VPAS 3340.501 (81942)
Writing in the Arts
Fall 2020
Dr. Charissa N. Terranova
University of Texas at Dallas
Arts & Humanities

Module 0.9 Early Computer Art: The Stuttgart School
Tuesday November 3 Professor Lecture

- Reading: Christopher Klütsch, "Information Aesthetics and the Stuttgart School," *Mainframe Experimentalism*, 65-89.

Module 9 Early Computer Art: The Stuttgart School 11/03/2020-11/11/2020

Tuesday November 3 4 pm

- Professor Lecture
- Reading: Christopher Klütsch, "Information Aesthetics and the Stuttgart School," *Mainframe Experimentalism*, 65-89.

Friday November 6 10 am

- Submit first draft of 500-word essay to peer-editor

Monday November 9 10 am

- Peer-editor returns 500-word essay

Wednesday November 11 10 am

- Final polished 500-word essay due to professor

The new deadline for the extra credit assignment is Monday November 23 at 10 am.

Generativity – Digital and Biological

Generativity, Recursion, and Feedback Loops

Generativity in Art – Digital and Biological…towards the death of the “masterpiece”

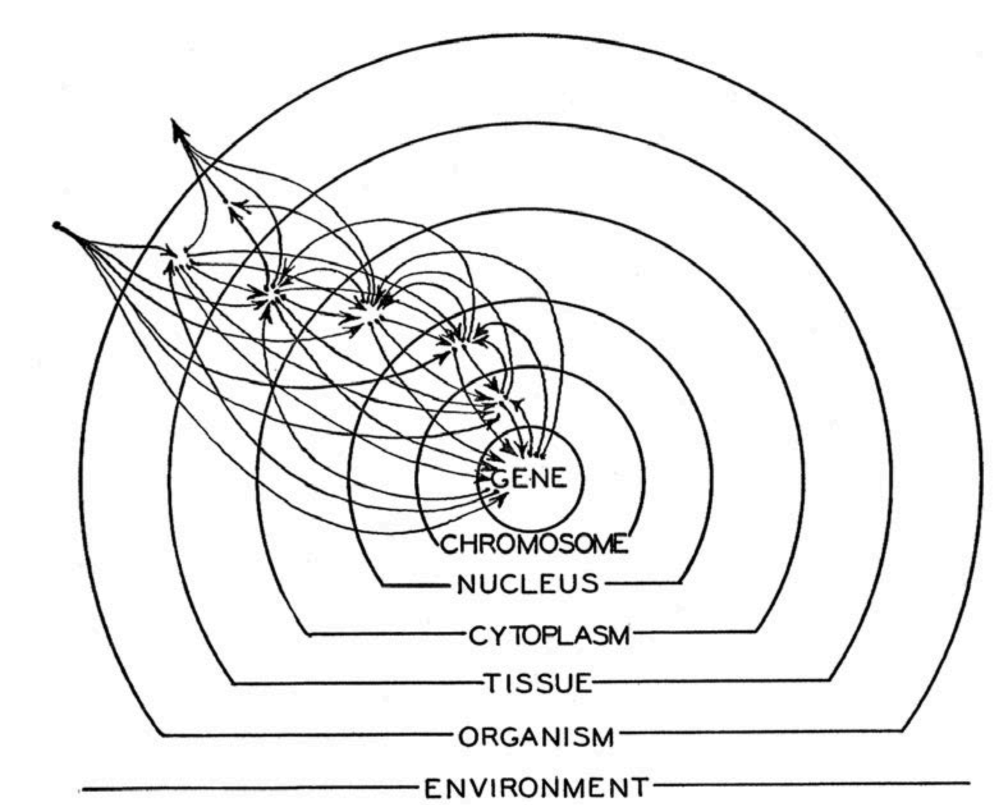
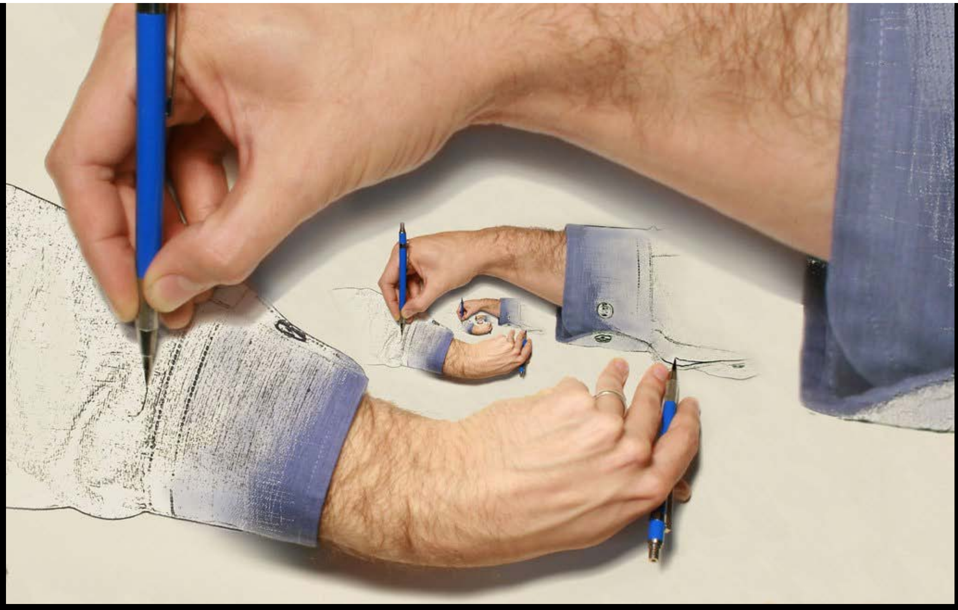


Fig. 6. Relations Diagram for Hierarchical Organization of the Body

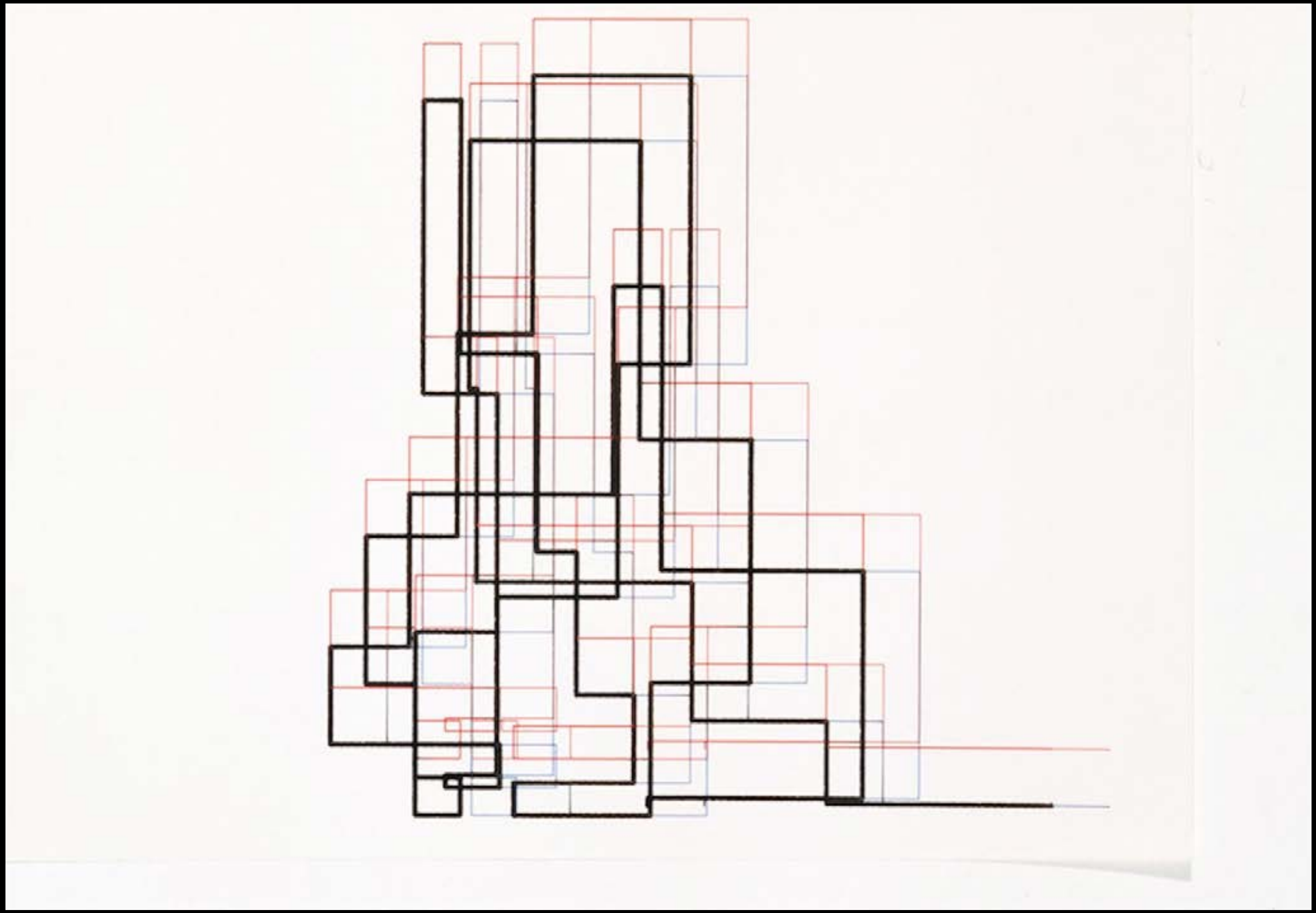


What is a “masterpiece?
Who are the “great masters?

Masterpiece: a work of outstanding artistry, skill, or workmanship; The word “masterpiece” refers to works of art made by “masters” of their medium.

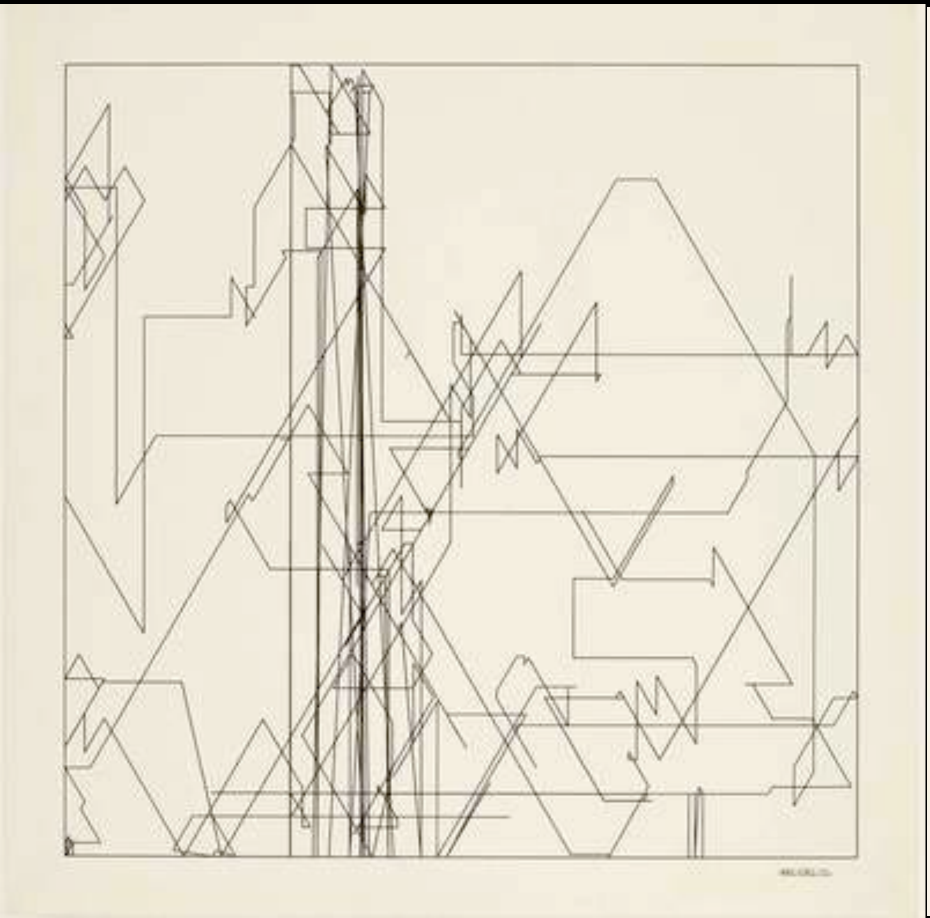
Great Master:
a: one held to be among the greatest or most skilled in one of the arts
b: a work of such a one especially in painting

The term “great masters” usually refers to painters of the Renaissance or Baroque period.

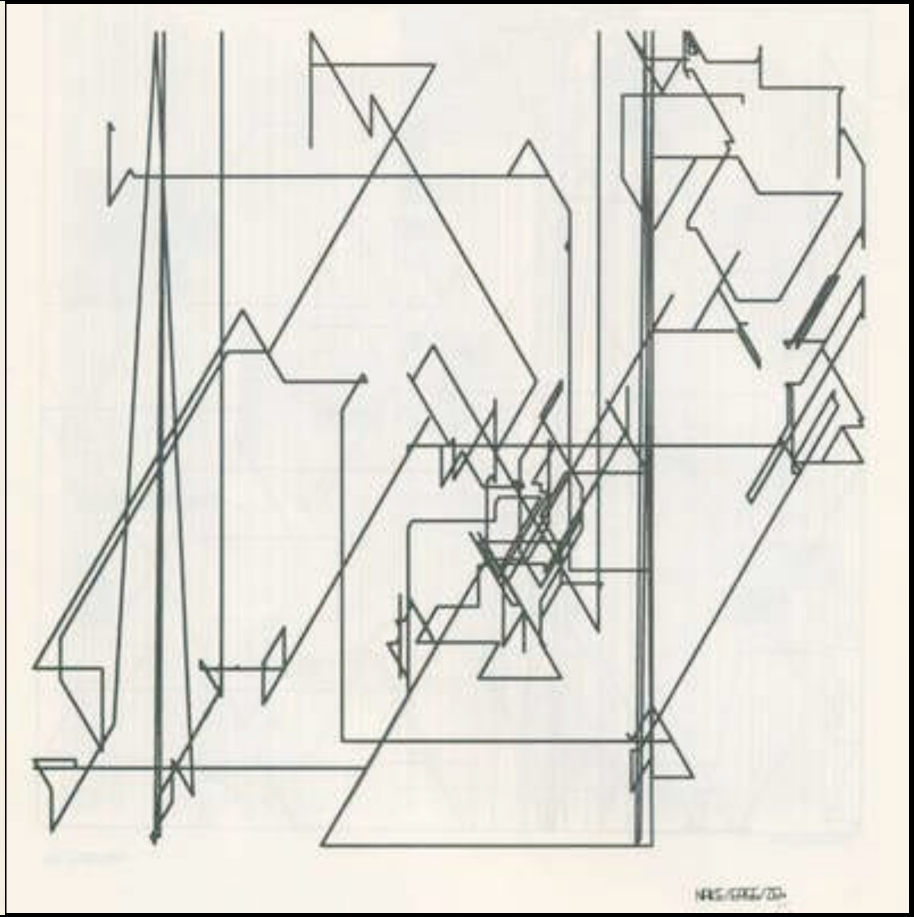


Frieder Nake, Zufälliger Polygonzug (Random Polygon Line), 1965

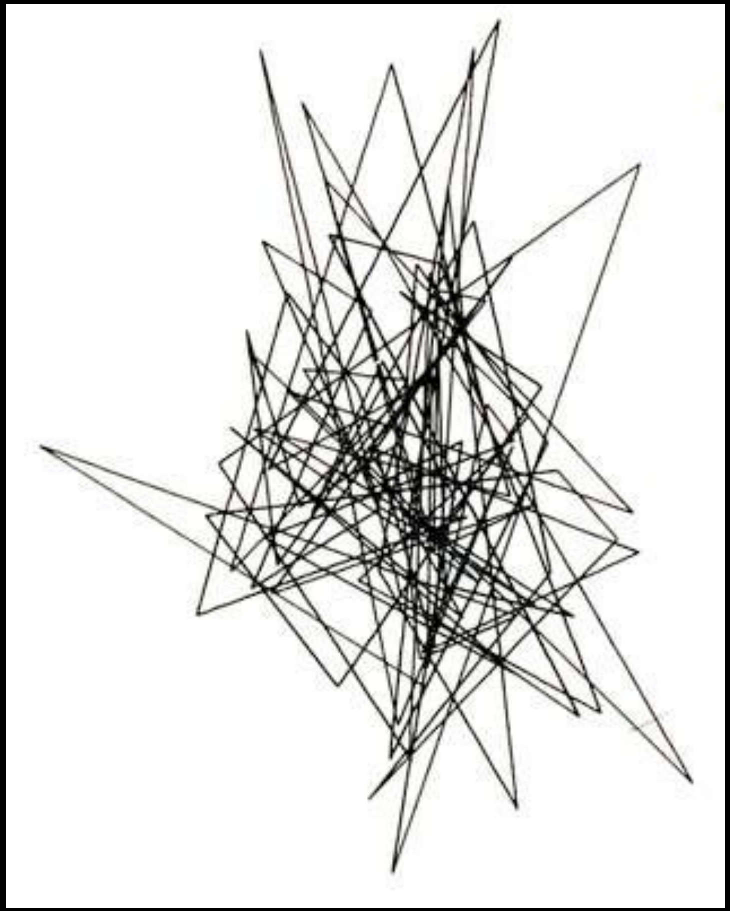
Frieder Nake (1938-) – member of the Stuttgart School
https://www.youtube.com/watch?v=UVtpAnvBXtM



Frieder Nake, Random Polygon, 1965



Frieder Nake, Polygonal Course No. 7, 1965



Frieder Nake, Polygonal Course No. 20, 1965

What is the Stuttgart School?

- The Stuttgart School, also referred to as Stuttgart Group, was an informal network of mathematicians, computer programmers, and artists, including Abraham Moles, Max Bense, Georg Nees, and Frieder Nake, which coalesced around 1960 in Stuttgart, Germany.
- The term was coined to name people doing literary experiments, especially **Concrete** Poetry, typography, and research on semiotics or Information Aesthetics with Max Bense as mentor and driving force.
- The group also sought to promote the "impersonal" and – in Bense's terms – "artificial poetry": so-called stochastic (chance-oriented) texts generated with the help of mainframe computers.
- The Stuttgart School's main achievements included the theory of "concrete poetry."

http://dada.compart-bremen.de/item/institution/265

We’ve been working on musique concrète and concretism in art in this class.

What is concrete poetry?

In order to create concrete poetry, artists use onomatopoeia (ex: bang, bark, buzz, bow-wow, etc.) and the arrangement of letters on the page for effect. In concrete poetry, artists arrange poetry according to mathematical principles.

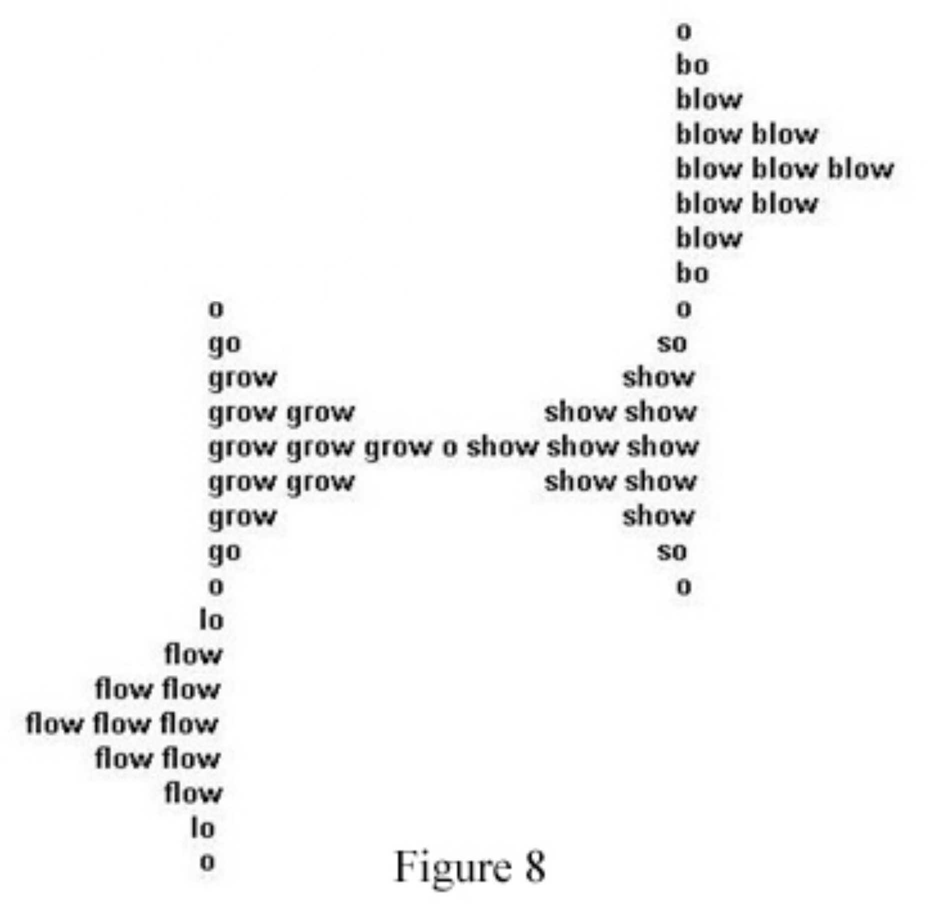
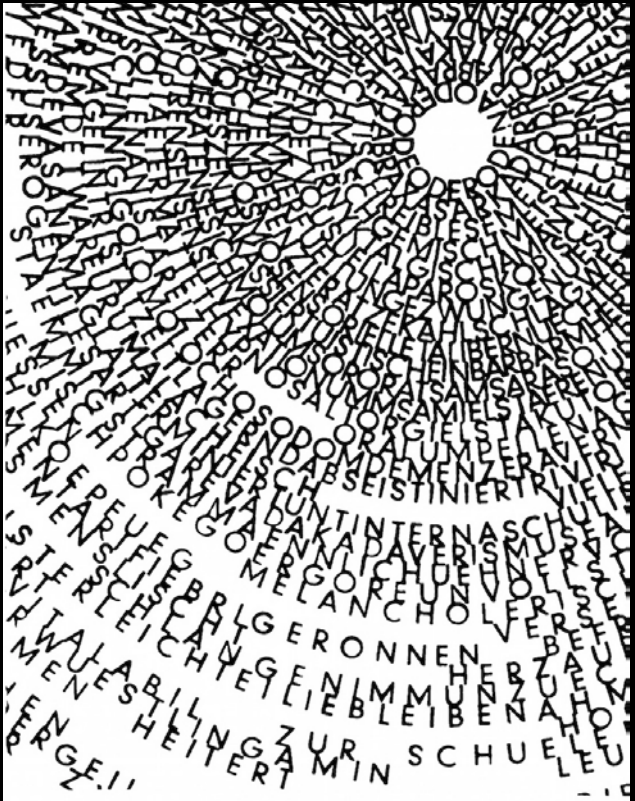
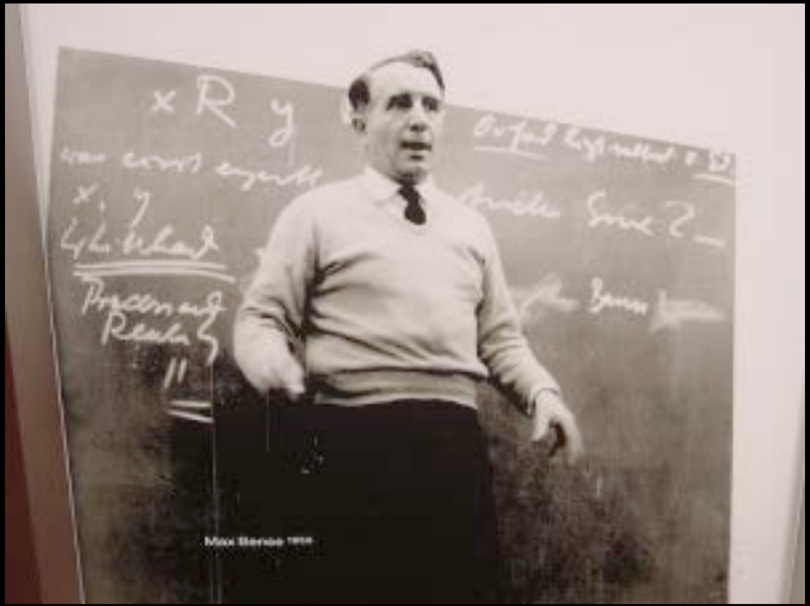


Figure 8

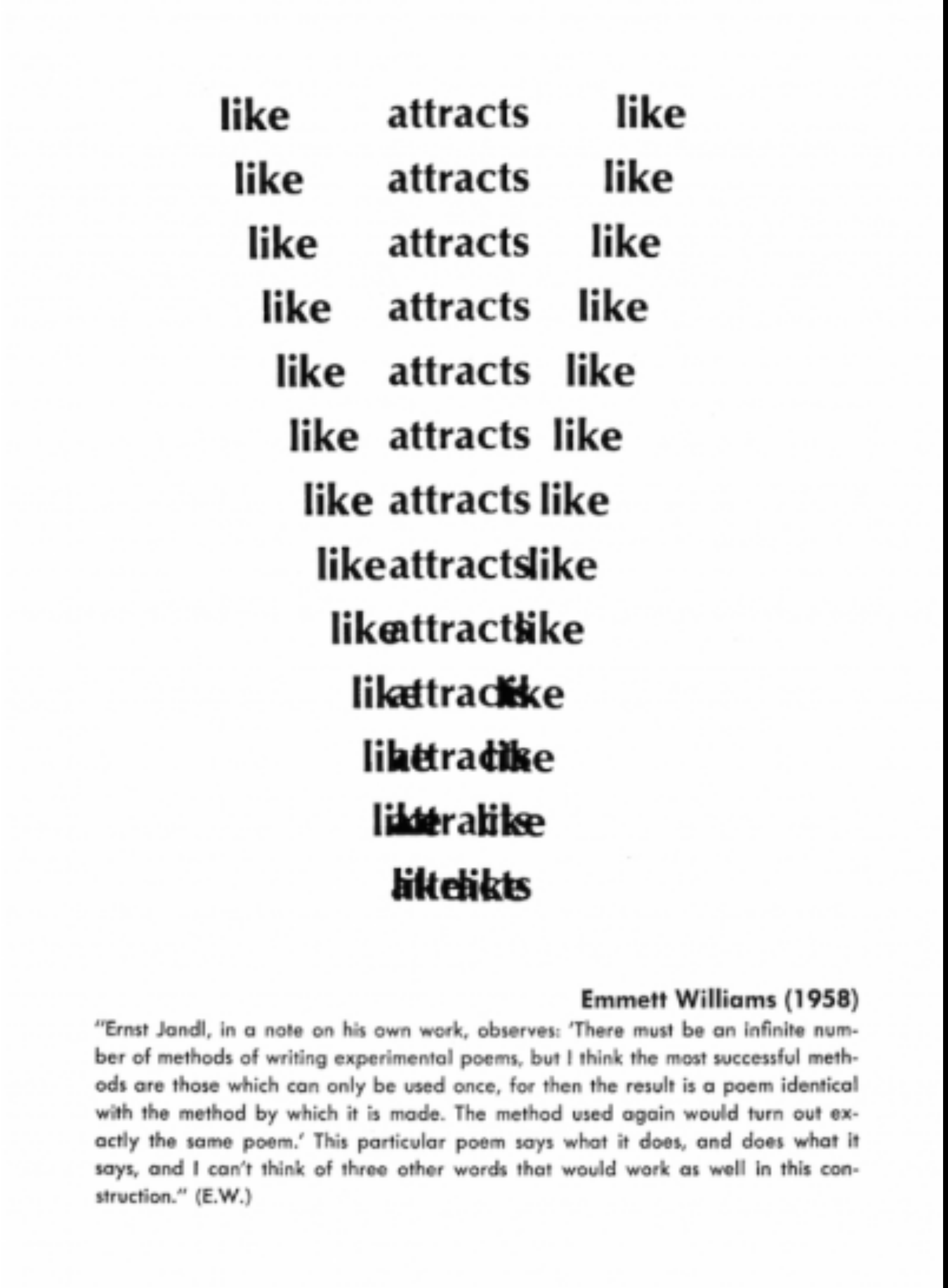

Ferdinand Kriwet, "ZUVERSPAETCETERANDFIGURINNENNENS-WERT OLLOS" (1962)
A detail, full-scale.


Max Bense [1910-1990]

Concrete Poetry

Information Aesthetics

Filippo Marinetti, Montage + Vallate + Strade x Joffre, (Futurist poetry) 1915

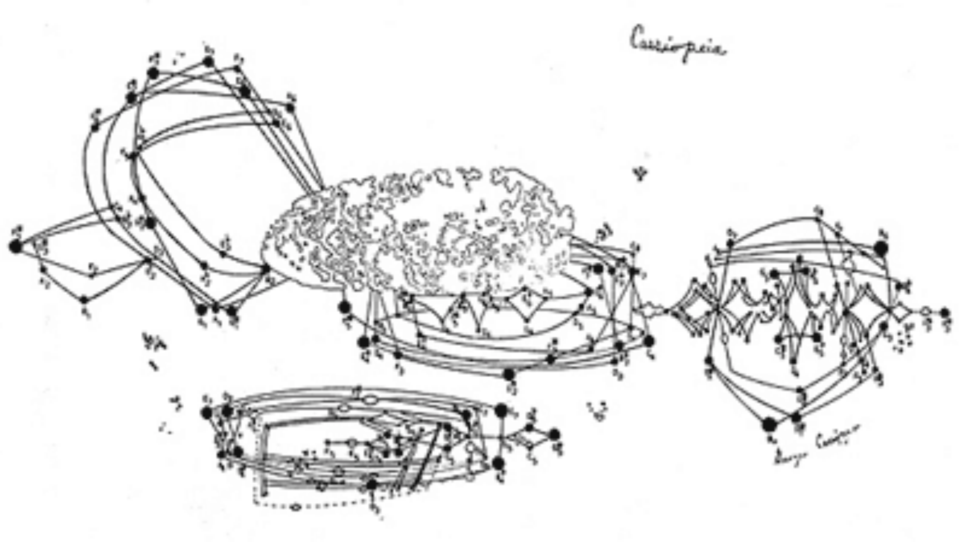


like attracts like
like attracts like
like attracts like
like attracts like
like attracts like
like attracts like
like attracts like
likeattractslike
likeattractslike
[illegible]
[illegible]
[illegible]
[illegible]

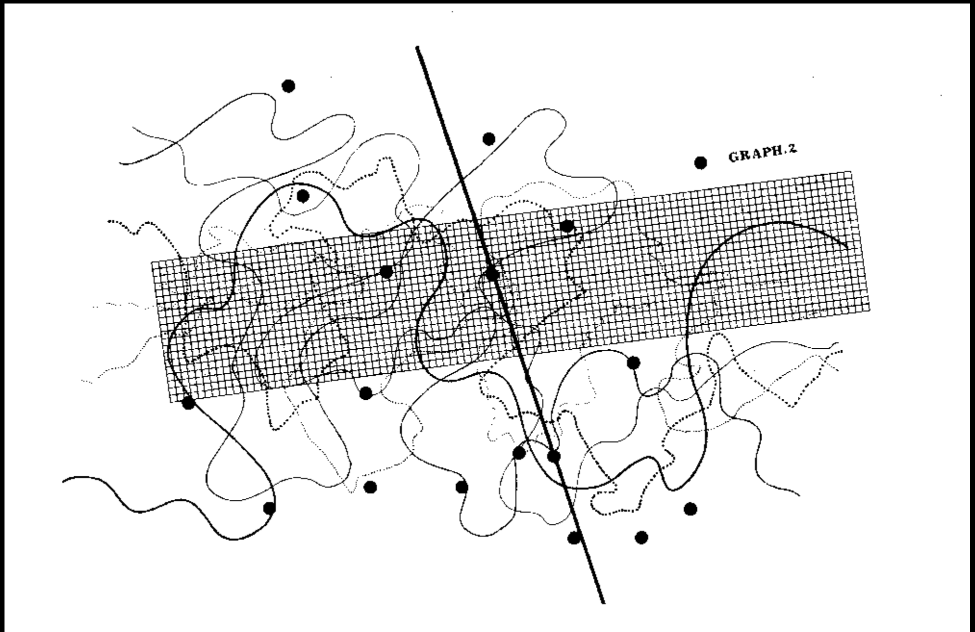
Emmett Williams (1958)

"Ernst Jandl, in a note on his own work, observes: 'There must be an infinite number of methods of writing experimental poems, but I think the most successful methods are those which can only be used once, for then the result is a poem identical with the method by which it is made. The method used again would turn out exactly the same poem.' This particular poem says what it does, and does what it says, and I can't think of three other words that would work as well in this construction." (E.W.)

John Cage, New School for Social Research, 1956-1960



George Gacioppo, Cassiopeia, sound pictogram, 1962



John Cage, Fontana Mix, sound pictogram, 1958

Max Bense (1910-1990)

- Studied physics, chemistry, mathematics, geology, and philosophy
- Dissertation: "Quantenmechanik und Daseinsrelativität" (*Quantum Mechanics and Relativity of Dasein* [presence/being there])
- Philosopher, writer, educator – Professor at University of Stuttgart, Ulm School of Design, Hamburg College of Visual Arts
- Brought together math and aesthetics
- Investigated mathematical principles of form in the history of art
- His thoughts assumed the correlation of a mathematical and linguistic consciousness, which have a common origin and have grown into complementary modes of thought
- Ethics of technology: considered the destruction of the social and intellectual middle-class world since the beginning of the 20th century
- He developed a *synthetic intellectual concept,* where classical humanism and modern technology constructively complement one another

Herbert Franke on Max Bense (1910-1990)

The most influential champion of exact aesthetics* is the German philosopher and mathematician Max Bense. In his writings particularly in his work *The Programming of the Beautiful*, Bense already anticipated the principle that was to be fulfilled at a later date in computer art…

Information Aesthetics: An aesthetic measure based on complexity and information

Bense saw the artistic process as a kind of anti-process of natural phenomena, along the line that nature tends to bring forth chaos, whilst art permits emergence of unlikely conditions of order…[entropy versus negentropy]

*Exact aesthetics is a challenging field of the computer-aided visual creativity, reconstructing the methods of design and criticism on an algorithmic basis and integrating a computer into processes of an artistic creation and aesthetic evaluation. The discipline involves principles of mathematics, geometry, theory of communication, perceptual psychology, computer graphics, or generative arts into classifying and assessing the aesthetic phenomena.

In the mid-1960s, a number of artist-scientists emerged from Stutggart who deployed computers in order to explore an "information aesthetic." The most influential of these artists was (philosopher and logician) Max Bense, who popularized the idealization of an objective aesthetic based on scientific principles, as well as the usage of a formula for measuring the aesthetic values of art.

Bense adopted this formula from David Birkhoff, who explored similar concepts of aesthetic measurement. The formula defines the aesthetic measurement M as a ratio of order O to Complexity.

$$M = O / C$$

Measurement = Order to Complexity

Algorithms and Constraints in Art

algorithm, noun: a procedure for solving a mathematical problem in a finite number of steps that frequently involves repetition of an operation; *broadly* : a step-by-step procedure for solving a problem or accomplishing some end especially by a computer

Etymology: 1690s, "Arabic system of computation," from French algorithme, refashioned (under mistaken connection with Greek arithmos "number") from Old French algorisme "the Arabic numeral system" (13c.), from Medieval Latin algorismus, a mangled transliteration of Arabic **al-Khwarizmi** "native of Khwarazm" (modern Khiva in Uzbekistan), surname of the mathematician whose works introduced sophisticated mathematics to the West

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Generativity, Recursion, and Feedback Loops

Generativity in Art – Digital and Biological…towards the death of the "masterpiece"

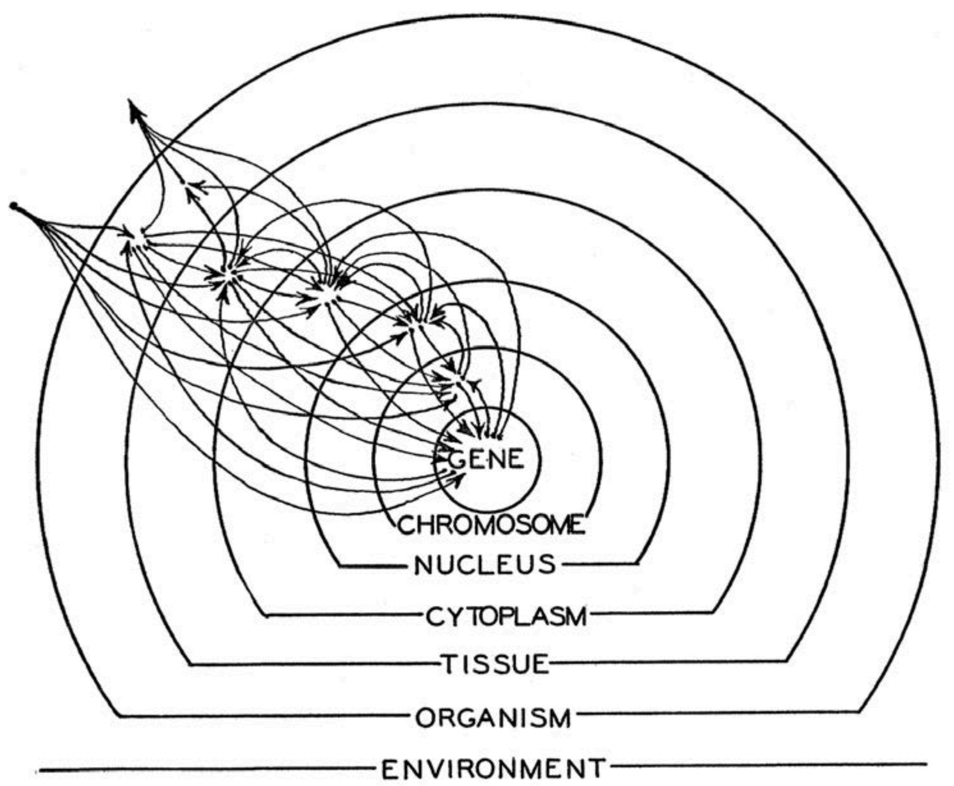
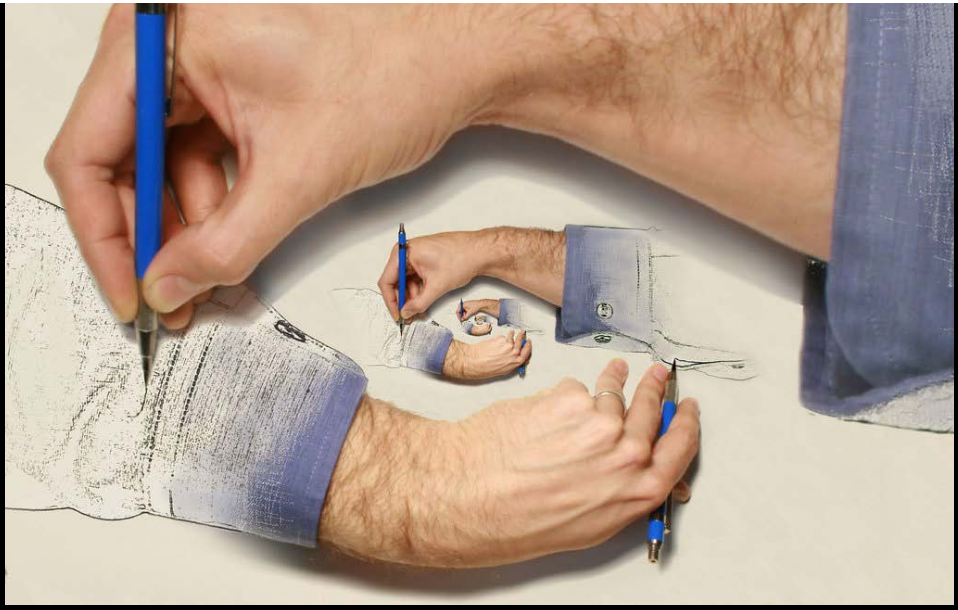
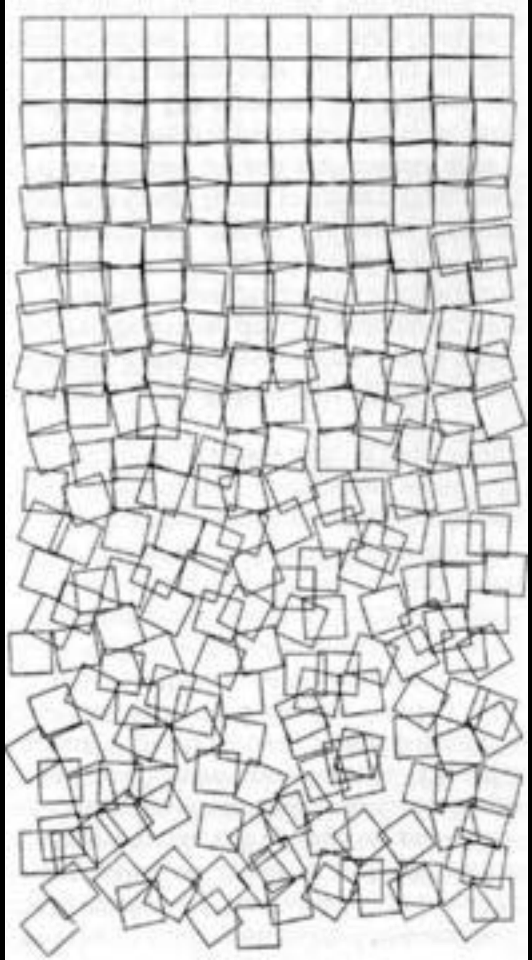


FIG. 6. RELATIONS DIAGRAM FOR HIERARCHICAL ORGANIZATION OF THE BODY

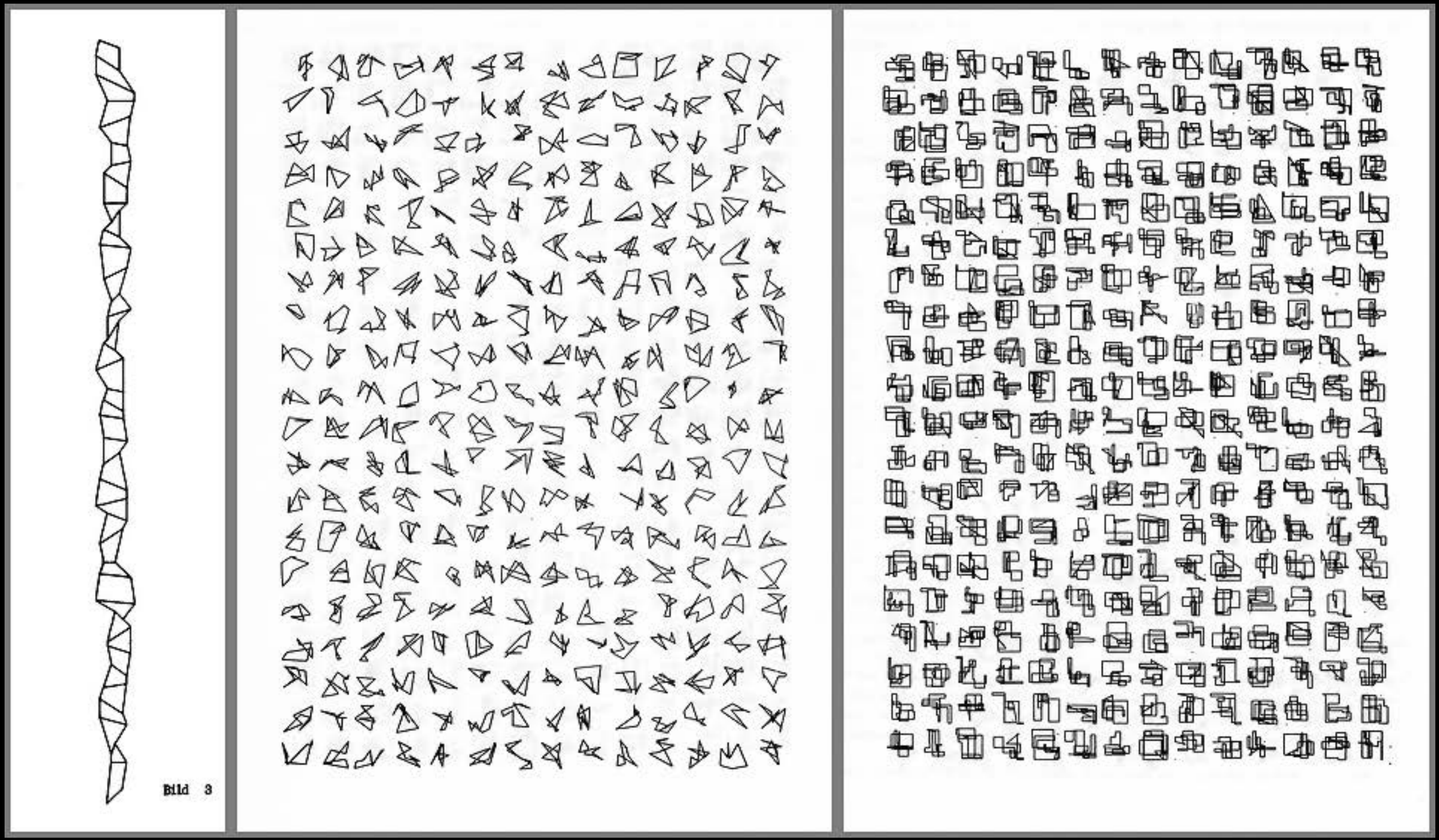


Georg Nees (1926-2016)



Georg Nees, "Schotter," 1965

"Schotter" is a computer graphic from the 1960s, produced by a structured operation by random generators that lead to the discovery of new images. This graphic visually displays the relationship between order and disorder, and the effects of change.



Georg Nees, Images in GrKG vol.5 Nr 3/4, 1964

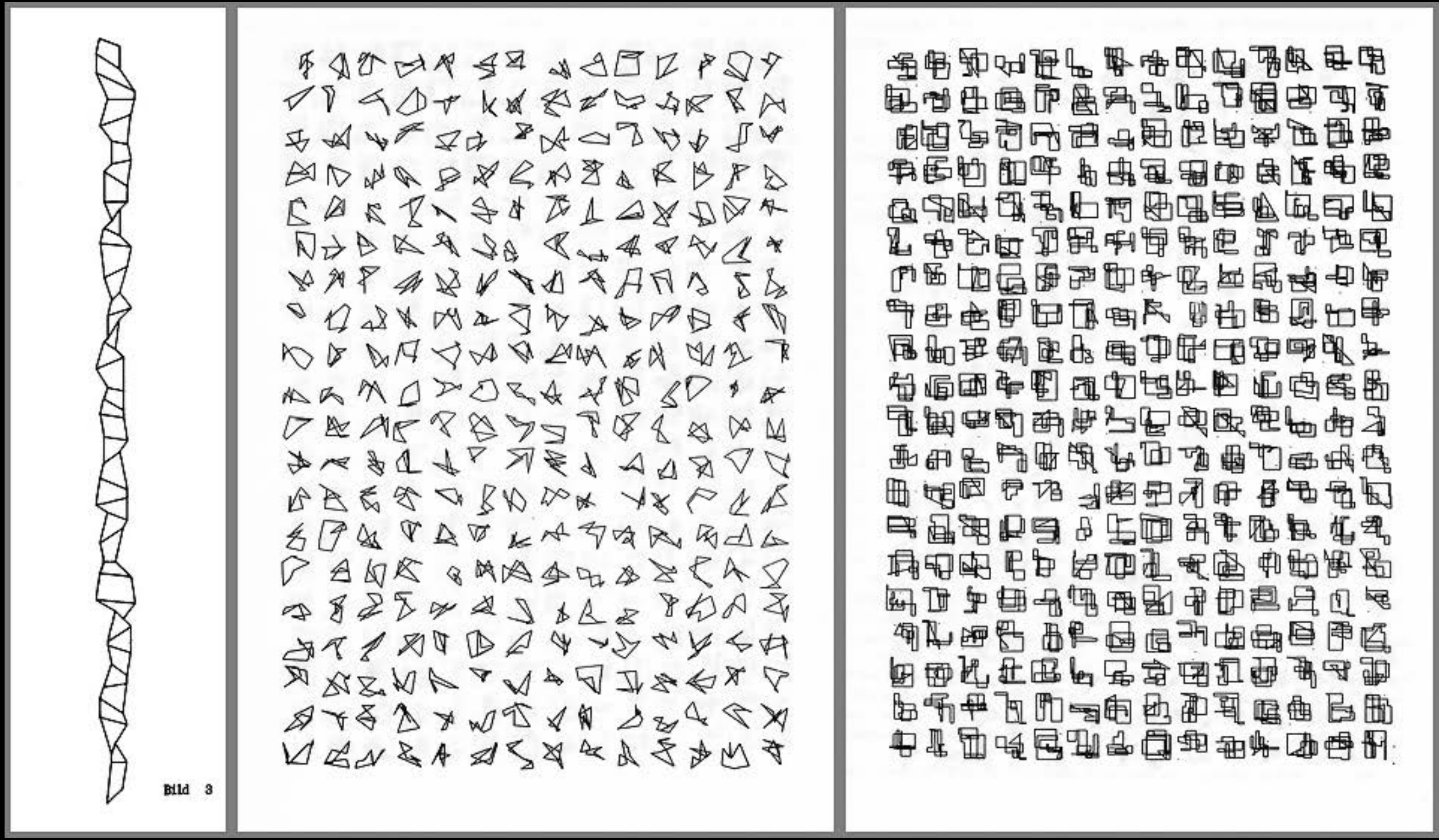
Georg Nees (1926-2016)

- Nees started to work at Siemens in 1951 and learned programming in Algol on Siemens 2002 computer in 1959. He was assigned to the new Siemens research center in 1960. In the winter of 1963-64, a Siemens colleague gave Nees the first seven issues of the new journal *Fundamental studies of Cybernetics and Humanities* (GrKG) and he found Max Bense's papers. In those days Bense had mentioned the idea of pictures as a subject for his information aesthetics, but his primary interest was in texts.

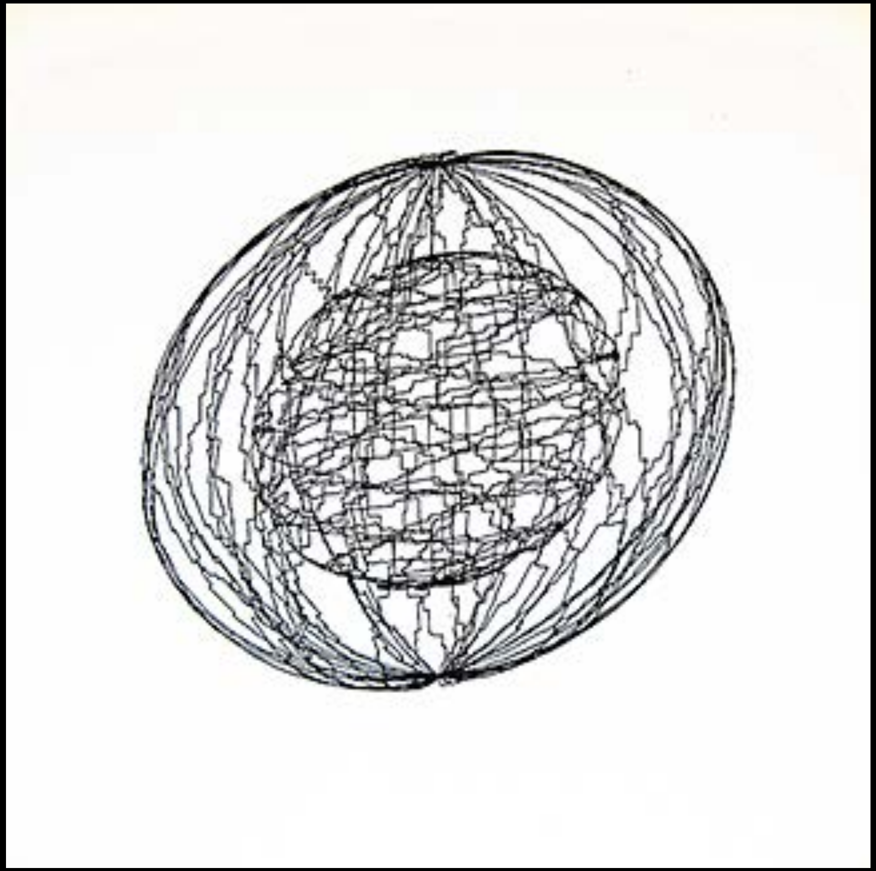
- In 1964, the computer center bought the Zuse Graphomat drawing table. This was used for the simulation of cutter paths for NC machines, but it provided Nees with the opportunity to make abstract drawings. His first drawings were produced in the fall of 1964.

- Nees was editor of *Fundamental studies of Cybernetics and Humanities.*

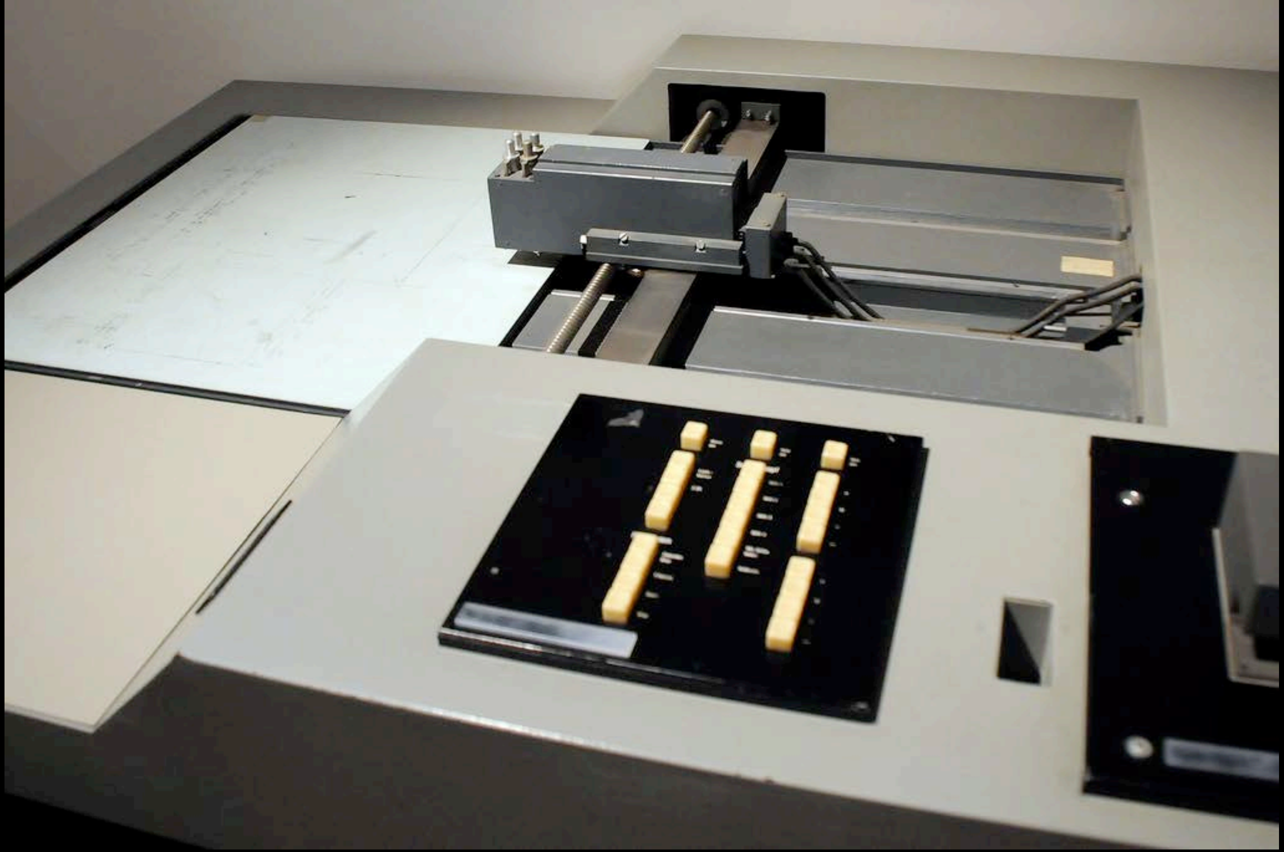
- On December 20, 1964, Nees wrote a letter to Bense including about a dozen computer drawings. Bense invited him to a colloquium at his institute. Two surprises were waiting for Nees in Stuttgart. A publication dated February 1965, rot 19, edited by Bense and Elisabeth Walther, included six drawings by Nees with his note, and a statement by Bense inaugurating the **generative aesthetics**. Second was the exhibition of his drawings at the Studio Gallery at the Technical University of Stuttgart. This is generally acknowledged as the first exhibition of digital computer graphics. A colloquium with known invited artists from the Stuttgart area on February 5th aroused much controversy.



Georg Nees, Images in GrKG vol.5 Nr 3/4, 1964



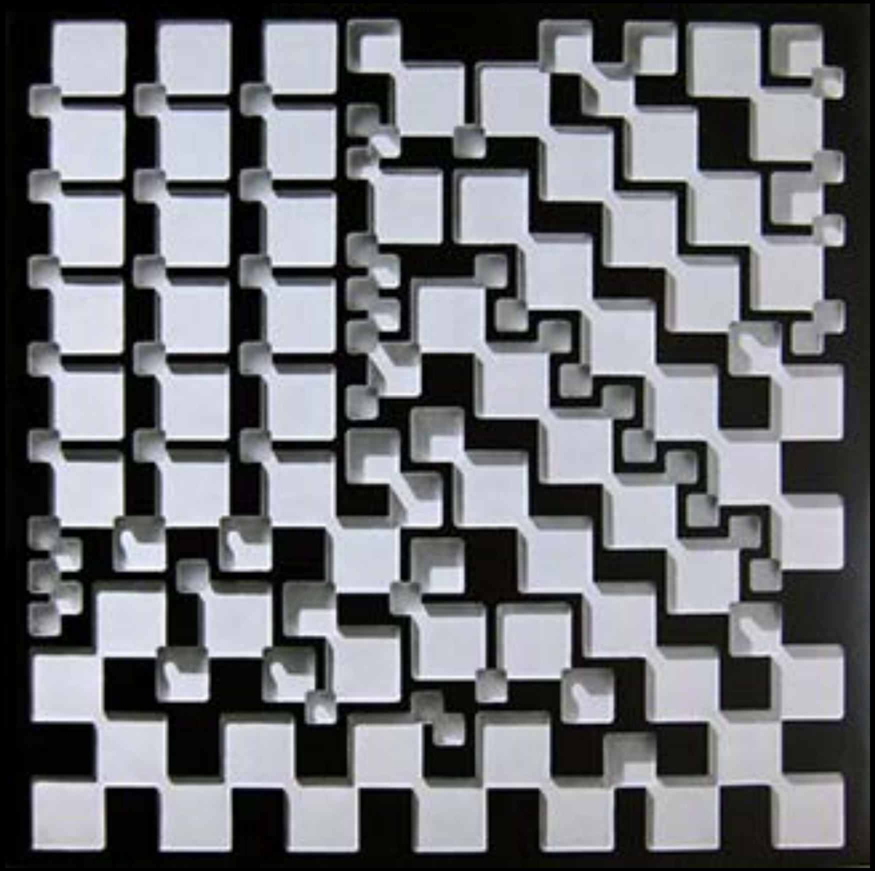
Georg Nees, Sphere in a Sphere, offset lithography after plotter drawing, 1970; Idea and program by Nees, generated around 1969 with Siemens 2002, programmed in ALGOL and drawn on a ZUSE-Graphomat plotter

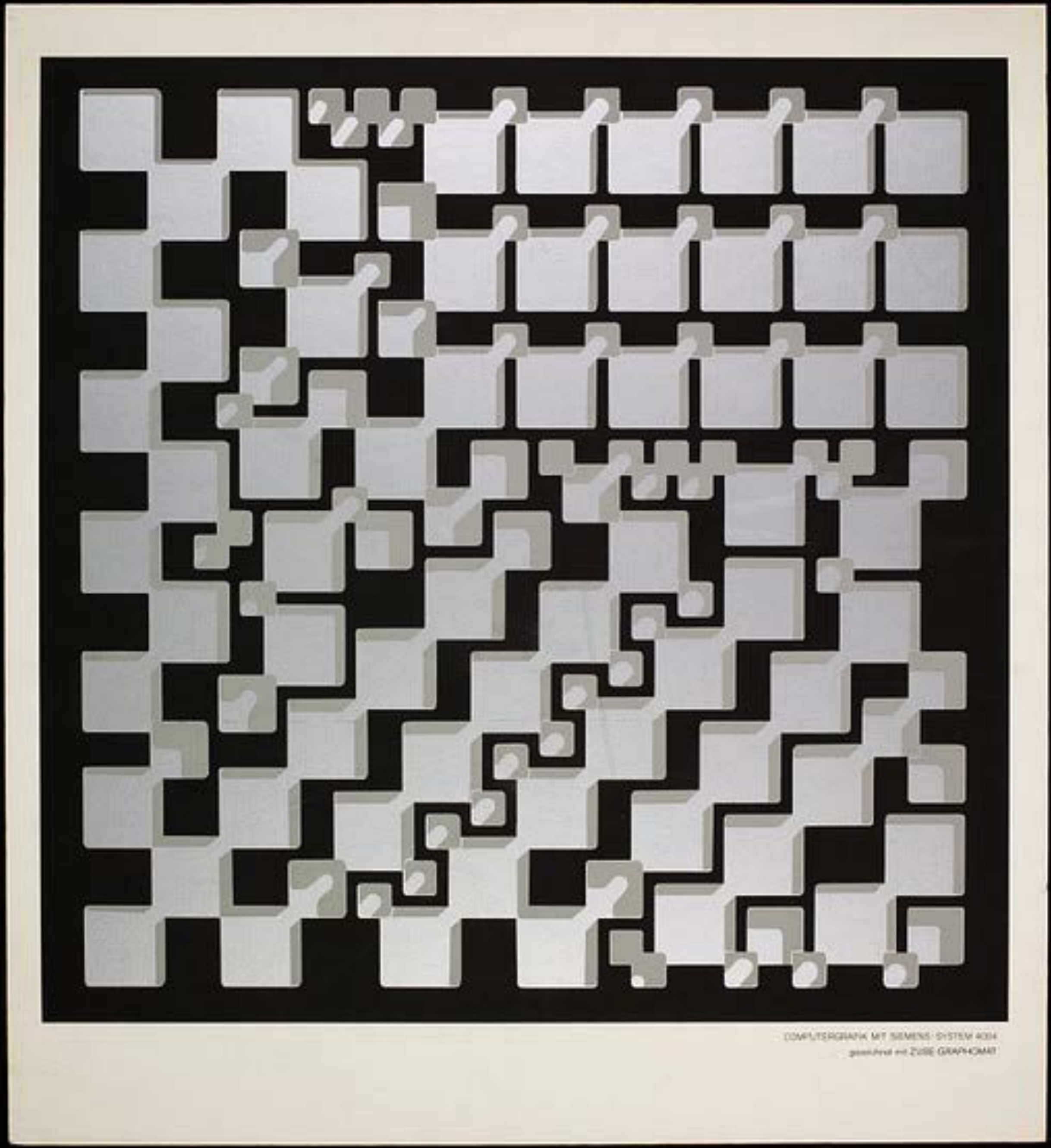


ZUSE Graphomat Z 64

The ZUSE Graphomat Z64 was a flatbed drawing machine of high precision. Its engineer, famous computer pioneer Konrad Zuse, had originally intended it to be used for the production of maps and for land registration purposes. Both Georg Nees and Frieder Nake did their first computer art pieces on the Graphomat. This historic fact may be seen as a case of an unintended use of a technical innovation. ’The Graphomat Z64 was fully based on transistor technology. It was controlled by a code that had to be input on punch tape or punch cards. The machine was first presented in 1961 at the Hannover Fair. Even though the first set of machines was ordered within a relatively short period of time, it did not become a great financial success.

http://dada.compart-bremen.de/item/device/5



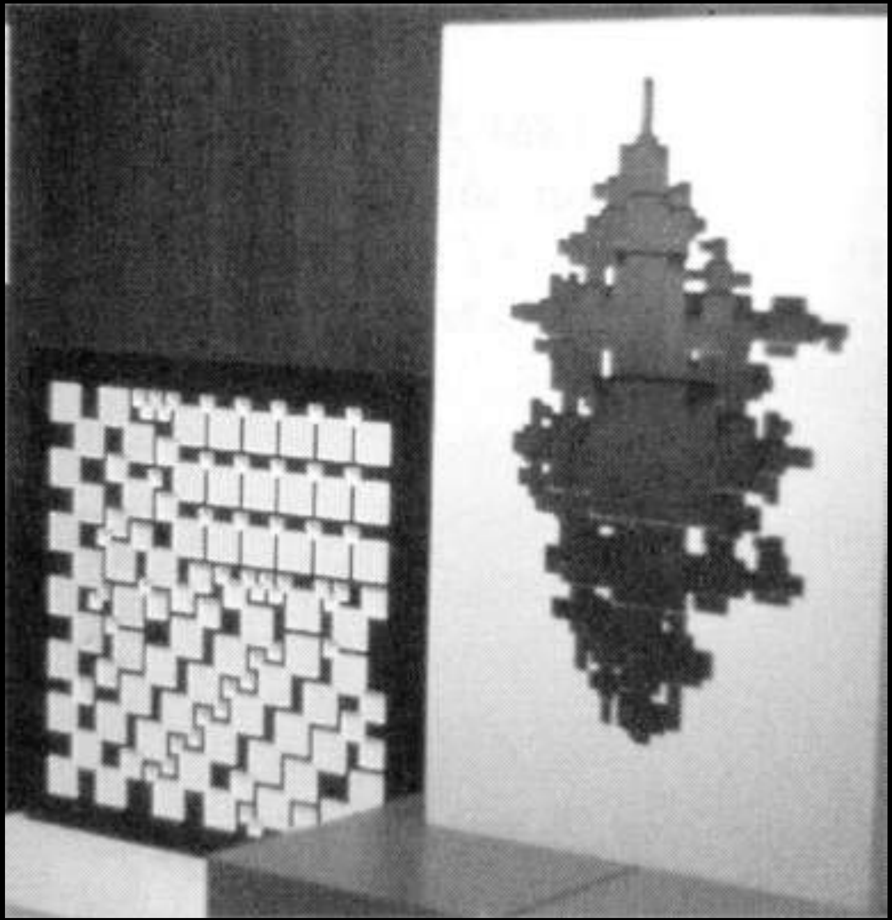


Left: Georg Nees, Sculpture 1, 1970 – Offset lithography after photograph of wood
Right: Georg Nees, Sculpture, 1968 – Screenprint after a computer milled aluminum plate

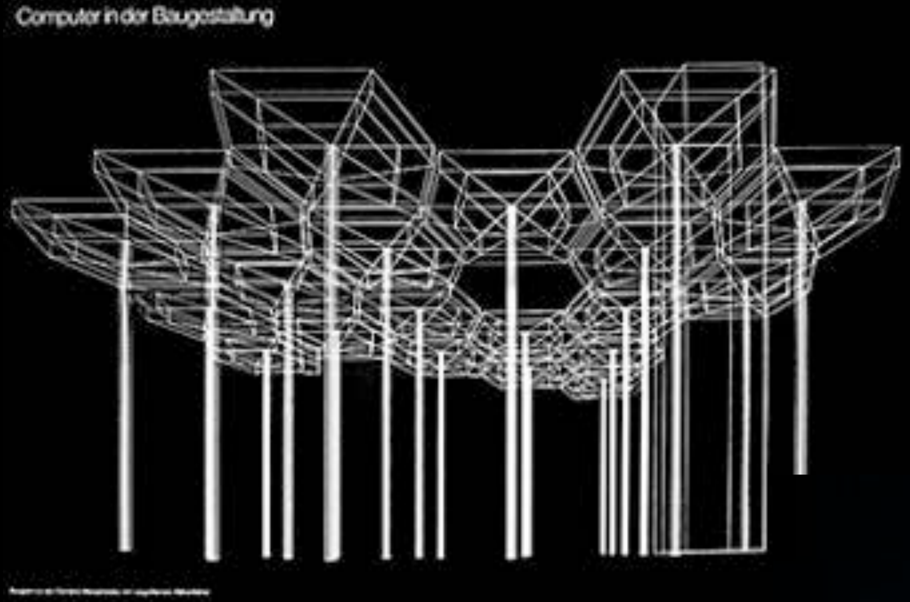
Idea and program by Georg Nees; Sculpture generated between 1965 and 1968 with a Siemens-system 2002 and 2004 programmed in EXAP-1 for a Sinumerik milling machine.

The first computer-generated sculpture in 1968 using a computer aided milling machine.

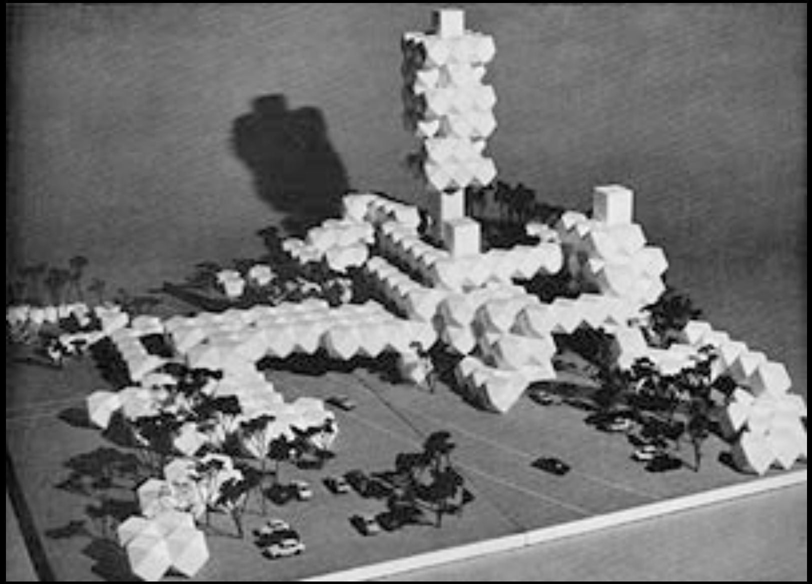
Georg Nees, 4SPAL Concept Sculpture, 1968

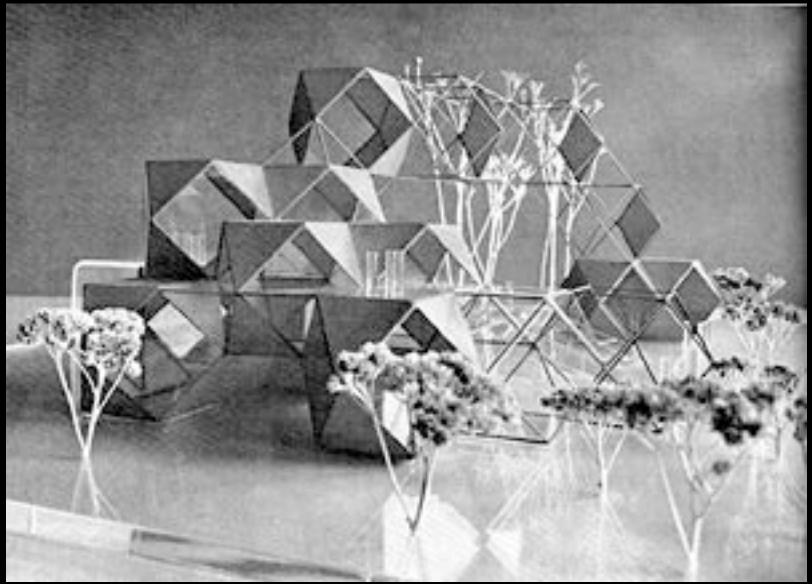


Architecture-Computation collaborations between Georg Nees and Ludwig Rase

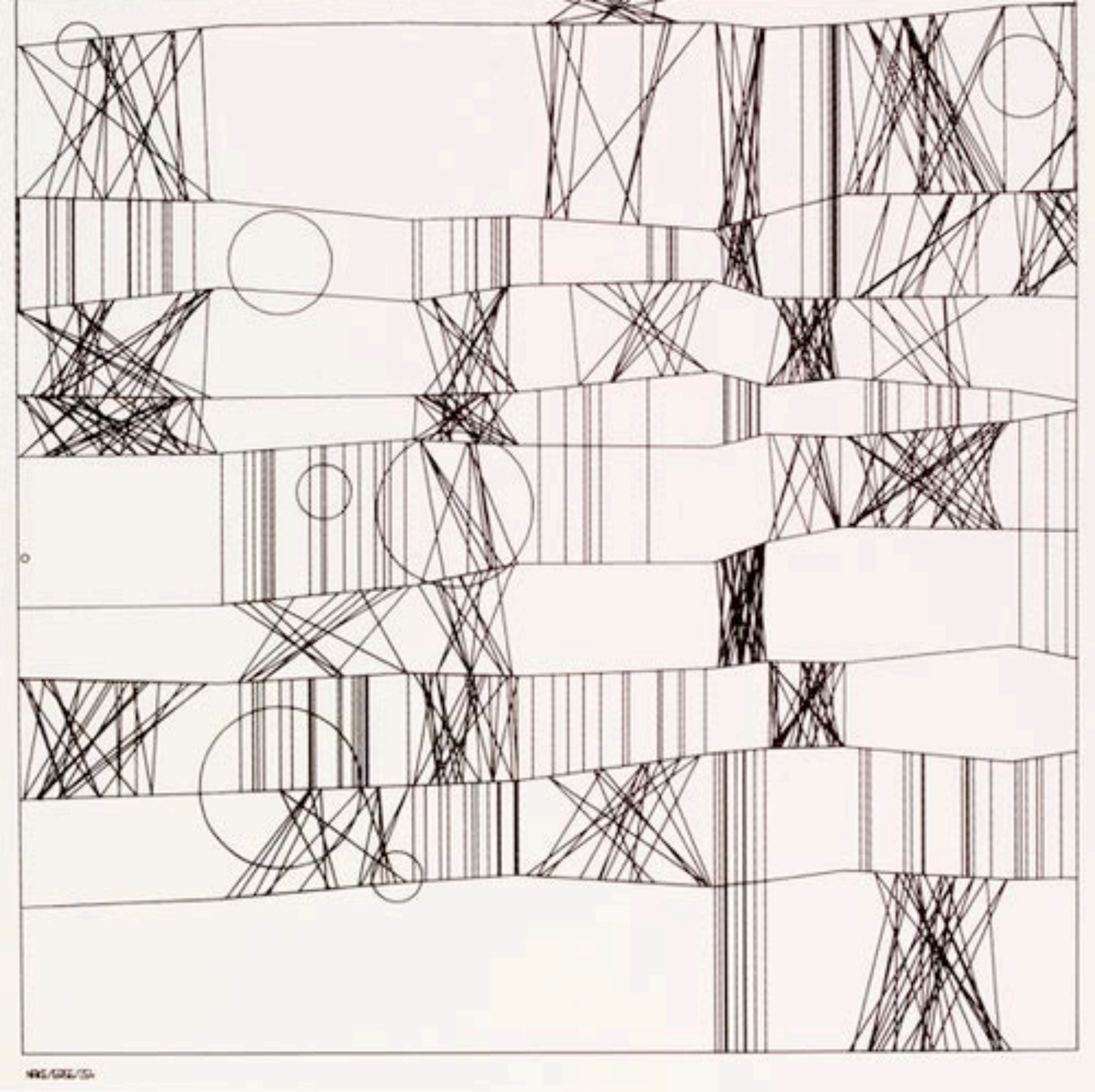


Left: Siemens Exhibition Hall, 1970
Center: Poster for Computer Art Exhibition in Hamburg, 1972-73
Top Right: Modular City Structure
Bottom Right: Cuboctaehdron (polyhedron with 8 triangular faces and 6 square faces) Structure

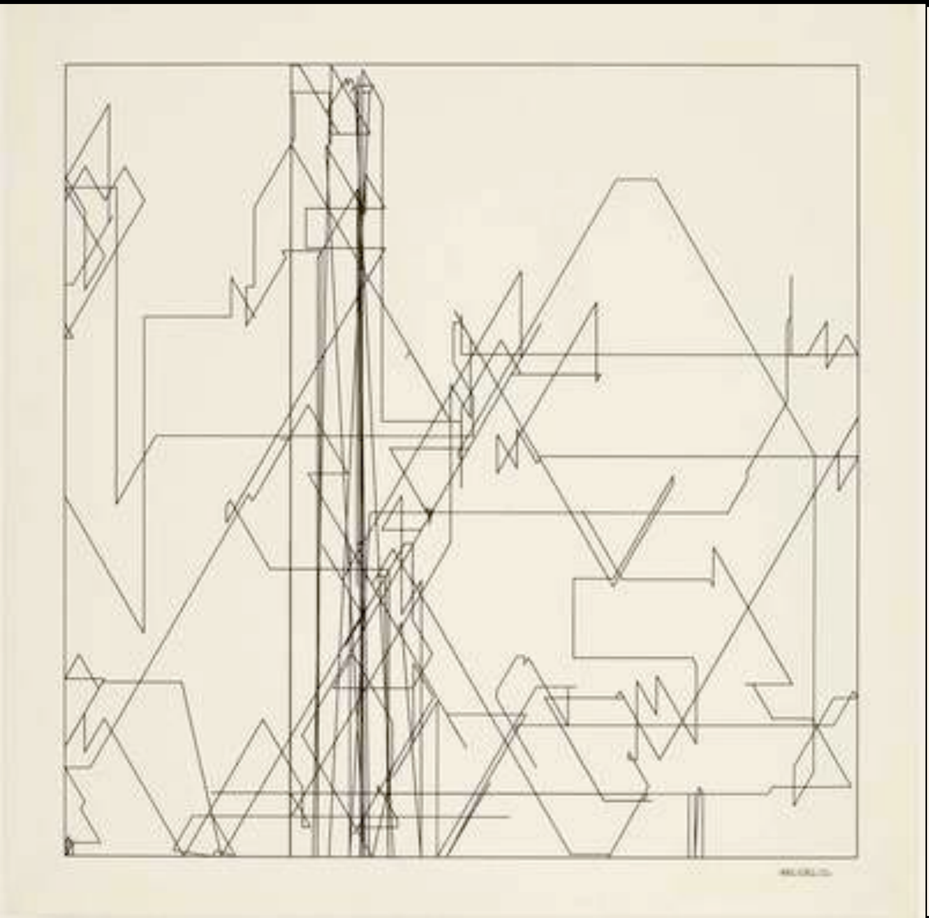




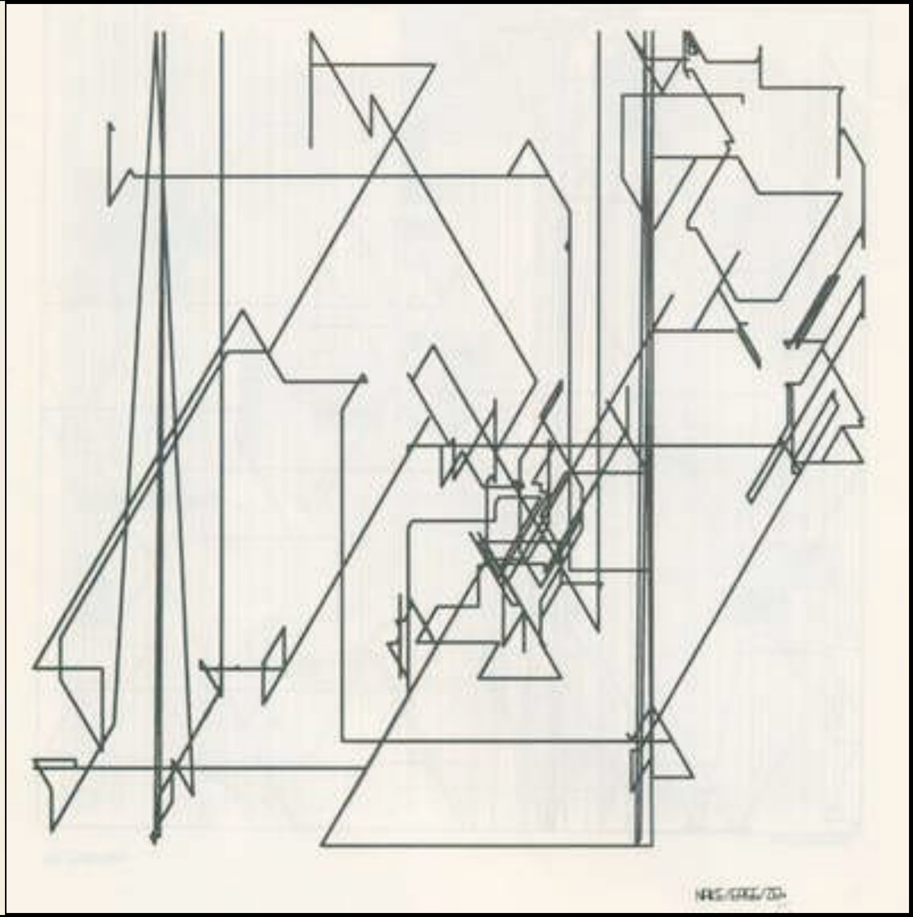
Frieder Nake (1938-)



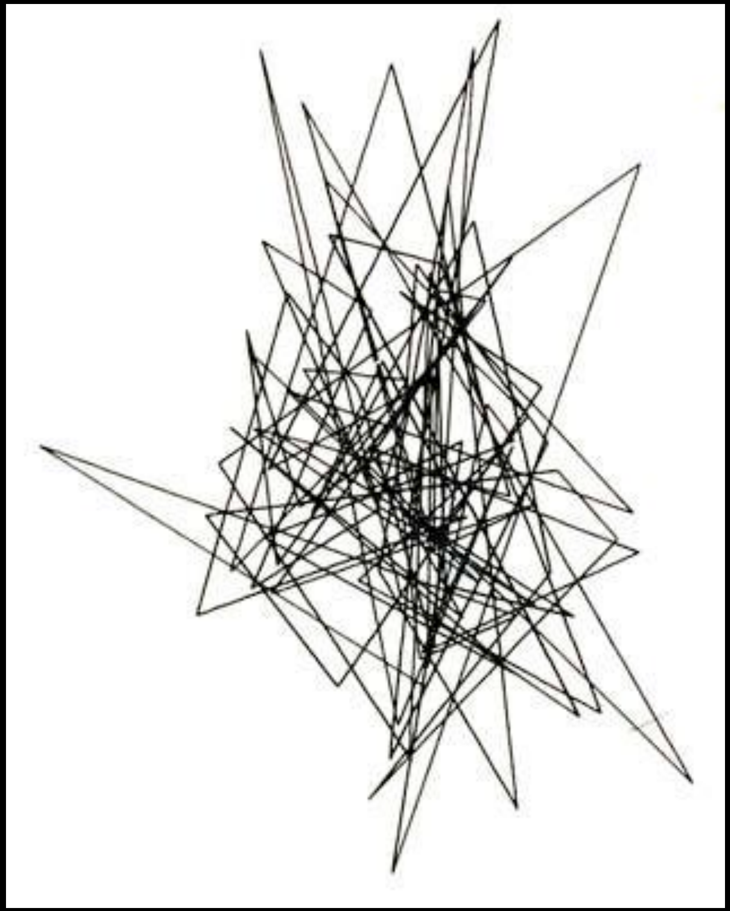
Frieder Nake, Homage to *Paul Klee* 13/9/65 No. 2, 1965



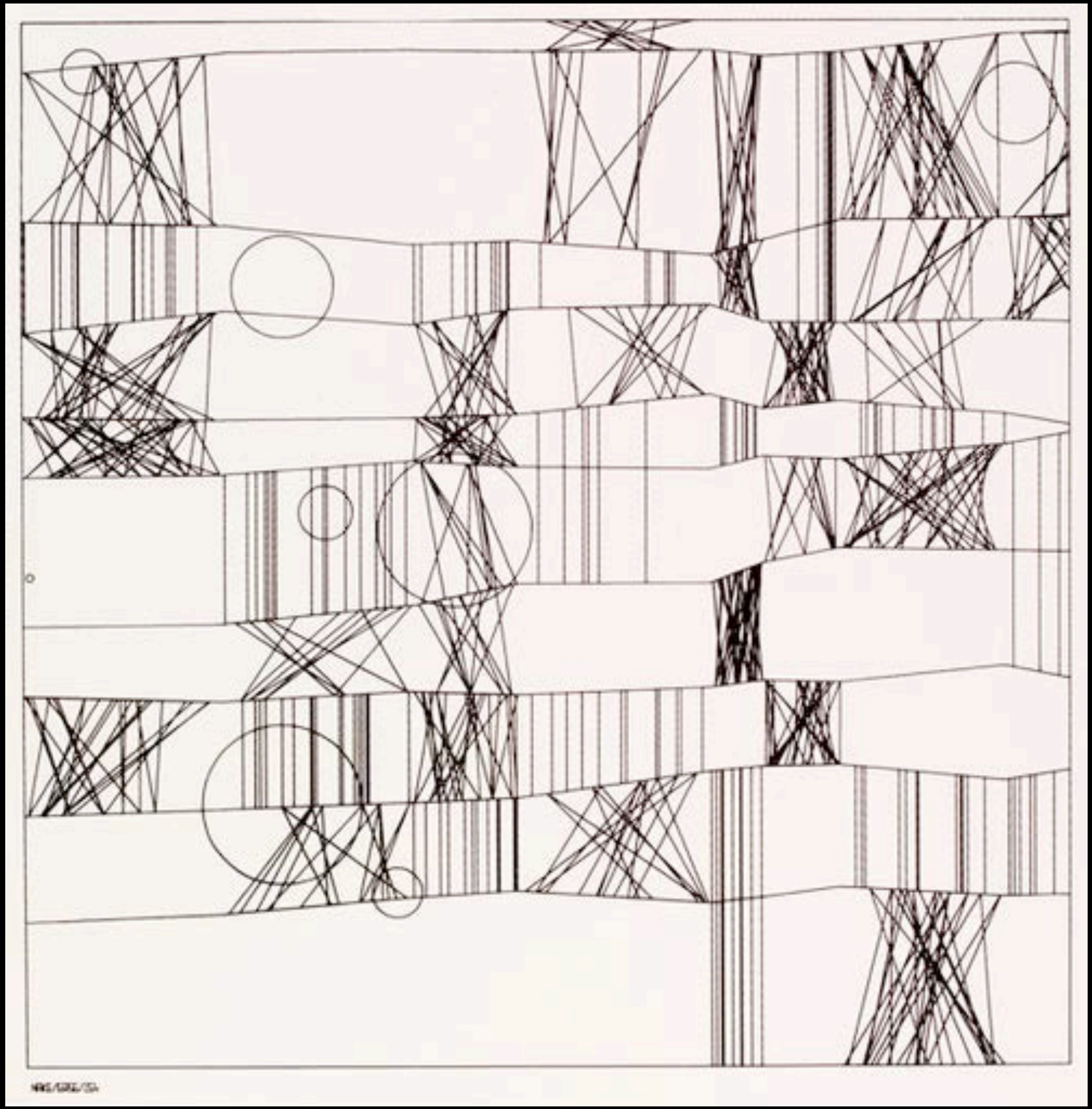
Frieder Nake, Random Polygon, 1965



Frieder Nake, Polygonal Course No. 7, 1965



Frieder Nake, Polygonal Course No. 20, 1965



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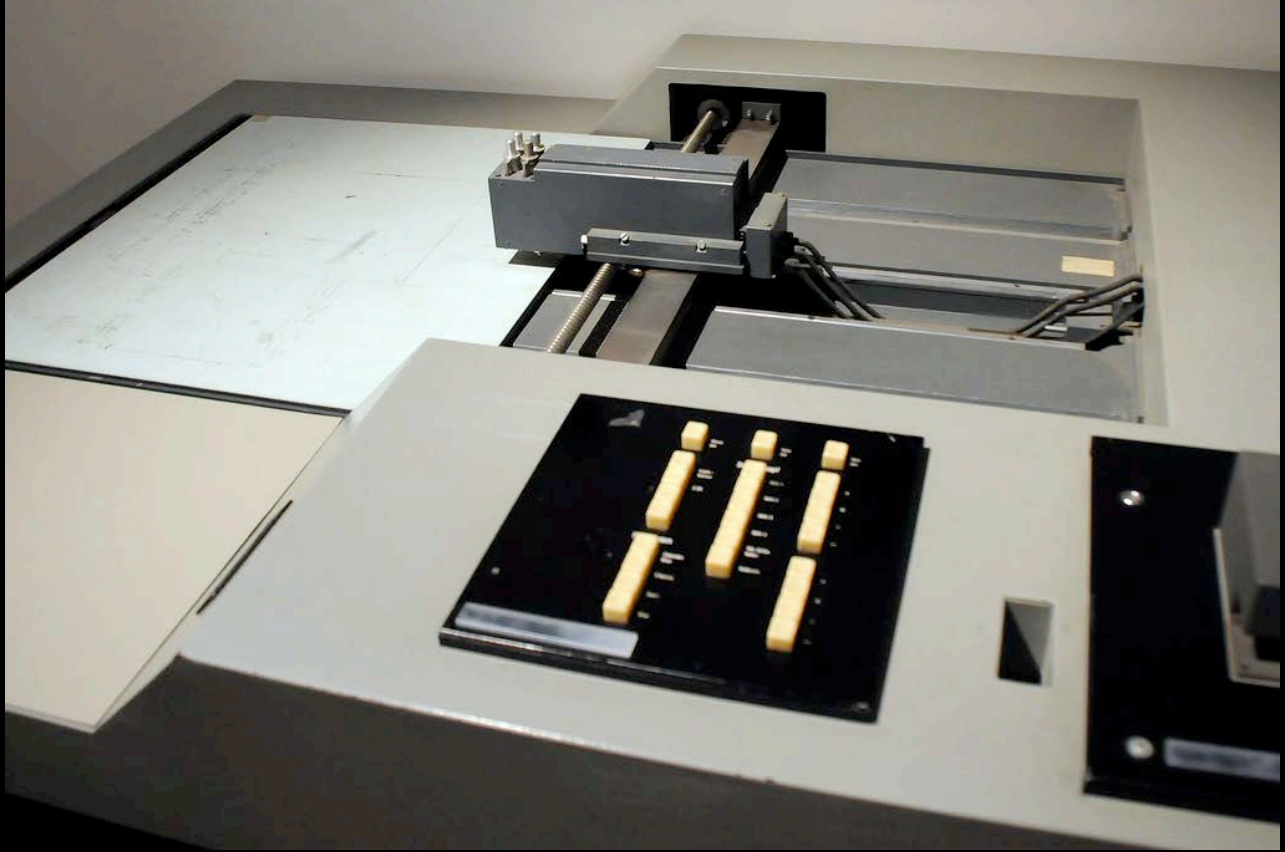

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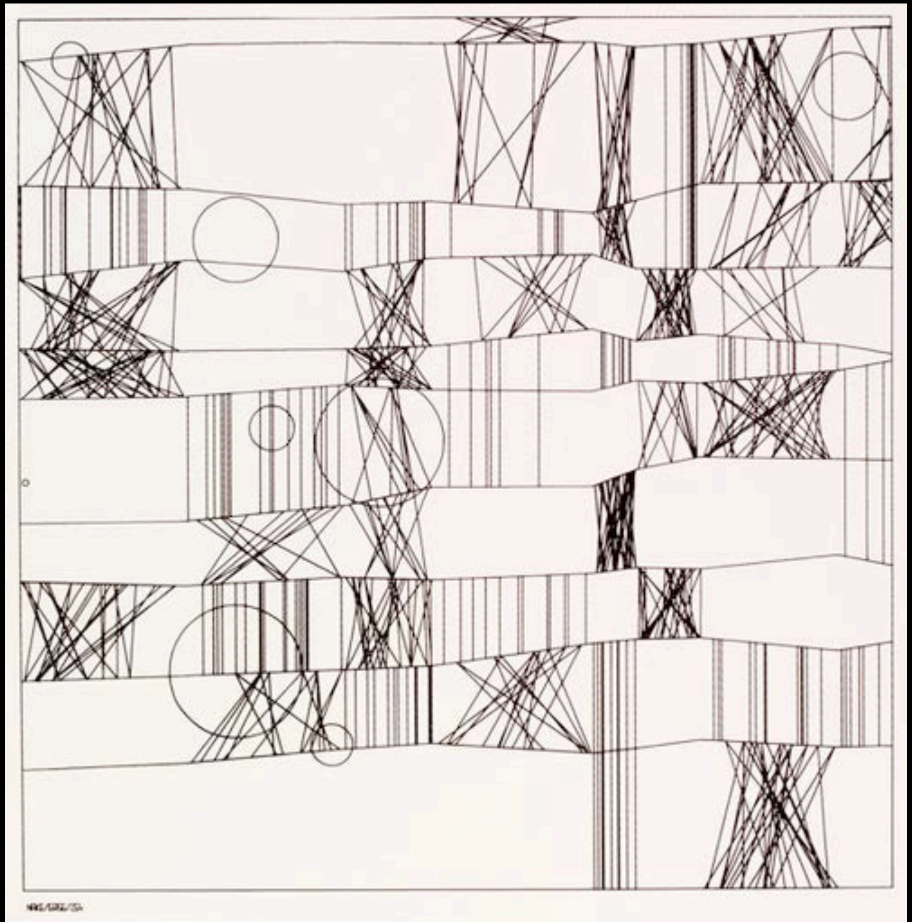
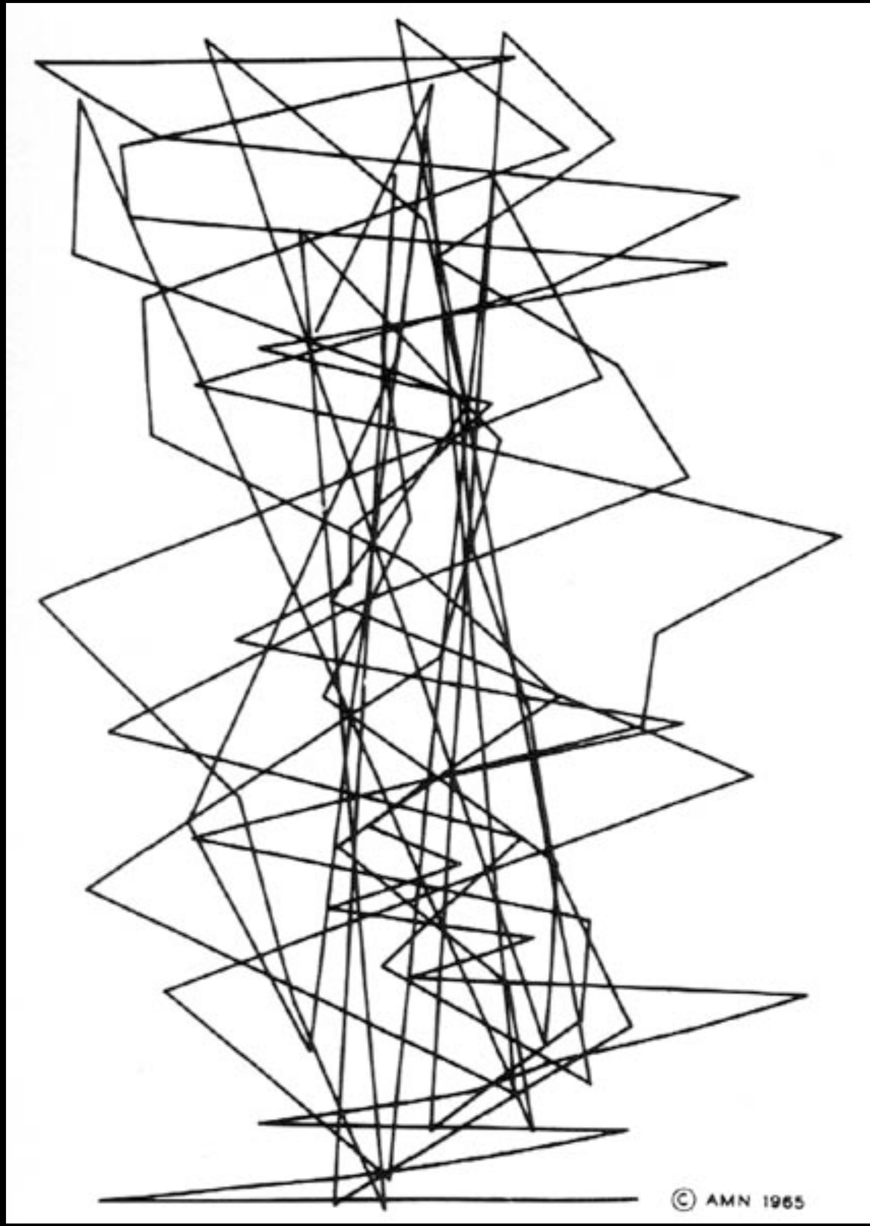


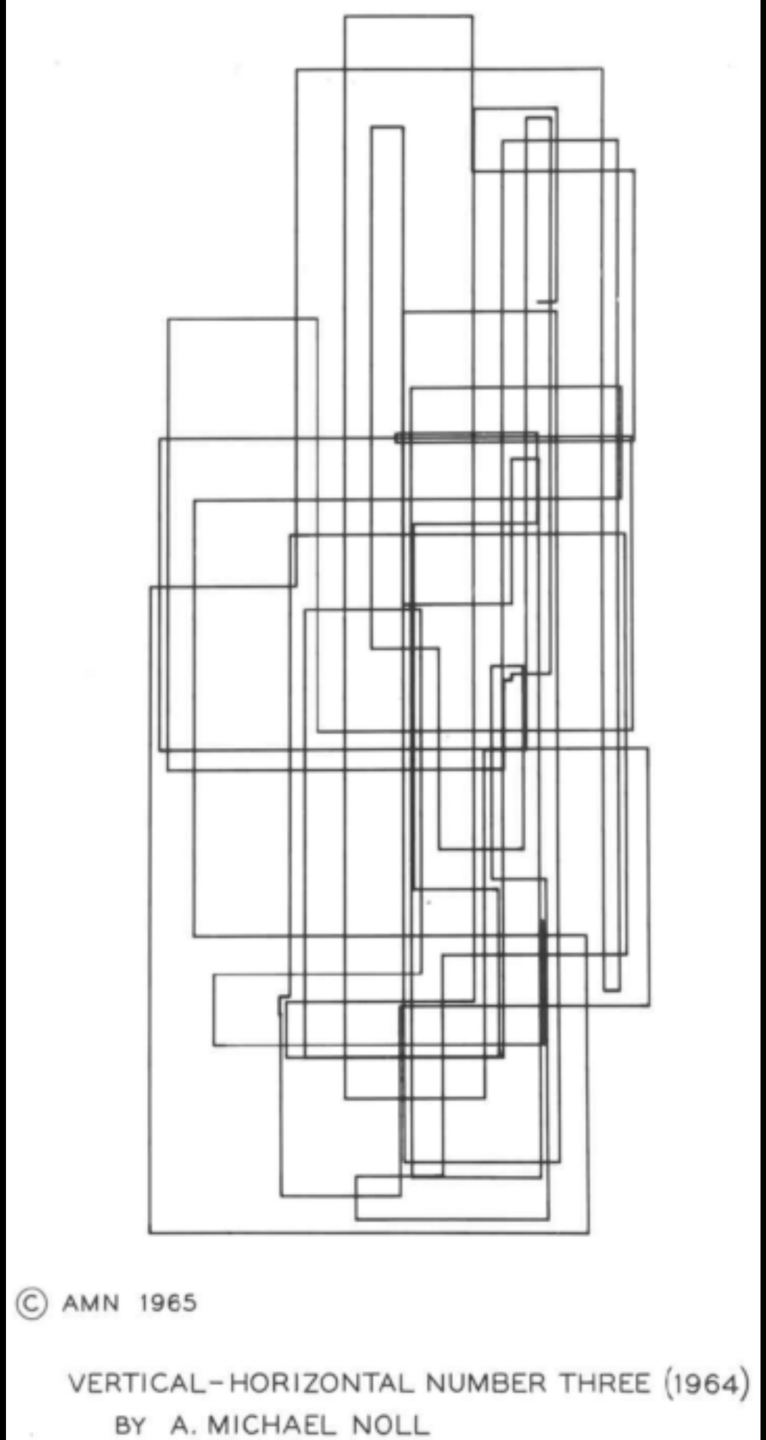
Frieder Nake, Hommage to *Paul Klee* 13/9/65 No. 2, 1965

Paul Klee, Haupt- und Nebenwege [Main and Sideways], 1929

Meanwhile in New Jersey…



A. Michael Noll, Gaussian Quadratic, 1962

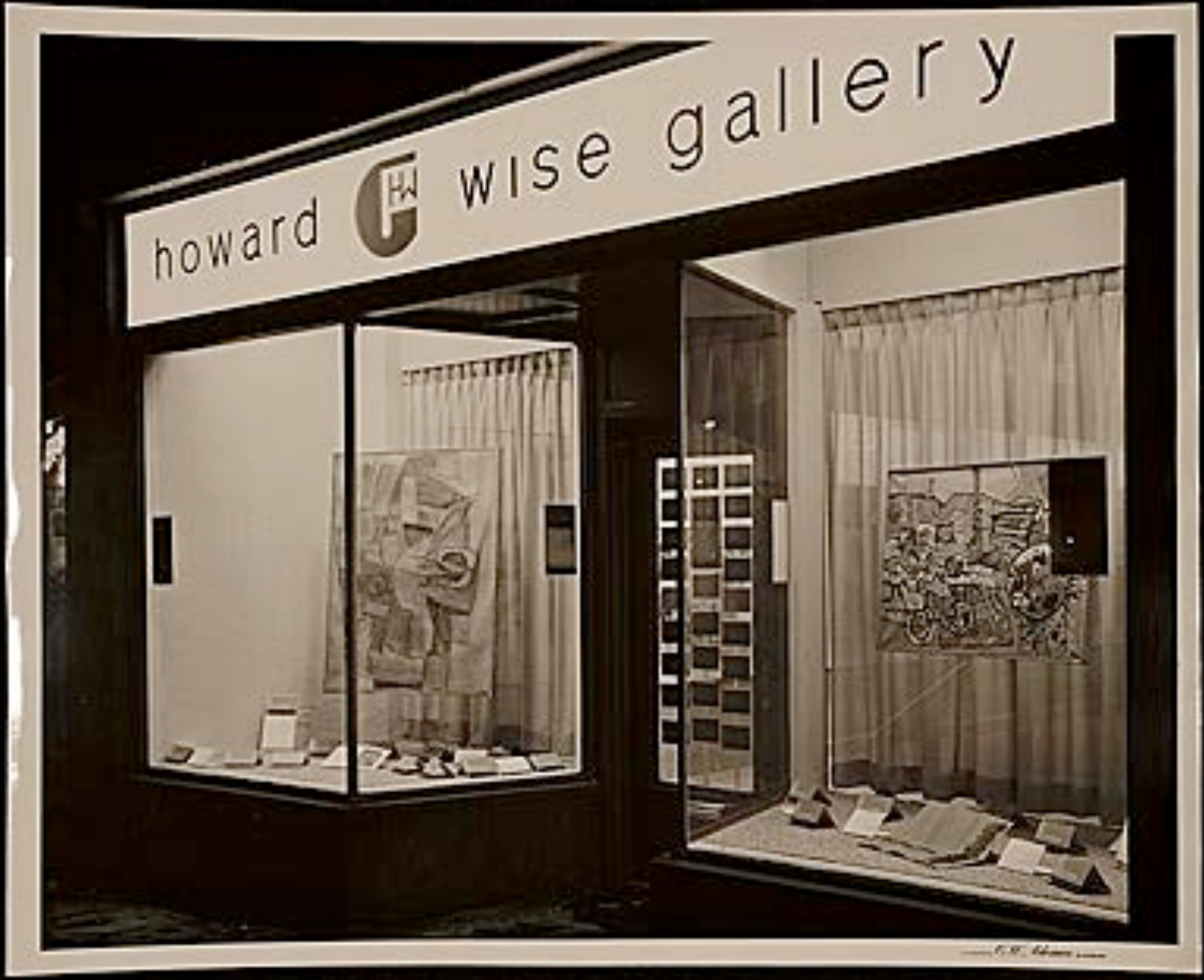


Bell Labs, Murray Hill, NJ

R&D

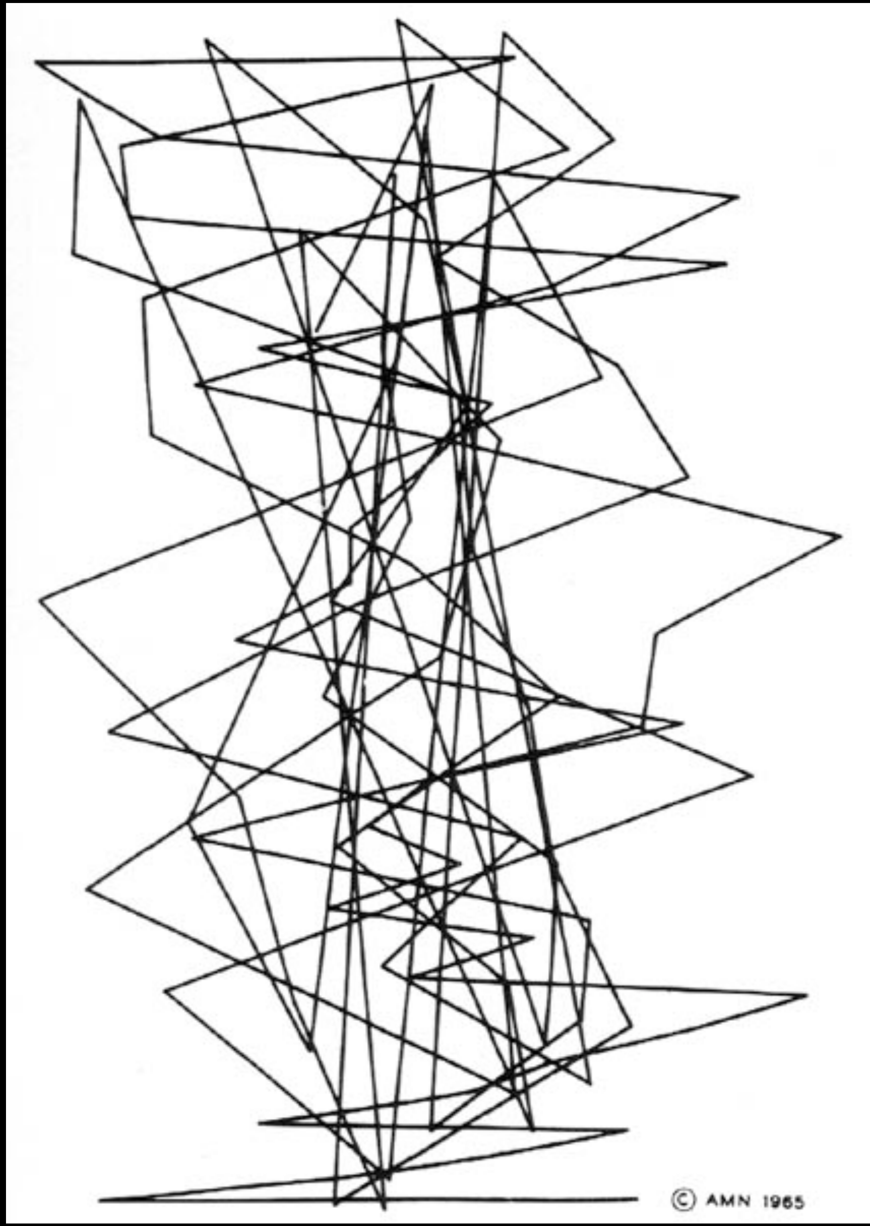
[research and development]

A. Michael Noll (1939-)



howard wise gallery

Exhibition of works by A. Michael Noll and Bela Julesz at the Howard Wise Gallery in New York City in 1965



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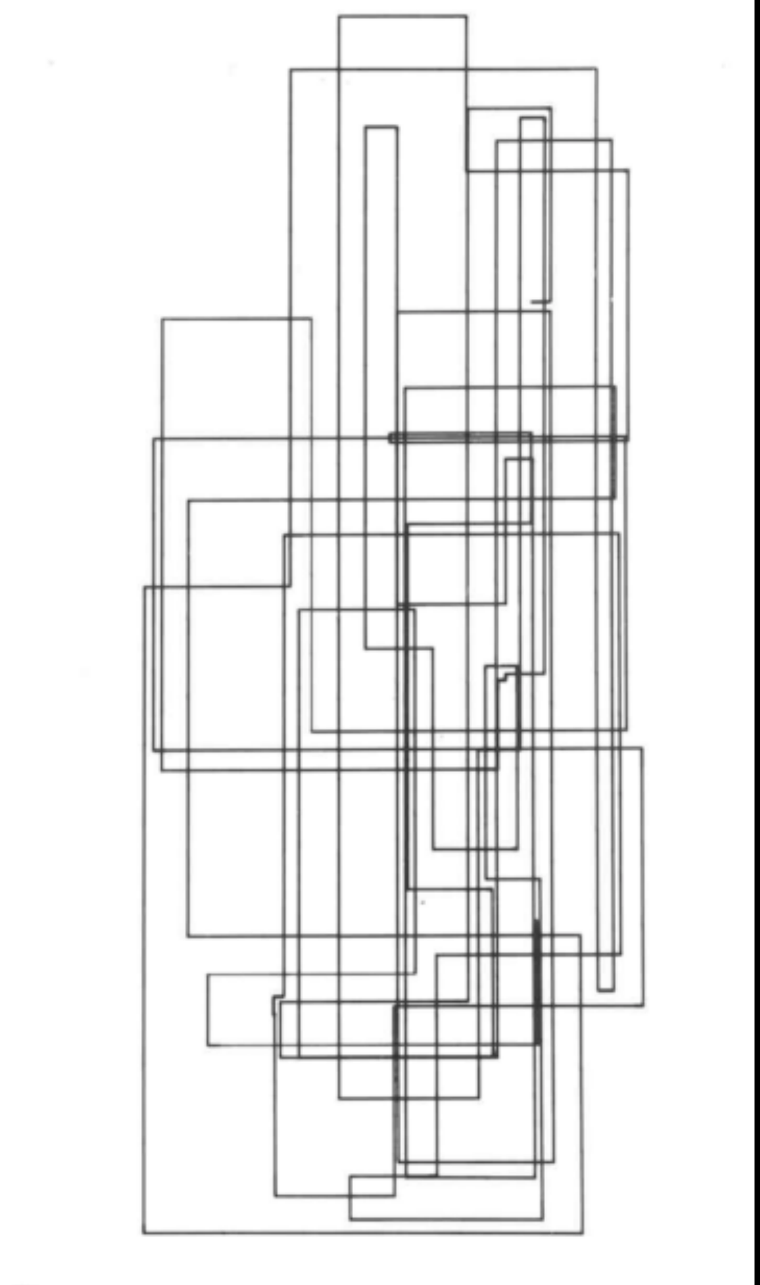
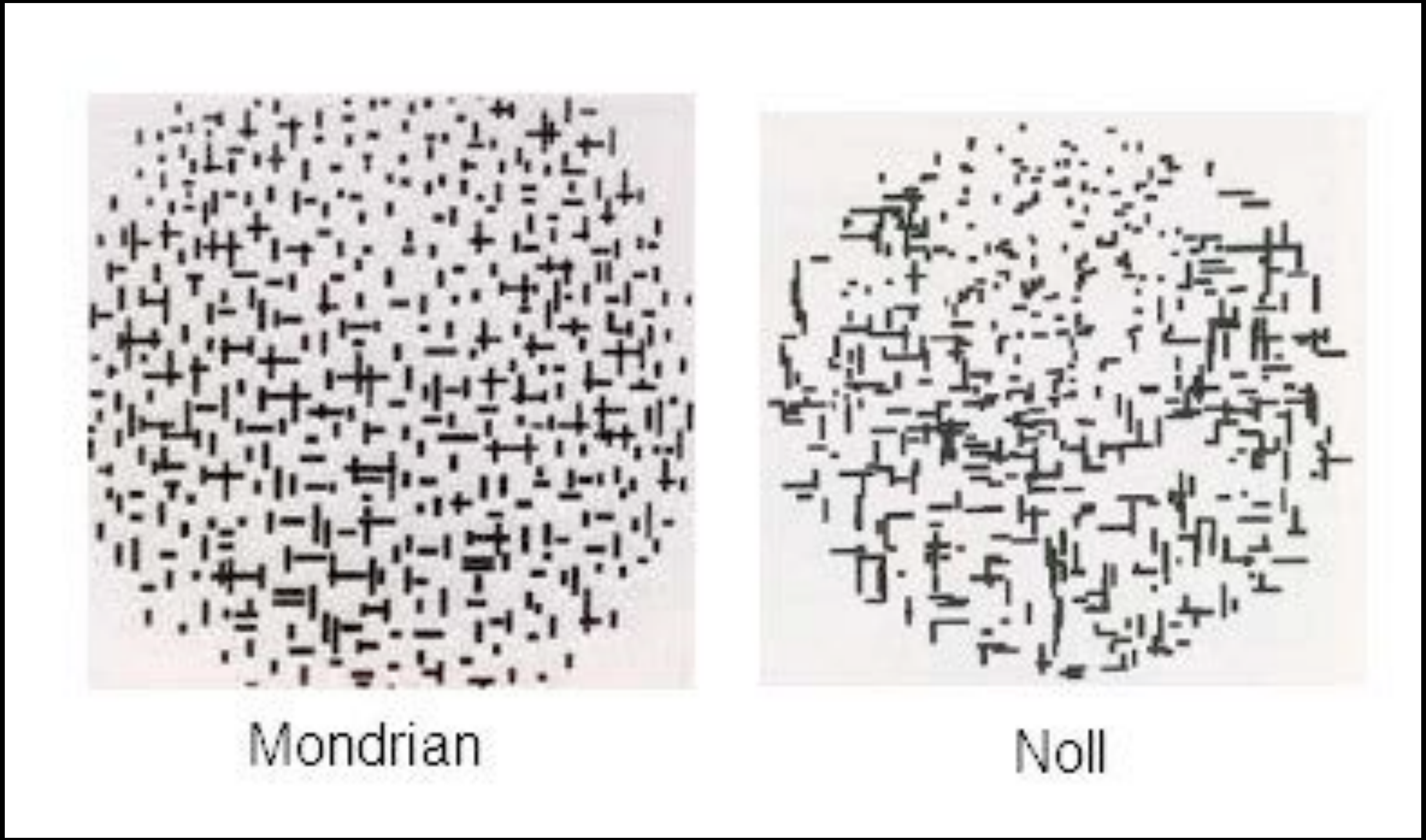
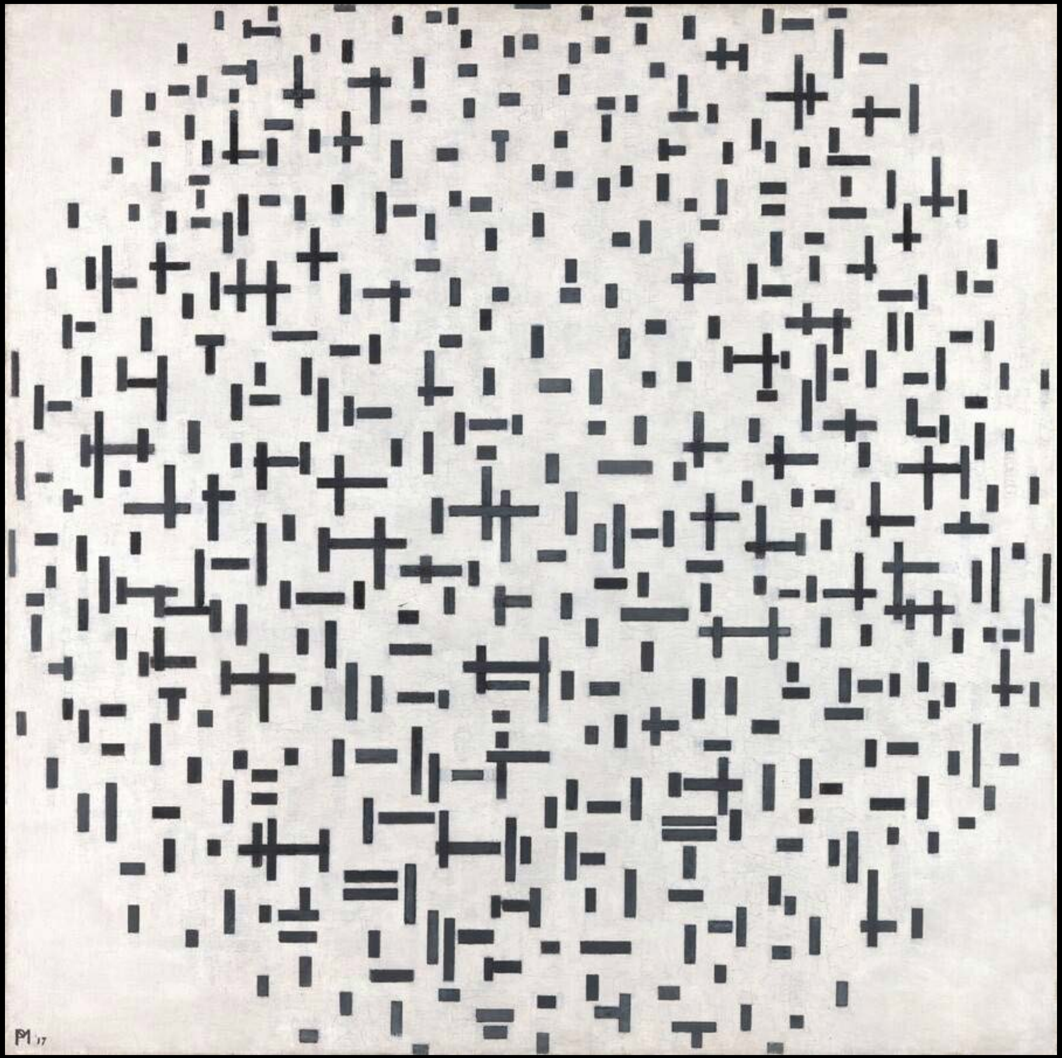


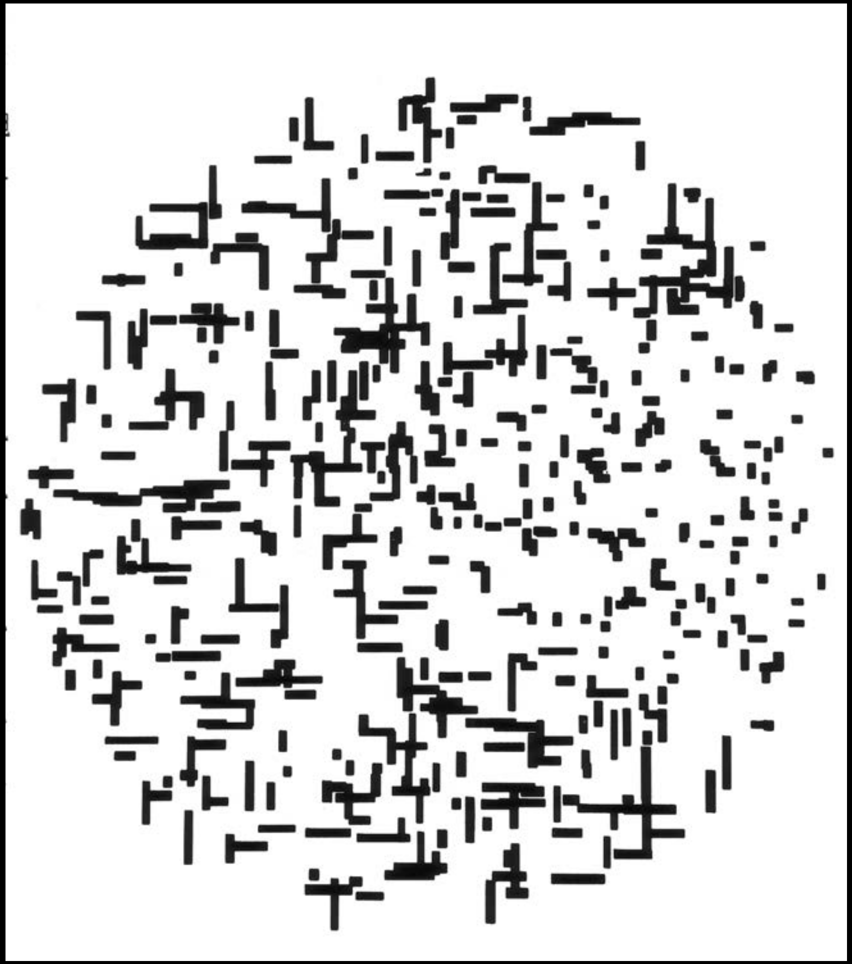
VERTICAL–HORIZONTAL NUMBER THREE (1964)
BY A. MICHAEL NOLL

How are these two works different? At left is an oil painting; at right is a computer-created print.



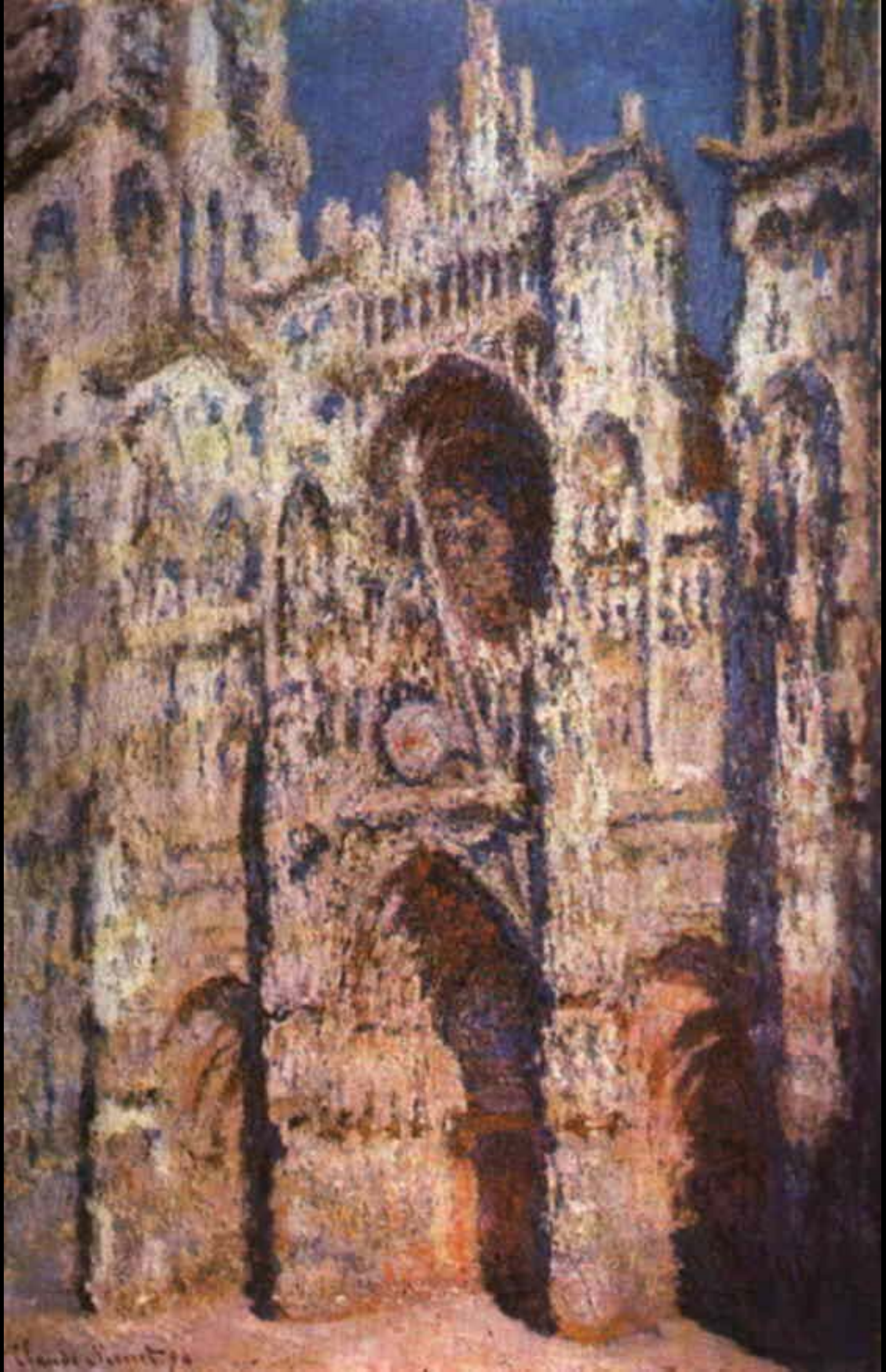


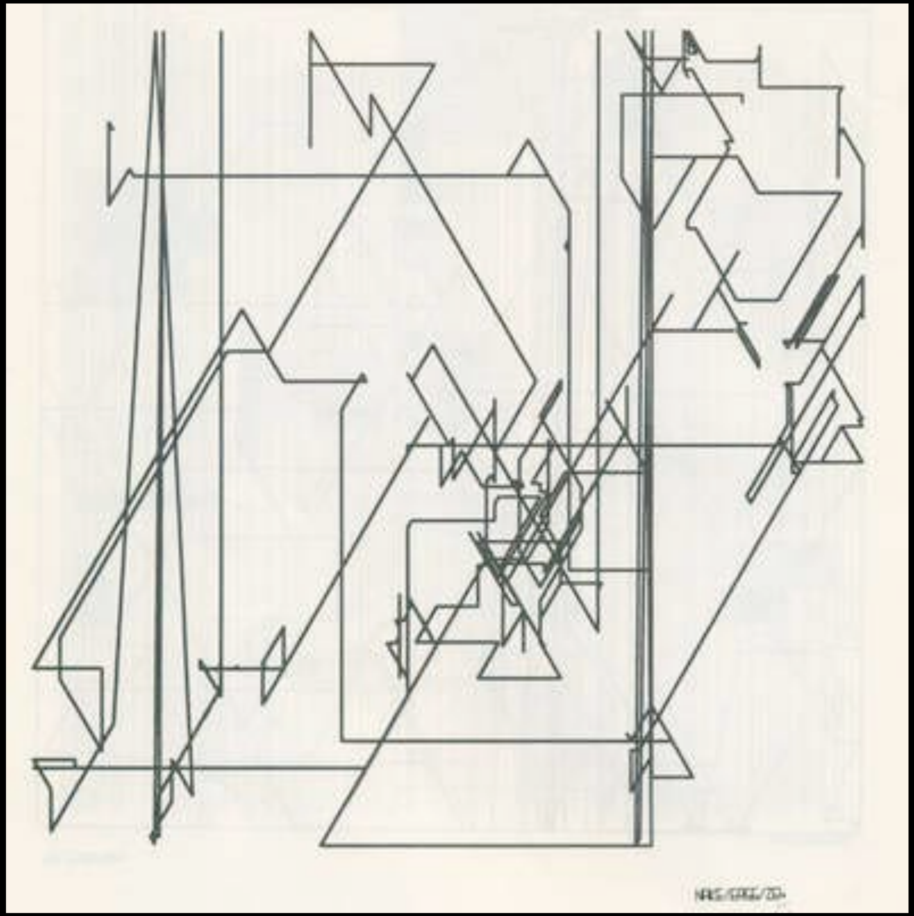
Piet Mondrian, Composition in line, second state, 1916-1917, Oil on canvas



Michael A Noll, Computer composition with Lines, 1964, digital computer and microfilm plotter

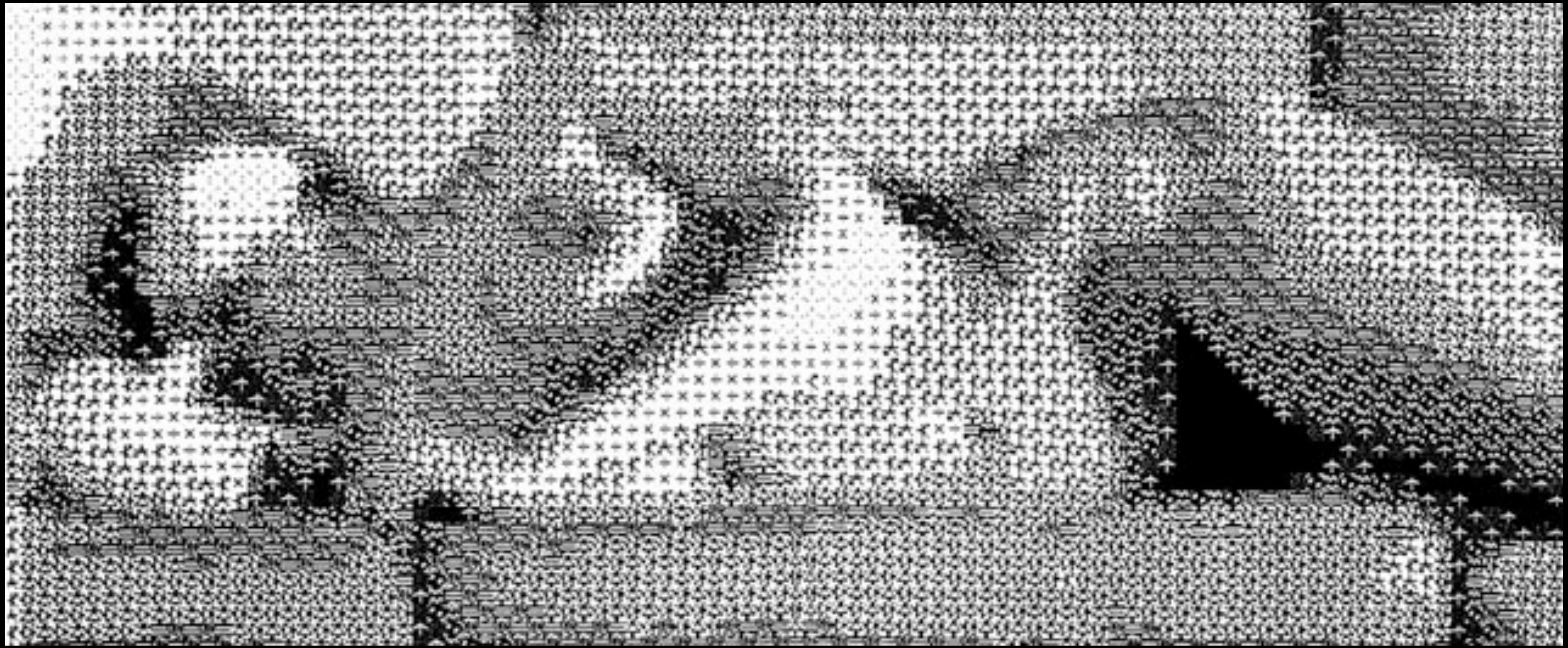
Where is the artist “present” in each work of art?





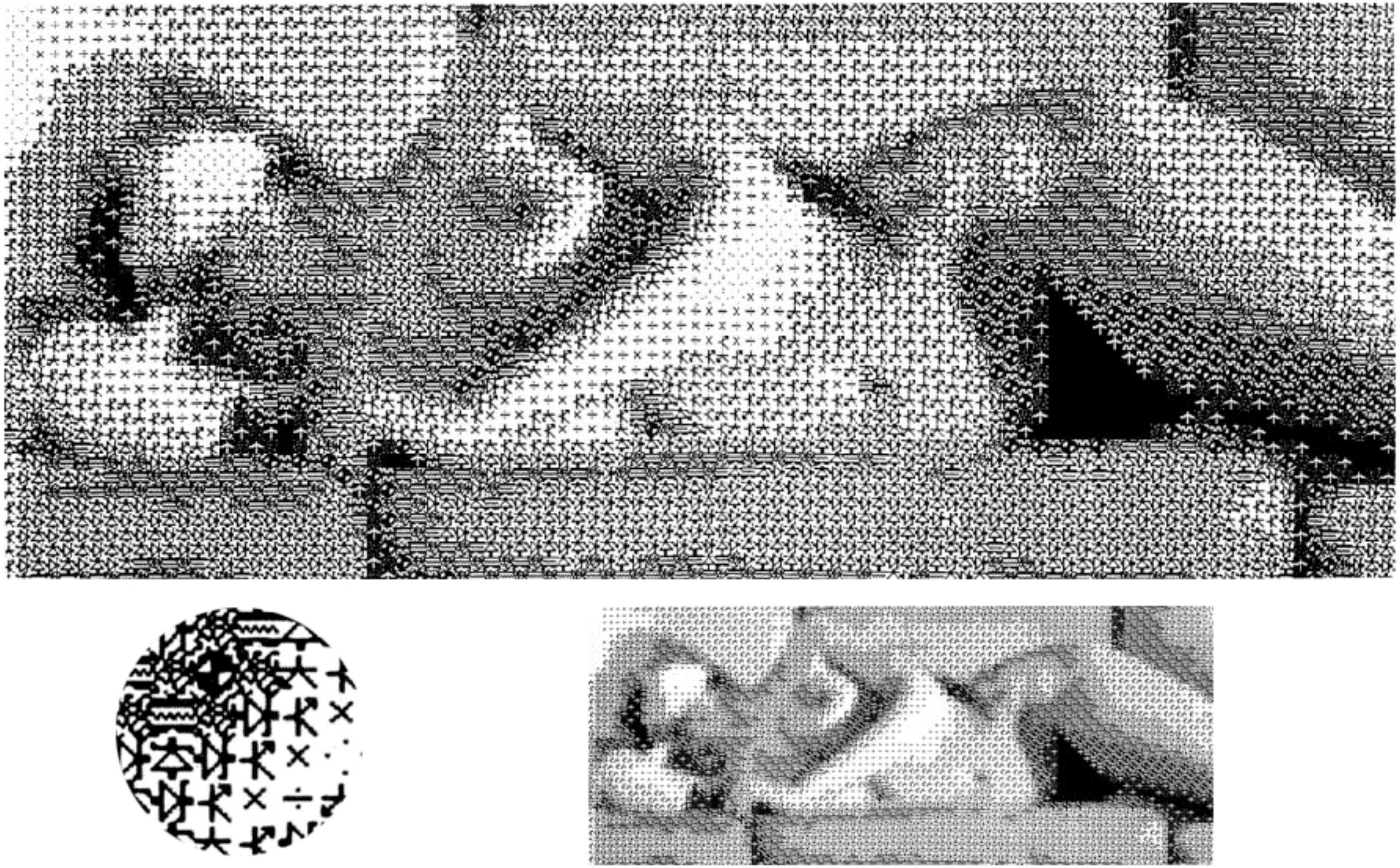
Left: Monet, Rouen Cathedral, 1894

Right: Frieder Nake, Polygonal Course No. 7, 1965



Kenneth Knowlton and Leon Harmon, Studies in Perception 1, 1966

In order to create the original version of this image, Leon Harmon and Ken Knowlton scanned a photograph of the choreographer Deborah Hay and converted the greyscale values into symbols. The resulting printout was 12 feet wide and was hung in a colleague's office at Bell Labs as a prank.



Studies in Perception #1. Computer-produced mural, as shown in the 10/11/67 New York Times, and the 1968 MOMA Machine Show, 5x10 feet, © Leon Harmon & Ken Knowlton, 1966.

Art and Science Proclaim Alliance in Avant-Garde Loft

By HENRY R. LIEBERMAN

In a sound-drenched Lower Manhattan loft building that was enlivened by revolving painted disks, film projections, floating pillows and miniskirted girls in paper smocks, representatives of industry and labor joined a number of artists and scientists yesterday to proclaim a "working alliance" between art and technology.

This modest and uncertain merger seeks to bridge the gap between the two worlds. It is intended to bring modern technological tools to the artist for creating new art forms and fresh insights and viewpoints to the engineer for creating a "people-oriented" technology.

The event was celebrated at a news conference "happening" in the six-story loft building at 381 Lafayette Street used for studio purposes by Robert Rauschenberg, the avant-garde artist.

Kheel's 'Biggest Mediation'

Mr. Rauschenberg, along with Dr. Billy Klüver, an electronics engineer who is specializing in laser research at the Bell Laboratories, and Theodore W. Kheel, the lawyer-labor mediator, are prime movers in the art-technology merger.

with a device operating like a television camera.

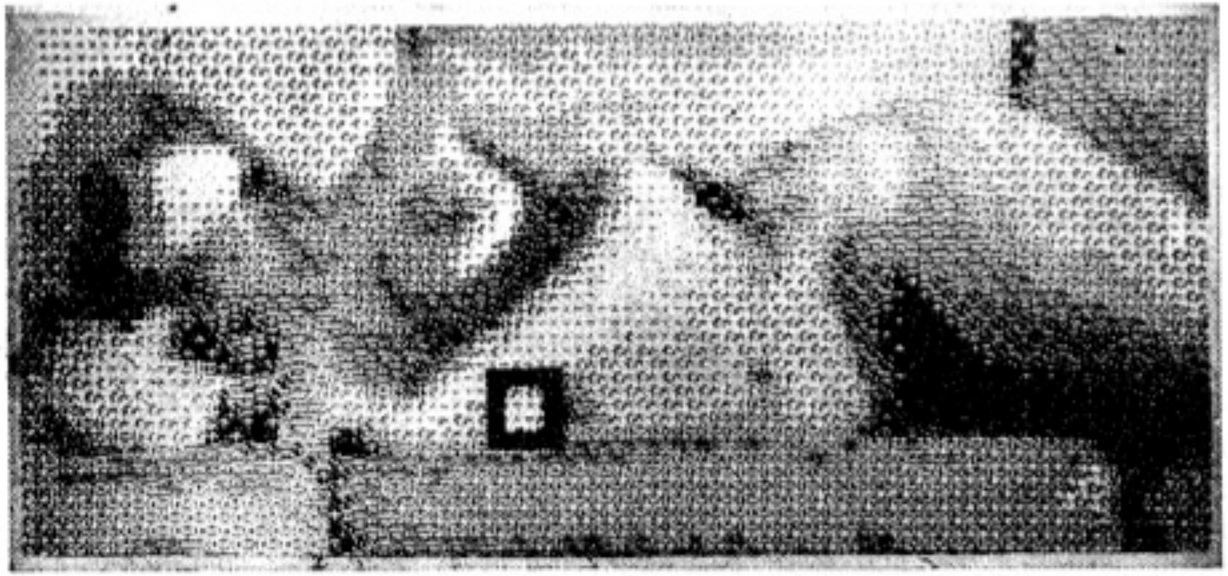
The information on the transparency was then stored on magnetic tape in the form of pulses standing for digits, with the brightness level of the picture elements represented by numbers ranging from 0 to 7. After processing all the numbers, the computer printed a drawing of micropatterns formed by clusters of symbols used in electronic design.

Visitors at the studios were intrigued by a sculptural representation of a woman taking a shower. As droplets of water dripped from the shower-head in a white stall, moving-picture images of the woman were registered by a projector behind the stall on a sand-blasted Plexiglass panel.

Rauschenberg's 'Oracle'

Another sculptural construction was a sound-emitting assembly consisting of a tire, truck door, window frame, bathtub and air vent. This is Mr. Rauschenberg's "Oracle."

Five radios are used, with the tuning dial of each being rotated by motor. Thus, each radio picks up snatches of the broadcasts of all the local



Drawing of nude above was generated by a computer under direction of L. D. Harmon and K. C. Knowlton, engineers. Black square encloses the detail shown.

contribution dollar that goes to the arts."

"Along with its obligation to be a profit-maker for its owners, the modern business corporation has an obligation to be a good citizen in the community," he said. "As a basic part of this obligation, the corporation must examine carefully its responsibility to

dividuals in seeking to make "valuable contributions."

He noted that union members were also consumers, members of audiences and citizens concerned with the quality of society.

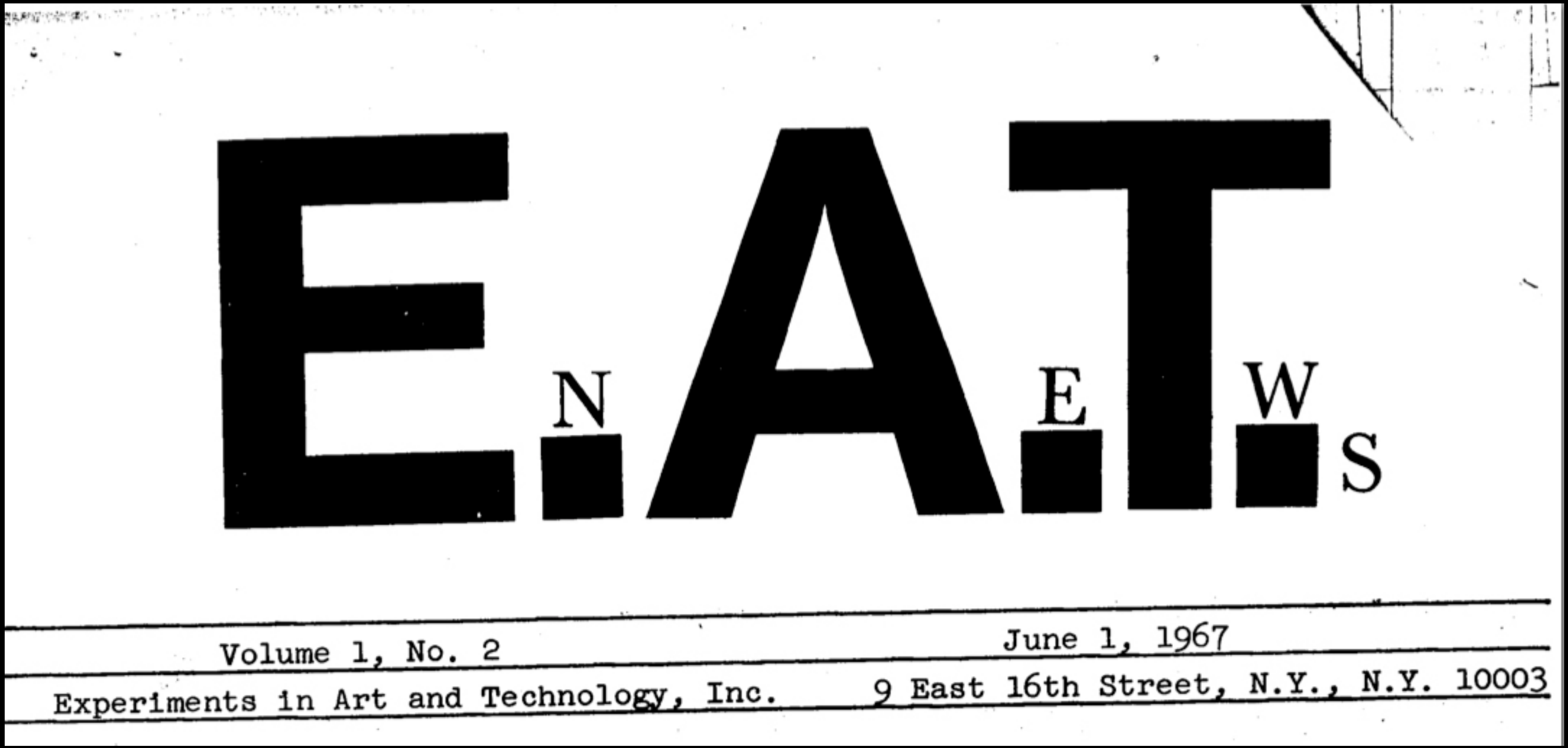
The event served to dramatize a drive to win organizational support for the art-technology merger and to mark the transfer of Experi-

with human problems caused by automation — notably the problem of individual "isolation."

Dr. Brodey, who heads M.I.T.'s science camp for underprivileged youngsters, noted that new technologies had opened large new areas of creativity. While the in-

The image found fame when it featured in a press conference in Robert Rauschenberg's loft and subsequently appeared in the New York Times on 11 October, 1967.

Digital Image in Art as Three and Four Dimensional

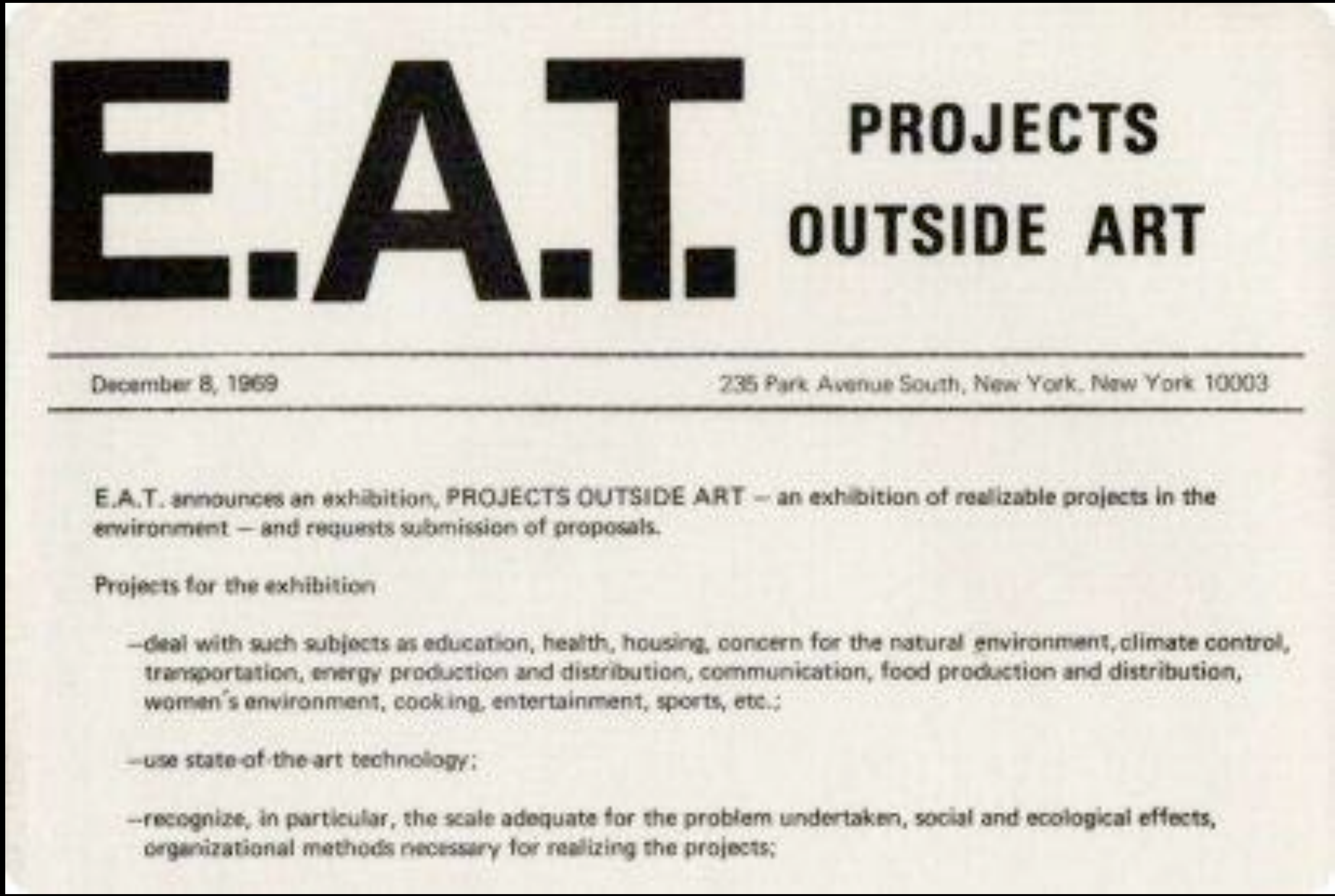

E.A.T. NEWS

Volume 1, No. 2 June 1, 1967

Experiments in Art and Technology, Inc. 9 East 16th Street, N.Y., N.Y. 10003

Experiments in Art and Technology was founded in 1966 by engineers Billy Klüver and Fred Waldhauer and artists Robert Rauschenberg and Robert Whitman.

Billy Klüver, Fred Waldhauer, Robert Rauschenberg, John Cage, David Tudor, Yvonne Rainer, Deborah Hay, Robert Whitman, Steve Paxton, Alex Hay, Lucinda Childs and Öyvind Fahlström



E.A.T. PROJECTS OUTSIDE ART

December 8, 1969 — 235 Park Avenue South, New York, New York 10003

E.A.T. announces an exhibition, PROJECTS OUTSIDE ART – an exhibition of realizable projects in the environment – and requests submission of proposals.

Projects for the exhibition

–deal with such subjects as education, health, housing, concern for the natural environment, climate control, transportation, energy production and distribution, communication, food production and distribution, women's environment, cooking, entertainment, sports, etc.;

–use state-of-the-art technology;

–recognize, in particular, the scale adequate for the problem undertaken, social and ecological effects, organizational methods necessary for realizing the projects;

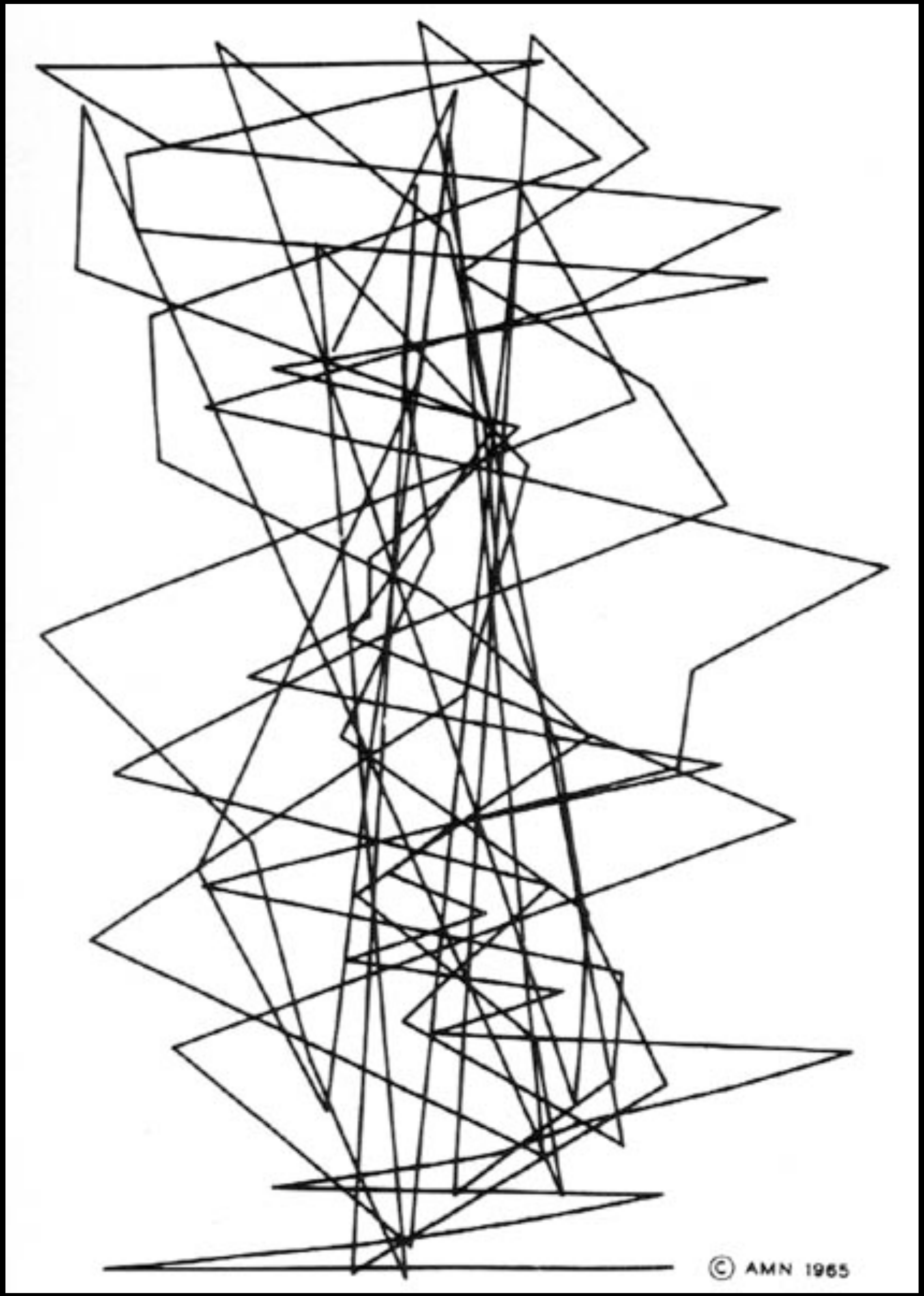
EAT/Robert Rauschenberg, Open Score, 1966

Each time Frank Stella and Mimi Kanarek hit the ball the vibrations of the racquet strings were transmitted to the speakers around the armory, and a loud BONG was heard.

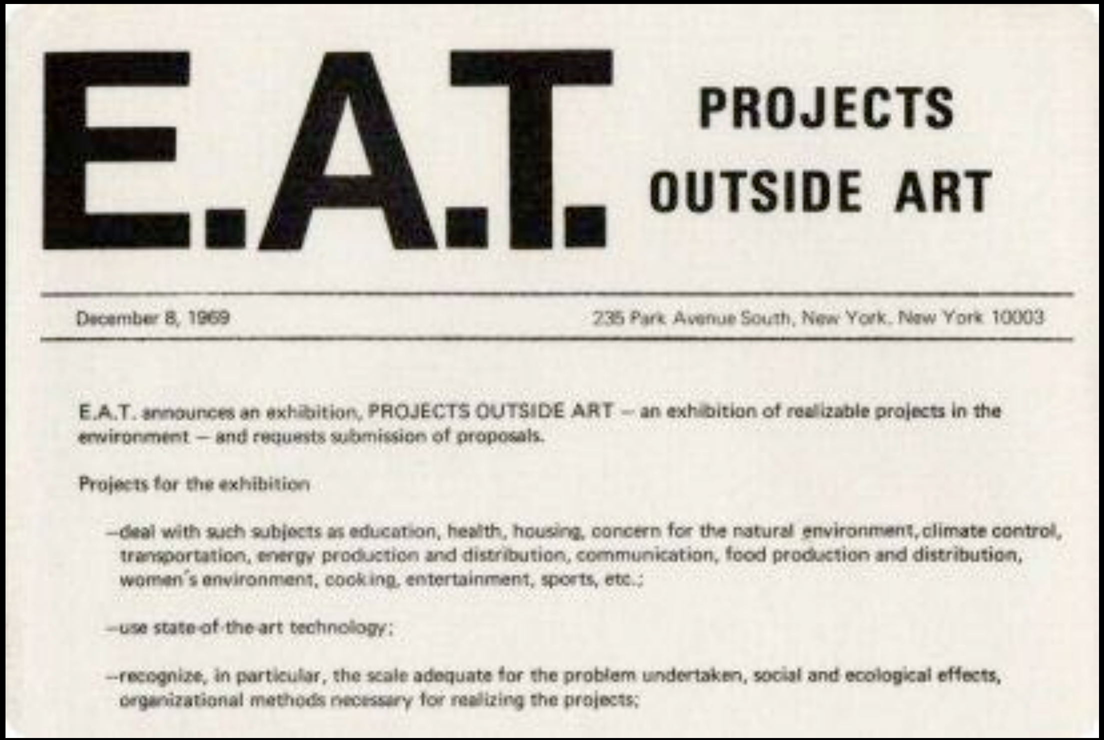
https://www.youtube.com/watch?v=kWadsDX1UxA

AUTONOMY, DIGITAL TECHNOLOGY, AND ART

DIGITAL IMAGE
VS.
DIGITAL PERFORMANCE



A. Michael Noll, Gaussian Quadratic, 1962



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How does digital technology challenge the concept and practice of "autonomy" within art?

The autonomy of art describes art’s existence sheerly for the sake of art.

Art begins not for profit and not as a tool of political propaganda. One of the ways we define ”art” is by its autonomy, that is, by its ability to communicate separately from the economic market and political system. This is so even while it is a product of culture, which is almost always defined by profit and politics.

If the development of digital technology is fundamentally bound to the market and military industrial complex, how can digital art be "autonomous"?

A very general history of the algorithmic image in and as a work of art…

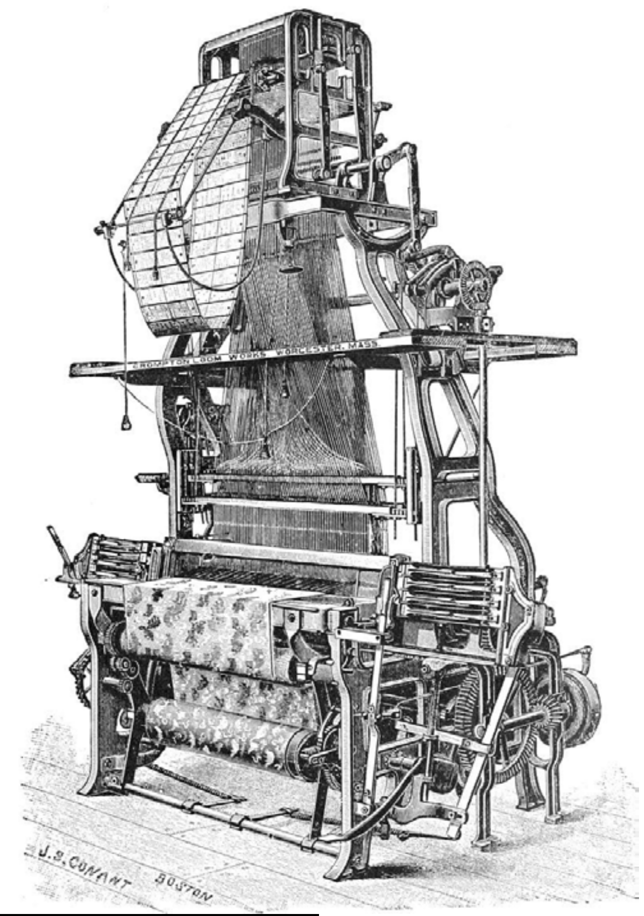
Joseph Marie Jacquard [1752-1834]
portrait of Jacquard was woven in silk on
a Jacquard loom and required 24,000
punched cards to create (1839).

Joseph Marie Jacquard, Jacquard Loom/Punch-Card Loom, 1801

In Lyon, France Joseph Marie Jacquard (1752-1834) demonstrated in 1801 a loom that enabled unskilled workers to weave complex patterns in silk. The Jacquard Loom is controlled by a chain of multiple cards punched with holes that determine which cords of the fabric warp should be raised for each pass of the shuttle. The ability to store and automatically reproduce complex operations found wide application in textile manufacturing.

Joseph Marie Jacquard [1752-1834] portrait of Jacquard was woven in silk on a Jacquard loom and required 24,000 punched cards to create (1839).

Joseph Marie Jacquard, Jacquard Loom/Punch-Card Loom, 1801

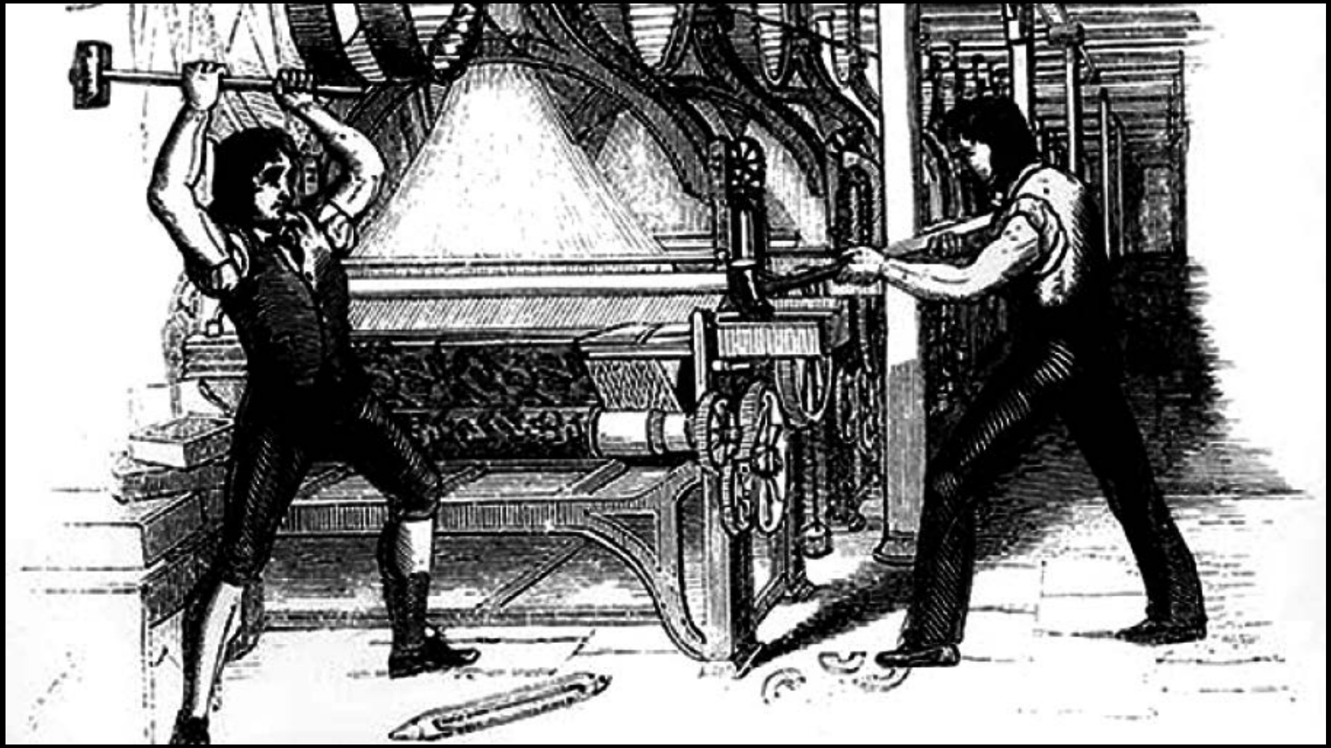


Jacquard Fabric Sample

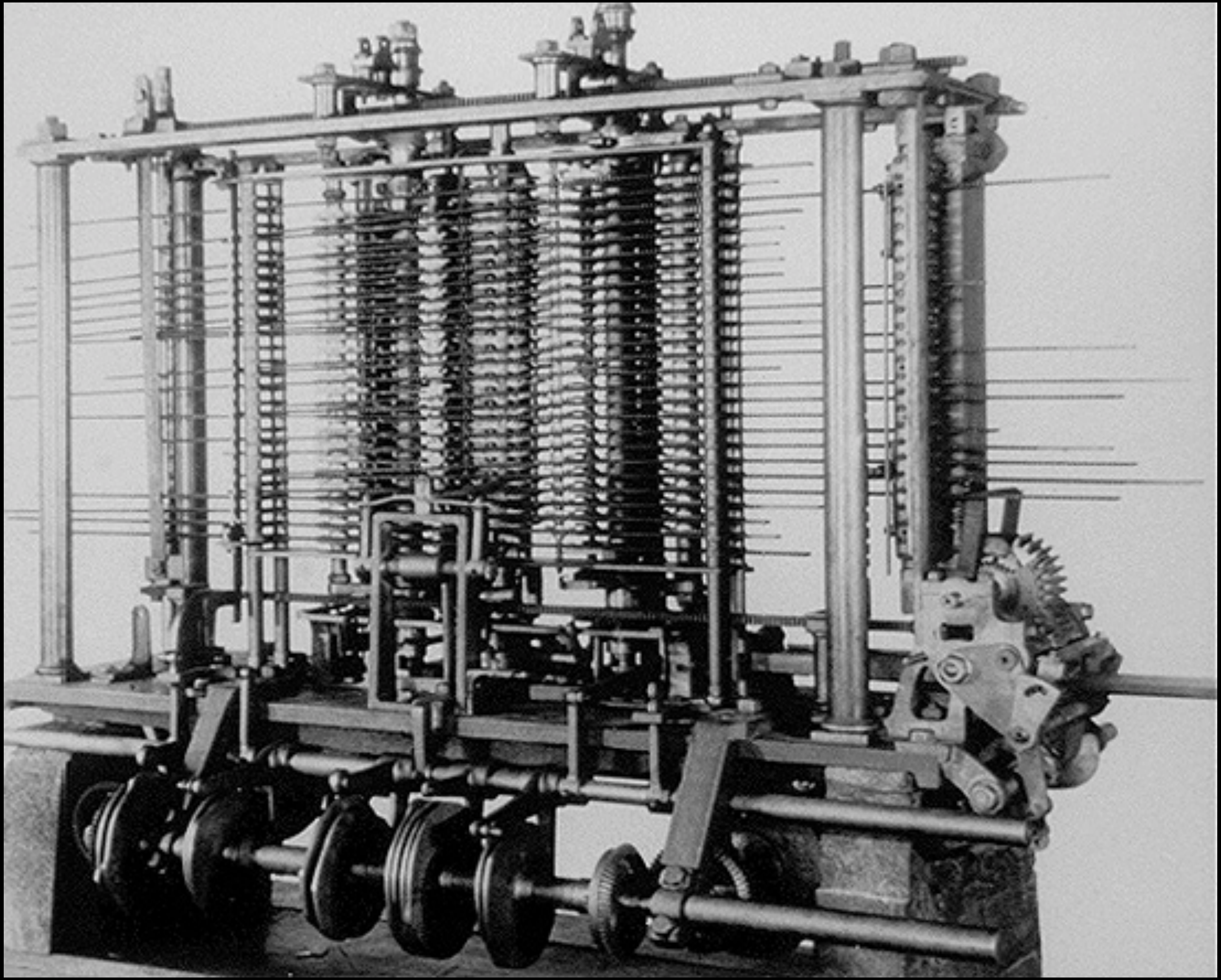
How do you think this type of automation affected textile and weaving laborers?

LUDDITES

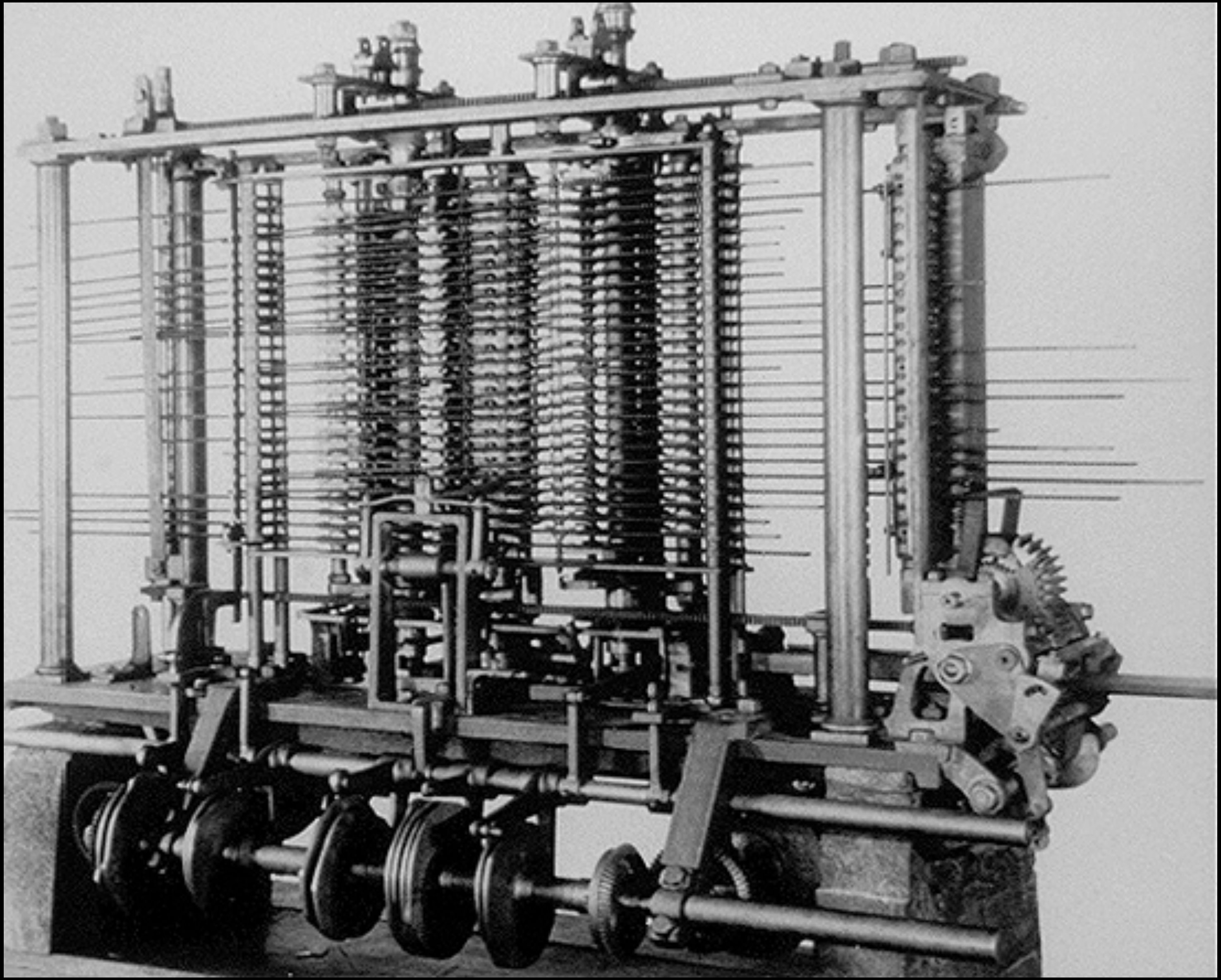
Luddite – DEROGATORY 1.) a person opposed to new technology or ways of working, as in "a small-minded Luddite resisting progress" HISTORICAL 2.) a member of any of the bands of English workers who destroyed machinery, especially in cotton and woolen mills, that they believed was threatening their jobs (1811–16)



Two Types of Punch Cards Used to Program His Analytical Engine of 1837



Babbage or Difference Engine 1822/1999
http://www.computerhistory.org/babbage/
Charles Babbage [1791-1871]



Babbage or Difference Engine 1822/1999
http://www.computerhistory.org/babbage/
Charles Babbage [1791-1871]

- Mathematician, philosopher, and inventor Charles Babbage wanted to create a mechanism to automate the process of producing error-free mathematical tables by teams of mathematicians and human "computers".
- He created the Difference Engine, an automatic mechanical calculator designed to tabulate polynomial functions in 1822.
- Its name is derived from the method of divided differences, a way to interpolate or tabulate functions by using a small set of polynomial coefficients.

Ada Lovelace
(1815-1852)

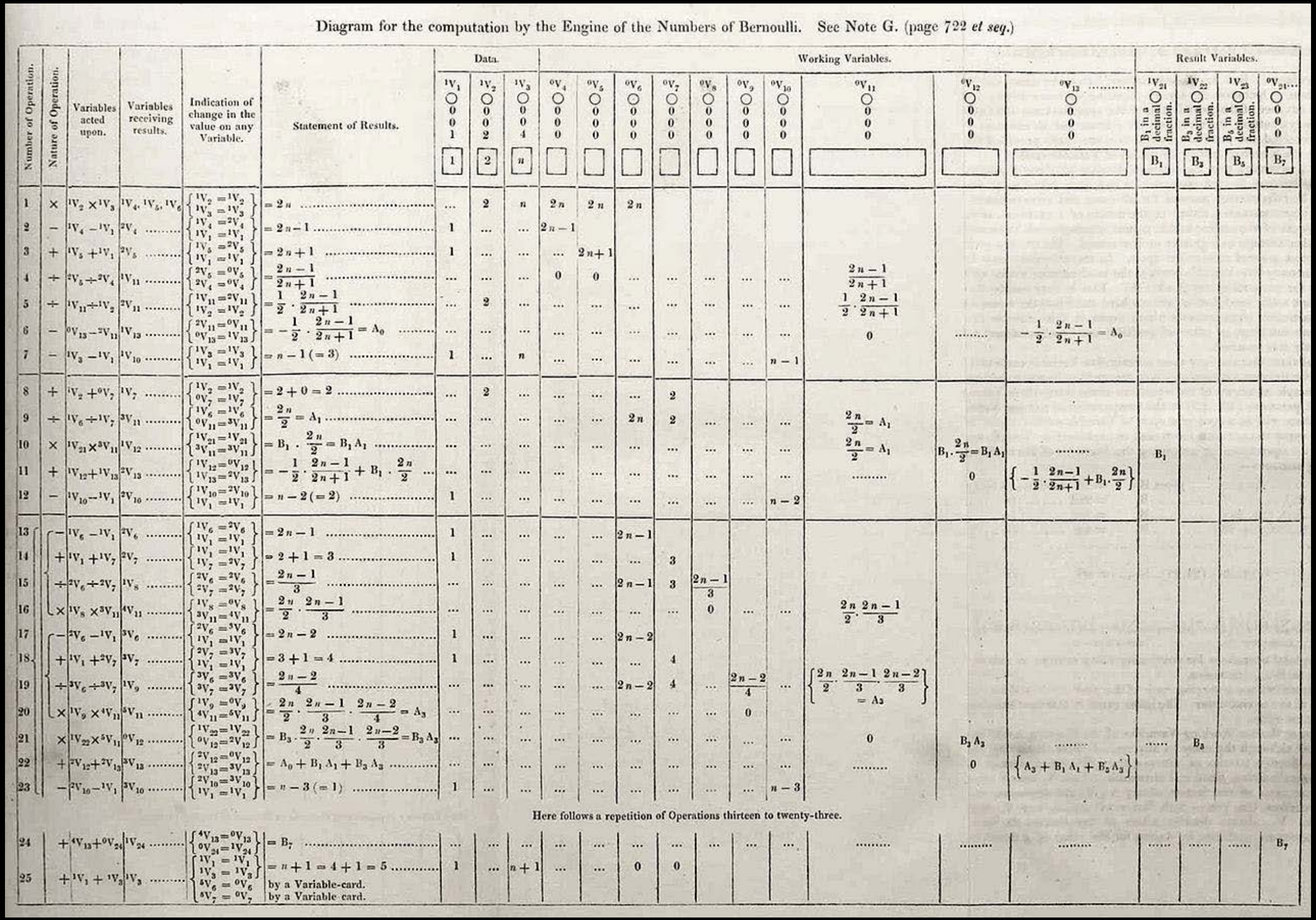


Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 *et seq.*)

Number of Operation.	Nature of Operation.	Variables acted upon.	Variables receiving results.	Indication of change in the value on any Variable.	Statement of Results.	Data. $^1V_1$ (0001) [1]	$^1V_2$ (0002) [2]	$^1V_3$ (0004) [n]	Working Variables. $^0V_4$ (0000)	$^0V_5$	$^0V_6$	$^0V_7$	$^0V_8$	$^0V_9$	$^0V_{10}$	$^0V_{11}$	$^0V_{12}$	$^0V_{13}$	Result Variables. $^1V_{21}$ B_1 in a decimal fraction. [B_1]	$^1V_{22}$ B_3 in a decimal fraction. [B_3]	$^1V_{23}$ B_5 in a decimal fraction. [B_5]	$^0V_{24}$ (0000) [B_7]
1	×	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{ {}^1V_2 = {}^1V_2 ; {}^1V_3 = {}^1V_3 \right\}$	$= 2n$	...	2	n	$2n$	$2n$	$2n$											
2	−	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{ {}^1V_4 = {}^2V_4 ; {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 1$	1	...	...	$2n-1$													
3	+	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{ {}^1V_5 = {}^2V_5 ; {}^1V_1 = {}^1V_1 \right\}$	$= 2n + 1$	1	...	...	...	$2n+1$												
4	÷	$^2V_5 \div {}^2V_4$	$^1V_{11}$	$\left\{ {}^2V_5 = {}^0V_5 ; {}^2V_4 = {}^0V_4 \right\}$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	÷	$^1V_{11} \div {}^1V_2$	$^2V_{11}$	$\left\{ {}^1V_{11} = {}^2V_{11} ; {}^1V_2 = {}^1V_2 \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	−	$^0V_{13} - {}^2V_{11}$	$^1V_{13}$	$\left\{ {}^2V_{11} = {}^0V_{11} ; {}^0V_{13} = {}^1V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	−	$^1V_3 - {}^1V_1$	$^1V_{10}$	$\left\{ {}^1V_3 = {}^1V_3 ; {}^1V_1 = {}^1V_1 \right\}$	$= n - 1 (= 3)$	1	...	n	...	...	...	...	...	...	$n-1$							
8	+	$^1V_2 + {}^0V_7$	$^1V_7$	$\left\{ {}^1V_2 = {}^1V_2 ; {}^0V_7 = {}^1V_7 \right\}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	÷	$^1V_6 \div {}^1V_7$	$^3V_{11}$	$\left\{ {}^1V_6 = {}^1V_6 ; {}^0V_{11} = {}^3V_{11} \right\}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	$2n$	2	...	...	...	$\frac{2n}{2} = A_1$						
10	×	$^1V_{21} \times {}^3V_{11}$	$^1V_{12}$	$\left\{ {}^1V_{21} = {}^1V_{21} ; {}^3V_{11} = {}^3V_{11} \right\}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	....	B_1			
11	+	$^1V_{12} + {}^1V_{13}$	$^2V_{13}$	$\left\{ {}^1V_{12} = {}^0V_{12} ; {}^1V_{13} = {}^2V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2} \right\}$				
12	−	$^1V_{10} - {}^1V_1$	$^2V_{10}$	$\left\{ {}^1V_{10} = {}^2V_{10} ; {}^1V_1 = {}^1V_1 \right\}$	$= n - 2 (= 2)$	1	...	...	...	...	...	...	...	...	$n-2$							
13	−	$^1V_6 - {}^1V_1$	$^2V_6$	$\left\{ {}^1V_6 = {}^2V_6 ; {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 1$	1	...	...	...	...	$2n-1$											
14	+	$^1V_1 + {}^1V_7$	$^2V_7$	$\left\{ {}^1V_1 = {}^1V_1 ; {}^1V_7 = {}^2V_7 \right\}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	÷	$^2V_6 \div {}^2V_7$	$^1V_8$	$\left\{ {}^2V_6 = {}^2V_6 ; {}^2V_7 = {}^2V_7 \right\}$	$= \frac{2n-1}{3}$	...	...	...	...	...	$2n-1$	3	$\frac{2n-1}{3}$									
16	×	$^1V_8 \times {}^3V_{11}$	$^4V_{11}$	$\left\{ {}^1V_8 = {}^0V_8 ; {}^3V_{11} = {}^4V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	−	$^2V_6 - {}^1V_1$	$^3V_6$	$\left\{ {}^2V_6 = {}^3V_6 ; {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 2$	1	...	...	...	...	$2n-2$											
18	+	$^1V_1 + {}^2V_7$	$^3V_7$	$\left\{ {}^2V_7 = {}^3V_7 ; {}^1V_1 = {}^1V_1 \right\}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	÷	$^3V_6 \div {}^3V_7$	$^1V_9$	$\left\{ {}^3V_6 = {}^3V_6 ; {}^3V_7 = {}^3V_7 \right\}$	$= \frac{2n-2}{4}$	...	...	...	...	...	$2n-2$	4	...	$\frac{2n-2}{4}$	...	$\left\{ \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = A_3 \right\}$						
20	×	$^1V_9 \times {}^4V_{11}$	$^5V_{11}$	$\left\{ {}^1V_9 = {}^0V_9 ; {}^4V_{11} = {}^5V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0	...							
21	×	$^1V_{22} \times {}^5V_{11}$	$^0V_{12}$	$\left\{ {}^1V_{22} = {}^1V_{22} ; {}^0V_{12} = {}^2V_{12} \right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	....	......	B_3		
22	+	$^2V_{12} + {}^2V_{13}$	$^3V_{13}$	$\left\{ {}^2V_{12} = {}^0V_{12} ; {}^2V_{13} = {}^3V_{13} \right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ A_3 + B_1 A_1 + B_3 A_3 \right\}$				
23	−	$^2V_{10} - {}^1V_1$	$^3V_{10}$	$\left\{ {}^2V_{10} = {}^3V_{10} ; {}^1V_1 = {}^1V_1 \right\}$	$= n - 3 (= 1)$	1	...	...	...	...	...	...	...	...	$n-3$							
					Here follows a repetition of Operations thirteen to twenty-three.																	
24	+	$^4V_{13} + {}^0V_{24}$	$^1V_{24}$	$\left\{ {}^4V_{13} = {}^0V_{13} ; {}^0V_{24} = {}^1V_{24} \right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....	....	....	......	......	......	B_7
25	+	$^1V_1 + {}^1V_3$	$^1V_3$	$\left\{ {}^1V_1 = {}^1V_1 ; {}^1V_3 = {}^1V_3 ; {}^5V_6 = {}^0V_6 ; {}^5V_7 = {}^0V_7 \right\}$	$= n + 1 = 4 + 1 = 5$; by a Variable-card.; by a Variable card.	1	...	$n+1$	...	...	0	0										

Lovelace's Analytical Engine algorithm for the computation of Bernoulli numbers

Margaret Sarah Carpenter, Ada Lovelace, 1836

Ada Lovelace (1815-1852)

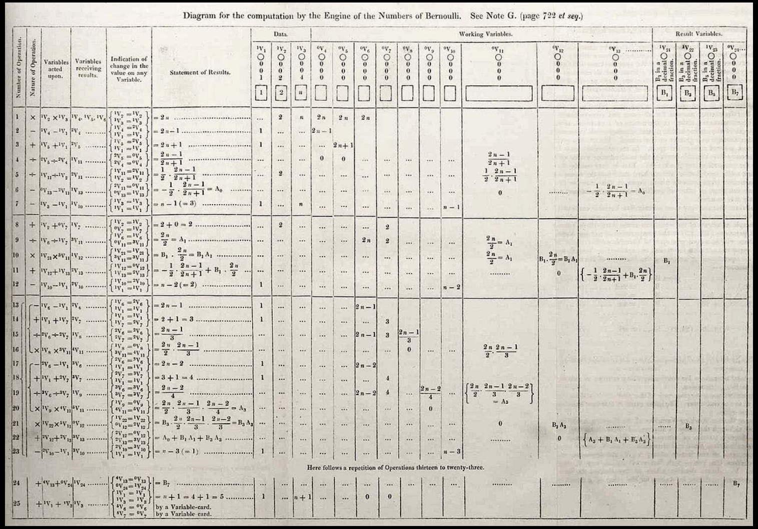


Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 et seq.)

Lovelace's Analytical Engine algorithm for the computation of Bernoulli numbers

Margaret Sarah Carpenter, Ada Lovelace, 1836

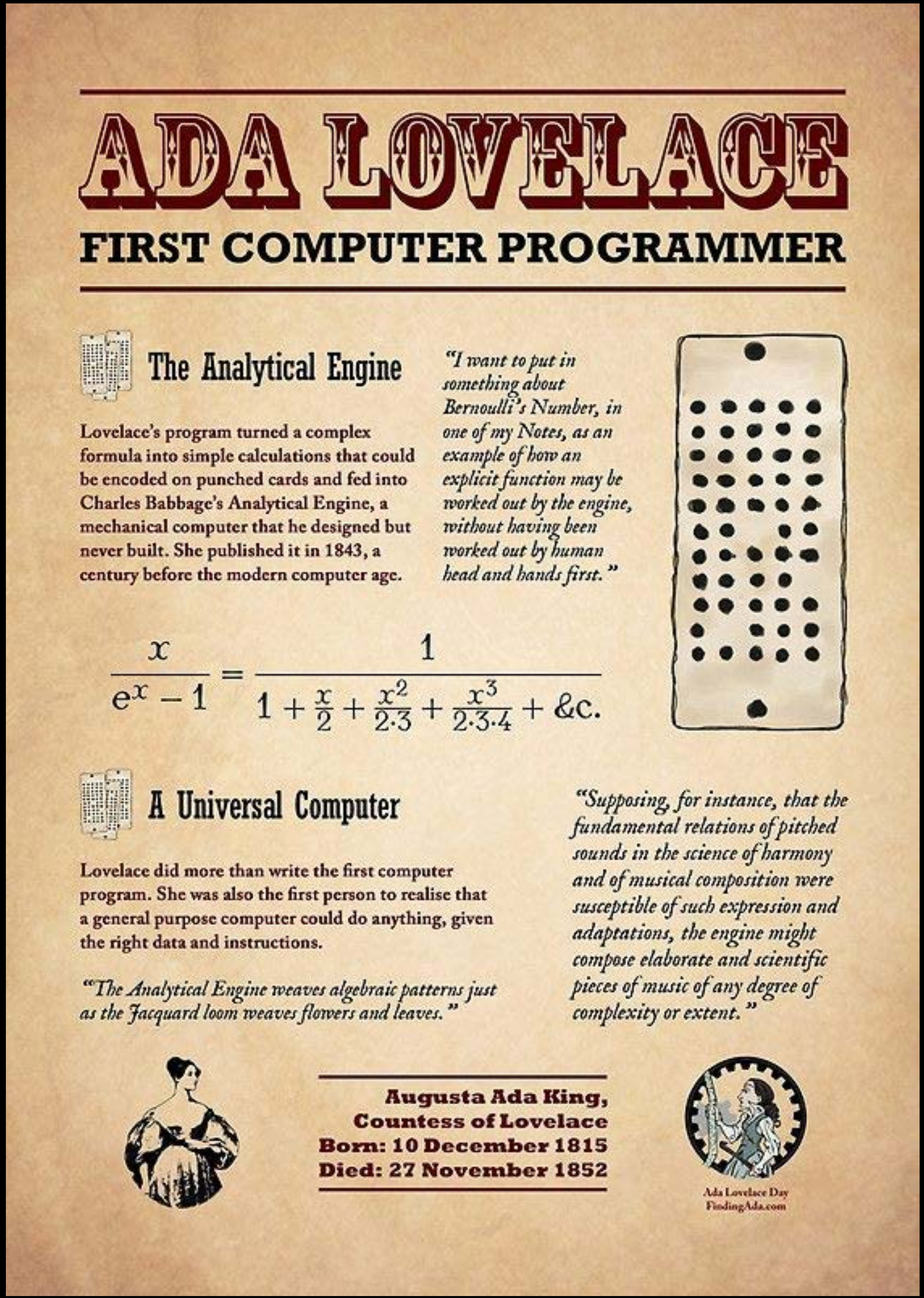
- A gifted mathematician, Ada Lovelace is considered to have written instructions for the first computer program in the mid-1800s.
- She was the only legitimate child of Annabella Milbanke and the poet Lord Byron
- Her mother, Lady Byron, had mathematical training (Byron called her his 'Princess of Parallelograms') and insisted that Ada, who was tutored privately, study mathematics too - an unusual education for a woman.
- Ada met Babbage at a party in 1833 when she was seventeen and was entranced when Babbage demonstrated the small working section of the Engine to her.
- In 1843 she published a translation from the French of an article on the Analytical Engine by an Italian engineer, Luigi Menabrea.
- Ada added extensive notes of her own to this essay.
- **The Notes included the first published description of a stepwise sequence of operations for solving certain mathematical problems and Ada is often referred to as 'the first programmer.'**

Anne Isabella Milbanke in
1812 by Charles Hayter

Gorging himself in gloom: no love was left;
All earth was but one thought--and that was death,
Immediate and inglorious; and the pang
Of famine fed upon all entrails--men
Died, and their bones were tombless as their flesh;
The meagre by the meagre were devour'd,
Even dogs assail'd their masters, all save one,
And he was faithful to a corse, and kept
The birds and beasts and famish'd men at bay,
Till hunger clung them, or the dropping dead

From Lord Byron, “Darkness,” 1816 – a poem about a vision of the end of the universe; darkness is an equalizer between men as it is the shared end of humans and humankind

The most flamboyant and notorious of the major English Romantic poets, George Gordon, Lord Byron (1788-1824), was likewise the most fashionable poet of the early 1800s. He created an immensely popular Romantic hero—defiant, melancholy, haunted by secret guilt—for which, to many, he seemed the model. Here we see a portrait of him by Thomas Philips (a replica of 1835 based on an original from 1813) in which the poet wears wearing the Albanian costume which he had bought four years prior to the portrait sitting.

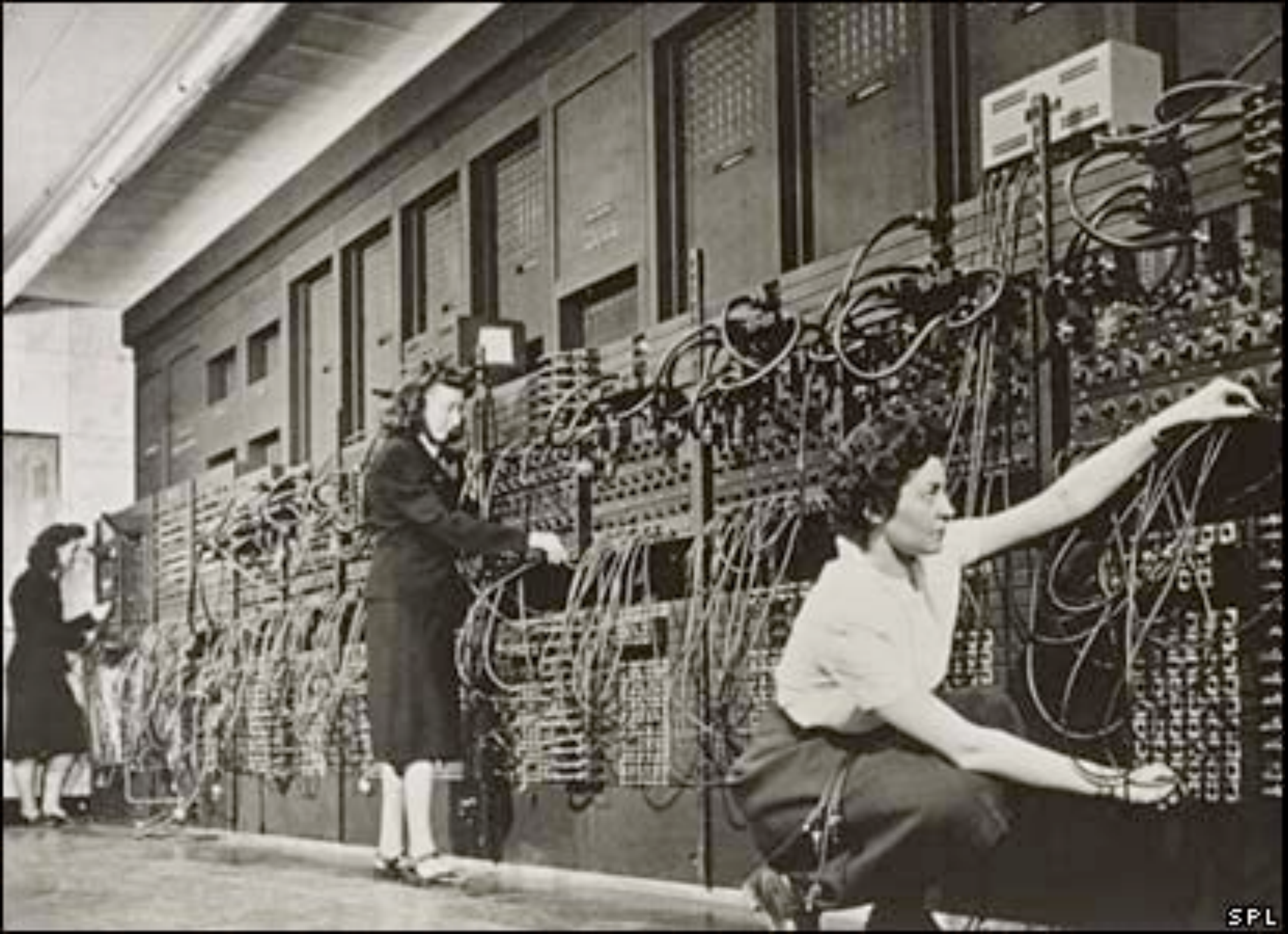


The article contained statements by Ada that from a modern perspective are visionary.

She speculated that the Engine "might act upon other things besides number... the Engine might compose elaborate and scientific pieces of music of any degree of complexity or extent."

The idea of a machine that could manipulate symbols in accordance with rules and that number could represent entities other than quantity mark the fundamental transition from calculation to computation. Ada was the first to explicitly articulate this notion and in this she appears to have seen further than Babbage. She has been referred to as 'prophet of the computer age.

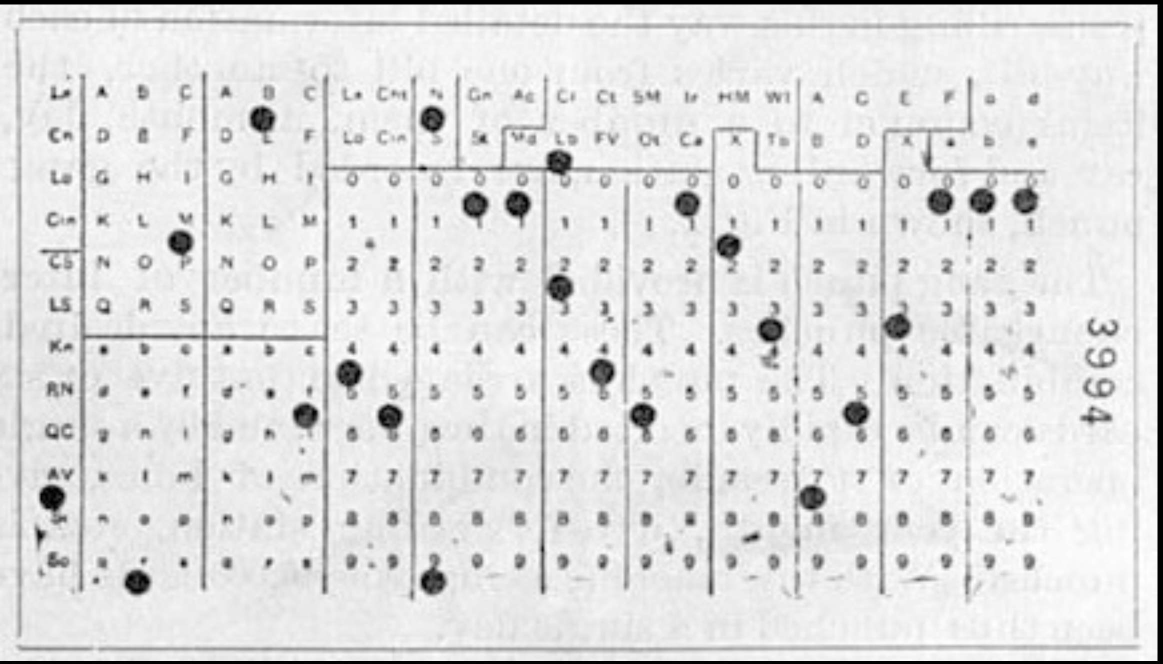
https://www.computerhistory.org/babbage/adalovelace/



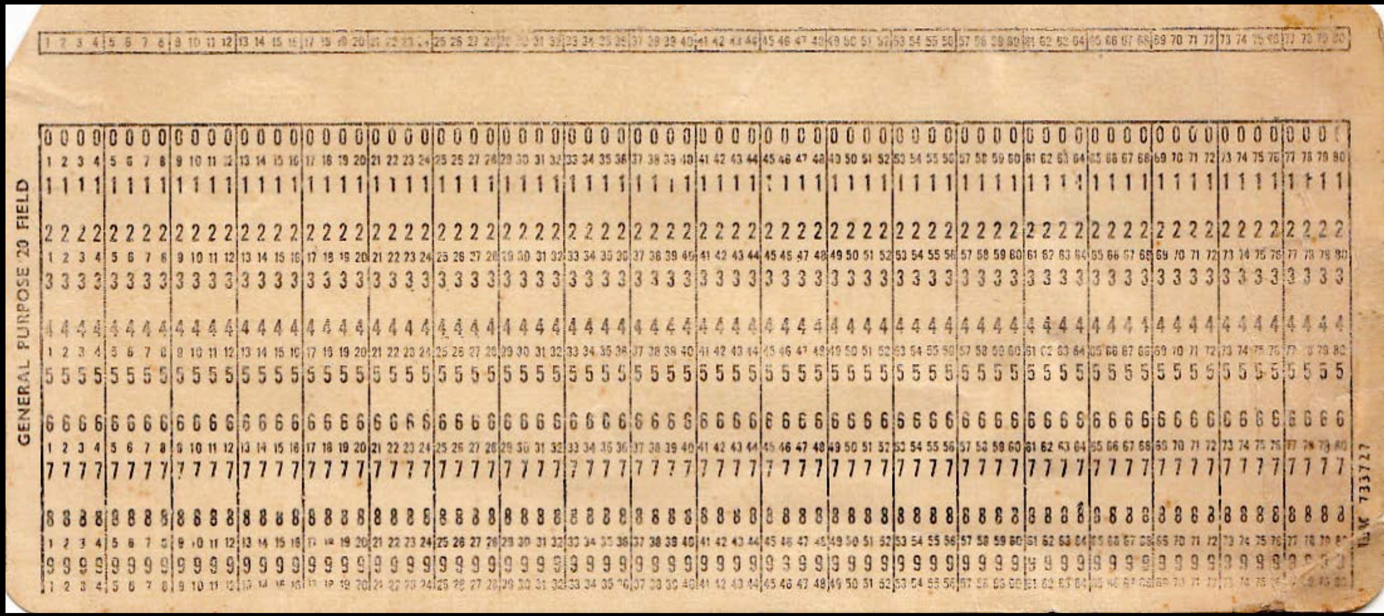
ENIAC [Electronic Numerical Integrator and Computer] Computer at the University of Pennsylvania, 1946, conceived by John Mauchly and J. Presper Eckert

- ENIAC stands for “Electronic Numerical Integrator And Computer”
- It was the first electronic general-purpose computer.
- It was digital Turing-complete, meaning it worked like a “Turing machine,” that it solves computational problems.
- ENIAC was designed to calculate artillery-firing tables for the US Army’s Ballistic Research Lab.
- When ENIAC was announced in 1946 it was heralded in the press as a "Giant Brain".
- It boasted speeds one thousand times faster than electro-mechanical machines, a leap in computing power that no single machine had since matched.
- The construction contract was signed on June 5, 1943, and work on the computer began in secret at the University of Pennsylvania
- ENIAC contained 17,468 vacuum tubes.
- This led to the rumor that whenever the computer was switched on, lights in Philadelphia dimmed.
- Input was possible from an IBM card reader, and an IBM card punch was used for output.

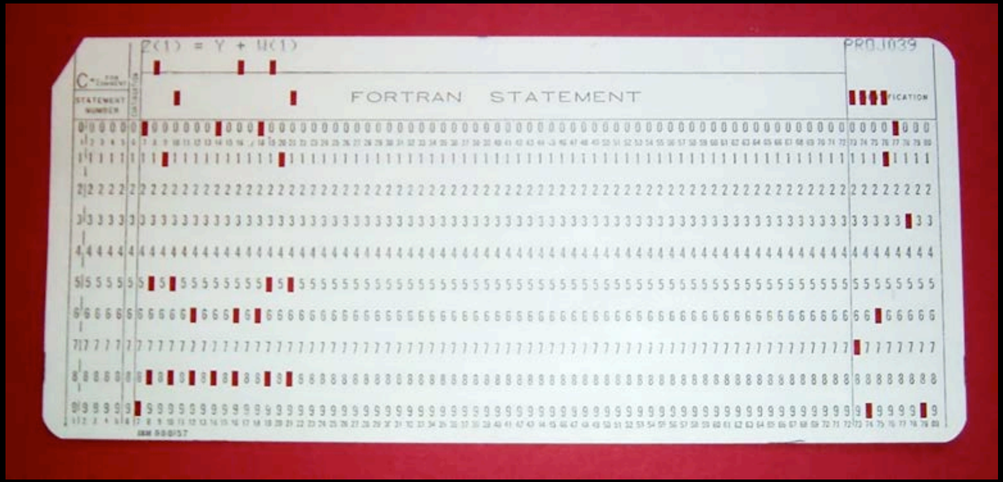
ENIAC vacuum tubes



Herman Hollerith’s Holerith card as shown in the *Railroad Gazette* in 1895

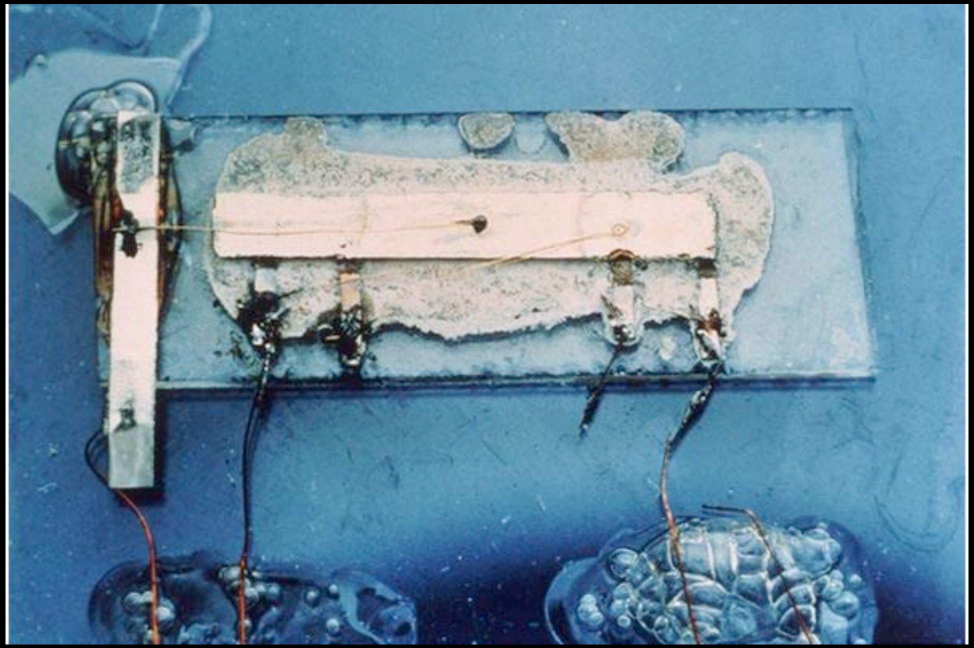


A general-purpose punched card from the mid twentieth century.

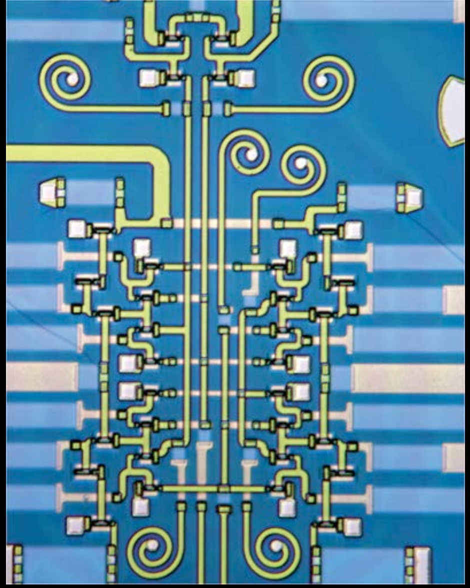


Card from a Fortran program: Z(1) = Y + W(1)

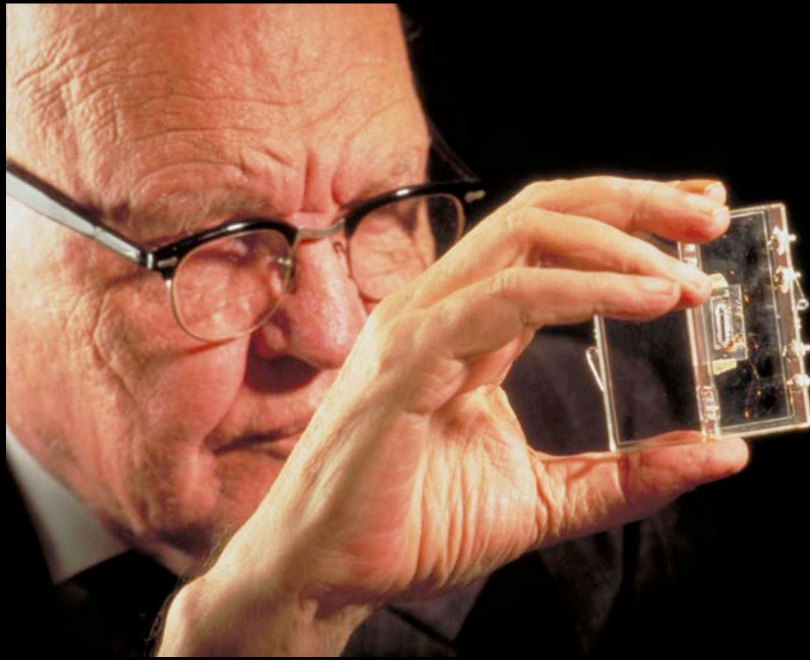
The Bell Labs team of John Bardeen, Walter Brattain and William Shockley won the 1956 Nobel Prize in Physics for their work in developing transistors.

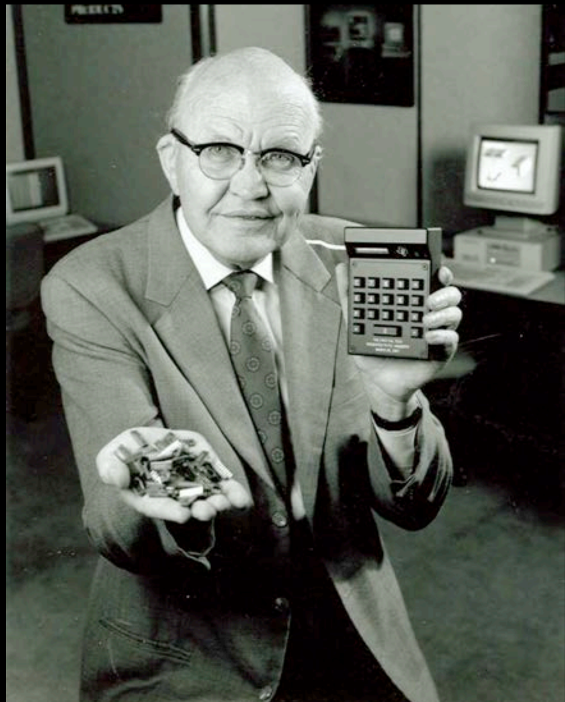


Jack Kilby's original integrated circuit created at Texas Instruments, 1958

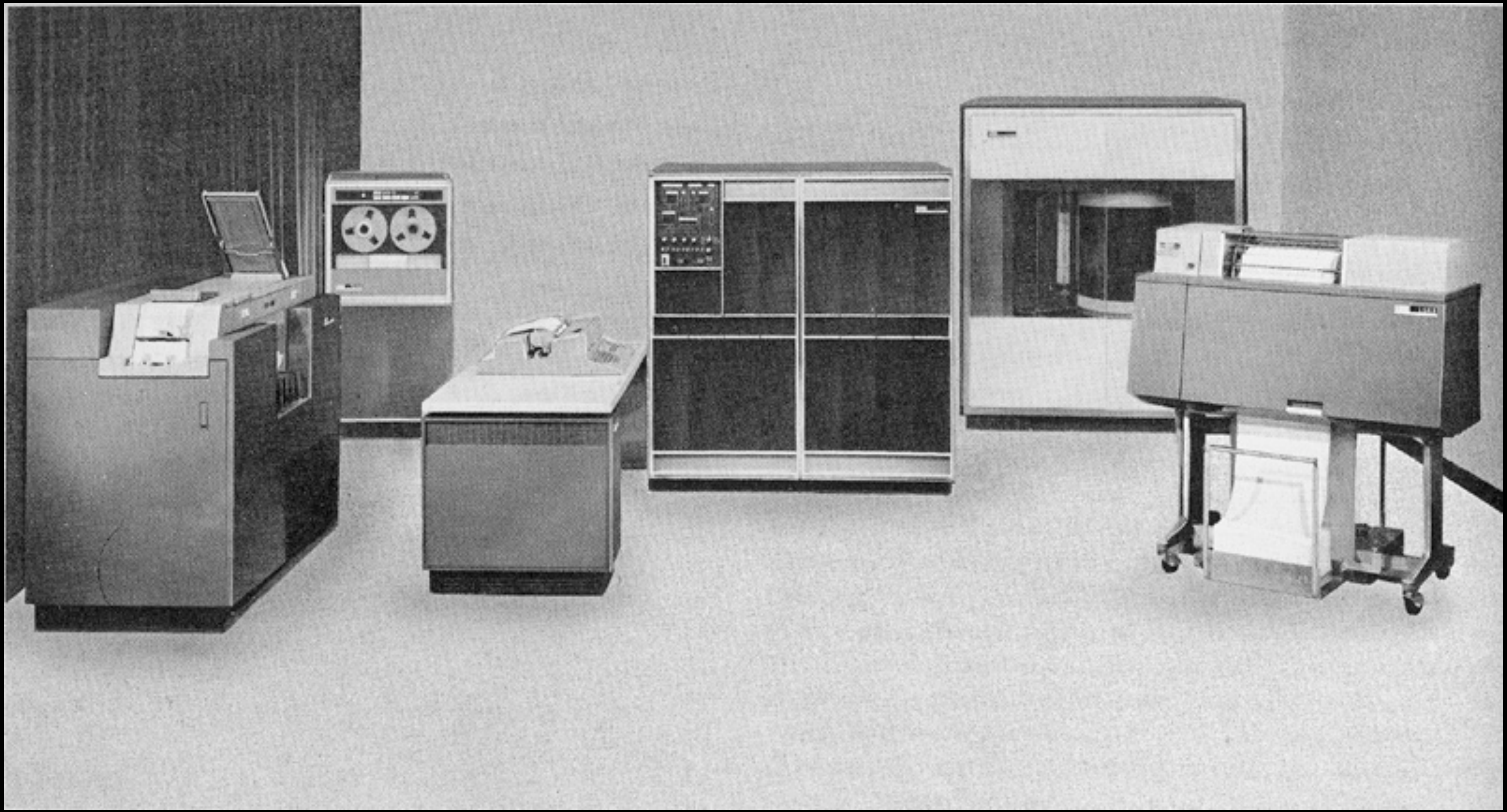


Integrated Circuit 1958





Untitled photographs by Jack Kilby, c. 1955

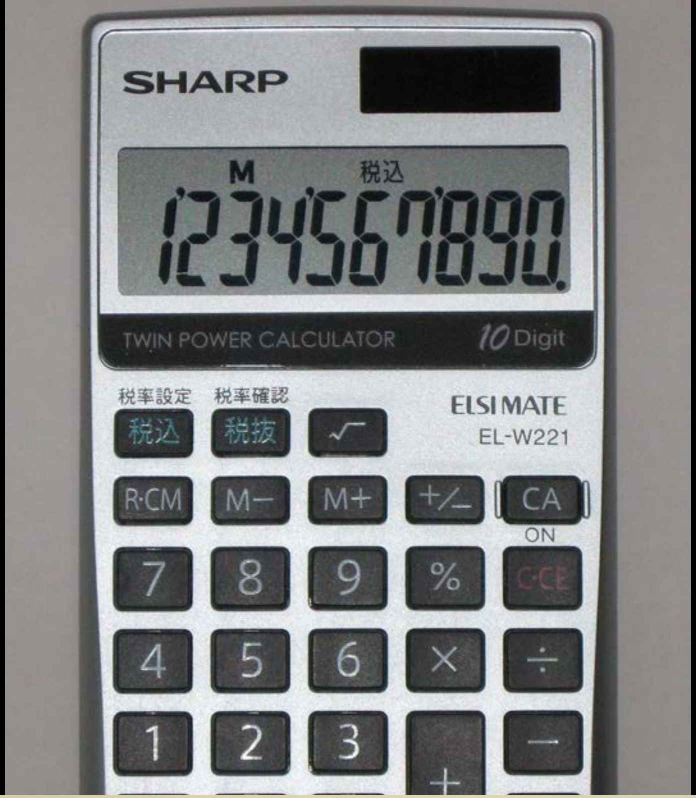


IBM 1401 Data Processing System, 1959

ENIAC vacuum tubes

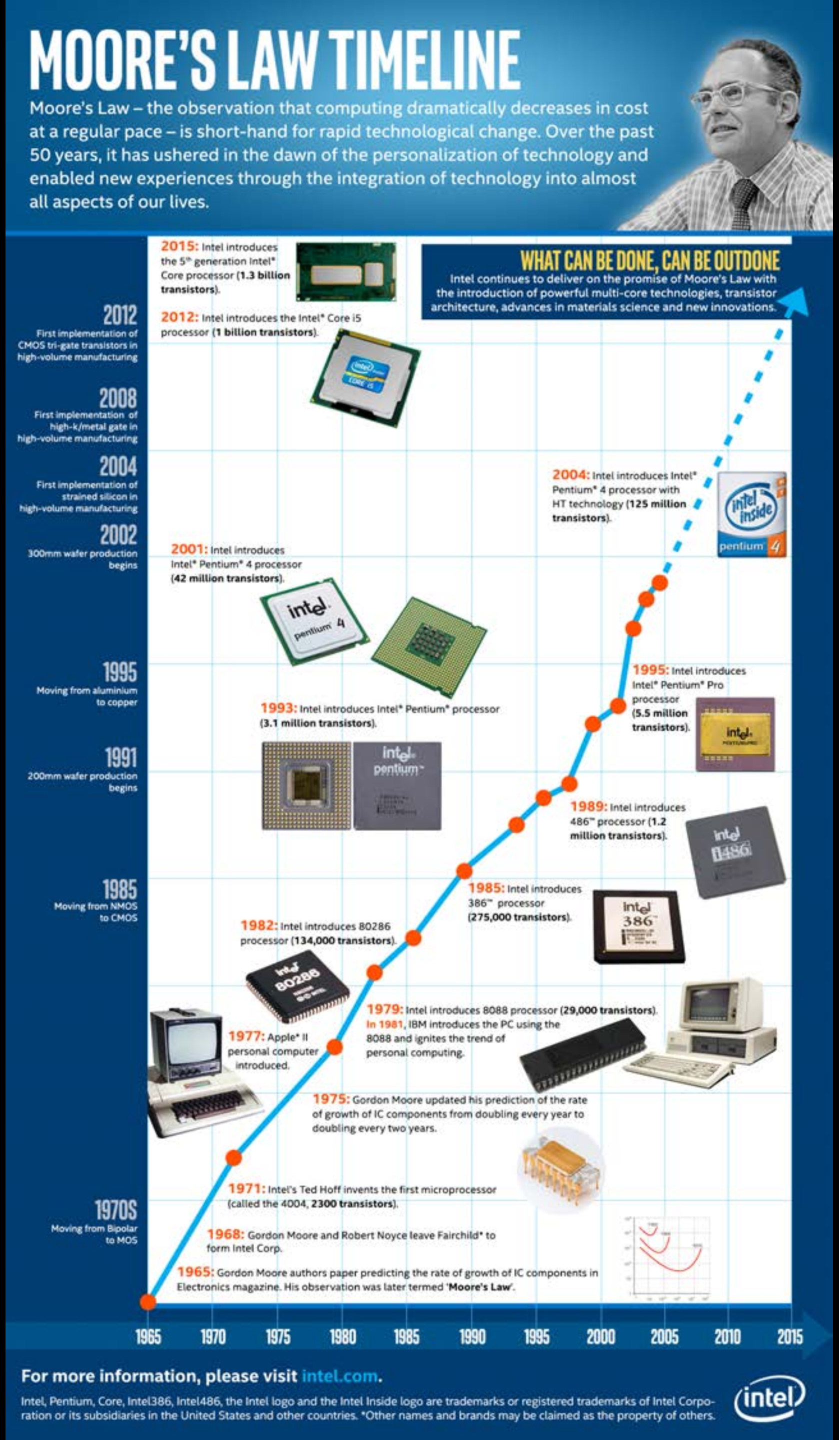
Integrated Circuit


SPELL A
OFF GO REPLAY REPEAT CLUE MYSTERY WORD SECRET CODE LETTER SAY IT SPELL ON
A B C D E F G H I J
K L M N O P Q R S T
U V W X Y Z #
MODULE SELECT ERASE ENTER
Speak & Spell™
Texas Instruments


SHARP
M 税込
1234567890.
TWIN POWER CALCULATOR
10 Digit
税率設定 税率確認
ELSIMATE
EL-W221
税込 税抜
R·CM M− M+ +/− CA
ON
7 8 9 % C·CE
4 5 6 × ÷
1 2 3 −

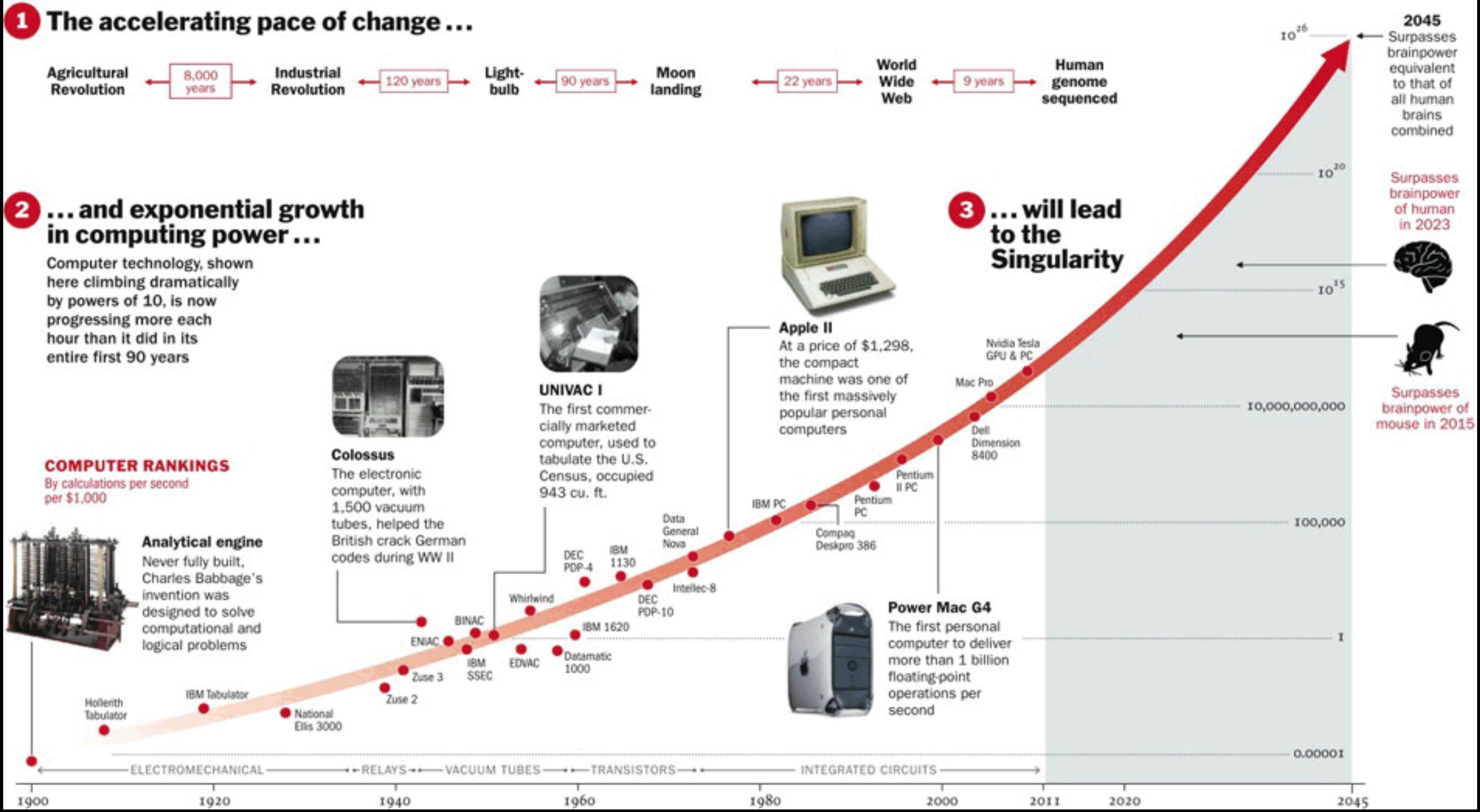

7 8 9 ÷
4 5 6 X
1 2 3 −
SET 0 GO +
"LITTLE PROFESSOR"™

Microprocessors and personal computers, 1970s



MOORE'S LAW

Named for Gordon Moore (b. 1929). It is the idea that the number of transistors in a dense integrated circuit doubles approximately every two years. He developed this idea in a 1965 paper.



1 The accelerating pace of change . . .
Agricultural Revolution
8,000 years
Industrial Revolution
120 years
Light-bulb
90 years
Moon landing
22 years
World Wide Web
9 years
Human genome sequenced
2 . . . and exponential growth in computing power . . .
Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years
3 . . . will lead to the Singularity
COMPUTER RANKINGS
By calculations per second per $1,000
Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems
Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II
UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.
Apple II
At a price of $1,298, the compact machine was one of the first massively popular personal computers
Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second
Hollerith Tabulator
IBM Tabulator
National Ellis 3000
Zuse 2
Zuse 3
ENIAC
BINAC
IBM SSEC
EDVAC
Whirlwind
Datamatic 1000
IBM 1620
DEC PDP-4
IBM 1130
DEC PDP-10
Data General Nova
Intellec-8
IBM PC
Compaq Deskpro 386
Pentium PC
Pentium II PC
Dell Dimension 8400
Mac Pro
Nvidia Tesla GPU & PC
2045
Surpasses brainpower equivalent to that of all human brains combined
Surpasses brainpower of human in 2023
Surpasses brainpower of mouse in 2015
10^{26}
10^{20}
10^{15}
10,000,000,000
100,000
1
0.00001
ELECTROMECHANICAL
RELAYS
VACUUM TUBES
TRANSISTORS
INTEGRATED CIRCUITS
1900
1920
1940
1960
1980
2000
2011
2020
2045

What is CP Snow’s definition of “communication” between two cultures? Is his rejection of the fusion of the humanities and natural sciences anti-avant-garde?