The perspective of print

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Abstract (Document Summary)

Ever since film, television, computer graphics, and virtual reality have made pictures move at ever faster rates, media theories have exhibited puzzling outbursts of delight. Writing in general and books in particular are said to be obsolete, while the image, more powerful and unifying than ever, is poised to reclaim its old rights. Kittler challenges this enthusiasm and the diagnosis it is based on with the counterargument that the book is not simply at the end of its tether.

Full Text (5891 words)

Ever since film, television, computer graphics, and virtual reality have made pictures move at ever faster rates, media theories have exhibited puzzling outbursts of delight. Writing in general and books in particular are said to be obsolete, while the image, more powerful and unifying than ever, is poised to reclaim its old rights. I would like to challenge this enthusiasm and the diagnosis it is based on with the counterargument that the book is not simply at the end of its tether. Rather, it was a singular medium that had the power to facilitate its own technological supersession; and that particular power (and the source of much of Europe's political power) was not derived from its printed words alone, but from a technologically sophisticated media link that joined these words to printed images.

Media theorists-that is, Marshall McLuhan and, in his wake, Vilem Flusser-made an absolute distinction between writing and pictures which, ultimately, was expressed in geometric terms: the one-dimensionality of printed books stood in clear contrast to the irreducible two-dimensionality of pictures. In final, simplified analysis this may be true, especially given that today's computerized text can be modeled as strings. But it elides a simple fact that was emphasized, not coincidentally, by Michel Butor, a nouveau romancier: the most widely used books-from the Bible to the telephone directory-are not read in a linear fashion at all. And with good reason: ever since Gutenberg, printed lines are as linear as book pages, since the age of twelfth-century scholastics, have been two-dimensional.1 All paragraphs, sections, footnotes, and headings are placed on a surface whose two-dimensionality is in no way distinct from that of pictures. As well-as Michael Giesecke has emphasized time and again-the fact that Gutenberg's movable types were designed not with mass production in mind, but in order to compete with the calligraphic elegance of handcrafted manuscript pages, further testifies to the pictorial origin of the printing press (which was, after all, nothing but a sobered-up winepress).2

While still residing in Strasbourg, and prior to his move to Mainz where he embarked on reproducing Bibles and calendars, Johann Gutenberg had been busy reproducing pictures of saints. Nonetheless, the geometry of the letters of Mainz was different from that of the icons of Strasbourg. As Sigmund Freud pointed out, "letters of the alphabet"-as opposed to faces-"do not occur in nature."3 Since everything depended on putting individual letters in their place, Gutenberg's print technology required a spatial geometry. Each lead letter was located in relation to its neighbor to the right, left, top, and bottom; in other words, each letter filled an empty space that was already waiting for it. Thus the typographic standardization of writing merely continued the standardization of numerals brought about by the medieval import of the Indo-Arabic place-value system. Zero-a sign wholly unknown to the Greeks and Romans-had referred all other numerals to their spaces, just as did the space that Gutenberg turned into lead and Mallarme into poetry.4 It was not until the possibility existed to replace the empty space by any letter that the inner ability to write was transformed into the materiality of the letter case. Writing in the age of its technological reproducibility is a combinatorics of standardized elements or characters, just as the old Greek vowel alphabet had been a combinatorics of a finite number of elements or letters.

The Greek stocheia or letters did not give birth only to the four elements of antiquity or the one hundred and twenty chemical elements of today: Elements was also the name of a book that for more than two millennia taught Greeks, Arabs, and Europeans the axioms of geometry. The current enthusiastic scholarly rediscovery of images, bodies, and natures tends to forget that elements exist only in sets-that is, in code systems-which is why Euclid's Elements became a very different book once it entered the Gutenberg galaxy in 1482. It was Regiomontanus himself, who had imported the new Arabic trigonometry to Europe and, in particular, to Albrecht Durer's home town of Nurnberg, who assisted in subjecting Euclid's rediscovered manuscript to the geometry of print. Ever since 1482 every axiom that defines point, line, or plane in writing has been accompanied by a typographic definition: the point appears as a point, the line as a line, and so on, until mathematics (to use Sybille Kramer's term) has become a "typographic" event.5 And once the points at either end of such a printed line are marked with letters that recur in the accompanying text, the geometric figure has obtained a name with which it and all its parts can be addressed. This may seem pretty evident to us whenever we look at technical or mathematical illustrations, but that is not at all the case. "How greatly this page here resembles a thousand other pages, / and how hard it is to be flabbergasted at that!" Hans Magnus Enzensberger begins his poem in praise of Johann Gensfleisch zu Gutenberg.6 The very same applies to Regiomontanus, his printer Ratolf, and scientific visualization in general. What counts today in the slow transition from European history to computer-aided posthistoire is neither mass movements nor gods of battle, but minor insignificant games of the signifier that (in Lacan's words) are shaking the moorings of our being.

None of Gutenberg's contemporaries understood the mathematization at the base of printing faster than Leon Battista Alberti, the noble Florentine architect, painter, and mathematician.7 Alberti himself tells the story of how one fine day in 1462 or 1463 he was strolling through the Vatican gardens accompanied by one Dato, who, as his name already indicates, worked as a papal cipher secretary. As is well known, all modern diplomacy evolved from the secret secretariats and chancelleries of the Roman curia and the Venetian Signoria. Alberti, however, was talking about the exact opposite of cryptography: in passing, he mentioned that the man from Mainz had once again copied, and thus presumably saved from oblivion, another irreplaceable antique manuscript. This must have prompted the papal cryptographer's response that, unfortunately, his wearisome task of replacing one letter after the other with another letter could unfortunately not be mechanized that easily. Whereupon Alberti took pen in hand and produced a treatise that was to become the basis of modern cryptography.
Antique cryptography, developed by Julius Caesar and adopted by Augustus, had been a

simple game with the Latin vowel alphabet: the two Caesars simply moved each letter one or more places down the alphabet so that A turned into B, B into C, C into D, and so on. The great Augustus, however, never grasped that his letter game was a modular arithmetic: X, the last letter of his alphabet, did not turn back into A but into an exceptional AA.8 Such primitive keys-which were still in operation in his lifetime-posed no difficulty for Alberti; he merely counted how often individual letters occurred in the Latin or Italian cleartexts, and then compared the result to the letter-- frequency in the cryptogram. In other words: Alberti simply transferred into cryptanalysis the elementary principle of Gutenberg's letter case, which was itself already a letter-frequency analysis since it had to provide more lead types for frequent letters than for rare ones.

Alberti approached cryptography or encipherment in the same way. To surpass the simplicity of the Caesarian code, he constructed a cipher disk made up of two concentric rings. The circumference of each ring was divided into twenty-four parts or cells, each of which contained a letter, so that moving the outer ring changed the correspondence between the two alphabets. The encipherer had only to copy one correspondence before moving the outer disk one place further. The painstaking craft of Dato and his colleagues had become a mechanics of movable letters in the strictly Gutenbergian sense of the word. Thus Alberti lived up fully to his Roman conversation: with a letter-frequency analysis for deciphering and a polyalphabetic code for enciphering, he presented Europe with the principle, or the power, of its strategic secrets. Around 1570, Giorgio Vasari's summary of Alberti's life in his Artists of the Renaissance already drew a parallel between Gutenberg and Alberti-though, significantly enough, between not print and cryptography, but print and perspective. Vasari claimed that in "1457, the year when Johann Gutenberg discovered his very useful method for printing books, Alberti similarly discovered a way of tracing natural perspectives and effecting the diminution of figures, as well as a method of reproducing small objects on a large scale: these were very ingenious and fascinating discoveries, of great value for the purposes of art."9 Vasari's postdating of Gutenberg's invention by ten years obviously grew from early modern chauvinism: if Germany had presented such a useful art to the world, then Italy "similarly" would have had to do so in the very same year. The artisan-engineers of both countries had drawn even, though it remains unclear what kind of instrument Vasari's badly informed account was referring to. Following another Alberti biographer, researchers believe that the device for diminishing and enlarging images was in fact a camera obscura: "By way of painting," this anonymous biographer wrote, "Alberti produced many unbelievable things which could be perceived by looking through the narrow opening in a small box. High mountains were to be seen and wide landscapes surrounding the immeasurable sea, and things that were so far removed from the eye that they could not be distinguished. These things he called demonstrations, and they were made in such a way that the experienced as well as the unskilled believed that they were looking at actual phenomena rather than at paintings."10 Provided that the anonymous biographer is more trustworthy than Vasari, it appears that Alberti's demonstrations enlarged what was at a distance and reduced what was close, following a projection technology that channels natural phenomena through the narrow opening of a camera obscura. Alberti had replaced painting as a craft-which it remained at least until the invention of photography-with an optical media technology. By implementing the perspectival geometry of our vision with the help of a diaphragm and projection screen, the camera obscura generated reproductions that were as free from mistakes as Gutenberg's printed books. This, it seems, is the crux of Vasari's Italo-German heroic epic.

The clerics witnessing the printing of the first edition of the 1485 Regensburg missal marveled at it as a "divine work of God": after comparing all the copies of the missal with the composition pattern, they concluded that "the letters, syllables, words, sentences, periods, paragraphs and all other aspects of the printed copies corresponded exactly to the original in our church .... Praised be the Lord."11 The "experienced and unskilled" who peered into Albert's camera obscura must have been equally happy and impressed by the way in which it reflected natural phenomena rather than paintings. Two contemporaneous technologies had taken on the task of eliminating the human hand as a source of noise and pollution from texts and pictures. At one and the same historical moment, books and paintings entered the age of their technological-that is to say, noisefree-reproduction.

In light of all this it comes as no surprise that the two reproduc tion technologies were to merge into one. The one geometry expounded in Euclid's incunabulum came to provide the elements for the production of texts and images; and it was none other than Alberti who initiated this integration. In 1435, less than ten years prior to Gutenberg's first printed Bible, Alberti wrote his Treatise on Painting (though it was not be printed until 1540). Not only did it turn a form of knowledge that hitherto had been passed on orally from masters to apprentices into a theory that could be acquired autodidactically, it was also the first presentation on paper of the silent technique of perspective.

The first of Alberti's three books on painting took off where the 1482 edition of Euclid was supposed to continue: with the geometric definition of point, line, and plane. Alberti, however, used Greek mathematics toward an end that had been wholly alien to antiquity: for the construction of pictures. The three dimensions are merely defined in order to introduce the fourth dimension-that is to say, the space of buildings and natural phenomena. Alberti's treatise teaches the painter to achieve with crayon and ruler precisely that which his camera obscura was able to do on its own. Right angles become obtuse, identical distances become different, and parallel lines turn into bundles of rays emanating from an infinitely distant vanishing point, until the completed painting has transformed all three spatial dimensions into their perspectival appearance. Half a millennium before Macintosh and Windows 95, the painting assumes the logical position of a window onto which the world graphically projects itself. And because Alberti (as if to conjure up a canvas) depicts this window as a semitransparent veil woven from a multitude of crisscrossing canvas threads, each detail of the world finds its own little square that belongs to it alone. As was the case with Gutenberg, a grid of right angles refers all data back to place values, which is why the comparison with today's desktop operating systems is not farfetched. The pixels on our computer monitors differ from television images in that they can be fully addressed as a two-dimensional matrix. Precisely for this reason it is possible to convert the monitor to text mode, which just like typography is based on place value. Thus, Alberti's theory of perspective not only turned art into writing, it also turned visual space into paper.

But all this labor of windows and veils, projection planes and vertical projection, obscured the sad fact that Alberti could not calculate his perspectival paintings. Just as in the case of the camera obscura, technical processes replaced calculations. For, according to Alberti's innocuous explanation, one could not expect painters to deal with a mathematics that transformed right angles into obtuse ones and integral ratios into irrational ones. But this kind of mathematics was about to evolve, as Regiomontanus imported the knowledge of Arab trigonometrists (though not their passion for the camera obscura) to Europe. It was precisely this type of mathematics that Alberti may have gotten to know when he met Regiomontanus in Rimini. Unfortunately, we will never know what the artisan-engineers talked about.

Linear perspective was nonetheless able to transfer visibilities onto paper, even without the modern trick of paper to solve equations. The question was, however, which visibilities were compatible with (to quote a famous Mirer title) compass and ruler. The fractal complexities of woods and trees were obviously not, simply because a geometry devoid of right angles cannot be transformed into an affine geometry of obtuse angles. In other words: the very visibilities with which linear perspective began its modern triumphant progress had to be constructions themselves. As we all know, ever since Egyptian and Babylonian times Europe has been

cherishing right angles.
Not coincidentally, Alberti dedicated his treatise to an architect who in 1420 had introduced the first perspectival painting to the amazed Florentines. As the subject of his painting Filippo Brunelleschi chose an edifice the doors of which he had designed himself: the Florentine Baptistery. Thus linear perspective began as an architectural drawing, as the affine, two-dimensional representation of a three-dimensional octagon. The fact that Brunelleschi's painting also contained clouds and other fractals does not contradict this in the least: for, unlike the Baptistery, Brunelleschi did not paint the sky, but left it as an empty background and inserted a mirror instead. In the eye of the observer assuming his preassigned place in the center of Florence, wandering clouds and solid stones, mirror reflection and painted illusion, merged into a virtual reality.
In other words, linear perspective as a technological construction had the goal of reproducing technological constructions. In strict accordance with McLuhan, the content of a medium is never nature but always another medium. Just as Gutenberg's printing press technologized handwriting, so did Brunelleschi's linear perspective technologize architecture. Hence it comes as no surprise that print and perspective entered a feedback loop. Not only did churches and baptisteries find their way into print and pictures, but so did the technical diapositives that enabled perspective paintings in the first place. The camera obscura that Alberti, if not Brunelleschi, had first used to reproduce what could be seen, could itself be reproduced in perspectival manner. As woodcuts or copper engravings, whose lines (like Euclid's geometric constructions) were once more named with telling letters, the principle of the camera obscura passed from autodidact to autodidact. Just like the proverbial dwarfs perched on the shoulders of giants, aspiring painters and engineers simply had to place themselves in the preassigned subject position in order to see farther and farther. All that European modernity has come to celebrate as progress is based on this feedback loop between mathematics, print, and perspective.
Alberti's pre-Gutenbergian book on perspective first appeared in manuscript form in 1435 and was not printed until 1540. In contrast, Durer's 1525 Manual of Measurement of Lines, Areas, and Solids by Means of Compass and Ruler, a direct sequel to Alberti, concluded with a praise to "the Lord" and a stern warning against all unauthorized reprinting.12 Where Alberti had been restricted to words only, Durer was able to publish words and images. The painter's manual concludes with technical drawings designed to illustrate Durer's theory of linear perspective. The painter, as it were, reproduces himself as well as his technical diapositive and his painterly subject matter. As a result Durer's manual is in stylistic terms no longer a theory, but a sequence of instructions that oblige the reader to reenact text and image:
You can render anything within reach in correct perspective by means of three threads and draw it on the table as follows:
If you are in a large chamber, hammer a large needle with a wide eye into the wall. It will denote the near point of sight. Then thread it with a strong thread, weighted with a piece of lead. Now place a table as far from the needle as you wish and place a vertical frame on it .... This frame should have a door hinged to it which will serve as your tablet for painting. Now nail two threads to the top and middle of the frame. These should be as long, respectively, as the frame's width and length, and they should be left hanging. Next, prepare a long iron pointer with a needle's eye at its other end, and attach it to the long thread which leads through the needle that is attached to the wall. Hand this pointer to another person, while you attend to the threads which are attached to the frame. Now proceed as follows. Place a lute or another object to your liking as far from the frame as you wish, but so that it will not move while you are using it. Have your assistant then move the pointer from point to point on the lute, and as often as he rests in one place and stretches the long thread, move the two threads attached to the frame crosswise and in straight lines to confine the long thread. Then stick

their ends with wax to the frame, and ask your assistant to relax the tension of the long thread. Next close the door of the frame and mark the spot where the threads cross the tablet. After this, open the door again and continue with another point, moving from point to point until the entire lute has been scanned and its points have been transferred to the tablet. Then connect all the points on the tablet and you will see the result.13

I have quoted Durer at length in order to show what, in 1525, printed book illustrations had made of linear perspective. All the instructions issued by text and image can easily be formalized: "Do this as long as x applies; do that whenever y applies; repeat this until z no longer applies, and so on." What Direr presents as perspectival construction by way of writing and illustration is something we are far more familiar with than his contemporaries. It is an algorithm, the Europeanized name of a great Arab mathematician. As opposed to mechanisms and theories, algorithms are defined by two things: unlike mechanisms, they do not simply proceed and take their course, but are subject to conditional jumps and loops; but unlike theories, they have to come to an end despite all jumps and loops. "After this, open the door again and continue with another point, moving from point to point until the entire lute has been scanned and its points have been transferred to the tablet. Then connect all the points and you will see the result."

Thus the discursive order that has been in place since the days of Kant and that decrees that art is no technology and technology is no art, did not apply at all to the Brunelleschis, Albertis, or Durers, the painters and architects of the Renaissance. On the contrary: Mirer's algorithmic perspective corresponds to present-day computer graphics and electronic music. Following an algorithm does not yield the musical instrument we know as lute, but a finite number of contour points; otherwise, the attempt to produce the silhouette with an infinite number of points would terminate in a vicious feedback loop. In other words, the painter does exactly the same thing that today's digital-analog converters of our computer monitors or sound systems do: he transforms a discrete number of points into a constant function. Enzensberger's poem on the inventor of the Raderuhr contains the lines: "Different words and wheels. But / the same sky. / That's the Dark Ages we still / live in today."14 But we live in these dark ages not because movable type and linear perspective emerge from the laws of technology, let alone from the essence of things. We reside within the space of these inventions only because they were contingent. They are a European heritage that was (and is) the source of Europe's power. Even the fact that print and perspective have now achieved a global and innocuous dominance is a result of that power. Nineteenth-century gunboats, Bible clubs, and machine guns finally managed to convert the whole world to movable type and perspectival vanishing points.

But that was not always the case.15 Around 1620, shortly after the formation of a propaganda office in the Vatican, the Society of Jesus resolved to bequeath print and perspective to all peoples and empires. To this end, a Gutenberg printing press was installed in Beijing, in the middle of the Middle Kingdom. As if paper, following its long detour from China over Arabia and Sicily to Mainz and beyond, had found its way back home, the Jesuits at first proceeded to convert the simple Chinese with simply illustrated Bibles. This failed to impress the Son of Heaven; converting an emperor required a more advanced European technology. Father Johannes Admann Schall von Bell, Matteo Ricci's successor in Beijing, imported from Rome an entire scientific library that contained no fewer than nineteen titles on perspective. All seemed set to bless China not only with reproducible texts, but also with equally reproducible drawings. But pride and/or delusion intervened, to the effect that missionary headquarters in distant Rome, not its outlet in Beijing, made a fateful decision: the natives who were to be instructed in the arts of engraving and perspective were not Chinese but Japanese from the Christian enclave in Nagasaki. In Nagasaki, however, tracts like those by Alberti or Durer were unavailable.

The outcome was inevitable. In 1627 Father Schall von Bell decided to print four ambitious volumes full of "diagrams and explanations of curious machines from the Far West" in order to confront the emperor of China with superior European technology.16 These so-called theaters of machines, a type of book that not coincidentally first flourished in the Renaissance, usually contained exact perspectival copper engravings or wood prints of existing or fictitious machines-drawings, in other words, that would enable observers to construct three-dimensional machines from their two-dimensional representations. Schall's native (presumably Japanese) illustrators went to work; but although they had European theater-of-machine books complete with Chinese translations in front of them, they were unable to copy the correct perspective of the originals.

Even worse, the illustrators did not seem to notice that, just like medieval copyists, they smuggled many mistakes into their reproductions. Thus water and pulp mills that nobody could have built circulated in magnificent volumes that nobody doubted, but from which nobody learned anything. According to Samuel Edgerton, these faulty graphics were still published in Chinese encyclopedias and scientific handbooks until the first decades of the nineteenth century. The results are well known. China, once the technologically superior idol of a medieval Europe, remained on a level that made it easy for Britain and other European powers to win one colonial war after the other. The Chinese simply were no subjects-that is to say, in the most literal sense of the word: they did not subject themselves to linear perspective. They preferred to remain loyal to Confucius or Lao-Tse.

Such was the dismal outcome for the technology transfer from West to East. In the opposite direction, however, things worked out splendidly: it was a technology transfer from Beijing to Hanover that made it possible to conceptualize print and perspective. The very same Jesuits who in vain had tried to impose European print technology had also studied old Chinese manuscripts and described them to a German philosopher. What Gottfried Wilhelm Leibniz came across in his global correspondence, however, was not the contents of the I-Ching but its signs. He discovered that twenty-six alphabetic signs and even ten Indo-Arabic numerals were a needless expenditure when it came to describing Being in its totality: the I-Ching or Book of Changes makes do with yin and yang, a whole and a broken line.

Based on this semiotic economy described to him by the Jesuit priests, Leibniz drew the startling conclusion that all signs are replaceable, even and especially the acclaimed Indo-Arabic numerals. In a dedicatory epistle to the Duke of Hanover, he explained that two signs would suffice to describe the world in its entirety. For reasons both theological and typographical, however, these signs were named Zero and One, rather than yin and yang. Leibniz, who had subjected (and, if necessary, corrected) all mathematical signs to Gutenberg's place-value logic, recognized in Zero the nothingness preceding creation, and in One, divine creation itself. No wonder, then, that his binary system was said to have been able to describe the whole of being.

But zero and one also describe something else. As a philosopher as well as the founder of analytic geometry, Descartes declared the world to be a three-dimensional space that was, quite literally, opposed by a thinking subject as a nondimensional point. The monadology of Leibniz went a step further by presenting the subject as a paradoxical punctiform architecture without windows in which the whole word appears nonetheless, simply because the monad has no windows but is a camera obscura.17 Creation or One can coincide with a monad or zero if that zero is always already the point of sight of linear perspective.

In other words, ever since Leibniz, print and perspective rule not only over so-called nature but also over so-called thought. A secondorder geometry, as the Chinese taught the most mathematically inclined of all philosophers, turned signs themselves into technologies. This typographic mathematics-to use Sybille Kramer's term -is powerful enough to retire the very media link that enabled it in the first place. Mirer's strange lute algorithm was based on a coupling of print, perspective, and learned craftsmanship; hence, it had to be addressed in simple Early New High German. Leibniz, in turn, replaced movable type with the even more movable symbols of his algebra, and perspectival nature with perspectival thought; hence, he was able to address algorithms that could do without any human handwork. In his calculating machine, which earned him membership in the London Royal Society, addition and subtraction, multiplication and division proceeded on their own. He had brought forth a machine whose end product needed neither print nor paper (though this did not keep the machine from appearing in the shape of printed blueprints). The successors of Leibniz only needed to look things up in order to widen the gap between human language and scientific technology. The media link of print and perspective enabled technological media-that is, it enabled the supersession of the media link that gave birth to it. The camera obscura evolved into cameras and computer screens, and movable letters evolved into movable electrons in silicon chips and, in the near future, into quantum transistors.

But this implies that the books we understand and the pictures we recognize are no more than a subset of a set of signs that defy all hermeneutics. What we have instead is a second-order geometry in which signs and atomic states configure themselves. The very last theory of geometry produced by Europe two thousand years after Euclid announces this is in a manner both comic and threatening. David Hilbert's Foundations of Geometry, published in Leipzig in 1899, was based on the axiom that the venerable tradition of visualizing points, lines, and planes is completely redundant. Instead of dealing with points, lines, and planes, Hilbert wrote, he could just as well have written about "'chairs', 'tables' and `beer mugs."18 This socalled formalism, however, included a second-order visualization of the signs themselves. As if Regiomontanus's edition of Euclid had really caught on, Hilbert referred to his symbols as "discrete objects, which as immediate experience precede all thought"; even more succinct-that is to say, even more theological or, as in the case of Leibniz, atheistic-was his pronouncement, "In the beginning was the sign."19

As we all know, in the beginning was the word, and the word has become flesh-and as such it entered print with Gutenberg's Bible and the camera obscura with Brunelleschi's perspective. The sign that was in the beginning, by contrast, has become flesh in digital computers during Hilbert's lifetime, and much to his dismay. Alan Turing simply needed to take his master literally and to feed signs that, as "discrete objects," "precede all thought," to machines rather than mathematicians to truly put an end to the history of Europe less than two years before the outbreak of the Second World War.

As you will have guessed, all my digressions were simply no more than a detour, a short-circuit between today and today. I simply did not want to once again tell the same old story of how machines (according to Turing's oracle of 1948) have assumed power. But maybe these digressions were not as redundant as the alphabet or the decimal system. In the politically correct nightmares that would like to bomb us back into an ecologically sound Stone Age, computers appear as homeless monsters hovering like vampires over a culture of books and pictures. In turn, in the fantasies of software magnates, books and pictures are just so much loot awaiting digital reproduction. For all their emphasis on pedagogy or economy, both fantasies forget that culture cannot be had without technology and technology cannot be had without culture. The "end of art" (to quote Hegel) could only emerge from art itself. Against these fantasies one may quote (with a slight variation) a sentence of Aristotle, who insisted that "tragedies and comedies are made up of the same letters." The element as such, not its changing implementations, has made our history. That is what my fast-forward account of the history of European technology had in mind.

[Footnote]

1. See Ivan Illich, In the Vineyard of the Text: A Commentary to Hugh's Didascalicon

(Chicago: University of Chicago Press, 1993).
2. See Michael Giesecke, Der Buchdruck in der frihen Neuzeit: Eine historische Fallstudie fiber die Durchsetzung neuer In formations- and Kommunikationstechnologien (Frankfurt anMain: Suhrkamp, 1991).

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3. Sigmund Freud, The Interpretation of Dreams, in The Standard Edition of the Complete Psychological Works of Sigmund Freud, ed. James Strachey (London: Hogarth, 1953), vol. 4, p. 278.

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4. Stephane Mallarme, "Un coup des des," in Oeuvres completes, ed. Henri Mondor and G. Jean-Aubry (Paris: Gallimard, 1945), p. 455.

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5. See Sybille Kramer, Berechenbare Vernunft (Berlin/New York: DeGruyter, 1988), passim.
6. Hans Magnus Enzensberger, Mausoleum: Thirty-seven Ballads from the History of Progress, trans. Joachim Neugroschel (New York: Urizen, 1976), p. 4.
7. For the following, see David Kahn, The Codebreakers: The Story of Secret Writing (New York: Macmillan, 1967), p. 127.

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8. Gaius Suetonius Tranquillus, The Twelve Caesars, trans. Robert Graves (Hammondsworth: Penguin, 1980), p. 91 (Augustus 88) and p. 35 (Caesar 56).

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9. Giorgio Vasari, Artists of the Renaissane, trans. Geroge Bull (New York: Viking, 1978), p. 131.

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10. Quoted in Giorgio Vasari, "oas Leben des tiorentinscnen Baumeisters Leon t5atsta Alberti," in Leben der ausgezeichnesten Mater, Bildhauer and Baumeister von Cimabue bis zum Jahre 1567, ed. Julian Kliemann, 2 vols. (Darmstadt: Wernersche Verlagsgesellschaft, 1983), vol. 2, p. 347.

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11. Quoted in Giesecke, Buchdruck (above, n. 2), p. 145.

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12, Albrecht Durer, er, nw PabtWs Mommi: AMmal ofw narr*er`s *r*ral: ,w Measu of Lkws, Areas, and SoM by pans of Cw*m Rue,ap4,Xukr,'tr&w, And comm. Walter L, Straus. t . water (New York: Aart, 1977) p. 393.

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13. DAd, p. 391-353.

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14. Enzensberger, Mausoleum (above, n. 6), p. 3.
15. For the following, see Samuel Y. Edgerton, Jr., The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution (Ithaca, MY: Cornell University Press, 1991), pp. 260-287.

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16. Ibid., p. 271.

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17. See, for example, Gottfried Wilhelm Leibniz, New Essays on Human Understanding, trans. and ed. Peter Remanat and Jonathan Bennett (Cambridge: Cambridge University Press, 1981). In this text Leibniz also draws a clear distinction between European perspective and Chinese aperspective.

[Footnote]
18. Quoted in Bettina Heintz, Die Herrschaft der Regel: Zur Grundlagengeschicht des Computers (Frankfurt/New York: Campus, 1993), p. 18. 19. Quoted in ibid., p. 58.

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