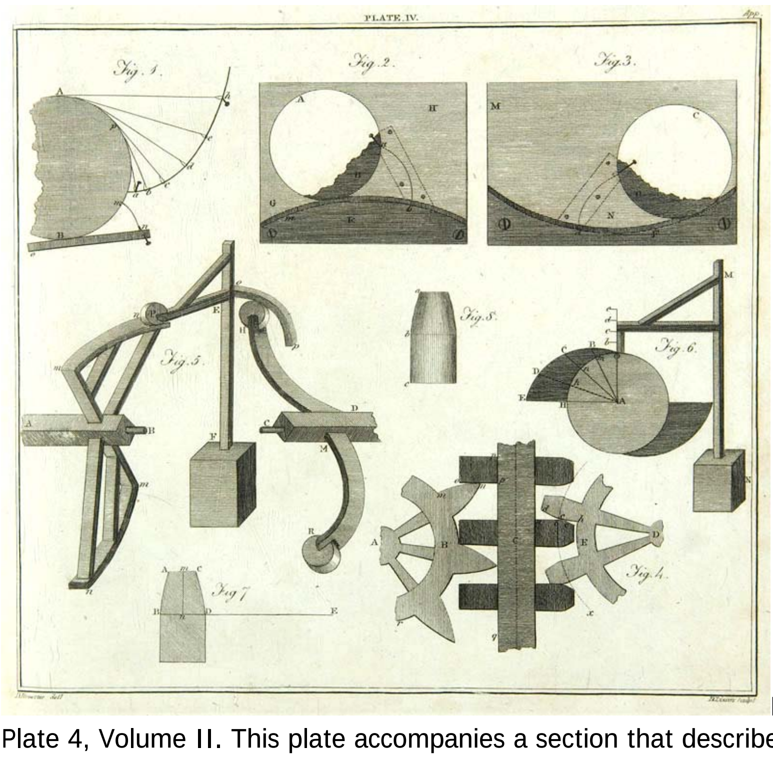


Figure 31: Ferguson 1805 Plate 4, Volume II. This plate accompanies a section that describes how to form epicycloids (used to calculate the form of the teeth for driving and gearing wheels) by rolling wooden templates together and thence scoring their path with the point of an attached nail (Ferguson 1805: 225)

but instead they show methods for developing habits of systematic analysis of observation into abstract visual elements, alongside techniques of using drawing for design and invention.

Many other drawing manuals from around 1800 onwards invited the reader to use mechanical drawing aids, whilst urging the development of similar mechanical and technical drawing skills in the depiction of man-made constructions. The desired drawing kit expanded to include equipment such as drawing boards and set squares. Nevertheless these same texts did not chase away picturesque or expressive effects, but included them in the repertoire of skills, regardless of whether the implied readers were assumed to be more technically or artistically oriented. In George Douglass's *The art of drawing in perspective from mathematical principles* (1805), he described his intended readers (Douglass 1805: xii) as those who wished to draw bridges, buildings, fortifications and machines. As Douglass was a teacher of mathematics with a wide curriculum that embraced geography, astronomy, navigation, gunnery and architectural construction (Douglass 1805: unpaginated advertisement following the preface) he probably aimed to attract students who might later try for military training. His worked examples were not strictly technical, but were suffused with a picturesque spirit, as in Problem XIII 'to put a circular tower, with battlements and embrasures, into perspective' (Douglass 1805: 51 not illustrated here). By contrast, Charles Hayter, (1761-1835) author of *An introduction to perspective, adapted to the capacities of youth* (1813) was a miniature painter and frequent exhibitor at the Royal Academy between 1786-1832.

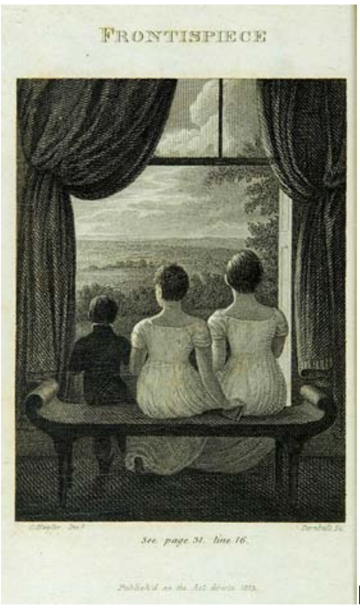


Figure 32: Charles Hayter frontispiece *An introduction to perspective, adapted to the capacities of youth* (1813)

His frontispiece image (Figure 32) demonstrates its address to both boys and girls (in the same manner as the *Transactions* of the Society of Arts), and appears to promise the reader a cultivated and genteel appreciation of landscape sketching. But this allusion to the dual meaning of the word 'perspective' is drawn back in the first stage of drawing instruction that opens uncompromisingly in a much more technical direction with a full battery of mechanical drawing instruments not normally associated with sketching: steel pen, drawing board, compass and parallel ruler (Figure 33). Also, rather than beginning with freehand drawing or sketching, the first exercises in this text ask the student to discipline their hand and body through the repetition of abstract elementary forms.

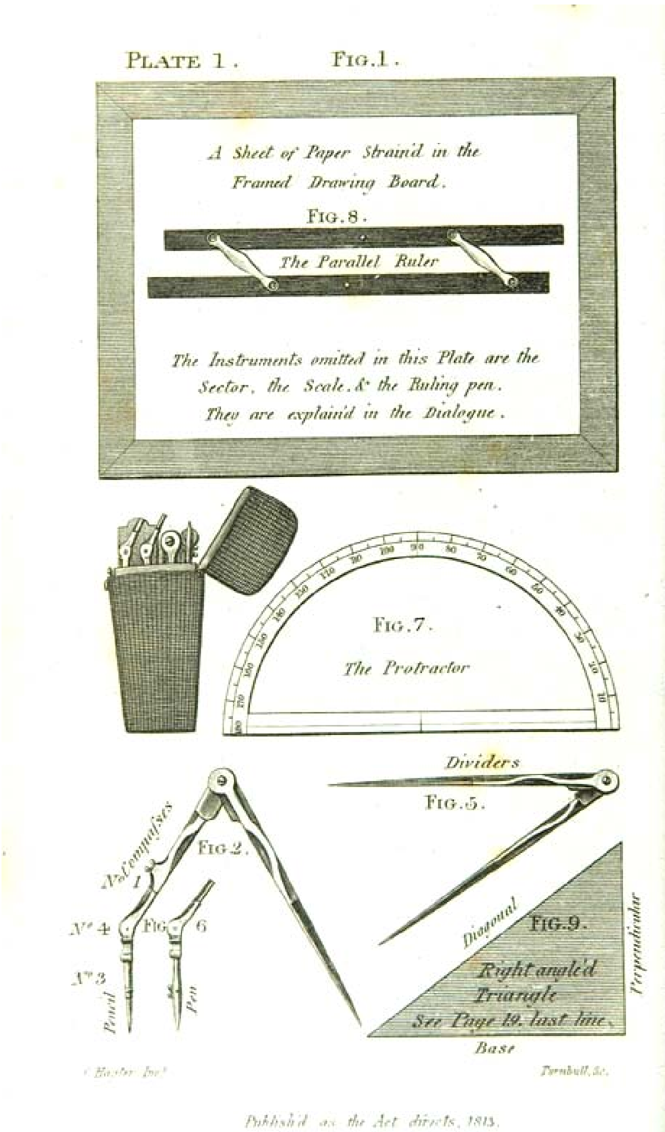


Figure 33: Charles Hayter Plate 1 *An introduction to perspective, adapted to the capacities of youth* (1813)

So even before1800, a range of drawing styles circulated in print. Manuals, in the manner of the *Artist's assistant* series, could be seen as a genre, but those who were teaching themselves to draw used many other types of illustrated source as exemplars.

After 1800, when changes in paper and print production techniques allowed an increase in all kinds of illustrated publications, the range of different styles of drawing reproduced in print expanded even further. Bicknell and Munro (1988) and more recently Ann Bermingham (2000) for example have pointed to the rapid expansion of manuals aimed at the amateur audiences who shaped landscape sketching into 'an agreeable pastime for ladies and gentlemen of leisure' (Bicknell and Munro 1988: 8). However, these authors have focused on landscape sketching by amateurs in order to argue, according to Bermingham, that such drawing activities developed predominantly into a vehicle for individual subjectivity or 'practice of everyday life' (Bermingham 2000: 83-90). These approaches offer the misleading implication that around 1800 there was a definite change in perception amongst the middle and upper classes that drawing was no longer seen as a useful skill but a polite accomplishment (Bermingham 2000: 1). While it is certainly true that such practices were an important new element, reflected in the publishing market around 1800, this is not the whole story as it denies the heterogeneous quality of drawing education and practice in Britain at that time. The evidence from other researchers and from surviving drawing manuals suggest instead that almost all students of drawing, from schoolgirls to factory owners or artisans, rehearsed many registers veering from rococo artifice, to spontaneous sketching and on to geometrical or perspective construction. Furthermore the invitation to use mechanical drawing aids in many manuals after 1800 contradicts the thesis that there was an emphasis on subjectivity expressed through free mark making in amateur drawing practice at this period.

Drawing manuals give more purchase to Bignamini's claim that a 'mature academic system' existed in Britain before the foundation of the Royal Academy. But equally, the evidence of the texts challenges the systematic methods that characterise academic teaching in an unruly mingling of methods and subject matter. Many manuals were eclectic digests of perspectival and geometrical construction methods, ornamental forms, as well as landscape and figure examples that appear to deny any separation between polite and useful arts. It is also important to remember that 'manuals' were only one kind of printed resource that could be used to develop drawing skills, or to train the eye to conventions of mark making. As already noted in Chapter 2, any illustrated work, such as William Chambers' *A treatise on the decorative part of civil architecture* (1759), could function as a resource for draughtsmen teaching themselves. Different drawing conventions as used in works such as illustrated encyclopaedias can be seen in Figures 9 or 15 in Chapter 2. Often different conventions representing the same object were displayed alongside one another as can be seen for example in the publication supported by the Society of Arts, William Bailey's *The advancement of arts, manufactures, and commerce* (1772; Figures 34 and 35) that used both an oblique perspective view and an orthogonal plan view (Bailey 1772: 241-6) for the same machine.

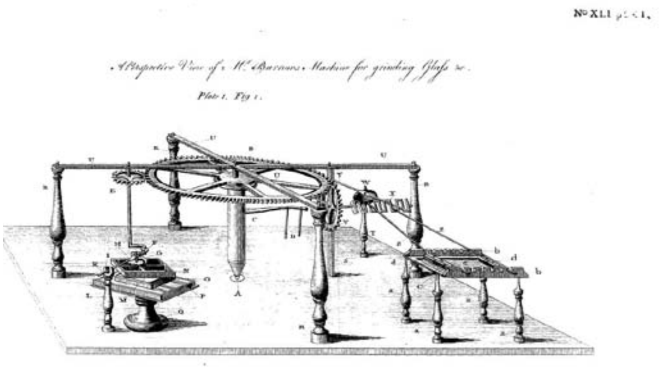


Figure 34: A oblique perspective view of Mr. Burrow's machine for grinding glass, &c. *The advancement of arts, manufactures and commerce*, Volume I (Bailey 1772)

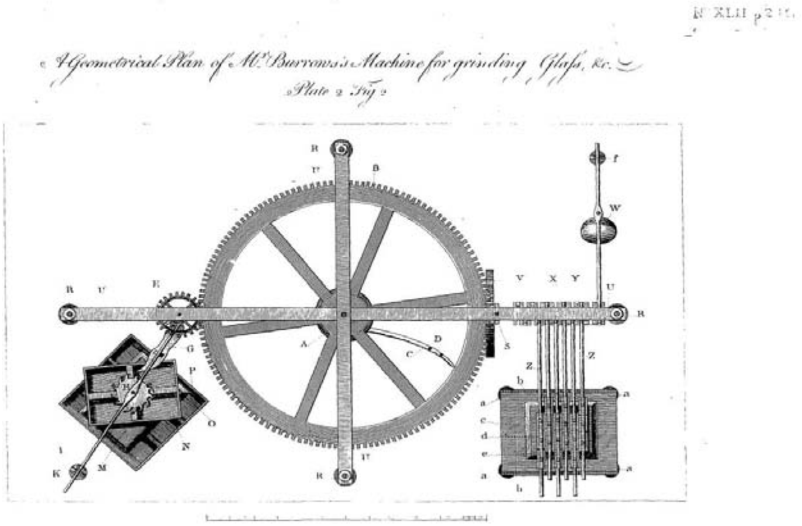


Figure 35: A plan view of Mr. Burrow's machine for grinding glass, &c. *The advancement of arts, manufactures and commerce*, Volume I (Bailey 1772)

Conclusion

This chapter has considered where students could have learnt to draw around 1800 beyond the Royal Academy schools or in engineering practices. The existence of other schools and institutions challenges accounts of drawing practice and education focused exclusively on the Royal Academy from 1768 or the Government Schools of Design from 1837, furthermore 'art school' historians have often been hampered by notions of creative practice that have interposed a veil on this period. For example, common drawing and design procedures around 1800 (such as copying) have either been condemned as ‘a step in the wrong direction’ (Carline 1968: 34) or swiftly passed over in silence so that by default, the Royal Academy has often remained central (Hoock 2003: 58-61). Nevertheless, provincial academies, military academies and organisations such as the Society of Arts developed distinctive modes of drawing education; in addition drawing manuals and images in print conveyed examples of different drawing styles in virtual ‘print academies’. In these contexts drawing skills were taught for a whole spectrum of applications in a way that suggests the distinctions that Reynolds wished to draw between polite arts and mercantile considerations were not apparent to most drawing practitioners before 1800. Furthermore the way in which the Society of Arts (through its *Transactions*) suggests a different model of practice, not centralising, but dispersed. While Swift attacked the ‘centralist view’ of art education that left out provincial academies (Swift 2004: 11), printed exemplars in the *Transactions* and in drawing manuals expand the notion of dispersed practices across Britain even further. In addition, bearing in mind that the distribution of mechanised industries across the country did not always coincide with established centres of polite cultural exchange (Berg 1980: 22-24; Pollard 2000: 80-103; Styles 1993: 527) suggests that one unconsidered aspect of the history of technical drawing might lie in an opposition between centralising tendencies in high culture and more dispersed or distributed drawing practices in the mechanical arts. If the previous chapter suggested that it is useful to consider separate communities of practice even within one institution such as the Royal Academy, this chapter has demonstrated that it might be useful to consider different geographies of drawing activities in this period.

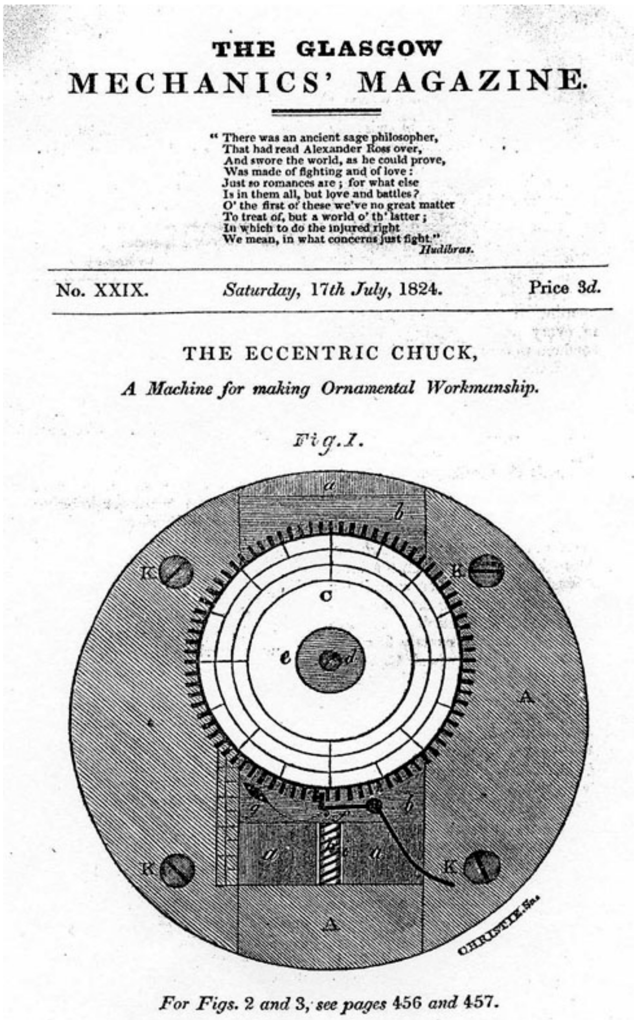
Additionally, and especially after 1800, an interest in mechanical arts in publications such as the *Transactions* of the Society of Arts, and in drawing manuals, favoured linear and geometrical mark making. This applied both to machines as subject matter (as in Figures 27, 31, 34 and 35) but also to techniques such as perspective drawing or the study of geometry executed with mechanical drawing aids. The evidence shows that these techniques were aimed not only at artisans but also polite readers, in contradiction to a common perception that this latter was a homogeneous group of amateur artists purely engaged in modes of freehand sketching as a means of developing an individual subjectivity (Bicknell and Munro 1988: 8; Bermingham 2000: 1). Artisans were engaged in many trades, and their engagement with different material processes was expressed through different drawing procedures, just as many polite readers also learned to draw for a variety of useful ends.

In this chapter and the last I have sought to indicate the range of drawing practices encountered within wider visual culture in the decades around 1800, in relation to the development of technical modes of drawing. In Chapter 2 by comparing artistic and technical drawing histories, and making detailed observation of examples associated with the firm of Boulton & Watt and with the Royal Academy, I showed how artists and draughtsmen often shared references to tradition and conventions of representation in both artistic and technical applications of drawing in these places. It was evident also that practices of drawing for both practical and fine arts purposes extended beyond these locations, in time, but also geographically. Through an examination of rival institutions and manuals for drawing education in this chapter I continue to show a far more textured version of the practices and purposes of drawing in Britain. By extending the consideration of drawing education and dissemination to printed matter, this chapter also suggests that 'technical drawing' should not simply be considered as a mode of communication and control in the factory, but as an expressive means of building an audience for engineering and mechanical arts. In relation to the development of drawing styles, in the teaching of schools such as the Trustees' Academy, in drawing manuals, and in production techniques for manufactures and commerce, the notion that '"design" was something to be bought alongside objects' (Craske 1999: 190) arguably also created a distanced appreciation of 'drawing', especially when drawing styles developed further by being transferred across mediums into print. When exhibition and education were carried forward in print, the medium itself had an effect on drawing style; in addition, this forum mixed up 'learning to draw' with 'teaching yourself to draw', so that production and reception of style became more fluid.

Printed manuals used line engraving and in turn promoted linear styles of drawing. Equally, an interest in the mechanical arts in publications such as the *Transactions* of the Society of Arts and in drawing manuals favoured particular styles of linear geometrical mark making. The next two chapters will address the social construction and development of technical drawing in relation to its material production in print, on paper and through the use of mechanical drawing aids at this period. Sparse line drawing became a dominant style in fine art at this period, and many art historians have made a connection between the fashion for bare outline drawing in the late eighteenth century and wider political events, such as movements to revolution and violent change. In this dissertation, that looks for connections between technical and fine art styles of drawing at this period, I will ask in the next chapter what expressive and symbolic significance could or should be attached to the use of line, and ruled lines, in the development of technical drawing in this same period.

Chapter 4: Fabricating the line: purity, progress and labour

Does it make sense to attribute aesthetic or symbolic meanings to styles of mechanical drawing that were adopted in the first half of the nineteenth century? In this period techniques of mechanical drawing developing in the workplace or in illustrated publications directed towards artisans and mechanics (Figure 36) seem to define and shape a convention with certain fixed limits.


THE GLASGOW
MECHANICS' MAGAZINE.

"There was an ancient sage philosopher,
That had read Alexander Ross over,
And swore the world, as he could prove,
Was made of fighting and of love:
Just so romances are; for what else
Is in them all, but love and battles?
O' the first of these we've no great matter
To treat of, but a world o' th' latter;
In which to do the injured right
We mean, in what concerns just fight."
Hudibras.

No. XXIX. *Saturday*, 17*th July*, 1824. Price 3*d*.

THE ECCENTRIC CHUCK,
A Machine for making Ornamental Workmanship.

Fig. 1.

For Figs. 2 and 3, see pages 456 and 457.

Figure 36: *Glasgow mechanics' magazine* cover image, 17 July 1824

Most evidently the use of fine uniform ruled lines and the strict alignment of horizontal and vertical forms with the rectangular page (see also Figures 4 and 5, Chapter 1 and Figure 7, Chapter 2) display an adherence to procedure that appears to leave little room for expression. This prosaic understanding of the function of such styles of drawing can be seen in Stafford's argument that the linear and geometrical style of technical illustrations around 1800 allowed 'even the minimally educated user to discover for himself steady and solid facts within a precariously shifting and expanding intellectual universe' (Stafford 1991: 144). In this comment, Stafford puts forward the opinion that this type of line marking is 'attenuated', in the sense developed by Nelson Goodman (1976: 229), implying further that it was directed at viewers with limited agency. Other writers, for example the cultural historian and anthropologist Tim Ingold (2007), have by contrast attributed a range of powerful meanings to the straight line, calling it 'a virtual icon of modernity' (Ingold 2007: 153). The development of technical drawing in this period, with its linear markings, coincided with a fashion for line drawing in art and design contexts at the end of the eighteenth century, and although technical drawing has not attracted the attention of many art historians, the outline style in art has aroused in observers strong emotions of both allegiance and hostility. This chapter will examine line marking in art, design, technical and architectural drawing in the period from the late eighteenth to the mid-nineteenth century, in order to evaluate the various claims that have been made about it by later scholars: that it is utopian; that it is in some sense a natural representation of what is found in the natural and material world; that is was used as an instrument of social control. I will examine these issues at various levels: levels of ideology, training, production, and historiography. Although my focus will be on historical material from the period of this thesis, I will note that the discussion by historians of these questions, by anthropologists, by art theorists, and indeed by twentieth century designers are all of relevance – but, in particular, there has been a tendency by the historians to impose, retrospectively, perspectives growing out of art movements *after* my period of study; and there has been a tendency by designers to attempt to 'naturalize' their own attitudes towards the relationship between form and function.

Two opposing methods are often used to explain changing styles in art: either a materialistic emphasis on technical constraints, or by contrast, a conceptual emphasis on ideas (one persistent example is the myth that the Cubist style of Picasso was in some way a response to Einstein's general theory of relativity (Laporte1966; Miller 2005; Dalrymple 2005: 349-398)). Technical drawings, in the examples cited at the opening of this chapter, use unadorned lines, produced with the aid of ruler and compass on an empty paper support. In the idealist mode of interpretation, drawings with these characteristics have been connected with revolutionary utopian politics and with a spirit of 'modernity'. Bearing in mind that the study of drawing falls under different disciplines, I will consider how to achieve the most useful explanation of the symbolic function of the use of line within technical drawing at this period. The discussion will move from line in general to focus on the characteristic straight ruled line, the ‘unmodulated’ line. By this is meant that the draughtsman attempts to make the line absolutely uniform along its whole extension, with the same width and the same depth of pigment. Many current theories of the significance of outline drawing around 1800 and through into the nineteenth century suggest that outline is an ahistorical style, and hence associated with utopian or modernist drives in society. In contrast to such approaches, I argue that line is best understood not as an immaterial concept but as the trace of material shaping, the sign or marker of an often laborious embodied process. What emerges is a complex and nuanced understanding of the purpose, construction, and meaning afforded the line (and its relationship to the material world). Examining the production of marking as a made object suggest other interpretations, derived from the history of science, of how practitioners asserted the authority of line marking in technical contexts.

‘A virtual icon of modernity’: outline style, utopia and revolution

Several writers from the 1960s onwards have linked the use of bare outline drawing in the late eighteenth century with wider revolutionary desires, pointing for example to the designs of Ledoux and Boullée in France, to David’s revolutionary social programme, or to Flaxman’s desire for archaic simplicity. Robert Rosenblum’s sweeping description of late eighteenth-century utopianism in art as the ‘dream of a *tabula rasa’* (Rosenblum 1969: 191) allowed him to attribute the development of the outline style to a ‘spirit of drastic reform’ (Rosenblum 1969: 146) that in some unspecified manner impelled both the revolutions in America and France, as well as creating austerely abstract outline styles in artistic practice. Rosenblum’s ideas have been influential, especially with writers addressing the so-called ‘revolutionary design’ methods of the neo-classical architects Etienne-Louis Boullée (1728-99) and Claude-Nicholas Ledoux (1736-1806; Picon 1992: 271-97; Vidler 2005).

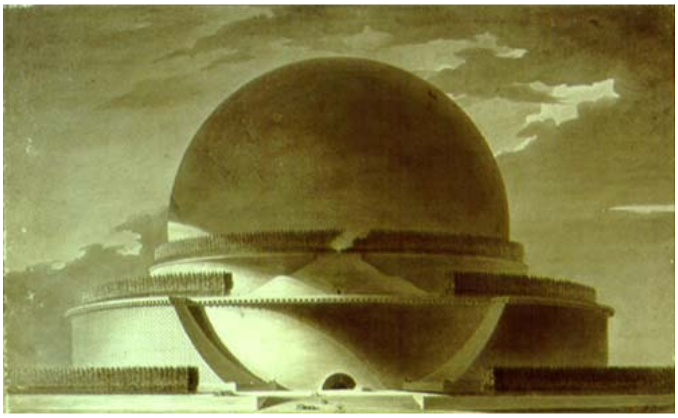


Figure 37. Etienne-Louis Boullée (c.1785) *Elevation for Newton’s Cenotaph* watercolour drawing

Hence Rosenau (1976: 18) explored Boullée's use of spare geometric forms in buildings associated with death and mourning to convey the terror of a realm beyond the everyday world, for example (Figure 37) in his famous but unrealised design for Newton's cenotaph (Rosenau 1976: 19). Meanwhile Vidler linked Ledoux's use of repetitive uniformity of effect to Burke's late 18th-century concept of the 'artificial infinite' aspect of the sublime (Vidler 2005: 72). A straight visual comparison, noting the use of simple geometrical forms and repetitive uniformity of form and marking, could be applied to the drawing of the 'eccentric chuck' in Figure 36 above. With its simple geometrical forms, diagonal line hatchings, and uniformly rendered gear teeth it appears to unite notions of the sublime proposed in the late eighteenth century by Burke or Boullée and developed by their later twentieth-century commentators, if the same method of visual and textual comparison were to be applied.

Rosenblum's concept of the *tabula rasa* derived from the way in which illusionistic space is allegedly abolished in some neo-classical outline drawings through the use of uninflected lines on a blank paper support as in Figure 38, an image that he described as being in 'an austerely abstract drawing style... particularly appropriate to a Utopian vision of a new unblemished architecture' (Rosenblum 1969: 128).

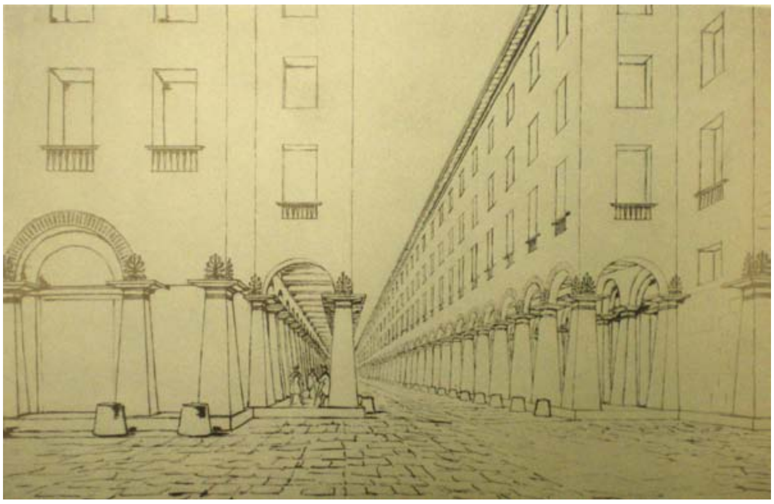


Figure 38. Friedrich Gilly (1797-8) *Rue des Colonnes, Paris* drawing Berlin, Technische Hochschule Bibliothek

Boullée and Ledoux developed a new vision of architecture through a sparse formal language of unadorned regular geometrical forms derived from mechanical drawing operations with rule and compass (Rosenblum 1969: 120-1). Boullée asserted firstly that geometry expressed the most profound structural laws of nature and secondly that as human observers are also subject to those same laws then, that his style of drawing and design would have a powerfully moving effect on the viewer; indeed, on all viewers in all places (Picon 1992: 266-8; Rosenau 1976: 86). Similar assumptions, as I will show, were also part of more recent modernist claims that abstract geometrical forms in design can be a universal and rational means of communication; and like Boullée, such claims often elided the question of whether that expression was in two dimensions on paper, or realised in three dimensional material form.

Rosenblum also included in his discussion of utopian style in the late eighteenth century the work of the British artist John Flaxman (1755-1826 Symmons *ODNB*), whose line drawings were known and copied across Europe at this time; his illustrations of subjects from Homer, Dante, Hesiod and Aeschylus were first published in Rome in 1793, then in several editions in London, Paris and Leipzig between 1795-1817 (Symmons 1984: 104; 277). Rosenblum described Flaxman's use of empty space and uninflected line as a utopian meeting ground, 'a vehicle for the presentation of a mythical world' (Rosenblum 1967: 169). Figure 39 manifests what Rosenblum calls a 'negation of space' (Rosenblum 1967: 189-91) because its sparse linear marks with no shading or other markers of plasticity give no clues about depth or orientation. There are hints of perspective-like constructions, but they all point in different directions; in perspective terms, this is a view from nowhere.

Figure 39. John Flaxman artist and Thomas Piroli engraver (c.1793) *Fall of Lucifer* steel engraving. Dante *La divina commedia* (Purgatorio Canto XII) 1st edition

In addition, a twentieth century modernist art historian using formal visual analysis would say that the use of line in Figure 39 emphasises the flat surface; it attaches the image to the picture plane. This method of analysis emphasizes the ambiguity of the interplay between 2-dimensional surface decoration and 3-dimensional representation; this technique of observation and argumentation was first used to theorise and give value to the work of artists (such as Cézanne) who were described by their supporters as harbingers of abstraction in the early twentieth century. Further manifestos of abstraction such as *Point and line to plane* (Kandinsky 1979 [1926]) elaborated the notion of pictures as an analysis of pictorial elements such as line. Such opinions had become routine later in the twentieth century, for example in the *Pelican History of Art* series from 1967 (Hamilton 1967: 46). When Rosenblum was writing at the same period, the concept of apparently free-floating unmodulated line charged with spatial and surface ambiguity had become naturalized enough to appear as the first meaning of its use, and was applied wholesale to many contexts, and in Rosenblum's case, backwards to the eighteenth century.

The context of revolutionary politics has also been used to add extra weight to readings of the outline style in the late eighteenth century, as developed for example in the work of the French artist Jacques-Louis David (1748-1825). David developed his outline style so that he could, as Craske puts it (1997: 168-9) 'bring truth, clarity and moral purpose' to images such as *The oath of the Horatii* of 1784-5 (Figure 40). Dorothy Johnson has described David's adoption of clear crisp outline drawing (*dessin au trait*) around 1780 as a deliberate rejection of his earlier Rococo training that broke up clear figure-ground divisions on the canvas (Johnson 1989: 103). Through emphasizing the contour of the body separated from the background Johnson claimed that David intended to display Diderot's emphasis on gesture as part of a 'utopian quest… that would offer direct and immediate communication between all societies, regardless of cultural or linguistic differences' (Johnson 1989: 96).

Figure 40. Jacques-Louis David (1784-5) *The oath of the Horatii* oil on canvas

We can attribute such interpretations to some largely unspoken assumptions (and a lot of hindsight) about the significance of the French revolution already noted in Chapter 1. This assumption is at work even in the more circumspect approach of Martin Kemp (1990: 229-231) who noted the desire in other writers to make links between artists, architects, and technical draughtsmen such as David, Boullée, and the geometer and educator Gaspard Monge (1746-1818 Booker 1961-2: 15-36) whose visual expression used strong clear outlines and simplified elemental forms set within rational empty spaces. Although Kemp treats this convergence very cautiously, attributing these visual similarities partly to closely related antecedents, he also suggests a 'spiritual affinity' between David and Monge (Kemp 1990: 321), by which he means the later direct involvement of both men in the politics of the French revolution that at its height attempted to sweep away previous hierarchies and institutions.

Some British artists working in the outline style have also been associated with revolutionary or republican movements, for example William Blake (1757-1827) the engraver and artist who attained cult status in the twentieth century. Blake allied his republican radical politics with his artistic creed of the 'distinct, sharp, and wiry bounding line' as a sign of artistic creation, unified in the skilled and expressive hand of the artist (Eaves 1992: 155; Viscomi 1993: 42-3). Less well-known as a 'revolutionary', however, Blake's fellow engraver and occasional collaborator (Eaves 1992: 130), Wilson Lowry (1762- 1824 Guyatt *ODNB*; Figure 41) should also be considered here.

Figure 41: 'Delineators' Rees' C*yclopaedia*, Volume 11, Plates Volume 2 (1819) Drawn by J. Farey, engraved Wilson Lowry

Lowry is celebrated today for his work as a steel engraver, and for his invention of a line-ruling machine that he used in the production of illustrations (such as Figure 41) for publications such as Abraham Rees' *Cyclopaedia* of 1819 (Hunnisett 1980: 88). However, Lowry's revolutionary and utopian tendencies, unlike those of Blake, have not attracted attention. Lowry's obituary recalled: 'At an early period of his public life, Mr. Lowry was a warm admirer of that patriotism which resisted oppression, and promised to restore liberty to mankind; and when the blaze of revolution burst forth in France, he hailed it as the dawn of that era which should usher into existence the reign of universal freedom, and establish a political millennium throughout the world' (*Imperial magazine* 1825: 125). Lowry's hitherto-unreported views might at first glance seem to support the argument that line marking at this period does denote some kind of utopian quest, particularly (in this study) because of his close links with the development of technical illustration, those who aimed to encourage the useful arts, and with natural philosophers. For in addition to his engraving work, Lowry was also an inventor, a founder member of the Geological Society in 1808 (Rudwick 1963; Laudan 1977; Porter 1977) and was elected a Fellow of the Royal Society in 1812. Indeed, when the anthropologist Tim Ingold asserted that the straight line is 'a virtual icon of modernity' (Ingold 2007: 153), he had in mind the late eighteenth century British context in which Lowry was operating. However, without further direct evidence of intention in Lowry's choice of style, or of reactions by his viewers at the time, it is not possible, without circularity, to ascribe revolutionary or utopian meaning to Lowry's use of line.

Historians looking to other parts of Europe have attributed the adoption of the outline style to a backward-looking antiquarian urge, an 'anti-modernity' that fed Romantic and even nationalist developments in art. For example, the conscious use of clear crisp outlines that we can see in the German Nazarene group (formed in Rome around 1810) has been linked to a celebration of the Renaissance artist Albrecht Dürer (Sieveking 2001: 116-20). This cult was part of the resistance by Germanic Romantic artists to the dominance of French culture in the context of the Napoleonic wars (Honour 1979: 218-227). The trouble with utopian accounts of line marking, as we see in closer scrutiny of Rosenblum's position, is that past and future get confused. So in Britain John Flaxman's style, according to both Symmons (1984: 43-5) and Rosenblum (1967: 169) was derived from a range of archaic and primitive sources. Indeed, like his friend William Blake, Flaxman's style as a draughtsman was taken not from the immediate past, but was synthesised from studying medieval statues in Westminster

Abbey and from Roman and Greek friezes, sculptures and red-figured vases (Symmons 1984: 33-45; Rosenblum 1967: 154-5; Irwin 1966: 21-8; 53-4), an eclectic array of sources separated from each other in time and space. Flaxman's style was not wholly derived from his immediate predecessors, or from his training in academic drawing, and other expected two-dimensional sources such as prints or paintings. Instead, it was derived from surface decoration of crafted objects (ceramics) or from sculptural free-standing figures, tomb monuments or classical low reliefs.

In contrast to utopian commentators, Symmons suggests that by reducing such disparate sources to 'a uniform colourless line', Flaxman allowed these styles to sit together, whilst displaying them to the educated connoisseurial eyes of his patrons (Symmons 1984: 45; 80-2). Here line becomes a 'lingua franca'; a way of representing disparate styles and objects to collectors and readers who could recognise and compare them. Rather than functioning as a utopian statement, line in this interpretation is described in a way that refers directly to Flaxman's audience as consumers and collectors of art and art in reproduction. This technique of using line also appears to fit the description of the new uses for line drawing in designing for decorative arts production as noted in Chapter 3. Artisans developed line drawing skills and a method of copying and juxtaposition of motifs because changes in production techniques in the last decades of the eighteenth century favoured applied surface decoration (Styles 1993: 532-4). In contrast to utopian approaches, writers such as Symmons or Styles and other design historians give an account of the development of linear styles in reference to the acts and decisions of designers, audiences and artisans. On one level these are potentially more convincing explanations because they relate to a much wider network of activity that is open to examination. Nevertheless they share one assumption with utopian accounts of change in emphasizing personal choice in the social, political and cultural formation of line drawing. Other approaches, suspicious of liberal notions of a society made up of individual human agents, have instead focused on the issue of line drawing as a means of control.

'The ideology of industrialisation': artisans, education and control

In contrast to more individualised descriptions of the symbolic meaning of line drawing in visual culture around 1800 focused on the world of a few elite producers such as Flaxman, I now turn to social approaches that discuss the education of the industrial worker in the first decades of the nineteenth century, where training in line drawing has been described as an instrument of control and class oppression. Ideological suspicion of the symbolic functions of line in technical drawing is derived from Michel Foucault's influential thesis in *Discipline and Punish* about the construction of 'docile bodies' through the imposition of an internalised self-discipline on to citizens of industrialising societies (Foucault 1991 [1977]: 135). To writers following these approaches the procedures and appearance of technical drawing have been seen as the means of indoctrinating workers into an 'ideology of industrialisation' (Brett 1987: 59). In a bitter inversion of earlier utopian notions David Brett has argued that the visual grammar of geometrical mechanical drawing was designed to displace existing techniques and styles that previously transmitted cultural traditions. Instead, he claimed, geometry was held to be factual, positive, modern and hence ahistorical (Brett 1987: 60). Brett's work has mainly been concerned with practices of decorative design and with the debates about what should be taught in the Government Schools of Design later in the nineteenth century. Nevertheless, the sweep of his argument is important to this study firstly because he is concerned with the visual education of all industrial workers and consumers in the first half of the nineteenth century, and secondly, because he moves freely between industrial drawing practices, making little distinction between ornamental and mechanical design activities.

Brett claims that as technical and design drawing was assumed to be the first stage of industrial production in the way described by Charles Babbage (1835, see Chapter 1), then factory owners set out to train workers to accept these methods of organisation. Brett developed his argument very broadly by claiming further that industrial production and 'science-based technology' were linked conspiratorially with the growth of 'mass education and bureaucracy'. Thus teaching drawing through geometrical and linear styles, perceived by their advocates as ahistorical, would break down worker resistance through the 'destruction of age-old habits of thought and behaviour' (Brett 1987: 3-4). Brett described the linear techniques in William Dyce's *The drawing book of the Government school of design* (1843: Figure 42) as a vehicle of indoctrination, that fostered abstraction as a means of breaking ties with traditional cultural forms.

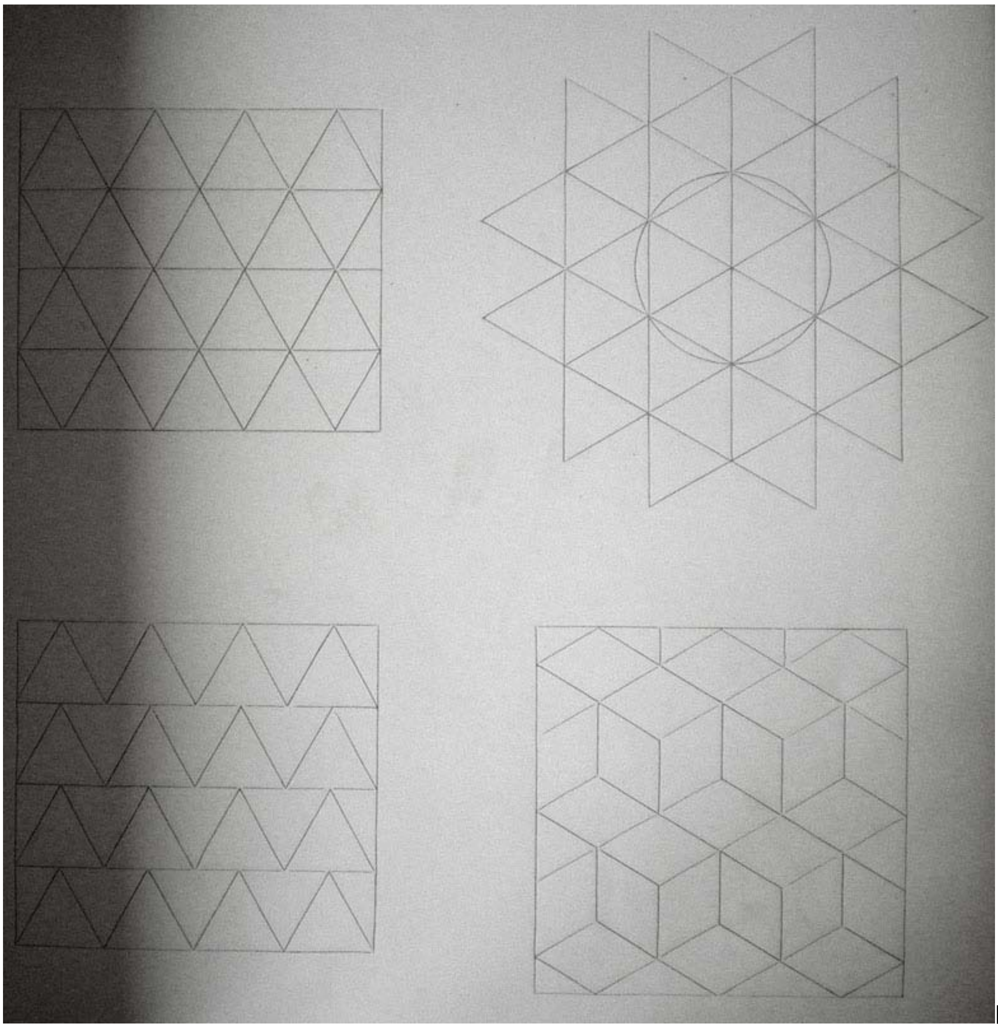


Figure 42: William Dyce *The drawing book of the Government school of design* 1843, exercise V begins with triangles and uses these to build composite forms

Dyce's *Drawing book* was intended to 'educate young persons in the art of inventing' and also 'manufacturers and pattern-draughtsmen' (Dyce 1843: np). Students began their course through graded exercises in geometrical drawing with ruler and compass. For example in Exercise I (on the page illustrated in Figure 42), the student executed parallel straight lines, which were then divided into halves, quarters, thirds and fifths. Exercise II introduced intersecting lines at 90º or 60º, once again constructed with ruler and compass. In comparison to the late eighteenth-century artisan drawing strategies that were discussed in Chapter 3, these examples demonstrate a move away from naturalistic rococo motifs derived from a world of luxury goods to a simplified rehearsal of geometrical drawing techniques, more closely allied to the visual world of engineering.

These teaching methods have attracted wide scorn, both at the time and since, for prescribing a 'stiff inflexible delineation' (Denis 1995: 71) as a design drawing strategy. Purbrick (1998: 275-93) and Denis (1995: 36-39) develop further Brett's hostile analysis of the use of linear styles of technical drawing as a means of controlling and coercing workers. The step-by-step laborious techniques in Dyce's drawing book are examples of the ways in which, according to this school of analysis, drawing instruction for artisans aimed to inculcate docility and an industrial vision through the physical imposition of a system; the notion of 'doing the right things in the right place' (Denis 1995: 71). Denis gave most attention to the period after 1850, but he has also surveyed drawing manuals from the first half of the nineteenth century to support his argument that the drawing conventions taught to workers were a means of creating 'mindless operatives' (Denis 1995: 82). Overall, the scholars in this section have at first glance claimed that line, far from being the expression of utopian desires by elite designers, was an inculcation of system and docility amongst a large class of visual labourers. But at the same time, they share some views with the elitist approaches noted earlier, as line drawing is described as a means by which factory owners and investors routinely exerted power. In addition, historians such as Brett, Purbrick and Denis also share with the previous more visionary interpreters the utopian notion that the practice of geometrical line drawing at this period was used to force a break with tradition. Such views appear to give to line drawing a power that is more than symbolic, and affords it a kind of agency that it is claimed paradoxically is lacking in human actors. In the end it is not clear where arguments such as those of Brett take us beyond the unmasking of ideology, especially as the specific nature and interests of the shadowy protagonists in his struggle are never clearly revealed (for example 'mass education and bureaucracy'). A further problem with Brett's approach lies with his claim that styles deriving from scientific and technical drawing traditions are 'ahistorical', which is a circular, even self-contradictory argument.

'Virulent anarchy': caricature and grotesque

In contrast to the ruled unmodulated line, and in contradiction to the notion of powerless workers, it is important also to recognise briefly that other new and unruly linear styles were gaining ground in visual culture, most notably in the development of the 'virulent anarchy' of satirical caricature in Britain from the late eighteenth century onwards (Fox 1988: 22). In graphic print journalism, many styles of freely drawn line images continued to develop after 1830 in print mediums such as wood engraving and lithography (Anderson 1991; Fox 1988). Out of many images produced by practitioners across Europe, Rodolphe Töpffer's lithographed visual narratives have attracted analysis from print scholars (Twyman 1990: 186-90), comic strip enthusiasts (Groensteen and Peeters 1994: 10) and art historians (Gombrich 1959: 284-9), because he wrote about his practice, praising the virtue of the deliberately uncontrolled line that invites the viewer to interpret and form their own narrative. Cheap printed caricatures were aimed at viewers from lower social classes as well as to more well-off buyers, and although reformers hoped that respectable pictorial reading matter, such as the *Illustrated London News* or *Pictorial Times*, might be able to convey to the working classes the 'intelligence and good feeling that could be acquired by the eye alone' (*Pictorial Times* 4 September 1847, quoted in Fox 1988: 10), they also feared the demoralizing effects of lewd or violent imagery that circulated in sensational cheap publications (Fox 1988: 191-200). Such accounts of a more uncontrolled process of selection and consumption of different types of drawings in print, sometimes with overtly 'anti-social' aims, contradict the notion of docile operatives under the spell of one style prescribed by the 'bosses'. Although these heterogeneous visual styles can only be noted in passing in this study, their existence can be seen at the very least as a corrective to accounts, such as those already presented in the first part of this chapter, that give authority to one single style of drawing by placing it in isolation.

More assertively, caricature drawing could be described as a romantic counter-culture responding to the dominance of the rationalist or utilitarian straight lines. It is also a further example of a drawing style from outside the academy that found an expression and a market in the decades around 1800 (the era from which Rosenblum extracted utopian styles of drawing). In *An historical sketch of the art of caricaturing* (Malcolm 1813), the author patriotically trumpeted this style as a new art form that was, in his opinion, most perfect in England: 'for the obvious reason, that in no other country has the art met with equal encouragement, because no other portion of the globe enjoys equal freedom' (Malcolm 1813: iii). Malcolm also insisted on the skill and creativity of the draughtsman in caricature: 'Like the composer in music, whose mind, turned to the art he professes, produces sounds and combinations he knew not, or thought not of before, the Caricaturist takes his subject, and borne away by his fancy, he nearly creates a new order of beings and things… he that would ensure success is aware he is expected to draw with great correctness; this having attained, he flies to his pencil, and thence to etching; and thus gives a spirit in every touch that could not be effected were he to proceed with caution' (Malcolm 1813: 157). Later in the nineteenth century, the ways in which such mark making developed alongside the more controlled rectilinear style of technical illustration does indeed appear to continue such a dialectic of line drawing in the nineteenth century. Towards 1850, the use of grotesque forms and motifs became the subject for debate in Victorian design theory (Wilson 1999: 143-72). For example, in Volume 3 of the *Stones of Venice* (1853) and further developed in Volume 5 of *Modern Painters* (1860), the art and social critic John Ruskin (1819-1900 Hewison *ODNB*) praised what he described as the 'noble' medieval grotesque: 'arising from the confusion of the imagination by the presence of truths which it cannot wholly grasp' (Ruskin 1903-12 Volume 5: 130). Ruskin's description echoes Victor Hugo's Romantic 'anti-cultural' defence of the ugliness of medieval grotesque forms that in his opinion harmonized 'not with man, but with the complete creation' (Hugo 1827 quoted in Rosen and Zerner 1984: 18-19).

Ruskin defended the noble grotesque as part of a campaign against what he perceived as the evils of working in modern industry. In his opinion this destroyed the true humanity of workers by monopolising their time in repetitive unskilled tasks under the division of labour system. The medieval craftsman, he asserted, enjoyed by contrast ideal working conditions that engaged his entire creative self. Drawing skills, and drawing techniques were at the core of his philosophy and ethos of self-development. He was one of the most vociferous opponents of the drawing programme of the Government Schools of Design (as described above), and teaching methods such as those of William Dyce, that started with repetitions of linear and geometric forms. As well as writing and lecturing to promote his cause, Ruskin also helped to found the Working Men's College with F.D. Maurice in London in 1854 (Haslam 1988: 65-70). Here the course of drawing instruction began in opposition to almost every other traditional method of instruction, not with line, but with shading and colour (Denis 1995: 276-305). So when Ruskin lamented the decline of the Gothic in the late Middle Ages he chose his language with care, using the imagery of technical drawing to denote the unhappy reversal of the once-noble form into: 'a mere web of waving lines... Redundance substituted for invention, and geometry for passion; the Gothic art became a mere expression of wanton expenditure and vulgar mathematics' (Ruskin 1859: 41). The main period of Ruskin's influence, which was considerable, began after the period of this study, growing from 1850 and extending beyond his death in 1900. The Working Men's College was only the first of many educational initiatives that Ruskin was involved in, all aiming to expand the expressive and creative lives of adult workers. In addition, Ruskin also promoted the virtues of handcrafts and of creative expression in the training of artists and designers; by 1900 these ideas had become a new orthodoxy in art schools (Hewison *ODNB*).

The overall effect of Ruskin's teaching on current perceptions of technical drawing will be discussed again in the Conclusion; meanwhile, in relation to the concerns of this chapter, we can note that linear and geometrical techniques of drawing were under attack from social critics such as Ruskin from around 1850 onwards. To Ruskin, linear styles denoted servitude and the perceived horrors of industrialisation. The act of drawing had a central role in these social and political debates, as it was seen as not simply a functional aid in working life, but as a fundamental technique of personal and creative development. At issue were questions such as who could be allowed to develop and demonstrate skill, and who could contribute to public speech. In his rejection of industry, Ruskin set up a misleadingly simple opposition between the 'artistic' judgement of the creative craftsman, and the 'technical' functionalism of the industrialist. This obscured hierarchies of skill and self-expression within technical work that will be addressed in the following chapters of this thesis. A simple characterisation of technical drawing as a means of social control obscures the range of styles and expressive means that were deployed in visual technical discourses. It also raises the question; if technical drawing indeed substitutes 'geometry for passion', what could provide motivation for the development and dissemination of this style. Deterministic accounts, that apply notions of technical and material constraints to the explanation of style change, should also be considered in relation to the development of outline drawing in the first half of the nineteenth century.

The constraints of nature and of art: technology, print, and mathematical visions

As noted, art historians have explained changing styles in art with either a materialistic emphasis on technical constraints or through a conceptual emphasis on ideas. Many recent writers, anxious to unmask the working of ideology, often reject explanations based on material constraints as reductive or misleading. For example, the notion that there may be a straightforward correspondence between geometrical drawing and shaping, to be examined shortly, has been attacked as a perception formed by naturalisation, not nature. In design theory this will be seen in the critique of Glenn Adamson on the position of David Pye. Working designers and engineers, on the other hand, often adhere to an instrumental view of geometrical drawing techniques. The use of ruled unmodulated line in technical drawing around 1800 has been attributed to at least two material constraints. As noted, the idea of 'natural' correspondences between geometrical drawing and material shaping matter has supported the perception that almost by definition technical drawing must use lines generated by ruler and compass. A second perceived constraint is the influence of print technology, where the predominance for technical reasons of intaglio printing for scientific and technical illustration (Ivins 1992: 49) led to the alleged 'tyranny' of hard engraved line in visual communication of the period (Ivins 1992:70). Questions of the significance of the relationships between print production and the development of technical drawing will be addressed at more length in the next chapter, picking up and developing at more length the notion of 'print academies' from Chapter 3 as resources for training and technique. However, in relation to the significance of line marking, it must be noted that any necessary connection that may have existed between hard engraved lines and technical illustration actually began to break down at the end of the eighteenth century, as Ivins himself admitted (Ivins 1992: 70), due to the invention of alternative print methods. In this context the most notable technique is the 'improper' print medium of lithography from 1798 onwards (Twyman 1990: 10-12; Senefelder 1819). In his use of the term 'improper', Twyman meant that lithograph printing techniques offer the possibility of many non-standard book and page layouts not possible under the constraints of letterpress production. Lithography can reproduce almost any type of mark, from severe ruled line through to sketchy or autographic blotting or scribbling (Twyman 1990: 16-20) so the continuing development of a severe line style in technical illustrations through into the middle of the nineteenth century and beyond cannot simply be due to technical constraints.

In relation to the use of lines generated by rule and compass in technical drawing, the belief that geometry is the 'natural' vehicle for structural design is so deeply ingrained in most practitioners of technical drawing that it is rarely discussed. While John K. Brown has noted that nineteenth-century engineers were impelled by a mixture of 'instrumentalist, professionalizing, and political motives' in making mechanical drawings, he also is aware that frequently only the 'objective' instrumental uses of technical drawing were acknowledged (Brown 2000: 196-8). For example, it is notable that the most frequently consulted historians of technical drawing, Booker (1973) and also Baynes and Pugh (1981), assume on the basis of their own twentieth-century training that these marks and techniques are inherent to their subject matter. However, in various practical ways, writers and practitioners did work to construct the 'naturalness' of the connection between line and mechanical reality. In the nineteenth century, Euclid's axioms were a standard part of the elementary stages of education, with the effect that by the mid-century such 'mathematical visions', according to Joan Richards, were perceived to be the key to an understanding of the 'fundamental properties of spatial reality' (Richards 1988: 1; 187). Pasley's *A complete course of practical geometry* (1822; see last chapter), in its linked method of teaching geometry and draughtsmanship simultaneously, provides just one example of the practical ways in which such tacit assumptions were formed. By contrast, when neo-classical architects such as Boullée and Ledoux proclaimed explicitly that geometry allows access to the most profound structural laws of nature (Picon 1992: 266-8; Rosenau 1976: 86), it should be seen not so much as a statement of normalised belief, but as a marker of change; a manifesto statement intended to shape future practices.

In some of John Smeaton's design drawings, for example *Plan of the tubbs (*sic*) at Vauxhall china mill* c. 1750 (Figure 43) he made a correspondence on paper between

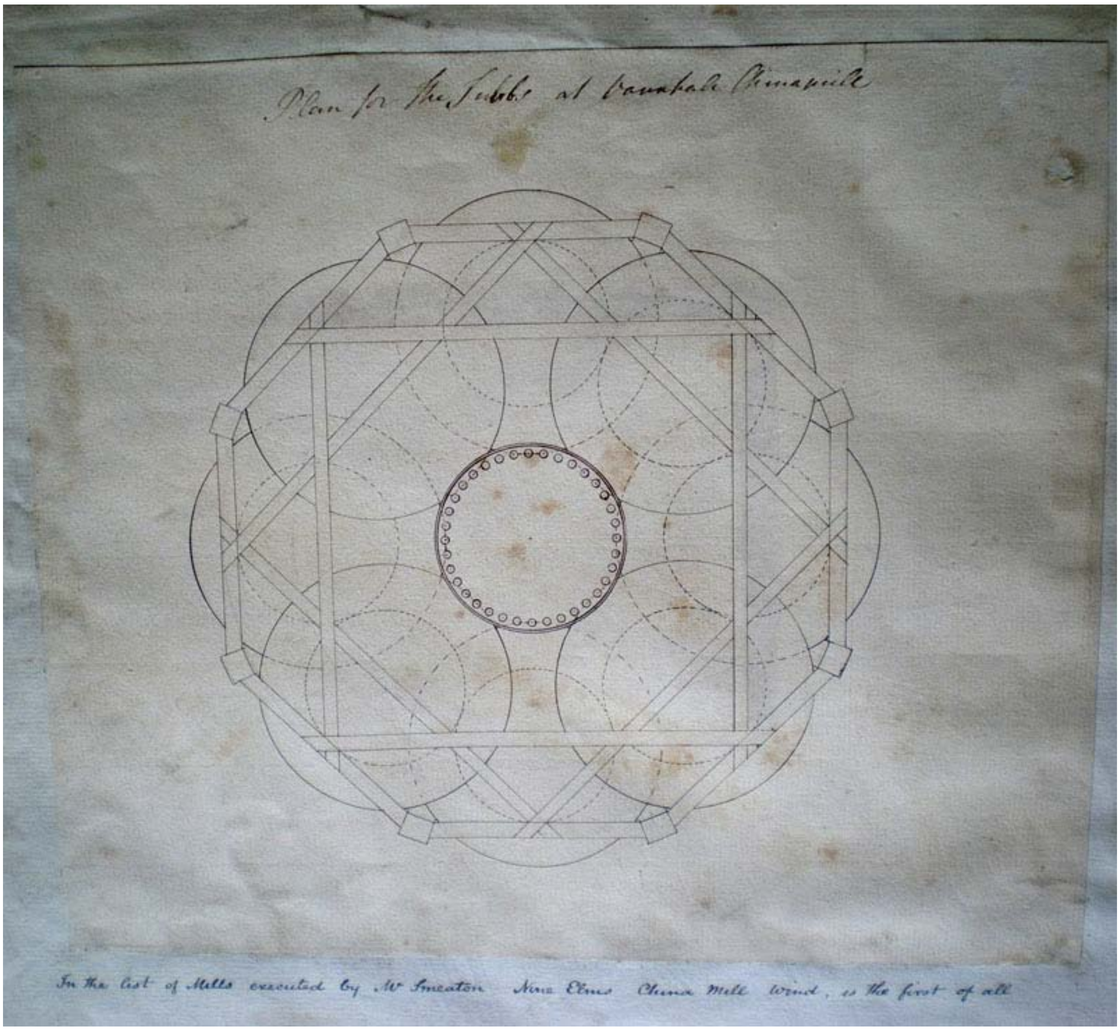


Figure 43: John Smeaton *Plan of the tubbs (*sic*) at Vauxhall china mill* c. 1750 Royal Society JS/1/12

drawn geometrical elements and a planned carousel of ponderous designed objects acting under the rule, in this case, of rotating movement in a water mill. Another variation on this method of manipulating simple geometrical elements through designs worked out on paper can be seen in Smeaton's design for the Hirst of Pilkington's flour mill of 1754 (Figure 44) where: ‘the design sufficiently explains itself, to be framed in a system of triangles, which are known to be the strongest figures possible, and do not depend on any mortising, because the angles, if united by bolts, so they cannot separate, will be far stiffer than any mortising or cramping can make a square frame ordered’ (Smeaton *Reports* Volume II 1812: 430).

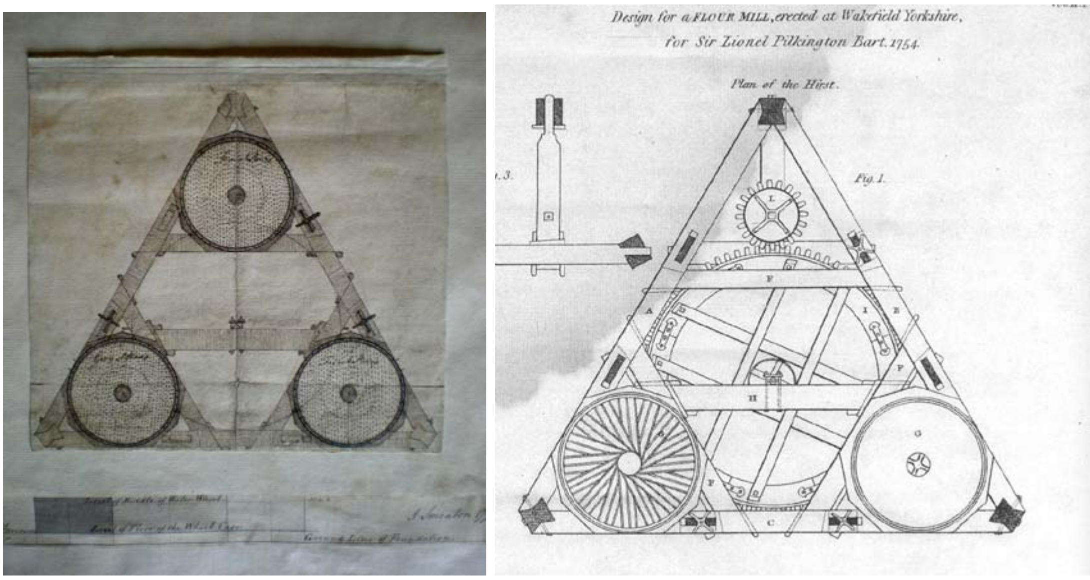


Figure 44: ‘Plan of the Hirst’ John Smeaton drawing for Sir L. Pilkington's flour mill, erected at Wakefield, Yorkshire, 1754 (*left*) and as reproduced in the reissued volume of the *Reports*, Plate Volume II Plate XX fp 430 J. Farey del. Lowry sculpt (reprinted in 1812 *right*)

In his essay ‘Nasmyth on tools and machines’ in the third edition of Robertson Buchanan’s *Practical essays on millwork* (1841), James Nasmyth adopted the language of geometry to describe his method of machine design as a systematic analysis of metal shaping work into ‘six primitive or elementary geometrical figures [line, plane, circle, cylinder, cone and sphere]... for the attainment of certain objects and performance of certain duties’ (Nasmyth 1841: 394). In his list of six elementary figures, Nasmyth puts two- and three-dimensional forms together, making the transition between paper and metal shaping appear effortless. Such an approach can be seen manifested for example in Nasmyth’s preliminary design drawing for an automatic speed regulator where the ruler and compass marks show traces in two dimensions of the envisaged three dimensional trajectories of parts (Figure 45). The systematic analysis of productive hand work into elementary parts was used by mechanical engineers in the first half of the nineteenth century to devise new types of so-called ‘self-acting’ machinery that would replace skilled workers; but in his essay, Nasmyth presents his method as a rational embrace of ‘absolute mechanical truth’ that allows ‘the machine [to] perform its duties’ (Nasmyth 1841: 394). The other, political, motives behind Nasmyth's use of self-acting machinery will be discussed at more length in Chapter 6. Here, Nasmyth's disingenuous emphasis on an ostensibly straightforward correspondence between geometrical drawing and material shaping can be taken as an example of the habit, noted by Brown, whereby nineteenth century engineers only acknowledged the 'objective' instrumental uses of technical drawing in order to conceal workplace strife and to assert elite theoretical know-how (Brown 2000: 196-8).

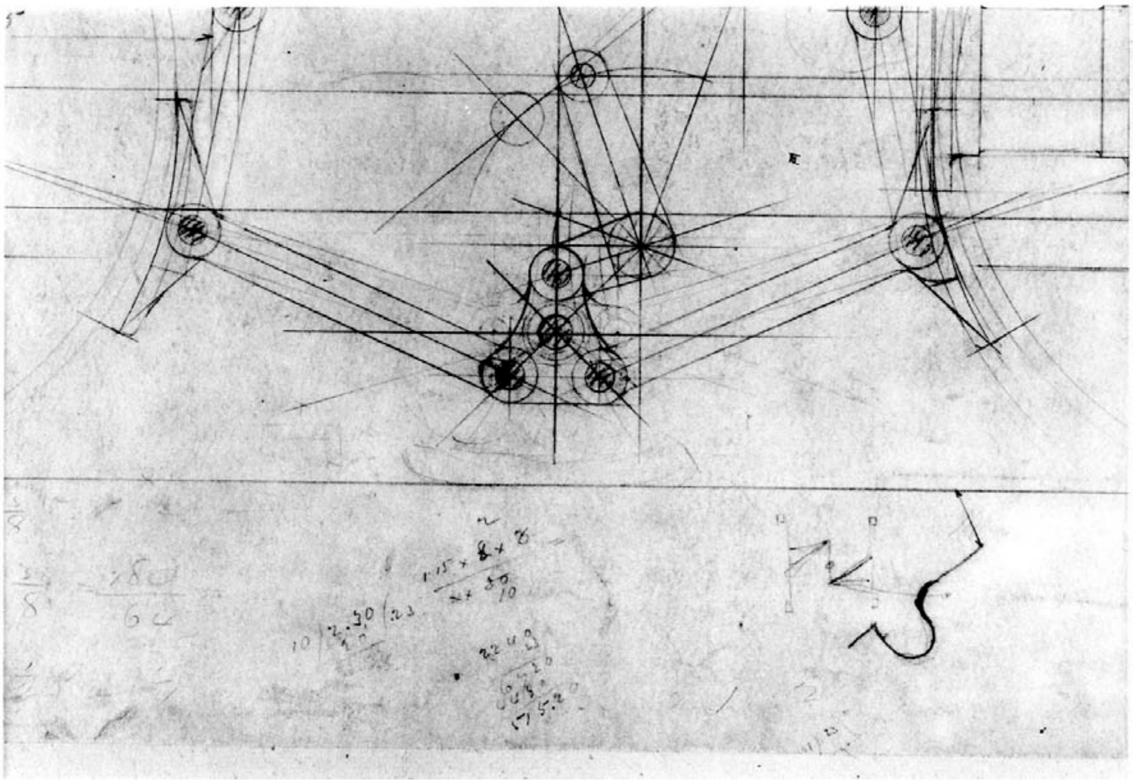


Figure 45: Nasmyth & Gaskell preliminary drawing of automatic speed regulator Institute of Mechanical Engineers END 14/7/1

More apparently straightforward statements of belief in the 'natural' correspondences between geometrical drawing and shaping matter can be found in modernist design theory in the twentieth century. For example, in *The nature and aesthetics of design*, (1978) David Pye aimed to empty out the choice from aesthetics by persuading us that function and form are, or should be, the same thing in design. In designing material objects Pye claimed that working with drawings made by mechanical instruments from ruled lines and arcs of circles is the same thing as working directly with the 'relevant determining systems in the material world' (1978: 55). Adamson has attacked Pye on theoretical grounds for implying that basic forms such as the wheel or the perfectly flat plane are just lying there in creation, without regarding the 'normative' role of simple geometries in Western culture that are apparent to later commentators such as himself (Adamson 2007: 70-8).

In the field of art and design history as well as in the history of technology, then, many writers agree that there are ideological motives for the adoption of linear geometric forms in design drawing that claim to be ‘abstracted’ from nature; and hence that notions of the geometrical constraints of design previously accepted are in reality deterministic, literal-minded and reductive. But despite some general agreements, some differences of approach between disciplines might be insoluble. Pye’s description of the function of drawing in the design process was aligned not to cultural theory, but to a technological, problem-solving approach. As noted, this instrumental view of design drawing has come under suspicion from writers such as John K. Brown for neglecting the underlying social motivations for such rhetoric (see also Lubar 1995; Stevens 1995). Nevertheless, working designers and engineers frequently continue to maintain an instrumental view of geometrical drawing techniques (Baynes 1992: 18-9; Brown, Downey and Diego 2009: 737-52). For example, Nasmyth’s creed of design, noted above, recently attracted uncomplicated praise from Ken Baynes for his ‘puritan insistence on simplicity and commonsense’ (Baynes 1992: 30). In addition, the critical stance often breaks down when historians engage with individual stories, as for example when John K. Brown sympathised with the efforts of Joseph Whitworth when he tried: ‘for two decades to place engineering on geometrically rational foundations’ (Brown 2000: 208). Such a continuing allegiance to this idea cannot be dismissed as simply due to naïve realism, however, but reflects a more detailed and probably unresolvable reflection on the interplay between drawing, material shaping, and mechanical theory in engineering design (Brown 2000: 239 fn.29).

Idealist and determinist approaches, often invoked to explain the adoption of sparse outline drawing styles in technical drawing and illustration, are both problematic. Frequently rooted in current mentalities, each approach is limited to its own sphere of the ideal or material. Furthermore, even the most politicised critiques of the development of style in technical drawing frequently paint a broad picture of class and ignore struggles for status within social groups and subgroups. Hence many approaches that appear at first glance opposed reduce to a single view of uncontested power. The instrumentalist view of technical drawing sees the engineer shaping matter, whilst the social and political critic attacks him for shaping people. Nevertheless, the evidence of interested, even amused, attention to line in visual culture in images and texts during the period around 1800 still invites explanation. By returning to sources of the period, other conceptions of the meaning of line in visual culture become available. These give not only a stronger historical understanding of ways in which practitioners and their viewers ascribed authority to line markings, but also offer a richer synthesis of the material and the ideal. The evidence I present also moves questions of interpretation away from the terms of art historical cultural theory towards discussions from the history of science of how trust, or credence have been established by practitioners. In particular, the use of the outline style, and the use of unmodulated ruled lines, can be seen on the one hand to make use of 'objective' mechanical techniques of automatic transcription, on the other to notions of personal embodied expertise.

Material shaping, mechanical traces and the 'value of the chaste outline'

Consideration of late eighteenth century practices of flat outline drawing offers us a range of techniques and associated claims of authority. Images that might now seem abstract, attenuated, and removed from three-dimensional substance, are revealed instead through the totality of working practice to be deeply embedded in material production. George Cumberland's *Thoughts on outline* (1796) advocated the 'inestimable value of the chaste outline' (Cumberland 1796: 1) as an aid to the sculptor. Cumberland (1754-1848 Greenacre *ODNB*), a watercolour painter, neo-classical polemicist, and a friend and supporter of William Blake, maintained that the best lines were the most self-effacing ones, as they best helped to indicate the subtleties of three-dimensional form. Cumberland explains this point by saying that a fine outline drawing could only be surpassed by a classical statue revolving in front of a lamp, so a changing outline is thrown out onto a wall (Cumberland 1796: 33). This conception of outline echoes the fashion for so-called 'silhouette portraits' in the eighteenth century from around 1770 onwards. In these images, an individual's profile was traced from life using pantograph-based drawing machines in order to capture an allegedly speaking likeness very inexpensively with some profilists advertising a sitting time of 'one minute' only (McKechnie 1978: 22; Kemp 1990: 186-7). Lavater's influential doctrine of physiognomy, the theory of character reading from profiles published in English translation around 1790 (Frizot 1998: 17), lent a dignified air of philosophical investigation to this pursuit, so that in silhouette images, outline was widely believed to be a means of capturing information from complex living bodies. Cumberland's use of the strongly moral term 'chaste' to advocate a technique for representing human bodies and their postures invites comment here (Cumberland's full book title described his method as the 'system that guided the ancient artists in composing their figures and groupes (sic)'). In art history, the word 'chaste' applied to antique figures might immediately conjure the notion of the Greek ideal proposed by the art lover and historian J.J.Winckelmann (1717-1768); 'like the purest water taken from the source of a spring, that the less taste it has, the more healthy it is seen to be' (Winckelmann 1769, quoted in Potts 1998: 78). Winckelmann's writings, strongly influential on the development of neo-classical thought in Europe, thus constructed according to Potts, the notion of an ideally beautiful human figure as a 'radical negation of any bodily substance' (Potts 1998: 78). However, if we search for the meaning of 'chaste' not in theory, but in a community of production techniques, Cumberland's desired ideal of the perfect outline (from a shadow projection) gets its force from the notion of a mechanically generated trace, with the minimum of human intervention.

In Cumberland's description, (1796: 11) and in the work of the sculptors he admired such as Flaxman or Francis Chantrey (1781-1841), contour drawing was envisaged primarily as the facilitator of sculpture; that is, the outline was conceived as the trace of an edge. Petherbridge has described Flaxman's practice of outline drawing in formalist terms as a 'collision between the three-dimensional world and its representation on a two-dimensional surface' (Petherbridge 2003: 7) that is, as a critical comparison between different artistic media of representation. However, a better description of the function of unmodulated outline drawing would be as a pivot between drawing and material shaping at this period. Sculpture was the predominant public art form during the period of the Napoleonic wars, attracting public subscriptions and government funding of £40,000 between 1802-12 for the erection of monuments to national heroes (Yarrington 1988: vi-ix; Macleod 2007: 16). Proposals for public sculpture often took on the quality of gigantic engineering projects, as in Flaxman's unrealised design for *Britannia triumphant* of 1799 that was intended to be a modern version of the Colossus of Rhodes, dominating the London skyline (Yarrington 1988: 57).

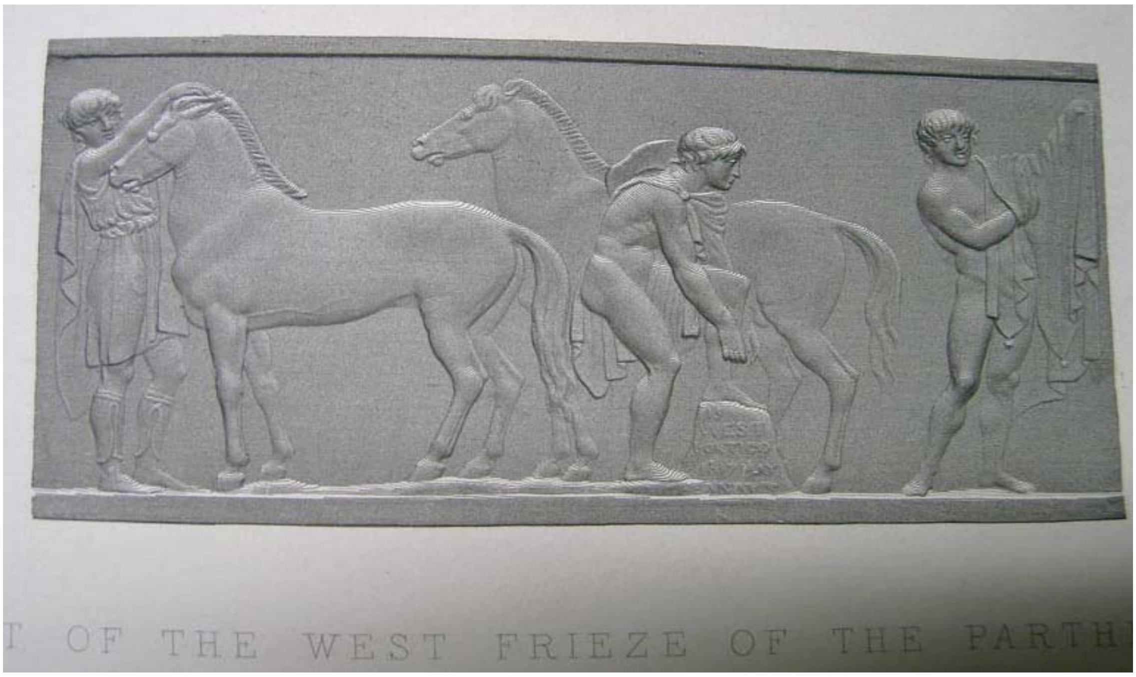
But production methods even of smaller scale works blended art, manufacture and commerce, and took advantage of experimental methods of image copying and mechanical drawing. One such invention included the *camera lucida*, an optical device for tracing the outlines of observed objects, patented in 1806 by the natural philosopher and geologist William Hyde Wollaston (1766-1828) as a means of aiding field observations (Williams ODNB; Kemp 1990: 200-1). Many men of science such as John Herschel (Schaaf 1990: 10-17; Kemp 1990: 220-1), or technical illustrators such as John Farey (1781-1841) used this invention (Woolrich 1998: 49-67); equally the drawing in Figure 46, from the workshop of Francis Chantrey, was also made using the *camera lucida*, and demonstrates a typical procedure, where first sittings with a client were devoted to capturing a full-face and profile view of the head by this means (Potts 1980: 26). This is an adaptation of the academic sculptural technique discussed in Chapter 2, with the aim of inscribing a single line drawing of the front and side elevation of a proposed sculpture to an uncut block of stone. With this technique, the sculptor's observational drawing skills are bypassed in a mechanical transfer of a traced line from the body of the subject.

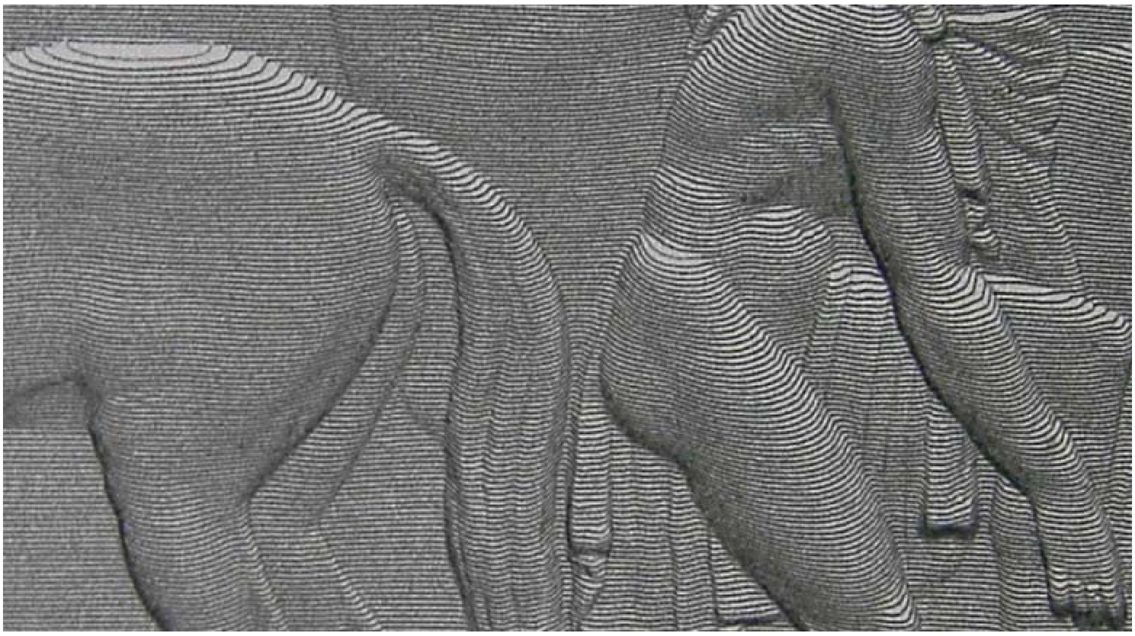
Figure 46. Sir Francis Chantrey *Mr Scott* pencil camera lucida tracing of James Scott (1770-1848) full face and profile national Portrait Gallery London

Other inventors devised further operations for mechanically tracing a profile in line in order to generate three-dimensional form, for example in James Watt's sculpture machine, an invention he was working on around 1811, and inspired by a medal-copying machine he had seen in Paris in 1802 (Muirhead 1854 Vol. I: ccxli). Watt adapted the same pantograph principle he had already used for his perspective-drawing machine and for the development of parallel motion for the steam engine (noted in Chapter 2) in order to copy statues. The profile of an existing statue would be traced by a guide-point and transferred to a cutting tool, with both ends moving in parallel lines across a completed statue and a block of raw material simultaneously. In effect the three-dimensional object has been re-imagined as a stack of two-dimensional cross-sections, each one with its distinctive contour. A similar principle was at work in the mechanical drawing devices developed around 1830 to produce the printed image form known as anaglyptography or confusingly, ‘medal engraving’ (Figures 47 and 48), in which, in another application of the pantograph principle, a drawing of a low-relief sculpture was produced by a ruling machine with two connected needle-points; one tracing the surface in relief, one drawing on a recording surface (Harris 1970: 71-82; McConnell 1993: 29-31).Muirhead describes this as: ‘an illustration of Euclid’s position, that the motion of a point generates a line, and the motion of a line generates a surface’ (Muirhead 1854 Vol. III: 330).

In these techniques, unmodulated outline was used to inscribe a mechanical transcription of form, to copy three-dimensional objects or to transfer profiles between two and three dimensions, as a self-registering technology that had no need of hand crafting skills. In association with these techniques of production, ‘chaste’ line marking gains authority because it was mechanically drawn.

Figures 47 and 48: see over page





Figures 47 (above) and Figure 48 (below)
A.R. Freebairn (1849) *West Frieze of the Parthenon* anaglyptic engraving taken from John Henning's plaster cast reconstruction of this part of the Elgin Marbles *Art-journal* 1 April 1849: fp 114 *The image in Figure 47 shows the reproduced image in the journal, the enlarged detail below in Figure 48 shows the lines used to build up the three-dimensional effect in this process*

The 'evidence of the senses': straight lines as embodied geometry

In this final section I will consider the straight ruled unmodulated line as an expression of personal craft expertise. Twentieth century and contemporary perceptions of the straight line—seen as basic, simple or totally boring—are simply misleading. Line has become colourless, but in the late eighteenth and early nineteenth century straight ruled lines were anything but boring. Rather, they were a considerable manufacturing challenge.

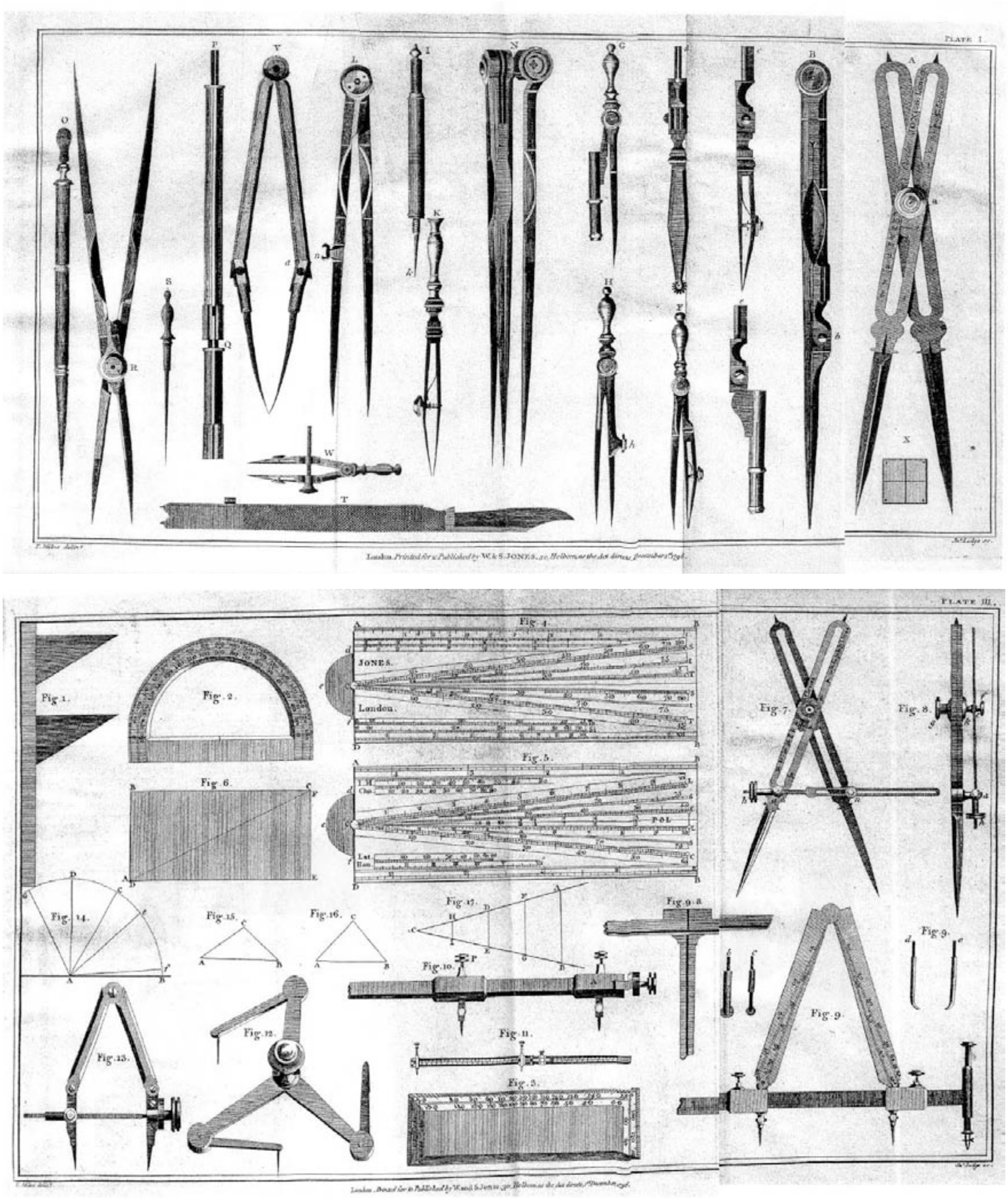


Figure 49. George Adams (1813 [1791]) Plates I and III from *Geometrical and graphical essays*

In his *Geometrical and graphical essays* (1813 [1791]) the instrument maker George Adams, Jr. (1750-95; Hambly 1988: 44-5; Taylor 1966: 315) enunciated a philosophy of line that was the result of long attention to interactions between the material and the conceptual (Figure 49). The material difficulties of line drawing are evident in Adams's account of his work. Rather than being easy, unskilled, or routine, Adams made it clear that it was particularly difficult to place and draw a straight line: 'it is almost impossible to draw a knife a second time against the rule, and cut within the same line as before' (Adams 1813: 114). In this practice, making a ruler, using a ruler, and visualising an ideal line were all part of one continuum. Adams describes eloquently his best method for producing a controlled line using the compass as a marker to cut intersecting arcs to mark the end points:

> In striking the primitive circle by the beam compasses, the cutting point raises up the metal a little on each side of the arc; the metal so thrown up forms what is called the bur ... the arcs struck across the primitive circle also have their bur ... you may therefore feel what you cannot see ... they will guide (Adams 1813: 111).

This gentle groping for the intersection was only the first stage of more fingertip work: after this, the cutting point was inserted into this point and turned, in order to leave behind a more permanent hole (still not entirely visible) waiting for the beam compass to be inserted for marking and measuring operations, and once again located by feel (Adams 1813: 112). Such accuracy was a hard taskmaster, as Adams further counsels the instrument maker: 'never have a fire, or another person in the room to avoid expansion when laying down the principal points (Adams 1813: 112). There is a parallel here in Adams's aside with aspects of the work of James Prescott Joule (1818-1889) in the mid-nineteenth century on the precision measurement of heat from mechanical work. Joule's measurements of temperature were so precise that the effects of the body heat of the experimenter in the room had to be managed by careful procedure (Sibum 1995: 77). Like Joule in Sibum's account, Adams announced his cognisance of this subtle constraint in order to stress his expertise as a skilled craft worker; he asks us to give credence to his ruled lines because he is a skilled operator. And in Adams's specific community of art and knowledge, instrument making was related to machine making intimately, but also image making, because instrument makers were also engravers. Inscribing on metal was the same process of engraving used for intaglio printing as well, the preferred method of detailed illustration in print. Material techniques and skills thus created a continuum between drawing, mechanical arts, and the social circulation of technical drawing.

Mechanical design drawings, such as those of James Nasmyth (Figure 45) worked out actions of planing or rotation in three dimensions through two-dimensional marks executed by ruler and compass. In technical drawing on paper, a ruled line is a command that denotes the production of a straight edge or a flat plane surface; in short it denotes something that has to be achievable. Without reliable flat planes, the possibilities of machine production were limited; the ability to make a flat plane was vital to the effective working of steam engine valves, lathe beds or printing press tables, although it was one of the hardest forms to produce. The effort to master techniques for making plane surfaces became one of the standard tropes of industrial hagiography. So the first systematic user of the accurate standard plane for testing surfaces, Henry Maudslay, was cited over and over again in different industrial biographies (see Cantrell and Cookson 2002: 28; 94; 111 for an account of the claims and counter-claims between Whitworth and Nasmyth on this), whilst the inventors and owners of planing machines, such as Richard Roberts or Joseph Clement, could earn a substantial fortune from hiring out their magic by the hour. Indeed, this narrative continues: -as we can see in the Science Museum of London's online exhibition and learning site 'Making the modern world' that celebrates Robert's 1817 plane as the first machine of its kind (Figure 50).

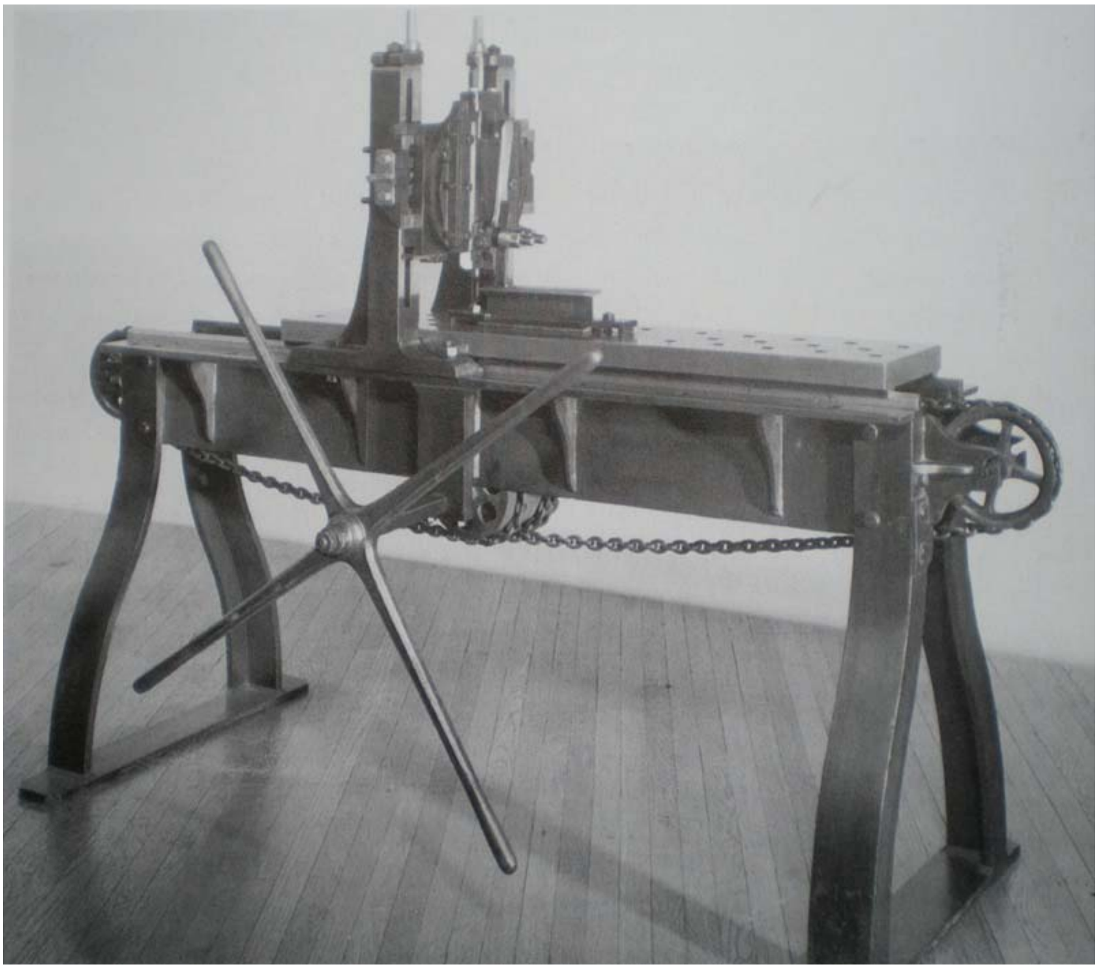


Figure 50: Richard Roberts Planing machine (1817) Science Museum, London online image from http://www.makingthemodernworld.org.uk/stories/manufacture_by_machine/03.ST.01/03.SC.RM.05/03.SC.RM.05.swf accessed 20 August 2008

Nevertheless even accurate gauges such as Maudslay's testing surface, or the level planes achieved by the machines of Roberts or Clements, were simply very refined versions of empirical methods of approximation. Hand craft methods, for example the technique of laboriously grinding and then testing three plane surfaces against each other systematically, were admired when successful as a demonstration of personal expertise. Furthermore, the development and use of planing machines in mechanized production that might be understood by a commentator such as Ruskin as an inhuman mechanical process was in reality an extension of such craft skills. Joseph Whitworth (1803-1887) gained status while in training with Henry Maudslay by fabricating true plane surfaces through hand craft methods, but he also became an industrialist who used precision measuring techniques and self-acting machines to act out his personal skill and at the same time deny the exercise of skill to his workers (Buchanan 2002: 111-119). Unlike in the act of drawing a circle, where the mechanical theory is enacted by the compass, straight edges, flat planes and ruled lines were made by testing against other straight edges, an obvious regression. A geometrical solution to the problem of drawing a straight line remained evasive in the first half of the nineteenth century. James Watt's 'parallel motion' of 1784 that moved the piston of condensing steam engines up and down without too much deviation had offered a partial response to this question as it enacted an approximate straight line linkage mechanism in its construction and workings (Marsden 2002: 117-121). Despite the authority given to Euclid's axioms in the nineteenth century, and the frequent invocation of his name, a truly theoretical description of how to draw a straight line only developed later towards the 1840s and beyond in the science of kinematics (Marsden 2004: 420-22; Kempe 1877: 1-12).

So in the first half of the nineteenth century drawing a straight line was in reality provisional and empirical. Indeed, popular educators often described line drawing in sensual or craft terms. For example towards 1830 the French industrial educator Baron Charles Dupin (1784-1873) used many registers of description from the rarefied to the homely in order to convey this concept. In the English translation of his textbook for artisans on the application of practical mathematics to industrial production Dupin repeated the by now standard refrain: 'there are few problems of practical geometry more difficult than to form a perfect straight-edge' (Dupin 1827: 7) as a prelude to several pages of descriptions on the actuality of line in the material world. Hence we read about the production of reliable straight edges through such familiar and traditional trade techniques as striking a taut cord rubbed with charcoal, or hanging a lead-weighted plumbline. Dupin's examples of the synthesis of the material and the cultural significance of line drawing in industrial production were intended to make his work accessible and unthreatening. Nevertheless they do also have an artful faux-naïve air, perhaps in deliberate homage to the characterisation of useful knowledge laid down in eighteenth-century projects such as that of the *Encyclopédie* and its successors (Yeo 2001: 152-3), for when D'Alembert and Diderot included the mechanical arts in their compendium it was because they believed that the embodied and tacit processes they observed and recorded were a vital part of the *enchaînement* of knowledge (D'Alembert 1963 [1751]: 111).

Theories of line (as line) around 1800 were scarce in sources aimed at general readers, in contrast to the variety of abstracted twentieth century accounts of the period noted earlier in this chapter. However, there is enough evidence to note changing concepts of line in the early part of the nineteenth century and an incorporation of elements of reflection about drawing and representation. Earlier, we can see the bald quality of the entry on line in Rees' *Cyclopaedia* of 1819:

> LINE, in *Geometry*, a quantity extended in length only, without either breadth or thickness. A line is supposed to be formed by the flux or motion of a point; and it is to be conceived as the termination or limit of a surface, and not as part of that surface, however small. There are two kinds of lines; *viz*. *right* lines, and *curve* lines. (Rees 1819 (21):n.p)

By 1833 the *Penny Cyclopaedia*, in its article 'Solid, surface, line, point' made an anxious differentiation between theory and representation:

> We cannot ... imagine what Dr. Beddoes meant when he said ... "Draw your lines as narrow as you conveniently can, your diagrams will be the clearer; but you cannot and need not, conceive length without breadth". *Why* are diagrams the clearer, the narrower the lines of which they consist? Diagrams have no clearness in themselves, the comprehension of them is in the mind of the observer ... it matters nothing that the point, line or surface are mechanical impossibilities' (*Penny* 1833 (XXII): 205-6).

Standard mathematics textbooks, for example Robert Potts's *Euclid's elements of geometry* (1845), invited the student to employ tacit methods in order to enact knowledge of simple geometrical forms such as the straight line. Potts's widely-used text thus questioned and modified Euclid's ideas:

> the synthetic method is followed by Euclid not only in demonstrations, but also in definitions. He commences with the simplest abstractions, defining a point, a

> line, an angle... This mode of proceeding involves a difficulty almost insurmountable of defining satisfactorily the elementary abstractions of geometry. (Potts 1845: 44)

Instead, Potts stated, we must go from the particular to the general; the sensible to the abstract:

> Now the only possible way of explaining terms denoting simple perceptions is to excite those simple perceptions... The only way of rendering a simple term intelligible is to exhibit the object of which it is a sign... a straight line must therefore be drawn, and by drawing a curved line and a crooked line, the distinction will be perfectly understood... the sensible evidence of things is only to be acquired by the evidence of the senses (Potts 1845 Appendix: 1)

In the late eighteenth century, the act of line drawing in the specific environments where technical drawing developed frequently demonstrates a heterogeneous chain of knowledge through physical, ideal, elevated or everyday elements that are at odds with more contemporary perceptions. For example, the process of surveying and mapping the earth in the period around 1800 has recently been characterised as a distinctive line-drawing activity that imposed a 'triumph of rational, purposeful design over the vicissitudes of the natural world'. (Ingold 2007: 153). In the context of practice on the ground, however, mapping had a more provisional flavour. *The young surveyor's guide* of 1806 listed the very disparate bundle of tools and skills required for this project that ranged from a case of mathematical instruments to a surveying axe 'for cutting away hedges and other obscuring growth' (Cotes 1806: n.p.). Thus although we might not initially object to Ingold's claim that the straight line is some kind of icon of modernity, we can see that it is possible to challenge many of the assumptions and methods that lie behind such statements. Although the straight ruled line was charged with cultural meanings in the late eighteenth century, those meaning were multiple and contested; and the straight ruled line was not perceived in the same way as it is now.

Conclusion

Noting that 'straight' in everyday speech generally means enlightened, purposeful, and correct, Ingold attributed the beginnings of the high value of the straight line to enlightenment ideas of progress, when as already noted, the wayward undulating landscape was surveyed so it could be parcelled out into ownership following a rectilinear grid system (Ingold 2007: 153). Ingold's claim gives a lot of 'power by association' to drawn lines, but is ambiguous in political terms and strangely disassociated from real events: while landlords enclosing common land (see Chapters 1 and 3) might have found such an activity enlightened and correct, dispossessed day labourers would have disagreed. The meaning that Ingold canvasses so vigorously, a kind of all-powerful bureaucratic 'modernity', is as anachronistic as an ecstatic utopian reading. Straight lines did not make their viewers into helpless prisoners but were evaluated by comparison, debate and use. So for example the *Edinburgh Encyclopaedia* urged the use of a clear outline style as a mode of persuasion. In the article 'Drawing', a contrast was made between the use of 'ragged and uneven lines' (only appropriate for ruins) with the 'precision and firmness in all their details' of the outline used for complete buildings, that: 'instantly convince the spectator of the intelligence of the draughtsman, and the truth and accuracy of his work' (*Edinburgh Encyclopaedia*, Volume 8: 115). Straight ruled lines were also coopted to urge or persuade 'right thinking', rather than being a naïve or unreflecting espousal of 'enlightenment ideas' (Ingold 2007: 153) in the invention of statistical graphics by William Playfair. As noted in Chapter 2, Playfair worked briefly as a technical draughtsman for James Watt in 1777 before compiling *The commercial, political and parliamentary atlas of England and Wales*... (1786) where he developed his argument in graphic form (Baynes and Pugh 1981: 63; Pollard 1965; Wainer 2005: 21; Tufte 1983). Playfair deliberately exploited a sparse, clean and linear style because it was the most striking effect available for deploying the mass of statistical data he used to support his theories of how for example changes in taxation had certain specific effects on trade (Funkhouser and Walker 1943: 105).

This chapter has also considered the meaning and the processes of material production in relation to deterministic accounts of the use of line drawing. Whereas Ivins's thesis about the 'tyranny' of intaglio line and Pye's account of the rightness of the ruled line suggest a policy of least resistance in the face of material facts, Adams's note of the difficulty and annoyance involved in producing this allegedly simple and natural figure sounds a note of caution. Although functional explanations for the use of line could be accused of being reductive, and too much in thrall to the notion of technological constraints, consideration of just how much craft and skill it took to fabricate ruled lines prompts the question as to why those specific materials, marks, and processes were chosen. In evaluating the symbolic function of the use of line within technical drawing in the period from the late eighteenth to the mid nineteenth century this chapter also considered the symbolic function not just of images, but of practices. Practices that produce representation contribute to an alternative 'iconography' of materials and methods, and also open up alternative interpretations taken from debates in the history of science. Geometrical drawing can only be treated as a harbinger of utopia when it is treated as an abstraction, a chimera. Instead, in considering drawing as visual expression, a material artefact, and embodied practice we can see two methods that were used to create belief and engagement within the apparently sparse expressions of line drawing; either an appeal to the supposed authority of ‘self-registering technology’ (Schaffer 1992: 362) in techniques of ‘chaste’ mechanical tracing of outline, or through the demonstration of the private expertise of the skilled craft operator (Sibum 1995: 101) in the ruling of straight lines.

Chapter 5: Fabricating the line: multiplying marks

This thesis explores technical drawing as one of the cultural manifestations of industrialisation from the late eighteenth century to the first half of the nineteenth century by considering technical drawings as manufactured objects that relate to their conditions of production. This approach is in contrast to connected work such as *Art in the industrial revolution* (Klingender and Elton 1972) or *The arts of industry in the age of enlightenment* (Fox 2009) that give more attention to depictions of industry, for example in paintings of industrial scenes and artefacts. In this chapter I will examine the material production of technical drawing and illustration by considering how in the first decades of the nineteenth century, engineers, draughtsmen and illustrators developed a technical style of drawing through incorporating procedures derived from the factory system of manufactures. For example, the notion of repeatability was enacted both through mark-making into the drawing, and through copying the drawing in print. Such techniques familiarised viewers with these conventions, and also built an audience for industrial methods, for ‘engineering’ and for engineers in cultural life. Focusing mainly on the period 1800-*c*.1830, I will argue through selected examples that technical drawing and technical illustration in print began to develop in tandem to create a visual style that explicitly celebrated and displayed the industrial system to viewers outside the factory. Thus, although technical illustration has often been excluded from accounts of technical drawing, the means by which these genres entered public discourse together at this period suggest that it is misleading to consider one without the other. This chapter considers line drawing in relation to mark-making tools, drawing machines, surfaces, and transfer to print, and continues the argument of the previous chapter, by exploring some of the material awkwardness involved in transferring and copying from one medium to another. The material nature of the processes of technical drawing and illustration, conveyed to viewers and readers, developed a shared cultural knowledge that contributed to the expressive and aesthetic effects of technical representations.

Previous scholars with an interest in the significance of materials and processes in the development of new visual styles at this period have influenced the development of this chapter. These writers include Peter Bower (1999: 29) who has argued that the smoother, thinner, and stronger surface of gelatine-sized, machine-pressed paper at the beginning of the nineteenth century had an effect on the kinds of marks made on it, Tony Woolrich (1998: 49-67) who studied the visual forms produced by the invention of drawing machines for technical illustration, and Basil Hunnisett (1980: 88) who noted the influence of the technical engraver Wilson Lowry's diamond point and ruling machine on the visual style of nineteenth century steel engraving. Without repeating this established research, this chapter will consider to what extent material elements contributed to the symbolic meaning of drawings and prints. I consider accounts of the significance that has been accorded hitherto unremarked items of equipment used in technical drawing such as pens, paper and watercolour paint before turning to the connections that I wish to make between the development of drawing instruments, image printing technology and technical illustration. Many engineers, draughtsmen and engravers submitted designs and models for image-making machinery to 'print societies' such as the *Transactions* of the Society of Arts and this chapter considers the reception and use of some of these devices such as the ruling machine, ellipse-drawing machines, rose lathe and pantograph. In researching this chapter, personal observation and testing of examples of technical drawing equipment in the collection of the National Museums of Scotland allowed me to discover differences in use, for example between different ellipse-drawing machines, that are not apparent from printed textual and visual resources.

The danger in making a connection between the material qualities and symbolic meanings of technical representations is that it invites technological determinism. However, paying attention to technical constraints need not be reductive. In addition to their subject matter, images speak of the processes that went into their material form. The example of machine-made paper as a support for technical drawing that appears at first glance to offer a unity of medium and message, offers instead a complex accumulation of cultural readings. Images also act as a residue of the decisions of draughtsmen, illustrators, and engravers, arrived at through their relationships to social networks in art, science, invention and education. Engineers, inventors, or engravers tried out various methods for constructing a distinctive visual expression for the mechanical arts in the public sphere in this period. Practitioners made alliances with different communities in order to gain work and prestige; in the process they recruited different visual discourses to lend authority to their expression, so the decisions that were made to adopt one process rather than another were anything but determined.

Choosing and using 'permanent equipment'

Howard Becker has noted how the conventions of specific artworlds become embodied in 'permanent equipment' so they appear entirely normal (Becker 1982: 57). One example is the relationship that has been noted between orthographic projection in architectural and technical drawing and the T-squares and rectangular boards in standard drawing kits (see also Chapter 2); thus Robin Evans has claimed that this meant nineteenth century designers would rarely build anything except symmetrical boxlike structures (Evans 1995: 118). In the nineteenth century one can indeed find this assumption about orthographic drawing in 'naturalised' form quite frequently, for example when the Penny Cyclopaedia commented that as machines and building have symmetry, then the 'forms most commonly required to be delineated are reducible to a series of regular geometrical solids, the planes of which are either parallel or perpendicular to the horizon and reducible to plans, elevations, section and profiles' (*Penny cyclopaedia* 1840, Volume XVII: 491). However, as I will demonstrate later in this chapter, orthogonal drawing was not an automatically determined choice. In technical illustration, other types of perspective conventions were also applied in a much more experimental manner, and new, expensive 'permanent equipment' was invented and purchased in order to inscribe these expressions on paper. Firstly, however I will examine accounts of more apparently mundane items that have been so effectively naturalised that they have become invisible.

Significant 'permanent equipment' need not be complex; indeed, changes in everyday items can escape attention. In technical drawing applications around 1800, for rapid notation on to such smooth paper, so-called 'lead' pencils came into use and displaced the older meaning of pencil as a slim brush for line marking (Petroski 1989: 68-76; Hambly 1988: 65-7). Petroski is one of several scholars who have addressed the histories and meanings of such invisible 'things' in art, science and domestic life in accord with 'material culture' approaches (Petroski 1992; Lubar and Kingery 1993; Daston 2004). At the simple level of the inked line, for example, Seymour Howard has argued in his article 'The steel pen and the modern line of beauty' that the introduction of industrially produced steel pens at the beginning of the nineteenth century reinforced a 'social, political, and cultural revolution' (Howard 1985: 788); the steel pen ousted the more flexible quill that had preceded it, and invited the 'thin, hard and strong neoclassical contours' in vogue around 1800 (Howard 1985: 789). The introduction of outline drawing, as discussed in the last chapter, is thus in Howard's account presented as a journey, initially deterministic, that runs from the manufacture of pen nibs towards a sweeping utopian vision of art, industry and the visual style of technical drawing. But although unmodulated inked lines are certainly central to the style of technical drawing, technical draughtsmen did not use single nib steel pens (which were new) to make these marks. Instead they had double steel pens with a central reservoir that had been part of the kit of mathematical drawing instruments since 1700 (Hambly 1988: 57-8); the thin hard lines produced by technical draughtsmen were not derived from the introduction of mass-produced cheap steel nibs, but from craft instrument making traditions, displaying an allegiance with the tools of expertise of the mathematical arts and sciences (Gerbino and Johnston 2009: 1).

Paper is another unremarked item of 'permanent equipment'. The fact that works on paper have been in existence for a long time has obscured the real changes in paper use for communication and teaching in the later eighteenth century. Machine production increased the amount of paper that was available, and also its surface, shape and the way it was delivered to the user. Before the development of machine processes, all paper had been made by craft methods whereby a specialist worker formed individual sheets of paper from rag pulp. The water in the pulp drained away through woven or laid screens of wire to give the so-called 'wove' or 'laid' texture to the paper. Although the resulting sheets of paper could later be pressed or polished smooth, even before the continuous-web process was invented (Bower 1999: 18; Chappell and Bringhurst 1999: 164-5), it was then an extra task at additional cost. Paper, as a surface for drawing and writing, automatically had a smooth machine finish after the invention of Louis Robert's continuous-web paper machine in 1798 (Tomlinson 1854; Herring 1856; Hills 1988; Andre 1996). In contrast to hand-made paper, standard machine-made paper was formed in a long continuous process that shaped and dried an endless length through heating and pressing as it ran through the apparatus. During this chain of operations the surface of the paper was smoothed through rollers and stabilised with gypsum fillers and gelatine sizing. Heating and pressing made all paper stronger even as it became thinner (Bower 1999: 29), and such smooth glazed surfaces changed the nature of all the marks made on it, including drawing, note-making, writing, and casual scribbling, as well as images in print. From the beginning of the nineteenth century, descriptions of paper making machinery (with illustrations) were frequently circulated and cited as a significant example of the ways in which industrial invention was hastening the progress of civilisation (Secord 2000: 52-4). Commentators frequently gave a visionary, metaphorical import to descriptions of the ways in which industrially produced paper, circulating everywhere, resurrected and purified discarded clothing and other textile waste (Dickens 1850; Herring 1856: 93), absorbed and reprocessed old books into new ideas (St. Clair 2007), creating a universal vehicle for learning (Secord 2000: 52-4). Although Andrew Warwick has noted how quickly the move to paper-based mathematics teaching at Cambridge University in the nineteenth century had become naturalised and completely unremarkable by the 1880s (Warwick 2003: 115-37), this observation is mainly directed at current perceptions, for cheap smooth machine made paper is still seen as a normal vehicle of communication. In the early decades of the nineteenth century, however, the choice of white paper for ‘working out’ and presenting technical drawing might, one could argue, have been a signifier of ‘progress’; thus making Rosenblum’s *tabula rasa*, the white sheet of utopia from the last chapter, an example of how everyday items such as paper get hidden while in plain view. However, although this might be one reading of the significance of the paper support of technical images, especially in print, a brief examination of the context of technical presentation drawings and the medium of watercolour painting, reveals a more complex picture of cultural affiliation for ‘works on paper’.

Technical draughtsmen developed watercolour techniques, facilitated by particular paints, brushes, and paper, in the second half of the eighteenth century; and adopted by fine artists in the late eighteenth century (see Chapters 2 and 3). As noted, watercolour painting gained considerable cultural status in Great Britain around 1800 as a medium for professional artists, as can be seen in the foundation of the Society of Painters in Watercolour in 1804 (Parkinson 1998: 9-10) or by the way in which a prestigious painter such as J.M.W. Turner (1775-1851) experimented with this medium in the first decades of the nineteenth century (Bower 1999). Peter Bower has argued further that Turner, already renowned as a watercolour painter, experimented with the use of smooth machine made paper from 1830 onwards, adding to the visual language of the medium. Bower’s account, focused on the fine art practice of Turner, presents this ‘discovery’ of smooth paper surfaces for watercolour painting as an innovation. However, in technical applications a distinctive mode of watercolour painting demanding unbroken paper surfaces had already been established with stylistic continuity from the 1770s through to the 1840s (Figure 51) and beyond.

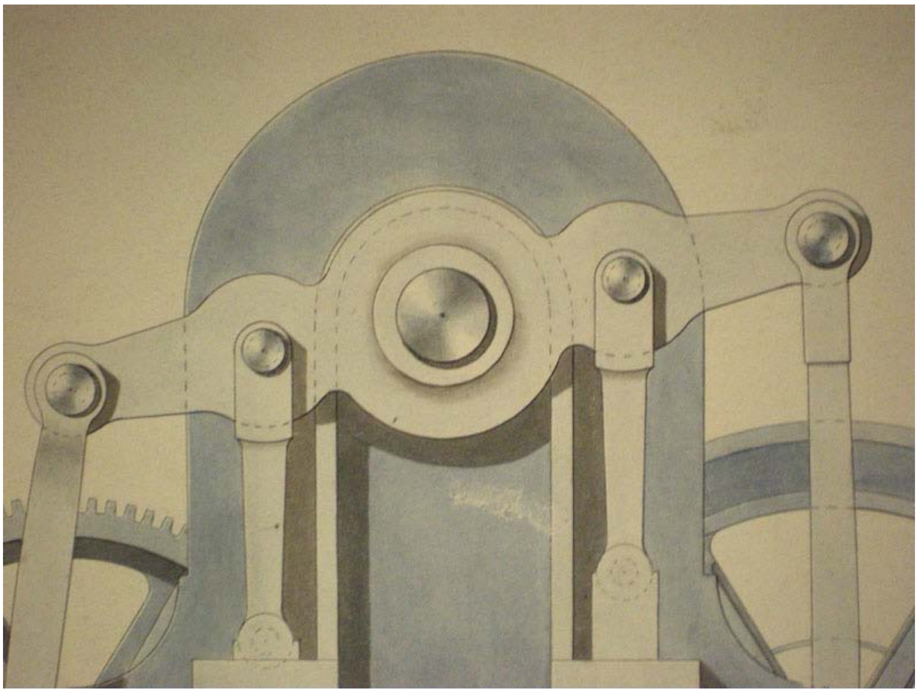


Figure 51: Detail of presentation drawing by E. Barlow (1848), showing side view of riveting machine. Nasmyth & Gaskell archive, Institute of Mechanical Engineers, London END/14/5/4

The drawings by Watt and Smeaton already shown in Chapter 2 (Figures 10 and 12) were made in the late eighteenth century on hand-made paper; nevertheless these presentation drawings were already using effects of evenly ruled ink lines and flat or graded colour washes that can best be achieved on smooth paper surfaces. The *Catechism of drawing*, a handbook for readers who were not fine artists, shows through its matter of fact tone that techniques such as watercolour painting (*Catechism* 1821: 55-9) and mechanical drawing (*Catechism* 1821: 62-5) were considered everyday working practice by the early 1820s. For watercolour effects in mechanical drawing the author of the *Catechism* advised 'colours should be as few, as little gaudy, and laid on as lightly as possible. The light tints should all be transparent…' (*Catechism* 1821: 64). These precepts on colouring continued to be manifest not only in presentation drawings of the 1840s, but also in drawing equipment.

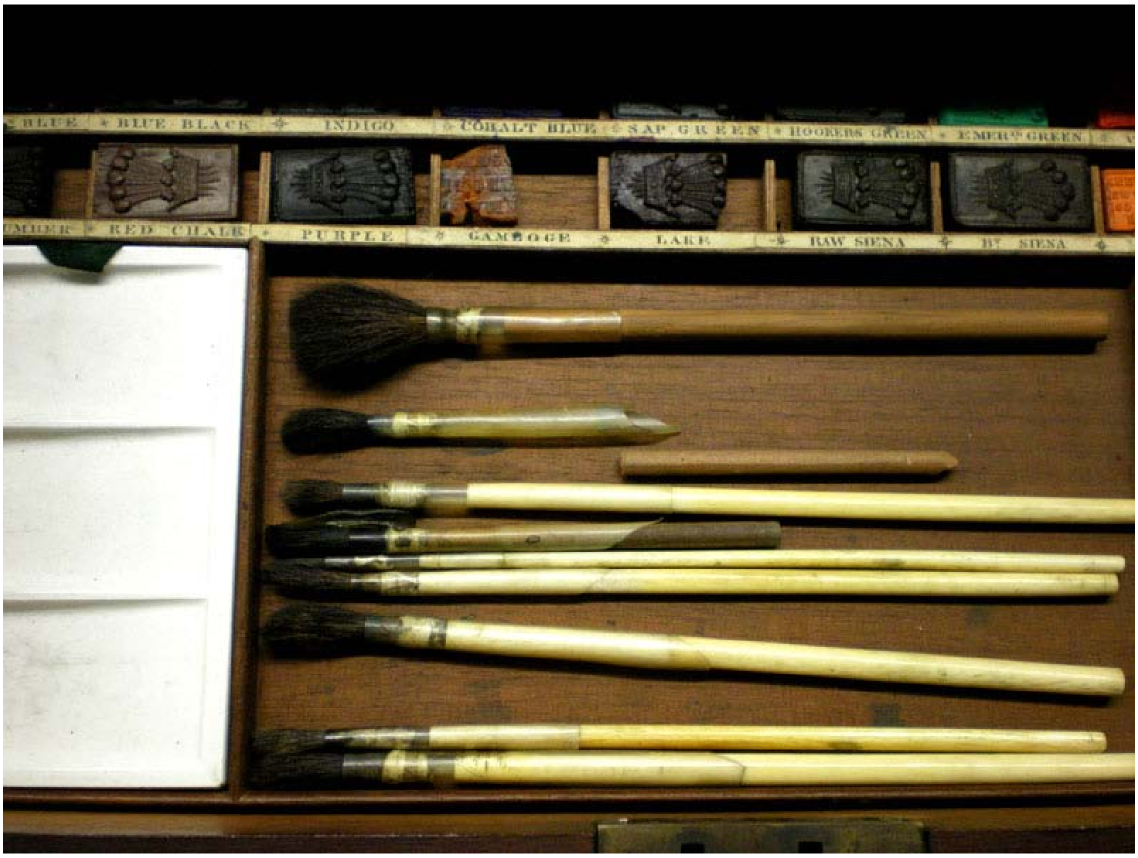


Figure 52: This presentation case of instruments was made and sold by Elliot’s, instrument makers, London c.1840. It is a large and opulent case with several layers of different drawing tools such as sectors, protractors and compasses; French curves; and a watercolour painting layer, as here. In part it has been preserved in such careful order on account of its presumed elite connections, due to its inscription ‘To John Farey, Esq. from Robert Stephenson’. Nevertheless the watercolour section supports the notion of an established style of technical watercolour painting in line with other sources such as drawings and texts. National Museum of Scotland NMS T.1989.3.

The presentation case of instruments shown in Figure 52, although at the other end of the scale of opulence, still contains the same range of colours, brushes, and other aids, as dictated by the *Catechism*. Moreover, throughout this period, the main demand for smooth watercolour paper came from technical draughtsmen, not artists, in engineering, map-making and architectural surveying who were all using similar pens, pencils and watercolour washes to artists (Bower 1999: 18) for example in the 1.5 million drawings produced by naval architects during the Napoleonic wars and now held by the National Maritime Museum (Bower 1999: 24, n.5). For technical design drawings used in the factory, and for presentation drawings shown to clients, heavy smooth cartridge was used throughout the period 1770-1860 and beyond because of its durability. Bower, studying the works of Turner, emphasised the ability of machine-made paper to withstand an onslaught of sketchy, gouging, and scribbling marks. But the other face of this strength is that machine made paper could also withstand the hard directed pressure of steel pens, and the glazed surface supported firm marks that did not spread, reinforcing a style that had already been established.

Technical drawing should, therefore, be included in an account of the watercolour movement in the late eighteenth century particularly in view of the substantial volume of work produced; in addition, both working drawings in the factory, and presentation drawings shown to clients were designed for heavy use, to be scrutinised and carried around the workspace, prodded at and measured from, continually exhibited. Technical presentation drawings demonstrate a parallel process of exploration of the watercolour medium to that of fine art. But there is no deterministic correlation between the advent of machine made paper and the development of visual style in this case; rather the increasing smoothness of machine-made paper after 1800 appears as a confirmation of the demands of an already established market for drawing paper by technical draughtsmen. Here a conscious decision about style by draughtsmen became translated into the 'permanent equipment' of industrial paper production.

Manufacturing images: mechanical drawing aids, mechanical reproduction and print

Engineers, inventors, or engravers also used print as a medium to display allegiance with communities of visual practice, as well as in drawings that enjoyed more limited circulation amongst workers and customers. For printed images, further specialist drawing instruments were developed that displayed the 'mechanical arts' in a reflexive way. Instrument makers developed specialised drawing equipment in the late eighteenth century for an expanding market of technical professions such as engineers, surveyors, architects and military engineers (Hambly 1988: 7). So while draughtsmen's equipment from the 1780s included pens, ink, lead pencils, compass, ruler, T-square and watercolour paints (Lever 1991: 64), the engineer John Smeaton's drawing instruments at his death in 1792 included in addition parallel rulers, long straight edge rulers, beam compasses, protractors, and an instrument for drawing in perspective, as well as mathematical and surveying instruments (Skempton 1981: 247-51). Technical draughtsmen displayed allegiances in drawing practice with these professions but also with the world of instrument makers themselves. Instrument makers promoted their wares in shops, lectures and in print. For example, George Adams, Snr. (c.1720-1773) was mathematical instrument maker to George III, and also supplied drawing and surveying instruments to the Board of Ordnance and to the East India Company (Taylor 1966: 61). His son George Adams, Jnr. (1750-95), continuing the business, in addition wrote and published *Geometrical and graphical* *essays* (1791) where he explained how to use and where to purchase drawing instruments (Hambly 1988: 44-5). A further amalgamation of advertising with specialist writing developed when William Jones (1763-1831 Taylor 1966: 315) took over the Adams' instrument making business and publication rights in 1798, and reissued the updated edition of the *Geometrical and graphical essays* (Adams 1813 [1791]) cited in the last chapter. Hence the 1813 edition included images of current stock, and an extensive trade catalogue at the end of the book. Jones also wrote articles for Rees' *Cyclopaedia*, for which he also took care to give details of his own company as a supplier of mathematical instruments. Other instrument makers, surveyors and cartographers were closely involved with new publishing enterprises of this period, with encyclopaedias, maps, and atlases in cities such as London (Taylor 1966) and Edinburgh (Bryden 1972; Clark, Morrison-Low and Simpson 1989; Yeo 2001; Morrison-Low 2007). Technical draughtsmen, illustrators, and engineers negotiated for status and for visibility within this expansion of drawing practices beyond the limits of polite culture through publications such as Rees' *Cyclopaedia* and the *Transactions* of the Society of Arts both through producing images and through inventing mechanical aids to drawing.

Technical illustrations are frequently, and misleadingly, characterised as a peripheral or non-serious byproduct of the development of technical drawing, either through simple exclusion (e.g. Baynes and Pugh 1981) or through explicit rejection. For example, in design history, we have seen how Purbrick (1998: 275-93) condemned the 'ideologically technical' way in which illustrations of the mechanical inventions in popular newspapers after 1850 might have claimed to be educational, whereas in her opinion they simply bamboozled their readers—a position close to Belofsky's suspicion of technical illustration in the European tradition that he rejected as being 'incongruous with workshop conditions' (Belofsky 1991:35). Behind these rejections lies the belief that true technical drawing is the trace of a creative process, in accord with the concept of technology as three-dimensional 'visual thinking' (Ferguson 1977: 827-36). This thesis contests these approaches, for the evidence suggests that technical illustration should not be discounted when considering the development and reception of technical modes of drawing. Even at the most superficial level of analysis it is apparent that engineers, draughtsmen and would-be educators made use of technical illustration to build audiences, to support trade, and to develop professional standing. This chapter will examine in detail how technical styles were given status and currency in publications such as Rees' *Cyclopaedia* and the *Transactions* of the Society of Arts.

The development of technical illustration in these publications provided a basis for the development of technical styles and subjects in more general illustrated journals and magazines later towards 1850.

The expansion of so-called ‘print culture’ in the nineteenth century was, as noted in Chapter 1, already a subject for comment and celebration during the period (King and Plunkett 2004: 6; Secord 2000: 30) and has been amplified since by many twentieth century commentators. William Ivins has suggested that the smooth surfaces of machine-made paper encouraged the emergence of new surface-print and relief-print image technologies in the early nineteenth century, notably lithography and wood engraving. In contrast to older techniques such as intaglio etching and engraving, these newer mediums did not need to use line. According to Ivins, intaglio techniques had held sway between 1600 and 1800 because they had been able to convey more finely detailed imagery when up against the ‘wove’ or ‘laid’ texture of hand-made paper (Ivins 1992: 47-9). The roller pressure of intaglio printing squeezed the paper right down into the delicate inked lines below the surface of the metal plate, giving exact reproduction of the drawn image without loss, whereas surface printing contact by contrast could not suppress the texture of the paper sufficiently to stop it from interfering with the inked image. The advent of smooth machine-made papers in the nineteenth century, according to Ivins, saw the end of the ‘tyranny of line’ (1992: 49) and the start of new ways of drawing for print. Lithography, as already noted, is a very flexible medium. However, despite these changes in paper and print technology, technical drawing and technical illustrations continued to use linear styles and also to develop them further through the nineteenth century, which suggests that this was a conscious decision about style and presentation.

There was an expansion in the volume of illustrated periodicals from 1830, including those targeted at working class readers (King and Punkett 2004; Jobling and Crowley 1996). Some aimed to improve and educate through ‘self-help’ or popular science (Anderson 1991; Haywood 2004; Secord 2000) others to amuse (Fox 1988). Although it is evident that new non-linear styles of drawing and illustration developed during the nineteenth century it is also true that, despite Ivins’ assertion (Ivins 1992: 49), a ‘tyranny’ of linear styles continued to develop and even dominate visual communication after1800. Indeed, in place of the subtle repertoire of lozenges, flicks, and other means that earlier engravers had invented to vary their linear marked surfaces (Figure

53), many nineteenth century illustrations used a smaller repertoire of hard ruled parallel lines.

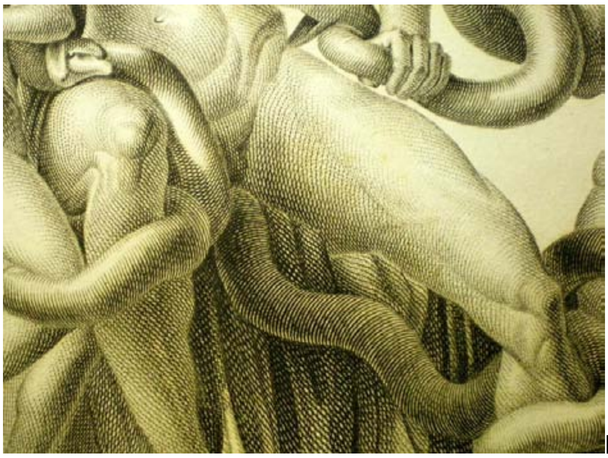


Figure 53: Detail of figure of Laocoon used to illustrate article 'Drawing' *Edinburgh Encyclopaedia*, Vol.8 (1830) Plate CCXXXIV

The convention of ruled parallel lines, that had developed to represent manufactured and turned surfaces migrated to cover almost every part of images destined for the illustrated press, even for non-technical subjects (Figure 54 and 55). Admittedly there were logistical reasons for the proliferation of line markings in composite wood block prints prepared for rapid newspaper deadlines, as it meant that images could be divided up between relatively unskilled engraving hands and later recombined, saving time and money (Fox 1988; Griffiths 1996: 21-2). Nevertheless it is also possible to ask why there was a preference for such effects. Hard-edged 'technical' line marking styles gained currency through the dual development of technical drawing and technical illustration in the early nineteenth century, from techniques of self-representation developed by engineers, draughtsmen and engravers in debates about drawing tools, mechanical reproduction, and the value of images.

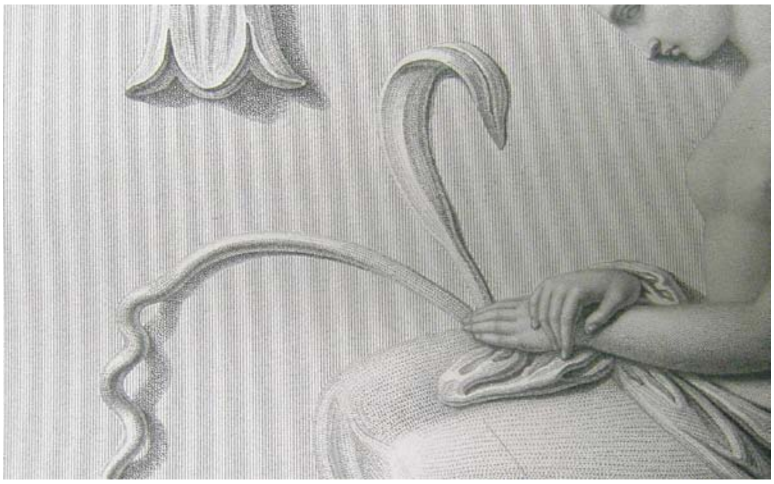



Figure 54: *The Blue-bell*, engraving by W.R. Roffe from bas relief by R. Westmacott, *Art-journal* 1 February 1849, facing page 56 (*detail at right*)

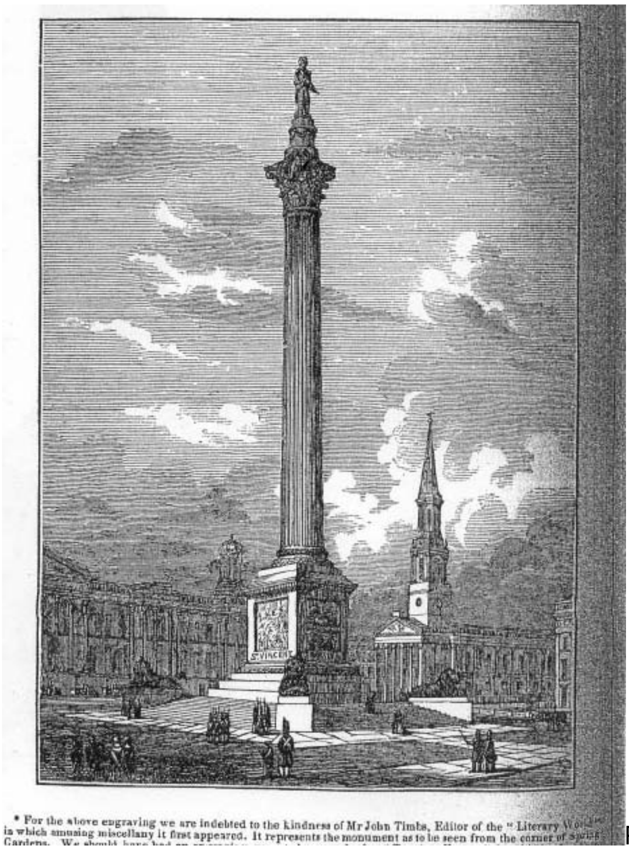


Figure 55: 'Selected design for the Nelson testimonial' *The Art-union* July 1839: 100

'Regularity and sweetness': the art of technical engravers

Technical engravers like Wilson Lowry or Edmund Turrell (d.1835 Canfield 2002: 729) contributed alongside draughtsmen and engineers to the developing visual language of technical illustration. Their position and status contrasts with that of line engravers enmeshed in the world of fine art, who have, unlike technical engravers, been the subject of considerable scholarship (Ivins 1992; Eaves 1992; Dyson 1984; Fyfe 1996;Griffiths 1980; Fox 1976). The work of fine art engravers lay mostly with the reproduction of the appearance and atmosphere of drawings and paintings into the medium of copper plates for the fine print trade. Line engraving was extremely skilful, painstaking work with a tradition of technique going back to the Renaissance. Around 1800 a large engraving often demanded several years' work, longer than that given to the original painting (Griffiths 1980: 55-6). But in terms of status, fine art engravers were in a thankless position. As already noted, engravers were excluded from full membership of the Royal Academy until 1855 (Fyfe 1996: 202-3; Dyson 1984: 58). And while their work enhanced the earnings and reputations of painters and print dealers enormously in the lucrative nineteenth-century market for prints, they themselves did not gain proportionally. Middlemen and dealers promoted mixed technique plates that could be produced rapidly by unskilled labourers, squeezing down the wages of skilled artisans (Fyfe 1996: 206; Eaves 1992: 186-8; Guise 1980: 5). William Blake, most of whose work was as a reproductive engraver, famously railed against this 'counter-arts conspiracy' whereby the grandees of art and 'ignorant hirelings' between them aimed to obliterate the skilled craftsman from the republic of esteemed creative arts (Eaves 1992: 177).

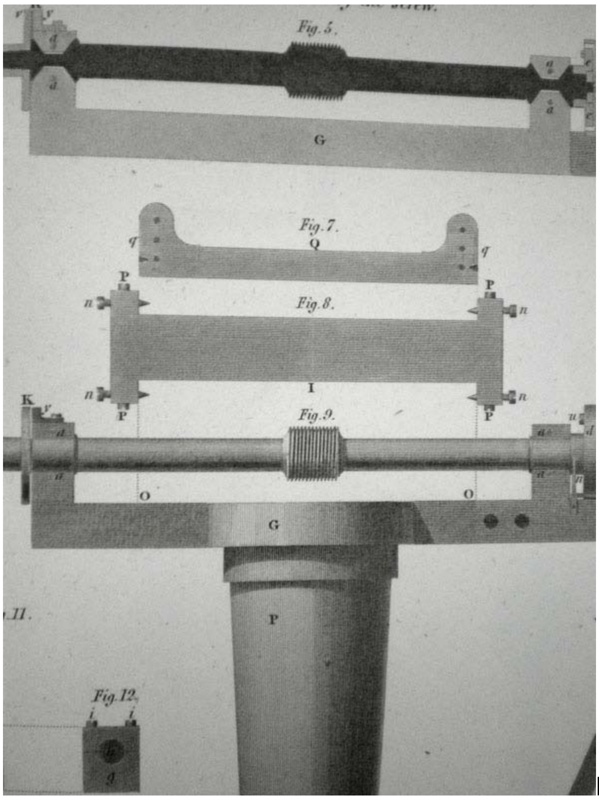


Figure 56: Detail of Mr. Ramsden's dividing engine from 'Engines' *Rees' Encyclopaedia*, Plates Volume 2 (1819) Drawn by J. Farey, engraved Wilson Lowry

By contrast, in the artworld of publications such as the *Transactions* of the Society of Arts, engravers appear to have been accorded higher status. The example of the credits given to all the individuals involved in the image of the medal in the *Transactions* of 1807 (Figure 28, Chapter 3), has already suggested a kind of equality of production. One possible reason for the enhanced status of technical engravers could be their active role in a culture of invention. One example, Wilson Lowry's ruling machine, also incorporated a second innovation, the diamond engraving point. He brought these together from around 1790 to create parallel ruled lines to denote shaded areas in engraved images, as shown in the example at Figure 56 (Dyson 1984: 126-130; Hunnisett 1980: 88; *Imperial Magazine* 1825: 118; Tomlinson 1854, Volume 1: 309; Woolrich 1998: 50). Lowry was one of the foremost London engravers of his period, and although he also reproduced artistic images for print, he specialised in technical subjects. Lowry engraved thousands of plates most notably for Rees'

Cyclopaedia, the *Edinburgh Encyclopaedia*, and for the *Transactions* of the Society of Arts amongst many others (Hunnisett 1980: 88). His ruling machine was invented to produce rows of parallel straight lines, and the diamond point used to engrave these onto the plate made those lines exceptionally fine and unvarying, having the effect of ideal or axiomatic marks.

The ruling machine saved time and labour and rapidly became a widely used device, being of: 'as much importance to engravers, and the advancement of their Art, as the steam engine is to the manufacturer' (Society of Arts *Transactions* 1826: 44). The effects created were also valued in their own right, the ruled lines being praised by T.H. Fielding for the 'admirable degree of regularity and sweetness' given to the image (Fielding 1841: 33). Twentieth-century artistic judgements have by contrast taken sides with William Blake who feared such machines as the agents of unskilled working practices (Eaves 1992: 186). Hilary Guise, for example, cautioned unwary print collectors to be on guard against the 'lifeless regularity' of the ruling machine (Guise 1980: 4) that in her opinion tainted the rendering of the sky in Charles Mottram's engraved version (1861) of William Holman Hunt's painting *The Scapegoat* of 1854.

The impression of extreme accuracy and neatness of Lowry's diamond point and ruling machine led to a kind of technological brinkmanship, evidenced by the note of desperation in Edmund Turrell's announcement to the Society of Arts of a modified drawing board, at Figure 57: 'The invention of ruling machines in the art of Copper Plate Engraving has produced such a degree of perfection in the tints ruled by them, that a corresponding degree of accuracy was immediately required in all other departments of the art... [this produced] a degree of difficulty in the drawing and finishing department, such as had never been experienced' (Society of Arts *Transactions* 1816: 139-40).

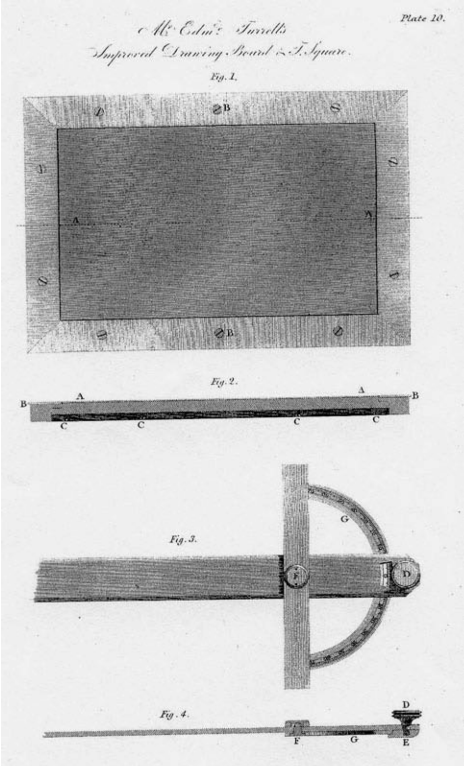


Figure 57: ‘Mr. Edmund Turrell’s improved drawing board and T-square’ Society of Arts *Transactions* 1816, Plate 10

As Turrell described it, the really tricky problem was not in the drawing, but in copying and transferring the image to the print plate. The established transfer technique for this had involved passing tracing paper through a rolling plate to press red chalk marks from the back of the tracing paper onto a copper plate. The paper would buckle and shift, and the red chalk lines, smudgy enough at best, were almost invisible on the copper plate. Turrell’s rolled zinc board was intended to support the thinnest possible bank post paper on its featureless surface that could be constantly smoothed down between drawings, in order to allow drawings to cross to the medium of print and be reproduced with minimum distortion.

Turrell’s difficulties were caused because of the decision to embellish technical illustrations with increasingly finely ruled parallel lines and mechanically-generated curves in a way that instantly showed up any deviation from regular mechanically drawn forms, and hence increased the anxieties of transfer across mediums. His example also demonstrates the interaction of material production in the image, between drawing, copying and printing, and between the extra fine strong machine-made paper, the rolled zinc surface of the drawing board, and the engraving plate. Although the many drawing aids shown in the Society of Arts *Transactions* were described as if they were simply the most efficient methods for the production of imagery, they also manifest an excessive drive towards marked accuracy and neatness that point to aesthetic decisions behind the new visual forms produced by drawing machines. Both draughtsmen and engravers invented drawing machines in order to generate superhumanly regular forms in printed technical illustrations. One well-known example is the collaboration between Wilson Lowry and the draughtsman John Farey (1791-1851 Woolrich *ODNB*), in the production of the enormous volume of plates for Rees' *Cyclopaedia* (Woolrich 1998: 49-67; Farey's self-presentation through technical authorship will be discussed in Chapter 7). The collaboration began in 1805 when Farey was just fourteen; to create images of the many structures and inventions described in the *Cyclopaedia*, Farey used delineating machines and mechanical drawing aids. After observing with the aid of a *camera lucida* (see last chapter) and registering a preliminary drawing in pencil, Farey worked up his final versions in ink, using only mechanical drawing aids for line drawing, right from the basic level of ruler and compass, assisted by his other inventions such as the elliptograph and the centrolinead (Woolrich 1998: 50; Figure 58).

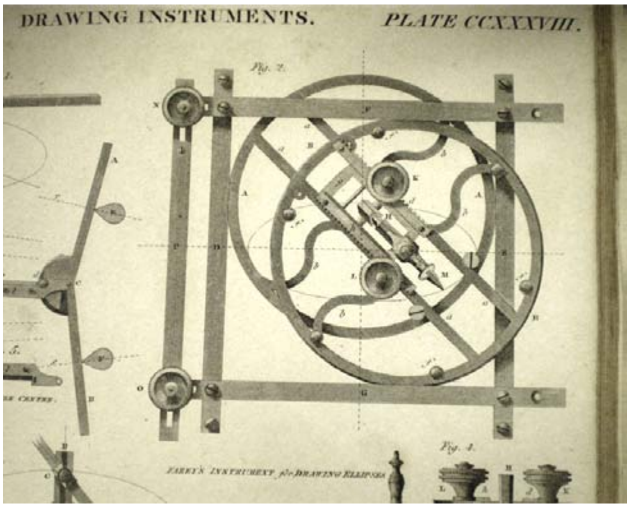


Figure 58: Detail of elliptograph used to illustrate article 'Drawing instruments' *Edinburgh Encyclopaedia*, Vol.8 (1830) Plate CCXXXVIII

In the *Transactions* of the Society of Arts inventors, illustrators, and engravers constructed an even more interdependent and self-reflexive artworld. Announcements of new drawing machines increased noticeably from 1815 onwards, with inventions such as William Cubitt's Ellipsifex (Society of Arts *Transactions* 1816, Volume 34: 131-7) or Thomas Barber's Angulometer (Society of Arts *Transactions* 1816, Volume 34: 150-4). Two possible candidates with the same name suggest themselves for the Cubitt contribution: either a civil engineer (1785-1861; Hobhouse *ODNB*) or a building contractor (1791-1863; Hobhouse *ODNB*); neither are draughtsmen or engravers. Indeed, descriptions of professional networks behind the inventions were occasionally given in print to give further credibility to reports. For example, in 1817 we read about a Mr. Warcup's curvagraph (Society of Arts *Transactions* 1817, Volume 35: 109-112) that was commended by two eminent engineers of the day: first by Henry Maudslay who had been charged to try out this new mechanical aid for ruling curved lines; and second by M.I. Brunel (1769-1849 Wood *ODNB*). Mausdlay and Brunel had been associated together in developing a mechanised technique for making standardised pulley blocks for the navy at Portsmouth Dockyard in the first years of the nineteenth century during the period of the Napoleonic wars (Gilbert 1965); by 1817, Brunel still continued to design woodworking machinery for government mills at Woolwich and elsewhere, evidently with Warcup as a draughtsman, for he praised the invention for having 'saved much time in the course of Mr. Warcup's employment under my direction'. Also in 1817, we read about an instrument for drawing in perspective invented by Mr. D. Dick (Society of Arts *Transactions* 1817, Volume 35: 89-109), which allowed one to construct perspective lines with centres of convergence well outside the picture area, in a similar manner to Farey's centrolinead. Edmund Turrell engraved Dick's invention (facing page 89, not illustrated) for this report, stepping back from his role of drawing board inventor of the year before (Society of Arts *Transactions* 1816, Volume 34: 139-144).

There were no absolute distinctions between the roles of inventor, draughtsman and engraver in this self-styled forum of the useful arts, giving more equality of status. Technical engravers such as Wilson Lowry gained status by links with other social and professional networks such as the Geological Society and the Royal Society (see Chapter 4), by engaging in debate, and through collaboration with other investigators. Both technical engravers and illustrators took an active role in a culture of invention so that the marks made on the page, the images that were produced, and the mechanical ingenuity were presented as a continuum of creative practice that had clear allegiances to larger state-sponsored engineering and manufacturing projects.

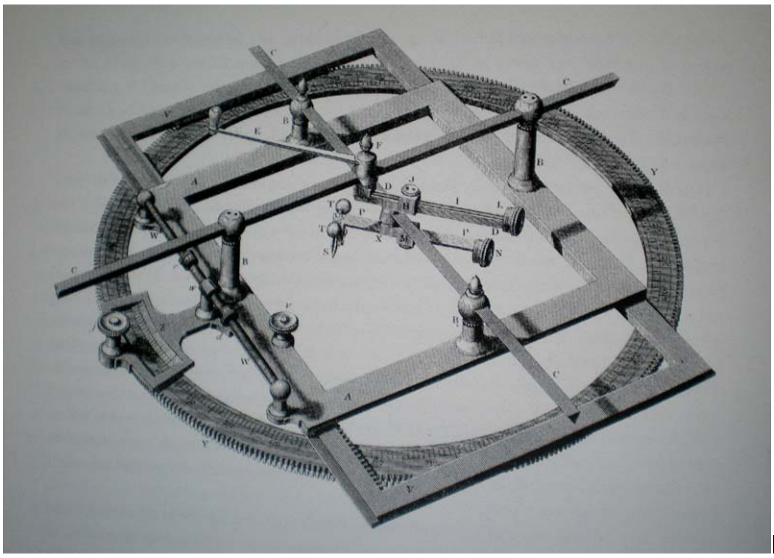


Figure 59: Joseph Clement engraved image of ellipse-drawing machine announced in his report, Society of Arts *Transactions* 1818, Volume36:133-77

'Strength, beauty, convenience and cheapness': elliptical thinking

Drawn ellipses offered a powerful lure to the inventive talents of draughtsmen and engravers. As a display of inventive prowess, at least three ellipse-drawing devices jostled politely for the attention of the Society of Arts before 1820: Cubitt's ellipsifex (Society of Arts *Transactions* 1816: 131-7); Joseph Clement's instrument for drawing ellipses (Figure 59) which was awarded a Gold medal (Society of Arts *Transactions* 1818: 133-77); and John Farey's elliptograph (Society of Arts *Transactions* 1813: 117-130). In the image shown at Figure 60, Farey displayed not the machine, but the forms his machine could generate on the page. The draughtsman and historian Tony Woolrich celebrated this period of invention at the beginning of the nineteenth century when he claimed that a machine for drawing ellipses was 'vital for engineering and architectural engravers, as it automatically generated accurate ellipses and curves on the copper plates from which the drawings were printed, a far higher degree of accuracy than could be generated by hand' (Woolrich 2002: 95). Even more than ruled lines, this abstract form compressed many layers of symbolic meaning into its material expression. The varieties of ellipse-drawing machines invented during this period and their projected use in technical drawing and illustration demonstrate how this aspect of the visual artworld as constructed by draughtsmen and engineers was intended to reach beyond the factory.

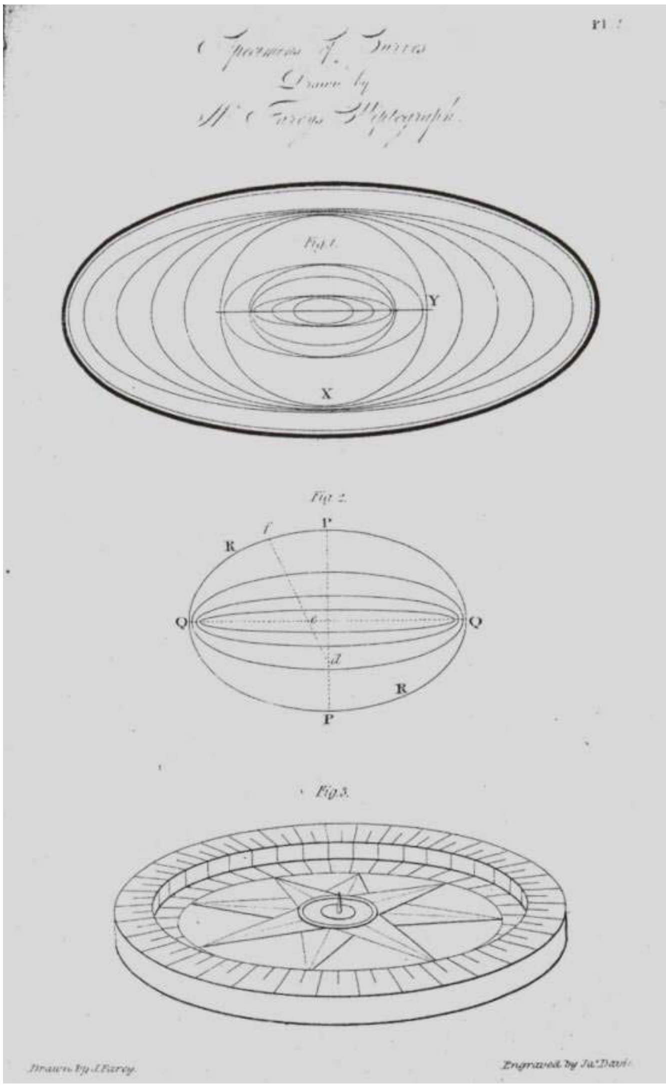


Figure 60: 'Specimens of curves drawn by Mr. Farey's elliptograph' Society of Arts *Transactions* 1813 Plate 5

An ellipse was not a new form, but one that was long established in Western cultural practices, holding different kinds of significance for geometers, builders, and artists. Its compressed circular figure is generated by two fixed points (foci), unlike the circle, which is drawn from one centre. One traditional rule-of-thumb method for drawing an ellipse was to tether a loop of string to two fixed points and to pull the drawing point around within this constraint; this is one of the methods, along with the trammel, that were included in Pasley's *Practical geometry* system of 1822 (see Chapter 3). By the eighteenth century, the trammel, established since the Renaissance, had become the most common mechanism for drawing ellipses (Figure 61).

Figure 61: George Adams Semi-elliptic trammel (c. 1775) National Museums of Scotland T.1897.185

When a material ellipse was intended in a final built structure, for example in boat building or in bridge arches, it was important to calculate and draw out the complex curves correctly for transfer to the builders' templates at full scale. By 1800 such applications were common on account of the 'strength, beauty, convenience and cheapness' (*Rees' Cyclopaedia* 1819, Volume II: 'Arch') of elliptical forms, manifested for example in Robert Mylne's Blackfriars' Bridge, opened in 1769 (Figure 62).

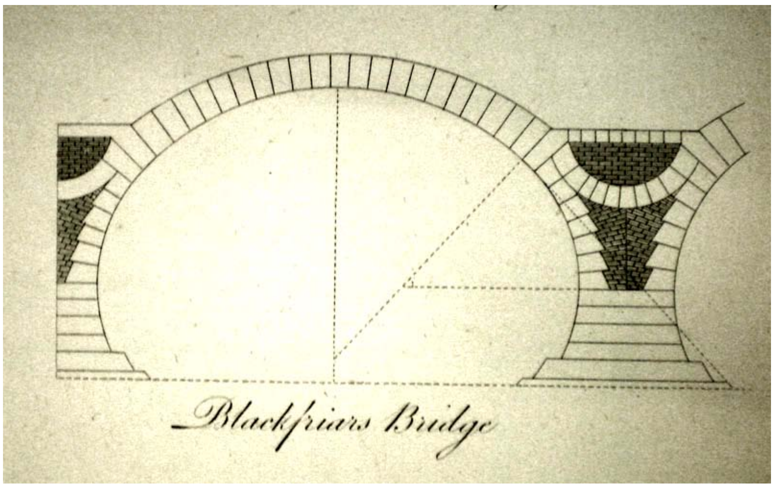


Figure 62: detail of Blackfriars' Bridge used to illustrate article 'Bridge' *Edinburgh Encyclopaedia*, Vol.4 (1830) Plate CI

Draughtsmen were thus already accustomed to drawing this curve. New instruments such as the elliptograph incorporated already familiar geometric principles of drawing into a smooth automatic mechanism that on the face of it seems excessively complex and expensive. In 1859, for example, the catalogue of Elliot Brothers' instrument manufacturers gave the price of a trammel from £2-12s-6d, whilst Farey's elliptograph cost £7-17s-6d. (Heather 1859: appendix). The familiarity of the ellipse form, and the neatness of its appearance in printed images can obscure questions about why such expensive new instruments were in demand and in which specific contexts they were used at this period.

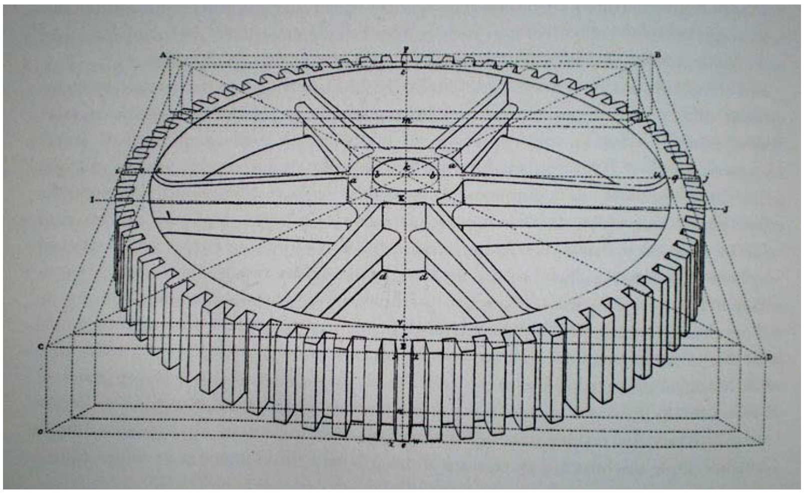


Figure 63: Joseph Clement example of an ellipse drawn with the machine (see Figure 59) announced in his report, Society of Arts *Transactions* 1818, Volume36:133-77

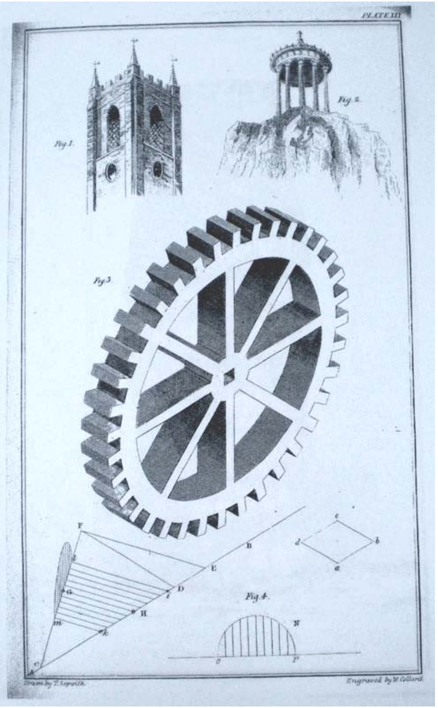


Figure 64: Thomas Sopwith (1834) *A treatise on isometrical drawing* Plate XX

The drawn ellipses in Figures 63 and 64 both display a long-established visual convention in Western art, which is to denote the appearance of a circular form that is tilted away from the viewer in pictorial perspective. Since the Renaissance, achieving such visual appearances through perspective drawing was one aim of an artist's training, and developing a hand steady enough to create a convincing-looking ellipse was one of the most difficult tasks facing the novice draughtsman who wished to furnish his image with the realism of everyday artifacts such as cups, glasses and plates. Of course, the elliptical visual form is at odds with the circular conceptual form that we also hold onto to make sense of such shapes; a point that might now seem too self-evident to need comment. Nevertheless, in this context, it seems odd that machines to render these pictorial perspective effects were 'vital' enough to be made and purchased in the context of technical representation, as pictorial perspective effects deviate from the normally relentless orthogonal frontality of technical drawings as they were used in the factory or for presentation drawings.

The elliptical forms in Figures 63 and 64 show a circular objects receding in perspective; we know that the toothed wheels are not really elliptical in shape, unlike Blackfriars' Bridge (Figure 62) because pictorial perspective has long been a dominant convention. In accord with Descartes, (1988 [1637] 6: 68) this kind of discrepancy in what Marr has called 'viewer-centred images' (Marr 1982: 25) between visual and conceptual form might lead to doubt about the knowledge we get from sense perception, or from pictures. Moreover, this effect of playful ambiguity, seen as proper to artistic images, is what orthogonal representation tries to suppress. In the context of technical drawing in the period 1800-1830, then, the invention of expensive machines to generate such images appears to threaten the authoritative objectivity of frontal technical drawing by circulating another, apparently more subjective convention for denoting three-dimensional form. In fact, if we also look closely at Figure 64 (which is in isometrical projection) we can see that the same elliptical form could signify in three different perspective systems: 1) as a 'real view' of an elliptical form, 2) in a viewer-centred 'pictorial' perspective to denote a circular form at an oblique angle in space, and 3) a circular form in isometric projection.

Getting the chance to handle two devices for drawing ellipses, the trammel (Figure 61) and the elliptograph (Figure 65) gives more idea about the objects in use, and the differences between them. The moving circles in the elliptograph are only 4" (10cm) across, so the drawn ellipses we can see in Figure 65 are no larger than 7cm in length, whereas the ellipse that can be drawn using the trammel has its drawing point on an extensible arm that could throw out a curve up to ten times that size. Unlike the larger curves of the trammel which were used to make workshop and production drawings, the images drawn by the elliptograph are small because they were intended to produce authoritative illustrations for books and periodicals, in accord with Farey's own practice.

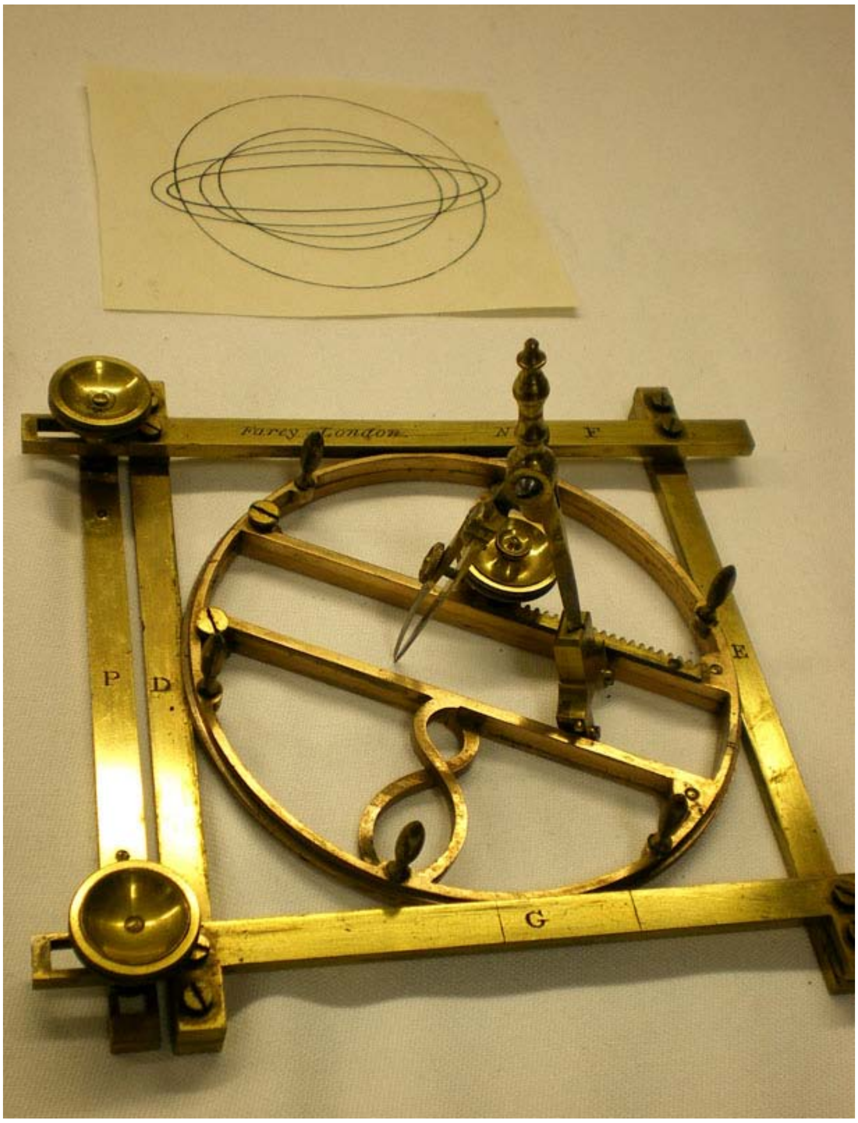


Figure 65: John Farey Elliptograph (c.1812) National Museums of Scotland T.1969.16

However, Farey's carefully delineated drawings are not necessarily reliable guides to structure. After trying in vain to reconstruct a device from a drawing, Tony Woolrich warned: 'historians... must beware of thinking that if the drawing looks high-quality and well-engraved the information on it must be accurate; this is not always so' (Woolrich 1998: 65; see also discussions of the 'Oldenburg project' on the difficulties of reconstructing experiments from drawings and descriptions in Sibum (1995) and Höttecke (2000)).

Clement's instrument (Figure 59) for drawing the kind of ellipses shown in Figure 63 had the extra refinement of a division plate (Woolrich 2002: 95-6) which meant that circular objects could be accurately divided into equal units in perspective –this is how the teeth in the gear wheel in the figure have been placed. Normally, fixed point perspective is used to simulate a subjective human viewpoint, so the accurate placing of so many sharply delineated teeth gives rise to a type of hyperrealism in contrast to the much more fuzzy knowledge that human vision of the same wheel would produce.

The new ellipse drawing machines produced as a matter of course perfect denotations of circular forms in space, which had heretofore been one of the marks of a highly skilled draughtsman trained in hand-eye coordination. Machine drawing also displayed skill, but of a different kind; in the machines shown in the *Transactions* they displayed the ingenuity and craft making skills of the inventors, and when the machines were operated in the drawing office they also required experience in handling, and in calculating the sizes and settings of the forms required. Ellipses drawn by machine were devised for technical illustration, and they aimed to display an authority of control, of neatness and miniaturisation, but to do this they had to invoke pictorial fine art perspective traditions. Although this system of representation might in theory allow the skilled geometer to calculate the exact dimensions of the forms depicted (Kemp 1990: 194-6), it would never be used for this purpose unlike the orthogonal projection used for technical drawing in the factory.

In technical illustrations in the first decades of the nineteenth century in Britain, three perspective systems could be encountered: orthogonal projection (as in the presentation drawing in Figure 10, Chapter 2), pictorial perspective, and from the early 1820s, isometric projection, described by Booker (1979: 114-5) as the most ubiquitous mode of technical drawing in Britain after that date (see also Chapter 6 and 7). Isometrical drawing is a so-called 'parallel projection' system in which parallel lines run away to infinity in parallel without ever converging. Objects with right-angled corners are presented obliquely, so that right-angled forms become flattened out into a symmetrical lozenge. Visually, it presents a compromise between the two other conventions of representation, the technical mode of giving plan, elevation and side view and fine art pictorial perspective that uses effects of foreshortening and diminution of forms to create the illusion of three dimensions. In publications intended to promote the mechanical arts, such as Rees' *Cyclopaedia*, one page of illustration might include two or three of these conventions of representation, along with texts and diagrams. In this context, draughtsmen and engravers presented a conscious play of visual meaning through juxtaposing genres and traditions of representation from both technical and artistic modes, thus setting up a critical distance in the viewer. Ellipse drawing machines were invented and used, despite their cost; here 'permanent equipment' for technical illustration did not normalise one convention and fix representation with one social group; instead it displayed the ambiguities in this mode of visual representation.

Print and the lure of 'exactly repeatable pictorial statements'

Print, with its multiple copies, has since the late eighteenth century been regarded as a partner to systematic industrial production. In *Tools for the job*, a history of machine tools, L.T.C. Rolt invoked print not merely as a partner to industrialisation but as its model, when he recalled Eli Whitney's aim in 1798 to establish a factory that would assemble guns made from multiple interchangeable parts: ' as much like each other as the successive impressions of a copper-plate engraving' (Eli Whitney, quoted in Rolt 1986: 150). Print, freedom, and industrial progress were also frequently linked together; 'the Press' was apostrophised as a 'powerful engine' for improvement (*Glasgow mechanics'magazine* 1824: v). Charles Dupin's popular textbook addressed to artisans (see Chapter 4), *Mathematics practically applied* managed to cram in a homily on the press during a discussion of cylindrical forms, by praising the 'current timely and frequent newspaper production in volume allowed by cylinder printing' that allowed social life to proceed rationally and calmly instead of being 'agitated by false rumours' (Dupin 1827: 146-7). Maintaining this campaign into the twentieth century, William Ivins' formula that prints are not important as works of art but as 'exactly repeatable pictorial statements' celebrated the virtues of print as synonymous with industrial progress and free thinking connected by the central notion of standardised multiple copies (Ivins 1992: 2-3).

The virtues of replication in industrial production had already been given currency in the early nineteenth century, in popularising works such as Charles Babbage's *On the economy of machinery and manufactures* (1835). Here, when writing 'of the identity of the work' Babbage proclaimed: 'nothing is more remarkable, and yet less unexpected, than the perfect identity of things manufactured by the same tool' and he clumped together in a cloud of examples machines such as the lathe and slide-rest, along with printing, and also general operations such as punching (Babbage 1835: 66). Equally, in 'of copying' Babbage had observed that the cheapness of articles produced by industrial methods is a result of their being copied, noting: 'almost unlimited pains are, in some instances, bestowed on the original, from which a series of copies is to be produced. The larger the number of copies, the more care the manufacturer can afford to lavish on the original. The instrument or tool actually producing the work, shall cost 5- or even 10, 000 times the price of each individual specimen in its power' (Babbage 1835: 69).

At a more specific level, technical drawings were routinely copied and circulated, functioning as communication and as contractual statements from the late eighteenth century onwards, often laboriously through pouncing (pricking through the paper and dusting marking powder through the holes) and tracing. As noted, James Watt experimented with various mechanical copying techniques. At least half the bulk of drawings in the Boulton & Watt archive made after 1780, for example those shown in Chapter 1 (Figure 4) are duplicates of others, made in the copy press that Watt patented and marketed from 1780 (Rhodes and Streeter 1999: 9; Andrew 1981-2: 5; Richardson 1989: 118-21). The Instruction Book of 1778 (Figure 8, Chapter 2) meanwhile was a small printed edition using steel engraving. According to James Andrew, the development of industrial practices such as the interchangeability of parts, or the sourcing of production in distant parts of the country, could not have taken place without the cheap direct transfer of original design drawings that devices such as the copy press provided (Andrew 1983: 2). Andrew's statement tells us more about the allure of 'print culture' than of actual practice, for workers modify as they make, improvising between the gaps in representation, for example as in the apparently detailed accurate work of John Farey. Equally, as shown in Chapter 2 and 3, draughtsmen relied on images in print, 'paper academies', when imbibing their craft. Two versions of the same drawing by Cornelius Varley, shown in Figure 66, show the two-way process of moving between the mediums of drawing and print, with stylistic language changing in the transfer from drawing to print. So for example, most print mediums around 1800 would turn tonal or colour block effects from a painting or drawing into lines; equally knowledge of the end use might modify the style of the drawing as well.

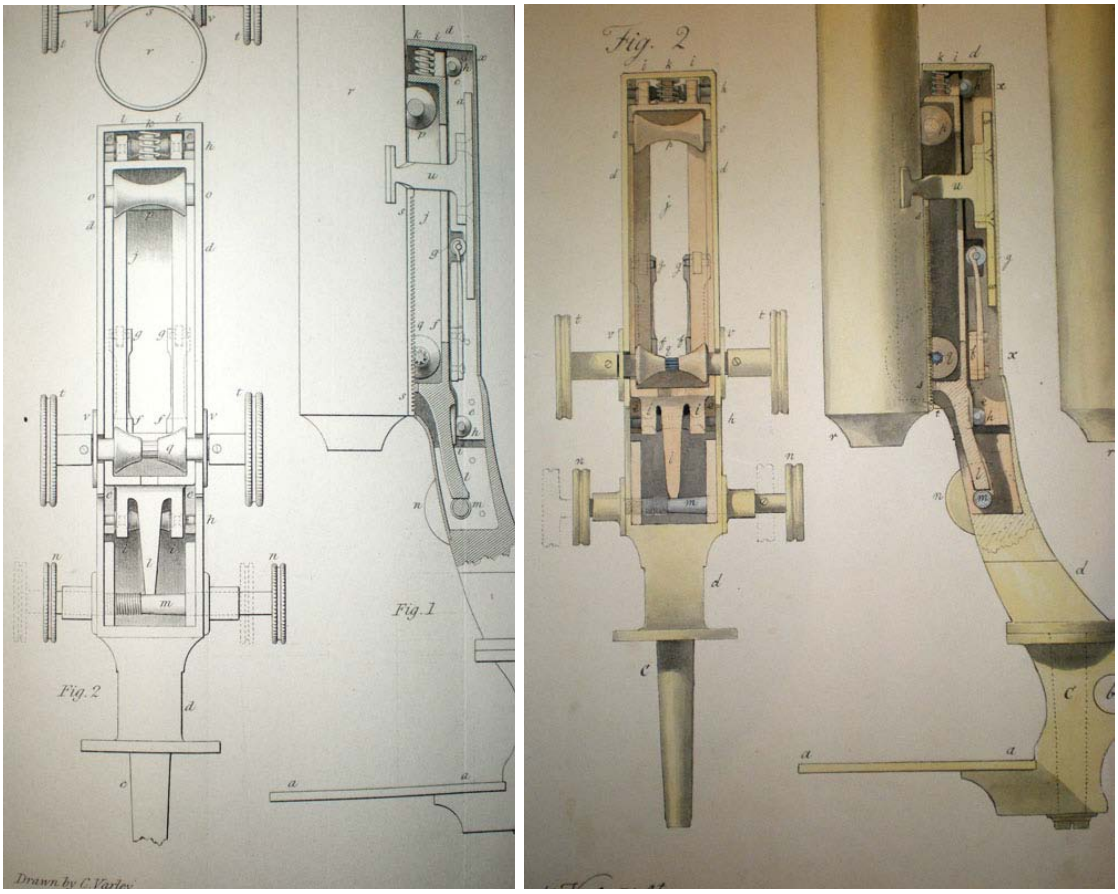


Figure 66: 'Mr Hugh Powels mode of mounting the body of a microscope' Society of Arts *Transactions* 1839-41: 78-81 plate detail (*on left*), Cornelius Varley, delin,. G. Gladwin, sculpt. *On right*, Cornelius Varley original drawing Society of Arts (uncatalogued).

However, rather than pursuing these familiar connections between the factory system of manufactures, technical drawings and notions of 'print culture', the remainder of this chapter will consider how engineers, draughtsmen and engravers developed drawing machines that were intended to construct a visual artworld with a distinct mechanical aesthetic well removed from the practice of making technical drawings for the factory. Drawing machines such as the rose engine and the pantograph demonstrated skills of invention and created marks that asserted the values of standardisation and repeatability. While these machines generated visual images for a general audience, the making of them presented engineers opportunities for demonstrating allegiances and rivalries with other occupational groups.

The first example of invention presents a collaboration of civil engineers, mechanical draughtsmen, engravers and artists within the pages of the *Transactions* of the Society of Arts, in response to the question of banknote forgery. This was a major public concern in the aftermath of British military involvement firstly in the American War of Independence, and then the Napoleonic wars that had forced the suspension of metallic cash currency between 1797 and 1821 (Robertson 2005: 32-4). The problem of forged banknotes somewhat paradoxically elicited a series of inventions for copying and duplicating images at various levels. This depended on the risky strategy of being one step ahead of the criminals; the aim was to create a printed image that was too innovative, too difficult, and hence too expensive to merit the labour of forgery.

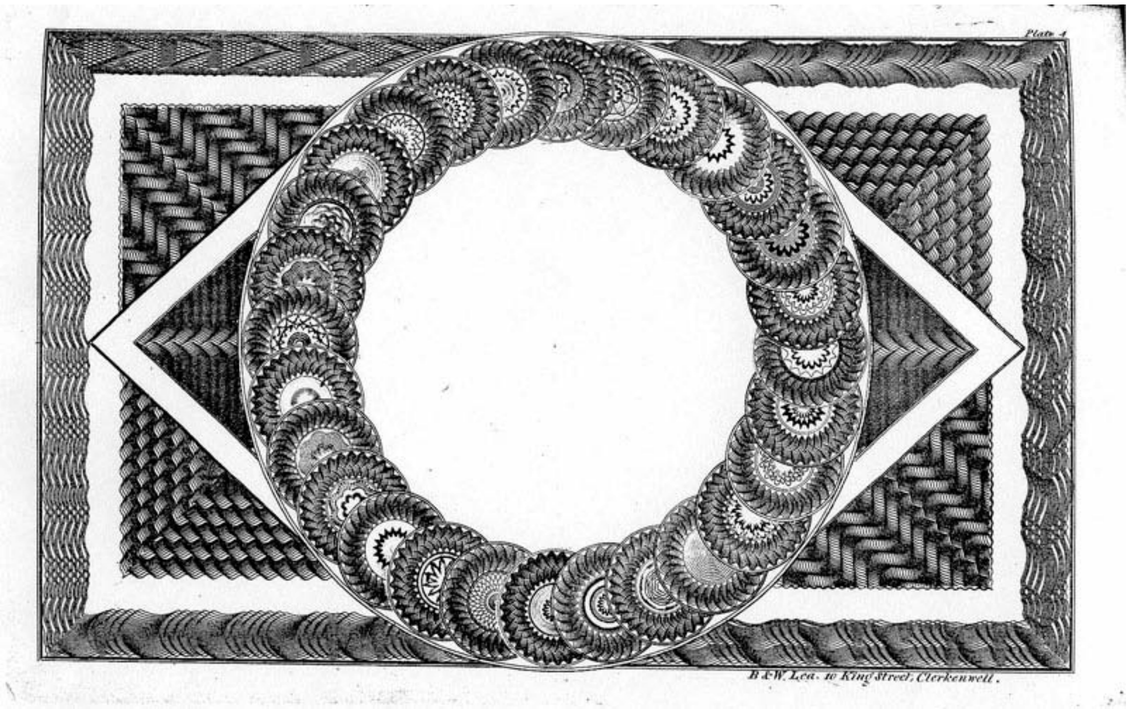


Figure 67: Specimen of engine turned engraving applicable to bank-notes submitted by Mr. Lea of Clerkenwell, made with the rose-engine for series of articles ‘Prevention of forgery’, Society of Arts *Transactions* 1824 Plate 4

One technique that was considered was the so-called siderographic process for multiplying steel engravings from Messrs Perkins, Fairman and Heath shown in Figure 67 (Society of Arts *Transactions* 1820: 47-56). In this technique, the very fine indented lines of an engraving were first transferred to a steel roller (where they appeared in relief), and then impressed back into a new plate. Each of the steel surfaces involved also had to be successively softened or hardened according to whether they were about to receive or to punch in an impression during this process (Dyson 1984: 133-7). For the banknote imagery to be applied to such a plate, one favoured motif as a supposed anti-forgery device was a so-called *guilloche* type of pattern generated by the rose lathe. This machine, sometimes also called a geometrical lathe, is a circular turning device that inscribes a series of self-replicating proliferating curves (on the same principle as a spirograph). The actual form of the curve depended on a series of interlocking cams that could be arranged in an almost infinite number of permutations.

This is like a code with the key known only to the holder. The report on siderographic printing also introduced another invention, Mr. Asa Spencer's rose lathe and invoked effects of the unpredictable visual dazzle in the patterns it could generate by making a topical reference to the phantasmagoric effects seen in the kaleidoscope, a recent invention from David Brewster (Morrison-Low and Simpson 1995: 15-17):

> 'its powers of producing variety are equalled only by the kaleidoscope, *viz*. that the turning of a screw, like the turning of the kaleidoscope, produces an entire new pattern, much of which was never before seen, and perhaps would never be seen again.' (Society of Arts *Transactions* 1820, Volume 19: 50)

An example of rose lathe engraving submitted to a later article in the series on the 'Prevention of forgery' was accompanied by an equally puffing report by Mr. W. Palmer in which he observed there were three kinds of engraving to use on bank-notes: writing, vignette, and engine engraving. In his opinion, engine engraving was the most secure and had symbolic qualities that made it the best mode of ornamenting banknotes as it united 'utility' with 'beauty' and finally most importantly 'what our country prays for—security', on account of an intricacy and regularity that went far beyond hand work (Society of Arts *Transactions* 1824: 65-8). Engine engraving created a motif that was completely detached from the artist's hand and yet was decorative and intricate. The rose lathe was a self-acting mechanism that reiterated identical lines, displaying a rival drawing philosophy to that of fine artists. This technique carries through a drawing procedure already implicit in simple mechanical aids such as ruler and compass; every mark made is not so much as copy as a standardised unit that can be called up and executed at will.

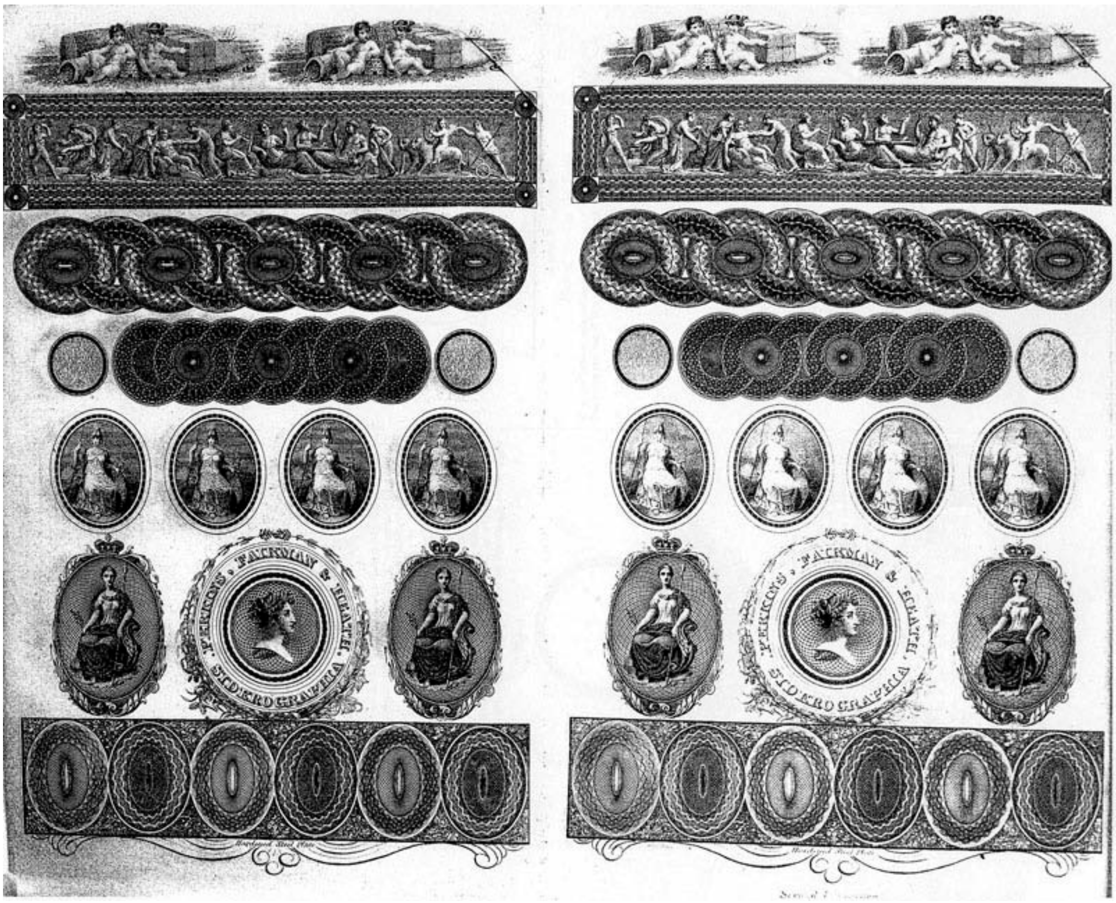
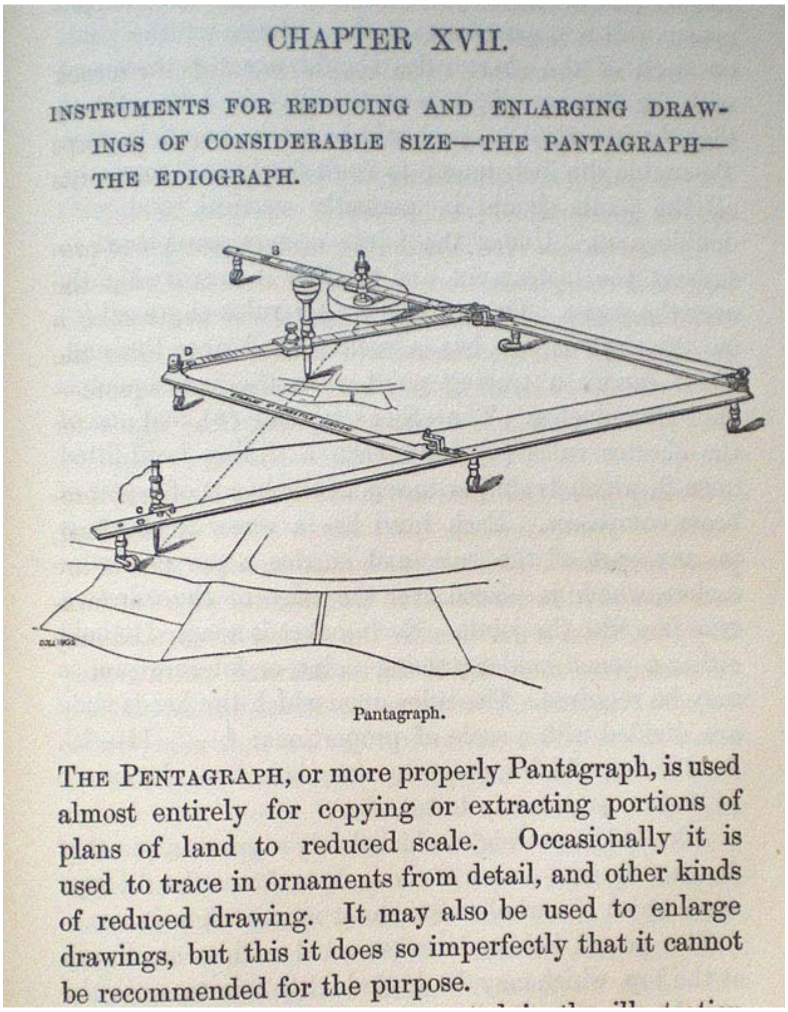


Figure 68: 'The impressions taken from plate on left are first impressions, the one on the right after 35,000 impressions. The medallions by inspection will be found to be perfectly the same, line for line and dot for dot. Also, two styles of work, copper-plate and letter press have been combined in one plate, effected by the process of transferring and re-transferring. This kind of engraving is extremely difficult to imitate. Finally the geometrical lathe patterns, from the invention of Mr. Asa Spencer of the United States'. Society of Arts *Transactions* 1820: 50 and plates 39 and 40

The illustration in the Society of Arts report on siderographic printing (Figure 68) displayed further processes of duplication in its internal structure: firstly a selection of engraved motifs were laid out in lines to form a block of pattern, then each pattern block was repeated to form a larger pattern: as the final flourish the highly patterned plate itself was repeated, facing its original, thanks to the siderographic process. Perkins, Fairman and Heath proclaimed, 'it is the power of reproducing and multiplying the works of our greatest artists, which constitute the strength of this system... the impressions taken from the plate on the left are first impressions, the one on the right after 35,000 impressions. The medallions by inspection will be found to be perfectly the same, line for line and dot for dot...' (Society of Arts *Transactions* 1820: 47-56).

Outside the *Transactions*, the bank note question had also been addressed by a large collaboration of 'artists, engineers, &c.' who agreed to review several proposals and finally recommended the siderographic technique to the commissioners for preventing forgery (*Specimens and description* 1819). The 81 signatories to the report included 26 engravers, including Edmund Turrell and Samuel Porter, ten civil engineers such as Mark Isambard Brunel, Henry Maudsley, and Joseph Strutt, and mechanical draughtsmen such as Joseph Pinchback and Cornelius Varley. The introduction of paper money in Britain in the first half of the nineteenth century created an extremely large general audience (the adult population) for the modes of image copying and mechanical drawing discussed here. The ornamented banknote juxtaposed artistic and technical styles of drawing in equality and tacitly forced recognition upon the viewer of the improving status of 'engineering' through visual means.

In this chapter I have discussed technical drawings and illustrations as manufactured objects, with the aim of communicating not simply within the factory, but with other occupational groups and general readers. Technical drawing procedures at the end of the eighteenth century made use of technical and artistic techniques, from mechanical drawing to watercolour painting. In constructing a visual discourse for the mechanical arts, engineers, draughtsmen and engravers demonstrated their understanding of the factory system in the production of images by breaking picture making down into elements that could be produced by machine. In my final example, I will discuss the involvement of engineers in the invention and production of a drawing device that used a mechanism of parallel movement that was very familiar to them; the pantograph. The many variations on the pantograph proposed in this period led to conflicts between engineers themselves and between engineers and other social groups. The conflict also demonstrates that engineers, draughtsmen, and other skilled artists such as engravers were involved with aspects of image production beyond the genre of technical drawing for the factory, for the machine was not widely used in factory drawing offices.



CHAPTER XVII.

INSTRUMENTS FOR REDUCING AND ENLARGING DRAWINGS OF CONSIDERABLE SIZE—THE PANTAGRAPH—THE EDIOGRAPH.

Pantagraph.

THE PENTAGRAPH, or more properly Pantagraph, is used almost entirely for copying or extracting portions of plans of land to reduced scale. Occasionally it is used to trace in ornaments from detail, and other kinds of reduced drawing. It may also be used to enlarge drawings, but this it does so imperfectly that it cannot be recommended for the purpose.

Figure 69: ‘Pentagraph’ W.F. Stanley (1866) *A descriptive treatise on mathematical drawing instruments* London: W.F. Stanley: 101

The pantograph (it has various spellings) was used for copying, enlarging or reducing drawings, and for transferring an image across mediums, for example to a print matrix such as an engraving plate. Other forms of this device have been discussed in Chapter 4 in relation to the parallel motion of Watt’s steam engine, and to medal and sculpture copying machines. The principle behind this machine is that of a flexing parallelogram with one tracking point and one movable drawing point set in (Figure 69). Placed flat, the operator can copy a drawing by running the tracking point along the lines of the drawing, and the second drawing point, by shadowing the movement, will in theory reproduce the same outlines. Placed vertically, with the tracking point used to trace the outlines of objects in the world, it could be used as a perspective device for producing observational drawings (this is the way it was used by silhouette artists, and also surveyors). Because it was fairly simple to make and operate, the pantograph has been used in different forms since the beginning of the seventeenth century (Kemp 1990: 180). By the late eighteenth century machines like this were in demand for example by the print trade for the production of illustrated encyclopaedias, atlases, scientific and technical works (Simpson 1991: 49). The other large demand came from surveyors (for both observation and map enlargement and reduction), and also from textile printers to manipulate motifs for engraving onto copper printing rollers.

Although there was a demand for rapid and correct copying, mechanisms such as the pantograph were not necessarily as smooth-running as their owners had hoped, especially when the operator was up against the fine accurate lines that Turrell described so feelingly in his report. So when the engineer David Napier (1788-1873; Moss 2002: 74-93) presented a rival copying device to the Society of Arts he took the chance to remind his readers of the inadequacies of the pantograph. His own machine, Napier claimed, would by contrast:

> copy outlines of any kind, either right, or reversed on copper for the engraver. I am aware that this may be done with more or less correctness by the pantograph, but… I believe engravers are not at all in the habit of making use of that instrument partly on account of the want of precision in the execution, and partly because the slightest carelessness or inattention in drawing up the tracer is sure to produce false lines (Society of Arts *Transactions* 1819, Volume 38: 63-6).

In 1866 W.F. Stanley warned in his *Descriptive treatise on mathematical drawing instruments* that the pantograph is too imperfect for reproducing drawings (see text in Figure 69). My own experience of assembling and testing out different styles of pantograph mechanism in the collection of the National Museums of Scotland confirmed the suspicions (admittedly raised by jealous inventors) that many versions of the pantograph, even in more expert hands than mine, remained about as steerable as a supermarket trolley. Nevertheless, the demand for copying machines, and the lure of imperfection in existing designs, spurred inventors. In Edinburgh, a dispute in 1822 between rival inventors of copying devices illustrates, in the account of A.D.C. Simpson, a clash of academic and professional interests (Simpson 1991: 47-73). Engineers and associated mechanical trades, it is often noted, had comparatively low status at the beginning of the nineteenth century (Buchanan 1983) in relation to 'gentlemen of science (Morrell and Thackray 1981). In the pantograph dispute, one inventor, initially supported by David Brewster (1781-1868), was a manufacturer Andrew Smith with a device of *c*.1822 he called an apograph. The other inventor with his 'eidograph' (also *c*.1822) was William Wallace, a self-taught scholar and writer who became Professor of Mathematics at Edinburgh University in 1819. Both inventors were intending to make money from this invention; this was not a dispute that pitted a gentleman against 'trade'. The dispute was framed within an artworld in which images were only useful if they could be duplicated and circulated; moreover this was an artworld alive to the commercial possibilities of invention to that end. Nevertheless, Simpson argues that Brewster, who switched allegiance from Smith to Wallace, was motivated by the desire to please the patrons and men of science in Edinburgh at that time. In this particular struggle, science beat off entrepreneurship through Wallace recruiting prestigious supporters, ultimately including Brewster who was himself anxious to maintain influence as a man of science (Shapin 1984: 17-23).

This chapter has argued that the materials, machines and processes involved in fabricating linear modes of technical drawing were used by engineers, draughtsmen, and other skilled artists such as engravers to construct a visual artworld with a distinct mechanical aesthetic in the first decades of the nineteenth century, even when those products were not necessarily the same as technical drawings in the workplace. In publications such as the *Transactions* of the Society of Arts, in relation to artists and engravers in the fine art world, contributors comparatively attained a greater sense of agency and improved cultural status, especially when as already noted, the majority of artists and engravers in Britain had an insecure existence with low status, poverty and often drudging work for survival (Gillett 1990: 22-6).

As noted, the visual style of technical illustrations served as exemplars for draughtsmen in workplace drawing offices. In addition, the expressive and aesthetic effects of technical drawing built an audience for this style through pictorial values and also through an 'iconography of materials' –a conscious display of production techniques that celebrated mechanical reproduction in a self-reflexive way. Such techniques familiarised viewers with these conventions, and also arguably built an audience for industrial methods, for 'engineering' and for engineers in cultural life. Although technical illustration has often been excluded from accounts of technical drawing, the means by which these genres entered public discourse together at this period suggest this is an artificial separation imposed at a later date. In this chapter, the products of technical drawing and illustration have been characterised as marks and forms on paper, mainly produced by draughtsmen and engravers. In subsequent chapters I will be considering technical drawing and illustration not so much as a single artworld, a common task of engineers and draughtsmen, but as an arena in which engineers, draughtsmen and industrial workers competed for status and agency with other groups, in the manner suggested by the pantograph dispute.

Chapter 6: Social networks: artisans, draughtsmen and working relationships

Straightforwardly this chapter is about draughtsmen as industrial workers. In common with many other non-elite occupational groups, a descriptive history of who undertook this form of employment, how draughtsmen were trained, and the expectations and aspirations they had about their own work does not really exist. It is, of course, a truism of social and cultural history that the experiences of anonymous workmen are by definition hard to access. However in addition the relative lack of knowledge of the drawing practices of ordinary draughtsmen also comes from a denial of their experiences from many quarters because the very formation of 'draughtsmen' as a social group, and their claims for status, brought them into conflict with designers and elite engineers through the medium of drawing.

Below the level of elite individuals, evidence about technical draughtsmen in the first half of the nineteenth century is elusive. The evident existence of this population is implied by the material residue of their activities, the visual testimony of technical drawings in archives and publications. The substantial Boulton & Watt archive, already noted in Chapter 2, is one. Other notable resources were accumulated during the development of the railway industry from the 1820s onwards, for example in the records of Robert Stephenson & Co. (Warren 1973 [1923]; Chrimes 2003: 40-50; Bailey 2003: 163-210). Although most archives are associated with a few famous names, many drawings within archives were made and signed by a host of other individuals, such as the otherwise unknown W. Hall of 1841 whose work is in the Nasmyth & Gaskell archive at the Institution of Mechanical Engineers (IMechE END 14/5/2: Figure 70). Even where such archives no longer exist, one might speculate that the expansion of the factory system of production, if it was at all in accord with Charles Babbage's *Economy of machinery and manufactures,* would require an equal expansion in the numbers of technical draughtsmen (Babbage 1835: 262). Nevertheless, the evidence of the census records is at odds with this intuition, as it shows that in 1851 there were only 597 respondents in Great Britain who described themselves as draughtsmen (*1851 census* 1854 Volume 2:1: cxxi). Against this slender number, however, one could place the testimony of Peter Booker, the historian of technical drawing, who asserted that by mid-century a 'considerable population of draughtsmen' had come into being in Britain (1979: 133). If true, this would represent a great change from the situation of only sixty years earlier when Watt and Smeaton in the late eighteenth century feared delegating their drawings to others (Richardson 1989: 130; Skempton 1981: 2-3).

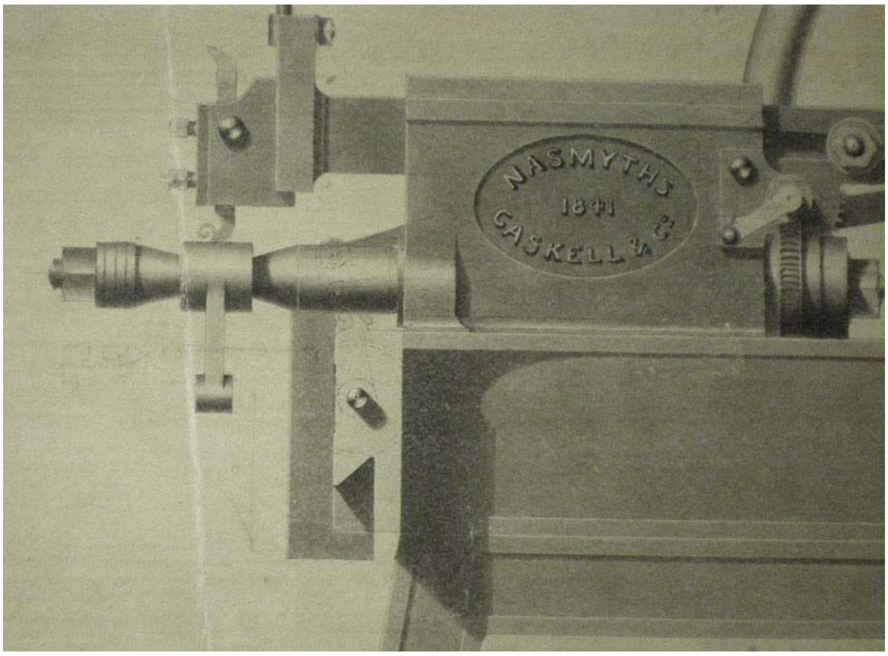


Figure 70: Detail of drawing by W. Hall 1841 Nasmyth & Gaskell technical drawings from the Bridgewater Foundry 1841-62 (Roll 52) IMechE END 14/5/2

In *A history of engineering drawing* Booker's short detour into social history on behalf of draughtsmen (Booker 1979: 133-4) was in itself surprising, for the rest of his narrative concentrated on presenting a chain of intellectual and technological progress. Further, a closer reading shows that Booker's claim that there was a 'considerable population' of draughtsmen was supported only by a couple of excerpts of correspondence from *The Engineer* of December 1859 on the subject of founding an association of draughtsmen (Booker 1979: 133-4). However, it would be hasty to dismiss Booker's statement, as he is one of the few writers to have considered the topic at all. Instead, this passage represents an attempt in passing to reconcile a perception that there is a material record of objects, and a lack of information about the human actors. Although Booker himself did not pursue the topic he raised so briefly, one of the aims of this chapter will be to fill that gap by bringing forward examples as evidence.

Equally, the shadowy image of 'the draughtsman' in the first half of the nineteenth century could be a product of terminology. 'Draughtsman' was used more often before 1840 to refer to someone who could 'write a fine hand' (The *Times* 23 June 1800: 1) or who was engaged in drafting reports or legal documents, as for example: ‘Mr Perry was called to the bar in 1825, but never practised except as a conveyancer and equity draughtsman’ (The *Times* 23 June 1846). So without necessarily looking for ‘draughtsmen’ a more informed reading of the 1851 census reveals 5170 workers described as pattern cutters and civil engineers whose work and training would also have included technical drawing, in addition to 5507 engravers (*1851 census* 1854 Volume 2:1: cxxi). As noted briefly in Chapter 2, pupils and assistants in engineering and architectural practices from the late eighteenth century onwards took on the role of draughtsmen as part of their training and later working lives, even though their occupation was not described using that term. Continuing changes in working practices through the first half of the nineteenth century developed tensions between expectations and reality in the draughtsman’s role that will be developed at more length here. Chapter 2 noted how some architects, aiming to distance themselves from manual labour of any kind, even wielding a pencil, used the word ‘draughtsman’ to exclude their employees and potential rivals from intellectual status in the late eighteenth century (Savage 2001: 207). In engineering the word ‘draughtsman’ as an occupational category came into use later, towards the middle of the nineteenth century, but arguably it reflected in a similar way changing labour relations and a growing hierarchy of specialisations in engineering (Berg 1980: 153). Meiksins and Smith have suggested that technicians, in a definition that includes all technical workers from elite ranks to the most humble, have an ‘ambiguous and intermediate’ status in the class formation of modern industrial societies, acting as deputies for capital against broad labour interests (Meikskins and Smith 1987: 235; Smith and Whalley 1996: 27-60). Within engineering itself, the role of draughtsmen became equally indeterminate. Although Antoine Picon (2004: 421-36) chides fellow researchers for slipping into detailed empirical case studies, the case of the invisible draughtsmen in Britain suggests that without such fragmenting details, it would be deceptively easy to talk about ‘engineers’ as a single broad class or profession. I propose that we can apply the notion of technicians inwardly to the microcosm of the technical world, where draughtsmen become as it were the ‘technicians’ of technicians.

Workplace conflicts must also be placed against wider conflicts in society about status and power. The period before the Reform Act of 1832 was informed by constant political agitation that included both middle class liberals and working class radicals, who were all seeking enfranchisement (Rubinstein 1998: 37-46). Trade rivalry with France after the lifting of trade embargoes in 1826 kept alive the ‘myth’ of the superiority of French design (Rifkin 1988: 91), inflamed by a general bewailing of the deficiencies in 'taste' amongst British designers and makers of export goods that allegedly damaged sales. This fear was translated into demands for design education amongst workers that became most insistent around the time of the Select Committee hearings in 1835-6 (Romans 1998; Bird 1992; Brett 1992; Macdonald 1970; Bell 1963; Tylecote 1957: 38). In combination, these issues gave rise to a complex cultural debate in which questions of worker education, design, and the development of good taste, were all intermingled and enunciated under the single topic of draughtsmanship. Pronouncements about the ability to draw, and the function of drawing, were carried on both by elite reformers and by artisans themselves, in journals and magazines, in places of education such as the Mechanics' Institutes, and not least during the Select Committee itself. But despite such pronouncements about drawing in the abstract, draughtsmen themselves became almost invisible, largely due to some uncomfortable collisions about the cultural and social status of these workers and their drawings. Witnesses from the Government Select Committee on Arts and Manufactures of 1835-6, for example, often give unwitting testimony of drawing work in the factory even whilst lamenting the lack of it.

Indeed, the idea set in motion at that time of the 'apathy' of British workers and their ignorance of mechanical theory and technical draughtsmanship still has some purchase today (Booker 1979: 130). While French state initiatives, so alarming to British design reformers in the first half of the nineteenth century, have invited a range of research into French technical drawing education (Edmonson 1987; Alexander 2008; Fox 1974; Day 1987; Weiss 1982), nineteenth-century British industrial draughtsmen have not been so well served by contemporary scholarship. Two separate approaches to the interpretation of technical drawing have perhaps shaped this neglect. In the first mode, that of individuals celebrated for their action and achievements, technical drawing has frequently been discussed as an expression of technological and creative thinking, the 'mind's eye' of the engineer (Ferguson 1977). In the second, technical drawing has been given an overriding function of social control. In relation to draughtsmen in drawing offices, any accounts that do exist tend to subsume draughtsmen into a larger body of anonymous and passive oppressed workers. This is due in part to the influence of Foucault's thesis in *Discipline and Punish* (Foucault 1991 [1977]) about the characteristic systems of power in modern industrialising societies where for example the drawing classes of the Gobelins manufactory were used to show the 'new technique for taking charge of the time of individual existences' through the development of an internalised self-discipline. (Foucault 1991:157) Further examples of this approach can be seen in Ken Alder's description of technical drawing as a 'common referent' whose seemingly autonomous objective status was used to evaporate conflict between power groups, (Alder 1997: 140) or Louise Purbrick's characterisation of technical illustration as a ruse to overawe factory workers (Purbrick 1998: 275-93). So the two apparently opposing discourses, of celebrated individual agents or of an oppressed and passive mass, both collapse into one overriding narrative of power, masters and men characterised as human agents versus 'mindless operatives' (Denis 1995: 82). Such a view of the function of technical drawing reduces the scope of interpretation as it excludes the experience and aspirations of the subjects in the social body it appears to champion.

Additionally, the specific situation of draughtsmen at work, which might be characterised as supporting the research practice of engineers through creating a body of drawings in an atelier-like structure appears to fit well with the notion that technicians in science (Shapin 1989: 554-63) and in art (Becker 1982: 77) have systematically been made invisible. Such 'invisibility' could be demonstrated for example in *A glossary of civil engineering* (Brees 1841) that introduces a host of useful objects from 'abbrevoir' to 'wood-screw', but makes no mention of 'drawing', 'drawing office' or 'draughtsman'. However, against the view that industrial workers like draughtsmen became increasing powerless and anonymous, other writers have argued that the very unfamiliarity of certain types of factory work (machine production being a key example) actually demanded increased skills and initiative from workers both in Britain (Pollard 1965: 101-3) and France (Edmonson 1987: 201-2) in the first decades of the nineteenth century. Schmeichen (1995: 167-77) for example has argued that artisans, having consciously set out to acquire drawing and design ability through self-education actually increased the demand for such skilled industrial labour in the 1830s and 1840s. As draughtsmen prepared presentation and other publicity drawings as well as technical illustrations, they might seem to be in a good position to exhibit such a 'property of skill' (Morus 1996: 417-20). In this chapter I will develop the argument that British draughtsmen in the first half of the nineteenth century aimed to resist invisibility through asserting their skilled status, which I will consider in combination with broader theories about the 'ambiguous and intermediate' status of technical workers in the class formation of British industrial society (Smith 1987: 235; Smith and Whalley 1996: 27-60).

Draughtsmen's claims for status also brought them into conflict with radical positions of 'artisan resistance' (Desmond 1987: 77-110). Draughtsmen's own opinions about their self-worth were often opposed to any proletarian class solidarity. This chapter and the next shows that the advocacy of a particular view of 'professionalisation' in engineering in the nineteenth century had a divisive effect, tending towards a proliferation of localised groups and sub-groups each vying for respect; in the case of draughtsmen I argue this resulted in their eclipse.

To explore the issue of draughtsmen's work and status in the contexts I have outlined, this chapter will place the work and training of draughtsmen in relation to the politics of working class education and the development of the mechanics' institute movement. It will then discuss the politics of taste and class revealed by the evidence of the Select Committee on Arts and Manufactures of 1835-6 and responses to these issues in mechanics' magazines. I then consider the trajectories and aspirations of individual draughtsmen from the evidence of reminiscences and sketchbooks before moving to examples of factory drawing office practice. To conclude, I will return to the issues raised by correspondence about the role of the draughtsman from *The Engineer* of December 1859, mentioned so briefly by Booker (1979: 133-4), which gives further evidence of the ongoing changes in draughtsmen's work and status through the first half of the nineteenth century.

'Undignified scenes': education, politics, and class

Education for the working classes in the early nineteenth century has frequently been described in terms that emphasize discipline, not empowerment. Even in the period *c.*1790-1810 when radical agitators promoted self-education by workers as a 'prized measure of the right to [full] citizenship, not social mobility' (Haywood 2004: 24), sobriety, rationality, and self-discipline were lauded as a means to power (Prothero 1979: 192). Radical self-directed political expression came under attack in the following decades with such violent events as the Peterloo Massacre in 1819 and measures such as the Six Acts in the same year intended to curtail uncontrolled publication (Haywood 2004: 83). Political agitation before the Reform Act of 1832 had appeared to offer an alliance between liberals and radicals (Rubinstein 1998: 37-46), that in the cold light of the actual legislation created a 'crisis of expectations' (Secord 2000: 68) benefiting only a few from the well-off middle classes, and adding further feelings of betrayal to those in the majority who were still shut out from power (Belchem 1996: 59-64).

The rancorous period 1820-32 also saw the development of a much more paternalistic approach to worker education. For example, Henry Brougham (1778-1868 Lobban *ODNB*) was an active and prominent promoter of education for the 'operative classes', a supporter of Mechanics' Institutes and a founder of the Society for the Diffusion of Useful Knowledge (SDUK) in the late 1820s, but had also been a supporter of the Six Acts (Brougham 1825; Haywood 2004: 101). In the twentieth century, historians revived the radicals' suspicion of the general philanthropic claims of middle-class liberal reformers such as Brougham. For example Mabel Tylecote pointed to the 'fear and loathing' beneath the philanthropy (Tylecote 1957: 26) where the middle classes feared unrest caused by large new urban groups of factory workers, seemingly cut off from traditional communities and established systems of skill and knowledge, whilst loathing their perceived 'unbridled license' (Tylecote1957: 26) and 'nightly scenes of drunkenness and riot'. More recently, Shapin and Barnes (1977) took suspicion of liberal reformers as their starting-point. By the time they were writing, they asserted, it had become 'standard' for scholars to attribute innovations in education in the early nineteenth century to an interest in social control (1977: 41). Indeed, they asserted that this desire for control was clearly and invariably stated at the time by the liberal reformers themselves (Shapin and Barnes 1977: 40).

However, it could be argued that the interpretation of Shapin and Barnes suggests a misreading and rational Machiavellian policy of self-interest in middle class reformers in the period before the Reform Act, whereas in actuality, the situation was more confusing to the actors. Adrian Desmond has noted how artisan radicals, labour activists, and elite liberal reformers of education were all enmeshed in social networks in London in the late 1820s (Desmond 1987: 105-8). Brougham himself attracted wide ridicule in the 1820s from both right and left (Haywood 2004: 119). Radicals attacked him for advocating a style of education that suppressed political discussion, whilst from the right he was enfolded in a wider contemptuous attack on the presumptions of ignorant self-education. This was an alarming topic to reactionaries in the 1820s, not only on account of the Mechanics' Institutions but also because of the proposed establishment of University College London (founded 1828), which was attacked in *John Bull* on 3 July 1825 as the 'cockney college' (George 1967: 177) and reviled for its 'godless' modern curriculum (Reader 1966: 136; Simon 1977: 119-20). Satirical responses to the whole notion of workers' education included coining the term 'steam intellect' (Inkster 1985: 1-2; Secord 2000: 41-52) and an outburst of caricatures such as 'The March of Intellect' of 1828 (Figure 71) which shows a dustman all kitted up with cigar and monocle lolling in front of his fireside whilst perusing a tome titled: 'an introduction to the pleasures of science dedicated to the majesty of the people' (George 1967: 177). So while conservative critics felt that it was dangerous to educate workers to thoughts of rebellion, liberal reformers feared the brutishness of ignorance. The political agitation in the era of the Reform Act, and the growth of socialism, marked in 1848, the 'year of revolutions', by the publication of the *Manifesto of the Communist Party* (Marx and Engels 1970 [1848]) did nothing to resolve this distressing dilemma.

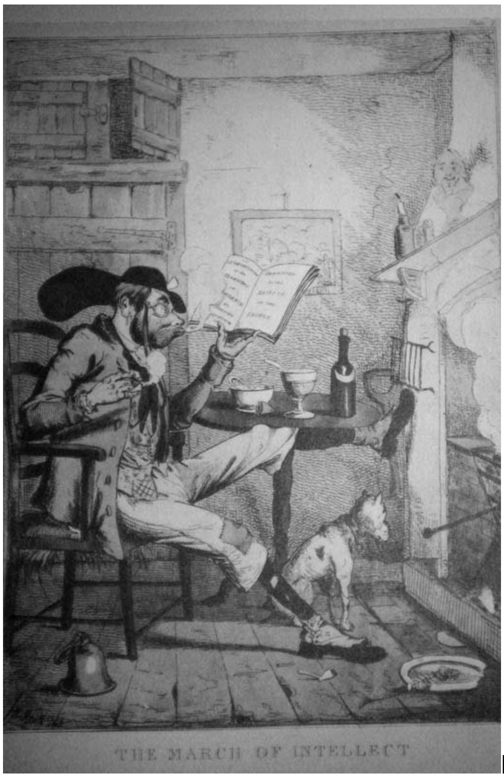


Figure 71: H. Heath 1828 *The march of intellect* Victoria & Albert Museum (George 1967: 177)

One possible solution mooted by liberal reformers in the period was to find subjects of study that would make mechanics more docile. Shapin and Barnes have suggested that the adoption of the sciences by mechanics' institutes was an attempt to naturalise the status quo: 'the world of workers' science was a world of facts and laws [not provisional theories]' (1977: 50). But other subjects also came forward towards the 1840s. The article 'On the cultivation of taste in the operative classes' in *The Art-Journal* of 1849, whilst praising the schools for mechanics in Edinburgh and Glasgow, managed to frame their achievements in the most alarming terms:

> but when we ascend a little higher in the scale of society, and examine the condition of the children of a class superior to those who take advantage of public or private bounty, the provision [is worse than in any other civilised country]. Nothing could be more dangerous to society than for the middle classes to find their position periled and their social relations dislocated by the upheaving of intellectual pauperism from underneath... To confer on the lower classes the knowledge which Lord Bacon rightly identifies with power, and to leave the classes immediately above them in a deplorable state of weakness... is to prepare an assured way for a revolutionary pressure of class upon class... Communism and Red republicanism... are nothing more than educated distress struggling upwards against what it... regards as unenlightened oppression. (*The Art-Journal* 1849 IX: 3)

In the year after the revolutions of 1848, the study of literature in particular was far too inflammatory, warned the *Art-Journal*, but luckily there was one important antidote to this wilful courting of danger. According to this article, the visual arts, and the exercise of drawing skills, had the unique functions of calming, not inflaming, the pretensions of the mob. Art, it was claimed, soothes everyone, and it also has an economic function, as it is ineffective ‘to train designers without training buyers’. Furthermore, the cultivation of taste will strengthen man’s individuality, and this would make the artisan contented in his work. The writer concluded, ‘we do not venture to hope that any artistic education can completely refute the dangerous but tempting fallacies of Communism and Socialism: but we are convinced that the development of taste has great conservative efficacy in resisting these pernicious doctrines’. (*The Art-Journal* 1849 IX: 3) Hence, unlike the more problematic aspects of education, the unique skill of the draughtsman, drawing, was welcomed for its contribution to evolving discourses of taste and the associated virtues of respectability at this period. Just as Robert Peel and other early supporters of the National Gallery in the 1830s wished to soften the effects of the Reform Act’s ‘political excitement’ through viewing fine art (Trodd 1994: 33) so the practice of drawing might also continue to work against the rebellious ‘upheaving of intellectual pauperism’.

But artistic subjects on the curriculum of the mechanics’ institutes were attacked in turn, as a lure that might attract the wrong kind of poor person. In his encyclopaedic survey of mechanics’ institutes across Britain in 1851, J.W. Hudson berated the annoyingly jumped up small clerks and shopkeepers who were in his opinion swamping the institutions. He poured scorn on the constituency of the London Mechanics’ Institution especially after 1830: ‘each quarterly meeting was rendered notorious for undignified scenes of boyish boisterousness and disorderly debate: the attorney’s clerk out-talked and ultimately, out-voted the working mechanic’. He noted how the ‘shopkeeper' passed himself off as a 'worker of fabric' (1851: 52) and that lectures on serious scientific topics had been cut short and replaced by subjects such as 'light literature, criticism, music and drama' (1851: 57). Nevertheless, he conceded that students were serious enough to continue signing up for evening classes in architectural, geometrical and mechanical drawing (1851: 58).

These conflicts over education clearly relate to the status of draughtsmen in the first half of the nineteenth century. If draughtsmen learned to draw in mechanics' institutes, according to Shapin and Barnes (1977) the perception that any scientific or technical knowledge they had had access to would have been formulaic at best would reinforce their low social status. The two disciplines that most closely inform technical drawing—natural philosophy and artistic training of hand and eye—were the two subjects that had been deemed most suitable to quieten political protest. Together this could make draughtsmen appear as uncritical stooges of the system. Equally, the fluidity of drawing in relation to specialised disciplinary training—as we have seen in previous sections drawing education and practice straddled both artistic and technical applications—had the ability to prick both professional and class sensibilities. Skilled artisans or self-made entrepreneurs were perhaps acceptable and respectable additions to the social order, but disorderly and boisterous members of the lower middle classes with artistic pretensions may have been much more distasteful creatures, stirring up unwanted recognition of the discomforts and complexities of class and professional aspiration.

Mechanics' institutes: developing visual and manual skill for self-advancement

The mechanics' institute movement began in the 1820s, and as noted was an amalgamation of disparate radical, reformist and self-help movements that aimed to give working people access to knowledge and dominant modes of culture previously closed to them (Inkster 1985). As such, the institutes were, and remain, the focus of moral and political debate. Hence even the most apparently straightforward nineteenth century descriptive histories such as those of Hudson (1851), Brougham (1825), or Dupin (1825; 1827) promote their viewpoints, just as much as the more overt critiques from recent writers. Most hostile commentators agree broadly with Maxine Berg that the movement was a kind of conspiracy by 'middle-class ideologues' wishing to promote the introduction of machinery and mass production as an expression of the doctrines of political economy (Berg 1980: 146). In reaction to such single-minded readings of the mechanics' institutes, Russell (1983: 173) has pointed instead to local expressions of patriotism, based in non-establishment radical and dissenting traditions as a motive, whilst Ian Inkster argues that critical attacks pay no attention to the experiences of the recipients of this education, by only analysing the 'proponent' point of view (Inkster1985: 6). Instead he suggested that the interpretation of function should be broken down into points-of-view; so whereas privileged reformers and entrepreneurs might have intended social control over local labour forces, the recipients aimed to improve their knowledge and get social advancement. By different methods, using an analysis of building design and function, Markus has noted that purpose-built Mechanics' Institutes were modelled on genteel and elite models of philosophical societies and academies in their layout and functions. The spaces of libraries and lecture theatres, for example at Liverpool Mechanics' Institution (constructed in 1835-7), did however differ from previous models in not including segregating functions (by class or gender) into their design (Markus 1993: 240-4). As such, interpretation of their controlling function is ambiguous, as the spaces alone can be seen either as the uncritical adoption of existing hierarchy or as an appropriation and challenge to the structures of power.

The beginnings of the movement are usually attributed to key locations such as the foundation of Anderson's Institution in Glasgow in 1796, Glasgow Mechanics' Institution in 1823, the Edinburgh School of Arts in 1821, and the London Mechanics' Institution in 1824. Some sources also include initiatives in Birmingham such as the Artisans' Library of 1795 and the Brotherly Society of 1796 (Tylecote 1957: 3-4; Hudson 1851: 29-31). Glasgow Mechanics' Institution in particular received a lot of attention from industrial tourists on the trail of James Watt or Robert Owen, with Charles Dupin (1784-1873) promoter of worker education in France, for example adding lustre to his own narrative of a journey through Britain in 1817 by noting his meeting with the illustrious Watt in Glasgow (Dupin 1825: 224; Bradley and Perrin 1991: 47-68; see also Chapter 4 where Dupin's writing on practical geometry for artisans was introduced). On a later visit to Glasgow, prompted by his host Andrew Ure of Anderson's Institution, (Dupin 1825: 236) Dupin had admired the number of Sunday Schools, free schools and paid schools in the city, claiming that the sheer volume of education for workers and children explained the 'progress of the art and industry in the town of Glasgow', as it resulted in 'sagacious workmen, judging rationally [and] making improvements due to reasoning' (Dupin 1825: 237). Although Glasgow and Edinburgh were not unique as locations for mechanics' institutes, these two sites attracted attention from observers, offering potentially useful sources for descriptions of the rationale and content of drawing education for artisans and industrial draughtsmen in the first half of the nineteenth century that can be placed against information about other known art schools and academies such as the later Glasgow Government School of Design (from 1845), and the Edinburgh Trustees' Academy as discussed in Chapter 3. Even though the style and direction of the many other mechanics' institutes across Britain had many local differences that make generalisations impossible (Tylecote 1957: 58-75), the range of sources associated with these two sites, taken together, suggest that mechanics' institutes did allow active self-education for would-be industrial draughtsmen.

In Glasgow, working class men attended classes at Anderson's Institution from 1796, founded as an independent college after the bequest of John Anderson (1726-96), who had been a professor at Glasgow University (the Anderson's Institution archives, now held by Strathclyde University, will be referred to using their catalogue code, Strathclyde OB). A 1799 inventory shows that the Institution had one room set up with equipment for teaching the mechanical arts. Specific models such as 'a Mule Jennie with 6 Spindles' were used alongside more abstract demonstrations, such as 'an oblate spheroid for the Whirling Table'. To teach geometrical drawing and millwork, the room had several intermediate objects that functioned as material aids to visualisation, such as 'a cone with sections and stand for it', a 'circular piece of wood for the cycloidal curve', alongside 'two parallelograms of wood, two cylinders of wood, two circular planes, a hexagon, a cone, a pyramid, a prism, two triangles, a double cone and a trapezium' (Strathclyde OB/10/11). The library catalogue of apparatus and furniture (OB/10/1/2) shows manuals on drawing that included: *Elements of geometry* (Scott 1782), *A treatise on geometry* (Gregory 1796), *A familiar introduction to the theory and practice of perspective* (Priestley 1770), *The art of drawing in perspective made easy; to those who have no previous knowledge of the mathematics* (Ferguson 1775), *An essay on the study and practice of architecture* (Laugier1756), and *Discourses to the Royal Academy* (Reynolds 1778).

Glasgow Mechanics' Institution was a direct (though rebellious) offshoot of Anderson's Institution in July 1823; these archives are also now held by Strathclyde University (Strathclyde OC). The committee of the new Mechanics' Institution first met at Mr. Warren's Academy (a drawing school). It is clear there was interest in running drawing classes at this date but less indication that they actually happened, as the minute book gives a patchy record of events up to the mid-1830s (Strathclyde minute book OC/1/1), although notes of confusion and personality clashes remain: for example, Mr. Warren offered to give lectures on mechanical and architectural drawing (OC/1/1 1 December 1823) but due to some unspecified 'unfortunate mistake' of communication, he resigned and withdrew completely from any involvement with the Institution not long afterwards (15 May 1824). The presence of Joseph Swan (1796-1872) of Glasgow's Trongate, another artist, engraver and printer on the Committee from 1826 (OC/1/1) suggests that there was probably a continuing interest in education in mechanical drawing in the Institution. Swan engraved many illustrations for the *Glasgow mechanics' magazine*, launched in 1824, designed and engraved banknotes for Scottish banks in the 1830s, and produced a series of teaching manuals and copy books (Hunnisett 1980: 128; Fairfull-Smith 1996: 81-92). Sadly the Mechanics' institution minutes in the first decade give few further details, apart from the fact that the whole teaching programme appeared to be a continuing anxiety to the committee: 'lectureships are sought by well educated young men, chiefly to acquire some distinction, and to help them to an appointment of more emolument' [and as soon as they succeeded in this, they left the Institution] (Strathclyde minute book OC/1/1 10 May 1833).

It is only later in the 1830s that a more detailed discussion of the curriculum emerges, when we see that the 'most sustained classes' up to that date have been in natural philosophy and chemistry, anatomy, physiology, moral science, political economy and phrenology and that the committee was now wishing to establish 'new classes' in mathematics, algebra and architectural drawing. By the 11th annual report (6 May 1834), a class in mechanical and architectural drawing was in progress with 46 students, and the institution afterwards began to enter into correspondence with other institutions about exhibitions (Strathclyde letter file incoming OC/11/1; *The Printing Machine* 19 April 1834: 213). For example, Manchester Mechanics' Institution sent a copy of their Christmas 1838 exhibition list which included apparatus, models, and carpentry, alongside sculpture, painting, drawing and engraving (OC/11/1/100). In April 1840 a prize was awarded to Adam Rankine for a drawing of a pair of Marine Engines (Strathclyde OC/11/1/155), and by July 1856 the management committee were busy hiring two separate drawing teachers in order to offer classes not only in mechanical and architectural drawing, but also in painting and perspective (Strathclyde letter file outgoing OC/ 12/ 2). So in terms of these bare notations of events, drawing classes in both mechanical and ornamental mode at the mechanics' institute expanded, even with the competition from the newly founded Government School of Design in Glasgow from 1845, now Glasgow School of Art (Fairfull-Smith 1999: 9-16; Rawson 1999: 18-25) noted later in this section.

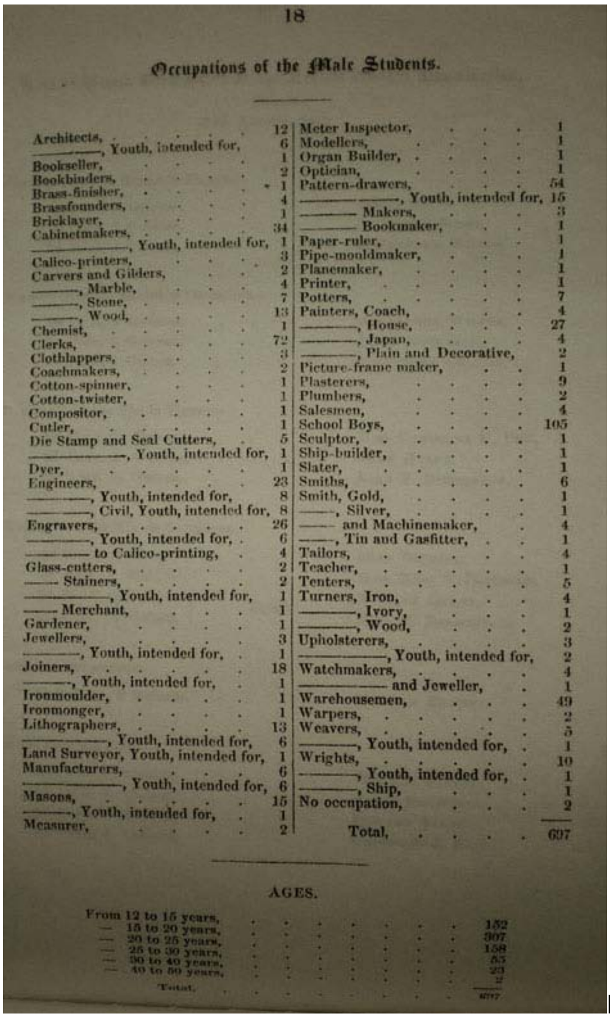
In Edinburgh, the School of Arts began as a riposte to the Edinburgh Trustees' Academy, for although the Trustees' Academy had been intended for pupils engaged in trade, by the 1820s its teaching curriculum had moved much closer to the fine art academic model, with life classes and copying from the collection of casts, thus continuing further in the direction outlined in Chapter 3 (Smailes 1991: 128-9; Irwin 1975: 92-6). The School of Arts, according to Hudson the 'the only establishment in Britain deserving the title of a "people's college"' (Hudson 1851: 75), was founded in 1821 with over 400 students enrolled in the first year (Edinburgh First report of the directors P56/14:15). The technical aims of the School can be seen in its initial lecture courses in chemistry, mechanics, architecture and farriery. The trades of the students suggest that this institution drew on a similar constituency to that of the Trustees' Academy: cabinetmakers, joiners, smiths, brassfounders, millwrights, masons, watch and clock makers, and opticians. Mechanical and architectural drawing classes were a permanent part of the curriculum from 1822 onwards (Edinburgh First report of the directors P56/14: 26), and according to Hudson this demand continued through to the mid-nineteenth century; out of an annual enrolment between 1840-50 of 600-700 students, 65 pupils a year on average took on drawing classes (Hudson 1851: 76-7). When the Rev. Dr. Brunton, Professor of Oriental Languages at Edinburgh University came to address the directors of the School of Arts in June1826 he chose to praise:

> Drawing, which some may regard as a mere embellishment. This is a great mistake. Drawing –such, at least, as is taught in the Institution, is immediately subservient to the other studies of the Pupils… But farther –drawing leads to professional usefulness. All must have had to regret the inability of an otherwise intelligent tradesman to give his employer a sketch of what words only imperfectly and obscurely describe… I should not regret it if even those parts of Drawing which are more strictly called an embellishment, were cultivated in the Institution; for they teach the Pupil to look with a more observant and intelligent eye on the objects of both nature and of art. (Edinburgh Fifth report of the directors P69/12: 5)

In addition to the support of the directors, and the existence of drawing classes, the library borrowing lists also demonstrate an interest in drawing practice with one sixth of loans, according to Woodall (1969: 24), being for books on architecture, drawing and painting.

The archives of these two institutes in Scotland confirm a similar level of demand for and participation in drawing education as reported for other mechanics' institutes in manufacturing towns in Lancashire and Yorkshire before 1851 (Tylecote 1957) and more widely across Britain (Hudson 1851; Inkster 1985). In his survey of adult education in 1851, Hudson claimed that unlike the drawing classes at the Government Schools of Design, which in his opinion were an expensive and futile experiment, those in the mechanics' institutes were local, effective, democratic and much better value for money: 'There is not an active partner or practical manager of any large engineering establishment in Manchester, Leeds, and Newcastle, who is not enabled to point out either in his own person, or in his best hands, the former students of the drawing classes of the Mechanics' Institution. These classes have indeed proved greater aids to manufacturing industry, than all the government schools united' (Hudson 1851: 208). Hudson, however, places too much emphasis on engineering alone. It was certainly true that artisans could get work as draughtsmen or chief foremen in engineering works after signing up for drawing classes at their local mechanics' institute (Tylecote 1957: 166), but decorative, architectural and fine art modes of drawing, were also pursued by artisans in order to get work in different local manufacturing industries. In terms of drawing activity, all sources appear to support Schmeichen's claim that artisans organised themselves and developed new drawing and design skills for industrial manufacture (Schmeichen 1995: 176-7).

In terms of constituency, the reports of Edinburgh School of Arts in the 1820s show a similar range of manual trades to those noted for example in Leeds in 1850 (Tylecote 1957: 75). Equally, in accord with Hudson's complaints about the invasion of clerks in London, mechanics' institutions such as that in Manchester reported that by the late 1830s, two-thirds of students were 'clerks in counting houses' (Tylecote 1957: 139). In 1847 the Government School of Design in Glasgow reported a range of students' trades and occupations that included some of the manual trades that Hudson might have approved of such as masons, along with decorative arts trades, print trades, engineers and architects; but equally the students included 49 warehousemen, 72 clerks and 105 unspecified 'schoolboys' (Figure 72).


18

Occupations of the Male Students.

Architects,	12	Meter Inspector,	1
——, Youth, intended for,	6	Modellers,	1
Bookseller,	1	Organ Builder,	1
Bookbinders,	2	Optician,	1
Brass-finisher,	1	Pattern-drawers,	54
Brassfounders,	4	——, Youth, intended for,	15
Bricklayer,	1	—— Makers,	3
Cabinetmakers,	34	—— Bookmaker,	1
——, Youth, intended for,	1	Paper-ruler,	1
Calico-printers,	3	Pipe-mouldmaker,	1
Carvers and Gilders,	2	Planemaker,	1
——, Marble,	4	Printer,	1
——, Stone,	7	Potters,	7
——, Wood,	13	Painters, Coach,	4
Chemist,	1	——, House,	27
Clerks,	72	——, Japan,	4
Clothlappers,	3	——, Plain and Decorative,	2
Coachmakers,	2	Picture-frame maker,	1
Cotton-spinner,	1	Plasterers,	9
Cotton-twister,	1	Plumbers,	2
Compositor,	1	Salesmen,	4
Cutler,	1	School Boys,	105
Die Stamp and Seal Cutters,	5	Sculptor,	1
——, Youth, intended for,	1	Ship-builder,	1
Dyer,	1	Slater,	1
Engineers,	23	Smiths,	6
——, Youth, intended for,	8	Smith, Gold,	1
——, Civil, Youth, intended for,	8	——, Silver,	1
Engravers,	26	—— and Machinemaker,	4
——, Youth, intended for,	6	——, Tin and Gasfitter,	1
—— to Calico-printing,	4	Tailors,	4
Glass-cutters,	2	Teacher,	1
—— Stainers,	2	Tenters,	5
——, Youth, intended for,	1	Turners, Iron,	4
—— Merchant,	1	——, Ivory,	1
Gardener,	1	——, Wood,	2
Jewellers,	3	Upholsterers,	3
——, Youth, intended for,	1	——, Youth, intended for,	2
Joiners,	18	Watchmakers,	4
——, Youth, intended for,	1	—— and Jeweller,	1
Ironmoulder,	1	Warehousemen,	49
Ironmonger,	1	Warpers,	2
Lithographers,	13	Weavers,	5
——, Youth, intended for,	6	——, Youth, intended for,	1
Land Surveyor, Youth, intended for,	1	Wrights,	10
Manufacturers,	6	——, Youth, intended for,	1
——, Youth, intended for,	6	——, Ship,	1
Masons,	15	No occupation,	2
——, Youth, intended for,	1		
Measurer,	2	Total,	697

AGES.

From 12 to 15 years,	152
— 15 to 20 years,	307
— 20 to 25 years,	158
— 25 to 30 years,	85
— 30 to 40 years,	23
— 40 to 50 years,	2
Total,	697

Figure 72: Glasgow Government School of Design Report 1847. Table of student occupations (men)

Extra statistics in later reports, such as in 1877, give occupations of the fathers of students that confirm the suggestion of the 1847 figures that the family background of about half the students included fathers who were described as merchants, manufacturers and engineers (Figure 73). In relation to draughtsmen's education, mechanics' institutes' archives and other related sources can only give a broad picture lacking in details, confirming that their students did study mechanical drawing; that this training could lead to work as draughtsmen or designers in industry; and that students largely came from a background of skilled manual work, manufacturing, trade, or commercial office work. This avenue of drawing education began in the 1820s before the establishment of the Government Schools of Design, and continued through to the 1850s and beyond. Classes at the Government Schools of Design often expanded the number of classes already available in one location, but despite claims made in connection with the Government Select Committee on Arts and Manufactures of 1835-6, they were not necessarily providing anything new.

Analysis of the Occupation of Students attending the School during the Years 1876-77.

Occupation.	1877.	1876.	Occupation.	1877.	1876.	Occupation.	1877.	1876.	Father's Occupation.	1877.	1876.
Accountants,	..	4	Governesses,	2	2	Salesmen,	15	9	Manufacturers,	12	8
Artists,	5	10	Ironmongers,	..	9	Sculptors,	7	..	Measurer,	..	1
Architects,	59	44	Joiners,	95	99	Slaters,	2	3	Merchants,	20	29
At School,	20	10	Lamplighter,	..	1	Students,	6	8	Painters,	3	9
Blacksmiths,	15	10	Lithographers,	8	2	Teachers,	21	18	Physicians,	3	..
Builders,	4	11	Marble Cutters,	2	2	Travellers,	2	1	Plumbers,	3	1
Cabinetmakers,	15	18	Masons,	50	68	Upholsterers,	6	7	Publishers,	4	..
Carvers,	20	9	Measurers,	14	12	Warehousemen,	17	15	Sculptor,	1	1
Chemists,	1	3	Merchants,	8	11				Shipowners,	4	..
Clerks,	91	90	Modellers,	..	8	FATHER'S OCCUPATION.			Shoemaker,	1	..
Clothlappers,	3	2	Office Boys,	5	3	Architect,	1	1	Teachers,	5	1
Coppersmiths,	..	4	Painters,	46	48	Artists,	1	2	Travellers,	..	2
Designers,	14	20	Pattern Drawers,	..	3	Builders,	1	2	Warehousemen,	4	5
Draughtsmen,	32	25	Photographers,	8	9	Clergymen,	5	4	Writer,	..	1
Dressmaker,	..	1	Photo. Colourists,	2	5	Clerks,	7	3			
Engineers,	116	134	Plasterers,	6	4	Engineers,	10	7		857	869
Engravers,	19	23	Plumbers,	3	..	Janitor,	..	1	No Occupation,	310	262
Gilders,	..	2	Printers,	3	..	Jeweller,	1	1			
Glass Stainers,	8	5	Pupil Teachers,	20	17	Manager,	1	1	Total,	1167	1131

Figure 73: Glasgow Government School of Design Report 1877. Table of student occupations (all students)

Although detailed information is sparse about the content of drawing classes in Mechanics' institutes, the claim by observers such as Hudson (1851: 208) that the former students from the drawing classes of the Mechanics' institutions might find work as an active business partner or 'practical manager' is at odds with the more pacifying notion that art might put a stop to the 'upheaving of intellectual pauperism' feared by the Art-Journal. The social background of students in the Mechanics' institutions and in the Edinburgh School of Arts appears similar to those of students in both the earlier Edinburgh Trustees' Academy and the later Glasgow Government School of Design; skilled trades and those engaged in business as small proprietors or clerks. In addition, the evidence of continuity and of active voluntary self-enrolment in Mechanics' institutes' classes for drawing from the late 1820s onwards challenges some of the assertions, made in the Government Select Committee on Arts and Manufactures of 1835-6, that artisans could not draw.

Attacking the 'debased styles' of artisan design: the Select Committee of 1835-6

As already noted, the House of Commons Select Committee on Arts and Manufactures 1835-6 looms large in many accounts of the politics of taste. It was set up to inquire into the 'arts and principles of design and their connexion with manufactures' tendentiously described as the 'best means of extending a knowledge of the arts and of the principles of design among the people (especially the manufacturing population) of the country' (Select Committee Report 1835: ii-iii). Following the general election after the Reform Act of 1832, it is claimed, new liberal MPs responded to the economic fears of their political allies, British manufacturers in rivalry with French exporters, by setting up the Select Committee of 1835-6, stuffed with witnesses who claimed that untutored British workmen and uneducated consumers were incapable of supporting anything beyond rudimentary and unappealing design (Bell 1963: Macdonald 1970: 67-

70; Rifkin 1988: 91-93). The proposed solution put forward was to promote 'the cultivation of taste in the operative classes' (as The Art-Journal put it) largely through teaching drawing skills. In a variation of this narrative, Mervyn Romans has argued that the cultivation of 'taste' was an offensive campaign designed not to wage economic war on the French but on the home population in order to 'give moral justification to consumerism, with art and design education harnessed as the vehicle for its implementation' (Romans 1998: 196). The outcome of the deliberations was the prompt establishment of the first Government School of Design in London in 1837 (Bell 1963; Bonython and Burton 2003: 103-7), the first of many more in towns and cities across Britain. If the Select Committee has thus become a standard landmark in many histories that relate to art and design education, its emphasis on the formation of taste and the development of trade also make it significant in histories of a 'consumer society' in nineteenth-century Britain, pointing towards that other milepost of display and manufacture, the Great Exhibition of 1851.

The most frequent refrain from witnesses and questioners alike during the Select Committee hearings was that the art of design, and the love of art, which should have been developed though education in drawing from the elementary level onwards, did not exist. By contrast, evidence was solicited in order to underline the fact that industrial rivals France or Germany already supported schools of design education for workers, often prompted through leading questions such as: 'Do you consider the English manufactures to be superior as far as regards the manufacture of the goods, but inferior in that portion of them which is connected with the arts?' (as posed to witness J.Morrison, Select Committee 20 July 1835: 20). A later witness, the engineer James Nasmyth, lamented: 'if the master mechanic has acquired a taste for the fine arts as applied to manufacturing purposes, it requires agents to bring such objects into existence. These agents are his workmen', but unfortunately, continued Nasmyth, there is so much disparity of training between the master and his men: 'in many cases the forms which he wishes his workman to adopt are not those produced' (Select Committee 8 March 1836: 29). In turn this opinion was carefully fielded by Nasmyth's questioner, who obligingly picked it up by elaborating a notion of industrial elegance couched in terms of 'abstractive' ornamental design that elide together the 'natural' connections between geometrical drawing and material shaping discussed in Chapter 4: 'Is it not a fact, that... beautiful forms are grounded in geometric proportion, and therefore adapted to the minds of mechanics whose machinery is connected with geometric proportion also?' (Select Committee 8 March 1836: 30).

As noted, many older histories of the Select Committee shared one common limitation in placing it as a point of origin; the stimulus for the beginning of art and design education for the working classes. Although this perception is misleading, both in relation to artisan self-education through drawing manuals or through classes at mechanics' institutes, this has often meant that the texts associated with the Select Committee, previously taken without comment, are now instead dismissed. While historians have paid attention to the choreography of intentions amongst the participants in the Select Committee (Bell 1963; Romans 1998), little attention has been given to what the Committee evidence might reveal about existing drawing practices amongst 'the manufacturing population'. Despite frequent claims that British workmen could not draw and had never been taught to do so, many recorded statements give examples of unwitting testimony to the contrary.

For example, the witness John Jobson Smith described a seething world of unofficial drawing activity amongst the ornamental ironfounders of Sheffield and its surrounding district, in which manufacturers constantly sought new ornaments and procured them either from self-taught designers or through getting draughtsmen to steal or copy new designs from others (27 July 1835: 11). Other witnesses connected to textile trades and industries also confirmed that every factory first had a constant demand for new designs, and second for pattern-drawers to translate designs from paper into a format suitable for specific textile processes, such as Jacquard weaving or printing from engraved rollers. This is shown in the evidence of Benjamin Spalding (31 July 1835: 23), Thomas Field Gibson (3 August 1835: 27-8), Robert Harrison (3 August 1835; 33), and Claude Guillotte (14 August 1835: 55-7). Witnesses and questioners frequently stated that workers could not draw when what was really meant was that they would not draw in an approved manner. This was clearly expressed in J.B. Papworth's attacks on the 'debased' style of Rococo 'grotesque scrollwork': 'designers and artists of very mediocre talents are preferred to better artists... little amenable to the criticism of the judicious, and the workmen are usually free from the trammels of artist-like education' (21 August 1835: 92). This final comment suggests that a continuing non-formal drawing culture amongst artisans and smaller manufacturers in the 1830s, with an attachment to the design procedures and Rococo embellishments and motifs of the late eighteenth century, still existed (see Chapter 3 for a discussion of these issues in artisans' use of drawing manuals). It also reminds us that insistent and elaborated surface decoration was an important aspect of designing for manufactures in the first half of the nineteenth century, despite Nasmyth's emphasis on 'primitive or elementary geometrical figures' for plotting machine actions (see also Chapter 4). But while the Government Select Committee of 1835-6 might have aimed to suppress the voices of artisans and tradesmen in favour of more powerful manufacturers, politicians and fine arts spokesmen, their viewpoints of what drawing was or should be, was contested on behalf of artisans through vehicles such as mechanics' magazines, where a far more diverse range of drawing activity relating to manufacture can be seen.

'Knowledge is power': mechanics' magazines and drawing to 'keep your mind active'

The *Mechanics' magazine* was founded in London in 1823. In contrast to the deliberately non-controversial policies of mechanics' institutes, the *Mechanics' magazine* when it started was a disputatious forum for debate, comment, and mockery, apart, that is, from the space devoted to a reverent worship of mechanical invention, in particular the steam engine, and Watt's improvement to it, that by this date had come to represent the 'quintessence of British ingenuity' (Macleod 2007: 91). The frontispiece of Volume 1 (Figure 74) proclaimed an allegiance to the scientific method with its aphorism 'Knowledge is power' derived from Francis Bacon (1561-1626). The columns flanking the figure of Mercury, carrier of intelligence, are engraved with the names of illustrious inventors and men of science. At the first rank come Watt and the Marquis of Worcester, as heroes of the history of steam power (Macleod 2007: 88-90), supported by the image at the foot of the page; a sublime landscape of sea and cliffs, each effortlessly dominated by engines under steam. Lower down the columns come names such as Newton, Smeaton, Priestley, and Stanhope, this latter celebrating Charles Mahon, third Earl of Stanhope, inventor of a metal frame printing press. The frontispiece to Volume 2 (also Figure 74) develops this homage to the Press and print trades. The tag at the foot of the page 'Whiting & Branston, printers and engravers to his majesty for the prevention of forgery' strikes a topical note of financial emergency. Whiting & Branston here display the two-colour process invented by Sir William Congreve (1772-1828) in 1818 as part of the anti-forgery campaign already discussed in Chapter 5 (Mosley 1978-9: 87). Hence the legend at the foot of the frontispiece to Volume 2 of the Mechanics' magazine literally underlines the significance of the apparently frivolous and fussy details of decoration, with its engraved vignettes and Rococo scrollwork, from the blue roundels to the pink background, covered in a fine tulle-like white reticulation, all announcing the work of the rose engine and the siderographic process. In the hands of capable mechanics, this page proclaims, ornamentation can be a weapon of national security. The cult of the press was also continued in the editorial features; if the *Glasgow mechanics' magazine* had praised the press as a 'powerful engine of improvement', the London *Mechanics' magazine* celebrated the eternal virtual existence of knowledge in print: 'the arts of the workshop [have been]... placed beyond the reach of vicissitude and decay. They cannot do else than go on improving' (Volume 6, 1 January 1827: iv). These opening images in *Mechanics' magazine* assert they will exhibit the 'property of skill' of artisans (Morus 1996: 403-417); in this case of the engravers, illustrators, inventors and printers already noted in Chapter 5. Indeed, the *Mechanics' magazine* was perhaps particularly suited to express this message, as many workers in the print trades: engravers, illustrators, writers, editors and printers, lived and worked in close association together in the Fleet Street area at this time, and frequently shared the radical politics that were expressed in the magazine (Fox 1988: 33-38).

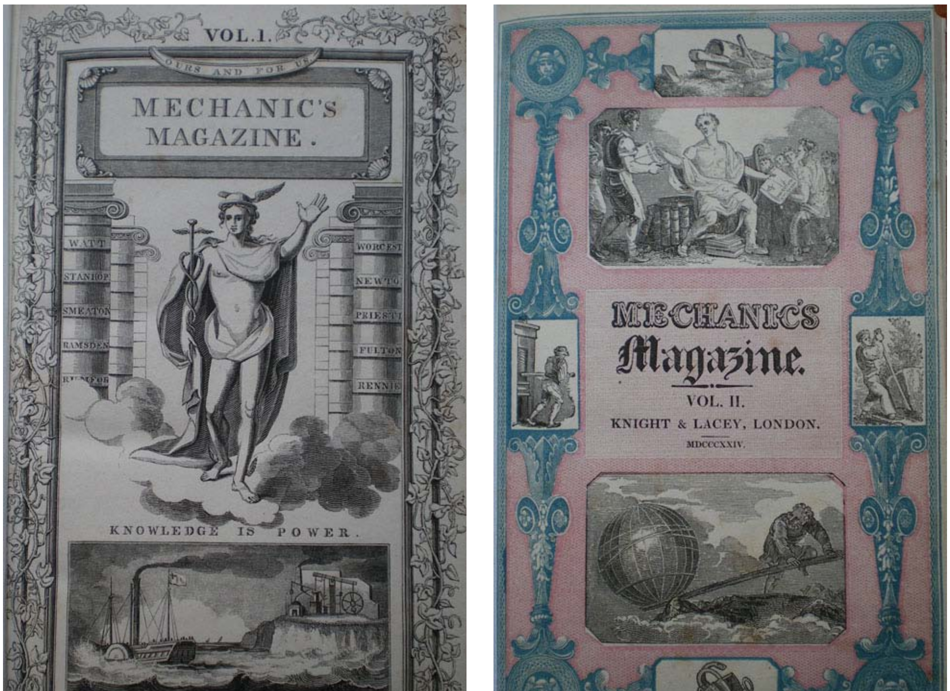


Figure 74: *Mechanic's magazine* title pages for Volumes 1 (*left*) and 2 (*right*)

Drawing skills and techniques were to the fore in this journal. For example the *Mechanics' magazine* was one of the first publications to announce and describe William Farish's technique of isometrical drawing beyond its Cambridge University milieu (10 April 1824: 66-7; see also Chapter 7). The magazine started a series of practical geometry lessons by T.S. Davies (on 23 October 1824: 70-75), and answered questions sent in by perplexed students, as for example when 'R' of Manchester wrote to ask how to draw the teeth of bevill wheels in perspective (6 November 1824: 105). Readers carried on a long correspondence, for example about drawing paper with the best qualities, and where it could be procured (1833: 191; 239; 262; 356), and professional draughtsmen also became regular contributors, for example with a description of a machine for drawing ellipses and spirals sent in by J. Murdoch, mechanical draughtsman of Mile End, London (26 September 1830: 65-7).

The January to July issues of 1827 saw a spirited and prolonged argument about correct methods of perspective constructions in drawing. Most of the nine contributions came from two main protagonists, masked in cryptic pseudonyms, apart from one moment when Christopher Davy, Teacher of Architecture and Perspective at the London Mechanics' Institute also waded in (1827: 168-9). A correspondent, 'Alpha Beta' had submitted an article and was being repeatedly taken to task by his anonymous critic, 'H.M.S.'. In defending himself, Alpha Beta did not spare his opponent, accusing him early on in the argument of 'quibbling and evasion' (1827: 147-8). 'H.M.S.' remained tenacious, continuing to press his complaints even after Davy had joined forces against him. This prompted Alpha Beta to swagger: 'I could not… suppress a smile at the exulting confidence with which he announces the "complete refutation" of [my] erroneous assertions…' (1827: 262). During this exchange, what had begun as a teaching mission became a forum where draughtsmen jousted in terms whose bumptious high spirits appear to chime with J.W. Hudson's scandalised description of 'undignified scenes of boyish boisterousness and disorderly debate' (Hudson 1851: 52). The editors' choice to run this dispute at length, and the somewhat minor dispute itself, show that the process of acquiring skill in geometrical drawing was, in this magazine, seen as an interchange between equals that could be playful and open-ended, rather than of applying a formula by rote.

More serious concerns about a draughtsman's role and status came forward in an article by C.G. Jarvis 'Practical hints on mechanical drawing' (16 February 1833: 334-5). Jarvis, who had been Joseph Clement's chief draughtsman, and was about to enter a contract with Charles Babbage to develop the Analytical Engine (Babbage 1864: 112-41; Schaffer 1994: 203-227; Woolrich 2002: 103-106), discreetly noted that his writing was based on his experience as an employee in a drawing office. He began neutrally enough with a discussion of technical questions about conventions and techniques, but then shifted to giving advice about how to deal with office politics, noting how draughtsmen soon became disheartened by a lack of praise or encouragement from employers. However, he counselled: ‘still I advise you to name any improvements [in machine design] which may occur to you; it will keep your mind active and prevent your sinking into the mere delineator of other men’s inventions’. At the same time, Jarvis allowed himself and his readers a smirk at the ‘want of taste’ betrayed by employers. He advised draughtsmen to avoid all controversy on this topic, even whilst noting gleefully in an aside: ‘I could point out a steam engine made by a man of some note’, that was blighted (in the writer’s opinion) by ‘a profusion of bright work and mouldings’. The crime noted here was not so much the ornamentation, but the redundancy of parts such as extra columns added simply to add to the beauty of the machine: ‘unfortunately there is nothing which these columns are required to support… as an apology for their being stuck where they are… he has placed an acorn-shaped piece of cast iron on top of each which he calls an *ornament*’ (16 February 1833: 335).

So for a full decade before 1835, the magazine commented on drawing, technique and taste, and provided a forum for draughtsmen and mechanics. But in the period 1835-6 while the Select Committee was in session there was a noticeable increase in coverage by the *Mechanics’ magazine* of these topics. Firstly, many sections of evidence of the Committee were printed in full; for example, the statements of the witness John Smith the ironfounder already noted (7 November 1835: 109-110). Angry correspondents to the *Mechanics’ magazine* attacked the inconsistencies and contradictions in the Select Committee Reports; their critical eyes support my own reading when they claimed that even while witnesses were lamenting the lack of drawing and design ability in the British population, it was only their unwillingness to give recognition to artisans and workmen that forced them to discount the evidence of their eyes (18 December 1836: 187-8; 31 December 1836: 242-5; 4 February 1837: 323-9).

Articles that commented on the aesthetics as well as the mechanics of design, already noted by Jarvis, increased in frequency in response to the Select Committee. For example, a review of a Royal Academy exhibition exclaimed: ‘utility is now required to be set off with splendour, who ever thought of looking for elegance in bridges over canals’, whilst admiring Brunel’s drawings for the Brent Viaduct at Hanwell: ‘the arches are truly gigantic; their form is stern and massive; the whole is of a colossal grandeur’ (27 May 1837: 116-9). Meanwhile, draughtsmen-inventors continued to send in short notices of improved mechanical aids for technical drawing, such as ‘J.C’ from

Manchester with his dotting pen (19 December 1840: 577-8), or an improved drawing square (14 November 1840: 474-5).

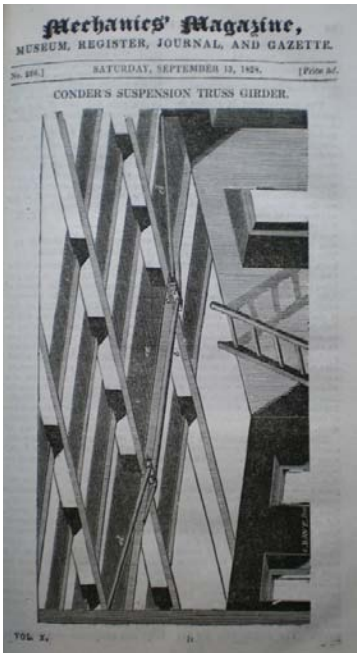


Figure 75: *Mechanic's magazine* title page Volume 10, 13 September 1828

In the 1840s, although discussions about drawing or draughtsmen became less frequent, images of newly designed items continued to appear. In this decade, any earlier aversion to 'profusion of bright work' evaporated. For example, and in contrast to the somewhat severe aesthetic seen in the frontispiece to an issue in Volume 10 (Figure 75) announcing an article by Christopher Davy (see above) on architectural structure (13 September 1828: 97-8), an article on Craig's patent rotary steam engine (Figure 76) gushed artlessly about the 'simplicity of working parts... and compactness' without any sense of the marked contrast of these qualities in relation to its strenuous surface ornamentation (20 March 1841: 225-8).

Figure 76: *Mechanic's magazine* title page Volume 34, 20 March 1841

In this period, the *Mechanics' magazine* also began to adopt a more measured, even neutral tone, in contrast to its new rival, the *Artizan*, launched in 1843. For example, in terms redolent of elite liberal reformers selling 'political economy' the editors accused the *Artizan* of the 'greatest crime... a contempt for education' manifested by its support for imagination, instead of 'training—discipline—learning'; 'greater harm to the working man—the artisan—no one can do, than to induce in him a belief that eminence is only to be attained by bold flights and happy fancies... the only sure path to fame is industry—hard persevering industry' (*Mechanics' magazine* 17 August 1844: 107-9).

According to its own editors, the *Artizan* was intended for an alliance of artists in the older sense of the word; that is, mechanical, chemical, and fine artists such as: 'carpenters, masons, engineers, plumbers, bakers, brewers, carvers, gilders, painters, modellers, etc.' (1844: 197; see also *New keywords* Bennett, Grossberg, Morris and Williams 2005: 6-8). The journal content was a mixture of diverse subjects, comprising contemporary fine art and architecture, mechanical arts and manufactures (with a stress on the latest inventions), educational articles (for example on practical geometry), and finally comic dramatic interludes. At this period, increases in the industrial manufacture of objects of decorative design were also offering other opportunities to workers with drawing skills (Schmeichen 2005: 168-9; Brett 1992: 2). In this labour market draughtsmen with 'bold flights and happy fancies' could have valued his skill as an end in itself, not as a route into becoming an engineer; and this particular notion of draughtsmanship comes across forcefully in the *Artizan*.

The journal was a lively read insofar as it adopted a robust and combative approach. For example, the first issue contained a scornful report on the Putney College for Civil Engineers (Marsden 2004: 415-7) for its allegedly foolish pedagogy based on scale models (described as 'Lilliputian tunnels'), an attack on Charles Holtzapffel's *Turning and mechanical manipulation* (1843) for its 'heavy and clumsy writing' (*Artizan* 1844:17), before turning aggressively on W. Cooke Taylor, the author of *Hand Book of Silk, Cotton and Woollen Manufacturers* (1843), attacking Taylor for his defence of child labour and his assumption that there is 'no possible alternative between work and vagrancy' –unlike the *Artizan* which championed education for all children.

The mix of mechanical, chemical and fine art registers in this journal were placed in startling juxtaposition, where articles on the 'Morality of taste' (January 1844), 'Modern art in Germany' (1844: 221-2), the 'Construction of sewers' (1846: 29) or of 'Staircases in octagonal towers' (1846: 26) followed one another in rapid succession. Throughout, the editors insisted on the unity of fine arts and mechanical arts embodied in the persons of their imaginary readers: 'It is with the *artizans* that art has ever originated: it was born in the workshops of Athens, and resuscitated in the workshops of Italy… it will be in the workshop, we are confident, where the revival [of art] will take place' (1844: 81). The specific material forms of this heralded revival were also discussed in an article 'The march of art' later in 1844: 'Ancient Greece had her temples, and Italy in the middle age her churches… we have no such outlets for the productions of genius, while persons of moderate means cannot purchase them… By extending design to manufactures, however, the cost of such design is spread over a large surface' (1844: 218).

When the *Artizan* championed the production of decorative art in the factory on the grounds that 'the cost of such design is spread over a large surface' (1844: 218) the reader could take this statement quite literally, and as a motive for developing drawing skills. Continued developments in the production methods for the decorative arts, noted in Chapter 3, meant that design was often conceived and executed purely as surface decoration, for example as applied to ceramic tiles, mural painting, wallpaper, *papier mâché* and electrotyping (1844: 218). In relation to the draughtsman's working life, this suggests that in the 1840s there was a real incentive to remain a 'mere adventurer in drawing'; such work, unlike the work of the engineer, began and ended on the surface, in two dimensions. In relation to drawing skills and artistic ambitions, the scope of the draughtsman's ambition indicated by this journal's 'march of art', although grandiose in scope, were not completely unrealistic. The open competitions in the early 1840s to propose decorations for the new Palace of Westminster were an aspirational embellishment to the journal through the inclusion of advertisements to tender designs for wood carvings or stained glass windows (1844: 148) that would take their place alongside the more prominent fine art frescoes, also open for competitive tender at this time (Treuherz 1993: 42-4; Willsdon 2000: 47). These decorations did not all depend on traditional hand craft skills as almost all the surfaces of the building and its fittings, both inside and outside, were covered in insistent patterning in neo-Gothic style; repeated units that had frequently been made by industrial techniques in wood, ceramic or stone (Brett 1992: 16), so that both the construction and decoration in building projects like this came to depend not so much on the exercise of traditional craft knowledge but on draughtsmen's plans for machine production (Brett 1992: 2). To critics such as Ruskin (see Chapter 4) contemporary neo-Gothic art was especially perverse as a standardised 'expression of wanton expenditure and vulgar mathematics' (Ruskin 1859: 41). To the tradesmen and small businessmen in the world enclosed in the *Artizan*, Schmeichen's cheery notion of 're-skilling' as a draughtsman or designer (1995: 167-77) is cast in a more distressing, ambiguous light, where drawing for a living might appear to be one way of defending and selling craft knowledge of material shaping in the context of industrial making.

The *Mechanics' magazine* and the *Artizan* were similar in content to many other self-help publications of more neutral tone of the period. Almost all journals aimed at workers carried articles that aimed to teach drawing skills, alongside the 'inculcation of an industrial vision' (Denis 1995: 36-39). For example, *The practical mechanic and engineers' magazine* published from 1841 onwards ran a series of illustrations of mechanical drawing with practical instructions (1844: 253; 268; 352 and 1846: 17; 129; 157; 205) alongside digests of articles from other sources aiming to give a progressive general introduction to subjects such as physics, chemistry, anatomy and linear perspective, alongside feature-type articles such as a description of Daguerre's diorama, (1841: 185) and uplifting biographies, for example the life of James Ferguson trumpeted as model 'miracle of self-instruction' (*The practical mechanic and engineers' magazine* 1841:135). The *Artizan*, whose approach indicates a much wider range of drawing conventions, from artistic to mechanical, that might have been of use to workers, is unusual in comparison to more uniform characterisations of useful drawing techniques, as geometrical and mechanical, that are found for example in other magazines or in the reports of drawing classes at mechanics' institutions. However, visual examples from the *Mechanics' magazine*, for example Craig's patent rotary steam engine shown in Figure 76, suggest that decorative ornamental drawing was also a part of draughtsmen's work, even in engineering firms. Overall, the content of the *Mechanics' magazine* from the beginning showed that several contributors called themselves 'draughtsmen' and wrote as if drawing was their trade or skill; the question of how those skills were put to use, in bravura or decorative forms of draughtsmanship, will be considered at the end of this chapter. The argument so far has suggested that skilled workers, tradesmen and craft workers did acquire technical and other more artistic forms of drawing skills through self-education, and that these skills did not enforce passive uniformity; but were rather part of an assertive or aspiring self-image.

Miracles of self-instruction: sketchbooks, draughtsmen and visual training

Engineers, draughtsmen and other trade apprentices were accustomed to keeping sketchbooks and notebooks during their training and later working lives. This practice was a long established element in craft traditions of learning on the job (Booker 1979: 29) forming a personal record of observations and analysis of techniques and structures. Sketchbooks also show draughtsmen's use of drawing conventions and how they chose to shape their own visual training through the selection and copying of examples. From around 1800, well-known examples of observational sketchbooks include the sketch-like visual diaries of Joshua Field (1787-1863) of his travels as an industrial tourist in the 1820s, reproduced in facsimile in the *Newcomen Society transactions* (Hall 1925-6: 1-41; Smith 1932-3: 20), or the more detailed 'exploded view' drawings of machinery observed by John Farey around 1805 and rendered in oblique linear perspective (Woolrich 1998: 51). This technique of representation, derived from the *Encyclopédie* of Diderot and d'Alembert (Baynes and Pugh 1981: 99) was according to Booker the most common style of drawing at the time, which he describes as 'craftsman level' pictures (Booker 1979: 128-30).

However, apart from sketchbooks based on observation and invention, draughtsman also directed their own visual education through more direct copying of pre-existing printed material. This type of sketchbook activity in engineers' training is not so well known, probably because it is not in accord with the notion of inventive design creativity. Two examples show particularly well how such copying was executed; the Manuscripts (1800) of William Creighton (1778-1831; later head of the Boulton & Watt drawing office from 1815; Birmingham City Council Library MS 117631 IIR 44: Figure 77) and William Weston's notebook from the archive of the Institution of Civil Engineers in London (ICE Accession number 1780 WESN *c.*1780-90).

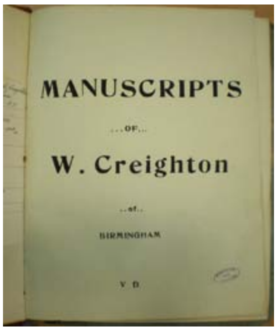


Figure 77: Manuscripts of William Creighton title page IIR 44 MS117631 Birmingham City Council archives and heritage service

William Creighton came to Boulton & Watt as an apprentice, first mentioned by name in the Drawings Day Book on 16 April 1793. After his apprenticeship ended in 1800, he entered into a five year agreement with the company as an agent and engineer on 12 July of that year (Birmingham City Council Library MS Boulton & Watt “Expired Articles of Agreement…”). As well as being an agent and engineer, Creighton worked in the drawing office when at Soho, and he later succeeded John Southern as head of that office in 1815. Creighton frequently puzzled or annoyed his employers and colleagues on account of his ‘bashfulness and diffidence’ (Birmingham City Council Library MS Parcel C/19, Lawson to Boulton Watt & Co., 18 October 1802), his ‘talent for destroying time’ and other ‘unlucky peculiarities’ (Box 33/3, Gregory Watt to James Watt Jr., 13 Sep. 1803). Even in 1822 when he was in charge of the Drawing office it was noted: ‘he seems almost incapable of directing his attention with effort to any one Subject. His demeanour yesterday in the Drawing office had much the character of frenzy’ (M. R. Boulton to James Watt Jr., 29 Nov. 1822).

In turn, Creighton had an unusual and often vitriolic sense of humour, and many of his letters and memoranda contain grotesque and profane sketches of the people and events that annoyed him (Tann 1998:47-58; Hunt and Jacob 2001: 491-521). With the less prickly side of his nature, Creighton kept up a detailed and intimate correspondence with a few friends, such as his brother Henry, a fellow agent and engineer at Boulton & Watt until Henry’s death in 1820, and he also maintained a lively friendship with James Watt’s son Gregory Watt around 1800 as evidenced by their letters that mixed up geologising and scientific or literary talk all heavily laced with a saucy ‘anal erotic fixation’ (Hunt and Jacob 2001: 494).

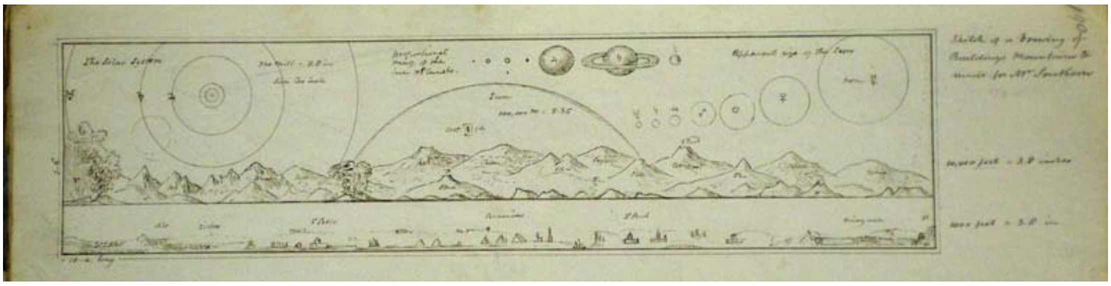


Figure 78: Manuscripts of William Creighton ‘Sketch of a Drawing of Buildings Mountains & made for Mr. Southern’

The Manuscripts of William Creighton of 1800 present over 700 drawings from the period of Creighton’s early self-education. They demonstrate Creighton’s self-education and self-presentation as a draughtsman, and tell us which visual sources he used and the styles he adopted as models of drawing practice. The collection tells us about technique; and it also suggests a novel concept of the reader in the context of training for a life in arts and manufactures. Figure 78 shows Creighton's 'Sketch of a drawing of buildings and mountains made for Mr. Southern' (Southern was the head of the Drawing Office at Boulton & Watt), presenting a graphic comparison of the heights of various structures, topped by Chimborazo in Peru, at that point renowned as the world's highest mountain (Birmingham City Council Library MS 117631 IIR 44). This very compressed sketch, with its dedication to a named 'patron' appears as a deliberately throwaway display of the range of Creighton's readings in architecture, geography, narratives of exploration, and astronomy. Figure 79 shows a copy Creighton made (*Birmingham City Council Library* MS 117631 IIR 44: 463) from *A treatise on civil architecture* by William Chambers (Figure 80), in accord with similar practices, noted in Chapter 2, of pupils in architecture offices who used Chambers as a 'key text' during their training (Worsley 1991: 4).

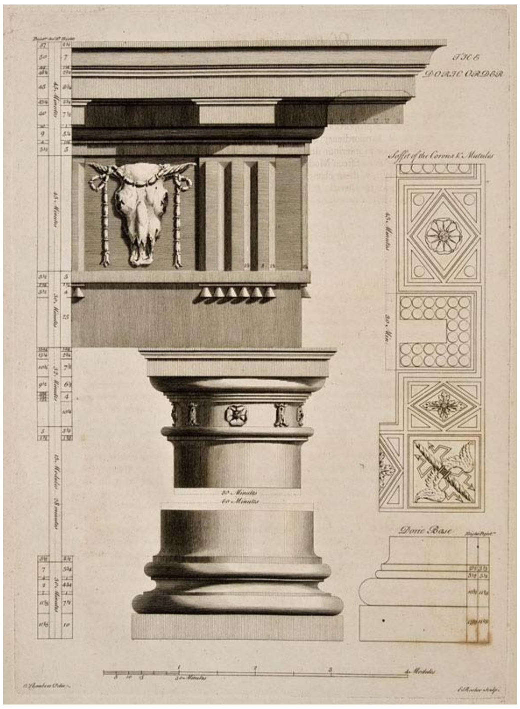


Figure 79 (above *left*): Manuscripts of William Creighton, p.463, pencil, ink and wash. Figure 80 (above *right*): William Chambers (1759) *A treatise on civil architecture* Plate 'The Doric Order' facing page 17, steel engraving

The exceptionally close copying technique shown in Figure 79 was not the enemy of creativity, however. For example the handling of the classical column in the sketchbook (Figure 81) abstracts this motif into a freestanding unit that was thus made available for transfer to later mechanical design drawings (see below, Figure 92).

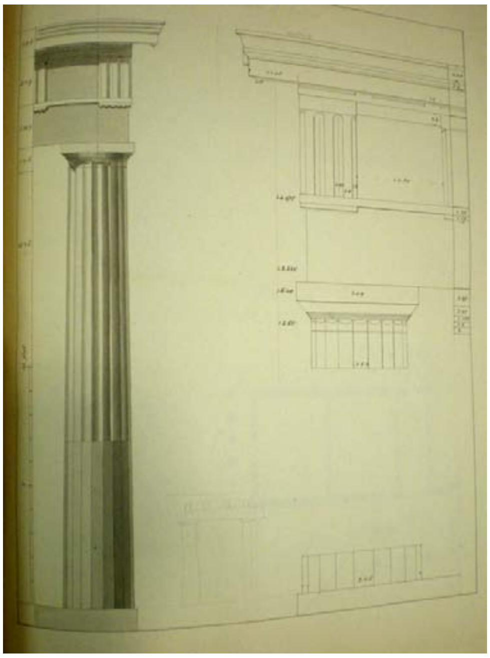


Figure 81: Manuscripts of William Creighton, p.369, pencil, ink and wash

In a move to various different idioms Creighton for example also copied images with picturesque subject matters and styles that he faithfully rendered in an ostensibly freehand manner (Figure 82). Despite the apparently open-air observational appearance of these sketches, the majority of images pasted across the double pages shown in Figure 82 are direct copies from printed sources. Creighton also copied cartographic prints minutely, for example maps of Leinster and Munster ‘copied from the *Political magazine* 1782’ (Birmingham City Council Library MS 117631 IIR 44: 96 not shown), or of the Campae phlaegri at Naples from Hamilton (Birmingham City Council Library MS 117631 IIR 44: 112 not shown).

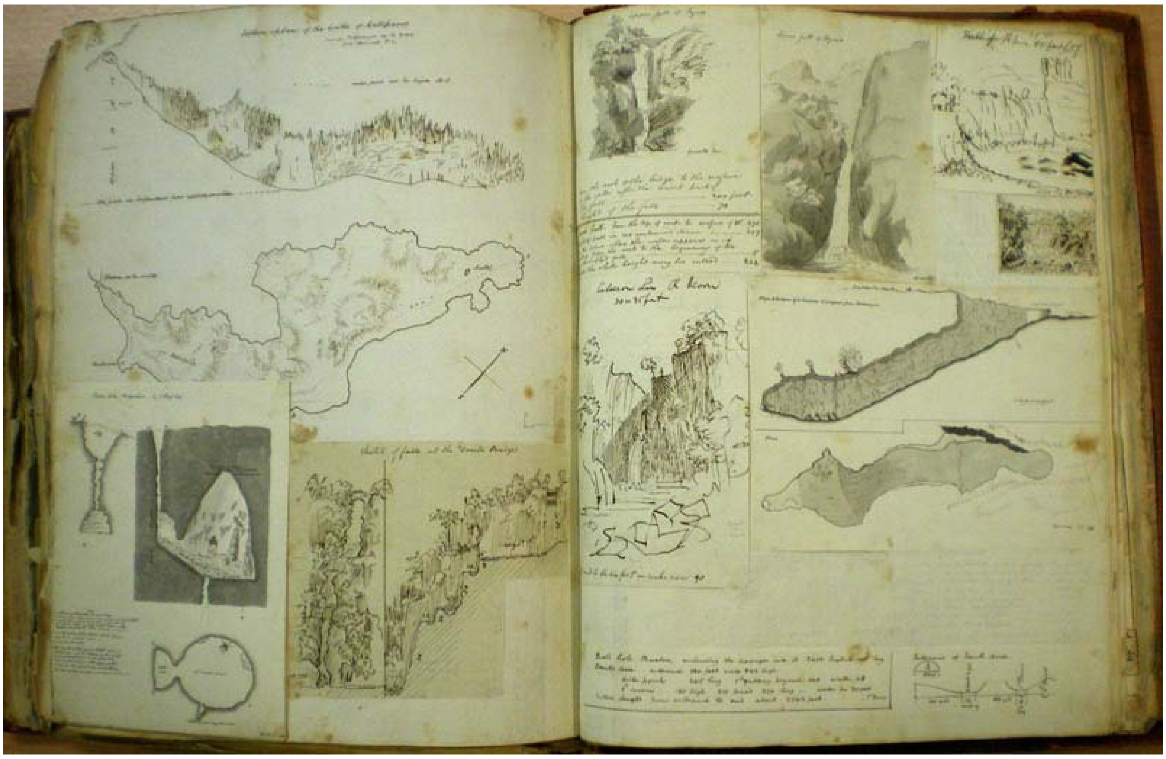


Figure 82: Manuscripts of William Creighton, pp. 656-7

Instead of being a passive and silent reader, Creighton's reading was more invasive. In making his own picture library of 700 drawings over ten years, Creighton assimilated his source material through re-making or inhabiting it at a level that the pale word 'copying' fails to conjure. The range of styles in this collection demonstrates that he taught himself to ventriloquize drawing conventions that were conventional to their subject matters, such as picturesque blottings for landscape, or severe line and graded washes for architecture. He absorbed the elements and motifs through repetitive copying so closely that they could then be recombined in a way that recalls the design strategies of artisans composing in the Rococo style, noted in Chapter 3. Although it might be argued that Creighton was a one-off, a character with known 'unlucky peculiarities', nevertheless he was not alone. Apart from the parallel of practices shared with architectural pupils, the example of William Weston's notebook from the archive of the Institution of Civil Engineers in London (ICE Accession number 1780 WESN *c.*1780-90) also demonstrates this method of drawing.

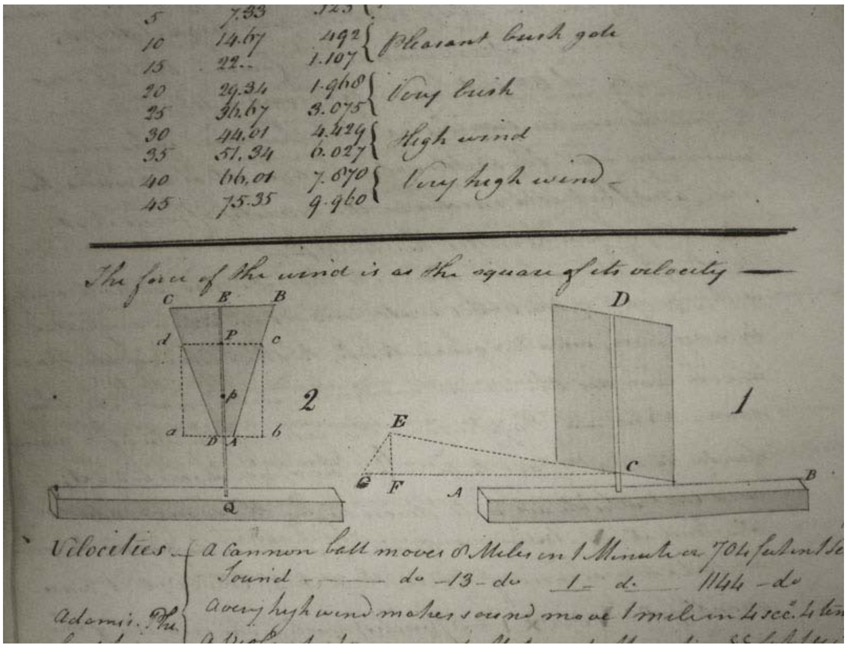


Figure 83: William Weston notebook c.1780-1790 Accession no. 1780 WESN ICE, London

William Weston (*c*.1763-1833) probably began his working life during the later stages of the construction of the Oxford Canal (constructed between 1769-1790), before working as Engineer and managing contractor for the design and construction of Trent Bridge at Gainsborough 1787-91. On emigrating to America, he became Engineer for the Schuykill and Susquehanna Navigation Company, Pennsylvania (Cross-Rudkin and Chrimes 2008). Weston's notebook, composed between about 1780 and 1790 was a personal compilation of topics in mathematical and natural philosophy copied direct and verbatim from his reading. Topics included mathematical and mechanical theorems, gravity, the properties of matter and materials, hydraulics, and navigation of rivers. The lines drawn by hand for the images in his notebook all mimic the appearance of the fine steel engravings from printed texts (Figures 83 and 84). Like Creighton's, Weston's manuscript book demonstrates by example the method of self-teaching in the language of visual conventions through making faithful copies from printed illustrations. These examples show that William MacGregor's account of the 'intellectual authority' first given to print mediums in the seventeenth century (MacGregor 1999: 391; 404-11) was still in evidence in the material practices of draughtsmen and their use of 'printed academies' (see also Chapter 3).

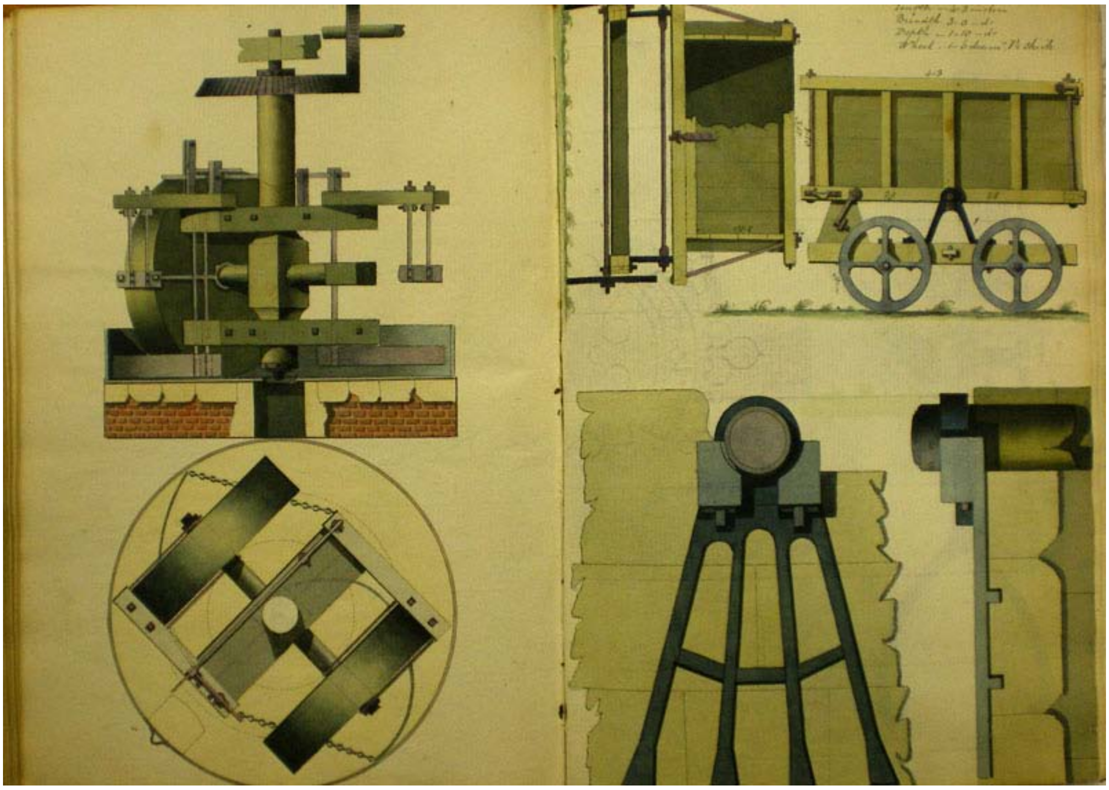


Figure 84: William Weston notebook c.1780-1790 Accession no. 1780 WESN ICE, London

Copying the drawing conventions of other artists and ordering them into categories can be understood as part of the ‘pursuit of self’ described by recent studies of the role of commonplace books in eighteenth century culture (Dacome 2004: 606). But these visual examples expand the notion of the conscious development of memory through inscriptions into an account that also recognises the role of physical bodily habits expressed through disciplines of repetitive mark-making. These examples of work demonstrate first that these techniques developed a facility to move between conventional styles in a distanced fashion, second that motifs mastered and abstracted in this way could be lifted and transferred to other contexts, and third that printed images may function as originals and models for future mark making techniques. Both sketchbooks also indicate the range of reading and of visual resources that men working as draughtsmen in the period *c*. 1790-1820 incorporated into their own personal training. To supplement these visual examples, I now turn to personal autobiographical accounts of drawing self-education from individual engineers.

Several engineers who started work around 1820 published or composed their memoirs towards the 1880s (Mitchell 1971 [1883]; Nasmyth 1883; *John Brunton’s book: memories of John Brunton, engineer 1812-1899* Clapham 1939; Fairbairn 1877). These narratives, although nostalgic, often contain fairly straightforward reports of the ways in which technical drawing skills were acquired in the workplace decades earlier, and the way that drawing training fitted into a wider sequence of training. Most narrators came from middle class or skilled artisan families where fathers could afford to pay for some education for their sons in line with the observations of Burnett, Vincent and Mayall (1984). In a bibliographic survey of working class autobiographies these authors have demonstrated that in this genre, despite the exhortations of liberal reformers, there were few stories of upward mobility due to the rigidities of nineteenth century social hierarchies (Burnett, Vincent and Mayall 1984: xvi). Nevertheless, with the considerable influence of Samuel Smiles and the cult of invention, engineers' autobiographies frequently came closest to the self-improvement genre, as seen for example in *Lives of the engineers* (Smiles 1861; Cookson 2002: 12; Macleod 2007: 257). Many writers emphasize drawing ability in their narratives, echoing the life story of James Ferguson, who attributed his later success to the support he gained through early demonstrations of this skill (Brewster 1805: x-xi). James Nasmyth, who had persuaded Smiles to act as editor of his *Autobiography*, attributed his first entry to engineering training and advancement in the firm of Henry Maudslay to this skill (Nasmyth 1883: 124). In the same manner Joseph Mitchell (1803-1883), the son of a mason, related how he had been educated at Inverness Academy for four years and then placed in an architect's drawing office for a year before being apprenticed himself around 1820 as a mason to the works for the Caledonian Canal (Mitchell 1971: 66-7). While working Mitchell continued his drawing lessons in the evenings with a carpenter who was also working on the same stretch of canal construction, until a lucky chance brought Mitchell's 'turn for drawing' to Telford's attention, who then set him the test of making a panoramic sketch of the whole of the west side of the canal from Inverness to Fort William. As a result, Mitchell became one of Telford's assistants in London (Mitchell 1971: 69). While this element of Mitchell's story undoubtedly echoes the hero's ordeal of popular tales it also shares many similarities with James Ferguson's life story (Brewster 1805: x-xi). For all these men, a demonstration of drawing skills signalled a significant milestone in self-education and self-presentation in their life stories.

John Brunton (1812-1899) the son of a manufacturer had a different trajectory. After school, he attended University College London, then worked in the drawing office at his father's works in London for two years, until he was given a free place as a pupil with the Cornish engineers, Harvey & Co. (Clapham 1939: 8-9) thanks to his father's connections. Brunton's training there began with work in the smith's shop, blowing the bellows, then advancing to becoming one of a team eight hammermen or ‘strikers’. On moving to the fitting shop, he worked on hand shaping of parts which included making a portion of steam gearing, working strictly to the drawing. After this he worked in the pattern shop, then the Foundry, making castings from patterns, and finally in the erecting shop where machines and engines were fitted together (Clapham 1939: 11-13). John Wigham Richardson (1837-1908) in the next generation also came from a similar comfortable middle-class background. After school he was sent to learn drawing for a year with a family connection, then apprenticed for three years in the workshops of an engineering business, starting in the pattern shop. After one year at University College London in 1856 (Richardson 1911: 71-87), Richardson gained his first professional post as a mechanical draughtsman at the Forth Banks Engine Works near Newcastle-upon-Tyne in 1857. According to Richardson, this drawing office was a ‘new world’ where the decent and reasonable companions he was used to were replaced by ‘an atmosphere of debauch from highest to lowest’ with drunkenness everywhere amongst workers, and in the drawing office ‘a continual chatter going on about amusements or sprees and much coarse practical joking, and just about as little work done as would pass muster’ (Richardson 1911: 105).

At Boulton & Watt in the 1820s, the role of ‘draughtsman’ was a pinnacle of achievement. Correspondence from Henry Wright between 1828-34 in the Boulton & Watt archive shows how after Wright was engaged as a clerk to the Drawing office (Birmingham City Council Library MS 3147/8/41, 21 August 1828) he began seeking promotion to draughtsman (25 May 1829). In 1830 he repeated this request with supporting details, noting that he had already worked in the engine counting house for seven years, followed by two years in the foundry (30 August 1830). Henry Wright gained his promotion and worked for the company until 1838. In this period he kept a visual record of work in a series of sketchbooks (Figure 85), using a ready-made item of stationery, Adcock’s Engineers’ Pocket Book (1829) that alongside the drawing pages carried short texts on engineering and science from authors such as the natural philosopher Thomas Young, educationalist George Birkbeck, and architectural educator Peter Nicholson, alongside printed tables of the strengths of materials. The drawings in this notebook present a record of projected works, using a linear diagrammatic annotation with added dimensions and comments. The example in Figure 85 shows the jostling internal configurations of one specific steam engine worked out across the page, with the fragment of a decorative classical column included as just one of the intractable physical objects to be brought into a working whole.

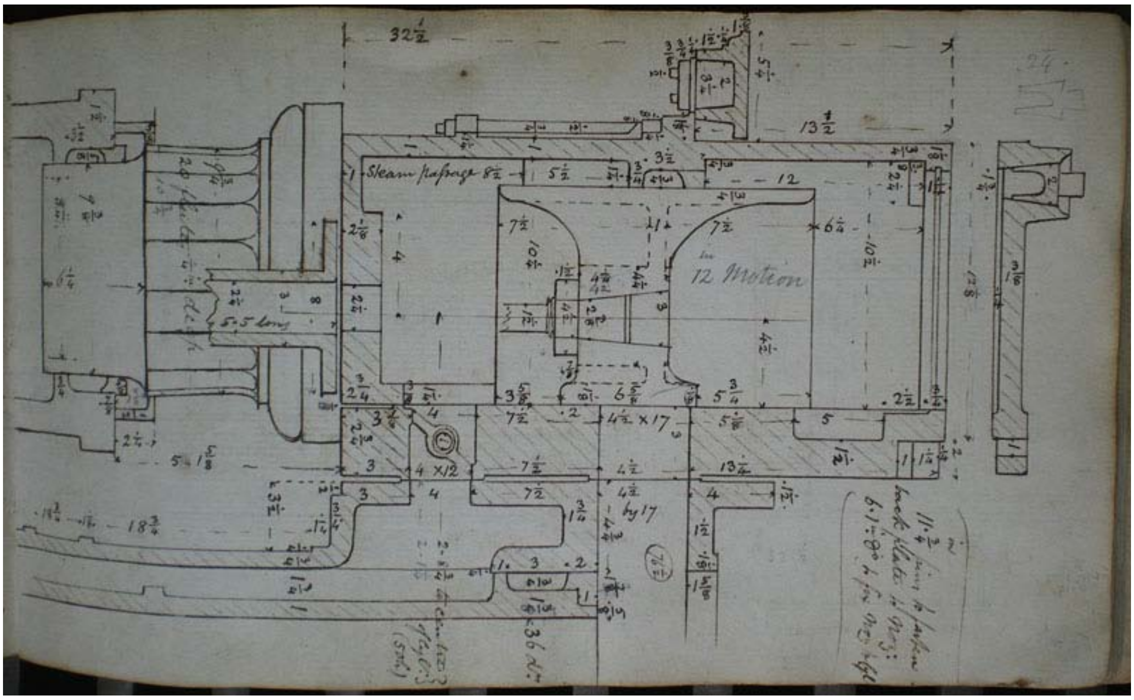


Figure 85: Henry Wright notebook 1833-5 IMechE IMS 231

The sketchbooks and memoirs considered in this section can only indicate a few details of personal practice that relate draughtsmen's training and working contexts in the first decades of the nineteenth century. Draughtsmen learned through self-directed learning, including observation, analysis and recording of machinery, but they also worked to acquire cultural capital through reading and through mastering the forms and motifs of polite visual culture. Most of the subjects of this section intended that their work as draughtsmen would be just one stage in a sequence leading to the further goal of becoming a professional engineer. However the establishment of drawing offices as a separate environment in larger engineering concerns in the first decades of the nineteenth century also formed 'draughtsmen' as a separate occupational group. In place of earlier, more certain pathways, John Wigham Richardson's account also implies that by the 1840s, for some draughtsmen, the drawing office, rather than the larger engineering concern, had become a self-contained working community.

'The straight line system': factory draughtsmen

Engineers such as Brunton, Wright, Mitchell or Richardson worked in drawing offices as a step in a career trajectory. However, the establishment of drawing offices as a separate environment in larger engineering concerns in the first decades of the nineteenth century also formed 'draughtsmen' as a separate occupational group. This environment formed a separate culture in which the final goal of becoming an engineer was less certain. Not all engineering companies employed draughtsmen, however. Metal working concerns such as tool makers, railway manufacturers, and other mechanical engineers separated design and drafting functions first (Smith and Whalley 1996: 43), but only if they were large enough. In Britain, most engineering firms remained as small family-owned businesses with weak occupational structures right through to the twentieth century; in such smaller firms, skilled artisan methods in the workshop, not reliant on direction from a central drawing office were most common because this method of working did not need high capital investment (Smith 1987: 83). There is a shortage of information in general about day-to-day working in engineering (Cookson 2002: 13), even before reaching down to the level of the drawing office. However, in association with other resources and contextual information, drawings from the Boulton & Watt and Nasmyth & Gaskell archives can be used to discuss the working practices and possible aspirations of draughtsmen who were not elite consulting, resident, or mechanical engineers.

In total, the Boulton & Watt archive has more material generated by the draughtsmen that followed James Watt, even though these drawings have not attracted the same level of attention. James Watt had produced all final drawings by himself until around 1782 (see also Chapter 2). At this point John Southern began work as his assistant (Hills 2005: 157-8), even though the ‘drawing office’ was still a room in Watt’s house, until a new office was established in the Soho manufactory in 1790 with Southern in charge. Watt kept records of projects in a drawings daybook; the same system of a diary of work in progress continued through when the separate drawing office opened. The daybook, which runs from October 1784 to 19 December 1842, records how the range of work being carried forward at one time expanded after Watt stepped back from drawing. The names of projects and customers were noted in this book but the draughtsmen’s names were recorded much more rarely (Birmingham City Council Library MS 3147/4/145). Figure 86 shows examples of the daybook that follow this pattern.

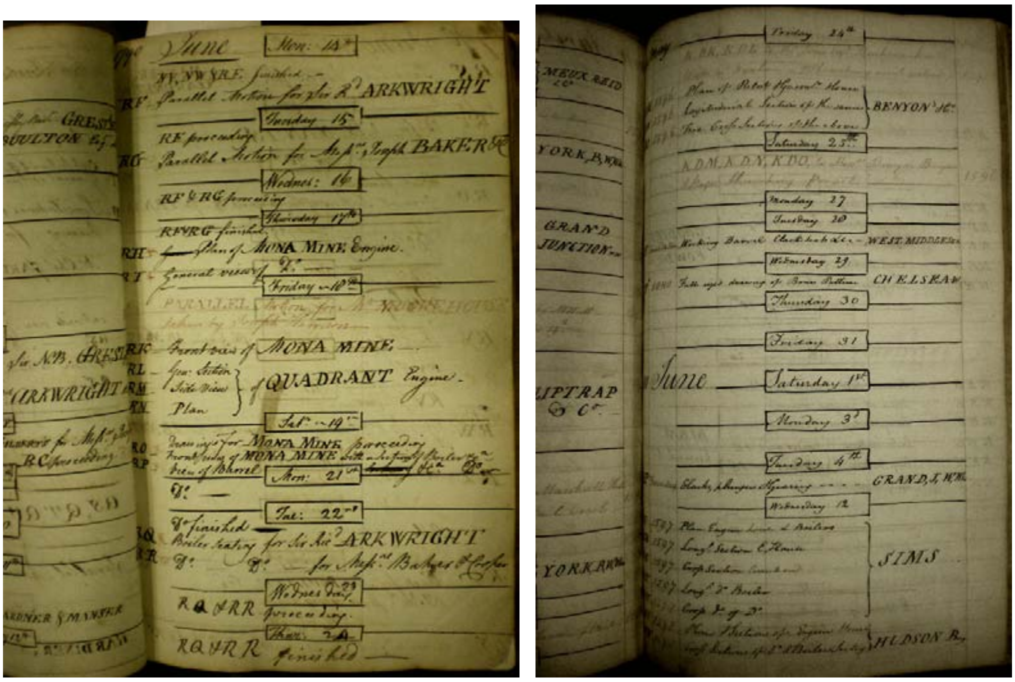


Figure 86: Boulton & Watt archive Drawings MS 3147/4/145 Drawings day Book 1784-1842 June 1790 example entry of 18th June: ''Front view of MONA MINE; General section, side view, plan of QUADRANT engine' (*left*) and May 1811example entry for 29th May: 'Full size drawing of brass pattern CHELSEA' (*right*) Birmingham City Council archives and heritage service

The opening of the new manufactory at Soho in 1795-6 is often held to signal a change in Boulton & Watt's business, when the company took direct control over making the parts for steam engines previously made and built under licence by others (Marsden 2002: 153-7). This made changes in drawing office work; detailed drawings of parts to be made on site meant that the number of drawings attached to the work expanded as well as developing a change in the amount of attention that draughtsmen gave to the objects they were designing. Even before 1796 this approach to manufacturing can be seen in drawings, for example in the detailed parts drawings made for Cockshead colliery in 1793 (Birmingham City Council Library MS 3146/5/246).

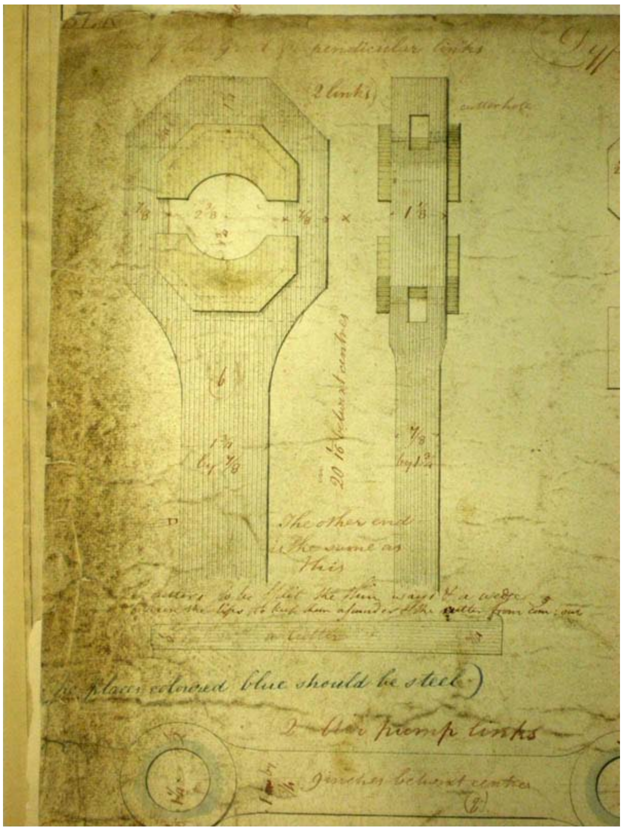


Figure 87: Boulton & Watt archive Drawings MS 3147/5/246 Cockshead colliery 10 June 1793 Birmingham City Council archives and heritage service

The drawing in Figure 87 specifies ‘parts will be made at Soho’; ‘the places coloured blue should be steel’ along with written dimensions, for example noting there should be twenty and one-sixteenth inches ‘betwixt centres’. Alongside these rare examples of detailed working drawings of parts, the Cockshead colliery drawings also contain overall views of the machinery workings, in full presentation mode, with fine pen lining and transparent watercolour washes to create naturalistic effects of light falling onto the metal machine parts in Figure 88 (see also Figure 4, Chapter 1). Alongside this increase in the volume of design drawing for contracts, and the increased variation in style and technique, the draughtsmen themselves have become more anonymous, hidden behind the name of the company and the specific project both in the daybook records and in the archived drawings.

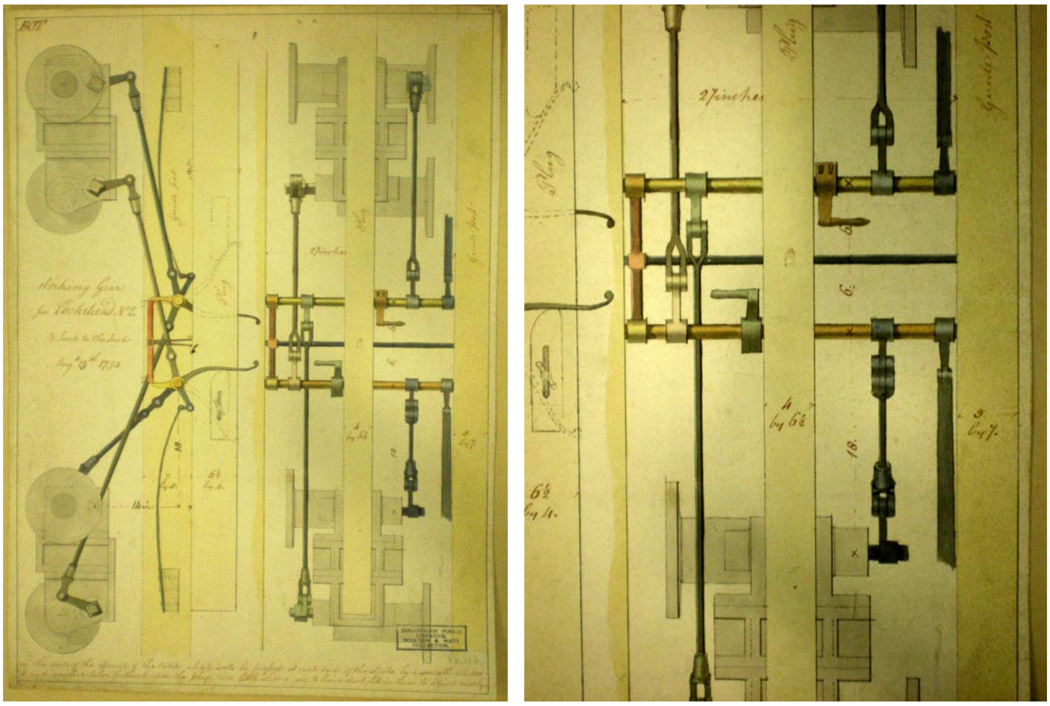


Figure 88: Boulton & Watt archive Drawings MS 3147/5/246 Cockshead colliery 13 August 1793 Birmingham City Council archives and heritage service

There were variations in levels of attention demanded of the draughtsmen, depending on the project. The 'City of Edinburgh' steam packet (1819-1834) in Figure 89 had more generalised drawings, with details left to the contractors on site (Birmingham City Council Library MS 3147/5/1123).

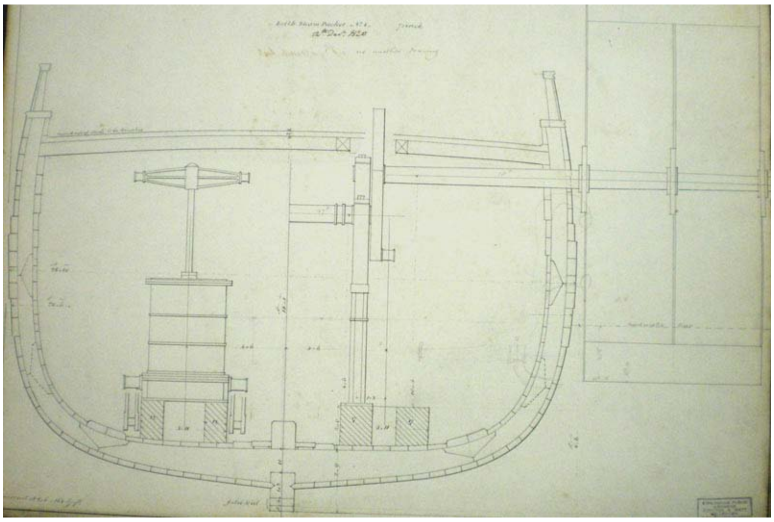


Figure 89: Boulton & Watt archive Drawings MS 3147/5/1123 *City of Edinburgh* Steam packet no. 1 (1819-1834) Birmingham City Council archives and heritage service

By contrast, the drawings for 'El Rapido' steamer for Seville (1841-57) in Figure 90 were much more detailed in their working out and specifications of sizes and materials.

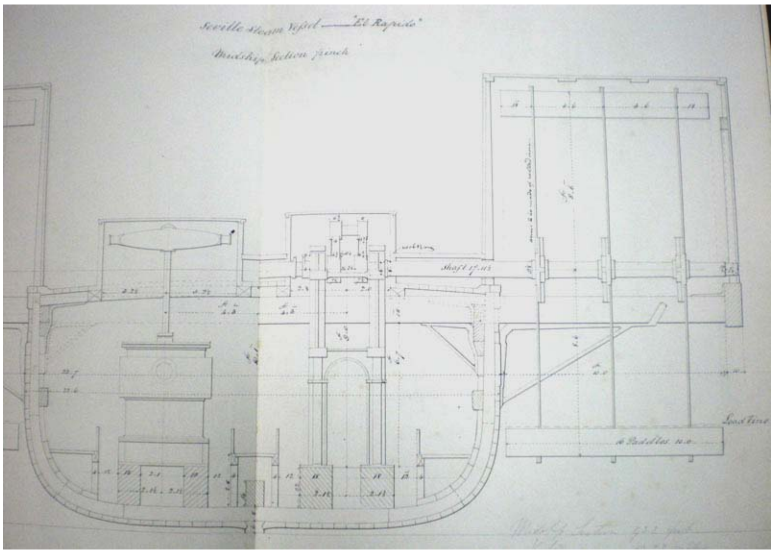


Figure 90: Boulton & Watt archive Drawings MS 3147/5/1187 J.W. Lubbock & Co. Seville Steamer *El Rapido* (1841-1854) Birmingham City Council archives and heritage service

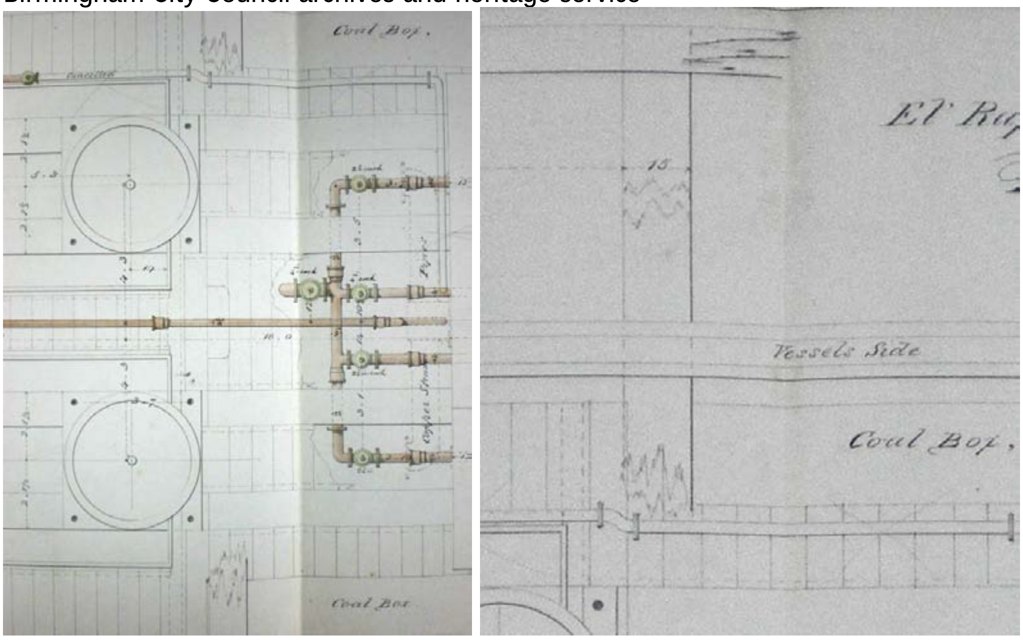


Figure 91: Boulton & Watt archive Drawings MS 3147/5/1187 J.W. Lubbock & Co. Seville Steamer *El Rapido* (1841-1854) Birmingham City Council archives and heritage service (detail on left, enlarged detail on right)

The drawing in Figure 91 shows both wooden and metal parts, where in this phase of the drawing work, the draughtsman has apparently seized the chance to embellish his drawing by exploiting the convention that incomplete forms are denoted by irregular edges. In carrying out his task the draughtsman adds decorative and expressive elements through his enthusiastic rendering of the splintered ends of wood to denote incomplete form, different from those of the metal forms in the same drawing (Birmingham City Council Library MS 3147/5/1187).

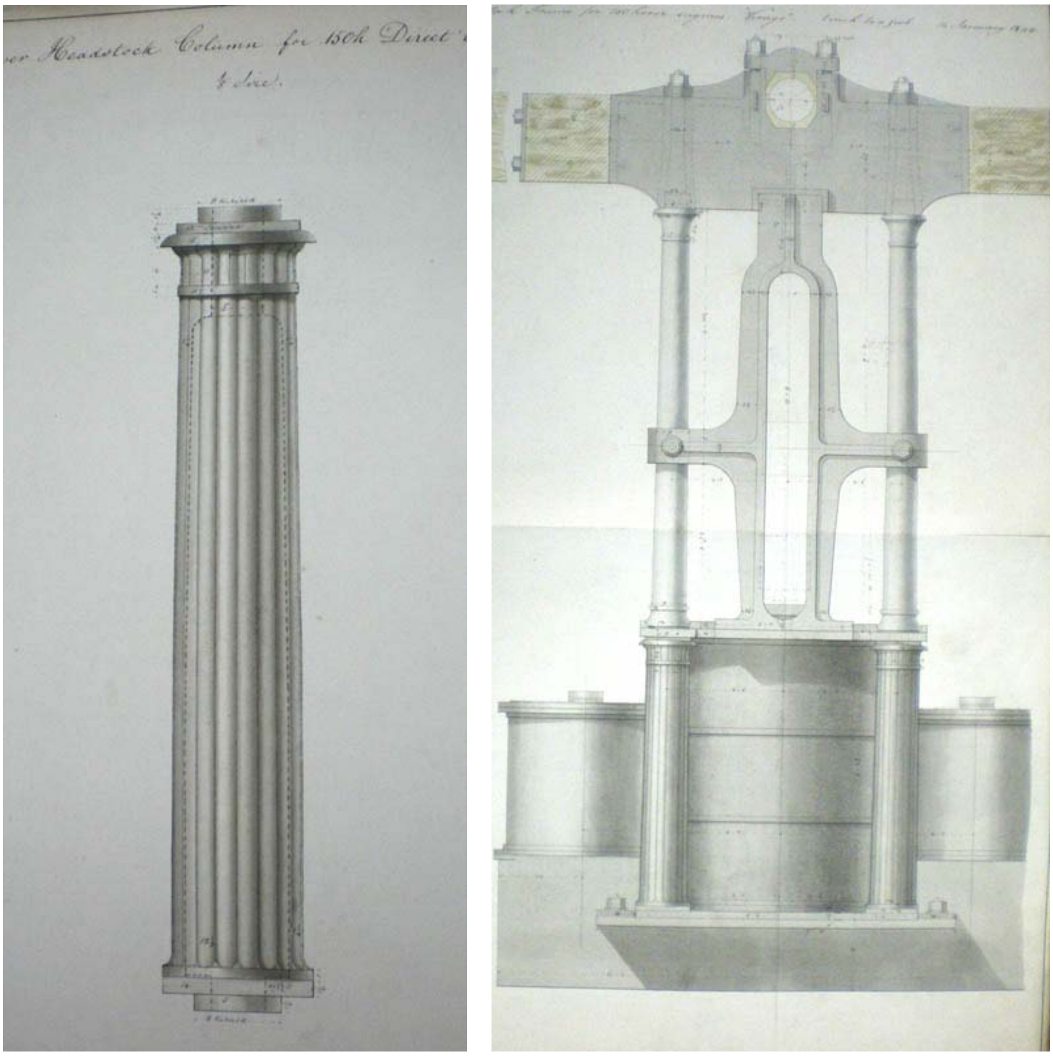


Figure 92: Boulton & Watt archive Drawings MS 3147/5/1230 HMS Steamship vessel Virago 1841 Lower headstock column (*left*) and View of headstock frame (*right*) Birmingham City Council archives and heritage service

The desire to display ornamental and expressive additions to technical drawings that can be seen in the 'El Rapido' drawings also appears in the highly finished drawings used for prestigious naval contracts such as in the drawings for the 'Virago' of 1841 (Birmingham City Council Library MS 3147/5/1230). Classical details, rendered naturalistically in pen and wash were worked out and inserted into functional machinery such as the headstock frame (Figure 92). This demonstrates how non-technical visual resources that draughtsmen like Creighton used to train themselves entered technical design vocabularies for later use (see also Figure 79 this chapter, and discussion), although it would require further research to discover who got to choose which drawing elements were used; whether it was up to individual draughtsmen and the chance selections of their self-training, or whether it came from clients or company directors. Certainly, the suite of approximately seventy 'Virago' drawings gives a strong visual display of draughtsman virtuosity by running through a range of registers and skills from the classical, architectural mode of the headstock drawings, to the almost ‘mechano-biomorphic’ forms of the scheme for disengaging apparatus and eccentric gear (Figure 93), that suggest an element of free play by the draughtsmen involved.

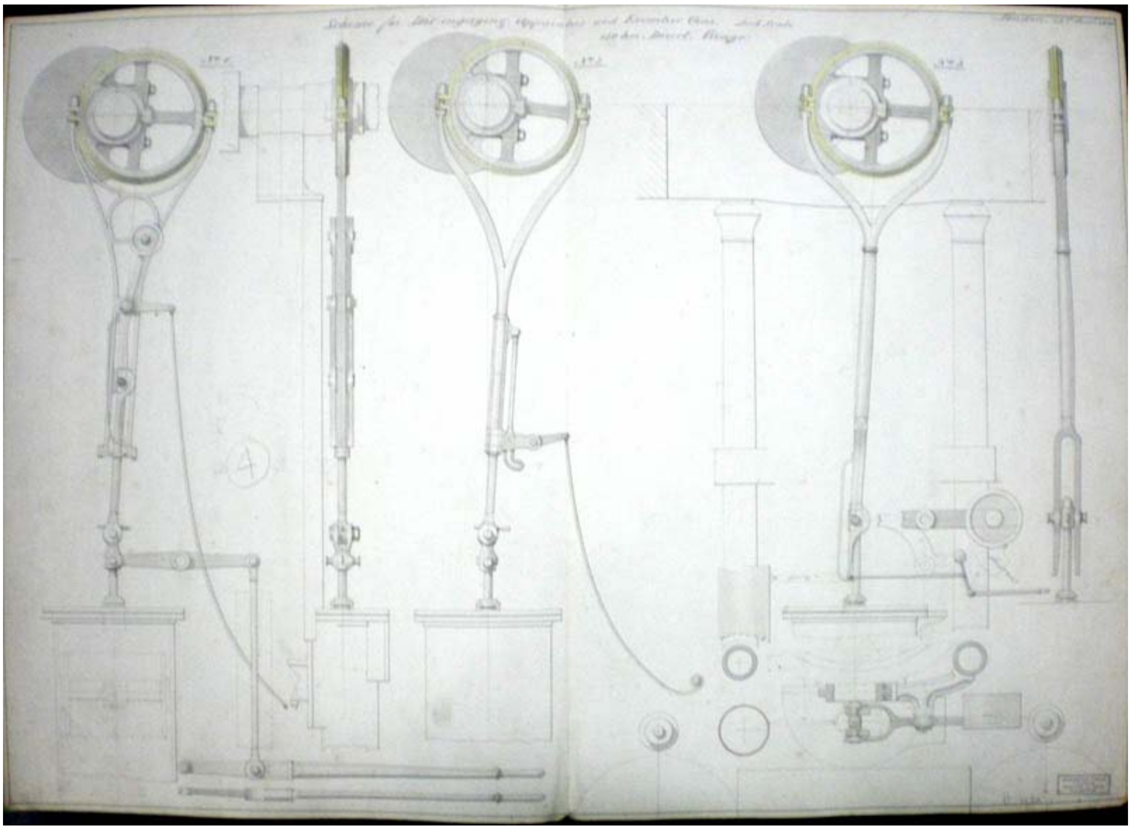


Figure 93: Boulton & Watt archive Drawings MS 3147/5/1230 HMS Steamship vessel Virago 1841 Scheme for disengaging apparatus and eccentric gear Birmingham City Council archives and heritage service

The Soho drawing room draughtsmen had a set of strict rules to follow; here personal demeanour, rather than drawing style, was laid down. Directions for copying drawings using the machine, and proposed rules for the drawing office were composed in 1791 exhorting draughtsmen to stick to efficient record-keeping, cross-referencing, and established procedures, with ‘no personal letter writing or drawing allowed’. Work was to start at 9 o’clock, continuing through to ‘Bellringing in the evening’ making up a total of 10½ to 11 hours, plus two meal breaks (Birmingham City Council Library MS 3147/4/152). Discussions about working conditions seem to have prompted changes to the rules in the 1820s. The Drawings day book on 8 October 1827 has some observations about hours in other drawing offices in the hand of the head draughtsman, with additional scribbled comments in the margins by other writers that seem to be those of other draughtsmen apparently pushing for easier conditions: ‘hours of attendance to business at Liverpool 10-5 is considered regular’. Unfortunately, the resulting list of amended directions only became a little more lenient, so that although the new schedules dropped to nine drawing hours a day, the total time at work still stretched out with meal breaks to twelve hours. At the same time, an extra dose of punctiliousness was added to keep up morale: ‘Further directions not foreseen when the proper ORDERS was wrote: paste order in on right date; cut upper edge parallel to writing; a small speck of paste is as good as great daubs; superfluous paper to be cut off, not torn as the latter has an ill looking ragged appearance; leave no paper flapping loose, as they are sure to get creased’ (Birmingham City Council Library MS 3147/4/152).

Although other writers have mentioned the existence of the rules as evidence that the Soho drawing office was intended to be the control centre in a rational factory system (Roll 1935: 155; Richardson 1989: 160-9), the fussy and somewhat tetchy details quoted in the new rules of 1827 also suggest that the drawing office (a concentration of young men) should also be considered as a site of potential disruption. Nor could all the technical drawings be trusted, according to private complaints exchanged between the Creighton brothers: ‘Most drawings of parts are wrong for all engines, unless the said drawings are made after… temporary joins exist in abundance in the press copy way’ (William Creighton to Henry Creighton, nd quoted in Tann 1998: 57-8). Despite an insistence on routine and rationale in the drawing office rules, the question of style, and of personal expression within the drawings, was not addressed.

The men in charge of the Drawing office after Watt, John Southern and William Creighton do not completely conform to strict models of rational efficiency either. Creighton’s moods of ‘frenzy’ have already been noted. John Southern, his predecessor, became a trusted partner in the firm of Boulton & Watt and in the Soho Mint (Marsden 2002: 132-4; Doty 1998: 51-5). However notes in the day book give hints of distractions caused by events and by his own personality in the Drawing office. Southern’s assertive and decorative graphic style of presenting the daybook entries, seen in Figures 86 (left) and 94 lend a flamboyance to the procession of work entries processed under his regime, and suggest a pleasure taken in creating graphic effects for their own sake.

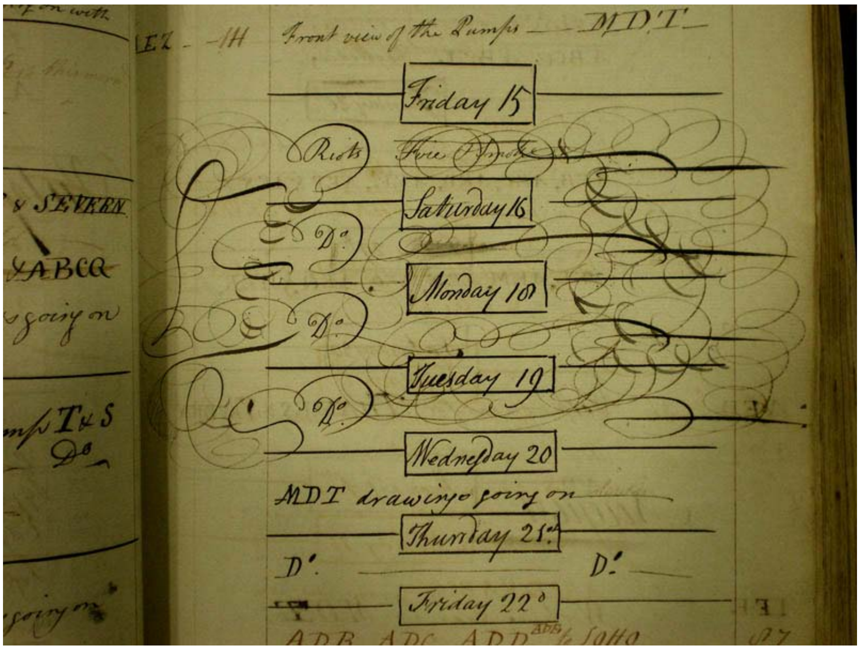


Figure 94: Boulton & Watt archive Drawings MS 3147/4/145 Drawings day Book 1784-1842 15-19 July 1791 'Riots' Birmingham City Council archives and heritage service

Indeed, while the Birmingham riots of 1791 (Figure 94) were outside Southern's control, his entries with wreathing penmanship to remark on the 'fire' and 'smoke' that presumably halted work between 15 and 19 July that year lend a strangely festive or ironic decorative note to this otherwise terse record of customers and their orders. Summer weather disruptions continued to elbow work out of the daybook for example with 'fiddle-faddling' between 24 July and 4 August 1814 or (from Creighton) the 'multitudes of young toads about the shop outside, also frogs' on 21 July 1830. Suggestions of a playful and even sparky atmosphere in the drawing office have also been preserved beyond the day book with its informal entries and marginal comments. 'Personal drawings' survive, despite the ban. Creighton's 'Sketch of a drawing of buildings and mountains made for Mr. Southern' noted above is one example, along with other 'miscellaneous' drawings in the Boulton & Watt archive (Birmingham City Council Library MS 3147/1437). The examples at Figure 95, apparently in Southern's hand, show a small engine house sketch with the joking heading 'the *ne plus ultra* of the elegance' and a scowling profile with the legend 'pretty on yourself'.

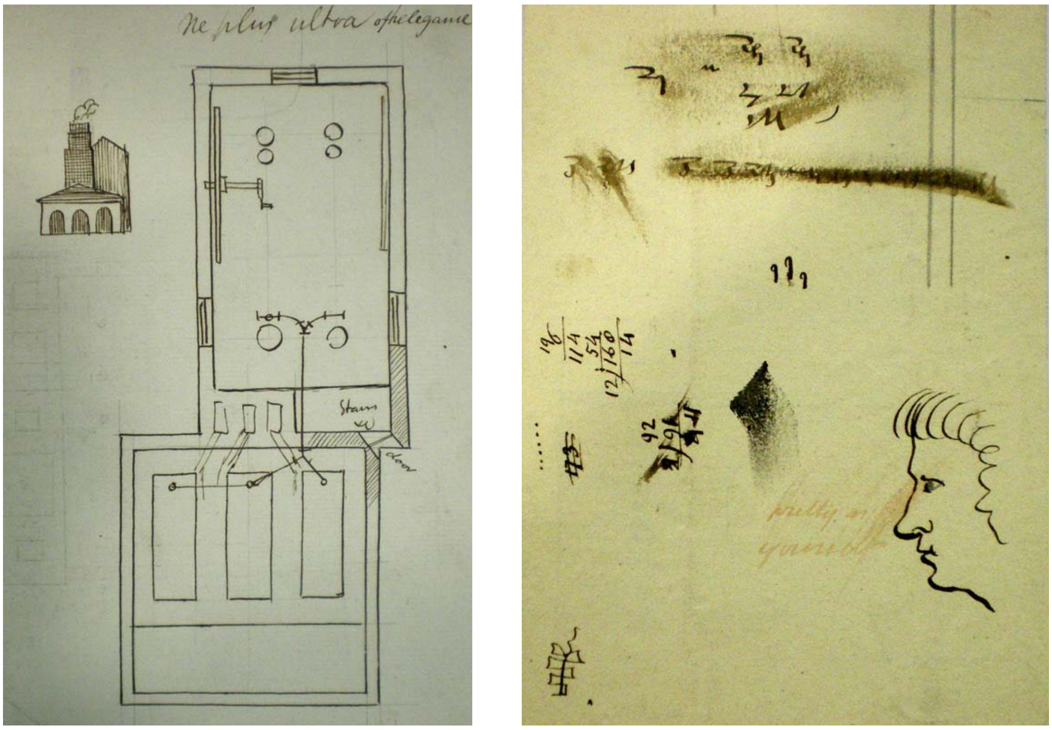


Figure 95: Boulton & Watt archive Drawings MS 3147/1437 Miscellaneous sketches Birmingham City Council archives and heritage service

Although the picture of the drawing office operations at Boulton & Watt, pieced together from contextual information, daybook entries and observations of individual drawings, can only be partial, nevertheless enough evidence is conveyed to challenge the notion that the office can be briefly categorised and dismissed as the control centre of a rational factory system. I have sought to show that in this enclosed environment draughtsmen took pleasure in the expression of drawing skills for their own sake, using a range of classical and architectural references in their design language. Draughtsmen released their energy and exercised their fancy in a range of subjects, from classical columns, to splintering wooden beams to lucid presentation drawings of oiled and docile metallic parts. The example of Henry Wright's applications to his employers considered in the previous section also shows that advancing to the draughtsman position was only possible after undergoing years of training in the factory with ability and initiative. Establishing a separate drawing office in a large manufactory like Soho might certainly represent an attempt to control work and workers in other parts of the organisation, but in the 'control centre' itself the concentration of a group of such workers, young and self-directed, with bodily energies that were not drained by physical labour, disruption and individualism was always present.

The development of railway engineering and the establishment of a rail network in Britain also affected the working practices of draughtsmen through into the 1840s and beyond. Robert Stephenson & Co., founded in 1823 to make railway engines and other machinery, established a drawing office in 1825 (Warren 1923: 63-4; Bailey 2003: 163-9; Baynes and Pugh 1981; Edmonson 1987). As appears to be the case in Boulton & Watt, working in the drawing office was perceived as one of the most important aspects of training to paying pupils in this company, but they were constantly competing with apprentices for this work (Warren 1923: 89). The subsequent construction of railway lines, for example of the London and Birmingham Railway from 1833 with George Stephenson as chief engineer was, according to Mike Chrimes, an important marker of the professionalisation of engineering in this period (Chrimes 2003: 39). The scale of railway construction and the way the work was organised led to an increased demand for draughtsmen. Preparing the route and laying the line meant the project had to be both coordinated as a whole but also separated out into small units; Lecount notes how work would be parcelled out into approximately five-mile stretches in which the draughtsmen would address the surveying and subsequent drawings for structures such as embankments, bridges, and tunnels (Lecount 1839: 51). Over two thousand drawings were required for the whole line, made in two company drawing offices, one at either end of the project. Thirty staff were employed in Birmingham; in addition work was contracted out to independent drafting offices such as that of Charles Cheffins (1807-1860) (Chrimes 2003: 47; Bailey 2003: 181).

The demand for draughtsmen reached a peak with the railway 'mania' of 1846 (Bailey 2003: 201), heralded for example by a flurry of no less than thirteen advertisements in one day in the *Times* in late 1845 that appealed variously for: 'railway map and plan draughtsmen... those accustomed to use the pentagraph (sic) preferred'; 'plan draughtsmen—wanted immediately'; 'a good draughtsman capable of copying and tracing'; and to 'mappers and draughtsmen wanted immediately; three good and expeditious draughtsmen' (The *Times* 17 November 1845: 1). The range of drawing registers demanded of draughtsmen, as displayed in the *Railway practice* of Brees (1840) was very wide in terms of subjects, styles and knowledge of material shaping. Brees' text illustrated numerous specific examples through reproducing both working drawings and specifications and contracts verbatim (Brees 1840: iii). The subjects of the drawings included plans and elevations for stone bridges, including earthworks, foundations and abutments (Plate 7 not illustrated); iron girders, framing and bracing (Plates 8 and 9 not illustrated); a Gothic revival style depot building for Tewkesbury

(Plate 10 not illustrated); and the embankment wall for the new houses of Parliament with details of the pile-driving machines employed (Plate 36 not illustrated). In the context of railway construction, then, draughtsmen were selling specialised skills, in a volatile labour market, often with short contracts, but where the types of drawings in demand were not fixed in one style, but were derived from different professional areas such as architecture, mechanical engineering, or civil engineering.

In the field of toolmaking and mechanical engineering the archive of drawings from the firm of Nasmyth & Gaskell in Manchester offer a chance to decipher the role and status of draughtsmen in the company in relation to other known working practices in this organisation from around 1840 onwards, in particular the policy of mechanical engineer and industrialist James Nasmyth (1808-1890) to develop self-acting machinery in order to reduce the power of skilled workers. James Nasmyth established his business in Manchester in 1834 on account of the 'commercial and manipulative energy' he perceived there (Nasmyth 1883: 182; 139-74; 408-9). Earlier mechanical engineers in the town, Peel, Williams & Co. who were gear wheel manufacturers, already employed a large workforce by the 1820s in Manchester, and had presumably established a specialist drawing office at this early date, because their contingent in the trade procession to mark the coronation of George IV in 1821 included draughtsmen with banners (Musson and Robinson 1969: 467). However, surviving drawings are rare, and records of draughtsmen and their work are even scarcer, making the drawings in the Nasmyth & Gaskell archive at the Institution of Mechanical Engineers in London (I.Mech.E. END 14) an unusual resource. The archive contains machine drawings from the period 1841 to 1862, and is known as 'Roll 52' according to the designation of the company. Most items are presentation drawings produced either by James Nasmyth or by one of the nineteen drawing office staff employed through this period. Although these draughtsmen's names appear on the drawings, little else is known about them. None of the named draughtsmen appeared later in obituaries in the *Engineer*, for example, or in the *Biographical dictionary of civil engineers* (Cross-Rudkin and Chrimes 2008). In addition, the surviving drawing types in the Nasmyth & Gaskell archive are unrepresentative, when considering the detailed parts drawings that must have been made to specify the construction of accurate self-acting machines, but no longer exist. Most of the drawings in this collection are presentation drawings, and they only represent some of the items made by the Bridgewater Foundry.

At the Bridgewater foundry, constructed between 1836-8 (Cantrell 1984: 13), Nasmyth experimented with new production methods for machine tool manufacture (Cantrell 1984: 61), praised by the *Mechanics' magazine* for their layout on the 'straight line system' (*Mechanics' magazine* 14 December 1839: 191) that emulated the method of Boulton & Watt's Soho manufactory by sending all orders through for construction and assembly in a planned sequence that was intended to cut out time spent on unproductive labour. Apart from the invention and patenting of the steam hammer that made his fortune (Cantrell 2002: 138-141), Nasmyth also applied himself to changing his factory workforce, in particular to getting rid of troublesome skilled craft workers, through 'extensive use of active handy boys to superintend the smaller class of self-acting tools. To do this required very little exertion of muscular force, but only observant attention. In this way the tool did all the working (for the thinking had before been embodied in it), and it turned out all manner of geometrical forms with the utmost correctness' (Nasmyth 1883: 308). As an employer Nasmyth was involved in several attempts to break the power of skilled workers and trade unions; the first major tussle was during a strike in 1836, then in 1852 Nasmyth combined with a national combination of employers in the lock-out that aimed to crush the demands of the newly founded trade union the Amalgamated Society of Engineers (Cantrell 1984: 240-2). Nasmyth's development of self-acting machinery in this context is an example of 'machine politics' (Lubar 1993: 200) as he deliberately aimed to curtail the control that skilled workers traditionally exercised over their workplace and the pace of their labour (Morus 1996: 406; Cronin 2001: 4). Instead, he aimed to replace workers with machine intelligence. Self-acting tools could make parts that were beyond the hand craft skills of any human worker: 'self-acting tools were now enabled to complete, with precision and uniformity, machines that had before been deemed almost impracticable' (Nasmyth 1883: 237).

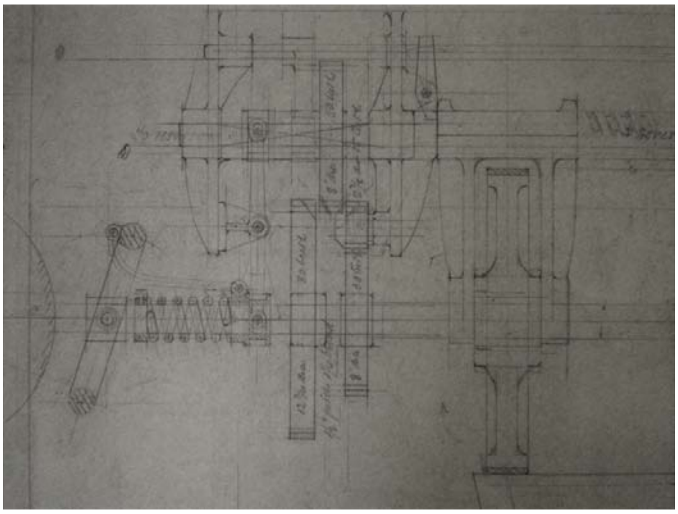


Figure 96: Nasmyth & Gaskell archive END 14/7/1 Automatic speed regulator details IMechE London

However, although Nasmyth aimed to reduce skilled workers overall, this type of production would nonetheless require draughtsmen to design (Schmeichen 1995; Smith 1987; Smith and Whalley 1996) and also skilled workers to set up and maintain the precision-engineered self-acting machine tools. Drafting office work would include for example an analysis of the movements of production into the simple geometrical operations described by Nasmyth in his essay ‘Nasmyth on tools and machines’ (1841; discussed in Chapter 4), and to design automatic mechanisms, as in Figures 96 and 97.

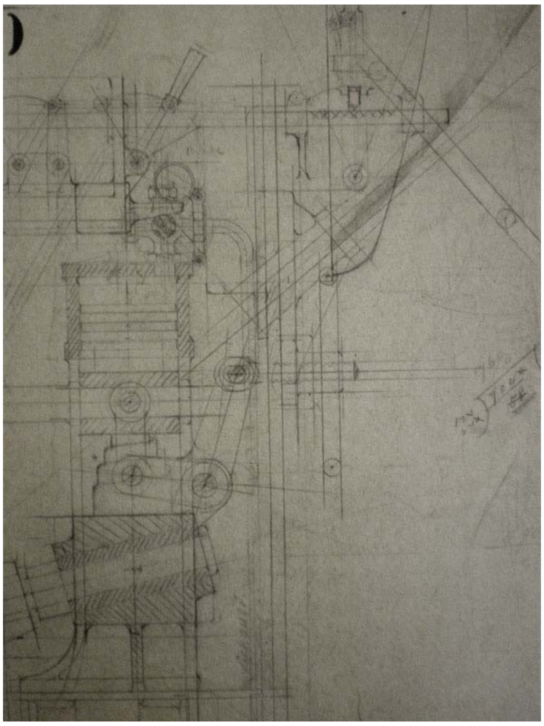


Figure 97: Nasmyth & Gaskell archive END 14/7/1 Automatic speed regulator details IMechE London

In this type of organisation, draughtsmen might at first glance appear to take on the ‘ambiguous and intermediate’ status that has been attributed to all technical workers in the wider class formation of British industrial society (Smith 1987: 235), by acting as deputies for capital against broad labour interests. However, the situation is more complicated than that, as Nasmyth also aimed to make and sell a mainly standardised range of regularly produced articles that were cheaper than custom-made items. For these, orders were made using pre-existing wooden pattern templates, bypassing the need for drawings (Cantrell 1984: 62). Although some of the presentation drawings depict standard items (such as in Figure 100), others were for single, and thus more expensive orders (as in Figures 101 and 102).

Unlike the more uniform style of drawings in the Boulton & Watt archive, the Nasmyth & Gaskell drawings appear in two broad styles. The first style is more akin to the Boulton & Watt 'lucid' style of clean line drawing and transparent watercolour washes, as seen in Figures 98 and 99. In both drawings, for example in the detail shown in Figure 98, the marks of drawing construction, with pinpricks from the compass points, can be clearly seen between the teeth of the wheels.

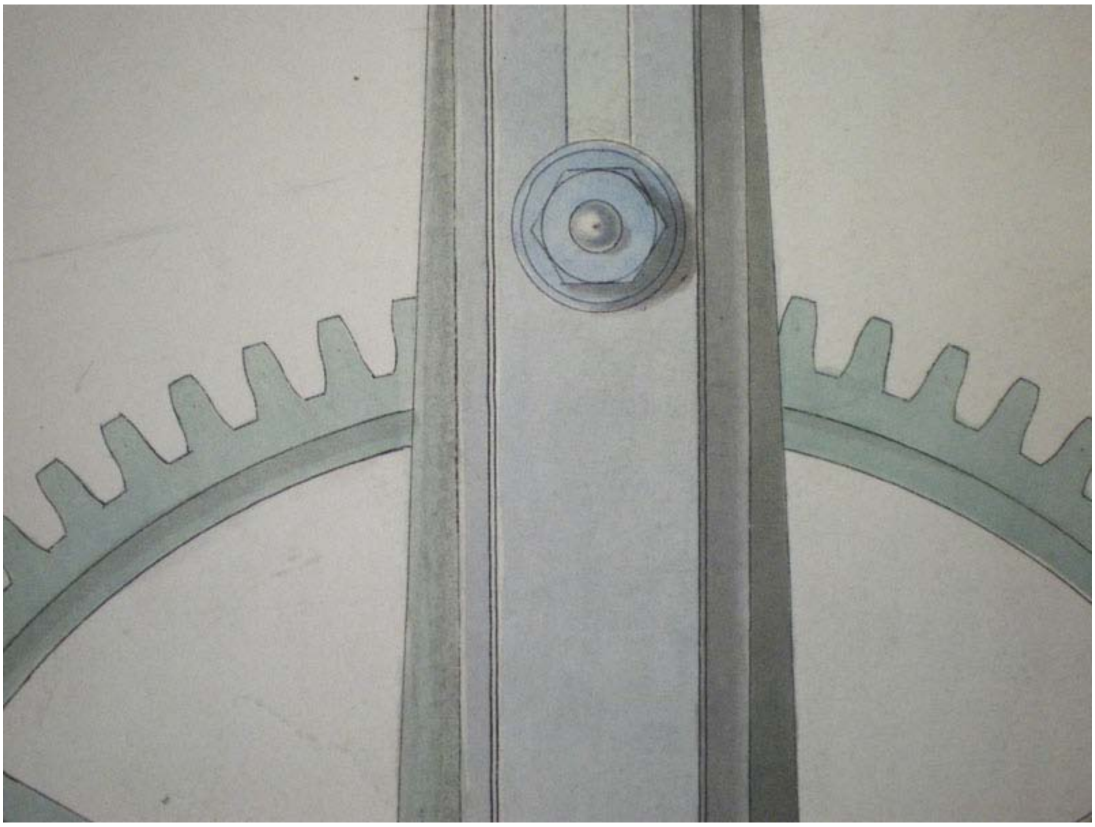


Figure 98: Nasmyth & Gaskell archive END 14/6/9 Laurence IMechE London

Unlike the Boulton & Watt drawings, however, these drawings have more effects of light and shade to enhance an appearance of three-dimensionality. The light comes conventionally from the upper left in all drawings, as denoted by cast shadow, but in addition the draughtsman has taken care to render the effect of gleaming lights, for example of the ends of bolts or on smoothly turned cylinders each with different applications of texture and contrast. In these two examples the machine has been placed into an empty paper space, enhancing the effect of clarity and light, whilst other examples of drawing instead place the machine firmly onto its supporting bed of stone or wood (as in Figure 100, over page) with very strong effects of light and shade to achieve strong three-dimensional effects.

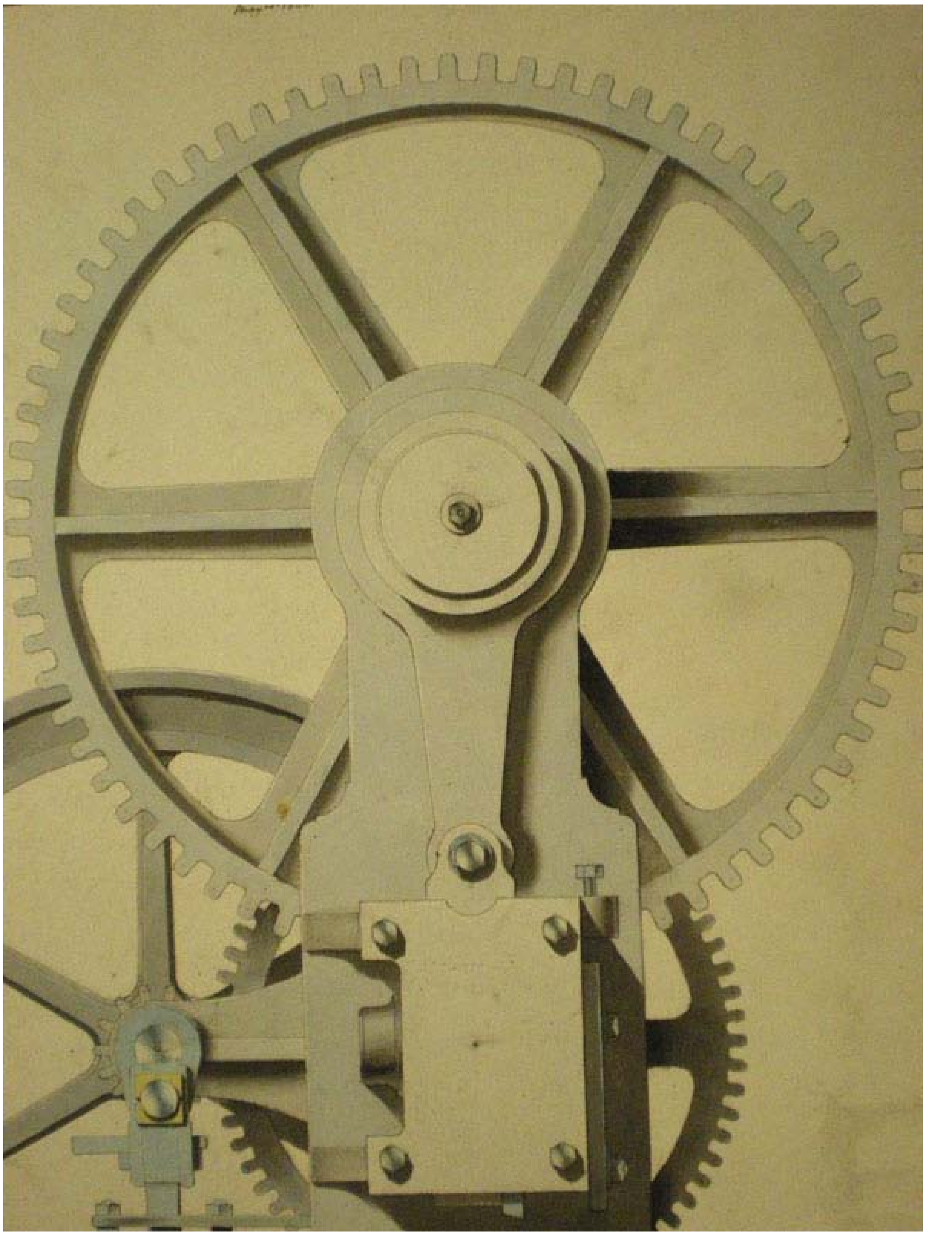


Figure 99: Nasmyth & Gaskell archive END 14/7/6 Richardson 1853 IMechE London

In Figure 100, a key-grooving machine patented in 1838, the effect of solidity and calm comes across both through the gentle smooth graded tonal effect, and also through the use of unadorned classical columns standing firm as the machine supports. The machine was intended to automate the laborious and costly craft process of cutting the ‘key seats’ in wheels or pulleys that engaged revolving drive shafts; in other words it was intended to speed up the production of powered machinery of all types. Early sales of this machine had been good based on its publicity (it was Nasmyth’s first patent application), but once delivered customers found it to be disappointing and expensive, and it was commercially unsuccessful (Cantrell 1984: 100-105). The date of this drawing, 1849, is much later than would be expected, and suggests that it was made as an archival image of record.

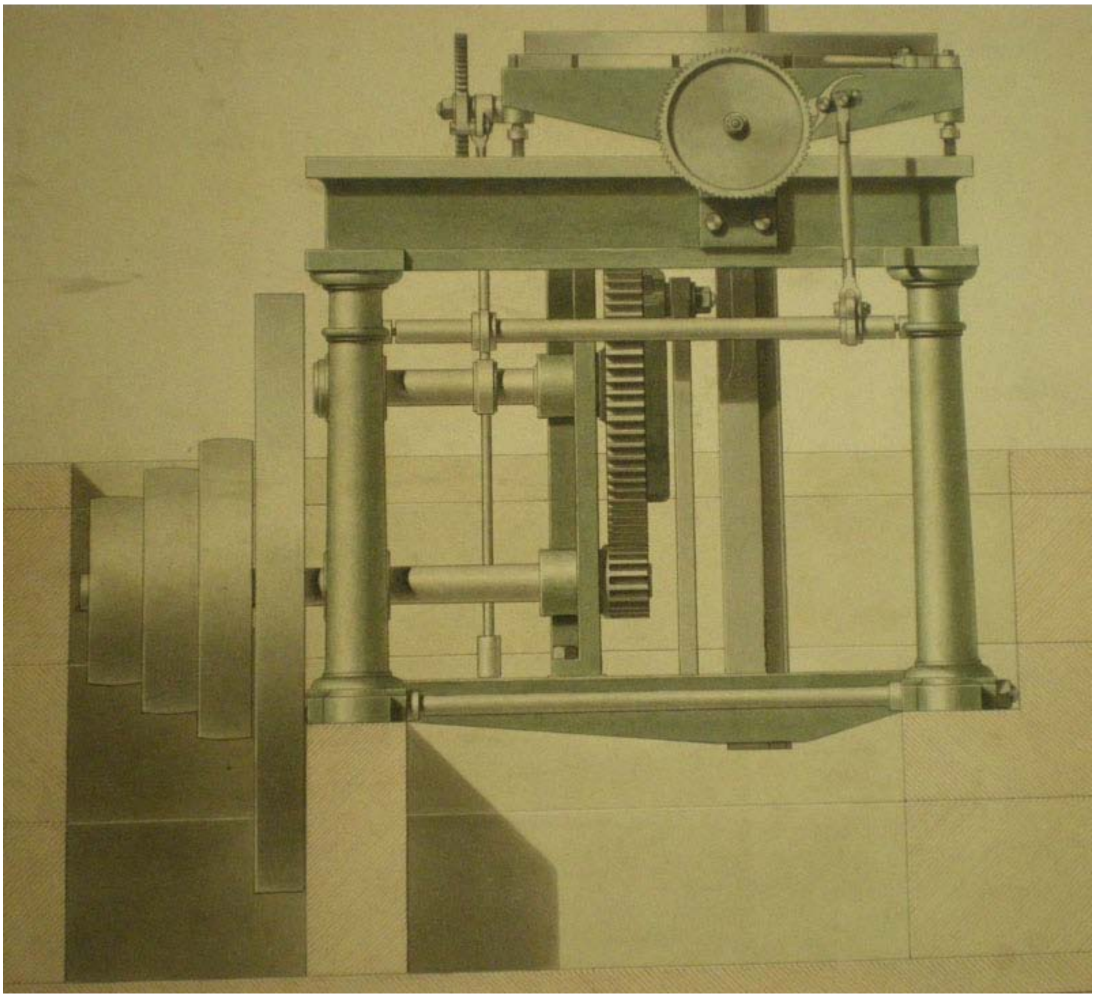


Figure 100: Nasmyth & Gaskell archive END 14/6/4 Sykes 1849 IMechE London

By contrast to these calm smooth styles, several draughtsmen instead produced more stormily worked atmospheric drawings, usually in monochrome, as for example in Figure 101 and 102 (details of the same drawing by Farthing of a ‘train of rolls’). The draughtsman has used strong contrasts, fitful cast shadows that give the effect of coming and going, and strongly varied textural effects to capture material and surface qualities. In dramatic effect, these drawings seem to be in accord with some of the more atmospheric drawings of Smeaton, noted in Chapter 2.

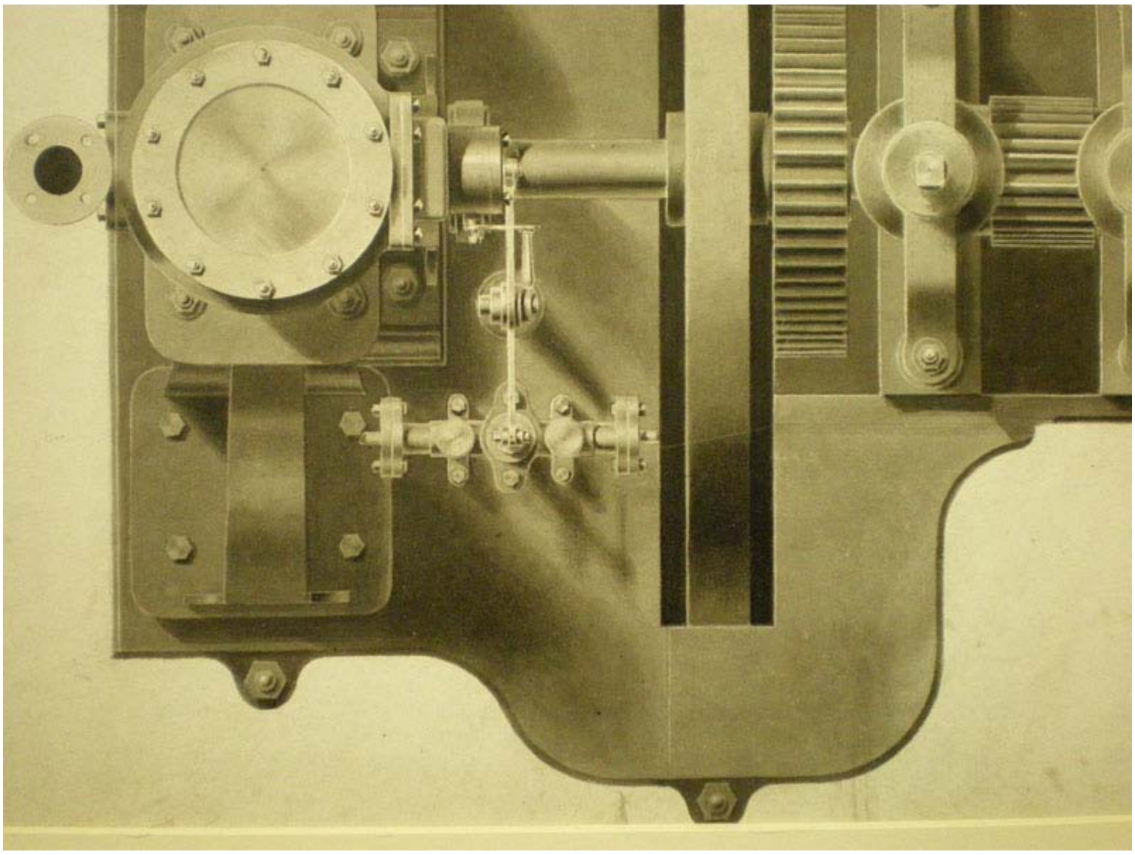


Figure 101: Nasmyth & Gaskell archive END 14/6/2 Farthing IMechE London

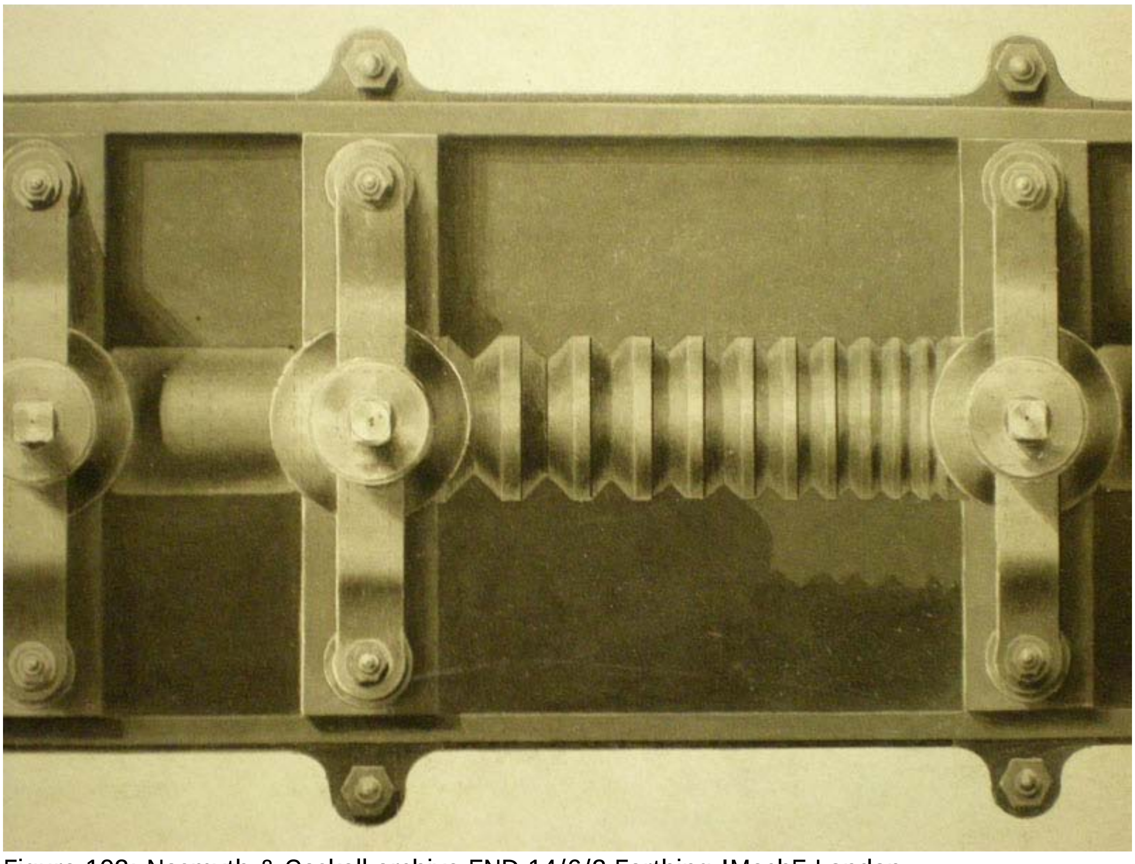


Figure 102: Nasmyth & Gaskell archive END 14/6/2 Farthing IMechE London

The machine depicted in Figures 101 and 102 was for a single particular order where Nasmyth's 'registered engine' (a steam engine with an action and appearance that resembled the steam hammer) was adapted to drive a 9-inch train of rolls for a company in Malaga (Cantrell 1984: 116-8). This would have been an expensive item for the customer, demanding design drawings for production (these are not in the archive). The drawing that is preserved is a presentation drawing; like the drawing in Figure 100 it may have been a record of work prepared after the event.

All the Nasmyth & Gaskell presentation drawings have a presence and drama that varies according to the style favoured by different draughtsmen; there was not one 'house style' imposed overall. In part, the drama of the presentation drawings comes from the application of strongly illusionistic effects of light that serve to lift the drawing out of its regular two-dimensional mode. Strong shadows give a sense of volume and indicate the shape of forms projecting towards the viewer, but also have an inherent expressive quality. Equally, effects of light helped to indicate the material qualities of the object depicted, as in the turned and gleaming metallic surface of the bolts. All these effects demanded time and skill from the draughtsman; they are not strictly or purely informative, but are for display and spectacle. The expressive and varied effects of the presentation drawings that survive in the archive, and the choice that seems to have been allowed to draughtsmen in relation to style appears to be at odds with Nasmyth's domineering approach, not only to his factory workers, but also to his works managers and even business partner, Holbrook Gaskell (Cantrell 1984: 54; 236-43). However, Nasmyth did make efforts to keep his foremen 'comfortable, and consequently loyal' (Nasmyth 1885: 311-12) as he saw their role in controlling the workers as key. Towards mid-century, as we see in the next section, draughtsmen came to be described by employers and fellow workers as somehow equivalent in status to foremen, no longer engineers in waiting, but as agents of management. Equally, as already seen, Nasmyth had decided views on the value of drawing as a key skill for the engineer. His own visual expressions, to be discussed in the next chapter, did not include presentation drawings that were finished to the same level as those of his draughtsmen. In relation to Nasmyth's philosophy of industrial organisation, and his views on drawing, it is possible to see the varied styles of his draughtsmen as the permitted leeway of hired artists, analogous to the division of labour that was in place between 'draughtsmen' and elite architects at the beginning of the nineteenth century (Savage 2001: 207). One rare public debate about the status and role of draughtsmen at mid-century, in the *Engineer* journal in 1859, also supports the view that displays of artistry by draughtsmen were becoming increasingly associated with such a subservient role.

'Mere adventurers in drawing': squabbles about status in the 1850s

In Booker's history of technical drawing, which was presented as a series of creative proposals by inventors and theorists, the debate he reported from *The Engineer* sounded a discordant note, namely that by the mid-nineteenth century many draughtsmen were beginning to be derided as 'mere copyists' (*The Engineer* 30 December 1859: 471; Booker 1979: 134). Although Booker attempted to defend these scorned figures, he did so by elevating them to the status of 'artists' (Booker 1979: 133). Hence he was able to retain his main emphasis on the functional and intellectual qualities of the drawings themselves, and withdraw swiftly from this short diversion into social history. However, if we examine the full correspondence more closely it can reveal more about the contradictions noted throughout this chapter, in the roles of draughtsmen in the first half of the nineteenth century. Those contradictions became more explicit and more pointed towards mid-century due to changes in the workplace; in mechanical engineering, drawing offices were only established in larger engineering firms as part of a policy of establishing control over the workforce (Cronin 2001: 9-10). In 1859 a yearlong debate about the duties and status of draughtsmen grumbled forward in the *Engineer* journal, prompted by a letter of domineering tone:

> Draughtsmen are sufficiently designated by the name. It is the duty of these servants to draw the various parts of machinery in order that the men may be able correctly to execute them, and correctness in design is more necessary than colour and shading which only tends to confuse. A good line and correct measurement are the chief essentials. In foremen's duties… [he has] to see the workmen do their duty… the drawing being made… he should make the men work to the drawings and not expect draughtsmen to draw to or from work'. (*The Engineer* 21 January 1859: 45)

Several outraged correspondents responded to this slighting description by insisting that draughtsmen ought to be recruited only from premium paying pupils, so that this occupation would be 'a society composed of gentlemen' (*The Engineer* 4 February 1859: 82). Other draughtsmen proposed instead a 'meritocratic' strategy of professional gatekeeping (see next chapter), advocating 'a strict exam consistent with the profession', in rejecting the genteel camp with scorn: 'masters will always object to pay high salaries to draughtsmen whose principal pretensions are those of being a gentleman' (*The Engineer* 11 February 1859: 100). In contrast again a third strand took a more 'proletarian' stance:

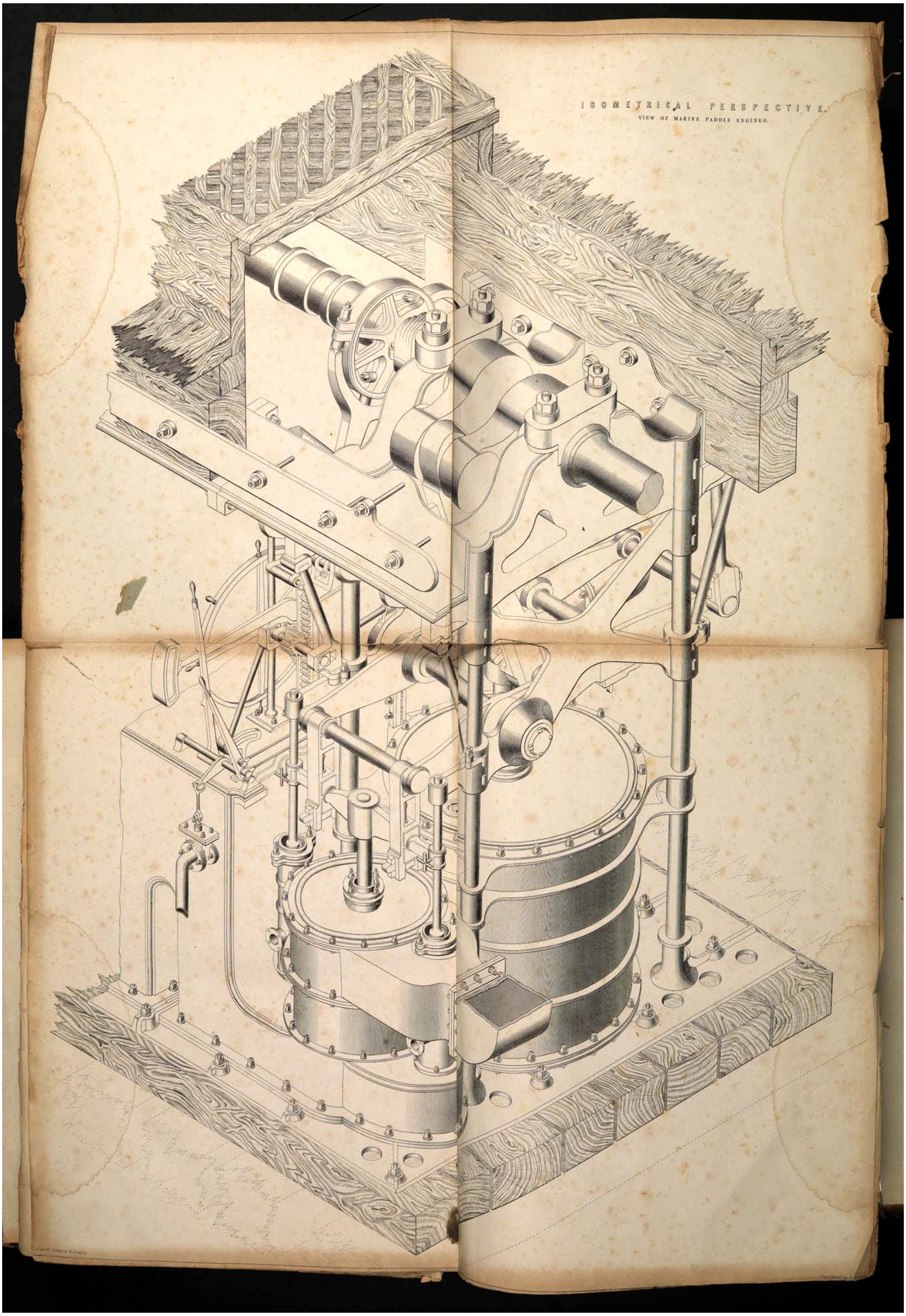
> Mechanical draughtsmen, like commercial clerks, will become a drug on the market... One competent person to superintend, and half a dozen boys to make circles, curves and straight lines, will compose the staff of most offices; and when the boys become men and require the pay of men, they will be discharged, to look back with disgust upon a portion of the best part of their life, which they have spent for nought, and which has unfitted them, to a great extent, for active exertions in other walks of life. Their vacant places will be supplied by other boys, to serve awhile and share the same fate. (*The Engineer* 18 February 1859: 119).

This is the voice of a draughtsman to whom adversity and inferior status are reasons for mutual association with skilled workers such as foremen, not to be denied or blustered away, and acknowledging that being 'plodding' and 'a servant' had become part of the contradiction of being a draughtsman. At the same time the claims of other draughtsmen for gentlemanly or professional status inflamed conflict within this occupational group, and also brought them into outside conflict with radical positions of 'artisan resistance' (Desmond 1987: 77-110), adhering instead to the precarious individualism of such marginal middle class occupations (Crossick 1977: 17). The editors of the *Engineer* themselves took a more simplistic line at the end of this debate, and reduced the complexity of workplace changes to a misleading and unfavourable comparison between the 'excellent draughtsman' and 'mere adventurers in drawing' (*The Engineer* 30 December 1859: 471); characterised as those with engineering training versus those with artistic pretensions.

In their attack on 'adventurers in drawing' the editors of the *Engineer* may have had in mind examples of bravura draughtsmanship from the period around 1850 . Figure 103 shows an image from the *Imperial cyclopaedia of machinery* (Heming 1852 in Johnson nd [1852-6]) that accompanied a short essay on 'isometrical drawing'. Heming, the author and draughtsman, explained rather disingenuously that this dominating image was chosen to illustrate 'the admirable use to which isometrical drawings can be put as substitutes for expensive working models' (Heming 1852: 12). Instead, this image appears to be entirely expressive and rhetorical, starting with its vast 56x76cm A1 size (it is a four-fold print in a quarto book). More like a Baroque god in a cloud chariot than a sober design exercise, the engine forms curve and gleam, framed by the dramatic conceit of the flame-like shattered wood surround. In everyday technical drawing, uneven edges are used to denote a structure that continues indefinitely out of the frame, but the conventionality of this device has been exaggerated and literalized. The draughtsman did not of course invent this commonplace device, for the effect has already been noted in orthographic technical drawings, for example from the Boulton &

Watt archive, seen earlier in this chapter at Figure 91, and can be also be seen in earlier oblique perspectives, for example in the Plate 'Horology' in Rees' Cyclopaedia (Figure 104). However, Heming has systematically taken all aspects of his drawing to such extremes that it stands as a self-contained expression of graphic exuberance, from the gratuitously decorative waves of wood graining in the supporting structure, to the selective application of shading to some forms and not others, and an overall exploitation of the ambiguities of viewpoint in oblique projection.

Figure 103: (*see next page*) G. Heming (1856) Isometrical perspective view of marine paddle engines
From William Johnson *Imperial Cyclopaedia of Machinery* (nd [1852-6])


ISOMETRICAL PERSPECTIVE.
VIEW OF MARINE PADDLE ENGINES.

Although the forms in this image do not skip between convex and concave, as seen for example in the visual jokes of Escher or in 'shaded cube' patterning, the image sets up a strong visual *contrapposto* in which the eye twists between a left-hand entry to the upper half of the form, and the stable gateway of the lower right. Although the image is extremely successful in that it conveys the inherent dynamism of steam power through a static image, it is only successful in its own terms as a work of spectacular draughtsmanship in print. The image is rendered in isometrical projection, a simple technique of representation that was familiar to a wide readership through publications such as the *Mechanics' magazine* from 1824 (see above, also next chapter).

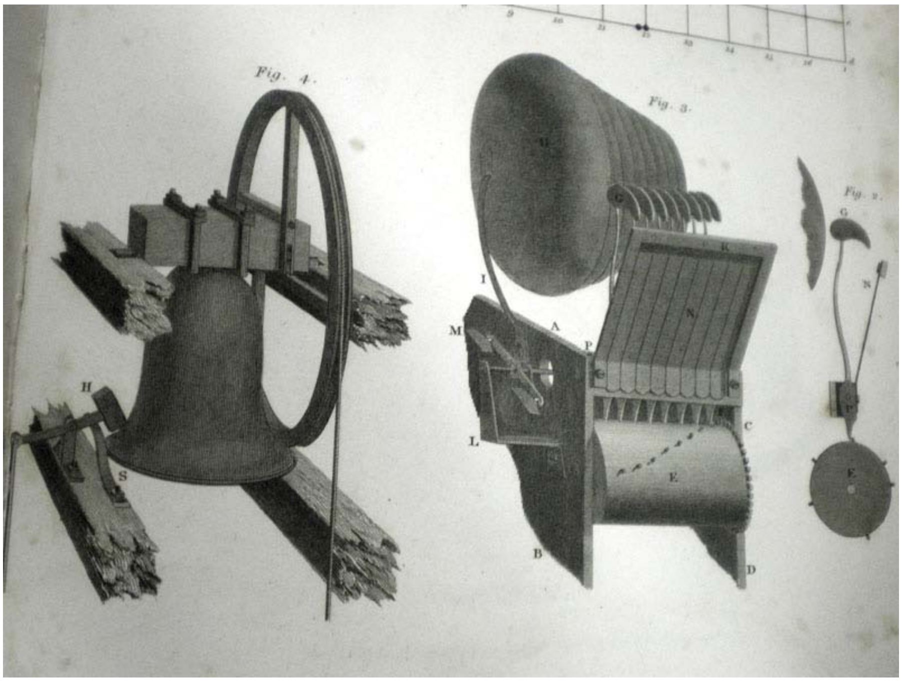


Figure 104: Detail of Plate VII 'Horology' from Plate Volume 2 of Rees' *Cyclopaedia* 1819

The image in Figure 103 demonstrates graphic drawing skills of linear invention and dramatic composition energetically, while getting over a sense of busy mechanical detailing. However, the drawing could not be used to make an engine; or even buy one with any certainty. The draughtsman who produced this was not a 'servant' of factory production in line with the characterisation of this work in the *Engineer*, but an illustrator using the techniques and subject matter of technical drawing to craft an object to be consumed in its own right, in print. This practice is much more in alignment with the notion of draughtsman's work conveyed by contributors to the *Mechanics' magazine*.

Conclusion

Mechanical drawing as a technique of industrial production is often described as a place where the theory and practice of material shaping intersect. This conceptualisation is in accord with the way in which pupil engineers worked as part of their training, one aspect of ‘mechanical science on the factory floor’ (Jacob 2007: 197-202) in the early nineteenth century. This notion of three-dimensional materiality is fairly straightforwardly situated in an industrial environment. However the establishment of drawing offices as a separate environment in larger engineering concerns in the first decades of the nineteenth century also formed ‘draughtsmen’ as a separate occupational group. Draughtsmen began working in drawing offices having previously learnt to draw in a range of styles either in classes or from a range of printed sources, both practical and artistic, and largely self-selected. Technical support workers often develop their own aims that are not always in harmony with those of the organisation or with management (Becker 1982: 82), and as specialist draughtsmen became confined to the drawing office towards the middle of the century, they entered the two-dimensional Flatland of the paper world, with an allegiance to the trades of illustration for print. In this environment they were also subject to wider debates about the unique cultural value of drawing as the bearer of good taste. In these culture wars, draughtsmen came under fire from fellow skilled technical workers for being a standoffish snobbish crew (*The foreman engineer and draughtsman* 1876: 19).

John Wigham Richardson, recalling his life in the 1850s, had recoiled like Hudson from the ‘continual chatter going on about amusements or sprees’ (Richardson 1911: 105). As an elite engineer he was in accord with the strictures in *The Engineer* against ‘mere adventurers in drawing’; an example of the kind of freezing hostility that Jonathan Rose describes as the weapon of intellectuals trying to maintain a ‘perilous social distinction’ against the pretensions of those just snapping at their heels in the quest for social advancement (Rose 2001: 393-4). In this light, draughtsmen have been eclipsed like other marginal members of the middle classes described by Henry Crossick: they had to be men of ‘respectability, education and address’ but they lacked the means to keep these up, constantly bemoaning a golden age before their own day, ‘when their predecessors had been regarded as gentlemen’ (Crossick 1977: 62). A more favourable account of draughtsmen’s ‘amusements and sprees’ of the 1850s would have instead emphasised their access to educated urban pleasures, encompassing the works outings and amateur dramatic performances described by James Houston, apprentice engineer with Robert Napier & Co. in this period (Houston 1889: 8-18).

Due to changes in workplace organisation, and to developing hierarchies within engineering practice, the status and role of draughtsmen changed in the first half of the nineteenth century. While there is a relative lack of knowledge about the training, aspirations and drawing practices of British draughtsmen, that lack of information is also due to a denial of their experiences from many quarters. One factor in their invisibility is the British laissez-faire approach to education and professional pathways in the nineteenth century. This obtained at all social levels. Bernard Cronin has claimed that employers lobbied hard to block effective state education for technical workers, favouring instead unsystematic, largely unobserved part-time methods of self-education (Cronin 2001: 7), while Andrew Saint has more dramatically stated that 'the spectre of Britain haunts the topic of technical education for architects and engineers' suggesting that there was a rejection of education by elite engineers and the state and that is a 'puzzle', when combined with Britain's economic dominance (Saint 2007: 256). However, as this dissertation demonstrates, even although there may have been a lack of state institutions and 'school culture' (and this can be disputed) it does not mean that there was no training or education, just that it becomes harder to get hold of information about it. Artisans learned to draw through various means such as mechanics' institutes and mechanics' magazines. To describe the mechanics' institute movement as simply an exercise in power by elite power groups is too limiting. Instead, the mechanics' institute movement was a location for more complex negotiations of status, especially in conjunction with working relationships and with private reading and study. In the conditions of the early decades of the nineteenth century, young men were eager, in the words of one correspondent to the *Engineer* to risk 'a portion of the best part of their life' to this occupation as a route to becoming a professional engineer. Later towards 1850 such elevated aspirations were more often disappointed, in part perhaps due to the changing social background of draughtsmen themselves. This chapter has also discussed the relationship of skill and display in technical representations to the question of control and power in the workplace, and the formation of professional structures in engineering. In the final chapter, I will continue this discussion in relation to the ways in which elite engineers also negotiated their own status and self-presentation through visual means.

Chapter 7: Social networks: professional engineers in the world of industrial readers

This chapter will discuss the visual practices of elite engineers in the first half of the nineteenth century in relation to questions of professional formation, self-presentation, and authorship. How did engineers aim to establish respect for themselves and their occupation? The working practices of engineers were in part derived from those of manual craft trades, at odds with eighteenth century views that only the man of leisure, the gentleman, was considered to be able to judge impartially and make trustworthy statements in the public interest (Reader 1966: 3; Barrell 1992: 90-1). Part of the aim of groups such as the Institution of Civil Engineers (founded 1818) was to promote confidence in engineering as a rational public enterprise, for example by popularising engineering with descriptions of projects and explanations of how engineers created and used knowledge. But within such projects is a tension, and the implication that engineers had access to special expertise and knowledge that is not freely available to all. Engineers presented ‘engineering’ in print, in images and text, to general non-expert readers and also to other groups claiming expertise. Even ‘big names’ strove to achieve professional status with their peers but also through an appeal to other target audiences such as men of science or civil servants concerned with state policy for education in design and technical skills. For elite engineers, as for draughtsmen, the problem was negotiating how different kinds of visual display related to status.

I begin this chapter by considering accounts of professional formation, such as the notion of the ‘rise of the professional classes’ (Reader 1966: 70-71; Buchanan 1983: 407-29; Corfield 1995:19; 181-2) in relation to engineers before noting how this generalised notion of professionalisation has its limits (Morrell 1990: 980-989). Engineers cultivated many different personal styles; for example Fairbairn aimed to gain status as a man of science through allegiance to the British Association for the Advancement of Science (BAAS) whilst others such as Brunel highlighted instead their capacity for masculine daring and risk-taking (Marsden and Smith 2005: 243). The visual strategies adopted by engineers were so various they could not all be covered in this chapter, even if I wanted to. Instead, I continue to develop questions from Chapter 6, where I discussed the self-education of draughtsmen, and their assertion of skill through drawing. I will describe ways in which writers aimed to promote engineering as a rational public enterprise through popularising or communicating engineering practices. Texts and images addressed to the general reader or aspiring mechanic can be used to find out about readers, as in Chapter 6 (Cooter and Pumfrey 1994: 237-67; Brown et al 2009: 737-52; O'Connor 2009: 333-345; Cantor et al 2004; Lightman 2007: 29-30); however in this chapter I will consider the other face of popularisation by asking how some engineers aimed to create a professional niche for themselves through visual and literary practices, by developing public discourses of engineering in images and words.

I have mainly addressed a body of banal or textbook imagery not normally associated with elite engineers. Famous individuals have in the past more often linked to images that show the creative aspects of design, stern control in the factory or to sumptuous presentation drawings, whilst other more ephemeral printed material addressed to 'the world of industrial readers' (Johnson 1852: 196) has been neglected. Descriptions of technical drawing as a kind of privileged residue or insight into the private creative thoughts of the 'great engineers' that began with writers such as Samuel Smiles (1863) continue into the present (Booker 1979; Baynes and Pugh 1981), despite many critical attacks of this approach (Lubar 1995: S54) or (Stevens 1995). However, discussing the individual activities of elite engineers need not be a retrograde step, or an act of unreflecting homage (MacLeod 2007; Lightman 2007). The promotion of technical drawing skills in the work of such disparate popularisers of the mechanical arts as John Farey, William Johnson, William Farish, Olinthus Gregory and Thomas Sopwith show a range of strategies of self-formation and concepts of professional practice manifested in an apparently simple range of routine texts (Jardine 2000: 401-2).

The staging of the Great Exhibition in 1851 as a spectacle of progress brings forward some of the dilemmas faced by elite engineers in their quest for status. On the one hand this event appeared to be nothing but good publicity, asserting and confirming engineers as 'heroes of invention' (Macleod 2007) to an exceptionally large popular audience. But the opportunities presented by the exhibition did not necessarily mesh with the ambitions of some engineers to assert status through specialised theoretical and scientific expertise. At the Great Exhibition, engineers were in contact and competition with men of science and with civil servants who aimed to direct state policy for education in design and technical skills. I end this chapter with a discussion of how engineers James Nasmyth and David Kirkaldy demonstrate some of the complexities of visual self-presentation in negotiating allegiances with elite engineers and with men of science, in which key statements were made through images in print.

Professionalisation and the 'rise of the professional classes'

W.J. Reader developed the notion of the 'rise of the professional classes' (Reader 1966: 70-1; Buchanan 1983: 407-29; Corfield 1995: 19; 181-2) in order to explain the attempt by many middle class groups to secure status through their occupation in the nineteenth century. Reader argued that this was due in part to the frustrated political aspirations of educated members of the middle classes before the Reform Act who were excluded from prevailing power networks dominated by aristocracy, gentry and the older merchant families (Reader 1966: 3-9). As described in Chapter 6, agitation to change this status quo had been growing throughout the first decades of the nineteenth century. Reformist publications such as the *Westminster Review* eulogised the then-disenfranchised middle class in 1826 as: 'the heads that invent, and the hands that execute; the enterprise that projects, and the capital by which these projects are carried into operation. The merchant, the manufacturer, the mechanist, the chemist, the artist, those who discover new arts, those who perfect old arts, those who extend science; the men in fact who think for the rest of the world, and who really do the business of the world, are the men of this class' (quoted in Simon 1974: 78). The range of occupations quoted from the *Westminster Review* is extremely wide, and only some of these workers might have wished to aspire to professional status; and how this might be achieved, or defined, was uncertain.

Writers have tried to define professional work as the sale of intellectual labour; as the 'institutionalisation of a social distinction—a distinction between the leader and the led in a particular expertise' (Buchanan 1989:15), or as a kind of disinterest, the adoption of a stance of 'comparative aloofness' from business and commercial interests (Perkin 1969: 258) in order to mimic gentlemanly impartiality. Buchanan, historian of engineering, claims that all professions share certain distinguishing practices such as specialised education, controlled entry for newcomers, and an enforced programme of ethical and educational self-development (Buchanan 1989: 13). However, such generalised notions of 'professionalisation' are limited, even misleading (Morrell 1990: 980-989). Instead, trying to gain social distinction was constantly problematic, both within and also between professions. Even allegedly well-established professions such as the law or medicine were in transformation in the nineteenth century, working to consolidate informal practices into professional codes endorsed by the state, for example through legislation such as the Medical Act of 1858 (Reader 1966: 66). Above all, every would-be professional group was perceived differently in terms of status.

In 1857, those differences in status were made sharply apparent in the writing of one H. Byerley Thomson, the author of a guide to professional career choice. Despite some blanket praise of the professions as those who: ‘form the head of the great English middle class, maintain its tone of independence, keep up to the mark its standard of morality, and direct its intelligence’ (Thomson 1857: 5), the author could not maintain this level of bland approbation when up against specific cases. In his survey of the groups then accepted as professions at the time of writing, Thomson began with the three traditional groups, which he designated as ‘privileged’ because of legal restrictions on entry (Thomson 1857: 2; 5). He then listed, in addition to the army and navy, the ‘unprivileged’ occupations that had gained respectability in more recent times: artists, sculptors and architects, then civil engineers, and ‘professors of education’ (Thomson 1857: 2). In all these categories, a sharper tone of social distinction enters. Painters and artists in Thomson’s opinion were so low that ‘no one who is a gentleman or a scholar’ could stoop to such work (Thomson 1857: 267). Civil engineers the ‘modern profession’ received more approbation at first sight, as the executors of the ‘system of great works now overspreading the country’ (Thomson 1857: 293). However, Thomson soon modified his praise: ‘very few have received anything approaching an education in their calling. They have been military engineers, intelligent foremen of works, successful builders, and land surveyors’... (Thomson 1857: 294). In Thomson’s opinion James Watt was also in this second rank: ‘it was a hint of Dr. [Joseph] Black's theory of the expansion of gases, in the hearing of the practical James Watt, that added the vacuum-chamber to the steam-engine, and established the invention... [hence] we discover what the engineer is—he is a combiner of facts, not a discoverer of new ones...’ (Thomson 1857: 295). Thomson’s voice shows not only real and significant distinctions being drawn between old and new professions, but also how those distinctions were couched in terms of personal probity.

When Buchanan claimed that engineers had gentlemanly aspirations (Buchanan 1983: 407), he meant that they wanted to be taken more seriously than they were by Thomson, as discoverers of new knowledge. Steven Shapin has described how from the seventeenth century onwards, gentlemen established and defended a claim to be the unique truth-tellers in English science so that ‘epistemic capacity was expressed in the same idiom used to describe and justify the social order’ (Shapin 1994: 397). In the late eighteenth century, as Golinski (1992: 284-5) has argued, gentlemanly discourse and professional formation were often at odds. Golinski took as his example the culture of experimental philosophy that related to the formation of the discipline of chemistry around 1800, where ‘gentlemanlike facts’ (defined as those constructed by an autonomous learner in a ‘nondogmatic discursive structure’) curbed professional specialisation (Golinski 1992: 25). This description of gentlemanly discourse is derived in part from notions of the ‘public sphere’; a region proposed by Habermas of supposedly neutral and rational debate (Outhwaite 1996: 23-41) between the state and civil society where the workings and correct form of the state could be debated (Yeo 1993: 40-1). Gentlemen, it was argued, had the right mental equipment for making such judgements as developed through a ‘liberal education’ based on the classics: that is, a study of Greek and Roman literature and the systems of mathematical and geometrical reasoning associated with Euclid (Richards 1988:1;187). Thus, in the words of William Whewell, Master of Trinity College Cambridge from 1841, such studies united reasoning and literary expression, and would ‘connect a man’s mind with the general mind of the human race’ (Marsden 2004: 427; Williams 1991: 122; Yeo 1993: 220-8; Reader 1966: 10). In contrast, practical and vocational training was held to narrow the mind (Reader 1966: 10). Despite this, radical and dissenting members of the middle classes developed a rival modern curriculum of science, modern languages, history, mathematics and commerce in schools and academies that were separate from established English universities and public schools (Simon 1974: 18-25; 33). In addition, as noted in Chapter 6, universities and colleges in Scotland and on the continent favoured practical professional education, with lectures and courses addressing subjects of industrial relevance (Morrell 1971: 158-71; Cardwell 1972: 32-3; Shapin 1984: 17-23).

Moreover, even before the beginning of the eighteenth century the notion of a ‘gentleman’ had begun to drift. Langford claims that foreign observers in Britain were surprised to note how the term was claimed and applied to anyone who had the appropriate demeanour or monetary means, regardless of birth (Langford 1981: 66-73). Furthermore, it would be a mistake to overstate the aversion felt for practical and vocational training by the ruling classes. Aristocratic education from the Renaissance to the late eighteenth century embraced the mathematical arts and sciences applied to engineering problems of construction and war such as architecture, fortification and gunnery (Bennett and Johnston 1996: 13; Gerbino and Johnston 2009: 1;131-33), worked out through architectural and geometrical styles of drawing already discussed in earlier chapters. In Cambridge, William Whewell expanded his views on what went into a liberal education, suggesting in *The mechanics of engineering* (1841) that the study of engineering might become ‘a permanent possession of liberally educated minds’ (Yeo 1993: 228) so that everyday structures such as roofs, bridges and engines became a fit subject for informed judgement and contemplation (Marsden 2004: 427). In part, such statements were used in the campaign to make Cambridge into one of the centres of power of the ‘gentlemen of science’ (Morrell and Thackray 1981: 23-29) during the formation of the British Association for the Advancement of Science (BAAS) between 1831 and 1833. Morrell and Thackray have argued that the strengthening of ‘Cambridge savants’ (Morrell and Thackray 1981: 271) meant that contemplation of the science of engineering was given higher status in the BAAS rather than discussions about its practical application in industry (Morrell and Thackray 1981: 256-66).

Engineers attempt to ‘circumscribe the profession’

R.A. Buchanan’s *The engineers* (1989) aimed to give a comprehensive account of the professional formation of engineers (and in this context, my use of the word ‘formation’ takes note of the resonance of meaning understood in French; of apprenticeship, training and education, as well as of more general social forming). However, Buchanan’s own interest in the ‘institutionalisation of a social distinction’ frequently led him to concentrate not so much on the ‘community of engineers’ (Buchanan 1989: 37), as on the Institution of Civil Engineers. From its foundation in 1818 the Institution aimed to ‘facilitate the requirements of knowledge… circumscribe the profession… establish it in respectability [and] increase public confidence’ (Buchanan 1989: 62). Here are three ‘professional’ aims: the promotion of education as specialist knowledge, the desire to draw boundaries of exclusion, and finally of promoting public confidence through self-presentation. The founders of the Institution in 1818 were all young, with an average age of twenty-five (Watson 1988: 9), intending to supplant the earlier Society of Civil Engineers founded in 1771 by figures as John Smeaton and Robert Mylne (discussed in Chapter 2). But although the younger group of engineers at the Institution were reacting against the closed social circle of the older elite engineers, they inherited examples of their techniques for establishing respect and promoting their work. Garth Watson has claimed that the engineer Smeaton made a ‘professional’ assertion of status in 1759 by presenting himself in two theatres at once, practical and theoretical, through completing the Eddystone lighthouse and presenting his paper on the power and efficiency of windmills and watermills to the Royal Society (Watson 1988: 5; Alexander 2008: 15-32). Although Smeaton’s method of promoting public confidence in his occupation was gained partly though his demonstration to men of science of specialist experimental knowledge, he also presented his construction work as an illustrated ‘narrative of the building of the Eddystone lighthouse’, first published in 1791. This medium of self-presentation was derived from Smeaton’s habitual practice as a consulting engineer of preparing reports with plans and other illustrations noted in Chapter 2, although the diaristic narrative in the *Eddystone lighthouse* of dramatic events such as storms, collapses, or problems with getting materials, also conveyed to the general reader a range of other personal skills that Smeaton claimed as professional engineering conduct. In the image in Figure 105, Smeaton presented his design thoughts as a combination of observations of art and nature, using the strength of interlocked masonry construction developed by empirical craft methods, and the form of a tree trunk, able to stand and flex in the most violent winds.

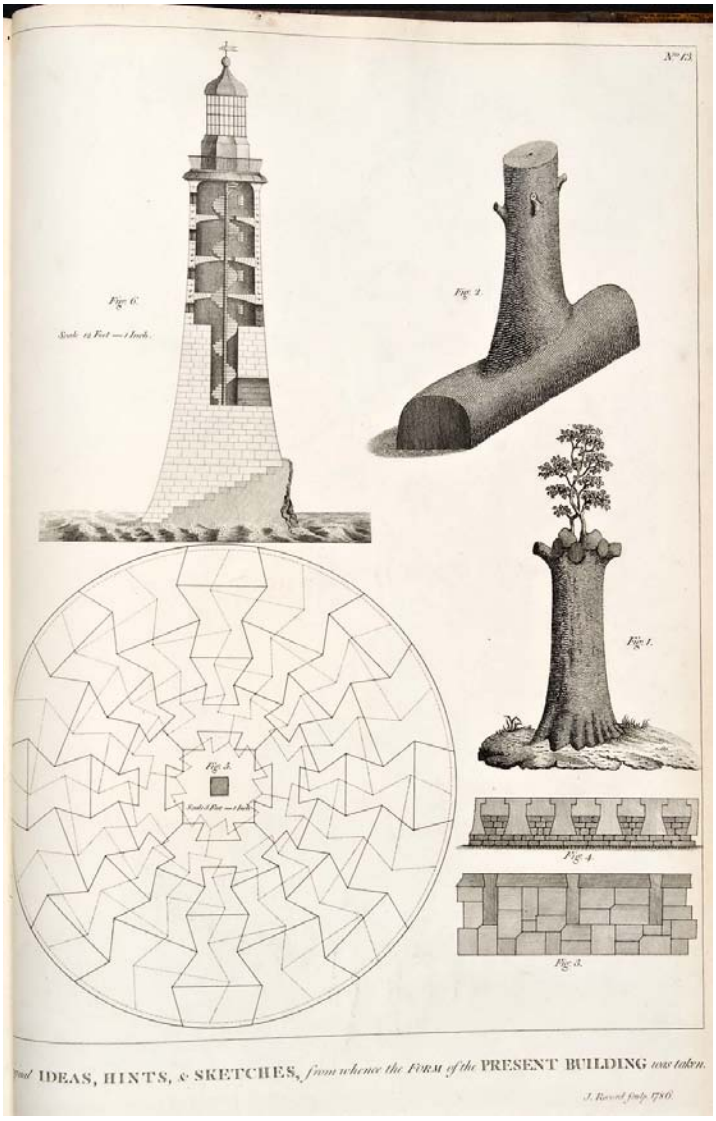


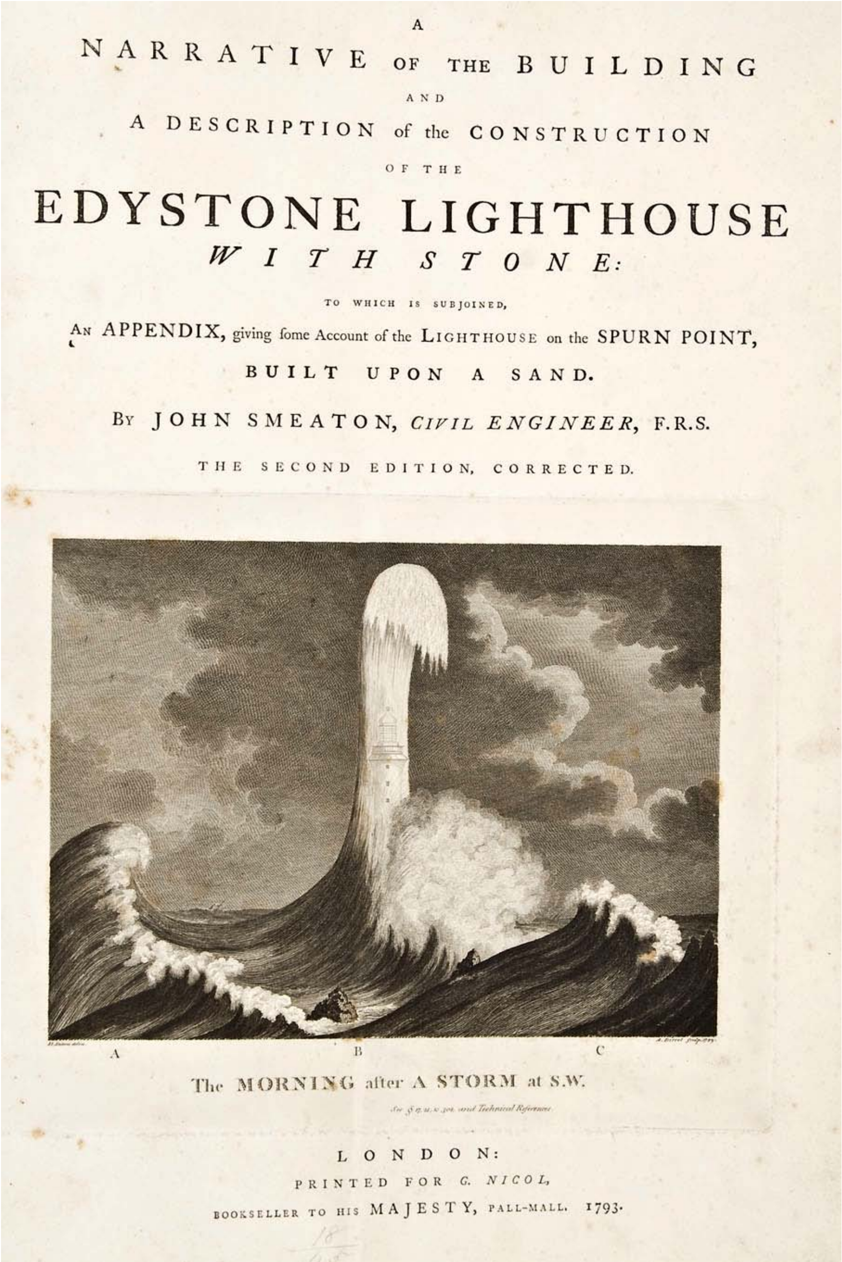
Figure 105: (1786) J. Record, sculp. ‘Plate 13: Original ideas, hints, & sketches from whence the FORM of the PRESENT Building was taken’ John Smeaton *A narrative of the building of the Edystone Lighthouse, second edition* (1793)

In the Institution of Civil Engineers, despite the constant growth in membership numbers (Buchanan 1989: 63), members resisted plans for formal control of entry either through educational standards, or ethical practices (Buchanan 1989: 70-73) until well after 1850. Buchanan's own recognition of the open-ended nature of entry to engineering and his note of the 'increasing fragmentation' of engineering associations that continued through to the end of the nineteenth century (Buchanan 1989: 124) thus constantly undermines his assumption that formation of a professional 'community' of engineers, was the same thing as the establishment of the Institution in the first half of the nineteenth century.

Other locations and social networks formed communities of engineers apart from the Institution of Civil Engineers. Well-known prestigious employers such as Boulton & Watt, George and Robert Stephenson, or Henry Maudslay (Cantrell and Cookson 2002: 12-14) all trained cohorts of engineers in their own distinctive practices; in turn, many of those engineers later set up in business independently and took their own pupils; these established networks were structures most apparent to outsiders: 'the education of the young engineer... follows the plan of most of the unprivileged professions; a system of private pupilage or apprenticeship' (Thomson 1857: 298). Equally, despite Thomson's inaccurate claim that 'a college of civil engineers once existed, but it has long ago been broken up' (Thomson 1857: 298), in fact many academic communities had come into being before Thomson's time to teach engineering. As well as the Putney College for Civil Engineers (Marsden 2004: 415-7), Thomson's probable reference, other courses were in existence such as at University College London from 1833 (Simon 1974: 124), King's College London (1838), Durham (1840), Glasgow (1840), or Owens College Manchester (1851) (Reader 1966: 136; Marsden 2004: 415-7). At Cambridge University, although there was no chair in engineering until 1875, courses in mechanics had been offered to students mainly through the vehicle of the Jacksonian Professorship of Natural Experimental Philosophy starting with William Farish (1759-1837) (Hilken 1967: 33; 38-45; Becher 1986: 67; Marsden 2004: 415). Academic communities like these had a fragmenting effect and made it hard to 'circumscribe the profession'. In addition, engineers were also being trained in military schools and practices (see Chapter 3), as well as continuing to enjoy close links with architects and their work (see Chapters 2 and 6). Such opposing locations, styles and philosophies of education shows that engineers had different ways of understanding and expressing professional aspiration, certainly in comparison to occupations with stronger and more definite boundaries such as medicine (Barley 2005: 391).

The world of industrial readers

Professional status depended on building an audience. This section is about engineers whose professional practice was formed through writing and also through developing and promoting modes of technical drawing in wider visual culture. As noted, consulting engineers like Smeaton had worked largely as authors of illustrated texts when they prepared reports of projected work. In Smeaton's case, this style of working was carried over to the narrative of the Eddystone Lighthouse, in which Smeaton popularised his work for general readers, presenting himself as an educated, brave and resourceful natural philosopher and master of the application of practical arts. Building a lighthouse allowed Smeaton to present engineering as a both a rational public enterprise and as a daring romantic gesture. Indeed, the title page of John Smeaton's second edition of *A narrative of the building of the Edystone* (sic) *Lighthouse* (1793) carried a dramatic image of the lighthouse almost swamped by supernatural wave forms: 'The morning after a storm at SW' (Figure 106, over page). This image was widely pirated and imitated through the nineteenth century, making the Edystone lighthouse into the supreme 'sublime edifice' of the period (Picon 1992: 233; 241). In addition, Smeaton's reports also functioned first as textbooks in their own right, later being appropriated into a genre of technical instruction by engineers such as John Farey, Jr. (Woolrich *ODNB* see also Chapter 5) and William Johnson (1824-1864).


A
NARRATIVE OF THE BUILDING
AND
A DESCRIPTION of the CONSTRUCTION
OF THE
EDYSTONE LIGHTHOUSE
WITH STONE:
TO WHICH IS SUBJOINED,
AN APPENDIX, giving ſome Account of the LIGHTHOUSE on the SPURN POINT,
BUILT UPON A SAND.
BY JOHN SMEATON, *CIVIL ENGINEER*, F.R.S.
THE SECOND EDITION, CORRECTED.

A B C
The MORNING after A STORM at S.W.

LONDON:
PRINTED FOR *G. NICOL*,
BOOKSELLER TO HIS MAJESTY, PALL-MALL. 1793.

Figure 106: M. Dixon, delin.; A. Birrel, sculpt. (1789) ‘The morning after a storm at SW’ , from the title page of John Smeaton *A narrative of the building of the Edystone Lighthouse, second edition* (1793)

In this section I examine the ways in which engineers aimed to promote confidence in engineering as a rational public enterprise through popularising or communicating engineering drawing techniques. John Farey and William Johnson both formed their own professional status as writer engineers. Farey demonstrated the use of technical illustration as a mode of data gathering and information management, appropriating knowledge through mechanical techniques of assembly and inscription; the apparent accuracy and openness of his style however does not necessarily reveal the ‘hidden workings’ of the machinery he depicts. William Johnson by contrast urges a performative style of authority, inviting the reader to develop their own personal skills though a union of art and theory in the habitual practice of drawing.

John Farey, Jr. achieved public eminence as an engineering consultant and patent agent; for example giving evidence to the Select Committee on Patent Laws in 1829 (Musson and Robinson 1969: 63; Dutton 1984: 86-8; Woolrich *ODNB*). He became a member of the Institution of Civil Engineers in 1826, and towards the end of his life acted as a juror for the machinery section of the Great Exhibition of 1851 (Woolrich *ODNB*). However, his later professional standing was based on the training he received by observing machinery and developing techniques of writing and draughtsmanship while working on Rees' *Cyclopaedia* (1802-1819) from 1805 in collaboration with Wilson Lowry the steel engraver (see Chapter 5). Farey observed and recorded many kinds of machines assiduously as part of the family business of writing about and popularising science and the mechanical arts. In this his training paralleled that of other engineering pupils who worked in the drawing office of their principal. However, Farey developed and expanded the visual language of engineering in a distinctive manner by elaborating mechanical drawing techniques. In his work he exploited a hidden resource in his possession, the Smeaton archive of drawings (Royal Society Smeaton drawings JS/1-6) and his Reports, acquired through a series of chances.

In the absence of other textbooks Smeaton's published drawings and Reports were, as noted in Chapter 2, sought after by engineers (Chrimes 2003: 39). However, they were almost impossible to find. After Smeaton died in 1791, Sir Joseph Banks (1743-1820) had purchased the almost complete set of Smeaton drawings and a substantial number of report books from the family (Skempton 1981: 236). In 1795, the Society of Civil Engineers suggested republishing a complete set of the Reports, and secured the agreement of Banks to use his archive without copyright for this purpose. The process of raising subscriptions and organising publication took some time, but in 1806 Banks handed the archive over to John Farey Jr. then aged fifteen, so that Farey could copy and reduce the drawings to quarto size, ready to be passed on to the engraver, Wilson Lowry (Skempton 1981:242). After Banks's death in 1820 the Smeaton papers that had been on loan to Farey, effectively passed into his hands, and they remained in the family until Farey's son eventually bequeathed them to the Royal Society in 1913 (Skempton 1981; 244-5). While Smeaton's drawings were in his care, John Farey organised them into a system of his own devising, pasting the drawings into bound volumes where they still remain (Skempton 1981: 245; Woolrich 1985: 181-216); these events have given the Smeaton archive a much more broken provenance (see Chapter 2).

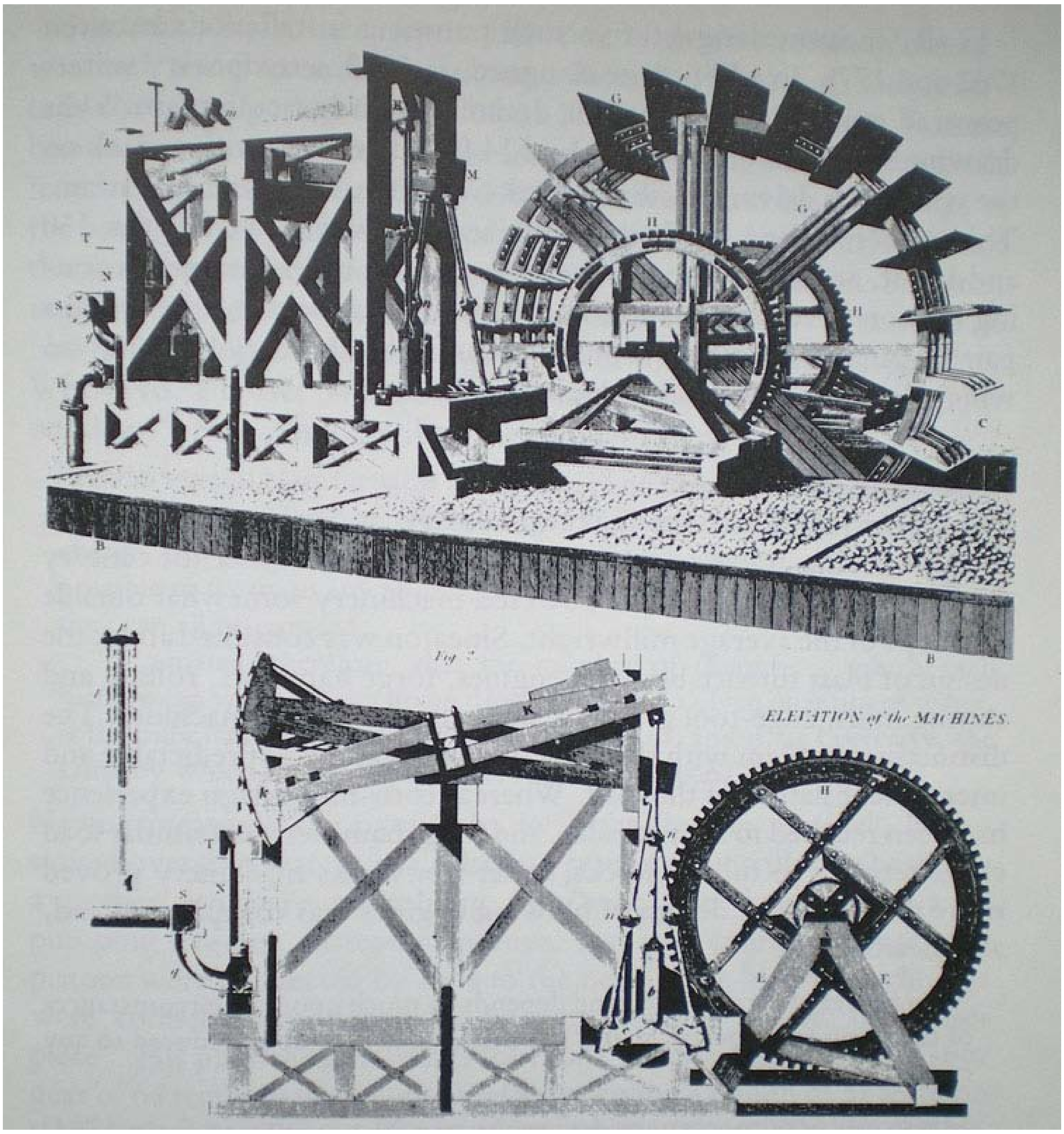


Figure 107: John Farey, draughtsman, Wilson Lowry engraver London Bridge engines in Rees' *Cyclopaedia*

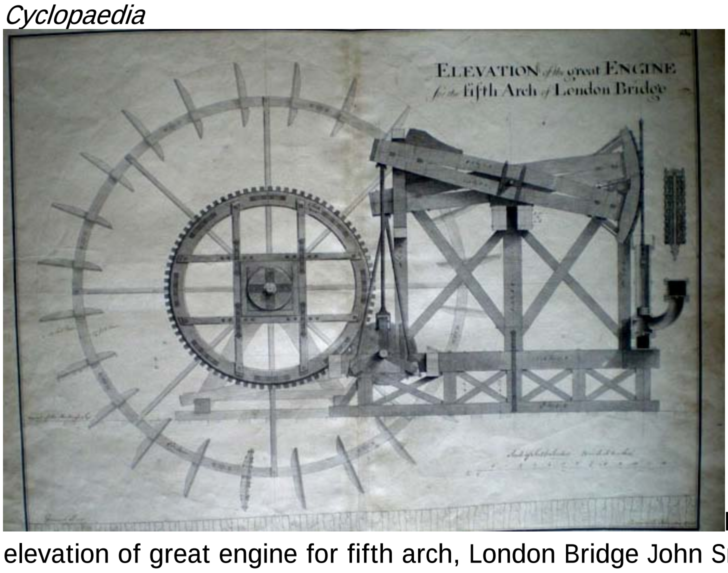


Figure 108: John Smeaton elevation of great engine for fifth arch, London Bridge John Smeaton drawings, Royal Society JS/2/183

Farey used the Smeaton drawings as illustrations for Rees' *Cyclopaedia*, and at the same time, by making substantial use of the written parts of the Reports, he began to produce articles and longer texts as well, such as his 1827 *Treatise on the Steam Engine* which drew heavily on Smeaton's notes (Skempton 243-40). He exploited his gift by adding his own ingenuity to it. In Rees' *Cyclopaedia* Farey developed new and different conventions of technical representation. In the example shown at Figure 107, he showed on one single page a conventional elevation as used by Smeaton, (Figure 108 shows the original drawing; the print version reverses this and also leaves out the external parts of the water wheel) supplemented by a pictorial perspective view to give a three-dimensional effect, from a slight oblique angle. To make such views, he would make a sketch of the machine in question on site with the help of a Wollaston-type camera lucida, using pencil. With the camera lucida the draughtsman in effect traces the outlines of the image seen in the viewing device in a mechanical way. All he wished to do at this stage was to establish a convincing perspectival recession, so he could position his vanishing points more firmly later on, and also note the details that needed to be worked up later. As can be seen in the detail shown from Figure 109, Farey's underdrawing at this point was extremely sketchy.

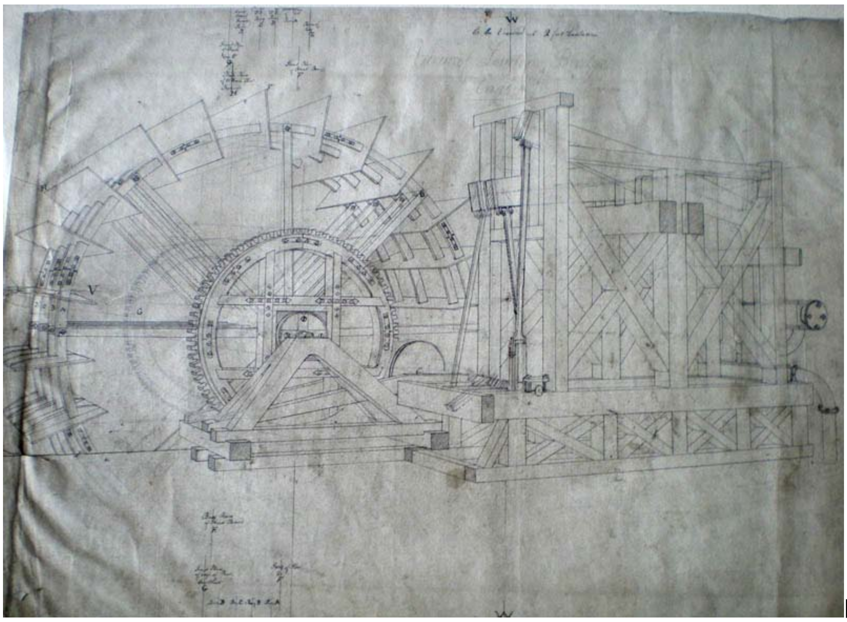


Figure 109: John Farey, Jnr. First drawing for London Bridge waterwheel. John Smeaton drawings, Royal Society JS/2/184, see over page for detail

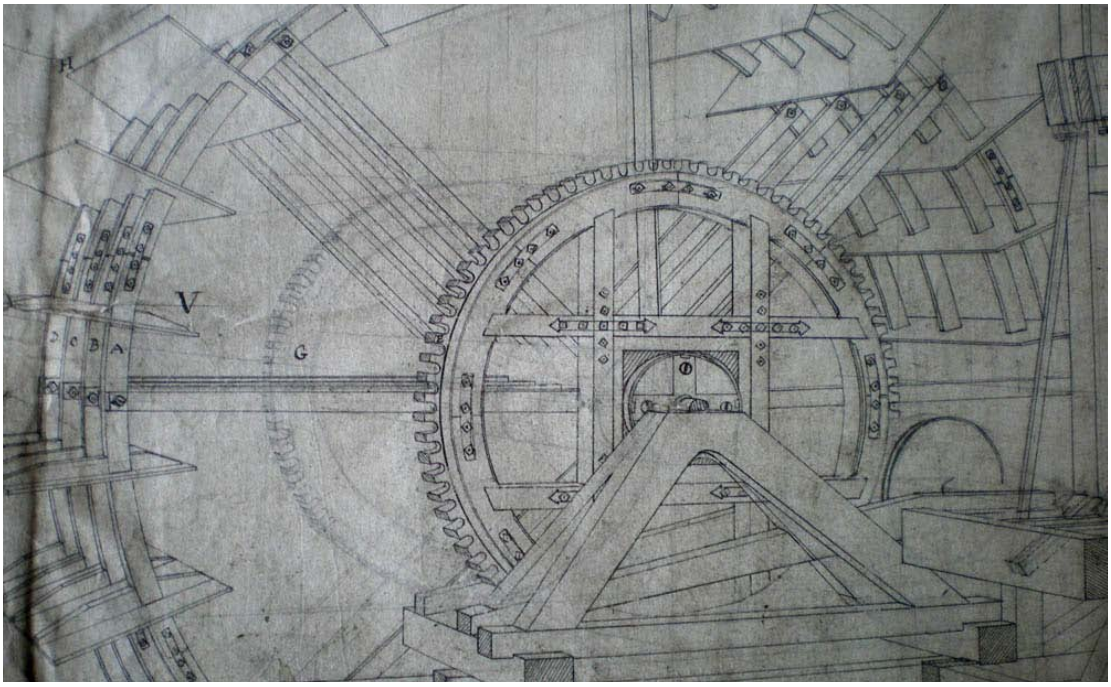


Figure 109: John Farey, Jnr. Detail of First drawing for London Bridge waterwheel, showing pencil underdrawing. John Smeaton drawings, Royal Society JS/2/184

Farey transformed his rough notation when he worked it up in ink, with the aid of mechanical drawing aids to create an effect of accuracy, ranging from ruler and compass, through to his own inventions, the elliptograph (see also Chapter 5) and centrolinead (Woolrich 1998: 50). A self-reflexive commentary on technical drawing, and the technical apparatus needed to support it, appeared in the article 'Drawing instruments' in Brewster's *Edinburgh Encyclopaedia* (Farey 1830: 121-132). We can see a description of his pragmatic method, dependent on the machine rather than on calculation in the use of the elliptograph:

> 'All that is required, as data for describing any ellipsis… is to sketch them in pencil on the paper, and mark, by the compasses, the four points upon each curve where its two diameters intersect it. Place the instrument upon the paper in such a position, that, by estimation of the eye, the centre of the four rulers seems to coincide with the centre of the intended ellipse' (Farey 1830: 132).

Farey is quite clear here; in place of the skill of the artist's hand and eye, that had previously been valued, he proposes both through text and through visual example an engineered solution to the task of observational drawing. Although many artists had used such devices in a secretive way, Farey did not hide this aspect of his practice. Instead, he celebrated mechanical drawing aids, and aimed to disseminate these techniques through articles such as the long essay in the *Edinburgh encyclopaedia* quoted above. Less openly, he appropriated, adapted, and disseminated Smeaton's drawings and reports in new forms and combinations; and equally, Farey's technique captured mainly a surface appearance. As noted in Chapter 5, these accurate-looking images did not reveal inner workings, nor are they necessarily accurate guides for assembly or construction (Woolrich 1998: 65). The totality of his working life, travelling and observing machinery, composing illustrations, writing and other journalistic work, built up a body of texts and images in the first decades of the nineteenth century that developed the notion of 'engineering' in public culture, and also built a professional expertise and reputation for Farey the future patent agent.

This notion of professional activity is in line with recent notions that one role adopted by technicians is as a 'broker': one who mediates between communities that produce technologies and communities of users that have little or no technical knowledge (Barley 2005: 391). Indeed, a similar role was outlined by Samuel Clegg, Jnr. (1814-56 Boase *ODNB*), the Professor of Civil Engineering and Architecture at Putney College, when he asserted how important it was for the engineer to produce 'pleasing effects upon the eye of the observer… [because] those for whom machines are constructed cannot enter into the merits of their internal action or their comparative performance; and therefore, not being willing to yield the right of opinion, judge from 'outside show' as they would of a picture or statue'(Clegg 1842: 2). Clegg and Farey both suggest in their visual practice that one aspect of professional behaviour is to sway the uneducated observer with a 'pleasing effect'. William Johnson by contrast suggests that professional engineers should use a variety of avenues, both theoretical and practical, to develop observers as knowledgeable associates.

Editing and writing texts on engineering and technical drawing dominated William Johnson's professional life. He was a working engineer and patent agent, becoming a member of the Institution of Mechanical Engineers from 1849 (IMechE MPF/1/13; MSB 1/100), and an Associate member of the Institution of Civil Engineers from 1850 (obituary, *PICE* 1866 (25): 528-9). From 1845, when he was aged 22, Johnson began working as the sub-editor of the *Glasgow practical mechanics' and engineers' magazine*, taking over as editor in 1848 when the title changed to *Practical mechanics' journal*. His most well-known and substantial publication was the *Practical draughtsman's book of industrial design* (1853), an edited translation from the French *Nouveau cours raisonnée de dessin industriel appliqué* (Armengaud and Amouroux 1848). The *Practical draughtsman's book*, praised by the *Mechanics' magazine* as meeting a long felt lack in the English-speaking world for such a text (19 February 1853: 152-3), was sufficiently in demand to prompt three editions to 1869.

The ostensible function of the *Practical draughtsman's book* seems to fit into a 'literary culture' of exposition and instruction in the mechanical arts that had been established since the eighteenth century through such exemplars as encyclopaedias or self-help magazines (Marsden and Smith 2005:239). The literary cultures of engineering developed to embrace several genres such as popular education, theoretical science, report-writing, biography, self-advertisement, or narratives of colonial conquest during the nineteenth century. Johnson's text unfolds into at least two types of writing; but more importantly it displays the overall characteristic that distinguishes the 'literary culture' of engineering predominant in encyclopaedias and similar texts, that is, the visual element. Such texts are not simply illustrated but more fundamentally engage with the practice and philosophy of drawing, so that there is a non-verbal discourse developing in the text alongside what is written.

It is important to note the derivation of Johnson's text, translated from French, the most-feared trade rival of Britain. The principal author of the French version Jacques Eugène Armengaud (1810-1891) was himself a prolific author, educator and promoter of the 'useful arts' in France. He was editor of the *Publication industrielle* 1841-75 a serial publication of elegant machine drawings and descriptive text (Edmonson 1987: 179), and Professor of machine drawing at the Conservatoire des arts et métiers in Paris from 1835 (Edmonson 1987: 200-209). The Petite école of the Conservatoire was a school of draughtsmanship directed not at elite engineers but at mechanics and foremen. In contrast to the abstract and theoretical teaching of Mongean descriptive geometry at the elite Ecole polytechnique, the Petite école approach insisted that the teaching of mechanical drawing should be completely integrated with design and construction of machines in the workshop (Edmonson 1987: 182-88). The first professors of the Conservatoire in 1816, Gérard-Joseph Christian and also César Nicholas Leblanc, wished to promote through their teaching an efficient, benign workers' utopia in which intelligent artisans delegated fatiguing work to machines (Alexander 2008: 33-51). So Johnson's adaptation of this French text played to several British anxieties about arts and manufactures as it was a document produced within the very French state system of technical education that British design reformers had been invoking since at least the time of the Select Committee of 1835-6.

The central section of the *Practical draughtsman's book* followed the French original closely, with graded instruction in both mechanical theory and in drawing techniques.

These were discussed systematically, and broken down into elements such as ‘shadow-lining’ (Johnson 1853: 26), or mixing and applying watercolour, with some suggested conventions of use, for example Prussian blue to denote wrought iron (Plate 10 in Johnson 1853: 35 *not illustrated*). The draughtsman was also introduced to the most frequent geometrical forms used in industrial drawing, with a discussion of techniques and drawing aids, starting with straight ruled lines, and geometrical constructions with ruler and compass, then expanding to include forms generated in a more complex way, for example the ellipse, and the various types of ellipse drawing machines (Johnson 1853: 17). Johnson’s notion of informed draughtsmanship embraced elegant delineation, industrial design, and pattern making, and his instructions mainly concentrated on the ‘geometrical demonstration [that is, the grasp of theory] embodied in the drawing’ in addition to a consideration of the ‘physical difficulties of making patterns for both wooden and cast iron construction’ (Johnson 1853: v). In this text drawing, that emphatically includes pattern-making, is defined as a kind of central cognitive activity between theory and material shaping. Examples of the tasks for students following the text included how to calculate and specify complex forms, as in Chapters V and VI on screws, helixes, and intersections of curves, including the theory and construction of toothed gearing mechanisms (Johnson 1853: 63-95). The edited text directed the reader both to further theory, as for example Robert Willis’s essay on the teeth of wheels, first presented to the ICE in 1835 (Johnson 1853: 84) and also gave examples of how to apply that theory in fully realised drawn visualisations (Figure110).

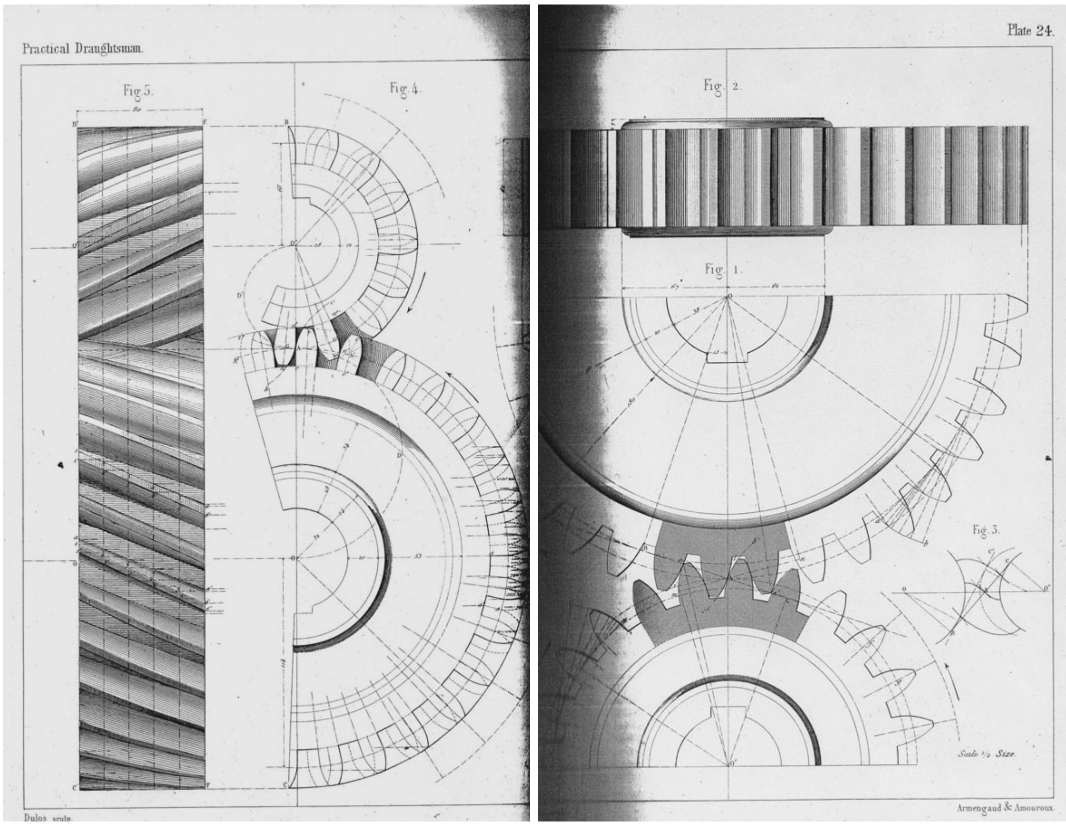
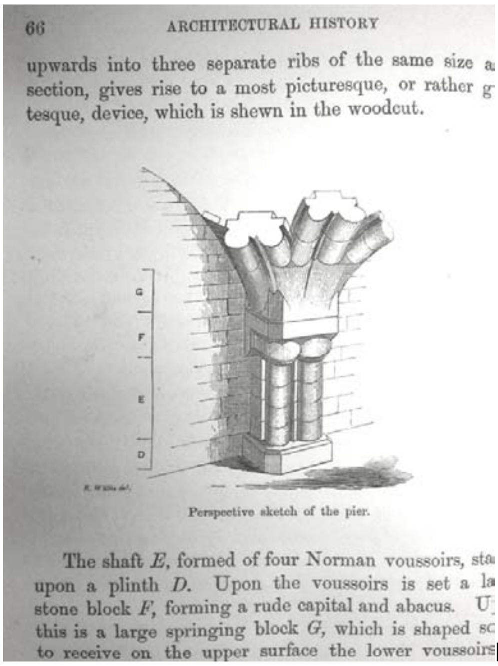


Figure 110: Plate 24 from the *Practical draughtsman's book of industrial design* (1853: facing 82-3)

So the main meat of this book is presented in the ostensibly objective, factual manner of the textbook, although there is a strenuous tone of constant striving and improvement built in. A similar but more overt mode of exhortation comes across in another publication that Johnson was associated with, the *Practical mechanic and engineer's magazine*. In the article 'Education of a civil engineer' a draconian programme of engineer self-education was put forward. The article advised the seventeen-year-old 'engineering chrysalis' to begin a course of exacting practical training; forging and shaping machinery in the factory, working in mines, taking in some architecture, and meanwhile not neglecting to use his leisure time in continually making sketches and drawings of machines (this assumed there had already been earlier years of study mastering modern languages, ornamental drawing and sketching, mathematics, mechanics, surveying, linear and isometrical perspective drawing and natural science). By the time he reached his early twenties the article conceded such an assiduous student might almost be ready to become the pupil of a working engineer (*Practical mechanic and engineer's magazine* 17 September 1842: 461-3).

In the *Practical draughtsman's book*, as well as the 'moral improvement' mode that inflects the textbook style, we can also see the influence of contemporary artistic preoccupations infusing the text, as for example in the instructions at a very early stage of the book on how to generate ‘elementary Gothic forms’ (Johnson 1853: 15). At first sight this seems to be a straightforward reflection of the widespread currency of this style in architectural and engineering structures in Britain at this time. It is however also likely that this also represents a nod of allegiance to the ‘rationalist’ camp of the quarrelsome Gothic revival, in accord with the views of William Whewell and Robert Willis. Whewell and Willis were enthusiastic amateurs of Gothic architecture, which they analysed as a play of structural forces (Becher 1991: 6; Mallgrave 2006: 362-5; Yanni 1997: 204-221), described by Whewell in visual terms as a kind of diagram: ‘lines of pressure... the prominent features through arches, vaults and ribs (Whewell 1842:15). Willis meanwhile relished the contortions of formal manipulation rather more anthropomorphically, as observed in the image shown in Figure 111. This structural view of the Gothic was in conflict with other influential advocates of this style, for example A.W.N. Pugin, who valued it for its invocation of a less materialistic past, or John Ruskin, who loathed the notion of formal and structural analysis, believing instead that the style, relying on attentive educated artisans, could destroy capitalist and industrial relations of production.


66 ARCHITECTURAL HISTORY

upwards into three separate ribs of the same size
section, gives rise to a most picturesque, or rather
tesque, device, which is shewn in the woodcut.

The shaft *E*, formed of four Norman voussoirs,
upon a plinth *D*. Upon the voussoirs is set a
stone block *F*, forming a rude capital and abacus.
this is a large springing block *G*, which is shaped
to receive on the upper surface the lower voussoirs

Figure 111: Robert Willis (1866) *The architectural history of Glastonbury Abbey*: 65-6, where he describes the ‘picturesque, or rather grotesque device’ where the forms are ‘ingeniously managed so as to represent dying downwards upon, or interpenetrating the upright prism

Whewell and Willis were both cited elsewhere in Johnson’s text as authorities on the science of engineering, and although the *Practical draughtsman’s book* does not refer to Whewell and Willis in relation to the Gothic revival, there is enough evidence in his writing to suggest that Johnson was signalling an allegiance to the ‘modernizing’ wing of wider cultural debates about the function of design. The date of publication (1853) and other references in the supporting essays in the *Practical draughtsman's book* indicate a direct allegiance with 'design reformers' such as Henry Cole, and with the context of the Great Exhibition of 1851 and its mission to educate and improve public taste.

These wider cultural claims are most evident in the preface and the substantial concluding sections that were written entirely by Johnson, and where he argued eloquently for the role of technical drawing as a means of expression in an educated modern society. This framing material appears to be in a very different genre. In the period to 1850, design reformers and men of science had formed strategic allegiances with engineers and entrepreneurs in the planning of exhibitions of design and manufactures, notably during the BAAS meeting in Glasgow in 1840 and accompanying exhibition of 'mechanical science' organised by James Thomson; also in the Great Exhibition 1851 (Morrell and Thackray 1981: 260-4; Marsden and Smith 2005: 232-3). In his flanking essays Johnson defended his own specialisms in relation to these specific contexts by making large, reasoned claims about the function of technical and mechanical drawing skills in artistic and also scientific intellectual life.

In the preface to the *Practical draughtsman's book*, Johnson cited Robert Boyle (1627-91 Hunter *ODNB*) the natural philosopher and John Herschel (1792-1871 Crowe *ODNB*) the Cambridge man of science, mathematician and astronomer, in his vision of a liberal commonwealth of knowledge in print: 'next to the establishment of scientific institutions, nothing has exercised so powerful an influence on the progress of modern science, as the publications of scientific periodicals... Yet, without the aid of Drawing, how can this desired reciprocity of information be attained; or how would scientific literature fulfil its purpose, if denied the benefit of the graphic labours of the draughtsman? Our verbal interchanges would, in truth, be vague and barren details, and our printed knowledge, misty and unconvincing' (Johnson 1853: iii). In addition, he claimed that drawing could instil 'sound and accurate ideas' because the act of delineation forced the draughtsman to develop an intellectual, theoretical grasp of his idea that was then consolidated by working out all details. Drawing, in his view had thus become a powerful stimulant to material and intellectual progress, because it is a mode of research: 'We have outlived the times of random construction, and the mere heaping together of natural substances. We must now design carefully and delineate accurately before we proceed to execute' (Johnson 1853: v).

Johnson's closing remarks made even more explicit references to contemporary debates about the ennobling mission of design. Here Johnson brought together in one passage the writings of both John Ruskin and of William Whewell in his address to the 'world of industrial readers' (Johnson 1853: 196). Johnson began with a quotation from *The stones of Venice*: 'On the right side are men of facts; on the left, the men of design; in the centre, the men of both' (Ruskin 1903-12 10: 217 [1853]), misattributed to *Modern painters* (Ruskin 1843-6), and then continued:

> Let it be our mission to weaken this disunion of the two first, by adding to the weight and number of the centre or composite class. The right and left may each hold to, and discuss their respective facts and designs, but nothing really good can arise from all this, until the practised experimentalist shall impose a check upon the theoretical designer, which the latter will again return, in opposing the false deductions arising from misapprehended facts. "Art," says Whewell, "is the parent, not the progeny of science; the realization of principles in practice forms part of the prelude, as well as the sequel, of theoretical discovery." But we must guard against the empiricisms of practice by judicious theoretical comparisons. Our men of practice and our men of science have lived too much apart. "The dexterous hand and the thoughtful mind," the labourer who toils with sweated brow, and he who exerts the conceptions of the imaginative brain, find their strength in union alone (Johnson 1853: 196).

This rousing defence of the middle way of the practical draughtsman ends with the author's dedication of his book to the 'industrial reader', embellished with the only non-technical image of the volume, a vignette of a great ship launching from the slipway and making for the bright open sea, surrounded by a cheering crowd, a symbol of new beginnings on the journey of life, and a compliment to his Glasgow readers and patrons in a city with an expanding shipbuilding industry.

In his writing and drawing practice, Johnson asserted his identity as a working engineer, through the demonstration of his own drawing skills and in this sense he appears to claim a 'performative' style of authority described by Gooday (2008: 445) as behaviour set in opposition to the intellectually specialized expert. Johnson invites the reader of the *Practical draughtsman's book* to follow the same path as himself in order to develop a similar level of tacit or embodied knowledge. Equally, the written text, and his editorship of the *Practical mechanic and engineer's magazine* was an assertion of the literary cultures of engineering developing through the nineteenth century. In this field of professional practice, unlike the 'expert' elite man of science, publishers preferred someone who could perform; with proven communication skills and also who knew how to keep to deadlines (Lightman 2007: 29).

Johnson's professional practice as a writer is one example of how status could be negotiated in public life by building an audience for the particular expertise of engineers at the time of the Great Exhibition of 1851. Sociological genre analysis addresses texts as negotiations made to advance the interests of a group (Duff 2000: 276; Bhatia 1993: 59); these texts show how engineers were embroiled with other groups competing for cultural status, for example the BAAS or the 'design reformers', and in his work Johnson defended his own specialism through argument and also through displaying a perfomative authority. Unlike Farey, whose writing appears to build a non-technical audience for engineering, some of Johnson's writing appears instead to recruit active technicians.

Isometric drawing

Isometric drawing was first developed in the privileged liberal environment of Cambridge University around 1820, but it was also later associated with the contexts of artisan self-education and with bravura draughtsmanship. In relation to visual practices, this apparently simple style illuminates some of the discords in accounts of professional formation of engineers in the nineteenth century in relation to social status. Isometric drawing, described by Peter Booker (1979: 114-5) as the most influential mode of technical drawing in Britain, was developed and used by William Farish (1759-1837 (see Hilken 1967: 38-45) as a method for assembling apparatus for his lectures, and subsequently published as 'Isometrical drawing' in the first volume of the *Cambridge Philosophical Transactions* that is, the organ of the Cambridge Philosophical Society (Farish 1821: 1-19). Farish's publication of his system of isometric drawing relates to narratives of professional formation (he announced this just after the institution of civil Engineers came into being), and to the communities of engineers and the 'liberally educated' connoisseurs of engineering structures that Whewell aimed to foster. Finally, as isometric drawing was a style that was appropriated by many draughtsmen and educators in other environments, it is an example of how notions of gentlemanliness, professional conduct and technical styles of drawing played out in practice.

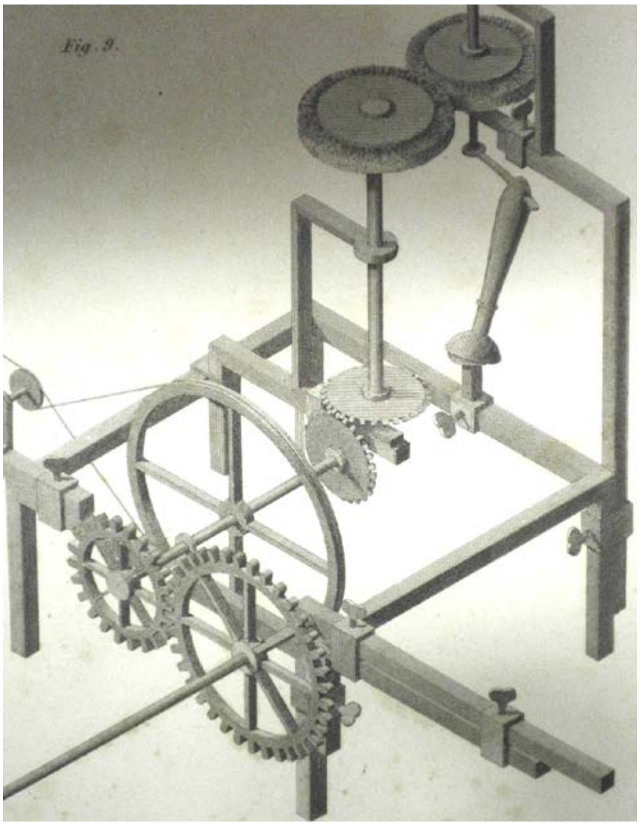


Figure 112: Plate illustration from William Farish 'On isometrical perspective' *Cambridge Philosophical Transactions* (1821: 1-19)

The style of Farish's isometrical drawing (Figure 112) is unexpected, because it is so four-square and simplistic. Stylistically it is very similar to Martin Rudwick's now well-known example of the artisanal, dogmatic, 'masonry-like' 'engineering' style used by 'mineral geographers' such as William Smith or John Farey, Snr. (Rudwick 1974: 180-1), that Rudwick used in contrast to the visual language of gentlemanly 'traveller-naturalists' (who had a tentative observational landscape sketching style). Rudwick's discussion is relevant to my argument as he used his analysis of visual style in order to illuminate notions of 'gentlemanlike' science that related to the emergence of different factions in the Geological Society geology as it developed (Rudwick 1974: 149-195). The slabs of strata drawn by John Farey, Snr. (Figure 113), not at all tentative, were not approved by the ruling section of the Geological Society that rejected theory-based extrapolations in favour of gentlemanly induction (Rudwick 1974: 164-70). Indeed, Farey and Smith were frozen out of the Geological Society while Farey, father of John Farey, Jnr. also lost his work as a writer on Rees' *Cyclopaedia* in 1811 due to a disagreement about geological theory (*ODNB* Torrens).

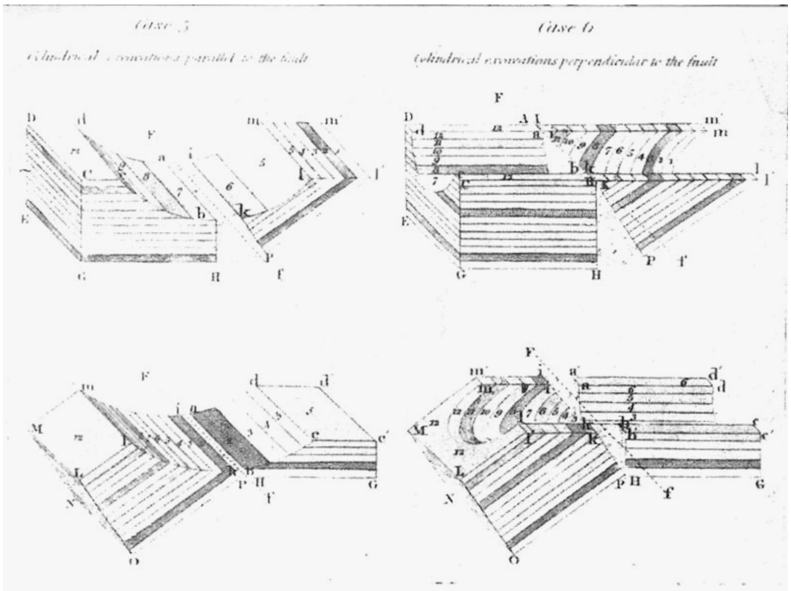


Figure 113: John Farey, Snr. (1766-1826) Plates from *Report of 1811 on Agriculture and Minerals of Derbyshire* described by Rudwick (1974: 180-1) as having a 'masonry-like ' and 'engineering' style.

In the same way, the style of isometrical drawing has a dogmatic simplicity that at first sight makes it appear more in accord with the 'artisan' style of Farey in Figure 113, or with the certainties that Shapin and Barnes discerned in the style of science conveyed to workers as a 'world of facts and laws [not provisional theories]' (1977: 50, Chapter 6).

Isometrical drawing is a so-called 'parallel projection' system (see also Chapters 5 and 6), presenting a compromise between two other conventions of representation, the technical and architectural orthographic style and the artistic pictorial style. Farish deliberately chose to make a new synthesis, rejecting firstly the technical mode of giving plan, elevation and side view because it failed to show at a glance how parts interlocked. But equally, he rejected pictorial perspective that uses effects of foreshortening and diminution of forms to create the effects of three dimensions because it is impossible to work out true scale easily, and because forms such as squares or circles become distorted into irregular forms. Farish's system was deliberately simple, both visually and in execution, as it can be drawn 'just with a common drawing table and two rulers' as in Figure 114 (Farish 1821: 2-3). Straight lines, which lie in the three principal directions, are all at the same scale (i.e. they are not foreshortened), and the right angles contained by those lines are represented by either 60º or 120º. Farish thus claims, with other technical draughtsmen, that his system of drawing for construction is natural and rational, for example when he states that he chose the angle of 60º because it is the easiest to draw of 'any angle in nature' (Farish 1821: 4).

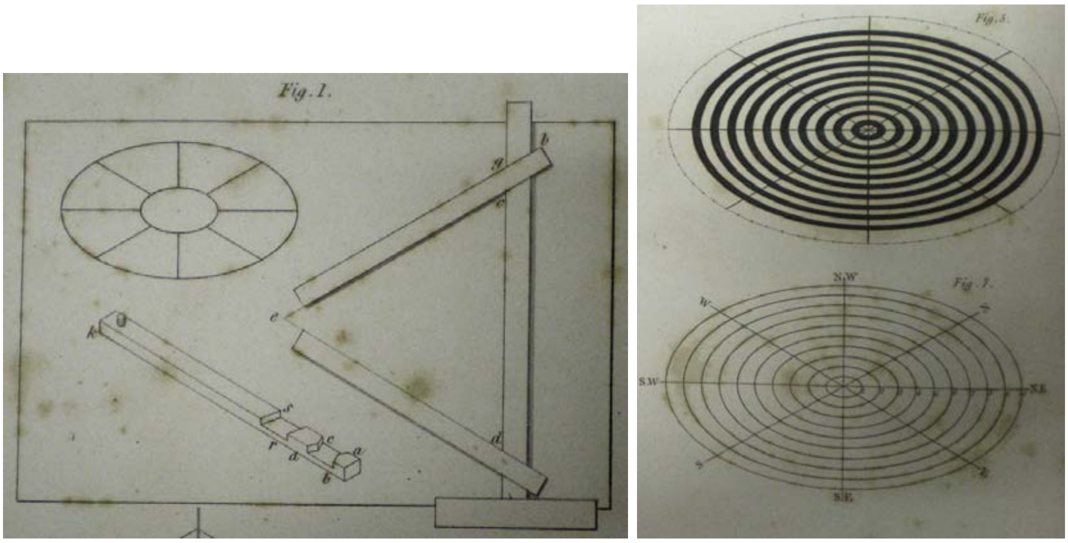


Figure 114: William Farish, details of second plate from ‘On isometrical perspective’ (1821: 1-19

Farish initially developed this style in order to direct the work of his assistants who had to set up apparatus for his lectures on the ‘The application of natural philosophy, natural history, chemistry, etc. to the arts, manufactures and agriculture of Great Britain’ given yearly from 1795 to1837 (Hilken 1967: 40-1). The section devoted to the construction of machines was the most innovative (and popular!) part of the course, both in content and method (Hilken 1967: 42). Farish’s desire was to exhibit principles of mechanism through actual working models of ‘all the most important machines which are in use in the manufactures of Britain.’ Having realised that it would be impossible to assemble and display detailed models of every individual example in use, instead Farish reduced them to an ‘apparatus, consisting of what may be called a system of the first principles of machinery; that is, the separate parts, of which machines consist’ and each part was so adapted to the other that they could be put together at pleasure (Farish 1821: 1) As the machine models thus had no permanent existence he wanted to make an accurate representation of them on paper so assistants could assemble them without supervision (Farish 1821: 2-3).

This narrative is well-known, largely through Peter Booker’s chapter in *A history of engineering drawing* (Booker 1979: 114-127), although as we shall see his attitude to this style is ambivalent. Isometric drawing was not new, although this application was. Similar constructions have appeared in non-Western art (Booker 1979: 18; Scolari 1985: 73) and, much closer to Farish’s knowledge, had been promoted as a useful kind of ‘military’ perspective in late eighteenth century Europe (Adams 1813: 465; Perez-Gomez 1997: 248; 274; Kemp 1990: 224). Several twentieth-century historians of architecture have interpreted the introduction of isometric drawing to visual culture as the harbinger of a modern technological world that for example was about to embark on the colonization of the 'fully de-sacralized' infinite resources of nature (Perez-Gomez and Pelletier 1997: 309; Brett 1987: 59; Bryon 2009: 339). By contrast, Farish's discussion of this style in the 1820s was very simple and unthreatening so that the method for creating representations became almost formulaic. For example, Farish noted that one big advantage of his method was that all ellipses denoting circles would be of the same form whichever plane they are on, so he even suggested using the template of concentric ellipses (Figure 114) he had already provided to trace off forms at the desired size (Farish 1821: 9-10), in other words he invites his readers to save themselves the trouble of calculating how to project forms. Farish's method of drawing was neither theoretical (he did not explain or describe the underlying theory of projection that lay behind this system) nor observational. Instead it was pragmatic and straightforwardly didactic; with a consciousness that the world and structures able to be delineated through this style would be equally simple. His technique worked, he noted, because machines themselves 'all lie in the isometrical planes', that is they were all strictly aligned on three perpendicular axes in a grid-like assemblage (Farish 1821: 8). Farish further asserted that his method was adequate to 'include almost every thing which occurs in the representation of models, of machines, of philosophical instruments, and indeed almost any regular production of art such as buildings, bridges, or interiors' (Farish 1821: 12). More boldly, his claim that this technique was very suitable for describing cities in plan because: 'most of the lines are isometrical' also shows his underlying assumption of a planned, grid-like neo-classical environment.

Interested observers from outside Cambridge soon spread Farish's method to different social environments. For example, Farish's article was summarised in 1824 in the *Mechanics' magazine* (Volume II (3) 10 April 1824: 66-7) and reprinted in full in Olinthus Gregory's *Mathematics for practical men* in 1825 (1825: 179-92). Gregory (1774-1841 Gordon *ODNB*) was a mathematician and educator at the Military Academy at Woolwich, who prepared his book for both military students and for members of the Institution of Civil Engineers.

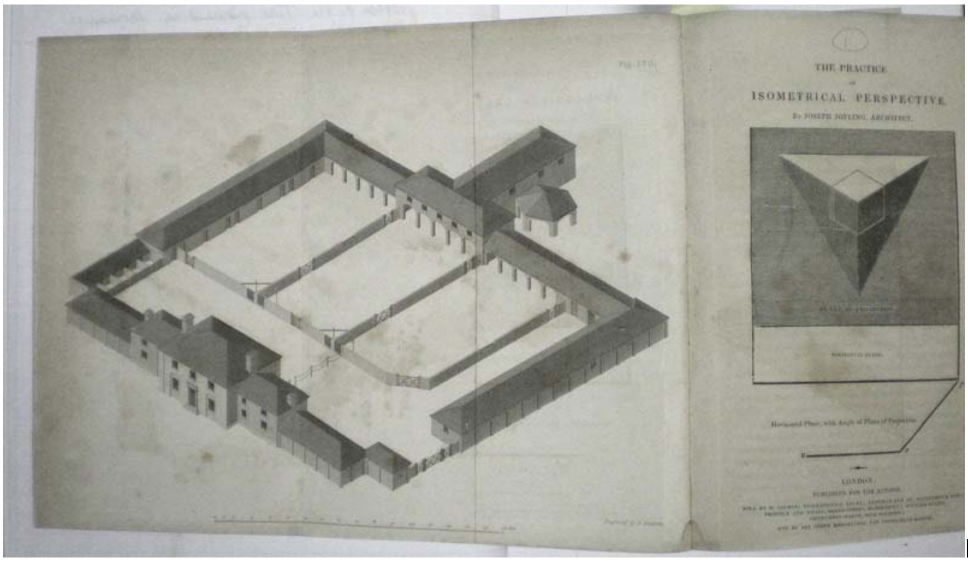


Figure 115: Joseph Jopling (1833) *The practice of isometrical perspective*, title page and frontispiece

Farish's work was acknowledged again in the 1830s when the method was explained and applied in more detail by Joseph Jopling firstly in more articles in the *Mechanics' Magazine*, then expanded in book form in *The practice of isometrical perspective* (Jopling 1833: iii), (Figure 115) followed by Thomas Sopwith's 1834 *A treatise on isometrical drawing* (1834) (Figure 116).

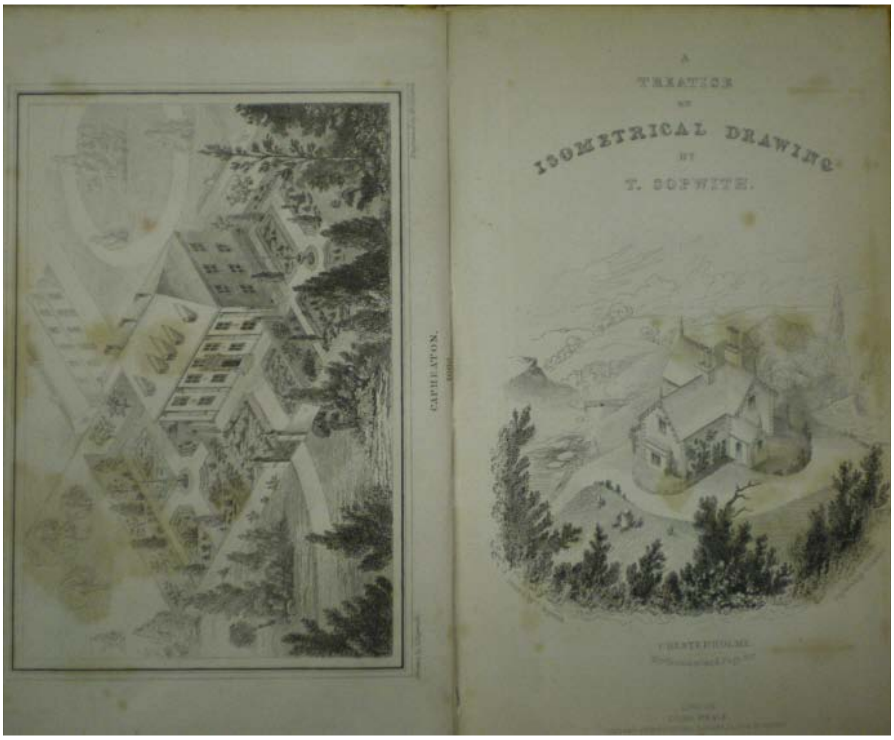


Figure 116: Thomas Sopwith (1834) *A treatise on isometrical drawing* Plate XXVI

Sopwith (1803-1879 Linsley ODNB) was a surveyor and engineer with many connections to literary, philosophical and scientific societies in the North East of England, with a particular interest in geology. He was influenced by the block diagrams of John Farey, Snr. of geological strata (Turner and Dearman 1980: 202) in his application of isometrical drawing to geological and mining plans as described in his book, addressing as his intended readers architects and civil engineers with further genteel additions, urging this technique as: ‘an agreeable occupation to Amateur Artists, and especially to Ladies, who are thus enabled to combine the beauties of Landscape, Architectural, and Flower Painting with correct delineations’ (Sopwith 1834: 1). In his treatise Sopwith advertised rulers and isometric paper for sale from his premises in Newcastle in his treatise, (Bryon 2009: 340) and we can see how one prominent engineer, Richard Beamish, was using isometric drawing onto ready-printed paper to make quick communications in his ongoing work on Brunel’s Thames Tunnel (Figure 117).

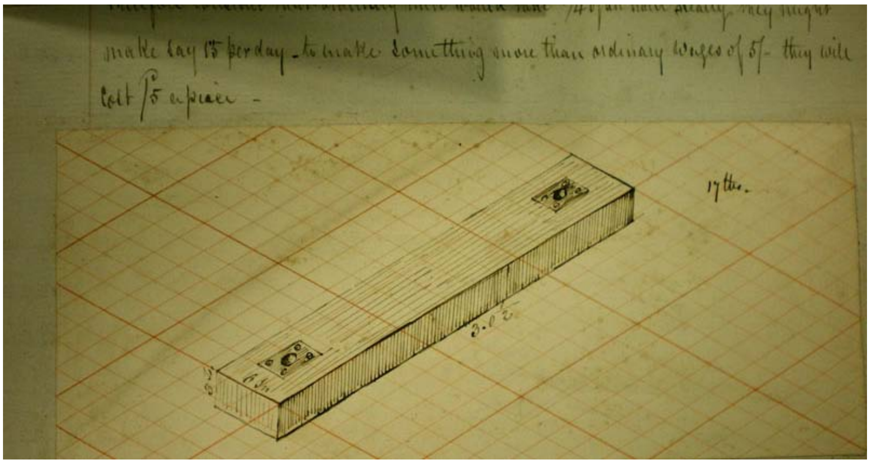
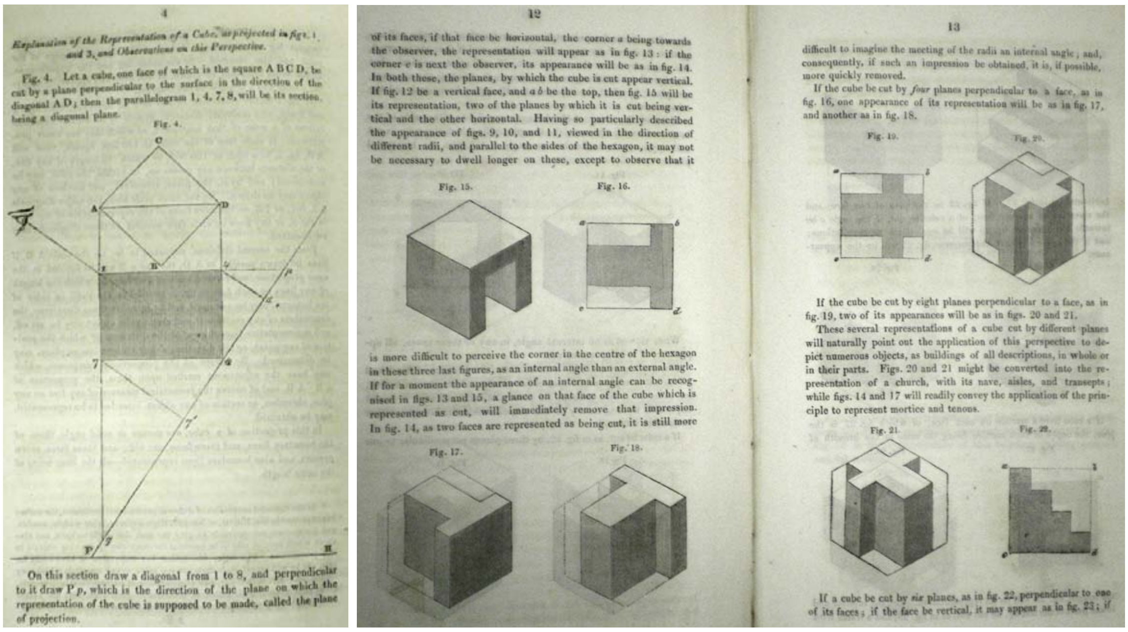


Figure 117: Richard Beamish Thames tunnel notebooks, Volume 3 (entry of 16th February 1836) Institute of Civil Engineers, Accession number 1827 BEADAD; UDC number 624.194 (421)

These examples show how engineers and educators disseminated this technique to working engineers, for scientific training of military men and amateur artists in different parts of Britain away from Cambridge. In the last chapter, we have also seen how the simple technique of isometric projection was adapted and elaborated to create spectacular decorative graphic work by the professional draughtsman Heming (Chapter 6, Figure 103). In addition, Joseph Jopling, architectural writer, developed a teaching text on isometrical drawing for artisans. In contrast to Farish’s light touch, Jopling’s text of 1833 (also printed in parts in the *Mechanics’ magazine*) really laboured at the opening to get across the conceptions and abstract geometric operation of the planes of projection (Jopling 1833: 1-8) before setting the conscientious reader on a muscular series of worked examples (see Figure 118) through fifty more octavo pages.



4

Explanation of the Representation of a Cube, as projected in figs. 1 and 3, and Observations on this Perspective.

Fig. 4. Let a cube, one face of which is the square A B C D, be cut by a plane perpendicular to the surface in the direction of the diagonal A D; then the parallelogram 1, 4, 7, 8, will be its section, being a diagonal plane.

On this section draw a diagonal from 1 to 8, and perpendicular to it draw P p, which is the direction of the plane on which the representation of the cube is supposed to be made, called the plane of projection.

12

of its faces, if that face be horizontal, the corner a being towards the observer, the representation will appear as in fig. 13: if the corner c is next the observer, its appearance will be as in fig. 14. In both these, the planes, by which the cube is cut appear vertical. If fig. 12 be a vertical face, and a b be the top, then fig. 15 will be its representation, two of the planes by which it is cut being vertical and the other horizontal. Having so particularly described the appearance of figs. 9, 10, and 11, viewed in the direction of different radii, and parallel to the sides of the hexagon, it may not be necessary to dwell longer on these, except to observe that it

is more difficult to perceive the corner in the centre of the hexagon in these three last figures, as an internal angle than an external angle. If for a moment the appearance of an internal angle can be recognised in figs. 13 and 15, a glance on that face of the cube which is represented as cut, will immediately remove that impression. In fig. 14, as two faces are represented as being cut, it is still more

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difficult to imagine the meeting of the radii an internal angle; and, consequently, if such an impression be obtained, it is, if possible, more quickly removed.

If the cube be cut by *four* planes perpendicular to a face, as in fig. 16, one appearance of its representation will be as in fig. 17, and another as in fig. 18.

If the cube be cut by eight planes perpendicular to a face, as in fig. 19, two of its appearances will be as in figs. 20 and 21.

These several representations of a cube cut by different planes will naturally point out the application of this perspective to depict numerous objects, as buildings of all descriptions, in whole or in their parts. Figs. 20 and 21 might be converted into the representation of a church, with its nave, aisles, and transepts; while figs. 14 and 17 will readily convey the application of the principle to represent mortice and tenons.

If a cube be cut by *six* planes, as in fig. 22, perpendicular to one of its faces; if the face be vertical, it may appear as in fig. 23; if

Figure 118: Examples from Jopling (1833: 4; 12-13) with part of his explanation of the theory of projection in isometric drawing, and its application to objects such as carpentry joints conceived within a cubic ‘box’

But despite the efforts of his more worthy followers such as Jopling, there is evidence that Farish’s rule-of-thumb method became widespread and popular in Britain because it was so simple and undemanding. William Binns, Professor of Applied Mechanics at the Putney Civil Engineering College 1846-51 and later 1853-7 Master of Mechanical Drawing at the Department of Science and Art, begun in 1853 (Binns 1857: iii; Cardwell 1972: 88-92), complained of the pernicious effects of this style in Britain, claiming that many students had learned how to make extremely polished attractive drawings without knowledge of theory, and that they were constantly tempted to represent cube-like objects ‘scenographically’ because it required less mental labour than visualising a projection (Binns 1857: 22). In the late twentieth century Peter Booker echoed this by lamenting: ‘isometric drawing was taken up by many who were ignorant of the projective theory behind it’ and simply battened on to its ‘secondary geometrical [and visual] properties’ (Booker 1979: 126).

The contrasts between Farish’s formulaic writing for gentlemen, who may have been studying for Cambridge’s mathematics tripos, and Jopling’s theoretical writing for artisans, many of whom we might expect to have only rudimentary mathematics, raise questions about the social and intellectual remit of isometric drawing. The differences between the amount of theory and mental effort in these two texts, and laid down in the drawing procedures, are at odds both with Rudwick’s account of gentlemanly inductive sketching, and also with two contrasting modes of science for gentlemen and artisans proposed by Shapin and Barnes (1977: 50). Farish's contribution is best interpreted as a way of making engineering visible, to legitimate the discourse in polite culture (just as this became the task of organisations such as the BAAS in science Morrell and Thackray 1981: 96; Yeo 1993: 38). Initially this was to his own students with 'leisure and disposition' to take part in 'voluntary science' using 'methods of reasoning by Analysis and Induction' (*Cambridge Philosophical Transactions* Volume 1 1821: iv-v; Becher 1986: 82). Overall, the visual record of isometrical drawing in context challenges other established interpretations of 'gentlemanly' modes of enquiry in experimental philosophy at this period. As an engineering convention, isometric drawing was a style with an alarming instability of social cachet in a way that suggests that 'professionalisation' if it existed at all, was inherently divisive, not unifying.

'Exhibitions and progress': display and disputes in public culture

Although exhibition and techniques of spectacular display offered another means of promoting public confidence in engineering, this strategy created difficulties for the ways that individual engineers chose to present themselves through drawing. In the period to 1850 and after, elite engineers were embroiled with other groups competing for cultural status through exhibition, such as men of science, artists or museum directors. Engineers were also co-opted into various 'design reform' initiatives. Design reform was not a unified movement but a loose constellation of manufacturers, entrepreneurs, social reformers and civil servants building personal careers by working towards the formation of a state policy for art and design education. Such involvements pulled the visual practices of engineers, in pursuit of recognition and status in cultural life, into different modes of expression where particular anxieties about levels of visibility and display were played out. According to Morrell and Thackray, engineers and manufacturers were recruited as allies by the 'gentlemen of science' during the formation of the BAAS in order to 'render visible the Association's attachment to the idea of progress' (Morrell and Thackray 1981: 266). Visitors to yearly BAAS meetings were shown exhibitions of local manufactures and inventions first staged during the Newcastle meeting of 1838 (Morrell and Thackray 1981: 264). Nevertheless, engineers were kept in a subordinate position, 'restricted to judiciously managed appearances in order to reinforce the claims of science' (Morrell and Thackray 1981: 265). Indeed, it is claimed that those engineers who did choose to associate themselves with the BAAS themselves colluded in this subordination, in order to 'validate the cultural claims of their work' (Morrell and Thackray 1981: 260). So although one of the leitmotifs of Morrell and Thackray is the notion of 'making science visible', their account also suggests that in the intellectual hierarchy of the BAAS, engineers had to negotiate the danger that they were possibly too visible.

On the other hand, the 'design reform' movement, with its roots in the Government Select Committee on arts and manufactures of 1835-6 continued to champion the need for drawing education. As shown in the previous chapter, although draughtsmen and artisans had challenged the workings of that Committee in the pages of the *Mechanics' magazine*, they appear to have accepted the broad principle that drawing was an important skill they wished to master. Isometric drawing was one technique that could be quickly assimilated—with or without a theory of projection—and was not a respecter of formal social hierarchies. Engineers such as John Farey, Jnr and William Johnson meanwhile constructed a professional practice for themselves through promoting more strenuous and bravura techniques of drawing aimed at mechanics and artisans. Government design schools were also promoting drawing styles characterised by geometrical and outline drawing that according to Brett, actively invoked a 'positivist ideology of industrialization' by excluding traditional fine art practices (Brett 1987: 63-5). In the decades after 1835, wide and sustained public discussion about drawing for design and manufacture meant that the visual practices of engineering became much more visible. For elite engineers, the problem was how to negotiate how different kinds of visual display related to status.

Figure 119: Benjamin Brecknell Turner (1815-94) *Crystal palace nave, Hyde Park 1852* Albumen print from calotype negative V&A Museum, prints and drawings study room

The Great Exhibition of 1851 is clearly one site of display of artefacts and visual representations proper to science, manufacture, and art (Fox 2009: 493-4; (Auerbach 1999: 1-2). Visitor numbers, the content of the exhibition, press coverage in journals such as the *Illustrated London News* or *Mechanics' magazine*, alongside associated publications such as the *The Illustrated exhibitor* (Maidment 2001: 81), *Art-Journal illustrated catalogue of the industry of all nations* (1851) or the *Imperial cyclopaedia of machinery* show that at this event elite engineers achieved status as heroic individuals through visual display. The machine exhibits were allegedly the most popular parts of the exhibition (Macleod 2007: 212-4), assisted by frequent newspaper reports. For example the *Illustrated London News* exhorted visitors not to miss Nasmyth's Steam Hammer: 'one of the more remarkable contrivances of modern days (*Illustrated London News* 7 June 1851), while the building itself was a display of industrial techniques of manufacture and of the designed forms generated through technical drawing, and frequently described as such to general readers (Figure 119).

The civil servant Henry Cole (1808-1882), one of the key organisers of the Great Exhibition, cultivated allegiances with engineers at many stages of his campaign to organise art and design education within state policy from the 1840s through to the end of his working life. One key friendship was with John Scott Russell (1808-1882) the engineer and naval architect, who introduced Cole to the Society of Arts in1845 (Bonython and Burton 2003: 70-1). Cole is best known as the 'design reformer' who eventually dictated the beginnings of art and design education through his control of the Government Schools of Design from 1848 (Bonython and Burton 2003: 147), the museum of design at South Kensington, and the Department of Science and Art (DSA) from 1853 (Cardwell 1972: 88-92; Bonython and Burton 2003: 154-8), and is most frequently associated with the development of decorative arts in the latter part of the nineteenth century and with art education policy. Cole's career however began at the Society of Arts, where he proclaimed himself a liberal in favour of 'exhibitions and progress' (Bonython and Burton 2003: 101-2), using the established mechanisms within the Society for promoting and exhibiting manufactures (see Chapters 3 and 5) as a vehicle for planning and realising the Great Exhibition. After the Great Exhibition, once he was in charge of the Department of Science and Art, Cole continued his close connection with engineers; officers from the Corps of the Royal Engineers were frequently seconded into the DSA, and valued both for their ability to teach drawing, and for their organisational abilities. These alliances allowed Cole, according to Rafael

Cardoso Denis, to consolidate his own position as a civil servant and the position of his own institution, presiding over the ‘meteoric rise’ of the government system of science and art education during the 1850s and 1860s (Denis 1995: 174).

The Imperial cyclopaedia of machinery (Johnson nd [1852-6]) was assembled as a souvenir of the Great Exhibition through displaying the drawing skills of the elite engineers who had shown full-sized machinery and models in the exhibition itself. William Johnson the engineering writer (see also above) produced this portfolio of images as the result of his work as Secretary to the Glasgow Committee for the Great Exhibition (*PICE* 1866: 528). This quarto-sized publication, dedicated to Robert Napier, was a large, brash celebration of ‘stationary, marine and locomotive engines, spinning machinery and grinding mills, tools, &c. from the Great Exhibition’ (Johnson nd: title page). Its dominating appearance comes from the lavish illustration spreads, with ninety-three double page steel engravings of technical drawings in the orthographic convention of plan, section and elevation in presentation; many of the draughtsmen, such as Benjamin Hick of Bolton, were also the manufacturers or inventors of the machines depicted.

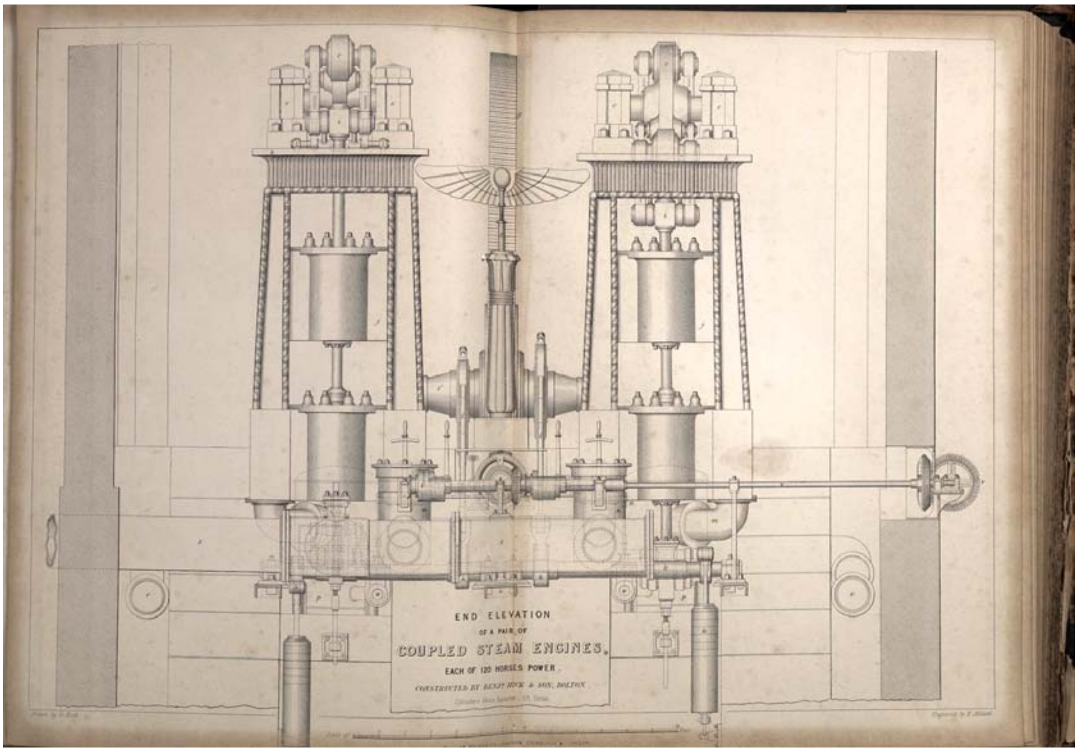

Figure 120: Benjamin Hick, Bolton, elevation of a pair of coupled steam engines (note the Egyptian decorative embellishments). B. Hick, del. H. Adlard, sculpt. *The imperial cyclopaedia of machinery*

Figure 120 shows a pair of coupled steam engines. All the Great Exhibition engines of Benjamin Hick & Son as recorded in this volume were all embellished with decorative and symbolic details, so that the engine shown in the example has a governor in the form of wings of an Egyptian deity; other examples of the engines illustrated in the text sport classical entablature and ribbed columns, or classical key designs. Figure 121 shows a detailed plan view with shadow effects of two marine steam engines by David Kirkaldy.

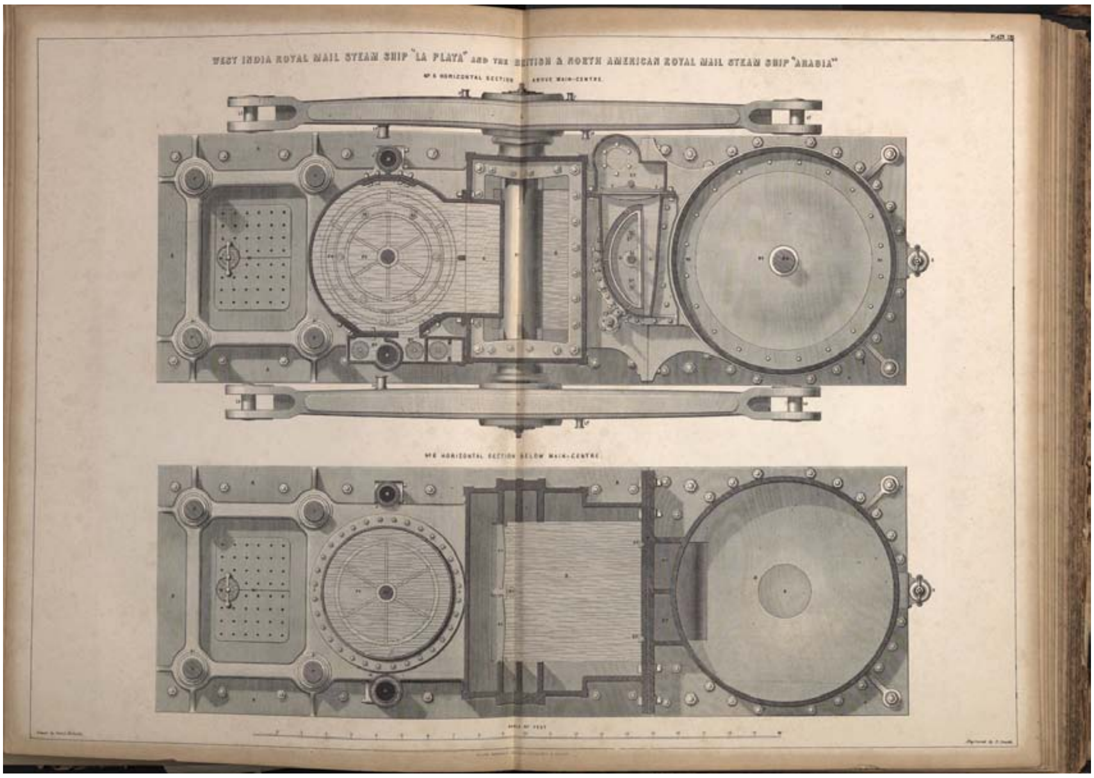

Figure 121: West India Royal Mail Steamship ‘La Plata’ and the North American Royal Mail Steam Ship ‘Arabia’. David Kirkaldy, del. B. Smith, sculpt. *The imperial cyclopaedia of machinery*

As well as celebrating engineers and engineering through the display of structures and technical drawings, the Great Exhibition was also useful to elite engineers in their quest to get a hearing for their ideas in scientific and government circles. For example Joseph Whitworth (1803-1887) used the exhibition to promote his ideas of standardised techniques of scientific manufacture, and of the importance of education (Buchanan 2002: 116) with the result that Whitworth and George Wallis, the head master of the Government School of Design in Birmingham, were sent to prepare an official report on the system of manufactures in the United States (Rosenberg 1969). James Nasmyth, the mechanical engineer, won a gold medal for his large drawing of the surface of the Moon that helped build his reputation as an inventive and dedicated amateur astronomer (Buchanan *ODNB*; Robertson 2005: 495-623). Nevertheless the very success of exhibition strategies that were presented by events such as the Great Exhibition presented difficulties to engineers who wished to develop their claims to specialised theoretical knowledge. Many of the visual languages that had been developed to assert the significance of engineering were not completely in tune with the ways in which men of science made use of images (Lynch 2006: 26-40).

Making drawing less visible: engineers, display, and men of science

The preference shown by men of science for drawing styles that appeared simply to record and not theorise visual data, already noted in Rudwick (1976), was reinforced by the promise of 'objectivity' in photographic representation after its invention around 1840. This idea was fostered by increasing distrust of the personal or rhetorical elements that draughtsman put into their drawings. Jennifer Tucker has noted how the scientific section of judges of photography at the Great Exhibition of 1851 wanted to encourage 'useful' representations rather than those that 'please the eye or administer to personal feelings' (Tucker 2005: 24). Although men of science did not establish trust in their own modes of photography until after 1870 (Tucker 2005: 61-4) nevertheless the notion that nature could be made to represent herself through this medium had considerable force (Batchen 1999: 63; Daston and Galison 1992: 81-128; Green-Lewis 1996). Lightman has described how from around 1850 onwards, elite men of science such as Darwin often avoided representing their observations of nature visually. In contrast, popularizers of science, aiming to 'keep natural theology alive' used detailed and spectacular drawings of scenes of the natural world (Lightman 2000: 651-80). In very broad terms, such conflicts of status about visual display within science might appear to place elite engineers in a dilemma. If an engineer wanted to display his professional expertise in designing and making manifest complex structures with detailed specifications, he might use arduous and detailed drawings in the manner proposed by William Johnson, even though such styles merged with spectacular modes of bravura draughtsmanship. On the other hand, if he wanted to be given a serious hearing in scientific circles such as the BAAS, the Royal Society or similar learned societies, status was attached to more muted conventions. These tensions can be seen in the range of visual practices associated with James Nasmyth (1808-1890 Buchanan *ODNB*), whose strategies will be briefly compared with those of another notable draughtsman, David Kirkaldy (1820-1897 Day and McNeil 39: 402)

James Nasmyth, whose writings on geometrical drawing, and entrepreneurial style, have already been discussed in Chapters 5 and 6, might at first glance seem to be the ideal recruit to the decorative or spectacular school of technical drawing. He was the son of the artist Alexander Nasmyth (see Chapter 3) whose interests had included not only landscape painting, but also engineering and architecture (Kemp 1970: 94; Irwin 1975: 138-9; Ruddock 2000: 142). James Nasmyth became a student in 1821 at the Edinburgh School of Arts (see Chapter 6) (Nasmyth 1883: 112) before gaining a place with the engineer Henry Maudslay, reportedly because of his drawing ability (Nasmyth 1883: 141). In Nasmyth's own estimation of himself he valued inspiration and skilled handwork, pronouncing as often as possible on his theme: 'the truth is that the eyes and fingers—the bare fingers—are the two principal inlets to sound practical instruction... No book knowledge can avail for that purpose. The nature and properties of materials must come in through the finger ends' (Nasmyth 1883: 97). In addition to his technical drawings and illustrations Nasmyth produced many private sketches and fantasy drawings that demonstrate the 'graphic eloquence' he valued (Nasmyth 1883: 99). By contrast, Nasmyth's habitual 'technical' drawing style was of relatively coarse simple line drawings that translated immediately to print; a method of spreading images of his products rapidly and far more widely than through presentation drawings. For example the Bridgewater Foundry mainly sold standard advertised items from a printed catalogue (Cantrell 1984: 127). Similar drawings were given to the third edition of Robertson Buchanan's *Essays on Millwork* (1841) where twenty-one out of the thirty three machines illustrated were from Nasmyth & Gaskell (Musson and Robinson 1969: 498-9). Nasmyth rarely changed this mode of presentation, providing direct copies of his own drawings for reproduction in print, for example for the image of the steam hammer in the *Engineer and machinist's assistant* of 1849 (Figure 122), or for a story headlined 'Nasmyth's anti-invasion floating mortar: a new implement of destruction' (Figure 123, *Illustrated London News*, 16 January 1853: 37-8) which was illustrated with a reproduction of the project drawing now held in the IMechE (END 14/13/4).

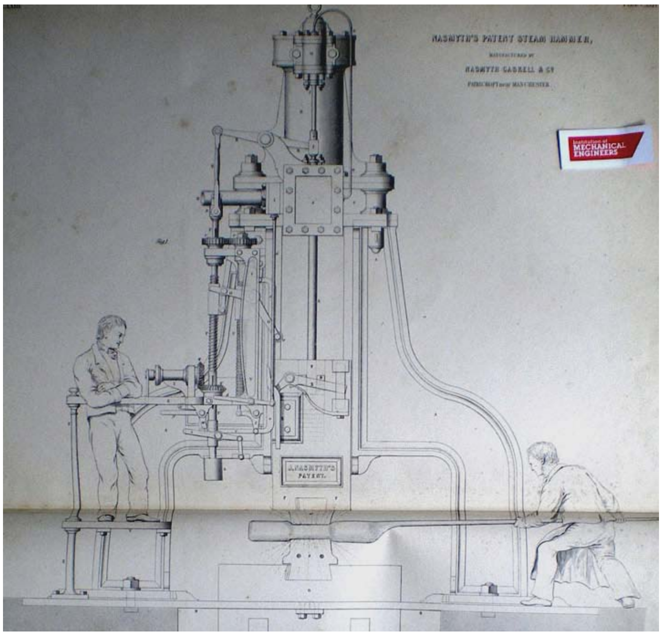

Figure 122: Nasmyth's patent steam hammer from the *Engineer and machinist's assistant* 1849

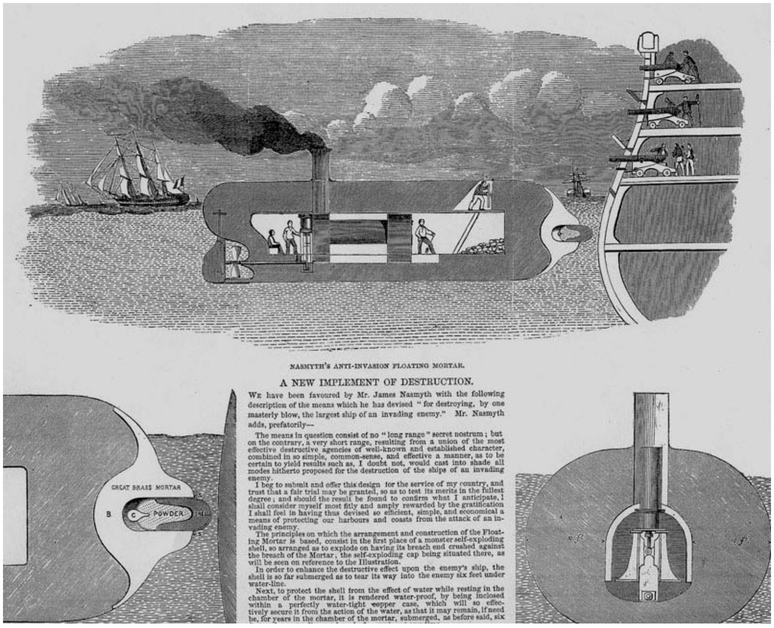

Figure 123: 'Nasmyth's anti-invasion floating mortar' Illustrated London News 16 January 1853

Nasmyth was filled with enthusiasm for astronomy very early on; making his own reflecting telescope in 1828 (Nasmyth 1883: 405); he was a constant attender at meetings of the BAAS and similar societies, and he made enough money to retire in 1856 while young enough to continue with the 'active leisure' of astronomy (Cantrell 2002: 133-44). He made many drawings of the Moon from frequent direct observation; these formed the basis for the production of the remarkable photographic images in his book *The Moon* (Nasmyth and Carpenter 1874). Although this aspect of Nasmyth's visual practice falls outside the scope of this study, it is important to note that he used his observational drawings and later the images in his book to court the approval of the grandees of observational astronomy, in particular Lord Rosse and John Herschel (Chapman 1998: 107; Chapman 1996: XIII 1-25), for example in a series of very deferential letters and invitations to Herschel that began in 1845 (Royal Society: HS.13.76 Nasmyth to Herschel letter 1 August 1845). Briefly, Nasmyth constructed plaster models of features of the moon surface and photographed them. Then these images were accepted by fellow astronomers because at the moment of publication they appeared to offer a more faithful recreation of their own sensations as observers than any type of representation that was available (Robertson 2006: 595-623).

Nasmyth also 'talked up' the virtues of drawing and developed this aspect of his public persona early on. For example, after only two years in business, and despite the small scale of his operations (Cantrell 1984: 38-40), Nasmyth was invited as one of the few witnesses from outside London to the 1836 hearings of the Government Select Committee on Arts and Manufactures (Romans 1998: 69). To the Select Committee, Nasmyth urged the soothing effects of art upon uncouth workers, claiming that a selection of the 'graceful forms of antique designs' would act as an antidote to drunkenness (Select Committee 8 March 1836:30). In 1839, still promoting these ideas, he was associated with Sir Benjamin Heywood in Manchester in projecting a scheme for a museum of objects of beauty open to the public. According to the *Art-Union* journal, they aimed to 'contrast as much as possible some of the forms now in general use with those of the best periods of ancient art' giving the example of a modern flower-pot, juxtaposed with 'some of the Pompeian vases' (*The Art-Union* 15 Sept. 1839: 137).

Figure 124: James Nasmyth *The alchemist just detecting a glorious passage in Geber* pen, with pencil underdrawing 1833, National Library of Scotland MS 3241, no.129

However his statements about the virtues of drawing skills, taken literally, are not completely in tune with his own practice. Nasmyth's drawing styles, far from manifesting the 'graceful forms of antique designs' were vigorous and simplified. His hand sketching, shown in the dramatic caricature of the alchemist (Figure 124) or in the rapid notation of design ideas in the Scheme book (Figure 125), is gestural and lively.

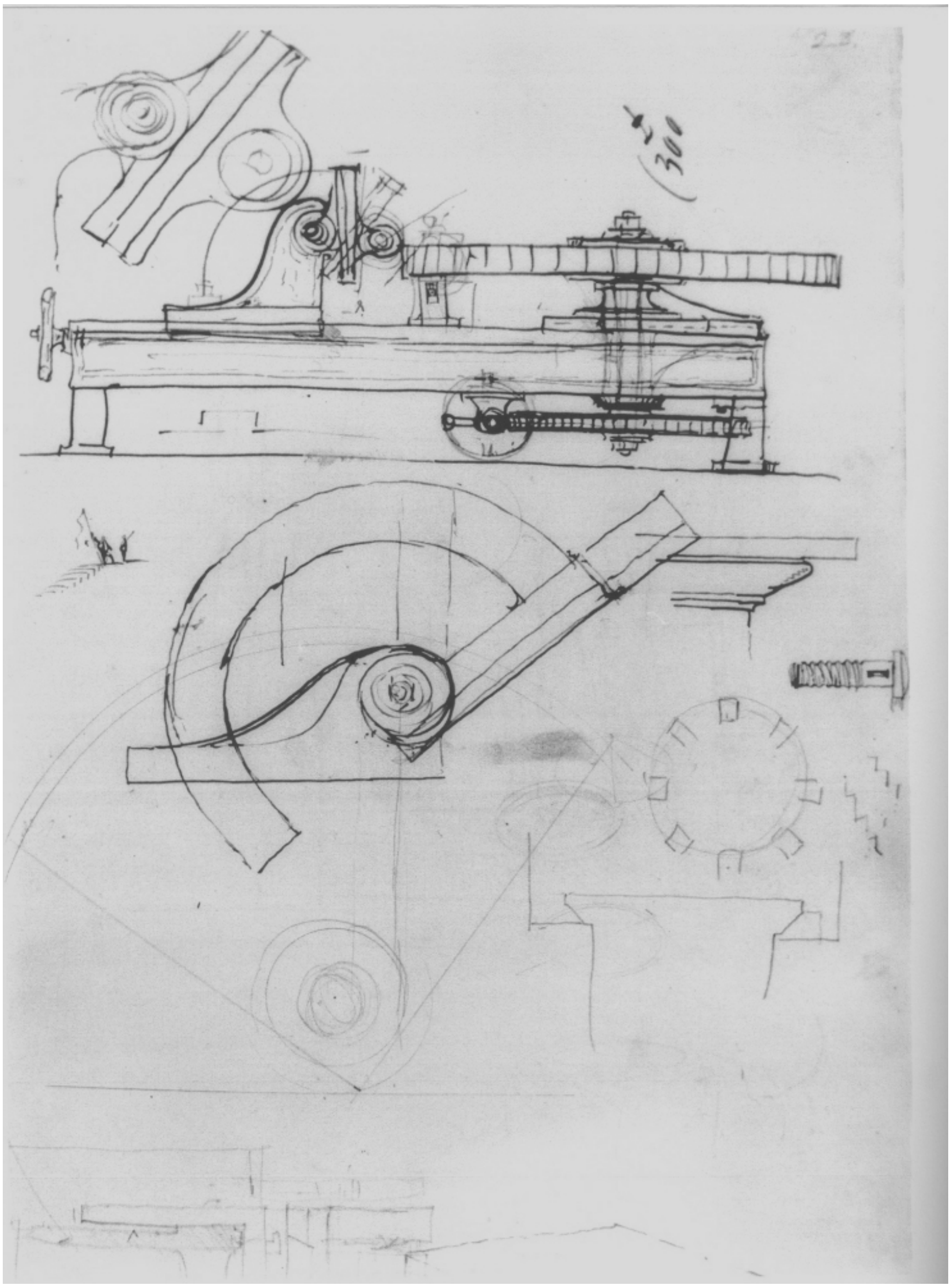

Figure 125: James Nasmyth Scheme book page 28 (ImechE IMS 98)

It is also notable that Nasmyth chose a flexible, wide-nibbed quill pen or a dark soft pencil for his personal annotations in the Scheme book; completely at odds with the sharp directed marking implements described with such care for example in the work of Farey or Johnson. The style of these drawings is much more in the genre of comic sketching in exchanges of educated masculine sociability that can be seen for example in the papers of Nasmyth's friend, Henry de la Beche (1796-1855 McCartney 1977: 54-9), the founder of the Museum of Practical Geology, of John Herschel (Schaaf 1990a: 17-25), or of the draughtsmen at Boulton & Watt in the period 1810 to 1820, seen in the previous chapter. Nasmyth's sketches were only nominally private; he circulated many sketches amongst friends, either directly by letter, or through short lithograph editions, while his portfolios of drawings, and even the Scheme book, appear to have been carefully edited and assembled as part of Nasmyth's self-presentation (Stevenson 1989: 23-6; Cantrell 1984: 134-55; Schaaf 1990b: 15-6). His drawing styles, both the laconic style of industrial promotion, and the autographic style of his sketches, appear to be in line with Nasmyth's own campaign to be considered a gentlemanly and dedicated man of science.

In his overall career, Nasmyth produced a wide range of visual statements for publication, to promote himself as an engineer and inventor, and latterly as a would-be man of science. However, unlike the carefully finished seductive quality of more elaborate bravura engineering draughtsmanship, his personal hand drawing skills appear almost rudimentary. His emphatic but simple style of drawing was a method of negotiating his allegiance with the 'gentlemen of science', and the way in which he approached the publication of his later book on the moon shows that this was an important consideration with him. The apparent modesty, but at the same time volume of his public visual statements appears as a strategy of dissimulation whereby his drawings contribute to his self-image whilst denying the spectacular qualities of presentation drawings (see also Chapter 6). In relation to his relationship with his industrial viewers, his approach could equally be seen as a display of the virtues of machine reproduction in his visual style. Rather than exploiting mechanical drawing aids to produce supernaturally correct lines, however, Nasmyth's technique was to produce images that were ready for rapid reproduction into print.

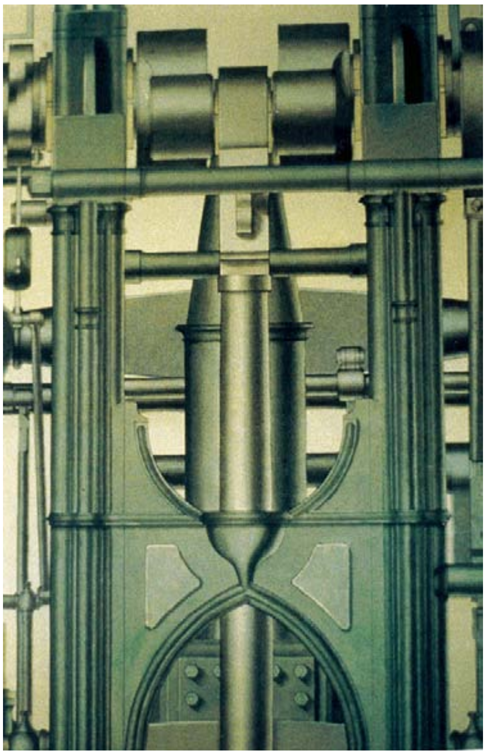
Figure 126: Workshop of Robert Napier, Glasgow detail of engines of the 'Thunderbolt' 1842, pen and watercolour (Glasgow Museum of Transport TD 232/10)

David Kirkaldy's work as a draughtsmen is well-known from the image in Figure 126, that was also reproduced in *The art of the engineer* where it was described as an 'unusually bravura display' (Baynes and Pugh1981: 363). In comparison to other presentation drawings shown in this dissertation (for example Figures 99 or 100, Chapter 6) this drawing pushes the conventions of presentation drawing in a more extreme and aestheticised direction. The lines used are exceptionally narrow and unvarying, and the effects of light have been systematically, indeed obsessively, represented, using a range of illusionistic devices. For example we see not only the application of carefully graded highlights on the cylindrical forms but also the unvarying notation of reflected light on the shadowed sides of the same forms to give a powerful, hyperreal effect. Complex forms, and their shadows, have been calculated and then rendered in a similar manner to that recommended by the *Practical draughtsman's book of industrial design* (Johnson 1853: 96-108). In addition to the working out of perspective construction, this image also displays technical, painterly control of its graded watercolour washes.

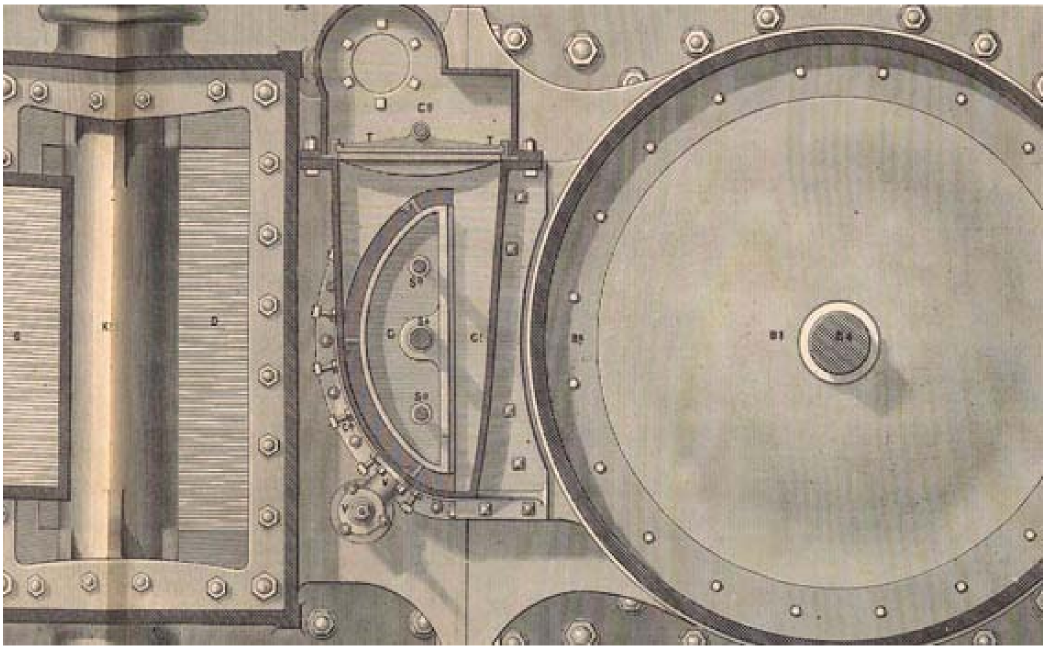

Figure 127: David Kirkaldy, detail from drawing of engine of 'La Plata' already shown in Figure 121 above from *The imperial cyclopaedia of machinery*

David Kirkaldy began work for the shipbuilding firm of Robert Napier & Sons of Glasgow as an apprentice, spending four years in the workshops before moving to the drawing office and then to the position of chief draughtsman (Kirkaldy 1891: 265). Kirkaldy's high level of spectacular draughtsmanship has already been seen amongst the work shown from the *Imperial cyclopaedia of machinery* (Figure 127 is a detail of Figure 121, Chapter 6). The appearance and the mode of exhibition of these drawings take an opposite approach to that of Nasmyth, flaunting the aesthetic without a smokescreen of utility. Kirkaldy also sent work for exhibition to the Royal Academy (Graves 1905, Volume 2: 33) in common with other engineers such as Brunel, shown in 1837 (see Chapter 6), or Charles Henman, who showed designs for embanking the river Thames in 1862 (Graves 1905, Volume 4: 70). Kirkaldy showed work at the Paris Exhibition of 1855, afterwards presented to Emperor Napoleon III (Kirkaldy 1891: 266). However, later in his career David Kirkaldy became most celebrated for his experimental work in the mechanical testing of the tensile strengths of materials (Smith 1981: 44-65) that evoked a completely different mode of visual expression.

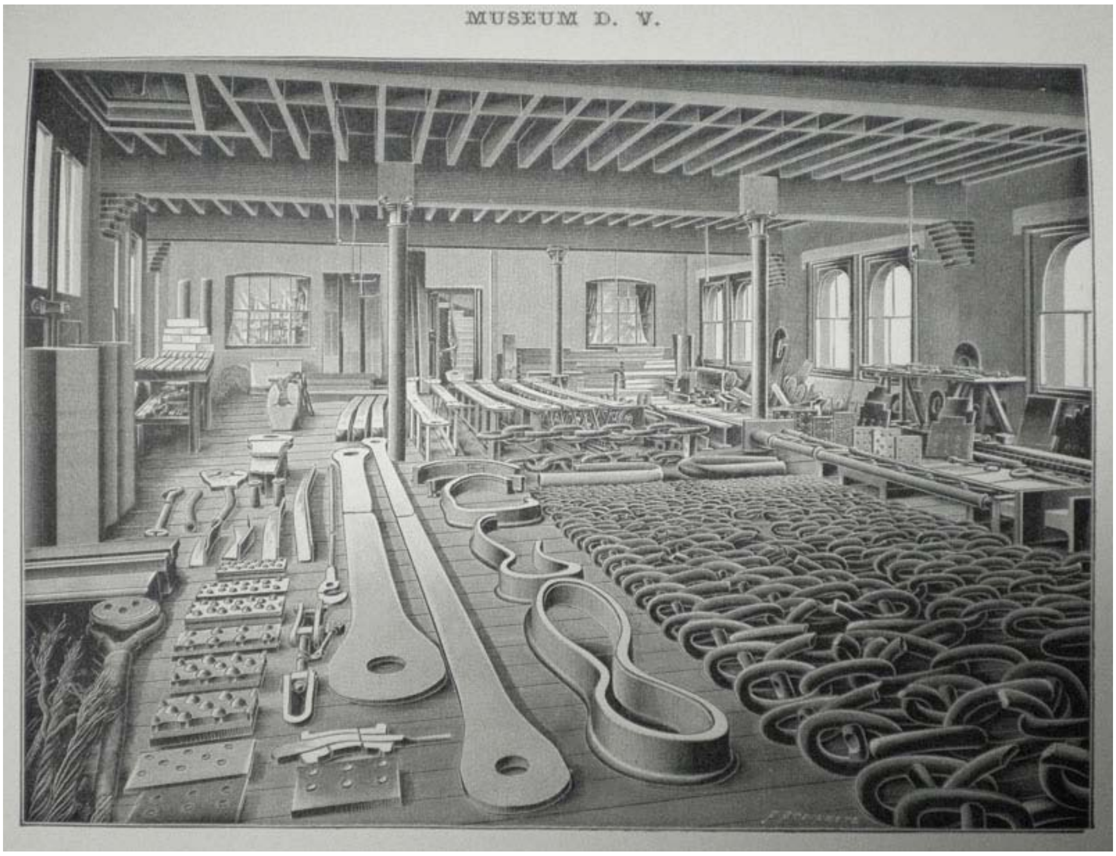

Figure 128: View of museum showing assemblies of shattered and wrecked forms after testing from *Illustrations of David Kirkaldy's system of mechanical testing* (Kirkaldy1891)

Kirkaldy's life story appears as a brief preface to the book *Illustrations of David Kirkaldy's system of mechanical testing* (Kirkaldy1891), written by his son. In this account, it appears that bravura draughtsmen, whilst having respect and status in the hierarchy of a company such as that of Robert Napier & Sons (Napier 1904), were nevertheless kept firmly in their place. While working for Robert Napier, the narrative claims, Kirkaldy began private research into materials and performance in order to ascertain the effect of variables such as the shape of vessels, propellers, engines and boilers, but through some annoyance and jealousy (darkly hinted at), these efforts were thwarted. In this account, Kirkaldy's decision to make finished drawings of the *Persia* in his spare time for the Royal Academy exhibition was presented as an act of independence and even defiance before leaving his employment as chief draughtsman. Kirkaldy resigned from Napier & Sons in late 1861 in order to start in business as a testing engineer, opening his London laboratory (that he called the 'museum') in 1866 (Kirkaldy 1891: 268-71).

The main part of *David Kirkaldy's system of mechanical testing* concerned the business of materials testing, with displays of data from twelve thousand experiments presented in twenty five lithographed plates of graphs (Kirkaldy 1891: viii), supplemented with illustrations of the workspaces in woodcuts based on photographs (Kirkaldy 1891: px). Figure 128 shows 'Museum D' with ranks of full-sized items such as wood joists, bridge and roof links, railway-axles, ropes and cables tested in practice. Figure 129 shows a selection of steel plates tested under pulling stress. All the 'testing' images, unlike the sumptuous design and presentation drawings that Kirkaldy made as a draughtsman, display observational data from experiments. Most displays are presented as graphs, but the illustrations in Figures 128 and 129 apply the photographic concept of getting nature to represent herself, with unedited raw visual data employed as a kind of 'ready-made' (Lynch 2006: 35). In the museum, ranks of shattered and wrecked forms display the gradations of stress that have been applied to them, whilst the tested steel plates in Figure 129, earlier inscribed with regular patterning, display the deformations and fractures of their carefully quantified ordeals. Kirkaldy thus rejected his impressive draughtsman skills he had developed earlier in his career, and negotiated his status as a serious experimenter by making a stylistic break in his practice.

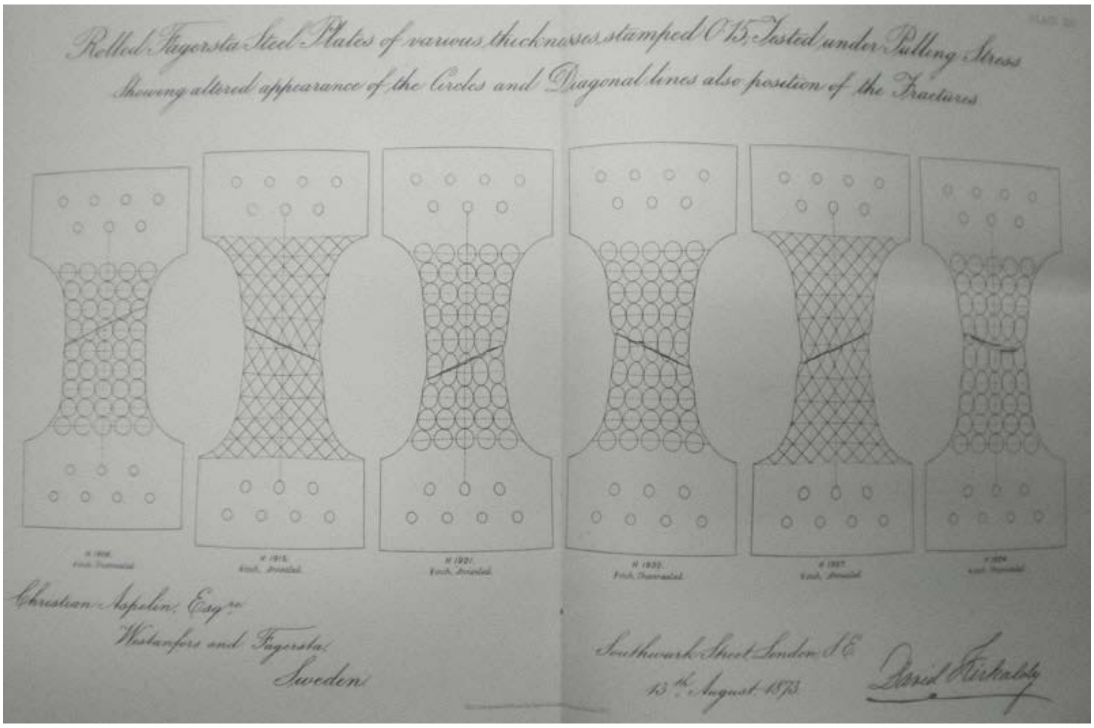

Figure 129: Rolled Fagersta Steel Plates of various thicknesses, stamped 0.15; Tested under Pulling Stress showing altered appearance of the Circles and Diagonal lines also position of the Fractures from *Illustrations of David Kirkaldy's system of mechanical testing* (Kirkaldy1891)

Kirkaldy's visual representations that he made to present himself as a man of science have some similarities to Nasmyth's 'moon' photographs; hand drawing has been removed from the production of the image. In Nasmyth's case, his strategy was to devise an ingenious means of arousing sensation that felt authentic to experienced astronomers. Kirkaldy by contrast devised methods for generating evidence visually that would be more likely to be accepted as a demonstration of testable experimental procedures by men of science.

What unites Kirkaldy and Nasmyth is their ability to devise, select from, and use a range of visual styles to communicate with different audiences. They demonstrate expertise in the selection and rhetorical use of technologies of inscription, from hand drawing, to the use of mechanical drawing aids and print techniques, including photography. In this sense they worked as 'visual technicians', just as engineers, draughtsmen and engravers discussed in Chapter 5 worked to construct an artworld that was not limited to technical drawings in the workplace, in the early decades of the nineteenth century.

Conclusion

In this chapter I have aimed to discuss questions that relate professional self-presentation by elite engineers to the subjects and issues of Chapter 6, in order to begin to break down the topic of 'technical drawing' into a much more differentiated field of human activity where visual descriptive analysis begins to have a purchase on issues of the social history of 'arts and manufactures' in Britain. Draughtsmen and engineers used drawing to contest their working relationships; self-taught draughtsmen were skilled workers who had developed close knowledge of geometrical drawing, projective geometry and decorative graphic elaboration in their work; by contrast, the drawing styles I have considered in this chapter in association with elite engineers, writers and educators are simpler and less spectacular. Although I have only selected and discussed a very small part of the volume of visual material associated with named elite engineers, the cases I have looked at support the notion that 'artistic' and spectacular modes of technical drawing came to be of lesser value, the permitted leeway of hired artists, analogous to the division of labour that was in place between 'draughtsmen' and elite architects at the beginning of the nineteenth century (Savage 2001: 207). So in contrast to the difference between the subjective landscape sketching of military officers and their geometrically-drilled men (see Chapter 3), in the cases I have reviewed in this chapter, 'artistic' denoted someone with less autonomy or status.

Much of the material in this chapter was to do with the ways in which questions of 'professionalisation' related to engineers' promotion of technical drawing through print as a way of building confidence in engineering as a rational public enterprise. In the first half of the nineteenth century, the Institution of Civil Engineers enunciated three 'professional' aims for engineers, to promote engineering as specialist knowledge, define terms for excluding rivals, and to present 'engineering' to the general public. A more recent formulation of this idea is contained in the notion that one role of technicians is as a 'broker': one who mediates between communities that produce technologies, and communities of users that have little or no technical knowledge (Barley 2005: 391). To examine these ideas, I considered examples of banal or textbook imagery not normally associated with elite engineers, suggesting however that this genre of self-presentation had developed from the practice of consulting engineers like John Smeaton, whose work consisted mainly of reports of projected work. Farey demonstrated the use of technical illustration as a mode of appropriating knowledge through mechanical techniques of assembly and inscription, while William Johnson by contrast invited his readers to develop their own personal skills though a union of art and theory in the habitual practice of drawing, a liberal idea that can perhaps be seen in the promotion of isometric drawing in Britain to many different social environments. Looking at the genre of simple drawing manuals in this chapter indicates an additional area in the study of the literary cultures of engineering in the nineteenth century and their relationship with other types of visual culture, for such texts are not simply illustrated but more fundamentally engage with the practice and philosophy of drawing. Finally, it was not possible to consider the professional formation of engineers in relation to visual practices without reference to the Great Exhibition and cultures of spectacle and display. The example of Nasmyth's and Kirkaldy's uses of different visual styles in contact with different occupational groups given in this chapter also suggest that events such as the Great Exhibition will have prompted many more visual dilemmas in engineers that are worthy of future study.

Conclusion

In my investigation of the development of technical drawing in Britain from the late eighteenth century to the mid-nineteenth century I asked how engineers, draughtsmen and mechanics learnt to draw, their motivations for doing so, and the cultural and social resources they employed. In this dissertation 'learning to draw' has also meant teaching yourself to draw, observing the drawing codes of other people, and adopting techniques that seemed useful. Although the working contexts for the draughtsmen I have studied, for example in factory drawing offices, mechanics' institutes and illustrated mass-market publications appear at first glance to be outside the framework of recognized fine art networks, I have demonstrated that draughtsmen absorbed, selected, and appropriated expressive practices and discourses from fine art in their work and in their self-fashioning as technical artists. At the same time, technical draughtsmen developed new conventions of composition, mark-making, medium and modes of display that were widely disseminated, both to technical working viewers, and more widely to general readers and viewers through illustrated periodicals and exhibitions.

In describing the development of technical drawing in relation to the decisions of engineers and draughtsmen I have developed a view of their role as visual technicians, working alongside instrument makers, engravers, and printers as illustrators and authors. The invention by technical artists of drawing machines such as the elliptograph inscribed forms that apparently owed nothing to hand crafting, in parallel to virtues that industrialists such as James Nasmyth celebrated in the self-acting machine, where: 'the tool did all the working (for the thinking had before been embodied in it), and it turned out all manner of geometrical forms with the utmost correctness' (Nasmyth 1883: 308). In technical representations, skill was often displayed visually as the product of mechanical invention, rather than direct hand marking.

In training themselves, technical draughtsmen and engineers developed their visual styles through copying from a wide range of examples and conventions, with the result that they were able to inhabit and reproduce the motifs and manner of artistic, ornamental and practical styles of drawing. Draughtsmen could reflect on their own selections, and create pictures that reflected their own making. Technical draughtsmen combined conventions that might otherwise have been kept apart. For example, I suggested that in Robert Mylne's drawing *c*. 1767 of the *Elevation of the principal front of Wormleybury* (Figure 23, Chapter 2), that his very crisp treatment of the edges of the cast shadow on the building created a visual 'double meaning' that was often exploited in later technical illustrations. In effect the cast shadow functioned as an oblique projection of a hidden side view that is obliterated in frontal orthographic presentation. The sparsity and graphic contrasts of technical illustrations allowed draughtsmen to take effects from different discourses of representation in a similar way, and them hold in place by means of the formal graphic design on the page. So for example in the representation of a slotting machine (Figure 130), from *The engineer and machinist's assistant* (1849), the perspective conventions of orthographic projection, rendered in line and unmarked paper, are used alongside oblique cast shadow projections in uniform blocks of tone. Meanwhile some forms display the pictorial effects of tonally graded shadow. This medley of conventions complements an assembly of design languages and structural functions in the object, in which a classical column has been welded in to other more overtly functional planes, cylinders, and gearing mechanisms.

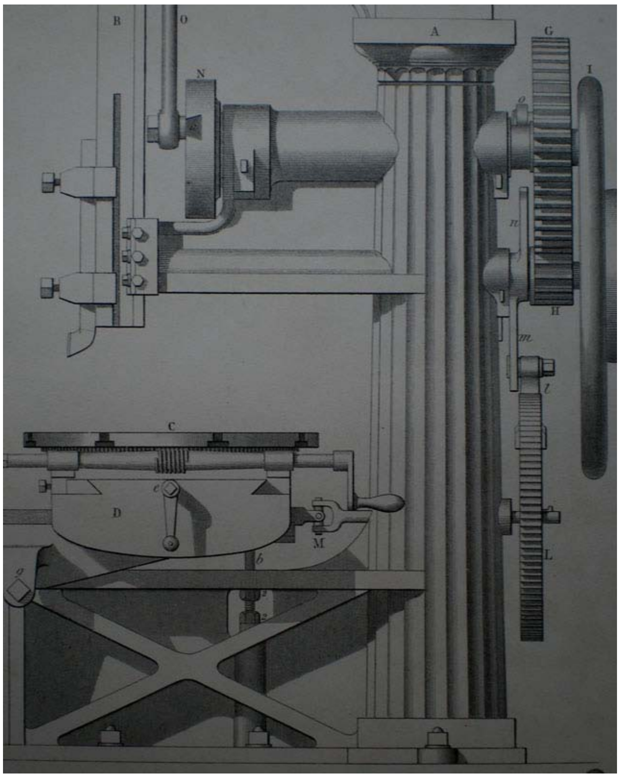
Figure 130: Self acting slotting machine, Caird & Co. Greenock Plate LXV *The engineer and machinist's assistant* (1849)

Technical drawing was a forum where worker education, professional formation and factory working structures were debated. Technical drawing for the mechanical arts were derived from artistic, artisanal and architectural precedents, and for both elite engineers and factory draughtsmen, this meant a continual negotiation to work out how different kinds of visual display related to status.

In the first half of the nineteenth century, fine art exhibitions were rare and access was only easy for ‘polite’ viewers. Although the founding of the National Gallery in 1824 and the British Museum in signalled a desire to ‘expand the conventional boundaries of citizenship’ to lower social ranks (Duncan 1995: 40), artisans and workers were still frequently scorned as ignorant intruders at mid-century and beyond (Trodd 1994: 39-40). Outside London, Manchester was a focus for art for middle class patrons, but there were few exhibitions before the late 1850s (Macleod 1996: 91-94; Seed 1988: 45-81), and exhibitions that welcomed the working classes did not get under way until the late 1870s (Kidd and Roberts 1985: 120-134). While the majority of artists and fine art engravers in Britain had an insecure existence with low status, poverty and often drudging work for survival (Gillett 1990: 22-6), printed publications that addressed the useful arts presented an exhibition space with wide access to general readers. Thus contributors of technical drawings and illustrations in publications such as the *Transactions* of the Society of Art comparatively attained a greater sense of agency and improved cultural status. In turn, other draughtsmen learnt to draw by studying a wide range of such sources, and made use of a range of references to styles and traditions in creating persuasive images from artistic, architectural, and mechanical precedents. As draughtsmen and engineers used many visual languages in order to develop technical drawing styles, the methods of art history have been necessary and relevant for informing my analysis of a topic that is usually confined to histories of technology or science.

I began in Chapter 2 by comparing drawing discourses from two familiar locations, the firm of Boulton & Watt in Birmingham and the Royal Academy in London. Here I discussed the role of archives and institutions in professional practice and on discipline formation, with specific focus on narratives of the history of drawing. If technical drawing is now perceived as inexpressive and inartistic, this is because it has rarely been considered to have any connection with fine art drawing practices. In part this is because influential members of the Royal Academy such as Joshua Reynolds set out to define and segregate high culture. Although his pronouncements were not reflected in actual practice, nevertheless his discourse has influenced the way in which art history has been written (Bourdieu 1993; Denis and Trodd 2000; Fyfe 2000). My comparison of artistic and engineering drawing practices in this chapter, that have previously been studied separately in histories of painting and fine art, architecture, and engineering, revealed both continuities of practice as well as interconnected groups of people. For example the engineer James Watt had contact with fine artists through his working connection with Matthew Boulton and his manufactory for elite decorative objects.

Drawing practices associated with the Academy were similar to those used in the same period for manufacture or engineering in the firm of Boulton & Watt. For example the training of painters and sculptors in the life room included designing in 'the flat' in a way that shaded towards designing for manufacture, whilst the projects and drawing practices of architects and engineers around 1800 were often very similar, encompassing geometrical drawing and use of orthographic and pictorial perspectival conventions. Equally, the abstract stylistic prescriptions laid down for elevated history painting from Joshua Reynolds's *Discourses* on art could also have been applied to technical presentation drawings: clear, ideal forms delineated with firm and determined outline, unambiguous use of discrete colours, and a concentration on one principal focus of interest, for example as seen in presentation drawings of machinery from the Boulton & Watt archive for Cockshead Colliery or Wilkinson's Bradley Forge (seen in Figures 4 and 10).

Moreover, Chapter 2 also demonstrated that accounts of drawing practices associated with the Royal Academy are not comprehensive. There were three modes of drawing associated with academic training and practice: the discipline of the life room (Goldstein 1994), of perspectival and mathematical drawing (Kemp 1990), and architectural practice (Lever and Richardson 1984), although writers have often discussed just one type of drawing in isolation. Although this separation into separate disciplines reflects separate professional communities of practice (such as architecture or sculpture), I suggested that these categories only refer to the relatively small number of former students who 'made it' in these professions. Instead, I noted the existence of an unconsidered community of 'student practice' leading to other types of less prominent work, for example as draughtsmen, surveyors, or studio assistants, that applied to the thousands of former Royal Academy students who did not become named practitioners. Finally, although architectural drawing styles and practices showed the most similarities to those of engineering, I noted that this area also offers an opportunity to observe fine differences in the visual decisions that 'architects' and 'engineers' might have made in order to mark a separation of professional allegiance, as demonstrated in my comparison of the work of Mylne, Watt, and other English Palladian architects.

In Chapter 3 I considered what other types of drawing education may have been available across Britain between the mid-eighteenth and the first decades of the nineteenth century. I looked at rival academies, the work of the Society of Arts, and also ‘printed academies’ (drawing manuals). These rival institutions and manuals offered a far more finely textured picture of drawing practice and purpose than that offered in Chapter 2, and extended the scope of study, both chronologically and geographically. By extending the consideration of drawing education and its dissemination to printed matter, this chapter also suggested that ‘technical drawing’ should not simply be considered as a mode of communication and control in the factory, but as an expressive means of building an audience for the mechanical and useful arts in print. Drawing for print created new sites of exhibition and exchange, and new networks of communication, for example through the *Transactions* of the Society of Arts. But although most of the sources of drawing education considered in this chapter were intended in part for artisans, printed sources such as the *Transactions* of the Society of Arts, and drawing manuals, were also directed to ‘polite’ readers. And as well as the mixed audiences addressed by printed manuals, many manuals conveyed a heterogeneous mixture of drawing styles, techniques and traditions, with elements of figure drawing from the antique, rococo decorative ornamentation, geometrical and perspectival instruction, and (after around 1800) landscape sketching.

The content of drawing manuals changed in emphasis around 1800. In addition to the now well-known expansion in the production of landscape sketching manuals at this time (Bicknell and Munro 1988: Bermingham 2000), in other manuals I found evidence for a move to more technical styles of drawing instruction even for polite readers, accompanied by an assumption that the student would learn to use a drawing kit that included mechanical aids such as rulers, compasses, drawing boards and parallel rulers. These styles of manual modify the notion that polite artistic practices after 1800 became mostly centred on techniques of ‘subjectivity’ and formation of the self, through landscape sketching (Bermingham 2000). In addition, the more technical drawing manuals, such as those of James Ferguson, demonstrated a change in styles of learning, from the older model of copying from a range of examples, to techniques of systematic observation and analysis of objects and drawings into abstract geometrical forms as a prelude to reassembly by the draughtsman.

Despite the apparently wide range of drawing subjects and styles conveyed in drawing manuals, line marking was predominant, smoothing out differences in the sources that had come from many different periods and mediums. Equally, in artisan academies, for example in Edinburgh and Dublin, ‘design’ training was equated with drawing instruction, thus distancing trades apprentices from immersion in the particularities of designing within the constraints of the specific and habitual materials of their trade. When exhibition and education were carried forward in print, the medium itself had an effect on drawing style; in addition, this forum mixed up ‘learning to draw’ with ‘teaching yourself to draw’, so that production and reception of style became more fluid. The material considered in Chapter 3 indicated that in Britain drawing skills were developed for a whole spectrum of applications in a way that suggests the distinctions that Reynolds wished to draw between polite arts and mercantile considerations were not apparent to most drawing practitioners before 1800. Furthermore the way in which the Society of Arts functioned does not simply challenge the idea that the Royal Academy was the only institution concerned with art or drawing education before the foundation of the Government Schools of Design towards 1840; rather, it suggests that there was a different model of practice, not centralising like the RA, but dispersed – and dependent upon locally varying industries and associated practices.

In Chapters 4 and 5, I considered the aesthetic or symbolic meanings that might be given to the marks, materials and techniques of technical drawing. In Chapter 4, I examined a range of interpretations that have been given to line marking, particularly the straight ruled line, described by Ingold as an ‘icon of modernity (2007). I examined accounts of outline drawing in the period around 1800 from twentieth century art historians and writers on architecture, and the utopian or revolutionary significance accorded to this style when considering the work of artists and architects such as Flaxman, David, or Boullée. This approach, that emphasises the individual creative agency of the draughtsman, is at first glance at odds with more recent attacks on line marking as the inculcation of an ‘ideology of industrialisation’ in the nineteenth century (Brett 1987) onto the bodies and minds of docile workers. I also examined other approaches that explain the introduction of line marking by an appeal to the notion of technical and material constraints, for example Ivins’s theory of the ‘tyranny of line’ (1992) in the period 1600-1800.

One particularly problematic aspect of describing the adoption of line marking for technical drawing in terms of material constraints is the idea of a ‘natural’ and rational correspondence between geometrical drawing and material shaping, because this is a theory that is still current amongst many working twentieth century designers and engineers. Although this attitude is easy to demystify in one sense, for example by referring to the historical cult of Euclid in the nineteenth century (Richards 1988), or by pointing to the ideological reasons for that cult (Brown 2000), nevertheless the continuing existence of this idea may indicate insoluble differences between working engineers and historians reflecting aspects of tacit engagement and interplay between drawing, material shaping and mechanical theory in engineering design that cannot be addressed by non-practitioners (Brown, Diego and Downey 2009). However, although all these different viewpoints of contemporary historians, anthropologists, art theorists and designers are of relevance nevertheless there has been a tendency by historians to impose, retrospectively, perspectives growing out of art movements after my period of study, just as there has been a tendency by designers to attempt to ‘naturalize’ their own attitudes towards the relationship between form and function.

Instead, using new sources of the period I argued that line is best understood not as an immaterial concept but as the trace of material shaping, the sign or marker of an often laborious embodied process. Although my argument here was initially informed by my own observations, ideas from the history of science allowed me to develop a more differentiated viewpoint, allowing me to suggest that in considering drawing as visual expression, a material artefact, and embodied practice we can see two methods that were used to create belief and engagement within the apparently sparse expressions of line drawing; either by an appeal to the supposed authority of ‘self-registering technology’ (Schaffer 1992: 362) in techniques of ‘chaste’ mechanical tracing of outline, or through the demonstration of the private expertise of the skilled craft operator (Sibum 1995: 101) in the ruling of straight lines.

In chapter 5 I continued my examination of the material production of technical drawing and illustration by considering how in the first decades of the nineteenth century, engineers, draughtsmen and illustrators developed a technical style of drawing that incorporated procedures derived from the factory system of manufactures. For example, the notion of repeatability was enacted both through mark-making into the drawing, and through copying the drawing in print. I argued that it is misleading to characterise technical illustrations as a peripheral or non-serious by-product of the development of technical drawing. Such rejection is based on the belief that true technical drawing is the trace of a creative process, in accord with the concept of technology as three-dimensional 'visual thinking' (Ferguson 1977: 827-36). My research contests this idea, for the evidence suggests that technical illustration was a key element in the development and reception of technical modes of drawing.

Chapter 5 argued that the materials, machines and processes involved in fabricating linear modes of technical drawing were deliberately used by engineers, draughtsmen, and other skilled artists such as engravers to construct a visual artworld with a distinct mechanical aesthetic in the first decades of the nineteenth century, and that the products that made up this artworld were not limited to technical drawings in the workplace. I developed my argument by considering the idea that drawing conventions are built in to 'permanent equipment' (Becker 1982); frequently we can see that technical draughtsmen made choices about equipment that then became 'permanent' in both general and specialist uses. For example, I examined the affiliations between technical drawings as 'works on paper', and the fashion for watercolour painting that acquired fine art and 'polite' cultural prestige around 1800. Technical draughtsmen developed techniques of graded or block washes, and uniform line markings on smooth glazed paper surfaces that later came to be standardised in the finish of mechanically made paper. Other more specialised drawing machines such as the elliptograph were used to establish and display a mode of excessive and rhetorical appearance of accuracy and neatness in drawings prepared for reproduction in print.

Engineers, draughtsmen and engravers devised techniques of replication for a range of drawing machines in order to display their inventive abilities in visual form. These examples of work suggested that engineers and draughtsmen should also be considered as visual technicians, working alongside instrument makers, engravers, and printers, while projects such as developing the security and authenticity of the ornamented banknote juxtaposed artistic and technical styles of drawing in equality and tacitly forced recognition upon the viewer of the improving status of 'engineering' through visual means.

In my two final chapters I built on these contextual supporting arguments in order to investigate in more details the social relationships around technical drawing, in the workplace and in professional formation in competition with other occupational groups.

I examined questions of professional formation and occupational fragmentation both in relation to elite engineers (in Chapter 7) and in relation to technical draughtsmen. Chapter 6 considered draughtsmen as industrial workers. Very little research has been produced about British draughtsmen, there are very few official business or educational records that relate to this work, and my information had to be assembled from a range of alternative sources. My findings allowed me to argue that the invisibility of draughtsmen was not so much the result of their non-elite status, but rather because their status was disputed and problematic. In the first half of the nineteenth century, draughtsmen were squeezed in conflicts about control and autonomy in the workplace, in public anxieties about worker education, and in cultural conflicts about the alleged deficiencies of taste in design for the products of British manufacture. My interpretation of my research, and my reading of the perceived status of industrial draughtsmen and their role in the workplace was informed by two ideas in particular, first the characterisation by Meikskins and Smith (1987) of the 'ambiguous and intermediate' status of technical workers, acting as deputies for capital against labour interests, and second by sentiments expressed by Jonathan Rose in his 'defence of the clerks' in the 'intellectual life of the British working classes' (Rose 2001). Many accounts of worker education and self-improvement, either from the nineteenth century or from more contemporary accounts, seem to express the kind of freezing hostility that Rose described, in his study of autodidact readers, as the weapon of intellectuals trying to maintain a 'perilous social distinction' against the pretensions of those just snapping at their heels in the quest for social advancement (Rose 2001: 393-4).

In the first decades of the nineteenth century, student engineers had aspired to work in drawing offices as a step in a career trajectory. However, the establishment of drawing offices as a separate environment in larger engineering concerns in the first decades of the nineteenth century also formed 'draughtsmen' as a separate occupational group. This environment formed a separate culture in which the final goal of becoming an engineer was less certain. To examine the changing status of draughtsmen, and their social background, I looked for evidence of drawing education in the records of mechanics' institutes and similar schools in Glasgow and Edinburgh, which I compared with accounts from other sources. In Britain, students of drawing from mechanics' institutes were able to develop working lives as industrial draughtsmen and ornamental designers for art trades. In social background, most of these students were probably already skilled manual workers, tradesmen, or commercial office workers, or were the sons of such workers. Written contributions, in the form of letters and articles from working industrial draughtsmen in sources such as the *Mechanics' magazine* suggested that learning and displaying drawing skills could be a vehicle for combative and playful self-assertion.

I also examined sketchbooks and autobiographies of engineers and engineering workers from earlier decades in the nineteenth century. The sketchbook of William Creighton, later the head draughtsman at Boulton & Watt, gave detailed visual evidence about his method of self-teaching through making faithful copies from printed illustrations. His method of copying the drawing conventions of other artists and ordering them into categories can be understood as part of the 'pursuit of self' described by recent studies of the role of commonplace books in eighteenth century culture (Dacome 2004: 606). But these visual examples expand the notion of the conscious development of memory through inscriptions into an account that also recognises the role of physical bodily habits expressed through disciplines of repetitive mark-making. Although this style of drawing education is familiar from accounts of fine art academic training, this technique has not been noted before in the context of training for machine design. I used drawings from the archives of Boulton & Watt and Nasmyth & Gaskell as sources to indicate the working practices of office draughtsmen in the period from around 1830 to 1850 and finally consulted printed correspondence from the *Engineer* journal of 1859 where debates about the duties of draughtsmen showed a new perception of more subservient draughtsmen in larger factory organisational structures.

Chapter 7 complemented the discussion of professional fragmentation in engineering in Chapter 6 by discussing the visual practices of elite engineers in the first half of the nineteenth century in relation to professional formation, self-presentation, and authorship. How did engineers aim to establish respect for themselves and their occupation in the social hierarchies of the period? While the working practices of engineers were in part derived from those of manual craft trades, the aim of groups such as the Institution of Civil Engineers (founded 1818) was to promote confidence in engineering as a rational public enterprise, with three 'professional' aims: the promotion of education for engineering as specialist knowledge, the desire to draw boundaries of exclusion, and finally the promotion of public confidence through self-presentation. This chapter explored aspects of the tensions involved in making a claim to special expertise and of popularising one's knowledge. And equally, while engineers presented ‘engineering’ to general non-expert readers they were also competing with other elite groups claiming expertise. My examples in this chapter were chosen to demonstrate how engineers made choices about visual display in relation to status within the scope of a range of simple images intended for reproduction in print.

I related my choice of examples to the themes of Chapter 6, where I discussed the self-education of draughtsmen, and their assertion of skill through drawing, and asked how some engineers aimed to create a professional niche for themselves through visual and literary practices, developing public discourses of engineering in printed publications for general and technical readers. I wanted to address a body of banal or textbook imagery not normally associated with elite engineers, whose status of ‘heroes of invention’ (Macleod 2007) has been bolstered by an analysis of their practice that gives attention to creative aspects of design, to control in the factory and to sumptuous presentation drawings. By contrast, almost no research has been given to the expression of professional engineering practice through the production of routine texts such as manuals or reports (Jardine 2000: 401-2). Work in the history of science on scientific writing and popularisation helped me to expand my interest in print and graphic communication, directed at the notion of engineers and draughtsmen as ‘visual technicians’ (Cooter and Pumfrey 1994: 237-67; Brown et al 2009: 737-52; O’Connor 2009: 333-345; Cantor et al 2004; Lightman 2007: 29-30)

I discussed the staging of the Great Exhibition as an event that brought forward some of the dilemmas faced by elite engineers when using visual representations in their quest for status, arguing that the opportunities presented by the exhibition did not necessarily mesh with the ambitions of some engineers to assert status through specialised theoretical and scientific expertise. At the Great Exhibition, engineers were in contact and in competition with men of science and with civil servants who aimed to direct state policy for education in design and technical skills, and I used examples taken from the visual self-presentation of engineers James Nasmyth and David Kirkaldy to demonstrate some of the complexities that were involved in negotiating allegiances with elite engineers and with men of science, in which the some key statements were made through images in print. Nasmyth and Kirkaldy, in different ways, chose to minimise their hand craft skills in presenting their ideas visually. Nevertheless I argued that their ability to manipulate a range of visual styles to communicate with different audiences demonstrated an expertise as ‘visual technicians’.

This dissertation has demonstrated that in the period to the middle of the nineteenth century styles of technical drawing and illustration were so varied, in technique, appearance and function, that any attempt to define this genre in standard terms would be misleading. Even though factory drawing office styles were more uniform, every company had different methods of working. In the second half of the nineteenth century, beyond the period of study, state technical education (Cardwell 1972) following the Education Act (1870) and the Technical Instruction Act (1889) aimed to encourage uniformity in drawing instruction, but provision was chaotic, and employers continued to block and resist efforts to allow workers to study until at least 1900 (Cronin 2001: 3; 237), while British Standard drawing regulations were not agreed until 1927 (BSI Standard No. 308, 1927, Booker 1979: 175). In the first half of the nineteenth century, and well beyond, draughtsmen learned to draw by several routes, nearly all self-directed, and engaged with many different traditions of drawing in artistic, architectural, geometrical and ornamental modes. In these circumstances it would be meaningless to assert that technical drawing in inexpressive and inartistic. However, this did become a common perception in the late nineteenth century, and persisted throughout the twentieth century until today. So for example when the conceptual artist and dada nihilist Marcel Duchamp (1887-1976) used technical line drawing (in his construction the *Large Glass* of 1923) to represent the nadir of art (Nesbit 1991: 372), his playful conceit was used in part to reflect the firm and unreflecting currency of that assumption.

Technical drawing has not been given more attention by art historians because of later changes of direction in art and design education policy, derived in part from the philosophies of anti-industrial campaigners such as John Ruskin (Haslam 1988: 65-70; Denis 1995: 276-305; Hewison *ODNB*), with the result that later commentators on the history of art and design education have frequently dismissed decades of policies and activities in the Department of Science and Art from 1853 as a faintly ludicrous episode dominated by a power-crazed Henry Cole (Frayling 1987: 132-3; Denis 1995: 18-22; 174). In the same period after1850, for practising fine artists, the market for contemporary fine art, and the power of artists, exhibitors, critics and philosophers created a discourse that excluded Cole's version of 'practical art' from art and aesthetics (Wolff and Seed 1988; Prettejohn 2005: 111-173). But apart from the exclusion of the useful arts from fine art discourse, moreover, many engineers also resisted the idea that technical drawing should be considered to be anything but functional. However, my study of technical drawing, using the methods of art history, has allowed me to break through these stereotypes and break down the topic of 'technical drawing' into a much more differentiated field of human activity where visual descriptive analysis begins to have a purchase on issues of the social history of 'arts and manufactures' in Britain in the period to 1850.

I began this area of research because there has been little or no discussion of the development of technical drawing by art historians, although the rapid expansion of technical representations in print and in factory contexts in this period seemed to demand some explanation. I wondered what mechanisms lay behind the apparent success of technical drawings. The accounts of technical drawing that did exist appeared to be limited either to a discussion of the individual creativity of elite engineers, or to an attack on the 'coercive' aspects of this style on passive workers. By moving inside the artworld of technical drawing I have been able to give a much more textured account of the ways in which different groups of practitioners sought to gain authority by visual means, either with their immediate peers and rivals, or with more general viewers. Methods of art history have allowed me to examine the visual resources and conventions that draughtsmen and engineers used, in their training and in their compositions, while the historians of technology and science have allowed me to examine social and technical means for negotiating status. In addition, two areas of interest from the history of science have given me a strong basis for future research into visual communications; first, questions about how truth claims have been established and contested through demonstration, and second, in relation to 'print culture' how areas of specialist expertise are constructed and presented to general readers. Overall, although I have seen that there are some areas of non-translation between disciplines, it has been important to work in an interdisciplinary way to develop this research in drawing practice.

In particular, I see several topics that develop immediately from this research. I intend to examine the artworld of the 'visual technicians' of useful arts publications in the early decades of the nineteenth century, to discover more details of draughtsman training and possible networks that might encompass the working lives of former Royal Academy students who developed technical roles in art as draughtsmen, studio assistants and illustrators. Second, I would like to investigate the working lives and visual productions of independent draughtsmen with relation to the discourses and social relationships in artisan publications such as the *Mechanics' magazine*. Finally, with the benefit of far more business and other documentation that is available for this period, I would like to examine the working conditions, social relationships, and cultural aspirations of factory office draughtsmen in the later half of the nineteenth century. Draughtsmen are not my only interest, but their contested status makes a good subject in my own field of art and design history, where the average or mundane worker is rarely studied. Office draughtsmen and women can be studied in relation to the development of technical and design education in Britain, or to the 'worker's dream of becoming an engineer' (Berner 199: 345-372). The visual training, and the cultural expression of office draughtsmen can also be placed in relation to mechanisms in the construction of the perceived 'lower middle class' with its allegedly self-imposed 'isolation and loneliness' (Crossick 1977: 27), the world described by poet Tony Harrison where to working class mothers the factory drafting office became the greatest aims they could conceive for their sons, to 'wear their own clothes into work but not go posh/ go up a rung or two but settle near' (Harrison 1987: 153). Whatever I discover, with the examples from my current research in mind, I believe will be more lively, and less limited, than the unexamined stereotype of the mundane technical worker. My research in this dissertation has been used to establish the case that the imagery, draughtsman training, cultural claims, and social networks in technical drawing and illustration in Britain in the period to 1850 should be of interest not only to historians of technology but also to historians of art, design and print culture. The networks of practice and culture I have outlined in this work are here to serve as a basis to approach new and more specialised areas of research.

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