Perspective and the Book

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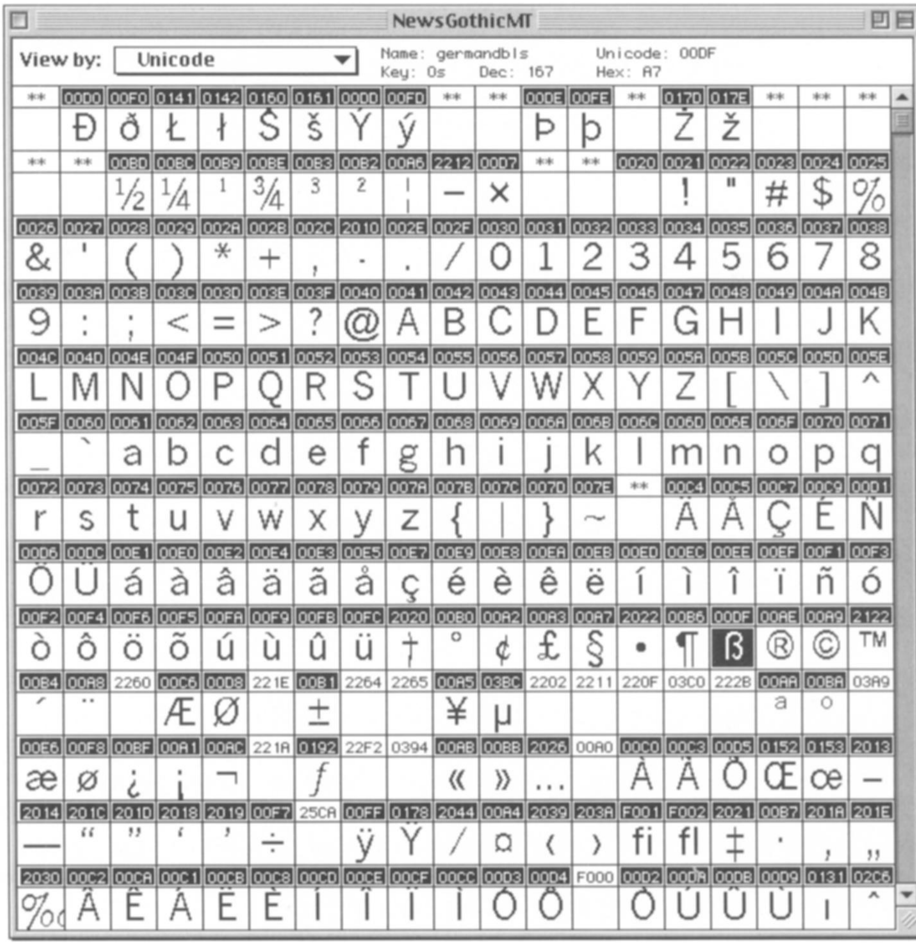
Film and television, computer graphics, and virtual reality have, as we know, caused images to run in ever faster sequences. Subsequently, a perhaps unwarranted jubilation has governed the past century's media theories: Writing in general and the book in particular are said to have been played out, while the image, more powerful and more able to unite humanity than ever, is reclaiming its ancient birthright. It is this jubilation, or at least the diagnosis upon which it is based, that I would like to contest. My counterargument, in brief, is that the printed book has not simply been played out, but rather that this unique medium was what made its own high-technological outdoing possible in the first place. This power, which in turn is probably the basis of all Europe's power, accrued to the book not because of its printed words alone, but rather because of a union of media that, with technical precision, joined these words with printed images.

Media theorists, specifically Marshall McLuhan and, succeeding him, Vilem Flusser, draw an absolute distinction between writing and the image that ultimately rests on concepts of geometry. They contrast the linearity or one-dimensionality of printed books with the irreducible two-dimensionality of images. Simplified in this manner, it is a distinction that may hold true even when computer technology can model texts as strings, as it does today. But it suppresses the simple facts emphasized long ago and, not coincidentally, by a *nouveau romancier,* Michel Butor: the books used most often—the Bible, once upon a time, and today more likely the telephone book—are certainly not read in a linear manner.

There is a perfectly good reason for this situation. Though the lines of a book have looked linear since Gutenberg, the page of a book has been two-dimensional since the Scholasticism of the twelfth century at the latest.[1] Each paragraph and section, footnote and title plays across a surface whose two-dimensionality is no different from that of an image. The fact alone that Gutenberg, before using his technology of movable type in Mainz on Bibles and calendars, had practiced the same technology in Strasbourg for reproducible pictures of the saints indicates that this pictoriality is at the origin of the printing press, which itself is not much more than a sobered-up Rhine wine press. The other issue, continually underscored by Michael Giesecke, that Gutenberg's movable type was never intended for mass production



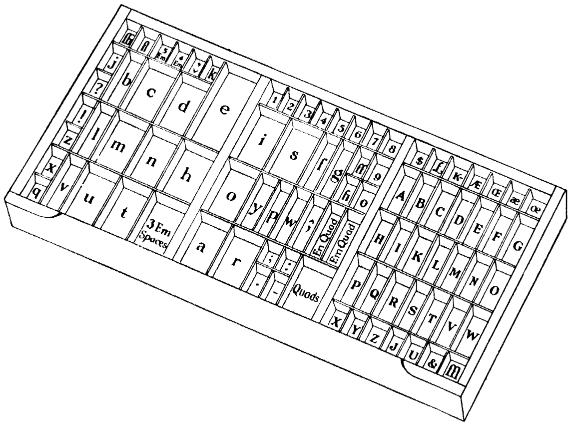
Digital typographic character set indexed by Unicode number. The Unicode standard (ISO 10646) is a unified superset of all established character sets within a single encoding system designed to support the worldwide interchange, processing, and display of written texts.

Type case showing the divided compartments for each character.

as such, but rather was supposed to compete with the calligraphic elegance of manuscript pages, also proves pictoriality as the goal of the printing press.[2]

And yet the geometry of the Mainz letters differed from that of the Strasbourg pictures of the saints. Unlike faces, "letters"—to speak with Sigmund Freud—"do not occur in nature."[3] Gutenberg's press required a geometry of surface, if only because everything depended on putting each individual letter in its place. Each lead letter was practically defined or situated by its right, left, top, and bottom neighbors. In this way each letter filled a gap that was already waiting for it. Letterpress, in its standardization of writing, just continued what the imported Indo-Arabic system of place values did to standardize numerals in the high middle ages. Just as zero, a numeral completely unknown to the Greeks and Romans, put all the other numerals in their proper places, so did the naked *spatium,* poured into lead by Gutenberg and into verse by Mallarmé, proceed with all the other letters.[4] Only with the possibility of replacing the *spatium* with any arbitrary letter did the internal process known as "the ability to write" get transferred to the external process known as the "typesetter's case." Writing in the age of its technical reproducibility is a combinatorial system of standardized elements or characters, just as it was already a combinatorial system of discreet elements or letters since the early Greek vowel alphabet.

The Greeks' *stocheia,* or letters, were not just the source of the four elements of the ancient world and the one hundred-twenty elements of the atomic present. *Elements* was also the title of a book that, for two thousand years, provided Greeks, Arabs, and Europeans instruction in the axioms of geometry. The current scholarly enthusiasm for rediscovering images, bodies, and natures forgets all too readily that the elements exist only in groups, which is to say, in code systems. For this reason even Euclid's *Elements* turned out to be a different book when it first entered the galaxy of Gutenberg in 1482. None other than Regiomontanus, who had imported the new Arabic trigonometry to Europe and, even more relevantly, to Nuremberg, lent his scholarly support to subjecting Euclid's rediscovered geometry manuscript to the printing press. While Euclid had used but words to define phenomena such as the point, line, and plane, each axiom was, as of 1482, accompanied by a print-technological definition: the point appears as a point, the line as a line, etc., until even—or rather, precisely—mathematics became a "typographical" event (to use Sybille Krämer's term).[5] And if the endpoints of a line printed in this manner are further marked with letters, then the geometric figure has been assigned a name that makes it addressable in all its parts. All this seems self-evident for mathematical or technical drawings, but it shouldn't be in the least. "How greatly this page here resembles a thousand other pages, and how hard it is to be



flabbergasted at that!": thus Hans Magnus Enzensberger begins a poem about Johann Gensfleisch zum Gutenberg.[6] The same holds true for Regiomontanus, his printer, Ratolf, and scientific visualization in general. What still matters in European history today, in its transition to computer-aided posthistory, are neither mass movements nor the gods of war, but rather the small-scale, unassuming play of signifiers, which nonetheless has shaken (in Lacan's words) the "moorings of our Being."

The first among Gutenberg's contemporaries to grasp mathematization, as it developed in the founding years of the printing press, was Leon Battista Alberti, the Florentine noble, architect, master fortress builder, painter, and mathematician.[7] One fine day in 1462 or 1463 he went strolling, as he relates, in the Vatican gardens with a man named Dato. Dato was, by profession, as his evocative name suggests, personal scribe to the Pope. As we know, all modern diplomacy had its origins in the private offices of secretaries or, rather, secret scribes of the Roman *Curia* and the Venetian *Signoria*. Alberti, though, was interested in the exact opposite of traditional cryptography. He remarked off-handedly, as the two were perambulating under Roman palms, that the man in Mainz was just now probably making ten copies of an ancient manuscript and thus saving it. That must have prompted the Papal cryptographer to reply that his tedious labor of replacing letter after letter with yet other letters would, alas, not be so easy to mechanize as printing presses or the printer's case. Whereupon Alberti took up his quill and composed a tract that to this day is the watershed of modern cryptography.

Ancient cryptography, developed by Julius Caesar and adopted by Augustus, was a simplistic game with the Latin alphabet. Both Caesars worked by displacing each letter one or more places, until, for example, A was B, B was C, and C was D—in the course of which it never occurred to the great Augustus that his letter game was a kind of modulus mathematics: X, the last letter of his alphabet, did not turn into A again, but rather an exceptional AA.[8] Alberti found codes of this simplicity, still prevalent in his day, to be but child's play. He merely counted the frequency of each letter in uncoded Latin or Italian texts and then compared them with the frequency of letters in the cryptogram. In other words: Alberti translated the principle of Gutenberg's printer's cases, which had to provide more lead characters for the frequently occurring letters than the rarer ones and so are always-already letter frequency analyzers, straight into cryptoanalysis.

He then applied this principle to cryptography, or encoding. To outdo the simple code bearing Caesar's name, Alberti constructed two concentric rings, each inscribed with differently scrambled alphabets, so that a turn of the outer ring changed the correspondence between the two alphabets. Consequently, the privy scribe had only to read the current correspondence and write it down, then turn the outer ring another space. The tedious labor of Dato and his peers became, once again strictly as a consequence of Gutenberg, literally a mechanics of movable characters. Thus Leon Battista Alberti pursued his conversation in Rome to its logical conclusion: with letter frequency analysis for decoding and a polyalphabetic key for encoding, he bestowed upon modern Europe the principle—or better, power—of its strategic secrets.

Even "The Life of the Florentine Architect Leone Battista Alberti," as Giorgio Vasari titled his 1570 biography of Alberti, already suggested a parallel between Gutenberg and Alberti—though, surprisingly enough, not between the printing press and cryptography but between the printing press and linear perspective. Vasari states:

> In the year 1457, when the very useful method of printing books was discovered by Johann Gutenberg the German, Leon Batista [sic], working on similar lines, discovered a way of tracing natural perspectives and of effecting the diminution of figures by means of an instrument, and likewise the method of enlarging small things and reproducing them on a greater scale; all ingenious inventions, useful to art and very beautiful.[9]

Precisely because he dated Gutenberg's accomplishment ten years too late, Vasari's mission seems to pander to an early-modern brand of local patriotism: an "art" that Germany had bestowed upon modernity is supposed to have been matched by Italy with a "similar" "art" in the same year. Now, what Vasari's ill-informed Alberti biography meant by that instrument, which sounds like Scheiner's pantograph of two centuries later, remains an occluded mystery for the history of technology. The scholarship assumes (on the basis of a second, anonymous Alberti biographer) that the alleged instrument for the magnification and reduction of images was in reality a *camera obscura.* "Alberti," writes this biographer,

> produced quite unbelievable things through paintings, which he had one look at through a narrow opening into a small box. There one saw the highest mountains and faraway landscapes around the vast ocean, and regions so far away from the eye, so distant, that one's power of vision was unable to distinguish them. He called these things demonstrations, and they were of a kind such that persons whether experienced and inexperienced would think they were seeing not paintings, but the natural phenomena themselves.[10]

Should the anonymous biographer deserve more credit than Vasari, then Alberti's demonstrations did exactly what this apocryphal pantograph did: they magnified distant objects and reduced close ones, entirely at the whim of a projection technology that sent natural phenomena through the narrow aperture of a *camera obscura*. Alberti had thus replaced a craft, which painting was to remain at least until the invention of photography, with an optical media technology. The *camera obscura*—because it, even as a construction consisting of just an aperture and projection wall, implements the linear-perspectival geometry of our seeing—created reproductions of the world exactly as free of copying errors as otherwise only Gutenberg's printed books were. This—it seems to me, at least—is the whole point of Vasari's German-Italian heroic saga.

The first edition of the Regensburg Missal of 1485 was praised by the clerics in charge of its production as a "miracle of God." The clerics had in fact, according to Michael Giesecke, compared all the individual copies of the missal with its setting copy, only to come to the conclusion that "in the letters, syllables, words, sentences, periods, paragraphs and all attendant matters, the printing of all the copies agrees, in every respect, with the setting copy . . . provided by our cathedral. For this we must thank God."[11] The "inexperienced" and "experienced" persons for whom Alberti's *camera obscura* projected the natural phenomena themselves in place of paintings could not have been more amazed and delighted. Two simultaneous technologies had appeared, poised to eliminate the disturbance of the human hand from texts and from images. In the same historical moment, books, and paintings entered the age of their technical, and thus noiseless, reproducibility.

It is no wonder, then, that both technologies of reproduction should melt into a single one. The single geometry, as presented in the newborn printed edition of Euclid, became equally an element of text and image. None other than Alberti was responsible for embarking upon this integration. In 1435, not quite ten years before Gutenberg's first Bible printing, Alberti's tract "On Painting," which would not appear in print until 1540, appeared as a hand-written manuscript. This text not only transferred a form of knowledge, one that for centuries had been handed down through workshop conversations between masters and apprentices, to an autodidactic theory; it was also the first time the mute technology of linear perspective, or the *camera obscura,* was put to paper.

The first of Alberti's three "Books on Painting" appeared at the exact point where, later, the 1482 Euclid edition would begin: with the geometric definitions of point, line, and plane. It misuses Greek mathematics, though, for a purpose quite unknown to antiquity: for the construction of linear-perspectival pictures. The three elements are only defined in order to convey a fourth, that is, the space of natural phenomena and buildings. Alberti's tract teaches the painter to pull off, with writing implement and ruler, exactly what his *camera obscura* did on its own. Right angles become oblique, equal distances become unequal, and parallel lines become bundles of rays from an infinitely distant vanishing point, until the finished painting translates all three spatial dimensions into a linear-perspectival illusion. In this way the painting—half a millennium before Macintosh and Windows 95—takes on the logical position of a window, within which the world is graphically projected. And because Alberti describes this window—as if to evoke the painter's canvas itself—as a semitransparent veil of interwoven threads of canvas, every detail of the world finds a tiny bit of the grid that belongs to it alone. Right-angled grids assign all data or givens to place values, as with Gutenberg. For this reason alone the comparison with today's desktop systems is not far-fetched: the pixels on our computer monitors are differentiated from television pictures precisely because they are fully addressable as a two-dimensional matrix. Only this is what makes it possible to switch the monitor into a text mode which, like all typography, depends entirely on place values. In this sense, Alberti's theory of linear perspective did not just convert an art form into text, but also made a visual space into paper.

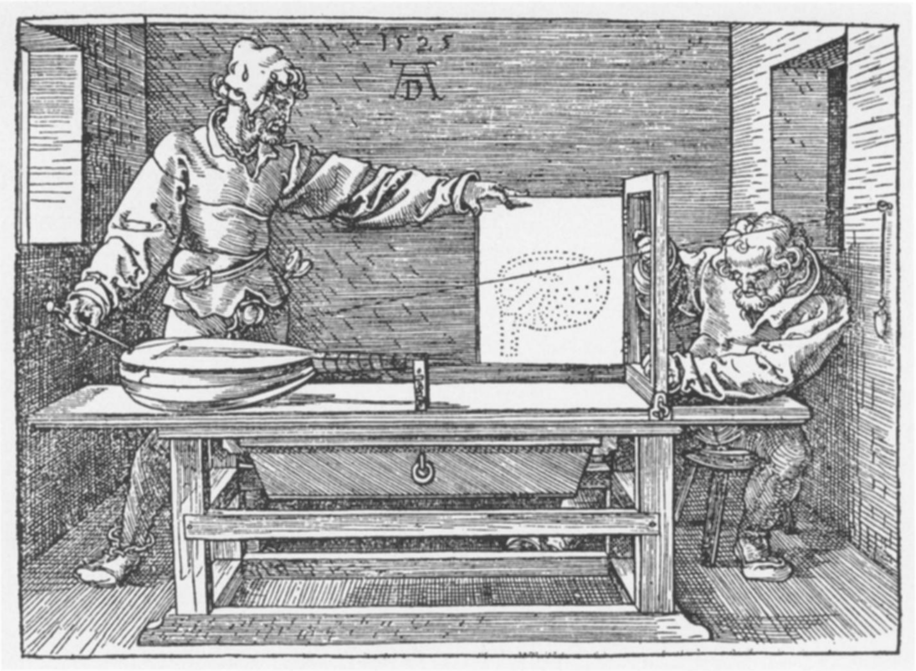
All of these contrivances of windows and veils, plans and elevations, only served to veil the sad fact that Alberti could not calculate his linear-perspectival images. Just as in the *camera obscura,* technical processes took the place of calculations. And naturally, a mathematics that would change right angles to oblique and whole-numbered ratios into irrational ones should hardly be imposed on painters, according to Alberti's innocent explanation. But precisely this mathematics was being developed at the time Regiomontanus was importing the learning of Arabic trigonometricians to Europe (minus their passion for the *camera obscura*). Alberti may have become familiar with this mode of mathematics in Rimini when he met Regiomontanus, then traveling in Italy. It is unfortunate that we will never find out what the two artist-engineers spoke about.

But even without the modern trick of solving equations on graph paper, linear perspective transferred the visible objects of this world onto drawing paper. The only question was what visible objects would even benefit from the application of ruler and compass (to use the words of the famous title of a book by Albrecht Dürer). The fractal branchings of trees or forests certainly would not, simply because geometries without right angles are not translatable into a correlated geometry of oblique angles.[12] In other words, the visible objects that would begin the modern victory march of linear-perspectival constructions had to be constructions themselves. For we know that ever since the Egyptian and Babylonian ages, Eurasia has been in love with the right angle.

It was no coincidence, then, that Alberti dedicated his tract on painting to the architect and fortress-builder who had presented the first perspectival painting to an amazed Florentine public in 1420. As the model for this painting, interestingly, Filippo Brunelleschi chose a building for whose doors he had submitted proposals himself: the Baptistery of Florence. Thus linear perspective began as architectural painting, as the projection of a three-dimensional octagon in its correlated two-dimensional representation. The fact that Brunelleschi's painting, according to his biographer's report, also contained clouds and other fractals, does not contradict this in the least. As a contrast to the Baptistery, Brunelleschi had not painted the sky at all, but rather simply left the background—which was an actual mirror—empty. To the eye of the observer, if he stood at the assigned place in the center of Florence, the wandering clouds and permanent stones, the mirror image and the illusionistic painting, would all melt together in a virtual reality.

In other words, linear perspective as technical construction aimed to reproduce technical constructions. The content of a medium, if we follow McLuhan strictly, is never nature, but rather always only another medium. Brunelleschi's perspective represented the technological adaptation of architectures or constructions, just as Gutenberg's book printing did with handwriting. Therefore it is no wonder that there soon arose a feedback loop between book printing and perspective. Not only did churches or baptismal chapels go simultaneously into print and images, but even that technological device that had first enabled the production of linear-perspectival images itself, the *camera obscura*—which Alberti, not Brunelleschi, first applied to the perspectival rendering of the visible—found itself reproduced using linear perspective. As a woodcut or copper etching whose lines were once again named in print with expressive letters (like Euclid's geometric constructions), the functional principles of the *camera obscura* migrated from one autodidact to another. Interested painters and engineers had only to place themselves at the appointed subject position (as did the observers of Brunelleschi's Baptistery) in order to see farther and farther, like dwarves on the shoulders of giants. Everything that European modernity has since celebrated as progress is based on this feedback loop between mathematics, book printing, and linear perspective.

We recall that Alberti's pre-Gutenberg book on linear perspective appeared as a handwritten manuscript in 1435 and was first printed in 1540. Interestingly though, Dürer's *Manual of Measurement of Lines, Areas and Solids by Means of Compass and Ruler,* a direct extrapolation of Alberti, ended with a thanks to "God our Lord" and with the firm resolution to protect the printed book against thieving presses that might copy it.[13] Precisely for this reason Dürer could publish his words and images simultaneously, while Alberti had offered only words. The instruction in measurement ends with technical drawings that repeat Dürer's theory



of linear-perspectival drawing once more in images. The painter reproduces himself, his technical devices, and his painterly model. Thus Dürer's instruction is no longer a theory, but rather a sequence of instructions that require the reader to grasp both text and image: "With three threads," begins one of these picture captions,

> you can put any tangible thing into a painting, drawing it on a tablet 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, parallel to the wall to which the needle is attached, but as high or low as you wish, and on whatever side you wish. This frame should have a door hinged to it which will serve as your tablet for painting. Now nail the 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 on 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.[14]

Albrecht Dürer. The Second Perspective Apparatus. Man Drawing a Lute. From *The Painter's Manual*, 1525.

I have intentionally quoted Dürer nearly unabridged, so that you can see what book printing and illustrations made of linear perspective in 1525. All the instructions communicated in text and image are easily formulated as: "Do this, as long as X is true, do that, as soon as Y is true; repeat the same, until Z is no longer true, etc., etc." What Dürer begins to at once write and draw up as a perspectival construction is something that we today are more familiar with than his contemporaries. It is the Europeanized name of a great Arabic mathematician, i.e. an algorithm. In contrast to both mechanisms and theories, algorithms are defined in two ways: unlike mechanisms they do not merely run a course, but rather undergo specific jumps and loops; but they must nevertheless, unlike theories and despite all jumps and loops, come to an end in finite time.

> Next close the door of the frame and mark the spot where the threads cross on 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.

For the painters and fortress builders of the Renaissance, whether their names were Brunelleschi, Alberti, or Dürer, the linguistic ruling since Kant that art is not technology and technology not art was hardly valid. Quite the contrary: Dürer's algorithmic linear perspective has as its counterpart only the algorithms that today are run as computer graphics or computer music. Not coincidentally, following the algorithm yields not quite the musical instrument called a lute, but only a finite number of outline points. Otherwise, for instance, in an attempt to create the outline itself through an endless number of points, the algorithm would have to end up in an unallowable infinite loop. Thus the painter does exactly what a digital-analog converter does in the input stages of our computer monitors or sound systems nowadays: it changes a discrete amount of points to a constant function.

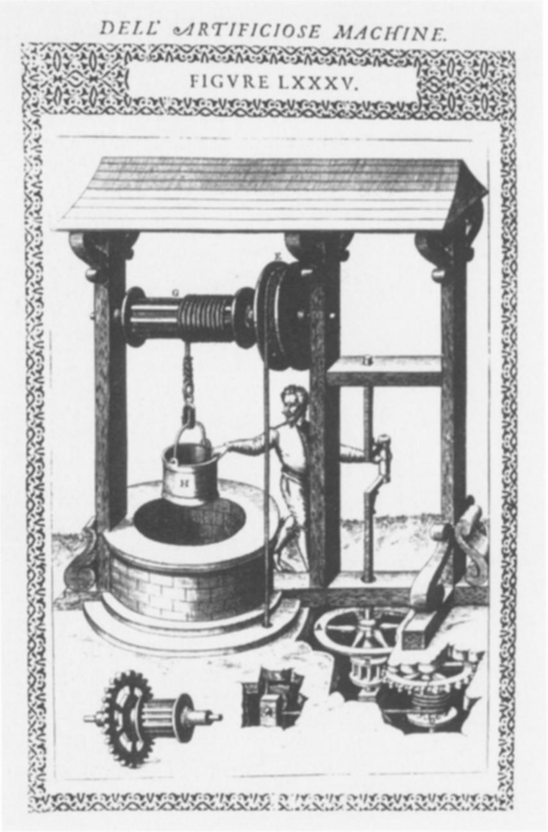
In Enzensberger's poem about the inventor of the mechanical clock it is said:

> Different
> words and wheels. But
> the same sky.
> That's the Dark Age we still
> live in today.[15]

We still live in these middle ages not because movable type and linear-perspectival images necessarily follow from the laws of technology or even from the nature of things. We live in the space of these inventions only because they were

Right: Agostino Ramelli. Engraving from *Diverse et Artificiose Machine*, 1588.

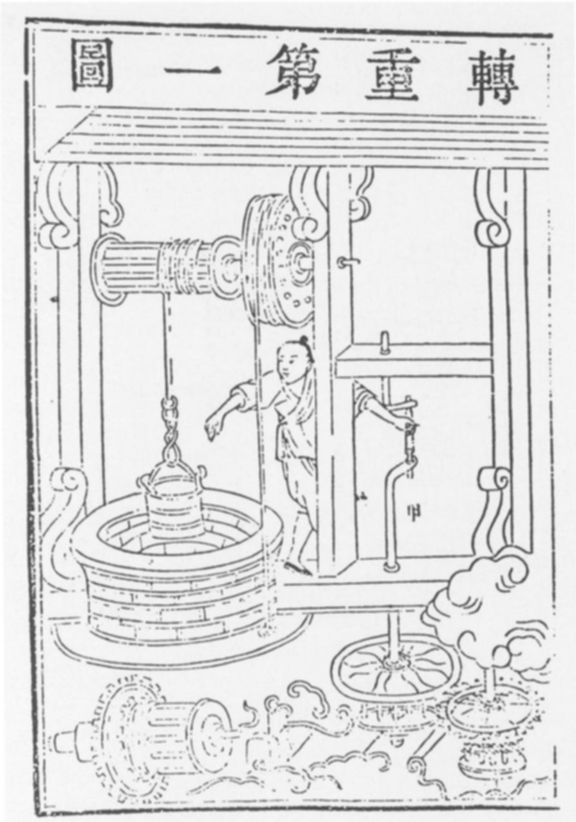
Opposite: Anonymous. Woodcut from Johann Schreck and Philip Wang Zheng, *Yuan-xi Qiqi Tu-shuo*, 1627.



contingent. They are a European legacy, upon which all Europe's power was based. Even the fact that book printing and linear perspective are today as unremarkable as they are widespread is a consequence of this power. The artillery ships, Bible societies, and machine guns of the nineteenth century have finally managed to recast the world in movable type and perspectival vanishing points.

This was not always the case.[16] Around 1620, immediately after the founding of their papal propaganda ministry, the Jesuits decided to give all nations and empires the gift of the new union between the media of printing and technical perspectival drawing. Consequently, a Gutenberg-like printing press was founded in Peking, the center of the empire of the center. As if paper had found its way home after its long travels from China via Arabia and Sicily to Mainz, the Jesuits set to work on converting the "simple" Chinese with simply illustrated Bibles. However, this technology apparently seemed too weak for the son of heaven himself. For the conversion of the Emperor, only one technology was considered for the presentation of Europe's higher technology. Thus, Father Johannes Adam Schall von Bell, successor to Matteo Ricci, imported a purely scientific library from Rome to Peking, containing nineteen titles on linear perspective alone. With this, everything seemed ready for bestowing China with the favor not only of reproducible texts but also of equally reproducible technical drawings. But, perhaps due to blindness and/or hubris, the mission officials—not in Peking, but in faraway Rome—made a remarkable mistake: as natives to be instructed in copper etching and perspectival drawing they chose not Chinese but rather Japanese from the Christian enclave that in 1945 would become world-famous as Nagasaki.[17] In Nagasaki, though—you guessed it—there were absolutely no tracts by, say, Alberti or Dürer.

And so the inevitable happened. Father Schall von Bell, in order to confront the Emperor of China with superior European technology, decided to put four ambitious volumes "with diagrams and explanations of curious machines from the Far West" through Peking's printing presses.[18] The so-called Theatra Machinarum, a book genre not coincidentally flourishing since the Renaissance, generally contained exact perspectival copper etchings or woodcuts of existing or else only fictive machines—drawings, that is, that were supposed to make it possible for



the observer to successfully reconstruct a three-dimensional machine according to its two-dimensional image. Accordingly, Schall's natives, probably Japanese woodcut makers, got to work. They had the European machine-theater books complete with a Chinese translation right before their eyes, but were nevertheless completely unable to copy correctly the perspectivally correct ratios of the original.

Worse yet, the Chinese draftsmen did not seem to notice that they—like medieval manuscript copyists once upon a time—had smuggled in any number of errors in the reproduction. Deluxe editions, too, tended, to contain entirely unbuildable mills and saw works, which no one would have suspected, nor did anyone find out. This kind of unintended parody of printed graphics was printed over and over in the Empire of China (as proved by Samuel Edgerton) until the first decades of the nineteenth century—in encyclopedias and scientific-technological handbooks. The results are well known. China, the high-technological model of the world during the middle ages,[19] remained at a stage that made it easy for the English and other European powers to win one colonial war after another after 1840. The Chinese simply could not become subjects—and that means quite literally underlings—of linear perspective. They preferred to remain loyal to Confucius or Lao Tse.

This was the sad end of the transfer of technology from West to East. Only in the opposite direction—from East to West—did everything run smoothly. It was a technology transfer from Peking to Hanover that first put the new geometry of book printing and print technology into words. The same Jesuits who vainly promoted European print technology also read ancient Chinese manuscripts and described them to a philosopher in Germany. What Gottfried Wilhelm Leibniz found then in his world-wide mail was not the content of the I-Ching but its sign. He read, in other words, that twenty-six alphabetical signs or even ten Indo-Arabic numerals are far too much effort in describing Being as a whole. The I-Ching or "Book of Changes" comes out, as we know, with the yin and yang, the whole and unbroken line.

From this economy of signs, as the Jesuit fathers had described it to him, Leibniz drew the daring conclusion that all signs are replaceable, even, or especially, the Indo-Arabic numerals he had once so praised. In a dedication to his absolute lord, the Duke of Hanover, he explained how the world could be completely explained using just two signs. These two signs, however, were no longer called yin and yang, the straight and uninterrupted line, but zero and one. There were good reasons for this, both theological and typographic. Leibniz, who as a rule checked all mathematical signs against Gutenberg's place value logic and corrected them in case of error, saw in "zero" the nothing that had prevailed before God's act of creation, and in "one" the divine creation itself. How can we be surprised, then, that his binary numeral system should be able to describe Being as a whole.

Zero and one describe something else, as well. Even Descartes, not only as a philosopher but also as the founder of analytical geometry, had declared the world a three-dimensional space that the thinking subject faces, literally, as a zero-dimensional point. Leibniz went a step further. His monadology imagines the subject as a paradox, a point-shaped architecture without windows, within which the entire world nevertheless appears. And this is simply because the monad *has* no windows but *is* a *camera obscura*.[20] Creation, or "one," can only collapse into the monad or "zero," insofar as this "zero" figures as the always-already eye-point of a linear perspective.

In other words, typography and linear perspective, since Leibniz, not only rule so-called nature, but also so-called thinking. A geometry of a second order, as China taught it to that most mathematical of all philosophers, recreates the signs themselves as technologies. This typographical mathematics—as Sybille Krämer designates it—is powerful enough to dissolve the very union of media that it historically had enabled. Dürer's wondrous lute-algorithm was based on a joining of book printing, linear perspective, and practiced painterly craft; as a result it had to be written up in straightforward Early New High German. Leibniz replaced movable type with the even more mobile signs of his algebra and linear-perspectival nature with linear-perspectival thinking. Thus he was also able to write down algorithms produced without handcrafting or any work of man. The calculator Leibniz brought to members of London's Royal Society automatically ran additions and subtractions, multiplications and divisions. A machine existed in the world whose end product came out without paper or book printing—not that this prevented the machine itself from ending up in print, like many another modern apparatus, as a construction drawing. Leibniz's successors had only to consult a reference work in order to render the gap between human language and the science of technology ever wider. The media-union between printing and linear perspective enabled the outdoing of the technological media themselves; that is, it enabled its own outdoing. From the *camera obscura* have come the photographic camera and the computer screen; from movable type, movable electrons in silicon chips or, soon, even quantum transistors.

But that would mean that the books we understand and the images we recognize form mere subsets of sign sentences, a mockery of all hermeneutics. We are dealing with a second-order geometry in which the signs or atomic states configure themselves. This was announced, ironically and threateningly, in the last geometry produced in Europe, the culmination of its two-thousand year history since Euclid. David Hilbert's *Foundations of Geometry*, which appeared in Leipzig in 1899, starts with the principle that the time-honored view—that is, the pictorial quality—of points, lines, and planes is entirely superfluous. In place of points, lines, and planes, wrote Hilbert, he could just as easily have spoken of "'chairs,' 'tables,' and 'tankards.'"[21] This so-called formalism nevertheless did not exclude a graphics of a second order, that is, the signs themselves; in fact, it necessitated it. Hilbert, behaving for all the world as if Regiomontanus's Euclid edition had become the accepted thing, called his signs "discrete objects that are visibly present as immediate experience before all thought." Even more concise, because just as theological, that is to say, as atheistic as Leibniz's approach, was his sentence "In the beginning was the sign."

The word that was at the beginning has, of course, become flesh. As such it went into print in Gutenberg's Bible and into the *camera obscura* with Brunelleschi's linear perspective. On the other hand, the sign that was at the beginning has also been incarnated, during Hilbert's lifetime and indeed to his dismay, in digital computers. Alan Turing had only to take his mentor at his word and feed "discrete objects" that are present "before all thought" to machines, instead of to mathematicians, in order to end the history of Europe not quite two years before the outbreak of World War II.

You already guessed it: All my excursions into early Renaissance legends were just a detour, a short-circuit between then and today. I just did not want to have to repeat the same thing again and again, namely, that machines are taking over (according to Turing's prophecy of 1948) and how they are doing it. But hopefully these excursuses have not proved as redundant as the alphabet and base-10 numbers, even though they may be attributed to the same. In the nightmares of those who would be happiest if we were bombed back into the ecologically safe stone ages, computers loom like homeless monsters over a culture of books and images that they can only vampirize. In the wish-fulfillment dreams of trans-Atlantic software magnates, books and images are just lying there as a gigantic, exploitable mass of resources that has yet to be digitally reproduced or digitally copyrighted. Both phantasms, be it for reasons of pedagogy or of economics, forget that culture cannot be had without technology nor technology without culture. The "end of art," to speak with Hegel, could only originate in art itself. One sentence of Aristotle's, slightly modified, is still true despite both of these phantasms: "Tragedy and comedy," wrote the philosopher, "are made of the same letters." The element as such, not its changeable implementations, has determined our history. A brief narrative of the history of European technology should entail nothing less.

Notes

1. See Ivan Illich, *In the Vineyard of the Text: A Commentary to Hugh's Didascalicon.* (Chicago: University of Chicago Press, 1991).

2. Michael Giesecke, *Der Buchdruck in der frühen Neuzeit: Eine historische Fallstudie über die Durchsetzung neuer Informations- und Kommunikationstechnologien* (Frankfurt am Main: Suhrkamp, 1991), 140–42.

3. Sigmund Freud, *The Interpretation of Dreams*, in *The Standard Edition of the Complete Psychological Works*, vol. 4/5, ed. Anna Freud et al., trans. James Strachey (London: The Hogarth Press/Institute of Psychoanalysis, 1953), 278.

4. Stéphane Mallarmé, "Un coup de dés," in *Oeuvres complètes*, ed. Henri Mondor and G. Jean-Aubry (Paris: Gallimard, 1945), 453–477.

5. Sybille Krämer, *Berechenbare Vernunft: Kalkul und Rationalismus im 17. Jahrhundert* (Berlin: De Gruyter, 1988).

6. Hans Magnus Enzensberger, "J.G.G. (1935–1468)," in *Mausoleum: Thirty-seven Ballads from the History of Progress*, trans. Joachim Neugroschel (New York: Urizen Books, 1976), 4.

7. David Kahn, *The Codebreakers: The Story of Secret Writing* (New York: Macmillan, 1967), 127.

8. Suetonius, *Lives of the Caesars*, trans. Catherine Edwards (Oxford: Oxford University Press, 2000), 28 (on Julius Caesar), 88 (on Augustus).

9. Giorgio Vasari, *Lives of the Most Eminent Painters, Sculptors and Architects*, vol. 1, trans. Gaston Du C. de Vere (London: Medici Society/Philip Lee Warner, 1912–1914), 494.

10. Giorgio Vasari, "Das Leben des florentinischen Baumeisters Leon Battista Alberti," in Vasari, *Leben der ausgezezeichnetsen Maler, Bildhauer und Baumeister von Cimabue bis zum Jahre 1567*, ed. Julian Kleimann (Worms: Werner'sche Verlagsgesellschaft, 1983), 347.

11. Giesecke, 145.

12. Hermann von Helmholtz, "On the Relation of Optics to Painting," in *Popular Lectures on Scientific Subjects*, trans. E. Atkinson (London: Longmans, Green and Co., 1881), 84–85. "If we look at houses, or other results of man's artistic activity, we know at the outset that the forms are for the most part plane surfaces at right angles to each other, with occasional circular or even spheroidal surfaces. And in fact, when we know so much, a correct perspective drawing is sufficient to produce the whole shape of the body. . . . The best perspective drawing is however of but little avail in the case of irregular shapes, rough blocks of rock and ice, masses of foliage, and the like."

13. Albrecht Dürer, *The Painter's Manual: A Manual of Measurement of Lines, Areas, and Solids by Means of Compass and Ruler*, trans. Walter L. Strauss (New York: Abaris Books, 1977), 393.

14. Dürer, *The Painter's Manual*, 391–93. Translation slightly modified.

15. Enzensberger, "G. de' D. (1318–1389)," in *Mausoleum*, 3.

16. See Samuel Y. Edgerton, *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution*, 2nd ed. (Ithaca: Cornell University Press, 1993), 260–80.

17. Edgerton, 266.

18. Edgerton, 271.

19. See William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000* (Chicago: University of Chicago Press, 1982).

20. See, for example, Gottfried Wilhelm Leibniz, *New Essays on Human Understanding*, ed. and trans. Peter Temnant and Jonathan Bennett (Cambridge: Cambridge University Press, 1996), 145. In the same text, incidentally, Leibniz finds an express difference between Chinese and European perspective.

21. Hilbert's quotations here and following are found in Bettina Heintz, *Die Herrschaft der Regel: Zur Grundlagengeschichte des Computers* (Frankfurt am Main: Campus, 1993), 58–91.