DHQ: Digital Humanities Quarterly
Preview
2022
Volume 16 Number 1

The Ebook Imagination

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Abstract

While popular histories of the ebook start in the 1990s, inventors were working on the form since at least the 1940s. In this article, I offer a media archaeological analysis of digital publishing patents to develop the ebook imagination, or the desires of readers and inventors for the future of reading on screen. Through an analysis of a corpus of 98 patents relating to ebooks, I demonstrate how the ebook imagination focused on the aesthetics of the book over focusing on replicating paper via a screen, which would later lead to the success of Amazon's Kindle in 2007.

During the 1940s, Ángela Ruiz Robles, a teacher from León, Galicia, had a prescient vision of publishing's future: Her *Enciclopedia Mecánica* would increase children's access to affordable interactive educational materials. Her 1962 sketch (Figure 1) featured a device with three slots for lessons presented in scrolls. Students would insert the scrolls, browse the content and then answer questions on each lesson through rotating disks immediately below each scroll. Just as with a combination padlock, correct answers would result in positive haptic feedback. The Spanish Patent and Trademark Office granted Ruiz Robles two patents [Ruiz Robles 1949] [Ruiz Robles 1962] for the device. El Ferrol Artillery Depot built a prototype based on the 1962 patent and in 1971, the Technical Institute of Applied Mechanical Experts explored the cost of manufacturing 10,000 units at 50-75 pesetas (around $1 in 1971) per unit but the initial start-up cost of 100,000 pesetas ($1,410) was prohibitive [Telefonica Fundación 2015]. Both Ruiz Robles and her invention languished in relative obscurity until around 2007, when the importance of her work was recontextualized by the launch of the Kindle and an exhibition of her work at Museo Pedagóxico de Galicia in 2008 [García 2012]. [1] Following this rediscovery, Ruiz Robles was honored by the Spanish Patent Office [Oficina Española de Patentes y Marcas 2011], a Google Doodle [Google 2016], a festschrift [Ministerio de Economía y Competitividad 2013], a Madrid street name [Jones 2018], and El Museo Nacional de Ciencia y Tecnología's acquisition of her archives [Telefonica Fundación 2015].

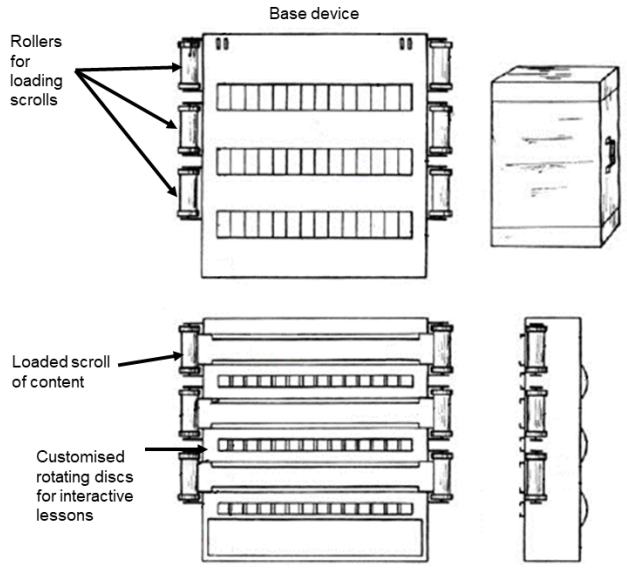

Figure 1. Ruiz Robles's mechanical cartridge system. Adapted from [Ruiz Robles 1962]

The retroactive recognition of Ruiz Robles' inventions reveals a 60-year gestation period for the e-reader to shift from a patentable idea to mass-produced commodity. Patent filings speculating about the future of reading on-screen accelerated following the establishment of the terminal-mainframe computational paradigm in the 1960s but, as with the case of Ruiz Robles, inventors were conceptualizing digital publishing before the emergence of the personal computer. Patents map amateur and professional ambitions for the book's future alongside the development of the digital computer. Previous histories of digital publishing often overlook this evidence base, creating a distorted narrative focusing on what appear to be a few outlier early devices rather than a concerted effort by several companies to create a functionable e-reader. As a corrective, in this article I offer a media archaeological analysis of digital publishing patents to develop the *ebook imagination*, or the desires of readers and inventors for the future of reading on screen.[2] I demonstrate that while patent filings confirm the theoretical existence of e-readers long before the technology was commercially viable, unfortunately this early work often fixated on replicating the book as an object, overlooking vital issues in recreating the reading experience such as developing high quality screens. These innovations can only be traced through efforts led by other industries, demonstrating the ebook's success relied on a convergence of adjacent technologies rather than an inevitability of early prototypes. 2

Erkki Huhtamo introduced media archaeology "as a way of studying recurring cyclical phenomena that (re)appear and disappear and reappear over and over again in media history, somehow seeming to transcend specific historical contexts" [Huhtamo 1997, 222]. Media archaeology as a methodology celebrates historical cul-de-sacs and counterfactuals as a way of challenging conventional chronological narratives of progress. It is therefore an ideal approach to the historical analysis of digital publishing, where important evidence exists outside of these linear narratives. Individual patents may appear fanciful in retrospect, but collectively they reveal a sustained effort to map linear reading onto contemporary time-based media technologies. Through treating media history as cyclical, Eric Kluitenberg positions media archaeology "primarily as a critique of progress" [Kluitenberg 2011, 51], a rebuke to patent scholarship's dominant emphasis on evolutionary models of technological development. While previous case studies of patents as evidence for technological developments reveal hierarchal networks of inventors [Lenoir and Giannella 2011] [O'Reagan and Fleming 2018], a media archaeology-informed approach instead emphasizes discontinuities within patents. Each generation reconceptualized the ebook based upon their own technological horizons shaped by their understanding of screen technologies. 3

The ebook imagination was shaped by long-running, contradictory desires to accurately replicate the printed book in digital form while improving upon its perceived limitations. The Kindle and competing platforms focused on mundane 4

remediations of print. While this was more successful than experimental forms of digital publication, there has been a growing resentment towards the perceived stasis of ebooks such as the former CEO of Hachette, Arnaud Nourry's dismissal of "the ebook [as] a stupid product [because] there is no creativity, no enhancement, no real digital experience" [Gill 2018]. Nonetheless, the simplicity of ebooks for consumers belies the complex infrastructure underpinning a seamless user experience. I have previously termed this 'ebookness,' or the development of the ebook as a suite of interconnected services rather than a straightforward product [Rowberry 2015]. This service-oriented approach to ebook platforms emerged in a pragmatic response to the challenges of encouraging readers to buy e-readers. Conversely, the hypothetical design documents that embody the ebook imagination documents what ebooks *could be*. Ebookness responded to the specific demands of the market (cheap content, always-on connectivity, social reading), while the ebook imagination presented an opportunity to reimagine reading on-screen. As I demonstrate in this article, designers struggled to move out of the codex paradigm in conceptualizing these new devices and disappointment around the Kindle paradigm has inspired designers to continue to consider the future of the ebook. My case study of early ebook patents reveals the tensions between a speculative vision of the future that is tied to nostalgia for print. Inventors were unable to push beyond this dichotomy to create a feasible technology that replicated the affordances of paper with comparable screen technology.

Methods

5 This article traces the development of the conceptual ebook drawing upon visual and textual evidence from granted patent applications to show how it was bound by the screen technology conventions of its day. I searched for patents with the words 'electronic book' in the title or abstract filed prior to 2000 in both the United States Patent and Trademark Office (USPTO) and Espacenet patent databases. I cross referenced these search results with United States patents featuring classification number 345/901 or "electronic book with display." The results included applications from countries including Japan, France, Germany, and the United States. I then followed citations in the 'prior art' of each of these applications to identify further relevant patents that did not appear in the initial search. While I noted all applications, my focus here is limited to Anglophone applications due to my language constraints although I consulted technical drawings from other languages. This returned a corpus of 98 applications ranging from 1893 to 2000 filed by both individual inventors and large media technology companies.[3]

6 The search and cross-reference facilities of the two patent databases significantly shape my dataset. For example, the formation of United States patent subclass 345/901 reveals the subjective nature of reconstructing a history of digital publishing through patent filings. It is a "cross-reference art collection," or "subject matter that is not specifically provided for in a particular subclass" that emerges between classes [United States Patent and Trademark Office 2005, 44]. Cross-reference art collections reveal the instability of patent classifications, which are constantly updated to account for new research fields [Kang 2012]. Older patents are often re-classified, as in the case of 345/901, where the earliest patent in the class is from 1979, but the parent class, '345' was only introduced in 1993 [Office of Patent Classification 2018]. Discrepancies between national digitization programs further re-enforce the perceived dominance of Anglo-European inventors. For example, the Indian patent database, InPASS, features only 23 total patents granted prior to 1990 despite a richer history of intellectual property protection dating back to the Patents and Designs Act of 1911. Conversely, the USPTO has a digital copy of all extant patents starting with Samuel Hopkin's 1790 patent for manufacturing potash. [4] Despite offering access to facsimiles for all granted patents, full-text search on the USPTO website is only available for those published since 1976. Patents filed prior to 1976 must be discovered through citations or limited metadata, which excludes the inventor's name and patent title. These geographical and historical weaknesses ensure a comprehensive history of ebook patents is beyond reach.

Patents as Evidence

7 Beyond tracing the desires of ebook inventors before 2000, this article offers a blueprint for using patents in contemporary publishing research. Scholars have developed sophisticated overviews of the sociological structures of the twenty-first-century book trade [Murray 2018] [Ray Murray and Squires 2013] [Striphas 2011], but less is known about the technical infrastructure underpinning contemporary publishing. We know more about hand presses and

distribution networks of the fifteenth century than Amazon's warehouse network or the digital asset management system of large publishers [Kirschenbaum 2020]. These blind spots emerge from the secrecy of large technology companies responsible for the creation, distribution, and reception of books and their digital equivalents. Public disclosures via patents reveals what Amazon, Apple and others intend to develop for the publishing industry. The USPTO archive also includes a range of patents filed by publishers including Elsevier and printing technology companies such as Konica Minolta [Hiramoto and Harada 2018] [Holt et al. 1998]. Analysis of publishing adjacent filings can reveal the corporate research and development driving contemporary publishing otherwise closed off from scholars and complement other forms of archival and oral history research into digital publishing [Grad and Hemmendinger 2018] [Kirschenbaum 2016] [Rubery 2016]. This does come with a major limitation, however, as patent filings do not necessarily indicate the direction of travel for a company as many corporations choose to apply for defensive patents just in case a technology later becomes viable.

8 The modern international patent emerged in the 1970s after the ratification of the Patent Cooperation Treaty in 1978 and the shift to electronic support mechanisms to relieve the increasing burden of processing patents [WIPO 2001]. By 2000, the USPTO offered public access to patents published since 1790 via its website. The resulting HTML version of a patent is rigidly structured to enable efficient searching and browsing of documents for relevant information including inventors, classifications, and claims. Researchers have explored the potential for quantitative analysis of the rich data contained in patent databases [Iversen 2000] [Lenoir and Giannella 2011] [O'Reagan and Fleming 2018]. For example, Manuel Trajtenberg proposed assessing the flow of knowledge as indicated by citations "as first-hand evidence of the path-breaking nature of the original patent" [Trajtenberg 1990, 184]. There are caveats to this approach. Patents granted before 1976 are only available as facsimiles with no metadata, requiring manual consultation of citations. Where citations are easily traversable, they might not be the result of influence: examiners can introduce citations in the equivalent of a peer reviewer suggesting additional sources. Citation networks are therefore of limited value compared to richer visualization techniques such as mapping co-inventors or affiliations [O'Reagan and Fleming 2018]. Tim Lenoir and Eric Giannella argue that there is still value in analyzing citation networks with caution as "the 'noise' can offer an opportunity for using patents as a vehicle for studying the coevolution of social and technical phenomena embodied in technological platforms" [Lenoir and Giannella 2011, 361]. My initial search of citation networks within the corpus suggested the geographical and technological discontinuities were too strong for such analysis to meaningfully trace a linear development of ebooks. Since there is no direct chain of influence, an archaeological approach examining the fractures and discontinuities is more useful.

9 Mario Biagiolo argues that the patent's power emerges from its form: "the idea of the invention did not emerge through a process of abstraction but through one of inscription — not by thinking it up but by writing it down" [Biagioli 2011, 31]. Inventors were free to imagine a technology if it was accompanied with a sufficiently convincing narrative for how it could be implemented, facilitating speculative applications. Viewing patents as discourse separate from socio-economic constraints encourages analysis through a media-archaeological framework. Erkki Huhtamo developed the concept of "unrealized 'dream machines,' or discursive inventions (inventions that exist only as discourses)" that "can be just as revealing as realized artifacts" [Huhtamo 1997, 223]. The shift from depositing physical prototypes to textualization enabled experimentation, but the system still favored physical objects. Despite the rigid linguistic conventions of the patent, the move to textualization encouraged more radical theoretical designs. At the same time, Hans Radder notes "Patentable inventions need to be material. [...] An important implication is that conceptual or theoretical inventions cannot be patented" [Radder 2013]. The current patent system was established by the arrival of the personal computer, offering limited protections for software. Algorithms and software fell into a grey area where it was unclear if they could be patented without a material form. G. Con Diaz documents the work-around: the computer was viewed as "an embodiment of the program, and it received patent protection in lieu of the program itself" [Diaz 2015, 8]. The issue affected the trajectory of early digital publishing patents since any innovation in process or software was accompanied by an implementation in hardware. If software was the intended focus, inventors would create speculative hardware to fulfill the criteria.

10 The development of electronic book patents does not follow a strict linear path through citations but instead reflects a disjointed history of experiments and failure. Major technology companies including Apple, Hewlett Packard and Xerox

worked on e-readers during the 1990s, but other than Apple's doomed Newton hardware series, no commercially viable product came of this experimentation [Henckel and Hospers 1995] [Lebby et al. 1996] [Saund n.d.] [Shwarts and Dunham 1996]. The relative boom at the turn of the millennium was driven instead by either start-ups (Softbook and NuvoMedia) or companies with a longer history of digital reference publishing (Franklin Electronic Publishers). Amazon's Lab126 hardware engineers led by Gregg Zehr exploited the fragmented history of ebook patents to claim substantial innovation in a series of four utility patents documenting the Kindle 1 filed in March 2006 [Zehr et al. 2011] [Zehr and Whitehorn 2010] [Zehr and Whitehorn 2016]. Zehr and his collaborators were keen to position the Kindle as an innovative mobile computer rather than limiting its appeal as an e-reader, leading to citations of mobile phones, personal digital assistants, and innovative display technology. The longer history of the ebook can only be found through a deeper search of the USPTO and Espacenet archives.

The First Ebook?

11 Identifying the first ebook is a tricky proposition, relying on an individual's interpretation of the meaning of 'electronic' and 'book,' reflecting Michael R. William's claim that "there is no such thing as 'first' in any activity associated with human invention. If you add enough adjectives to a description you can always claim your own favorite" [Williams 2002, 3]. Rather than attempt to identify the first e-reader, my aim here is instead to demonstrate the longer history of the conceptual ebook and explore why earlier attempts were unsuccessful. Nonetheless, locating the terminology's origins is useful. The term 'electronic book' dates back at least to the late 1970s and transformed from general nomenclature for reading on screen to linking specifically to e-readers and consumables designed for that hardware by the 2000s.[5] Following my previous definition of "ebookness," I restrict my definition of the electronic book to the latter, where specialist portable hardware (commonly known as e-readers) determines access to text rather than more general models of text retrieval including desktop systems such as the Memex. In the 1978 premiere of *The Hitchhiker's Guide to the Galaxy* radio play series, Ford Prefect, companion to the protagonist Arthur Dent, introduces the eponymous book in the first episode of the radio play as "a sort of electronic book. It'll tell you everything you want to know. That's its job" [Adams 1978]. *The Hitchhiker's Guide* is encyclopedic and therefore easier to conceptualize digitally than fiction or narrative non-fiction. Reference guides remained the dominant form of ebook rather than for entertainment or leisure until the late 1990s. The first instance of 'electronic books' in print appears in Harvey Poppel's speculative short story for *Harvard Business Review* set in the 1990s where "by the mid-1980s most American families owned or lease some form of home electronic information center" with a provision for ebooks [Poppel 1978, 14]. While Poppel focuses on consumable goods rather than hardware, the article was concurrent with David Rubincam's patent submission for an 'electronic book,' filed in 1977 [Rubincam 1979].

12 It is no coincidence that three sources independently coined the term "electronic book" in the late 1970s since, as Paul Ceruzzi notes, by 1977, the personal computer had matured with "a strong and healthy industry of publications, software companies, and support groups to bring the novice on board" [Ceruzzi 2003, 241]. During this time, the ebook imagination flourished while the technology remained commercially unviable. For example, in 1978 the Read Only Memory (ROM) storage for a single book cost around $300 per unit to manufacture. An experimental device produced by the US military, computer scientists from the University of Colorado, and Texas Instruments avoided these limitations by creating a separate ROM with an indexed dictionary containing "between 2,000 and 4,000 words account[ing] for 90% of most texts" [Poppel 1978, 14]. An algorithm generates a numbered list of words present in a book which are used in lieu of the word in text. The project team concluded that effective compression alone would not compensate for infrastructure that was too immature at time of the project report in 1989 to develop beyond the initial research [Wisher and Kincaid 1989, 15]. Likewise, the lithium-ion battery was developed in the early 1990s but did not appear in e-readers until NuvoMedia co-founders Martin Ebenhard and Marc Tarpenning released the second-generation Rocket eBook in 1999 [Fletcher 2011, 60–61].

13 Infrastructure and storage would remain insurmountable costs until the mid-2000s, so inventors instead filed speculative patents. Nonetheless, the broader reshaping of computing from terminals to home computers encouraged speculation about the benefits of the "personal" computer, tying together previous strands of innovation on reading mechanically and on-screen. The ebook imagination extends beyond the development of the technology, constantly existing at the

intersection of the inventor's contemporary understanding of mechanical reading and the book, which is evident in how inventors portray their theoretical devices through the figures in their patent applications.

Experiments in Print-Digital Hybridity

Early inventors conceptualized print and mechanical reading as a hybrid form that would improve upon its constituent parts. Rubincam's landmark patent established the experimental nature of early ebook design, where tropes of print met contemporary digital form. E-readers promised to replicate the tangible materiality of the printed page rather than attempting to simulate the page itself. This focus emphasized the form of the book over its accessibility as a technology, leading to several technological cul-de-sacs. Figure 2 visualizes the appearance of bookish features – cover, spines, and verso-recto spreads – as well as use of keyboards in the corpus of 96 patents' technical drawings. Only 39 patents include at least one of these features, since many patents extend back to the microfilm and projection era, and several of the more recent patents provide only flow charts and schematics. The Euler diagram shows the extent of inventors' interest in the book as opposed to hardware tropes. The relative lack of patents including keyboards or other mechanical references to digital culture demonstrates an interest in privileging the form of the book. Where patents include bookish elements, this mostly relies on page metaphors rather than engaging with the bound nature of the book. 14

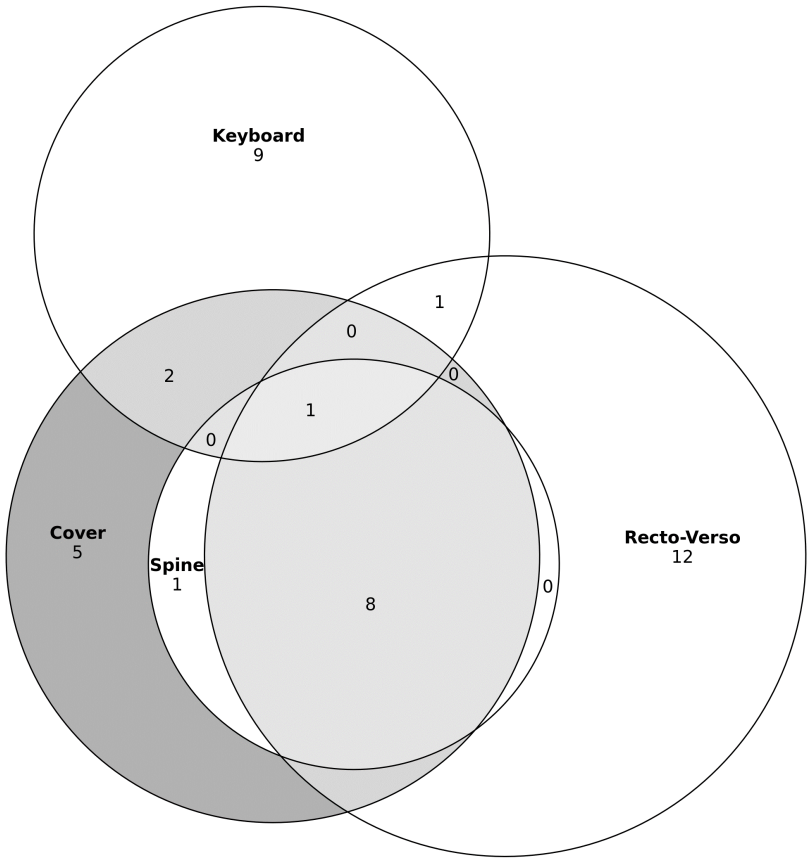

Figure 2. Euler diagram showing relationship between four aesthetic features of ebook prototypes

To illustrate how this shaped patent design, we can examine the differences between Michael Lebby, Thomas Blair, and Gary Witting's patent for an "electronic book" for Motorola (Figure 3) and John Harkins and Stephen Morriss's Personal Electronic Aid for Maintenance (PEAM) patent assigned to Texas Instruments (Figure 4). Lebby et al embraced metaphors of bookishness including page turn mechanisms and updatable title pages bound "with a leather or leather-like material so as to simulate a leather bound book" [Lebby et al. 1996, 2]. There are still external signs of computation, such as the ports on the spine which are never developed further in the patent specification. To protect their claims, Lebby's team included representations of their device with multiple pages and a flattened bifolio display. The patent lacks detail of how the more complex version would work, with the authors noting "turning of a last page of the plurality 15

of display page triggers the subsequent pages to begin on the first page of the plurality of display pages" [Lebby et al. 1996, 4]. The patent documents one of the most complete remediations of the book, but it lacks detail on implementation, especially given the immaturity of the technology required to create multiple responsive paper-like screens at the time. Conversely, the Texas Instruments patent, "Apparatus for delivering procedural type instructions," mimics the document through replicating the attaché case, a consequence of the project's origins within the US military. The prototype ignored the trappings of the codex to emphasize non-linear traversal of documents. The attaché case has connotations of collections of papers to be sorted but the actual device is more conventional in design.

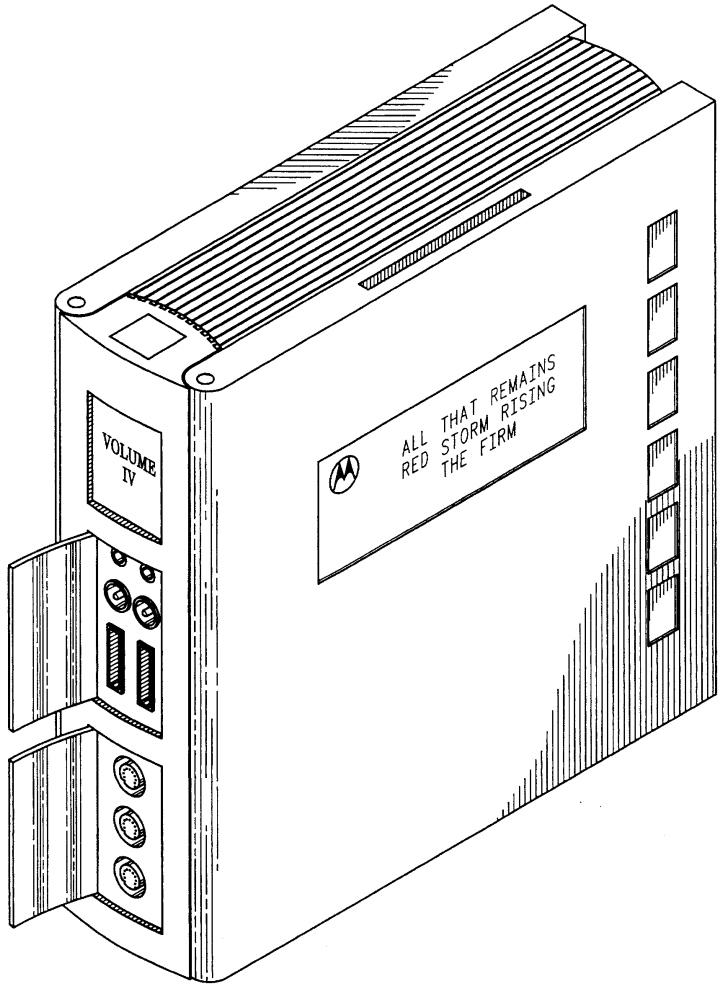

Figure 3. Motorola's Book-computer hybrid featuring a cover and several auxiliary ports. Adapted from [Lebby et al. 1996]

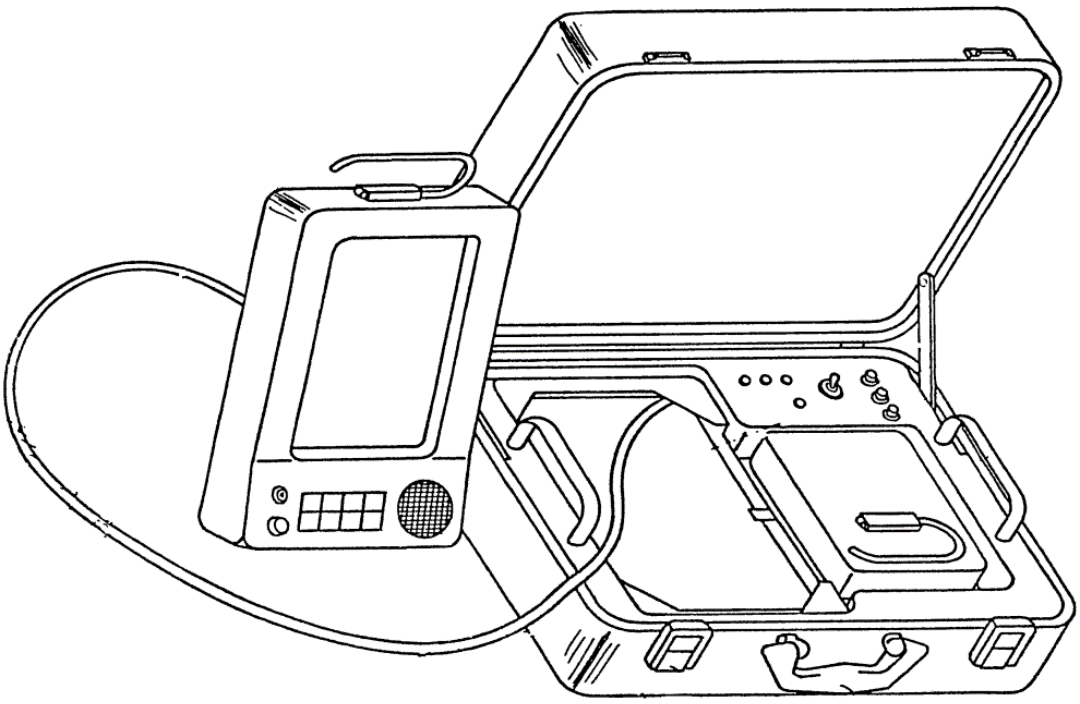

Figure 4. Texas Instrument's Attache case model of the ebook. Adapted from [Harkins and Morriss 1985]

While the ebook imagination explored the aesthetics of books, actual implementation trends towards generic mobile computing design tropes. My visual analysis of a range of e-readers launched between 1990 and 2013 shows ebook hardware became more homogenous in design to reflect a convergence towards the touch screen in the wake of the iPhone's success in 2007 [Rowberry 2015, 292–294]. This reflects a larger shift within the ebook imagination where the conceptual e-reader became less bookish over time as the design paradigm for portable computers, smartphones and tablets became more established. Nonetheless, despite the emphasis on these new forms of computers, the ebook imagination never managed to emerge fully before the mid-2000s as inventors prioritized the overall form of the device over the most important e-reader technology: its paper-like screen. 16

Overlooking Screens

Why did several companies invest in e-readers only to not release a commercial product? Partially, this was due to a lack of institutional memory and knowledge of competitors' failed attempts. The genre of patents is partially responsible as inventors are expected to demonstrate novelty rather than track down predecessors and the focus on tangible objects encourages experiments with form rather than function. Nonetheless, part of the early ebook imagination's failure rests on an inability to move beyond form when designing e-readers. Creating book-like e-readers allowed designers to experiment with form, but the direct presentation of reading material was a greater concern and challenge: How can digital technology replicate, or even improve upon, paper? Paper is a sophisticated, low-cost technology, while remaining easy-to-use and durable. At the turn of the twentieth century, microfilm offered one pathway towards a post-print reading machine.[6] The work of modernist Bob Brown and his Readies is well recited within histories of digital publishing despite the presence of earlier microfilm-based reading machines [Brown and Saper 2014] [North 2002] [Pressman 2011] . The New York Stock Exchange's ticker tapes, which constantly scrolled to offer updates on stock prices, inspired Brown to conceptualize a reading machine using microfilm. The medium appealed to Brown as he saw a parallel between developments in time-based media and speed reading. Brown opened his manifesto by acknowledging that "The written word hasn't kept up with the age. The movies have outmanoeuvered it. We have the talkies, but as yet no Readies" [Brown and Saper 2014, 1]. His bold vision argued "writing must become more optical, more eye-teasing, more eye-tasty, to give the word its due and tune-in on the age. Books are antiquated word containers." Brown proposed instead "reading will need to be done by a machine; microscopic type of a movable tape 17

running beneath a slot equipped with a magnifying glass" [Brown and Saper 2014, 3]. Brown considered a patent but never filed for one, preferring to leave his device as part of an adjacent literary ebook imagination, also featuring *The Hitchhiker's Guide to the Galaxy* [Saper 2016, 160]. If Brown had decided to file a patent for the Readies, his success was far from guaranteed. Developments with microphotography and microfilm led to a flurry of other patent filings during the early twentieth century, starting with Chenoweth and Rogers' "Memorandum Holder" patent, which used scrolling microscopic print attached to a pair of glasses to allow users to view their notes at will [Chenoweth and Rogers 1897].

18 While the preceding inventions were never launched commercially, time-based media was the inspiration for several patents that were adapted for market [Raba 1967] [Stoyanoff 1957] [Taylor 1950]. Like Brown's Readies, inventors such as L.J. Stoyanoff of Perceptual Development Lab, understood the power of microfilm for speed reading. The Lab launched an implementation of the technology described in his patent, "A Device for Reading Training," in 1957, called the 'PerceptoScope' [Acland 2012, 80]. The machine facilitated speedreading through "a pair of films in overlapping relationship for unison projection, a text film and a fixation film" [Stoyanoff 1957]. While acknowledging that competing devices were available, Stoyanoff suggested the PerceptoScope was less expensive. Just like the Readies, the PerceptoScope relied on the user's familiarity with time-based media and restricted reading to a strictly linear process. As a result, even at a lower cost, the device filled a niche in reading rather than offering the full affordances of the codex. Bootstrapping reading on-screen to time-based technologies was fleeting and largely disappeared once screen technologies were better equipped to maintain a static image.

19 Other inventors wanted to offer a more accurate remediation of the book. Microform viewers were often too bulky to be useful as portable book surrogates. Bradley Fiske, a US Navy officer and serial inventor of devices for military and civilian use, worked on a portable microphotograph reader throughout the 1920s and 30s [Panko 2019]. Fiske envisioned readers using a series of retractable lenses to view text at a smaller scale with one hand while adjusting the position of the microprint with the other. His first patent [Fiske 1923], filed in 1920, describes a device "intended principally as a substitute for books, magazines, pamphlets, newspapers, or any other vehicle by which printed words are read at the present time [….] to secure economy of paper." The emphasis on the economy of paper diverged from Bob Brown and Vannevar Bush's privileging of speed-reading and non-linear traversals respectively to instead replicate the page in a reduced format: a core feature of successful e-readers. Fiske iterated on the design over the 1920s [Fiske 1923] [Fiske 1926] [Fiske 1930], which worked to reduce both the complexity and size of his reading machine. He was renowned for his devices and Bob Brown corresponded with him when considering the development of the Readies for advice on the patent process [Saper 2016, 160]. Matts Lindström describes Fiske's print reduction mechanisms as an early form of 'micromedia,' or "various technologies of reproduction and representation on the smallest possible scale, beyond the very limits of human perception" [Lindström 2013, 185]. Micromedia only re-emerged with commercial e-reader hardware, but on an even smaller scale than Fiske envisaged. The introduction of optical media such as the CD-ROM enabled inscription at the nano-level, only visible through a microscope and able to contain much more information than previous micromedia [Kirschenbaum 2012, 2]. The various experiments in portable microfilm readers never overcame the limitations of the medium, and it was only with the combination of nanomedia and more appropriate optical technology that the ebook could succeed. Microfilm, ticker tapes and other facsimile-oriented platforms demonstrated the possibility of a post-print codex mechanical book but it would require a paradigm shift in visual reproduction technology to fully explore these possibilities. Luckily, the rising popularity of the television during the first half of the twentieth century led to investment in various forms of display screen technologies that would provide an ideal platform for developing the ebook imagination.

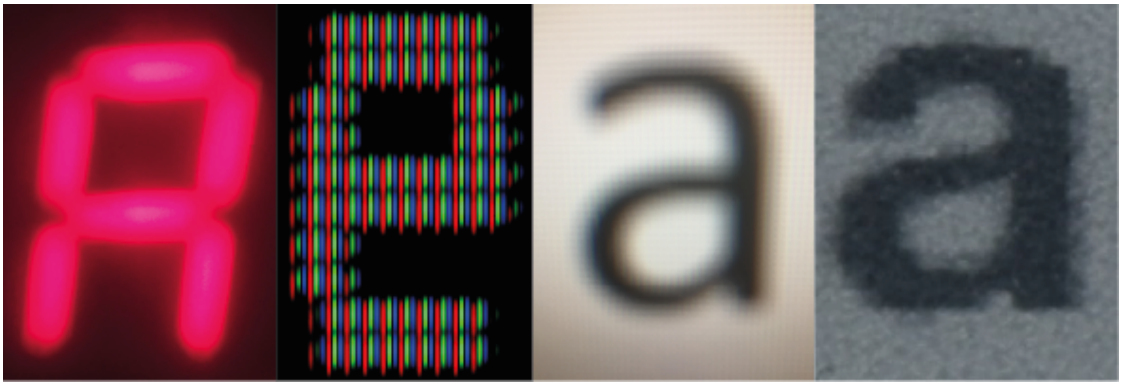

Figure 5. Text as rendered by (left-to-right) LED, CRT[7], LCD, and electronic paper.

During the twentieth century, three screen technologies dominated visions of reading on-screen: CRT (1858), LCD (Liquid Crystal Display, 1888) and LED (Light Emitting Diodes, 1907). Figure 6 shows a visual comparison of the three technologies alongside electronic paper, the screen technology used by most major contemporary e-readers. Nick Montfort and Ian Bogost state “in a CRT, patterns of electrons are fired at glass that is coated on the inside with phosphors. These glow to create the visible picture. The screen image is not drawn all at once, but in individual scan lines” [Montfort and Bogost 2009, 27]. A color CRT screen displays colors through clustering red, green, and blue phosphors as shown in Figure 6. The technology was integral to the uptake of televisions and early computing but was limited for mobile consumption due to its bulky nature. The “fast trace” powering CRTs made reading on-screen for an extended period difficult as the screen could refresh up to 60 times per second to avoid so-called “image burn-in.” Inventors only specified CRT as the primary display medium when the patent application was based around the terrestrial television network through extending teletext [Marti et al. 1979]. These sub-optimal conditions would be offset by the large audience who already had televisions at their disposal. The application of so-called “liquid crystals” such as cholesteryl benzoate that can exist in “an intermediate state between a crystalline solid and a normal liquid” to screens in the 1960s offered a solution to CRT’s limitations [Castellano 2005, 1]. LCD screens encapsulate liquid crystals that are manipulated by two polarized films to produce images. The liquid crystals do not emit light, which instead must be provided through a reflexive surface or light source behind the screen. LCD screens were more appropriate for electronic books as they were cheap and portable, with lower requirements for illumination. LED displays relied instead on arrays of individual lights. Alphanumeric LED displays most commonly appear as segmented matrices (as shown in Figure 6) where strips of LEDs combine to form text and numbers for electronic calculators and digital watches since the late 1960s [Krames 2012]. This success encouraged Russell Andrews and colleagues from the Stewart-Warner Corporation to file a patent for an LED-based “Traveling Message Display” and William Brooks filed a similar patent for “Variable Message Displays” [Krames 2012]. The technology had limited scope for longer-form reading as the pixel density was too low to scale to represent a whole page and its influence waned as other displays became cheaper.

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Since the patent system encourages making broad claims, unless the display was part of the claims, inventors would avoid specifying exact screen configurations. For example, Theodor Heutschi’s “Electronic Device, Preferably an Electronic Book,” filed in 1999, states: “The display preferably provided as an LCD-display” [Heutschi 2002]. Even when aspects of the screen were central to the patent’s claims, the inventors remained vague with specifications. Lebby et al.’s patent for Motorola provides minimal detail on implementation: “the plurality of displays is made by any suitable method or technology” [Lebby et al. 1996, 3]. It was not until the arrival of electronic paper that ebook inventors became interested in screen displays beyond such generalities.

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Innovations in screen technology happened outwith patent filings connected to electronic books, as inventors were more interested in the device’s form. These core technologies were instead developed by third parties for adjacent uses. The misplaced emphasis of inventors, ignoring the screen, led to the stagnation of the ebook imagination in transition to commercial products. This experimentation, and early commercial failures, coalesced to demonstrate the importance of screen technologies for the future of the ebook. When the Kindle and Sony PRS-500 launched with electronic paper screens in the mid-2000s, the devices exploited technology developed entirely outside of the ebook imagination. Visions

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of full-color, high-definition, constantly-refreshing bendable screens have remained in the realm of science fiction and largely out of the patent literature. This inspiration can be seen in Phillips and E Ink's collaboration to create what they termed "Radio Paper" in 2003. Radio paper would couple "the development of organic and plastic transistors" to create screens "flexible enough to fold and roll up […] with wireless Internet access," by 2005 [Costello 2001]. The ambitious goal is still beyond commercially available technology a decade and a half later, but it remains an active goal with substantial research and development investment from the now-defunct Amazon subsidiary LiquaVista, who received 240 patents for technology featuring "electrowetting" before being shut down in 2018.

23 Electronic paper was superior to other technologies but took longer to become commercially viable. Early implementations of electrophoretic displays, the most common form of electronic paper, date back to the 1970s, when contemporaneous developments in Matsushita Electric Industrial Company and Xerox Palo Alto Research Centre (PARC) arrived at the same conclusion [Ota et al. 1973] [Sheridon and Berkovitz 1977]. Electronic paper was designed for static visual display rather than time-based media such as CRT, which is sub-optimal for reading since a static image does not need to be refreshed, requiring a constant light and power source. A 'bistable display' electronic paper screen instead maintains a consistent image indefinitely without drawing further battery power. Electronic paper was developed simultaneously by the two companies for different ends. Matsushita saw the potential for advertising where screens need to be adjusted sporadically but otherwise remain stable for long passages of time. Conversely, Sheridan led the development of Xerox PARC's Gyricon technology as the display for its eponymous computer prototype. The technology remained dormant until the mid-1990s when Xerox PARC restarted its 'electric paper' through a subsidiary, Gryricon LLC, run by Nick Sheridan, between 2000 and 2005. [8] The company focused on digital signage rather than electronic books. E Ink, a spinoff from MIT, was the first to explore electronic paper's potential for digital publishing. Philips, the Dutch electronics company attained an exclusive license to E Ink's technology until the mid-2000s, but once the promise of 'radio paper' failed to materialize, other companies including Sony and Amazon licensed the technology to develop their own e-readers.

24 Unlike other parts of the ebook imagination integrated into ebookness, the vision of a paper-like display technology remains in flux. Dedicated e-readers were largely replaced by smartphones and tablet computers. Since electrophoretic displays are optimized to not refresh, e-readers struggle to compete with other mobile computers' versatility. Despite the lack of major breakthroughs a decade after the Kindle's launch, research and development labs still continue to prototype more sophisticated ebook display technology. Electrowetting is currently the most viable solution. The technology was unveiled by Philips in a 2003 letter to *Nature* by a team that would later spin off to Liquavista, which was acquired by Samsung before an eventual takeover by Amazon. Robert Hayes and B.J. Feenstra hyped the technology by suggesting "our display principle utilizes the voltage-controlled movement of a colored oil film adjacent to a white substrate" [Hayes and Feenstra 2003]. The use of fluid allowed for faster refresh times and more complex color arrangements where electrophoretic technology is largely stuck with sixteen shades of grey. Replicating the strongest benefits of both paper and screens remains out of reach within current technological paradigms. Nonetheless, despite the general move to a more pragmatic model of ebookness, the ebook imagination remains strong for next-generation electronic paper as the ideals of "Radio Paper" remain unfulfilled. The near simultaneous announcement of "bendable" screen phones from Samsung and Huawei in February 2019 demonstrates how elements of this idealized form of electronic paper dating back to Xerox PARC remain pervasive despite the diminished use of dedicated e-reader [Strumpf and Germano 2019]. Inventors such as Pei-Yu Chiou and his colleagues at University California-Los Angeles continue to patent electrowetting techniques and related technologies that, alongside bendable screens, have the potential to create something more akin to 'Radio Paper' that might convert ebook sceptics [Chiou et al. 2021]. The ebook imagination has outlived the mainstream acceptance and subsequent ambivalence around dedicated e-readers, demonstrating the continued yearning for a more sophisticated form of reading on screen.

Conclusion

25 Sony and Amazon's appropriation of electronic paper was pivotal to the transition of the ebook imagination from the conceptual ebook based on time-based media or facsimile to a more nuanced response to the affordances of the printed codex. The display technology provided the most accurate simulation of print while requiring minimal battery

power. The decision encouraged the rapid adoption of ebooks, but the reliance on a technology originally designed for digital advertising created a divide between the ebook imagination and commercial hardware. An evolutionary approach to histories of ebooks prioritizes a series of commercial hardware releases at the expense of a longer, more diverse history of experimentation . The dominance of Amazon, Apple, and Kobo has created a homogenized version of the ebook with a standardized hardware interface. The ebook imagination as evidenced in patent filings reveals how diverse inventors attempted to create an alternative using the most prominent technologies of the day. Ruiz Robles saw the educational use of interactive mechanical devices, while Brown and Stoyanoff wanted to explore the connection between time-based media and speed-reading. These functions have been incorporated more broadly into ebook reading software such as the Kindle's Word Runner function, albeit eluding dedicated hardware due to the constraints of electronic paper.

26 While previous scholarship on the development of ebooks focused on shifts in publishers' workflows and the emergence of e-readers, I have demonstrated a longer, often cyclical, history of reading on-screen that extends beyond the digital computer to earlier innovations in screen-based media. Patent filings recording the ebook imagination could not predict the Kindle's successful combination of electronic paper, lithium-ion batteries, and 3G cellular technology. Their greatest strength remains documenting an iterative process of developing the mechanical book from microfilm to the emergence of portable computers in the 1980s. The evidence of 'failed' inventions that never made it to market contradicts the dominant narrative within histories of the ebook that laud the Sony Data Discman or Kindle as necessary interventions in publishing's natural evolution. The patents discussed in this article instead show a longer history of experimentation that mirrors the medial affordances and limitations of their historical context. Reclaiming these lost histories emphasizes the role of marginalized figures including, but not limited to, non-Anglophone women such as Ángela Ruiz Robles who designed her mechanical encyclopedia for educational purposes rather than the market-driven vision of Amazon and its competitors.

27 Moving towards a cyclical rather than linear understanding of digital publishing's historical development allows scholars to recontextualize the ebook's supposed plateau since the late 2010s. Despite the maturation of e-reader hardware since the launch of the Kindle in 2007, ebooks are often seen as inferior to print publications, partially due to a perceived unfulfilled potential. This is the gap between ebookness (the current state of the technology) and the ebook imagination that is still driven by futuristic depictions of digital reading as found in science fiction and patent filings. As long as hardware does not match the expectations of these depictions, the malaise will continue. It is more profitable to reverse this thinking and return to the cyclical nature of innovation and previous failures to determine the overall feasibility of the technologies and the constraints that have held inventors back. A more grounded approach to this history and the current state of ebooks shows the pragmatic approach is better than the fantastical.

28 In this article, I have also proposed a new approach to the study of the history of digital publishing. Werner and Kirschenbaum conclude that the "largest challenges [for researching digital publishing] may not be technological but legalistic" [Kirschenbaum and Werner 2014, 453]. Examining patents for imagined but not actualized e-readers demonstrates the upside of the legalistic underpinning of digital culture. Future historians of the early twenty-first century book trade will benefit from exploring the USPTO's rich database further. For example, there are over 10,000 Amazon patents, revealing shifts in corporate priorities. The scarcity of evidence for the history of digital publishing prior to 2000, both physical and virtual, requires alternative approaches to remaining evidence rather than reverting to positivist corporate histories. Through casting a wider net, more stories such as Ángela Ruiz Robles may demonstrate alternative pathways to the current model of digital publishing. A more inclusive perspective on the history, and future, of digital publishing is vital to moving beyond the current impasse of antagonism between print and digital consumption. As I have outlined here, the rich history of the ebook imagination is often limited in technical specifications and with its clear own limitations, but it offers alternative visions to the corporatized platforms currently dominating the book industry.

Acknowledgements

29 This research was made possible by the generous funding from the Carnegie Trust's Research Incentive Grant and the 2018 Bibliographic Society of America McCorison Fellowship for the History and Bibliography of Printing in Canada and the United States. I am also grateful for thoughtful suggestions from Alan Galey, Claire Squires, Jim Mussell, John

Maxwell, and the two anonymous reviewers for *Digital Humanities Quarterly*

Notes

[1] Histories of Ángela Ruíz Robles's recovery as an ebook pioneer remain in Spanish [Sea 2015] [Universidade de Santiago de Compostela 2008]

[2] Borrowed from [Kirschenbaum 2012, 250]

[3] Since the metadata requirements for patents were updated repeatedly during the twentieth century, it's not possible to accurately break down the solo inventors from the corporate employees.

[4] Two fires at the United States Patent Office during the 1800s destroyed an unknown number of patents filed prior to the introduction of the current number sequence in 1836.

[5] These sources were discovered via the Oxford English Dictionary entries for 'electronic book' and 'e-book.'

[6] See [Panko 2019] and [Saper 2018] for a summary of microform publishing.

[7] CC-BY Selçuk Oral. Wikicommons. https://commons.wikimedia.org/w/index.php?curid=1213863

[8] Details of internal research and development at Xerox PARC around 'second generation electric paper' can be found in Box 18 of the Mark D. Weiser Papers, M1069, Dept. of Special Collections, Stanford University Libraries, Stanford, Calif.. Xerox PARC patents from this time include [Mackinlay and Stone 1998].

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