Fig. 1: Updike with his WangWriter II word processor, 1987. © Nancy Crampton. Used with permission.

All around us we are outlasted.
–Updike, "Plumbing"

Operating Systems of the Mind:
Bibliography After Word Processing
(The Example of Updike)

Matthew Kirschenbaum

I.

In 1983 John Updike acquired a Wang word processor, the same brand favored by another best-selling New England writer north of Boston, Stephen King. This was also the year that Adam Begley, Updike's biographer, identifies as the pinnacle of the author's literary career. By then Updike had published the third of his Rabbit books, *Rabbit is Rich* (1980), which had garnered in quick succession the National Book Critics Circle Award, the National Book Award, and the Pulitzer Prize for Fiction; his short stories, essays, reviews, and poems were a mainstay of *The New Yorker* and other magazines, and he was fast at work on the *Witches of Eastwick*, which was to become perhaps his best-known novel through its 1987 film adaptation. There could be no other candidate to play the role of a paternal dean of American letters: Tom Wolfe, with whom Updike suffered an ongoing feud, had not yet produced any fiction; Pynchon and DeLillo lacked Updike's broad public platform and

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appeal; David Foster Wallace was just then writing the senior thesis at Amherst that would become his first novel. One could, in fact, do worse than to name King—himself at the height of his career—as Updike's greatest rival for the attention and affection of the American reading public.

With regard to adopting word processing, however, Updike was neither a trendsetter nor a holdout. He was instead what he so rarely was otherwise: merely typical. The technology had been a staple of office work for nearly a decade by then, and systems like the Apple II, TRS-80, IBM PC, Kaypro, and Osborne were all popular on the home computer market. Word processing was thus of obvious professional interest for any working writer. Writers talked about it when they talked shop or were queried in interviews. Some swore by it, others ranted about and decried it. Innumerable advice articles and letters to the editor as well as long, earnest technical discussions appeared in venues like the *Writer's Digest*. Two years previously Updike had been quoted in *Time* magazine saying, "I am not persuaded that the expense and time it takes to learn the machine would be worth it. I'll stick to my manual, as I have for 20 years."[1] Nonetheless, 1983 was a year of transitions (he and his second wife Martha having just moved into their Beverly Farms, Massachusetts, home, where they would remain until Updike's death in 2009), so the time perhaps seemed right. He told Roger Angell, his editor at *The New Yorker*, that it would surely change his writing but he didn't know how.[2]

Like many others he was at first captivated by the strange new device, declaring it "dazzling" more than once. Evidence of writers test driving their first word processor is a minor genre in their personal papers. One of the best known examples comes from Russell Banks when he was writing the novel that became *Affliction*: "STILL VERY MUCH LEARNING TO THINK ON THIS MACHINE," he wrote in all caps at the beginning of a document that is a kind of stream-of-consciousness exploration of its capabilities. "STRANGE EXPERIENCE, UNFAMILIAR MIXTURE OF SPEED AND SLOWDOWN."[3] A similar page by Salman Rushdie survives in his collection at Emory University. Stephen King, meanwhile, wrote a short story, "The Word Processor," which was published in *Playboy* and stands as the first extended

1. J. D. Reed, "Plugged-In Prose," *Time*, 10 August 1981.

2. Author's interview with Roger Angell, 16 May 2014.

3. See http://blogs.utexas.edu/culturalcompass/2011/03/22/in-the-galleries-russell-banks-adapts-to-a-word-processor/.

fictional treatment of the technology (it was republished in *Skeleton Crew* as "Word Processor of the Gods"). King describes the compelling ease with which the machine could make sentences appear and disappear. The conceit of the story becomes a word processor that has similar wondrous capabilities for the people and things of the real world, thus allowing the frustrated writer who is King's protagonist to copyedit his own life.

   It was in such a spirit of novelty that on or about 13 March 1983, with the recently installed Wang in one of his dedicated writing rooms, that Updike sat down in front of it and did something different: instead of reaching for a pencil as was his habit with poetry, he composed the first version of the verses that would eventually be published as follows directly on its softly glowing (yet somehow insistent) screen:

INVALID.KEYSTROKE

> Wee.word.processor,.is.it.not
> *De.trop*.of.you.to.put.a.dot
> Between.the.words.your.nimble.screen
> Displays.in.phosphorescent.green?
>
> Your.cursor—tiny.blinking.sun—
> Stands.ready.to.erase.or.run
> At.my.COMMAND.to.EXECUTE
> Or.CANCEL:.which? The.choice.is.moot,
>
> So.flummoxed.are.my.circuits,.met
> This.way.by.your.adroiter.set.
> I.cannot.think..Your.wizardry
> Has.by.some.ERROR.cancelled.me.[4]

Updike played with the text, perhaps editing on the screen, but also printing at least five hard copies and heavily annotating one of them (it appears to be the first) by hand. One draft, for example, included this pair of couplets:

> The.mind.is.just.a.set.of.sparks
> Composed.inscrutably.of.quarks
> And.so.are.you,.you.dazzling.thing.
> I.touch.S.I.N.G;.you.sing![5]

4. In *Light Year '84*, ed. Robert Wallace (Cleveland: Bits Press, 1983), 110; used by permission of The Wylie Agency LLC.

5. The John Updike Papers (2527). Houghton Library, Harvard University.

Besides the comparison between human mind and electronic brain (a theme to which he would return in subsequent fiction), we see in this stanza evidence of further indulgence in the typographical effects that mark the poem. But Updike ultimately exercised the machine's delete function and discarded it. Off the text then went to *The New Yorker*, where it was rejected in short order; the letter, signed by Howard Moss and dated 24 March, reads in part, "[T]hough God knows this is timely, something kept us from taking it—I'm not sure what."[6] Referring to the digital provenance evoked by those oh so *de trop* "dots" between each word, Moss noted "the idea of the poem and the way its done being one, maybe it's that after the first few lines, you've got it."[7] The piece was instead published in an annual of light verse edited by Robert Wallace. Yet the story of its composition was memorable enough for Updike to use it to begin the preface of a 1991 gathering of essays he titled *Odd Jobs*, where he also noted that the word processor had made the prospect of taking on such occasional pieces all the more seductive.

"INVALID.KEYSTROKE" was not reprinted in any of Updike's poetry volumes, and to the best of my knowledge it has not otherwise resurfaced. I myself first encountered it in typescript in the reading room of the Houghton Library at Harvard. I had gone to the Houghton, which is of course where Updike's papers are kept, with a two-part question: What was his first computer, and exactly when did he start using it? This detail of the writer's life was not recorded in any published source I had seen at the time. In *Odd Jobs*, Updike mentions having acquired a word processor "not long" after compiling a previous collection, *Hugging the Shore*, in 1983, but he does not see fit to note the brand or model or any other technical specifics. In his 2014 biography (which appeared after my initial trip to the Houghton in October 2013), Begley reveals that Updike acquired a Wang word processor in 1983 but does not provide any documentation for this information.[8] As we will see, Begley is not wrong, but I would suggest that the casual approach to citation of what might no doubt seem a recondite technical detail mirrors Updike's own apparent lack of interest in identifying and detailing the system that otherwise so

6. Ibid.
7. Ibid.
8. Adam Begley, *Updike* (New York: Harper, 2014), Kindle Loc. 8216. In conversation with me, Begley suggested it was most likely something Updike mentioned in his correspondence to *The New Yorker*, archived at the New York Public Library—yet a check of the finding aid there reveals that its coverage ends in 1980.

captivated him—twin lacunae that contrast with the perspective I wish to cultivate here. After all, it is not as if writers are noticeably reticent when it comes to talking about the particulars of their tools: to take just one example, the contemporary Boston-based novelist Clare Messud has spoken often about her insistence on using Rhodia pads for longhand, a specific brand of graph-paper notebook.[9]

   Implied by the queries about Updike's computer are at least two larger questions: How should we find out the answers given that the man himself is now gone, and why does it matter? And to these I would also add a third: what does it mean to think about such questions not just in biographical but also in *bibliographical* terms, that is, to ask them with the presumption that by answering them we will illuminate some aspect of the composition, circulation, and reception of the writer's texts? For the last three years I have been collecting what we know about writers and their computers as part of my ongoing research on the literary history of word processing. Though not all writers use a computer even today, most do, including some—such as Michael Ondatjee and J. K. Rowling—who are routinely celebrated for supposedly not doing so. Yet we have no reliable way of recovering the technical specifics of their systems, even though such details will be vital to the future identification and preservation of any electronic files associated with them. Sometimes the answer is easy to find, as as when authors go on record about their use of word processors. Isaac Asimov, for example, revealed that a Radio Shack TRS-80 Model II accompanied by a daisy-wheel printer and the software Scripsit arrived at his 33rd-floor New York City apartment on 6 May 1981 at the behest of a computer magazine that had contracted him to write a series of articles about his first time using a word processor.[10] In other cases there is clear documentary evidence: we know from his financial records that Ralph Ellison bought an Osborne 1 on 8 January 1982 (some blame his subsequent failure to finish his long-awaited second novel on his transition to word processing).[11] The letters and emails of Charles Bukowski show that he got a Macintosh and a laser printer for

9. See http://www.bostonglobe.com/arts/books/2014/05/31/new-england-writers-work-claire-messud/aookuSDJg4Gixvm31AyqgI/story.html.

10. Isaac Asimov, "The Word-Processor and I," *Popular Computing*, September 1982.

11. Adam Bradley, *Ralph Ellison in Progress* (New Haven: Yale University Press, 2010), 217. Bradley also effectively debunks any simple narrative of the word processor as the reason the second novel went unfinished.

Christmas in 1990—and his already terrific productivity soared. As well, technical evidence exists within the archived electronic files themselves. Salman Rushdie has said that the first novel he wrote on a computer was *The Moor's Last Sigh*, and the digital files associated with that book that are part of his "papers" at Emory University should allow us to ascertain the date- and time-stamp to the second.[12] File formats and other system specifics can sometimes be reverse-engineered from opaque binaries. But just as often, I have found, the answer must be arrived at deductively, by triangulating statements the writer makes in passing in published or unpublished sources, checking them against the relevant product specs, and, when the opportunity arises, through archival research in the author's papers, which as the example of Rushdie demonstrates, can also include what are now termed born-digital records.

When I describe my work on literary word processing, people tend to assume my interests are stylistic. They ask about whether word processors have made some particular author's writing better or worse, sentences longer or shorter, vocabulary richer or poorer, and so on. These were also questions of genuine concern to the literati. Word processing was once ascribed powers far beyond the casual ability to edit and manipulate sentences. "The idea of literature," Gore Vidal solemnly declared in 1984, "is being erased by the word processor."[13] But my project is not stylistic, it is historical and ultimately bibliographical, having to do with our knowledge of the material histories and transmission of texts. Despite being a crucial tool in the production of literature for more than thirty years, computers have not yet been the subject of much serious work in literary history, let alone actual bibliography.[14] By contrast, authors and

12. *Conversations with Salman Rushdie*, ed. Michael Reder (Oxford: University Press of Mississippi, 2000), 172–3.

13. Gore Vidal, "In Love with the Adverb," *New York Review of Books*, 29 March 1984.

14. Of course there are exceptions. Alan Galey's "The Enkindling Reciter: E-Books in the Bibliographical Imagination" (*Book History* 15 [2012]: 210–47) is a tour de force of textual scholarship and digital sleuthing, deservedly recognized with the 2013 Fredson Bowers Prize; Miriam O'Kane Mara's "Nuala O'Faolin: New Departures in Textual and Genetic Criticism" (*Irish Studies Review* 21, no. 3 [2013]: 342–52) makes a nuanced but ultimately speculative case for the import of the digital manuscripts on O'Faolin's hard drive as O'Kane Mara does not have access to any of the actual files herself. In "Peter Carey's Laptop" (*Cultural Studies Review* 20, no. 1 [2014]: 100–120), Rowan Wilken meditates on the political and material significance of the State Library of Victoria's purchase of the Mac Classic the Austra-

their typewriters have long been an irresistible topic to scholars and the lay public alike. Richard Polt's Classic Typewriter Page on the web includes an extensive list of the machines associated with a wide variety of different writers.[15] Steve Soboroff's collection of typewriters belonging to John Lennon, the Unabomber, and yes, Updike, regularly tours and is exhibited. Computers are rarely treated as numinous objects in this regard, though there have been some exceptions, such as Peter Carey's Mac laptop under glass at the State Library of Melbourne. Likewise, serious textual scholarship has been done using typewritten documents, including Lawrence Rainey's work dating the composition of *The Waste Land*. Hannah Sullivan, meanwhile, in her recent book *The Work of Revision*, uses textual evidence to read the typewriter as central to high Modernism's poetics of revision. As a commonplace of literary history we know that the first typewritten manuscript was Mark Twain's *Life on the Mississippi*, published in 1883 and composed on his Remington #2. What was the first novel written with a word processor? The answer has not been commonly known, though I have published my candidate.[16] Could a bibliographical question such as Rainey's have been posited (let alone resolved) had Eliot sat by the waters of Leman with a Powerbook instead of a manual typewriter? (The answer is yes, but as with any true bibliographical question, not without the aid of specialized tools and the training to use them correctly.) How then can we ascertain relevant facts of a writer's computing history and avoid conjuring what I have taken the liberty of terming operating systems of the mind?

Let us start by coming back to the text of Updike's poem. The lines of this tetrameter apostrophe themselves contain certain clues and telltales.

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lian novelist used to write his prize-winning *True History of the Kelly Gang*. Finally, Doug Reside's ongoing work on Broadway composer and librettist Jonathan Larson is a model of theory and practice applied in tandem: see his "'Last Modified January 1996': The Digital History of *RENT* (*Theatre Survey* 52, no. 2 [2011]: 35–40), and Matthew Kirschenbaum and Doug Reside, "Tracking the Changes: Textual Scholarship and the Challenge of the Born Digital" in the *Cambridge Companion to Textual Scholarship*, ed. Neil Fraistat and Julia Flanders (Cambridge: Cambridge University Press, 2013), 257–73.

15. See http://site.xavier.edu/POLT/TYPEWRITERS/.

16. My candidate is Len Deighton's novel *Bomber* (1970), which he wrote on an IBM MT/ST with the assistance of his secretary, Ellenor Handley. See Matthew Kirschenbaum, "The Book-Writing Machine," *Slate*, 1 March 2013, http://www.slate.com/articles/arts/books/2013/03/len_deighton_s_bomber_the_first_book_ever_written_on_a_word_processor.html.

First, we are told that the monitor displays its text in green. (This is technically known as P1 phosphor, and was extremely common; amber and white were also used for monochrome displays.) Second, of course, there is the fact of the "dot" in the spaces between each word. Finally, there is reference to a series of seemingly generic commands, such as EXECUTE and CANCEL, as well as the title of the poem, typographically rendered as an error message: INVALID.KEYSTROKE. Of these, the most interesting is surely the dot between the words. What word processor then available to Updike would have rendered text in this way? In fact there are several, including Microsoft Word. Further checking, however, reveals that Word was not released until November of that year, in a carefully calibrated launch campaign that included diskettes with trial versions of the software bundled into that month's issue of *PC World*, the first time that particular gimmick, later a staple of the computing world, was ever employed. (I include this detail to remind us that when dealing with consumer software products mere months can mean the difference between a reasonable bibliographical possibility and a piece of evidence which would "conclusively falsify it," in D. F. McKenzie's phrasing.[17])

Displaying a dot between words may be a screen feature characteristic of early word processing systems, but it is of course a much older convention. It is properly known as an interpunct, and Paul Saenger, in his authoritative *Space Between Words* (1997), demonstrates that it was commonplace in the ancient world prior to the introduction of vowels into the Phoenician alphabet. Moreover, Nicholson Baker, himself making the connection to *scriptura continua*, stated that the convention was specifically revived by Wang in the 1980s.[18] Wang, incidentally, employed green monochrome for its displays, and a check of some old manuals reveals both EXECUTE and CANCEL as legitimate commands (in fact, both were actual keys on the keyboard). But there is also a typographic subtlety we must take note of. In the poem as printed, and indeed in the typescripts at the Houghton as well, the dots do not float midway between the top and the bottom of the line as they did when displayed in phosphorescent green upon John Updike's nimble screen. Rather, they

17. D. F. McKenzie, *Making Meaning: "Printers of the Mind" and Other Essays*, ed. Peter D. McDonald and Michael F. Suarez, S.J. (Amherst: University of Massachusetts Press, 2002), 17.

18. Nicholson Baker, "The History of Punctuation," in *The Size of Thoughts: Essays and Other Lumber* (New York: Vintage, 1997), 75.

are printed at the bottom of the line as ordinary periods. The center dot would have been present on Updike's display as a formatting code, much like tab symbols, hard returns, and other such marks. But these were never actually output to the printer, and there was no easy or obvious way to do it, certainly not for a novice user. What we see then is Updike substituting an approximation of a special formatting code with an ordinary punctuation mark, a gesture that speaks at once to his sensitivity toward the unique affordances of the machine as well as the limits of his own know-how.

In the preface to *Odd Jobs*, Updike tells us explicitly that he composed the poem "to" his word processor "on" his word processor.[19] Without this detail at our disposal, we might have cause to examine the typescripts for some material evidence of their origin, specifically whether they were the product of a manual or electric typewriter or a printer that was part of a computer system. This is, in fact, an obvious bibliographical question, and our ability to address it is vital for creating a complete profile of what writing tools an author was using at various points in their career. *If we can surmise that a given document was in fact output from a computer or word processor's printer, then we know that it also at one time existed in an electronic state, and we can seek out the physical media on which those files would have been stored.* Expert document examiners have long been able to identify and individuate typewritten fonts, and there are outstanding reference works, such as the *Haas Typewriter Atlas*, to aid in this endeavor. There is nothing comparable for computer printouts, though there have been some high-profile cases, such as the controversy around the CBS News documents used in support of allegations about George W. Bush's National Guard service, widely suspected of having originated on a word processor and not the manual typewriter an authentic provenance would have demanded. Dot matrix printouts are of course easy to spot, though even there we must be careful, such as with so-called "letter quality" dot matrix output. Moreover, the ink patterns left on paper when a typebar strikes the cloth typewriter ribbon can sometimes seem to approximate the pixelated look of a dot matrix printer and thus deceive the uninitiated. In the case of modern inkjet and laser printers, there is a body of experimental research around the forensic identification of individual machines, though the methods typically rely on access

19. Updike, "Preface" to *Odd Jobs: Essays and Criticism* (New York: Random House, 1991), Kindle Loc. 163.

to lateral cross-samples from the same make and model for comparison; there is also lore that circulates about the government's ability to individuate laser printed documents by a pattern of near-microscopic yellow dots printed on every page, supposedly originally an anti-counterfeiting measure.

Regardless of the efficacy of such techniques, they are unlikely to be available to the average scholar working in the reading room. Even so, there are certain indicators that can suggest a word-processed printout as opposed to a true typescript. These include the presence of proportional spacing, curly quotation marks, superscripts smaller than their neighboring text, and strong kerning. Above all, one looks for consistency in the weight and depth of the letterforms (which suggests automated rather than manual means of production) and the presence or absence of embossment indicating whether the impact of a hammering key has forcibly impressed ink into page. The so-called daisy-wheel printing technology that was widely used from the 1970s through much of the 1980s is especially tricky in this regard, since it does not produce such embossments, and both electric typewriters and early home-computer printers supported it; moreover, in the early days of mainframe computing, electric typewriters would have been the output device of choice for a computer text-editor. There is much more that could be said here by way of particulars, but my main point is to gesture toward the necessity for the bibliographer or textual scholar who is working on late twentieth-century texts to come to grips with the technological landscape his or her authors inhabited in order to reliably reconstruct knowledge of their writing instruments—something that becomes particularly important when the writing instrument itself is also an integral part of the system for the storing and recording of texts, as it is now. The practical ability to make confident determinations about the provenance of true typescript versus hard-copy output is a first step in this regard.[20]

Meantime, we are still not done with the Houghton's drafts. On the back side of the same one Updike annotated by hand, we find what appears to be an electronic file listing, dumped directly from screen to page for some unknown purpose (see fig. 2). Updike, one should understand, reused *everything*. He was known to write in the empty space of a retail store receipt. He recycled paper for both manuscript and typescript,

20. The Houghton's finding aid appears to use the terms "typescript" and "printout" to describe manuscripts more or less interchangeably.
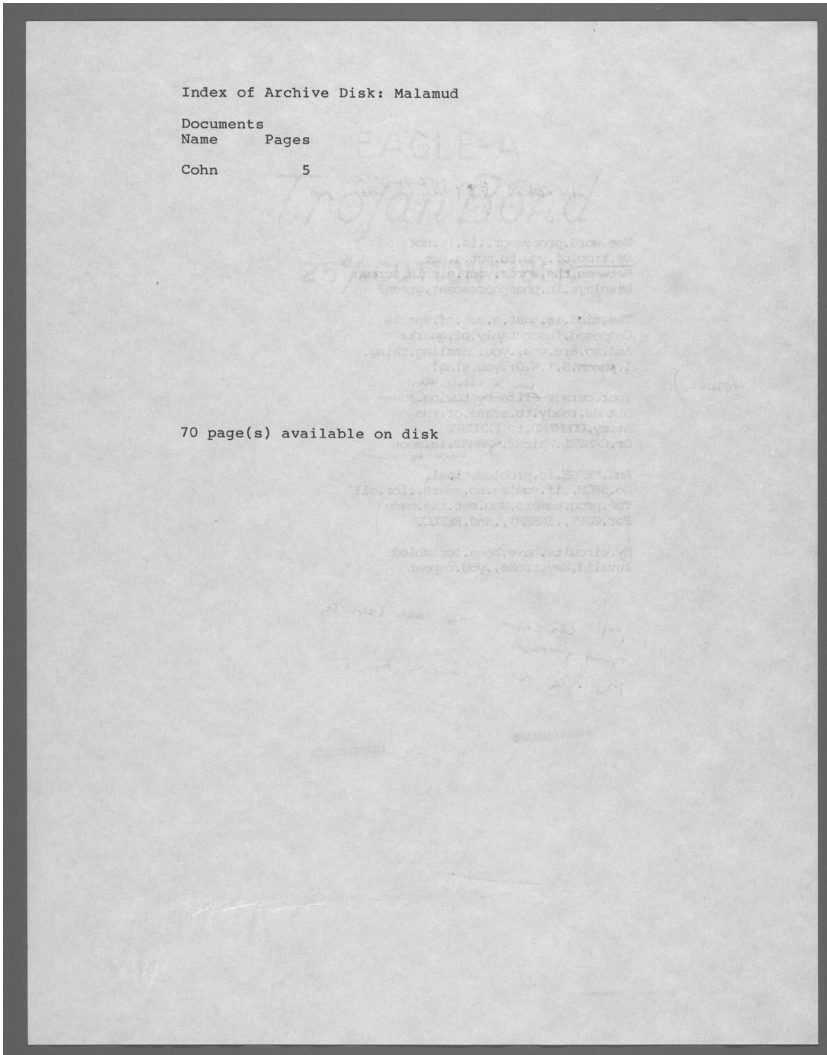
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Index of Archive Disk: Malamud

Documents
Name      Pages

Cohn        5




70 page(s) available on disk
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Fig. 2: Directory listing for one of Updike's lost Wang diskettes, overleaf of a type-script of "INVALID.KEYSTROKE" with autograph revisions. The John Updike Papers (2527). Houghton Library, Harvard University. Used with permission.

filling both obverse and reverse. Later in his career he used Post-It notes: using a sheet of paper in this way was consistent with his work habits, though I would underscore the serendipity of having this "vox machina" appear on the reverse of the most richly annotated draft of the very text Updike wrote extolling that machine's capabilities. The file listing reveals the existence of a disk named "Malamud" and a document named "Cohn." As it happens, Bernard Malamud's last novel, *God's Grace*, was published in 1982 and features a protagonist named Calvin Cohn. You can imagine my delight at this discovery! Not only was Updike using a word processor, so too was Bernard Malamud, and here we see Updike, frugal Yankee that he was, recycling a page from the printer originating on Malamud's own machine (the two did correspond). But no, this was not the case: Updike had, in fact, written a review of Malamud's novel, published in *The New Yorker* in November of the previous year. Obviously what I had here, then, was an index to one of Updike's own diskettes and an apparent record of a predecessor text he had composed on the word processor, perhaps as much as some six months earlier.[21] The file listing was of immediate importance to me for another reason though: in the sparse particulars of its syntax and semantics (notably the telling reference to the disk as an "archive") I had at last the skeleton key to the actual system that had been used to produce it. From there it was just a quick bit of Googling, which turned up a nice-quality PDF of the original machine's operating manual, to confirm that it was indeed a Wang.[22]

   I had answered my first two questions through a combination of fact checking, serendipity, and conjecture. I have subsequently come across only one place in Updike's writings where he makes reference to the

21. On a return visit to the Houghton Library I examined the drafts of the Malamud review, "Cohn's Doom." There are three typescripts, all variously dated in September of 1982, and all of them unambiguously true typescripts produced on a manual typewriter (as opposed to computer printout). There is, in other words, no evidence that Updike used a computer to compose the review at that time, and so as of this writing what to make of its apparent digital reincarnation as implied by the file listing remains a mystery. If it was electronically transcribed and saved to disk at some later date, no motive for doing so has presented itself.

22. A 1987 photo by Nancy Crampton depicting Updike seated in front of a terminal and keyboard that are recognizable as belonging to a Wang system was published with the *New York Review of Books'* 8 May 2014 review of the Begley biography (see fig. 1).

Wang by name, as opposed to just referring generically to a "computer" or a "word processor."[23] Yet surely such particular knowledge about a writer's computer is more than just a species of author worship, like asking what color the great man's favorite cardigan was, and it is not as if we don't know quite a lot about how Updike otherwise wrote. In one extended passage he characterizes his word processor ("a term," he quips, "that describes me as well") as the last in a succession of writing instruments that originated with crayons and colored pencils.[24] We know that Updike owned a series of typewriters, first manual, and then electric, before the Wang arrived. (Later he would migrate to an IBM computer and then a Dell.) But it would be a mistake to interpret this genealogy of machines as merely progressive; instead, they coexisted, literally side by side in his office, with different tasks associated with each.[25] He described the scene for the photographer Jill Krementz:

An oak desk bought at Furniture in Parts in Boston twenty years ago is, along with a metal typing table and an old manual Olivetti, where I answer letters and talk on the phone. An olive-drab steel desk, a piece of retired Army equipment bought over thirty years ago in Ipswich, is where I write by hand, when the fragility of the project—a poem, the start of a novel—demands that I sneak up on it with that humblest and quietest of weapons, a pencil. . . . The third desk, veneered in white Formica, holds the word processor where everything gets typed up and where many items . . . are composed.[26]

These casual details orient us towards what is in fact a very complex textual condition, with texts originating in various media and then migrating back and forth between them in the course of their revision—longhand and typescript, hard copy and disk. The point, of course, is not that Updike is in any way remarkable in this respect, just the opposite in fact—think of your own individual writing habits. McKenzie himself anticipated precisely this situation as early as 1985 in his Panizzi Lec-

23. John Updike, "The Writer in Winter," in *Higher Gossip: Essays and Criticism* (New York: Random House, 2011), 4.

24. Ibid.

25. We catch a glimpse of these habits in Updike's 2004 poem, "Death of a Computer," which describes the way in which he retained an ailing machine that would still read his older disks and then "turned them into final printed versions, | dark marks on paper safer than electrons" (*Endpoint and Other Poems* [New York: Knopf, 2009]).

26. John Updike, introduction to Jill Krementz, *The Writer's Desk* (New York: Random House, 1996), xi.

tures, when he explicitly included electronic files within the purview of bibliographical and textual studies. Yet Updike's study in Beverly Farms is also very different from the early eighteenth-century scenes McKenzie so painstakingly reconstructed, and I don't just mean in the obvious sense of its modernity. Here we inhabit a writer's office, not a printer's workshop, and the nature of contemporary office work (and the writing instruments that attend it) is such that production is part and parcel of composition.

The casual references to the typewriter where he answered letters and the word processor where "everything gets typed up" speaks to a blurring of boundaries between the author as a composer of texts and the author as a compositor of them. (Before long we would call this desktop publishing.) That contention is reinforced by what the papers at the Houghton, which contain innumerable proofs and galleys, tell us about Updike's relationship to his editors and proofreaders, and to the compositors who ultimately typeset his work professionally—he took an active interest in all of these matters, and the hard copy that emerged from his well-organized home office was in fact being "published"—if you will—to a select audience of in-house professionals. Indeed, Begley refers to Updike's deliberate arrangement of the various rooms containing his varied writing instruments as a "literary production line."[27] In May 1983 correspondence to one editor Updike notes: "The trouble with a word processor is I haven't figured out a way to put the page numbers in the margins . . . I hope the checkers will still find my manuscript useful."[28] Yet he figured such things out, for the most part anyway. That as much as anything may been what made word processing inevitable for him; it transformed the actual work, the very material labor of writing.[29]

II.

By now it should be evident that when text moves among multiple information states—from digital file to hard copy output, for example—those media transitions tend to produce what we might recognize as

27. Begley, *Updike*, Kindle Loc. 7065.

28. Letter to "Edith," 21 May 1983, The John Updike Papers (1703), Houghton Library, Harvard University.

29. In a keynote address to a 1988 computer-science conference at MIT, Updike would assert that word processing made the production of "perfectly typed" text "almost too easy." See "Where Money and Energy Gather: A Writer's View of a Computer Laboratory," in *Research Directions in Computer Science: An MIT Perspective*, ed. Albert R. Meyer, et al. (Cambridge: MIT Press, 1991), np.

bibliographical knowledge. John Lavagnino has explored the implications of these transitions through character-encoding problems—the glyphs and gibberish we sometimes see on our screens in an email or a web browser, now called mojibake—which may enable the identification of the originating computer.[30] Learning to recognize and leverage these transition and translation points is critical to an analytical and descriptive bibliography of born-digital texts since they are where the materiality of underlying systems and infrastructure becomes manifest. Thus far we have focused on evidence derived from the transition of digital text to paper. But what about Updike's born-digital materials? What can they tell us about his writing's transitions from screen, or more properly RAM, to long-term storage?

The Houghton Library has some forty 3½-inch IBM disks from a later phase of Updike's career, but none from his decade with the Wang.[31] At least until such time as these older diskettes may be located, bibliographical investigation of any of Updike's digital files from this era will be impossible. We cannot know, for example, whether "INVALID. KEYSTROKE" or any of the many more significant texts Updike wrote throughout those years exist in variant states *not* represented by corresponding hard copy on deposit with his papers. We cannot know if there are texts *never* consigned to paper or whose paper instantiation

30. Lavagnino's paper was presented at the 1996 ACH-ALLC conference in Bergen, Norway. Only the extended abstract published in the conference's proceedings is currently available: http://www.researchgate.net/publication/237216894_The_analytical_bibliography_of_electronic_texts.

31. Wang systems used a variety of storage technologies over the years, ranging from cassette tapes to 8-inch and 5¼-inch floppies to early hard drives, known as Winchester drives. Updike's model would have used 5¼-inch floppies. We know this from the product specs, but if we return to the print dump from the Malamud disk's directory listing we can also do a bit of arithmetic to confirm. Wang machines ran an operating system known as OIS, or the Office Information System; just like the more commonly known DOS, OIS used one byte to store a single character. The directory listing tells us that the single file on the disk, "Cohn," is five pages; it also tells us that there are seventy pages remaining, for a total storage capacity of seventy-five pages per disk. In OIS parlance, a page refers not to the physical page that is printed (the number of lines could vary and was set by the user) but rather to the screen display, whose configuration was 80 x 24 characters. Multiplying 80 by 24 tells us we have 1,920 characters per page; multiplying 1920 by 75 tells us each disk is capable of storing 144,000 characters, or bytes, or 140 kilobytes, which is indeed the standard storage capacity for a single-sided 5¼-inch floppy.

was subsequently lost or discarded. Given what we do know of Updike's methodical habits we might judge such scenarios unlikely, but the bibliographical reality is that in the absence of the digital media, which were themselves a distinct and sometimes primary site of composition for Updike, these uncertainties remain. The simple fact of the Wang's existence, in other words, means that in the absence of its accompanying storage media, there is an evidential limit to what we can know of Updike's manuscripts.[32] (And the true import of that observation is of course that the same holds for any other writer known to be working with a computer.)

The procedure for processing both the absent 5¼-inch Wang disks (should they ever be located) as well as the 3½-inch IBM disks is the same: extract what is known as a forensic or "physical" disk image from the original medium. A forensic disk image is a virtual surrogate of every single bit of information recorded on the actual disk in question; it is a perfect duplicate in so far as it bypasses the file system and other high-level data structures and simply treats the magnetic signals on the surface of the disk as one long string, or "bitstream," of ones and zeroes, regardless of whether they are associated with an intact file or not. Such bitstreams are routinely obtained from digital devices seized in the course of criminal investigations, and because they can be mathematically authenticated to approximately one-hundred times the accuracy of DNA they are legally admissible in a court of law.

The most basic way to examine a disk image involves a utility known as a hex viewer, which affords a window onto the raw bitstream. The data is presented in the geometry of its original physical storage on the medium. Even an untrained eye can use a hex viewer to read ASCII character data and thus explore certain kinds of files in that way. (This is useful if the appropriate software to open the files is lacking, or if the files themselves are no longer fully intact.) The trained eye is also able to discern file headers and other structural features for a variety of different data types. For a floppy-disk image, it is feasible to manually inspect the entire bitstream; for a hard-drive image, which will be larger by many

32. Some will want to know whether the magnetic recording media itself will have deteriorated and degraded beyond the point of any practical hope of data recovery. There is ongoing research in this area, sometimes referred to as "bit rot," but suffice to say that recoveries from floppies dating from the early 1980s remain commonplace, and if the diskettes have been kept in reasonable storage conditions there would be reason to be optimistic.

orders of magnitude, automated routines can extract text blocks as well as file headers and sensitive information such as dates, phone numbers, and social security numbers, even when these are stored in compressed formats. It is an open question whether such tools should be employed by the scholar in the reading room or by the archivist processing the collection, who can then either consult with the donor or otherwise arrive at reasonable determinations about what manner of sensitive information ought to be redacted before the data becomes accessible to patrons. This is no different in principle from the kind of appraisal, arrangement, and description that an archivist would undertake with an author's books and papers.

Exactly this kind of work is now underway at the Houghton.[33] Again I emphasize that we are dealing with a later portion of Updike's career; he had shifted to Windows-compatible machines by the early 1990s, and Wang itself filed for bankruptcy in 1992.[34] The material on the IBM disks consists of Updike's fiction, including the novels *Villages* (2004),

33. In May 2014 Porter Olsen and I visited the Houghton Library to instruct members of the staff in the use of the BitCurator environment, an open-source digital-forensics project whose development has been supported by the Andrew W. Mellon Foundation (http://www.bitcurator.net). BitCurator is being developed by the School of Information and Library Science at the University of North Carolina at Chapel Hill and the Maryland Institute for Technology in the Humanities at the University of Maryland, with Cal Lee as principal investigator and Matthew Kirschenbaum as co-principal investigator. It has two fundamental aims: the incorporation of digital-forensics tools into the workflow of archives/library ingest and collection management environments, and the provision of public access to born-digital collections material. Because BitCurator bundles together a number of existing forensic processing tools in a custom Ubuntu Linux distribution that can be run either through a dedicated hard drive partition or via virtualization software on a Windows or Macintosh host, it is becoming increasingly widely adopted in the library and archives community. During our site visit, we began by imaging a dozen of the Updike floppies using Guymager 0.7.3-2, which is bundled with BitCurator. Other analytics performed as part of the data capture included the generation of fiwalk metadata (including deleted files where present) for each disk, and a scan of the disk image for Personally Identifiable Information (PII). As of this writing, the Houghton intends to continue this processing sequence on the remaining diskettes as well as the CDs. The digital objects that are the disk images themselves await integration into a digital repository environment to manage and preserve them, as well as the establishment of protocols for researcher access.

34. Leslie Morris at the Houghton informs me she has seen an invoice for service of his Wangwriter II with "128K of [RAM] memory" dated 3 March 1989, suggesting that he was still using the machine at that time.

Terrorist (2006), and *The Widows of Eastwick* (2008), sequel to the more famous *Witches*; there are also short stories, poetry, essays, reviews, correspondence and, in at least one instance, apparently some family-related materials. The Houghton does not have any hard drives or actual computers; moreover, Updike never used email. The relatively modest scope of the digital materials and their self-contained nature on the diskettes thus makes them a good candidate for bibliographical investigation. Visual examination of the media is the first step, since there are things to be learned from the appearance of any material artifact, even a computer disk (see figs. 3a and 3b). Here again we glean something of Updike's habits, the density of written information evident on many of the labels presumably reflecting his desire to make full use of the actual storage capacity of each of the individual diskettes. The fact that Updike was in the habit of reusing his storage disks makes them particularly appealing for forensic examination since there is the promise of temporary or overwritten files to recover. (In general, the prospects for recovering "deleted" materials are a function of the amount of continued use the disk has seen. Moreover, while deleted files may be those actively discarded by their creator, they can also refer to temporary files created and cached automatically by a program such as word processor without the user's knowledge or intervention. These may thus reflect states of a document its author did not consciously intend to save.)

An obvious initial task is to reconcile the file listings we obtain through the forensic processing of the diskettes with the inscriptions on their labels along with the manuscripts and hard copy materials cataloged in the Houghton's finding aid for the collection. I have not produced a systematic collation study, nor can I claim anything on the order of a major literary discovery from amongst the born-digital materials I have seen. There is no "lost" manuscript or other *CSI*-like smoking gun to present at this time. But we have, I believe, established the utility of current tools and procedures for recovering electronic files from obsolescent media, that they are within the reach of scholars and archivists with some modest training in their proper use, and that the conditions exist for significant discoveries, whether or not among the digital files of Updike. It is vital that we come around to this way of thinking about electronic storage media and their relationship to our literary, historical, and bibliographical enterprise; while Gore Vidal once worried that word processing was "erasing" literature (an anxiety that surely now seems
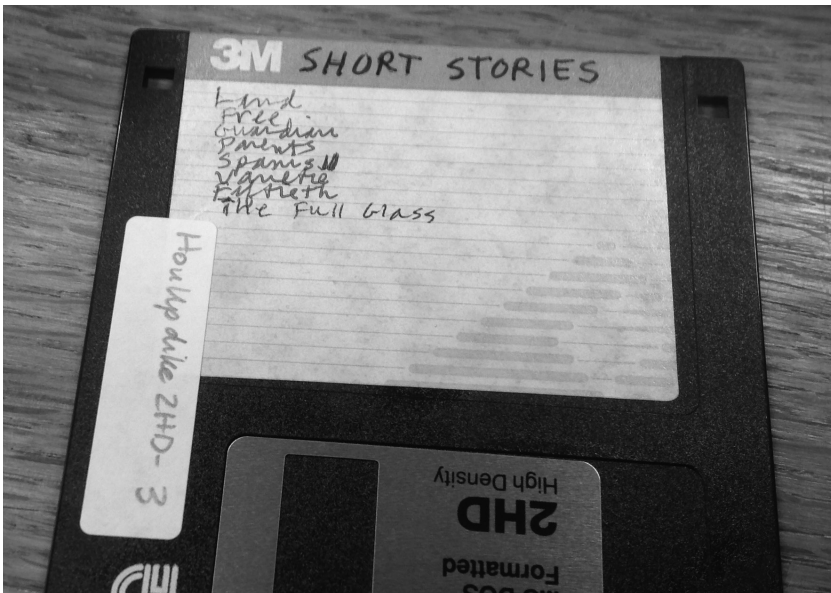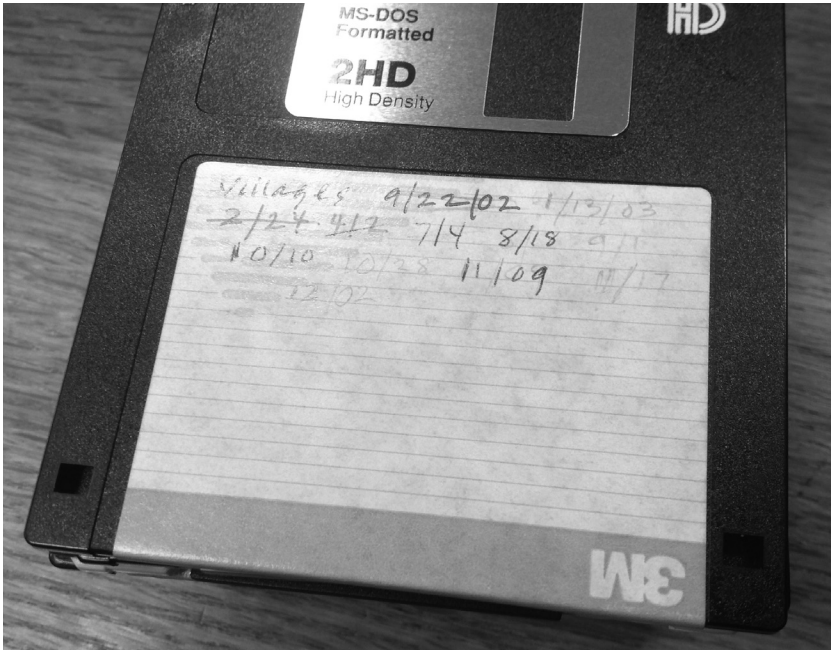
Figs. 3a and 3b: Two of Updike's 3½-inch disks from among the forty or so in the collection at the Houghton. Used with permission.

quaint), scholars and historians now fret that computing and word pro-
cessing are erasing or effacing their textual records at a very literal level.
But it is not true. Word processing and digital composition are undoubt-
edly changing the nature of texts and the textual record, but they are
technologies of inscription, nothing more and nothing less, and they
leave their own marks and traces—if one knows where and how to look.

One of the Updike floppies will serve as a demonstration of prin-
ciples: a high-density, IBM-formatted disk, meaning that it is capable
of storing 1.44 MB, or approximately a million-and-a-half characters,
roughly 30,000–40,000 pages of text depending on font size and other
variables. This makes the small, matte-black diskette a storage medi-
um of a different order of magnitude than we are used to confronting
when reckoning by print standards. We can see that the disk is labelled
"SHORT STORIES" by Updike, and the label lists eight items: "Land /
Free / Guardian / Parents / Spanisii [sic] / Varietie [sic] / Fiftieth / The
Full Glass" (the last title obviously written in a different ink). An ob-
server might also note that all but the last are single words that are eight
or less characters in length, in keeping with file-naming conventions
for earlier generations of DOS and Windows. "Varietie," for example,
is in fact the truncated title for "Varieties of Religious Experience," a
short story Updike published in *The Atlantic* in November 2002, and
"Spanisii" is shorthand for a story called "Spanish Prelude to a Second
Marriage" (presumably he had something like "Spanish II" or "Spanish
2nd" in mind—note also the suggestion of overwriting an original "h,"
which he might have first written reflexively, on the disk's label).

Imaging and processing this disk in the BitCurator environment
(see note 33) yields a great deal of additional information. All of the
files except "The Full Glass" were initially saved to this diskette on 23
September 2002 between 1:42 and 3:04 in the afternoon. Most com-
puter file systems include Modification-Access-Creation (MAC) times,
down to the second. These of course, can be tampered with, and they
may also be compromised by an incorrect system clock; moreover, the
interaction between MAC times and various operations such as open-
ing, copying, printing, or deleting a file is complex, and can sometimes
result in improbable permutations such as a modification time before a
creation time.[35] Given the compressed MAC times for most of the files

35. See Eoghan Casey, *Digital Evidence and Computer Crime*, 3rd ed. (Orlando,
FL: Academic Press, 2011), 525. Even more complex behaviors are possible, such as

on Updike's disk (within a couple of hours of each other) we can surmise that it was likely used as a backup, presumably for the now-absent hard drive. In other words, in the middle of a September afternoon at Beverly Farms, our author decided to do some housekeeping, moving copies of recently written stories from his hard drive onto a removable disk for safekeeping, and diligently labelling it in the process.

Still, even this is mere conjecture. The only way to effectively analyze and process digital data is by adding more data to it, what we nowadays call metadata, which is really just "information about information," as the phrase goes. Moreover, the analysis is itself often automated and algorithmic; indeed it must be, given the volume and scale of the data involved (a modern hard drive stores the equivalent of several Libraries of Congress worth of text). For this task we can use a software utility known as fiwalk ("file and inode walk"), which analyzes the contents of a disk image and produces a report expressed in DFXML, or Digital Forensics eXtensible Markup Language. In a normal archival workflow, such a fiwalk report would be generated from the disk image as a routine part of its initial acquisition from the source medium, and would become part of the record of that digital asset. This fundamentally descriptive act precedes any form of analysis (data carving, hex viewing) that an archivist or patron might undertake on the disk image itself; or rather, again, the distinction simply becomes difficult or irrelevant to maintain because practically speaking we are working with both data and metadata, shuttling back and forth between the bitstream and its second-order representations in the form of tags, filters, and the output of search strings. Thus the recursive nature of computation—data operating on more data, turtles all the way down—functions symbiotically between analytical and descriptive operations.

All of the files except "The Full Glass" also carry a SAM extension, telling us they were written with Lotus Ami Pro, the Windows-based word processor Updike favored after moving on from the Wang. One of these, SPANISII.SAM, he reopened and modified in some way in

a phenomenon Casey terms "time tunneling" in which a recently deleted file has its entry in the file system appropriated by a freshly created one, the new file thereby inheriting the MAC listings of its predecessor. I linger over these details in order to demonstrate the extreme intricacy of interactions that are possible, the need for expert knowledge, and the capacity of digital media and their file systems to yield situations as nuanced and vertiginous as those we encounter with physical book and manuscript materials.

January of 2003—we know this because there is an entry for a deleted file (as denoted by the underscore character) whose MAC time is within the original September range, but also a new entry for the same file (not deleted) with the January 2003 date. We can also see that the two files are close but not equivalent in size; more significantly, their MD5 values, which are their unique electronic signatures, do not match, thus indicating that there is at least one byte of difference between them (see fig. 4). Could we open the files to have a look? We could if we had a copy of Lotus Ami Pro installed on an actual or virtualized Windows system. Additionally, we can view both files in a hex editor, and while we find legible text in the up-to-date version, the original _PANISII.SAM now yields only junk data and may be irreversibly corrupted.

   "The Full Glass" represents the most fully intact digital artifact on the disk. It is in fact Updike's last published short story, appearing in the 26 May 2008 issue of *The New Yorker*. First, unlike the other files, it is saved in the familiar Microsoft Word DOC format. There appear to be three instantiations of it on the medium: what I will call the primary file (THE FULL GLASS.doc); a deleted temporary version of the primary that is the same size and with identical MAC times but a different MD5 value (_WRD1238.tmp); and finally, a seemingly deleted instance of the primary much smaller in size: (_THE FULL GLASS. doc). This last is actually what is known as a "resource fork"; it contains metadata about the file, its presence here indicating that the primary was at one point stored on an Apple Macintosh computer where such resource forks are generated. There is also a fourth artifact associated with these first three (._.Trashes) that likewise bears the traces of an Apple system. This particular instance of THE FULL GLASS.doc thus either originated on or was copied to and from a Macintosh system, a computer type I have found no mention of Updike ever owning or using.[36] Moreover, the MAC times (not to be confused with Macintosh) are similarly provocative: both the primary file and its temporary version appear to have been first created in October 2003, even though it wasn't submitted

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36. Sampling other diskettes at the Houghton also sometimes reveals traces of the Macintosh file system, suggesting that either Updike or someone else who was close to his workflow used such a machine fairly regularly, even if it was not Updike's preferred writing computer. Is this perhaps the "old" computer that takes "old" disks and turns them into "final printed versions," as narrated in the poem "Death of a Computer"? It may be tempting to think so, but based on the available evidence we cannot know.

Partition	Filename	Extension	Filesize	File format	Change time	Access time	Create time	Modification time	MD5 Hash	SHA1 Hash
1	SPANISII.SAM	SAM	42730	ASCII English text, with	None	None	None	2003-01-04T19:06:50	df15cabf9!	3e313ce343440997b!
1	LAND.SAM	SAM	37892	ASCII English text, with	None	None	None	2002-09-23T14:47:52	934ad50cf	210cf7f66e9e6fea2ee
1	GUARDIAN.SAM	SAM	32074	ASCII English text, with	None	None	None	2002-09-23T14:50:18	630d0bfb3	cc8475b5bf98646d0
1	FREE.SAM	SAM	36291	ASCII English text, with	None	None	None	2002-09-23T14:50:48	5bf997ec4	ef77d3bc78f1a9b90
1	PARENTS.SAM	SAM	47855	ASCII English text, with	None	None	None	2002-09-23T14:52:12	f52416649	926b9ca796568e793!
1	FIFTIETH.SAM	SAM	45983	ASCII English text, with	None	None	None	2002-09-23T14:54:52	3205942bz	4968e4888fb6d686c
1	_PANISII.SAM	SAM	42751	data	None	None	None	2002-09-23T15:01:42	5db9025b!	9f3e3f1a7c97fb7630a
1	VARIETIE.SAM	SAM	89653	ASCII English text, with	None	None	None	2002-09-23T15:04:04	ba7b735a!	080a0bafae947bb9d!
1	_WRD1238.tmp	tmp	79872	Composite Document F	None	2003-10-14T04:00:00	2003-10-14T05:04:50	2003-10-14T05:04:50	dd08330af	8296d45e3b9a97638
1	THE FULL GLASS.doc	doc	79872	Composite Document F	None	2008-05-05T04:00:00	2003-10-14T05:04:50	2003-10-14T05:04:50	6918e06f9	83ca65ca9a4fded72b
1	._Trashes	Trashes	4096	AppleDouble encoded I	None	2008-05-05T04:00:00	2008-05-05T15:33:44	2008-05-05T15:33:44	5ecad39c4	36dfed64b95c28cf63
1	._THE FULL GLASS.doc	doc	82	AppleDouble encoded I	None	2008-05-05T04:00:00	2008-05-05T15:34:36	2008-05-05T15:34:36	2276d0c53	8bb9867b4cf372abf8

Fig. 4: BitCurator's fiwalk output showing details of the contents of one of Updike's diskettes.

to *The New Yorker* until early 2008.[37] This would appear to represent a departure from his usual practice, as Updike wasn't given to sitting on material for extended periods.

We can open the primary file in any copy of Word today. Doing so is a curious experience: bracketing incidental variations such as screen resolution, we see the file just as Updike would have; moreover, there is a real sense, extending to the legalistic realm of evidence and courtroom admissibility, in which what we are witnessing is not a derivative or a copy of the file, but an original instance of it—an original multiple if you will. What we see is clearly not the "same" file from a material standpoint since its constituent bits are physically recorded on an entirely different medium, and yet there is not only no appreciable difference between this file and Updike's, there is no legal or computational difference. The net effect is one of both frisson and dissonance (see fig. 5). Doug Reside meditates on the paradoxical nature of digital "manuscripts" and notions of rarity tied to a print-based world in a recent issue of *RBM Journal*, concluding that notions of what constitutes a manuscript in a digital context may have more to do with whether or not a third party has intervened to make changes in a given instance of the file once it has left the desktop of the author.[38]

Scrolling through the document on our own screen, we quickly find that Updike used THE FULL GLASS.doc as a kind of container or repository for additional material associated with the development and

37. While the 2003 composition of the story may not be a first-time critical discovery, it nonetheless does not appear to be something widely known. In the first venue in which it was collected after its publication in *The New Yorker*, i.e. *Tears of My Father* (2009), it is the final offering in a volume whose front matter notes that the stories were "composed in the twenty-first century, in the order they have here." Nor is there any mention of 2003 in Christopher Carduff's notes in the Library of America edition of Updike's *Later Stories* (2013). Yet evidence for first composition in 2003 extends beyond the MAC times in the digital files: perhaps most strikingly, the opening line describing the narrator "approaching eighty" (as Updike himself was in 2008) initially read approaching "seventy five" in the hard copy at the Houghton (as Updike would have been in 2003); meanwhile, on a piece of yellow legal paper interleaved with the manuscript, there is a jotted citation, "A. N. Wilson, Paul (came out five years ago)." The reference is to A. N. Wilson's *Paul: The Mind of the Apostle*, published 1998. The digital materials thus corroborate and reinforce evidence ascertainable from the hard copy.

38. See Doug Reside, "File Not Found: Rarity in an Age of Digital Plenty," *RBM: A Journal of Books, Manuscripts, and Cultural Heritage* 15, no. 1 (2014): 68–74.
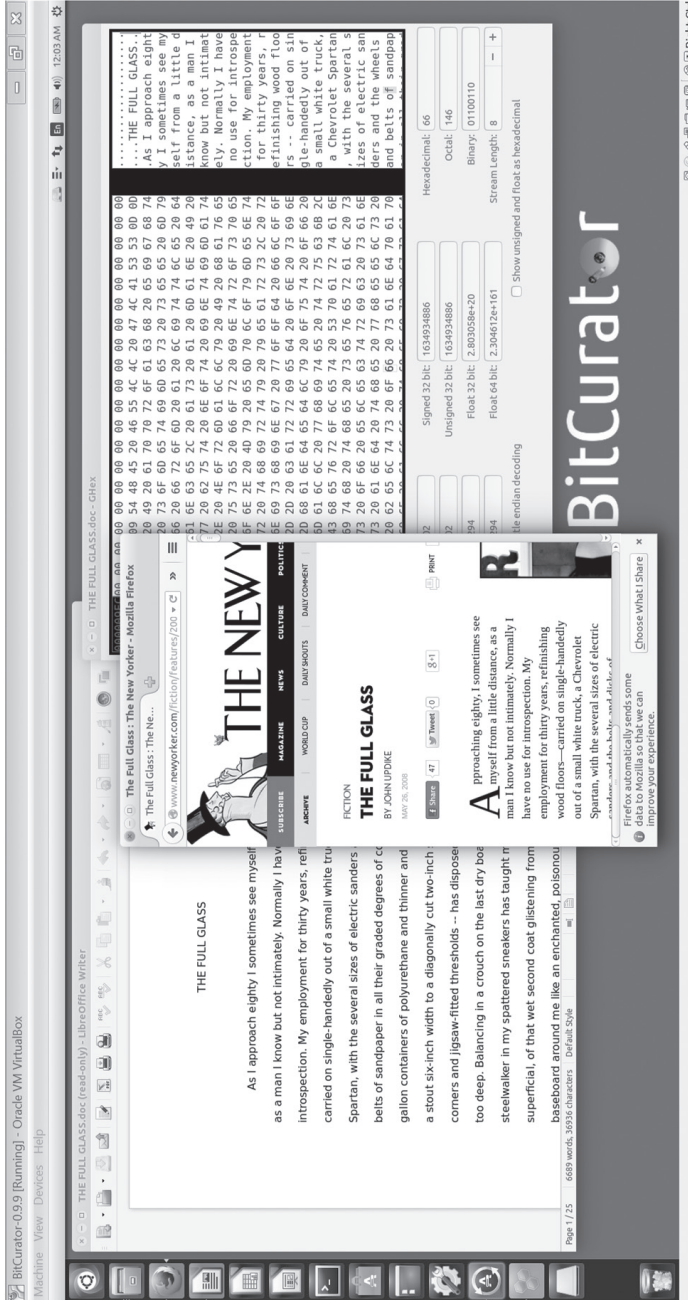
Fig. 5: Screenshot of THE FULL GLASS.doc open on the author's desktop in the BitCurator environment alongside the story as it is currently available in *The New Yorker* on the web, and a hex view of the original file. Note the variant in the first line.

composition of the story, including several pages of prose excised or heavily revised from the final version (this is also available in hard copy at the Houghton) as well as two cover letters to Roger Angell at *The New Yorker* (see fig. 6). Updike, in other words, composed the letters in the file after the text of the story; when he went to print the file, the letter would be there at the bottom of the pile ready to be signed and placed on top when the whole was put into the post (remember, he did not use email, let alone send attachments). These letters, each under a page, are *not* included in the manuscript material at the Houghton, at least not in the portion of the collection currently available to researchers. The first of these, dated 2 January 2007 [sic], corresponds to a handwritten date on the typescript at the Houghton, with the exception of the obviously in-correct year (Updike, like many of us, was not above making that annual mistake). This letter's two main points of interest are a mention of him having first begun the story after Henry Finder (another editor at *The New Yorker*) had recommended Brian O'Nolan's *At Swim-Two-Birds* to him, followed by some comments about Junot Díaz's short story "Alma," published in *The New Yorker's* 26 December 2007 fiction issue. (Unfortunately we have no way of knowing when Finder might have commended O'Nolan to Updike, so we cannot corroborate that refer-ence further.) The second letter, dated 21 April 2008, describes Updike having taken the manuscript of "The Full Glass" with him to Arizona, where he "went through it in a reckless summary mood, cutting the of-fensive sexy bits in the middle and adding whatever occurred to me, under the general topic of getting on in years." (Those "sexy bits" are pre-served in the portion of the extraneous material still present in the same file.) Some two weeks later, on 5 May 2008, this file was printed from a Macintosh, yielding the final hard copy that is collected at the Hough-ton, which itself manifests a handful of further autograph revisions. The digital file THE FULL GLASS.doc thus represents the actual fair copy of the manuscript, incorporating as it does all but one of these autograph revisions which (we know from the MAC times) were incorporated later that same day. (Some additional changes, including one to the opening line, were made in the galleys, not unusual for Updike.)
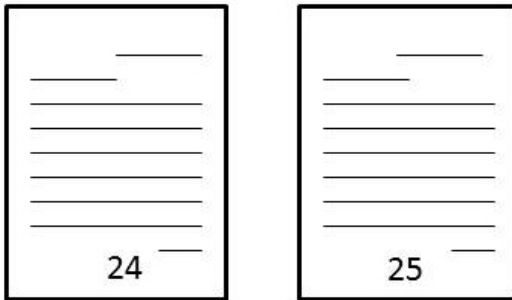
   It would seem, then, that the example of THE FULL GLASS.doc gives us cause to be optimistic: we have learned some additional things about the composition and transmission of its text based on a foren-sic examination of the digital files in conjunction with the traditional
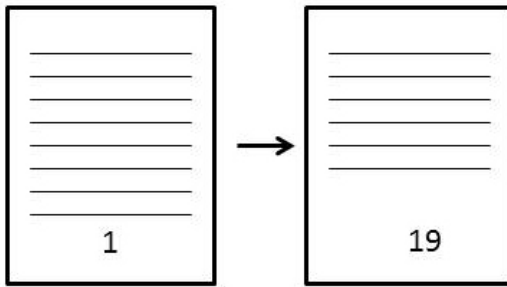
Fair copy of text, pages 1-19
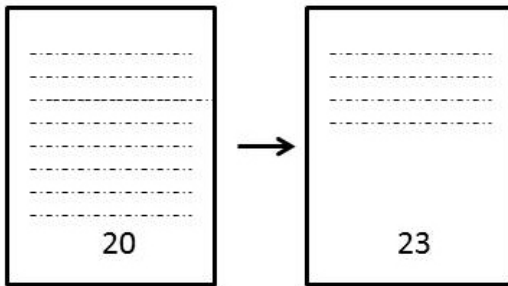
Extraneous material, pages 20-23

January 2
letter to Angell

April 25
letter to Angell

Fig. 6: Author's schematic illustration showing the internal arrangement of the 25 pages of content in THE FULL GLASS.doc file.

manuscript materials at the Houghton. Yet we are also frustrated by what we do not know: seemingly anecdotal details about Updike's own computing habits (did he have a Mac or not? If not, who did?), access to his absent hard drives (which would yield exponentially greater amounts of data), and so on. But these are the historian's gaps, not those of the technician. They do not, in other words, speak to the lack of material evidence in Updike's digital files but rather to the need to recognize new kinds of knowledge that must be collected and recorded in order to leverage that material evidence. Put slightly differently, born-digital materials ask us to rethink the nature of evidence in the bibliographical enterprise. Not because the evidence is now merely "virtual" or "immaterial," but because the storage medium will always inscribe exactly the material traces the programmed logic of the operating systems asks of it, and no more and no less. Computational storage media in fact present an extreme instance of what Fredson Bowers once termed "the postulate of normality." This is the assumption that bibliographical features should always be assumed to be explainable through the normative mechanical operations of presswork alone, unless and until there is "overwhelming evidence" to the contrary—the intrusion of some meddlesome external agent or idiosyncratic circumstance. Without such a postulate, Bowers insists, "no laws of bibliographical evidence could exist, for the unknown human equation could successfully 'explain' any abnormality observed."[39] Of course it is just such idealized "printers of the mind" that McKenzie took aim at; yet the complex and sometimes opaque but ultimately procedurally knowable routines of digital computation suggest that it is in fact the persistence of a naïve belief in inexplicable, irreconcilable computational phenomena that gives rise to an operating system that is wholly "of the mind," whereas it is the routinized, regularized, and predictable—that is, the normal—behaviors of programs that allow us to apprehend the operating system actually at hand. In other words, it is precisely the material specificity of digital computation that ensures the artificial existence of a formalized setting in which Bowers's postulate is helpful and not a hindrance to the study of the sociology of born-digital texts. But it is at the threshold *between* the formally idealized internal environment of the digital computer and the messy, external human lifeworld of the people who use them where the bibliographer must initiate his or her investigations.

39. Fredson Bowers, *Bibliography and Textual Criticism* (Oxford: Clarendon Press, 1964), 65.

David Greetham has usefully probed similar distinctions between internal and external bibliographical evidence, that is, evidence observed in the manuscript or codex versus evidence derived from the historical and documentary archive that surrounds it.[40] A bibliographer such as McKenzie turned to the archive to contextualize the text, whereas a bibliographer such as Randall McLeod literally inverts the book to ward away the pernicious influence of the ever-accumulating archive. Computers, or more precisely computational storage media functionally—materially—collapse such a distinction in at least one key respect. Because computers not only serve to produce text (like a typewriter or pen) but also register and record it, they embed the archive within the instrument of its own composition while also dispersing storage across multiple supports, ranging from various kinds of magnetic or optical media (often more than one in the same system) as well as hard copy output on paper.[41] Indeed, it was the convention of many early computer systems, including Wang, to refer to disk storage as specifically an "archive."

While it is true that bibliographical history teaches us that books also embed their own archive—sometimes in truly spectacular fashion, as an example such as the Archimedes Palimpsest reveals—I would maintain that there are qualitative differences when we speak of computational media, and indeed fidelity to material truths demands that we acknowledge, not suppress, those qualitative differences. The principle of storing data in the same medium and format as the instructions that operate

40. See David C. Greetham, "Textual Forensics," *PMLA* 111, no. 1 (1996): 32–51.

41. Typewriter ribbons can sometimes create narrow but startling liminal cases. In 2010, Updike's Olivetti 65c electric was auctioned at Christies. It was purchased by collector Steve Soboroff, who kindly sent me photocopies of the ribbon which indisputably dates from early 1983, as its various textual remainders, such as an introduction Updike was then writing to a collection of Kafka's short stories, testify. Included on it are also these three snippets: "This ms. may be the last messy one you get I've bought a word processor and we're slowly coming to an understanding. It's quick as the devil, but has very little imagination, and no smalltalk." That was addressed "to Roger [Angell, his editor at *The New Yorker*]" and dated 12 March—the day before the date on the typescript of "INVALID.KEYSTROKE" at the Houghton. Next: "I'm having a mechanical crisis; this is an electric typewriter, I have a manual, and also a word processor, and in going back and forth between them I keep hitting wrong keys, mostly the return button here which sends the carriage flying. Back to goose quill perhaps." That one was to "Susan," 19 April. And finally, addressed to his typist, one "Tiny," on 23 May 1983: "Why don't you charge me $1.25 per page? I have a word processor now and won't be needing too much more typing." That's very nearly the last thing we can read on the ribbon.

on it is a bedrock principle of computer architecture, formally instanti-
ated in the so-called Von Neumann model that has dominated computer
systems design throughout the second half of the twentieth century. (As
John Von Neumann himself was wont to put it, it was all the same "or-
gan.") So, when we speak of the way in which computers, as writing
instruments, operationalize both data-creation functions and their stor-
age, we are acknowledging the material specificity of them as humanly
engineered artifacts. From a bibliographical standpoint, we see what we
might think of as manuscripts and multiples hopelessly intertwined; as
many observers have pointed out, there is a very real sense in which there
is no such thing as an original when it comes to digital media since each
and every time a file is accessed it is in fact duplicated deep in the ma-
chinery of the operating system. Every act of computation is in fact an
act of multiplication.

III.

Adam Begley describes the Houghton's Updike holdings as "a vast
paper trail, possibly the last of its kind."[42] What's more, for all his varied
interests, we don't generally think of Updike—not a writer of science
fiction or techno-thrillers after all—as an author whose literary beat af-
fords him any special purchase with regard to technology.[43] Indeed, he
had a reputation for being something of a Luddite, as cemented by his
2006 exhortation to the booksellers of America to "defend your lonely

42. Begley, *Updike*, Kindle Loc. 99.
43. In fact Updike produced his share of writing about computers over the course
of his career. There is *Roger's Version* (1986), a novel that explores the nature of
computation through the device of a theologian's search for an algorithmic equa-
tion for God. On the strength of that book he received an invitation to keynote
an MIT computer-science conference two years later, which resulted in an essay,
"A Writer's View of the Computer Laboratory." His 2004 novel *Villages* features a
protagonist who develops "DigitEyes," a digital drawing tool. Besides "INVALID.
KEYSTROKE" he has also written the poems "Death of a Computer" (2004, pub-
lished 2009; unlike "INVALID," it was initially composed longhand); and "Birth-
day Shopping" (2007), about browsing a big-box retailer for a new one. Meanwhile,
in 1997, when such exercises were still very much a novelty, he participated in a
writing experiment for Amazon.com in which he supplied the beginning and end-
ing of a short story completed—via the internet—by others in the middle. The
stunt was widely covered in the popular media, and Updike wrote about it himself
in "A Writer at Large" in *The New Yorker*, 29 September 1997, 31–32. (The piece was
subtitled "Naked came the stranger to a mystery plot in cyberspace.")

forts," those few remaining outposts of gravitas and contemplation amid the "anthills" of electronic media.[44]

Nonetheless, in the midst of his literary career, indeed at its very height, he acquired and began using a word processor. It was in fact an object of some fascination to him, as it has been for other writers as well (besides Stephen King, one thinks of John Barth or Richard Powers). Moreover, the computer co-existed with, but did not replace, his other writing instruments. As a consequence, in Updike's papers we encounter texts in at least three basic states: manuscript (either longhand or true typescript); hard copy documents printed from digital files, "manuscripts" that must be understood as surrogates derived from a frequently absent original that itself may exist in multiple states; and actual digital files, whose processing will allow them to eventually join the full collection through integrated finding aids and the like. This composite textual landscape *will be the default* for most writers working today, and indeed it has been for several decades already. John B. Thompson has recounted the manner in which every published trade "book" is now first and foremost a network of digital assets and artifacts, and only secondarily, and in derivative fashion, a printed object (which is just one among several channels for its dissemination).[45] The example of Updike's papers and the associated born-digital files thus offers a case of stark simplicity compared to what we might encounter with an even more contemporary author, especially a best-selling brand name like King, whose printed books are merely one component of a vast transmedia franchise.

If we desire bibliography, as a set of articulated practices, to remain relevant to the study of authorship, publishing, and books, then the tools and methods I have been describing (or others very much like them) will have to become part of what bibliographers know and know how to do. A scholar working with born-digital materials must needs be conversant in the antiquarian cants of vanished operating systems, file systems, file formats, and data structures, as well as tools like hex viewers and emulators, just as we expect an early modernist doing book history to know something of formats, signatures, and collation formulæ. Patrons in the reading room with a hex viewer open on their laptops are doing nothing different in principle from those who set up a portable collator: they

44. "The End of Authorship," *The New York Times*, 25 June 2006.

45. See John B. Thompson, *Merchants of Culture: The Publishing Business in the Twenty-First Century*, 2nd ed. (New York: Plume, 2012), 355–7.

are both ways of seeing. And the strange but ineluctably material world of digital storage once again instructs us that bibliography itself is not bound to particular media, methods, and tools: it is instead a habit of mind, one we consciously adopt so as to avoid conjuring the mind's own printers—and now too, operating systems of the mind.[46]