14 Stacks, 'Pacs', and User Hacks: A Handheld History of Personal Computing*

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Introduction

In 1988, a churlish columnist for *The Daily Telegraph* by the name of Boris Johnson remarked upon the Whipple Museum's recent acquisition of Cambridge architect Francis Hookham's extensive handheld calculator collection. Ironically applauding the museum's curatorial foresight, the author encouraged it to 'branch out from mere science and become a major tourist attraction for its peerless collection of obsolete gadgets of every kind'.[1] This equation of calculators with worn socks and kitchen appliances pithily suggests how rapidly perceptions of earlier computing technology changed as 'personal' desktop computers became commonplace.[2] Conventional wisdom locates the origins of the personal computer (PC) in the Jobs family garage *circa* 1976 – the more erudite in the January 1975 issue of *Popular Electronics* announcing the Altair 8800 – but the first device actually marketed as such was a different 'PC' altogether: the HP-65, a programmable calculator launched in 1974.[3] In this

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1 The name is no coincidence: this was an early gig for the future Mayor of London and Conservative Foreign Secretary, Boris Johnson: 'Enter the Age of the Instant Antique', *Daily Telegraph*, 26 October 1988.

2 As David Edgerton argues, innovation-centred thinking conceals the more fundamental world of technologies-in-use: D. Edgerton, 'Innovation, Technology, or History: What Is the Historiography of Technology about?', *Technology and Culture*, 51.3 (2010), pp. 680–97.

3 P. E. Ceruzzi, *A History of Modern Computing*, 2nd edn (Cambridge: MIT Press, 2003), p. 213. John Markoff has argued that the term can be traced back into the 1950s: J. Markoff, 'How the Computer Became Personal', *New York Times*, 19 August 2001, www.nytimes.com/2001/08/19/business/how-the-computer-became-personal.html.

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Figure 14.1 The Whipple's Hookham Collection contains nearly 450 pocket electronic calculators, dating from the early 1970s to the present day. Image © Whipple Museum (Wh.4529).

chapter, I work from the Hookham collection (Figure 14.1) to investigate the material culture and moral economy of handheld programming, a granular approach to one of the more intractable questions in the history of modern technology: how did computing become personal?

Influential accounts of the history of computing in the United States have shown how computers were marked from the outset by their development within the Cold War military–industrial complex, but came to be embraced by the counterculture movement that coalesced in protest against it.[4] This appreciation for social politics has given texture to a narrative arc that privileges invention, market strategy, and pioneering industries that took on the overhead of

4 Paul Edwards's account of computers becoming thinkable only within a kind of 'closed-world' discourse of Cold War defence systems has been elaborated upon by Janet Abbate, who shows how the defence research network, ARPANET, formed the basis for the Internet, and Rebecca Slayton, who shows how ideas about expertise in missile defence were a moving target. See P. N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge: MIT Press, 1996); J. Abbate, *Inventing the Internet* (Cambridge: MIT Press, 1999); and R. Slayton, *Arguments That Count: Physics, Computing, and Missile Defense, 1949–2012* (Cambridge: MIT Press, 2013). While Fred Turner provides the best contextualised account of a counterculture information ethos evolving in tandem with defence research culture, he draws on earlier work including Steven Levy's earlier journalistic account of hacker culture. See F. Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of Chicago Press, 2006); S. Levy, *Hackers: Heroes of the Computer Revolution* (London: Penguin, 1994); T. Bardini, *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing* (Stanford: Stanford University Press, 2000); and Markoff, 'How the Computer Became Personal'.

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expanded information processing, a historiographical trail blazed by historians of technology working from business history.[5] Historians of science, on the other hand, have largely sought answers to the question set by Jon Agar in his influential article 'What Difference Did Computers Make?' by highlighting the continuities between pre-digital data practices and the forms of organisation required to successfully apply computers to scientific problems.[6] In the midst of software *and* hardware crises in the early 1970s, programmable calculators were readily calibrated to existing computational practices, but what's more is that they followed their users home.[7]

The appeal of early PCs was largely limited to a subset of electronics hobbyists: hardware enthusiasts who typically assembled the machines themselves. In contrast, the thousands of engineers, scientists, and professionals who got their first taste of programming through calculators made these commodities *work* in novel ways. Thus, following their uptake allows us to consider the merits of two increasingly powerful approaches within the history of computing. The first goes beyond the sociological conceptualisation of 'users' towards a politically grounded social history.[8] This project is perhaps

5 Some noteworthy examples of this literature include Ceruzzi, *A History of Modern Computing*; M. Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge: MIT Press, 2004); and J. Yates, *Structuring the Information Age: Life Insurance and Technology in the Twentieth Century* (Baltimore: Johns Hopkins University Press, 2005).

6 J. Agar, 'What Difference Did Computers Make?', *Social Studies of Science*, 36.6 (2006), pp. 869–907. Atsushi Akera approaches the institutional development of computing expertise as an 'ecology of knowledge', while other historians of science – many associated with a Max Planck Institute research group, 'Historicizing Big Data' – stress how scientific problems drove the application of new technologies. See A. Akera, *Calculating a Natural World: Scientists, Engineers, and Computers during the Rise of U.S. Cold War Research* (Cambridge: MIT Press, 2006); E. Aronova, C. von Oertzen, and D. Sepkoski (eds.), *Data Histories*, Osiris 2nd Series 32 (Chicago: University of Chicago Press, 2017).

7 For a comparative perspective on Hewlett Packard versus Texas Instruments calculators, and a parallel development in Soviet computing, see D. Ristanović and J. Protić, 'Once upon a Pocket: Programmable Calculators from the Late 1970s and Early 1980s and the Social Networks around Them', *IEEE Annals of the History of Computing*, 34.3 (2012), pp. 55–66; and Ksenia Tatarchenko, 'How Programmable Calculators and a Sci-Fi Story Brought Soviet Teens into the Digital Age', *IEEE Spectrum: Technology, Engineering, and Science News*, 27 September 2018, https://spectrum.ieee.org/tech-history/silicon-revolution/how-programmable-calculators-and-a-scifi-story-brought-soviet-teens-into-the-digital-age.

8 The move to re-centre the user in the sociology of technology came in response to criticisms that the Social Construction of Technology approach took only the engineer's perspective. See N. Oudshoorn and T. Pinch, 'Introduction: How Users and Non-Users Matter', in Nelly Oudshoorn and Trevor Pinch (eds.),

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best characterised by the work of Joy Lisi Rankin, who argues forcefully that the educational contexts of early computing experiments did much to teach the machines themselves, and reconstructs how a masculine culture of computing *citizens* crystallised out of more capacious attempts at inclusion – only to be later diverted towards consumption.[9] The second approach engages with historical epistemology and material culture to emphasise the discontinuities brought about by technical constraints and opportunities.[10] Stephanie Dick's work on mathematical proofs exemplifies the payoffs of this approach: the affordances which arise from the interaction between hardware and software shape disciplines and machines downstream.[11] Here, I seek a middle ground between these approaches, following the interplay between the affordances of devices and forms of social organisation that made them work in new ways.

This chapter takes up the development of HP's programmable calculators within the broader technological and organisational

How Users Matter: The Co-construction of Users and Technology (Cambridge: MIT Press, 2005), pp. 1–25; and R. S. Cowan, 'The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology', in Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (eds.), *The Social Construction of Technological Systems*, anniversary edn (Cambridge: MIT Press, 2012), pp. 261–80. Drawing on labour histories of white-collar work, an emerging historiography situates the office politics of data processing within broader developments in labour discrimination and the social movements that emerged in response. See T. Haigh, 'Inventing Information Systems: The Systems Men and the Computer, 1950–1968', *The Business History Review*, 75.1 (2001), pp. 15–61; R. Slayton, 'Revolution and Resistance: Rethinking Power in Computing History', *IEEE Annals of the History of Computing*, 30.1 (2008), pp. 96–7; N. Ensmenger, *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise* (Cambridge: MIT Press, 2010); J. Abbate, *Recoding Gender: Women's Changing Participation in Computing* (Cambridge: MIT Press, 2012); and M. Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing* (Cambridge: MIT Press, 2017).

9 J. L. Rankin, *A People's History of Computing in the United States* (Cambridge: Harvard University Press, 2018).

10 Examples of this approach within the history of science include P. Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997); and H.-J. Rheinberger, *An Epistemology of the Concrete: Twentieth-Century Histories of Life* (Durham: Duke University Press, 2010).

11 S. Dick, 'AfterMath: The Work of Proof in the Age of Human–Machine Collaboration', *Isis*, 102.3 (2011), pp. 494–505; and S. Dick, 'Of Models and Machines: Implementing Bounded Rationality', *Isis*, 106.3 (2015), pp. 623–34. Hallam Stevens argues along similar lines that focusing on data organisation obscures the process by which data are transformed by algorithms and digital work practices. See H. Stevens, 'A Feeling for the Algorithm: Working Knowledge and Big Data in Biology', *Osiris*, 32.1 (2017), pp. 151–74.

Figure 14.2
Included with Francis Hookham's donation to the Museum was a wide range of calculator ephemera, advertisements, and instruction manuals. Image © Whipple Museum (Wh.4529).

context of computing in the 1960s and 1970s. As mainframe systems and their attendant bureaucratic order were on the decline, handheld devices were viable alternatives that permitted a kind of personalisation without impinging upon institutional information-processing norms. One might even argue that handheld calculators prefigured the mass market for desktop personal computers and the software to run them. My aim here is a more modest exercise: to glimpse an aspect of a broader social and technical transformation through a focal and materially rich case, allowing me to foreground the shifting forms of agency at stake in the personalisation process. Ephemera and devices within the diverse Hookham collection (Figure 14.2) evidence a kind of mutualistic exchange between user and manufacturer that eventually soured. I analyse this material to show how the moral, monetary, and material economies underlying this user network offer insight into the changing cultures of computing during this crucial period.

Challenging a Computer: the HP-35 'Electronic Slide Rule'

Tom Osborne was an unemployed engineer in 1964 when he set his hand at building a calculator in his apartment. In his recollection, he turned out a machine with 'more computing power per unit volume than had ever existed on this planet' – power that must have been so

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unfathomable that it failed to land him a job.[12] Only after countless pitches did an HP employee recommend his assistance on a project that became the HP-9100A: a programmable desktop computer that utilised Reverse Polish Notation (RPN), a logical syntax that facilitated the storage of variables to increase coding efficiency.[13] Its 64-bit read-only memory (ROM) gave it the memory-retrieval and processing capabilities equivalent to most computers of the day, or so its 1968 marketing material declared by calling it equal parts 'personal computer' and 'electronic genie'.[14] Initial market research, however, suggested that the device would sell better as a *calculator*, and HP reconsidered its approach.[15] In this section, I unpack how HP constructed a market for scientific handheld calculators during a time of rapid industry upheaval.

Mainframes in the 1960s were conceived and sold as *systems*. The apotheosis of this model was IBM's System/360, launched in 1964: a line of mutually compatible computers designed to preserve software compatibility as business and research programs grew.[16] IBM's modus operandi was to lease hardware, while offering software and support free of charge. This bundle of red-and-blue tape cabinets and consoles consolidated IBM's dominance over its competitors – labelled the 'Seven Dwarfs' – for a time, but the hegemony of bundled software was on the wane. One such dwarf, the Digital Equipment Corporation, sold 'minicomputers' to clients at a fraction of IBM's lease fees and encouraged independent modification rather than providing full support. They simply gave away manuals to support their flagship model, the PDP-8. This strategy appeared to work: over 50,000 such machines were installed, beginning in 1965. While not in direct competition with large mainframes, a slew of independent rental companies provided support for these less expensive computers, and pressure from an antitrust suit eventually

12 T. Osborne, 'Tom Osborne's Story in His Own Words', *HP9825.COM* (blog), 11 November 2004, www.hp9825.com/html/osborne_s_story.html.

13 For a more detailed discussion of RPN, see below.

14 Hewlett-Packard, '*[HP-9100 Advertisement]*', *Science*, 162, no. 3849 (October 1968), p. 6.

15 Bill Hewlett thought, 'If we had called it a computer, it would have been rejected by our customer's [*sic*] computer gurus because it didn't look like an IBM.' Hewlett-Packard, 'History of the 9100A Desktop Calculator, 1968' (2012), www.hp.com/hpinfo/abouthp/histnfacts/museum/personalsystems/0021/0021history.html.

16 Ceruzzi, 'The Go-Go Years and the System/360, 1961–1975', in *A History of Modern Computing*, Chapter 5.

led IBM to unbundle its software from its hardware by the end of the decade.

The 1970s saw the development of microprocessor technology: thousands of integrated circuits printed onto a single chip.[17] Declining costs of equipment lowered the bar of entry for new computer firms, and concerns about market saturation led to industry-wide unrest.[18] Manufacturers of computer parts, like Texas Instruments (TI), turned towards consumer electronics to bolster their bottom line, secure brand recognition, and stay competitive in chip development.[19] Industry insiders were acutely aware that chip technology was not autonomous, and represented an educational problem first and foremost. As computer manufacturers turned from selling primarily to businesses towards targeting individuals, the new users needed to be made aware of problems before they could be sold on solutions.[20] This brief portrait of computing *circa* 1970 suggests an unsettled industrial matrix in which the prime movers were well aware that the idea of *where* computers belonged and with *whom* was in flux.

While one would be remiss to neglect how the centrifugal social politics of the 1960s provided a milieu for re-imagining the computer as a consumer good, the connections between Osborne's device and the counterculture are surprisingly direct.[21] Just as much of the New Left came together to protest against the military–industrial complex, some groups began to accommodate the ethos of technological reconversion.[22] The year 1968 marked the first publication of

17 On the origins of the semiconductor industry as an outgrowth of the wartime defence firms, see C. Lécuyer, *Making Silicon Valley: Innovation and the Growth of High Tech, 1930–1970* (Cambridge: MIT Press, 2006).

18 C. Beardsley, 'Forecast for '72', *IEEE Spectrum*, 9.3 (1972), pp. 4–8.

19 D. Mennie, 'Designers' Tools: The Big Roundup of Small Calculators: Hand-Held Calculators Are Getting Smaller and Smarter; They Make the Slide Rule a Museum Piece', *IEEE Spectrum*, 11.4 (1974), pp. 34–41; and Ceruzzi, *A History of Modern Computing*, 214.

20 Osborne reflected in 1976, 'I know it will be an order of magnitude easier to design and manufacture any futuristic "personal computer" than it will be to teach people how to use it.' See T. Osborne, 'Personal Thoughts on Personal Computing', *Computer*, 9.12 (1976), p. 23; and D. C. Brock (ed.), *Understanding Moore's Law: Four Decades of Innovation* (Philadelphia: Chemical Heritage Foundation, 2006).

21 On how the consumer politics of the 1960s departed from post-war mass consumption, see L. Cohen, *A Consumers' Republic: The Politics of Mass Consumption in Postwar America* (New York: Alfred A. Knopf, 2003).

22 Matthew Wisnioski has shown that engineers were themselves heavily involved in pushing for socially responsible technology, even though such efforts ended up reifying technology as an uncontrollable force existing outside of politics:

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Stewart Brand's *Whole Earth Catalog*, a compendium of 'tools' for what historian Fred Turner has described as the 'new communalist' movement. Nestled between advertisements for beads, yarn, and buckskin, the HP-9100A was described as 'a superb inquiry machine' and fitted the bill on the basis of its futuristic appeal rather than its $4,900 price tag.[23] Brand's advocacy of back-to-basics living and 'techno-utopianism' derived from the collaborative work practices of Cold War technologists led many to retroactively label him a pioneer of personal computing. When bootstrapped onto coeval imaginaries of power redistribution and autonomy, devices like the 9100A could be seen as more than mere number crunchers.

Nonetheless, a machine that took up half a desk was hardly suitable to a yurt. In 1972, HP engineers redesigned the 9100A to fit into a chassis the size of a shirt pocket, in the fashion of a transistor radio. The HP-35 was announced as 'the world's first pocket calculator that challenges a computer', and promised '[slide]-rule portability and computer-like power for just $395', a price initially deemed too high by corporate consultants.[24] This hardly deterred eager customers, and 50,000 units were sold in the first year as the device won accolades for its accuracy and likeness in operation to computers. HP's 'challenge' lay in the 35's portability, leveraging the popularity of Japanese four-function calculators to unsettle IBM and the Seven Dwarfs, and it helped establish calculators as the leading edge of consumer electronics using advanced chips. Put in context, the 35's success depended on and bolstered in turn the legitimacy of a notion that computer power could and should be uncoupled from the mainframe.

Ultimately, the fulfilment of HP's aggressive marketing claims required that the HP-35 fit into existing norms of calculation, routinised practices of reckoning that preceded the first digital computers by millennia. In fact, the device was marketed as an 'electronic slide rule' to suggest continuity with the ubiquitous instrument for logarithmic calculations.[25] RPN was the linchpin of this strategy.

M. H. Wisnioski, *Engineers for Change: Competing Visions of Technology in 1960s America* (Cambridge: MIT Press, 2012).

23 Turner, *From Counterculture to Cyberculture*, p. 138.

24 Hewlett-Packard, '[HP-35 Advertisement]', *IEEE Spectrum*, 9.8 (1972), inside cover; and C. H. House and R. L. Price, *The HP Phenomenon: Innovation and Business Transformation* (Stanford: Stanford Business Books, 2009), p. 165.

25 T. M. Whitney, F. Rodé, and C. C. Tung, 'The "Pocket Powerful": An Electronic Calculator Challenges the Slide Rule', *Hewlett-Packard Journal*, June 1972, Francis Hookham Archive, Whipple Museum (Wh.4529).

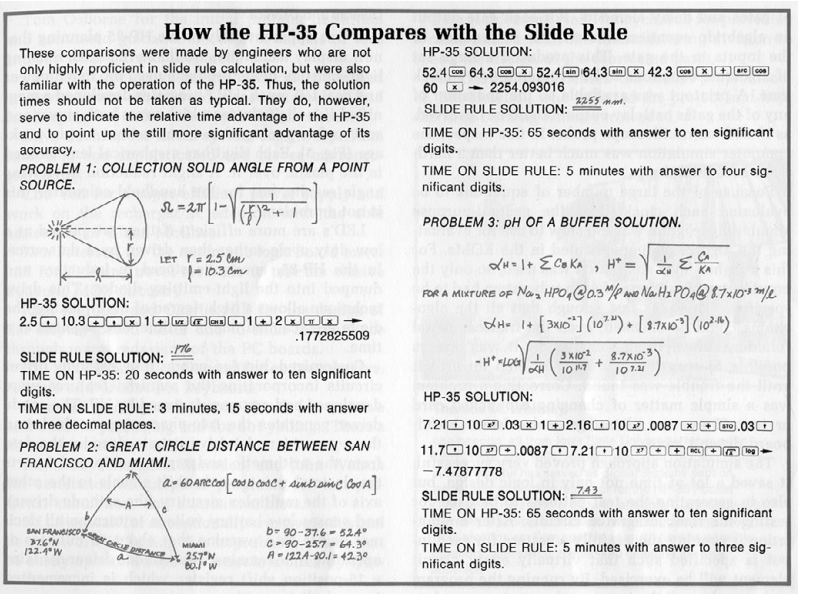

Figure 14.3 Racing the HP-35 against a slide rule. From *Hewlett-Packard Journal*, June 1972, p. 7, Hookham Collection. Image © Whipple Museum (Wh.4529).

Earlier scientific calculators were deemed too inaccurate for precision uses, as memory limitations required early rounding that affected the final result. RPN was a postfix notation that stored operands before their operators, assigning values to a 'stack' in one of the calculator's memory registers, where they could be called up when needed through successive operations.[26] While its speed was almost taken for granted as a benefit, HP foregrounded the calculator's *accuracy* vis-à-vis a slide rule in promotional materials (Figure 14.3).[27] This emphasis was reflected in the calculator's very design. Electronic calculation was not a matter of idly plugging in numbers and pressing the '=' button, because the HP-35 had no such

26 RPN was a notation system based on the development of prefix mathematical logic by the Polish logician Jan Łukasiewicz that placed the operator at the end of a string of inputs: Hewlett-Packard, 'Father of RPN', *The Hewlett-Packard Personal Calculator Digest*, 1980, Francis Hookham Archive, Whipple Museum (Wh.4529); and S. Davis and C. Eagleton, 'Touching Numbers', *Anthropological Theory*, 10 (2010), pp. 192–7, on p. 194. Davis and Eagleton give the example of *(3 + 4) × 2* in infix notation, which would be written as *3 [enter] 4 [enter] 2 [enter] + x* in RPN. Another aspect of RPN was its reputation in finance, a reputation garnered by the HP-12C, which became ubiquitous beginning in the 1980s; see K. Peterson, 'Wall Street's Cult Calculator Turns 30', *Wall Street Journal*, 4 May 2011, Technology Section.

27 Whitney, Rodé, and Tung, 'The "Pocket Powerful"', p. 7. Donald MacKenzie explores the various ways accuracy is claimed and reassembled in computational practices, see D. MacKenzie, 'Nuclear Missile Testing and the Social Construction of Accuracy', in Mario Biagioli (ed.), *The Science Studies Reader* (New York: Routledge, 1999), pp. 343–57.

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button – in its place was an arrow '➔' signifying that the 'program' was ready to run. RPN can and should be understood as a kind of programming *language*, and more generally as a *technique* that replaced slide-rule movements with mental manoeuvres that enthralled generalists with technical training.[28] While TI produced popular, affordable, and functional scientific calculators without RPN, HP users derived a sense of superiority from the likeness of their more expensive device to a digital computer, a trend that would continue.[29]

Dismantling the Mainframe: The HP-65, Programming, and Personal Autonomy

When the HP-35 wildly exceeded expectations, the company did not hesitate to design and market its next model explicitly as a 'personal computer', exhibiting a keen awareness of how users might exploit its major modification: full programmability.[30] The HP-65 was brought to market in 1974 and featured interchangeable magnetic cards as storage media for factory and user programs. Once loaded, a card could be slid into place above five assignable keys to remind a user of the functions and variables unique to the program.[31] Early press accounts of the device corroborated this likeness to a computer, but highlighted obvious differences in memory capabilities rather than the relative ease of personalisation.[32] HP countered this perceived shortcoming in its marketing material by showing the calculator in a variety of settings: in the laboratory, office, living room, and even next to an imposing mainframe (Figure 14.4).[33] By playing up the contrast between the centre–peripheral model of computing and the flexibility of handheld programmability, HP elevated a vision of autonomy predicated upon the deconstruction of the existing computing culture, a process that, as we have seen, was already in motion.

28 On the social history of programming languages, see Ensmenger, *The Computer Boys Take Over*.
29 Ristanović and Protić, 'Once upon a Pocket', p. 57.
30 C. C. Tung, 'The "Personal Computer": A Fully Programmable Pocket Calculator', *Hewlett-Packard Journal*, May 1974.
31 Mennie, 'Designers' Tools'.
32 R. Woolnough, 'They All Add Up to a Handy Way of Doing Sums', *The Guardian*, 27 August 1974; and V. K. McElheny, 'Hewlett-Packard Markets Pocket Calculator Doing Computer's Job', *New York Times*, 17 January 1974.
33 Hewlett-Packard, '[HP-65 Leaflet]', 1974, Francis Hookham Archive, Whipple Museum (Wh.4529).

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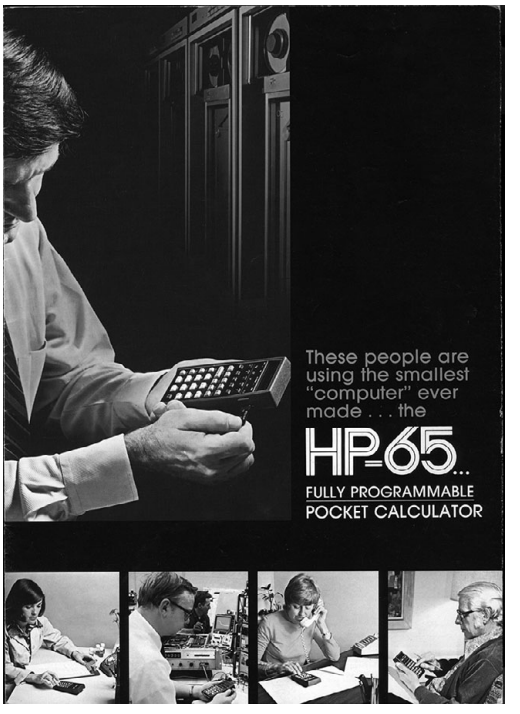

Figure 14.4
A 1974 HP-65 advertisement, showing the calculator in use in a variety of settings. Hookham Collection. Image © Whipple Museum (Wh.4529).

The *New York Times* initially cast doubt on the market for the HP-65, citing the prevalence of commercial and academic time-sharing systems.[34] While large mainframes had hitherto been a technological necessity, solutions to give more users access to a single machine provided a compelling principle of social organisation. Time-sharing was largely a creation of Cold War defence research, a model in which users at different terminals – even miles away – could access computer time on a mainframe, using batch processing to run programs so no precious computer time would be wasted.[35] In contrast, HP emphasised the importance of 'specialised' applications for different professions and branded their devices as '[gifts] for a lifetime', intimating a thread of computational continuity between job changes in a fragile economy.[36] Personalised electronics were premised upon ownership, a

34 McElheny, 'Hewlett-Packard Markets Pocket Calculator Doing Computer's Job'.
35 Time-sharing provided a key technological support for what Paul Edwards has termed 'closed-world' discourse, while Janet Abbate shows how the early ARPANET attempted to adopt a 'resource-sharing' framework on similar terms that was abandoned in favour of local files and programs, though the ability to communicate broadly over the network with applications like email stuck around: Edwards, *The Closed World*; and Abbate, *Inventing the Internet*.
36 Hewlett-Packard, '[Application Pac Leaflet]', 1974, Francis Hookham Archive, Whipple Museum (Wh.4529); and Hewlett-Packard, '[Gift for a Lifetime Ad]', *IEEE Spectrum*, 11.12 (1974), p. 21.

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departure from the modality of centralised control under which early computing had taken shape.

Such autonomy came at a price: $795 to be exact, effectively double the price of the HP-35. Many potential customers were driven to TI's SR-52, their answer to the HP-65 launched the following year at half the price with more memory, though devotees felt the 65 was 'clearly better in many ways . . . HP's keyboards *felt* like quality, and were reliable, unlike TI's.'[37] Ralph Bernstein, an IBM employee working on government research contracts, used the calculator to demonstrate results while travelling and to develop algorithms at his desk, minimising expensive mainframe usage, ironically, at the world's largest mainframe producer. He felt that the calculator engendered 'some kind of possessive instinct and pride of ownership', especially insofar as it allowed one to circumvent the sovereignty of system operators.[38] Programmable calculators functioned in a kind of technological ecosystem alongside mainframes, and could be more flexibly incorporated into work practices, providing their users with a sense of independence. American astronauts used the HP-65 to correct their flight course – it was more powerful than the on-board computer – during the 1975 Apollo–Soyuz Test Project, itself a symbol of the new geopolitics of détente: a shift from closed-world policy parallel to the transition from mainframe to microcomputer.[39]

The promise of autonomy, however, did not work alone to lure new calculator users. What was most remarkable about the HP-65 was the sheer amount of support material and social infrastructure built into its marketing apparatus. Within the Hookham collection, one can find boxes upon boxes of cards: many from specialised 'pacs' advertised with a forward-looking iconography – uncannily reminiscent of the 'apps' that run on smart phones – and many more programmed by Hookham himself (Figure 14.5).[40] While it is easy to

37 Some of the following material and perspective are derived from chat-room and email conversations with HP enthusiasts conducted in December 2013. See also 'New Product Applications', *IEEE Spectrum*, 12.11 (1975), pp. 57–60; and G. Wilson, 'Re: Project on Programmable Calculator User Networks', *HP41.Org*, 24 December 2013, http://forum.hp41.org/viewtopic.php?f=11&t=246&sid=4d7bd9025fb2b0966c4473d32d43b720#p683. On the personal dimensions of the calculator, see Davis and Eagleton, 'Touching Numbers'.

38 Ralph Bernstein, personal communication, 15 December 2013.

39 Hewlett-Packard, 'HP-65 in Space with Apollo–Soyuz', *Scientific American*, September 1975, Francis Hookham Archive, Whipple Museum (Wh.4529); and Ceruzzi, *A History of Modern Computing*, p. 189.

40 Hewlett-Packard, '[Application Pac Leaflet]'.

Figure 14.5 An HP-65 with its quick reference guide and magnetic program cards. Image © Whipple Museum (Wh.4529.227A).

think of calculators as workaday tools, to many users they courted intrigue, even obsession. A hobbyist who shelled out for an HP device might soon become preoccupied with unlocking its 'secrets'. Promotional letters for the HP-35 were headed by a well-known quote from polymath Gottfried Wilhelm Leibniz: 'it is unworthy of excellent men to lose hours like slaves in the labor of calculation.' As users came to devote considerable time, work, and social networking to augmenting their programming skills, the phrase 'labor of calculation' took on an ironic new meaning. Richard J. Nelson, who headed the most prominent HP calculator user group, observed that scientific calculators promised that practising engineers would be able to consolidate their libraries:

> I remember sitting in my living room with all of the books of math tables that I had collected. The stack was over two feet high . . . WOW, I could replace all of these gigantic heavy books with this handheld marvel![41]

While it is tempting to say that these unwieldy, if not quite towering, stacks of tabular compendia were replaced by stacks of assignable calculator memory, materials in the Hookham collection (Figure 14.3) show that these media were in fact only *displaced* by heaps of newsletters, program sheets, and books devoted to programming.[42] The programmable calculator as such owes its success to the reinvestment of infrastructure and literary culture it was intended to replace.

41 R. J. Nelson, 'Remembering the HP-35A', hhuc.us (2007), http://hhuc.us/2007/Remembering%20The%20HP35A.pdf.

42 For a parallel claim on the importance of writing practices in computing history, see S. Dick, 'Machines Who Write', *IEEE Annals of the History of Computing*, 35.2 (2013), pp. 85–8.

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Programming Infrastructure: HP's User Library, Publications, and Authorial Norms

The rise of microcomputers and their desktop successors posed a problem for the division of labour that had made electronic data processing successful: without teams of coders, operators, programmers, and system administrators, how could an individual make a computer useful?[43] The keynote speaker at the 1974 IEEE Computer Society Computer Elements Technical Committee held up the HP-65 as an example of how the power of newly advanced integrated circuits and microchips could be adapted to the needs and learning abilities of new users flying solo.[44] Alongside their 'Application Pacs', HP launched the 65 with two major social innovations: a library of user-submitted programs and a newsletter for users to voice concerns and share developments. To attract new customers, HP continued to expand its in-house product support, marketing specific applications geared towards ease of use and producing a voluminous product literature, both of which the PC industry lacked into the 1980s.[45] HP's support, however, largely stopped there. By 1975, over 25,000 HP-65s were being used by engineers, lawyers, financiers, and other professionals who had learnt most of the programming basics on their own.[46] HP helped engender an *infrastructure* in which it regulated moral, monetary, and material economies of program exchange, turning ordinary professionals into programmers by enrolling them in a sociotechnical system that redefined the calculator.[47]

Included with the HP-65 was a one-year membership of the HP-65 User's Club, which provided access to their user's library,

43 On the definition of computational labour roles, see A. Akera, 'Voluntarism and the Fruits of Collaboration: The IBM User Group, Share', *Technology and Culture*, 42.4 (2001), pp. 710–36; and Ensmenger, *The Computer Boys Take Over*.

44 M. H. Eklund, 'Technology in the Real World', *Computer*, 8.5 (1975), pp. 56–57. On developments in integrated circuits, see Ceruzzi, *A History of Modern Computing*, p. 195.

45 J. Raskin and T. M. Whitney, 'Tutorial Series 4 Perspectives on Personal Computing', *Computer*, 14.1 (1981), pp. 62–73.

46 Ceruzzi, *A History of Modern Computing*, p. 215.

47 According to information scholars Susan Leigh Star and Karen Ruhleder, infrastructure *emerges* when 'a complex constellation of locally-tailored applications and repositories, combined with pockets of local knowledge and expertise . . . interweave themselves with elements of the formal infrastructure to create a unique and evolving hybrid'. See S. L. Star and K. Ruhleder, 'Steps toward an Ecology of Infrastructure: Design and Access for Large Information Spaces', *Information Systems Research*, 7.1 (1996), p. 132.

program catalogs, and user newsletter, *HP-65 Key Notes*, all of which were nodes in a material economy of program exchange. The club subsequently cost $15 per year and programs $3 each to offset shipping and maintenance of the library in Corvallis, Oregon, with currency-adjusted prices for a parallel European library in Geneva.[48] HP encouraged users to submit personal programs to the user library, providing official templates that were often shared between users. Initially, the only remuneration that HP provided for an accepted program was a free program from the library in return; this was later elaborated into a points system through which one could purchase other HP products.[49] The magnetic cards themselves were the subject of much discussion in *Key Notes*: the introduction of cardholders met with much fanfare and users recommended different strategies for writing on and making the most of the cards (Figure 14.5).[50] Throughout the life of the periodical, HP followed the 65 with further fully programmable devices: the 67 and 97 upgraded the memory, with a built-in thermal printer added to the latter model to compete with TI, while the 41C brought the programmable calculator up to pace with advances in personal computing, adding four expandable ports and alphanumeric capabilities. The newsletter provided continuity between successive models.

This system of exchange was the cornerstone of a community visible in the pages of *Key Notes*, an essential complement to the emerging moral economy of HP programmers.[51] While finding programmers and regulating their activity had proved a persistent problem for business management since the 1960s, the dispersed, personal nature of calculator programming required a solution that would honour intellectual autonomy without turning the manufacturer into a publishing house.[52] HP adopted a model of authorship in which individuals published program abstracts in the journal, providing the

48 Hewlett-Packard, 'Users' Library Corner', *HP-65 Key Notes*, 1.2 (1974), p. 2; and Hewlett-Packard, 'Hewlett-Packard Order Form', *HP Key Notes*, 3.1 (1979), p. 8.

49 Hewlett-Packard, 'HP-65 Users Library Europe Program Submittal Form', 1974, Francis Hookham Archive, Whipple Museum (Wh.4529); and Ristanović and Protić, 'Once upon a Pocket', p. 60.

50 Hewlett-Packard, 'Accessories Update', *HP Key Notes*, 1.1 (1977), p. 1; and Hewlett-Packard, 'How Small Can You Write?', *HP Key Notes*, 4.2 (1980), p. 6.

51 For a discussion of the notion of 'moral economy', which has different resonances in the history of science than in E. P. Thompson's original formulation, see L. Daston, 'The Moral Economy of Science', *Osiris*, 2nd Series, 10 (1995), pp. 2–24.

52 Ensmenger, 'The Black Art of Programming' and 'Chess Players, Music Lovers, and Mathematicians', in *The Computer Boys Take Over*, Chapters 2 and 3, respectively.

social fulfilment sought by hobbyists, and gave these authors exclusive editing rights to pre-empt intellectual property disputes.[53] The library maintained a high rejection rate to ensure program quality and required extensive documentation with examples. Nonetheless, *Key Notes* also contained a column devoted to corrections, allowing both authors and HP officers to address bugs on a regular basis.

Finally, the periodical helped to put the 'personal' into personal computing by making the community visible to itself. The newsletter described a thirteen-year-old from Texas named Nickey who used the HP-65 to plot solar eclipses, 'celebrity' calculator enthusiasts working in the White House, and printed pictures of homemade HP rugs and T-shirts.[54] HP used the publication to cast calculators as companions and points of entry to new professional territory:

> Do you like challenging calculator games? Or – are you contemplating starting a photographic darkroom? Going into a small business? Learning more about Forestry? You'll find programs for all of those – and more.[55]

These user publications represent a mixed genre of advertising and technical support. Cultural historians of marketing have argued that advertisements should be read as expressions of norms, forms of consent building rather than bald-faced statements about social realities.[56] With this in mind, we can see HP's exhortations towards learning and regulated information exchange as expressing a kind of idealised curious consumer, cleansed of the transgressive hacker ethos that was taking hold as the dominant computational way of life.[57]

53 R. J. Nelson, personal communication, 16 January 2014; and Hewlett-Packard, 'When Contributing Programs', *HP-65 Key Notes*, 1.2 (1974), p. 3. On the complication of property in open-source programming, see S. Weber, *The Success of Open Source* (Cambridge: Harvard University Press, 2004), pp. 16–17.

54 Hewlett-Packard, 'An Amazing Young Man!', *HP-65 Key Notes*, 1.5 (1980), p. 1; P. W. Weiss, 'I Owe It All to My HP', *HP Key Notes*, 4.3 (1980), p. 7; and S. Seeherman, 'Some True Believers!', *HP Key Notes*, 1.2 (1977), p. 6.

55 Hewlett-Packard, 'Here Come the Solutions!', *HP Key Notes*, 1.3 (1977), p. 1. This was an advertisement for the forty volumes of *Users' Library Solutions* sold by HP, containing programs devoted to a specific application.

56 For influential examples, see R. Marchand, *Advertising the American Dream: Making Way for Modernity, 1920–1940* (Berkeley: University of California Press, 1985); and T. J. Jackson Lears, *Fables of Abundance: A Cultural History of Advertising in America* (New York: Basic Books, 1994).

57 Levy, *Hackers*; Adrian Johns, 'From Phreaking to Fudding', in *Piracy: The Intellectual Property Wars from Gutenberg to Gates* (Chicago: University of Chicago Press, 2009), Chapter 16.

'The World's Largest (and Poorest) Personal Computing Club'

HP's marketing strategies have driven much of the action in this narrative. By late 1977 there were nearly 5,000 programs in HP's user library, a testament to its runaway success. However, *Key Notes* and the user libraries continued only until 1983 when the editor retired, stating that the company had not yet found a replacement: 'I cannot foresee the future of KEY NOTES. I can tell you only that HP knows the value of staying in touch with you. I am sure an alternative to this newsletter will be found.'[58] While HP initially channelled the activity of users into a commercial resource, infrastructure requires investment, and a feature of the developing digital world was the ability for alternative systems to bootstrap onto successful ones. In this last section I want to make good on my promise to consider agency in a more expansive sense by highlighting the afterlife of the official user network through a grassroots one that emerged in parallel. As we will see, this group attempted to work in tandem with the manufacturer to leverage its interest in developing a product glitch as a community resource, resulting in fallout that led to its dissolution.[59]

When *Key Notes* was dissolved, its subscribers were referred to another group known as PPC, which stood for nothing in particular but could mean Personal Programmer Club.[60] PPC had been founded by Richard J. Nelson as the HP-65 Users Group not long after the calculator was launched in 1974.[61] Nelson was a seasoned hobbyist. Having been actively involved in amateur radio in the

58 H. C. Horn, 'My Last "Editorial"', *HP Key Notes*, 8.2 (1983), p. 1.

59 It should be stated that this group *did* continue in various guises. The UK Handheld and Portable Computer Club (HPCC) published an edited volume celebrating twenty years of activity in 2002, and remains active in 2019. See W. A. C. Mier-Jędrzejowicz and F. Wales (eds.), *RCL 20: People, Dreams & HP Calculators* (London: W. Mier-Jędrzejowicz, 2002); and 'HPCC: Handheld and Portable Computer Club', http://hpcc.org/ (accessed 13 March 2019). The HP Handheld Community has been meeting since at least 1999 and held its most recent conference, 'Celebrating 50 Years of HP Programmables' in September 2018, with roughly fifty attendees: 'HHC 2018: HP Handheld Conference, 29–30 September 2018, San Jose, California', http://hhuc.us/2018/index.htm. (accessed 26 October 2018).

60 R. J. Nelson, 'PPC Journal', *PPC Journal*, 5.1 (1978), pp. 1–2. The expandability of the abbreviation mirrored the flexibility of the community: 'The Personal Programmers Club does Prolific and Productive Computing with Hewlett-Packard Personal Programmable Calculators.'

61 R. J. Nelson, 'Starting a Calculator Club', in Mier-Jędrzejowicz and Wales, *RCL 20*. The group began with over 600 members in nine countries and had 3,100 members by 1981: Hewlett-Packard, 'HP-65 Users Club', *HP*, 2.1 (1975), p. 5; and R. J. Nelson, 'Member Letter', *PPC Journal*, 8.1 (1981), p. 16.

United States and the Philippines in the 1960s before the calculator consumed his interests, he got three issues of his own *65 Notes* newsletter out before HP launched *Key Notes*.[62] As a grassroots organisation, PPC employed print as the primary means for distributing programs – mailed or faxed in using HP's program sheets, then reproduced as facsimiles in the newsletter. Its monthly organ, *PPC Journal*, often exceeded fifty pages. PPC facilitated face-to-face interaction between members through meetings of various group chapters across the United States and Europe and larger annual conferences. The standards of program publication were also different: PPC maintained an open 'Share-A-Program' listing, while Nelson acted as the central arbiter for programs published in the newsletter. Here, unlike through HP, users were able to submit modifications of prior programs due to the programs' status as communal property.[63] Programming calculators was not always serious work: one published program, called 'DRINKS', was intended for users to monitor their drinking habits.[64] Though unrepresentative of the maths- and engineering-based programs regularly published in the newsletter, 'personal' programs such as these are artefacts of PPC's predominantly masculine hobbyist culture, wherein the boundary between 'personal' and 'computer' was eroded along particular lines of identity.

Nelson was also known to push boundaries, and got into trouble for publishing user information and estimates of the company's manufacturing output in the newsletter.[65] However, HP recognised the group's influence, and its Corvallis Division published a regular column. Nelson's philosophy for PPC explicitly addressed the inability of hardware manufacturers to support their products, maintaining that involvement with them must be limited to supporting the equitable exchange of information. He spurned the notion of for-profit developments from community resources, claiming that 'few, if any, commercial software, application, or even accessory concerns have been financially successful'.[66] Nonetheless, PPC would seek

62 There is a documented affinity between amateur radio enthusiasts and early personal computer users. M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine* (Boulder: Westview Press, 2004), p. 207. On the culture of amateur radio, see K. Haring, *Ham Radio's Technical Culture* (Cambridge: MIT Press, 2007).

63 Nelson, personal communication.

64 B. Lomasky, 'Drinks [Program]', *65 Notes*, 3.2 (1976), p. 19.

65 Nelson, 'Starting a Calculator Club'.

66 Nelson, 'PPC Journal'.

incorporation as a business to further develop technologies central to the activity of its members.

The watershed moment for PPC came in 1979 when Nelson and John Kennedy discovered a hack, and published a complete table of special display characters on the HP-41C that were inaccessible to standard user code.[67] More available characters meant more sophisticated programs, and this exposed machine code spurred the elaboration of a practice called 'synthetic programming', in which users could make more of existing memory registers by reassigning basic instructions elsewhere.[68] Realising the extent of interest, HP published an extensive description of the 41C system architecture in the following *PPC Journal*. Numerous programs utilising synthetic functions were published in the journal and even spawned a book. Nelson saw an opportunity to support the new practice with a manufactured component. He proposed that PPC build its own ROM unit – which could be inserted into one of the 41C's four ports – that would give programmers easier access to standard subroutine calls through the synthetic programming method. This would be a literal piece of collective memory for a group previously maintained by paper and conversation, a new technology to expand a shared practice.

The ROM project took nearly two years and strained the PPC's human resources, but HP agreed to produce a run of 5,000 for the group to purchase and distribute. It is not clear whether the company was uninterested in spinning off the project for conventional users, or whether PPC wished to keep the technology to itself. In order to handle financial matters more officially, PPC filed for non-profit incorporation in January of 1982.[69] The obligatory institution of a voting board compromised Nelson's autocratic position within the organisation, and the board fired him for refusing to make changes they demanded.[70] Nelson's sudden absence unsettled members of the group, and their unrest was fed by a rumour that he had been forced out of the PPC clubhouse by a security guard.[71] PPC continued until 1987, with its core comprised of device-specific user groups charging steep membership fees, some equivalent to the cost of previous devices. In attempting to expand its technological

67 J. Kennedy, 'HP-41C Combined Hex Table', *PPC Journal*, 6.5 (1979), pp. 22–5.
68 Ristanović and Protić, 'Once upon a Pocket', p. 61.
69 As a condition, PPC also had to support devices from other manufacturers – see Ristanović and Protić, 'Once upon a Pocket', p. 62.
70 Nelson, personal communication.
71 D. E. White, 'Member Letter', *PPC Journal*, 11.7 (1984), pp. 1–5.

capacity, the group's hobbyist ethos was supplanted by institutional formality. If the poor could, in fact, inherit the Earth in the early days of personal computing, seismic shifts in corporate interest and power would soon render the landscape unrecognisable.

Conclusion

Calculator user groups supported an infrastructure through which their device of interest became redefined as part of a way of life. This was a fragile consensus built upon shifting ground, but the economies of programmable calculators offer a focal window into the development of personal computing from a hobbyist practice to a traditionally consumer-driven one. As the story goes, Steve Wozniak sold his HP-65 after quitting his job with the company to fund Apple Computer.[72] This raises an important question that as yet remains unanswered: what, if any, were the convergences between calculator programmers and the PC users that followed them? PPC launched its own separate PC publication in 1979 to provide similar product support for these newer machines, though it lasted only two years.[73] Paul Ceruzzi claims that the major difference between calculator and PC enthusiasts was a bifurcated set of interests in personal computing: PC people cared about the *personal* whereas calculator people cared about the *computer*.[74] However, if we disabuse ourselves of the absolute distinction between programming as a practice and application use, itself a product of the commercial software revolution yet to come, this interpretation does not hold.[75]

There are remarkably forward-looking features of the culture of programmable calculators. Synthetic programming arose from the communalistic norms of PPC in a way that suggests an analogy with the more contemporary politics of open-source software. Through his ethnography of Free Software, Chris Kelty has developed the analytic of recursive publics: technological communities 'capable of speaking to existing forms of power through the production of

72 Levy, *Hackers*, p. 253.
73 R. J. Nelson, 'Member Letter', *Computer Journal of PPC*, 1.1 (1982).
74 Ceruzzi, *A History of Modern Computing*, p. 216.
75 Projecting his own vision, Nelson drew up a table of different computers in the first *Computer Journal of PPC* to contrast desktop 'Personal' computers with personal programmable calculators, touting the advantages of the latter. See Nelson, 'Member Letter'.

actually existing alternatives'.[76] PPC tried to leverage community knowledge to substantially augment the capabilities of their device of choice, but this gambit led to its dissolution. The hex codes that users unearthed provided a community niche, albeit one enmeshed in a recalcitrant matrix of production. Calculator users thought globally and acted locally, as the saying went. Their devices were a platform germane to techno-utopian futures, from the *Whole Earth Catalog* to HP's own marketing materials. An issue of *Hewlett-Packard Calculator Digest* in 1979 ran a cover story on a sci-fi dramatisation of its calculators as the personal assistants of the future, uncannily reminiscent of the iPhone and Siri despite retaining the button-based design of a calculator.[77] People dreamed about their present and future with calculators, though we have yet to fully understand the meaning of such dreams. Lest we cede curatorial authority to the Boris Johnsons of the world, collections of these materials in museums like the Whipple can help us to do so.

76 C. M. Kelty, *Two Bits: The Cultural Significance of Free Software* (Durham: Duke University Press, 2008), p. 3.

77 G. Dickson, 'Thank You, Beep . . .!', *The Hewlett-Packard Personal Calculator Digest*, 5 (1979), pp. 2–3.