Punched-Card Sorters and Rapid Selectors: Information Management between the Wars

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The contemporary nexus of technology, information management, and social practice has been characterized by James Beniger as the product of a "Control Revolution" that unfolded during the century leading up to World War I. What we now commonly call the "information society," Beniger argues, has evolved out of this "complex of rapid changes in the technological and economic arrangements by which information is collected, stored, processed, and communicated, and through which formal or programmed decisions might effect societal control" (vi).[1] Through the ongoing dialectic between technological innovations and bureaucratic institutions, each contributing to the propagation and development of the other, the Control Revolution continues, in Beniger's view, "unabated" to this day.

Beniger's Control Revolution involves mainly large-scale economic and sociocultural shifts, but we have also witnessed astonishing changes in how individuals can use technology (provided they have the resources) to generate, shape, and communicate information for ourselves. We produce and store our professional work and our private lives on personal computers. We send and receive virtually all forms of information by way of digital data transmissions. Many of us own microcomputers every bit as powerful as we once imagined they might become, displacing or obviating any need for a whole array of technological and professional services. Computers serve as desktop publishing houses, personal secretaries, and private accountants; customizable radio receivers and television transmitters; windows on thousands of instantly accessible library card catalogues; drafting tables that can help even the clumsiest draw perfect Bezier curves.

These developments reflect an important paradox in our relationship to information-management technology. On the one hand, any new technologies that provide the means to construct and communicate information—new "hardware" as well as "software"—can serve our individual interests in powerful and often unpredictable ways; on the other hand, these same technologies can serve established corporate and state interests and, thereby, exercise various kinds of control over the very information that produces us as subjects in corporate and state contexts. The sociologist Alvin Gouldner has put it this way: "Scientific and technological expertise [...] rationalize and legitimate only the instrumental *means* used to achieve the organizational goals given, but *not the goals* themselves"; these, he writes, "can only be legitimated by value systems and ideologies to which the controlling administrators may link their organizational directives" (241, emphasis in original). As history has shown, managing information with punched-card sorters and microfilm "rapid selectors" could be accomplished in good faith to further the achievements of the arts and sciences—or to identify, corral, and kill people, as IBM's German subsidiary helped to do in World War II.[2] Lars Qvortrup has succinctly characterized this paradox in terms of competing "ideals of the information society": "computopia" on the one hand, "the automated state" on the other (134).

One is reminded, in relation to this state of affairs, of Michel Foucault's observations about the role of "discipline" in modern Western culture, particularly his view that technological and organizational sophistication engender forms of information control that can both exploit and be exploited by individuals for productive as well as destructive ends. Disciplines, Foucault writes, typically correspond to "anonymous instruments of power, coextensive with the multiplicity that they regiment, such as hierarchical surveillance, continuous registration, perpetual assessment, and classification." These "multiplicities" include any population of human beings organized bureaucratically, "whether in a workshop or a nation, an army or a school," and "disciplined" through "the ensemble of minute technical inventions." "Technical inventions" in Foucault's view are not just new machines but the social uses to which they are put; they may often be exploited by "anonymous instruments of power" to objectify human subjects, but they also can be exploited by individual subjects to enhance their "sovereignty" (218-20).

The observations of Beniger, Gouldner, and Foucault provide a useful point of departure for understanding the important role that two technologies—Herman Hollerith's (1860-1929) punched-card sorting devices and Vannevar Bush's (1890-1974) microfilm "rapid selectors"—played in shaping the relationship between the individual and the "anonymous instruments" of information management during the first half of the twentieth century. The work of Hollerith and Bush is particularly worth re-examining here because it was central to the technological and organizational expansion of the interwar period, an expansion which was remarkable both in itself and for the surge in information artifacts it produced—from masses of coded data to research reports to intra- and inter-organizational communications.

Irene Farkas-Conn refers to this early-twentieth-century boom in both the volume of documents and the means for organizing them as a "crisis in scientific and scholarly communication," marked by the gravitation of "scientists, scholars, librarians, and archivists [...] to still imperfect technologies that had never been used before for scientific and scholarly publication" (vii). It is worth considering Hollerith's and Bush's devices together, because they were integral to many responses to this crisis, as they represented the state of the art in addressing the immediate technical need for efficiency in managing information in many of the most important cultural institutions in the United States and Europe. Taken together, they are also emblematic of what Michael Buckland characterizes as two general approaches to information management, one "based on finding uses for formal techniques, whether mechanical (such as punch cards and data-processing equipment) or mathematical (as in algorithmic procedures)," and one "based on concern with documents, with signifying records: archives, bibliography, documentation, librarianship, records management, and the like," e.g., microfilm ("Landscape" 970).

Serving similar cultural interests, the two devices were fairly distinct technologically. Punched cards, because they are essentially a medium for encoding discrete bits of data such as alphanumeric characters, were used for a variety of types of large-scale data-intensive processes that relied on operations such as sorting, tabulation, calculation, and after World War II, computer programming and database management. Microfilm, because it is essentially a drastically reduced photographic image of a document, was used largely for preserving and archiving existing artifacts, such as cancelled checks and scientific abstracts. The former embodied the principle of automation from the start—Hollerith's first census-tabulating machines were meant to replace hand tabulation; the latter embodied at first only the principle of radically compacting documents—Bush's "rapid selector" device was more a visionary innovation than a brand-new invention. It should be noted, though, that these characterizations are broad and general. Intriguing combinations of the media could be found, for example, in the "aperture" card popular from the 1940s onward, which was used for storing and reading images and data together by including, on an otherwise standard punched card, a space for a frame of microfilm.

As Farkas-Conn and others have observed, the complex relationship between technological functions and ideological presumptions in Western society has often been mediated through a cultural framework of utopianism. We can see this utopianism in Bush's idealized microfilm selector or "Memex" and in his writings of the 1930s (see Nyce and Kahn, "Machine" 40), in Watson Davis's ideas for a kind of abstracts-on-demand service ("Microphotographic"), and in H. G. Wells's idealized proposal for a "World Brain." As Wells writes in a brief article for the *Encyclopédie Francaise* notable for its contemporary ring, "There is no practical obstacle whatever now to the creation of an efficient index of *all* human knowledge, ideas and achievements, to the creation, that is, of a complete planetary memory for all mankind" (par. 5). This index insured that the "direct reproduction of the thing itself can be summoned to any properly prepared spot," such that "microfilm, coloured where necessary, occupying an inch or so of space and weighing little more than a letter, can be duplicated from the records and sent anywhere, and thrown enlarged upon the screen so that the student may study it in every detail" (par 5).

To complement these utopian dreams, the period after World War I provided inventors interested in information management with unprecedented opportunities for funding and resources. Although these opportunities faded quickly with the onset of the Great Depression and did not emerge again until the Second World War, this state of affairs made it possible for, as Beniger puts it, "the shape of the modern information-processing industry" to be "well established [...] before World War II" (425). Establishing national science organizations, for example, became an explicit aim of the U.S. federal government, resulting in a roughly decade-long period of generous contributions from entrepreneurs and philanthropists such as the Rockefeller and Carnegie foundations (Farkas-Conn 10).

The reproduction of a utopian ideology across American and European cultural institutions also created conditions ripe for the professionalization of information management. The new class of professionals, experts in both the technological development and institutional use of microfilm and punched cards, were, as Ronald Day puts it, "ideologically conformist" figures, "mainly from computer science, business and business schools, the government, and the quantitative social sciences" (5). Perhaps more than we realize, Day argues, they have shaped the culture we now inhabit.

Hollerith's punched-card sorters and Bush's microfilm selectors thus were not merely two among the countless technological innovations of the time; they were particularly emblematic of broad patterns in the relationship between technology and culture. Both men shared in the age's interest in forward-looking utopianism. Both also participated directly in and worked (unwittingly anyway) to edify the paradoxical relationship between information technologies and the people who use them. Throughout the period encompassing their productive lives—the 1890s through the early 1940s—both men sought not only to improve methods for conducting scientific research, with the hope of improving the lot of humanity, but also to have their inventions adopted by large bureaucratic and corporate entities, with the hope of extracting a profit. Hollerith and Bush, in other words, wanted both to enhance individual sovereignty and to serve the very interests that could undercut such sovereignty.

Chronologically, Hollerith's punched-card systems proliferated across the Western cultural landscape before the emergence of the microfilm technologies that made Bush's "rapid selector" possible. The "Hollerith," as it came to be called, also became more firmly embedded in the global economy than Memex-type devices, which were developed and used by a more limited array of specialists. Indeed, it is fair to say that one of the largest computer companies in the world today, IBM, can trace its technological lineage directly back to the punched-card sorter.[3]

Hollerith's original device was built not for general-purpose computing but, rather, for the specific task of census tabulation. In a paper read to Britain's Royal Statistical Society on December 4, 1894, the audience for which included British officials interested in the problems of census-taking, Hollerith writes of the inadequacies of the methods of 1880 United States census for answering many simple but important questions about the nation's population (678). He thus invented his punched-card tabulating system for a simple, complementary pair of purposes, the encoding and automated retrieval of cross-tabulated sets of census data. Hollerith won the U.S. Census contract in a competition against two other contenders to compile census data from four districts of St. Louis; his transcription system (punching cards) was twice as fast as either of the others, his tabulation system (sorting the cards electromechanically) ten times as fast (Blodgett and Schultz 224).

The system Hollerith devised for the 1890 census consisted of 180 *tons* of punched cards, inspired, Geoffrey Austrian notes in his biography, not by Jacquard's card-programmed looms but by the punched tickets one encounters while traveling by rail. These cards were "divided into 244 imaginary spaces ¼ inch square," such that, for example, "to each of these spaces some particular value or meaning is assigned; a hole in one place meaning a white person, in another a black" (679). One hole might designate an age-group, another the specific age within that group, and combinations of holes could indicate occupations.

With thousands of these cards at one's disposal (punched first by hand with a punching device and later automatically with a keyboard Hollerith invented in 1901), one could use Hollerith's machines to perform various sorting and tabulating operations. It is not especially difficult to understand the functioning of the machine, as it relied mainly on the opening or closing of a circuit (i.e., as when a light bulb is either off or on) using mercury switches of a sort still common today in thermostats. As Hollerith describes it,

> [The tabulating device] consists primarily of a press or circuit-closing device, the upper and movable portion of which is provided with projecting spring-actuated needles, or points corresponding in number and relative position to the holes which may possibly be punched in the record card. The lower or fixed plate consists of a piece of hard rubber provided with a corresponding number of cups partially filled with mercury, which through suitable wires are connected with the binding posts of the

> switch board. If a punched card is placed in this bed, and the handle depressed, wherever there is a hole in the card, the needle will dip down into the mercury, while at all other points the needles will be pressed back. (679)

With each card thus supplying a unique array of open and closed circuits, the final major step is to use this array to drive a system of counters, so that cards containing holes in the same spot are counted as elements of a particular set. With the addition of electrical relays, which in essence permitted a third counter to advance when two or more had advanced simultaneously, one could sort cards in terms of virtually any combination of hole punches. This system, simple as it may sound now, permitted the very sort of cross-tabulations that had eluded the Census Bureau well past the advent of numerous other complex electromechanical technologies (e.g., railroad switches, telegraphs, telephones, phonographs).

At the end of his address to the Royal Statistical Society, Hollerith suggested that the electrical punched-card tabulator could be used not only for processing census data, but also for any work requiring tabulation and statistical operations. This suggestion was born out fully in the following decades. Hollerith's commercial and government clients grew to include the New York Central Railroad, the Interstate Commerce Commission, the Pennsylvania Steel Company, and Marshall Field; as James Cortada has put it, "Firms used his equipment for purchase records, inventory management, overhead allocation, payroll analysis, shipping costs, sales projections, and market forecasting, all before World War I" (50).

As it proliferated through bureaucracies worldwide, the punched-card system became the primary tool for processing information. As such, it became the technology of choice for "processing" large quantities of human beings.[4] It was used by hospitals for compiling information on patients, including basic personal data and diagnoses, and for equipment inventory and billing; in all areas of university administration; in the first Russian census; in the United States Social Security office and War Department; and in the French military.[5]

The system's statistical prowess was deployed in research in fields from psychology and education to medicine, law, and agriculture. One author of the period recounts its use at a university for analyzing everything from the "biological significance of partial regression coefficients from the standpoint of probable errors" to the "correlation of mental test grades" (Snedecor 168-69) to, in one case, litter-size frequency in "2789 litters of Poland China pigs" (163). The system could be used not only for handling data, but for analyzing statistical processes themselves; in one case, for example, it was used to supply correctives for statistical problems such as biased samples.[6]

The punched card and its associated machinery also developed rapidly throughout this period. Hollerith's first punched cards, for example, had 24 columns of round holes; by the early 1900s, the number of holes increased to 45, and by World War II, IBM had begun to produce the familiar 80-column card with rectangular holes, which permitted denser packing of columns. In addition, as Beniger has noted, following Hollerith's patenting of the first punched-card tabulator in 1889,[7]

> large scale data processing [...] greatly increased in speed and volume with the automatic card sorter (1900), switchboard-type card sorter (1902), automatic printing card tabulators (1910s), multiple-register accumulating calculators linked as difference engines to produce data tables (1920s), and the modern 80-column punch card (1928). (396)

The various uses of the punched-card system also engendered variations in what might be called the card's morphology. By the 1930s, for example, cards with holes around their perimeter representing subject categories were developed as a means for researchers to perform simple Boolean searches, by notching certain holes and identifying "hits" with long pins that suspended the notched cards while dropping the rest (Kilgour 341). Figures 1 and 2 illustrate Hollerith's original card and the classic 80-column card.

Despite its popularity as a data-processing technology for a half-century, the punched-card method was not foolproof. Reviewing a book touting the method, one author notes several problems: all data had to be coded numerically, which raised questions about how complex, semantically-nuanced information is best "encoded"; the punches could contain errors, which introduced a problematic layer of "processing" activity; some applications were simple enough to necessitate "less devious methods"; and the system itself could be prohibitively expensive (Brunsman 774).

Nevertheless, the punched-card system only became obsolete when data entry and data processing no longer required it—that is, when digital computers that relied entirely on other means of data storage and control became a powerful and cheap enough substitute. This shift occurred relatively recently; although cardless "workstations" and "mainframes" came on the scene in the 1960s, it was not until a decade later that the punched card faced extinction in most of its familiar habitats. Yet the punched card lives on in some very important social practices—it is still used in voting, for example. And currently, the punched-card idea is being explored in ways hardly imaginable even with the advent of microcomputers. For example, IBM's current "Millipede" project is using nanotechnology to cram indentations into a polymer film at a density of over a terabit—or the equivalent of over two dozen DVDs-worth of data—per square inch (Knoll *et al* 1696).

Where "Hollerith" was a household name for several decades, that

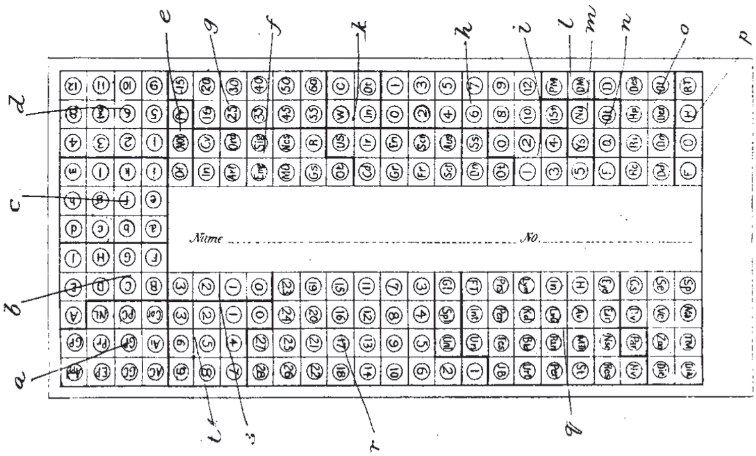

Figure 1: 24-column card as illustrated in Hollerith's 1889 patent.

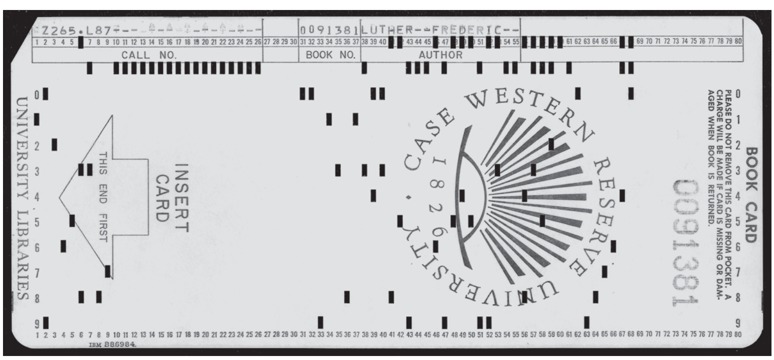

Figure 2: Standard 80-column card used for library inventory

of Vannevar Bush never became very familiar and is now largely forgotten outside computer and information science circles. However, Bush was a brilliant innovator and talented "schmoozer" who became a key figure in technology policy and initiatives in the 1930s and 1940s. During that period he occupied several important positions: vice president and dean of engineering at MIT, president of the Carnegie Institute of Washington, D.C., and, by 1940, Chairman of the National Defense Research Committee. Most current references to Bush, though, focus on his plans for microfilm management devices, plans which culminated in his famous *Atlantic Monthly* essay of July 1945, "As We May Think," which proposed the "Memex," a device meant to permit keyword searches of microfilm records.

In a nutshell, "As We May Think" proposed a system that allowed a user to search a large store of microfilm documents using keywords and to connect "hits" together through what Bush called "associative trails." The machine combined, in other words, the properties and functions we now associate with large hard-disk drives, "search" functions, and hypertextual linking. Although "As We May Think" has been treated as a watershed moment in computing history, Bush appears to have meditated on the idea of the Memex for at least a dozen years before the essay was published. In 1933, for example, he produced a comic essay, the narrator of which was supposed to be a man looking back at the 1930s from the vantage of the 1950s. In the essay, he writes, "The idea that one might have the contents of a thousand volumes located in a couple cubic feet in a desk, so that by depressing a few keys one could have a given page instantly projected before him, was regarded as the wildest sort of fancy" ("Inscrutable" 74-75).

In an oft-quoted portion toward the end of "As We May Think," Bush explains his vision using the utopian trope of the machine-as-extension-of-mind:

> Consider a future device for individual use, which is a sort of mechanized private file and library [...] A Memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory. (43)

Bush then describes the Memex in great detail; it is presented as a kind of personal workstation, an electromechanical microfilm processing device that one can use to (a) house large quantities of information, scientific abstracts in particular, but theoretically, any kind of document that can be captured on microfilm; (b) select items from this store of information using specified search criteria, and (c) create connections or "trails" among selected items. As Bush writes, step (c) is the *raison d'être* of the device: it represents "an immediate step [...] to associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of the Memex. The process of tying two items together is the important thing" (44).

Associative indexing was what made the Memex distinctive; to function properly, though, it required a device that could search very quickly through many thousands of microfilmed documents. This device was the rapid selector. The principle behind the rapid selector was not greatly different from that of punched-card tabulator. Codes of any kind could be inscribed (either as dots or as translucent "holes") in film, which could then be sensed as the absence or presence of light by a photoelectric sensor bank—a new and momentous electronic device capable of, in a sense, "reading" light patterns. Figure 3 is an example of a microfilm sheet from one of Bush's later projects;[8] as one can see, the left side is occupied by abstracts, and the right side contains the grid for codes. The grid is actually a set of eighteen columns containing twelve "cells" each. There is thus room for a fairly complex system of encoding.

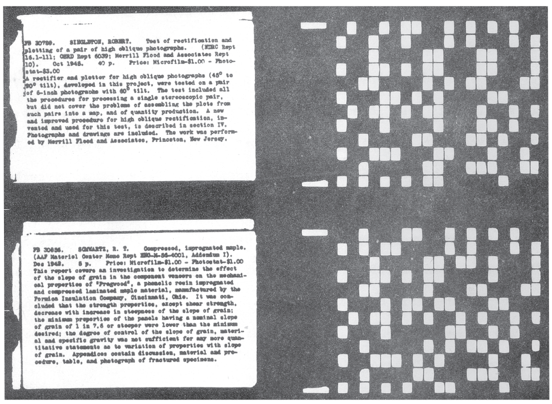

Figure 3: Example of microfilmed abstracts and associated code columns.

In the decades since "As We May Think" was published, the essay has been hailed as influential and visionary. One study measuring the influence of Bush's article employed citation analysis to suggest that the article has been appropriated across a wide range of disciplines, e.g.: as a milestone in "historical perspectives" on information technology; as one among many approaches to a "hardware" solution to information storage and manipulation; as a vision of a personal "information store"; as a visionary statement about the link between thinking and information architecture via the notions of association and linking (hence the essay's title); and as a premonition of the personal workstation.[9] It is no wonder, then, that in light of the creativity and novelty of Bush's proposal, contemporary interpreters have seen in the Memex the forerunners of hypertext, the modern personal computer, and perhaps even the Internet itself. However, there is a degree of anachronism inherent in these claims, and some recent discussions of Bush's idea contextualize it differently.

James Nyce and Paul Kahn argue, for example, that it is more appropriate to see "As We May Think" primarily as a reflection of Bush's interest in helping individual researchers expand their own minds, using the Memex as a memory "supplement" as Bush put it himself, than as a launching point for post-War information science. What Bush envisioned, they explain, was not a world-wide web of knowledge, but an electromechanical device that constituted, in a sense, an analogy of our own cognitive processes ("Machine" 40). In the same vein, Larry Owens has argued that the hypertext-forerunner argument obscures the important connections between the Memex and one of Bush's earlier projects, the Differential Analyzer, an elaborate mechanical device for solving and plotting equations. In the case of both devices, the technology was meant not only to make a human practice more efficient, but also to help people think their way through and around complex problems and vast volumes of information through visual and mechanical analogies (Owens 23-24). The Memex concept, in other words, may better be considered a product of Bush's interest in engineering, problem solving, and cognitive psychology, than as a prophetic vision of contemporary computing.

Moreover, the basic technology and, to some extent, even the concept behind the Memex had been established for some time prior to the 1930s, when Bush first began to imagine such a device. Experiments with microfilm, for example, began almost immediately after the advent of photography. In late 1839, John Dancer (inventor of the calcium spotlight, i.e., the "limelight") is reported to have created a 160:1 reduction of a document (Luther, "The Earliest"). By the middle of the nineteenth century, "microphotography" was firmly established—in the Franco-Prussian war of 1870, for example, homing pigeons were secreted out of the besieged Paris by balloon, and then used to bring news on microfilm back to the city. According to Farkas-Conn, figures such as Paul Otlet and others had discussed using microfilm for documentation by the beginning of the twentieth century, although the practical problems could not be addressed adequately until the 1920s, when Edwin Slosson and Watson Davis pushed for its use for preserving books, newspapers, and other valuable documents (17-18). By the time of the "V-mail" of World War II, microfilm had chalked up a century of development and use.

A Memex-like device had even been proposed some years before Bush had the idea. Emanuel Goldberg (1881-1970), as Michael Buckland has observed, appears to have designed and even tested "the first functioning document retrieval system using electronics" ("Emanuel" 288). In fact, Goldberg applied for a patent on an electronic microfilm selection device in Germany in 1927 and in the U.S. in 1928, and was granted the latter in 1931,[10] the same year in which he presented a paper the title of which Buckland translates as "The Retrieval Problem in Photography" at a conference in Dresden. The device, like all later microfilm selectors including Bush's, depended on the principle of optical coincidence, whereby an electric circuit may be opened or closed when light is either let through or completely blocked from a specific area in the device. Buckland argues that although Bush is often credited with the rapid selector idea itself, it is more accurate to say that Bush's key contributions are twofold: he and his colleagues developed "truly *rapid* prototype microfilm selector," and his "As We May Think" article intrigued and inspired a far larger audience than Goldberg's work could have (292).

Ultimately, technical as well as organizational difficulties besetting Bush's final efforts to produce a prototype of a "rapid selector" modeled on his Memex idea simply could not be overcome. As Colin Burke notes, Bush received $100,000 from Rockefeller foundation to build an electronic Differential Analyzer at MIT, while simultaneously he was trying to develop a rapid selector device called a "Comparator" for the Navy, "a superfast machine to count the coincidences of a letter in two messages of copies of a single message" ("A Practical View" 147). Although the Navy project looked very promising at first, it suffered from some major problems. Rather than a desktop workstation that could zip through tens of thousands of abstracts per minute, the Comparator was far larger and slower. In addition, the Comparator project was being "driven away from its original purposes." Rather than serving researchers in libraries, its function was being "changed from selecting and reproducing documents to incrementing counters when 'cross-classifications' of census material had to be done" (Burke, "Practical" 156). Instead of protesting, though, Bush went along with these shifts, and nothing like a true Memex ever was built.

Buckland's observations help us understand better not only the historical details related to the development of microfilm selector devices, but also the gap between what Bush was able to achieve and what had to remain a vision of the future. Though a "truly rapid" microfilm selector can be seen, in retrospect, as well within the technological capabilities of the day, the kind of searching and inter-linking of documents Bush sought was imaginable in principle but close to impossible in practice. It is clear why: microfilm affords no practical way to perform comprehensive searches for *random* strings, that is, search terms the *user* might invent rather than pre-indexed terms or codes. It was not until decades later that a computerized "document" or file could be reduced to its component parts, one of which would be the alphanumeric material that a computer program's "search" routine could process as such. To better understand what Bush was up against, we might consider how today we remain limited to text-string searches—though there have been attempts to perform searches on non-textual material, it is still difficult to imagine, say, scanning a picture of a coffee mug and producing "hits" which contain references to coffee mugs and like objects.

Nevertheless, "As We May Think" rightly remains a milestone in the history of information management. Although Bush may not have had visions of "hypertext" as we know it, he was certainly ahead of his time. In 1960, for example, Helen Brownson remarked on Bush's Memex idea, noting that as of that time no technology for associative indexing had been successfully developed. Although much progress had been made by then in the development of indexing and searching devices, all were based instead on the principle of what Brownson calls "coordinate" indexing, that is, matching pre-indexed key terms to entries in an index. Coordinate indexing was thus of limited utility—the user was forced to use only the search terms provided by the system. Even the most advanced systems of the time could not seem to break the coordinate-indexing barrier—automatic abstracting devices, for example, which used optical character recognition techniques to scan for frequently-used terms, still could not provide the user with anything better than a "thesaurus" of pre-packaged search terms from which to choose. Moreover, coordinate indexing offered no way of building linked "trails" of hits.

Unlike the punched card, however, the information-management functions of which have been almost entirely displaced by computers, microfilm lives on. For archival research, microfilm remains current and necessary, since it contains photographic images of documents which are artifacts just as distinctive and concrete as the original documents themselves. Today many firms offer microfilm scanning services, since many industrial and scientific documents of continuing relevance are available only on microfilm. Even with the advent of digitization, microfilm "originals" are thus likely to be preserved indefinitely whenever possible.

Like any history, technological history is neither linear nor monolithic. Buckland has observed, for example, that during precisely the period at hand here—the interwar period—we find that librarianship in the United States (as opposed to state and corporate information management) was largely disengaged from technological innovations being developed in Europe ("Documentation" 67). Ronald Day has expanded this point in *The Modern Invention of Information*, calling our attention to the interwar work of European "documentalists" such as Suzanne Briet and Paul Otlet, who shared in the utopian visions of the time and, much more directly than Hollerith and Bush, "emphasized the utilitarian integration of technology and technique toward specific social goals" (7). Moreover, neither Hollerith nor

Bush worked in isolation. Hollerith had competitors early on in the United States, France, and Norway,[11] and Bush worked so closely with some of his colleagues that the question arises of who exactly was responsible for their initial success in getting funding for the rapid selector.

Other figures as well, most notably Atherton Seidell, were at least as persistent as Bush in promoting the benefits of microfilm for information management. Seidell, a chemist by trade, helped to found the American Documentation Institute, which later became the American Society for Information Science (ASIS), and went on to establish the use of microfilm at important institutions such as the Army Medical Library, which became the National Library of Medicine. During the 1930s and 1940s, he wrote numerous articles championing the use of microfilm for distributing scientific literature, including a half-dozen in *Science*, focusing on technical, legal, and economic questions. Often noting the benefits of microfilm for "research workers," Seidell shared the utopianism of Paul Otlet and H.G. Wells;[12] he also designed and had several kinds of inexpensive, handheld microfilm readers produced in the early 1940s (Miles 301).

I have emphasized Hollerith and Bush here, though, because each seems to embody an atypical combination of engineering ingenuity and political power, and the technologies they developed have had profound and lasting cultural resonances. Though their respective projects differ in many details, when we view them together in historical perspective, we can begin to get a clearer sense of these resonances.

For instance, both Hollerith's and Bush's efforts reflect what Colin Burke would call the competing "logics" of information and secrecy peculiar to twentieth-century culture.[13] Burke argues that while the materials on which information technologies operate may lack agency in themselves, the social practices through which they are collected, stored and retrieved usually reflect aspects of both of these logics. As discussed above, Hollerith's and Bush's projects were appropriated early on by representatives of both: microfilm was used as early as 1870 to convey messages secretly, but it also has been long considered a means of preserving public documents; it remains a medium of both "secrecy" (e.g., when it contains classified documents) and "information" (e.g., when it contains public artifacts of use to scholars and researchers). Punched cards also reflect the dual logic Burke mentions, albeit indirectly. Steven Lubar notes, for instance, that early punched cards were devoid of any human-readable symbols since only machines read them; only later, when punched cards became public documents themselves, did some kind of writing appear on them (44).

It is possible, of course, to attribute the logics of information and secrecy to a wide variety of historical artifacts of any period. The punched cards driving Jacquard's looms could be seen as early nineteenth-century embodiments of both logics: information for creating woven goods, secrets held close by a distinct class of artisans. If we consider written language itself to be a sort of technology, as does Walter Ong in *Orality and Literacy,* we can see the logics of information and secrecy competing throughout the whole of history, as elites and the broader public have competed for the tools of literacy. Hollerith's and Bush's devices are distinctive, though, because they embody these competing logics in a peculiarly twentieth-century context, a context of dramatic technological advances, consolidation of cultural power in national governments and large corporations, artistic and scientific utopianism, and so forth.

In addition, these technologies remind us of the ways in which technical innovation in American culture is not so much neutral as paradoxical. Hollerith and Bush both were creative, thoughtful engineers, but their utopian visions were products of the prevailing political and cultural values of their time. Both, that is, were responsible for furthering the interests of knowledge and power in promoting their inventions. The tools they invented gave individuals power by increasing their control over information, yet this same control was used by large, abstract political and cultural institutions to "discipline" individuals as subjects of one or another bureaucratic regime. People used punched cards and microfilm to increase their personal agency; at the same time, people were abstracted into data points on cards or film by impersonal agents they could not control.

One lesson we might take from this examination of punched-card sorters and rapid selectors is that we must be wary about assuming that technical innovations simply serve admirable interests in some contexts and more worrisome interests in others—that the two sides of the paradox simply cancel each other out. Until we see some major shifts in the cultural conditions we have inherited from the late nineteenth and early twentieth centuries, it is likely that we will see many technical innovations in information management slide from one side of the paradox to the other—from utopian, altruistic visions of knowledge-sharing to cynical tools with which states and corporations can aggravate the self-alienation of prosperous, educated peoples.

Figures

1. Original twenty-four column card as illustrated in Hollerith's 1889 patent. Available on many open access patent websites.
2. Standard 80-column card used for library inventory control. Private collection.
3. Example of microfilmed abstracts and associated code columns. Enlarged detail from "Figure 6. Sample of Coded Master Film (Magnified)" in the *Report for the Microfilm Rapid Selector*. Arlingon, VA: Engineering Research Associates, 1949. 10.

Notes

1. I use the term “information society” to refer generally to the social framework in which the collection, control, and communication of information are broadly and deeply embedded cultural and economic practices. The import of that phrase, however, has been subject to critique in discussions such as Lars Qvortrup’s “The Information Age Ideal and Reality” and, more recently, Nicholas Garnham’s “‘Information Society’ as Theory or Ideology.”
2. As Edwin Black puts it, Dehomag, the German arm of IBM, “using its own staff and equipment, designed, executed, and supplied the indispensable technologic assistance Hitler’s Third Reich needed to accomplish what had never been done before—the automation of human destruction” (8-9).
3. After his success using the devices for tabulating and analyzing the data of the 1890 U.S. Census, Hollerith established the Tabulating Machine Company in 1896. This company merged with two others, International Time Recording Company and the Computing Scale Corporation, in 1911, to form the Computing-Tabulating-Recording Corporation (CTR), which was renamed the International Business Machines (IBM) Corporation in 1924.
4. For example, G. W. Baehne’s edited volume, *Practical Applications of the Punched Card Method in Colleges and Universities*, encompasses uses in registration, business, and other administrative offices.
5. See, e.g., Lars Heide’s “Monitoring People.”
6. See C. W. Vickery’s “Punched Card Technique for the Correction of Bias in Sampling.”
7. Hollerith’s patents (nos. 305,781; 395,782; and 395,783) can be found at the United States Patent at Trademark Office’s web site (<http://www.uspto.gov>).
8. This image is reproduced from a 1949 report of Engineering Research Associates, a firm that supported Bush’s final, unsuccessful efforts to launch his rapid selector.
9. See Linda Smith’s “Memex as an Image of Potentiality Revisited.”
10. Goldberg’s patent (no. 1,838,389) can be found at the United States Patent at Trademark Office’s web site (<http://www.uspto.gov>).
11. See Lars Heide’s “Shaping a Technology: American Punched Card Systems 1880-1914.”
12. See Atherton Seidell’s “The Utilization of Microfilms in Scientific Research.”
13. See Burke’s *Information and Secrecy: Vannevar Bush, Ultra, and the Other Memex*

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