David Pye's Fluting Engine

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Note: this is the author's final draft prior to typesetting. The full reference for the published book is: Carpenter van Barthold, B. (2020) 'David Pye's Fluting Engine' in Lee, Y. (ed.) *Surface and Apparition: The Immateriality of Modern Surface*, London; New York: Bloomsbury, pp. 99-115

[Figure 7.1 here]

Introduction

This chapter considers the fluted surface of a Brazilian rosewood dish (Figure 7.1) carved in 1980 by the British craftsperson David Pye (1914–93). The surface of this dish is inscribed by a unique hand-powered milling machine of Pye's invention, called the 'fluting engine'. This surface is an index of the operation of the engine, a system of making in which Pye (1986: 46) forms a human component, iteratively judging the spacing of the flutes by 'eye and hand' while the dish is being carved. The dish is part of a larger body of work made by the same process over a period of four decades. When this surface is considered alongside the evolution of the engine itself and the parallel evolution of gross form within Pye's work as a whole, the dish can be seen as a constituent of a larger and evolving system of production. This chapter therefore considers both the individual and the durational systems of production that are inscribed on the surface of the dish. The individual system is synchronic: it occurs at one moment in time and corresponds to the production of a single dish. The system is also diachronic: it is perpetuated over a long period of production. In this way, Pye's work forms a continuous project, composed of discrete instances that are distributed over time. The idea of the artist's body of work as a 'distributed object' is elaborated by the anthropologist Alfred Gell (1998: 232): 'It constitutes, as it were, an independent chunk of space-time, which can be accessed via each work individually, each standing, indexically, for all of them and the historical-biographical context of their production.' Following Gell, this chapter considers the surface of the rosewood dish as an index of a specific event of making and also of the

extended system of creative evolution. These are contextualized with reference to Pye's theoretical writing and contemporary responses to his work. The chapter asks what knowledge we might draw from the example of Pye's practice, and how this knowledge might guide our use of new technology.

Pye's practice is not reliant on computer technology, but his work and ideas were developed at the new technological horizon of computer-numerical-controlled (CNC) manufacture. Since 2011, a number of makers have revisited Pye's work, either by attempting to remake his milling machine or by reimagining his work using CNC milling machines (Wumkes 2017–18; Grimshaw 2017; Kettle et al. 2014; Leonard 2011). This strange homage is fascinating, but the example of Pye's practice has not previously been considered alongside a fuller understanding of his theoretical writing.[1] This chapter presents a synthetic reading of Pye's theoretical work alongside his practice, to give fresh insight into the nature of practice mediated by machines, the improvisatory role of the human operator, the role of the hand in making, and the relationship between tools and human creativity. Pye's work is an object lesson and orientation point for makers who seek to extend their embodied knowledge through new digital technologies. By developing understanding of Pye's improvisation as a maker though his unique system of mechanized production, this chapter will inform research into contemporary incorporations of human improvisation and machine production, and our own horizon of machine learning. It is informed by my own

[1] For instance, Peter Dormer (1997) presents a critical summary of Pye's writing on design and 'workmanship', but without reference to Pye's writing on *Ships* (1950), and – quite deliberately – without reference to the object of Pye's craft (1997: 71). Dormer's partial focus misrepresents Pye's ideas.

experience of making objects, and the insights that I bring through imagining myself as the human component in Pye's system.

'Craft' is a contested term.[2] A common-sense definition is 'skill in making things by hand' (Frayling 2011: 9). This identity is perceived as increasingly valuable when it is challenged by cheaper and – it is assumed – inferior alternatives (ibid.). Craft historiography charts a succession of fraught pairings, such as with industry (Adamson 2013) or fine art (Adamson 2007). This narrative of constantly reimagined skill can be found in the craft historian Tanya Harrod's recent introductory overview *Craft*. In this she writes that 'the realm of craft [is] making … something by hand' (Harrod 2018: 12), whether using traditional skills, such as glass-blowing, or the 'new kind of mastery of the hand in the iterative processes of programming' and rapid prototyping (ibid.: 16; see also DeNichola 2016; Sennett 2008: 24−7; McCullough 1996). But the challenge posed by computer technology to the crafts – and to the hand – is obvious. Either the screen replaces touch with sight, or, as touchscreen, it presents a surface on which the finger acts as an index of sight, a kind of touch without palpation, a dart of surrogate vision (Ingold 2017: 101–2). The new relation of maker, tool and material is governed more by eye than hand. In the words of the design academic David Grimshaw (2017: 3736), this is a diminution of the 'haptic and tacit knowledge … that are the traditions of craft and material making'. At the same time, of course, craft practice has evolved to embrace rapid prototyping and digital design (Johnston 2015; Openshaw 2015). In this respect, the example of Pye's work and its modern reimagining is both test bed and guide: it has a contemporary relevance and instructive power

[2] It is notable that the Crafts Council (2019) avoid offering a definition of craft on their website.

well beyond what Glenn Adamson (2007: 71) described as craft's historical 'ghetto of technique'.

There is a persistent and popular notion, tinged with an incipient romanticism, that craft as handwork is an instructive retreat from the alienation and damage of modernity. This is evident from John Ruskin's *The Stones of Venice* ([1851−3] 2009: 151−230) to Robert Pirsig's *Zen and the Art of Motorcycle Maintenance* (1974). Over the last decade there has been an eruption of this belief in popular literature and in the first-person accounts of craftspeople (see Davidson and Tahsin 2018; Korn 2013; Crawford 2010). Because craftspeople have palpable ability in navigating the affordances (Gibson 1979: 127–43) of the world of stuff, craft has also been treated as an object of instruction by academic authors, as paradigmatic of aptitude in negotiating the world's opportunities and ambiguities. In Richard Sennett's book *The Craftsman* (2008), the socialist sociologist explores the idea that the hand – or *an idea of the hand* – might play a vital role as a paradigm for a self-critical merging of subject and world, fit for application in a range of contexts, from town planning to coding, architecture and politics. A more interesting and disenchanted example is provided by the anthropologist Tim Ingold in *Making* (2013). Near the start of his argument, he considers two different modes of perception: the optical and the haptic. The optical mode sees the end before it is reached, like an object on the horizon that is approached. This mode of perception structures human creativity as the 'novelty of determinate ends conceived in advance'. This is contrasted with a haptic mode, the 'improvisatory creativity of labour' (ibid.: 20). Ingold argues that our epistemology is dominated by a project-orientated idea of making. In this view, the maker begins with a mental image. Nature provides a supply of material. The project is complete once the material has assumed the image conceived in the maker's mind. This 'hylomorphism' – from the Greek *hyle* (matter) and *morphe* (form) – posits a hierarchy of form over matter. Ingold's intention is to explore a radically different way to understand

making, one more attuned to a haptic mode of perception, to 'think of making, instead, as a process of growth' (ibid.: 21). Haptic engagement differs from project-orientated thinking in two crucial ways. The first is that the maker is continuous with the world. There is no way that an idea can be formed in advance of material. The second is that materials are not passive, but are in a process of continual movement, of growth and flux. A tree, for instance, can be seen to grow, and wood to age. But wood as a material for art is taken into culture's fold only through the agency of a sculptor: project-orientated thinking values the sculpture but not the tree. It is against this view, hegemonic in Western humanism, that Ingold proposes his idea of making as growth.

Ingold's work on making is informed by his fieldwork, secondary anthropological literature and various practical workshops. He is not a dogmatic author, but he can be abstract, and his brief attempt at, for instance, basket-weaving (ibid.: 22–4), instructive though it may be for his theoretical project, is of a rather different status from a lifetime's practice. If we want to understand how (and whether) his ideas are instructive in fact, we must find other examples. There are a few authors who write from the privileged position of being really expert at the things they make.[3] One such is the British craftsperson David Pye. Ingold mentions Pye in *Making*, but in relation to Pye's writing and not the objects of his craft (ibid.: 29, 62).

David Pye, in theory

[3] Among the most esteemed are Bernard Leach, Yanagi Sōetsu and Alison Britton; for more examples, see 'Statements of Practice' sections in *The Journal of Modern Craft*. However, examples of craft writer-makers are far outweighed by instances of academic authors who are without the authority of making.

Pye was a furniture designer and teacher who worked at the Royal College of Art (1949–74). He is best known today for his influential book *The Nature and Art of Workmanship* (1968). This book has dominated understanding of Pye's legacy. In it, Pye divides making into two distinct phases, placing ideation before realization, and following an optical mode of perception. But a fuller reading of Pye's legacy needs also to include his now less regarded book *The Nature of Design* (1964).[4] It is the task of this section to read these two works together, to reach a better understanding of Pye's model of making. Pye is also known for a series of accomplished bowls, carved from wood by means of the fluting engine, invented sometime between 1949 and 1950. This is a complex tool by which a hooked gouge may be directed by a lever to cut the distinctive flutes that characterize his bowls. Many of Pye's bowls are now in major collections, including the V&A Museum (London) and the Museum of Art and Design (New York), as well as specialist collections such as the Centre for Art in Wood (Philadelphia). The Brazilian rosewood dish that is the focus of this chapter is in the collection of the Crafts Council in London (W43; see Crafts Council n.d.; Crafts Council 1986: 63, Figure 7.1).

Pye is one of the few post-war British craft theorists of note. Definitions of apparently simple concepts such as 'skill' or 'craft' are hard to agree. Pye recognized that these terms are freighted with meaning to the point of uselessness. Consequently, he proposed new technical terms that now serve other authors well. Thus, Adamson (2007: 69–75) begins a chapter on skill with a discussion of Pye's terminology (see also Frayling 2011: 63–82).

[4] It is sometimes asserted (see Dormer 1997: 71) that Pye wrote two books on design and one on making. This is misleading. *The Nature and Aesthetics of Design* (1978) is a reprint of the earlier work *The Nature of Design* (1964), with the addition of some closing chapters on aesthetics. These have the quality of an afterthought.

Since Pye chooses to use the burdened words ‘craft’ and ‘skill’ as little as possible, the first of his precise alternatives is ‘the workmanship of risk’. This means facture that involves dexterity and care. The workmanship of risk is contrasted with ‘the workmanship of certainty’, making that is jigged or guided (Pye 1968: 4–12). Risk and certainty do not describe good or bad ways of doing something. They describe how things are made. For this reason, they can be employed with clarity, unlike ‘handmade’ and ‘manufactured’, words that come freighted with prejudice. Pye (1968: 13–19) proposed two further terms to describe the desired outcome of making, ‘rough workmanship’ and ‘regulated workmanship’. Regulated workmanship is the accurate disposal of design, ‘conveyed … by drawings and by specification’ (ibid.: 21), generally aided by jigs or guides. The aim of regulated workmanship is to realize an idea with the minimum of tolerance. By contrast, rough workmanship is an approximation. Again, these two terms are relative, and again, they are neither good nor bad. They describe an attitude to instruction.

In its invocation of design, the idea of regulated workmanship describes the priority of vision over matter. Pye is quite clear on this point. It is expressed in the title of *The Nature and Art of Workmanship*’s opening chapter: ‘Design proposes. Workmanship disposes’ (ibid.: 1–3). To adapt Ingold’s (2013: 20) phrase, design is a determinate end conceived in advance. It is an optical mode of making. Regulated workmanship is the process by which the design vision is disposed, the means by which matter assumes its form. But rather than being the end of the conversation, this rather lapidary division of labour into proposal and disposal opens the book. What follows is a rare attempt to understand the present tense of making, and how this stands in relation to the future tense of design. The crucial point is that workmanship indeed cannot be conveyed by words or by drawing, in advance. It is for this reason that workmanship merits its own book. Its strength is that it is pragmatically focused on

immediate interactions between hand, tool and material, and the effects of different kinds of making. But if this book is read in isolation, the reader is left with a partial picture.

It might be thought that his earlier and less regarded work, *The Nature of Design* (1964), would concentrate on intended function. The reader is disabused of this notion from the start: 'What is design? … Most of the nonsense probably starts at the point where people begin talking about function as though it were something objective: something of which it could be said that it belonged to a thing' (Pye 1964: 7). If the function of the object does not belong to it, then how might it be prescribed by design?

> When you put energy into a system you can never choose what kind of changes shall take place and what kind of results shall remain. God has already decided those things. All you can do, and that only within limits, is to regulate the amounts of the various changes. This you do by *design*, which is the business of ensuring that at least you get the change you want along with all the others which you don't such as heat, noise, wear and the rest. It is as though the world operated on the principle of 'truck'. If you want some of this then you must take some of that as well, even if you do not want it. (Ibid.: 15)

Pye was critical of design methods that considered objects separately rather than as components in a larger system. The book is full of verbal and photographic images of systems of different scales. On the cover of my edition, there is a photograph of a regulator clock (Benjamin Vulliamy, c. 1780). Later on, Pye describes a particularly important slide-

rest and leadscrew, made by Henry Maudslay in the early 1800s.[5] It is 'one of the most important determining systems and the parent of innumerable others' (Pye 1964: 54), an ancestor of the modern machine mill. All of these particular systems form their own internal economy, but in turn are part of a wider economy that contains all things: 'No system is self-contained. Every device is a subsidiary part of a more extended system (which must contain among its other components, man)' (ibid.: 31). If we consider Pye's recognition of 'truck' and his belief that the operative and the designer are both part of a dynamic system of flow, we might need to read his work on workmanship in a different light. Indeed, these books are larded with a strange sense of failure. Consider these quotations, one from each book:

> Nothing we design ever really works. … The aircraft falls out of the sky or rams the earth full tilt and kills the people. It has to be tended like a new born babe. (Ibid: 10)

> All workmanship is approximation. There are in the world of manufacture, and not only in that of metaphysics, certain Ideas of which the things we make are necessarily imperfect copies. (Pye 1968: 13)

Pye's theoretical contribution can be summarized as twofold. There is the very well-recognized contribution to our technical understanding of making. His categories of free and guided workmanship are still frequently referred to in the literature as precise critical alternatives to ideas of skill. His second contribution is much less well recognized. This is the

[5] A slide-rest is an adjustable device for holding tools on a lathe. A leadscrew moves the lathe's carriage. Used together, these appliances can regulate the production of spiral flutes.

idea that all human creative endeavour happens in a system of parts, people and material; and that, at a higher scale than this, each system is nested within a larger economy of materials and energy, long after and long before the act of making itself.

David Pye, in practice

The advantage of studying Pye is that we can do better than read his books against each other and think in the space between them. The evidence of Pye's own practice as a craftsperson can be used as well. Treating his fluting engine in this way forms a well-defined case for testing and developing his ideas. It is a very good example of a tool that forms a defined system, but which is also 'a subsidiary part of a more extended system' (Pye 1964: 31). The particular operation of this system is described below. It has two registers of time: the making of a single dish; and the longer evolution of the system, developing both the engine and the type-form of its products.

[Figure 7.2 here]

Pye describes the operation of the engine in a Crafts Council publication (1986: 43–9). It is a unique machine. When a bowl is turned on a conventional lathe, the woodturner works around the axis of rotation. The tooling appears as the spiral groove on a vinyl record, organized around the centre of the bowl. By contrast, Pye's innovation enables the operator to work at ninety degrees to the axis of rotation. In this case, the tool marks radiate in a linear fashion from the centre of the bowl. This can be seen in the surface of the rosewood dish. An understanding of the engine's operation is essential for understanding his relationship with the machine (Figure 7.2). The wooden 'blank' from which the bowl is to be carved is fixed to a rather stiff turntable. This can be rotated, as well as raised and lowered. The cutting blade of the fluting engine is a hook-shaped gouge. This is attached by a pivot to an A-frame that sits above the turntable. A lever operates this. As this is pulled, the gouge describes an arc

towards, and through, the wooden blank. It carves an elliptical groove from the wood. At the conclusion of each pass, the operator rotates the turntable by a few degrees, and then repeats the process until a circle has been turned. The turntable can then be raised slightly, and the operation repeated. This enables the operator to shave successively deep grooves from the blank until the bowl is finished. Without adjustment, this would produce a symmetrical product, but Pye describes how complexity is introduced. The gouge can sit at an angle to the blank, and thereby carve an arc that moves through two axes. Alternatively, an oval-turner's chuck can be used so that the movement of the turntable describes an ellipse rather than a circle[6]. All of these processes open up new possibilities of form. None of these processes were previously obtainable for woodturners, and the forms would be unachievable unless carved entirely by hand. Pye (1986: 50) made at least one other fluting engine, a smaller horizontal version, adapted for carving patterns on the lids of wooden boxes.

It is clear, from observing the fluting engine at first hand, that it is a system of interoperating parts. Taking our lead from Pye himself, let us speculate about his role as the human component in this system. There are some decisions that must be taken in advance of the equipment being used. The operator must choose a billet of wood and roughly shape the bowl with a 'heavy spout-adze' (ibid.: 46). The size of the billet creates an upper limit for the dimensions of the bowl. Rather than being concerned with the form of the bowl, the object at this stage is to 'show the figure of the wood – the pattern of the grain – to the best advantage, and to avoid defects in it which look unsightly or may weaken the thing to be made' (ibid.: 31). The gross form of the bowl is determined by the configuration given to the machine. By varying the relative positions of the cutter's pivot and the turntable centre, and by altering the cutter's radius and the angle of the plane through which it moves, a large variation of form is

[6] An oval-turner's chuck is a device that regulates the lateral movement of the centre of rotation in lathes and similar machines.

possible. If the oval-turner's chuck is used, then this increases it further. These parameters are fixed before the engine is used, and these prescribe a narrow set of potential outcomes. The form is latent in this configuration. The operation of the machine will translate this latent form from the engine to the material. Even in the production of one bowl, Pye and the engine are parts of an interrelated system. Furthermore, as the next section makes clear, the fluting engine is itself developing, through modifications made by Pye, and so the production of any individual dish should be regarded as a stage in the ongoing ontogenesis of the broader system of production. This procedural modification is instructive for contemporary digital craft.

Working with engines

[Figures 7.3 and 7.4 here]

Pye's fluting engine has a unique relationship with him, as the inventor of the tool and – in any meaningful sense – its only user.[7] Nevertheless, Pye's example has recently been emulated. An American craftsperson is in the process of making his own fluting engine after photographs of Pye's original (Wumkes 2017–18). But it is in relation to digital craft that the most interesting examples can be found. Even though he was writing in the 1960s, both of Pye's books describe the new technological horizon of numerical control:

[7] This was certainly the case in 1986 (Pye 1986: 43). Sometime after Pye's death, his cousin, the sculptor William Pye, attempted to better understand the operation of the fluting engine. This resulted in the abortive production of one bowl (Elizabeth Pye, conversation with the author, 2019).

> By numerical control certain designs can be translated (not interpreted) and 'told' directly to a machine tool so that a prototype or tool can be made without any care, judgement or dexterity being exercised at this stage. Ultimately automation may dispense with the operative altogether; but hardly the workman, who will presumably remain indispensable to it somewhere, even if numerical control advances to the point that a set of machines, given a suitable programme, can design and make another without the workman intervening at all. (Pye 1968: 26; see also Pye 1964: 55)

Pye's work is situated at the cusp of this technological revolution. It is perhaps not surprising that artists and designers have returned to it as a provocation, because it has a register of 'craft' but is mediated by machine. In 2011, the American designer and academic Zeke Leonard (2011) wrote about this and later created his own fluted bowl, *Homage to David Pye*, carved using a CNC routing machine (Figure 7.3). A few years later, the British design academic David Grimshaw made another *Homage to David Pye*, again using CNC technology (Kettle et al. 2014). Grimshaw says he was provoked by Pye's comment that Pye (cited in Grimshaw 2017: 3737) would have been 'fascinated to see the sort of things I make being turned out by a computer … [but] I bet I could do it better than the computer all the same'.[8] Grimshaw (2017; n.d.) followed his first reimagining with a more formally complex object, a form that it would not be possible to make using Pye's process, but which nevertheless still quotes from the characteristic internal fluting of Pye's dishes (Figure 7.4).[9]

[8] See Frayling (2011: 93−108) for a full transcript of this conversation.

[9] This work was exhibited at the Crafts Study Centre, University for the Creative Arts, Farnham, United Kingdom, 13 November – 15 December 2018.

Leonard and Grimshaw are both concerned with how and whether craft knowledge is manifested in their work. Leonard (2011) describes his homage as 'a craft object', but comments that 'something is lost in this particular amount of remove between the maker and the material. … Having that interaction modulated by a computer screen … feels too distant for me'. Leonard's comment is consistent with what Grimshaw (2017: 3736) sees as a general tendency towards deskilling in design education: 'I believe that the development of the design process from the physical to the digital has had some undesirable consequences and the current emphasis on developing design work using screen based CAD [computer-aided design] is detaching designers from the physical experience of material making.' In response to this challenge, Grimshaw's project interprets Pye's bowl forms, using a process where 'the final physical characteristics are not fully determined within the CAD modelling phase' (ibid.: 3735). Instead these characteristics are determined through an iterative heuristic process, in which the precise interaction of wood grain and cutting blade is observed, and the stepover of the milling blade adjusted accordingly.[10] Thus Grimshaw opens up a gap in an otherwise rigidly regulated process. These breaks of free judgement allow him to apply 'craft making knowledge within the digital machining process' (ibid.: 3735) – to use Pye's (1968: 26) terminology, in order to exercise his 'judgement or dexterity' – but as will be seen, the process is less continuous and less embodied than the example of Pye's own fluting engine.

Pye wrote relatively little about his own work, so it is not known how his fluting engine was conceived – whether he had a notion of a bowl in mind and wanted a tool to make it, or

[10] A 'stepover' is the amount of overlap provided for by each pass of a cutting blade in CNC milling. Typically, milling blades are rounded, and so a smaller stepover produces a more finely scalloped surface. Routed wood shows a more consistent grain when it is more finely scalloped.

whether the idea of a scraping tool came first and its application followed. However, there are clues that show how Pye's work progressed. The first of these is that his engine, and so his bowls, became more complex over time. In 1986, he described adaptations that he had made to the machine over the preceding ten years. One was to swing the gouge in a plane diagonal to the turntable, enabling the creation of spiral flutes. The other was the introduction of the oval-turner's chuck (Pye 1986: 46). Before 1976, all of his bowls' depressions were, perforce, circular. At some point between 1976 and 1986, oval forms became possible. The second clue to how Pye developed his work is a short comment that he made about the objects of his second, smaller fluting engine. This device is for the engraving of wooden box lids:

> The technique for engraving … lids is simply an adaptation of the bowl fluting technique and I developed it about eight or ten years ago. It is far less adaptable than the technique of the Ornamental Turning Lathe (though probably much quicker) but it is still capable of producing a surprising variety of patterns – some of them very nasty! (Ibid.: 46)[11]

This is an admission of surprise and discovery. From the evidence of Pye's account, his iteration of bowls and dishes over four decades is a slow improvisation. Following Pye's definitions, this can be thought of as 'the workmanship of slow risk'. Rather than his projecting his vision of form through the engine and onto the matter of the wood, a repertoire of forms can be seen evolving. Thus we can see the broad typology of the rosewood dish that we are concerned with here, repeated in approximation and variation, sometimes with

[11] An Ornamental Turning Lathe is a complex machine tool for carving, for instance, barley twist candlesticks.

handles, sometimes without, and in different kinds of wood.[12] If we return, then, to Pye's idea of the human component, it is clear that this component is not simply a command centre, a programmer issuing instructions; the process a kind of slow experimental play or improvisation. Rather than thinking about Pye's work only as the production of discrete bowls, it is more productive to conceive of this as a process of discovering the affordances of the system, of finding out what works and what does not. This creates a cognitive field, distributed through the technologies and materials that form the system of making and without which it is to be doubted whether these new forms would be created.[13]

So far the discussion has been limited to the determination of gross form, and the setting up of the machine – that is to say, everything that happens before the carving action of the

[12] I am grateful to an anonymous peer reviewer for drawing my attention to Pye's concern with the notion of diversity in made things. This is a quality of variation that is lost in the workmanship of certainty, and which is 'most valuable in the contrast and tension between regulation and diversity' (Pye 1968: 36). The fluting engine could be considered an attempt to develop 'limited risk' in manufacture. However, in this example, the regulation of risk changes over time, as a result of the improvisatory relationship between dish, maker and tool, and the corresponding evolution of the fluting engine. Moreover, the evolution of gross form in Pye's work is negotiated without predetermining its end point, and in concert with this slowly changing regulation. Thus diversity emerges in Pye's practice as gradual change in the potential limits of production. The duration of practice and the improvisatory feedback between change and regulation is what I seek to emphasize here: hence 'slow risk'.

[13] For a contemporary example of a similar process of form evolution through technological innovation, see Jerhoen Verhoeven's *Cinderella Table* (2004; Johnston 2015: 258–61; Openshaw 2015: 263–5; V&A 2016).

engine starts – though it should be clear by now that the making process never really starts or stops. Let us turn our attention to that part in the process where a blank is in place and the machine is being used. The operator takes up the lever, to which the gouge is attached by a bell crank, and pulls it down, pushing the gouge through an arc, and shaving a sliver of wood from the blank. The turntable is then rotated by a small degree, and the operation is repeated. Eventually a whole circle is turned, and the bed is fractionally raised, allowing another pass to be made, carving a deeper depression. Incrementally, the bowl is formed. Each stage in the process is determined by the step before. We might think again of a modern process such as rapid prototyping, which is like a kind of sedimentation. But while it is running, Pye's engine has a human component that is following and modulating the flow of information within the system of production. As Pye explains, the fluting engine is only moderately jigged: 'I have never cared to put a dividing plate on the turntable so that all the flutes could be indexed to an equal width. It could be done, but would mean that the inside of the bowl was all regulated. I have preferred the element of freedom introduced by spacing the flutes by eye and hand' (1986: 46). Regulated workmanship is the accurate disposal of design 'conveyed … by drawings and by specification' (Pye 1968: 21), generally aided by jigs or guides. In spacing the grooves 'by eye and hand', Pye is inside the adaptive operation of the engine and improvising through the process. While the broad shape of the dish and the discovery of pattern belong to a longer duration of evolution, the fine detail evolves while the dish is carved. This effect is clear on the surface of the rosewood dish. It looks regular, but – and especially once one knows how the engine works – it reveals the evidence of this incremental process. By looking at the surface of the rosewood dish, we can see that each pass of the gouge carves a flute, and that each flute forms a structuring basis for subsequent judgements and subsequent flutes. In the same way, each dish forms a structuring basis for the ongoing modification of the engine itself. It is the surface of the dish that tells us most about its

concrete realization, and that gives most insight into Pye's relationship with his unique technology. Pye is embroiled in both systems of production: the production of an individual dish, and the evolution of the engine.

The French philosopher Gilbert Simondon describes this kind of process as 'transduction':

> This term denotes a process – be it physical, biological, mental or social – in which an activity gradually sets itself in motion, propagating within a given area, through a structuration of the different zones of the area over which it operates. … The simplest image of the transductive process is furnished if one thinks of a crystal, beginning as a tiny seed, which grows and extends itself in all directions in its mother-water. Each layer of molecules that has already been constituted serves as the structuring basis for the layer that is being formed next, and the result is an amplifying reticular structure. The transductive process is thus an individuation in progress. (Simondon [1958] 1992: 313)

In this extract, Simondon describes individuation as movement from a pre-individual state in which being is immanent or virtual but not actual. The implication here is that the creative process is a repeated movement between individuation and disindividuation. In particular, Simondon's project exposes the 'technological insufficiency of the matter-form model' of ontogenesis (Deleuze and Guattari [1987] 2007: 408), which, in the context of this chapter, we can understand as the future tense of design ideation. Pye's practice involving the fluting engine is a good example of transduction in Simondon's terms, especially when we follow Pye's lead in locating the maker *within* the system of production: the latent potential of the system of making is distributed throughout all components of the system, from the billet of wood to the engine and the maker's own embodied material knowledge.

Pye's book on workmanship contains a typically lapidary description of a self-jigging tool. This provides a verbal image of a transductive process, just as much as his rosewood dish provides a concrete example: 'Many tools are partly self-jigging. The adze is, for one. The whole secret of using it accurately is that the curved back of the descending adze strikes tangentially on the flat surface left by the previous stroke – which becomes a partial jig – and rides along it so that the new stroke more or less continues the plane of its predecessor' (Pye 1968: 18). Pye's example of transduction is characteristically physical. An adze is a tool that is handheld, and it provides substantial feedback to the user of the tool, transmitted through its handle to the operator's hand and body. From a contemporary point of view, Pye's engine also looks heavy and clunky: something that must be negotiated through the human body as a part of the system. The two contemporary responses to Pye's work that I have mentioned sit in a somewhat different relation to the bodies of their makers. Leonard (2011) describes the loss of feeling involved in having 'interaction modulated by a computer screen' as opposed to the 'butt of a chisel'. Grimshaw describes a process that opens up to his judgement in stages, but that otherwise proceeds without the continuous embodied care – the slow risk – of Pye's fluting engine. By contrast, when Pye entered the system of production that we have been concerned with here, he must have felt considerable physical feedback as the hook gouge carved the wood. His daughter describes seeing as a child the shavings left by her father's work. Rather than being smooth, continuous lengths, they formed tight bunches of short arcs joined at one tip, leading to the family renaming the fluting engine the 'banana machine'.[14] These bunches are evidence of the effortful actions of the gouge through the wood. This feedback is concrete touch, as opposed to the much-discussed haptic perception – the virtual touch – of recent debate (see for example Ingold 2017; Bruno 2014). This is not to suggest

[14] Elizabeth Pye, conversation with the author, 2019.

that handwork or machine work is more material than its modern and digital equivalents, but there is an important difference. Digital technology demands less from the bodies of its users. But the fluting engine's operator must have had to contend with its materiality. Considering the likely effort involved in using the fluting engine, I suggest that it is not just Pye's mind that is extended through the engine, but his body too. We should consider his hand and engine together as the location of Pye's own embodied stylistic knowledge, his personal handwriting. Embodied knowledge is the kind of knowing-how-to-act that describes riding a bicycle or steering a ship. It also describes forms of cultural production, such as figure skating, drawing, and carving a bowl. As the art historian and curator Lionel Lambourne (1986: 23) puts it: 'Handling a Pye bowl is like being at an ice rink immediately after the performance of a great skater, when we can trace the perfectly calculated, exactly controlled choreography, punctuated by a geometrically perfect "death spin", judged to a millimetre, the precisely considered effect of the inner and outer edge of the skate leaving a sharply engraved pattern.' This same author has described the 'unforced evolution of the "handwriting" of [Pye's] own style' (ibid.: 21). All of these actions are negotiated in the concrete realm, requiring the actual touch of the human component. This is what we see when we examine the surface of the rosewood dish.[15]

To summarize: in relation to Pye's practice we have described two types of system. The first is the durational system by which the engine, the broad morphology of the bowls, and Pye as the human component evolved. The second is the operational system at each specific point of time, in which individual pieces are made. In both types, the process is transductive.

[15] I am grateful to an anonymous peer reviewer for the observation that further analysis along the lines of Gell (2013) may reveal more regarding the link between the surface of the bowl and Pye's distributed personhood beyond the confines of the third dimension.

Therefore, it would be a mistake to imagine Pye projecting his design vision through the engine. Instead, we should understand the system as a process of negotiation and informed discovery. Of course, in practice, the design-workmanship divide does happen. There are designers who do not make. There are pattern-makers who do not design. Instructions can be issued, in words and diagrams, with a reasonable expectation that something will be made conforming to the command. But there are two aspects of Pye's work that must be taken into account in considering his theoretical legacy. The first of these is a critical sense of failure, the diminution of 'determinate ends conceived in advance': 'Everything we design and make is an improvisation, a lash-up, something inept and provisional. We live like castaways' (Pye 1964: 10). The second is his insistence that all action is related. No gesture, no thought, no movement takes place on its own. Everything that is made is contained in a system. Every system is contained within a larger system (ibid.: 31). The actions of the designer and the workman are restricted to making adjustments within a system of flow, from within it, and as a part of it. His own practice, in which he plays the twin role of designer and workman, forms an excellent illustration of this process.

Conclusion

This chapter has examined the surface of a rosewood dish by David Pye and its indexical relation to its system of production. The material and stylistic qualities of the surface of the dish give insight into the particular system of making and the role played by the maker's experiential and embodied knowledge, dexterity and care throughout the making process. This synchronic system is also a 'subsidiary part of a more extended system' of adaptive change (ibid.). Here there is a reciprocal relationship between the gross morphology of the dishes and the increasing complexity of the engine. This diachronic system is marked and

enabled by discovery and surprise, which is described, in a modification of Pye's terminology, as the workmanship of slow risk.

Pye's unique technology is situated at the cusp of the technological revolution of CNC manufacture. As this chapter describes, it has been a creative provocation to contemporary makers. Whereas Leonard's homage forms a somewhat mournful resignation to the separation of maker from material that is the default condition of computer-mediated practices, Grimshaw has designed a system of production that is iteratively opened to his material judgement and craft knowledge. In this way, Grimshaw's project is exemplary of the 'new kind of mastery of the hand in the iterative processes' of computer-aided manufacture (Harrod 2018: 12). It will be interesting to see how it develops from this point, and whether there is the same quality of haptic improvisation in the slow evolution of his project as can be traced through the evolution of Pye's work. Nevertheless for the present moment, there is a marked difference between the continuous physical contact of Pye's making and the slow risk of its evolution, and the iterative modification of jigged making that constitutes Grimshaw's project. Grimshaw (2017: 3736) has himself drawn attention to the etiolation of material skill in design education and the consequent loss to industry. His project is a response to this challenge. The close look at Pye's work that has been the subject of this chapter puts a sharper focus on this observation. The lesson of Pye's practice is to ask better questions of 'digital craft', and to be more sensitive to the difference between the haptic touch of digital creativity and the concrete touch of material palpation.