

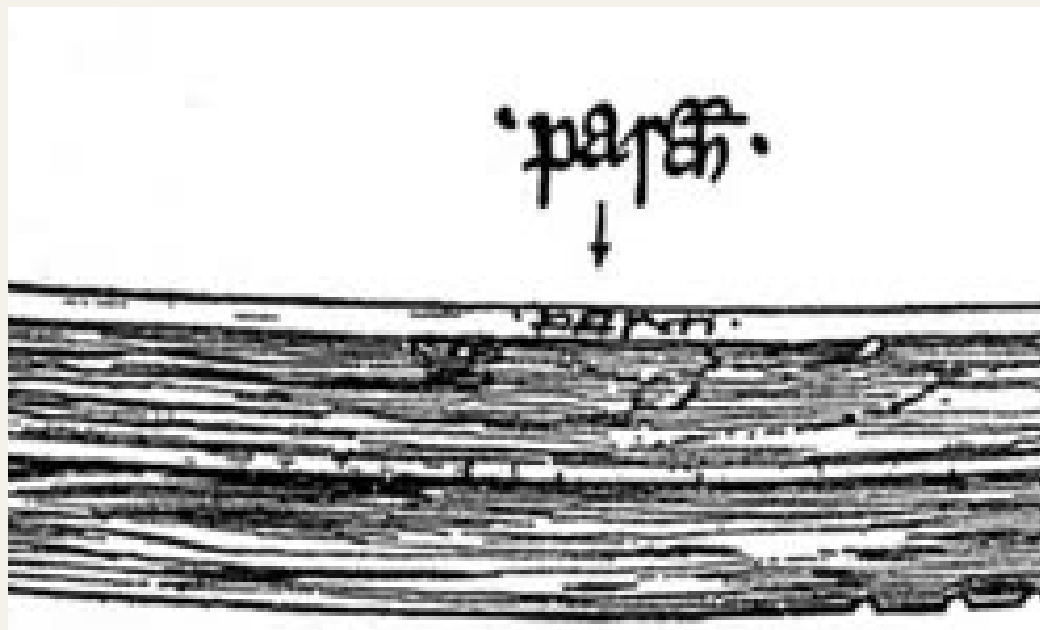
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THE NUMERAL

An essay on the figures: the pebble, the tally, the nothing, the ledger, the square, the folio.

GEVIERT · SEVEN CHAPTERS AND EIGHT PLATES

Plate 2. An exchequer tally: notched, split, unforgeable. The holder of the longer piece held the stock.



1

THE FINGER AND THE PEBBLE

Counting is older than the figures, and it left its fingerprints in the words.

Before there were figures there were fingers, and the fingers are still in the language. A numeral is called a digit because digitus is the Latin for finger, and nothing about that is a metaphor: the first counting instrument was the hand, and the base we still count in is the number of fingers on two of them. The second instrument was the pebble. The Latin for a small stone is calculus, and to calculate was, literally, to move pebbles about, because that is how arithmetic was done: little stones laid in the ruled columns of a counting board, each column worth ten of the column

to its right. The board did the positional work. The stones did the remembering. Nobody in that room needed a written zero, because an empty column is its own zero, visible to anyone standing over the table.

The counting board ran Europe for the better part of two thousand years, and it ran England's treasury under a name that gives the whole apparatus away: the Exchequer, called after the chequered cloth spread over the reckoning table, whose squares were the columns of account. Sums were laid out in counters, moved, resolved, and only then written down. What was written was a record of a result, not a calculation; the calculation had happened in space, on the cloth, and vanished the moment the counters were swept.

The stick that remembered

Alongside the board stood an even older instrument, the tally: a stick of hazel notched across its width, a wide notch for a large sum, narrower cuts for smaller

ones, then split down its length so that the notches ran through both halves (Plate 2). Creditor and debtor each took a piece, and the split grain of the wood made the pair unforgeable, because no two sticks split alike. The longer piece was called the stock, and the party who held it, the holder of the stock, has kept that name in the language of finance ever since. The Exchequer issued and archived tallies for centuries after the pen had made them unnecessary, which is the ordinary way of institutions and their instruments.

The tallies got their monument in the end, though not the kind anyone

to think of a cleaner allegory for the end of an instrument. The counting board and the tally were arithmetic as furniture, as cloth and wood and stones. What replaced them weighed nothing at all: nine small marks and a sign.

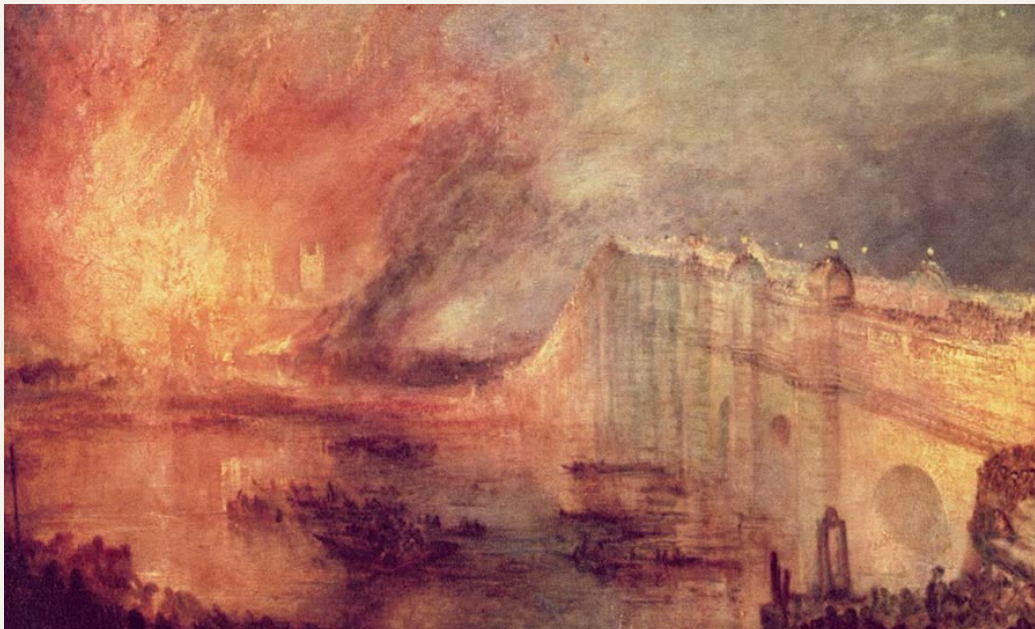


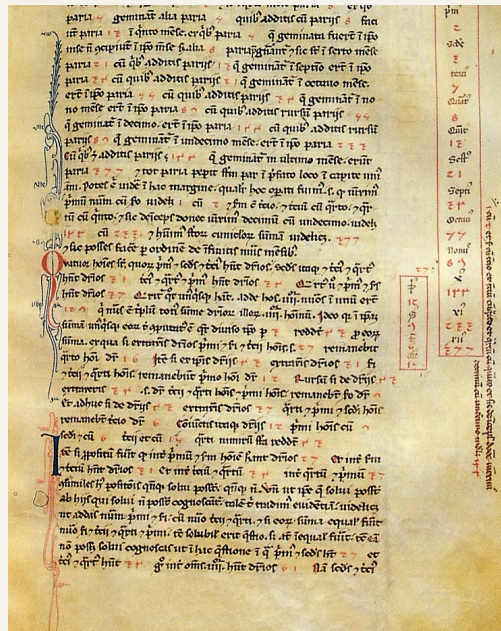
Plate 3. Turner, The Burning of the Houses of Lords and Commons, 1834. The tallies, retired, took the building with them.

intended. In 1834, two cartloads of obsolete tally sticks were fed into the furnaces beneath the House of Lords. The flues overheated, and by morning the Palace of Westminster had burned to its walls. Turner stood in the crowd on the south bank and painted what he saw: Parliament on fire, the sky orange over the Thames, the oldest data store in the kingdom destroying the building that had kept it (Plate 3). It is difficult

2

NINE FIGURES AND A NOTHING

Plate 4. A leaf of the Liber Abaci, 1202: nine Indian figures and the sign 0 suffice to write any number whatsoever.



The positional decimal system arrives, carrying its empty place with it.

The figures we write are Indian. Positional decimal notation, nine digits whose value depends on where they stand, together with a mark for an empty place, was developed in India and travelled west through the Arabic-speaking world; that is why Europe came to call the figures Arabic, naming the messenger rather than the sender. In the ninth century the Baghdad scholar al-Khwarizmi wrote a treatise on reckoning with the Indian numerals, and when Latin translations of that work

spread through Europe, pen-reckoning itself took its name from him: algorism, the art of computing with figures, a word that has since narrowed and hardened into algorithm. It is a fine irony that the most modern word in software is a ninth-century surname worn smooth by copyists.

The decisive import was not any of the nine figures. It was the tenth mark, the one that means nothing at all. On the counting board an empty column takes care of itself; on paper, absence must be written down, or three hundred and five collapses into thirty-five. The Arabic name for the empty place was sifr, emptiness, and Europe took the word twice: Latinised once into zephyrum, which wore down into zero, and again into cifra, which became cipher, a word that first meant the zero itself, then any figure, and then a secret writing, as if the language remembered how much suspicion the new marks attracted. A sign for nothing that changes the value of everything beside it is a genuinely strange object, and the languages treated it accordingly.

A merchant's son at the customs house

The book that carried the system into European practice was written by a customs official's son. Leonardo of Pisa, called Fibonacci, learned the Indian figures as a boy at the Pisan trading colony of Bugia on the North African coast, where his father kept the customs house, and in 1202 he set them out in the Liber Abaci, the book of calculation (Plate 4). Its opening moves directly to the point: the nine Indian figures, it says, together with the sign 0, which the Arabs call zephir, suffice to write any

number whatsoever. That sentence is the whole revolution in one clause. A finite alphabet of ten marks, and the promise of every number that will ever exist; the page had acquired a positional system, which is to say the page had acquired a grid, invisible but load-bearing, in which the place of a mark is half its meaning.

It is worth pausing on how much of this book's own machinery is already in that promise. A system in which position carries value is a system in which position must be kept, exactly, or the value is corrupted. Pen-reckoning made every writer of numbers a keeper of columns. The ledger ruled its pages into vertical lines for the same reason this page rules itself into fields: alignment is not tidiness, it is meaning.

Plate 1. Adam Ries,
reckoning on the lines
and with the pen:
both instruments in
one schoolbook, for a
century of reprints.

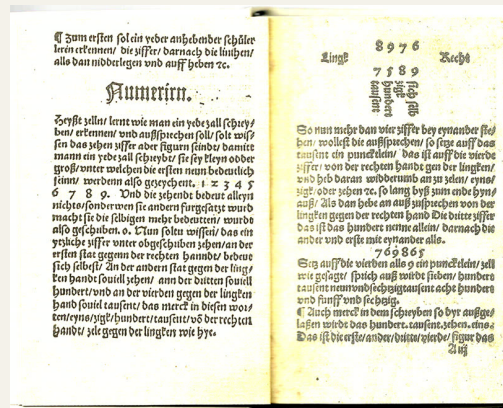


Plate 5. Reisch,
1503: Arithmetic
presides while
the pen-reckoner
smiles and the
board-reckoner does
not.

THE BOARD AGAINST THE PEN

*Three centuries of coexistence,
suspicion, and instruction manuals.*

The new figures did not sweep the board away. They fought it, slowly, for about three centuries, and for much of that time the two systems ran side by side, the board for the counting-house, the pen for the record. The resistance was not stupidity. A counting board is public and auditable: every step of a sum happens in the open, in front of witnesses, and cannot be quietly amended afterwards. Figures on paper can be altered with a stroke; a 0 becomes a 6 or a 9 with one curl of the pen. So the money-changers' guild of Florence, at the end of the thirteenth century, forbade the new figures in account books and required sums to be written out in words, the way a bank cheque still asks for the amount twice,

once in figures for reading and once in letters for law. Institutions distrust what can be edited. They were right to, and their caution outlived its cause by centuries.



The turn, when it came, came through schoolbooks. Adam Ries, the most famous of the German reckoning masters, published a manual whose title says everything about the moment: reckoning on the lines and with the pen, instruction in both instruments in one volume, the counting board for those who had it and the figures for those who were ready (Plate 1). The book was reprinted for over a century, and to this day a German who checks a sum may say it is right nach Adam Ries, according to Adam Ries, the reckoning master having become a unit of correctness. Instruction, not decree, is what actually replaces an instrument.

The allegory with the smile

The contest even got its official picture. In 1503 Gregor Reisch printed the *Margarita Philosophica*, a university compendium of the liberal arts, and its page for arithmetic is a woodcut of the quarrel itself (Plate 5). The figure of Arithmetic, a woman with numerals embroidered on her dress, presides over

a contest: on one side sits Boethius, computing with the Indian figures, and on the other Pythagoras, working a counting board. The attributions are cheerful nonsense, since neither man used the instrument he is given, but the verdict is unmistakable, because the woodcut lets Boethius smile and gives the board-reckoner a long face. Arithmetic herself looks toward the pen. By 1503 a printer in Freiburg could assume every student would read the joke. The board had lost, and the picture is its concession speech.

Plate 6. Luca Pacioli among his instruments, attributed to Jacopo de' Barbari. Double entry in a portrait.



THE MERCHANT'S TRUTH

Double entry, and arithmetic as a promise of honesty.

What the figures won, in the end, was not a mathematical argument but a commercial one. The pen scaled and the board did not: a firm trading between Venice and Bruges could not ship its counting table with every consignment, but it could ship a ledger, and a ledger written in positional figures could be summed, checked, copied, and audited by anyone trained in the algorism. On that foundation the Italian merchant cities built the practice that still underwrites every balance sheet on earth: double entry, each transaction written twice, once as debit and once as credit, so that the books themselves contain their own

proof, and an error announces itself as an imbalance.

The man who fixed that practice in print was Luca Pacioli, a Franciscan mathematician who in 1494 published the *Summa de Arithmetica* in Venice, a compendium of everything then known of practical mathematics, with a section on the method of Venice, the keeping of books in double entry. It is the first printed, systematic description of the practice, and it made Pacioli the most read mathematics teacher of his age. There is a portrait, attributed to Jacopo de' Barbari, that shows him at a table dense with instruments: compasses, chalk, an open Euclid, a glass polyhedron hanging in the air like a proof made visible (Plate 6). It is a painting of a man for whom number had become a profession of order, and the painter has set him in the middle of his own apparatus the way this book sets a figure in the middle of its grid.

Double entry deserves one more sentence of admiration, because its idea is the idea of this library wearing period dress. It is redundancy as verification: write the fact twice, in two registers, and let agreement stand for truth. A page composed on a grid makes the same wager. Every alignment is a small act of double entry, the picture's edge agreeing with the column's, the caption's baseline agreeing with the text's, and a reader checks the books at a glance without knowing that is what the glance is doing.

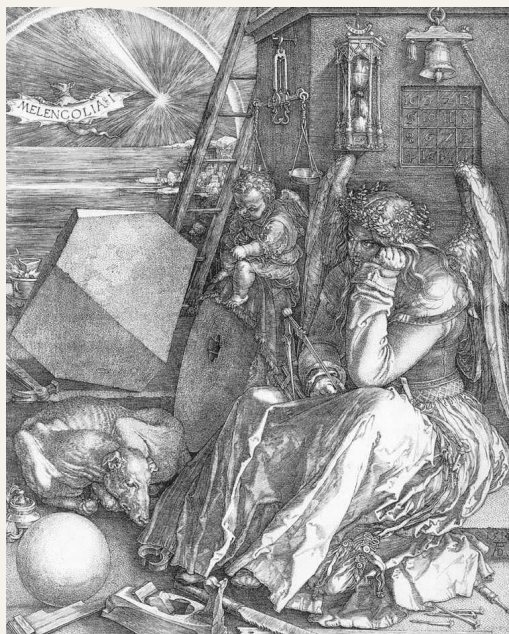


Plate 7. Dürer, *Melencolia I*, 1514. The tools of measurement, and sixteen numerals holding a lattice of sums.

5

THE SQUARE THAT DATES ITSELF

Dürer engraves sixteen numerals and hides the year among them.

In 1514 Albrecht Dürer engraved *Melencolia I*, the brooding angel of the artists and the mathematicians, surrounded by the tools of measurement: compasses, scales, an hourglass, a polyhedron cut strangely, a sphere (Plate 7). High on the wall behind the angel hangs a four-by-four square of numerals, and it is the earliest magic square published in northern European art. Every row sums to thirty-four. So does every column, both diagonals, the four corners, the four centre cells, and each

quadrant. And in the middle of the bottom row, the square quietly signs its own birth certificate: the two central cells read 15 and 14, the year of the engraving, set there like a date stamped in the masonry.

It is worth being precise about why this object belongs in an essay on numerals rather than an essay on magic. The square is sixteen figures doing exactly what positional figures do best, which is to hold more structure than they show. Nothing about the marks themselves is arranged; the arrangement lives entirely in their values, in a lattice of sums that the eye cannot see and the mind cannot miss once told. It is composition conducted purely in number, ornament with no visible ornament, and it hangs on the wall of the picture the way a grid hangs behind a page: invisible in the result, present in every measurement of it.

Dürer's square is also, quietly, a seed. Sixteen cells, one arrangement chosen out of the many thousands of magic squares of order four, and the chosen one encodes its date. A constraint system, a large space of valid solutions, and a selection that carries meaning: an artist in 1514 performing, in copper, the exact gesture this book performs in software every time it is rerolled. The angel looks despondent about it, but the angel had to do the enumeration by hand.

Plate 8. Caslon's
specimen, 1734:
old-style figures
ranged among the
alphabets like citizens
rather than officials.



THE SHAPE OF A FIGURE

Old style and lining, proportional and tabular: the numerals learn to dress.

The figures spent their first European centuries learning to look like text. The numerals of the great old faces behave like lowercase letters: a 0 the size of an o, a 6 and an 8 reaching up like ascenders, a 3 and a 4 and a 7 and a 9 descending below the line like a p or a y. Set inside a sentence they keep the sentence's texture, and a date sits in prose as quietly as a word. William Caslon's famous specimen sheet of 1734 shows them at their best, ranged among the alphabets like citizens rather than

officials (Plate 8). These are the figures typographers call old style, and their manners are the manners of running text.

The nineteenth century, which needed numbers that shouted across a ledger and a timetable and a price list, pushed the figures up to a uniform height and set them on the baseline like a row of capitals: lining figures, all shoulders, made for commerce. Neither kind is better; they are dressed for different rooms. A date inside a paragraph wants old style. A column of sums wants lining. The mistake is only ever to send one into the other's room, where the old-style figures look like they have slouched and the lining figures look like they are selling something.

The width of a column of sums

There is a second wardrobe distinction, invisible until it is violated. Proportional figures take each their natural width, a 1 narrower than an 8, which is right for prose; tabular figures all share one fixed width, so that in a column of sums the tens stand over the tens and the units over the units, row after row. Tabular setting is the ledger's demand carried into type: a column of numbers is a positional system twice over, once inside each numeral string and once down the page, and both positions must hold. This book sets its own page numbers and its measurements in tabular figures for exactly that reason. And one last costume note, from the dials of clocks: the four on a clock face is traditionally written IIII rather than IV, a convention as old as the dials themselves, whose explanations are many, confident, and mutually contradictory. Typography keeps both kinds of convention, the load-bearing and the merely worn.

7

THE NUMBER OF THE PAGE

Foliation, pagination, and the little figure that runs the book.

The humblest numeral in the world is the page number, and it is the one this book cares for most. Printers arrived at it slowly: many early printed books numbered leaves rather than pages, one figure for each sheet's front and nothing for its back, foliation rather than pagination, and readers navigated by recto and verso the way one navigates a street with numbers on only one side. Numbering every page, so that a citation lands on a page rather than in its neighbourhood, took decades to become a habit. Which is a reminder that even the most obvious apparatus was once an invention, argued about, adopted unevenly, and finally made so ordinary that it became invisible.

Josef Müller-Brockmann, whose rules govern the pages you are holding, treats the folio with the seriousness other designers save for title pages. Where may the page number stand, he asks, and answers with positions and measurements: set off from the type area by one line of leading if below, its distance fixed, its position constant from page to page, because a wandering folio is a small lie about where the reader is. In one of his worked grids the page number is placed below the type area at the beginning of the second column of

type, with two lines of leading. Not near the second column. At it, with two lines, a rule with a dimension, for the least glamorous object on the page. That is the whole Swiss faith in one instruction: nothing is beneath measurement.

This book obeys him. Its folios stand at the outer edge, in tabular figures, mirrored recto and verso, and they were placed by the same programme that placed everything else. Which brings the essay to its last numeral. Somewhere in the machinery that composed these pages there is one more figure you cannot see: the seed, the small number that chose this arrangement out of every arrangement the rules permit. Change it and the pictures walk, the columns rebalance, the titles choose new clothes, and every page number ends up under a different last line, correct in exactly the same way. The pebble, the tally, the zero, the ledger, the magic square, the folio: the whole history of the numeral is the history of trusting a mark to hold a position. The seed is simply the newest mark, and the position it holds is the book.

Set in Constantia, 10 on 13, whose figures are old style, with titles in Bahnschrift on a five-column grid of forty fields; two columns of text, one column of captions, mirrored margins, folios at the fore edge in tabular figures. Composed by programme from a space of valid books; this is seed "numeral-3". Chapter titles stand on two body lines and their numerals on three, on the cross-size register of a thirteen-point module. All plates public domain, via Wikimedia Commons. Plate 1: Adam Ries. Plate 2: Encyclopædia Britannica, 11th ed.. Plate 3: J. M. W. Turner. Plate 4: Liber abbaci magliab f124r. Plate 5: Gregor Reisch (author) / illustrator unidentified. Plate 6: Attributed to Jacopo de' Barbari. Plate 7: Albrecht Dürer. Plate 8: William Caslon. Typeset by GEVIERT, das Geviert, the em quad.