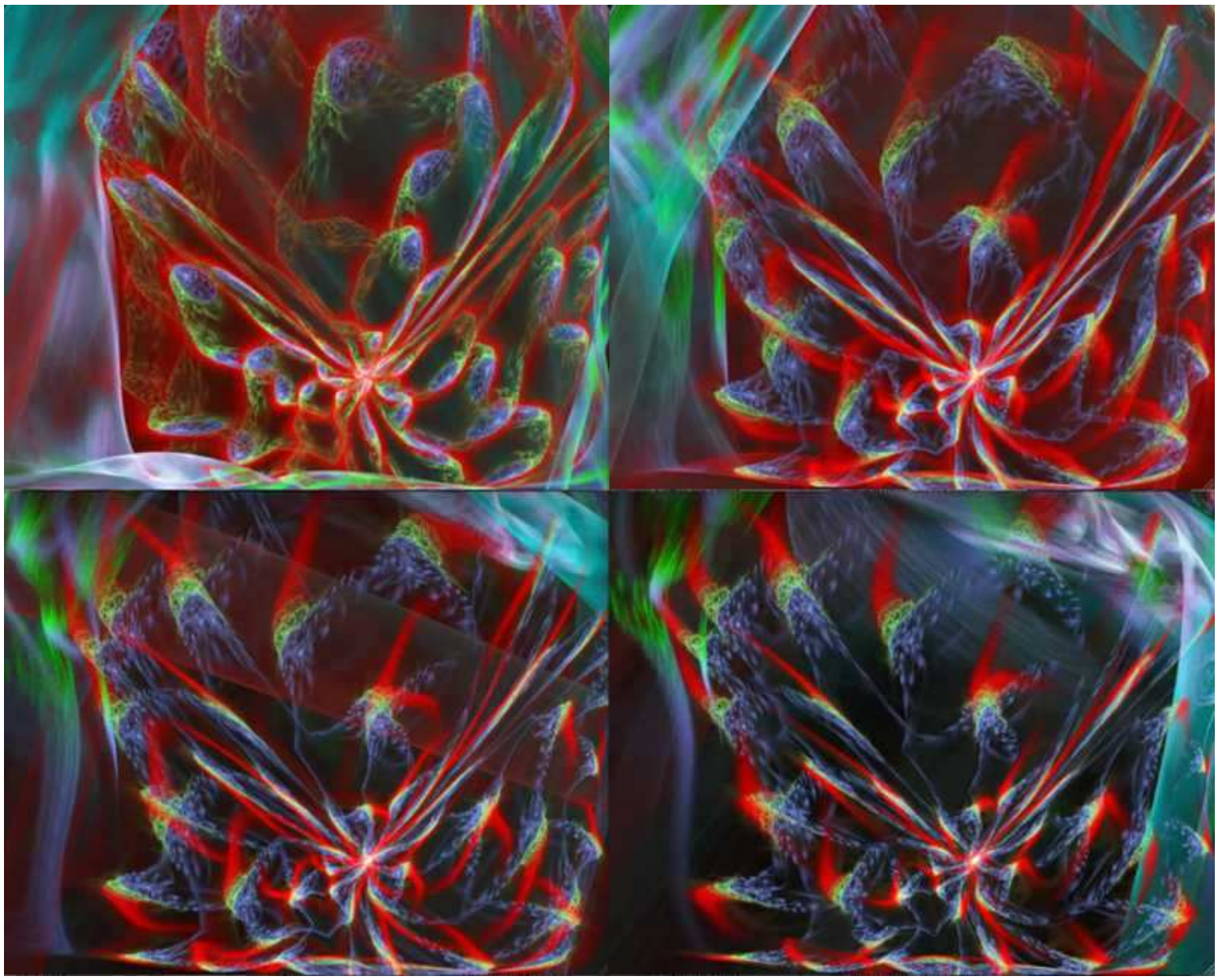
Thomas Dreher

History of Computer Art



Impressum

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Draves, Scott: Electric Sheep, internet-connected personal computers, screensaver, 1999.
Screenshots of two succesive phases (March-April 2012).

Thomas Dreher

History of Computer Art

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I. Introduction

Books on the history of computer art discuss either the developments being contemporary at the time of their publication 1, or they integrate computer art into histories of new media art. 2 After five decades of computer art more detailed reconstructions of the development lines of the use of computers and computing processes in artists´ projects are helpful for being able to recognize computer art as a distinct field of media art.

Computer experts experimented in the fifties and sixties for the first time with mainframe computers and developed several ways to use them in art and entertainment. Several projects of pioneers have been developed further by younger artists profiting from the progress of technology producing smaller and smaller computers. These works constitute a dense field of possibilities that contemporary artists can take up and evolve further. Meanwhile in the sixties and seventies information aesthetics offered a goal turning working with computing processes into a project shared by many artists, after the postmodern criticism of such dominant `projects´ a plurality of technological configurations has been developed complicating the effort to present an overview: We are faced with an advanced stage of the differentiation of computer art.

This overview integrates animation and games as relevant development lines of computer art and doesn´t avoid confrontations between corporative organized and distributed arts on one side and on the other side artistic developments beside the interest of investors and corporative organized production methods, because both sides realize different aspects of "computational aesthetics". 3 To avoid artificial separations between three-dimensional visual simulations in digital film animations and computer games on the one hand and in computer art on the other hand these developments are discussed as being equivalent, complementary, or paradigmatic.

Computer art evolves partially in simultaneous development lines: The evolution of computer art is multilinear. Each of the chapters features one of these lines. The sequence of the chapters results from the dates of the early mature projects being examples for the main characteristics of a line in a trailblazing manner. The successors of the first mature projects are not included in this outline of the history of computer art. Some development lines have longer evolution phases provoked by the evolution of computer technology from mainframe computers to personal computers (see chap. IV.2.1, VI and VII).

The development lines are sketched out hereinafter, and the succession of the chapters helps to get a survey of the overal development.

Cybernetics thematise characteristics common to technic and biologic systems (see chap. I.1). William Ross Ashby´s "homeostat" and the self navigating robots constructed by William Grey Walter are technical models whose characteristics to react to external factors are to find in biological systems, too (see chap. I.2). These cybernetic models are technical demonstrations for systems navigating themselves in environments under changing conditions. Ashby´s und Walter´s models prefigured cybernetic sculptures. Cybernetic sculptures differ from three-dimensional kinetic art with moving parts 4 in its capabilities to react to environmental influences with programmed elements (see chap.

II.3).

The capabilities of mainframe computers to combine signs following programmed rules demonstrate texts that have been generated for the first time in the fifties (s. Kap. III.1). The combinations of letters to build words, combinations of words, parts of sentences, and sentences prefigure a method to organize computing processes that was used and modified in the sixties in computer graphics to generate configurations with a repertory of visual signs. Computers are used as instruments to generate partial realisations of the possible combinations of a visual system´s elements. The results of the computing processes are printed by plotters.

The cybernetics-based information aesthetics offer ciriteria for combinations of visual elements avoiding over- as well as undercomplexity of a print´s appearance. Meanwhile works of Serial-Concrete Art are composed by rules combining visual elements without derivations 5, computer graphics combine serial with pseudo-random procedures (algorithmic procedures to generate non-serial events). Information as a measure for visual perception (see chap. II.2.2) is added to "information" as a measure for technical procedures (see chap. II.1.3).

In the seventies the arising video cultures follow political and formal experimental tendencies. A part of the last tendency are the developments of video synthesizers beginning with analogue components and using digital components since the end of the seventies. Artist use the video synthesizers for the production of 2D-video films (see chap. IV.1). Simultaneously in the seventies methods for 3D simulations with digital mainframe computers are developed and at the beginning of the eighties it is possible for the first time to produce the figures and spaces of sequences for movies exclusively with computer animation (see chap. IV.2).

In the eighties animation procedures for virtual bodies and surfaces are integrated in Evolutionary Art by borrowing from theories on evolution (see chap. IV.3).

Since the end of the eighties reactive installations offer interfaces for real-time navigation in simulations of three-dimensional worlds to visitors of art exhibitions (see chap. V). In the eighties on one side mainframe computers offer 3D real-time animations, meanwhile on the other side personal computers are used (simultaneously with consoles) for games with still rudimentary 3D simulations (see chap. VII.1.3).

In the eighties programs are developed in the demoscene for introductions (intros) to cracked games using codes for scroll texts and moving graphics to control directly the graphic chips of personal computers (see chap. IV.4.3).

In the nineties on one side the 3D animation for personal computers in games, demos and others becomes usual, on the other side a culture of linked (parts of) texts is created by the web´s combination of hypertext and telecommunication (see chap. VI.2.2, VI.2.3) with possibilities to embed low resolution images and short films. In the web of the nineties images and films can get no other than accompanying functions because the transmission time still stretches the users´ patience.

The personal computer culture in bulletin board systems was a precursor of the web in the nineties. The development of net art starts with the internet of the eighties (see chap. VI.I.2), meanwhile the basics of computer networks and the hypertext have been worked out much earlier (see chap. VI.2.1).

In relation to their precursors in the fifties and sixties (see chap. III.1.2, III.1.3, III.2.2) the mutual influences between literature and art are intensified in the networks of the

eighties (see chap. VI.1.2) and in the internet of the nineties (see chap. VI.2.2, VI.2.3) because net literature as well as net art use and thematise hypertext structures.

Projects of HTML art (see chap. VI.3.2) and projects of browser art (see chap. VI.3.3) thematise the web conditions of the nineties. Some source codes of these projects don´t operate after the disappearance of the early web conditions.

The easy availability of data via web access, its storability and their repeatability in follow-on projects provoke artistic projects demonstrating and thematising (apparent) transgressions of copyright restrictions. The American copyright permits in the "Doctrine of Fair Use" to repeat parts of art works for comments. Artists criticise a certain kind of commercialized culture by using montages and modifications of copyrighted works. These re-uses provoke the proprietors of copyrights (and its exploiters) to strengthen their efforts to restrict the applicability of the "Doctrine of Fair Use" via jurisdiction. 6 Two websites from 2002-2003 are selected as examples presenting texts and artistic projects as critical studies of this important aspect of the net culture (see chap. VI.3.4) offering pleas for a Copyleft and Creative Commons culture.

In the forties computer games were not only a side-line of experts but a means to demonstrate the performance of computers to a lay public (see chap. VII.1). The arcade games for amusements centers and the consoles for consumer TVs made it possible to play video games with a hardware constructed for specific needs. In the seventies they became a branch of the entertainment industry (see chap. VII.1.2).

In the eighties personal or home computers are are not only used for EDP (electronic data processing), but with games they become a device for leisure activities. In the nineties strategy games offer an alternative to the popular shooting games. Both kinds of games integrate players in different ways into 3D simulations (see chap. VII.1.3).

Contrary to the multiplayer online games (MMOG), pervasive games are played with and against participants in real environments. Characteristics of pervasive games are short play times without levels and the players´ task to coordinate informations received via mobile devices with conditions as they are found in the environment (see chap. VII.2).

The game-oriented interface-model presented in the chapter on pervasive games is developed further to a method for discourses on interactions between humans and computers (see chap. VIII.2). The developments of computer art are systematized as three modes to organize computing processes: Hypertextual, modular and generative procedures are the main ways to organize computing processes in projects realised by artists (see chap. VIII.1).

Annotations

1 Franke: Computergraphik 1971 on computer art of the fifties and sixties; Goodman: Visions 1987 with priority for the eighties; Paul: Art 2003 with priority for the nineties. Taylor: Machine 2005 presents the history of computer graphics until the eighties. According to Taylor "the real legacy of the computer art phenomenon" (Taylor: Machine 2004, S.236) ended with a questionnaire of the art journal Leonardo (Supplemented Issue 1989) on the actual state of computer art and critical evaluations in the artists´ answers. For Taylor the key aspects of computer art are presented by computer graphics. The projects presented in the chapter VI, VI and VII can be used as examples to demonstrate that computer graphics lost this role in the seventies and eighties.
For improved readability masculine forms stand for the female forms as well: "He" or

"his" are short forms for "she/he" and "her/his". back

2 Davis: Art 1973; Lovejoy: Currents 1997; Popper: Art 1993; Shanken: Art 2009. Stephen Wilsons adds in "Information Arts" (Wilson: Information 2002) many short descriptions of many projects to many short chapters. His waiver of creation dates demonstrates that he didn´t intend a historical overview with a characterisation of central aspects. back

3 The use of the term aesthetics for artistic developments for and with computing processes makes sense only if its meaning is not restricted to visual phenomena. Hardware functions, interfaces, programs (software codes) and computing processes need to be taken into consideration as components of "computational aesthetics". back

4 In Kinetic Art parts of the works are moved by either engines or by movements of the air. On Kinetic Art: Buderer: Kinetische Kunst 1992, p.45-78; Burnham: Modern Sculpture 1968, p.262-284; Davis: Art 1973, p.53ss,123-135; Popper: Kinetische Kunst 1975, p.28-40. back

5 Compare series of works (and series in works) by Richard Paul Lohse, François Morellet and Marcello Morandini. On a Concrete Art organized by mathematics: Crone: Order 1978; Guderian: Parallelen 1997. back

6 Without author: United States Code, o.J. back

II. Cybernetics
II.1 Basics of Cybernetics

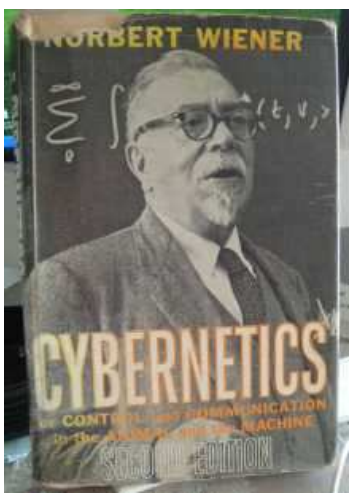
II.1.1 Ballistics

The basics of cybernetics were presented by technically constructed models (see chap. II.2). These models became fundamental for the development of cybernetic sculptures (see Chap. II.3), meanwhile the information aesthetics based on cybernetics offered criteria for the serial artists programming computer graphics (see chap. III.2). This shows: There is no alternative to an introduction to cybernetics.

In 1948/49 Norbert Wiener and Claude Elwood Shannon published in their classic books on cybernetics and information theory the basics of the American army´s ballistic research in the Second World War. The calculation of the flight path of an enemy´s airplane presupposed to know how pilots navigate to reach their target. 1 However, in practice, the pilots changed their approach to targets according to their knowledge of the air defense and made forecasts of the meeting between an airplane and a projectile impossible. 2 The problem to predict this crash made relevant the problem to calculate the probability which flight path will be chosen (see chap. II.1.2).

The cybernetics´ basic texts are the fruits of the research for air defense 3 being able to resolve the feedback (see chap II.1.4) between the movements of the targets and the projectile much later with the development of missiles.

At first the integration of mathematics into engineering was discussed controversal by researchers of ballistics and cryptography. 4 "It was only in 1945, when the usefulness of mathematics was upgraded for strategic and technic tasks." 5 Before 1945 Wiener and Shannon investigated the fields of convergences between mathematics and engineering, and in their later published writings they laid down the basics for an understanding of the term information as integrating the opposing research poles (see chap. II.1.3). For mainframe computers the American and British army developed simultaneously uses in ballistics, early warning systems, and cryptography. 6



Norbert Wiener (Cover of "Cybernetics", second edition, 1962).



Claude Elwood Shannon with "Theseus" (1952) and the mouse navigating itself through the labyrinth (compare chap. II.2.2).
(Credit: MIT Museum, Boston / Nixdorf MuseumsForum, Paderborn)

II.1.2 Stochastics

Stochastics combine calculations of probabilities and statistics of frequencies. The possibilities of a system to combine its elements with each other can be restricted to probabilities by statistics informing about the frequency of their earlier occurrences. Predictions indicate the probability of a systems´ elements by indicating how often they appeared in the past and how these occurrences relate to all possible combinations : The reappearance of a more frequent used element is more probable than the reappearance of a seldom used element. Shannon used stochastics as a means to construct the English language for a second time by generating combinations of its elements and their combinations – following the frequencies of their occurrences. The computer calculates the possibilities of combinations fast and the frequency statistic of letters in units of a selected language serves to restrict these possibilities. In the course of this selection procedure the probability rises that the calculated possibilities and the chosen language coincide (see chap. III.1.3).

The approximation to a language by the recombination of its elements in regard to the frequencies´ statistics of their occurrences in the everyday language recalls procedures of the cryptography: The signs appearing often in a code are compared with the frequencies of signs in the language of the message to be decoded. Shannon won the characteristics of a not decryptable code with cryptographic methods: It should be constructed only by chance operations, it should be as extensive as the urtext, and it has to be kept secret. 7

II.1.3 Information

For Shannon and Wiener the term information serves to denote a measure of a technical system´s capacity. A system´s technology can be able to transfer a certain amount of

information. There is a distinction to be made between this measurement of its transmission capacity and the "semantic information" (see chap. III.1.3). 8 The basis of a definition of "information" is formed by the probable distribution of physical elements in a closed system with its tendency to entropy ("particular disorder, mixture"), as elaborated by Ludwig Boltzmann in his statistical thermodynamics 9, and its opposite, the "segregation" and "demixing" 10: information as negentropy. Cybernetics use the negation of entropy (negentropy) to develop a theory of information.

The alternative between two values is measured as 1 "bit". The relais of calculating machines and computers switch between the two values "0" and "1". 11 The possibilities to select are calculated as 2^n. "n" stands for a number of decisions to choose one of the values "0" and "1". "Probabilities of selection" $p_1, p_2 ... p_n$ belong to any independent, selectable sign. The probability of selection specifies the probability of an element´s occurrence (see chap. II.1.2). The probability of selection is multiplied by the logarithm with the base 2 of the probability of selection ($p_n \log_2 p_n$). The products calculated with each probability of selection are added. The sum is negated to obtain the negentropy resp. the information "I":

$$I = -(p_1 \log_2 p_1 + p_2 \log_2 p_2 + ... p_n \log_2 p_n)$$

$$I = -\Sigma\, p_n \log_2 p_n \ (\Sigma = \text{sum for n = 1 until n})$$ 12

II.1.4 Feedback

The system-internal transmission, its disturbances ("noise") and the feedback of the output into the system belong to the processing of input: The system controls the output by detecting the deviations and by reacting to them. This control procedure is called "feedback" 13 and the correcting technical element is named "observer". The "observer" couples the output to a circuit integrating the output data and correcting the subsequent output. In the case of deviations above a certain threshold this corrective "observer" is activated. 14

The connection between a system with an internal "observer" and its environment is recognized by an "external observer" 15 integrated by second- order cybernetics as part of a more extensive system. This more extensive system contains the environment of the first system as well as its observer orienting himself by perceptions and moving himself in this environment. 16 The external observer of the first system becomes an internal observer of the more extensive system.

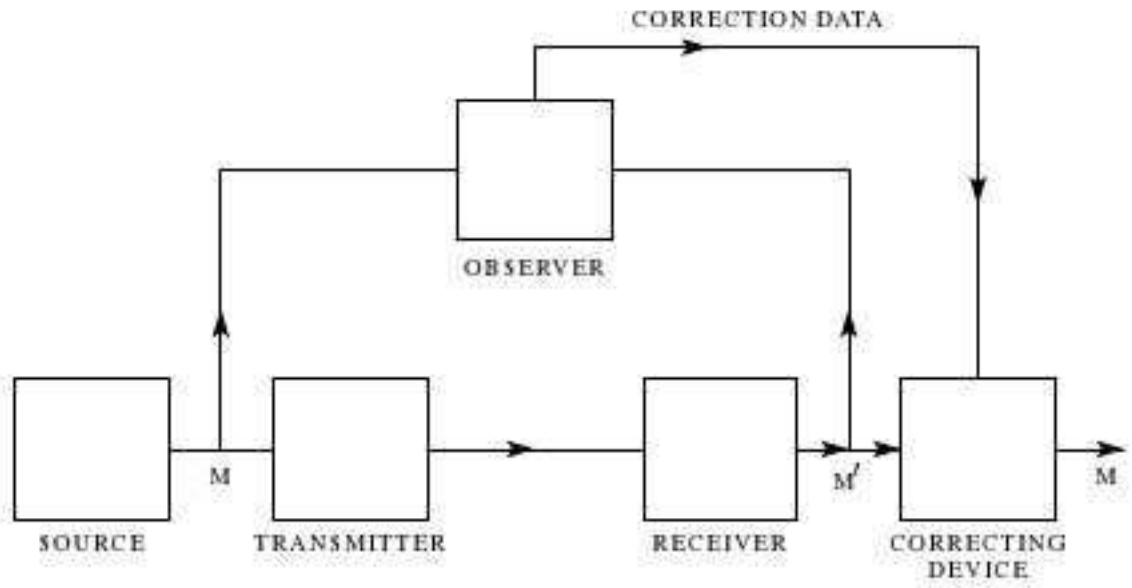


Fig. 8 — Schematic diagram of a correction system.

Shannon, Claude Elwood: A Mathematical Theory of Communication. In: Bell System Technical Journal, Vol. 27/Nr.3, 1948, p. 409.

II.1.5 Homeostasis

A system communicates with its environment by trying to use the internal structures for accomodations to disturbances being caused externally. William Ross Ashby´s cybernetic model of a "homeostasis" (see chap. II.2.1) presents a system with internal functions seeking equlibrium. 17 A multipartite system uses its internal variability to react to external disturbances with balancing moves by other parts than the disturbed part. In its stable overall condition all parts are either in the middle or at the extreme states balancing themselves reciprocally. This internal differentiation constitutes the capability to react self-regulatory to external disturbances: The "Homeostat" is a model for the "law of requisite variety". 18



William Ross Ashby beside the "Homeostat", realised in 1946-47.

Niklas Luhmann´s "autopoiesis" 19 presupposes Ashby´s "law of requisite variety". The evolution of system-internal differentiations improves the capabilities of social, biologic and cognitive systems to react to the environment. 20 Because systems are not as complex as their environment they develop their complexity reducing "selection strategies" 21 for the observation of the environment. These developments presuppose a "requisite variety" emerging in differentiations of "inter system relations". 22

Annotations

1 Bluma: Wiener 2005, p.90s.; Wiener: Cybernetics 1948, p.11ss. back

2 Roch: Shannon 2009, p.43-82,125-144,156-162; Roch/Siegert: Maschinen 1999, p.219,222-229; Wiener: I 1956, p.243-263. back

3 Roch: Shannon 2009, p.145: "Shannon worked out first the answer for the discrete case of a secure communication in `A Mathematical Theory of Cryptography´ ([unpublished, Bell Laboratories] 1945), then he prepared the continuous case of a disturbed transmission for `Transmission of Information´ ([manuscript]1947, [publication: Shannon: Communication 1949]). In 1948 Shannon brought the methods and results of all preparatory works together in `A Mathematical Theory of Communication´ [Shannon/Weaver: Theory 1949/1998]. Shannon problematised not only the question of an effective communication, but concretely the theoretical basics of a secure and effective navigation of electronic air defence systems."
Roch: Shannon 2009, p.104, quoting Shannon: "`When I came out with my paper in 1948, part of that was taken *verbatim* from the cryptography report, which had not been published at that time.´ [Shannon quoted in Price: Conversation 1985, p.170] For the scientific public Shannon simply devided his 114 pages long `cryptography report´ in two parts: one part more about communication theory and another one on codes."
Cf. Roch: Shannon 2009, p.82,120ss.,128ss.,144s.,159.
Norbert Wiener on feedback and the theory of prediction in its use in antiaircraft fire in the Second World War: Wiener: Cybernetics 1948, p.11-14,23s.,55; Wiener: I 1956, p.249-255,260-265.
On Wiener´s anti-aircraft research and its pioneering role in cybernetics: Bluma: Wiener 2005, p.108ss.,116. back

4 Roch: Shannon 2009, p.57-64. back

5 Roch: Shannon 2009, p.63. Cf. Wiener: Cybernetics 1949, p.20s. back

6 Augarten: Bit 1984, p.109-112,120-131,210ss.,195-202; Gere: Culture 2008, p.46-50,65ss.; Roch: Shannon 2009, p.34; Wiener: Cybernetics 1949, p.22. back

7 Shannon on the reconstructability of languages using stochastics: Bense: Aesthetica 1982, p.335s.; Roch: Shannon 2009, p.26s.; Shannon: Communication Theory 1949, p.656s.; Shannon: Redundancy 1950, p.249; Shannon/Weaver: Theory 1949/1998, p.39-44; Wardrip-Fruin: Media 2007, p.236-239.
Shannon on cryptography: Shannon: Communication Theory 1949. The unpublished "A Mathematical Theory of Communication" of 1945: see ann.3. Cf. Roch: Shannon 2009, p.96-123; Rogers/Valente: History 1993, p.39,42ss. For antiaircraft systems the security of the transmission of control signals was crucial: Roch: Shannon 2009, p.144-152. back

8 Shannon: Redundancy 1950, p.123/248; Wiener: Cybernetics 1949, p.18. back

9 Bense: Aesthetica 1982, p.153,160,211,325; Roch: Shannon 2009, p.115s. back

10 Bense: Aesthetica 1982, p.213. back

11 Cf. Roch: Shannon 2009, p.33s.; Wiener: Cybernetics 1949, p.22s.,139ss. (with comparisons between relais and nerve cells). back

12 Bense: Aesthetica 1982, p.212s.; Porr: Systemtheorie 2002, p.6; Shannon/Weaver: Theory 1949/1998, p.14,32s. back

13 Wiener: Cybernetics 1949, p.13,113-136. back

14 Roch: Shannon 2009, p.160s.; Shannon/Weaver: Theory 1949/1998, p.68. back

15 Bense: Aesthetica 1982, p.364s. back

16 Gregory Bateson and Margaret Mead in Brand: God 1976. back

17 Ashby: Design 1960, p.100-121; Ashby: Introduction 1957, p.73-85. Cf. Wiener: Cybernetics 1949, p.134ss. back

18 Ashby: Introduction 1957, p.202-219; Ashby: Variety 1958; Porr: Systemtheorie 2002, p.11ss. back

19 Luhmann: Systeme 1984, p.60s. back

20 Porr: Systemtheorie 2002, p.13s.,18,41s.,51. Cf. Ashby: Variety 1958, chap. Operational Research. back

21 Luhmann: Systeme 1984, p.47s. back

22 Luhmann: Systeme 1984, p.249. back

II. Cybernetics
II.2 Cybernetic Models

II.2.1 Homeostat

In 1946/47 William Ross Ashby realised a technical system as a model for his theory of homeostasis (see chap. II.1.5). This system offering a theory´s test case inspired in the fifties and sixties artists constructing cybernetic sculptures (see chap. II.3). "Homeostat" is a technical model demonstrating a system´s limited capabilities to adapt itself to environmental conditions. The flow of energy in the technical model is used to demonstrate how the system/environment relation functions in biological systems, for example to maintain the body heat. Cybernetic scientists develop theories valid across systems, construct technical models for them, and compare them with characteristics of creatures: from theory to machine to creature – and back. 1



FIGURE 8/2/1 : The Homeostat. Each unit carries on top a magnet and coil such as that shown in Figure 8/2/2. Of the controls on the front panel, those of the upper row control the potentiometers, those of the middle row the commutators, and those of the lower row the switches *S* of Figure 8/2/3.

FIGURE 8/2/2 : Typical magnet (just visible), coil, pivot, vane, and water potentiometer with electrodes at each end. The coil is quadruple, consisting of *A*, *B*, *C* and *D* of Figure 8/2/3.

Ashby, William Ross: Homeostat, 1946-47 (Ashby: Design 1960, p.101).

Four units being sensitive to disruptions and compensating them are connected by Ashby to build the system of "Homeostat". On each unit a magnet controls the deflections of a needle. Placed in a conductive liquid the needle reacts to the system´s voltage fluctuations. "Uniselectors" introduce system-internal disturbances by chance-operations. Controllers ("commutators and potentiometers") on the four units make the regulation of

energy possible. The system reacts to changing energy flows within its possibilities to execute compensation movements: The output of one unit becomes the input of the next unit. This results in a system behaviour keeping the needle stable in the midst of its swinging possibilities. Ashby designates this self-regulation as "ultrastability". 2

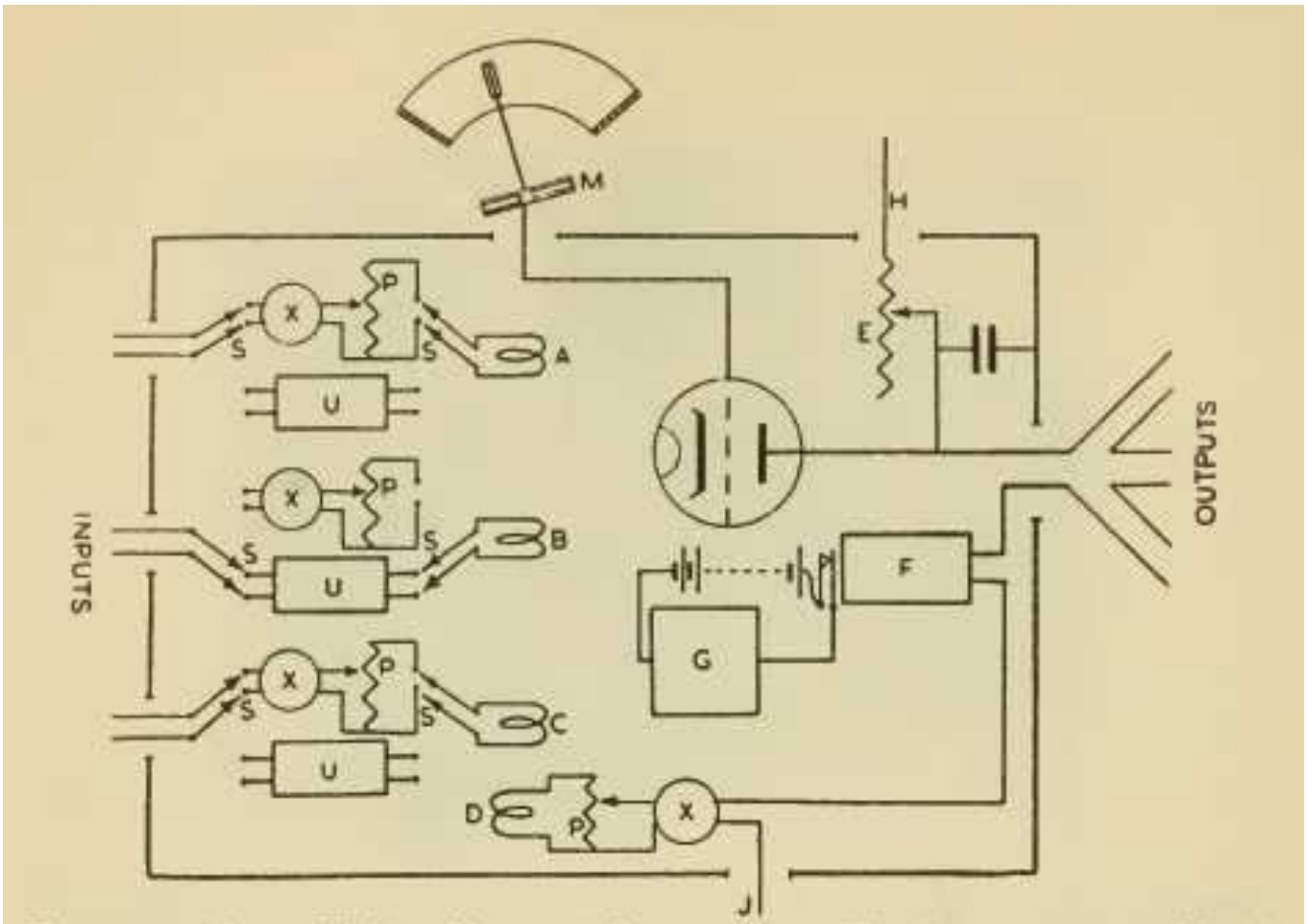


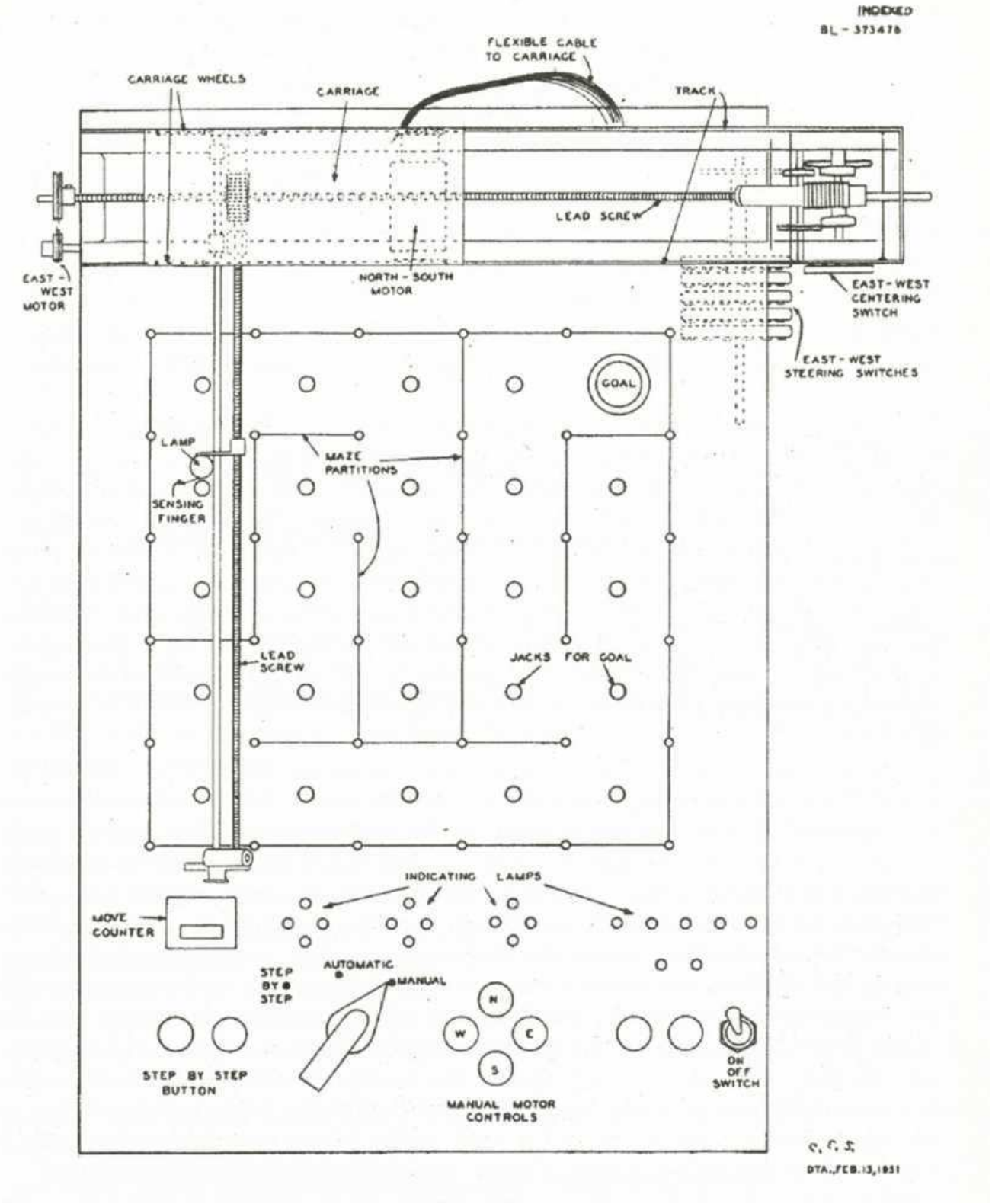
FIGURE 8/2/3: Wiring diagram of one unit. (The letters are explained in the text.)

Ashby, William Ross: Homeostat, circuit diagram (Ashby: Design 1960, p.102).

II.2.2 Memory

In his presentation of the "Homeostat" in 1952 at the ninth Macy Conference in New York Ashby was faced with expectations that his system should have a "memory" 3 to be able to store previous processes and to use the store to learn not to repeat them. For the participants of the Macy Conferences was a consequence of this expectation and the assertion to be able to realize technically the functions of a concept 4 to ask how the capabilities of memorizing and learning can be implemented technically.

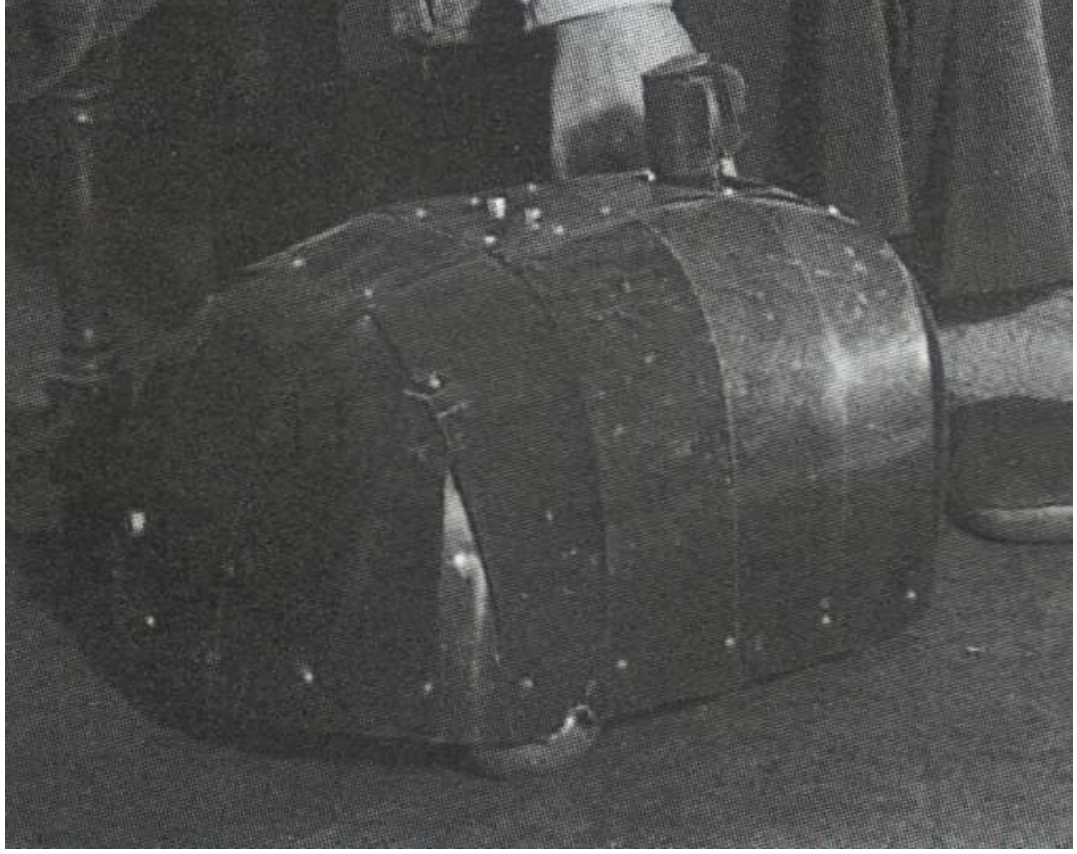
In 1951 Claude Elwood Shannon presented a system with memory at the eighth Macy Conference: The "sensing finger" of the "Maze Solving Machine" 5 memorized previous paths and returned to them if it moved to a blind end. The way to the goal became shorter because after failure the search had not to be started from the beginning, meanwhile Ashby´s "Homeostat" compensated deviations each time as if it had never before done that in the same situations. But Shannon could not present a model with the ability to draw conclusions from elder experiences for new navigation strategies.



Shannon, Claude Elwood: Maze-Solving Machine, plan (Shannon: Presentation 1951, p.174, figure 8).

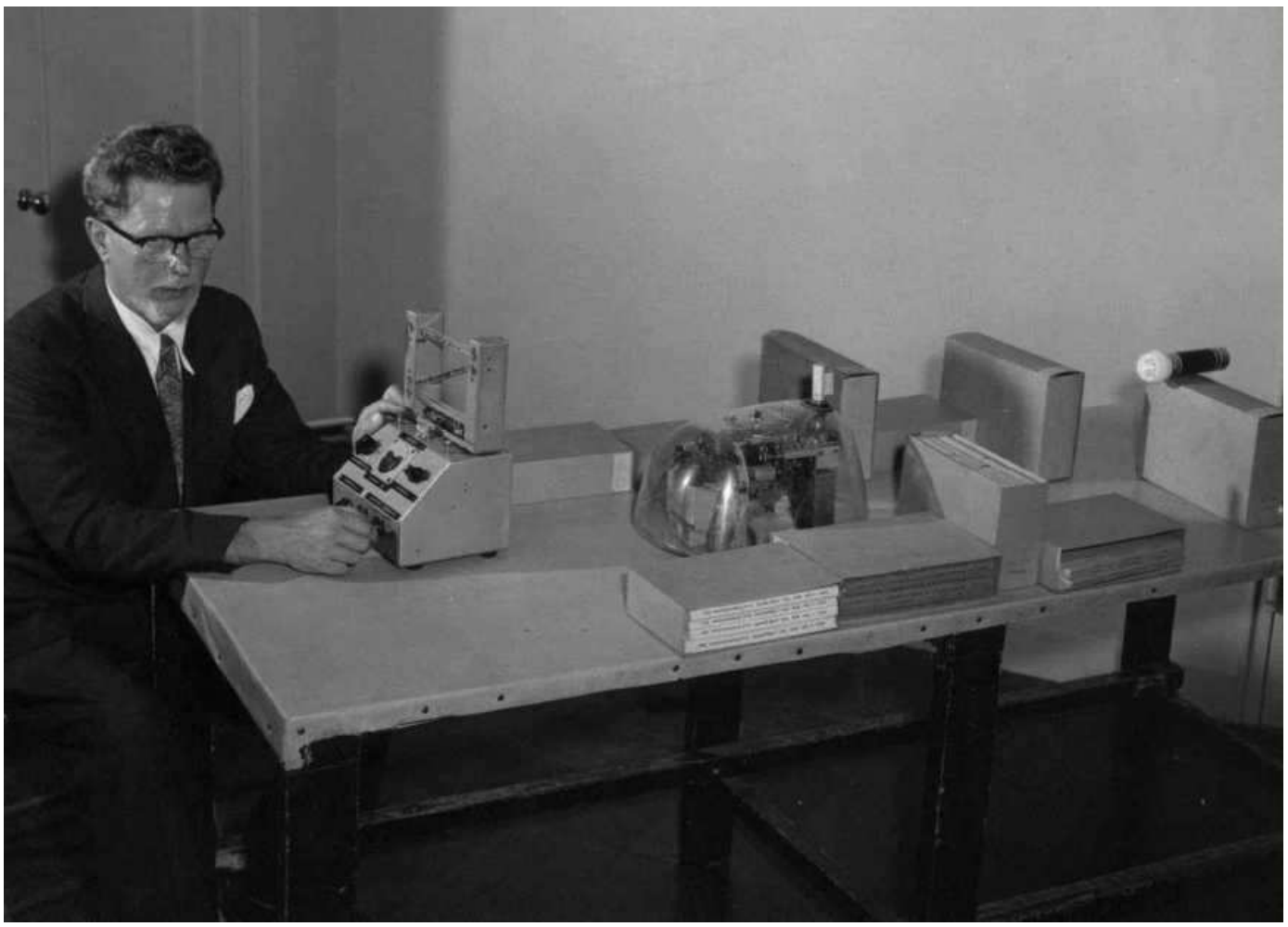
II.2.3 Path Finding

In 1948 William Grey Walter constructed his first roboter "Elmer" finding his path between obstacles by self navigation. To construct the robot Walter used radio tubes, switching relays, photocells, and little microphones. Three years later he constructed "CORA" as a robot memorizing obstacles: In its search for a path "CORA" circumvented the positions of obstacles or of test persons. A test person could signal with a whistle to the robot: Don´t move in this not any further leading direction.



Walter, William Grey: Elmer, 1948.

The three-wheel robot construction was not only sensitive to sounds and touch contacts but to light, too: It reacted to reflexes of the light mounted on its covering. A mirror´s reflexes of its own light provoked a dance because the mechanism to change its direction caused repeated, staggered motions. 6 The progress from the "Machina Speculatrix" "Elmer" to the "Machina Docilis" 7 demonstrated "CORA" with its capability to memorize obstacles and to find itself the path to its garage with electricity supply: "CORA" is seen as a precursor of "artificial intelligence". 8



Walter, William Grey: Cora, model for demonstrations on a table, 1951 (constructed by Bunny Warren for the Festival of Britain in London, Exhibition of Science, Science Museum, South Kensington, 1951).

In the book "The Living Brain", published in 1953, Walter compared "an electrical oscillation at low frequency" of "CORA" with "feedback circuits from cell-group to cell-group" in the brain. 9 He measured brain events as electroencephalogram in sequential phases of time. So it became recognizable if an event was forgotten, memorized, or processed. 10

In the forties and fifties Shannon, Ashby and Walter developed technical constructs for cybernetic theories anticipating later developed programs for computers.

Wiener designated processes of calculators from the abacus to the digital computer as "computing". 11 The cybernetic models featured in this chapter present concepts of computing processes in systems reacting to external events in a state of differentiation becoming relevant for early artistic projects for computers (see chap.II.3.1, chap. II.3.2.3).

Annotations

1 Ashby: Design 1960, p.98s. on the "homeostat" as an "analogue computer" for the research of "ultrastable systems", and Ashby: Variety 1958, chap. The Message of Zero Entropy on "the homeostatic mechanism" to maintain the body heat. back

2 Ashby: Design 1960, p.98s.,103s.; Pickering: Brain 2010, p.101-106. back

3 Ashby: Homeostasis 1952, p.104/615s.; Bluma: Wiener 2005, p.156s. back

4 Ashby: Homeostasis 1952, S.107f./618 includes the following discussion contribution by Walter Pitts: "At the very beginning of these meetings, the question was frequently under discussion of whether a machine could be built which could do a particular thing, and, of course, the answer, which everybody has realized by now, is that as long as you definitely specify what you want the machine to do, you can, in principle, build a machine to do it." back

5 Bluma: Wiener 2005, p.157; Shannon: Presentation 1951. back

6 Walter: Brain 1961, p.241: "turn- and- push manoevre".
On "Elmer": Hoggett: Elmer 2009.
On "CORA": Hoggett: CORA 2009; Pickering: Brain 2010, p.64-67; Walter: Brain 1961, p.118,155ss.,245-250. back

7 Pickering: Brain 2010, p.64; Walter: Brain 1961, p.155ss.,241-244. back

8 Holland: Walter 1997.
For Reuben Hoggett there was not only a static object to demonstrate functions of a machinic brain but a robot, too, with an integration of that machinic brain (Hoggett: CORA 2009). back

9 Walter: Brain 1961, p.163. back

10 Burnham: Modern Sculpture 1978, p.331,334s.; Pickering: Brain 2010, p.64ss. back

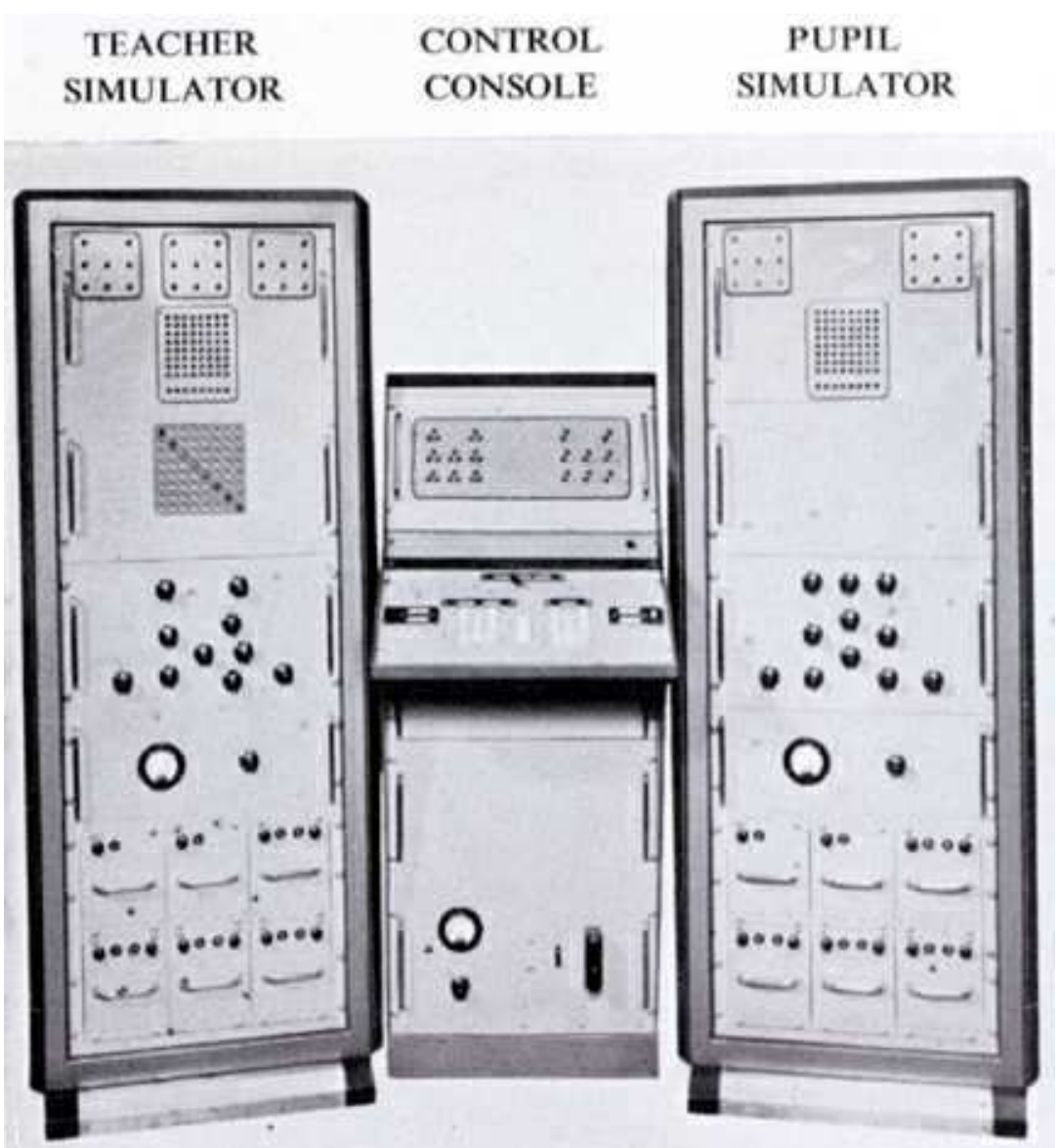
11 Wiener: Cybernetics 1949, p.20. back

II. Cybernetics
II.3 Cybernetic Sculptures

II.3.1 Pioneer Works

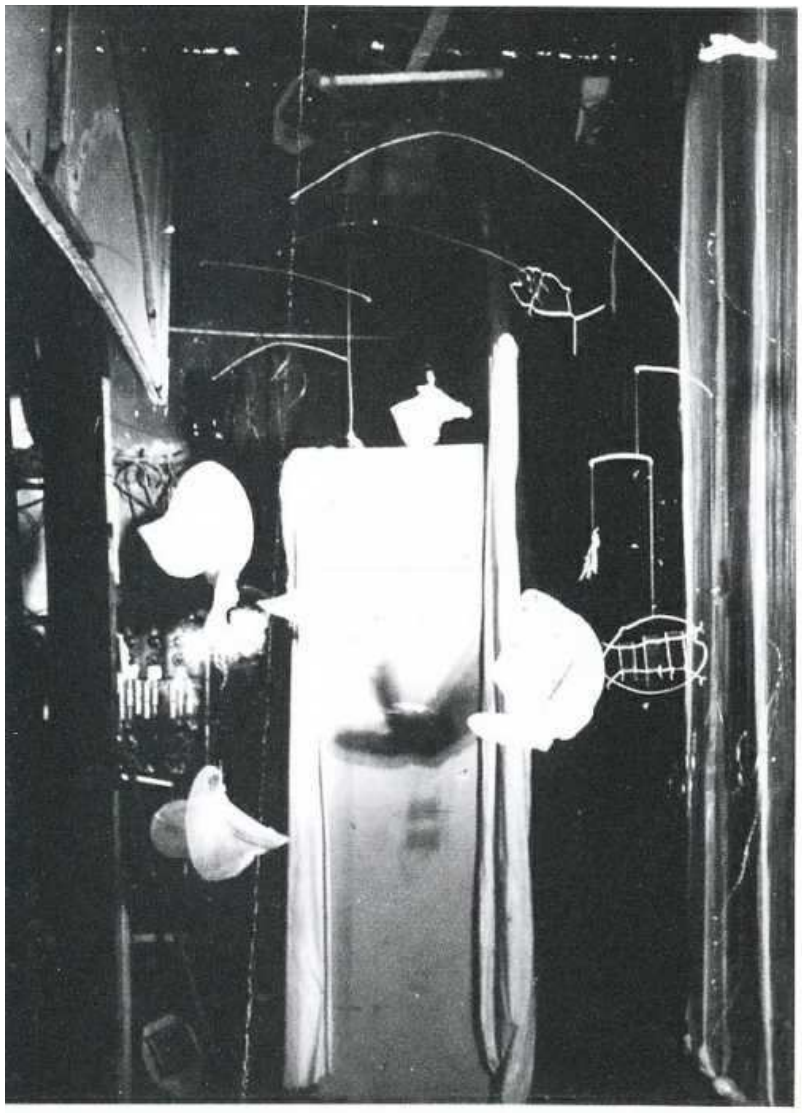
II.3.1.1 Gordon Pask´s "Musicolour System"

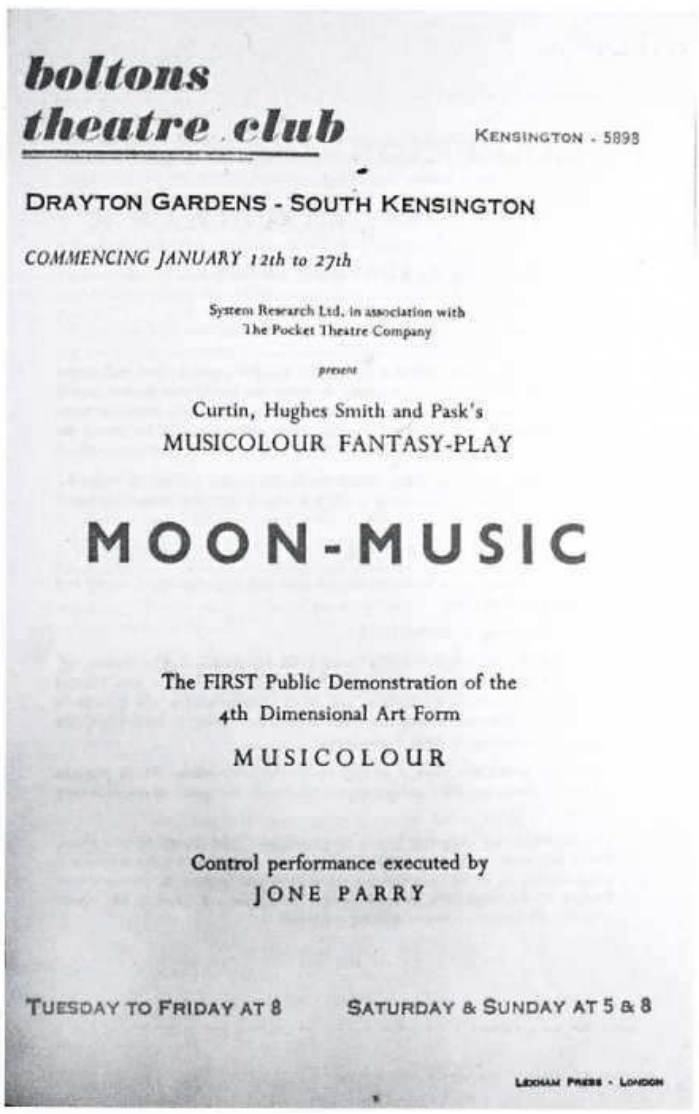
In his book "An Approach to Cybernetics" (1961) Gordon Pask presents "learning machines". Pask designates "Eucrates" (1955) as "simulating a pupil-teacher system". 1 The model reconstructs the behaviour of "real neurones" and their "`absolute refractory period´". 2 The reactions of the "motor-elements" to the input are varying because of a shifting threshold: The threshold increases after the first input with the consequence for learners that they have to wait with further inputs until the threshold falls. "`Memory´-elements" react to the output of the "motor-elements". The "`memory´-elements" are constructed following the example of "the synaptic connections of a neurone" 3: "Now it is obvious that various modes of activity and various forms of interaction [between a pupil and a teacher or the learning machine] will build up the network." Pask writes this sentence after a short explanation of possible "interconnections" between "motor-elements" and the learning activities within the "network". Capable of surviving within the "network" are only the connections which "mediate a favourable behavior". 4



Pask, Gordon: Solartron EUCRATES II, ca. 1956 (Pask: Approach 1961, pl.I 8(i)).

"Musicolour" (1953-57, built in collaboration with Robin McKinnon-Wood) was a reactive system for theater productions. The system´s analogue computer was transported from performance to performance.

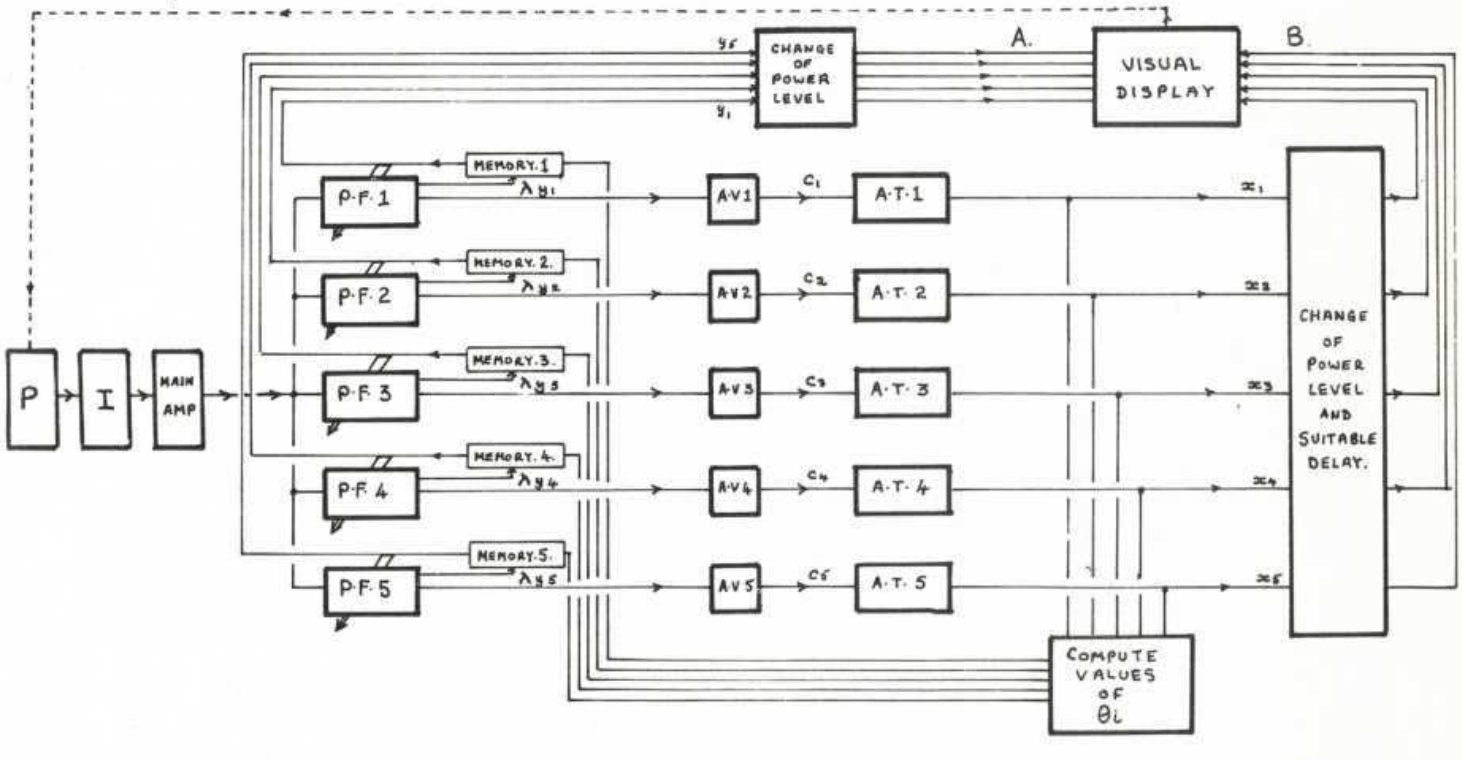




Pask, Gordon: Musicolour, Boltons Theatre Club, South Kensington 1954.
Left: Stage with a projection screen for Musicolour.
Right: Moon-Music, playbill (Rosen: Control 2008, p.139).

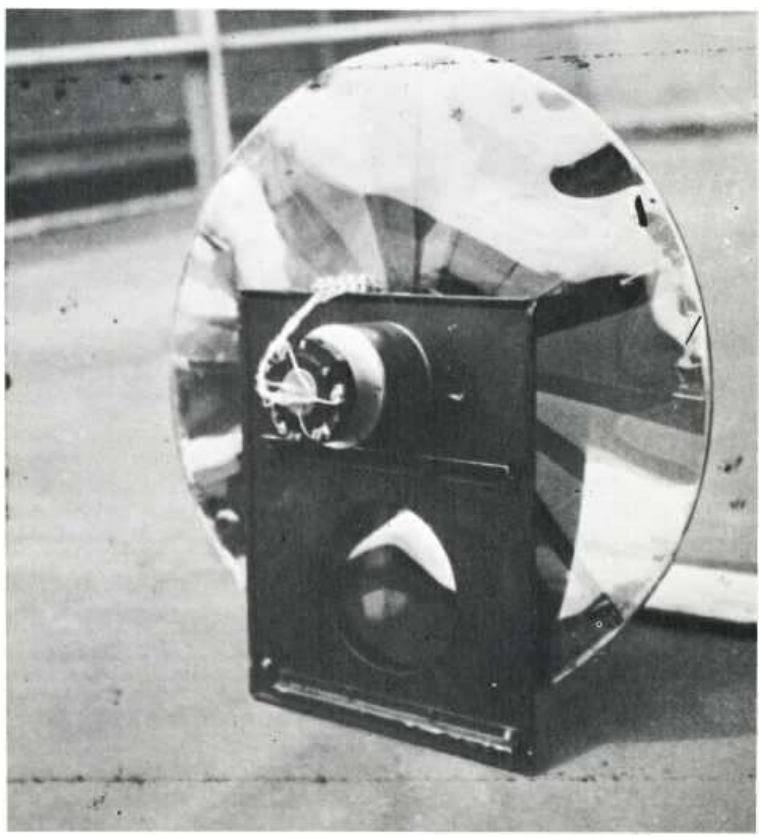
If a musician produced input via a microphone for "Musicolour", then the system reacted with visual output – "a predetermined vocabulary of visual symbols". The "visual vocabulary" could be modified from performance to performance. 5 Pask describes the system´s procedures as including "a rudimentary learning facility" 6 being capable to modify the sound-image relation in the course of the performance. If the music stopped then the system reacted with a growing sensitivity to each kind of sounds. In practice, this growing sensitivity had to be moderated by an "arbitrary gain control circuit". "Musicolour" reacted for a while to "repetitive input" with a constant output before it stopped to react. The musician was forced to change her/his performance to get again the visual output. A musician could follow the reactions of the machine and could try after "several gambits" 7 to modify the audio input and to develop ways to control the audio-visual correlations.

Fig. 26 Outline of a typical Musicolour system. P = Performer, I = Instrument and microphone, A = inputs, y_i, to visual display that specify the symbol to be selected, B = inputs, x_i, to the visual display that determine the moment of selection. PF = property filter, AV = averager, AT = adaptive threshold device. Memories hold values of (y_i) and (y_i). Control instructions for adjusting the sequence of operation are not shown. Internal feedback loops in the adaptive threshold devices are not shown.



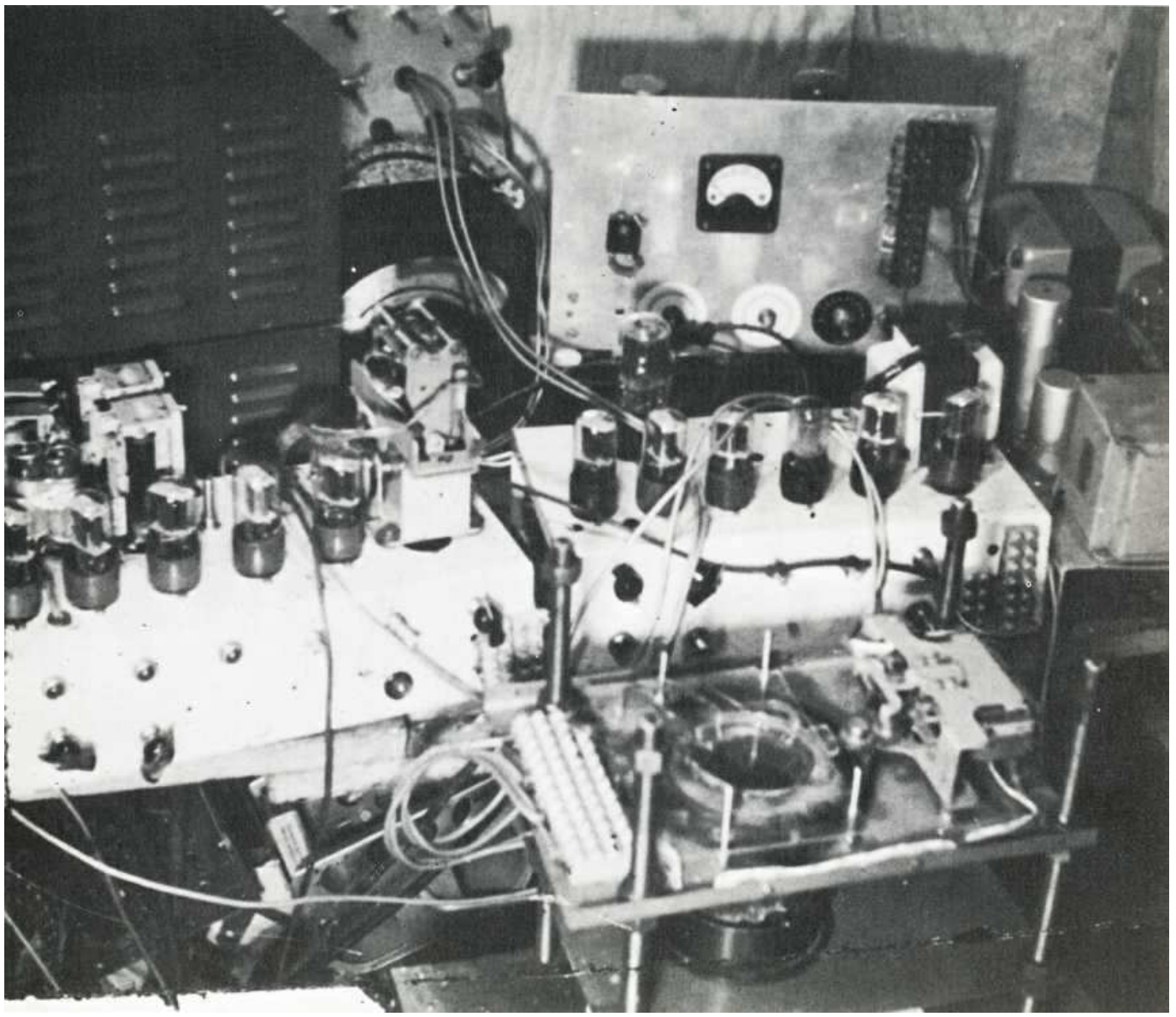
Pask, Gordon: Musicolour, 1953-57, circuit diagram (Pask: Comment 1971, p.79, fig. 26).

"Property filters" select sounds following different and modifiable criteria. On the one hand the storage units of each filter can memorize the filtered sounds and these sounds can be utilized to influence the visual output´s "power level". On the other hand the filtered sounds can be processed with "averagers" and "adaptive threshold devices" with "internal feedback loops". The "threshold devices" install a lower limit causing a suppression of too weak input. The conflation of the processed and stored sounds influences the visual output that in turn inspires the musician. Light projections direct the visual output to a projection surface. The light is emitted through color and pattern filters constructed as controllable wheels or reflectors. 8



Pask, Gordon: Musicolour, 1953-57, projection wheel controlled by a servomechanism (Pask: Comment 1971, p.81, fig.27).

For light modifications an "electro-chemical display" is developed for "Musicolour" between 1954 and 1957. Bowls are placed on rotating supports. The bowls contain electrolyte solutions and indicators: The pH of the solutions is changed by electrolysis. These changes activate electrodes mounted on the bowls. The activated electrodes in turn navigate the projections of colour patterns. In his description of the "display" Pask doesn´t refer to the learning system mentioned above. 9



Pask, Gordon: Musicolour, 1953-57, electrochemic system (Pask: Comment 1971, p.85, fig.31).

Pask designates the musician as a "converse participant" of the "learning mechanism" of "Musicolour". 10 Machine and musician should accomodate to each other: Both sides `learn´. 11 How redundancy is avoided by modifications depends on one side from the "Musicolour´s " changing ways to react 12, on the other side of "the observer´s [resp. the musician´s] frame of reference" 13: Musicians explore the "Musicolour system´s" capabilities to react and conclude how they can create their next actions.

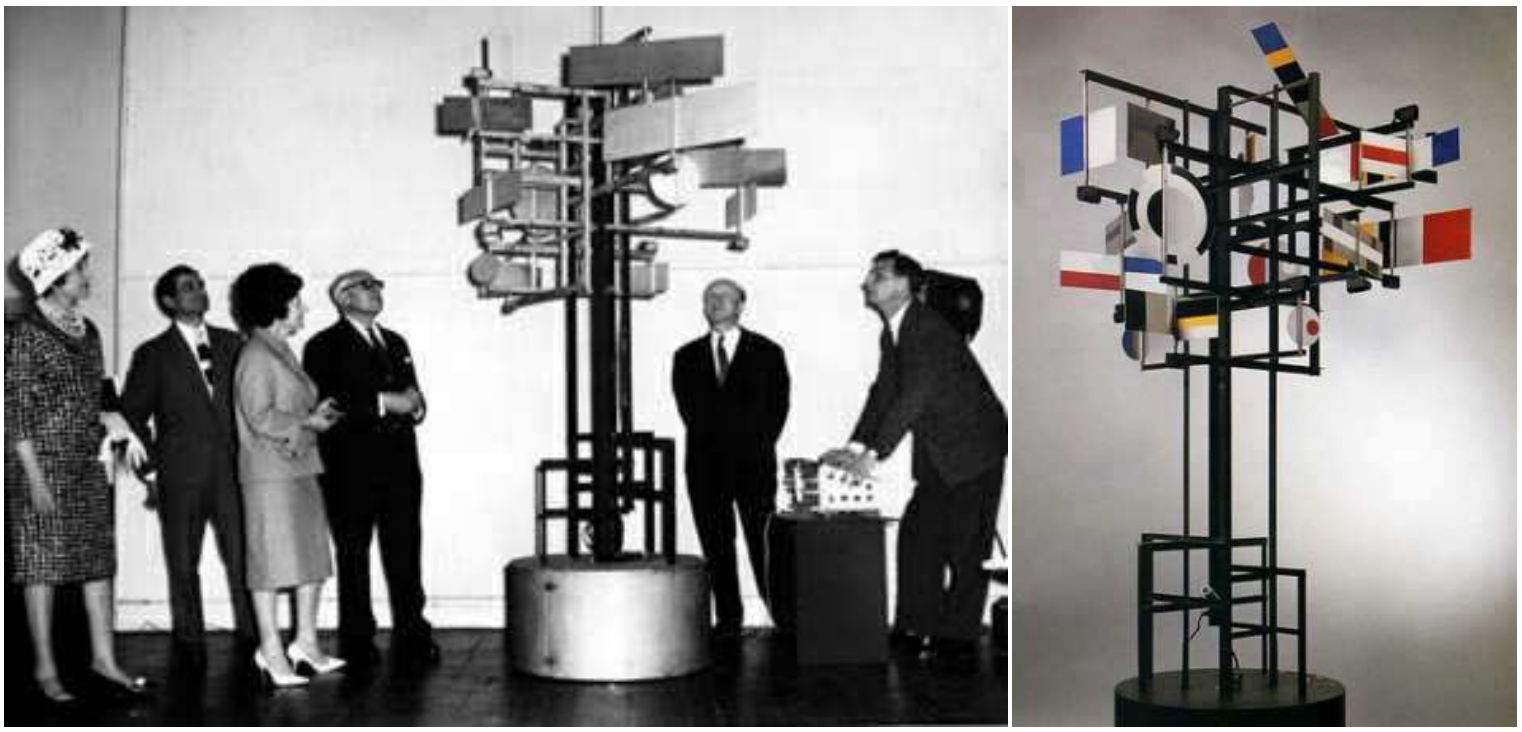
Pask´s "Musicolour" offers a "responsive environment" 14 being integratable as a partial system with participant into wider performance systems. With "Musicolour" Pask became a pioneer of computer art.

II.3.1.2 Nicolas Schöffer´s "CYSP 1"

In 1956 Nicolas Schöffer realised "CYSP 1" as a mobile kinetic sculpture. Round and rectangle aluminium plates, each unilateral colored and structured by geometric forms, rotate in a steel structure meanwhile its basis drives in the space either of an exhibition or outdoors. Little engines move the plates. The basis contains electric motors for

movements on four rubber wheels in two speeds, accumulators for the electricity supply and an "electronic brain" («cerveau électronique», vacuum tube based) by Philips organizing the navigation between obstacles and the rotation of the aluminium plates. 15

The "electronic brain" includes a random generator organizing the self mobility. If the kinetic sculpture´s self navigation around the obstacles of an environment is overstressed then observers can intervene from a control desk being connected with the sculpture via radar. This description of Reuben Hoggett is contradicted by Jean-Noël Montagné who was involved in a recent restoration of "CYSP 1". Following Montagné the first version of "CYSP 1" had an antenna. It was used for experiments with a "capacitive sensor" "but the electronic has too many natural and in-board parasites". Montagné describes the control of "CYSP 1" as either "autonomous" or by a "remote control" connected "by cable". 16



Schöffer, Nicolas: CYSP 1, 1956. Left: exhibition, Institute of Contemporary Arts, London 1960.

Photoelectric cells and a microphone are used as sensors registrating changings of light intensity, colors, and sound volume. These sensors supply with the input for the navigation of the moving parts. The "electronic brain" organizes the simultaneous control of the speed of the plates´ rotation up to "stroboscopic effects" and the movement of the basis. 17 The "electronic brain´s" coordination varies the reactions of "CYSP 1" to external events by "disturbing parameters" 18 and avoids predictability.

Jacques Bureau, the developer of the "electronic brain" integrated in "CYSP 1", and the artist use Ashby´s terms "homeostasis" and "homeostat" (see chap. II.1.5, II.2.1) for the capabilities to move and adapt to external events featured by "CYSP 1". 19 The system moving itself by random generators and the limited adaptability to environmental conditions are capabilities common to Ashby´s "Homeostat" and "CYSP 1". Schöffer creates not only a moved three-dimensional object as kinetic art but constructs cybernetically a relation to the environment using an adaptive system with self-navigated movements.

The "electronic brain" of "CYSP 1" transfers the sensors´ input caused by several external factors in a program for navigation and movements. Meanwhile the "Homeostat" is an experimental arrangement with controls turned by humans to cause disturbances, they are caused in "CYSP 1" by changing environmental conditions. The internal balance of the "Homeostat´s" four subsystems reacting to each other is in "CYSP 1" replaced by

an electronic control system. After the self navigation of William Grey Walter´s robots (see chap. II.2.3) follows in "CYSP 1" a self navigation controlled by programmed electronics.

II.3.2 "Cybernetic Serendipity"

II.3.2.1 The Exhibition in London

Jasia Reichardt followed a suggestion by the German philosopher Max Bense when she started in autumn 1965 the preparations for the exhibition "Cybernetic Serendipity". 20 From August to October 1968 the London Institute of Contemporary Arts exhibited predominantly examples for the uses of computers in art, literature, and music. Following Reichardt 60.000 humans visited the exhibition on "The Computer and the Arts". 21 Beside Schöffer´s then twelve year old "CYSP 1" cybernetic sculptures of Edward Ihnatowicz and Gordon Pask have been exhibited for the first time in "Cybernetic Serendipity". In 1968 they demonstrate the development status of three-dimensional works reacting to visitors´ actions.

The catalogue of the exhibition and two publications later edited or written by Reichardt document the development for the art for and with the computer. 22

II.3.2.2 Edward Ihnatowicz´s "SAM" and "Senster"

Edward Ihnatowicz´s "Sound Activated Mobile", in short "SAM" (1968), reacted to more quiet sounds. A sound reflector made in fibreglass contained four microphones in a cross-shaped configuration. The eight hydraulic controlled vertebrae cast in aluminium constituted a mechanical backbone. The vertebrae rotated and directed a reflector to the input of the microphones. The microphones were mounted in pairs, two vertical and two horizontal to each other, and each of the pairs were connected with their own analog system. These two systems measured the time intervals between their microphones and used this measurement to `recognize´ the direction out of which a sound event came. "SAM" then used the hydraulics of the backbone´s vertebrae to direct the reflector to these events.



Ihnatowicz, Edward: SAM, 1968, exhibition "Cybernetic Serendipity", Institute of Contemporary Arts, London 1968.

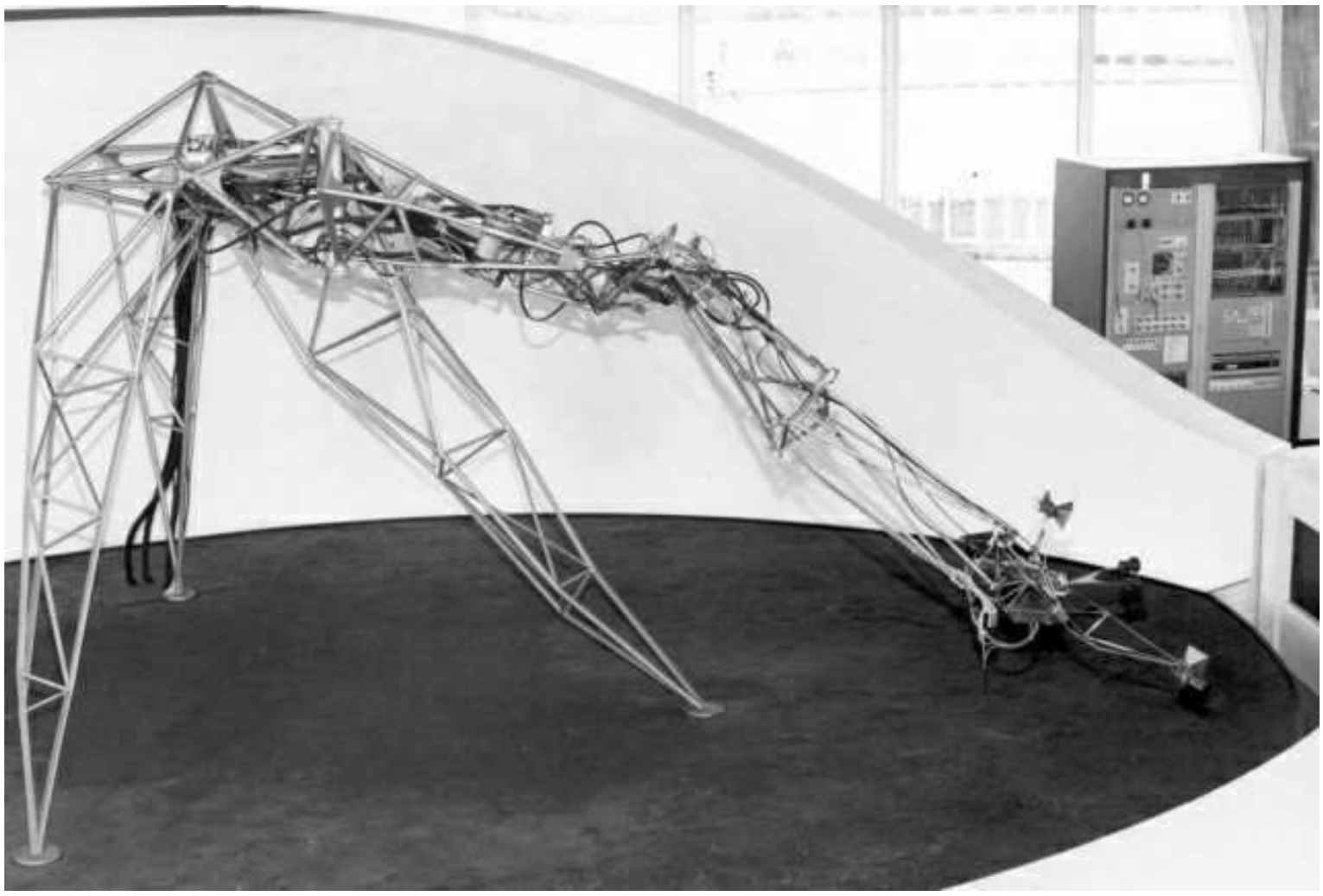
John Billingsley developed the analog circuit for the measurement of the audio input, meanwhile Ihnatowicz realised the `backbone´, its hydraulics, and the analog computer being hidden in the socle and used for the coordination of the motions. The technology of the hydraulicservo system was based on biological prefigurations. The reflector looked like a four-leaved clover, a flower or a head.



Ihnatowicz, Edward: SAM, 1968 (Ihnatowicz: Cybernetic Art 1986, Cover).

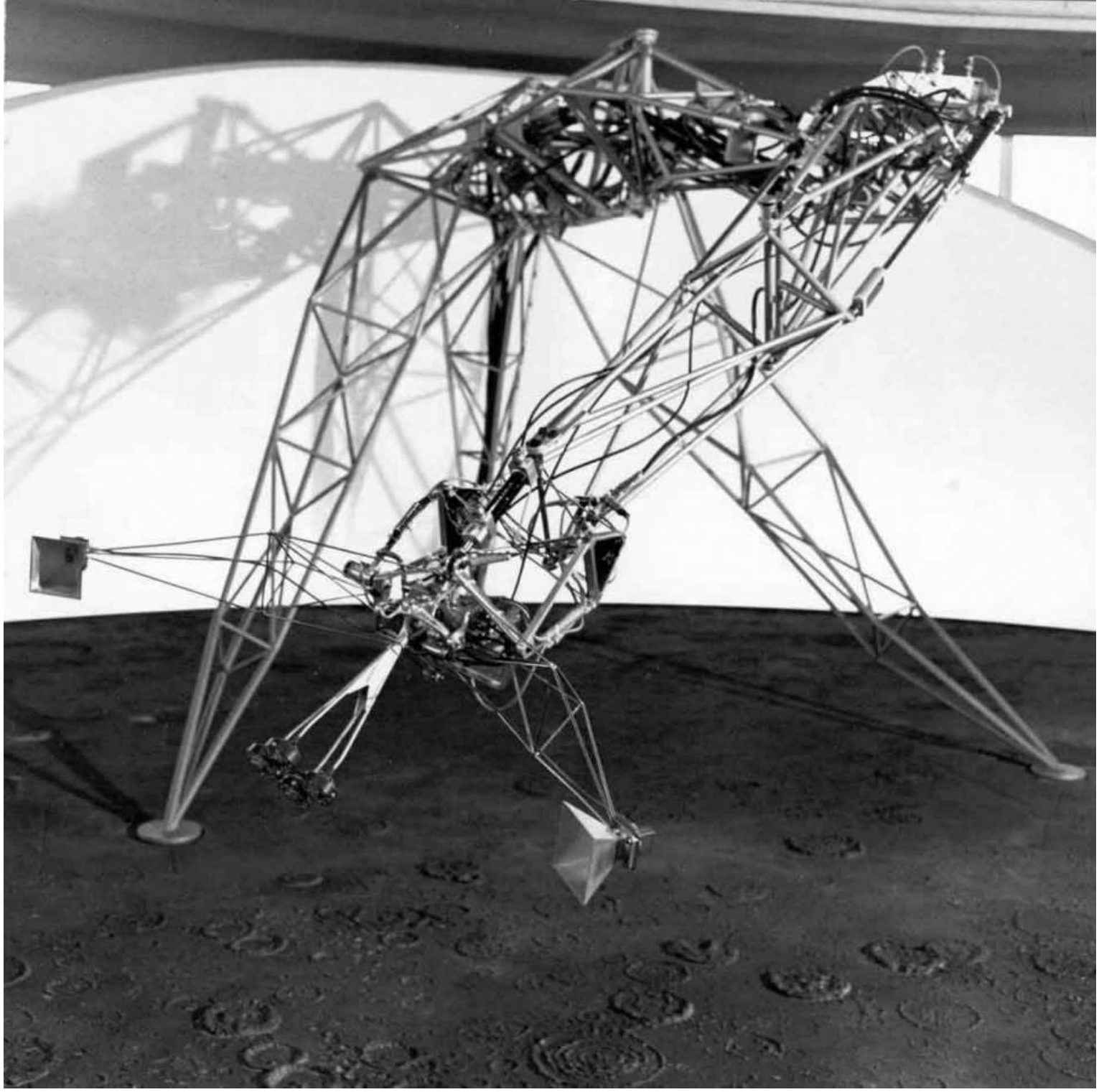
Ihnatowicz entertained the visitors with the surprising skills of an environmentally sensitive system. It was not his main interest to present a model of human intelligence, as William Grey Walter understood his robots (see chap. II.2.3). 23

In his catalogue contribution to "Cybernetic Serendipity" Ihnatowicz announced a "large structure" "to be operated by a computer." 24 Ihnaotwicz prepared at that time The Senster. In September 1970 it was installed on a round basis in the foyer of the "Evoluon", a technical museum at Philips´ factory site in Eindhoven. Until December 1973 it reacted each day to the visitors´ motions and sound productions. From September to December 1970 Ihnatowicz stayed in the Evoluon to program a computer Philips P 9201 in assembly language for an input via punch cards. He used the visitors as test persons. 25



Ihnatowicz, Edward: The Senster, 1970, in Evoluon, Eindhoven.

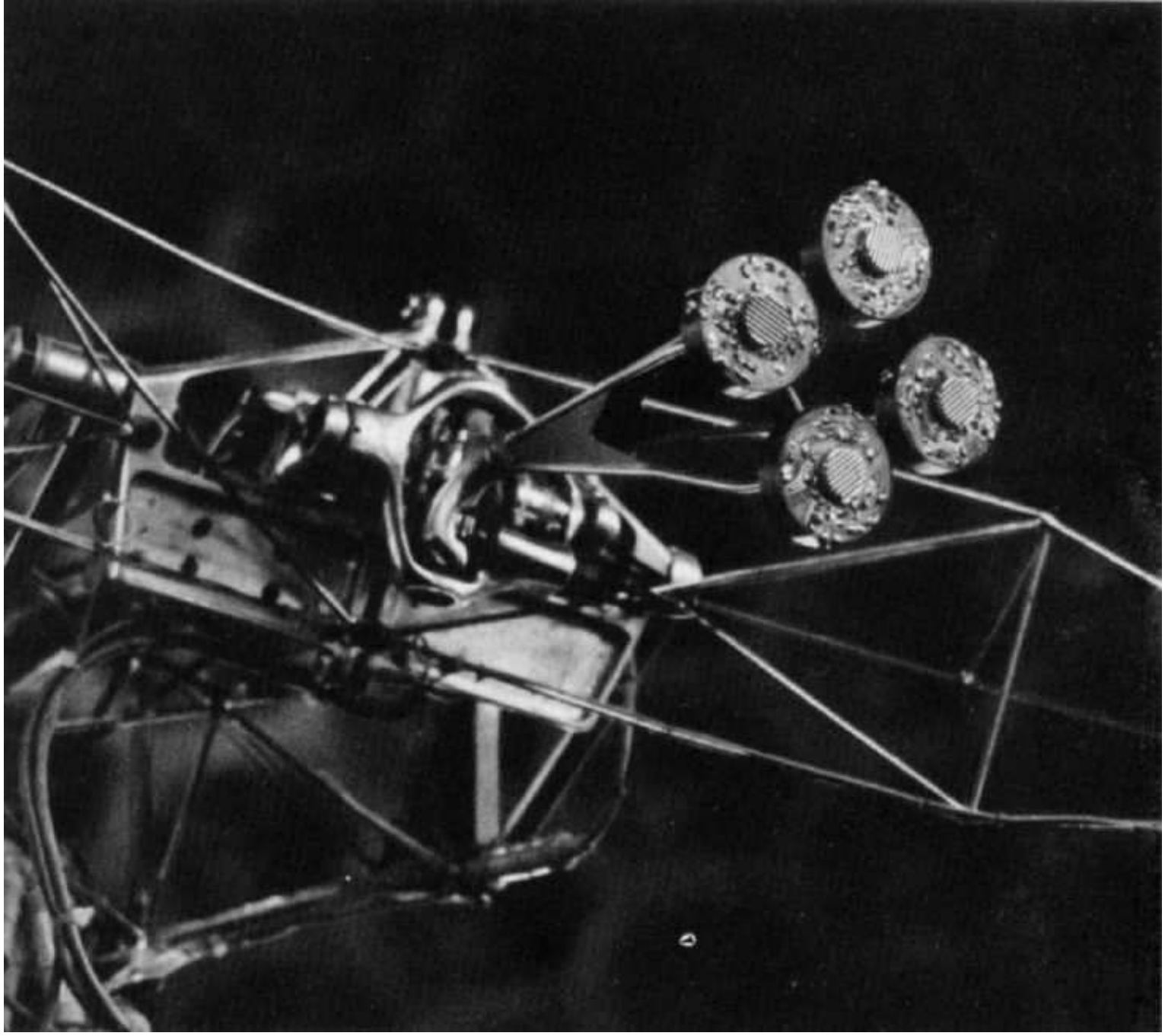
"Senster" was a tubular steel construction on three static legs carrying a mobile structure. The steel tubes of this part were moved by six independent electrohydraulic servo systems. The tank and the pumps of the hydraulic systems have been installed under the basis. The computer controlled hydraulic cylinders and the potentiometers of the servo systems. The mobile structure largely overhanging in the direction of the visitors orientated itself by following the input of its sensors. These sensors were installed on a mobile part mounted on the overhanging end of the mobile structure.



Ihnatowicz, Edward: The Senster, 1970, in Evoluon, Eindhoven.

When Ihnatowicz constructed the joints he was inspired by lobster claws because they are able remarkably easy to move with six simple swivel joints. The artist constructed "Senster´s" mobile structure as a big lobster claw. He substituted the claw with a mobile fixing of the sensors.

Two Doppler radar units were mounted on arms overhanging on the left and right side of the microphones. These units recognized the visitors´ actions. The pair-by-pair configuration of the four microphones between the Doppler units enabled the technical system to recognize the direction of a sound. At first "Senster" moved these microphones into the direction of sound events, then in the case of longer lasting sounds it moved the mobile parts of the tubular steel construction to the sound sources, too. Loud noises and fast body actions cause retreating movements of the mobile structure. "Senster" reacted to body actions below the threshold for the relevant audio- and radar input by turning itself into directions offering stronger input. Following Ihnatowicz the observers´ actions were not determined by "Senster´s" form but by its moves. 26



Ihnatowicz, Edward: The Senster, 1970, four microphones.

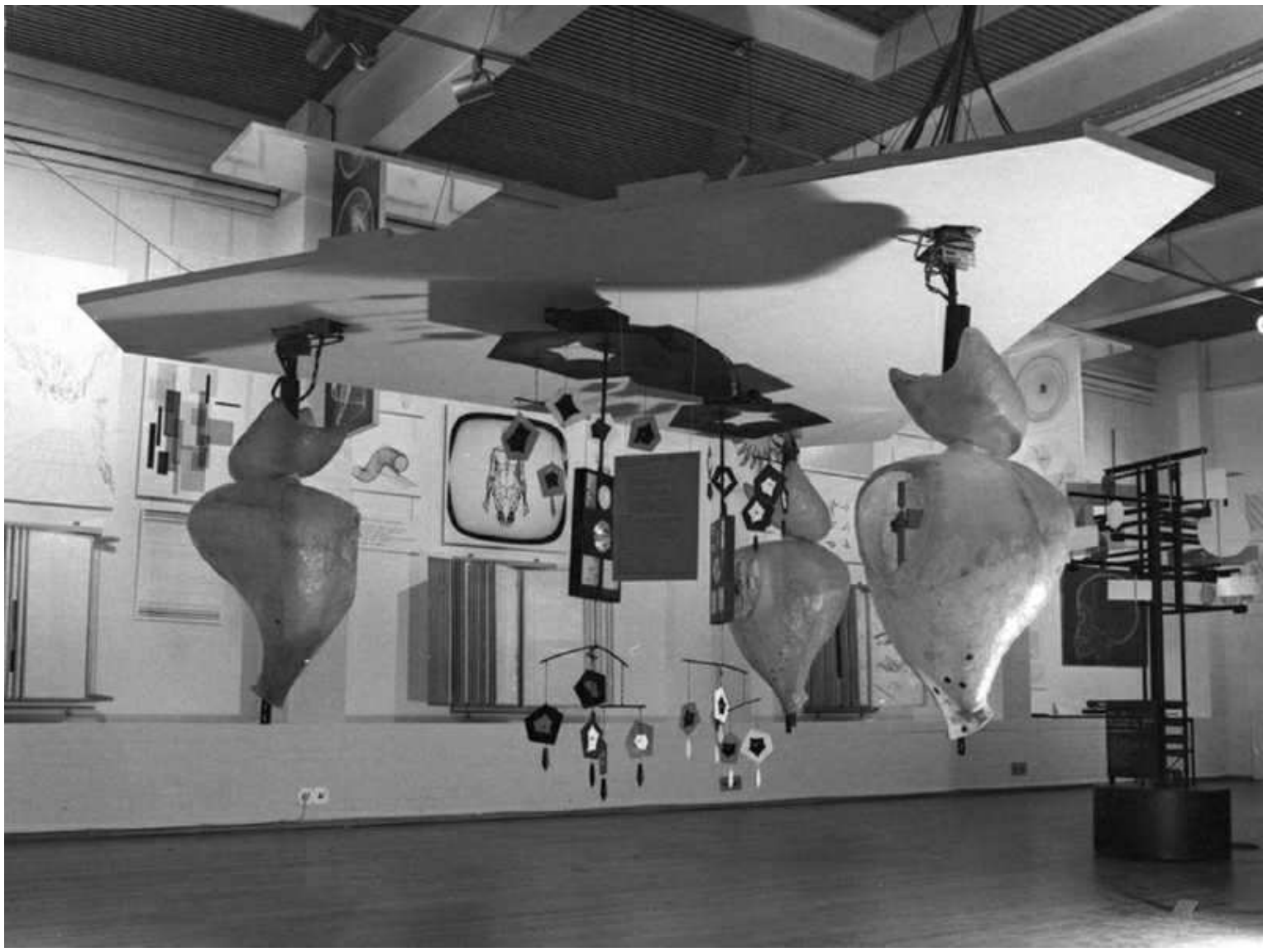
Visitors of the Evoluon were diverted by sounds produced by other visitors exploring the "Senster´s" capabilities. Without consulting the artist the Senster´s" program was changed and, finally, in 1973 the now uninteresting cybernetic sculpture was removed. 27

Meanwhile Ihnatowicz developed in "SAM" and "Senster" programs for machine bodies reacting with motions to the environment and did with the work as an object isolated from its surrounding nothing more than to modificate the established delineation between art space and environment, Gordon Pask (see chap. II.3.2) and James Seawright (see chap. II.3.3) realised new concepts of the integration of observers into the work space in installations being able to react to observers´ operations.

II.3.2.3 Gordon Pask´s "Colloquy of Mobiles"

Gordon Pask´s "Colloquy of Mobiles" was an installation offering the visitors of "Cybernetic Serendipity" to use torches as means in interactions with the motions of its five parts. Five hanging objects navigated their motions mutually via beams of light and light reflexes. Three organically formed objects hung at the truncated corners of a triangle hanging horizontally at the ceiling. Between these objects two mobiles with inorganically formed elements hung on a further element mounted on the big triangle and rotating under it horizontally. These five objects hung on vertical axes that were rotated by electric motors. Pask designated the mobiles with inorganic formed elements as

"Males" and the three organic elements clad with fibreglass bodies as "Females". Yolanda Sonnabend drafted the semitransparent fibreglass bodies illuminated from inside. 28 The "Males" constituted an inner rotating system with the "Females" circulating around them.



Pask, Gordon: Colloquy of Mobiles, 1968, exhibition "Cybernetic Serendipity", ICA London 1968 (rear right: Schöffer, Nicolas: CYSP 1, 1956) .

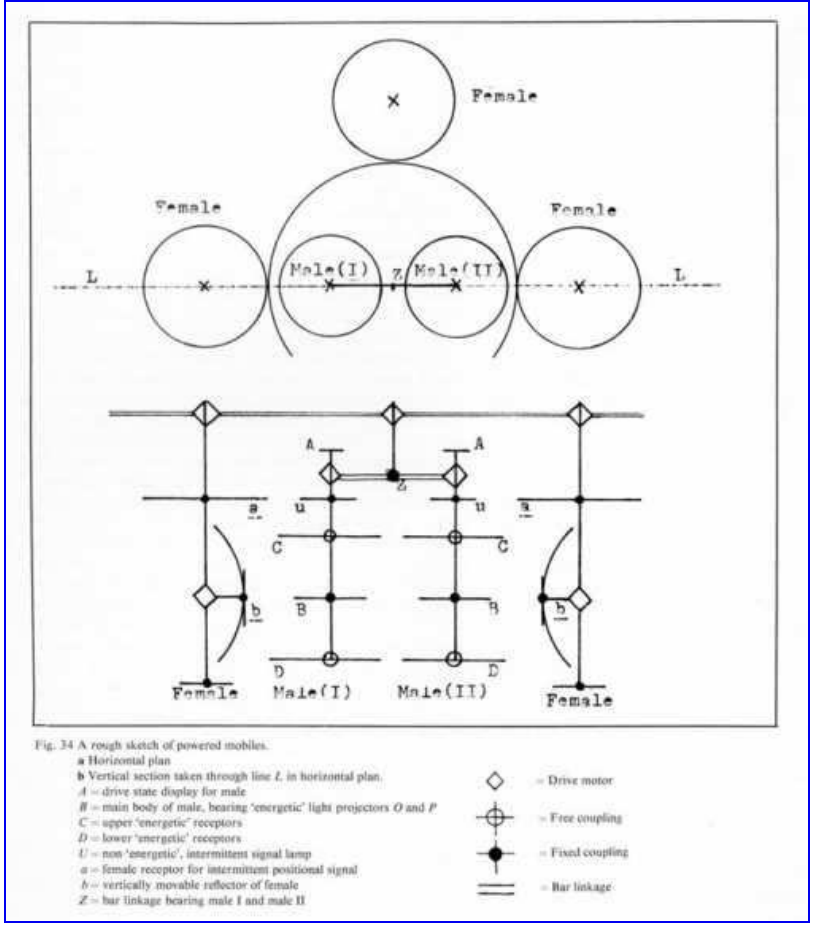
The "Males" and "Females" are programmed to relate themselves to each other by contacts produced by light rays and light reflexes. These contacts cause the rotating objects to change their motion sequences. The motion sequences of the "Males" and "Females" are controlled by a computer located outside the installation. The installation is connected to the computer by cables laid from the static horizontal element to the ceiling. 29 The "Males" contain photo cells and elements emitting orange and dark red light. Light reflecting objects are fixed in the "Females´" openings. The "Males" come closer to the "Females" by rotations of the mobile horizontal element and by their own motions. In some positions a "Male" is only able to follow its goal by hampering the other "Male". 30



Pask, Gordon: Colloquy of Mobiles, 1968, exhibition "Cybernetic Serendipity", ICA London 1968 (Pask: Comment 1971, p.97, fig.40).

After phases of inactivity the fibreglass bodies of the "Females" are illuminated by lights from inside and the "Males" start to emit light rays that can hit mirrors in the openings of the "Females" fibreglass-bodies. Some light interactions provoke the "Males" to change the light colour and the rotation speed if the "Females" redirect the light rays of the "Males" to their photo cells. In the course of such light interactions both sides send sound signals. Sound signals emitted by the "Males" are received by a cooperating "Female" and replied by a corresponding sound. 31 After this audio cooperation a sequence with visual cooperations can follow.

The mobile elements pursue "goals" – for example the heterosexual cooperation in one of both rotation speeds 32 – in a system organizing the cooperation on several levels: The "goals" are compartmentalised in "sub-goals". The "Females" and "Males" pursue "goals" independently of each other. They are not only able to compete with each other, but also to prohibit themselves in pursue of their "goals". 33



Pask, Gordon: Colloquy of Mobiles, 1968, ground and vertical plan of the mobile elements (Pask: Comment 1971, p.90, fig.34).

The mobile elements need memories for their cooperations to be able to store which element corresponded in which action phase with their "goals". The actual cooperation phase until the next phase is stored by the "short-term memory". The "long-term `memory´" stores elder cooperation experiences and learning processes. Potential partners are able to memorize the different preferences developed by the mobile elements and to adapt themselves to the preferences. 34.

Visitors of "Cybernetic Serendipity" could intervene in the "aesthetically potent social environment" 35 using flashlights or mirrors and producing sounds. Visitors were enabled to influence the interaction between "Females" and "Males" by interventions and to use the system´s reactions in investigations of the programming. 36 Obviously "Colloquy of Mobiles" was capable to react in a sufficiently complex manner to attract observers for a longer period of time. The complexity of the system-internal capabilities of the five moving objects was the precondition to react to system-external changes and – with it – to interventions by the visitors.

After Ashby´s "Homeostat" (see chap. II.1) Pask offers a further model for the "law of requisite variety" (see chap. II.1.5) postulating the system-internal (system/system relations) differentiation as precondition for the system/environment relations. The "Homeostat´s" four subsystems constitute the environment mutually: The "Homeostat" is enabled to react to certain environmental conditions by a subdivision in internal system/environment conditions. The "Colloquy of Mobiles" features comparable relations. Not only learn the internal elements of "Colloquy of Mobiles" from each other, but also the installation is able to learn from external operations of observers: The work reacts to external events in the same way as it organizes the actions of its own elements.

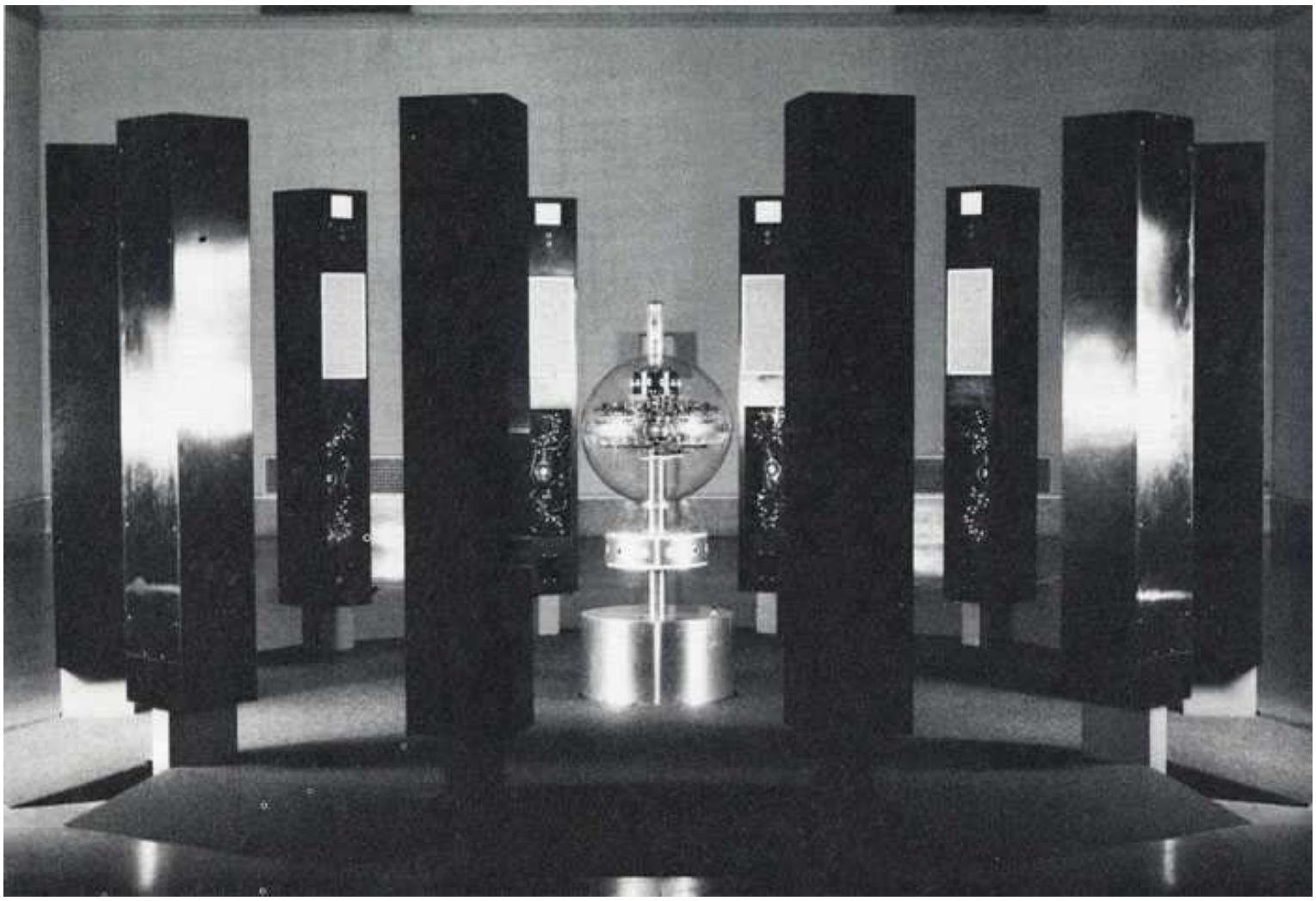
Pask´s model includes the learning capability based on machinic memory missed by the participants of the ninth Macy Conference in 1952 in their discussion of Ashby´s "Homeostat" (see chap. II.2.2). The segmentation into several internal, separately and autonomously operating subsystems and the structuring in "short-term memory" and "long-term `memory´" constitute the "requisite variety" of the computing processes

offering relations reconstructable for observers by the installation´s audio and visual manifestations. The interface between human and machine consists of the light and mirror actions as possibilities for human input as well as of the actions to be seen and heard as machinic output. Observers can recognize the possibilities for human input by reconstructions of the machinic `conversation´ between mobiles that can be interpreted as a rudimentary model of social interactions. The model is rudimentary as a test case for communication because it operates on the level of signals starting functions, not on the level of symbolic interactions.

II.3.3 Light and Sound Installations by James Seawright and Vladimir Bonacic

In 1968 artists and musicians like Stephen Antonakos, Terry Riley, Charles Ross and Robert Whitman realised installations producing light and sound events for the exhibition "The Magic Theatre". James Seawright constructed "Electronic Peristyle" 37: an uncommon work for an uncommon exhibition.

He installed "power supplies" in a base under a sphere. The sphere was made of transparent plastic and contained 12 photocells. A "cylindrical metal box" with 12 "light beam projectors" was mounted underneath the "plastic sphere". The electronics in this vertical structure with round segments "was either digital (the earliest family of Motorola RTL logic chips)" or it contained "conventional analog transistor circuits." These electronics controlled the generation of sounds by "electronic synthesizer modules". These modules were developed by Robert Moog. He integrated his analog equipment in Seawright´s installation.





Seawright, James: Electronic Peristyle, 1968, exhibition "The Magic Theatre", William Rockhill Nelson Gallery of Art, Kansas City/Missouri 1968. Photo on the previous page: Larry B. Nicholson (Davis: Experiment 1975, p.96). Photo on this page: James Seawright.

The vertical element with the "plastic sphere" was placed in the middle of a circle built by 12 steles coated with black resopal. In the circle with a diameter of 21 feet (resp. 6,4 m) the visitors walked on an elevated second floor hiding the steles´ support structure constructed of steel and the technical equipment ("multi conducted cables"). The light beams sent from the ring underneath the "central sphere" to the steles hit there on photocells except visitors on the heightened floor interrupted the beams. Photocells paired with mirrors constituted the steles´ "receptors". The mirrors reflected the light beams. These reflexes recorded the photocells within the "plastic sphere". The "shift register" reacted to the photocells´ input produced by the mirrored light beams and their interruptions, as they were caused by the visitors. In the "plastic sphere" the "circuit boards" of the "shift register" are mounted behind the photocells.

This register shifted its "twelve data bits" "at varying rates" "clockwise" "around the twelve stages". The "shift register´s" "12 stages" were "connected in a circle". A "12-bit binary number" was "shifted "by a pulse" in the "circle" from "stage" to "stage". The "stages of the shift register" corresponded with the 12 steles. The "numbers" of each "stage" were "read out by sound synthesizer modules" developed by Robert Moog including "two 8-bit input voltage-controlled oscillators, two 6-bit voltage controlled amplifiers (envelope generators, intermodulators and a voltage controlled filter)."

The data generated by these modules "could be patched into the shift register outputs in a wide range of possibilities": For the programming of a "permanent setup" one of the technical possibilities was selected to coordinate the "shift register" with the "synthesizer modules". The "12-bit binary numbers" circulating between the "stages" resulted in "digital values" causing "the outputs of the synthesizer modules to assume appropriate values -- differing pitches in the case of digital oscillators, different loudness values in the case of amplifiers (or level controls) and so forth, including the timing intervals of the shift register's shifts. A digitally controlled filter could alter overall timbre, etc." before

the "mixed audiosignal" was "sent out" to the steles´ loudspeakers. By walking on the heightened floor visitors could listen to "...the constantly changing data decoded into a melodious, background of sound".

Meanwhile the "central sphere" produced sounds the light beam interruptions caused by visitors were recorded by the steles´ photocells and thus started further sound productions: Slowly louder growing "low frequency tones" were emitted by the steles´ loudspeakers into the circle with "a few Hz differences to each other so that the sounds `beat´ against each other". If these sounds "reached a sufficient threshold" then "the tone generators" were switched off. This switch activated "ventilation blowers" in the steles producing "a gentle breeze" in the height of the visitors´ feet.

The "composite audio output" sent from the "central unit" to the steles was mixed "in each stele" with its "low frequency tones". These mixes were made audible by the loudspeakers of the steles.

The light beam interruptions produced by the visitors and registered by the "photocells" within the "plastic sphere" "change the state of the data bits in the stages of the shift register": In a technical sense the data circulation between the "stages" was produced system internal by a "pulse" as well as system external by visitors. But spatially these visitors don´t act from outside, they move in the circle of steles: They act and react to the system´s output from within the environment.

"A rotating scanner atop the plastic sphere overrode the data currently in the shift register once every two minutes" to avoid with a "fresh start" that all "twelve bits" of this register were "set to all ones or all zeros" and could thus cause "a `lock-up´ state".

In the plastic sphere pairs of yellow and white lamps indicated "the instantaneous state of each stage of the shift register". The upper yellow lamp "lighted to denote a state of `1´ and the lower [white lamp] to indicate `0´." For each "state" a lamp pair indicated with "1" or "0" if visitors activated the coordinated "photocell" in the "plastic sphere" ("photocell" – "state" – "lamp pair"). Furthermore the pairs of lamps marked the changes of the "states" effected by the "shift register". "Other sets of [green and red] lamps denoted the states of the digital inputs of the audio synthesizer modules."

Seawright integrated the visitor into the installation by offering her/him only there to disturb and activate the functions for wind, light, and sound. Visitors could use the "changes of the audio program" and the lamps in the "plastic sphere" to control if the system reacts to their motions between the steles and "the plastic sphere". 38



Seawright, James: Electronic Peristyle, 1968, "central unit" removed from the installation. The transparent "plastic sphere" is divided by a "metal band". In the lower half "the circuitry of the sound synthesizer" is visibly installed. Above the "metal band" the 12 photocells are recognisable, "looking a bit like little cannons". The "black metal drum" contains the lamps indicating states of the "shift register" and the "audio synthesizer modules". Above the "metal drum" are the cables of the "patch panel". The "rotating scanner" is located on top of the "plastic sphere" (photo and quotes: James Seawright).

Vladimir Bonacic used minicomputers early. In 1969 he and Miro Cimerman started in Zagreb to use the computers PDP-8 of the Digital Equipment Corporation (DEC) and SDS 930 of Scientific Data Systems with "self built electronics" to produce "pseudo-chance-transformers and generators" via Galois fields. 39 The calculated polynomial equations (of Abstract Algebra) were "implemented into the electronic circuits of a control unit" 40 producing light sequences on grids with sometimes different coloured elements.

In "G.F.E. (16,4)" (1969-71) visitors could modificate light sequences by using cotrollers and a remote control (via radio waves). Three Galois field generators produced the sequences on 1024 light elements with 16 colour hues. The light elements constituted a

"dynamic object" measuring 1,78 x 1,78 x 0,20 meter. 41 64 sound oscillators produced sounds by interactions with the Gallois field generators. The sounds became audible by two stereo amplifiers. As indicated by Bonacic the "dynamic object...was capable" to produce "1 048 576 different configurations" by different adjustments from the most rapid in six seconds to the slowest in 24 days. "Each image" was accompanied by "a specific sound". 42



Bonacic, Vladimir: G.F.E. (16,4), 1969-71.

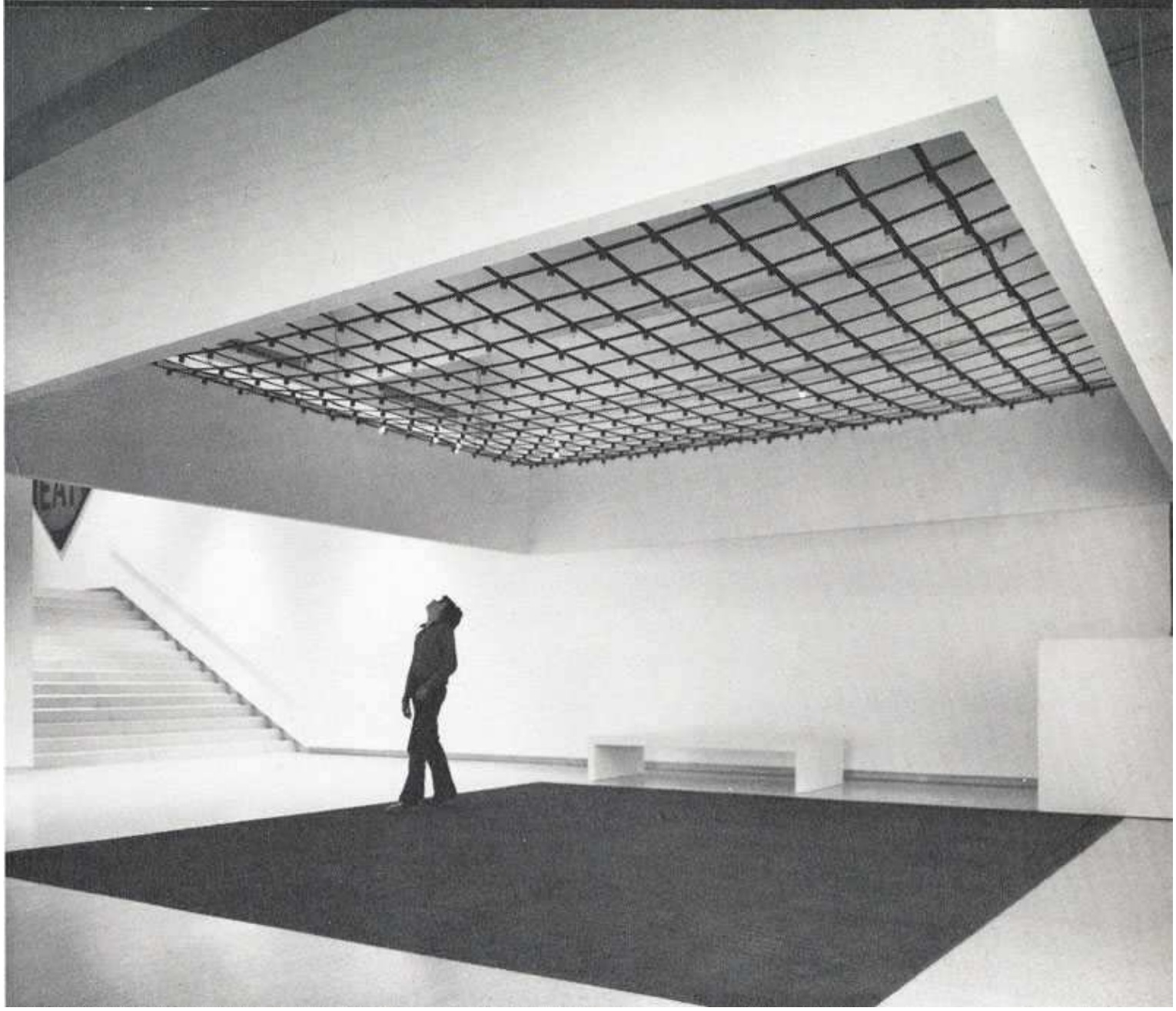
Compared to Seawright´s "Electronic Peristyle" Bonacic developed the light and sound variations to further differentiations, but neglected the integration of observers into the installation´s space by uncommon interfaces and arrangements of the material elements.

In 1971 Seawright´s "Network III" was installed at the Walker Art Center in Minneapolis. If visitors walked on pressure-sensitive elements then they produced patterns on a grid of overhead lights placed directly above the sensors. "6 x 6 arrays of pressure-sensitive mats, normally used to control the opening of automatic doors" were hidden under " a 20´ x 20´ [6,09 x 6,09 m] square of industrial carpeting". On the ceiling 400 lamps were mounted "at the intersections" of "a grid of web-belting" "at an 11´´ [28 cm] interval".

The input of the floor sensors was prepared by a minicomputer PDP 8-L. It executed programmed algorithms structuring the lights to build patterns. The computer, hidden under a white box, could control each light.

To the moves of one or two visitors the program reacted with light patterns. Seawright programmed in the "PDP 8 assembly language" "a circle about two feet [60,96 cm] diameter" with a "blinking circle" as its variant. "A cross or plus sign" could appear as "rotating", too. Furthermore a certain sensor´s input caused "a solid square box" as an output.

If three or more visitors entered the carpet, then the program shut down with "a spectacular blowup". The "processing speed and memory capacity" of the minicomputer were insufficient for algorithms enabling the system to react with light patterns to more than two persons. The program identified the persons on the sensors as "target 1" or "target 2" and assigned to them different "overhead patterns". If both visitors moved to "adjacent" sensors then the "overhead patterns" for "target 1" and "target 2" "would superimpose, but when either one moved to a new location their identities (the coordination visitor – target) would sometimes be exchanged." 43



Seawright, James: Network III, 1971, Walker Art Center, Minneapolis 1971. Photo: Eric Sutherland (Davis: Experiment 1975, p.195).

Seawright anticipated interfaces of computer-aided installations of the nineties (see chap. V.1) in "Network III" with its pressure-sensitive floor sensors and the location of the visitors between planes for in- and output. In the nineties Seawright´s patterns for sounds and lights are substituted by digital simulations of three-dimensional spaces and interfaces like floor panels are used as opportunities for observers to switch between real and virtual spaces. 44

II.3.3 Nicolas Negroponte, the Architecture Machine Group and "Seek"

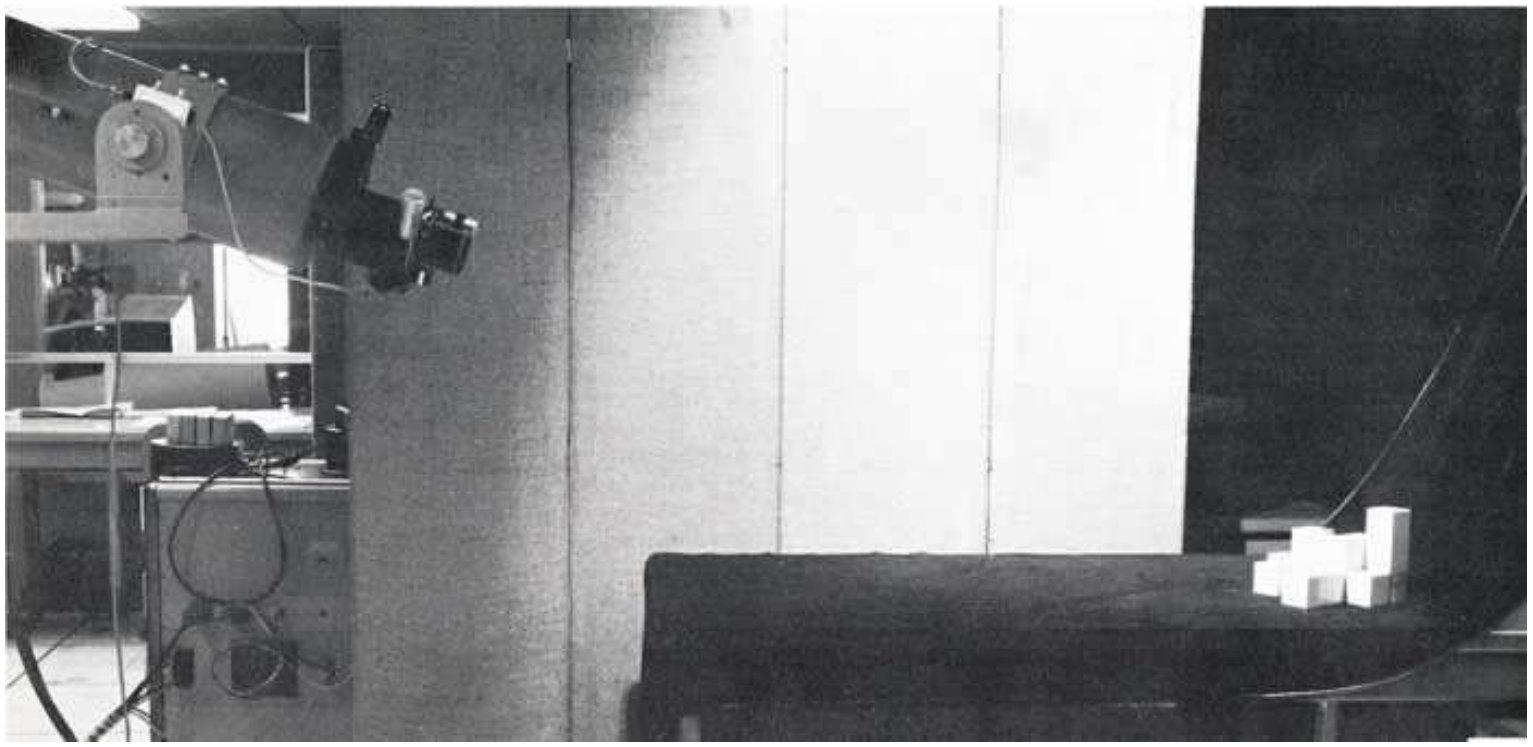
In 1967 the "Architecture Machine Group", directed by Nicolas Negroponte and located in the Urban Systems Laboratory at MIT (Massachusetts Institute of Technology, Cambridge/Massachusetts), developed the computer-aided design system "URBAN5" for architects to be used as a means to ameliorate planning procedures. Planners could operate with the system via keys on a console and a light pen for the activation of functions on the screen. Cubes were the basic elements of the graphic system. For Negroponte "URBAN5" was not complex enough for a change of planning strategies. 45



The Architecture Machine Group: Urban 5, 1967.

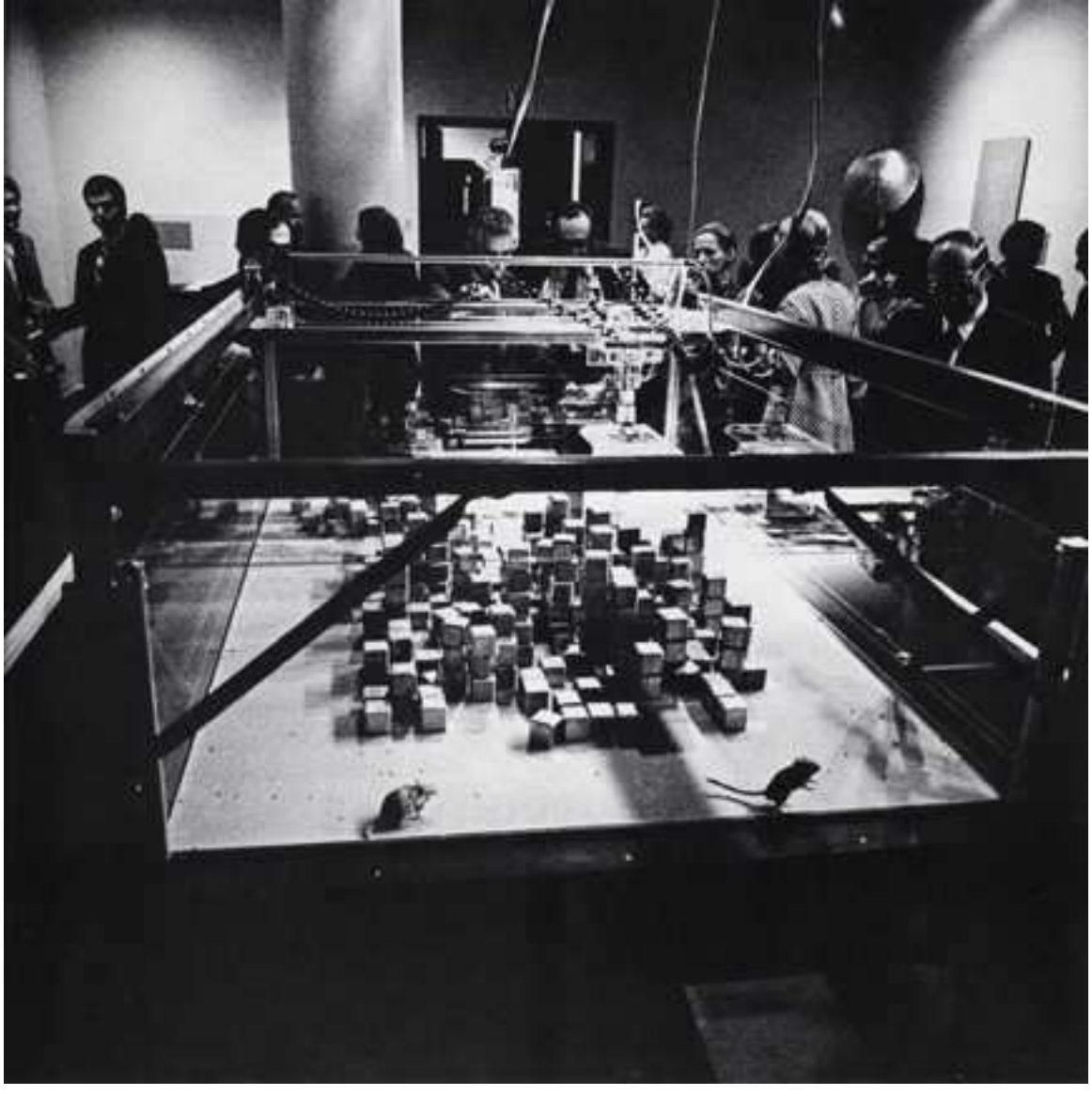
Meanwhile "URBAN 5" was not capable to integrate the environment into planning procedures 46, "The Architecture Machine" was a learning system with a mobile unit containing photocells. The system was able to recognize environmental conditions and a robot arm developed by students could move stereometric elements on a table.

The "Minsky/Papert-eye" developed at MIT could recognize stereometric elements. It was a result of a research to transfer the contours of a constellation of bodies on a table into a data landscape. The data were processed by the minicomputer Interdata Model 3. The parameters of a learning robot should "develop its own conditioned reflexes" 47 in interactions with an architect. This was the research goal of the project being oriented to "architectural intelligence". 48



Minsky/Papert Eye, M.I.T. (Negroponte: The Architecture Machine 1970, p.106).

In 1970 Jack Burnham curated the exhibition "Software" in the Jewish Museum in New York. "The Architecture Machine Group" realised in the installation "Seek" an environment for 500 gerbils enclosed in a glass container open at the top. An arm was mounted on two rails on the top of the glass container. The arm moved a magnet to replace blocks. Via sensors reacting to pressure the system used an Interdata Model 3 computer to control mouses moving the blocks out of the grid structure. Then the computer activated the moving arm placing the blocks into another structure following the right angle of the grid. 49



The Architecture Machine Group: Seek, 1970, exhibition "Software", The Jewish Museum, New York 1970 (Negroponte: Architecture 1975, p.46, fig.1).

The intended "artificial intelligence" 50 provoked expectations that the arm and its computer-controlled navigation reacts directly to the mice´s actions. 51 The Architecture Machine Group´s contribution to the catalogue points to the still existing gap between "Seek" and the project of "artificial intelligence": "...`Seek´ deals with elementary uncertainties in a simple-minded fashion." 52

The Group presents with "Seek´s" relation between animals and machine a rudimentary model of a social system reacting with a machine-controlled flexibility to the creatures´ motions within the system. With that model The Architecture Machine Group anticipates the model of a flexible architecture as it became an ideal for many architects in the seventies and was realised in projects like Cedric Price´s "InterAction Centre" (Kentish Town, from 1976 to its demolition in 2003) and the Centre Pompidou (Paris, 1977) by Renzo Piano and Richard Rogers. Meanwhile these buildings first of all offered possibilities for a flexible use by elements displacable within a supporting structure, in 1976-79 Cedric Price, John and Julia Frazer designed the "Generator Project" with sensors to whose input react four computer programs, and a mobile crane installed permanently to move flexible elements. The crane shall be a means for the execution of propositions for modifications planned by computers. These propositions react to the sensors´ input containing data on the use of the flexible elements. According to John Frazer the computer programs shall offer better propositions for the users of a house than their own plans: Gordon Pask´s "Learning machines" (see chap. II.3.1.1) and "The Architecture Machine" with its concern to the environment´s changes caused by its use become model examples for the further development of flexible architectural structures. 53

In the sixties the project of an expansion from sculpture to the environment and to action has been realised in different ways. The development of "responsive environments" as a forerunner to a "responsive architecture" 54 was shaped by the possibilities of computer-aided organization procedures. Limits of art are transgressed by demonstrations of non-realizable architectural concepts. The model "Seek" installed by the MIT in the exhibition "Software" anticipated more extensive future-oriented projects and implicated research tasks. The experimental status of the animals in "Seek" was controversial for art critics and provoked them to express doubts about the research goal. 55

Annotations

1 Pask: Approach 1961, p.32, pl. I(i). In 1955 C.E.G. Bailey, T. Robin McKinnon Wood, and Gordon Pask developed "Eucrates" (Pask: Approach 1961, p.67). back

2 Pask: Approach 1961, p.67s. back

3 Pask: Approach 1961, p.68. back

4 Pask: Approach 1961, p.70. Cf. Burnham: Modern Sculpture 1978, p.337s. back

5 Pask: Comment 1971, p.77-88; Pickering: Brain 2010, p.317ss.; Rosen: Control 2008, p.136-145. back

6 Pask: Comment 1971, p.78. back

7 Pask: Comment 1971, p.80. Cf. Pickering: Brain 2010, p.316.
Pask: Comment 1971, p.78 on the musician: "The musical performer (who may, incidentally, be replaced by a small group or band) must first be able to see the visual display and second be able to modify his performance according to what he sees. The latter condition can be satisfied in various ways. At one extreme, the performer has a (usually memorized) score and he modifies his performance by giving a different interpretation to the piece. At the other extreme, he improvises in a fashion that is only constrained by canons of music and his own disposition." back

8 Pask: Comment 1971, p.78ss.; Pickering: Brain 2010, p.314, fig. 7.2, p.316; Rosen: Control 2008, p.136. back

9 Pask: Comment 1971, p.86.
Gordon Pask´s "electro-chemical display" is a part of a research investigating the relations between "stability and variety" in "self-organizing systems". In the course of the research Pask began to develop "chemical computers": "Chemical computers arise from the possibility of `growing´ an active evolutionary network by an electro-chemical process." (Pask: Approach 1961, p.105) On the insights in emergence that Pask was able to win within the research project: Cariani: Emergence 1991, p.789; Cariani: Ear 1993; Pickering: Brain 2010, p.334-343; Whitehead: Metacreation 2004, p.223. back

10 Pask: Comment 1971, p.78ss. back

11 Pask: Comment 1971, p.86: "From the performer´s point of view, training becomes a matter of persuading the machine to adopt a visual style which fits the mood of his performance. At this stage in the development of the rapport, the performer conceives the

machine as an extension of himself, rather than as a detached or disassociated entity." back

12 Pask: Approach 161, p.48: "A system is `self-organizing´ if the rate of change of its redundancy is positive." back

13 Pask: Approach 1961, p.48. In this case the musician is the "observer".
Pask describes "observers" as "men, animals, or machines able to learn about their environment and impelled to reduce their uncertainty about the events which occur in it, by dint of learning." (Pask: Approach 1961, p.18) "Some simplified abstractions from the real world" can be falsified in their character as fundamentals for predictions: "Any observation of the real world is fallible..." (Pask: Approach 1961, p.19) Learning became a presupposition to obtain sufficient "requisite variety" (Pask: Approach 1961, p.51ss.; see chap. II.1.5) for adequate reactions to environmental events. back

14 "Responsive environment": Burnham: Aesthetics 1970, p.108; Burnham: System Esthetics 1968, p.35; Krueger: Computer 1976; Krueger: Environments 1977/1996, p.481s.; Krueger: Videoplace 1985, S.145,147. back

15 Bruinsma, A.H.: Practical Robot Circuits. A Philips Technical Publication. Quoted in: Hoggett: CYSP 1 2009. Jean-Noël Montagné in 10/27/2013 in an e-mail to the author. The name "CYSP" is an abbreviation. It consists of the first two letters of «cybernétique» and «spatiodynamique» (Cassou/Habasque/Ménétier: Schöffer 1963, p.50).
On a justified criticism of the term "electronic brain", published in 1951 in the leaflet of the Science Museum in South Kensington for the "Festival of Great Britain" in London: see chap. VII.1.1 on "Ferranti NIMROD". back

16 Hoggett: CYSP 1 2009; Schöffer: Apparitions 2009 and Jean-Noël Montagné in 10/27/2013 in an e-mail to the author. Following Montagné "CYSP 1" was self-navigating and "not programmable...but there were 2 speeds possible for the main moving motors". The external control is not illustrated and only indirectly described in Cassou/Habasque/Ménétrier: Schöffer 1963, p.50-57,137. back

17 Without author: CYSP 1. In: Reichardt: Cybernetic Serendipity 1968, p.45: "...the sculpture consisting of combined travel and animation. For example: it is excited by the colour blue, which means that it moves forward, retreats or makes a quick turn, and makes its plates turn fast; it becomes calm with red, but at the same time it is excited by silence and calmed by noise. It is also excited in the dark and becomes calm in intense light." back

18 Nicolas Schöffer talking to Hans-Jürgen Buderer in 30.9.1983. In: Buderer: Kinetische Kunst 1992, p.191 (cf. Buderers comment, ibid., p.127s.).
Cf. Jacques Bureau´s "Annotations of the Philips Company..." (1955). In: Cassou/Habasque/Ménétrier: Schöffer 1963, p.45: An "indifference cell" causes an "uncertainty factor" (Cf. Cassou/Habasque/Ménétrier: Schöffer 1963, p.50,60,136). back

19 Buderer: Kinetische Kunst 1992, p.124s.,190,193s. (Schöffer 1983, see ann.18); Schöffer: Spatiodynamisme 1955 (I thank Jean-Noël Montagné for the tip about that text). Bureau presents the "electronic brain" in "Annotations of the Philips Company..." (see ann.18) as "homeostat" (Cassou/Habasque/Ménétrier: Schöffer 1963, p.45s.). back

20 Klütsch: Computergrafik 2007, p.198ss.; Mason: Computer 2008, p.101-110; Prince: Women 2003, p.3s.; Reichardt: Serendipity 1968, p.5. back

21 Reichardt: Cybernetics 1971, p.11. In contrary, according to Michael Kustow, the

former director of the Institute of Contemporary Arts, the show attracted 45.000 visitors (Usselmann: Dilemma 2003, ann.4). "Cybernetic Serendipity" was a travel exhibition shown in 1969 in the Corcoran Art Gallery (Washington, D.C.) and in the Exploratorium in San Francisco, too (Henning: Museums 2006, p.87ss.; Mason: Computer 1968, p.212). back

22 Reichardt: Computer 1971; Reichardt: Cybernetic Serendipity 1968; Reichardt: Cybernetics 1971. back

23 Ihnatowicz: Cybernetic Art 1986, p.5; Ihnatowicz: Forty 2008, p.113; Mason: Computer 2008, p.81s.; Reichardt: Cybernetic Serendipity 1968, p.38; Zivanovic: SAM 2005, p.2s.; Zivanovic: Technologies 2008, p.97ss. back

24 Ihnatowicz, Edward: Sound-Activated Mobile. In: Reichardt: Cybernetic Serendipity 1968, p.38. back

25 Philips P 9201: clone of the minicomputer Honeywell DDP-416 (since 1967. See Zivanovic: Technical Info undated; Zivanovic: SAM 2005, p.4). The computer was located in view beside the round base. back

26 Ihnatowicz: Cybernetic Art 1986, p.6. back

27 Mason: Computer 2008, p.91; Zivanovich: SAM 2005, p.5. Further writings on "Senster": Benthall: Ihnatowicz 1971; Gardner: Elephants 1983, p.143-146; Ihnatowicz: Forty 2008, p.114s.; Zivanovic: Technologies 2008, p.100-107. back

28 Realisation of the fibreglass bodies: Pip and Adele Youngerman (Rosen: Control 2008, p.167 with ann.128). back

29 Pask: Comment 1971, p.97 with fig. 40, p.98. Electronics: Mark Dowson. Electromechanics: Tony Watts. The computer was constructed by Pask, Dowson and Watts using "electromechanical relais and simple electronics " (Rosen: Control 2008, p.168 with ann.129). back

30 Pask: Comment 1971, p.89. back

31 Pask: Comment 1971, p.89. Cf. Pickering: Brain 2010, p.357s.; Rosen: Control 2008, p.168. back

32 "Odrive and Pdrive", in: Pask: Comment 1971, p.91. back

33 Pask: Comment 1971, p.88s. back

34 Pask: Comment 1971, p.91. back

35 Pask: Comment 1971, p.88. back

36 On the problem to inform visitors about the system´s fundamentals to enable them to reconstruct the programming of its functions by activating its machinic reactions: Rosen: Control 2008, p.172 with ann.136. Cf. in contrary Pickering: Brain 2010, p.360 on visitors interacting with "Colloquy of Mobiles" for several hours without preinformations. back

37 Group exhibition "The Magic Theatre", William Rockhill Nelson Gallery, Kansas City/Missouri 1968. Later exhibited in the art museums of St. Louis/Missouri and Toledo/Ohio. In: Davis: Art 1973, p.75s.,156; Ehrlich: Magic Theatre 1969. Permanent

installation of "Electronic Peristyle" since 1997: New Jersey State Museum, Trenton/New Jersey. back

38 Quotes from e-mails sent by James Seawright to the author in 9/28/2013, 10/7/2013, 10/10/2013 and 17/10/2013.
Writings on "Electronic Peristyle": Kostelanetz: Soho 2003, p.153; Light: Peristyle 1997; Seawright: Art 1970, p.89,91ss. back

39 Rosen: Maschinen 2007, p.50. The SDS 930 was programmed in FORTRAN and assembly language (Frits: Work 2011, p.51). back

40 Rosen: Maschinen 2007, p.51. back

41 Bonacic: Mensch 1973, p.216: "The dynamic object GF E 16-4/69-71...was constructed with 1024 quadratic aluminium tubes. Because of the tubes´ different length the object constituted a relief. At the end of each tube a transparent glass in one of 16 colour hues is mounted (antique glass made in West Germany). Each tube contains a lamp for a control independent of the arithmetic unit of the computer." back

42 Bonacic: Mensch 1973, p.217. Cf. Fritz: Work 2011, p.52s.; Shanken: Art 2009, p.67. back

43 Quotes from e-mails sent by James Seawright to the author in 10/6/2013 and in 10/10/2013.
Seawright about the programming: "The programming was all mine, with considerable advice and hand-holding from computer professionals and hackers. The language was PDP8 assembly language. The program was coded in ASCII on paper tape, and read in using the teletype which came with the computer. Loading or reloading the program took over 4 hours!"
Seawright expanded the program for the installation in the group exhibition "The Responsive Environment", New Jersey State Museum, Trenton/New Jersey 1972.
Writings on "Network III": Davis: Art 1973, p.156; Goodman: Visions 1987, p.142; Kac: Telepresence 2005, p.176s. back

44 Cf. Weibel, Peter: On Justiying the Hypothetical Nature of Art and the Non-Identicality within the Object World, 1992 (see chap. V.1); Rogala, Miroslav: Lovers Leap, 1995. In: Druckrey: Lovers Leap 1995. back

45 Negroponte: The Architecture Machine 1970, p.70-99. back

46 Negroponte: The Architecture Machine 1970, p.63. back

47 Negroponte: The Architecture Machine 1970, p.100-117.
"The M.I.T. Minsky/Papert eye": Negroponte: The Architecture Machine 1970, p.105ss.
At the MIT Artificial Intelligence Lab Marvin Minsky and Seymour Papert developed among other things "The Logo Turtle" in 1969 (Hoggett: Logo Turtle 2010), using "LOGO" to develop further William Grey Walter´s robots (see chap. II.2.3). "LOGO" is a computer language developed in 1967 and is based on LISP ("LOGO"-developer: Wally Feuerzeig, Seymour Papert).
On Papert, Minsky, Negroponte and "The Architecture Machine" as documents for relations between art and "artifical intelligence": Burnham: Aesthetics 1970, p.111-114. back

48 Steenson: Artificial Intelligence 2010. back

49 The Architecture Machine Group: Seek 1970 (students at M.I.T. constructed "Seek" as members of the "Architecture Machine Group"); Davis: Art 1973, p.101s.,107; Goodman: Visions 1987, p.40s.,43; Hess: Gerbils 1970; Montfort/Wardrip-Fruin: Reader 2003, p.247; Negroponte: The Architecture Machine 1970, p.104s.,112s.; Pickering: Brain 2010, p.376s., fig. 7.27. back

50 The Architecture Machine Group: Seek 1970. back

51 Davis: Art 1973, p.102; Goodman: Visions 1987, p.40. back

52 The Architecture Machine Group: Seek 1970. back

53 On the "InterAction Centre": Mathews: Agit-Prop 2006, part 2 and 3.
On the "Generator Project": Pickering: Brain 2010, p.372s.; Steenson: Cedric Price 2007. back

54 Grünkranz: Phenomenology 2009.
On the art expansion in the sixties from the isolated object to the environment and to architecture: Claus: Expansion 1970, esp. p.54-109; Krauss: Sculpture 1979. back

55 Davis: Art 1973, p.107; Hess: Gerbils 1970; Goodman: Visions 1987, p.43. back

III. Information Aesthetics
III.1 Computer Literature

III.1.1 Word Processing

The previous chapter on "Cybernetic Sculptures" (see chap. II.3) presents the development of systems from 1953 to 1971 integrating self constructed computers (see chap. II.3.1.1, II.3.2.3), analog computers (see chap. II.3.2.2) and digital minicomputers (since 1969, see chap. II.3.3, II.3.2.2, II.3.4): Alternatives to mainframe computers were constructed to make possible the inclusion of computers in installations (that can be rebuild on several locations).

With the use of mainframe computers in electronic literature an alternative was developed to electronic data processing as a means for administrative needs. The history of an experimental utilisation of mainframe computers to test their possibilities for word processing began in the fifties. In contrast to the cybernetic sculptures the computers are not a part of a work that can be categorized as computer literature or computer graphics (see chap. III.2) but a means to produce the work. The results of the computing processes are printed by plotters.

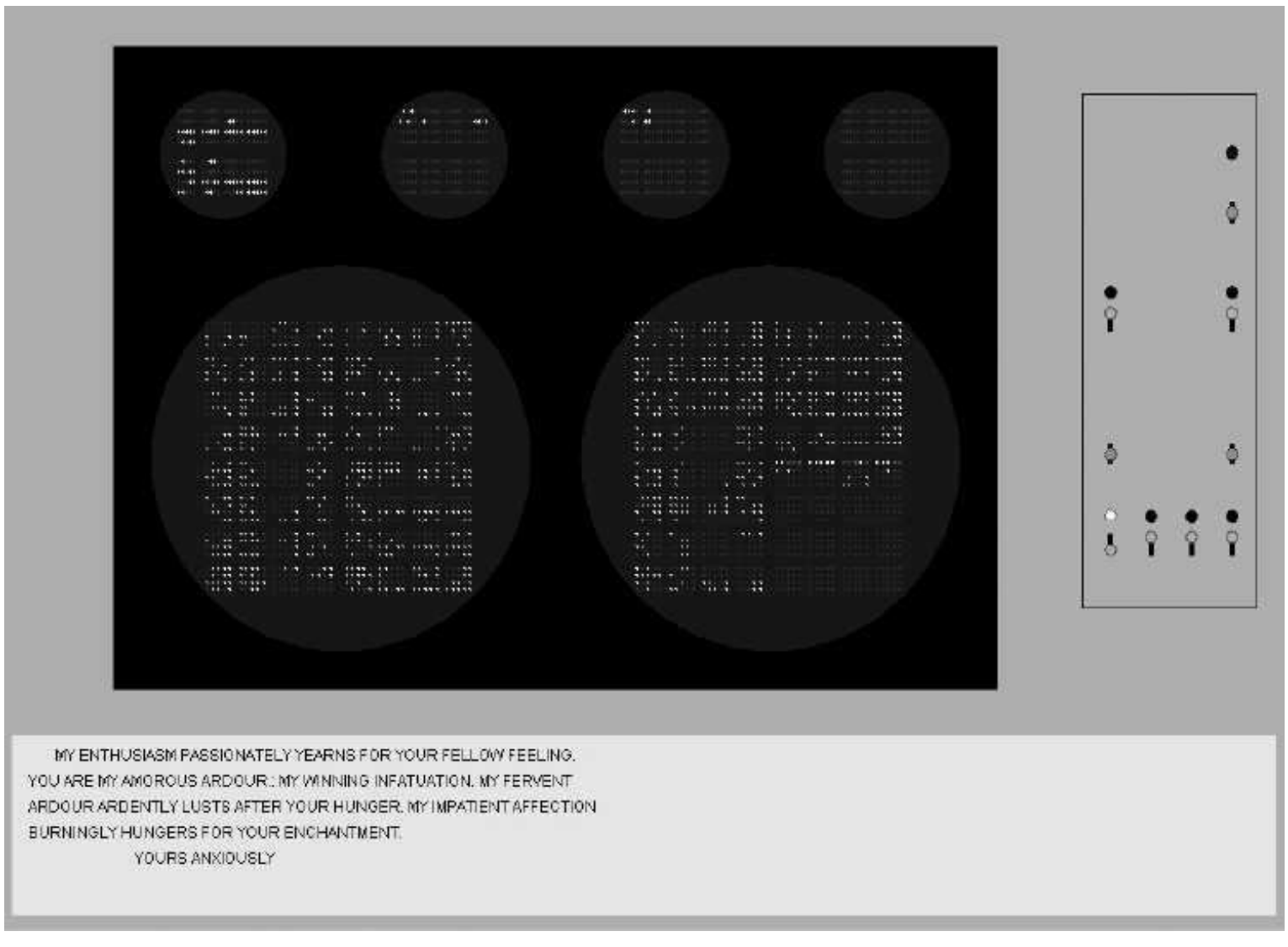
In reactive installations cybernetic circuits support the integration of the observer. In computer literature and computer graphics the circuits are reduced to the sequence from input media – punch cards or magnetic memories – to the mainframe computers executing the computing processes and the printers or plotters as output media writing letters or graphic signs on papers. These prints present the results of computing processes executing the program´s instructions. If the computing process will be restarted then the results can vary. This variety is not seldom caused by algorithms for pseudo random sequences (see chap. III.1.2, III.2.2).

III.1.2 Christopher Strachey´s "Love-letters"

Christopher Strachey met Alan Mathison Turing during his studies (of mathematics and physics, from 1935 to 1938) at King´s College in Cambridge. From 1949 to 1952 Strachey was a teacher at Harrow School (Harrow on the Hill/Middlesex). In 1951 Mike Woodger introduced Strachey to the project Pilot ACE at the National Physical Laboratory in Teddington/Middlesex. Since 1950 the laboratory developed the reduced version of Turing´s "Automatic Computing Engine" called Pilot ACE. 1 In February 1951 Strachey developed for Pilot ACE a program for a game of draughts running for the first time in 30th July 1951. As soon as Strachey received informations about the bigger main memory of the mainframe computer Manchester Mark I (1948-50) he wrote his program for a game of draughts in the machine code of this computer (October 1951, see chap. VII.1.1). 2

The Ferranti Mark I (1951) was constructed on the base of the Manchester Mark I. It was

the first purchasable computer. In February 1951 Manchester University received its exemplar. A program for computer music was developed by Strachey for this Ferranti Mark I. It generated songs like "God Save the King" (1951). [3] After having presented his program Strachey was hired by the National Research and Development Corporation as a "technical officer" (June 1952).



Link, David: Ferranti Mark I Emulator with a reconstruction of Christopher Strachey´s "Love-letters" 1952 (Link: Angel 2006, p.16, fig.1).

In 1952 he wrote a program to generate "Love-letters". The program combined words by selecting them form a database via the random generator of the Ferranti Mark I. The stored word library contained a selection from Roget´s Thesaurus. The words supplied with syntax indices – "adjectives", "substantives", "adverbs" and "verbs" – are combined following two syntactical structures: "My—[adjective]—substantive—[adverb]—verb —Your—[adjective]—substantive" or "You are my—adjective—substantive". In the case of repetitions the second structure was reduced to "My—adjective—substantive". After a salutation combined by using a database called "Letter Start" to select words followed five sentences generated by combinations of stored words using the syntactical schemes described above. The end of the letter was constructed with the scheme "Yours—adverb —MUC" (MUC = Manchester University Computer). The program "Love-letters" could generate 318 billion different letters. The results of the computing processes were presented without commas by a teleprinter. Meanwhile Strachey´s "Game of Draughts" had to choose the best of all possible moves, "Love-letters" recognized only the syntactical structures but no semantic restrictions. Noah Wardrip-Fruin proposes to understand "Love-letters" as to produce semantic accidents as parodies of "normative expressions of desire". [4]

Strachey anticipates basic elements of the sixties´ computer literature and computer graphics with his structuring of the programming into a selection of elements, a random generator, a syntax for combinations and the presentation of a plotter output.

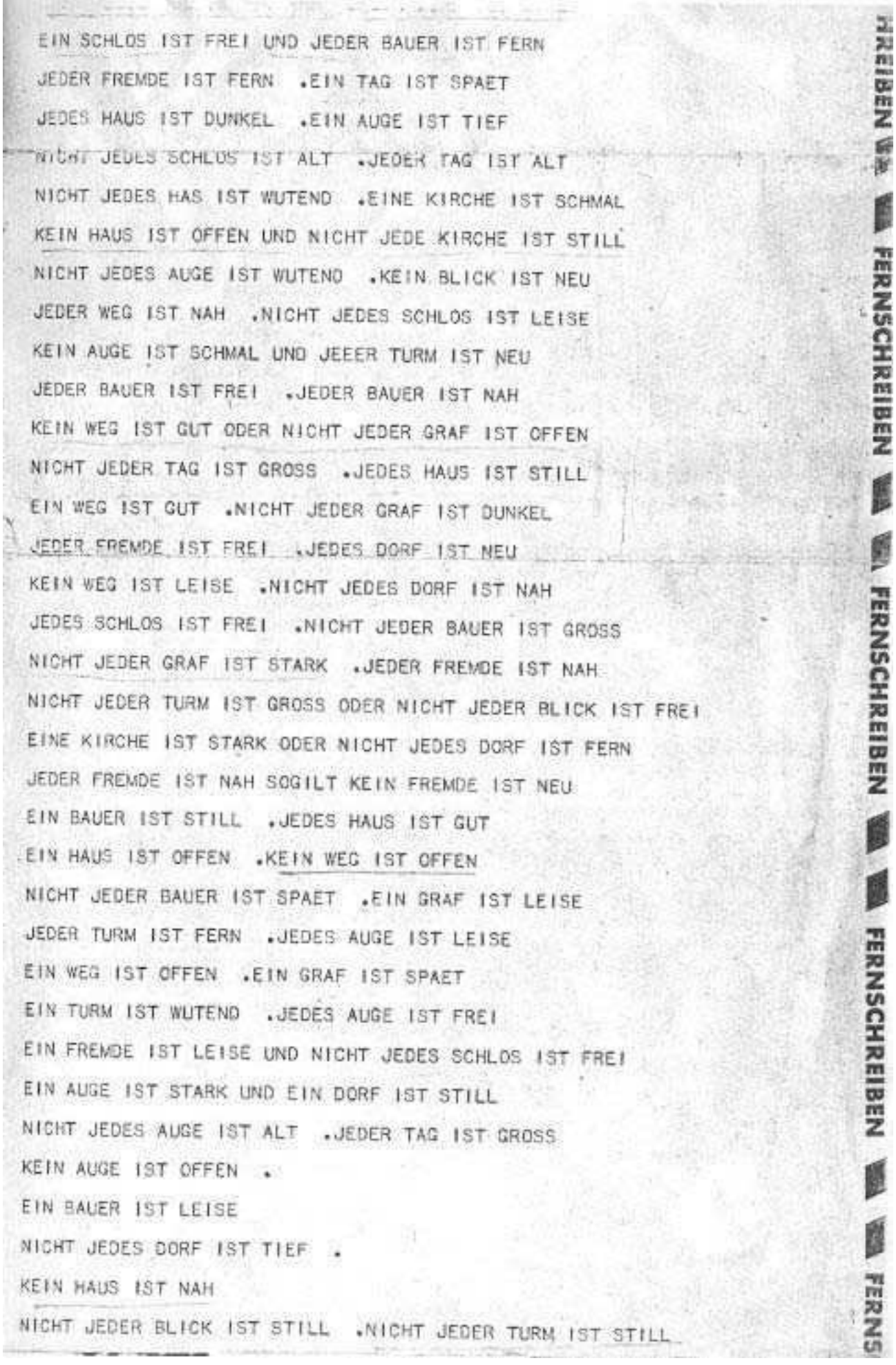
III.1.3 Stochastic Texts

Until 1959 Theo Lutz studied mathematics, physics and electrical engineering at the Technische Hochschule of Stuttgart. As a degree candidate of Max Bense he knew the philosopher´s information aesthetics. Bense proposed Lutz to install in his text generating program "a database with 100 words from Franz Kafka´s novel `The Castle´ [1922] and simple sentence structures." 5

Max Bense´s "Aesthetica" was published in five parts from 1954 to 1965. In the first part Bense explained the "classical and nonclassical Seinsthematik [epistemology]". He situates Hermann Melville´s "Bartleby" and Franz Kafka´s "The Castle" between a reality derived from divine possibilities in the sense of the classical epistemology and the nonclassical opposition between the "term of a (human, personal) existence" and the "term of a system containing everything, transcendence as well as immanence, god as well as the world, reason as well as history". 6

This epistemological discourse presented Bense in part 1 of the "Aesthetica" as a central problem of the artistic and literary avant-garde. It was taken over in later parts (since part 3, published in 1958) by explanations of the "aesthetic" and "semantic information". Bense defines "information" among others as "a measure of a scheme´s regularity". 7

In 1959 Theo Lutz´s "stochastic texts" were produced at the Rechen-Institut of the Technische Hochschule of Stuttgart in the time when Bense developed a new core subject in "Aesthetica". In Lutz´s texts the selection of words is determined by a syntactical scheme, a random generator and frequency criteria. Lutz´s program used a word database to generate with the valve computer Z22 of the firm Zuse (1958) sentences with a correct syntax. Lutz´s procedure to use the stored words provides a model for Bense´s change of "Aesthetica´s" core subject.



Lutz, Theo: Stochastic Text, Zuse Z22, teleprinter output, 1959.

Lutz used punch tapes as input medium to start his in ALGOL written program in the computer Z 22 of the Rechen-Institut. Then he could read the result on the teleprinter´s output. The database contained a selection of 16 subjects and 16 predicates as they were found in Kafka´s "The Castle". Four "logical constants" ("and", "or", "if...then", ".") for the syntax of the combinations, four "logical operators" for the subject´s existence ("one", "each", "no one" and "not each" in feminine, masculine and factual German forms) as well as the stored subjects and predicates should appear with equal frequency in a computer-generated text. Only the "relative frequency" of the point (the sign for the negation) was determined higher than the frequency of the other logical constants.

Between subject-predicate pairs the logical constants create irritating relations – for example:

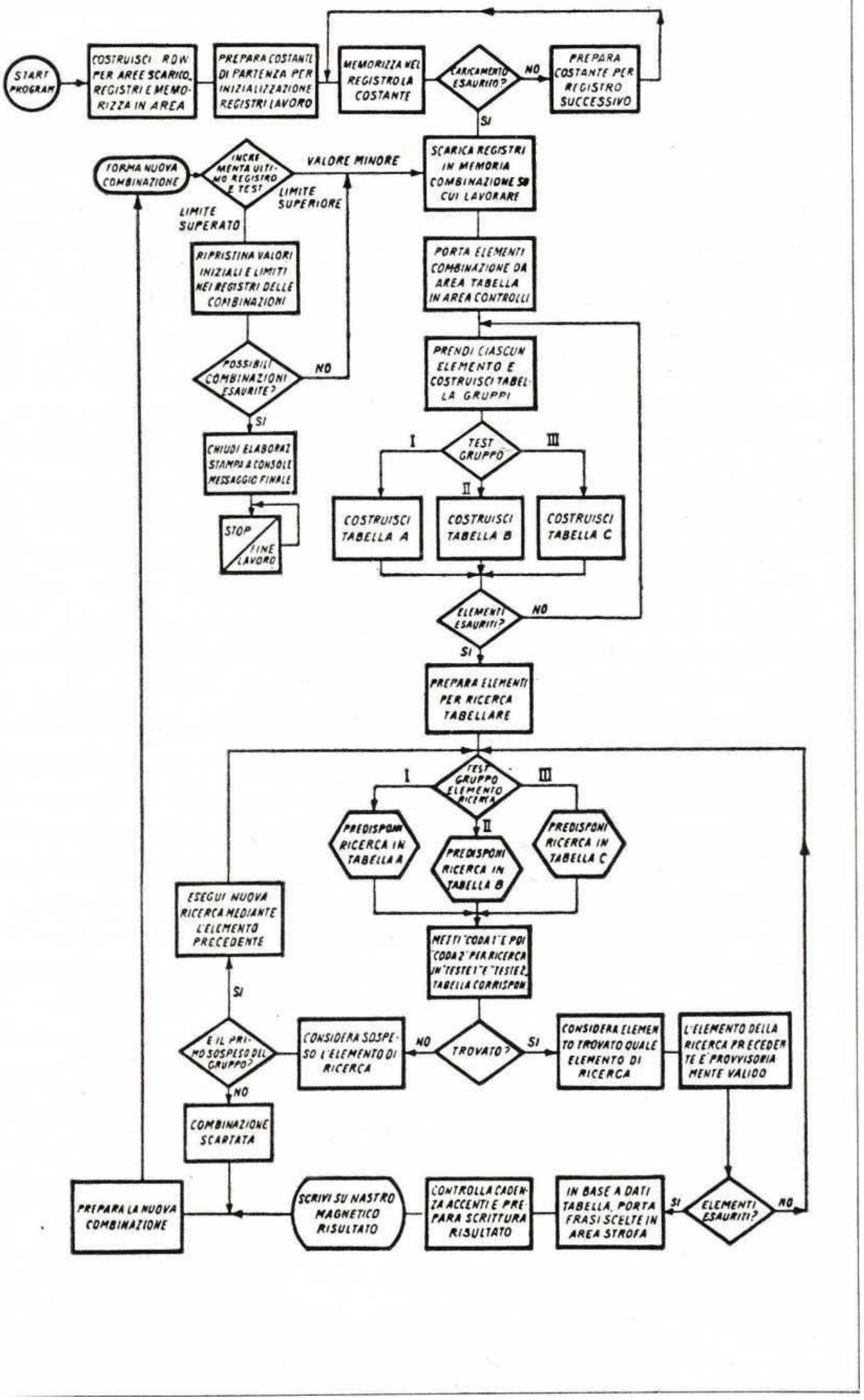
> Jeder Fremde ist nah, so gilt kein Fremder ist alt (If each stranger is close, then each stranger is old). 8

The second part of the if/then operation seems to be a conclusion from the first part of the phrase but this is wrong for our world knowledge. Which roles play such wrong conclusions for the poeticity of a computer-generated "artificial" literature 9: Does the artificial literature try to provocate us to understand the "aesthetic information" as a quality being independent from the "semantic information" 10 and ignoring the truth content of the message?

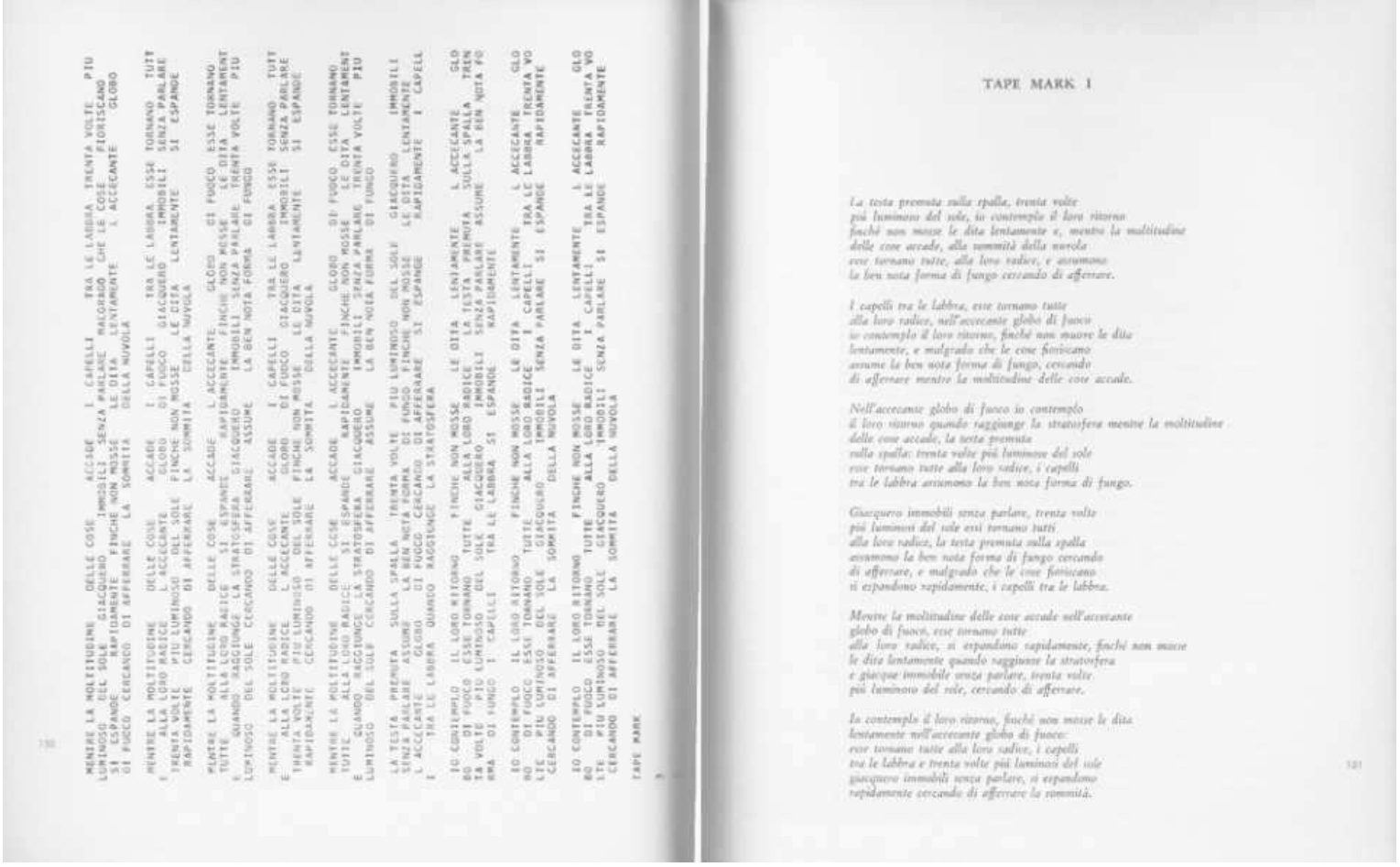
Bense based his integration of the semantic terms `true´ and `false´ in the information theory 11 on theories of Donald M. MacKay and Rudolf Carnap. 12 The semantic information in logics and the information in cybernetics (see chap. II.1.3) are presented as alternatives 13 that can be combined in "Aesthetica" in a "general communication research" to be able to discuss the relations between "semiotics" and "information theory". 14

Shannon´s model of a reconstructing production of a language based on frequency statistics of the use of basic elements and their combinations (see chap. II.1.2) is turned in Lutz´s "Stochastic Texts" into a procedure to obtain "aesthetic information" renouncing any dependence on conventional forms of literature. The frictions between text production and the conclusiveness of a statement in relation to the experience of reality, between "aesthetic" and "semantic information", are a key issue. The results of a machine production become experiments for readers who decide if the tension between reliable and unreliable statements is attracting or if the text provokes a collapse of their attention.

In 1960 Brion Gysin utilised a program developed by Ian Somerville for the permutation of words without regard to syntactical structures. In contrast to Lutz Gysin doesn´t install a database as an archive with combinable words but selects five words to be used in all combinations. The sequence of the words in the start phrase "I AM THAT I AM" was permuted from one line to the next until all variants were realised. 15 The relations between syntax and semantics can appear to readers of "I AM THAT I AM" cancelled by the permutation of the words with the recurring vowels "i" and "a" in varying changes with the recurring consonants "h", "m" and "t": Semantics are replaced by visual and onomatopoetic effects.



Balestrini, Nanni: Tape Mark I, Flow Chart, 1961 (Reichardt: Serendipity 1968, p.65).



TAPE MARK I

La testa premuta sulla spalla, trenta volte
più luminoso del sole, io contemplo il loro ritorno
finché non muove le dita lentamente e, mentre la moltitudine
delle cose accade, alla sommità della nuvola
esse tornano tutte, alla loro radice, e assumono
la ben nota forma di fungo cercando di afferrare.

I capelli tra le labbra, esse tornano tutte
alla loro radice, nell'accecante globo di fuoco
io contemplo il loro ritorno, finché non muove le dita
lentamente, e malgrado che le cose fioriscano
assume la ben nota forma di fungo, cercando
di afferrare mentre la moltitudine delle cose accade.

Nell'accecante globo di fuoco io contemplo
il loro ritorno quando raggiunge la stratosfera mentre la moltitudine
delle cose accade, la testa premuta
sulla spalla: trenta volte più luminose del sole
esse tornano tutte alla loro radice, i capelli
tra le labbra assumono la ben nota forma di fungo.

Giacquero immobili senza parlare, trenta volte
più luminosi del sole essi tornano tutti
alla loro radice, la testa premuta sulla spalla
assumono la ben nota forma di fungo cercando
di afferrare, e malgrado che le cose fioriscano
si espandono rapidamente, i capelli tra le labbra.

Mentre la moltitudine delle cose accade nell'accecante
globo di fuoco, esse tornano tutte
alla loro radice, si espandono rapidamente, finché non muove
le dita lentamente quando raggiunge la stratosfera
e giacque immobile senza parlare, trenta volte
più luminoso del sole, cercando di afferrare.

Io contemplo il loro ritorno, finché non muove le dita
lentamente nell'accecante globo di fuoco:
esse tornano tutte alla loro radice, i capelli
tra le labbra e trenta volte più luminosi del sole
giacquero immobili senza parlare, si espandono
rapidamente cercando di afferrare la sommità.

Balestrini, Nanni: Tape Mark I, 1961. Left: plotter print. Right: print version (Balestrini: Tape 1962, p.150s.).

Nanni Balestrini invented for "Tape Mark I" a method to generate poems that fall between the concepts for desemantising procedures and for procedures to integrate syntax and semantics. Balestrini selected 15 words from three textual sources for an archive with stored words to be combined in October 1961 by an IBM 7070 (since 1960) of a Milanese bank. 10 words were selected from the archive and were combined with regards to syntactical structures. These combinations were merged in texts with six lines, each constituted by "four metrical elements". This process led to poetic results provoking readers to search for meaning. The poems perform neither radical semantic breaks nor do they include elements comparable to Lutz´s "logical constants" being able to cause the construction of statements without conclusiveness in relation to our experience of reality. 16



Stickel, Gerhard: Autopoem No.1, 1965 (Herzogenrath/Nierhoff-Wielk: Machina 2007, p.159).

In 1965 Gerhard Stickel reconstructed the forms of poetry. In his "Autopoems" generated between 1965 and 1966 by a mainframe computer IBM 7090 (since 1959) he circumvents the problem of the conclusiveness of a statement in relation to the experience of reality that Lutz posed with his use of "logical constants": The relations with references to reality described in Lutz´s computer-generated texts get a peripheral character by the poetic forms of Stickel´s "Autopoems". In its selection of words from a database Stickel´s program follows syntactical criteria. A random generator selects the words, the syntactical structures of phrases (280 structures in all) and the number of lines (between 4 and 26 lines). 17

Annotations

1 Hodges: Turing 1983/1992, p.442s.; Link: Angel 2006, p.17; Turing: Proposal 1945/1992; Wardrip-Fruin: Media 2011, p.304s. back

2 Copeland: History 2000, chap. "The Manchester Machine"; Link: Angel 2006, p.17; Strachey: Machine 1954, p.27; Wardrip-Fruin: Media 2011, p.304s.,312ss. back

3 Fildes: Computer Music 2008; Link: Angel 2006, p.17s. back

4 On "Love Letters": Bülow: Sinn 2007, p.148-151; Hodges: Turing 1983/1992, p.477s.; Link: Angel 2006; Wardrip-Fruin 2011, p.302-316. Examples: Bülow: Sinn 2007, p.150; Strachey: Machine 1954, p.26.
Re-engineering: Link, David: LoveLetters_1.0. MUC=Resurrection. A Memorial. Exhibited in: YOU_ser 2.0. Celebration of the Consumer. ZKM/Center for Art and Media. Karlsruhe 2009. In: URL: http://www02.zkm.de/ you/ index.php?option=com_content& view=article& id=98%3Aloveletters10&catid=35%3Awerke&lang=en (8/10/2013). back

5 Walther: Bense 1999. back

6 Bense: Aesthetica 1982, p.85. Bense mentions Gottfried Wilhelm Leibniz´s "Theodicy" (Essais de théodicée, 1710) as an example for the "classical Seinsthematik" and Søren Aabye Kierkegaard´s "Philosophical Fragments" (1844) as an example for the "nonclassical Seinsthematik". back

7 Bense: Aesthetica 1982, p.220. back

8 Lutz: Texte 1959. Cf. Bense: Einführung 1969, p.111; Bülow: Sinn 2007, p.152-156; Cramer: Statements 2011, p.186s.; Funkhouser: Poetry 2007, p.37s.; Gunzenhäuser: Synthese 1963/2004, p.175-178; Hartling: Autor 2009, p.300s. (referring to Lutz´s manual postprocessing on the prints); Herrmann: Programmierung 2004, p.155,161s.; Moles: Art 1971, p.167; Stürner: Poesie 2003, p.18-21.
Re-engineering: Auer, Johannes: free lutz. Municipal Gallery Wroclaw/Poland 2005. In: URL: http://copernicus.netzliteratur.net/index1.html (11/14/2011). back

9 Max Bense on "artificial art" ("Künstliche Kunst"): Bense: Aesthetica 1982, p.337s.: "In all, as it is possible to formulate it, differ the `artificial´ and the `natural´ production category in introducing a scheme mediating between creator and work, as it is constituted by the program and the programming language, and this leads to a division of labor which is unfamiliar in the aesthetic process." Cf. Nees: Computergraphik 1969/2006, p.XIII. back

10 "Aesthetic" and "semantic information": Bense: Aesthetica 1982, p.224,282,327; Moles:Théorie 1958, p.133-139; Moles: Art 1971, p.34-37. back

11 Bense: Begriff 1963/2000, p.151: "It makes no difference for the statistic information theory if a sequence of signs is true or false. Only its statistic innovation, novelty, information is relevant. But the semantic information theory takes into consideration if a statement is true or false." back

12 Carnap/Bar-Hillel: Outline 1953. back

13 Bense: Begriff 1963/2000, p.152. Cf. Bense: Aesthetica 1982, p.304 (part IV, first published in 1960). back

14 Bense: Aesthetica 1982, p.303 ((part IV, first published in 1960). back

15 Funkhouser: Poetry 2007, p.38ss. with ann.9 (p.279): "The programming details are not available." back

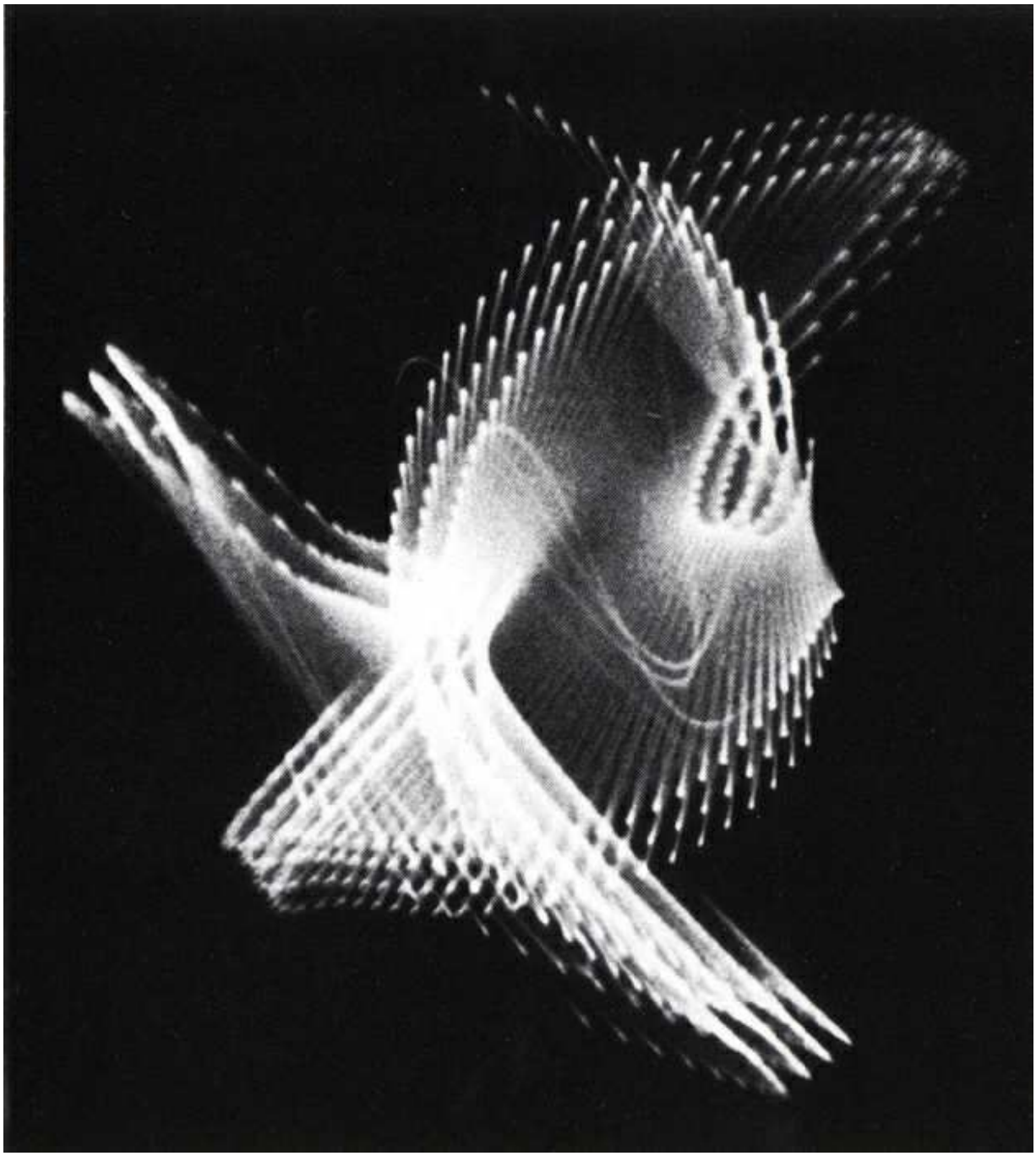
16 Balestrini: Tape Mark I 1962/2012; Balestrini: Tape Mark I 1968. Funkhouser: Poetry 2007, p.12,41s. with ann.13 (p.280) on the uncertainty about the software being used (Autocoder, FORTRAN or RPG). Balestrini: Tape Mark I 1962/2012 refers on page 268 to "punched cards in Autocoder language" and names Dr. Alberto Nobis as programmer. back

17 Programmed in FORTRAN (main program) and FAP (sub program). In: Bense: Aesthetica 1982, p.111s.; Bense: Einführung 1969, p.111s.; Bülow: Sinn 2007, p.156-162; Funkhouser: Poetry 2007, S.37f.; Herzogenrath/Nierhoff-Wielk: Machina 2007, p.107,466s.; Moles: Kunst 1973, p.176; Stürner: Poesie 2003, p.22s. back

III. Information Aesthetics
III.2 Computer Graphics

III.2.1 Analog Graphics

The early use of mainframe computers to generate texts (see chap.III.1) provides us with one prehistory of computer graphics (see chap. III.2.2). The other prehistory contains artistic uses of cathode ray oscillographs being applied as control display in electrical engineering and as output medium of analogue computers.

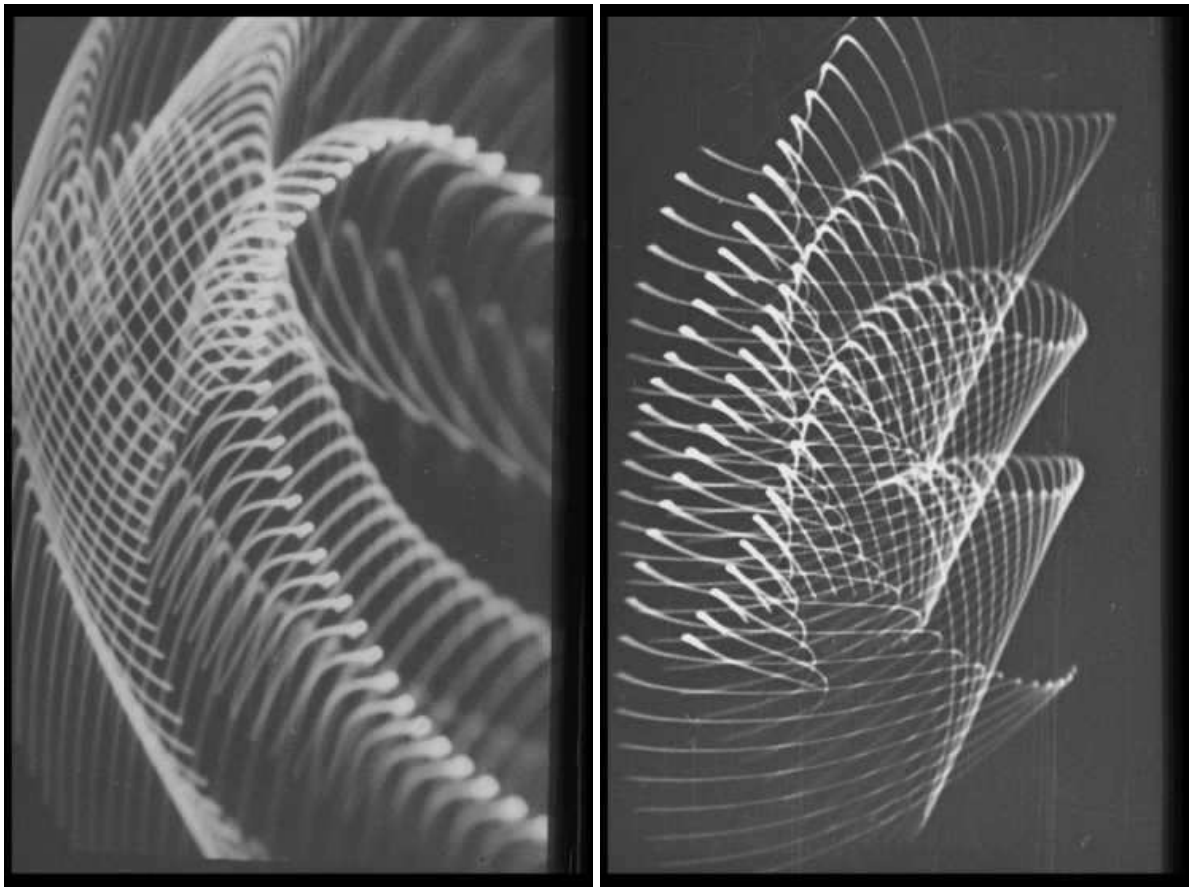


Laposky, Benjamin Francis: Oscillon Number Four, 1950, photo of an oscillograph´s

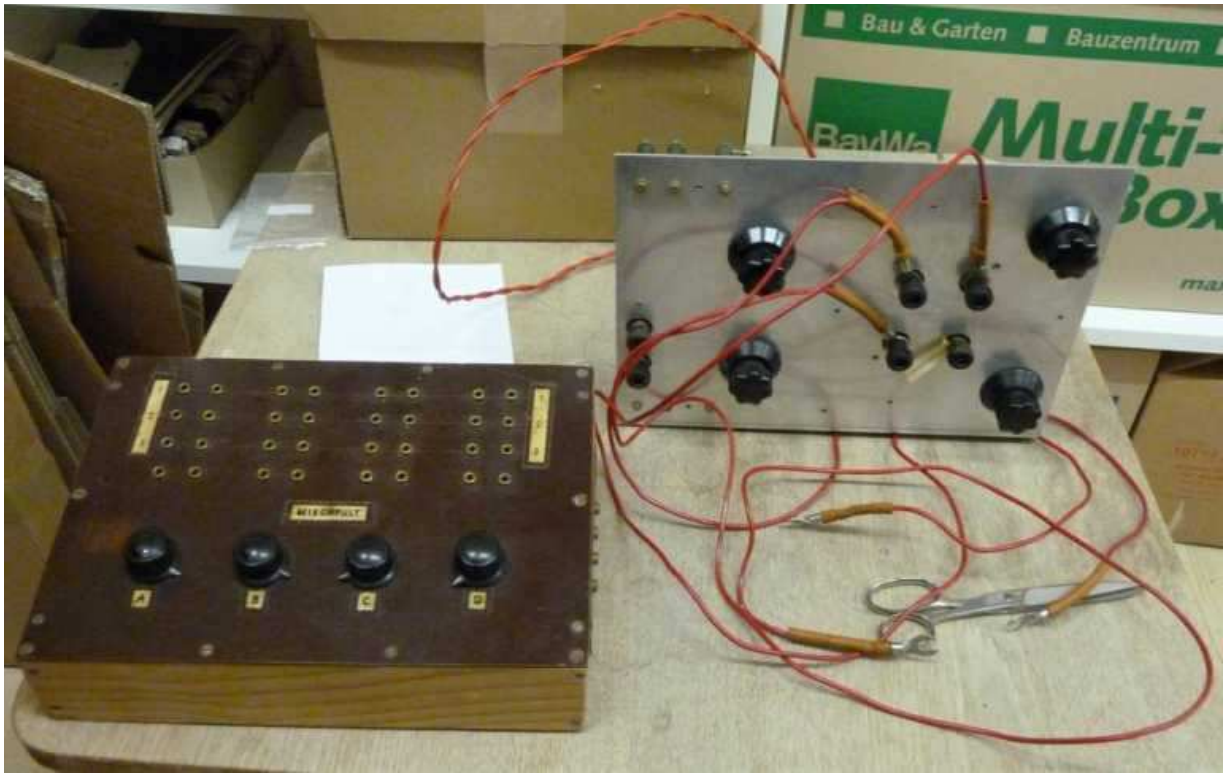
screen.

Since 1950 Benjamin Francis Laposky photographed the screen of his modified oscillograph combined, among others, with a sinus wave generator. The elimited amount of the oscillograph´s wave forms was expanded by Laposky adding "other electrical and electronic circuits...to create the almost infinite variety of forms." Laposky drew a connection between his "electronic abstractions" 1 and computer art:

> The relationship of the oscillons to computer art is that the basic waveforms are analogue curves of the type used in analogue computer systems. 2



Franke, Herbert W.: Oscillograms, 1956, photos of an oscillograph´s screen.

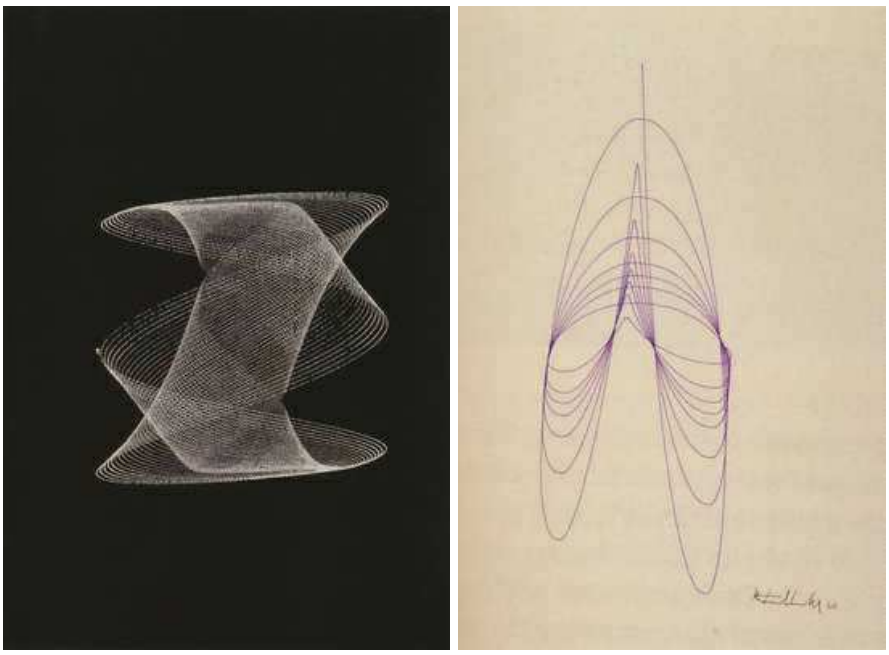


Franke, Herbert W./Raimann, Franz: Analog devices to be connected with an oscilloscope. Photographed in 8/13/2014 in Puppling nearby Egling/Bavaria. Photo: Thomas Dreher.

In 1955/56 Herbert W. Franke produced "pendulum oscillograms" ("Pendeloszillogramme") in moving a Contaflex mirror reflex camera before the screen of an oscillograph presenting curves. For the production of these curves Franz Raimann constructed "an analogue calculation system" for Franke "...being capable to mark out the elementary curves...It was possible to adjust different kinds of overlay [of complicated curves] in real time on a mixing console." 3 With the mixing console modifications of the electron beam´s motion along the horizontal and vertical axes were possible. In oscillosgraphs a horizontal base line motion is usually deviated vertically. Raimann´s analog calculation system offered possibilities to control movements along the horizontal and vertical axis depending on the time dimension.

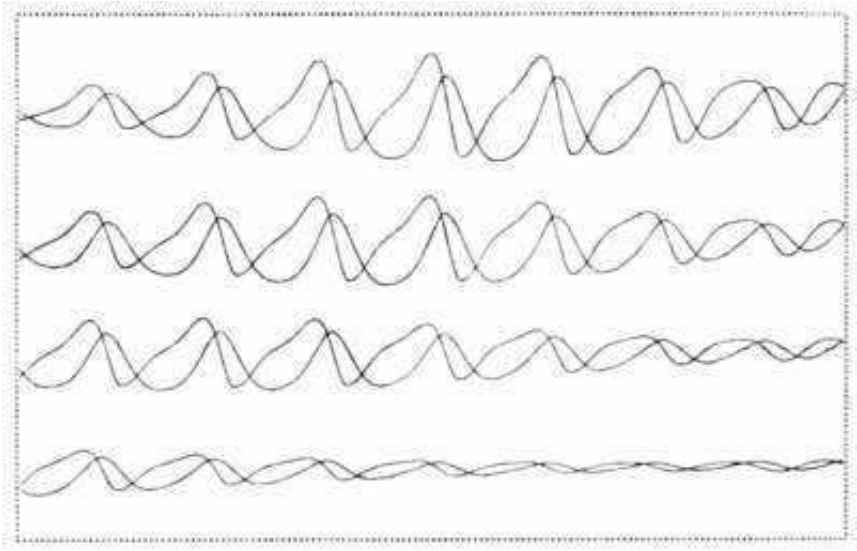
Franke utilises a calculator constructed for his purposes similar to Schöffer who integrated into "CYSP I" (1956, see chap. II.3.1.2) a little computer built for him by Philips before the production of minicomputers started in the sixties. As Schöffer installed a small computer custom-made by Philips in "CYSP I" (1956, see chap. II.3.1.2) before the minicomputers became available in the sixties, so Franke used a small computer custom-made for his needs. This computer was connected with an oscillograph "producing only thick drawn lines on a screen with a diameter of only 5 centimeters. To be able to receive viable images at all, I experimented with different procedures, but I obtained the best results when I moved the camera with open aperture in a darkened room... before the screen. To obtain a regular movement I mounted the camera at a cord like a pendulum in my first trials but the I finally gained the best results when I moved the camera in my hands continuously – so I trained myself and learned to coordinate the adequate movements. The images show the overlaps of curves as a grid-like structure, often with spatial visual effects." 4 The curves being produced in real time on the oscillograph´s screen were documented by Franke not simply as photographic reproductions, but he obtained structures with visual depth effects in moving the camera with an open aperture. The restrictions for the organization of forms caused by the "thick drawin lines", as they were presented on his oscilloscope´s screen, were transgressed by

the artist in moving the camera at varying distances from the screen: Closely following lines and superimpositions became possible.



Fuchshuber, Roland K.: Left: Rocker, 1960, plotter drawing.
Right: Polstelle, 1960, plotter drawing.

In 1960 Roland K. Fuchshuber became a member of the founding commission of the Centre Européen de Traitement de l´Information Scientifique (CETIS). At Euratom (European Atomic Energy Community) in Brussels and Ispra (Italy) Fuchshuber started to produce graphics with PACE analogue computers constructed by Electronic Associates Incorporated (EAI). The "distortion factor of an amplifier" influenced the course of parallel curved lines documented as plotter drawings. 5



Alsleben, Kurd/Passow, Cord: Computergrafik 4, 1960,
plotter drawing (Alsleben: Redundanz 1962, p.52, ill.d).

In 1960/61 the artist Kurd Alsleben and the pyhsicist Cord Passow used an analogue computer (EAI 231 R) of the Deutsche Elektronen Synchotron (DESY) in Hamburg to produce waves printed in horizontal rows above each other as well as overlapping. Five computer graphics produced as plotter drawings document results of computing processes. One of these prints presents four horizontal rows. Each row is constituted by

two overlapping wave lines. "Parameter shifts" determining the course of the wave lines were produced by potentiometers. 6

III.2.2 Digital Computer Graphics

An analogue computer offered patchboards and potentiometers for manipulations of the computing processes in real time, in contrast to the digital mainframe computers used by Béla Julesz, A. Michael Noll (since 1962), Frieder Nake (since 1963) and Georg Nees (since 1964) allowing only to control the results printed by plotters after the computing processes worked out the instructions (that had to be installed via punchcards or magnetic storage units). FORTRAN or ALGOL, the higher programming languages for compilers, are used for the coding of instructions. Compilers translate programming languages into machine language. Since a few years before the artists mentioned above started to work with digital mainframe computers the first compilers simplified the programming. 7 Before the integration of compilers programming was only possible in machine languages.

In the sixties A. Michael Noll, Georg Nees and Frieder Nake created pioneer works of computer graphics. Their procedures are based on the early computer literature presented in chapter III.1, especially on the works of Christopher Strachey (see chap. III.1.2) and Theo Lutz (see chap. III.1.3):

- *a*. the selection of a few elements to be stored in a database,
- *b*. a syntax to combine the elements,
- *c*. a random generator,
- *d*. a determination of the frequency defining how often the program can select the elements.

If visual elements are used as basic elements instead of textual signs then the artistic production is transformed to the creation of structures that shouldn´t be neither too simple nor too complex for the visual perception of the whole field as well as for the relations between single elements, as information aesthetics articulated the goal of artistic creation by defining the best relation between order and information for an aesthetic experience. In computer graphics the following modifications of the procedures developed in computer literature can be found:

- *ad a*. The word database is substituted by elements – mostly lines – constructed by the computing processes executing the instructions of the program (f.e. lines connecting points).
- *ad b*. The position and the length of basic elements vary with the combinatory manner replacing the textual structure of left to right relations (from word to word) and up-down differentiations (from line to line) by an organisation of the whole plane. The structure of text lines is substituted by a visual arrangement in zones within which the program starts again.
- *ad c*. Because the random generator has its effects not only in the selection of elements but in the modification of the combinatory method from zone to zone, the spectrum of variations determines the overall view.
- *ad d*. The limitation of the selection frequency concerns not only the selection of elements but the combinatory method, too, with consequences for the visual effect of the work in its totality, not only for some sentences within an ensemble of

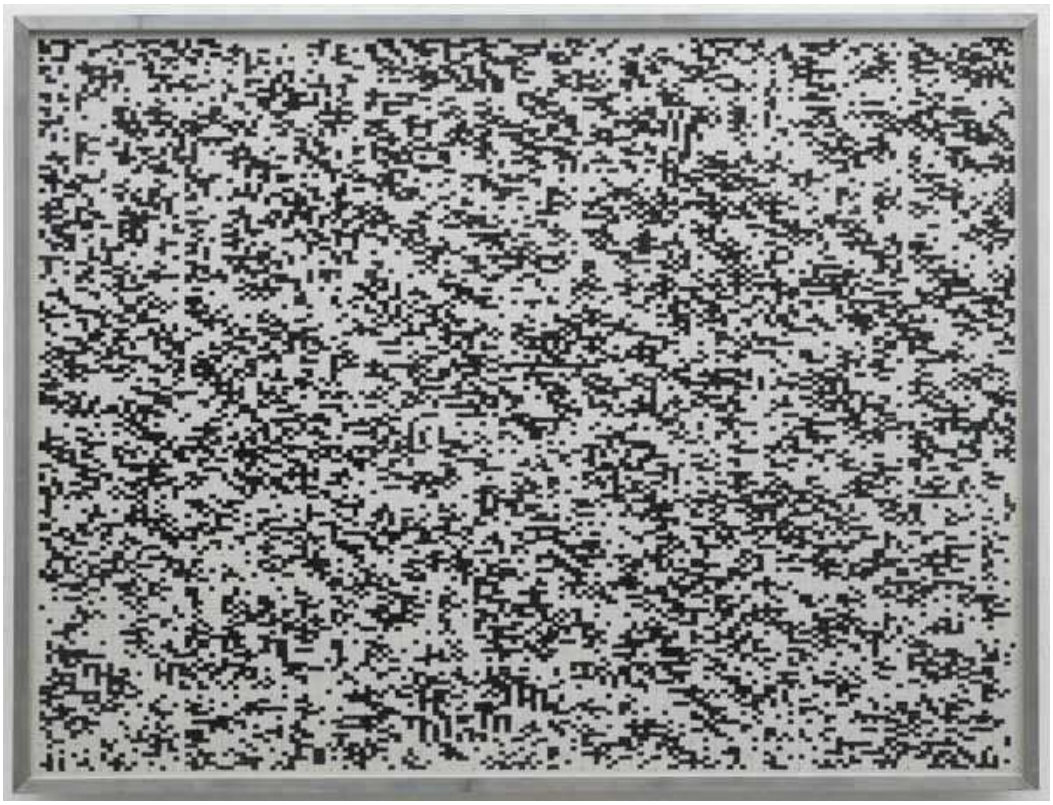
sentences. The readability of sentences and/or lines of a text is substituted by the relations between the programmed structure of the plane and the optical effect of the overall view. 8

Before early examples of digital computer graphics fulfilling the criteria mentioned above will be explained a short ouline of the goals of information aesthetics is presented because they influenced especially Georg Nees and Frieder Nake.

A core subject of information aesthetics are the relations between the structure of a program and the visual perception of its presentation. Max Bense and Abraham Moles define the "aesthetic measure" by exploring the best possible relation between the "complexity" of the visual "information" and the "orderliness" ("redundancy") that can be recognized in the process of perceiving the work: Bense determines the aesthetic measure in using George David Birkhoff´s definition as `order divided by complexity´ ("Birkhoff´s quotient"). 9 In contrary Moles refers to empirical investigations in his argument for the `multiplication order by complexity´. 10

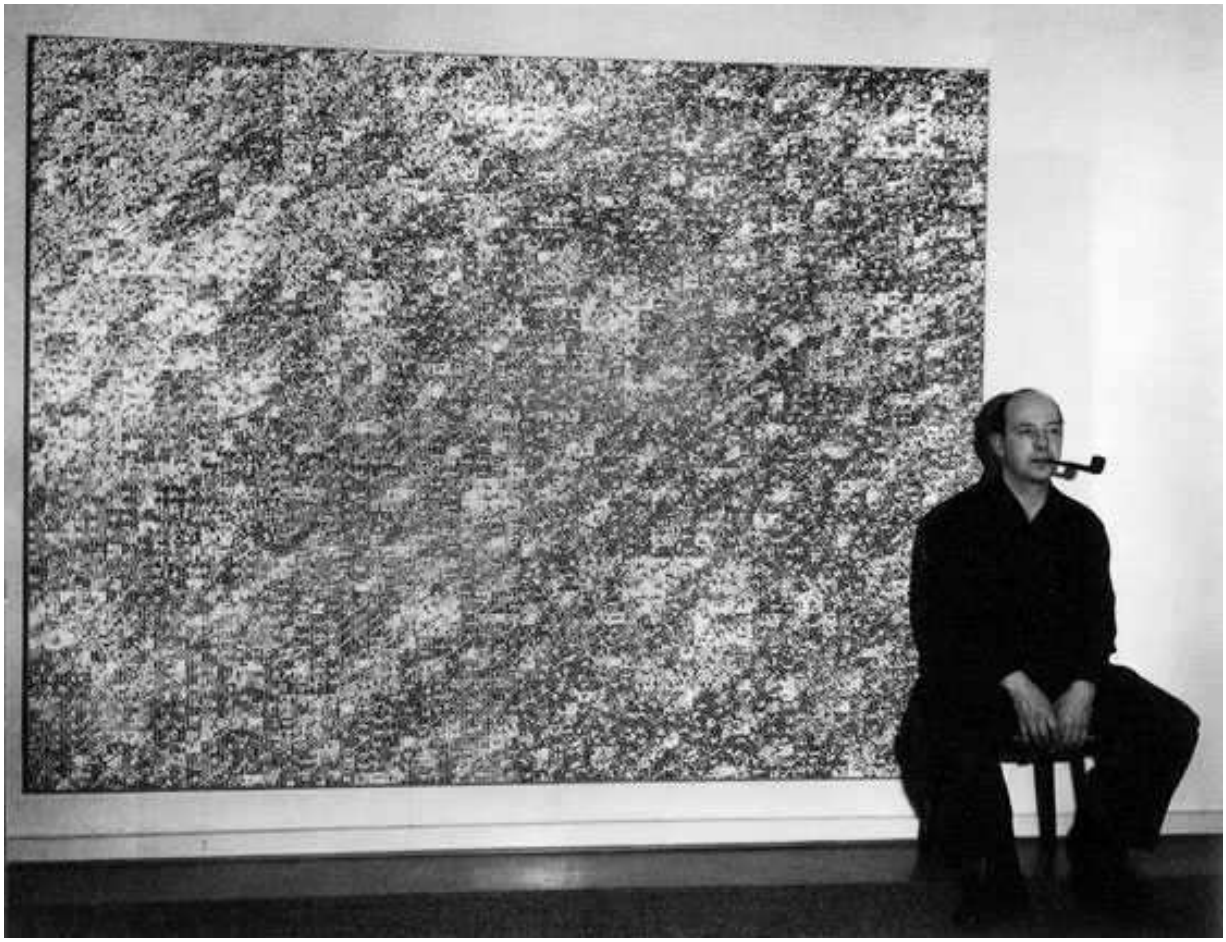
Shannon´s "statistic information" provides the basis for this numerical definition of the "aesthetic measure". 11 It presupposes precise knowledge of the number of used elements ("sign repertoire") and the possibilities to combine them. 12 That´s why concrete-serial and programmed art offer model cases for information aesthetics.

Following Bense in art improbable orders are realised by the "elimination of the avoidable" and the "reduction of redundancy". 13 Meanwhile Bense discusses characteristics of art works, Moles thematises their perception. In Moles´ reflections the receiver´s "limit of apperception" and its dependency on the observer´s previous knowledge are dominant subjects. If the visual complexity is above the "limit of apperception" then there is no order recognizable. That´s why this limit should not be transgressed. 14 Thus, a certain amount of redundancy is inevitable. Contrary to John Cage´s non-normative aesthetics of simultaneous chance operations 15 the information theory explicates an objectifiable aesthetic goal: For aesthetic factors it defines the best relation between information and redundancy.



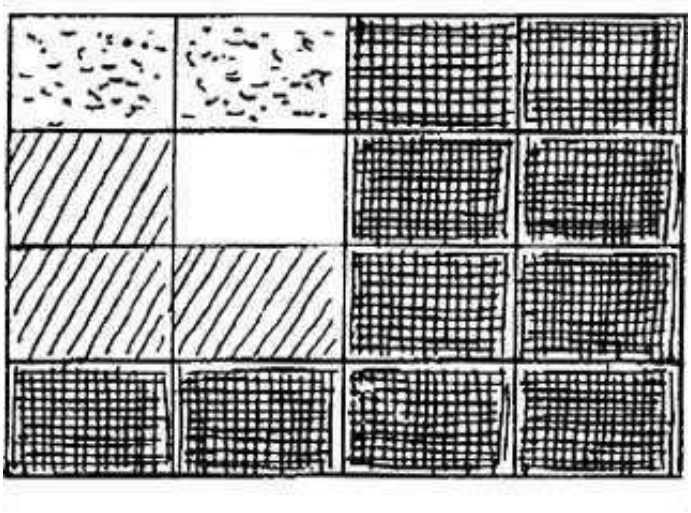
Götz, Karl Otto: Statistic-metric Trial 4:2:2:1, concept Summer 1959, realisation with pencil and felt pen on cardboard 1960. Photo: Kukulies. Collection Etzold. Städtisches Museum Abteiberg. Mönchengladbach (Kersting: Sammlung Etzold 1986, p.206).

In the fifties Karl Otto Götz became known as an informal painter and as a member of the artists´ group Quadriga. From 1959 to 1961 Goetz experimented in "statistic-metric modulations" with grids filled with black and white rectangles. These "modulations" were still carried out manually.



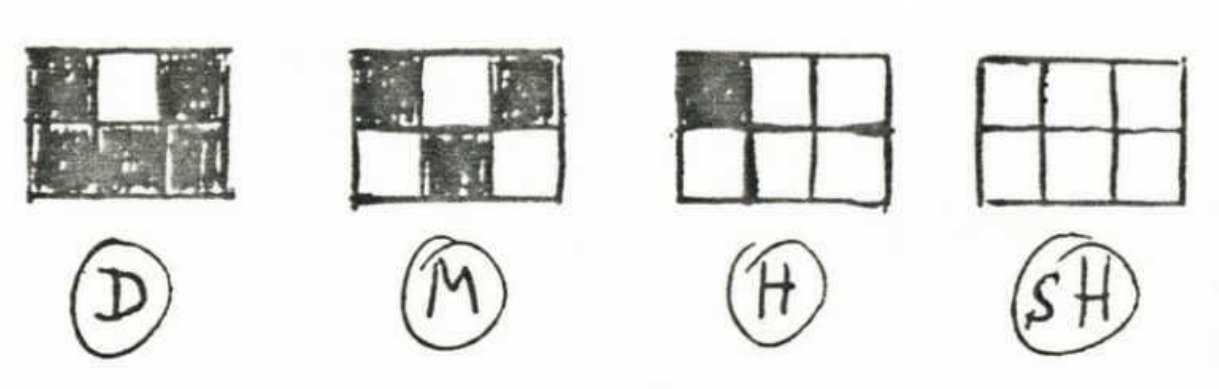
Karl Otto Götz before Density 10:3:2:1, 1961, felt pen and tusche on Bristol cardboards, mounted on canvas (Götz: Erinnerungen 1983, p.900, ill.1016).

In "Density 10:3:2:1" (1961) Götz divides the "image area (200 x 260 cm)" in "16 super zones" and subdivides them in "16 big zones" of equal size. He determines the frequency of the black rectangles (in relation to the "2 brightness degrees" black and white) in the four "density degrees" indicated by the title. The basic unit is a grid with four by four rectangles (16 big zones", each with 16 "little zones"). One of these 16 rectangles is white (density degree "very bright") and 10 rectangles are black (density degree "dark"). In relation to the density degrees between black and white rectangles are 2 rectangles brighter ("lower density") and 3 rectangles darker ("middle density"). The title "Density 10:3:2:1" designates 10 times the density degree "dark", 3 times "middle density", two times "lower density" and one times the density degree "very bright".



Götz, Karl Otto: Density 10:3:2:1, sketch, 1961, division of the image´s surface in super zones with four density degrees (Götz: Malerei 1961, p.14).

Götz visualises the realisation of the four density degrees with a grid of 2 by 3 squares: From these six squares with increasing density no field ("very bright"), one field ("low density"), three ("middle density") and five fields ("dark") are filled with black colour. The brighter or darker appearances of the grids are a result of a number of black or white elements being distributed randomly: "statistic relations between quantities".



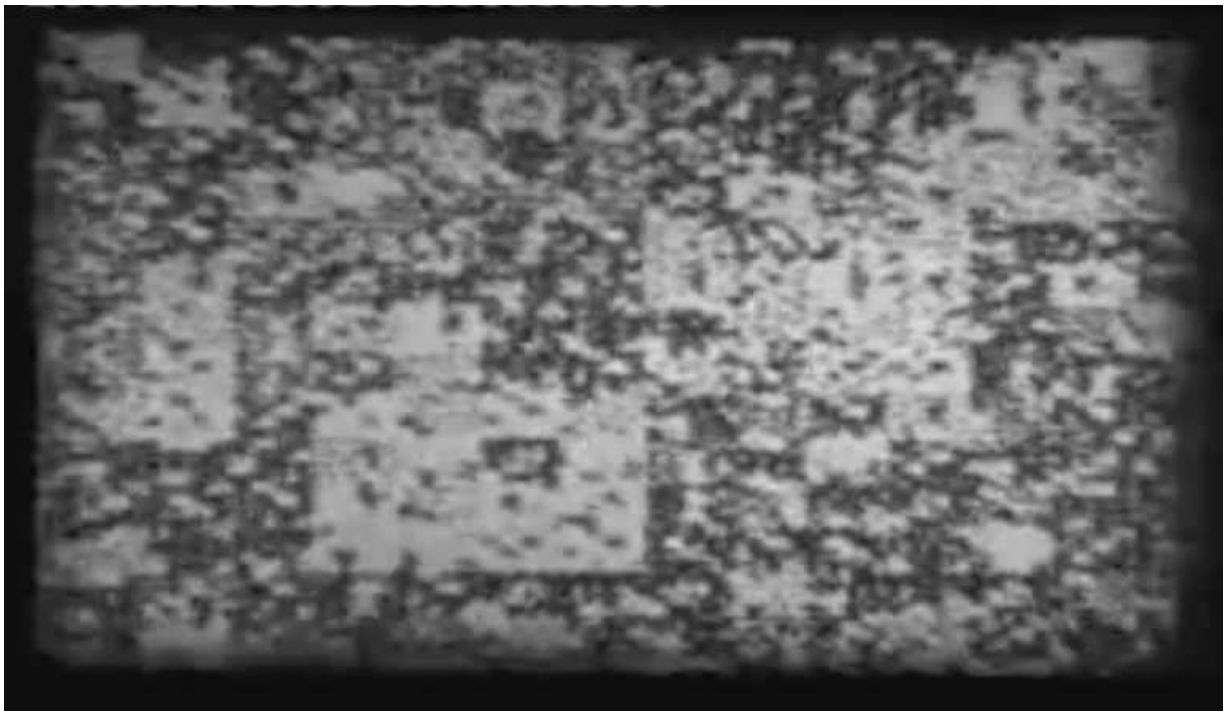
Götz, Karl Otto: Density 10:3:2:1, sketch, 1961, little zones with four denstiy degrees: D = dark, M = middle density, H = low density, sH = very bright (Götz: Malerei 1961, p.23).

The 16 x 16 (=256) big zones distributed on 16 super zones constitute a plane provoking the eye to slide between the zones with different amounts of black and white elements, and to look for visual cues at prominent, particularly dense black or white fields. The partition in "big zones" is recognizable at horizontal and vertical break lines between zones with dominant black squares on one side and dominant white squares on the other side.

Students work out at home their area on "pre-rasterised drawing cardboards" with felt pen and tusche. Then the grid image was "put together by mounting the cardboards" prepared in labor division "on canvas". The realised "ca. 400.000 image points (elements)" constitute a "model image" that could be realised as an "electronic television image". The two "brightness degrees" of Götz´s "model images" could be substituted by the "ca. 40 brightness degrees" of the television image with "450.000 image points".

In 1960 Götz tried to persuade Siemens to realise his "grid images" but failed. In 1962 the film "Density 10:2:2:1" (8 mm) was produced by combining photographed

permutations of parts of the "grid image" as shots. Intertitles indicate which grid elements – "basic units in little zones", "little zones", "big zones" – have been replaced from shot to shot. Götz photographed these permutations. The photographs constitute the shots of the film. The sequences of shots presenting the raster permutations are brought into motion by the projection of the film and provoke the impression of a flickering image. The permutations proceed from the smallest "units" to the "big zones", and the changes become recognisable in the course of seeing longer phases of the nearly three minutes lasting film.

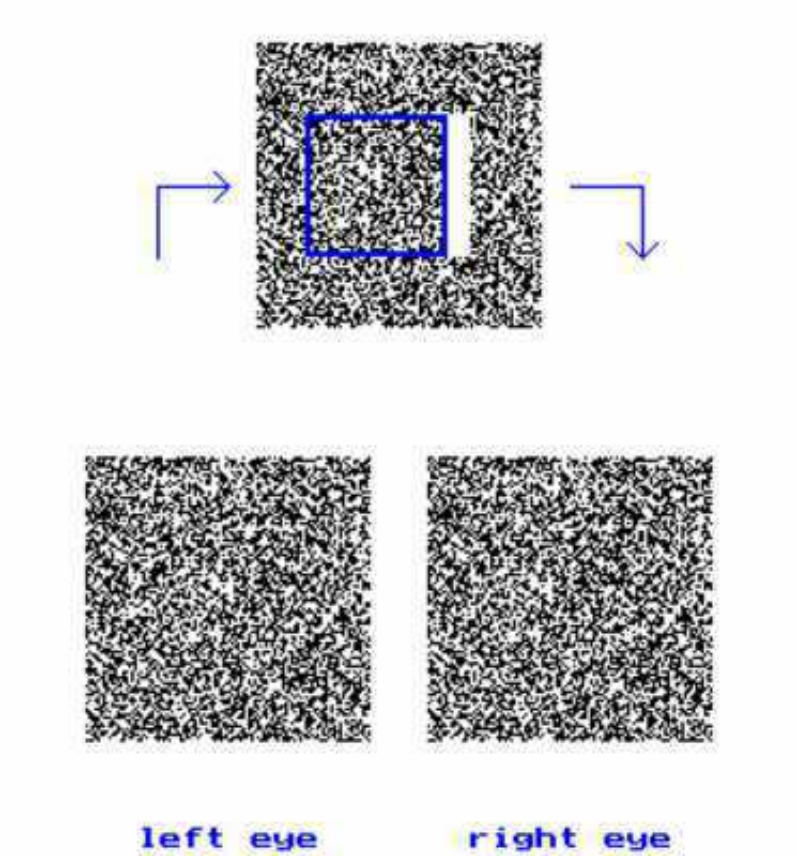


Götz, Karl Otto: Density 10:2:2:1, 1962, film (8 mm) in Vimeo, Screenshot (Claus: Zeitalter 2008).

Götz calculated the "information content" ("Informationsgehalt") of his images. Concerning the observers´ problems to recognize order in the connections between the rectangles of the "statistic-metric modulation" it is no surprise that a high "total information content" ("Gesamtinformationsgehalt") and few "redundancy" have been the result of his calculations. Götz pursued "information theoretical observation" and investigations of "gestalt psychological values" as separate fields of study. 16

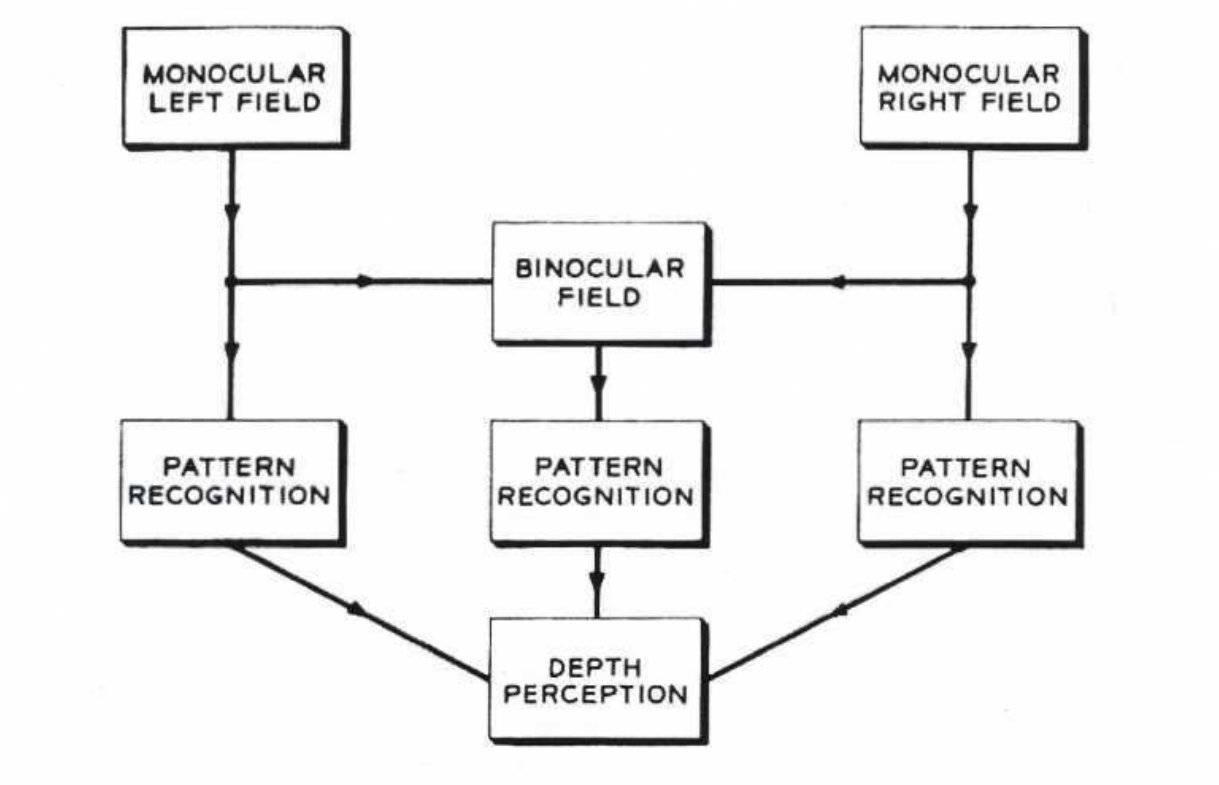
Götz anticipates algorithms of digital computer graphics in a still manual realisation: The reduction of the realisation process to a few elements, the combination rules and the selection possibilities limited by rules based on criteria of frequency are aspects of information aesthetics that recur in later computer graphics.

In 1956 the electronics engineer Béla Julesz obtained a doctorate from the Hungarian Academy of Sciences. After the army of Soviet Union invaded Hungary, Julesz emigrated to the U.S.A. Several weeks after his arrival the Bell Laboratories in Murray Hill/New Jersey affiliated Julesz to their technical research team. 17



Julesz, Béla: Stereopsis, 1959, plotter drawing.

In 1960 Julesz published his investigations of the "Binocular Depth Perception of Computer-Generated Patterns" in "The Bell System Technical Journal". This issue of the "Technical Journal" contained glasses to observe the random dot stereograms illustrating Julesz´s contribution: These glasses anticipate LCD shutter glasses. 18 Pro stereogram a mainframe computer IBM 704 (1954-60) calculated images with 10.000 points. A pseudo-random generator distributed 16 brightness degrees. 19 The rectangles, printed and published beside each other, had the same random distribution of points except specific divergences in their middle zones: Within each of the rectangles an identical square field was displaced to the left and to the right ("parallax shift"). The deviations concern a displaced square zone and its environments. 20 This "parallax shift" provoked in the binocular perception with glasses a three-dimensional effect, nevertheless no features of the images suggest a resolution by visual patterns for three-dimensional objects.



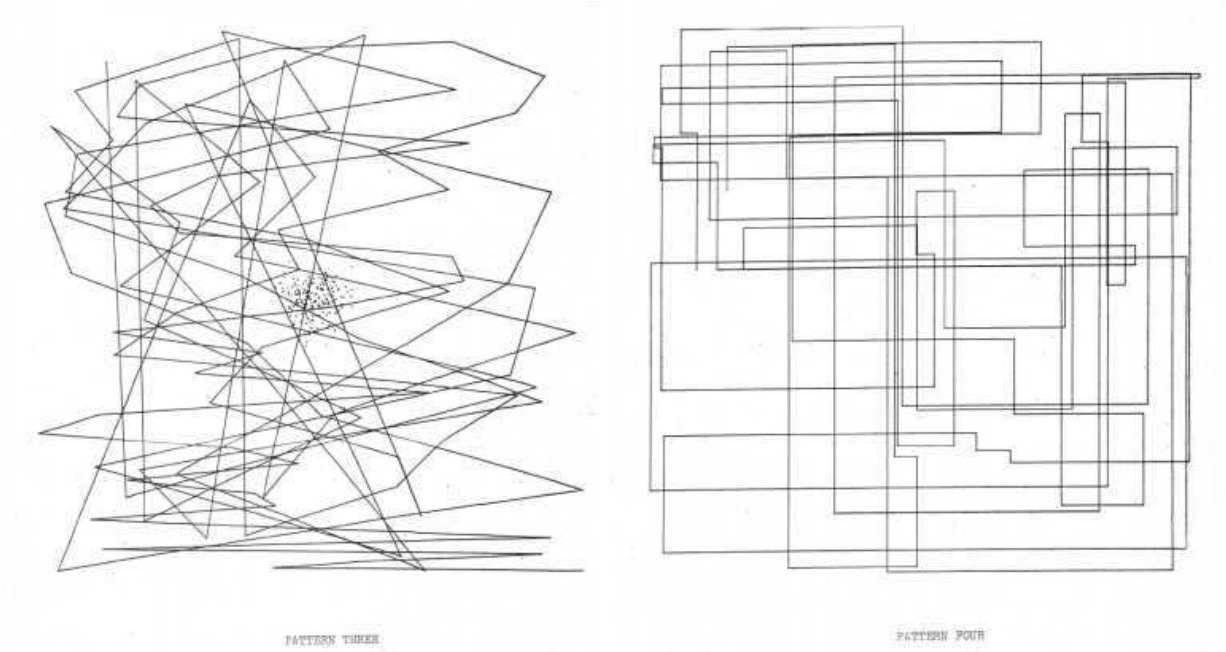
Julesz, Béla: Depth perception by monocular and binocular pattern recognition, 1960 (Julesz: Depth Perception 1960, p.1128, fig.3).

Julesz identifies a genuine "binocular pattern recognition" without presupposing a "monocultural pattern recognition": The binocular pattern recognition follows its own rules. 21 Depth perception can arise not only on the basis of "binocular pattern recognition" but as a "combination of binocular and monocular pattern recognition", too: "Monocular macropattern recognition" intensifies the depth effect. 22 Julesz´ investigations of the "cyclopic perception" demonstrate that the depth perception combines visual patterns recognizable with one eye and binocular visual patterns. Julesz ´s investigations had consequences for the perceptual psychology, the cognition research and the development of autostereograms with only one image. 23 In 1965 Julesz´s perceptual experiments were exhibited together with A. Michael Noll´s computer graphics in the Howard Wise Gallery in New York. 24

In 1961 A. Michael Noll completed his studies at the Newark College of Engineering with the B.S.E.E. (Bachelor of Science in Electrical Engineering). From 1961 to 1971 he worked in a department for telephone transmissions at the Bell Laboratories (Murray Hill/New Jersey). 25

In Summer 1962 Noll programmed "Patterns" in FORTRAN and produced them with an IBM 7090 (since 1959) of the Bell Labs. Noll didn´t want that they may be understood as "`true art´". 26 A Stromberg Carlson 4020 Microfilm-Plotter presented the results of the computing processes on a cathode ray tube as configurations of electrons. The computing processes lead to the production of images on the screen via a "Decoder and Command Generator". Noll´s FORTRAN code included instructions for the microfilm plotter to start further "subroutines". The resulting image on the screen was photographed and the 35mm negative was "multiplied by photo printing in different sizes." 27

The computer was instructed to produce lines as connections between points located by a "White Noise Generator". A combination of lines in different length constituted a jagged line.



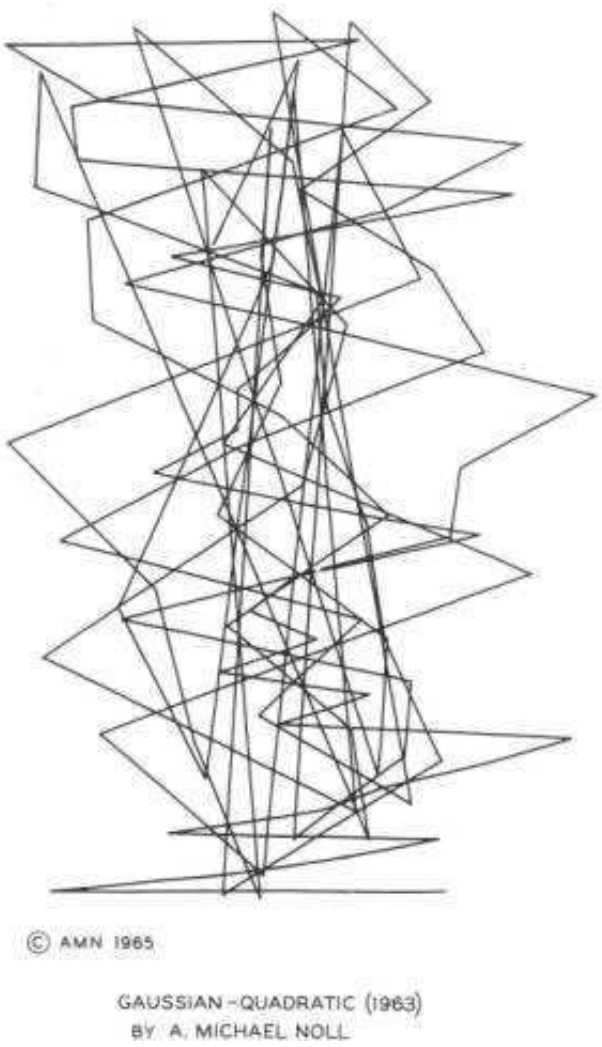
Noll, A. Michael: Left: Pattern Three, 1962, photo print.
Right: Pattern Four, 1962, photo print (Noll: Patterns 1962, unpaginated).

Noll programmed the point clouds on the jagged lines in "Pattern One", "Two" and "Three" around a central point. In "Pattern Four" and "Pattern Five" points with values calculated by random procedures for x- and y-axes served for the localisation of lines: These points are "alternately repeated to make the lines horizontal und vertical." The line connecting all points changes its direction exclusively at right angles. In "Pattern Four" are both ends of the line recognizable within fields marked by this line. 28

In "Gaussian Quadratic" (1962/63) Noll distributes 100 points on the horizontal and vertical axis following different criteria: The localisation in the horizontal axis follows the Normal- or Gaussian distribution, meanwhile the vertical localisation is calculated based on an equation:

> The vertical position increase quadratically, i.e., the first point has a vertical position from the bottom of the picture given by $1^2 + 5x1$, the second point $2^2 + 5x2$, the third point $3^2 + 5x3$, etc. 29

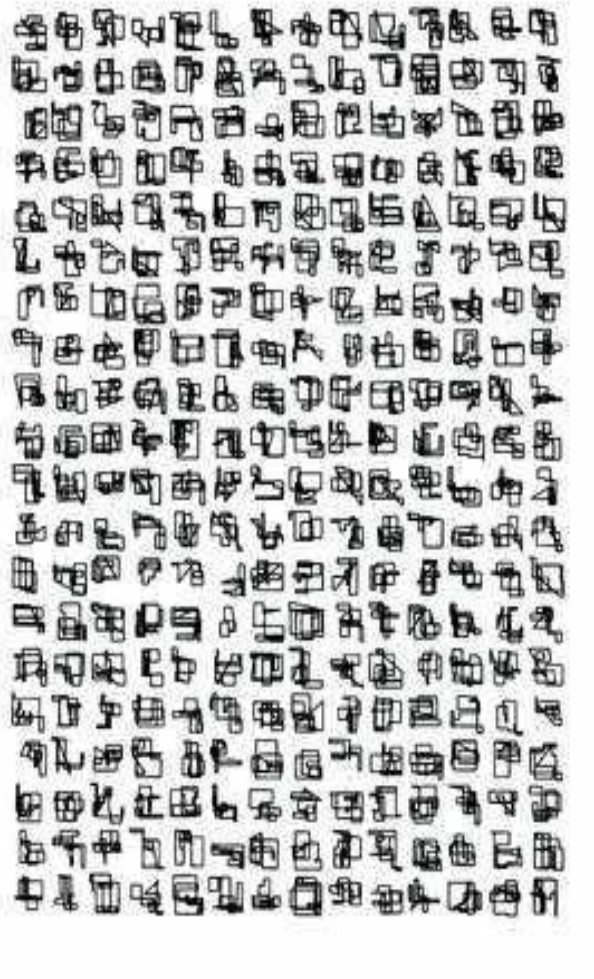
To avoid points located outside the determined size of the work´s area the distribution on the vertical axe at the top edge of the frame was mirrored at the bottom. The Gaussian distribution on the horizontal axis follows the standard normal distribution. The connections of the points constitute 99 lines crossing each other several times in a vertical midfield. These lines form a jagged line with accidental direction changes and some remarkable deflections on the horizontal axis. The jagged line appears as a vertical formation that balances on the lowest horizontal line serving as a base.



Noll, A. Michael: Gaussian Quadratic, 1962/63, photo print.

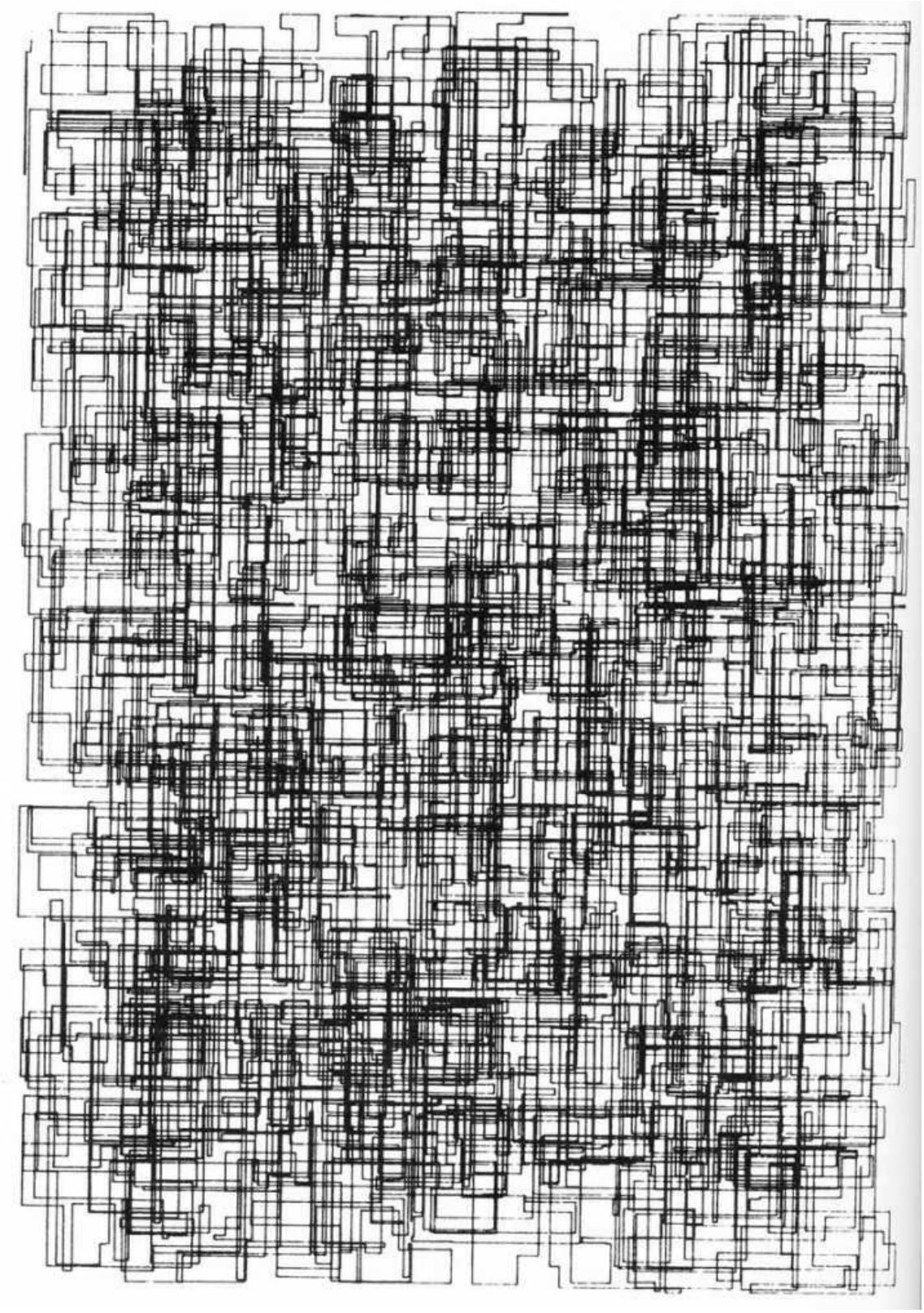
In "Gaussian Quadratic" Noll follows the strategy of a line´s accidental direction changes that he used in many other of his "Patterns", too. He expands the algorithmic criteria in "Gaussian Quadratic" in a way that the relations between order and chance in its configuration of lines provoke a perception searching for the "aesthetic measure" more than the "Patterns". 30

The "patterns" realised by Noll in 1962 are designated by Frieder Nake as "polygon moves" ("Polygonzüge"). 31 In December 1964 "polygon moves" programmed by Georg Nees were published in issue 3/4 of the "Grundlagenstudien aus Kybernetik und Geisteswissenschaft" ("Basic Studies in Cybernetics and Humanities"). 32 The instructions written in ALGOL ran on a mainframe computer Siemens 2002 (1959-66). A Zuse Z64 Graphomat printed the results.



Nees, Georg: 23-Ecke, 1964, plotter drawing
(Nees: Grundlagenstudien 1964, p.124, ill. 2).

The polygon moves occur several times next to each other and one below the other. The algorithm starts anew in fields respectively "matrices" 33 and determines via random generator the distribution of consecutive lines. The number of lines is defined by the program.



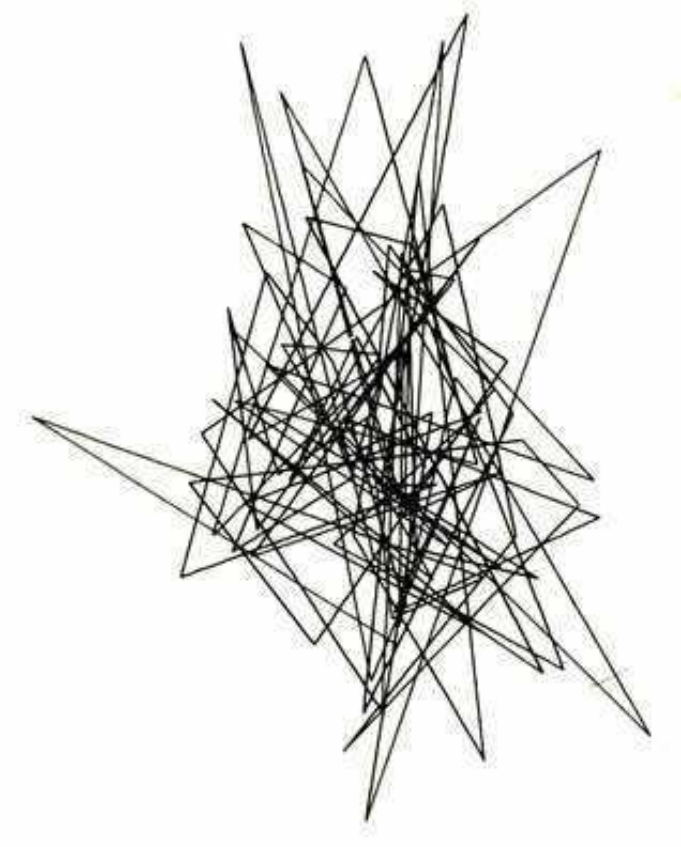
Nees, Georg: Untitled (Micro Innovation), 1967, plotter drawing (Nees: Computergraphik 2006, p.222, ill. 31).

In a series of computer graphics realised between 1965 and 1968 Nees defines how far the "polygon moves" can transgress the fields within which the program restarts the configuration of lines. 34 Because the distances between the "matrices" are short the transgressing polygon moves interpenetrate each other. At a quick glance they appear as a complex snarl of lines. 35 The structure of a snarl with lines crossing each other tilted and rectangular can be recognised only by a closer examination at a short distance, in a reconstruction of the relations between the line configurations. In a total view zones of denser superimpositions and dominating directions of lines across several zones attract

the attention.

In Nees´ works the observation of relations oscillates from work to work in different manners between a complexity by plurality (via the division in "matrices" and the superimpositions of line configurations) and a simplicity provoked by the structuring process of the perception for the whole field. 36 The graphics of Georg Nees can be seen as models for an investigation of the problem how "order and complexity" 37 can be mediated to obtain a better "aesthetic measure".

Looking for similarities and repetitions to simplify the formation of visual schemata – in terms of information theory: to enable the recognition of order via redundancy (as a return of the same) – observers refocus a print´s surface several times. Nees calls this process a "gradation of the type heap-variation-gestalt" ("Gradation vom Typus Haufen–Variation–Gestalt"). 38 The "micro-aesthetics" of the produced object – determined by the "creation of texture by overlapping" 39 – and the "macro-aesthetics" – as a cognitive restructuring by the use of schemata in the process of seeing – constitute inter-related levels: "Gestalts are aesthetic information units with a local and distal nexus." ("Gestalten sind ästhetische Informationseinheiten mit Lokal- und Distalnexus.") 40



Nake, Frieder: Random Polygon Move, 1963, plotter drawing, 10 x 10 cm (Nake: Ästhetik 1974, p.19, ill.5.2-7)/1964, plotter drawing, 15,5 x 11,5 cm (Herzogenrath/Nierhoff-Wielk: Machina 2007, p.424, nr.259).

Since 1963/64 Frieder Nake developed the translation program Compart ER 56 in the machine language to control via the mainframe computer Standard Electric Lorenz (SEL) ER 65 (since 1959) the drawing board Zuse Z64 Graphomat bought by the Computer Centre Stuttgart shortly before. In 1963 Nake used his program to create "random polygon moves" with lines connecting points located by a "pseudo random generator". Nake realised his works after Noll´s "polygon moves" and evidently before Nees´ works with such combinations of lines. 41

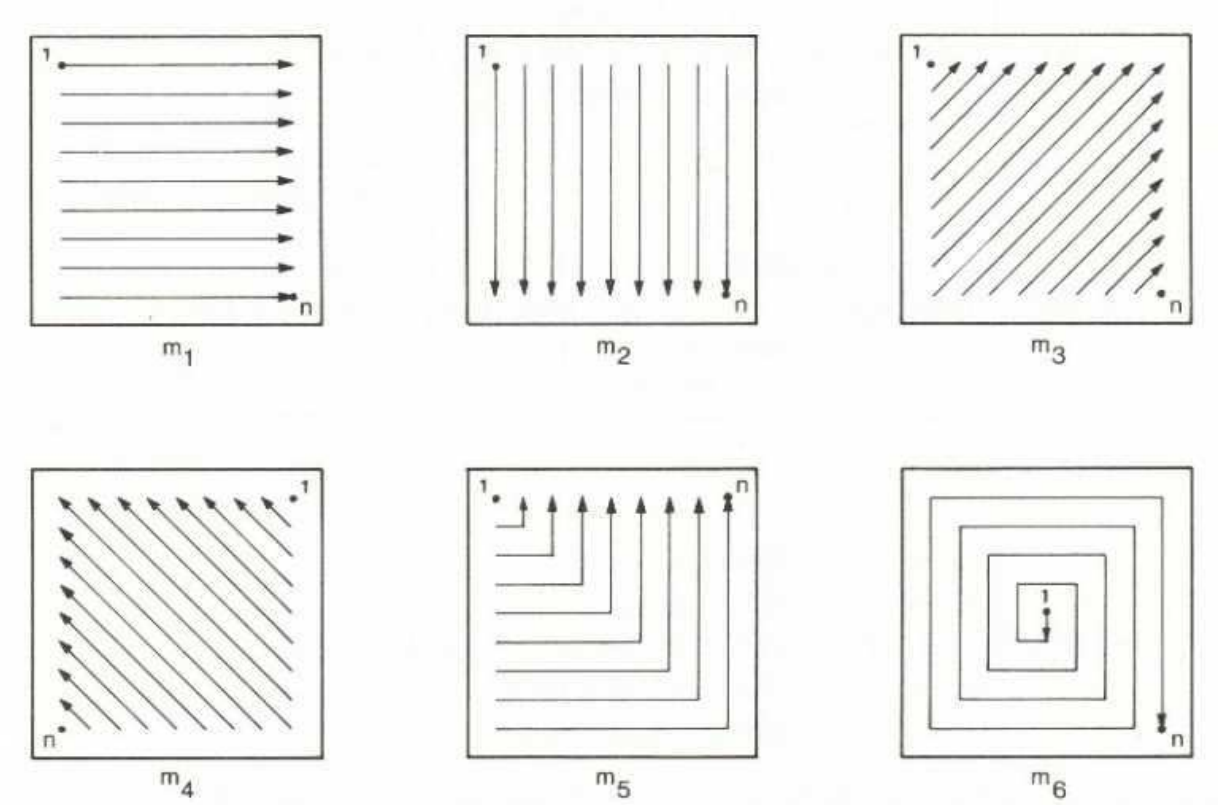
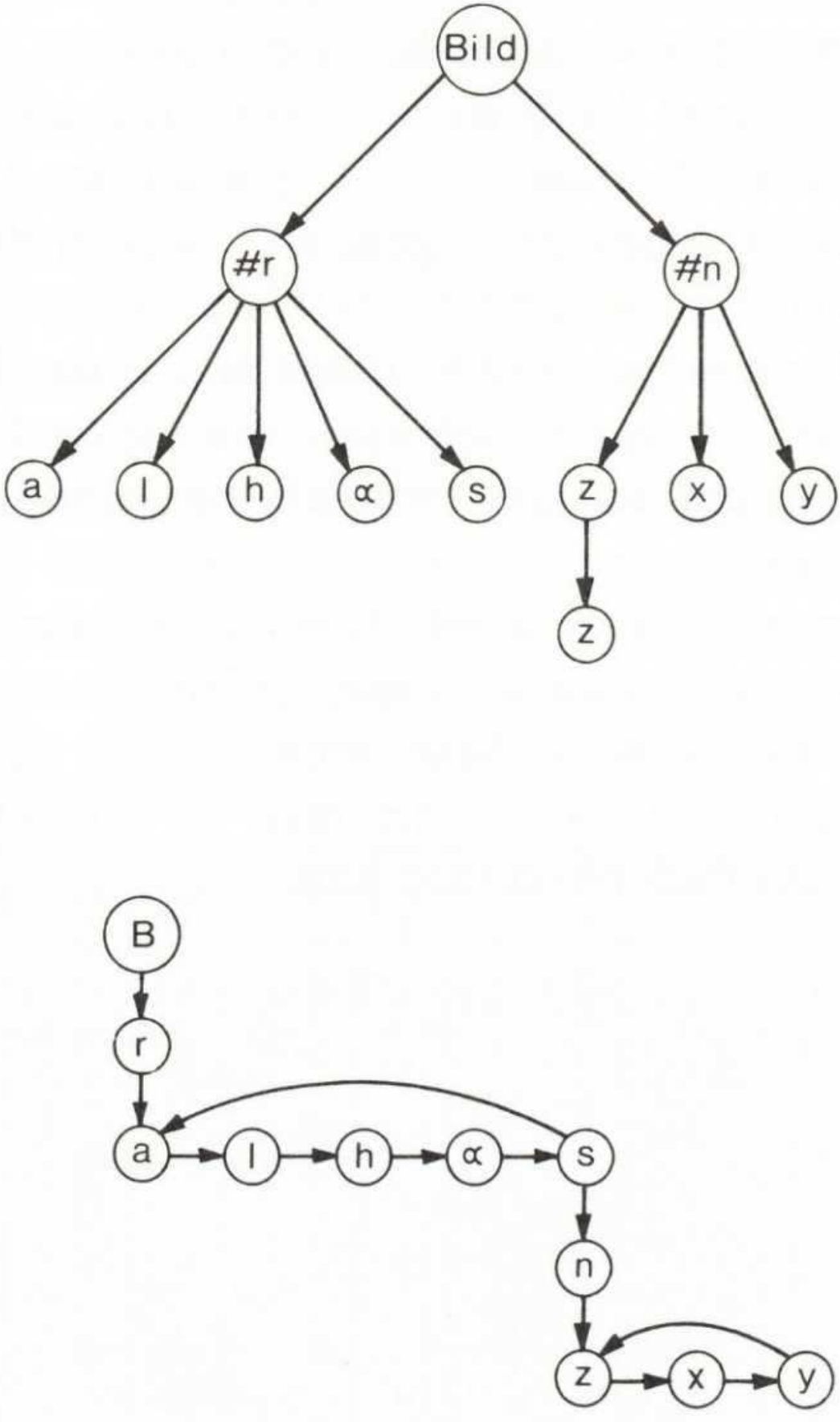


Abb. 5.5-1. Sechs Modi für das Auftragen einer linearen Kette in der Ebene

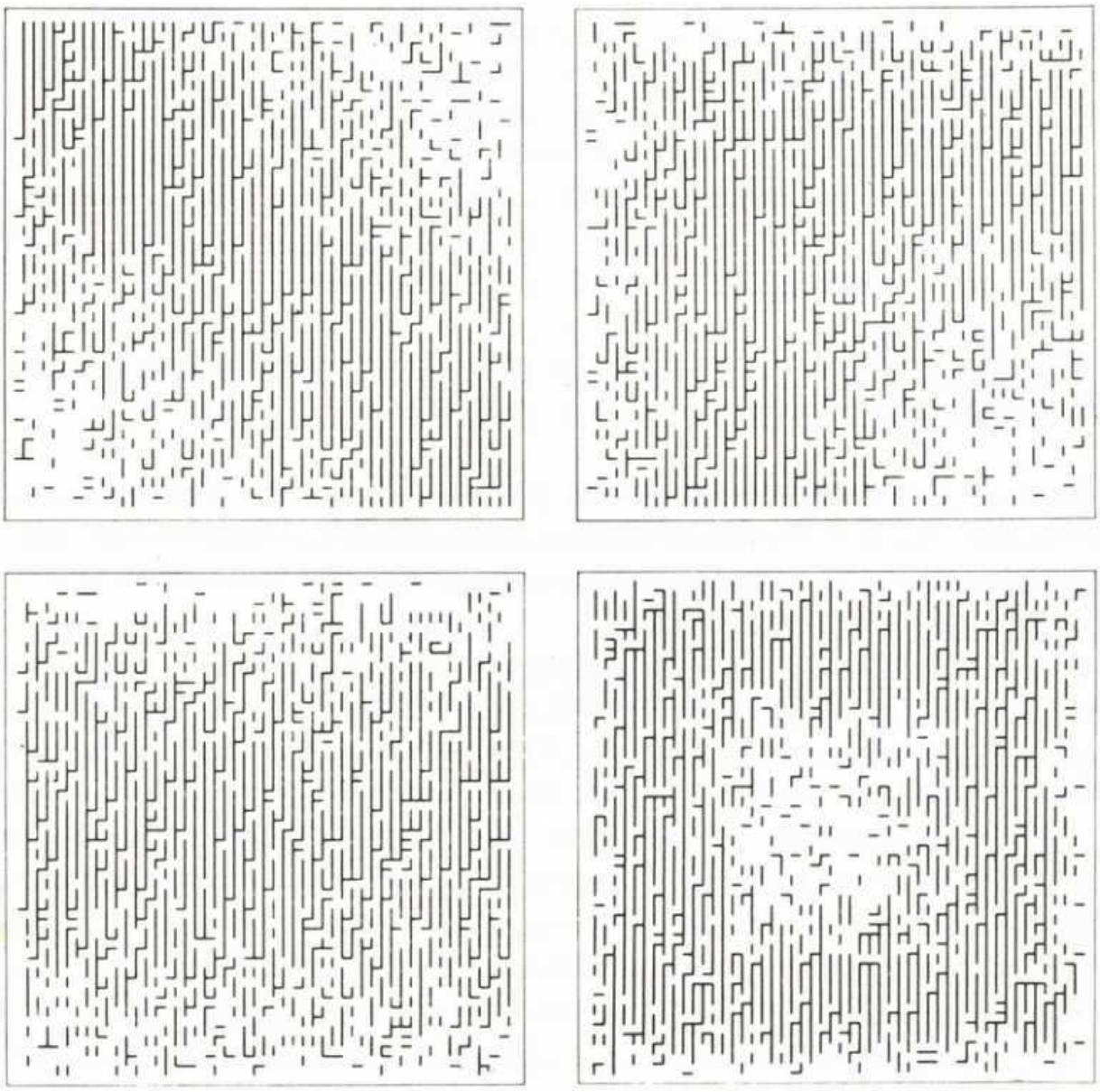
Nake, Frieder: Walk-Through-Rasters, 1966, six modes (Nake: Ästhetik 1974, p.229, ill. 5.5-1).

In 1966 Nake developed the program "walk-through-raster" in "ALGOL60 (with some assembler-sub-programs)". A punch tape contained the instructions for a Telefunken TR4 (since 1962) of the Stuttgart University. The results were printed by a Zuse Z64 Graphomat.



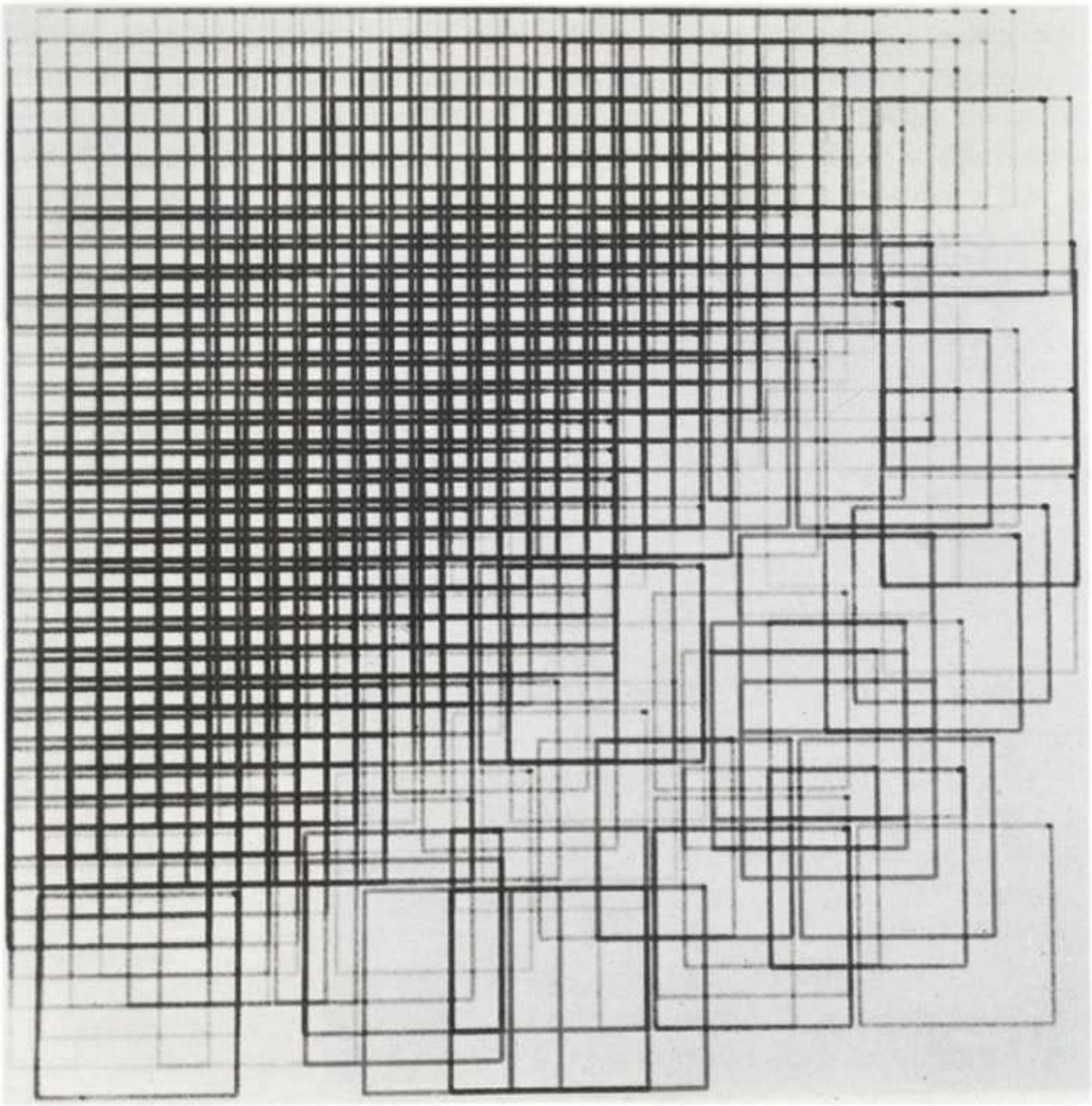
Nake, Frieder: Walk-Through-Raster, 1966, diagram of the tree structure (Nake: Ästhetik 1974, p.235, ill. 5.5-4).

The program selected signs from a repertoire depending on "the last chosen sign". As explained by Nake, the program simulated a "short memory". 42 The program exchanged the signs at specified positions. The exchange is determined by programmed "transition probabilities" ("Übergangswahrscheinlichkeiten"). 43 The program stepped in one of "six modes" 44 through a field divided in rectangles and decided where which kind of transition will be computed. The decision procedures can be illustrated as tree structures unfolding themselves in the horizontal axis as well as in the "depth". 45



Nake, Frieder: Walk-Through-Raster, series 2.1, four realisations, 1966, plotter drawings (Nake: Ästhetik 1974, p.236, ill. 5.5-5).

The sign repertoire of the series "2.1" is constituted by vertical and horizontal lines as well as by a blank field. For the "6 modes" of the directions in which the computing process runs step by step across the plane six variants with "defined repertoire and defined probabilities" were created. 46 For the series "7.3" squares marked by lines in different colours were selected. The squares were "remarkably larger than the fields of the grid". The squares´ overlaps constitute configurations described by Nake as a "destruction of the basic repertoire" ("Zerstörung des Elementarrepertoires"). 47 Nake refered in his description to Nee´s explanation of the "destruction of the matrices´ arrangement" ("Zerstörung der Matrizenanordnung"). 48



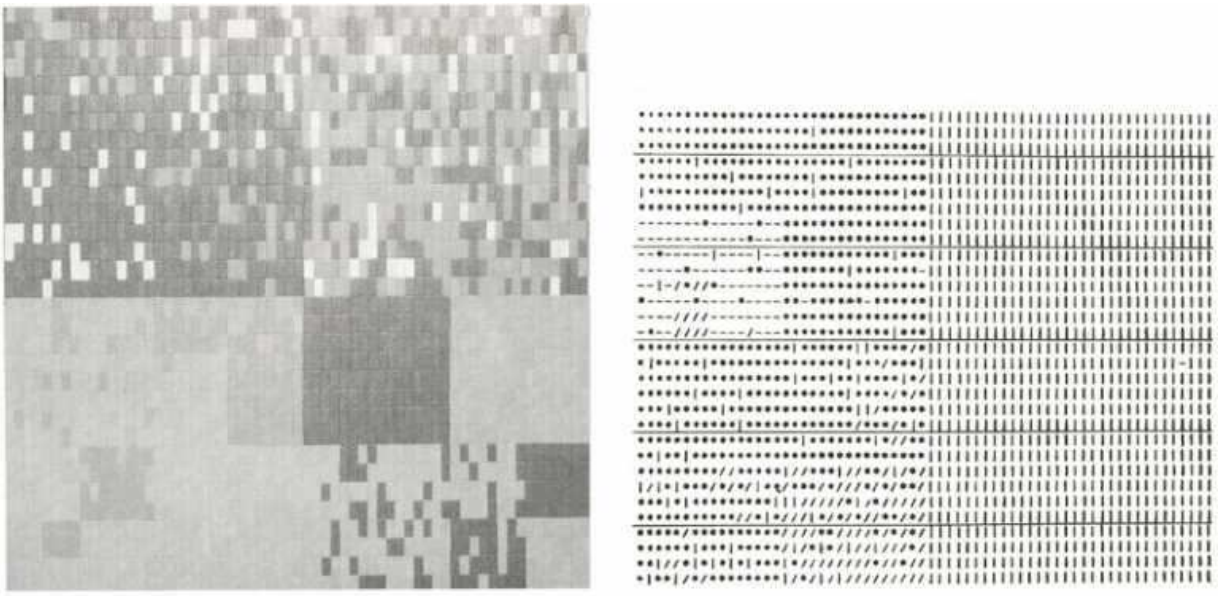
Nake, Frieder: Walk-Through-Raster, series 7.1, 1966, plotter drawing in four colours (Nake: Ästhetik 1974, p.237, ill. 5.5-6).

The "walk-through-raster" program was able to execute "a series of measurements following criteria of information aesthetics" like "redundancy and information values as well as distinguishing features and the surprise measure of each sign" ("Redundanz und Informationsgehalt sowie Auffälligkeit und Überraschungsmaß jedes Zeichens"). 49 To be able to integrate the measurements as a "selector" ("Selektor") of the generated signs into the computing process, Nake installed in his program "Generative Aesthetics I" a "preselector" ("Vorselektor") with statistic measures for the frequency of colours. The "statistic preselector" could not differentiate between pictures with the same frequency of colours. 50 The "topological selector´s" ("topologischer Selektor") programming of the colour distribution on the plane used a frequencies´ measure, and it was based on the raster principle:

> A probability distribution $p=(p_1,..., p_r)$ for r colours has to be determined for each image. These colours should be distributed on the plane of the image. For the realisation of this goal the plane will be divided in 4 equal rectangles and the whole "mass" of each colour will be distributed on these 4 rectangles. The process will be repeated for each of the rectangles etc., until a lowest level that can´t obviously be deeper than the level of the raster

fields, but usually the goal will be realised earlier. 51

The "generator" combines the statistical and topological preselection in procedures following each other comparable to Marcow chains. The output of a line printer presents the notations. The notation´s signs contain the information, how little rectangular leaflets in four colours should be distributed on the plane. In 1969 two examples were realised on hardboards. 52



Nake, Frieder: Generative Aesthetics I, 1969. Left: Experiment 6.22, coloured leaflets on hardboard. Right: print of a result of the programmed computing process, Experiment 4.5a (Nake: Vergnügen 2004, unpaginated).

In "Generative Aesthetics I" Nake realised an integration of frequency criteria into the computing processes going further than earlier computer graphics. In the book "Ästhetik der Informationsverarbeitung" ("Aesthetics of Information Processing") Nake explains how to investigate relations between the preselection and a selection following information theoretical criteria of the "aesthetic measure":

> Comparable to a physicist´s method to formulate propositions on nature by controlled models in the laboratory, an aesthetician is imaginable preparing and examining statements on `art´ via controlled models in a laboratory (that still has to be constructed). 53

In reply to Bense´s "Generative Aesthetics" 54 investigating the properties of realised works, Nake plans to offer a programming making an "aesthetic description before the [experience of a realised work as an] aesthetic reality is possible." 55

Information aesthetics inspired the development of strategies to develop procedures of programming as a precondition for the production of art. The problem of the "aesthetic measure" has not lost its actuality: It reappears in the recourse of contemporary Generative Art on cybernetic relations between chaos and order, as in 2003 Philip Galanter explained it in his lecture "What is Generative Art? Complexity Theory as a Context for Art Theory". 56

Annotations

1 Laposky: Oscillons 1953, p.2. back

2 Laposky: Oscillons 1976. back

3 Franke/Nierhoff-Wielk: Ästhetik 2007, p.110 (quote); Herzogenrath/Nierhoff-Wielk: Machina 2007, p.336,338, Nr.68s.; Piehler: Anfänge 2002, p.149-152, unpaginated with ill.29s . back

4 Herbert W. Franke, e-Mail, 8/17/2015. There Franke wrote about "the standard setting of an oscillograph": "With this setting the electron beam moves back and forth on a base line...the beam goes slowly (traceable with the eyes) from the left to the right side and it jumps then back to the left side again. A horizontal line at the bottom would arise. But the line is distorted by impulses of the measuring process pointing to the y-[vertical] axis: The result is an 'image' of the alternating current´s course. If one modifies experimentally the settings, then this will cause 'arbitrary' other images...I needed the analog computer to produce curves z(x,y). The value z stands for the luminance of the image on the screen. x and y are the coordinates [of the horizontal and vertical axes] of an image point leaving behind traces of light on the screen. The curve is produced as follows: The analog computer processes two functions f1x(t) and f2y(t) depending on the time t physically as two independent oscillations (by determining the forms with its frequencies and being tunable as well as modifiable in real time)." back

5 Herzogenrath/Nierhoff-Wielk: Machina 2007, p.150,232,362s., nr.150s.; Nierhoff-Wielk: Machina 2007, p.28s. back

6 Untitled, 1960, plotter drawing. In: Alsleben: Redundanz 1962, p.52. with ill. d; Piehler: Anfänge 2000, p.204s., unpaginated with ill.33; Rosen: Story 2008/2011, p.248. On plotter drawings by Alsleben and Passow: Alsleben: Redundanz 1962, p.51s.; Alsleben/Eske/Idensen: Aestheticus 2011, p.149ss.; Herzogenrath/Nierhoff-Wielk: Machina 2007, p.65,234,297s.; Nierhoff-Wielk: Machina 2007. p.27s.; Piehler: Anfänge 2000, p.203ss., unpaginated with ill. 33s.; Reichhardt: Serendipity 1968, p.94; Weiß: Netzkunst 2009, p.326ss. back

7 IBM delivered the first FORTRAN compiler since April 1957 (Without author: User Notes 1996-98). The Electrologica X1 compiler (August 1960) by Edsger Wybe Dijkstra and Jaap A. Zonneveld is deemed to be the first compiler for ALGOL60 (Daylight: Dijkstra 2010).
On plotters: Piehler: Anfänge 2000, p.177-180. back

8 In Gerhard Stickel´s "Autopoems" from 1965 the syntactical structures are selected by a random generator, too (see chap. III.1.3), but the frequency of the access to each one of the structures is not limited – contrary to Lutz´s "stochastic texts". back

9 Bense: Aesthetica 1982, p.33s.,322s.,328s.,354f.; Bense: Einführung 1965/1968, p.30-35; Bense: Einführung 1969, p.43ss.,55s.; Bense: Informationstheorie 1963/2000, p.136; Birkhoff: Measure 1933. back

10 Moles: Information 1965/1968, p.23; Moles: Art 1971, p.24ss. back

11 Bense: Aesthetica 1982, p.212,325; Bense: Einführung 1965/1968, p.34; Shannon: Communication 1949, p.16. back

12 On the "aesthetic measure" discussed by Birkhoff, Bense, Moles et al.: Nake: Ästhetik

1974, p.75ss,82ss. back

13 Bense: Aesthetica 1982, p.147,211,214s.,217,223,225 (citation). back

14 Moles: Théorie 1971, p.170,180. back

15 Cage defines his random procedures as not determined (Schulze: Spiel 2000, p.161-179), meanwhile the information aesthetics start out from stochastics (see chap. II.1.2): The probability to select an element via random procedure is already determined by the selection of the elements and their possible combinations. Florian Cramer demonstrates that Cage´s methods for chance operations don´t eliminate determinations (Cramer: Statements 2011, p.199-202). back

16 Götz: Malerei 1961, p.14 with fig.1, p.23 (citations). Cf. Götz: Erinnerungen 1983, p.899s.,902; Klütsch: Computergrafik 2007, p.148; Mehring: Television Art 2008, p.36. Further examples of "Statistic-Metric Modulations" in: Beckstette: Bildstörung 2009; Götz: Erinnerungen 1983, p.869-905; Kersting: Sammlung Etzold 1986, p.206 (with four examples being planned in summer 1959 and realised in February 1960).
Precursors of an aleatoric configuration of squares: Kelly, Ellsworth: Spectrum Colors Arranged by Chance I-VIII, 1951, collages made with coloured papers. In: Bois/Cowart/Pacquement: Kelly 1992, p.42ss.,168ss.,192. Morellet, François: Repartitions aléatoires, since 1958, oil or acryl on canvas. In: Holeczek/Mengden: Zufall 1992, p.23,46s.,278-281. back

17 Julesz: Dialoge 1997, p.137. back

18 Kovács: Julesz 2007. back

19 Julesz: Depth Perception 1960, p.1127,1134. back

20 Julesz: Depth Perception 1960, p.1134s.; Noll: Beginnings 1994, p.39. back

21 Julesz: Depth Perception 1960, p.1128 with fig.2, p.1154,1159. back

22 Julesz: Depth Perception 1960, p.1128 with fig.3, p.1156,1159. back

23 Julesz: Foundations 1971; Kovács: Julesz 1997; Weibel: Konturen 1997, p.40f.
In 1979 Christopher W. Tyler developed "Autostereograms". The visual depth effect of the "Random Dot Stereograms" anticipates the depth effect that "Autostereograms" provoke by a single image (Tyler/Clarke: Autostereogram 1990). back

24 Julesz: Dialoge 1997, p.138. back

25 Noll: Beginnings 1994, p.39. back

26 Noll: Patterns 1962, p.4. back

27 Herzogenrath/Nierhoff-Wielk: Machina 2007, p.445 (citation); Klütsch: Computergrafik 2007, p.166s.; Noll: Human 1966, p.2. back

28 Noll: Patterns 1962, p.2s. back

29 Noll: Computers 1967, p.67. back

30 Davis: Art 1973, p.99; Herzogenrath/Nierhoff-Wielk: Machina 2007, p.444ss., nr.356; Klütsch: Computergrafik 2007, p.167ss.; Noll: Computers 1967, p.67; Piehler: Anfänge

2000, p.235f., unpaginated with ill.46; Reichardt: Serendipity 1968, p.74; Rosen: Story 2008/2011, p.249.
Noll was not inspired by information aesthetics (Klütsch: Computergrafk 2007, p.165s.). Nevertheless his works offer models for discussions of the "aesthetic measure". back

31 Nake: Ästhetik 1974, p.199. back

32 Nees: Variationen 1964. Cf. Nees: Computergraphik 1969/2006, p.XIs., ill.4; Nees: Künstliche Kunst 2005, unpaginated with ill1s. back

33 Nees: Computergraphik 1969/2006, p.208. back

34 Nees: Computergraphik 1969/2006, p.208. back

35 Herzogenrath/Nierhoff-Wielk: Machina 2007, p.434s., nr. 309s.; 314, 317ss.; Nees: Computergrafik 2006, p.216ss. und 222ss. with ill.28-33, p.231 with ill.36, p.244 and p.247f. with ill.39-41. back

36 Nees: Computergraphik 1969/2006, p.27: "The perception dependency of the image nexus..." ("Die Perzeptionsabhängigkeit des Bildnexus..."). back

37 Nees: Computergraphik 1969/2006, p.29. Nees presents on page 24 a longer citation of Max Bense´s differentiation between "micro-aesthetics" ("orders [in the sense of orderliness] and complexity") and "macro-aesthetics" ("redundancy and information"), published in 1965 in part V of "Aesthetica" (New in: Bense: Aesthetica 1982, p.334. Cf. Klütsch: Computergrafik 2007, p.67-71). back

38 Nees: Computergraphik 1969/2006, p.209. back

39 Nees: Computergraphik 1969/2006, p.220. back

40 Nees: Computergraphik 1969/2006, p.213. Cf. p.177 with a further citation from Bense´s "Aesthetica" (part V of 1956. New in: Bense: Aesthetica 1982, p.142) on criteria to differentiate between "micro-" and "macro-aesthetics" (see ann.37). back

41 Nake, Frieder: Random Polygon Move, plotter drawing, 1963/64: Herzogenrath/Nierhoff-Wielk: Machina 2007, p.424, nr.259 (collection Herbert W. Franke); Klütsch: Computergrafik 2007, p.131-139; Nake: Ästhetik 1974, p.199s. with ill. 5.2-7. Nake presents an illustration of the same "Random Polygon Move" that is a part of the collection Franke (Kunsthalle Bremen), but with the date 1963 and the size 10 x 10 cm. Franke´s plotter drawing is combined with a history of its making: It was realised in "6/7/64" with the program COMPART ER 56 and the Zuse Graphomat Z64 (with the size 15,5 x 11,5 cm on a paper with the size 21,1 x 15,1 cm). The program COMPART ER 56 was developed since 1964, as it is noted by Nake: Ästhetik 1974, p.192 and Klütsch: Computergrafik 2007, p.132, but following Herzogenrath/Nierhoff-Wielk: Machina 2007, p.236 it was developed since 1963.
Other early computer graphics: Electronic Associates Incorporated (EAI): Stained Glass Window, 1963 (Herzogenrath/Nierhoff-Wielk: Machina 2007, p.63,238 with ill.13, p.332, nr.66); Bäumer, Wolfgang: Untitled, 1963/64 (Herzogenrath/Nierhoff-Wielk: Machina 2007, p.94,309, nr.9s.); Kawano, Hiroshi: Design 2-1 Markov Chain Pattern, 1964 (Rosen: Kawano 2011); Sumner, Lloyd: Eye´s Delight, 1964 (Dika: Computerkunst 2007, p.75ss., ill.32). back

42 Nake: Ästhetik 1974, p.229. back

43 Nake: Ästhetik 1974, p.232. back

44 Nake: Ästhetik 1974, p.229. back

45 Nake: Ästhetik 1974, p.235. back

46 Herzogenrath/Nierhoff-Wielk: Machina 2007, p.426, nr.267; Klütsch: Computergrafik 2007, p.152ss.; Nake: Ästhetik 1974, p.236s. with ill.5.5-5; Rödiger: Algorithmik 2003, p.98,134,141,164. back

47 Herzogenrath/Nierhoff-Wielk: Machina 2007, p.426f., nr.268,271,273; Nake: Ästhetik 1974, p.237s. with ill. 5.5-6. back

48 Nake: Ästhetik 1974, p.241; Nees: Computergrafik 1969/2006, p.208s. back

49 Nake: Ästhetik 1974, p.236,262. back

50 Nake: Ästhetik 1974, p.263. In 1970 Nake presented "Generative Aesthetics I" for the first time at the symposium "Computer Graphics 70" in Uxbridge (Nake: Generative Aesthetics 1970). back

51 Nake: Ästhetik 1974, p.264-271. back

52 Nake: Ästhetik 1974, p.273-276 with ill.5.8-7, 5.8-8 (with examples of 1969 for notations and realisations with coloured little sheets). The preselectors "have been implemented in PL/I at the university of Toronto in 1969 on an IBM 360-65 since November 1965] " (ibid., S.273). Nake: Brief 1973, p.225: "Only two examples were realised by hand, because I wanted to produce works in seizes greater than the seizes that were realisable with plotter drawings." Cf. Klütsch: Computergrafik 2007, p.155-158 with ill.33ss. back

53 Nake: Ästhetik 1974, p.277. back

54 Bense: Aesthetica 1982, p.333-338. back

55 Nake: Ästhetik 1974, p.277. back

56 Galanter: Generative Art 2003 refering to Moles: Théorie 1958. back

IV. Images in Motion
IV.1 Video Tools

IV.1.1 Video Cultures

Since the mid of the sixties video is an emerging film system usable to produce and to store electronic signals. The mobile elements of the video system are the camera and the recorder meanwhile the player is not moved to the recording location and remains connected with a cathode ray tube (of a TV set). Signals stored on magnetic tapes contain information being sent by players to cathode ray tubes for video presentations.

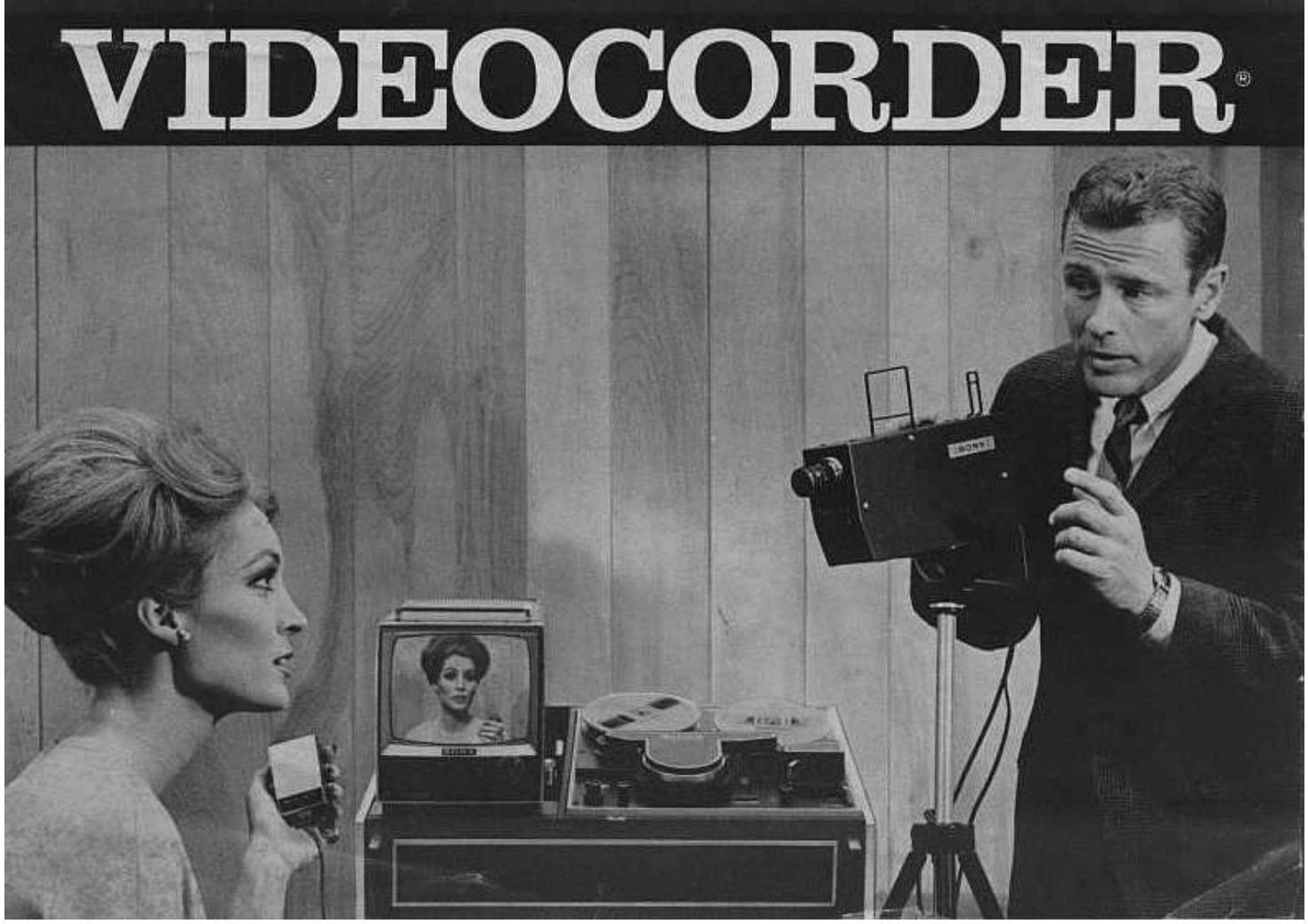
The sequence of shots (frames) on a film stripe is transformed by a projector into a movie: Meanwhile the film is screened as a moved sequence of images and a light projection, the video system directs electron beams in a vacuum tube. A light emitting video presentation replaces the film projection in a dark room.

The celluloid stripes being editable shot by shot (the frame as a phase image) at cutting tables were substituted by magnetic tapes, video recorders for editing and the `tools´ for `electronic image processing´. The transformations of electronic signals by mixer, sequencer, switcher, keyer and other means replaces film animation techniques developed since the end of the 19th century for the editing of frames and their montage. 1

In the sixties and seventies Stephen Beck, Robert Cahen, Tom DeFanti, Tom DeWitt, Ed Emshwiller, Bill Hearn, Barbara Aronofsky Latham, Phil Morton, Nam June Paik, Eric Siegel, Barbara Sykes, Stan VanDerBeek, Steina und Woody Vasulka, Jim Wiseman and others (see chap. IV.1.2) experimented with processors, synthesizers as well as analogue and digital computers. 2

The signals can be produced with video cameras. They conduct the signals to the storing on magnetic tapes, but storing is not necessary: Systems processing signals can transform the data input of several sources into data controlling the electronic beams in vacuum tubes. Not only video cameras but also music synthesizers (developed by Robert Moog, Don Buchla 3 and others) supply video systems with input for transformations in signals controlling monitor presentations. An example offers Stephen Beck using audio signals produced by a Buchla synthesizer as an input for his "Direct Video Synthesizer" (1970) to produce visual signals (see chap. IV.1.2).

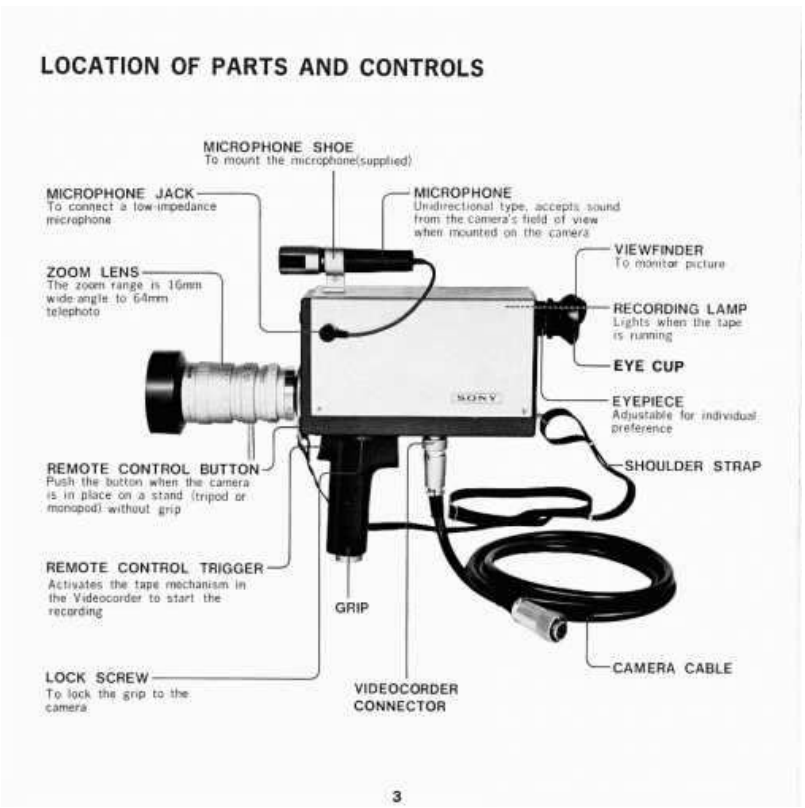
Before these and other kinds to produce signals via analogue computing processes of video synthesizers have been developed video became known by recording devices being light compared to the weights of professional motion-picture cameras. The video cameras being acquirable since 1965 were still connected via cable with a heavy weight, unportable recording device for magnetic tape storage. Intermediary production steps like the film processing were dropped. The reach of the camera was dependent from the length of the cable to the recorder. The video system was offered with a monitor mounted on the recorder for the filming of persons who kept themselves within the reach of the camera meanwhile they could observe themselves on the monitor: home video tape recording. 4



Sony VCK 2000, since 1965. A woman with microphone and a man with the video camera mounted on a tripod. Behind it: Recorder with magnetic tape and monitor. Photo: Sony.

Since 1968 the Sony Porta Pak Ensemble (Sony Porta Pak CV 2400) with a light-weight video recorder portable on the shoulder and a video camera became a mobile system for live film recordings. Sequences taking up to a duration of 20 minutes were storable on magnetic tapes. With a video player connected to a television set it was possible to play the tape immediately after the recording. Since 1970 takes were observable in real time at the recording locations by playing back the tape with the portable video recorder. The take was then presented in the camera search field (Sony Porta Pak AV 3400). [5]





Sony Porta Pak CV 2400, since 1968. Left: Woman with video camera and portable video recorder. Right: Video camera. Photos: Sony.

The video recording system was cheaper and more light weight than the recording devices used at the early seventies by camera teams of television channels before they migrated to video systems. 6 Video was a chance for persons in social contexts neglected by television stations to produce videos documenting their social situation and criticising the origins of their problems. In workshops activists offered not only to use the video equipment but also possibilities to learn the technical skills that were necessary for the filming of documentations. 7 In addition to the distribution of video documentations by sending copied tapes the expansion of the cable systems in the United States offered in the seventies possibilities to install non-commercial advertising-free local channels whose programmes were created by the inhabitants (Community TV).

For antenna reception the famous private TV startions used channels in the high frequency spectrum. To avoid interferences only a limited number of frequencies was available. In their fight for usable frequencies the private TV channels payed high prizes. These restrictions of the commercial broadcast didn´t exist for the use of cable TV. George Stoney became a pioneer of the video activists´ use of cable TV. In 1972 he realised the first programme for the Austin Community Television (ACTV): He was filmed in front of the antennas used to feed the recorded film live into the cable network. Stoney reported about his experiences with cable access in Mexico. 8

Video and TV





First Transmission of ACTV, Video, 1972. First transmission of the cable station Austin Community Television (ACTV), 1972. George Stoney tells about his experiences with cable access in Mexico. He was filmed on the hilltop with the cable company´s antenna which was the head-end for the distribution of broadcast signals through the cable network. URL: http://www.vdb.org/smackn.acgi$tapedetail?FIRSTTRANS



VanDerBeek, Stan: Violence Sonata, 1970, TV-transmission, WGBH, Boston, channel 2 (above) and channel 44. URL: http://main.wgbh.org/wgbh/NTW/ES/Video/violence201.html



right: Radical Software. Vol.1/Nr.4, Summer 1971, p.23: Call for the use of cable accesses for the broadcast of videos produced with "half-inch portable equipment".

Beside the activists efforts to develop programmes for community TV some artists succeeded to interest program directors of terrestrial channels in their experimental videos. It was planned to use video techniques to develop new ways of filming and to include them into new programmes integrating audience participation. In 1969 the Boston station WGBH-TV produced videos and programmes planned by artists and supported their realisations technically.

In the "Boston-Cambridge area" WGBH-TV had installed a camera network for real time transmissions (closed-circuits) from public institutions like the Massachusetts Institute of Technology (MIT). In 1969 Allan Kaprow used this camera network in "Hello". The

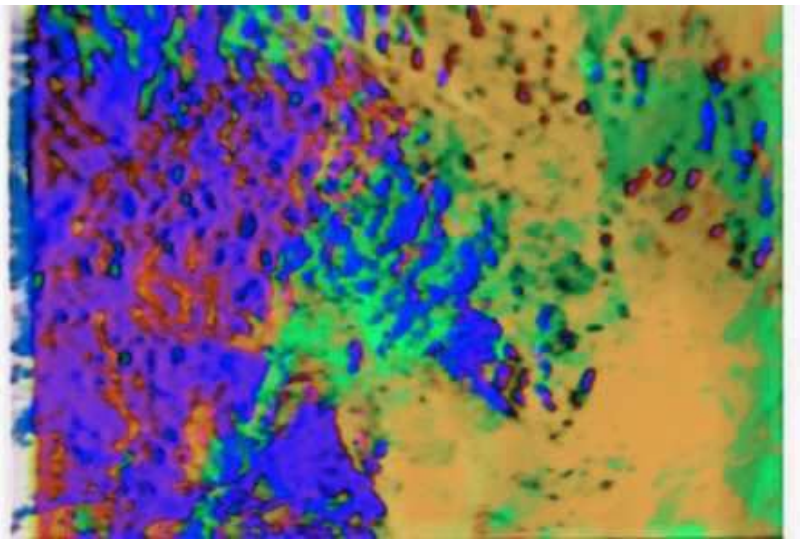
participants´ actions in front of external cameras were presented in the studio of WGBH-TV on 27 monitors. The video "Hello" documents some of Kaprow´s actions in the studio: He switched between the cameras and interacted with the participants acting in front of the cameras. 9



Kaprow, Allan: Hello, TV broadcast "The Medium is the Medium", WGBH, Boston, video, 1969.

In March 1969 WGBH-TV presented in The Medium is the Medium" six videos realised by artists for this programme: Beside "Hello" Nam June Paik´s "Electronic Opera #1" was broadcasted. In Paik´s video act a female bare-chested dancer, two persons kissing each other, Richard Nixon, Hippies and others in TV-images being manipulated by a magnet. On or before these sequences floated transformations of three green-blue figure-eight loops laying on or above each other. The figure-eight loops were created by direct processings of the electronic signal. 10





Paik, Nam June. Left: Electronic Opera #1, WGBH-TV, Boston, video, 1969. Right: Video Commune – The Beatles from Beginning to End, WGBH-TV, Boston, video, 1970.

The TV channel WGBH-TVfinanced the development of Nam June Paik´s and Shuya Abe´s "video-synthesizer". The studio of the station received the first "synthesizer". It was utilised for the first time in the programme "Video Commune – The Beatles from Beginning to End". 11 Under David Atwood´s direction Paik realised with the synthesizer video animations to the Beatles´ oeuvre. Following Paik´s invitation into the studio passersby operated the synthesizer, too.

In 1970 Stan VanDerBeek combined in "Violence Sonata" participation TV, presented in "Hello" as documented action only, and experimental film. It was produced by WGBH-TV and broadcasted simultaneously on the station´s channels 2 and 44. Only observers with two television sets next to each other were able to view on channel 2 footage edited

with "overlays and color saturation" and, simultaneously, on channel 44 live broadcast of an audience in the studio discussing the shown experimental films. Furthermore each TV viewer could communicate via telephone with three participants of the discussion in the studio. Stan VanDerBeek expanded his experiments with electronic image processing, that he began in 1964 creating "Poem Fields" in collaboration with Kenneth Knowlton in the studios of the Bell Telephone Company (see chap. IV.2.1.2), to the TV-experiment "Violence Sonata". 12

Experimental filmmakers and artists understood their concepts for alternative uses of media as a provocation of the established cinematic presentation of fictional films and of the mass medium of television. The viewers should be liberated by participation from a passive consuming and observing position. Thus, Nam June Paik wrote in 1971:

> Communication means the two-way communications. One-way communication is simply a notification...like a draft call. TV has been a typical case of this non communication and mass audience had only one freedom, that is, to turn on or off the TV. 13

Between 1970 and 1974 eleven issues of the video journal "Radical Software" were published. The journal edited by Phyllis Gershuny, Beryl Korot, Michael Shamberg and others contained informations on projects by media activists and experimental filmmakers. 14 The video-activists informed about groups offering conveyable documentations of critical social imbalances and injustices filmed by concerned persons as well as about community TV, meanwhile the experimental filmmakers presented new technical possibilities. Alternative strategies to develop new media and new forms of media utilisations complementing each other in a common search for new TV forms were on the one hand the use of video by the experimental filmmakers augmenting their technical equipment with tools developed for their needs and on the other hand the use of standard video equipment by activists concentrating themselves on the production of documentations in situ with the persons concerned by social problems as well as on the short-term processes of editing and distributing.



Radical Software, Vol.1/Nr.1 and Nr.2, 1970.

The activists´ goal of a "participatory democracy" with possibilities for all citizens to express themselves in a community TV was the result of a criticism of the use of media in a "consciousness industry" and its "one-way communication". 15 Furthermore video tools could become publicly accessible, as Paik demonstrated in "Video Commune".

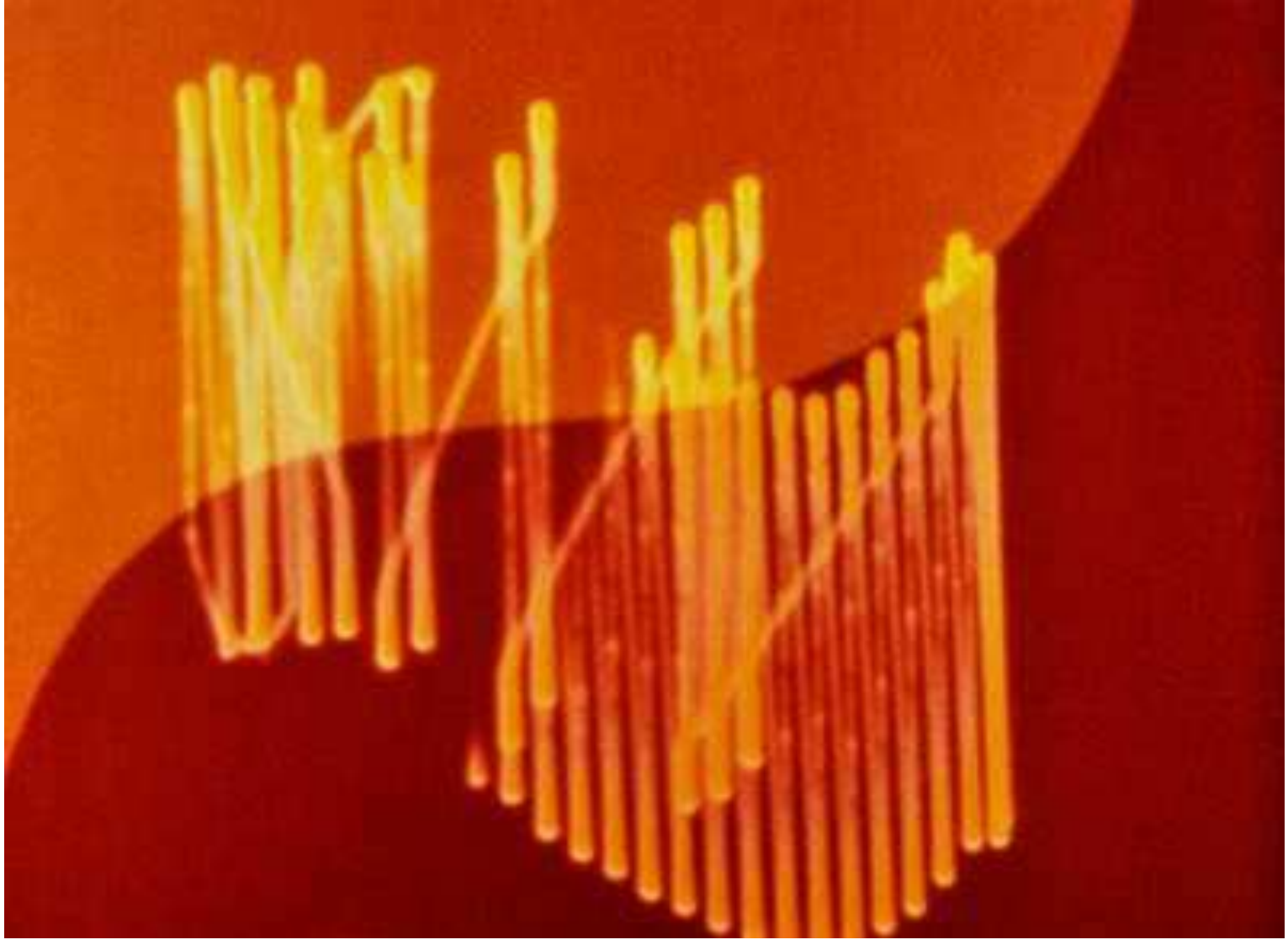
IV.1.2 Video Synthesizers

Video synthesizers and processors were analog computers constructed to process images by controlling the movement of electron beams in cathode ray tubes. These movements were often not storable otherwise than by recordings of the monitors. 16



Bute, Mary Ellen: The artist at the fine-tuning of her oscillograph. Photo: Ted Nemeth, c. 1954. Courtesy Center for Visual Music (Zinman: Circuit 2012, p.140).

Precursors of this technique were animations built by manipulations of oscillographs and recordings of their monitors. In 1950 Benjamin Francis Laposky started to photograph the monitor of his modified oscillograph (see chap. III.2). In her films "Abstronic" (1952) and "Mood Contrasts" (1953) Mary Ellen Bute used an oscillograph custom-built by Ralph K. Potter, the director of the Department for Transmission Research at the Bell Telephone Laboratories, to create "visual music": Bute used music recordings as "electrical inputs" and modified these signals via the oscillograph´s buttons and switches. Then the "figures and forms" on the oscillograph´s screen were "photographed on motion picture film". 17



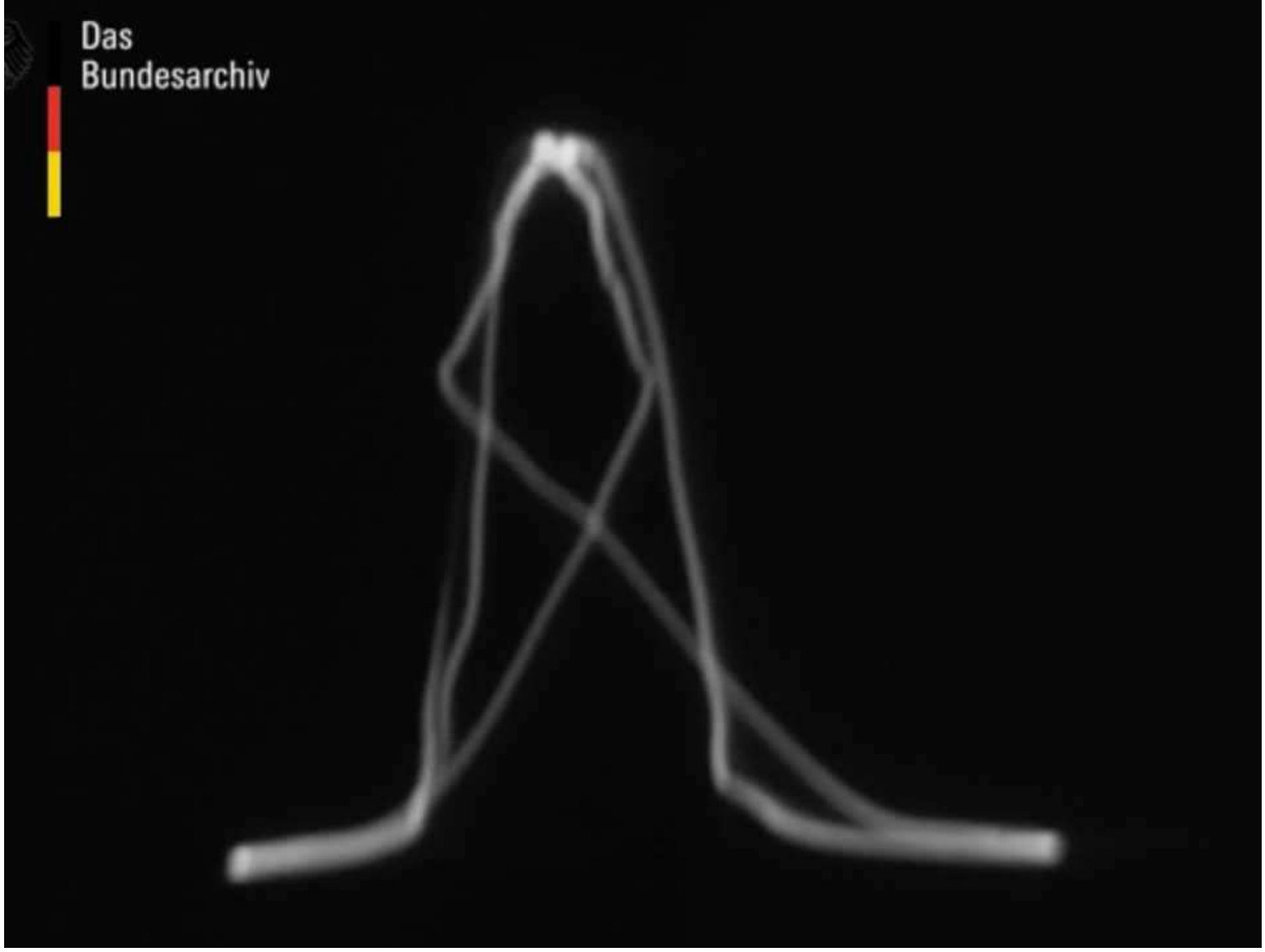
Bute, Mary Ellen: Abstronic, film, 1952.

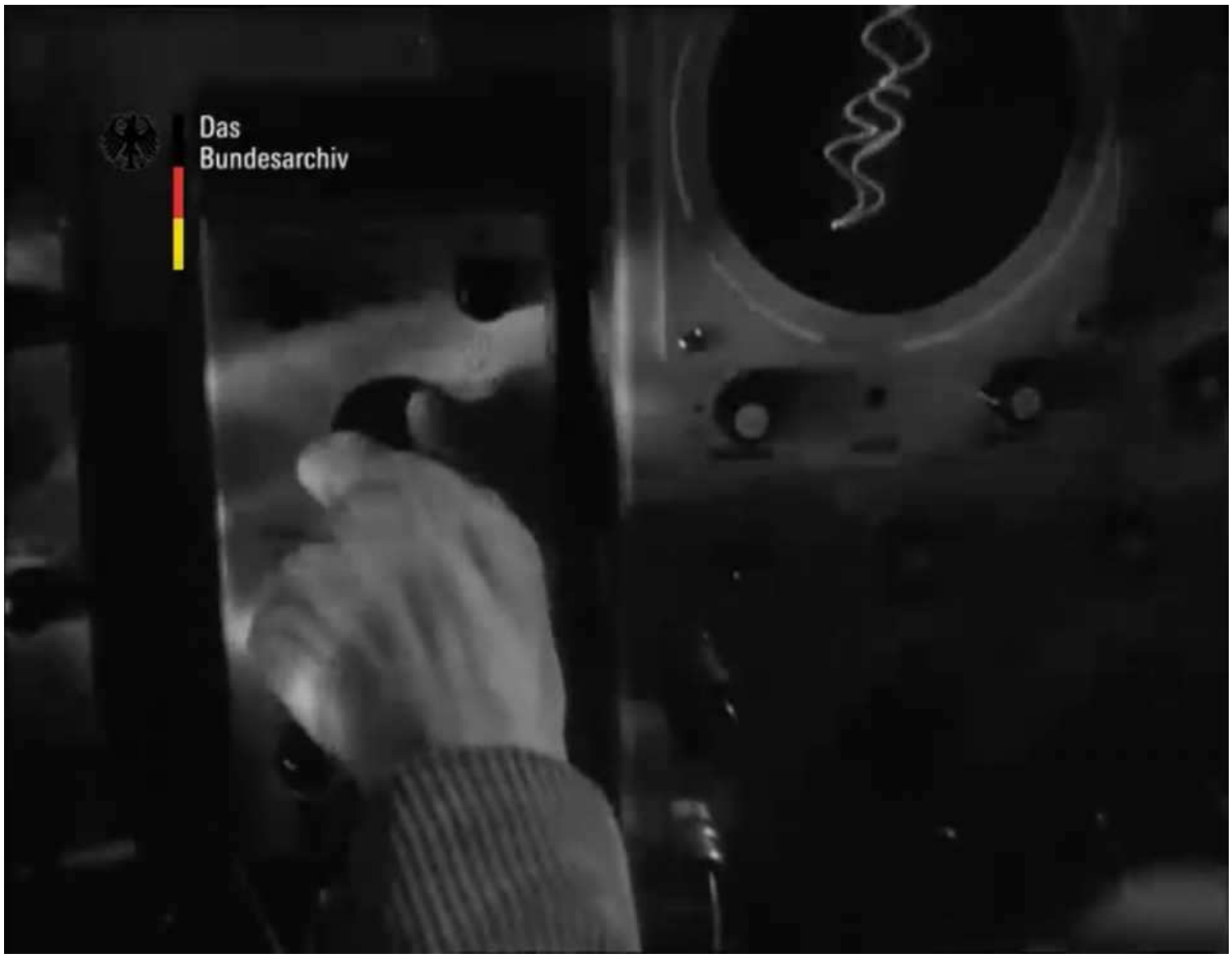
Herbert W. Franke used an analog computing system built by Franz Raimann to control two independent parameters for length and height to create arrays of curves not only in computer graphics (see chap. II.1) but in films, too. In 27th October 1959 a sequence of the UFA-Wochenschau (German weekly show for cinemas, a preprogram to movies) presented Franke controlling the electron beams´ moves on the screen of an oscillograph: With these "animations in real time" he created "a dance of electrons".

The "voltage fluctuations" of a "magnetophone device" are used by Franke as "impulses" activating the oscillograph. They were added to the impulses of Raimann´s analog calculation system. In the film some devices like "presumably adapters, filters, potentiometers, et cetera" are presented in short sequences because they are used by Franke to integrate the impulses of the magnetophone. The thus created control of the screen via music "can be seen in the film´s last seconds presenting movements of some visual elements determined by music." 18

Raimann´s construction (analog elements for calculation processes and a control device) in connection with a monitor anticipated the technology used in the seventies for productions of experimental videos: Raimann´s device with bottoms and connecting plugs was in the seventies developed further to the patch cables of video synthesizers being used to control the electron beams of cathode ray tubes (among others, the monitors of TVs).

Former processes to create film animations were substituted by electronic signals being navigable in no other way than via control devices: The production of film stripes frame-by-frame on the cutting table has been dropped – and with it the animation procedures developed for this kind of production. The film recording of the oscilloscope, as it was made by the UFA´s camera man, anticipated later video recordings of the electronic beams´ moves on monitors.





Franke, Herbert W.: [UFA-Wochenschau 170/1959], film, 10/27/1959 (weekly show for cinemas). Cameraman: Vlasdeck.
Above: screen of the oscillograph.
Bottom: The units on the left of the oscillograph were used by Franke to readjust in real

time the screen´s output, as it was produced by Franz Raimann´s analog calculation system.

Nicolas Schoeffer describes his «Luminoscope 1» (1959) as designed to look like "a television receiver with control knobs being either attached to the receiver or being part of a device (for remote control)." The Luminoscope´s possibilities to produce "coloured images with depth effects and effects of multidimensional moves" were presented in black-and-white by the French Broadcast ORTF in 25th October 1961: In «Variations luminodynamiques 1» film recordings of a Jazz combo (Martial Solal Trio), a Gospel singer (Gordon Heath) and two ballett dancers (Hélène Longuet and Jean Beaufort) were mixed with non-representing and often transparent image layers. These image manipulations anticipate distortions of later developed video processors and synthesizers. 19



Schoeffer, Nicolas: Luminoscope I, 1959.



Schoeffer, Nicolas: Variations luminodynamiques, film, 1961. Documentation of the programme sent by the television channel ORTF, 25th October 1961. Still with the gospel singer Gordon Heath.

Lee Harrison III developed "The Bone Generator" (the late fifties) further to ANIMAC (between Christmas 1959 and New Year 1960). The tool for animations was constructed with tube technology and included "a patchy panel, potentiometers, joysticks, dance interfaces, and a flying spot scanner. Analog and simple digital circuits were patched together physically through the patch panel..." With ANIMAC´s "patch panel" stick figures were realisable. They were presented on XY oscilloscopes. The sticks were "basically line segments" and constituted the "bones" of the represented figures. With "`spinning vectors´ called Skin" the "surface characteristics" were stored. These vectors were constituted by "high frequency sin/cosine oscillators." Their outputs "created the three electronic signals representing the animation´s image." The perspective of an animation produced with this "3D-output" could be determined by the "Camera-Angle Network". This network transformed "three signals" of an animation "into two signals" ("2D perspective"). The two signals of the animation were emitted to the oscilloscope and its screen was filmed. The recordings were colorised by filters being placed "in between the oscilloscope and the camera".

Participants with sensors fixed to their bodies could navigate the motions of the figurative line patterns in real time. The sensors reacted to body movements and changed the voltage. That caused the animation to react. The changing voltage navigated control signals that moved the lines of the figure on a 3D rotation matrix. 20



Harrison III, Lee: ANIMAC, 1962. A dancer controls the line patterns of a figure by activating sensors mounted on her body. Denver 1962 (photomontage).

Before Lee Harrison III developed "SCANIMATE" (1969, see below) with all-encompassing possibilities for the production of animations, Ture Sjölander, Robert Cahen and Eric Siegel created films and videos with distorted electron beams. The distortions were realised in using procedures made possible by devices being constructed for productions of experimental animations. These artists were able to use technical equipments being more diversified than manipulations of usual television receivers by changing their settings and by distorting the electron beam in the cathode ray tube via magents 21, but with minor functions compared to the video synthesizers of the seventies.

In 1966 Ture Sjölander, Bror Wikström and Bengt Modin realised "Time" for the Swedish Broadcast (Sveriges Radio, Stockholm). A black-and-white film recording of a Jazz quintet (led by Don Cherry) was distorted by the "Temporar Video Synth" (1966-69) realised by the three collaborating artists: The video signal directing the electron beam was distracted by a waveform generator. Furthermore the "luminance signal" was changed by electronic filters. 22



Sjölander, Ture/Wikström, Bror/Modin, Bengt: Time, 1966. Film for Sveriges Radio (Stockholm).

In 1967 the programme "Monument" was televised in France, Italy, Sweden and Germany. Sjölander and Lars Weck distracted photo portraits and short films of celebrities by combining them in a video, filming the video and activating a rasterised light source for projections of this video on a photocell. The light beam was distorted by deflection voltage. The distortions´ frequency and amplitude were controlled with wave generators being used later in video synthesizers, too. 23

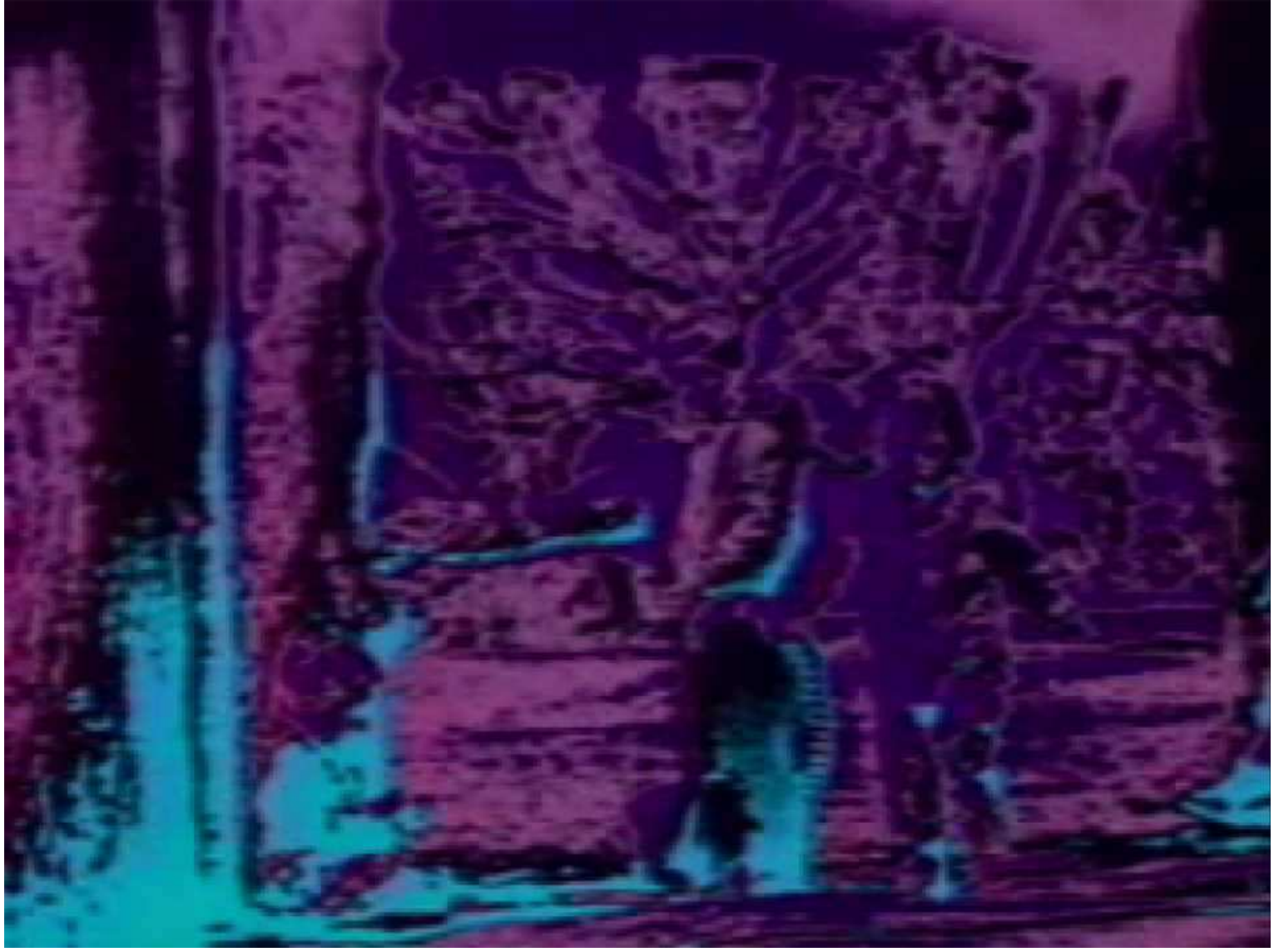


Sjölander, Ture/Weck, Lars: Monument, 1967. Film for Sveriges Radio, Stockholm, January 1968.

In 1968 Francois Coupigny constructed the «Truqueur Universel» as a processor with modules for the manipulation and colorization of images. These modules were controllable via sliders. In 1973 Robert Cahen used the processor in the production of the video «L´invitation au voyage» to distort black-and-white photos of a town and film recordings (16 mm) in the Provence by colour overlays – Robert Cahen:

> I tried at the same time to make the black and white photos come alive, their colours becoming superimposed giving a semblance of movement to the frozen image and that fascinated me. 24

A text (by Jo. Attié) on «cette petite gare de Provence» ("this little train station in Provence") is spoken off-voice. With this text Cahen expands the visual experiments to a video essay supported by electronic music. 25



Cahen, Robert: L´invitation au voyage, video, 1973.

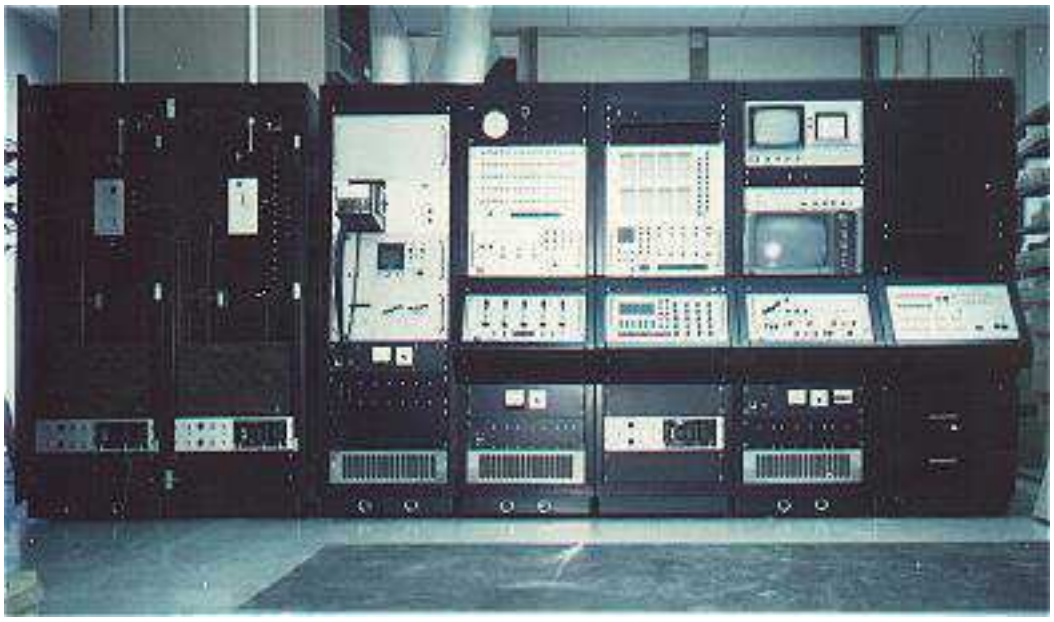
Eric Siegel presented "Psychedelevision in Color" (1968-69) at the exhibition "TV as a Creative Medium", organized by the Howard Wise Gallery in New York. Recordings made with a mobile camera were changed by Siegel in using a "video effects generator". He colorized them with his "Video Colour Synthesizer" (also named "Processing Crominance Synthesizer", 1968-69): It changed the grey tones of a signal into colour tones on a TV monitor. 26 Because it was not possible to store the navigation of the electron beam with the first version of the synthesizer, Siegel repeated the production of "Einstine" (one of "Psychedelevision´s" three parts) after the exhibition: This document shows a portrait photo of Albert Einstein dissolved in "psychedelic effects" 27 via video feedback and colorization.



Siegel, Eric: Einstine, video, 1969. (Kane: Algorithms 2014, p.73).

When Lee Harrison III started in 1969 to develop SCANIMATE on the basis of ANIMAC then he chose analog computers (with transistors) and a two-dimensional animation system to transform scanned drawings. Harrison integrated a light table and a camera to capture drawn figures. SCANIMATE made it possible to transform these figures, to present them on a cathode ray tube and to record them with "a monochrome NTSC video camera". ANIMAC´s colour-filters were substituted by "electronic

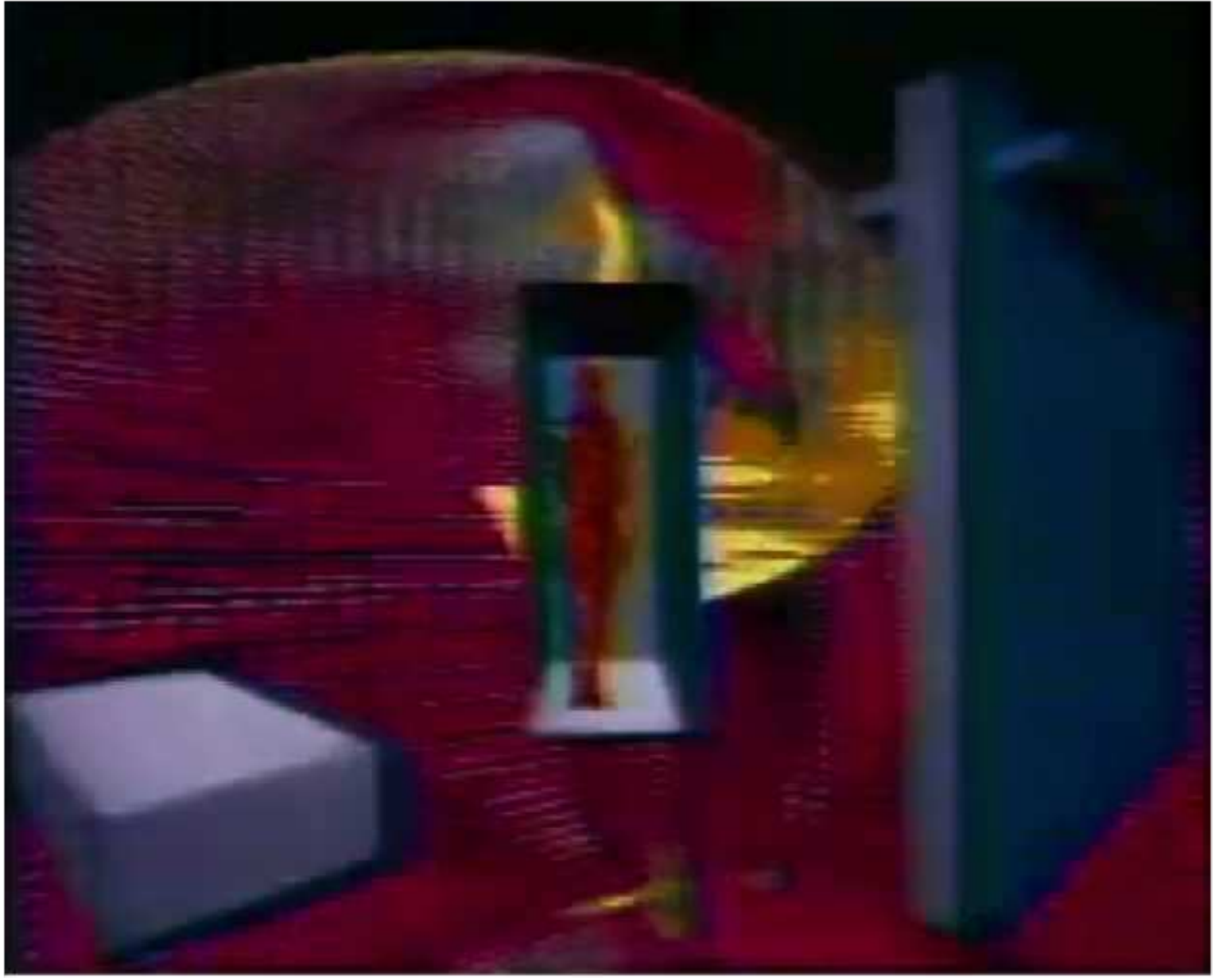
colorizers". The results could be stored on magnetic tape. 28



Harrison III, Lee: SCANIMATE, 1969.
Brand new SCANIMATE at Dolphin Productions, New York City 1973.

In 1972 Ed Emshwiller built the video "Scape-mates" with SCANIMATE in the TV Lab of the New York station WNET/Thirteen. At the start the image processing was constituted by 24 black and white cells in five different shades of grey. Two cameras of the two computers of SCANIMATE provide the input for the cells. The cells were animated as well as colorized in real time. A computer processed the background and the other one the foreground. Recordings of dancers have been partially edited with "SCANIMATE" before they were included via chromakey procedures in the fore- and the background. 29 Emshwiller utilised the Paik/Abe-Video Synthesizer (see below), too. The video distributor "Electronic Arts Intermix", founded in 1971 by Howard Wise, explains the importance of "Scape-mates" for the development of video films:

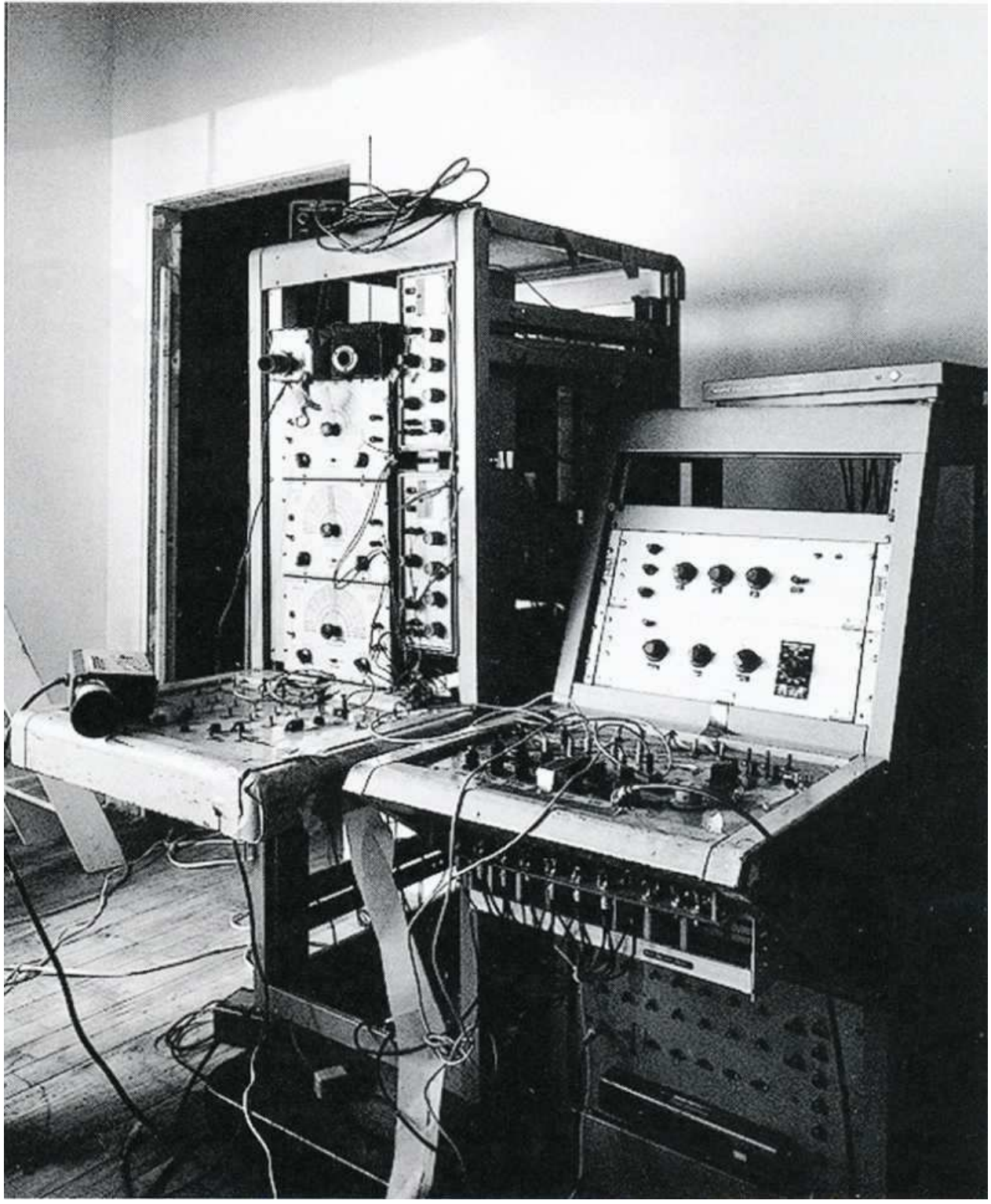
> With its witty interplay of the `real´ and the `unreal´ in an electronically rendered videospace, and the skilfull manipulation and articulation of sculptural illusion of three-dimensionality, scape-mates introduces a new vocabulary of video image-making. 30



Emshwiller, Ed: Scape-mates, video, 1972, screenshot from YouTube.

The central focus of the video tools´ developers is directed to the control of the electron beams´ motion in the cathode ray tube. A bundled electron beam is directed in the vacuum tube between anode and cathode to a screen coated with phosphorous. Electronic impulses constitute an electromagnetic field directing the electron beam. The electron beam is controlled along horizontal and vertical axes, the "xy plotting coordinates". 31 The horizontal and vertical steering between two magnet pairs constitutes either the vector images in oscilloscopes as well as early computer monitors or the raster images in television and later computer monitors (since the midst of the seventies). Raster images are a special form of vector images. For "bitmaps" raster images require memory capacities not available for the early computers.

The manner to provoke the optical effect of motion pictures changes from film to video. Meanwhile the film is constituted by frames for motion phases and these frames are moved mechanically by the projector, the videofilm activates the screen by the writing of the raster image´s "scan lines" with steered electron beams to create the impression of moving images. The possibility to create "transformation images" 32 stored on magnetic tapes becomes the technical basis of experimental videofilms.



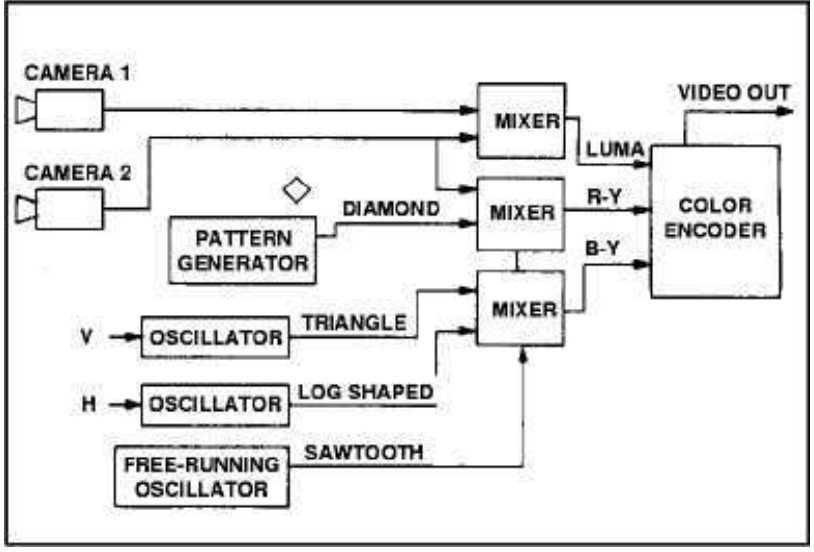
Abe, Shuya/Paik, Nam June: Paik/Abe Video Synthesizer, model of 1972, made for WNET/Thirteen in New York, and photographed in Paik´s studio in 1982 (Courtesy Nam June Paik Studios, Inc. In: Joselit: Feedback 2007, p.47).

The first version of the Paik/Abe video synthesizer from 1970 (see chap. IV.1.1 with ann.11) was not a synthesizer. It could be used to mix and colourize seven external image sources. The colours were invertible and manipulable:

> Combining video feedback, magnetic scan modulation and non-linear mixing followed by colorizing, generated its novel style of imagery. 33

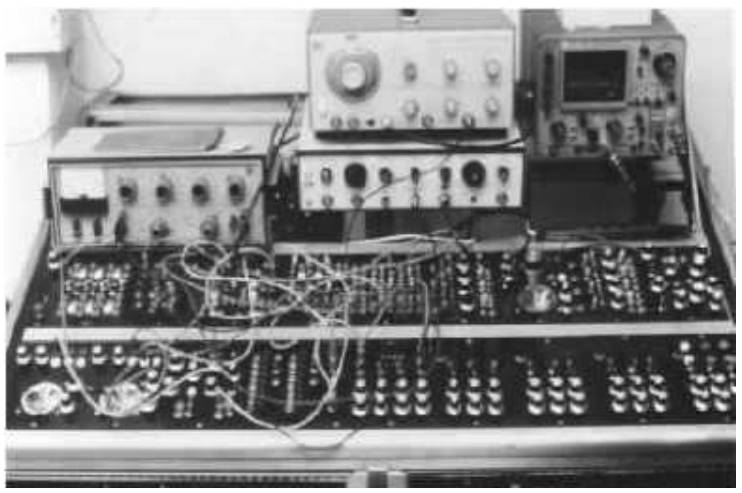
External sources (cameras) are used as an input to start signal processes by scan processors like the Paik-Abe synthesizer and the tools by Francois Coupigny, Lee Harrison III (SCANIMATE), Ture Sjölander (presented above), Dan Sandin, Bill Etra and Steve Rutt (presented below). In contrast, Stephen Beck´s "Direct Video Synthesizer" (1970) and Eric Siegel´s "Electronic Video Synthesizer" (1970) generate signals. Both synthesizers can mix these internally generated signals with external camera input.

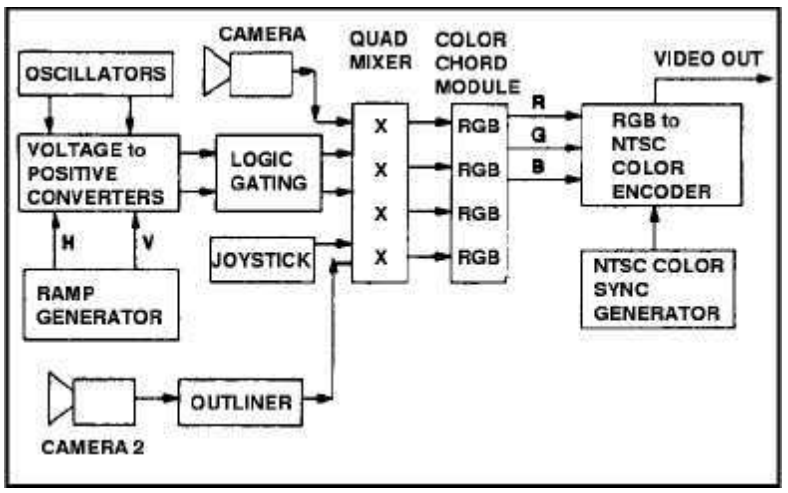




Siegel, Eric: EVS Video Synthesizer, 1970.
Left: Eric Siegel in the office of Electronic Arts Intermix, New York, ca. 1971.
Right: function diagram by Jeffrey Schier.

Siegel´s "Electronic Video Synthesizer" used generators and oscillators to process moving patterns. Two mixers conflated the waves of the oscillators and the generators. A third mixer united the input of two cameras. A "color encoder" combined the three to build the "color video signal" 34 Siegel described the possibilities of the "EVS" to process patterns as selectable symmetrical and asymmetrical "geometric formations". Furthermore a video creator could decide if the patterns, the colors or both remain constant or changing. 35 In 1973 Siegel utilised the "EVS" in the performance "Yantra Mantra" at New York´s "The Kitchen". The difficulties to find film documents created with the EVS can be traced back to Siegel´s lack of interest in the production of video documents. Furthermore he prevented Howard Wise in his efforts to produce and to sell the synthesizer. 36

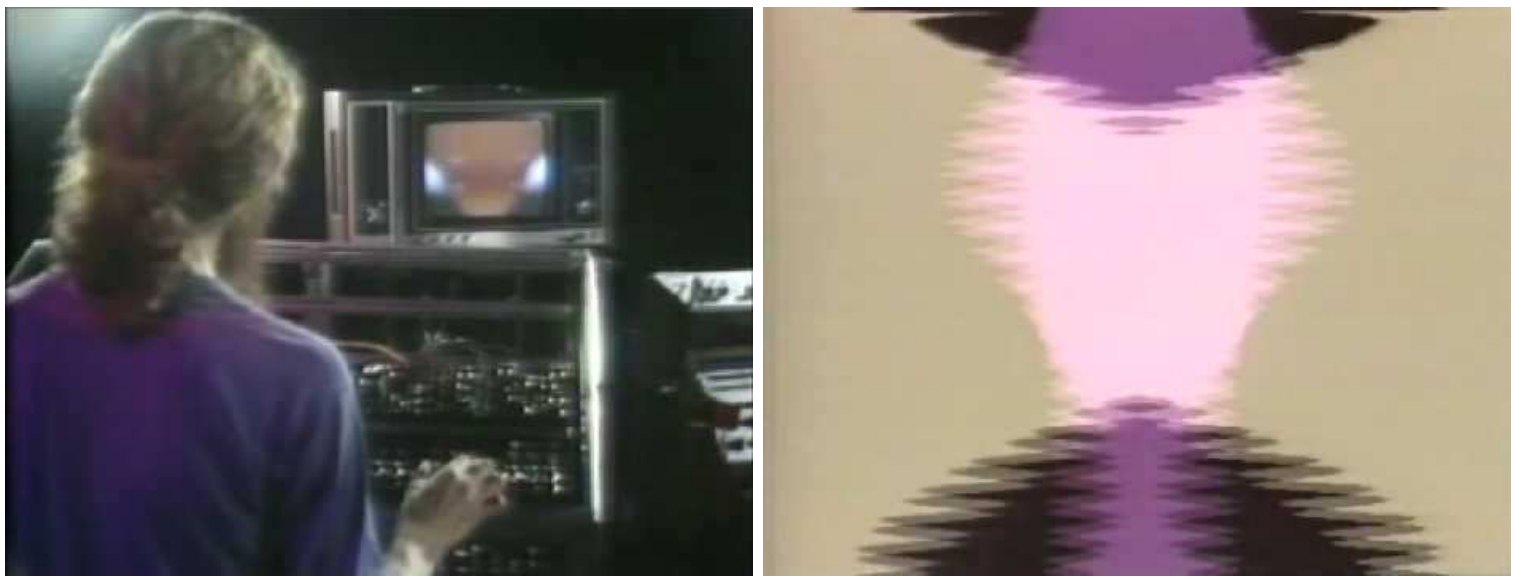




Beck, Stephen: Direct Video Synthesizer, 1970. Left: top view.
Right: function diagram by Jeffrey Schier.

Stephen Beck´s prototype of the "Direct Video Synthesizer" ("Direct Video #0") included a modified television set with possibilities to control the cathode ray tube´s colour generation. The components for the colour generation were audio signals, oscillators and external analogue mixers. A Buchla synthesizer provided the functions for the colour setting. 37 The Buchla synthesizer was developed for musicians to generate sounds. Beck added to it a further analogue synthesizer with capacities to visualise sounds. But the frequency spectrum of audio synthesizers was not appropriate for interesting visualisations. With a grant from the National Endowment for the Arts (NEA) Beck was able as "artist-in-residence" in the National Center for Experiments in Television (at the station KQED-TV, San Francisco) to solve his problems to visualise sounds and to develop his prototype further. The modules for form, motion, texture and colours of the "Direct Video #1" could be controlled via voltage regulators in real time, for example in

live performances. 38



Beck, Stephen/Jepson, Warner: Illuminated Music 2 & 3, video documentation of a PBS broadcast (Public Broadcasting Service), 1973. Left: Beck at the Direct Video Synthesizer. Right: Beck´s visualisation of Jepson´s music.

In "Illuminated Music 1", a live broadcast of the station KQED-TV (San Francisco) at 19th Mai 1972, Beck visualised Yusef Lateef´s improvisations on "Like It Is". In 1973 the National Center for Experiments in Television recorded "Illuminated Music 2 & 3" for a broadcast of the PBS/Public Broadcasting Service, Arlington/Virginia. The recordings show Warner Jepson at the Buchla Synthesizer in a live performance with Stephen Beck at the "Direct Video Synthesizer". Meanwhile Beck controlled the output on a little cathode ray tube, the public could follow the visualisations of Jepson´s music on big screens. 39 Coloured areas with wave-like contours overlapping and concealing other planes, wave-like moving particles and continuous as well as broken waved lines dominated the visualisation of a music accelerating and slowing down the tone sequences like ascending and descending waves. Several times the visualisation reacted only after a number of sound waves with perceptible changes of the visual patterns.



Sandin, Dan: 5 Minute Romp Through the IP [Analog Image Processor], video, 1973, screenshots from YouTube.

Dan Sandin presents the technical basis of his "Analog Image Processor" (1971-73) as a "general purpose analogcomputer" being programmable via "patch cables". Sandin has "optimized" the analog computer "for processing video information...[and] television information". 40 The "processing modules" can be activated via "patch cables". With these modules image sequences from an external source can be transformed by the manipulation of controllers: "The instrument is programmed by routing the image

through various processing modules and then out to a monitor or video tape recorder." 41 Between "processing modules" and the output for the monitor the "output color encoder" adds colours. 42

In 1973 Sandin demonstrates in the video "Triangle in Front of Square in Front of Circle in Front of Triangle" that the signal processes in the cathode ray tube being controlled with his video tool contradict the concept of perspectival image space:

> A demonstration of the fact that thinking of video keying as putting one thing in front of another is inaccurate and limiting. The Analog Image Processor was programmed to implement the logic equations if triangle and square show triangle, if square and circle show square, if triangle and circle show circle. 43

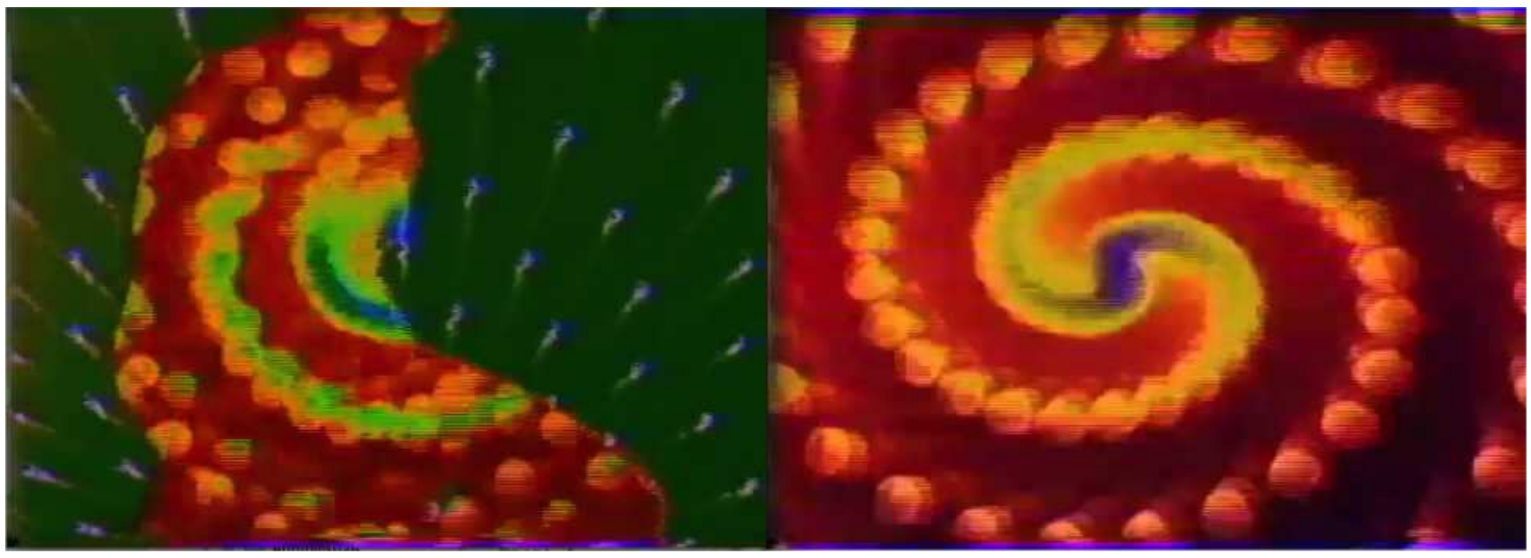


Sandin, Dan: Triangle in Front of Square in Front of Circle in Front of Triangle, video, 1973.

Meanwhile Steina and Woody Vasulka used a "George Brown Multi-Level Keyer" (1973) to provoke the impression of three-dimensionality by the layering of levels (cf. "Golden Voyage", 1973), Sandin tried to proove that the result is not an adequate design for the cathode ray tube. 44 The vocabulary of the video technology should – as Sandin demanded – supersede the perspectival image space.

In 1973 Tom DeFanti developed GRASS (Graphics Symbiosis System) for the digital minicomputer PDP 11/45 of the Digital Equipment Corporation (DEC, since 1972). 45 It was possible to build two-dimensional elements as vectorial animation in black and white by typing instructions on a keyboard and to control the result in real time on the cathode ray tube. David Sturman characterises the possibilities of GRASS: "With GRASS, people could script scaling, translation, rotation and color changes of 2D objects over time." 46 At the University of Illinois in Chicago the colour animation could be

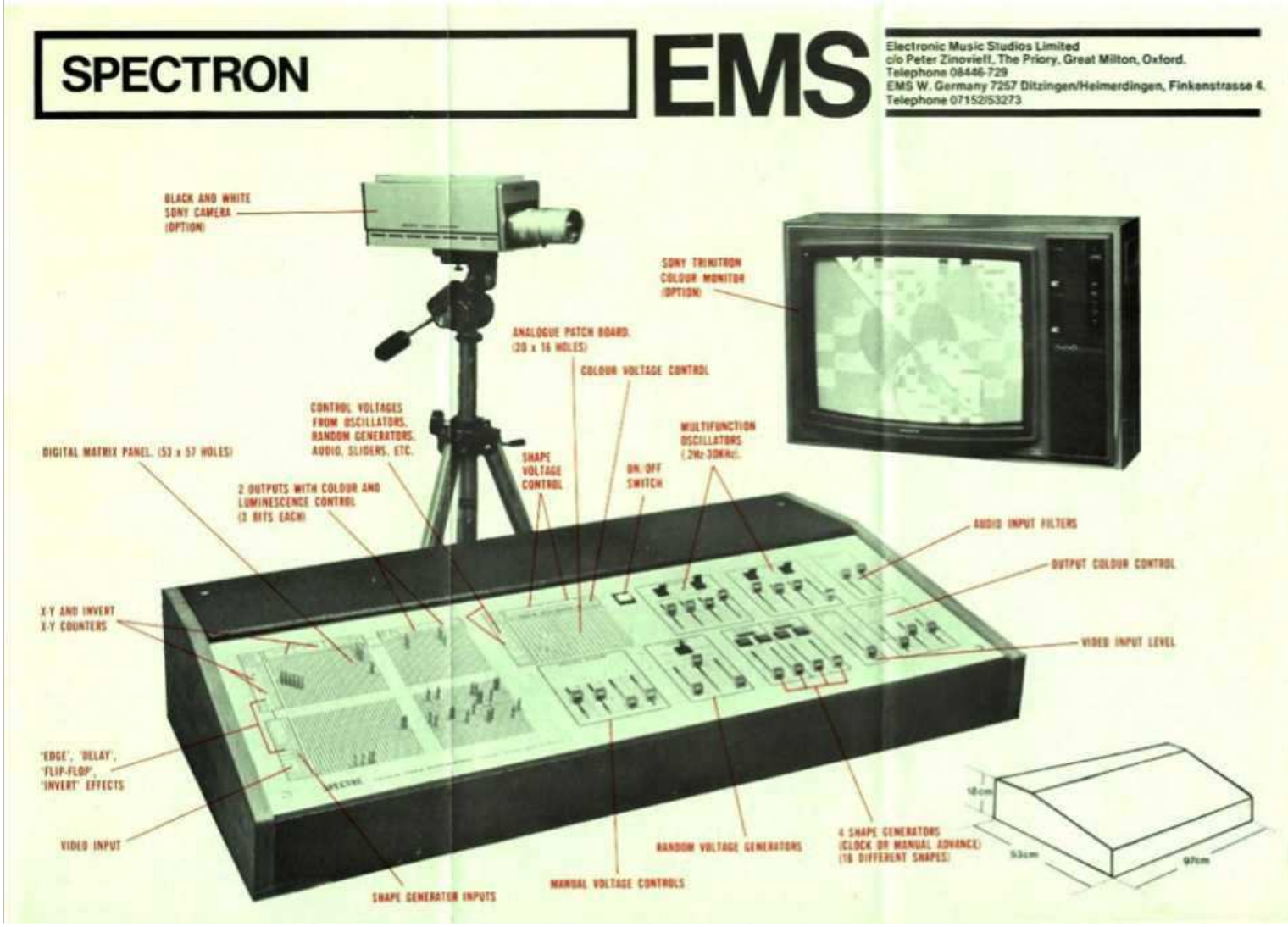
realised with a "Sandin Analog Processor" (see above): The digital animation was followed by an analogue animation.



DeFanti, Tom/Morton, Phil/Sandin, Dan/Snyders, Bob: Ryral, video of a live performance at the University of Illinois, Chicago 1976, screenshots from YouTube.

In 1976 Dan Sandin and Tom DeFanti presented their video animation system in "Ryral", a computer performance with music and animations processed in real time at the second "Electronic Visualization Event" organized at the University of Illinois in Chicago: Bob Snyder´s music processed by an "analog EMU Synthesizer" was to hear simultaneously. The dancers oscillating in Emshwiller´s "Scape-mates" (see above) between fore- and background recur in "Ryral" changed into an actrice sometimes recognizable as a silhouette: Camera recordings of a dance performance are transformed in a two-dimensional image processing creating perceptual tensions by contours and colours especially in cases if the planes merged together. These tensions provoke difficulties to sort out the levels between fore- and background. In some colour constellations patterns with circles and spirals in moving dotted lines provoke flickering effects. 47

Richard Monkhouse designed and built the first Spectron Video Synthesizer (named Spectre) for Electronic Music Studios, Ltd (EMS) London, in 1974. The same "pin-matrix patch board" 48 was used for the EMS Spectron as was the case for the company ´s VCS 3 Audio Synthesizer (1969, and its later developed audio synthesizers), but the board was expanded to accommodate the video structures required. There are two main patchboards: the "Digital Signal Matrix" (DSM), and the "Analog Control Matrix" (ACM). The analog synthesizer EMS Spectron worked with digital video signals since, according to Richard Monkhouse, digital signal processing prevented the inevitable crosstalk associated with video frequencies.49



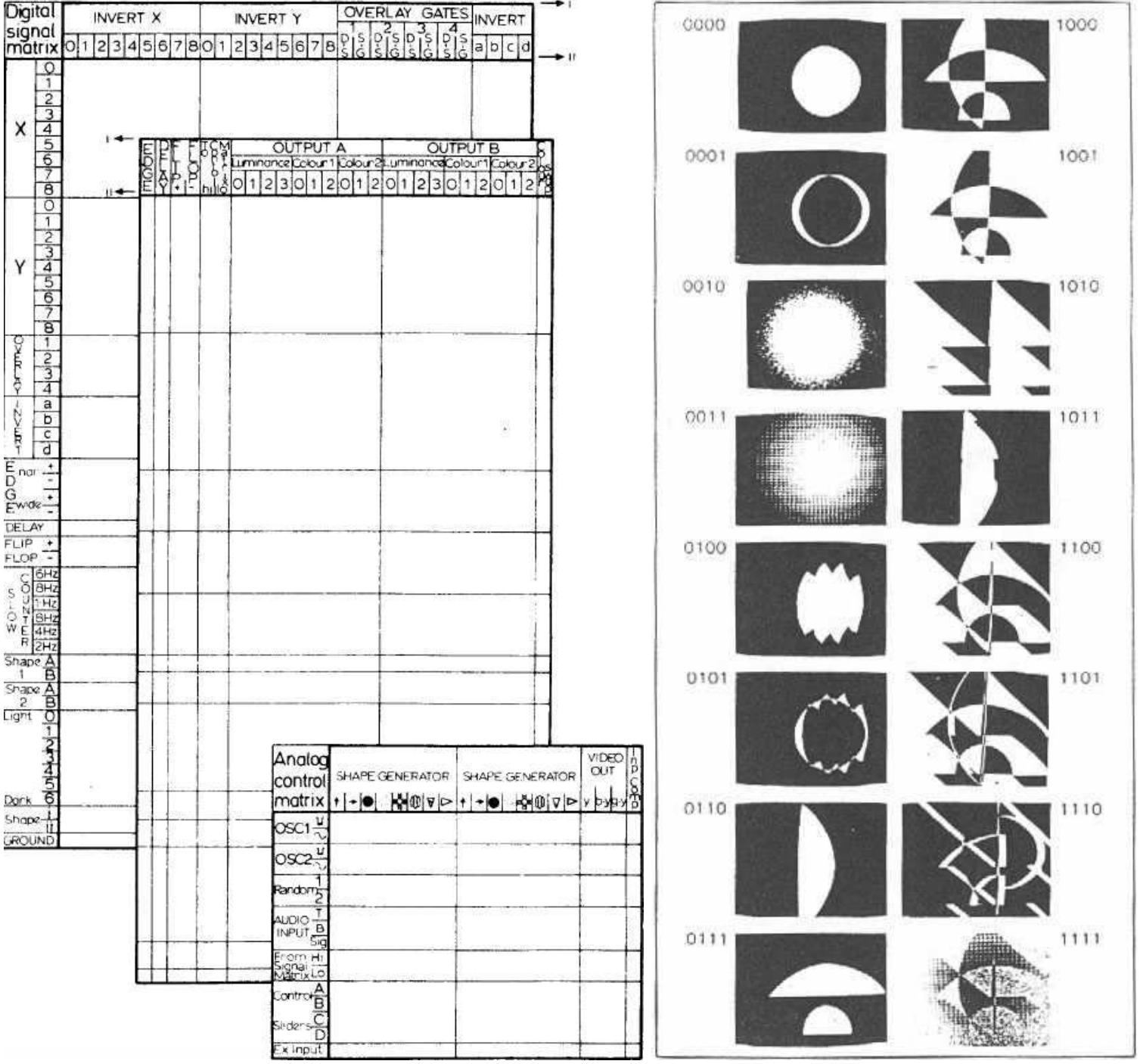
Electronic Music Studios, Ltd (EMS): Spectron, 1974. Video synthesizer (Siedler: EMS undated, p.7).

The video synthesizer could produce its own shapes and colours, or could be used to modify the colours of an external video input signal. An existing video signal could be colourised or patternised, then it could be combined with a moving or static electronically-generated image. Audio signals could also be used to dynamically change image attributes in real-time.

Two identical "shape generators" included 16 basic forms. These forms were "derivatives of a circle and segments of a circle with logic or modulation effects applied" and were changeable by the analog voltage control (see below). The basic forms could be selected manually or by automatic cycling selection. In the last case the synthesizer replaced the basic forms "at a pre-determined rate". 50 Beside these internal image sources an input from external image sources (video camera) was possible, and it could be processed as well. The images of this input could be superimposed by static or moving forms and patterns containing elements generated from internal sources (basic forms).

The "X" and "Y" counters of the digital patchboard (DSM) were used to produce static images with horizontal ("X") and vertical ("Y") stripes in binary width multiples. "Slow counters" provided six binary-related square waves – used for state change to import flash and movement effects.

The edges of a form were modifiable with the "edge generator" and "echo oscillations" were producable with the "delay"-function. To change the distances between `echoes´ "flip flops" were usable because they were able to "halve the horizontal spacial frequency of any form patched into them".



Electronic Music Studios, Ltd (EMS): Spectron, 1974. Video synthesizer.
Left: Digital Signal Matrix and Analog Control Matrix
(Monkhouse: Art 1974, p.26).
Right: 16 basic forms (Siedler: Spectre undated).

The "video comparator" was used to divide the grey scale of a black-and-white camera input signal into seven areas. The spacing of the input´s grey tones could include all ("maximum") or only the lowest values ("minimum"). Seven "output rows" corresponded to the seven grey levels. Each of these "output rows" was modifiable via the "Digital Signal Matrix" (colour, colour tone, luminance). To each "output row" patterns could be added in using the patchboard´s function "overlay gates". Via "overlay gates" it was possible to produce "layers of moving patterns". 51

The "Digital Signal Matrix" enabled artists to combine the basic forms with regards to the logical criteria conjunction ("AND"), disjunction ("OR") and exclusive disjunction ("XOR"). 52 The voltage of the output signals was controllable via the "Analog Control Matrix". This "matrix" made it possible to control "four separate shape outputs" (luminance, colour, movement, size etc). Each of the two "shape generators" supplied two "shape outputs". Further modifications of the video output were the two oscillators for "sine or square wave outputs". Random voltages could be used, as well as audio signals. Using the separate A and B outputs, these outputs could also be combined for varied logical combinations.

If it was planned to use a background pattern in further film sequences then it could be

transferred with the "inverters" into the foremost layer and transformed further. 53



Guyonnet, Jacques: Lucifer Photophore, video, 1975.

Jacques Guyonnet´s «Lucifer Photophore» (1975) presents sometimes only the borders (like fluctuating edges – noise effect) of its leitmotif – a repeating, mostly red oval. It appears several times as being a part of and constituted by variations of the Spectron´s basic forms developed themselves as circles blended into one another.

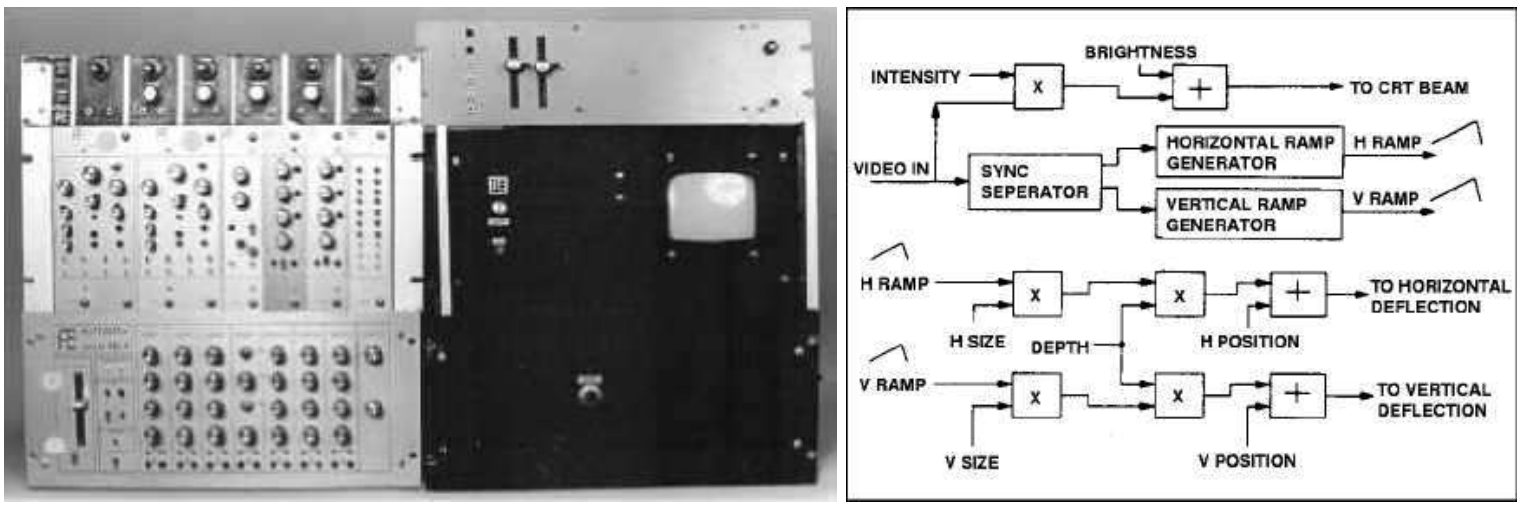
One of the best examples of the potential of the EMS Spectron is illustrated in the work «Labyrinthe Fluides» by Geneviève Calame and Jacques Guyonnet (1976). One of the mysteries of the counter logic combinations is the "maze patch" in the background of «Labyrinthe Fluides». The "digital adder" technique is used here with the X and Y counters in a particular combination that has not been explained. All that is known is that many, if not all, logic combinations of a set of binary bits can be made by asymmetric functions such as AND and OR, and inversion/symmetrical controlled inversion such as XOR. Sets of pins in the same column in the DSM patchboard do a wired OR function. If one uses the OR on a series of X counter outputs, one gets thin vertical lines. If one then applies XOR to the invert input of each X counter bit, one effectively makes a sort of digital adder, turning the vertical lines into diagonal lines. With variations modes of experimentation, "many kinds of linear, diamond, maze and 'fractal'- like patterns" can be produced.

The directions and tempi of the "maze patch´s" animation are often presented in a manner derived from the modifications of the forms in the foreground. Video feedback is used here to merge forms from the background into the foreground, so that enlarged versions of shape and texture interpenetrate each other – producing many fluid and organic developments and moiré texture "weaves" of modulated line interactions. If abstract forms in the foreground are dissolved into organic patterns then visual interferences with deformations of the "maze patch" in the background can arise. Sometimes the "maze patch" overlaps or interpenetrates abstract forms. 54

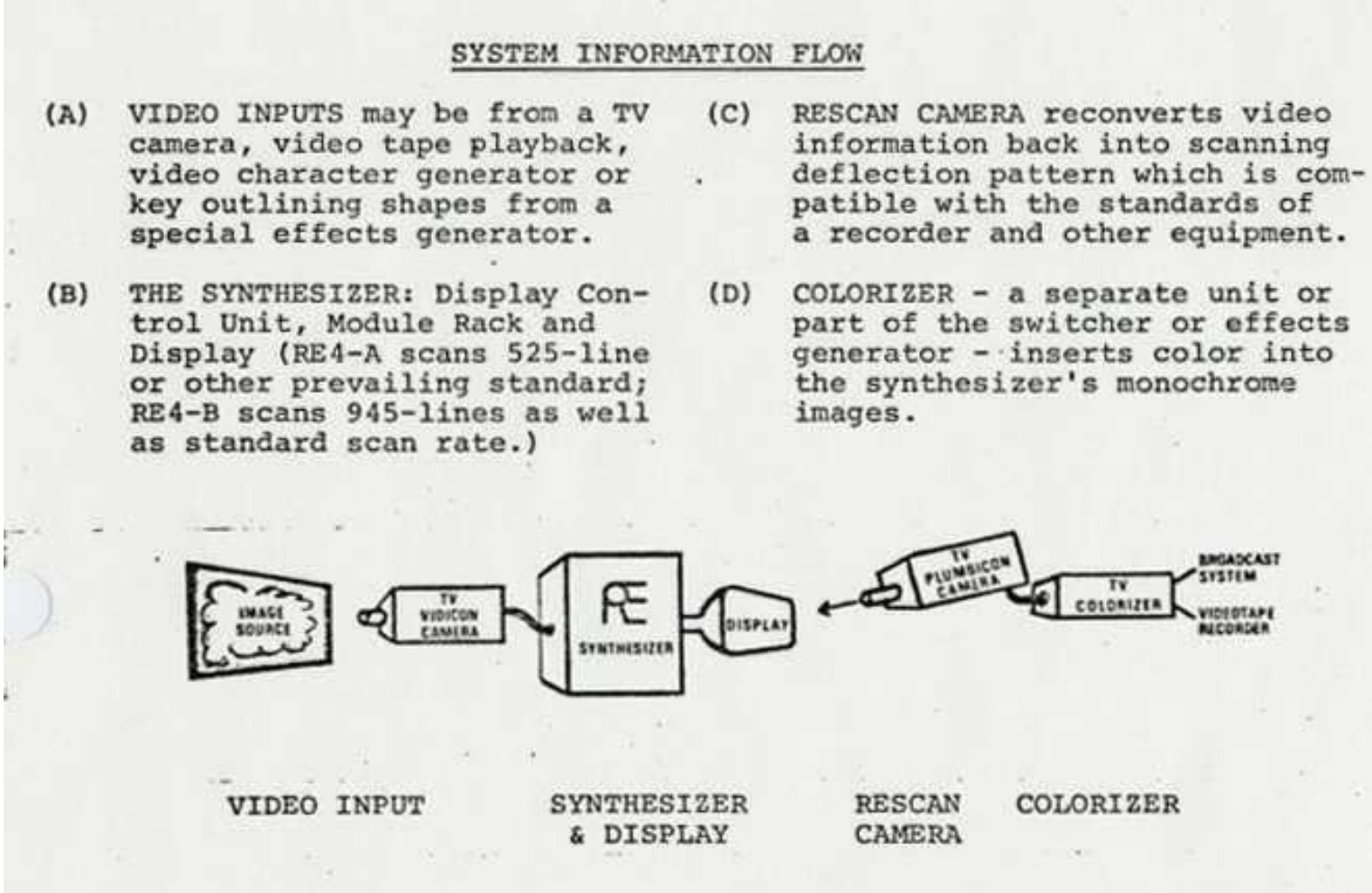


Calame, Geneviève/Guyonnet, Jacques: Labyrinthes fluides, video, 1976.

From 1977 to 1980 Warren Burt, Robert Cahen, Richard Monkhouse and Plastic Bertrand (Roger Jouret, in a music video) used the EMS Spectron to produce video art. [55]



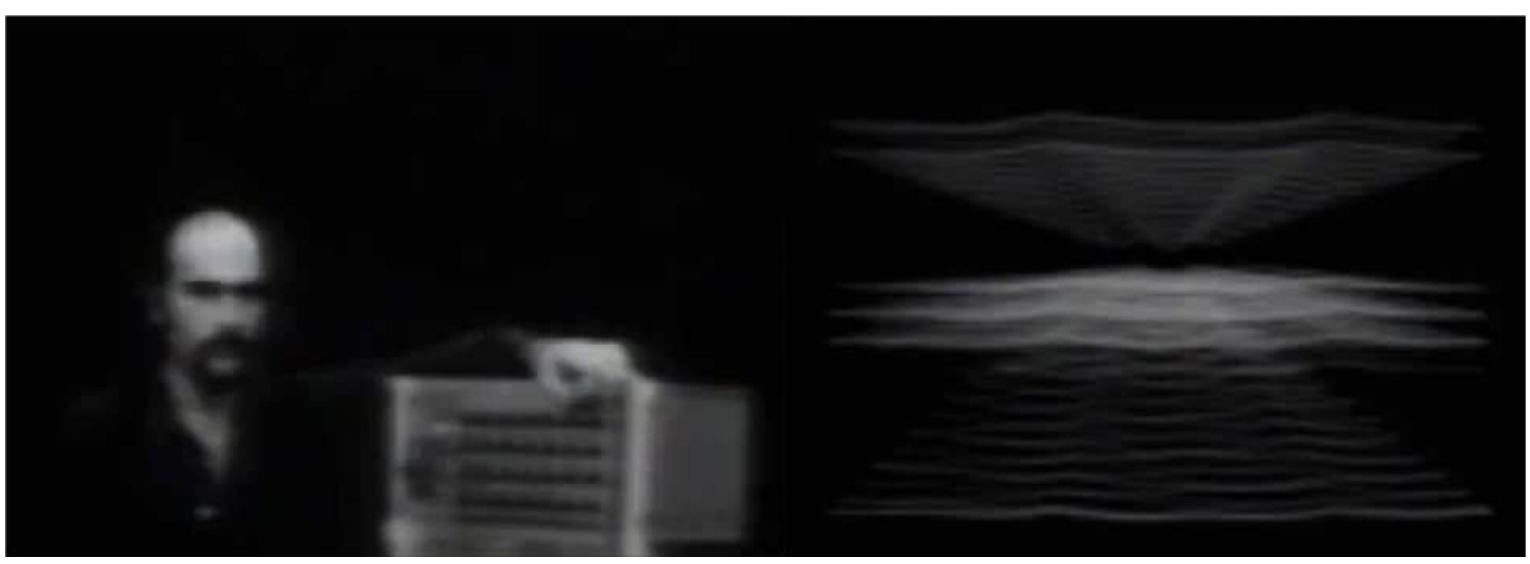
Etra, Bill/Rutt, Steve: Rutt/Etra Scan Processor, 1973.
Left: Rutt/Etra Model RE-4 Scan Processor.
Right: function diagram by Jeffrey Schier.



Etra, Bill/Rutt, Steve: user manual for the Rutt/Etra Scan Processor with "system information flow".
(Rutt/Etra: RE Video Synthesizer Systems Models RE 4A and RE 4B 1974, p.3).

In 1973 Steve Rutt, Bill and Louise Etra developed a "scan processor" that was utilised in video productions by Nam June Paik, Steina and Woody Vasulka as well as Gary Hill. 56
With the "Rutt/Etra Scan Processor" signals of a black-and-white monitor can be modified. The signals are modified by controlling the voltage along the horizontal and vertical axes. It is possible to locate the images of a video input on different places of an image raster. Furthermore the dates of the image portions´ screen presentations are modifiable – Bill Etra:

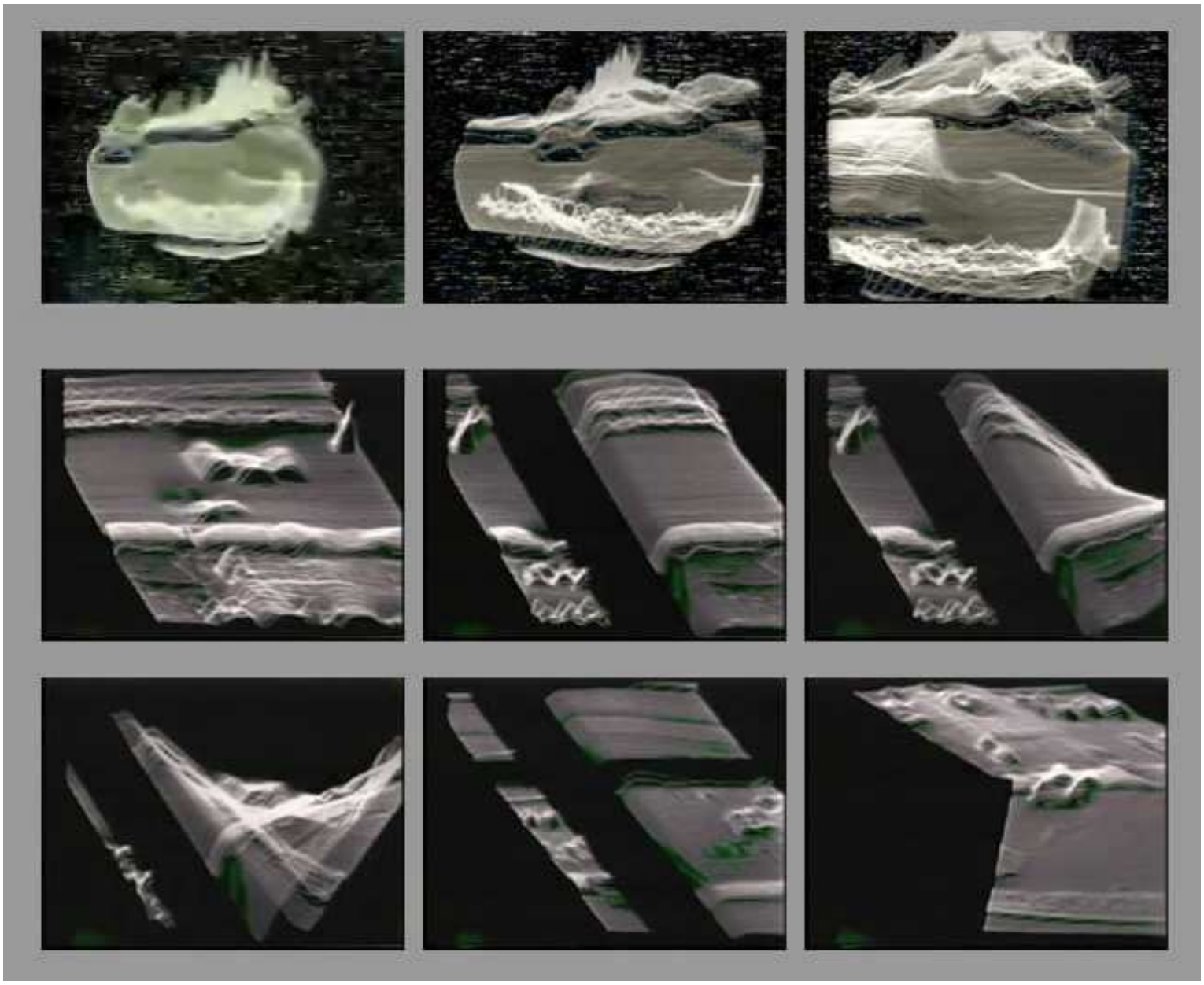
> The Rutt/Etra changes the time in which you see parts of the picture. It is a machine that manipulates images in time. 57



Etra, Bill /Rutt, Steve: Rutt/Etra Scan Processor, 1973. Demo by Bill Etra, video, screenshots from YouTube.

Since 1975 the scan processor was distributed commercially with waveform generators, four-quadrant multipliers and a summing amplifier. Optionally it could include a ramp generator for the processing of many motions. Seizes, localisations, zoom and intensity

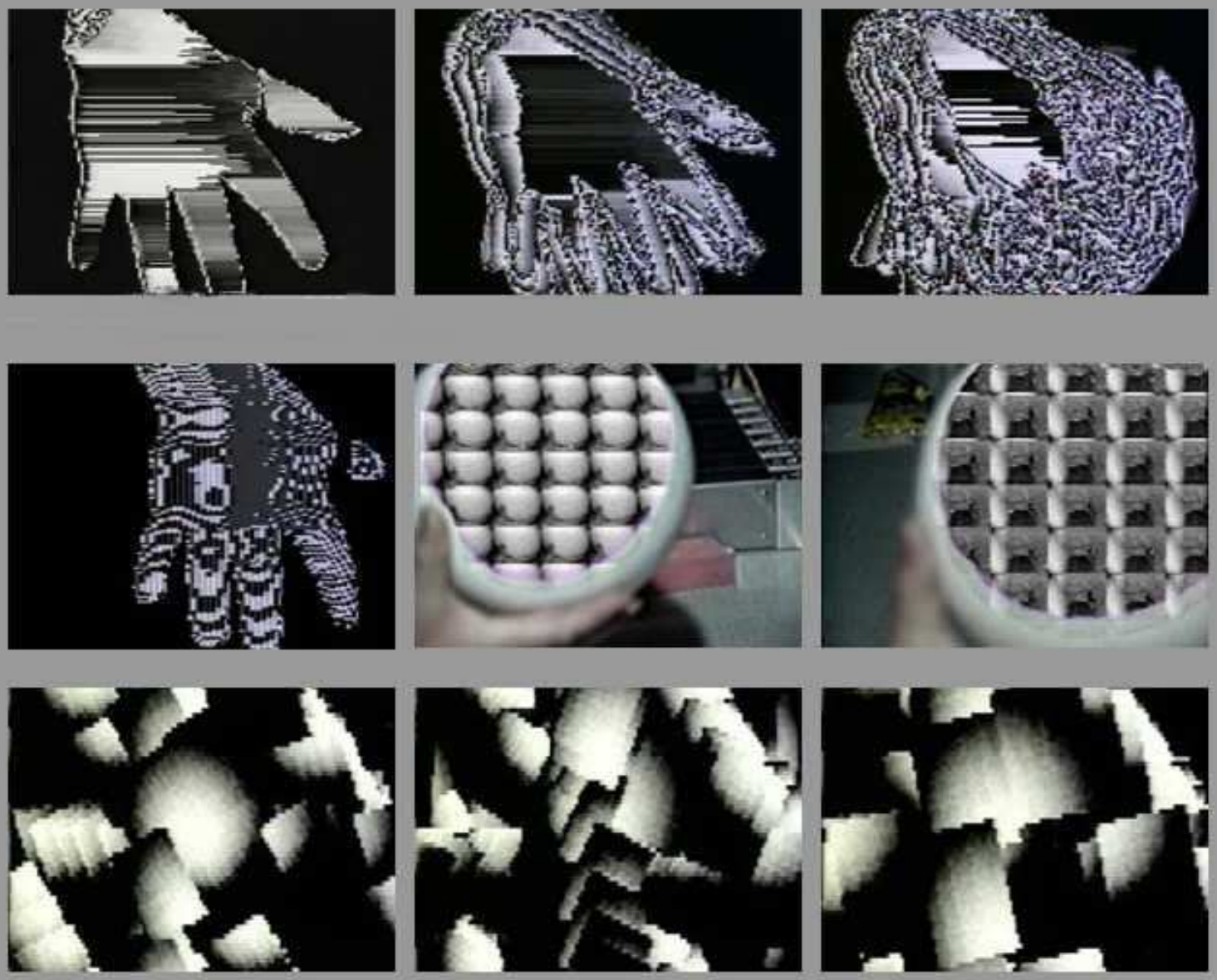
could be adjusted on 15 turning knobs. The monitor was integrated into the scan processor and presented the transformed images. Deflection yokes were mounted around the monitor. The "sine, triangle, or square waves" processed by deflections appeared on the monitor whose images were recorded by a camera, colorised and led to a videotape recorder of a broadcast system. 58



Vasulka, Woody: C-Trend, video, 1974.

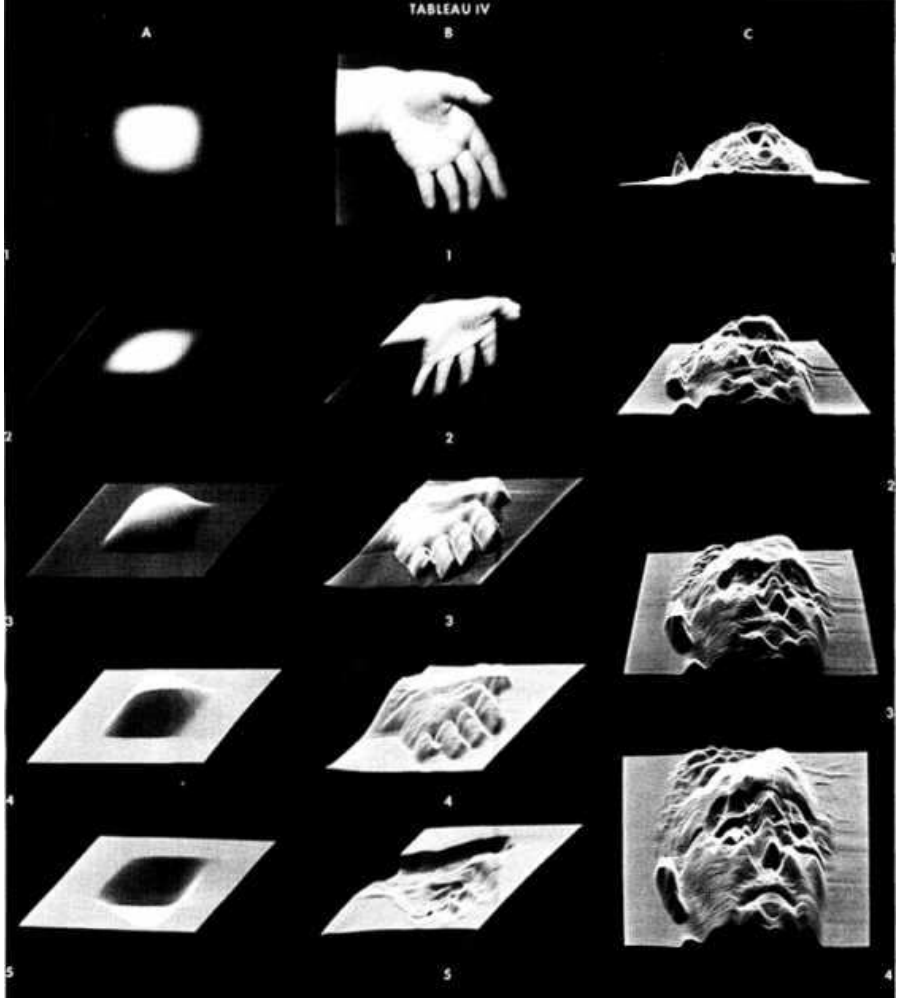
In the "Vasulka effect" (see below) the brightness of the video input determines the positioning on the vertical axis. Zones becoming brighter and darker move up and down: "When combined with other synthetic waveforms, the raster forms a three dimensional contour map where video brightness determines elevation." 59

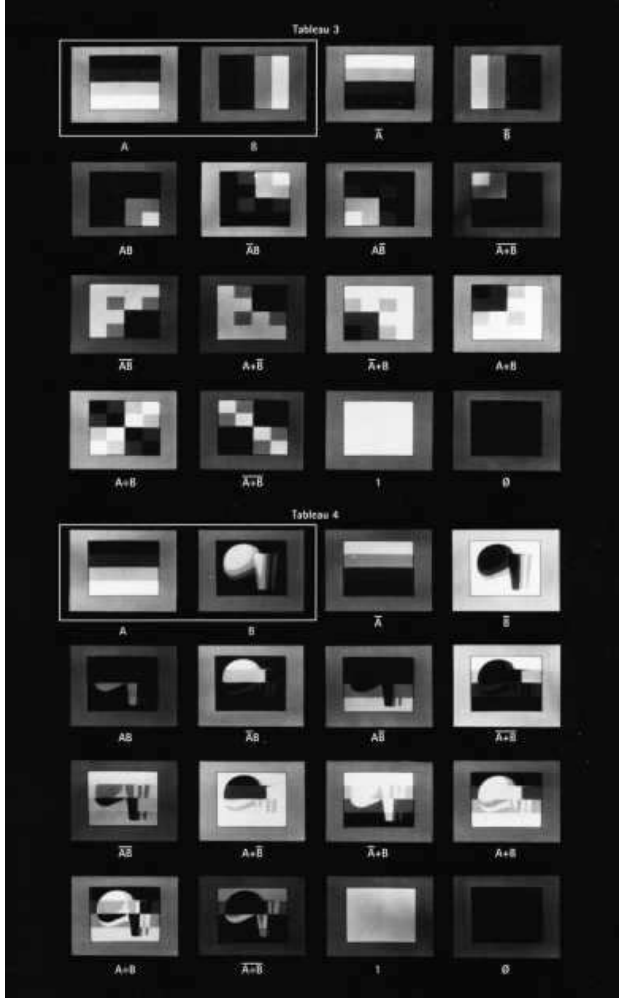
Woody Vasulka transforms in "C-Trend" (1974) driving cars into disturbed sinus waves. Street scenes were recorded with a camera placed in a window. The recordings are "scanned again" and are "modulated" in the "Rutt/Etra Scan Processor" via "retiming and repositioning" with "deflections" whilst the sound is reproduced unchanged. 60 The staggered wave lines facilitate observers to structure them visually in a spatial manner as the layers are successively arranged behind each other: Disturbances in multiple layers appearing simultaneously or following in short distances one after another provoke the impression of moving bodies. Because the recorded driving cars are not easily recognisable, an "intermediate sphere" ("Zwischenreich") appears situating the recognition of moving objects between still recognisable recordings and already constructed images. When the black background is substituted by "video `noise´", then it is "created by blackout intervals which normally fill the `gap´ between the scanning of singular fields." 61



Vasulka, Woody: Artifacts, video, 1980.

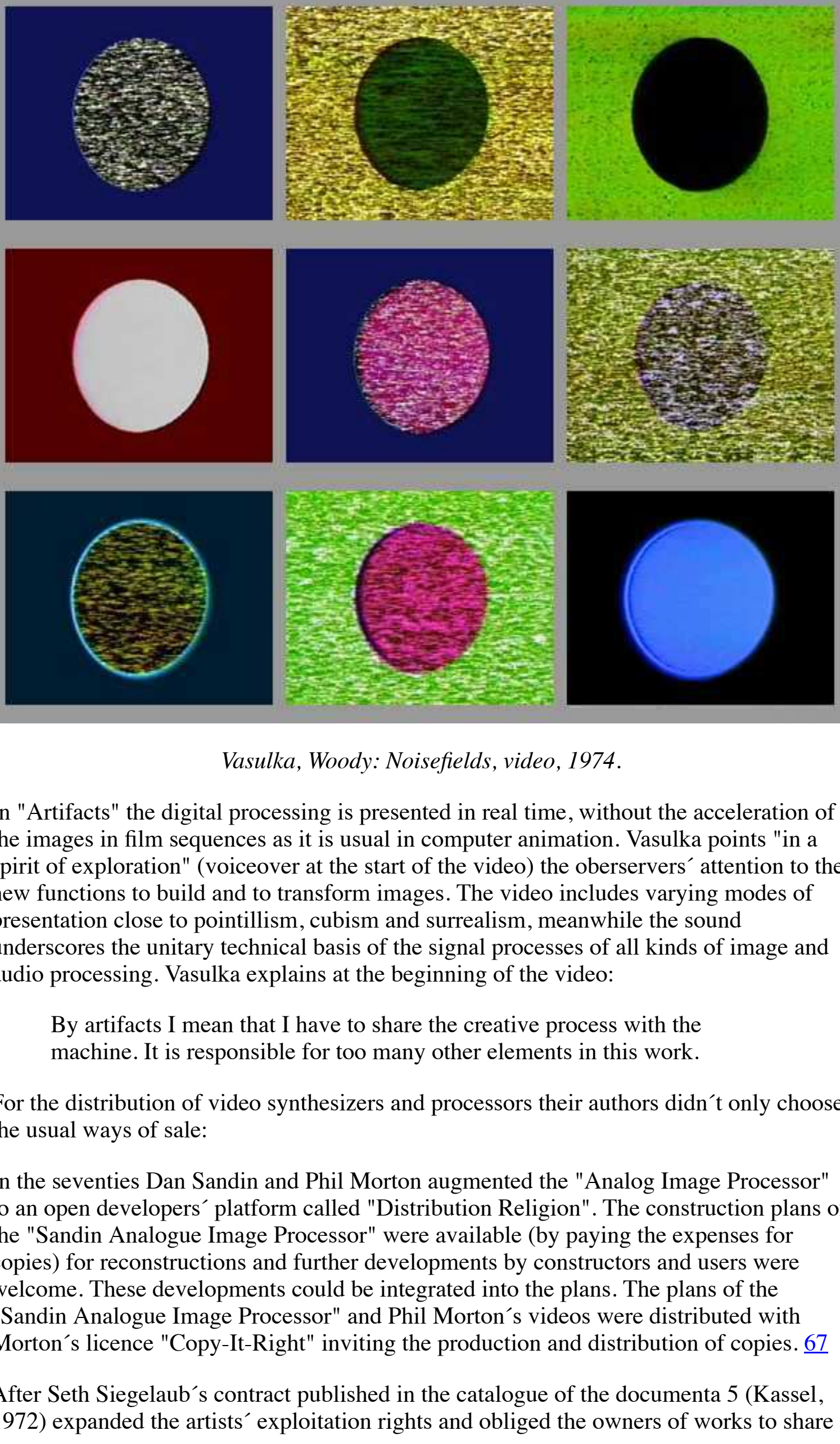
Woody and Steina Vasulka bought a minicomputer DEC LSI-11 (since 1975), a version of the PDP-11 (PDP-11/03). When their student Jeffrey Schier developed concepts, how to use the minicomputer in video image processing, he initiated the construction of the "Digital Image Articulator" (1976-77). 62 The result of the programming can be seen and corrected without a recognisable time delay. The "Digital Image Articulator" processes images by combining rectangular basic elements: The partition into discrete basic components substitutes the waveforms of the "Rutt/Etra Scan Processor". Woody Vasulka constructs in "The Arithmetic Logic Unit (ALU)" the relations between discrete elements "A" and "B" in following the Boolean algebra. 63 The new structure creates "unusual patterns of color and box-like textures without equivalence in analog video". 64 In 1980 Woody Vasulka demonstrates that in "Artifacts": The structure is relatively rough and appears today again relatively uncommon. The creation of super-signs and textures with microstructures built by rectangles alternately attract the observer´s attention. An optical flicker constituted by discrete elements forms recognisable formations again and again in the course of the film. 65





Vasulka, Woody. Left: Didactic Video, Tableau IV, 1975 (Vasulka/Nygren: Video 1975, p.13), demonstration of the Rutt/Etra Scan Processor.
Right: Syntax of Binary Images, Tableau 3 & 4, 1978 (Vasulka/Weibel: Buffalo 2008, p.423), demonstration of the relations between the discrete elements "A" and "B" in "The Arithmetic Logic Unit (ALU)".

In "Artifacts" Woody Vasulka demonstrates the differences between the analogue image processing of the "Rutt/Etra Scan Processor" and the digital image processing of the "Digital Image Articulator" by picking up a hand as subject again that he used earlier to demonstrate the video vocabulary made possible by the "Rutt/Etra Scan Processor": "Tableau IV" of his text "Didactic Video" (1975) presented four transformation phases of a hand. The hands appeared in concave and convexe reliefs built by the waveforms in inclined planes constituted by staggered horizontal lines. In contrary, a hand is presented in "Artifacts" on a sphere whose outline is multiplicated meanwhile the surface of the hand is dissipated into optical flicker. In a comparison with an earlier video it becomes easier to recognise that the flicker elements in "Artifacts" are rectangles and not flickering signals as in "Noisefields" that was realised in 1974 with analogue video tools: In both videos a circle is raised from the ground and then again merged with it, but in "Noisefields" the circular outline given by the video input remains preserved also and especially in positive-negative inversions, meanwhile in "Artifacts" the circle forms can be recognised sharper or weaker because their outlines are constituted and dissipated by combinations of rectangles. "Electronic Snow" is in "Noisefields" the basis of audio noise as well as of visual flickering. 66



Vasulka, Woody: Noisefields, video, 1974.

In "Artifacts" the digital processing is presented in real time, without the acceleration of the images in film sequences as it is usual in computer animation. Vasulka points "in a spirit of exploration" (voiceover at the start of the video) the oberservers´ attention to the new functions to build and to transform images. The video includes varying modes of presentation close to pointillism, cubism and surrealism, meanwhile the sound underscores the unitary technical basis of the signal processes of all kinds of image and audio processing. Vasulka explains at the beginning of the video:

> By artifacts I mean that I have to share the creative process with the machine. It is responsible for too many other elements in this work.

For the distribution of video synthesizers and processors their authors didn´t only choose the usual ways of sale:

In the seventies Dan Sandin and Phil Morton augmented the "Analog Image Processor" to an open developers´ platform called "Distribution Religion". The construction plans of the "Sandin Analogue Image Processor" were available (by paying the expenses for copies) for reconstructions and further developments by constructors and users were welcome. These developments could be integrated into the plans. The plans of the "Sandin Analogue Image Processor" and Phil Morton´s videos were distributed with Morton´s licence "Copy-It-Right" inviting the production and distribution of copies. 67

After Seth Siegelaub´s contract published in the catalogue of the documenta 5 (Kassel, 1972) expanded the artists´ exploitation rights and obliged the owners of works to share

future income with their creators 68, Dan Sandin and Phil Morton choose the opposite strategy by eliminating the restrictions that have been installed via copyright and the contracts for the distribution and further developments.

Dan Sandin´s practice to disseminate the construction plans of his "Analog Image Processor" and the commercial distribution of the Rutt/Etra Scan Processor are counter-models. This opposition continues to determine the discussions on copyrights until today. Sandin wrote:

> The Image Processor may be copied by individuals and not-for-profit institutions without charge, for-profit institutions will have to negotiate for permission to copy.

Nowadays the alternative propositions to use copyrights published by Creative Commons offer authors ways to announce how they differentiate between releases of restrictions for non-commercial users and restrictions for commercial users of their files. Permissions for non-commercial multiplications and distributions can be announced via links to the relevant propositions of the site "Creative Commons". Then the determination of the amount of fees for commercial distributions remains a task of negotiations with the author. 69

The video practice of the activists and the experimental filmmakers continues the development of alternatives to the role play in movies. This development was driven by the experimental filmmakers of the fifties and sixties in frame-by-frame animation procedures. The camera as a reproducing technology and image creating procedures constitute the opposite ends of a scale. In the sixties these both ends of the scale of experimental filmmaking can be found in films realised by people of Andy Warhol´s factory ("Sleep", 1963 and others) on one side and on the other side in structural films by Peter Kubelka ("Arnulf Rainer", 1958-60), Tony Conrad ("The Flicker", 1966) or Paul Sharits ("Ray Gun Virus", 1966). 70 The camera fixated at a static place in Warhol´s Factory is substituted in the seventies by the mobile video equipment of activists and the self-presentation of actresses or actors in front of the camera is transformed into a critical self-embedding of the filmmaking and filmed persons into their social context. Warhol´s negation of a director-dependent language is substituted by renewed forms of film documentations and TV news. The cutting procedures for the combination of frames in structural films substitute the authors of experimental videos by tools directing the motions of electron beams in the cathode ray tube. This causes in "Noise Fields" a change in the function and meaning of the "flickers" being produced in structural films by the thematisation of film as material via filmcuts and the combination of frames. The criticism of the cinematic film language by non-narrative film forms is augmented by the video practices to a television criticism (see chap. IV.1.1). "Commercial broadcast" appears reduced in forms and contents if it is compared to the explored possibilities of video technology.

On the one hand the constructors of video tools developed new means of production and partially they demonstrated themselves the possibilities to develop a video-specific film language. On the other hand the video activists used the video camera as a means to create critical statements and broadcasted the documents produced by the persons living under the criticised conditions or sent copies on videocassettes. On the experimental side the signal processes were central, on the activist side the mobile camera. The experiments with the new medium resulted in new means of production and new methods to distribute these means ("Distribution Religion", see above), meanwhile the media activists thematised the contemporary social conditions by utilising available means of production and the distribution of the results (Community TV, see chap. IV.1.1)

in uncommon ways.

Annotations

1 Russett/Starr: Animation 1988, p.32-177. back

2 Dunn/Vasulka/Weibel: Eigenwelt 1992; Miller Hocking: Principles 1978; Russett/Starr: Animation 1988, p.178-210; Spielmann: Video 2008, p.46-57,89-112. back

3 Dunn/Vasulka/Weibel: Eigenwelt 1992, p.96-103. back

4 Sony CV/VCK 2000, since 1965: without author: Sony CV 2000 (undated); without author: Sony CV Series Video (undated); Sherman: Birth 2007. back

5 On the Sony Porta Pak video equipment and its different meanings for activists as well as experimental filmmakers: Vasulka: Sony CV Portapack 1992.
Sony CV 2400 Porta Pak, since 1968: without author: Sony DVK-2400/VCK 2400 (undated); Miller Hocking: Texts 1992.
Sony Porta Pak AV 3400, since 1969/70: Bensinger: Video 1981, p.157ss.,161,164,166s.,172,174; without author: SONY AV-3400 PORTA PAK (undated). back

6 Murphy: Television 1997, chapter "Local Television News Archives": "In the mid-1970's, a period marked by the transition from 16mm news film to 3/4-inch U-matic cassettes, about 700 commercial television stations were operating in the United States. Less than 10% of the stations transferred their news film to public archives. The rest was mostly destroyed." back

7 without author: Program Guide 1972, unpaginated: "In issue one, volume one of Radical Software (Summer, 1970) we introduced the hypothesis that people must assert control over the information tools and processes that shape their lives in order to free themselves from the mass manipulation perpetrated by commercial media in this country and state controlled television abroad. By accessing low cost 1/2" portable videotape equipment to produce or create or partake in the information gathering process, we suggested that people would contribute greatly to restructuring their own information environments: YOU ARE THE INFORMATION...Through such decentralization of the information medium, we asserted that the overall information environment of this country could be humanized and revitalized." back

8 Stoney, George: First Transmission of ACTV, Video, b/w, sound, 8 min., 1972. back

9 Video, 4 min. 23 sec., b/w, sound, in: Nadeau: Medium 2006, p.53,57-62; Youngblood: Cinema 1970, p.343s. back

10 Barzyk, Fred: The Medium is the Medium, WGBH-TV, Boston, 3/23/1969: Nadeau: Medium 2006, p.34-72.
Paik, Nam June: Electronic Opera #1, WGBH-TV, Boston, 3/23/1969: Decker: Paik 1988, p.150,152,193,200, ill.99; Fifield: Paik/Abe Synthesizer 2000; Joselit: Feedback 2007, p.48s.; Nadeau: Medium 2006, p.64-67; Youngblood: Cinema 1970, p.306. back

11 Paik/Abe Synthesizer at the WGBH-TV, Boston: Decker: Paik 1988, p.151; High: Mods 2014, p.367. Previously the broadcast WNET (Channel 13 in New York City) is said to have bought a prototype (without author: Paik-Abe Video Synthesizer (undated)).

Paik, Nam June/Atwood, David: Video Commune – The Beatles from Beginning to End, WGBH-TV. Video, 8 min. 36 sec., colour, silent, 1970 (film documentation: Yud Yalkut, 1972-92): Decker: Paik 1988, p.152; Fifield: Paik/Abe Synthesizer 2000. back

12 VanDerBeek, Stan: Violence Sonata, WGBH-TV, Boston, 1/12/1970: Davis: Art 1973, p.90; without author: Vanderbeek (undated); O´Grady: Vanderbeek 1970. Knowlton, Kenneth/VanDerBeek, Stan: Poem Fields, 1964, in: Auzenne: Visualization 1994, p.29s.,45; Youngblood: Cinema 1970, p.246-249; see chap. IV.2.1.2.
More experiments with participation TV:
Davis, Douglas: Electronic Hokkadim, WTOP-TV, Washington D.C., 6/12/1971. In: Ross: Davis 1972, unpaginated; Deecke: Davis 1978, p.7.
Davis, Douglas: Talk Out: A Telethon, WCNY-TV, Syracuse/New York, 12/1/1972. In: Davis: Talk Out 1973; Deecke: Davis 1978, p.6ss.,17,96; Torcelli: Video 1996, p.24. back

13 Paik: untitled 1971. back

14 Gigliotti: History 2003; Joselit: Feedback 2007, p.93-99. back

15 "Consciousness industry"/"Bewußtseins-Industrie": Enzensberger: Aporien 1962/1980, p.60,68,73; Enzensberger: Baukasten 1970/1997, p.97-101,106s.
"Participatory democracy": Hill: Attention 1996, p.2 with ann.8 (with reference to: Students for a Democratic Society (SDS): Port Huron Statement, 1962). back

16 as, f.e., in "ANIMAC" (1959/60), "SCANIMATE" (1969) and the "Rutt/Etra Scan Processor" (1973, see below).
Furthermore in "video feedback" the result presented on the monitor of a video synthesizer equipment is recorded with a camera. These recordings are led back to the video synthesizer for further processings. (Jones: Synthetics 2011, p.205ss.) back

17 Bute: Abstronics 1954 (quotations).
Naumann: Sound 2009, p.48: Ralph K. Potter "designed a custom-built device through whose buttons and switches she could influence the emerging Lissajous curves, changing their position, speed, and brilliance, as well as creating an impression of three-dimensionality." Cf. Betancourt: History 2013, p.88s.; Kane: Algorithms 2014, p.132; Naumann: Sound 2009, p.48ff.; 279f.; Zinman: Circuit 2012, p.140s. Oscillographs were used in productions of film animations by Hy Hirsh ("Divertissement Rococo", 1951; "Eneri", 1953; Come Closer, 1953. Lit.: Betancourt: History 2013, p.140) and Norman McLaren (Around Is Around, 1951, with Evelyn Lambart; Naumann: Sound 2009, p.279). For the first half of the fifties the author knows no other use of custom-built oscillographs in productions of animations than the one by Mary Ellen Bute. back

18 Franke: Grafik 2014 (quote); conversation with Herbert W. Franke, 8/13/2014 in Pupling nearby Egling/Bavaria, and e-mails, 8/17/2015 and 8/21/2015 (quotes).
Oscillograph: constructed by Siemens (and called "Vorführgerät"/"demonstration device") with a sharpening screen, diameter between 10 and 12 centimeter. Among others the oscillograph made by Siemens was used for the "presentation" of "alternate current". The sharpening screen enabled Franke to place lines "so near to each other" causing the effect to receive "light-dark transitions". These transitions were not possible with the oscillograph used before (see chap. III.2.1) because of its "thick drawn lines" (Franke, e-Mail 8/17/2015). back

19 «Luminoscope I», 1959. In: Cassou/Habasque/Ménétrier: Schöffer 1963, p.86 (quotations).
Variations luminodynamiques 1, 1961. Film, 16mm, b/w, sound. Collection Centre

Pompidou, Paris. In: Cassou/Habasque/Ménétrier: Schöffer 1963, p.86-89. Thanks to Jean-Noel Montagné for directing my attention to Schöffer´s videographic experiments. back

20 According to Jeffrey Schier the "ANIMAC was developed in the early 1960´s" (Schier: Scan Processors 1992, p.94), but Walter Funk mentions the turn of the year 1959/60 (see above) as the date, when the "first version" was realised, but he does not indicate any document as proof (Funk: Animac 2010, p.53). Further Lit.: Funk: Animac 2010, p.53s.,58 (quotations); Harrison: We 1992; Schier: Scan Processors 1992, p.93ss.; Smith: Computers 1974, p.149; Youngblood: Cinema 1970, p.200. back

21 See the manipulations of television sets, esp. cathode ray tubes, by Nam June Paik (television set with distorted images on monitors in the exhibition "Exposition of Music – Electronic Television", Gallery Parnass, Wuppertal, March 1963; Magnet TV, 1965) and Wolf Vostell (television set with distorted images on monitors in the exhibition "TV Decollage", Smolin Gallery, New York, Mai 1963; Sun in Your Head, Film, 1963).
In the early sixties Stan Ostoja-Kotkowski manipulated a television set for the first time, and in 1962 he found an engineer (Malcolm Kay?) at the Philips Research Laboratories in Hendon/South Australia constructing a device with oscillators for his needs to control the electron beams in the cathode ray tube of a television set. In July 1964 Ostoja-Kotkowski exhibited the "electronic drawings" realised with this device for the first time at the Argus Gallery in Melbourne (Jones: Synthetics 2011, p.126-129,131s. with fig.5.8ss.; Meigh-Andrews: History 2014, p.10s.,14). back

22 Meigh-Andrews: History 2014, p.135; Zinman: Circuit 2012, p.146s. back

23 Meigh-Andrews: History 2014, p.135,209-212; Youngblood: Cinema 1970, p.331-334; Zinman: Circuit 2012, p.147. back

24 Robert Cahun 2005. In: Meigh-Andrews: History 2014, p.138. back

25 Meigh-Andrews: History 2014, p.137f. Furthermore, Meigh-Andrews mentions Dominique Belloir, Olivier Debré and Piotr Kamler as artists having used the «Truqueur Universel» to create videos. Other artists: Jean-Paul Cassagnac, Peter Foldes, Martial Raysse (Langlois: Schaeffer 2010). back

26 Youngblood: Cinema 1970, p.314ss. Meigh-Andrews: History 2014, p.138s.; Kane: Algorithms 2014, p.71-74. back

27 Hill: Siegel 1996. back

28 Betancourt: History 2013, p.167ss.; Funk: Animac 2010, p.53s.,58 (quotations); Harrison: We 1992; Youngblood: Cinema 1970, p.200; Schier: Scan Processors 1992; Smith: Computers 1974, p.149,151s. back

29 Scape-Mates: 28 min. 16 sec., colour, sound, in: Russett: Robert: Interview Ed Emshwiller (1974). In: Russett/Starr: Animation 1988, p.207; Spielmann: Video 2008, p.92.
In chroma keying an image layer with only one colour range is substituted by a filmed overlay. Objects which move before the image layer for chroma keying remain unchanged. Television presenters can walk before a film projection substituting a studio wall painted blue for chroma keying. back

30 without author: Scape-mates (undated). back

31 Youngblood: Cinema 1970, p.194: "...at a rate of 100,000 per second within a field of 16.000 possible xy coordinates". back

32 "Transformation image"/"Transformationsbild": Spielmann: Video 2008, p.4s.
On the cathode ray tube as a display for vector and raster images: Johnson: Synthetics 2011, p.40,43s.
Magnetic tape, first video cassettes: Sony U-matic, since 1971. In: Bensinger: Video 1981, p.131-145. back

33 Schier: Paik-Abe Video Synthesizer 1992. Cf. Betancourt: History 2013, p.163-167; Decker: Paik 1988, p.150s.; Furlong: Notes [1] 1983, p.36 with ann.13; High: Mods 2014, p.365ss.; Joselit: Feedback 2007. p.47-50; Spielmann: Artists 2014, p.518s.; Spielmann: Video 2008, p.98ss. back

34 Schier: Eric Siegel EVS Synthesizer 1992. back

35 Yalkut: Electronic Video Synthesizer 1977/78. Cf. Dolanova/Vasulka: Vasulka 2014, p.286. back

36 Furlong: Notes [1] 1983, p.36; Sturken: TV 1984, p.8. back

37 Buchla Synthesizer: Buchla 100 Series, 1964, in: Dunn/Vasulka/Weibel: Eigenwelt 1992, p.96-99. back

38 Description of the modules, in: Schier: Direct Video Synthesizer 1992, p.124s. back

39 Beck: Beck Direct Video Synthesizer 2000; Beck: Music (undated); Beck: Video (undated); Furlong: Notes [1] 1983, p.37. Beck and Jepson used video projectors of the type "Eidophor GE Light Valve" in performances of "Illuminated Music 2 & 3". back

40 Dan Sandin in "5 Minutes Romp thru the IP", 1973, video, b/w, sound, 3 min. 52 sec. In: URL: http://www.youtube.com/ watch?v=8qh6jRzjmcY (12/17/2011). back

41 Dan Sandin, in: Morton, Phil/Sandin, Dan/Wiseman, Jim: In Consecration of a New Space. A Color Video Process. Information sheet, 1/26/1973. Cited from: Spielmann: Video 2008, p.99s. with ann.69. back

42 Schier: Image Processor 1992. Cf. Miller Hocking: Grammar 2014, p.461; Spielmann: Artists 2014, p.507s. back

43 Dan Sandin 2004. In: Spielmann: Video 2008, p.99s. with ann.69. Cf. Dolanova/Vasulka: Vasulka 2014, p.289s. back

44 Brown, George: Multikeyer, 1973. In: Dolanova/Vasulka: Vasulka 2014, p.288; Schier: Multi-Level-Keyer 1992; Spielmann: Video 2008, p.103s., 200. back

45 Magnenat-Thalmann/Thalmann: Computer Animation 1990, p.31,33. back

46 Sturman: State 1998. back

47 Cates: Ryral 2009. back

48 Siedler: Spectre undated. back

49 Monkhouse: Art 1974, p.22: "Signals on this patchboard are carried in digital form because crosstalk problems at video frequencies make an analog patchboard well nigh

impossible." back

50 Siedler: EMS undated. back

51 Monkhouse: Art 1974, p.22ss. back

52 EMS: User undated. back

53 EMS: User undated; Monkhouse: Art 1974, p.23,26 (quotes); Siedler: EMS undated (quotes); Siedler: Spectre undated (quotes); Jeffrey Siedler, e-mail, 8/25/2015 (quotes). back

54 Siedler: Secrets undated; Jeffrey Siedler, e-mails, 8/18/2015 and 8/25/2015 (quotes). back

55 Warren Burt: Five Moods (3x4x) (for Ned Sublette), 1979; Return to Uranus (after Ruggles) Veils 2, 1979; Watermusic Dazzler (after Monk), 1979, Georgeous Formalisms (Even 5 More Moods, Yet), 1979. Robert Cahen: Sans titre, 1977; L´Eclipse, 1979; Trompe l´oeil, 1979; L´ent´apercu, 1980. Richard Monkhouse: Shine on You Crazy Diamond, 1977; Transform, 1978. Plastic Bertrand: Ca plane pour moi, 1978 (Meigh-Andrews: Donebauer 2007, S.464; Meigh-Andrews: History 2014, S.158f. I would like to thank Jeffrey Siedler for informations about artists using the "EMS Spectron", for the mailing of documents and for corrections). back

56 The "Rutt/Etra Scan Processor":
– in Nam June Paik´s Videos: Spielmann: Video 2008, p.154s. (on "Global Groove", 1973); Spielmann: Video 2009, chap.4.
– in Steina and Woody Vasulka´s Videos: Spielmann: Video 2009, chap.4; Hatanaka/Koizumi/Sekiguchi: Vasulka 1998, p.14ss.,21,34,42,46,48; see below.
– in Gary Hill´s Videos: Broeker: Hill 2002, p.96-99; Furlong: Manner 1983, p.13 (on "Videograms", 1980-81, and "Happenstance (part one of many parts)", 1983); Spielmann: Video 2008, p.108s.; Spielmann: Video 2009, chap.4. back

57 Cited in Miller Hocking: Rutt/Etra 1986. back

58 Miller Hocking: Grammar 2014, p. 458,460; Miller Hocking: Rutt/Etra 1986; Rutt: What 1992; Rutt/Etra: RE Video Synthesizer Systems Models RE 4A and RE 4B 1974; Schier: Rutt/Etra 1992; Spielmann: Artists 2014, p.519ss.; Vasulka/Nygren: Video 1975, p.9. back

59 Schier: Rutt/Etra Scan Processor 1992, p.139. Cf. Spielmann: Video 2008, p.205. back

60 Spielmann: Video 2008, p.204s. back

61 Dolanova/Vasulka: Vasulka 2014, p.291. Cf. Meigh-Andrews: History 2014, p.152. "Zwischenreich": Klee: Denken 1964, p.91s.,313. back

62 In 1980 Steina Vasulka documented the development of the "Digital Image Articulator" in the video "Cantaloup", in: Hatanaka/Koizumi/Sekiguchi: Vasulka 1998, p.20; Vasulka/Weibel: Buffalo 2008, p.496s. back

63 Vasulka/Hagen: Syntax 1978. back

64 Schier: Digital Image Processor 1992, p.145. back

65 Furlong: Notes [2] 1983, p.16; Spielmann: Artists 2014, p.516s.; Spielmann: Video 2008, p.207s.; Vasulka/Weibel: Buffalo 2008, p.448s.,452s.
In 1979 the video "Bad" presents an utilisation of the "Digital Image Articulator", that was done before "Artifacts" was realised: Spielmann: Video 2008, p.208s. with ill.104; Vasulka/Weibel: Buffalo 2008, p.496s. back

66 "Didactic Video", "Tableau IV": Vasulka/Nygren: Video 1975, p.13.
On the digitalisation in "Artifacts": Dolanova/Vasulka: Vasulka 2014, p.296ss.; Spielmann; Video 2008, p.207s. with ill.121s.; Spielmann: Woody Vasulka 2004; Sturken: Artifacts 1996; Vasulka/Weibel: Buffalo 2008, p.461.
"Noisefields": Dolanova/Vasulka: Vasulka 2014, p.288; Spielmann: Video 2008, p.203s.; Spielmann: Video 2009, chap.4. back

67 Cates: Copying-It-Right 2008; Cates: Copying-It-Right 2014; Furlong: Notes [1] 1983, p.38; Sandin: Distribution Religion 1992; Sandin/Morton: Distribution Religion 2014; Schier: Image Processor 1992, p.134. back

68 Siegelaub: Artist´s Reserved Rights Transfer and Sales Agreement 1972. back

69 Sandin: Distribution Religion 1992 (quote); Sandin/Morton: Distribution Religion 2014. Cf. the choice of licenses offered by Creative Commons, in: URL: http://creativecommons.org/choose/ (12/22/2011). back

70 Hein: Film 1971, p.103,106; Hein: Structural Film 1979, p.96s.; Sitney: Film 1974, p.409ss.,424s.; Vasulka/Weibel: Buffalo 2008, p.315s.,542s. back

IV. Images in Motion
IV.2 Computer Animation

IV.2.1 The Development from the Sixties to the Eighties

IV.2.1.1 An Outline

The history of the digital computer animation starts in the sixties. The early computer graphics with configurations of lines representing three-dimensional bodies were mounted to construct film sequences "frame-by-frame". 1 The sixties and seventies were the pioneering years in the development of animation software for the programming of moving objects. This software was developed at universities in the U.S.A., for example at the Ohio State University and at the University of Utah. 2 In the eighties proprietary animation software was developed by and for commercial firms using it for 3D animations in sequences for movies and commercials as well as for TV spots and music videos.

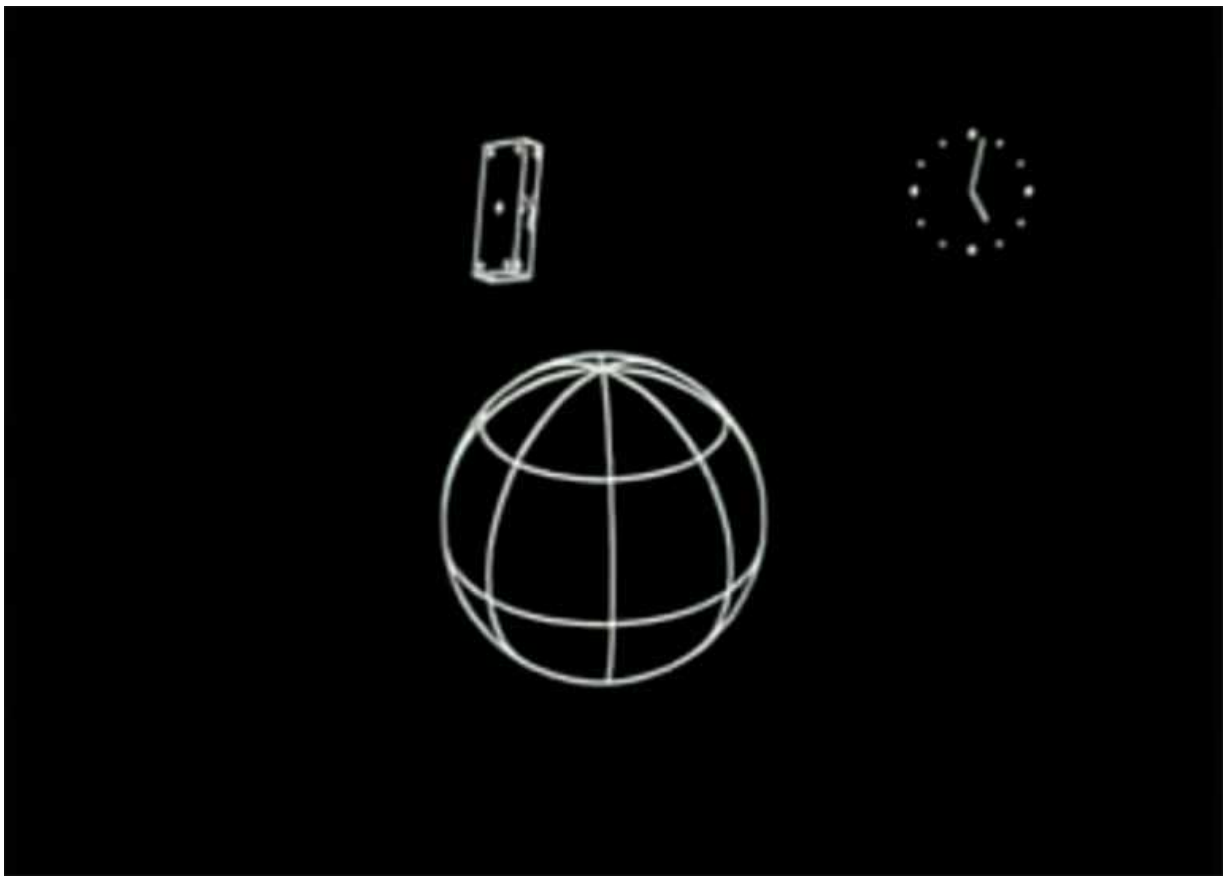
Since the early days of the demoscene in the eighties the creators present their animations on public demo-parties. In the demoscene the storing of images in a "frame-by-frame" procedure on carriers has been, was and is obsolete: Authors of demos generate moving combinations of texts and images by codes controlling the graphics cards of personal computers. The members of the demoscene communicated with each other about the programming. 3 Demo-codes were offered on bulletin board systems (see chap. VI.1.2) for download.

In the eighties mainframe computers were utilised to produce animations for film sequences according to the tasks presented by the storyboards for movies. Meanwhile the sequences for movies were realised by following the requirements of the plots, the creators of music videos combined techniques of computer animations with procedures used in experimental films and videos. Further alternatives to movies offered films by artists who partially took up some elements of the animation software developed in the seventies for mini- and microcomputers 4, and the demoscene. Its members competed with each other in demonstrations of their capabilities to develop real time animations for the limited technical possibilities of personal computers (A summary of the eighties´ developments offer the last three sections of chap. IV.2.1.4.3).

IV.2.1.2 The Sixties

In 1963 Edward E. Zajac constructed the first computer animation at the Bell Laboratories (Murray Hill/New Jersey). A box with edge lines gyrated round a sphere. The sphere should outline the earth and the box should represent a satellite gyrating round the earth. The satellite always turned only one of its sides to the earth: "Gyro gravity gradient attitude control system" was the film´s title and its content. The frames were programmed in FORTRAN and generated by a mainframe computer IBM 7090 (since 1959). A Stromberg-Carlson 4020 Microfilm Recorder (made by General

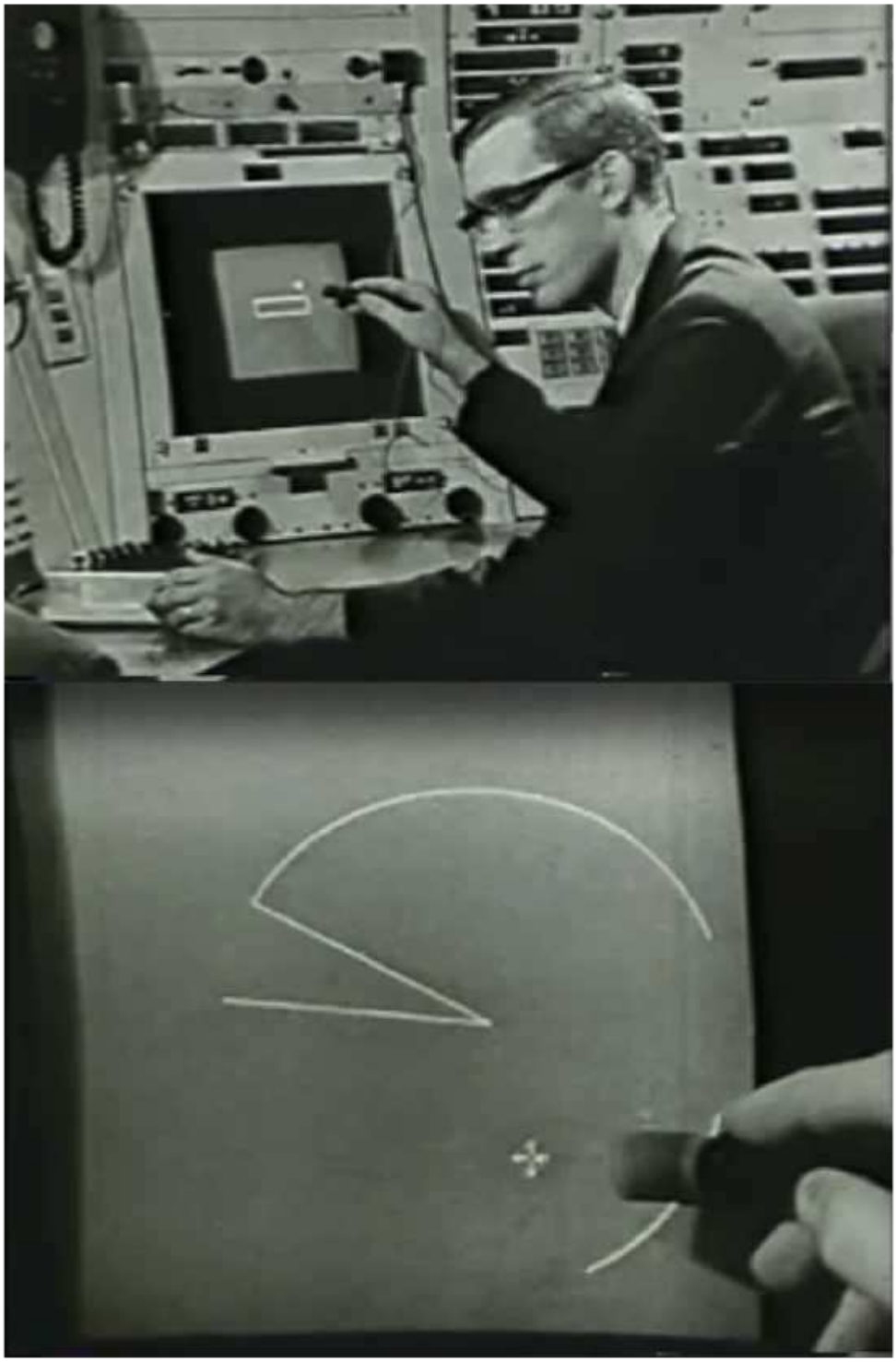
Dynamics/Electrics, San Diego/California, since 1959) presented and stored results. 5



Zajac, Edward E.: Gyro gravity gradient attitude control system, film, 1963. Bell Laboratories, Murray Hill/New Jersey.

In the following the development of two and three dimensional computer graphics are presented because they provided the preconditions for the developments of computer animation.

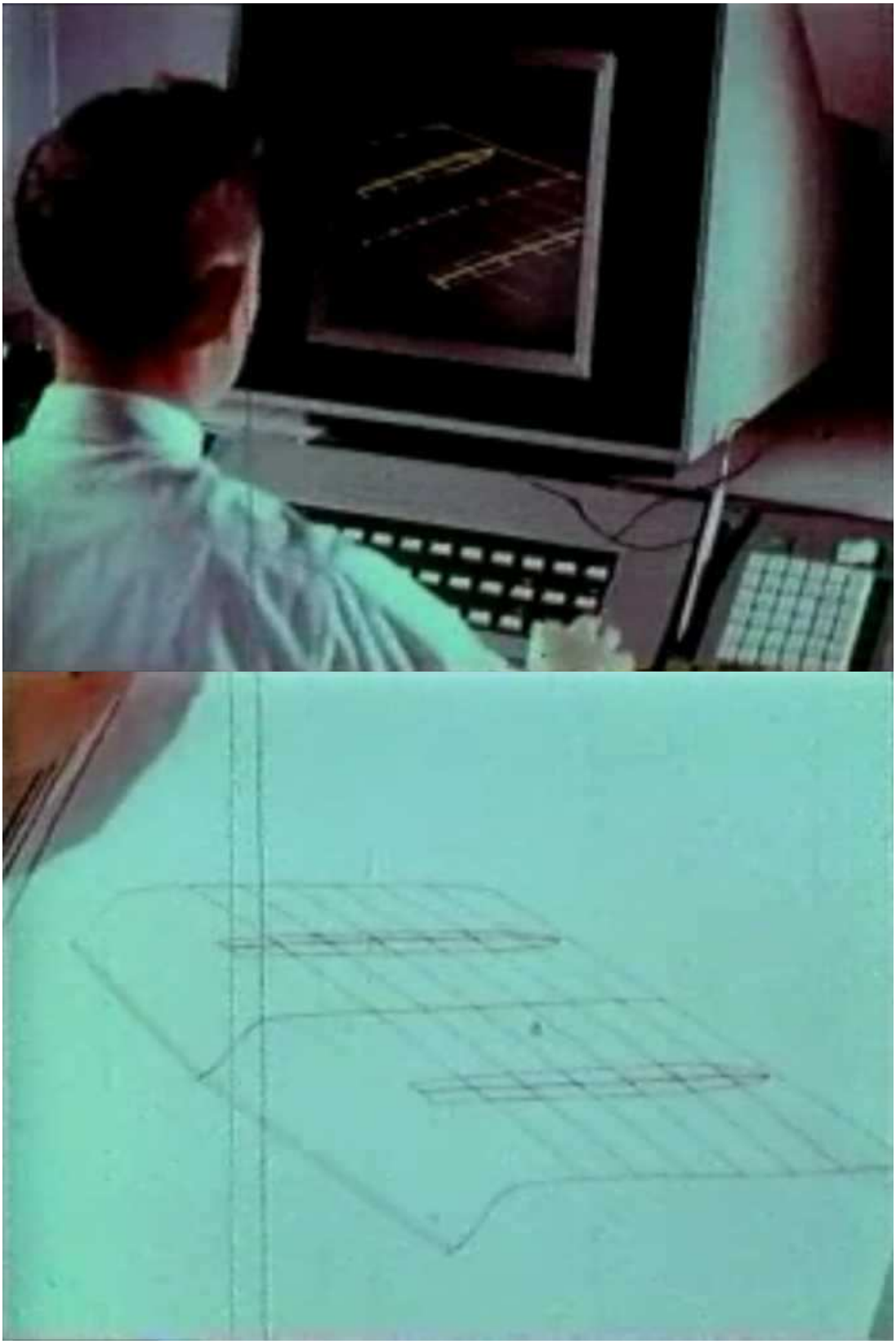
In 1963 Ivan Edward Sutherland presented "Sketchpad" in his dissertation: Points could be marked on a monitor. Then an analogue computer (Lincoln TX-2, since 1957) followed instructions to build either lines or circles between the points. For the choice of instructions a little box with knobs stood beside the computer´s manual. With "Sketchpad" it became easier to accomplish two-dimensional drawings or plans with many repeated or varied elements. Sutherland´s interface was planned to allow an easy application. 6 Beside Douglas Carl Engelbart´s research developments at the Stanford Research Institute "Sketchpad" was one of the early user-friendly human-computer interfaces (HCI, see chap. VIII.2).



Morash, Russell: [Ivan Edward Sutherland´s] Computer Sketchpad. National Educational Television. Filmed by WGBH-TV, Boston. Massachusetts Institute of Technology/Lincoln Laboratory. Lexington/Massachusetts 1964 (Screenshots from YouTube).

Since 1959 researchers at the General Motors Research Laboratories collaborated with IBM to develop software for three-dimensional Product Design. The computer language MAD (Michigan Algorithm Decoder) being developed out of ALGOL-58 was itself developed further together with the compiler to NOMAD ("Newly operational MAD"). The programming with DGL (Descriptive Geometry Language) simplified the use of the DAC (Design Augmented by Computers)-1 System (since 1963) in drafting processes. The programming language DGL consisted out of "Variables, constants, statements, branching, looping, subroutines, and parametrization in which INTERSECT, SMOOTH, and DISPLAY were just three of a large number of operational statements." A program with "DGL procedures" was feeded via punch cards into a computer (IBM 7094, since

1962). Then it was possible to start the drafting process by working with an electronic pen directly on the screen. DAC-1 could recognize the position of the electronic pen because a conductive material was applied on the screen.



General Motors Research Laboratories: DAC-1,
development of a boot lid, between 1965 and 1967.
Above: Graphics console with electronic pen.
Below: Printout. Stills from a film by GM Photographic.

The possibility to draw with the electronic pen on a vertical erected screen was not useable by ergonomic reasons. Nevertheless the manual of the DAC-1´s console used for

the control of the image processing was a remarkable step in the history of the CAD (Computer-Aided Design) development:

> ...the mode of operation was to program specific application-defined functions for each button on the keyboard.

Transparent shells on the manual´s keys made it possible to rename them if their functions have been changed. Then the developers´ team introduced icons on the screen. The icons marked programme applications. With a touch by the electronic pen on an icon a specific application was chosen.

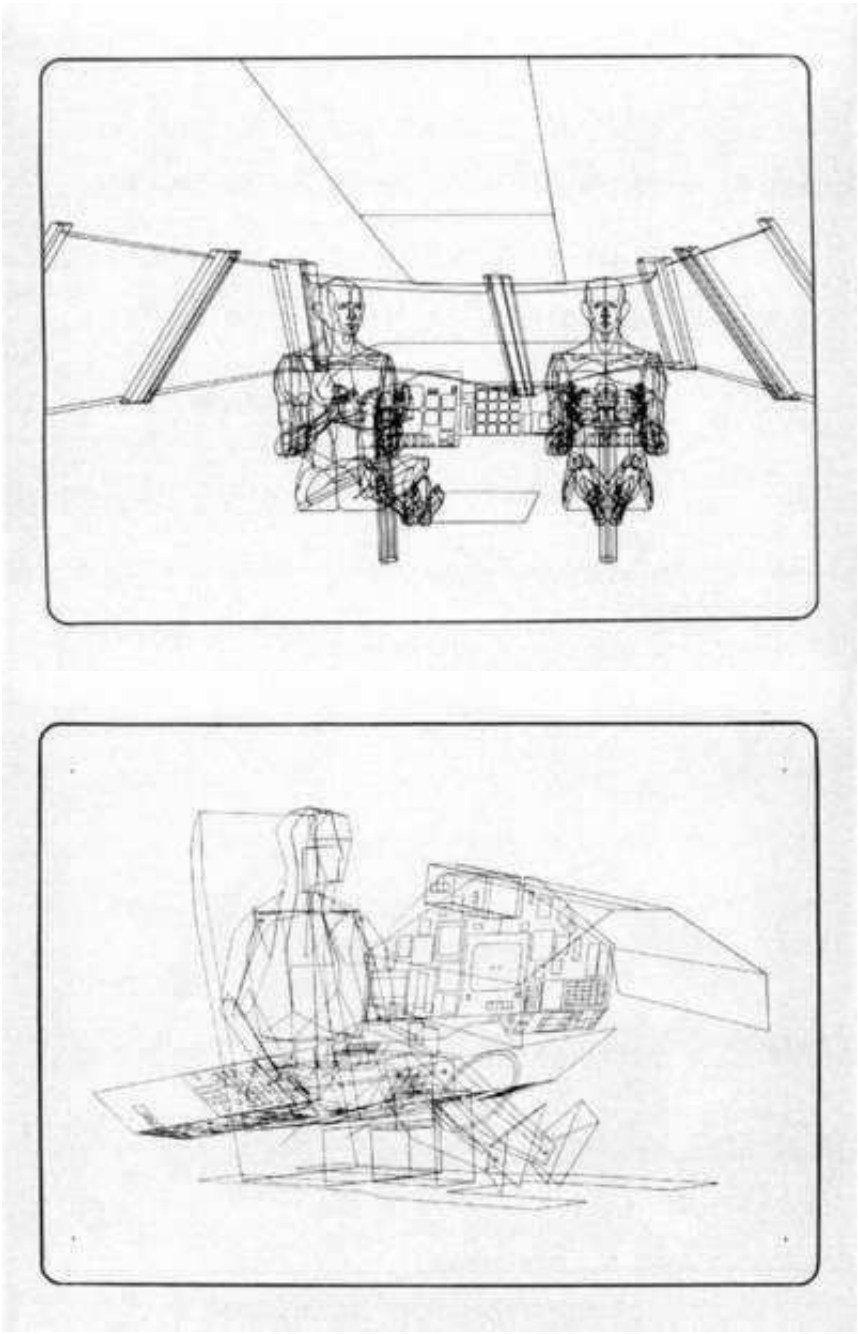
The graphic console of the DAC-1 was connected to the mainframe computer IBM 7094. Since 1965 the console could process three-dimensional objects as wire-frame presentations (with perspectival overlaps). The image processing programme for wire-frame models was based on points, lines and surfaces. Instead of formerly three axes were now five axes used for the localisation of each element. Nevertheless newer CAD programmes work out the localisations with only three axes.

The object could be rotated, and designers could zoom into it and out of it. The parts of the object being not relevant for the angle of a screen view could be cut off with a "no display" function (actually named "clipping"): These parts were not calculated in the processing of the screen view.

The menu offered icons for the functions "line overlay" and "surface overlay". "Surface overlay" was the term for the programmed elements used for the processing of the surfaces of a planned object.

DAC-1 offered a design system for the processing of objects by the development of codes for punching cards and by the subsequent corrections via numerical manual inputs of values for variables as well as via the light pen used to work directly on the screen. 7 The control of programmes for 3D objects via the coordination of input devices and screen views was realised in DAC-1 in a manner anticipating such coordinations in later projects.

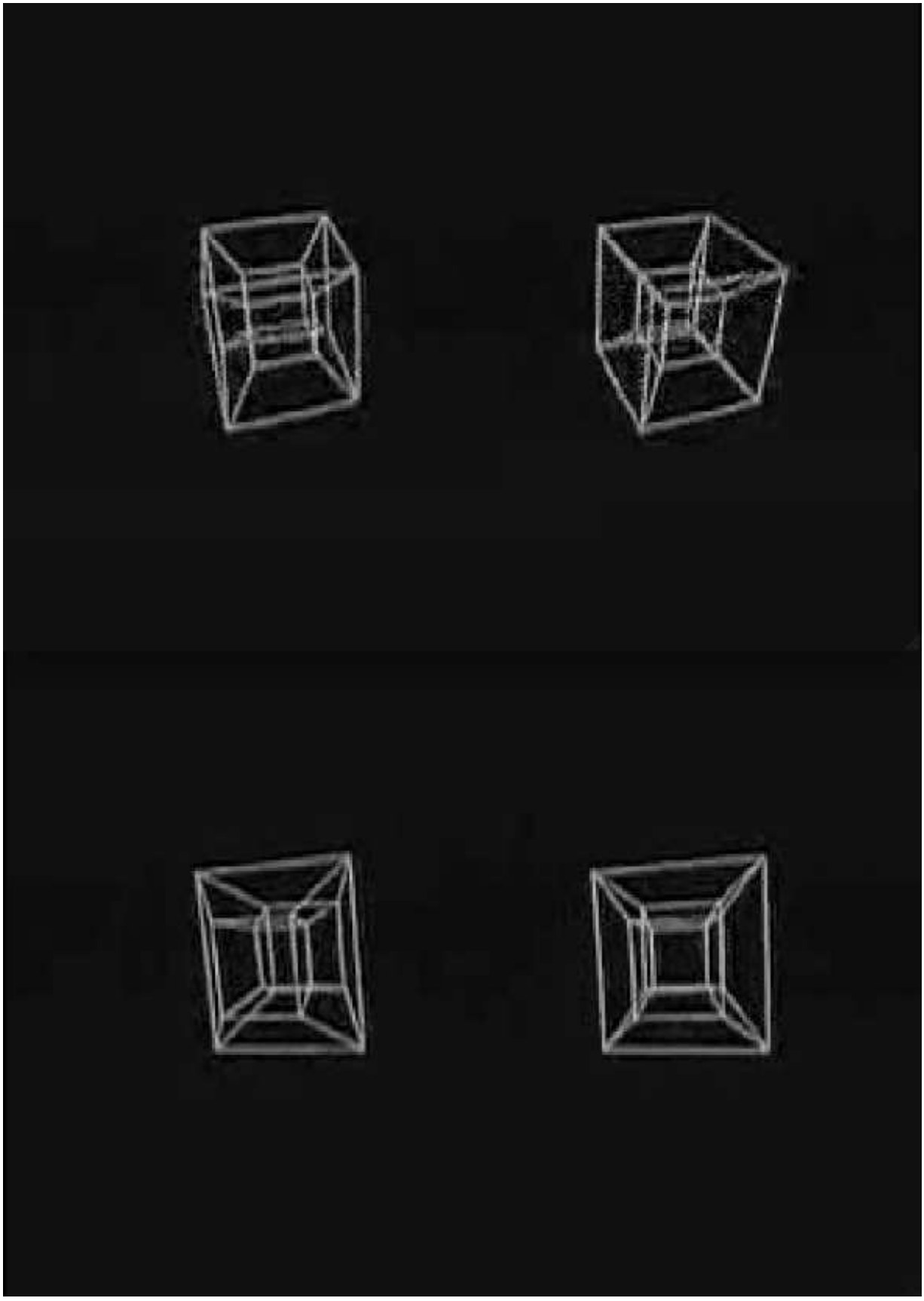
Sutherland´s "Sketchpad" and the interface of the graphics console for DAC-1 are early examples in the development of user-friendly interfaces for CAD. In the seventies Alan Kay´s research group at Xerox PARC (Palo Alto Research Center) took up the problem to design user-friendly interfaces to facilitate non-professional object-oriented programming. The menus with icons of DAC-1 not only reappeared in the Xerox Star (1981) but in the graphical user interfaces of the Apple Lisa (1983) and the Apple Macintosh (1984), too. 8 The mouse (see chap. VIII.2) superseded the electronic pen. The electronic pen reappeared in CAD systems´ graphic tablets for the ergonomic adequate fine-adjustment on a horizontal plane.



Fetter, William Allan/Boeing Aircraft Company:
Above: Fifty Percentile Human Figures Related to Cockpit.
Below: Twenty-Element Figure Placed in Cockpit Geometry.
Photo reproductions of plotter drawings representing humans in cockpits, between 1966 and 1969. Collection Clarissa, Sprengel Museum Hannover (Piehler: Anfänge 2002, p.315s., unpaginated with ill. 84,86).

In the early sixties three-dimensional graphics of human figures were developed by a department of the Boeing Aircraft Company (Seattle/Washington) directed by William Allan Fetter with the goal to ameliorate the cockpits of airplanes. The first graphical model of a human figure was processed by a mainframe computer IBM 7094 and consisted of lines marking the outlines of volumes without omitting the undercuts. Prints presenting wire-frame models of human figures were shown in exhibitions on computer art, for example in 1968 in "Cybernetic Serendipity" at the Institute of Contemporary Art in London. Further prints presented the human figures in three-dimensional line representations of cockpits. In 1966 the representations of cockpits were used as technical preconditions for the film "SST Cockpit Visibility Simulation" of eight minutes length. 9

From 1964 to 1965 A. Michael Noll realised films using a program of the Bell Laboratories. The stereoscopic films exposed one object in slightly displaced perspectives. A film realised in 1965 presented a four-dimensional hypercube as a rotating "cube-within-a-cube".



Noll, A. Michael: Hypercube, film, 1965. Bell Laboratories, Murray Hill/New Jersey. Two stills (among themselves) of the film presenting a turning four-dimensional hypercube with two views (horizontally next to each other) for stereoscopes.

The animation program could represent objects as lines connecting points. Three-dimensional objects were rotatable. The perspective (with overlaps) and the stereoscopic projection were constituted by programmed "formulas". The development of a sequence could be organized by instructions for transformations from one image to the next one. The program controlled the electronic beam of a cathode ray tube. Its screen was recorded by a 16 mm camera. 10

In 1964 Kenneth C. Knowlton developed BEFLIX (abbreviation for "Bell [Laboratories] Flicks"). The program was based on FORTRAN IV and made it possible to construct abstract films with mosaic patterns in using a mainframe computer IBM 7094 and a Stromberg-Carlson 4020 Microfilm Recorder. A coordinate system with a maximum of 252 x 184 "squares" made it possible to allocate grey values in eight levels to these elements. The grey values were coded with a 3 bit system. Among others, the system offered functions to connect points to construct lines, to draw curves as well as to copy and move fields. 11

The frames produced as described above became the fundament for the production of a master magnetic tape: A film laboratory repeated the frames as often as required by the planned time duration of a sequence. The then following presentation of the master magnetic tape in the Charactron cathode ray tube of the Stromberg-Carlson 4020 Microfilm Recorder was recorded by its camera being adjusted to transform discrete elements into "contiguous blobs of different intensities". 12 In a second step the colorization followed with other technical means.



VanDerBeek, Stan/Knowlton, Kenneth C.: Poemfield No.2, film, 1966, screenshots from YouTube.

In "Poemfield No.2" (1966) words and background patterns are dissolved again and again into entropic fields with a vast amount of elements before new calligraphic patterns and readable words arised. The program´s grid for the distribution of elements is used for the creation of patchwork rugs as well as for the production of patterns in the forms of letters. Typically for the ten films realised by Stan VanDerBeek with BEFLIX and the extensions developed by Knowlton for the artist is the "zig-zag character" of patterns. The black-and-white film produced with the use of a mainframe computer IBM 7094 and a Stromberg-Carlson 4020 Microfilm Recorder was projected by Vanderbeek onto a colour film. He commissioned Robert Brown and Frank Olvey to colour the frames "with a vibrant palette of red, green, and blue light". 13

For the film "Hummingbird" (Part 1/Part 2 1967) Charles Csuri and James P. Shaffer scanned the drawing of a bird with extended wings. The digitised drawing made by Csuri was cut up into lines. These lines were transformed by the program written in

FORTRAN. The transformations generated by a mainframe computer IBM 7094 were the results of modifications of the coordinates for height and length ("xy coordinates"). "Hummingbird" was realised with a 835 Microfilm Plotter of the California Computer Products Company (Calcomp). The film contains 14000 frames presenting configurations of lines changing step by step.



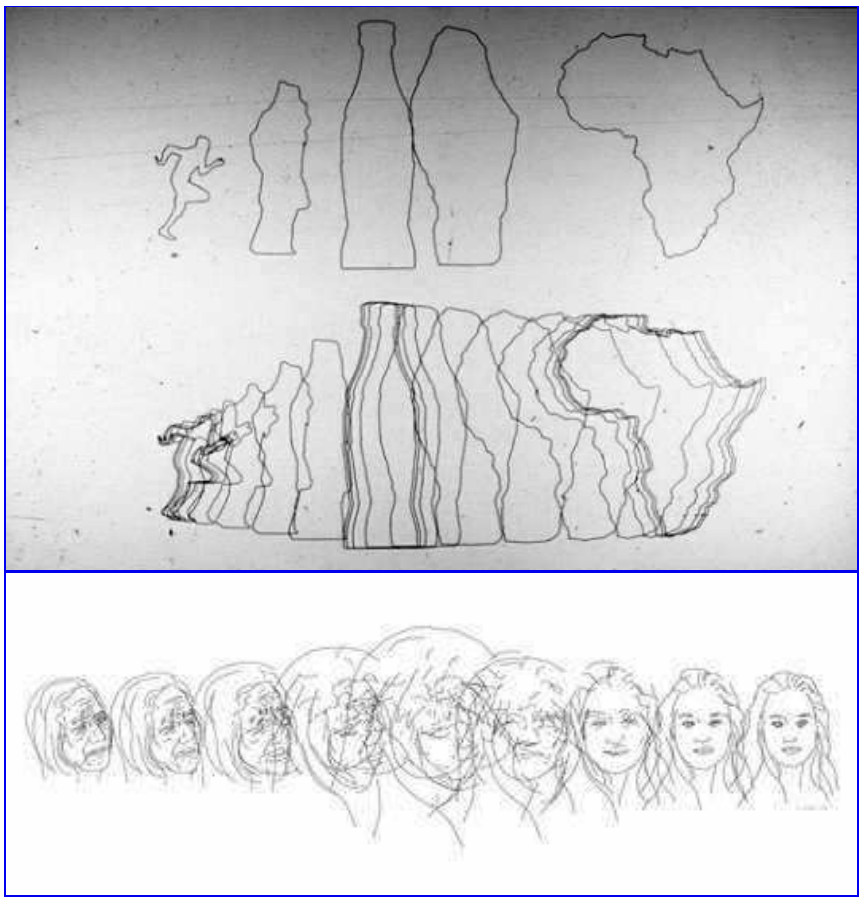
Csuri, Charles: Hummingbird, film, 1967, screenshot from YouTube.

The film doesn´t present a moving bird but the drawing gets a time dimension by the filmic construct: The drawing of the bird dissipates into lines sprawling and is put together again to the image of a bird with extended wings. The drawing becomes distorted and its size as well as its location within the frames are modified. 14

Meanwhile the examples from Zajac to Noll mentioned above are steps in the development of 3D simulations for CAD and films, the 2D digital film animations by Knowlton and Csuri showcased in the first case a software for bitmapping and in the second case a procedure for morphing: In two-dimensional animations both cases anticipated procedures being integrated later in three-dimensional digital animations.

IV.2.1.3 The Seventies

Today the conversion of an image into another image is called "morphing". The Computer Technique Group (CTG, 1967-69) presents in the computer graphic "Running Cola is Africa" (1967/68) the conversion of a runner first into a Cola bottle and then into Africa´s geographic outline. 15 Charles A. Csuri converted in "Aging Process" (1967) a girl into an old lady. 16



Above: Computer Technique Group (CTG): Running Cola is Africa, plotter drawing, 1967/68. Collection Computer Arts Society, London.
Below: Csuri, Charles: Aging Process, plotter drawing, 1967 (Glowsky: Csuri 2006, p.71).

In 1974 Peter Foldes received wider recognition for his two-dimensional animation "Hunger/La Faim", that takes over characteristics of cartoon films: Foldes used linear interpolation procedures developed by Nestor Burtnyk and Marcelli Wein to transform among others humans into cars, music stands into women, women into milk ice, crayons into food. 17

Since 1971 Burtnyk and Wein presented in several texts 18 the key-frame animation as a procedure to use the computer-aided interpolation of images to generate film sequences out of "key images". The manners of interpolation and the time intervalls ("key intervals") were selectable.

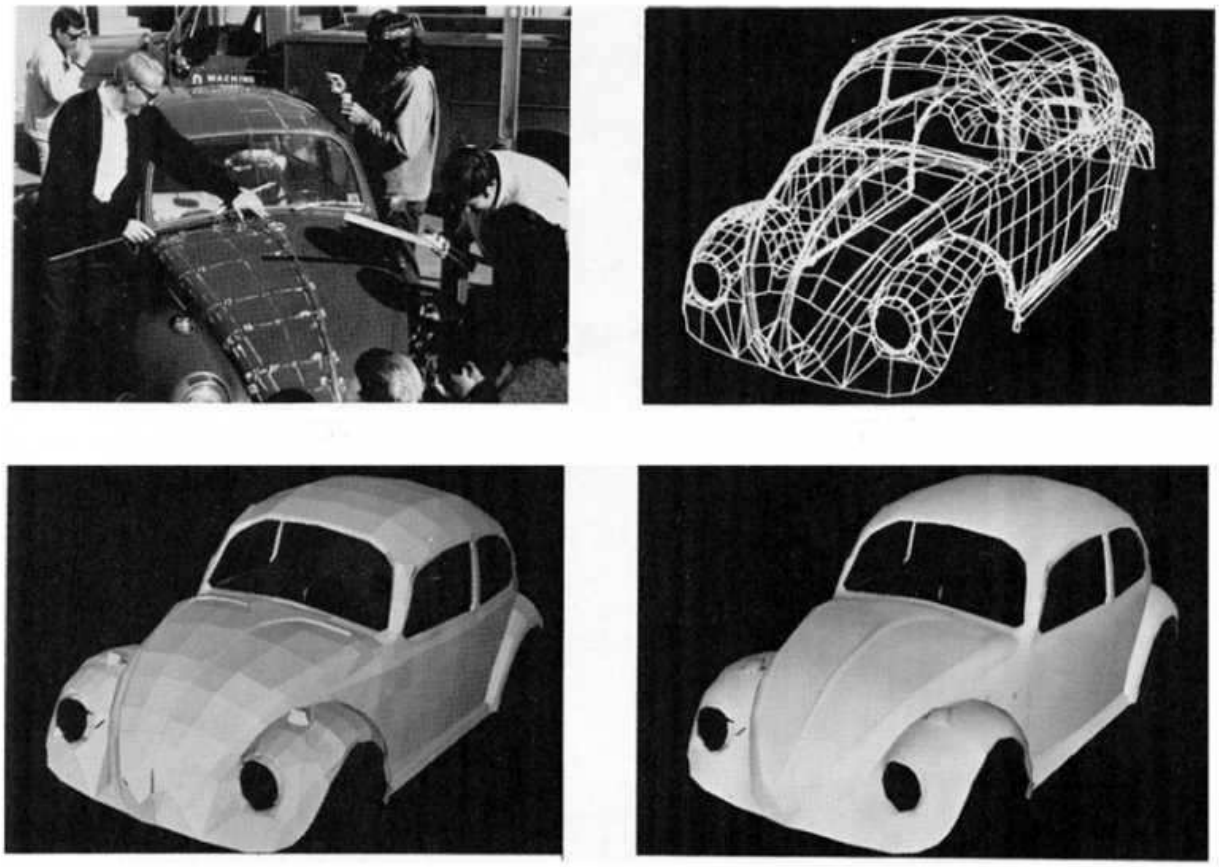


Foldes, Peter: Hunger/La Faim, film, 1974.

For the "stroke to stroke mapping" the lines of a drawing were transfered for computation by using a graphics tablet. In interpolations the sequence of the lines stored in "key images" determines "the form of the intermediate image." 19 Foldes´ "Hunger/La Faim" demonstrated the possibilities of the interpolation as a method for the realisation of

surprising and sometimes grotesque deformations.

For three-dimensional animations real objects are reconstructed at first as wire frames. Wire frame models present – like Noll´s "Hypercube" (see chap. IV.2.1.2) – all sides of an object regardless of overlaps. The wire frame provides in a further step the basis for the break up of curved surfaces into flat areas with edges (polygons). For the construction of a polygon model the overlapping areas (one surface behind the other) of the wire frame model and their changes in rotations have to be calculated. In 1963 Lawrence Gilman Roberts developed the first program for the calculation of hidden surfaces. In 1974 Ivan Edward Sutherland, Robert F. Sproull and Robert A. Schumacker investigated alternative programs with "hidden surface algorithms", described their advantages and disadvantages, and draw their conclusions. 20



From the object to the wire-frame and polygon model with smoothed planes (Sutherland/Sproull/Schumacker: Characterization 1974, p.5, fig.2c-f).

In the simulations of three-dimensional objects in an "interactive perspectivalism" 21 all sides are digitally constructed. An observer in front of the screen sees only parts of the simulated three-dimensional object as it was organized for a program-internal observer (as an observer constructed within the program). Parts of the construction of an internal observer are the perspectival overlaps changing with the objects´ motions. The observer within the simulation system is adjusted to the visual perceptive faculties of humans at the interfaces to the system (external observer).

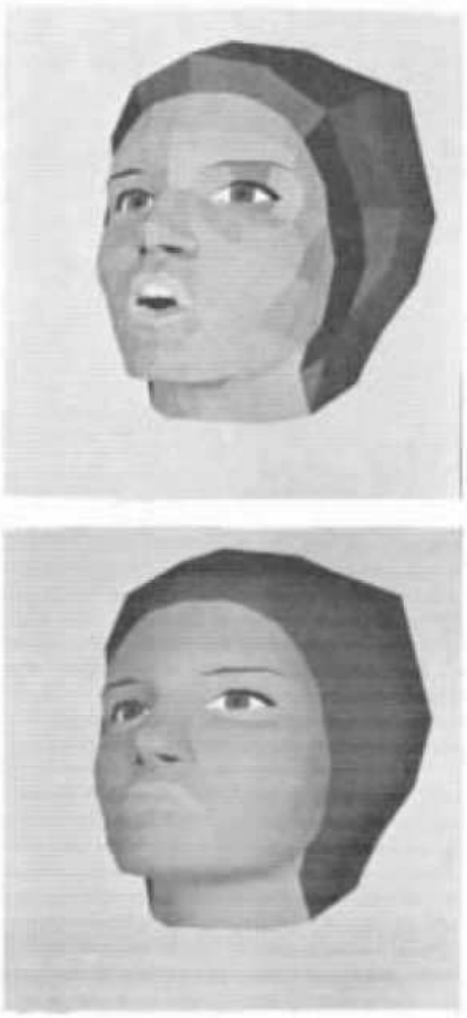


Figure 1
Two expressions of the same face. The top one was rendered using polygonal shading. The bottom one was rendered using Gouraud's smooth shading algorithm.

(Parke: Animation 1972, p.452, fig.1).

The presentation of virtual objects in different angles poses problems to program light and shadow. In 1971 Henri Gouraud developed a method to calculate a "continuous shading" for surfaces being converted into polygons:

> The approach...is to keep the polygon approximation of the surface, but to modify slightly the computation of the shading on each polygon so that continuity exists across polygon boundaries.

The polygons surfaces are calculated at the interpolation of the colours at the vertices of adjacent polygons. Then the interpolations are projected on a curved surface with a continuity of the "shading" dependent from a continuity between the polygons.

The calculation of the Gouraud shading proceeds through several steps: For the calculation of colour values for a polygon the adjacent polygons offer the relevant informations at the vertices. Gouraud describes the goal of this method:

> Each polygon has a different shading for each of its vertices, and the shading at any particular point inside the polygon has to be computed as a continuous function of the shading at the vertices of the polygon.

In a cathode ray tube used as a screen for the simulation the lines of an electron beam constitute cut surfaces ("scan lines") through polygons. If an electron beam constitutes a polygon line by line within a cathode ray tube then the colours of its vertices are interpolated with the colours at the polygon´s edges (between the vertices). Then the colours of the polygons adjacent to these edges are interpolated with the colour values at the points of the lines constituted by the electron beam.

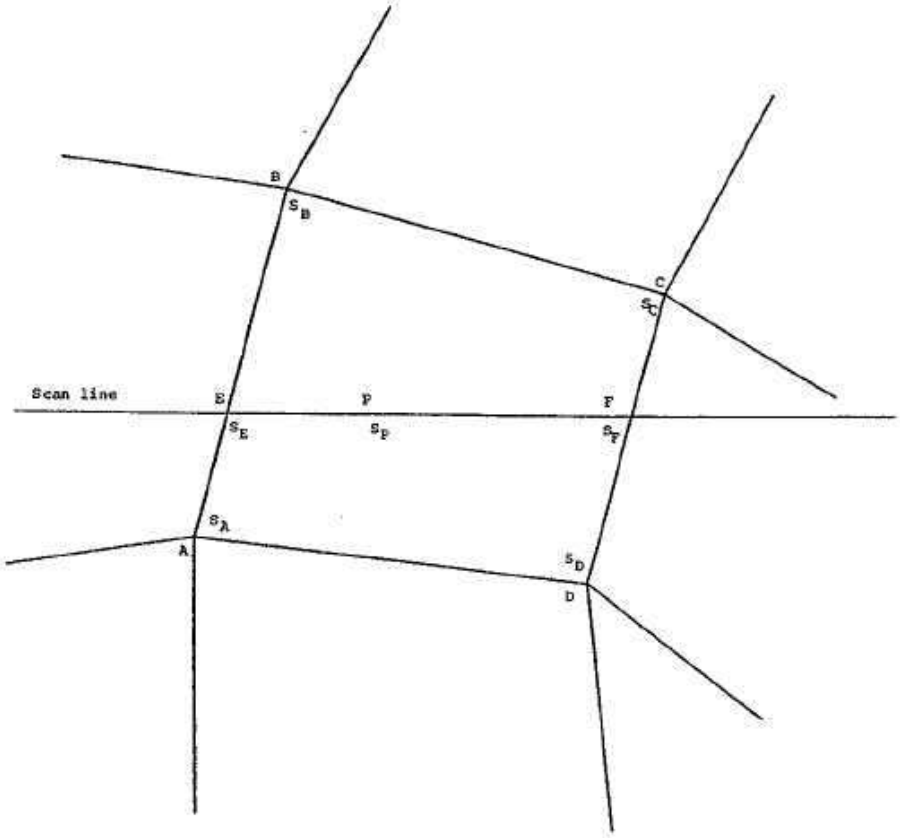
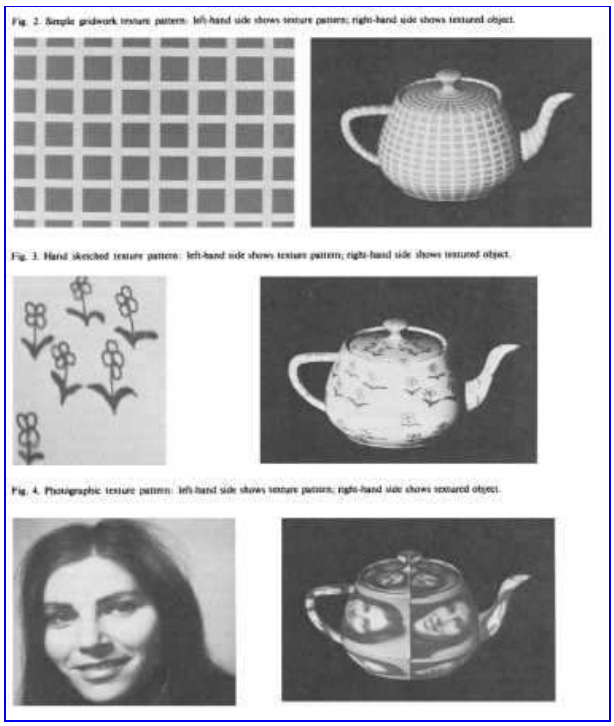


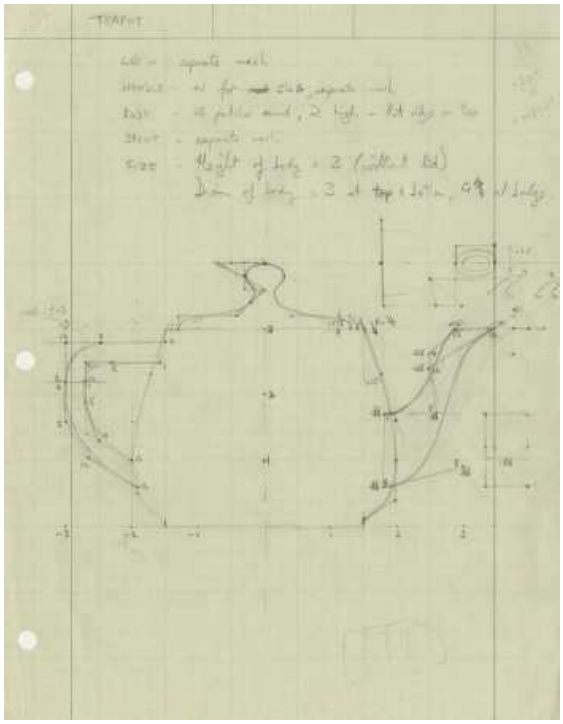
Fig. 5. Projection of one polygon intersected by the scan line.

Polygon A-B-C-D and the "Scan line" E-P-F built by the lines of the electron beam in a cathode ray tube E-P-F (Gouraud: Shading 1971, p.91, fig.5).

In Gouraud Shading a polygon´s surface properties are dependent from the properties of the adjacent polygons: Vertices, edges, surface normal (calculated as a vector perpendicular to the polygon´s surface) and relations within each polygon are correlated. At the vertices the passages between the polygons are smooth, meanwhile the outlines of edges are broken instead of constituting continuous lines (because the interpolygonal mediation of the Gouraud shading is absent at the edges). The absence of highlights causes a diffuse overall impression. 22

In 1975 Bui-Tuong Phong proposed a procedure to calculate zones with different texture-dependent light properties for each polygon. For each point within a polygon Phong interpolated "the surface normal vector" between surface properties like light reflexes and shading. That increased the computational work considerably compared to Gouraud shading. 23 The disadvantage of Gouraud shading – its rougher procedure without gloss lights – also was its advantage. Meanwhile Ivan Edward Sutherland´s professorship at the Computer Science Faculty of the University of Utah (1968-74) Gouraud (1971) and Phong (1973) graduated about the problems of shading mentioned above. 24





A Melitta teapot ("Utah teapot") from 1974 became a model for computer animations. Left: Three examples for texture mapping (Blinn/Newell: Texture 1976, p.544, fig.2-5). Right: Martin E. Newell´s measurement of the Melitta teapot on squared paper. Computer History Museum, Mountain View/California.

In 1968 David Evans set up a department for the development of programs for CGI (Computer-generated Imagery) at the University of Utah. Michael Newell´s "Utah teapot" was a three-dimensional simulation of a Melitta teapot. In 1974 Newell bought it in a supermarket at Salt Lake City. At the University of Utah the Melitta teapot was used as a test case for problems of three-dimensional simulations: from wire-frame models via (the smoothing of) polygon surfaces to the working out of textures, shades and light reflexes. 25

Edwin Earl Catmull invented texture mapping and z-buffering. In 1974 the application of two-dimensional surface structures (textures) on three-dimensional virtual objects was made a theme in Catmull´s dissertation (under the supervision of Prof. Ivan Edward Sutherland) as well as z-buffering calculating the hidden and visible parts of an object. Pixel values stored in the framebuffer (image memory) are compared with information about the depth of a new pixel. The z-axis is the depth axis, and the z-buffer contains the information about the depth of a visible object. If a new pixel is stored in the framebuffer, then in the framebuffer the value of the new pixel will be stored as the value to be used in presentations. In 1974 the procedure was developed by Wolfgang Straßer, too, in his dissertation on "Schnelle Kurven- und Flächendarstellung auf graphischen Sichtgeräten." 26

James Frederick Blinn developed many programs for CGI, among others for rendering, clipping, lighting atmospheric effects and environmental mapping. Rough surfaces can be simulated with Blinn´s bump mapping (1978). Problems with surfaces still looking flat in 3D animations can be solved by combining texture mapping with bump mapping. 27

In the seventies The Graphics Research Group of the Ohio State University developed under Charles Csuri´s direction the animation systems ANIMA (since 1975), ANIMA II (since 1977) and ANTTS (since 1979). ANTTS (ANimated Things Through Space) was running on a DEC (Digital Equipment Corporation) VAX 11/780 minicomputer (since

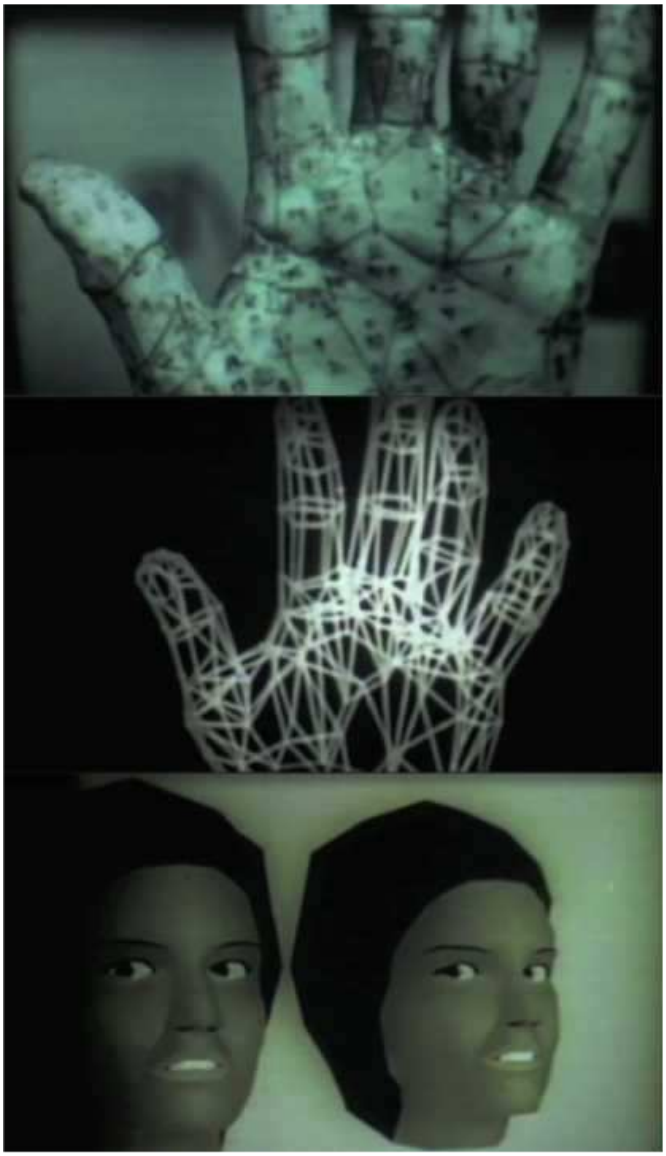
1977). The system operated with two buffers, a frame buffer and a buffer for the duration of sequences. 28 The systems of the Ohio State University anticipated the development of the eighties and nineties: Animation systems were created at first for mainframe and minicomputers, then for personal computers, too. 29

Meanwhile in the seventies experimental films were realised with video tools for two-dimensional animations (see chapter IV.1.2), software for three-dimensional animations was developed in research projects for mainframe computers resulting in presentations of the state of the development and occasionally in sequences for movies (see chap. IV.2.1.4.1). Contrary to the experimental filmmakers with mostly analogue video technology the developers of software for mainframe computers were oriented on the production of movies and commercials. In the eighties this led to image simulations provoking expectations about virtual worlds (see chap. IV.2.1.4.4). Imaginations of simulations becoming autonomous worlds reappeared as contents of movies (see chap. IV.2.1.4.1). The means of the computer-aided image processing had to be accomodated to the requirements of directors realising films with such contents. Science fiction novels of William Gibson, Bruce Sterling or Neil Stephenson could suggest to their readers that the technical development will proceed until in a not too far future virtual worlds with autonomous developments ("cyberspace") will arise. 30

IV.2.1.4 The Eighties

IV.2.1.4.1 Film Sequences

In 1972 Edwin Earl Catmull and Frederick I. Parke documented in "Halftone Animation" an animation in the making: It started with the scanning of plastic models (a plaster model of Catmull´s hand) on whose surfaces line networks were drawn for the partitioning into polygons. Furthermore "Halftone Animation" presents the animation of a face with Gouraud shading (see chap. IV.2.1.3). 31



Catmull, Edwin Earl/Parke, Frederick I.: Halftone Animation, film, 1972, screenshots from Vimeo.

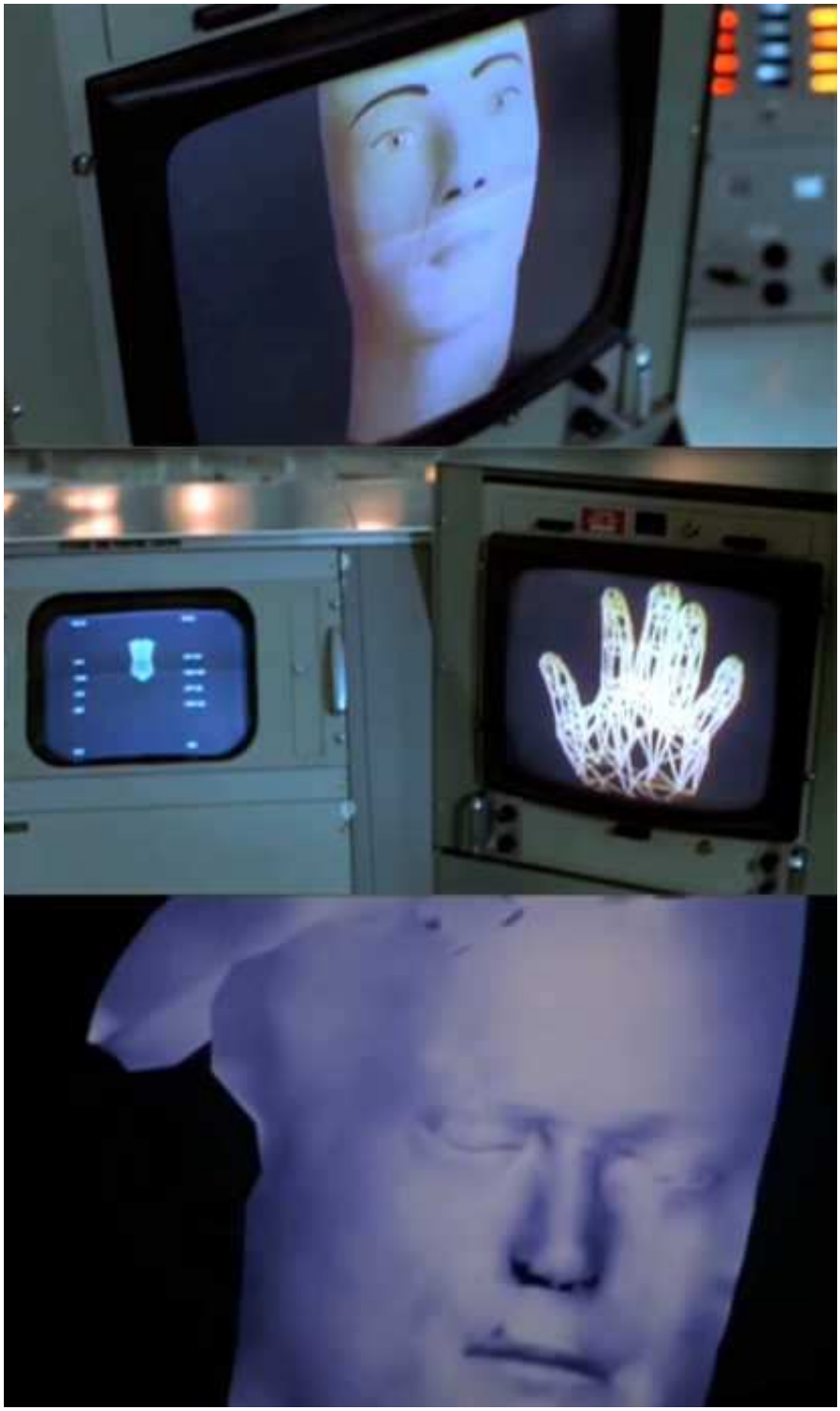
In Michael Crichton´s "Westworld" (1973) Yul Brynner appeared in the role of the android "Gunslinger" challenging visitors with prepared weapons in the amusement park "Delos" to duels. The harmless fights for the visitors´ distraction changed to mortal fights. Gary Demos and James Whitney Jr., colleagues at Triple-I (Information International Inc.), presented Gunslinger´s observation of his environment as digitised and modificated film recordings: The digitalisation via colour film scanner, made possible by the high resolution cathode ray tubes of Triple-I, was transformed into a rough pixel grid. For this procedure the colours were separated into three tonal values and a mask for black areas. The separated was converted into rectangular blocks. The tonal values resulting from this conversion were translated into colour values. For the 10 second during sequences of the android´s view with a total duration of 2,5 min an eight hours lasting computing process was needed.



Crichton, Michael: Westworld, film, 1973 (excerpts), screenshots from YouTube.

Simulations of hands and faces realised by Catmull and Parke between 1972 and 1974 were in 1976 presented in Richard T. Heffron´s (director) "Futureworld", the sequel to "Westworld", as sequences on a control monitor.

The animation on the monitor presents Peter Fonda´s head in a transition from a polygon animation to smoothed facial features with light reflexes as a part of the production of a doppelganger. Gary Demos and John Whitney Jr. photographed Fonda´s face from different angles and transfered these data via graphics tablet in a digital 3D space. This archive with face data was the starting point for further animation steps being presented on the control monitor as the becoming of the doppelganger´s head in a change from edged to smooth surfaces. 32



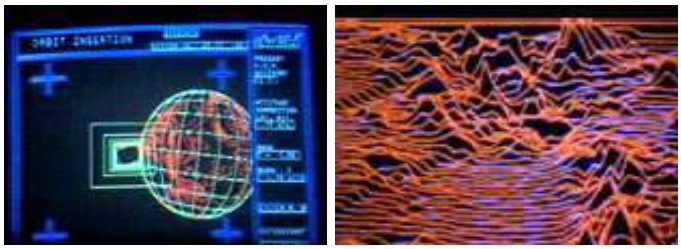
Heffron, Richard T.: Futureworld, film, 1976, screenshots from YouTube.

Fonda plays the journalist Chuck Browning. Browning discovers a clone production in the amusement park "Delos". For the clone production genetic codes by well known and influential persons are used – without the knowledge of the cloned persons. Browning is cloned, too. The doppelgangers are used for the far-reaching ambition to achieve the world supremacy.



Lucas, George: Star Wars Episode IV: A New Hope, film, 1977 (scene with the projection of the Empire´s station "Death Star" and its production with GRASS, explained by Larry Cuba).

In 1977 Larry Cuba used Tom DeFanti´s animation program GRASS (see chap. IV.1.2) to realise a wire frame simulation for a two minutes lasting sequence in George Lucas´ movie "Star Wars Episode IV: A New Hope". The animation presented the Empire´s station "Death Star" as a projection in a training session of the Rebel Alliance´s pilots directed by General Dodonna. The simulation should correspond to the public´s expectations of computer-generated animations. That is why Cuba renounced to use animations simulating surfaces of objects.



Scott, Ridley: Alien, film, 1979. Alan Sutcliffe´s computer animation on navigation screens in the spaceship Nostromo.

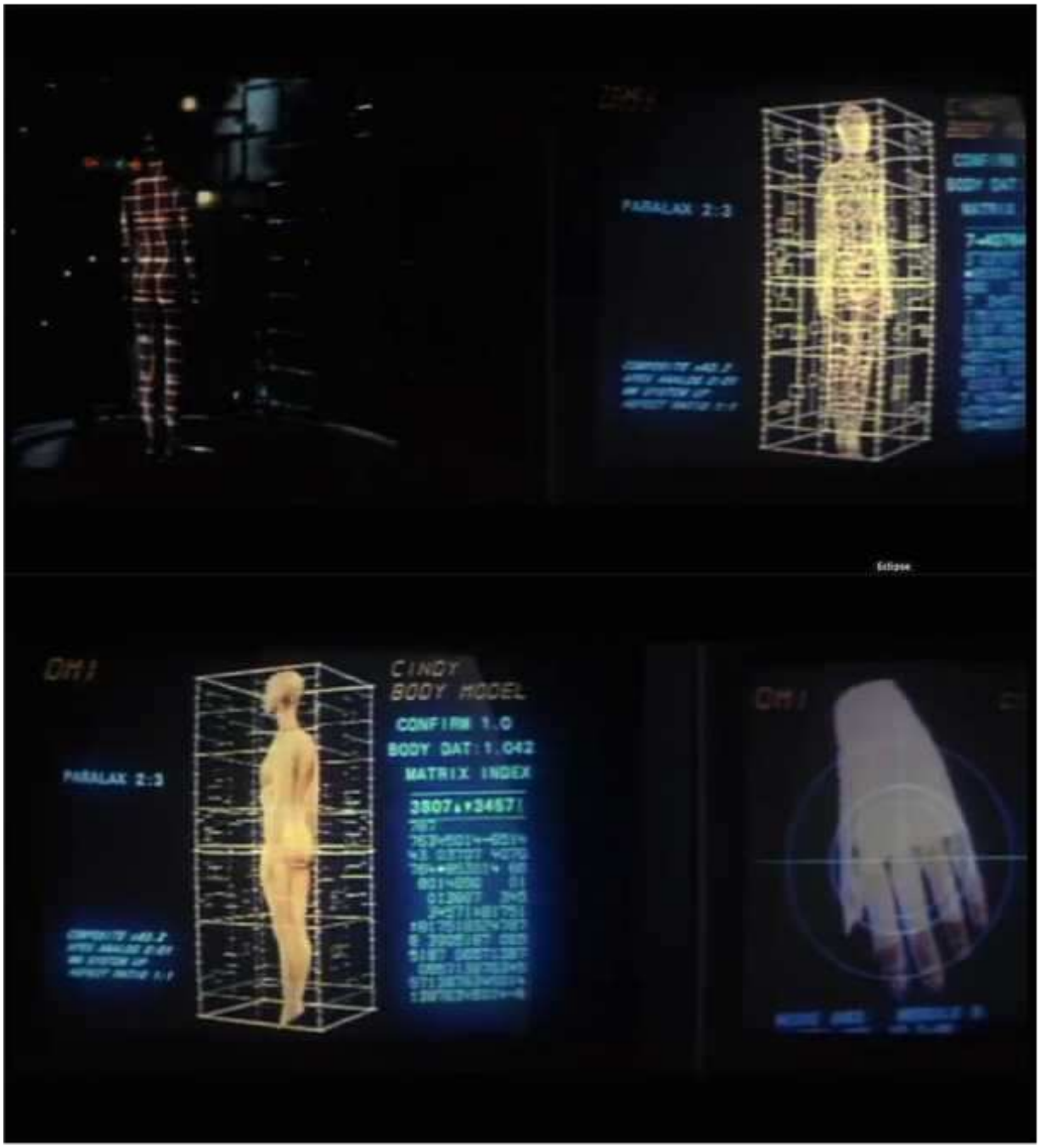
In 1979 Ridley Scott integrated in "Alien" wire frame simulations by Alan Sutcliffe in a scene during the landing of the spaceship "Nostromo" on its navigation screens: In the descent mountains appeared as wave lines. 33



Carpenter, Loren C.: Vol Libre, film, 1980, screenshots from Vimeo.

In 1980 Loren C. Carpenter featured in the short film "Vol libre" a computer animated mountainscape generated by fractals. Carpenter´s demonstration of the use of fractal geometry in a three-dimensional landscape representation was his ticket to Lucasfilm. 34

In 1981 appears the first computer animated actress in Michael Crichton´s "Looker". Meanwhile in "Futureworld" the animated body parts still appear as film-within-the film, "Looker" is the first movie presenting a simulated actress.



Crichton, Michael: Looker, film, 1981. Scene with a scan of a fashion model´s body, screenshots from YouTube.

In "Looker" fashion models offer their bodies for digitalisations to receive monthly salaries for the rest of their lifetime. The virtual models are then used by Digital Matrix in advertisement films. After the scan process of a model´s body (model played by Susan Dey) follows directly the construction of a body simulation. The animation skills of Triple-I made it possible to represent the model´s digitalisation.

The film features the investigations to find out the causes for the deaths of three of the virtualised models. Meanwhile the movie leaves the cinema visitors in the dark about the causes, the TV version uncovers them: The living proofs for the existence of the digital bases with body data are eliminated by Digital Matrix – like all documents that could be useful for competitors. 35



Meyer, Nicolas: Star Trek II: The Wrath of Khan, film, 1982. Genesis demo, screenshots from YouTube.

In 1982 the Lucasfilm Computer Graphics Research Group created a one-minute demofilm sequence for Nicolas Meyer´s "Star Trek II: The Wrath of Khan" ("Genesis Demo sequence"). The sequence presented a planet being revived by a "Genesis Torpedo", as prescribed by the plot. For the three-dimensional animation Reyes Rendering was utilised. Loren C. Carpenter realised the simulation of the landscape with fractals. Agitated surfaces representing fields of heat energy among others were generated with Particle Systems. 36

Reyes Rendering and Particle Systems are developed by the Lucasfilm Computer Graphics Research Group. The versatile animation system Reyes Rendering is constructed to need as less computing capacity as possible for realistic simulations. Therefore Ray Tracing is reduced to a minimum. 37 Curved surfaces are divided in "micropolygons". In Reyes rendering the "micropolygons" are the geometric basic element of nearly all algorithms: "They are flat-shaded quadrilaterals that are approximately 1/2 pixel on a side." The needed computational effort is reduced by simple procedures running parallel. Basic elements ("primitives") are transfered to "micropolygons" only so far as it is necessary for the simulation of smooth surfaces. Shading is simplified by a condensation of "micropolygons" to wider raster areas (leading to savings of identical edges at adjacent "micropolygons") and by a vectorisation of the "shading operations". 38

"Particle Systems" was developed by William T. Reeves at the New York Institute of Technology. The program for "Modeling a Class of Fuzzy Objects" offers animators procedures to simulate "clouds, smoke, water, and fire":

> They are not rigid objects nor can their motions be described by the simple affine transformations that are common in computer graphics. Particles change its form and move with the passage of time. 39

Particles are more simple basic elements ("primitives") than the polygons. the model is procedurally defined and can be programmed that – similar to fractals – in zooming in a

"particle system" with stochastic procedures constantly new details become recognisable. New particles arise while elder particles disappear.

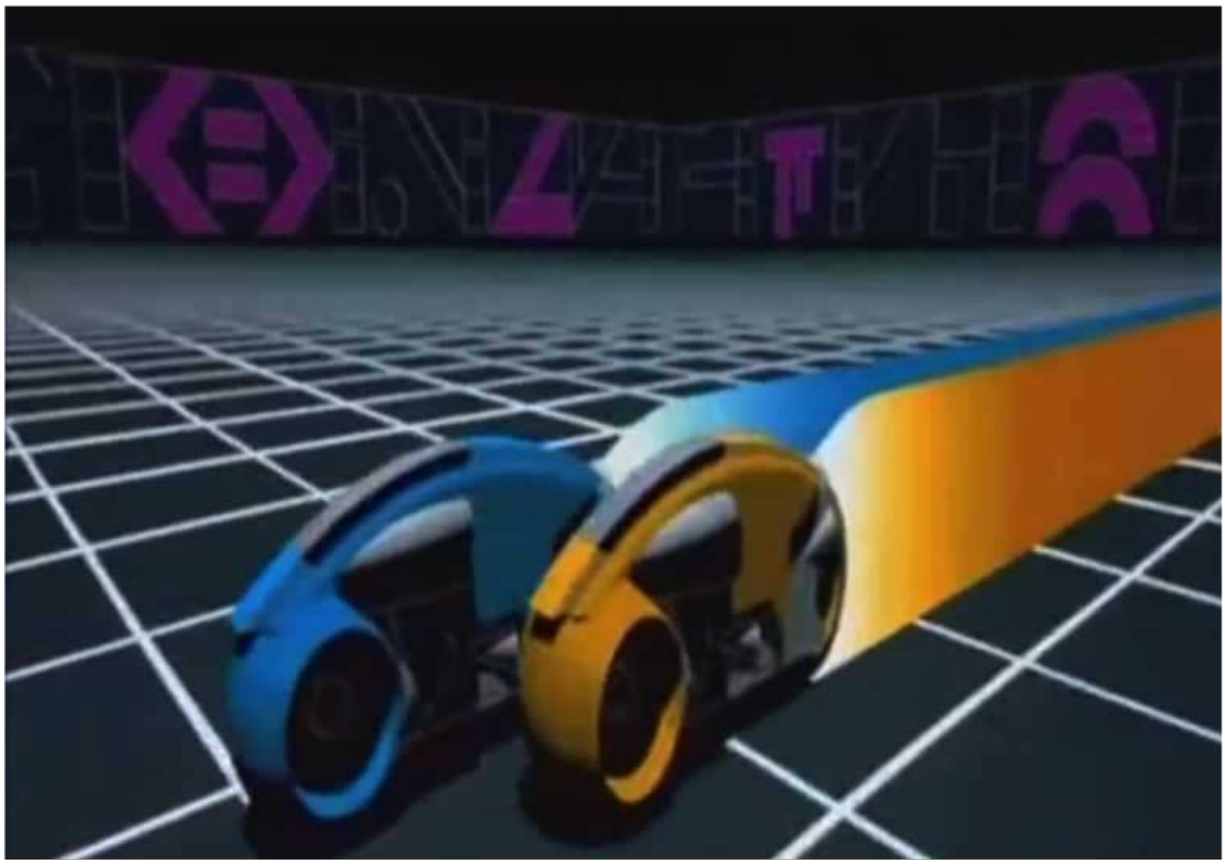
According to Reeves, in the "Genesis demo" for "Star Trek II", a fire wall of the revived planet was generated with "400 particle systems" which included 750.000 particles. 40



Sims, Karl: Particle Dreams, film, 1988, screenshots from YouTube.

In 1988 Karl Sims demonstrates the possibilities of "Particle Systems" in "Particle Dreams". The particles in motion don´t represent bodies, nevertheless they can be coordinated to simulate snowflakes or running water. At the beginning of the film a pointillistic head-shaped configuration arises by a three-dimensional spreading of particles that are then ejected out of the mouth. This process grows up to a self-dissolution, as if heads never were solid bodies. With this scene Sims points out the program´s possibilities beyond movie sequences: It involves more than the results of experts for specific special effects realising the director´s ideas and the requirements of the storyboard.

Sims implemented "Particle Systems" on a "data parallel computer", The Connection Machine CM-2 of the Thinking Machines Corporation (since 1985). Sims wrote his program in "a parralel language called Starlisp" for the simultaneous operations of "thousands of processors" including the virtual processors. 41 Cliff Lasser and Steve Omohundro wrote Starlisp for the Connection Machine. The program used PVARS (Parallel Variables) for computing in vectors.



Lisberger, Steven: Tron, Film, 1982. Lightbike scene, screenshot from YouTube.

In 1982, after "Star Trek II: The Wrath of Khan" the cinemas presented "Tron" (1982), directed by Steven Lisberger (direction and script). In "Tron" Ed Dillinger (played by David Warner) manages the media imperium ENCOM whose supercomputer controls with its self-developing "Master Control Program" most of the computer systems and prevents the ingress into protected sectors. Kevyn Flynn (played by Jeff Bridges) was a former employee of Dillinger´s company ENCOM and works now in amusement arcades controlled by ENCOM. Flynn tries to utilise the security programme "Tron", which is independent from the "Master Control Program", to infiltrate the center of the "Master Control Program" and to destroy the "Master Control Unit". Flynn tries to proof that Dillinger became president of ENCOM because of data theft: He presented computer games developed by Flynn as his invention.

The story of "Tron" is structured in three levels: the amusement arcades controlled by ENCOM, the ENCOM premises, and within ENCOM the "Master Control Program" running on the supercomputer. This program decouples avatars from its system-external users. These avatars are prisoners of a virtual world forcing them either to survive in winning games played on technically installed platforms against other prisoners or to be eliminated as losers. The "Master Control Program" menaces Dillinger by using his control of the database storing the evidence of Dillinger´s fraud. With this control the power seeking "Master Control Program" takes over ENCOM´s control of the games in amusement arcades.

Via the combat between users and their avatars against the "Master Control Program" the movie thematises the balance between programming for external aims and correlations within the program. Independent from the "Master Control Program" is the safeguarding program "Tron" maintaining the contact to the users and supporting their control over their avatars. "Tron" takes up science fiction patterns in its presentation of a system being controlled by a totalitarian power to be combatted.

For "Tron" Triple-I, MAGI/Synthavision, Robert Abel & Associates and Digital Effects realised computer-based animations with different programs. The combination of these animation companies was a result of the challenge to develop computer animated film sequences for "Tron" with a total duration of 30 minutes (including background animations). The involved animation companies received instructions from Richard Taylor (computer effects supervisor) and Bill Kroyer (computer image choreographer) being obligatory for the fitting-together of the contributions. Digital Effects realised the title sequence and "Bit", a crystal-shaped polygon object changing form and colour with its binary replies (yes/no). The "Light Cycles", "Recognizers" and "Tanks" were animated by MAGI. The company executed with their animations of a total length of 15 minutes the largest part of all computerised animations. Triple-I realised the "Master Control Program", a solar glider and Sark´s spaceship. The sequence with Kevyn Flynn entering the system of the supercomputer was developed by Abel & Associates. Syd Mead and Jean `Moebius´ Giraud drafted the two-wheel vehicles ("light cycles") and their environment within the supercomputer´s system. 42

MAGI´s Software "SynthaVision" "converts models of quadric surfaces, polygons, and other geometric forms into three-dimensional images. These can be shaded and textured." In SynthaVision a director´s code offered animators the definition of motion patterns for objects and the preliminary fixing of cameras and lighting. With SynthaVision fluid motion sequences could be achieved easily. SynthaVision´s capabilities to simulate complex elements were limited compared to the simulation of poygon nets by Triple-I. Abel & Associates realised vectorial effects with their animation software developed under the directon of Bill Kovacs. 43

After "Tron" virtual worlds were presented again in movies like the TV series "Max Headroom" (1985-87) and in novels like William Gibson´s "Count Zero" (1986) as autonomous electronic systems `communicating´ with reality in various ways. 44 Presented in films, novels and postmodern criticism of the media these fictions constituted elements of a "techno-imaginary" (see chap. IV.2.1.4.4) projecting the contemporary computer animation into a future of autonomous virtual systems because this evolution seemed to be inevitable.



Lasseter, John: Toy Story, film, 1995. Still.

In the eighties and nineties the expectations toward the computer animation for movies were shaped dominantly by Pixar (Lucasfilm´s former department for computer animation turned autonomous) and Industrial Light and Magic. The next steps of the history of movies with computerised animations to "Insektors" (1993, broadcast in 1994, Studio Fantome), the first TV series made exclusively with computer animations, and to "Toy Story" (1995, Disney-Pixar), the first movie completely animated by computer-based image processing will not be considered here. It is sufficient for the "History of Computer Art" to work out relations between computing processes and forms of presentation up to a degree of differentiation suggesting expansions of technical and artistic possibilities as well as the search for combinations with other fields to construct hybrids and intermedia (see chap. I).

Since the eighties the computer animation was and is augmented for the realisation of movies, meanwhile with the utilisation of animation technologies in reactive installations new concepts of human-computer interfaces (HCI) were and are explored (see chap. V).

IV.2.1.4.2 Music Videos

For the realisations of three-dimensional computer animations the technical equipment for music videos included in most cases cheaper products than the equipment for sequences in movies. The products used to create the clips presented below were the Evans and Sutherland Picture System (since 1974), the Quantel Paintbox (since 1981) and the Bosch FGS-4000 Computer Graphics System (since 1983). For animations these systems included hardware-specific software. Their purchase prices were cheap enough to be used in productions of TV programmes, advertisements and music videos. In the examples below, the technical efforts for the video with Mick Jagger´s "Hard Woman" (1985, see below) stands out because it was realised on a supercomputer.

Technical Equipment for Music Clips

Technical Equipment used to create 3D Animations for Music Videos:



Left, top: Quantel Paintbox, 1981. Image source: URL: http://blog.quantel.eu/2011/03/the-quantel-paintbox-a-pioneering-computer-graphics-workstation/

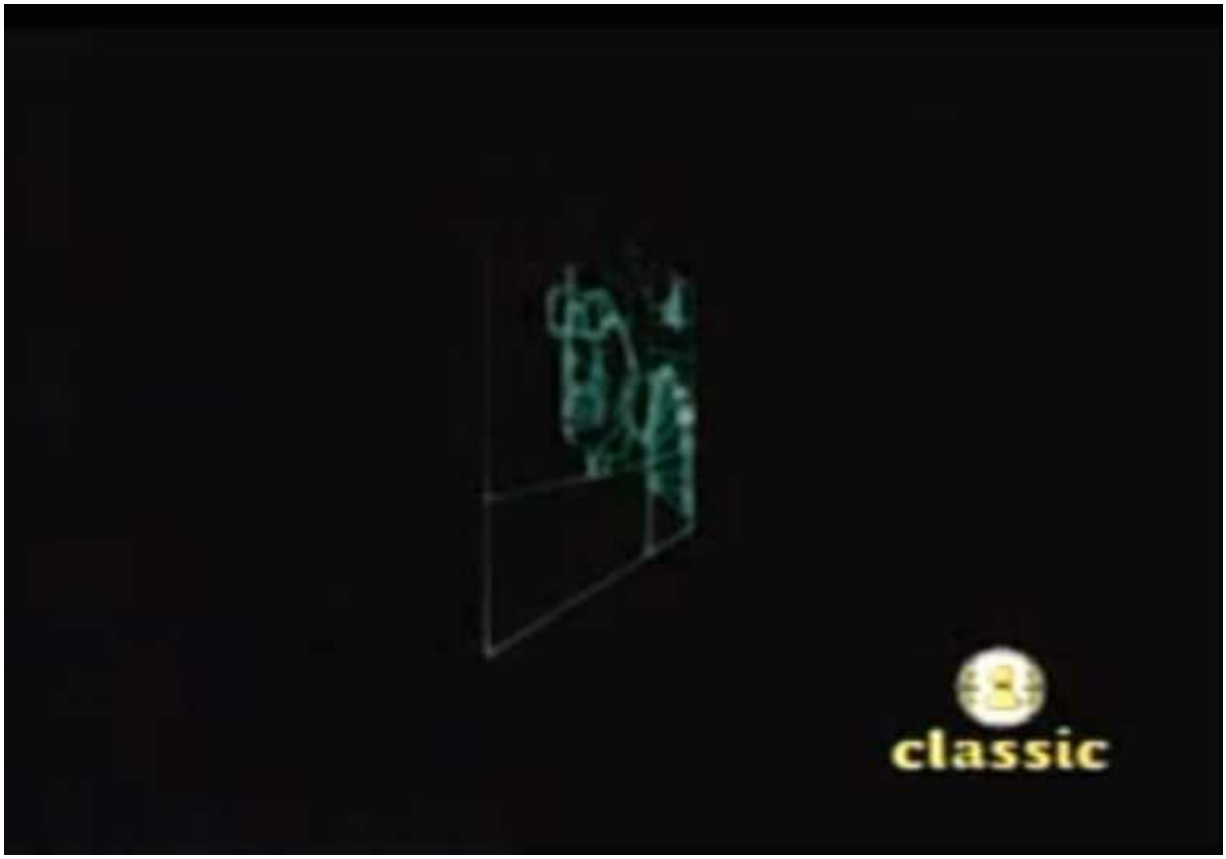
Left, bottom: Chairman of Rushes, Godfrey Pye, stands in front of the company's first Bosch FGS 4000 computer graphics system. Image source: URL: http://www.animatormag.com/archive/issue-18/issue-18-page-16/





Right: Quantel Harry, 1985-86.

Image source: URL: http://www2.tv-ark.org.uk/miscellaneous/other.html



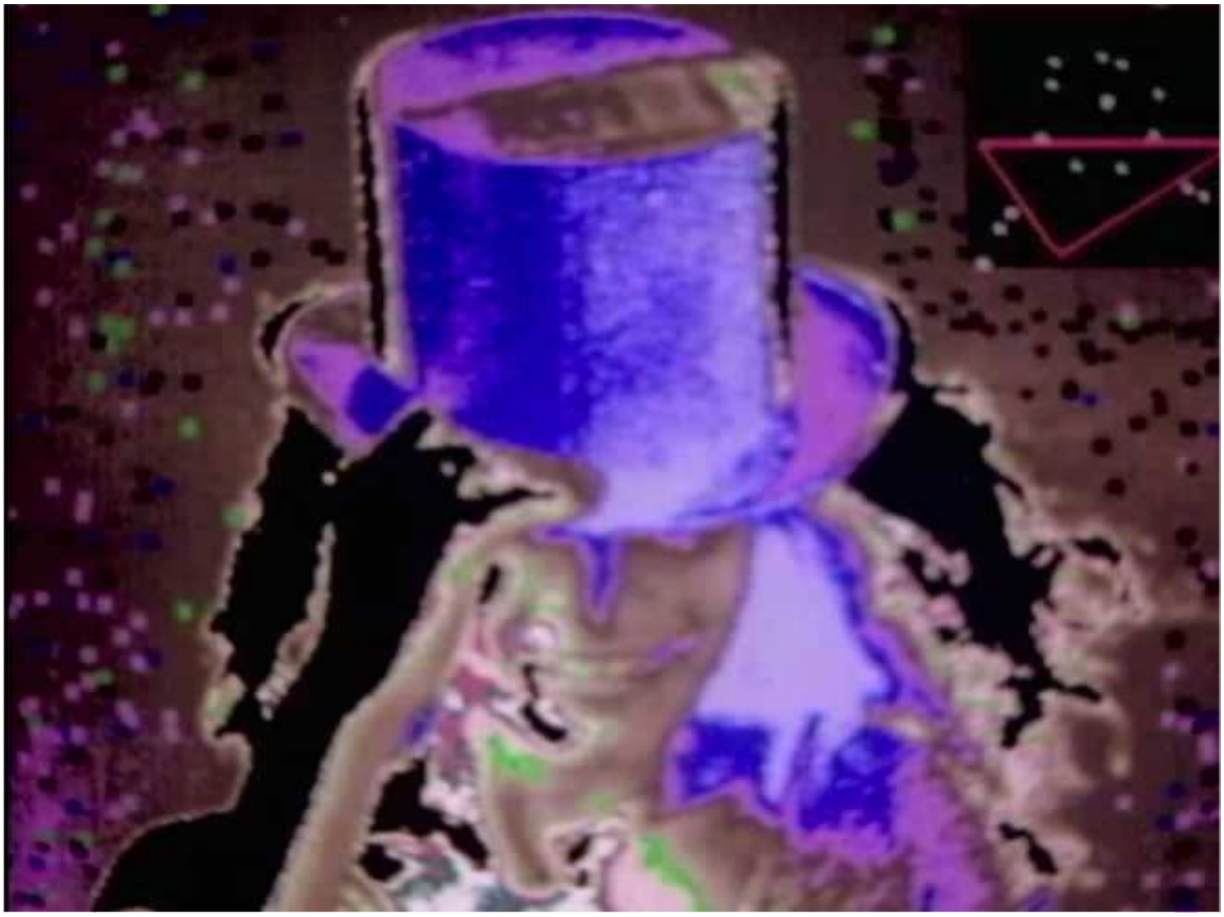
Costello, Elvis: Accidents Will Happen. Music video with animations of Annabel Jankel and Rocky Morton, 1978, screenshots from Dailymotion.

In 1978 Annabel Jankel and Rocky Morton created a music video with animated drawings for Elvis Costello´s "Accidents will Happen". It ended with vector graphics presenting outlines of Costello´s face. 45



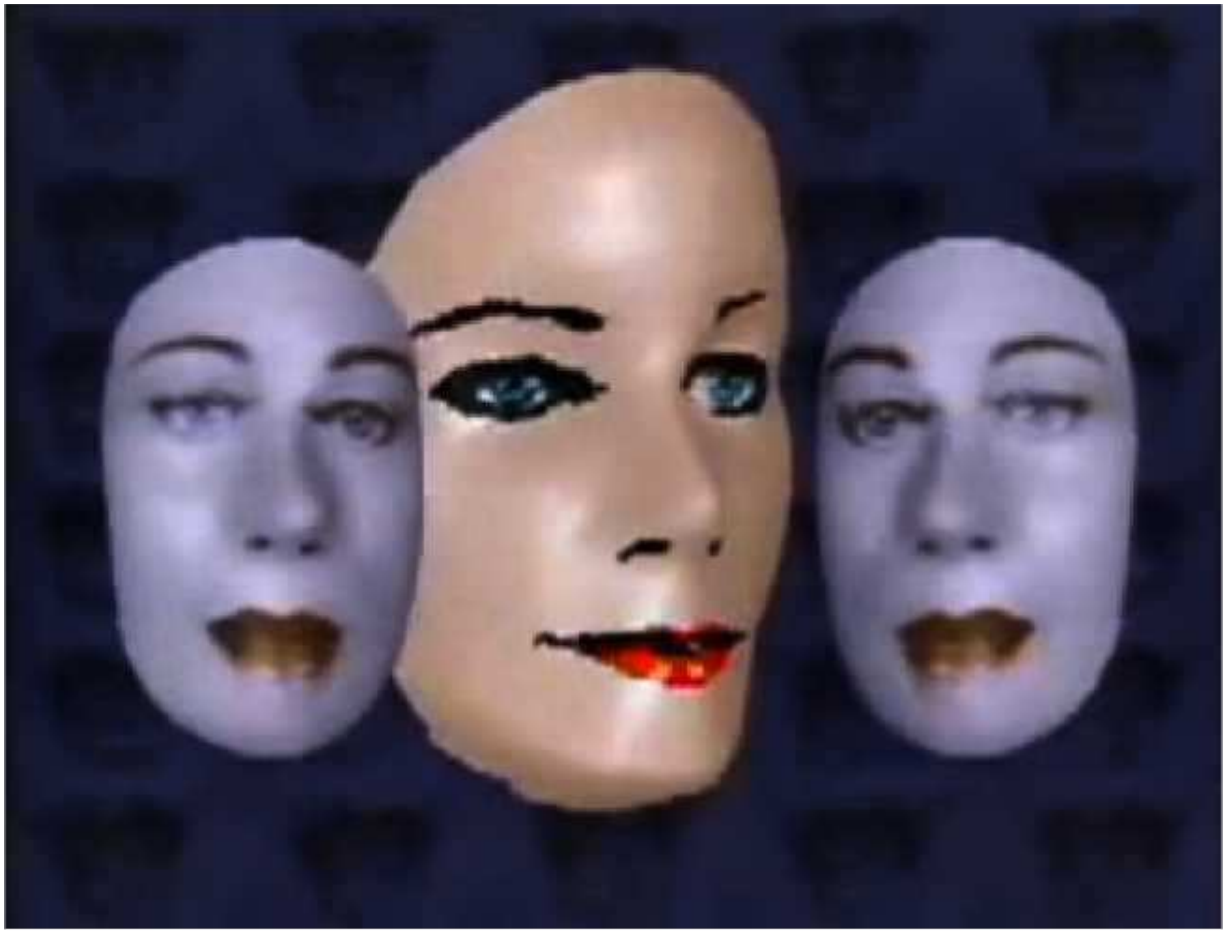
Tharp, Twyla/Byrne, David: The Catherine Wheel, dance performance, 1981. Computer animation by Rebecca Allen for the film version, 1982.

In 1982 Rebecca Allen drafted the figure of Saint Catherine in Twyla Tharp´s 90 minutes long dance film "The Catherine Wheel" von 1982 (with music by David Byrne) as a computer animation with chaotically crossing white lines on a black background and as a multicoloured wire frame figure. The dancer Sara Rudner coordinated her actions with the motions of the animated saint, thus provoking observers to ask themselves how long it will still be recognisable who reacts to whom.



Steve Miller Band: Abracadabra, 1982. Music video by Peter Conn. Screenshot from the Animator´s Site.

In 1982 Peter Conn (Homer & Associates) created a music video for Steve Miller Band´s song "Abracadabra" by transforming a digitised film with the software "Forth" running on the "8-bit computer paint system" that was developed by Paul Rother (Homer & Associates). The console consisting of 24 channels for editing and the paint system were utilised for a presentation of relations between actress, actors and magic props in a studio installed with low expenses. A "burning flame" praised in the lyrics reoccurs several times in the video. In several sequences the image processing via paint system takes on a life of its own in the form of colour patterns built by overlapping rectangles spreading out for a short time and then disappearing again, meanwhile coloured squares sparking out of a sorcery query their representing function by a confetti-like colourfulness. The love song can be related to the bandleader and composer Steve Miller blended in with his guitar at the beginning and at the end. 46



Powers, Will (Goldsmith, Lynn): Adventures in Success, 1983. Music video by Rebecca Allen. Screenshot from YouTube.

In 1983 Rebecca Allen (animation) with Will Powers (Lynn Goldsmith), Robert Palmer and Sting (music) thematise in "Adventures in Success" a seemingly automated wish fulfillment: The message of the refrain "It´s you. Make it habit. Make it happen. Only you" tells us that the trail from the wish to its successfull realisation is nothing more than a demand for an imaginary self creation. In the computer animated clip three masks move their mouths as if they sing the refrain. Via texture mapping (see chap. IV.2.1.3) two of the three masks show the facial features of Will Powers. If the masks turn so far that they have to unveil their backside, then reappear their fronts: They are only facades. The impression of a reversal of the direction is produced by an optical illusion.

In "Adventures in Success" Allen melds film recordings with two- and three-dimensional animations. The two-dimensional animations look often like cartoon figures and allude to advertising claims. 47

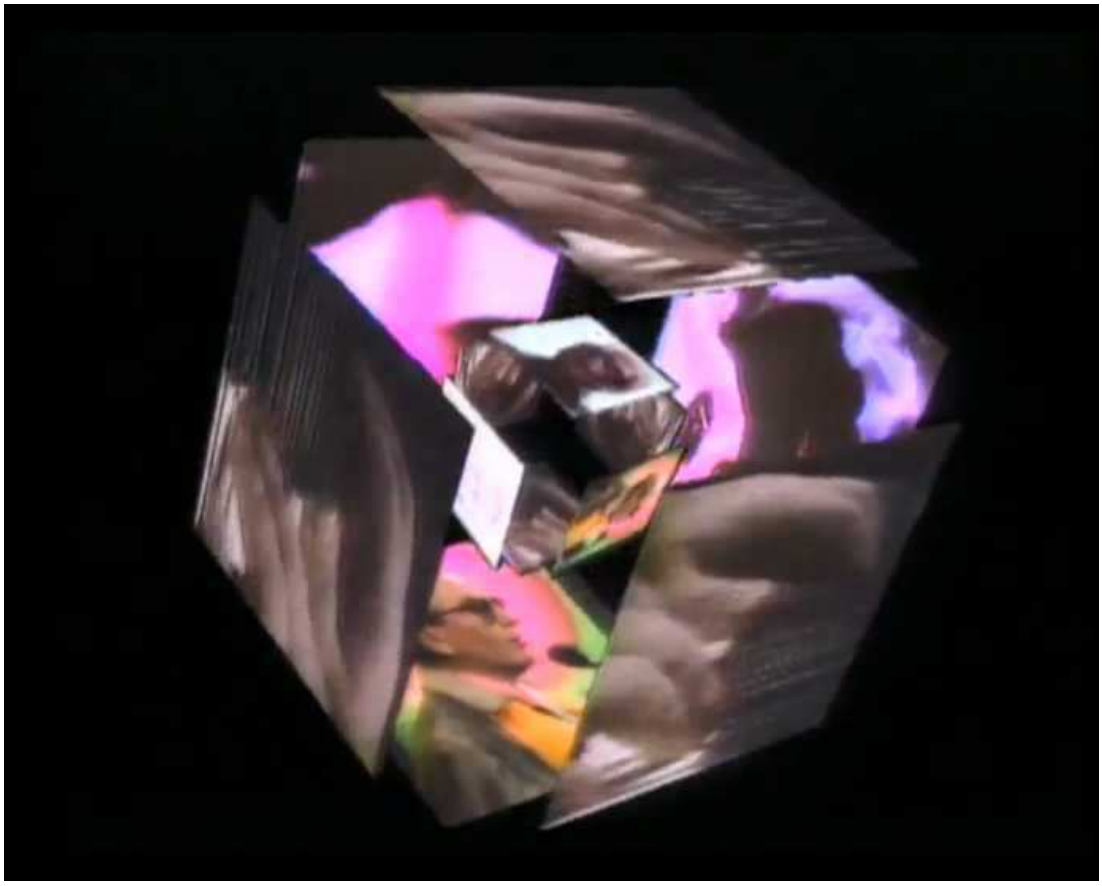


Ashley, Robert: Perfect Lives, 1983, Part 1 of Part 2: The Supermarket. Video opera, visualised by John Sanborn and Dean Winkler. Screenshot from YouTube.

John Sanborn and Dean Winkler visualised Robert Ashley´s "Perfect Lives" (1983). The composer Ashley performs the multiple storylines. He and the piano player "Blue" Gene Tyranny dominate image and sound: Repeating motifs are Ashley´s upper body with hands gesticulating in the course of his speech presentation and fade-ins on "Blue" Gene Tyranny´s hands playing piano. Ashley, Sanborn, Tyranny and others involved worked with variations of leitmotifs on the levels of images, sound and speech. They created a postmodern "video opera" with seven half-hour-long episodes. 48



Emshwiller, Ed/Smith, Alvy Ray: Sunstone, video, 1979.



Ashley, Robert: Perfect Lives, Part VII: The Backyard, 1983. Video opera, visualised by John Sanborn and Dean Winkler. Screenshot from YouTube.

The animation programmed digitally by Alvy Ray Smith in 1979 for Ed Emshwiller´s "Sunstone" treated images in the virtual space like turning windows in a cube-like arrangement. 49 Smith´s animation anticipated Sanborn´s and Winkler´s sequence in

"Part VII: The Backyard" in "Perfect Lives" with Ashley speaking in an associative manner about a "polychrome heart service". On the cube´s sides appear Ashley´s head and Tyranny´s hands playing piano. Between the loose coupled planes of the cube appears a little cube reflecting the form of the wider cube and its projections on each plane.



Tacuma, Jamaaladeen: Renaissance, 1984. Music video by John Sanborn and Dean Winkler. Screenshots from YouTube.

In 1984, for the opening of the Computer Museum in Boston, Sanborn and Winkler created the clip "Renaissance" accompanying Jamaaladeen Tacuma´s funk jazz instrumental music. The video with its images of Boston Harbor, stereometric bodies flying above raster planes and turning grids can be observed as if it is created by using elements of the history of computer animations in a toy world. The animation was built with a Quantel Paintbox (since 1981) and integrated spatial layers for recombinations and transformations of buildings and stereometric objects.

Between the video segments of "Abracadabra" Conn changes the camera perspective on the studio room. The actress and the fireballs are the constants between the segments. On the other hand, Sanborn and Winkler choose for "Perfect Lives" a multi-perspective montage-pictorial space constituted by fade-ins with changes in the type of composition. Sanborn and Winkler create in "Renaissance" an image space graded in deep layers, but buildings and stereometric objects become moving motifs as if flying objects constitute the urban space. The extensions into the depth of the image space change with the constellations consisting of arbitrary multipliable and manipulable elements. "Renaissance" is an example for the transition from film recordings edited in post-production to videos with image spaces mostly constituted by computer animations. In "Adventures in Success" Allen varies the modes of representation. Cuts are softened to transitions via corresponding background designs of the cartoons representing projections of a better self. In contrarary Sanborn and Winkler present in "Renaisance" continuous transformations of the image space by digital image processing: from cutting sequences to the transformations of the image space by digital image processing.



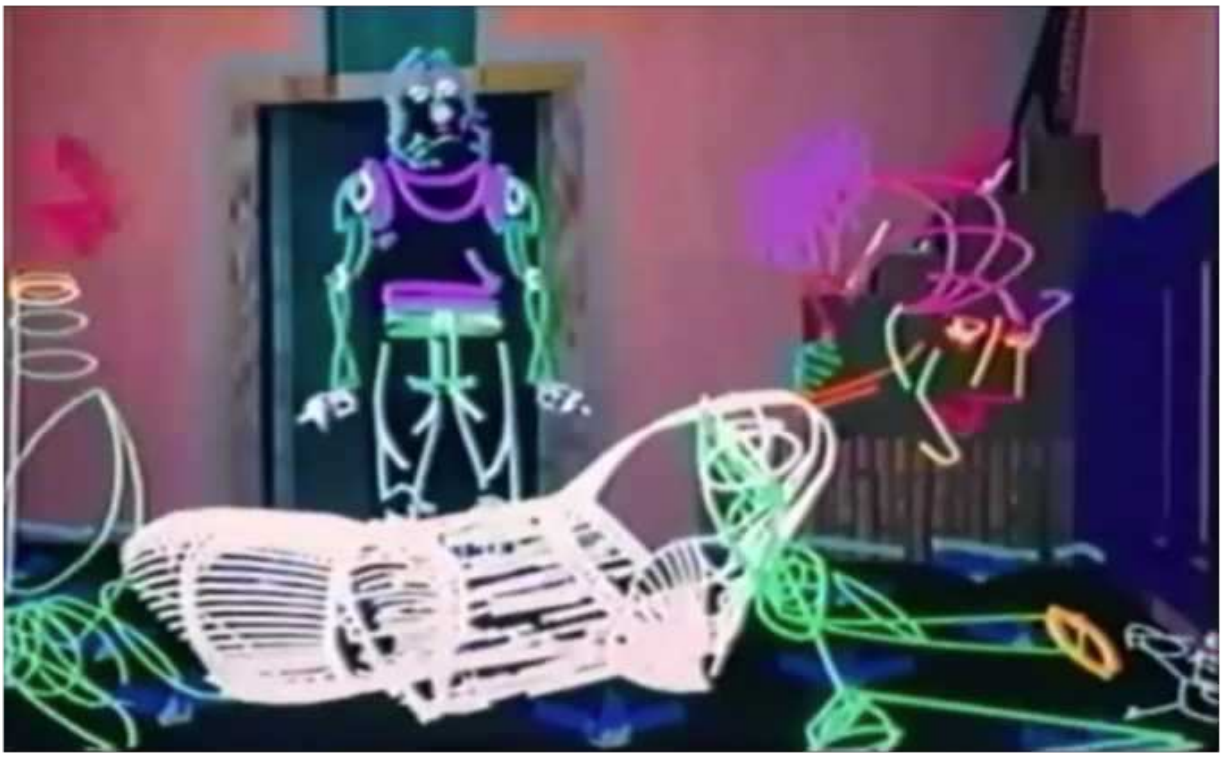
Dire Straits: Money for Nothing, 1985. Music video by Steve Barron. Screenshots from Dailymotion.

In 1985 Steve Barron produced a clip to Dire Straits´ "Money for Nothing". The composer Mark Knopfler featured a seller´s thoughts: Musicians receive "Money for Nothing". Knopfler wrote the lyrics in memorizing the comments of a seller whom he met at a "hardware department in a television/ custom/ kitchen/ refrigerator/ microwave appliance store". 50

Ian Pearson and Gavin Blair used the animation system Bosch FGS-4000 and a Quantel Paintbox. They preferred monochrome surfaces and renounced shadings and textures.

The animation artists divided the seller in two virtual figures ("Sal" and "Harv") composed with stereometric volumes. The virtual sellers acted in simulations of a sitting room with a TV and a salesroom with a television wall and a large projection. The MTV lifestyle mentioned in the lyrics got its visual counterpart in the MTV logos presented on the television wall. Film recordings of a Dire Straits concert appeared on screens within the virtual space. Several times these concert recordings took over the complete screen and replaced the virtual space. Some parts of the live recordings were edited by rotoscoping and it looks as if the contours of microphones and others have been traced with a highlighter.

In contrast to the fade-ins with the musicians in concert the sellers are animated as combinations of stereometric elements carrying appliances through the salesroom. The function of this deindividualising typecast is ambivalent: Meanwhile it offers the sellers a protection by anonimisation, it is degrading, too. With the accentuation of the criticism´s function as a psychic valve of humans in dependent working conditions listeners are influenced to understand the sellers´ utterances as improper. With the animation of their bodies as combinations of blocks the virtual sellers appear as caricatures of real sellers because the whimsical faces and the gaudy colorization provoke doubts concerning the adequacy of their ciriticism.



Jagger, Mick: Hard Woman, 1985. Music video by Digital Productions. Screenshot from YouTube

In 1985 Digital Productions created for Mick Jagger´s "Hard Woman" animations on the super computer Cray X-MP (since 1983) with the company-owned software "Digital Scene Simulation". The body volumes of a female and a male figure are only slightly outlined by `luminous´ colored lines meanwhile the background shines through. Not only "Hard Woman", the subject of the lyrics, but also Jagger appear as figures constituted by lines. Furthermore film recordings of the singer appear within a street simultaneously in several entrances of the animated houses. The content of the lyrics is not interpreted by the animation: It plays visually around some elements of the lyrics. 51 The 3D animations of the `luminous´ stick figures are further developments of the 2D figures created by Allen for Tharp´s "The Catherine Wheel" (see above).

If the lyrics contain only variations of the subject love then the possibilities to create extraordinary music videos are very limited, if animators are restricted to visualise motifs of the lyrics. Then computer animators are not only incapable to change the lyrics´ trivial and redundant characters but rather they inforce it. At least Conn´s video for "Abracadabra" (see above) and "Hard Woman" suggest this conlcusion.

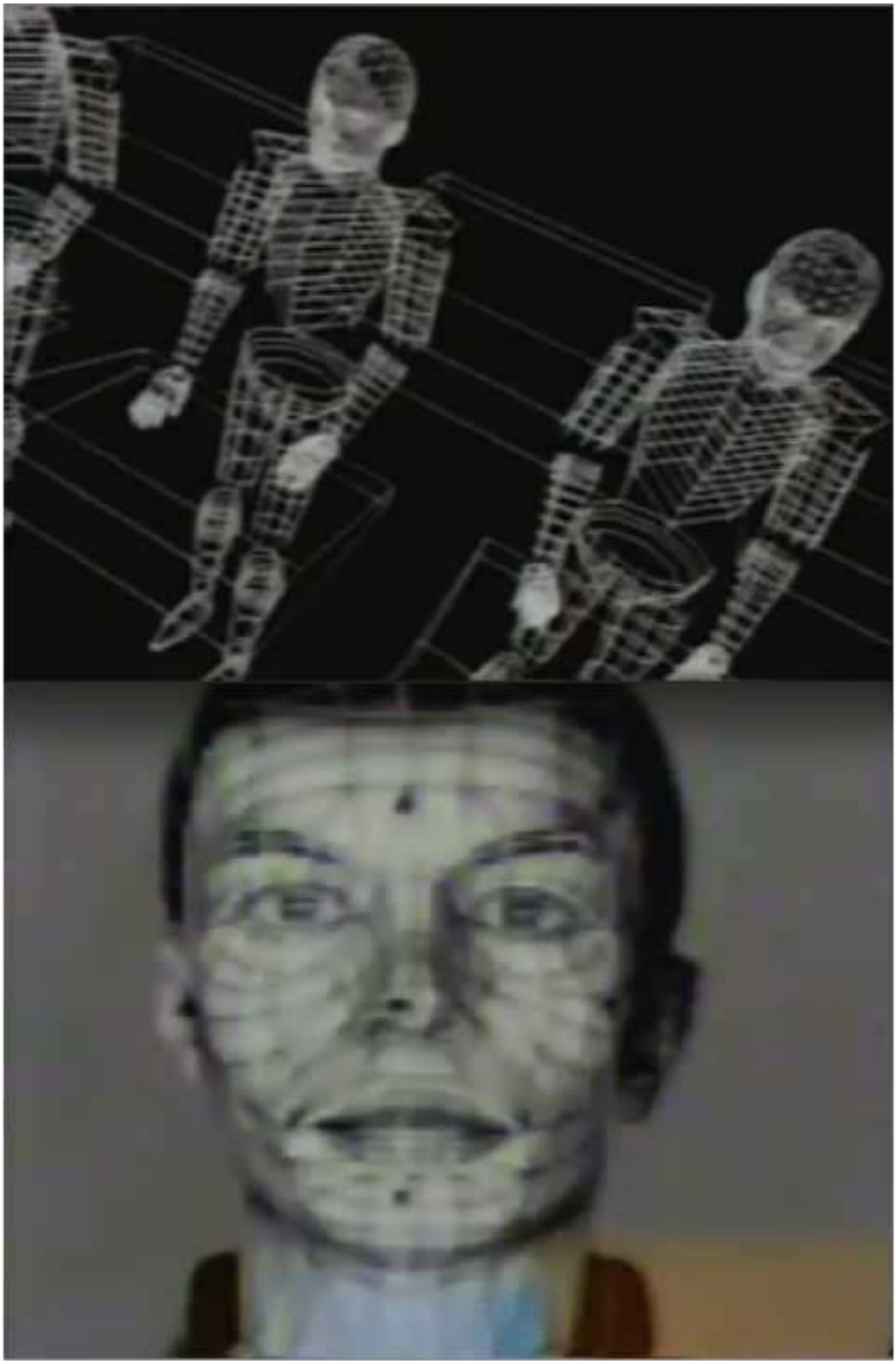
The huge hits as "Video of the Year Winners" of the broadcast MTV in Los Angeles were in 1986 the clip for "Money for Nothing" by the Dire Straits and in 1987 the clip for "Sledgehammer" by Peter Gabriel.



Gabriel, Peter: Sledgehammer, 1986. Music video by Steven R. Johnson. Screenshot from Dailymotion

In 1986 Aardman Animation and Brothers Quay were directed by Steven R. Johnson to create a clip for Peter Gabriel´ s "Sledgehammer". The clip is realised without computerised image processing and takes up early animation methods with his fast cuts and fade-ins of `flying´ objects that move through the image space. The scenes with modelling clay animations incorporate elder animation methods for the revivification of inanimate objects. The motion animation via pixilation is not only used for the modelling clay figures but demonstrated with the singer Peter Gabriel, too: Recordings of his head are are edited frame by frame – he appears as "living stop motion puppet". So he is a figure in the video that is treated in the same way as the modelling clay figures. Peter Gabriel is said to have been lied 16 hours under a sheet of glass meanwhile the animation artists recorded the takes.

"Sledgehammer" offers in the genre music video a successful counter-image to music videos with computer animation. Nevertheless the counter-image offers also artificial image spaces, montages of moved objects in unreal sizes and fast image or cut sequences. 52 "Sledgehammer" became the most sent clip in the history of the MTV station.



Kraftwerk: Musique non Stop, 1986. Music and video by Rebecca Allen. Screenshot from Vimeo.

When Rebecca Allen started in 1983/84 to prepare a clip for Kraftwerk´s "Musique non Stop" she used the same equipment of the Computer Graphics Laboratory at the New York Institute of Technology, as in "Adventures in Success" (see above). Because Kraftwerk´s musicians finished the sound studio editing of their recording only in 1986, Allen was not able to complete her animation at an earlier date.

In her animation she uses no film recordings of the musicians. Nevertheless with her animation of heads and bodies she takes over the characteristics of the musicians´ performance in concerts: The four musicians are dressed with the same clothes and with

the same hairstyle. They stand in identical distances behind their tables on which their equipments are installed to operate with them.

Allen divided plastic models of the musicians´ heads in fields, photographed them from different angles to receive the informations being relevant for the preparation of animated wire frame models. In the clip these four heads are presented in different arrangements as figures in wire frame simulations (without overlaps), polygon animations and animations with smooth surfaces. At the end of the clip Allen presents recordings of fielded head models reminding crashtest dummies. Then a white masks appears, receiving at first eyes then facial colours before it changes into a black-and-white simulation with lines as basic elements.

Parallel to Kraftwerk´s technopop with its minimalist repetitions and a few variations as well as their de-individualized concert performance with a few standardised gestures Allen combines phase segments of the process to construct the musicians´ 3D-simulations. She presents these elements as if they were segments of a repeatable studio process.

Meanwhile "Sledgehammer" escapes digital smoothness with impure surface stimuli of the film recordings, this smoothness is celebrated by by Allen and Kraftwerk: The `impure´ against the reduction to `pure´ elements of a machine-made precision. By taking up Kraftwerk´s hybrid esthetics between human, machine and computer as well as the wire frame animations of the seventies´ science fiction movies (see chap. IV.2.1.4.1), Allen plays with elements precoded as technoid. (The animations of) the humans look as if they are de- and reconstructable like robots. 53



Walczak, Diana/Kleiser, Jeff: Don´t Touch Me, video, 1989. Screenshot from YouTube.

In 1989 Diana Walczak und Jeff Kleiser present the animation of a female singer in "Don´t Touch Me". The animation created with Wavefront is mentioned in histories of CGI

(computer-generated imagery). 54

The singer Perla Batalla was the model for recordings of body motions by Motion Analysis Inc. The motion patterns were translated into a digitised model of an actress called Dozo: Dozo with a smooth skin appearing lifeless moves like Perla Batalla and sings with her voice. Dozo sings lyrics written by Walczak and Kleiser about her situation as a virtual performer (music: Frank Serafine). In "Don´t Touch Me" Kleiser and Walczak used motion capture not anymore as a modular building block system for the presentation of a virtual world parallel to the concerts of a band – like the animated versions of the Kraftwerk´s musicians in "Musique Non Stop" – but present an artificially made star. The audiovisual performance of the music clip presents a musician in a star-like position. But this musician should be able to present himself without concerts, and has to try to become independent of a career as a concert star. Meanwhile the distribution of music clips remains bound to media packages with concert stars, "Don´t Touch Me" is a model for the computer animation of human bodies and their motions developed out of the forms of music videos.

After 1987 the sales of music videos on videocasettes collapsed. The major labels of the music industry reduced their budgets for clips. 55 Music clips remain distributed by television boradcasters like MTV (since 1981): The character of a designed interplay between the levels of image and sound shifts more then before to the promotion of musicians as stars dominating the visualisation. The fast replacements of sequences would have been too time-consuming and expensive for the film animators´ montages of frames at cutting tables. These fast following cuts remained a core element of the promo(tion) style after the decline of the sales of music videos on videocasettes. 56

Kleiser and Walczak conceptualised "Don´t Touch Me" not anymore as a video to a musical work. Instead they designed it as an art film financed by Hewlett Packard to demonstrate in 1989 the technical development of virtual actors in its actual state – without references to stars in concerts.

The combination of simulated figures and life recordings in "Money for Nothing" was a compromise between Mark Knopfler and the task of MTV to present interesting clips instead of documentations of concerts. 57 Between virtual performers as main actors – like Dozo in "Don´t Touch Me" – and their degradation to statists beside filmed concert stars in "Money for Nothing" offers Allen in "Musique Nonstop" a third possibility to relate musicians and computer animation to each other: the simulation with virtual actors as a parallel world to the concert performance and its real actors.

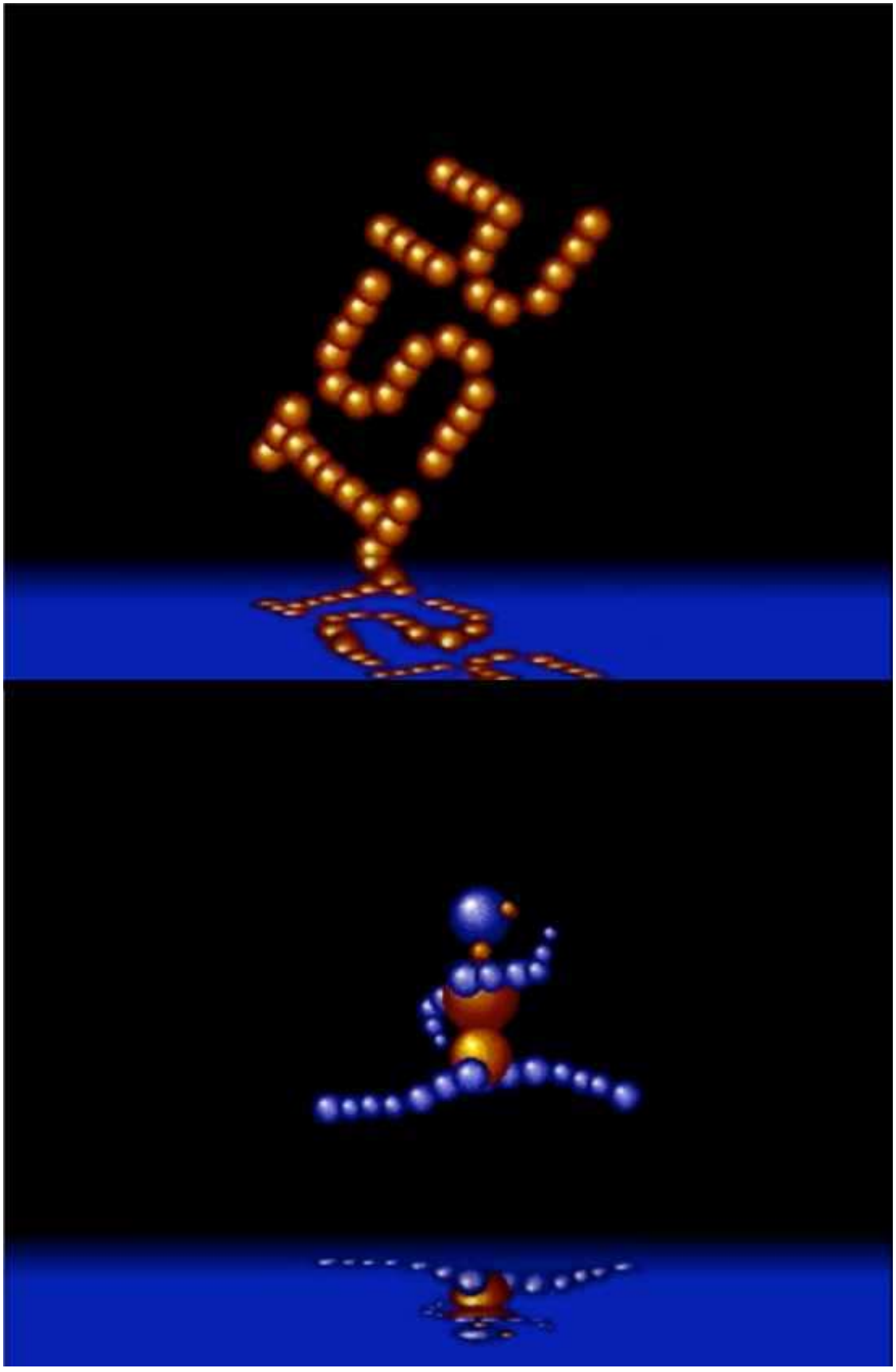
IV.2.1.4.3 Demoscene

In the eighties the demoscene arose out of the activities of crackers who removed the copy protection (in the software) of computer games and added intros to their copies. These cracktros for the personal computer Commodore 64 (1982-94) were distributed since 1983. Cracktros included the logos of their creators (sometimes moved), a scroll text, graphic elements (sometimes moved), and music. The music was written in formats similar to MIDI files. Furthermore the cracktros contained instructions for computing processes first in assembly language and later for C and C++. 58 The codes were written for computers with 8-bit processors which realised the screen presentation in real time 59, without recognizable time delay. An alternative to these processors of the Commodore 64 offered since 1985 the 16-bit processors of the Commodore Amiga. 60



German Cracking Service: Slamball, cracktro for Commodore C64, 1984 (Botz: Kunst 2011, p.54ss.). Screenshots from the file with the cracktro´s code (opened with an emulation of Commodore 64).

The cracktros were developed to autonomous demos. From 1987 to 1990 groups presented their demos one after another in megademos. 61 Since 1987 a scene for personal computers with the operating system MS-DOS arose and became independent from the Amiga demoscene in 1992. Today demo competitions are organized for participants with different kinds of personal computers of the eighties. 62



RED SECTOR INC: Megademo, Commodore Amiga, 1989 (Botz: Kunst 2011, p.145-153), Screenshots from YouTube.

Supercomputers and mainframe computers were used for the frame-by-frame creations of film sequences. This technology for computer animation constituted the bottom end of a scale of available computing capacities, and the demoscene built the opposite end using the low computing capacities of personal computers for real time animations. 63
Between these extremes of animations for big and little computers tools were available for digital mini- and microcomputers like Tom DeFanti´s GRASS (since 1973, for DEC PDP 11/45, since 1972, see chap. IV.1.2) and ZGRASS (since 1978, for Datamax UV-1, since 1978) 64 as well as Woody Vasulka´s and Jeffrey Schier´s Digital Image Articulator (1976-78, for DEC LSI-11, since 1975, see chap. IV.1.2). In the eighties Steina and Woody Vasulka realised interesting videos with the Digital Image Articulator. 65 At the same time Mary Jane Veeder developed with ZGRASS a two-dimensional visual language with signets resp. icons as well as a two-dimensional personal language derived from arcade and video games. 66



Veeder, Jane: Montana, video, 1982.

The animations realised with mainframes and supercomputers were oriented to the ideal of hyperrealism. Hyperrealism was (yet) no goal for many digitally produced videos by artists and for the demo scene´s real time animations: Contrary to the simulation machines for cinemas (and advertisement) were alternative concepts exploring the possibilities offered by the computing capacities that were affordable for private persons. Authors of music videos hark back to various artistic as well as cinematic forms of animations and combine the aesthetics of videos and movie. 67

The animations for film sequences being realised with mainframe and supercomputers were commissioned by producers of the entertainment industry. These films should fulfill the expectations of the movie goers. In contrary the animations created by Mary Jane Veeder, Steina and Woody Vasulka with mini- and microcomputers were experimental films made with the goal to find new film forms. On the other hand creators of the demoscene used personal computers to develop their own subculture´s aesthetics with

running text-(three-dimensional augmented) icon-combinations despite limited technical possibilities.

The creators of demos practice a counter model to the commercial exploitation of copyrights by the movie distributors and the video game industry. The authors of demos abstain from profits and distribute their products free of charge. This distribution in combination with open software (with sites containing collections of files with codes for free download) sustains a collaborative development of programming. 68 This open culture and its use for collaborative developments became a model for alternative digital cultures.

IV.2.1.4.4 The Techno-Imaginary

In the eighties computer art was perceived by humanities scholars from the point of view of a "techno-imaginary". The term stood for a virtuality being valued positive. Recent and possible future developments of digital media and telecommunications were imagined as the constituents of this virtuality. With the upcoming telecommunications (see chap. VI.1.2) scholars foresaw an ubiquitous distribution of signs 69 causing an imagination not only of a deterritorialised socialisation but of a virtual world, too, allowing to connect it to the reality as if we live in an electronic world and need interfaces not as accesses to virtual worlds, but to reality. 70 Paul Virilio´s theses on the development of relations between media, time and territories in the 20th century were combined with Jean Baudrillards theses on simulation 71 to an analysis of an accelerated sign distribution leaving behind referential functions. This sign distribution removes the experience of a material presence into a distance as if the everyday world can be observed only from a historicising and museumising point of view. The "hyperreal" of a remoteness leaving behind the reality as uncatchable infects already the experience of the presence, meanwhile in earlier times this remoteness has been only a problem of reconstructions of the past. 72

On the one hand the exchange of commodities should not always have been a distribution oriented to the exchange value: As proofs serve comparisons with gifts and their functions in not mercantile organised societies. On the other hand in mass media the communication of signs with signs is accelerated in media assisted ways oriented to exchange values replacing communication increasingly by "floating signifiers". The symbolic interaction (communication) looses its community constituting functions and is replaced increasingly by specatacle organisations constituted by corporative organised connections between distribution systems for different kinds of media. Within these connected systems the music video is only one product in a row with others (records-TV-movies-concerts-videos-advertisement). 73

With the Situationists the pure spending of gifts without responding gifts by the donees became a model for free exchange. 74 A precondition for a free exchange is configured by `objects´ or signs not tied to codes as they are constituted by exchange values among others. These ties are transformed under conditions of the "hyperreal" into shadows of its own past in which they arose. Recipients finally accept spectacle organisations, because the signs circulating as parts of these spectacles impregnate the consciousness until it is impossible to distance oneself from imaginations determined by others. The world of illusions constituted by "simulacra" becomes all-embracing. 75 The 3D simulation created with computer animation can be interpreted as a part of the spectacle organisation especially if the simulated objects are presented as parts of an autonomous virtual world.

In a time when computer games still were not able to simulate in a hyperrealistic way a world with immersion producing effects (see chap. VII.1.3.1) the movie "Tron" (see chap. IV.2.1.4) demonstrated how the virtual worlds of computer games provoke fictions of `other worlds´. Nevertheless these worlds behind screens are accessible only by technical interfaces the simulations are primarily experienced as emotionally experienced environments.

Lisberger´s movie shows the fight between the "Master Control Program" and the safeguarding program maintaining the users´ control. This fight reacts to the vision of simulated actors supervising our imaginations of a socialisation in a technically organised world that produces not only games but assimilates itself to them ("gamification"). Nevertheless Tron´s reconstructed balance between virtual and real worlds was presented on a literary level as a science fiction and on a filmic level as a spatialisation of the plot: In "Tron" the computer animation served as a means to realise the literary and filmic fiction of an interaction between human and computer, as it was developed in the plot and in the storyboard with `pencil and imagination´, independent of computing capacities. Contrary to this fictionalisation are we faced today in the web 2.0 with real problems to organise big data with either an open or a hidden control of data streams.

Although Baudrillard tried in his criticism of the simulation and the simulacra to explain the spectacle organisation as a civilisation distributing signs so that its members loose increasingly the capability to recognise dependencies from outside controls, his criticism is tuned by some of his followers to an euphoria over technology. 76

The accelerated distribution of signs can not only be a part of the spectacle organisation of simulations but a cause for the dissemination of gender patterns, too. This possibility arised with the technological means offered by an accelerated computer aided image processing and a layered virtual image space replacing representations of real spaces by possible phase spaces. Peter Weibel presented these spaces in his theses on the "Pictorial Space in Electronic Art" 77 and in collaboration with Valie Export in the performance "Voices from an Inner Space" (1988) 78 as a possible way to a civilisation reorganising itself digitally and transgressing gender specific role patterns.



Export, Valie/Weibel, Peter: Voices from an Inner Space, intermedial performance, Brucknerhaus, Linz 9/17/1988.

After algorithms generating fractals were used in computer animtaion to create formations perceived by humans as landscapes (compare Loren C. Carpenter 1980 in "Vol Libre" and 1982 in "Genesis demo" for "Star Trek II: The Wrath of Khan", see chap. IV.2.1.4.1), Export and Weibel get inovled in "Voices from an Inner Space" with the two-fold tie of computing processes to representing as well as symbolic functions and transgress it unilateral: They dissolve symbolic functions nevertheless they provoke imaginations of bodies beyond gender stereotypes and renounce with it to transgress representing functions, too. However these functions aren´t used anymore for renderings of real states of affairs but for their transgressions.

A precondition of a "Chronocratie" accelerating the distribution speed of digital organised knowledge is the distribution of personal computers: In Silicon Valley the counterculture of hackers and early networks became neoliberal (see chap. VI.1.2) 79 and provides with the distribution of personal computers and their increasing capacities the precondition of a technoperspective 80 that is shared by cyberfeminism´s theses on "cyborgs": If biological restrictions of human bodies, as they are given for example by sexual characteristics, become transgressable by new possibilities for biological transformations, then the social ties between the biological sex and gender specific role patterns are obsolete, because the first one becomes as flexible as the last ones. 81

The cyberpunk suggestion of a living with "biochips" facilitates to imagine `the human´ as a "prosthetic god" 83 augmenting himself and being able to extend this process to a transformation of himself into a self-navigating computer. Contrasting to this conception of a technoid self-transformation published by Oswald Wiener already in the midst of the sixties 84 the real problems are, how to generate artificial life by self-transforming computing processes. Each computer and each software set insurmountable limits to self

transformations because the transformation rules of computing processes always determine how codes can be developed: The ideal of an unlimited emergence is a technically unreachable long-term goal. 85

In the eighties authors combined the possibilities of 3D simulation with an artificial intelligence and an artificial life taking up concepts of evolutionary art ((see chap. IV.3.1 and chap.IV.3.2) as well as with telecommunciation as if these scopes inevitably will grow together to a "cyberspace". 86 But these scopes don´t merge as seamless together as a technoperspective of the eighties promised it. Perhaps "Second Life" fulfills today some of these ideas on the combination of 3D simulations with telecommunication, but this platform offers to bring in ideas on artificial life only on a semantic level but not on an algorithmic level.

Theories of cyberspace obscured that the technical possibilities of 3D simulation needed above all the human imagination to develop image sequences and film sequences: Humans work on the interfaces to computers and computing processes in using systems combining several software evolutions with the goal to prepare phase spaces until they are conclusive for observers whose expectations were shaped by pictorial, photographic and filmic codes. Computer animation is used by creators of movies especially to develop further the concepts of art that were shaped by these codes: Digital animations are `projection machines´ created by humans for humans.

The meaning of the word "machine" can´t be restricted in this context to the frameworks of technical terms. "Machine" is a psychological term, too, which means here the imagination´s fitting together of heterogenous elements to new syntheses 87, but not algorithms of transformations executed in computing processes, in whatever way humans may be able to perceive the presentations produced by these generations (see chap. VIII.1 on modular and generative procedures). The "desiring machine" cinema affects the expectations of computer animations´ creators, meanwhile Evolutionary Art gives the "technical machine" an autonomy by liberating computing processes controlled by algorithms from hereonomous functions. The outputs of these generative processes become an experiment for humans´ observing operations: Here it is open what can constitute the "desiring machine" in the future. 88 But this openness presupposes a generative art using evolution only as a point of reference (see chap. IV.3.3). However Evolutionary Art´s variant simulating plants and bodies binds the "technical machine" to the "desiring machine" by the representational function of the presented sign configurations (as organic bodies) and their symbolic function (via the chosen vicinity to the biologic evolution (see chap. IV.3.1 and IV.3.2)). In this case the "desiring machine" is not liberated by twofold representational and symbolic ties but contents itself with the extension of the imagination and representation of relations between art, technology and science. But these ties were criticised by the philosophers of postmodernism as "dispositives" that should be deconstructed. 89

Annotations

1 Jones: Synthetics 2011, p.45; Magnenat Thalmann/Thalmann: Computer 1990, p.14s.; Weibel: Geschichte 1984, p.18.
The digital "frame-by-frame" procedures take up the image-by-image procedure of the classic films storing sequences of images on footage made of light-sensitive material (celluloid and others). In the film projector the spooled film is led over a light emitting projection mechanism respectively reeled off and spooled again. The procedure of the

image production, the storing medium and the coordination of the image sequences in this medium are substituted by other procedures in video technology (magnetic tape) and digitalisation. The "frame-by-frame" procedure permits to use the entire computing capacity for the production of each of the single images ("frames") constituting the film. The monitor presentations of the calculated frames are photographed. A sequence of photos combined "frame-by-frame" on the footage provokes the impression of movement.
In the eighties the creation of image sequences with a computer executing programmed transformations from frame to frame was a long-standing process with results being surprising for the programmers, too. If images were moved on the film spool or on magnetic tape as well as on the projectors or recording devices, then the computer was nothing else then an an image processing device and the playback didn´t cause any problems because no computing devices were needed (Magnenat Thalmann/Thalmann: Computer 1990, S.14s.). back

2 Auzenne: Visualization 1994, p.33-37; Carlson: History 2003, chap. A Short History of CCRG and ACAD; Magnenat Thalmann/Thalmann: Computer 1990, p.25-35. back

3 Botz: Kunst 2011, p.13-16; Tasajärvi: History 2004, p.12-15. back

4 Mary Jane Veeder, Tom De Fanti, Steina and Woody Vasulka (see chap. IV.1.2, IV.2.1.4.3 with ann.65s). back

5 Auzenne: Visualization 1994, p.28; Goodman: Visions 1987, p.153ss.; Holbrook/Brown: History 1982, p.14; Jankel/Morton: Computer Graphics 1984, p.21 with ill.1.5, p.24; Knowlton: Movies 1968. back

6 Buxton: Interaction 2005, p.1163,1166; Flückiger: Effects 2008, p.53s.; Halbach: Interfaces 1994, p.156ss.; Jankel/Morton: Computer Graphics 1984, p.19; Sutherland: Sketchpad 1963; Wagner: Computergrafik 2004, chap.2. back

7 Carlson: History 2003, Section 3; Goodman: Visions 1987, p.21s.; Krull: Origin 1994 (quotes). back

8 Interfaces for the human-computer interaction:
Alan Kay and his research group at Xerox PARC, Palo Alto (Palo Alto Research Center): Bardini: Bootstrapping 2000, p.215s.; Flückiger: Effects 2008, p.54; Friedewald: Computer 2009, p.237-355; Manovich: Kay 2007; Manovich: Software 2008, Part I, Chapter 1; Rheingold: Tools 1985, Chapter 11.
Xerox Star, Apple Lisa und Apple Macintosh (cf. ann.64): Friedewald: Computer 2009, p.343-351,379-409; Matis: Wundermaschine 2002, p.270s. back

9 Lansdown: Computing 1980; Magnenat Thalmann/Thalmann: Computer 1990, p.223; Reichardt: Computer 1971, p.15ss.; Reichardt: Serendipity 1968, p.88ss.; Youngblood: Cinema 1970, p.194s. back

10 Knowlton: Movies 1968, p.68; Noll: Movies 1965.
Hardware: Mainframe Computer IBM 7094 (since 1962), Stromberg Carlson 4020 Microfilm Recorder (since 1959), 16mm camera. back

11 Dietrich: Intelligence 1986, p.163; Knowlton: Computer 1964; Magnenat Thalmann/Thalmann: Computer 1990, p.19s.; Reichardt: Computer 1971, p.77s.; Youngblood: Cinema 1970, p.246. back

12 Knowlton: Computer 1964, p.67 (quote). Cf. Auzenne: Visualization 1994,

p.29s.,39s.,45; Youngblood: Cinema 1970, p.246-249. back

13 Le Grice: Computer 1974, p.163 (first quote); Sutton: Vanderbeek 2012, p.320 (second quote).
Knowlton used the experiences he made in collaborations with VanDerBeek to develop TARPS ("Two-dimensional Alphanumeric Raster Picture System"). With TARPS the films from "Poemfield No.1" (1964) to "Poemfield No.8" (1967) were created (Lansdown: Computing 1975; Patterson: Vision 2015, Kindle ebook position 1473). As the program used for the realisation of "Poemfields" Carolyn L. Kane, Gloria Sutton and Gene Youngblood mention only BEFLIX, bot not TARPS (Kane: Algorithm 2014, Kindle ebook position 2649; Sutton: Machine 2015, p.173,175; Sutton: Vanderbeek 2012, p.313,315s.; Youngblood: Cinema 1970, p.246). In "New Talent – The Computer", when Vanderbeek explains the programming in his description of the production process, then he mentions only BEFLIX (Vanderbeek: Talent 1970, p.86,91).
On the coloration: Glora Sutton quotes Vanderbeek´s "EAT [Experiments in Art and Technology] talk, c. 1968": "Starting with a black-and-white film on one end of an optical printer and projecting it on color based film and sticking color filters in the way, you superimpose a color layer over your black-and-white material." (Sutton: Machine 2015, p.173s.). According to Zabet Patterson the film was "carefully colored by hand." (Patterson: Vision 2015, Kindle ebook Position 1524. Cf. Kane: Algorithms, Kindle ebook Position 1490). back

14 Csuri/Shaffer: Art 1968, p.12,97; Jankel/Morton: Computer Graphics 1984, p.22s. with ill. 1.10.1-4; Youngblood: Cinema 1970, p.202s. Rosen: Record 2006, p.46 with ill.42: "Programming Assistance: Samuel J. Cardman, and J. Carroll Notestine...Shaffer developed the technique to bring in short segments of the plotter drawings. Csuri developed the ideas of morphing, randomness and fragmentation, which were implemented by Shaffer, Cardman, and Notestine. Charles Csuri, e-mail to [Margit Rosen]..., 8 May 2006."
Further Examples of two- and three-dimensional computer animations in the sixties:
Pritchett, Tony: Flexipede, 1967-68. Film, 16 mm, b/w, sound, 2 min. 10 sec. In: Mason: Computer 2008, p.211s.
Yamada, Gaku/Tsukio, Yoshi: The Art of Fugue, 1968. Film, 16mm, s/w, 3 min. In: Sakane: Computer. back

15 Reichardt: Computer 1971, p.81s.; Reichardt: Serendipity 1968, p.75s. back

16 Glowsky: Csuri 2006, p.33,71. In chap. IV.2.1.2 Csuri´s procedure to create animations was sketched out in the description of the film "Hummingbird". back

17 Auzenne: Visualization 1994, p.14,24,55; Burtnyk/Wein: Key-Frame Animation 1974, p.38; Flückiger: Effects 2008, p.113s.; Magnenat Thalmann/Thalmann: Computer 1990, p.25s.,28,48. back

18 Burtnyk/Wein: Key-Frame Animation 1971; Burtnyk/Wein: Key-Frame Animation 1974. back

19 Burtnyk/Wein: Skeleton 1976, p.564. back

20 Roberts: Machine 1963 (cf. Gouraud: Shading 1971, p.87s.); Sutherland/Sproull/Schumacker: Characterization 1974. back

21 Manovich: Mapping 1993, Chap. 3-D Computer Graphics: Interactive Perspectivalism; Wagner: Computergrafik 2004, chap.2.1. back

22 Gouraud Shading: Gouraud: Computer 1971/1979; Gouraud: Shading 1971 (quotation p.90); Magnenat Thalmann/Thalmann: Computer 1990, p.93; Morrison: Computer 1994, chap. 1970-79; Parke: Animation 1972, p.452. back

23 Phong Shading: Magnenat Thalmann/Thalmann: Computer 1990, p.94; Morrison: Computer 1994, chap. 1970-79; Phong: Illumination 1975, p.312: "When planar polygons are used to model an object, it is customary to shade the object by using the *normal vectors* to the polygons. The shading of each point on a polygon is then the product of a shading coefficient for the polygon and the cosine of the angle between the polygon normal and the direction of incident light." back

24 Magnenat Thalmann/Thalmann: Computer 1990, p.93ss.,147. back

25 Carlson: History 2003, Section 20; Flückiger: Effects 2008, p.58s. with ill.8s., p.86 with ill.10, p.270 with ill.81. back

26 Catmull: Subdivision 1974; Catmull: Computer 1975; Magnenat Thalmann/Thalmann: Computer 1990, p.88; Morrison: Computer 1994, chap. 1970-79; Straßer: Kurvendarstellung 1974. back

27 "Bump Mapping": Blinn: Simulation 1978; Flückiger: Effects 2008, p.85s.
On James F. Blinn: Auzenne: Visualization 1994, p.52-59. back

28 Magnenat Thalmann/Thalmann: Computer 1990, p.26,30s. back

29 Autodesk, since 1982; Wavefront, since 1984; Prisms, since 1985; TOPAS, since 1986; Pixars Render Man, since 1988 (acquirable since 1989); Autodesk Animator, since 1989 (for personal computer); Wavefronts Composer, since 1991; Wavefronts Kinematon and Dynamation, since 1992; After Effects, since 1993 (see Manovich: Effects Part II 2006, chap. Deep Remixability: "remixability of previously separate media languages"). back

30 Gere: Culture 2008, p.184s.,190ss.; Neuhaus: Gibson 2006. back

31 Parke: Computer 1972, p.452s. back

32 Westworld: Auzenne: Visualization 1994, p.21,53,67s.; Flückiger: Effects 2008, p.115,424s.; Jankel/Morton: Computer Graphics 1984, p.111; Manning: Blocpix 1975.
Futureworld: Auzenne: Visualization 1994, p.16,21,53; Flückiger: Bodies 2010, p.7s.; Flückiger: Effects 2008, p.115,423s.; Jankel/Morton: Computer Graphics 1984, p.118. back

33 Star Wars Episode IV: Jankel/Morton: Computer Graphics 1984, p.111; Weibel: Geschichte 1984, p.27.
Alien: Jankel/Morton: Computer Graphics 1984, p.110s.; Mason: Bits 2006, p.12-15; Mason: Computer 2008, p.233ss.: Sutcliffe´s "program was written in FORTRAN with calls to FROLIC subroutines". Colin Emmett developed the animation software FROLIC and Alan Sutcliffe used it on a minicomputer Atlas Lab Prime 400 (since 1976/77). Sutcliffe created a polystyrene model of the mountains. He used their measures as basic elements of his simulation (Mason: Bits 2006, p.14). back

34 Auzenne: Visualization 1994, p.85; Carpenter: Computer 1980; Flückiger: Effects 2008, p.66; Franke: Kunst 1986, p.17,32; Magnenat Thalmann/Thalmann: Computer 1990, p.118; Morrison: Computer 1994, chap. History 1980. back

35 Auzenne: Visualization 1994, p.53,67,86; Flückiger: Effects 2008, p.62,424; Jankel/Morton: Computer Graphics 1984, p.118s.; Wikipedia: Looker 2012.
Flückiger: Effects 2008, p.424 on the scene with the simulation coming after the whole body scan: "As in `Westworld´...the digital figure´s construction is simultaneously present as the narration´s subject; in the narrow sense no illusionment takes place with the artificial body, but the representation is framed as technically made..."
Animated sequences in "Westworld", "Futureworld", "Looker" and "TRON" (see below) were created by Triple-I (Information International Inc.) (Flückiger: Bodies 2010, p.7ss.,12s.; Flückiger: Effects 2008, p.62,115,423s.,427; Magnenat Thalmann/Thalmann: Computer 1990, p.37). back

36 Auzenne: Visualization 1994, p.76s.; Flückiger: Effects 2008, p.66,116s.,132s.; Jankel/Morton: Computer Graphics 1984, p.39,49s.,115ss. with ill. 7.12.1-8; Magnenat Thalmann/Thalmann: Computer 1990, p.35,120. back

37 In 1986 a computer was developed especially for the animation system: Reyes had complex algorithms implemented on its graphics machine and was more powerful than its predecessor Pixar and the Cray X-MP utilised for example by Digital Productions (Conlan: Computers 1986, p.83,90).
Ray Tracing simplifies the calculation of light beams. Not all beams reflected by an object, but only the reflexes are calculated that became visible from the observer´s point of view. In the beginning of the seventies the Ray Tracing technique was used first by the MAGI (Mathematical Applications Group Inc.) animation system (Flückiger: Effects 2008, p.181s.; Goldstein/Nagel: Simulation 1971; Magnenat Thalmann/Thalmann: Computer 1990, p.101s.). back

38 Cook/Carpenter/Catmull: Reyes Image Rendering 1987 (quote p.97). back

39 Reeves: Particle Systems 1983, p.359. Cf. Flückiger: Effects 2008, p.132s.; Jankel/Morton: Computer Graphics 1984, p.39. back

40 Reeves: Particle Systems 1983, p.365-371. back

41 Sims: Particle 1990, p.405. back

42 Carlson: History 2003, Section 6; Conlan: Computers 1986, p.75-83; Flückiger: Bodies 2010, p.12s.; Flückiger: Effects 2008, p.7s.,117,216s.,427; Gere: Culture 2008, p.182ss.; Jankel/Morton: Computer Graphics 1984, p.110 with ill.7.1, p.112-115 with ill.7.2-7.10, p.118s.; Weibel: Musik 1987, p.141. back

43 Auzenne: Visualization 1994, p.62,68; Carlson: History 2003, Section 6; Conlan: Computers 1986, p.75-83; Magnenat Thalmann/Thalmann: Computer 1990, p.37; Morrison: Computer 1994, chap. History 1980.
"Tron" (1982) as Arcade Game of Bally/Midway Games contained four little games that included sequences of the movie (Wirsig: Lexikon 2003, p.471). The game was more successful than the film. back

44 Gere: Culture 2008, p.190s.
The main character in the TV series "Max Headroom" was not simulated via computer animation: The contemporary techniques of film production (actor Matt Frewer with make-up) were extended by video editing. Computer graphics realised in 1987 on a Commodore Amiga for the American version of the series included only the appearance of the protagonist on monitors. After an accident (by disregarding the warning "maximum headroom") the main character "Max Headroom" existed only as a monitor phenomenon, as prescribed by the plot (Masson: CG 101 1999, chap. History of

Computer Graphics). back

45 Jankel/Morton: Computer Graphics 1984, p.133; Weibel: Musik-Videos 1986, p.40s. back

46 The Catherine Wheel: Jankel/Morton: Computer Graphics 1984, p.35,85,88s.,133. Abracadabra: Conn: Promos 1983, p.8. back

47 Goodman: Visions 1987, p.163 (Software: system with face parameters developed by Frederick I. Parke, director of the Computer Graphics Laboratory at the New York Institute of Technology. Hardware: Digital Equipment Corporation (DEC) Vax 11/780 (since 1977), Evans and Sutherland Picture System, Ikonas Frame Buffer); Jankel/Morton: Computer Graphics 1984, p.,119,133s. with ill. 8.34 back

48 Ashley: Perfect Lives 1991; Machan: Ashley 1986; Nabakowski: Geld 1985.
John Sanborn and Dean Winkler used "Video Image Processing" for editing (video synthesis and video editing).
Richard Wagner, "Oper und Drama" ("Opera and Drama"), 1952, on the "leitmotif" as a conception of the music drame: Wagner: Oper 1994, p.163,286,298-308,332s.,349-365,419,446ss., 492s., 532s. (On the "leitmotif" in "Perfect Lives": John Rockwell, cited in: Nabakowski: Geld 1985, p.91). back

49 Auzenne: Visualization 1994, p.110s.; Jankel/Morton: Computer Graphics 1984, p.46ss.; Weibel: Geschichte 1984, p.32. Programming: Alvy Ray Smith, Lance Williams und Garland Stern (at the Computer Graphics Laboratory of the New York Institute of Technology, Old Westbury/Long Island). back

50 Knopfler 1994 in: Flanagan: Interviews (undated).
On the music clip "Money for Nothing": Barron: Dire Straits 2006; Girl on Film: Anniversary 2010.
On rotoscoping: Flückiger: Effects 2008, p.110,216. back

51 Flückiger: Bodies 2012, p.10s.; Flückiger: Effects 2008, p.425s.; Goodman: Visions 1987, p.2s.,162s.,187.
On the economic efficiency of supercomputers for animations (using Digital Productions as an example): Auzenne: Visualization 1994, p.86ss. back

52 On the interpretation of "Sledgehammer": Drewett/Hill/Kärki: Peter Gabriel 2010, p.57-69,195-209. back

53 Bussy: Kraftwerk 2006, p.154-157. back

54 Flückiger: Bodies 2010, p.9 with ann.8; Flückiger: Effects 2008, p.424 with ann.8; Magnenat Thalmann/Thalmann: Computer 1990, p.238; Morrison: Computer 1994, chap. History 1980.
Motion Capture was developed by Jim Hanson and Brad de Graf (Morrison: Computer 1994, chap. History 1980). In the closing credits of "Don´t Touch Me" De Graf is named as one of the "body flexing software consultants". The face animation was realised by the interpolation of key frames using software developed by Larry Weinberg. The body animation was created with software from Konrad Witz. back

55 Wikipedia: MTV Video Music Award 2012. back

56 Fast following cuts resp. fast change of short sequences in music videos: Poschardt: Video 2004, p.14.

After 1987 exceptions from the music video as a promotion for the concert star are for example Daft Punk (because of their self chosen anonymity (f.e. "909 Revolution" (1998), directed by Roman Coppola)) and Aphex Twin (f.e. "Rubber Johnny" (2005) by Chris Cunningham). back

57 Barron: Dire Straits 2006. back

58 On the form of Cracktros: Botz: Kunst 2011, p.14; Tasajärvi: History 2004, p.13.
Cracktros, since 1983 for Commodore 64: Botz: Kunst 2011, p.14,46,51s.,63s.
Examples by TRIAD und FAIRLIGHT: Botz: Kunst 2011, p.77s.
Programming languages of the cracktros: Botz: Kunst 2011, p.59s. back

59 Botz: Kunst 2011, p.15. back

60 Botz: Kunst 2011, p.46-50,103-107; Matis: Wundermaschine 2002, p.283ss.
The illegal copies of computer games made and distributed by a cracktro scene dominated by Commodore users caused a decrease of the sales being earned by game enterprises with their versions for the Commodore computers. After all the game producers reduced the versions made for Commodore personal computers.
Commodore had no success with its efforts to reach more clients of business computers. One of the reasons for this failure was Commodore´s fame as a producer of personal computers for gamers and creators of videos. These people used the capabilities of Commodore computers for graphics presentations and the tape deck for audio casettes (Tasajärvi: Demoscene 2004, p.12; Wikipedia: Amiga Software 2012, chap. Piracy). In 1994 the image problems originating in these technical characteristics as well as other reasons led to the bankruptcy of Commodore Business Machines.
In 1986 Andy Warhol demonstrated in a TV programme the capabilities that personal computers offer to creators of graphics: He used a paint system (Graphicraft by Commodore Amiga Inc.) on a Commodore Amiga 1000 to rework a digital image representing Deborah Harry (Goodman: Visions 1987, p.89). Warhol showcased how simple it was to use a Graphical User Interface (GUI) (Lambert: Computer 2003, chap.6: The Act of Using) and presented the graphics possibilities of the Commodore Amiga 1000. The demoscene did not need programmes that kept users via GUI away from the source code. back

61 Botz: Kunst 2011, p.132-153 (with an interpretation of Red Sector´s Megademo 1989, from p.145 onwards). back

62 Botz: Kunst 2011, p.15,220-232,241-249; Reunanen: Computer 2010, p.47s. back

63 Important producers of personal computers were in the seventies and eighties: Xerox (Alto, 1972; Star, 1981); MITS (Altair 8800, since 1974); IMSAI (8080, since 1975); Apple (Macintosh, since 1976; Apple II, since 1977); Commodore (PET, since 1977; C 64, since 1982; Amiga, since 1985); Atari (400/800, since 1979); IBM (IBM 5150 Personal Computer, since 1981). Lit.: Augarten: Bit 1984, p.270-281; Friedewald: Computer 2009, p.366-409; Matis: Wundermaschine 2002, p.271-288. back

64 ZGRASS: Dietrich: Real Time Animation Techniques 1982; Jankel/Morton: Computer Graphics 1984, p.84; Magnenat Thalmann/Thalmann: Computer 1990, p.33. Datamax UV-1 is a small computer constructed for ZGRASS. Bally planned to market the Datamax UV-1 as a home computer. Datamax UV-1 should have to compete with the Apple II (see ann.63). But Bally gave up this sphere of business in 1980. back

65 Vasulka, Woody: Bad, 1979 and Artifacts, 1980. In: see chap. IV.1.2 with ann.45.
Vasulka, Steina: Selected Treecuts, 1980. In: Hatanaka/Koizumi/Sekiguchi: Vasulka

1998, p.19. back

66 Veeder, Mary Jane: Montana, 1982. In: Magnenat Thalmann/Thalmann: Computer 1990, p.33s.; Popper: Electra 1983, p.418s.
Furthermore with ZGRASS:
Cuba, Larry: Calculated Movements, 1985. In: Youngblood: Cuba 1986. Further examples: Jankel/Morton: Computer Graphics 1984, p.82 with ill.6.6, p.84. back

67 Diedrichsen: Kunstvideo 2004, p.73-78: Feinemann: Kunst 2004, p.87s.; Theweleit: Frühgeschichte 2004, p.58-65; Weibel: Musik 1987. back

68 Botz: Kunst 2011, p.14,17s. back

69 On the Techno-Imaginary: Rötzer: Technoimaginäres 1988, p.66ss.; Rötzer: Technoimaginäres 1989, p.55. The concepts of a "techno-imagery" are bound to computer technology, meanwhile Villem Flusser defined the "techno-imagery" independent of this technology (see ann.76).
Telecommunication and sign distribution: Virilio: Bild 1989; Weibel: Beschleunigung 1987, p.110ss.,125. back

70 Baudrillard: Ecstasy 1983, p.127 ("The subject himself, suddenly transformed, becomes a computer at the wheel, not a drunken demiurge of power."); Rötzer: Technoimaginäres 1989, p.55. back

71 Baudrillard: Simulacres 1981; Virilio: Véhiculaire 1975; Virilio: Intervall 1990. back

72 The Hyperreal: Baudrillard: Simulacres 1981, chap. VIII.
"Museumification" of the present: Baudrillard: Simulacres 1981, chap.1. Cf. Jeudy: Welt 1987, p.10s.; Lübbe: Zeit-Verhältnisse 1990. back

73 Floating signifiers: Derrida: Ecriture 1967, p.423s.; Rötzer: Technoimaginäres 1988, p.67.
Marketing strategies connecting distribution systems for different kinds of media and the music videos within these strategies: Weibel: Musik-Videos 1986, p.27,38s.
Spectacle-organisation: Debord: Société 1967/1992, chap.1-3, p.9-41; Dreher: Performance Art 2001, p.353 with ann.574. back

74 Dreher: Valie Export/Peter Weibel 1992, p.19s. back

75 Baudrillard: Simulacres 1981, chap. XVII. back

76 Villem Flusser uses the term "techno-imagination" in a positive sense for an exploration of the possibilities offered by the technological progress to create new `technical images´ (Flusser: Umbruch 1998, p.169,209-222; Krtilova: Bild-Theorie 2010, p.11). Flusser explained these possibilities at a point in time when the correlations between technical and social progress seemed to open new perspectives on a better future. back

77 Weibel: Raum 1986. Cf. Weibel: Beschleunigung 1987, p.40s.,117ss.,125; Weibel: Ausstieg 1989, p.72. back

78 Dreher: Valie Export/Peter Weibel 1992; Schuler: Weibel 1997, p.258-263,276; Weibel: Stimmen 1988. back

79 Gere: Culture 2008, p.142-149. back

80 Weibel: Beschleunigung 1987, p.152: "High performance computers should become cheaper like electricity in earlier times." back

81 Haraway: Cyborg Manifesto 1991, p.150. back

82 Gibson: Zero 1986. Cf. Baudrillard: Videowelt 1988. back

83 Dreher: Performance Art 2001, p.349s. with ann.571. back

84 Wiener: Bio-Adapter 1965-66. back

85 Cariani: Emergence 1991; Whitelaw: Metacreation 2004, p.217-221; see chap. IV.3.4. back

86 F.e. Rötzer: Technoimaginäres 1988, p.66ss.,73s. back

87 Schmidgen: Unbewußte 1997, esp. p.76s.,145ss.: "[Gilles] Deleuze and [Félix] Guattari...tell us that the technical machine is a representation of the desiring machine." (p.77) back

88 Schmidgen: Unbewußte 1997, p.75-81. back

89 Deconstruction: Derrida: Semiologie 1986, p.80s.
Dispositives: Foucault: Jeu 1977. back

IV. Images in Motion
IV.3 Evolutionary Art

IV.3.1 Biomorphs

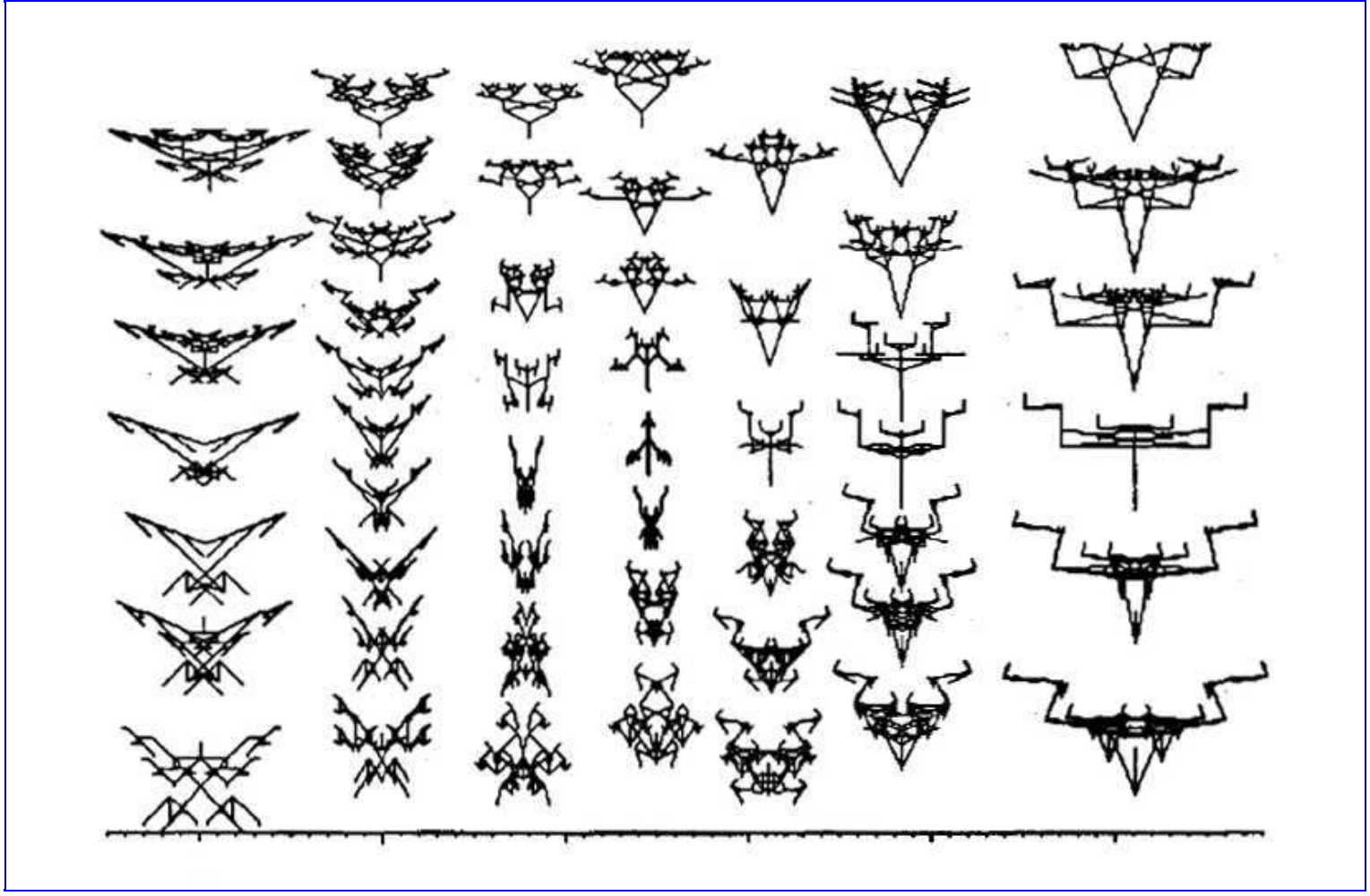
In the case of movie sequences the "synthetic realism" 1 of computer animation (see chap. IV.2.1.3 and IV.2.1.4) is a result of compositions with three-dimensional programmed objects in movable perspectival views. The animators follow visions presented in the drawings of a storyboard: Although the perspectival views of the three-dimensional elements are calculated and their transformations follow the algorithms of the animation program, these elements are reworked by the animators with an attention to details fulfilling the requirements of the drawings being parts of the storyboard.

This patchwork character use William Latham and Karl Sims (see chap. IV.3.2) in another manner than the movie animators: With the film´s storyline the cinematigraphic function of the storyboard is cancelled, too. The storyline is substituted by algorithmically structured generations of the computer animation.

From the biologic concepts of the evolution of cells and living beings Latham and Sims derive the limitations of possible generations by environmental factors. Their animation programs contain evolution possibilities and humans – the artist or observers – can replace the environmental conditions by selecting values influencing the computing processes enfolding the programmed evolution in generations. Instead of hiding the character to be composited behind cinematographic "reality effects" 2 Latham and Sims develop their three-dimensional image worlds by intervening into the programmed generation. An interplay between generative processes and artists´ interventions substitutes the interplay between biologic evolutions and environmental factors.

For their Evolutionary Art Latham and Sims found suggestions in biological research: Scientists use in theoretical biology models presenting concepts of the evolution as computer programs. The conceptualisation of the biologic evolutions´ possibilities is preferred over laboratory tests with real cells. 3

In the third chapter of "The Blind Watchmaker" (1986) Richard Dawkins presents a computer simulation of branching processes building "trees". In the case of repeated symmetric branches Dawkins reduces the amount of codes resp. the "genes" containing the elements for the branching program. "Biomorphs" with forms similar to plants and animals grow out of combinations and repetitions of these genes. 4 Dawkins takes up the term "biomorph" of the English coologist and artist Desmond Morris. As "biomorphs" Morris designated the animal-like figures of his late surrealistic paintings that were influenced by Yves Tanguy. 5



Dawkins, Richard: The Blind Watchmaker, 1986, examples of a model for the "evolution game" (Dawkins: Watchmaker 1986, p.70, fig.8).

Dawkins´ model shows the relation between genotypic codes ("genes") and phenotypic features ("biomorphs") realised by these codes in recursive procedures. The biologic developments proceed "bottom up" without a superior goal. From the "cumulative selection" 6 over generations arise context-sensitive reactions between simultaneous developments. This sensitivity is exclusively "locally determined". 7

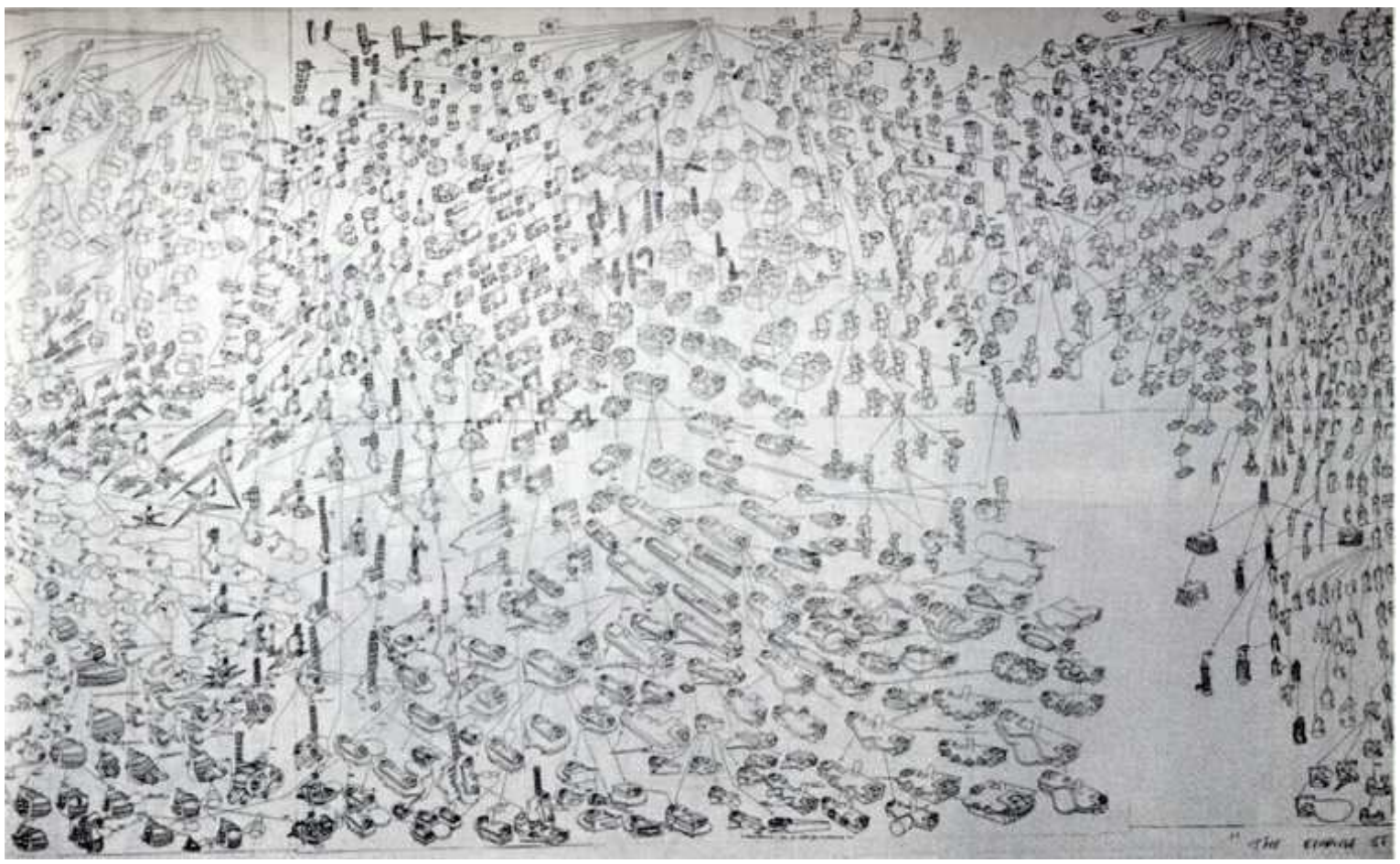
On the one hand there is an "evolution game" with development rules contained in the "genes" producing elements that vary by mutation, on the other hand a "human selector" 8 can influence the development and is able to reduce a multilinear plurality to a certain development line. 9

Dawkins highlights the difference between an unguided development in Artificial Life and the computer games simulating worlds. He distinguishes "computer games" from "evolution games": The former are "designed by a human programmer", meanwhile in the latter case "the monsters that one encounters are undesigned and unpredictable." 10 For Dawkins "evolution games" consist of the relation between development rules and pseudo-random producing mutations.

IV.3.2 Evolution and Processing

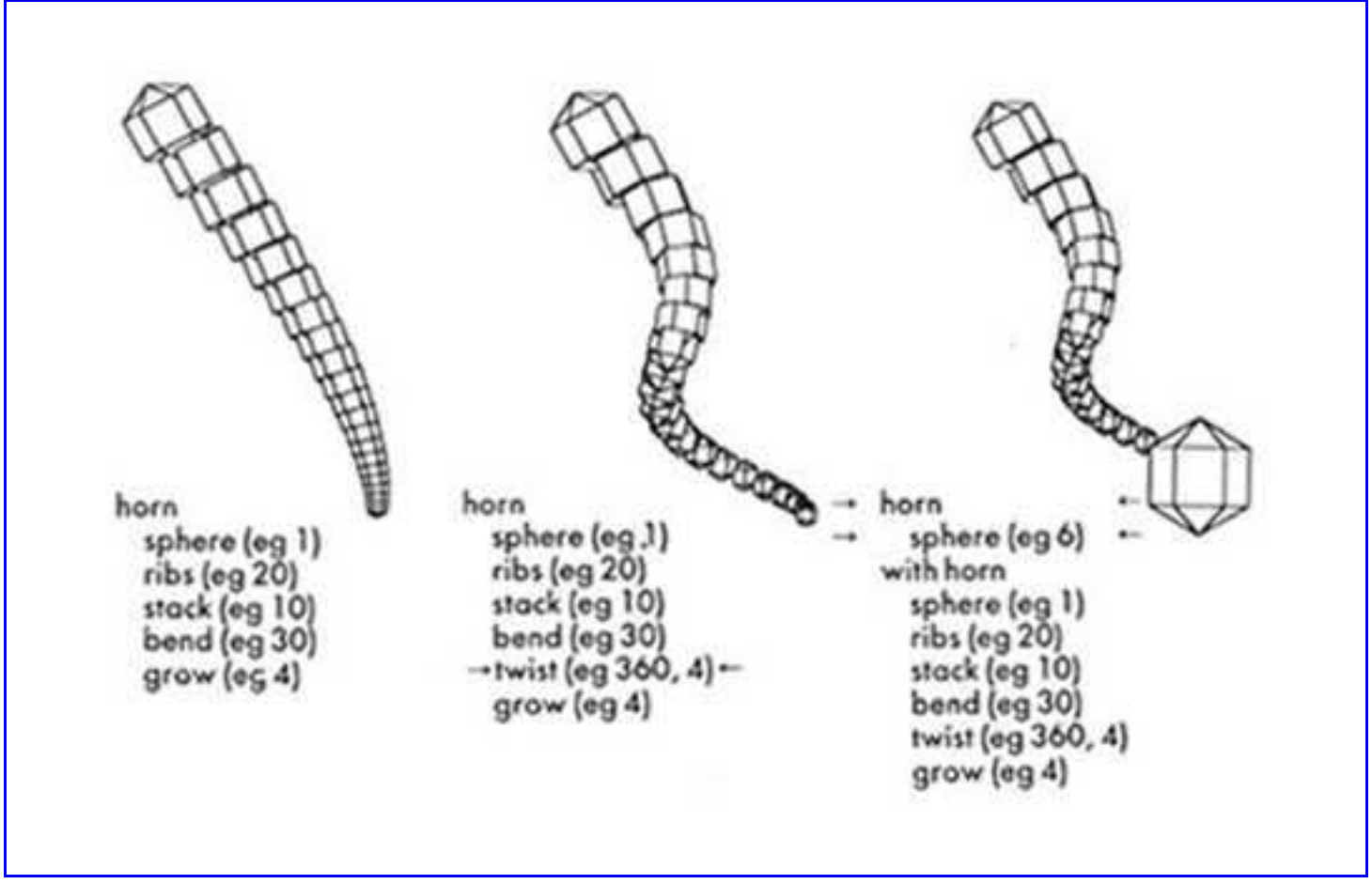
In 1992 William Latham and Stephen Todd presented their creative work on and with a program for the generation of biomorphic forms. At the IBM United Kingdom Scientific Centres in Winchester Todd developed the program for an IBM 3081 Mainframe Computer (since 1980) with IBM 5080 (since 1983) and 6090 Graphics Systems. 11 For William Latham Todd´s editors simplified the selection of three-dimensional elements and their possible combinations. The editors made it easier for Latham to concentrate himself on the best ways to use the properties of the software. The artistic selection takes

place in phases and the program offers new possibilities for further creative phases. The editors offer schemes with lines marking the limits and edges of objects. Later on, colors, surface properties and shadows are added. With a "three space tracker" Latham can move the virtual object in the image space. 12



Latham, William: Form Synth, 1989, detail of a drawing, 10 meter long (Todd/Latham: Evolutionary Art 1992, p.5, fig.1.6).

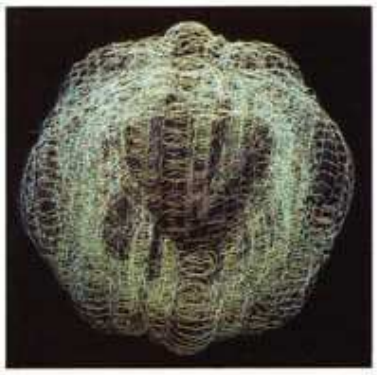
When Todd developed the software "Form Growth" with the "ESME (Extensible Solid Model Editor) programming tool" then he reconstructed characteristics of Latham´s "evolutionary trees". In 1989 Latham presented these drawings of the series "Form Synth". 13 "Form Synth" furnishes a vocabulary with three-dimensional elements being indicated by the CSG (Constructive Solid Geometry) program as line drawings. 14 There are elements that can be combined as "horns". Via input to the editor Latham can determine the quantity and the combination manner of the elements. 15 The element combinations in turn can build groups that are presented in the series "Mutations" (1991-92) in random order next to and beneath each other. "Continuous evolutions" can lead to "gene banks" for further selection phases and to animations with "life cycles" determining how long "genes" will reappear in an animation. 16



Latham, William: Horns, structure mutation with the software Mutator (Todd/Latham: Evolutionary Art 1992, p.99, fig.5.26).

Latham and Todd explain the development of their animations:

> In our earliest animation, "The Conquest of Form" [1987] , the view of the rigid forms moved but the forms themselves did not change – so called `view animation´. Later in "A Sequence from the Evolution of Form" [1989] the forms metamorphosed using a technique called "gene interpolation" 17, but only a single form was visible at any one time. Our latest animation "Mutations" [1991-92] illustrates the process of a surreal evolution, involving breeding and growth, with many forms animating with complex interactions. 18



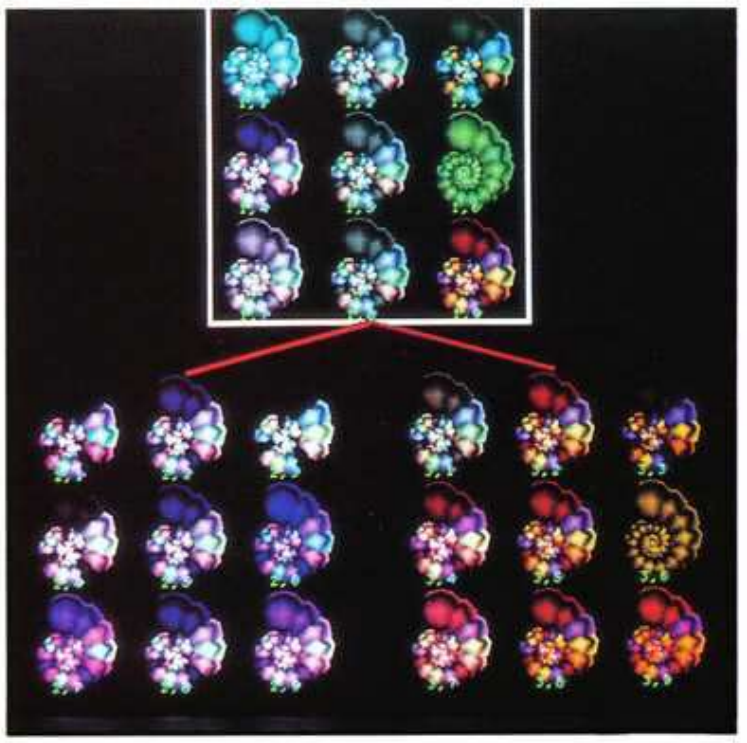
(31 a) Sculpture Wire Frame.



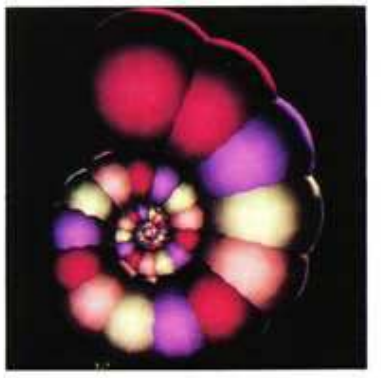
(31 b) Sculpture Rendered.



(31 c) Sculptured Textured.

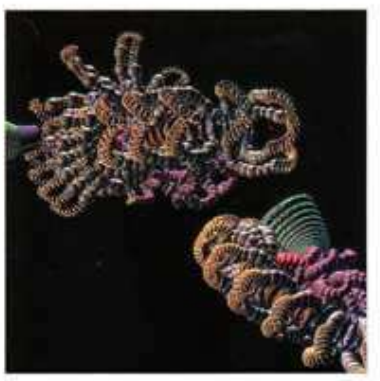


(31 d,e) Evolution of Colour.









(31 f.g.h.) Sequence of Frames from the Film "Mutations". Latham 1992.

Latham, William: Mutations, film, 1992
(Todd/Latham: Evolutionary Art 1992, unpaginated, fig.31).

In Todd´s program Latham takes on the function of a "human selector" (see chap. IV.3.1). Latham describes himself as an "artist gardener" creating his "parody" of Artificial Life science by following aesthetic criteria. 19 The processing of forms in Latham´s and Todd ´s "Evolutionary Art" doesn´t take care about biologic criteria. This indifference can be understood as a "parody" of the problems of the theoretical biology to design computer simulations as reconstructions of the laws of the natural cells´ development (see chap. IV.3.1). "Form Synth" already demonstrates with its selection of basic elements and their combinations that it is not a biological model. Instead it only follows sugestions by "biological forms": "Our systems...often bear no relation to biological reality." 20



Sims, Karl: Panspermia, film, 1990.

In 1990 Karl Sims presents in the short film "Panspermia" an artificial world of biological forms as an autonomous cosmos with recurring parallels to the evolution of geology and fauna on earth. For the program Particle Systems Sims finds after the short film "Particle Dreams" (1988, see chap. IV.2.1.4.1) with the artificial world of "Panspermia" a new adaptation of three-dimensional bodies in processes of de- and reconfiguration.

The film sequences show the "artificial evolution" of recurring branchings and mutations of three-dimensional elements with stem- and leaflike forms. In the framework created by Sims´ software for Thinking Machines Corporation´s Connection Machine CM-2 the human selection determines the progress of the artificial selection. From the functions offered by the program the artist chooses a sufficient complex amount. These functions determine the constructions of two-dimensional elements (x- and y-axes). To these elements a third axis (z-axis) with spatial depth is added for shading and textures.

"Genetic cross dissolves" use different properties of similar images as a basis for further evolutions. Images with different genetic origins are used to construct third images connecting both branches. External image sources can be integrated into these procedures and submitted to the general transformation processes.



Sims, Karl: Primordial Dance, film, 1991.

"Primordial Dance" (1991) features the transformation of face shapes at the end of a film with an image vocabulary being in general lesser oriented to biologic forms than "Panspermia" but more to abstract-organic forms and oriented to a design of the whole image surface. Evidently Sims is lesser interested to demonstrate 3D effects but rather to present continuously changing structures with spatial depth characteristics being generated by his program written in Lisp. In 1991 Sims explained in his article "Artificial Evolution for Computer Graphics" his programming method not without references to Richard Dawkins´ "biomorphs" and their two-dimensional branches. 21



Sims, Karl: Genetic Images", installation, Linz 1993. Screenshot from Vimeo.

This "artificial evolution" is supported by the parallel processing Connection Machine CM-2 with 32 768 processors. It was developed by the Thinking Machines Corporation, for whom Sims worked as an artist-in-residence. The installation "Genetic Images" (1993) 22 demonstrates the capabilities of this computer: 16 monitors present the evolutionary states of an image. Pressure-sensitive sensors are placed before each one of the monitors and make it possible for observers to choose the preferred state that will be the origin for the parallel processing presented on all monitors. The images on the

screens change every 30 seconds. 23

Compared to Latham and Todd Sims shifts the focus of the "human selector" (see above) to the evolutions implemented by the software – the "functions" using the "genotypes" to compute the "phenotypes". 24 The "human selector" doesn´t act like a sovereign creating "gardener" (William Latham, see above) following criteria of visual perception, but as a selector of sequences provided in the system. 25

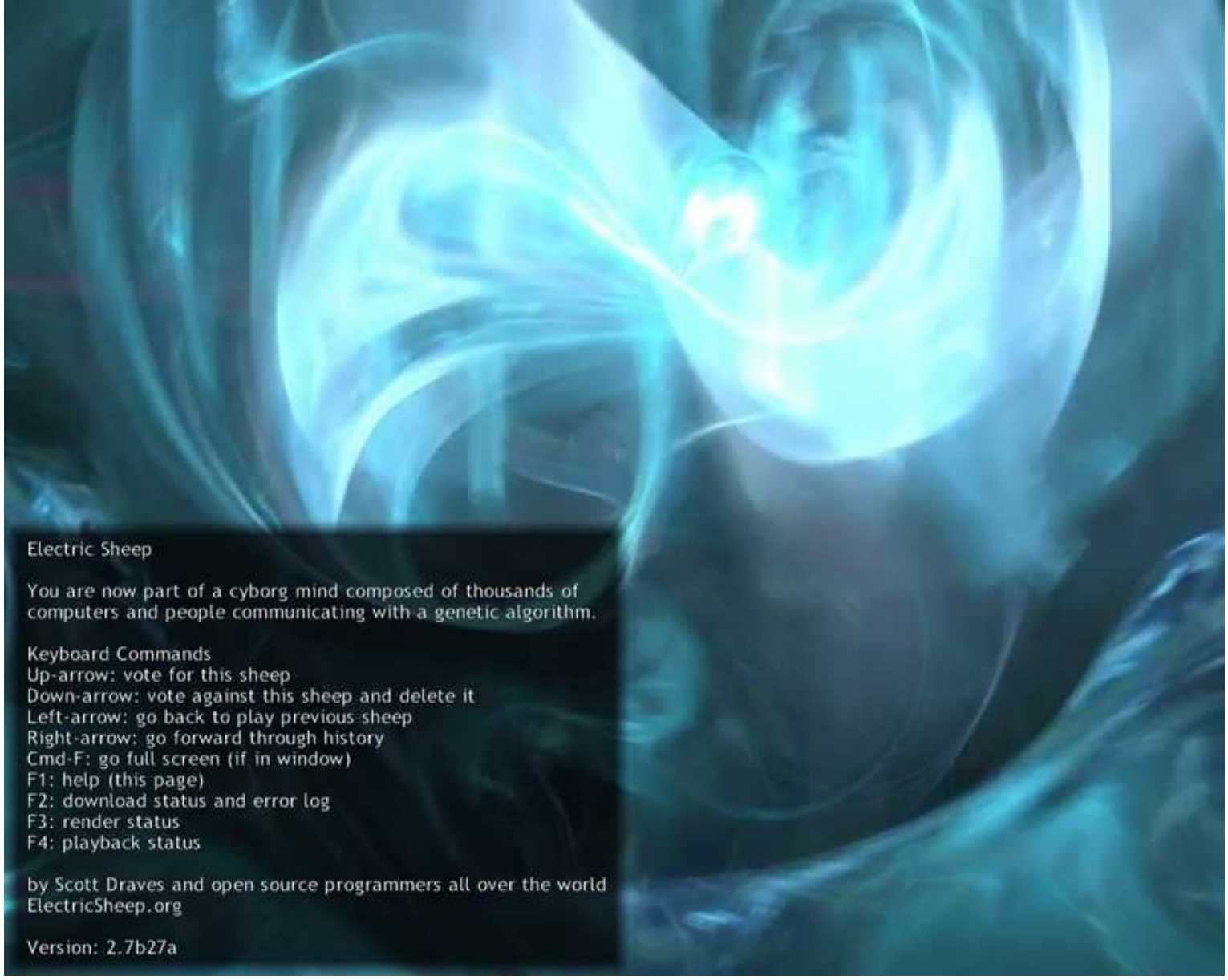
IV.3.3 Fractal Flames

In 1991 Scott Draves developed the "Fractal Flame Algorithm" and published it in 1992 with the General Public License (GPL), that permits to develop the program further: Mark Townsend did it in 2004 by translating Draves´ program from C to Delphi Pascal for his project "Apophysis". 26 In 1999 Draves transformed his tool for image processing in the screensaver "Electric Sheep" into an ever changing animation: A network of computers generates new fractals out of elder fractals. After having installed the screensaver on their computers observers can choose fractals they like. Often selected fractals survive longer within the network and will be presented for a longer time. With the longer survival of the chosen fractals observers influence further evolutions.

"Fractal Flames" is based on repetitions of forms and generations by recursive "affine" transformations. After these linear transformations follows a further transformation phase with non-linear functions. In a third phase further affine functions generate "a post transform". The image generating process of a "flame" can be completed by a "final transform". 27

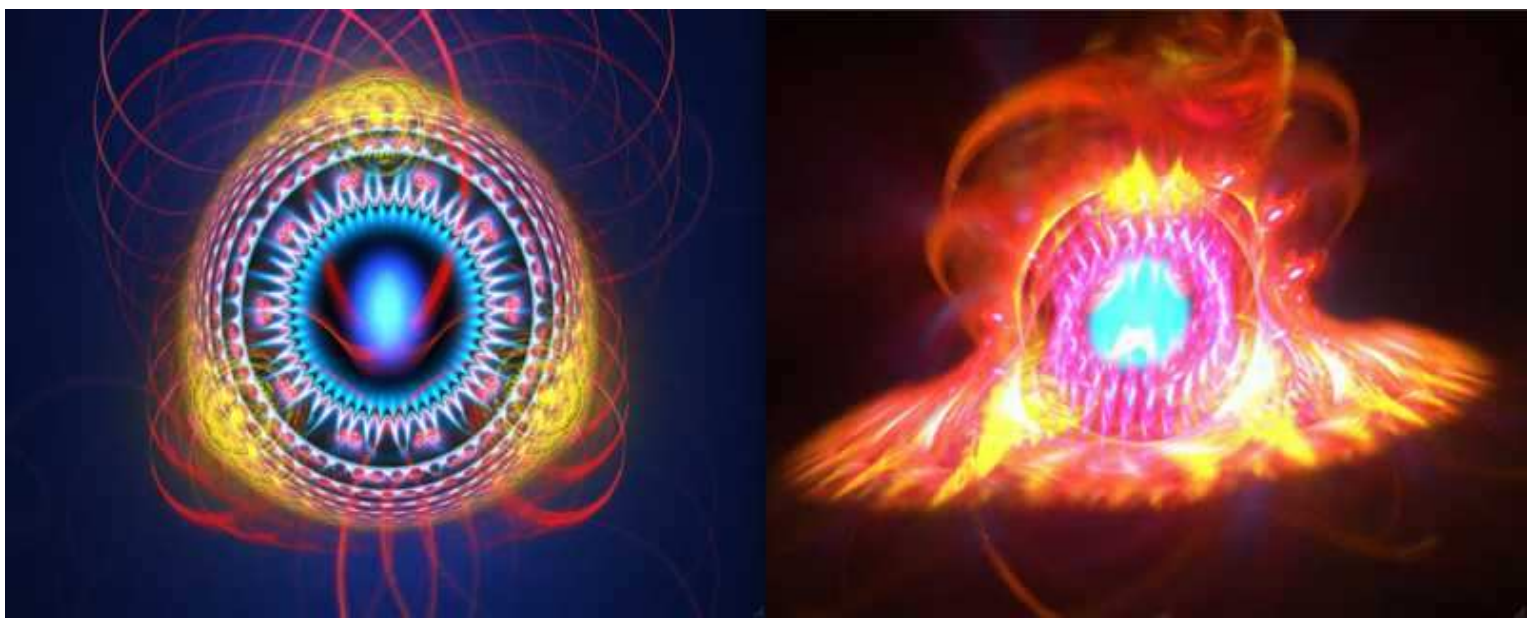
The "tone-mapping" is a "log-density mapping": During the transformation each pixel is beset several times. A "histogram" counts these fillings containing informations about the "tone-mapping". In the third transformation phase ("post-transforms") a further coordinate is added for the attribution of colours to functions. The transformations are stored in two-dimensional caches until the image generation is finished. The two-dimensional image generation provides three-dimensional optical effects. 28

Since 2001 a forth channel is added to the three colour channels. This new channel prevents a too dark presentation of dark parts of the image in the cathode ray tubes. Since 2003 the "flame" manifestations are partially rearranged by symmetry effects and thus simplified for the visual perception. 29



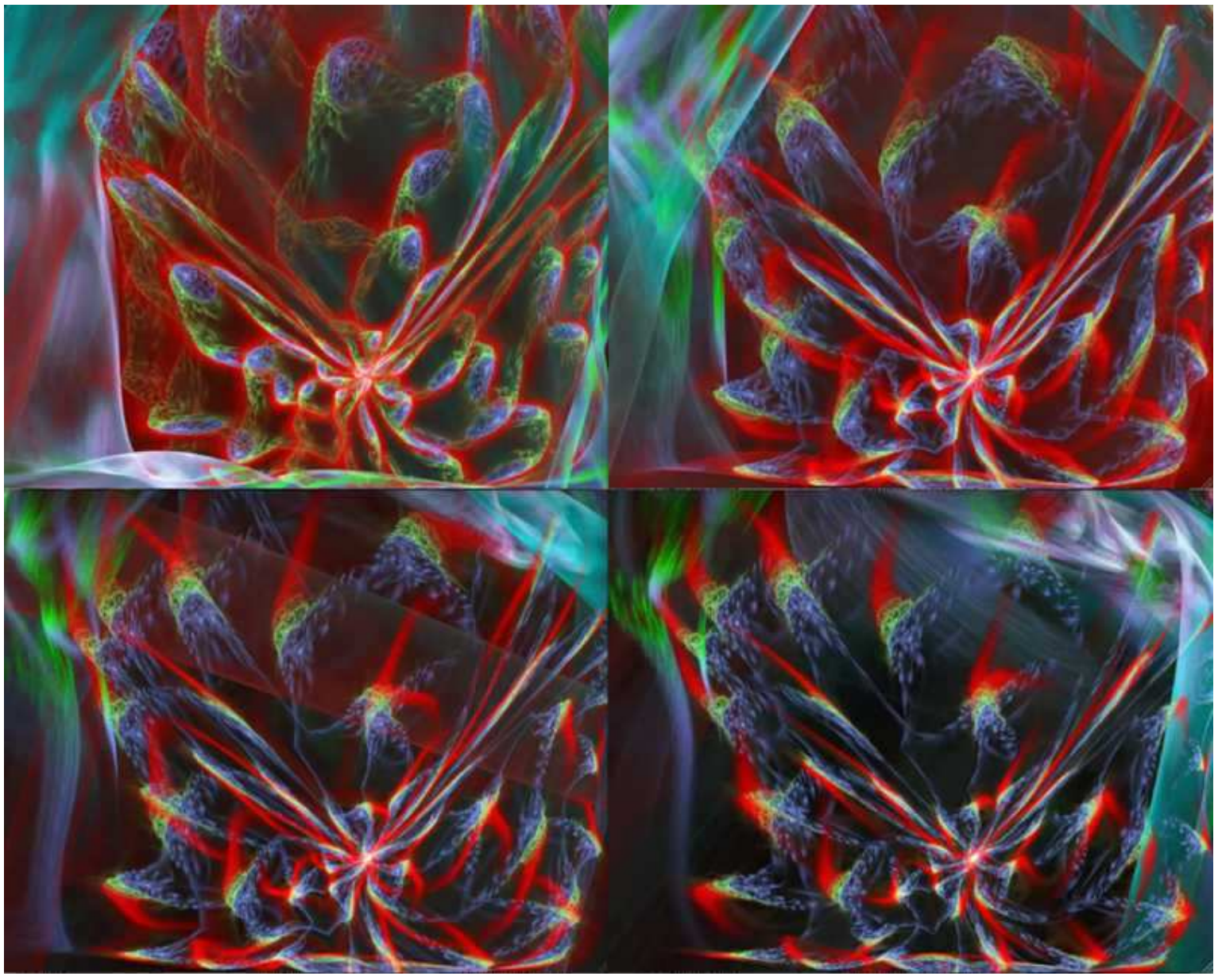
Draves, Scott: Electric Sheep, internet-connected personal computers, screensaver, 1999. Screenshot (March 2011) with user manual.

In "Electric Sheep" the computers with installed screensavers receive fractal animations from a "distributed system...with client/server architecture". Each of these "sheeps" is constituted by 128 frames and "160 floating point numbers" as its "genetic code". Observers can select preferred "sheeps" with a click on the key marked with an arrow showing upward. The lifetime, that a "sheep" can have in the system, depends from the amount of votes. Draves mentions Karl Sims (see chap.IV.3.2) as an inspiring example for the "fitness" by the observers´ choices. Draves substitutes Sims´ supercomputer by a "distributed system" built by internet-connected personal computers. 30



Draves, Scott: Electric Sheep, internet-connected personal computers, screensaver, 1999. Screenshots of two succesive phases (April 2012).

Since March 2004 net participants can send self-designed "genomes" via "Apophysis" to the server of "Electric Sheep". Then this server distributes the "genomes" to "all active clients" (the computers constituting "Electric Sheep´s" network). 31 The "clients" store the uploaded "sheeps". These "sheeps" are transformed by the "clients" following the "genome specifying a frame to render" received by the server. Then the "clients" send their transformations to the server. The server integrates two machines. One of them "runs the evolutionary algorithm, collects frames and votes, compresses frames, and sends genomes to clients for rendering". The other one sends the thus processed "MPEGs" via internet to computers with installed screensavers. 32



Draves, Scott: Electric Sheep, internet-connected personal computers, screensaver, 1999. Screenshots of two succesive phases (March-April 2012).

Draves developed with "Electric Sheep" the former Evolutionary Art for mainframe computers further into a networked system whose output can be received via screensaver and can shape the everyday life and work at personal computers: The times of computer standstills are the times of "Electric Sheep´s" screen presentation. It can become a habit during work breaks to select between transformation states of "Electric Sheep". "Electric Sheep" offers a diversion that may facilitate the return to concentrated work.

IV.3.4 Emergence

Peter Cariani differentiates in "Emergence and Artificial Life" degrees of emergence. Cariani points to Gordon Pask´s successful experiment from 1956 or 1957 with a solution of iron sulfide and electrodes giving rise to formations of iron filings that become audio sensitive. In this extreme form of emergence something new comes into being. 33 The limits of Evolutionary Art´s systems are below this extreme because their

goal is not to develop capabilities to adapt themselves to environmental conditions up to self transformation but to use self contaminations by elements from different evolution lines and states (via interpolation and crossover) to construct visual structures integrating external selections by artists and observers. They restrict the system´s possibilities to generate structures out of its own resources.

Referring to Henri Focillon´s «La vie des formes» Niklas Luhmann explains in "Art as a Social System" the relationship between "system and evolution" in the "art system" as an autopoietic differentiation of forms – as "a re-entry of the form into the form". 34 In Evolutionary Art the program installed on appropriate hardware is the "system", the computing processes generate the "evolution" and when the author or observer chooses one of the interim results then he supplies the disturbance that causes reactions in the following evolutions of the system.

When Luhmann explains the "autopoiesis" in a system as its development by internal differentiations causing growing capabilities to react to external disturbances 35, then he presupposes William Ross Ashby´s "homeostasis" as a recreation of the system´s balance via self-regulation reacting to external disturbances. Ashby features in his "law of requisite variety" internal differentiations as a fundamental capability of a system to be able to react to environmental conditions resp. external disturbances. 36 Luhmann transforms Ashby´s "homeostasis" based on "requisite variety" into the "autopoiesis" of the system that includes the excluded via "re-entry" if its internal differentiation is sufficiently developed. 37

In "Art as a Social System" Luhmann defines the "communication system art" as an autonomous system defining itself by marking limits (resp. by excluding non-art) and including the heteronomous elements via "re-entry". A disturbance doesn´t cause a system´s revision but provokes decisions that can allow the system to stand the test by evolution or by exclusion of the disturbances. The observers as participants of the "communication system art" can stimulate the system´s evolution with critical contributions and provoke a shift of the border between art and the environment. 38

In Evolutionary Art the participant is integrated as a selector of forms and is then involved in the discourse on this art form as an insider, but as such he never transgresses the interface between external observation and system-internal organization.

Evolutionary Art can be considered to be a plea for autonomous art within the "communication system art". With reference to exceedable technical limits Evolutionary Art can be understood as pointing towards changeable characteristics. They offer new impulses for discourses in the "communication system art". 39 Thereby, questions concerning the self-demarcations of the system art are at disposal for new discussions.

Annotations

1 Manovich: Realism 1992. back

2 Manovich: Realism 1992. back

3 Langton: Artificial Life 1993, chap. 1, p.25ss.; Reichle: Kunst 2005, p.127,133. back

4 Dawkins: Watchmaker 1986, chap.3, p.43-74. back

5 Dawkins: Watchmaker 1986, p.55. back

6 Dawkins: Watchmaker 1986, p.45,49. back

7 Langton: Artificial Life 1993, chap. 4.2, p.40s. back

8 Dawkins: Watchmaker 1986, p.57,60. back

9 Dawkins: Watchmaker 1986, p.58, fig.4. back

10 Dawkins: Watchmaker 1986, p.60. back

11 Todd/Latham: Evolutionary Art 1992, p.167,169: Before the IBM 5080 a Vector General 3300 was used. back

12 Todd/Latham: Evolutionary Art 1992, p.170s. back

13 Todd/Latham: Evolutionary Art 1992, p.2-6,33s.,37s. back

14 Todd: Techniques 1990; Todd/Latham: Evolutionary Art 1992, p.134-137,171-180. CSG is based on the WINSOM renderer developed in 1983 by Peter Quarendon 1983. back

15 F.e. "Structure mutation": Todd/Latham: Evolutionary Art 1992, p.99ss. back

16 Todd/Latham: Evolutionary Art 1992, p.102s. back

17 Annotation: "This is usually called `parameter interpolation´, but `gene interpolation´ fits better with our terminology." (Todd/Latham: Evolutionary Art 1992, p.109) back

18 Todd/Latham: Evolutionary Art 1992, p.109. back

19 "Artist gardener": Todd/Latham: Evolutionary Art 1992, p.12,98,207,209.
"Parody": "We create computer sculptures using a parody of genetic engineering." (Todd/Latham: Evolutionary Art 1992, p.208). back

20 Todd/Latham: Evolutionary Art 1992, p.40. back

21 Sims: Evolution 1991. back

22 Sims: Evolution 1993; Sims: Bilder 1993, p.404s. back

23 Whitelaw: Metacreation 2004, p.24.
On the technics of the Connection Machine: Langton: Artificial Life 1993, chap. 7.7, p.61ss.
On the design of the Connection Machine: Thiel: Machina Cogitans 1993. back

24 Sims: Evolution 1991, chap.2.1, 4.1. back

25 Sims: Bilder 1993. back

26 Draves/Draves: Flame 2010; Draves/Reckase: Flame 2008. back

27 Draves/Reckase: Flame 2008, p.4ss. back

28 Draves/Reckase: Flame 2008, p.9. back

29 Draves/Reckase: Flame 2008, p.11. back

30 Draves: Electric Sheep 2005. back

31 Draves: Electric Sheep 2005, PDF p.1 (April 2012: The mailing list Genetic-design can be used to send contributions realised with Fractal Flame editors to the list archive). back

32 The server is programmed with Perl, meanwhile the clients are programmed with C, C++ and Objective-C. All codes are open source (GPL. In: Draves: Electric Sheep 2005, chap.2, PDF p.2s.). back

33 Cariani: Emergence 1991, p.789. Cf. Whitelaw: Metacreation 2004, p.222s. During the experiment Gordon Pask said to Stafford Beer: "It´s growing an ear." (Pickering: Brain 2010, p.341s.)
Definitions of "emergence": Cariani: Emergence 1991, p.775s.; McCormack/Dorin: Art 2001, PDF p.4. back

34 Luhmann: Art 2000, p.184 with ann.34.
Luhmann´s reference to Focillon (Focillon: Vie 1934): Luhmann: Art 2000, p.109 with ann.19, p.118 with ann.34. back

35 Luhmann: Art 2000, p. 49-52, 185, 203ss., 207. back

36 See chap. II.1.5 with ann.18 on Ashby´s "homeostasis"; Luhmann: Art 2000, p.298. back

37 Porr: Systemtheorie 2002, p.12s. back

38 Dreher: Kunstwerk 2008, p.57; Luhmann: Art 2000, p.79. back

39 For observers Draves´ "Electric Sheep" can be used at work as described at the end of chap. IV.3.3 and as a provocation in discourses about the "communication system art". back

V. Reactive Installations and Virtual Reality

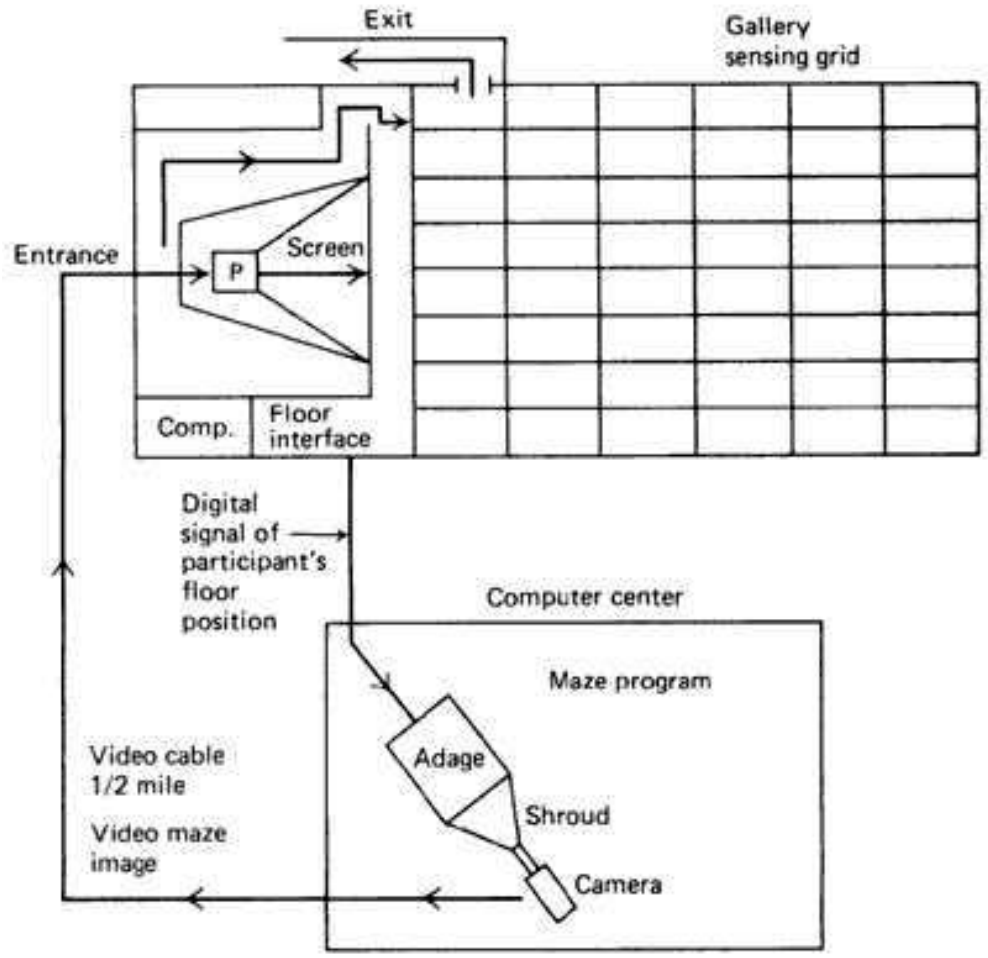
V.1 Operations of Observers on the Interface to the Image Simulation

Between the seventies and nineties Myron Krueger, Jeffrey Shaw and Peter Weibel realised reactive installations. The installations presented below react to observer operations 1: A technical system using cameras or especially designed surfaces as sensors can be provoked by observers with body movements to react with an output. The computer-aided systems change their projections of two-(Krueger) and three-dimensional (Shaw, Weibel) picture worlds in reacting to the input being produced by observers and registered by sensors. If observers act on or before an interface with the goal to change the projections then they provoke questions about the self-orientation mediating between spaces of the projected images and the real space.

With their operations on an interface in the real space the observers cause changes in a not walkable virtual space. The navigation in an animated `space of the image´ (Bildraum) with gravitationless objects is coordinated by observers on an interface under gravity conditions. Observers coordinate their actions on the technical interface with the `spaces of the images´ in recursions: The system´s possibilities can be reconstructed in cognitive reactions (observing operations) to the triggered mechanical reactions. For further explorations of these possibilities observers modify their actions on the interface (observer operations). These exploring observer operations cause modifications in the cognitive efforts to reconstruct the system´s possibilities (observing operations). The question if the system can be reconstructed adequately with the last reconceptualisation may lead to further observer operations.

Observers can construct a mental plan for the technical functions in a highly simplified form if it seems to be useful for explorations of the virtual space presenting the projected animated image on an interface. Recursions between observing operations (Beobachtungsoperationen) and observer operations (Beobachteroperationen) are parts of the investigations exploring the presented programmed animations. Observers can construct a second plan containing the relations between the technical interface and cognitive recursions to navigate their explorative behavior.

The artists and programmers did not publish the codes for the technical functions of the installations explained below. The effects of these functions can be tested by observers in operating on or before the installations´ technical interfaces and looking on the projections or on screen presentations of the animations.



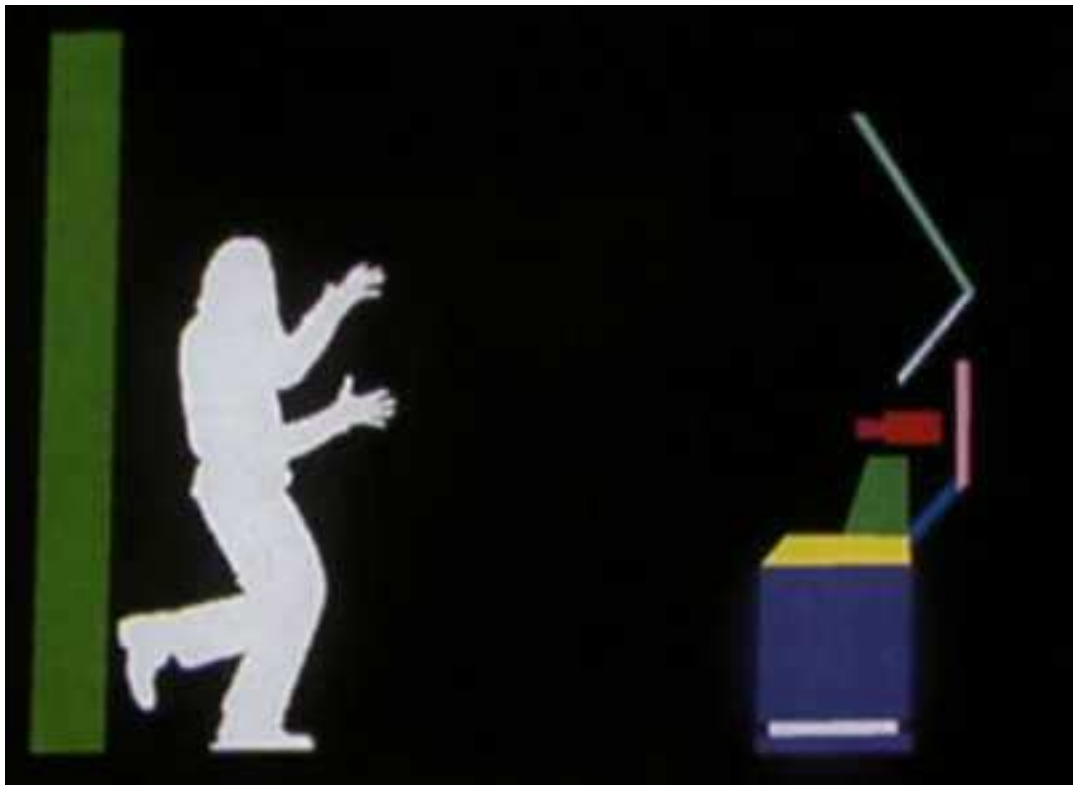
Krueger: Myron: Psychic Space, 1971, ground plan
(Krueger: Reality 1991, p.26, fig.2.9).

In 1971 Myron Krueger´s "Psychic Space" was installed in the Memorial Union Gallery of the University of Wisconsin. From the exhibition space an installation space was separated by partition walls. This space contained 48 black pressure-sensitive base plates and a projection surface. The longitudinal walls are made of black polyethylene. Observers were able to move on the base plates between the rear projection on one narrow side and the other narrow side being coated with phosphorescent paint. In moving on the plates observers activated a sound program and an animation program. A minicomputer PDP-11 since 1969) of the Digital Equipment Corporation (DEC) transmitted the input of the pressure-sensitive base plates to a Moog Synthesizer (since 1964) generating sounds. An Adage AGT-10 Graphic Display Computer supplied the rear-projection with the ground plan of a labyrinth. Within the labyrinth observers could move a rhombus by changing their locations on the base plates – not without activating the sound generation.

The sound generation reacted to observers entering and leaving the "sensing grid" as well as to actions like jumping on the base plates and lifting legs. The latter two operations of observers suspended the sound generation. After a `playtime´ used for explorations of the base plates observers could activate high- and low-pitched sounds on different sides and recognised this interface functioning like a keyboard of a musical instrument. But the distribution of pitch levels on the "sensory grid" could rotate 90 degrees. This could cause irritations.

The Adage graphics system´s monitor was recorded by a camera and the rear projection presented its images in the environment. When observers entered the enviroment then they saw the rear projection of a square. Via pressures on the base plates observers could move the rhombus to the square. With the approximation of the rhombus and the square the projection of the labyrinth started. The projection of this configuration was dissolved if observers didn´t move the rhombus within the limits of the labyrinth. The observers could easier be successful in directing the rhombus to the goal because the projected obstacles contained target-oriented barriers. But the labyrinth was dissolved before

observers could reach its innermost part. 2



Krueger, Myron: Videoplace, since 1974, installation set up.

Krueger developed "Videoplace" from 1974 to the nineties. 3 "Videoplace" takes up the closed-circuit video installation prefigured in 1969 in Nam June Paik´s "Participation TV II" 4 and modifies it: In Paik´s installation observers could use a control panel to manipulate video images recorded by video cameras and projected on monitors. Krueger replaces Paik´s interface (control panel and cameras) by a series of programmes transforming the recordings of a black/white-surveillance camera. The camera mounted underneath the projection surface records observers and their operations "against a brightly backlit sheet of translucent plastic". On a computer with parallel active "specialized processors" the software gathers the camera´s input as a "binary image" transforming the observers´ contours in a field with ones and zeros for recognised/non recognised observer operations. The software registers motions of heads, hands, fingers, legs and feet. 5 These data are used by programmes transforming and colouring the observers´ contours in different manners. If obervers leave the camera´s range of vision then the system switches to another animation programme. 6 "Videoplace´s" switching system and programmes replace Paik´s control panel and the functions of the video synthesizer.

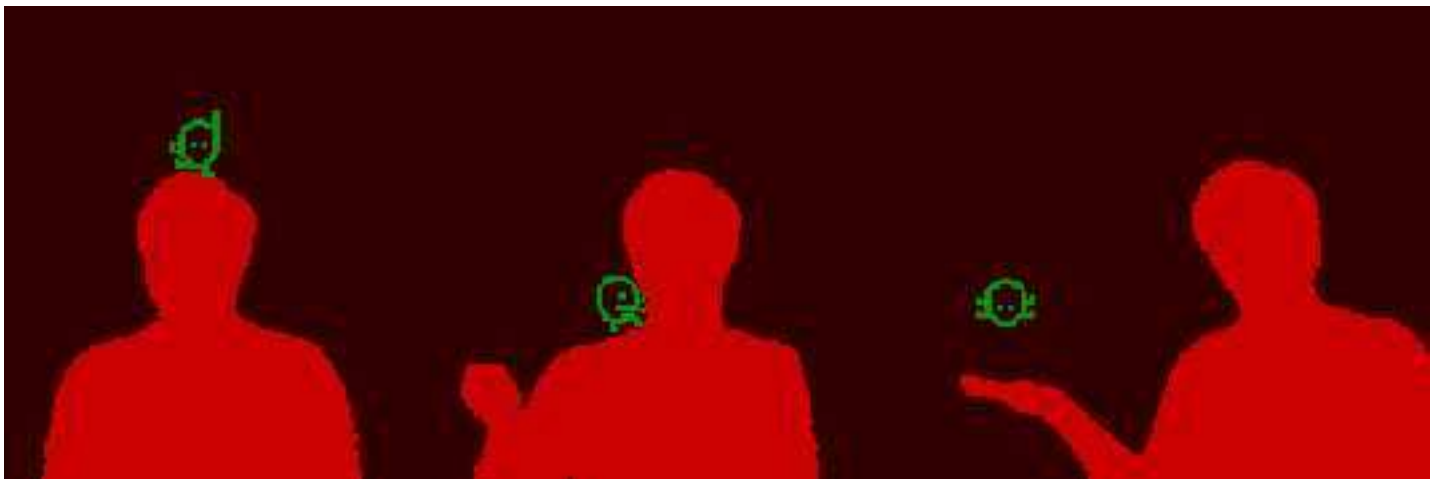


Krueger, Myron: Videoplace, since 1974, program "Individual Medley".

The programme "Individual Medley" (since 1976 in b/w, since 1979/80 in colour) was developed for "Videoplace" and uses overlaps of eight contours recorded successively ("sampling-rate") and stored them for the animation programmes´ different kinds of colourising and sound generations. Observers have to move, if they want to activate the programmes for animations and to keep them running:

> ...a participant creates feedback for himself only as long as he keeps
 moving. 7

"Critter" offers observers to act with their contours with and against a sign figure constituted by a circle – as its head – with two little circles as eyes and four lines as legs: A dialogue develops between the machine creature and the observer – on the part of the observer based on the body language, without control panel or manual. 8 "Individual Medley" and "Critter" are only two of fourteen examples presented in 1991 by Krueger in his book "Artificial Reality II". 9



Krueger, Myron: Videoplace, since 1974, program "Critter".

In 1975 Krueger installed "Videoplace" for the first time in the Milwaukee Art Museum: Two installations with camera-computer-projector units were located in two rooms in 300 feet distance. In each room the contours of the persons were projected who acted before the cameras of both installations. Observers looked at their own contours and at the contours of observers of the other installation: Observers in both rooms communicated with each other via the projections. 10

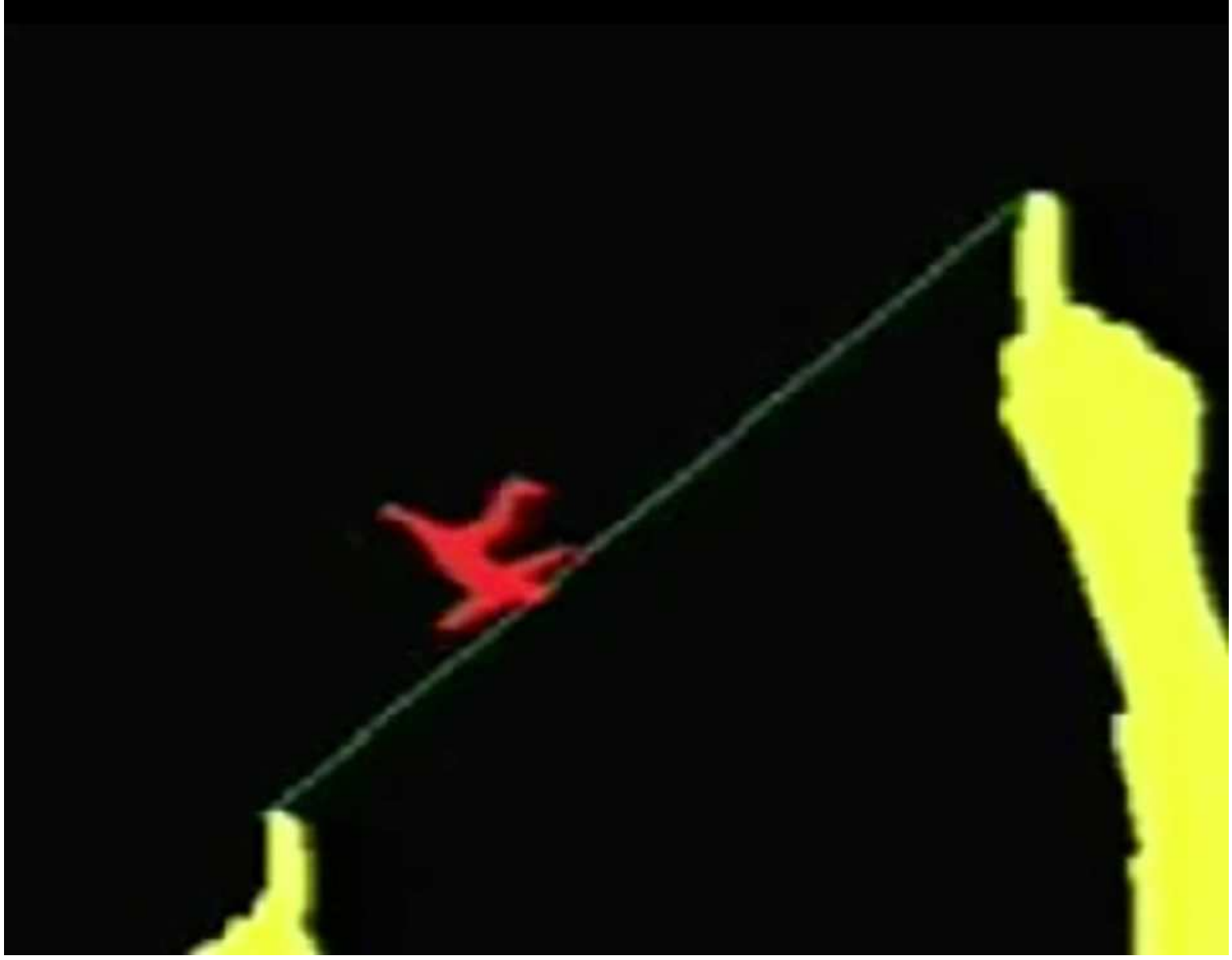
In 1987 Krueger realised "Videodesk" for an "operator" being familiar with the "Videoplace" system. If "Videodesk" is combined with "Videoplace" then the operator is enabled to provoke the observers in "Videoplace" to interactions in various ways.



Krueger, Myron: Videoplace, since 1974, with Videodsk, 1987. Krueger at the Videodesk, studio in the Museum of Natural History, Vernon/Connecticut 1988. Screenshot from YouTube.

The "Videodesk" operator sits on a table. On a monitor behind the table he sees the contours of his hands recorded by a camera hanging from above the table. This input is transmitted to the "Videoplace" system. Some programmes are developed for the interactions between the observers´ contours in "Videoplace" and the recordings of the operator´s hands in "Videodesk".

In "Man-Ipulate" the observer´s silhouette falls over after being tossed on its upper body by the operator´s hand, meanwhile in "Telecision" observers can divide the contour of the operator´s arm as if they can separate his hand from his body. 11 In "Artwheels" observers move their contours between the operator´s hands. 12



Krueger, Myron: Videoplace, since 1974, with Videodesk, 1987. Program "Artwheels". Screenshot from YouTube.

Since 1983 Jeffrey Shaw develops reactive installations with image projections. 13 The observers´ coordinations between the orientations in real spaces and spaces of images are provoked in "Legible City" (variants for Manhattan, Amsterdam and Karlsruhe, 1989-91) and in "The Virtual Museum" (1991) to be organized in multi-layered ways: Observers are prompted to activate and control mutations of the space of the image by body motions (observer operations) on the interface. Navigating in the virtual space with its three-dimensional `gravitationless´ elements is made possible in realising body motions under the conditions of gravity.



Shaw, Jeffrey: The Legible City, reactive installation, 1989-91. Two screenshots from YouTube.

In "Legible City" the houses of a city´s simulation are replaced by letters. (In the variants for Amsterdam and Karlsruhe) the letters possess the height of the replaced houses and are parts of a text describing the urban situations reconstructed by the simulation. Before the projection wall a bicycle is mounted on the floor allowing to turn the handlebars and to pedal. A potentiometer at the handlebars measures the steering angle. A rear wheel tachometer gauges the speed.

A personal computer digitises these informations and transmits them to a Silicon Graphics Personal IRIS 4D/20TG Workstation (since 1988). The workstation calculates the location in the virtual urban space in accordance with the observers´ operations on the bicycle. 14 Meanwhile observers with local knowledge pedal to move themselves in the simulation and try to imagine the real street views they are supported by city maps in their efforts to identify the real urban spaces. These maps are presented by a liquid crystal display mounted on the handlebars: The display presents the biker´s location as a wandering point. 15

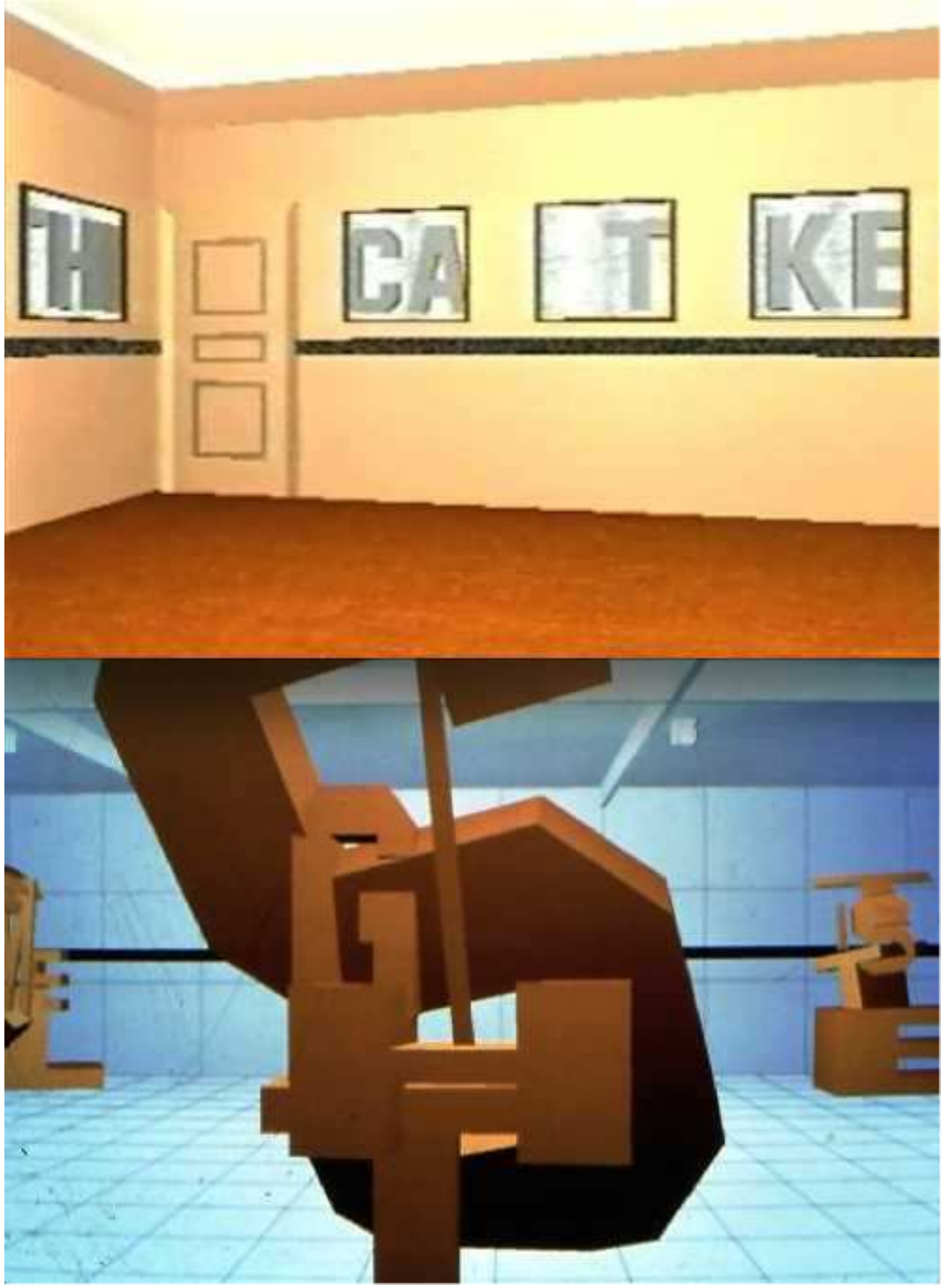


Shaw, Jeffrey: The Virtual Museum, reactive installation, 1991, Oberösterreichisches Landesmuseum Francisco Carolinum, Linz 1992, the rotatable base with a chair and a monitor with the first virtual space representing the exhibition room.

This self localisation of the observer at an installation-external place is substituted in "The Virtual Museum" by a self localisation within the installation´s space.

An observer sits on a chair in front of a monitor. If the observer sitting on the chair moves his body then he activates the monitor projection and a rotable base. On this base the chair and the monitor is mounted. Sensors react to rotations of the chair and movements of its seat-back caused by observer operations. To the sensors´ data in turn react the image projection and the base.

In 1992 all walls of an exhibition space in the Oberösterreichisches Landesmuseum Francisco Carolinum (Linz) were painted with a black horizontal stripe situated circa one meter above the floor. The first virtual space represents this stripe and the rotable base. If the observer uses the chair to navigate himself in the virtual space onto the stripe then it is usable as an interface to four virtual spaces. Three of these spaces refer to art media like painting, sculpture and cinema, meanwhile a fourth space thematises characteristics of computer animated environments via signs ("A", "2", "Z") floating and moving without aim. The floating and jigging signs illuminate the virtual space.



Shaw, Jeffrey: The Virtual Museum, reactive installation, 1991, Oberösterreichisches Landesmuseum Francisco Carolinum, Linz 1992, the second and third of five virtual spaces.

If an observer takes place on the chair-as-interface of the "Virtual Museum" then he looks at the first virtual space as a simulation of the exhibition space including the rotable base with chair and monitor, but without observer. If an observer directs himself in the virtual exhibition space to the black stripe then he recognises it as a switch to further virtual spaces integrating simulations of the exhibition space without the rotable base. For the observer navigating within the virtual space the black horizontal stripe is `readable´ as an indication of a switch function.

Within a sequence of spaces this switch function is a connecting part being only possible in virtuality because it allows to enter a digitally animated space and it is repeated in it as an entrance to other simulated spaces iterating the stripe-as-switch, too: With the switch across the black stripe into the next virtual space the observer is led from the actual virtual space to the next virtual space. Nevertheless this interface within the animation

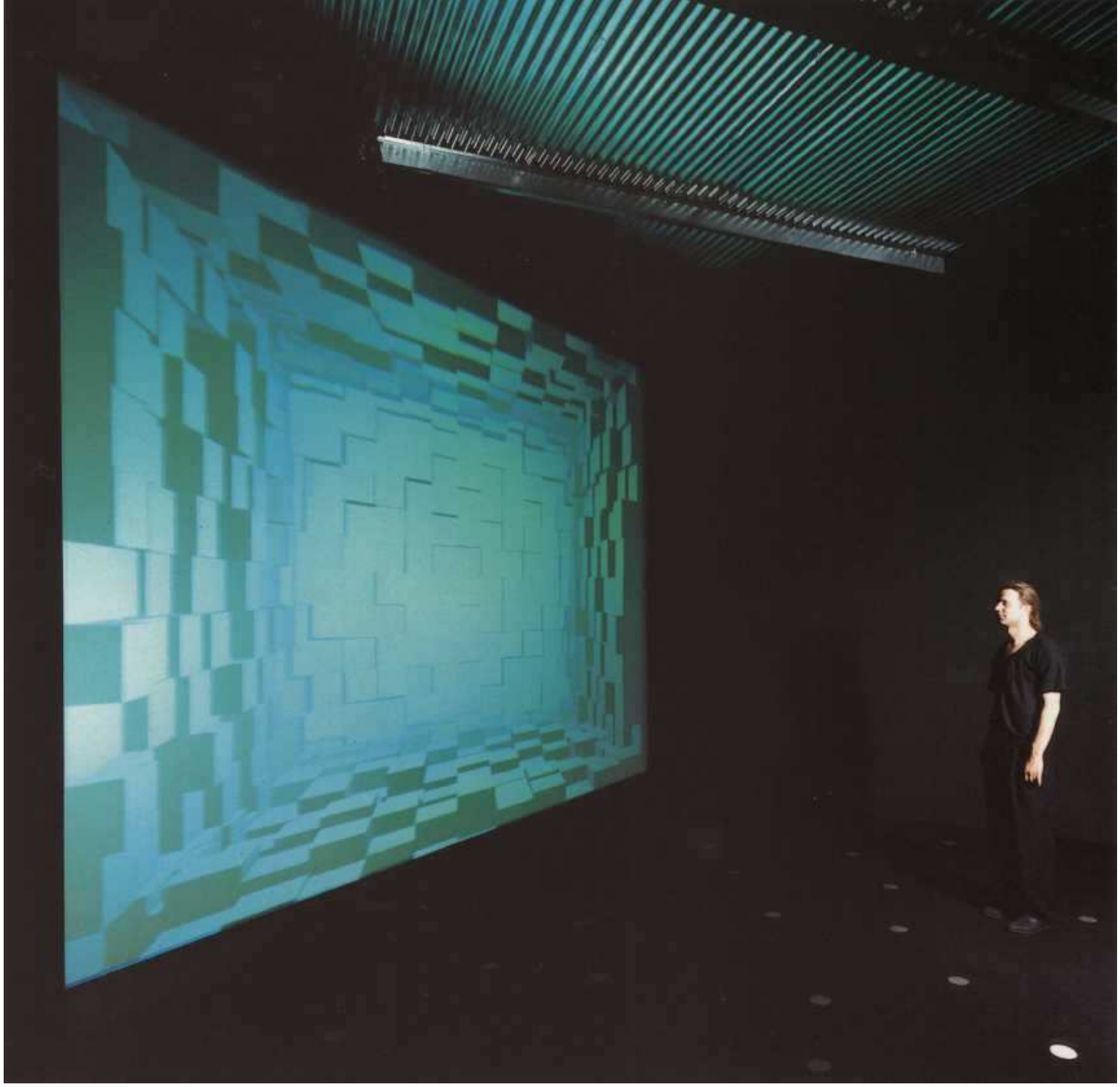
offers no floor plan relating the simulations spatially to each other. The simulated passages represent the passages (doors, wall-openings) in the exhibition space of the Francisco Carolinum to adjacent rooms but the simulations of these architectural elements have no functions in the digital context.

Shaw writes on the availability of an arbitrarily expandable sequence of simulated spaces:

> My installation of `The Virtual Museum´ embodies the idea of a single-room museum whose quantity of the virtual exhibition rooms can be infinitely extended. 16

The installation reduces the arbitrarily continuable sequence of virtual spaces to simulations of spaces reconstructing characteristics of `old´ media. With this "remediation" 17 in three virtual spaces Shaw facilitates himself to expose characteristics of 3D simulations in the fourth virtual space. The four spaces are only a few parts within an arbitrarily expandable sequence of virtual spaces. These parts are enfoldings of a partially unfolded and potentially further unfoldable media development.

At the Institut für Neue Kunst of the Städelschule in Frankfurt the installation "On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World" was realised under the supervision of Peter Weibel. The artwork combines four visual worlds conceptualised and programmed by staff members of the Institut für Neue Kunst. When in 1992 the Cologne gallery Tanja Grunert presented the installation an observer walked along a dark corridor to enter a room. It was illuminated by a reactive computer-aided image projection as soon as the floor sensors were activated. Contact mats are set into a floor area of 5 x 5 meters. The incoming visitor has just activated the projection when he is able to recognise the 32 pressure-sensitive elements in the floor and their relations to the programmes of the visual worlds. The observer can activate four coloured floor sensors to select the letters´ projection of the "text world" (Constanze Ruhm/Bob OKane), an "architecture" respectivley "space world" (Dieter Beck/Christian Möller), an "object world" (Akke Wagenaar) or the "gas world" (Gideon May/Laurent Mignonneau).

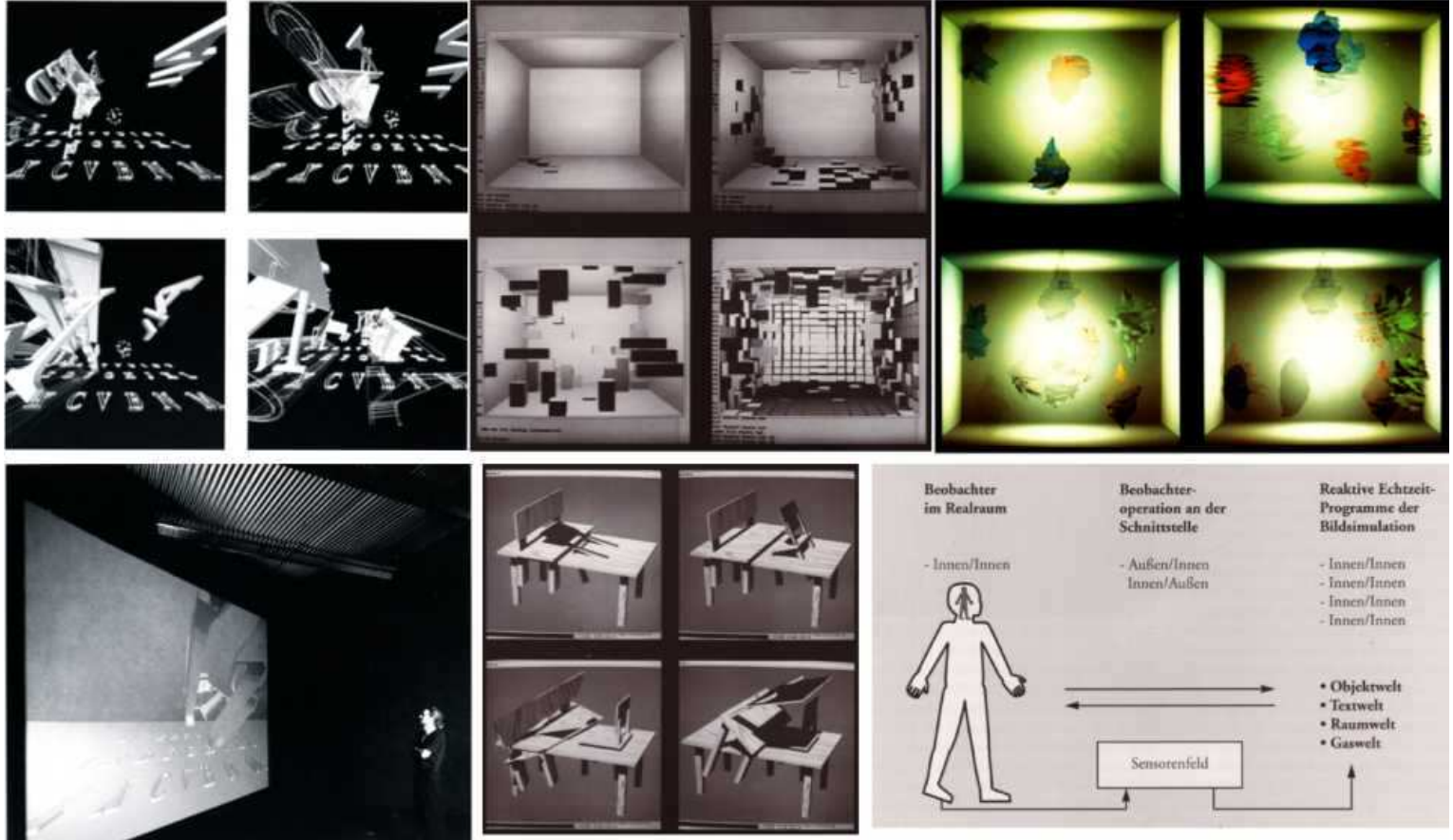


Weibel, Peter a.o.: On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World, reactive installation, Gallery Tanja Grunert, Cologne 1992 (Schuler: Weibel 1997, p.246, fig.113.6).

When an observer enters the installation room then he activates one of the floor coloured sensors located next to the entrance and starts one of the four visual worlds. The observer sees each of these virtual worlds unmodified until he activates further grey sensors. 25 sensors offer to the observers possibilities to coordinate scaling, proportion and rotation. Further three sensors allow to control twirl, twist and wave functions. 18

Observers can use the floor sensors to influence the virtual worlds in different ways. Especially the "gas world" has a highly developed life of its own and is a specific variant of "artificial life" in Evolutionary Art (see chap. IV.3.1-IV.3.2). Weibel designates the "variability" of self-unfolding virtual worlds as "viability". 19

If observers want to switch between the virtual worlds or to modify one of them then they have to change their distances to the image projection: The activation of the sensors and the observer´s location are coupled to one another. In operating on the technical interface the observer´s attention switches between the body coordination in the real space and the projected space of the image – and vice versa.



Weibel, Peter/Institut für Neue Medien, Städelschule, Frankfurt: Zur Rechtfertigung der hypothetischen Natur und der Nicht-Identität in der Objektwelt/On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World, 1992, installed at Gallery Tanja Grunert, Cologne 1992 (Schuler: Weibel 1997, p.45,244s.,247,249,251).

Left above and bottom: Text World (Constanze Ruhm/Bob O´Kane), middle above: Architecture World (Dieter Beck), right above: Gas World (Gideon May/Laurent Mignonneau), middle bottom: Object World (Akke Wagenaar), right bottom: diagram of the interface to the virtual worlds. 5

In front of Barnett Newman´s big lengthwise rectangular paintings with monochrome planes and vertical stripes an observer´s attention switches between the self localisation in the real space (image space) and the space of the image: In displacing himself in the real space the observer tries to find out the best position for a switch into the space of the image. In turning their attention to the space of the image observers switch from a cognitive-corporeal self orientation in the real space with a peripheral visual perception of the picture as an object on a wall to the orientation within the depth effects provoked by the concentration on the visual perception of the colour field with an ongoing peripheral self orientation within the real space. This transition marks the interface between observations of the real space and spaces of the images. 20



Newman, Barnett: Cathedra, 1951, oil and Magna on canvas, 96 x 204 inches, Stedelijk Museum Amsterdam. .



Barnett Newman and female observer in front of "Cathedra" (oil and magna on canvas, 244 x 541 cm, 1951) in Newman´s Front Street Studio, New York. Photo: Peter A. Juley and Son. Smithsonian American Art Museum, Washington D.C. (Anfam: Abstract Expressionism 1990, p.147, fig.110).

The technical interface of the installation "On Justifying..." takes up this switch between the image space (Raumbild) and the space of the image (Bildraum). The technical interface provokes observers to refocusings and reconceptualisations by exploratory motions between the sensors in the real space and focusings of the attention to the spaces of images. The image space/space of the image (Raumbild/Bildraum) switch is the cognitive correlate to the technical interface.

In their efforts to find out which sensors offer to activate which kind of image transforming functions observers switch from a self orientation primary focussed on the real space to a self orientation primary oriented to the space of the image, from an image space/space of the image orientation to a space of the image/image space orientation. If observers construct a cognitive interface for their explorations on the technical interface between real space and the space of the image then it presupposes an inside/outside switch in the relationing of the image space and the space of the image: from the observer´s self orientation within the space of the image as `the inside´ and the orientation within the real space as `the outside´ to the body coordination to activate the sensors within the real space (`the inside´) with an observation of the produced changes within the space of the image (`the outside´), and vice versa. After changing over from one virtual world to another one observers can repeat explorative sequences of actions with refocusings on the image space and the space of the image via inside/outside switch.

The installation "On Justifying..." focuses the attention of observers to the inside/outside switch in a "duo-pluriversum" confronting the observers´ image space with several successively changeable spaces of the image. A model for "world observation" is put on by the operative relation between the technical and the cognitive interface. 21 Weibel bases this model theoretically on an "exo/endo interface" of the observer to the world refering to Otto Eberhard Rössler´s "endophysics" and their concept of an "explicit internal observer":

> The virtual worlds are...a special case of endophysics." 22

Annotations

1 Observer operations (physical level: body movements) and observing operations (cognitive level: perceptual schemata, plans for the coordination of actions, self orientation): Dreher: Performance 2001, p.20-23 with ann.12 and 14. back

2 Dinkla: Pioniere 1997, p.72-75; Hansen: Bodies 2006, p.33ss.; Krueger: Environments 1977/1996, p.476s.; Krueger: Reality 1991, p.24-31; Krueger: Videoplace 1985, p.147. back

3 Krueger: Reality 1991, p.43. back

4 Paik, Nam June: Participation TV II, video-closed-circuit, three cameras combined with a Paik/Abe synthesizer and four monitors, Galleria Bonino, New York 1971: Davis: Experiment 1975, p.189; Decker: Paik 1988, p.65s.,151; Kacunko: Circuit 2004, p.187s. back

5 Krueger: Reality 1991, p.105ss. back

6 "The hardware of Videoplace": "...the system consists of two general-purpose

computers and a number of highly specialized processors including one that executes forty million instructions per second." (Krueger: Videoplace 1985, p.147)
Most parts of the software were written in C (Dinkla: Pioniere 1997, p.80; Oelinger: Sinn 1999, chap. I: Aktion und Reaktion). back

7 Krueger: Reality 1991, p.48. Cf. Dinkla: Pioniere 1997, p.81; Heim: Realism 1998, p.103; Krueger: Videoplace 1985, p.149; Krueger: Videoplace 1989, p.210,213; Popper: Art 1993, p.113 with ill.190s. back

8 Krueger: Videoplace 1985, p.148s.: "There are approximately 100 states that determine CRITTER behavior...Synthesized sound communicates the personality of the creature." Cf. Dinkla: Pioniere 1997, p.84-87; Kacunko: Circuit 2004, p.235; Krueger: Reality 1991, p.46s.; Krueger: Videoplace 1989, p.210s.; Oelinger: Sinn 1999, chap. I: Aktion und Reaktion. back

9 Krueger: Reality 1991, p.46-56. back

10 Krueger: Reality 1991, p.43. back

11 Krueger: Reality 1991, p.58ss. back

12 Krueger: Reality 1991, p.61s. back

13 Dinkla: Pioniere 1997, p.104-128,132ss.,145s.; Klotz/Weibel: Shaw 1997. back

14 Dinkla: Pioniere 1997, p.115, ann.302. back

15 Cooperation of Jeffrey Shaw and Dirk Groeneveld. Software written in C for Silicon Graphics Computer: Gideon May. Software for a personal computer: Lothar Schmidt. Hardware: analog-digital interface: Charly Jungbauer. Conversion of the bicycle: version for Manhattan: Tatje van Vark; versions for Amsterdam and Karlsruhe: Huib Nelissen (Colpaert/Shaw: Legible City 1990, unpaginated). Lit.: Dinkla: Pioniere 1997, p.114-123; Klotz/Weibel: Shaw 1997, p.126-129,169; Manovich: Language 2001, p.260s.; Paul: Digital Art 2003, p.6s.,72s.; Popper: Art 1993, p.110s., ill.180-182; Shaw: Modalitäten 1989, p.209. back

16 Shaw: Home 1994.
Computer: Silicon Graphics 4D/310VGX. Software: Gideon May. Hardware: Huib Nelissen, Bas Bossinade. Lit.: Dinkla: Pioniere 1997, p.126s.; Dreher: Kunst 1994, p.101ss.; Klotz/Weibel: Shaw 1997, p.132s.,171; Shaw: Museum 1992. back

17 Bolter/Grusin: Remediation 2000, p.65. back

18 The explanation of "On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World" is taken over almost verbatim from: Dreher: Beobachter 1996, p.418.
Architecture of the installation: Christian Möller.
The floor sensors are connected by a "circuit board" with the 32 switchers of a "button box": Bob O´Kane.
Coordination of the virtual worlds with the "button box": Gideon May.
Computer: Silicon Graphics 4D/320 VGX.
(Craemer: Rechtfertigung 1992, p.6s.; Möller: Architektur 1994, p.28ss.; Schuler: Weibel 1997, p.288). back

19 Weibel: Welt 1994, p.46,51; Weibel: Kunst 1997. Cf. Hünnekens: Betrachter 1997,

p.60ss. back

20 See Dreher: Weibel 1997, p.52s. with ann.62 on Barnett Newman´s explanation of the relation image space ("environment") and space of the image ("sense of space"). back

21 "Duo-pluriversum": Dreher: Weibel 1997, p.44ss.
"World observation": Dreher: Performance 2001, p.27 with ann.24, p.407s. back

22 Weibel: Welt 1992, p.10. Cf. Dreher: Weibel 1997, p.48ss. and Rössler: Endophysik 1992 (Editor: Peter Weibel). back

V. Reactive Installations and Virtual Reality

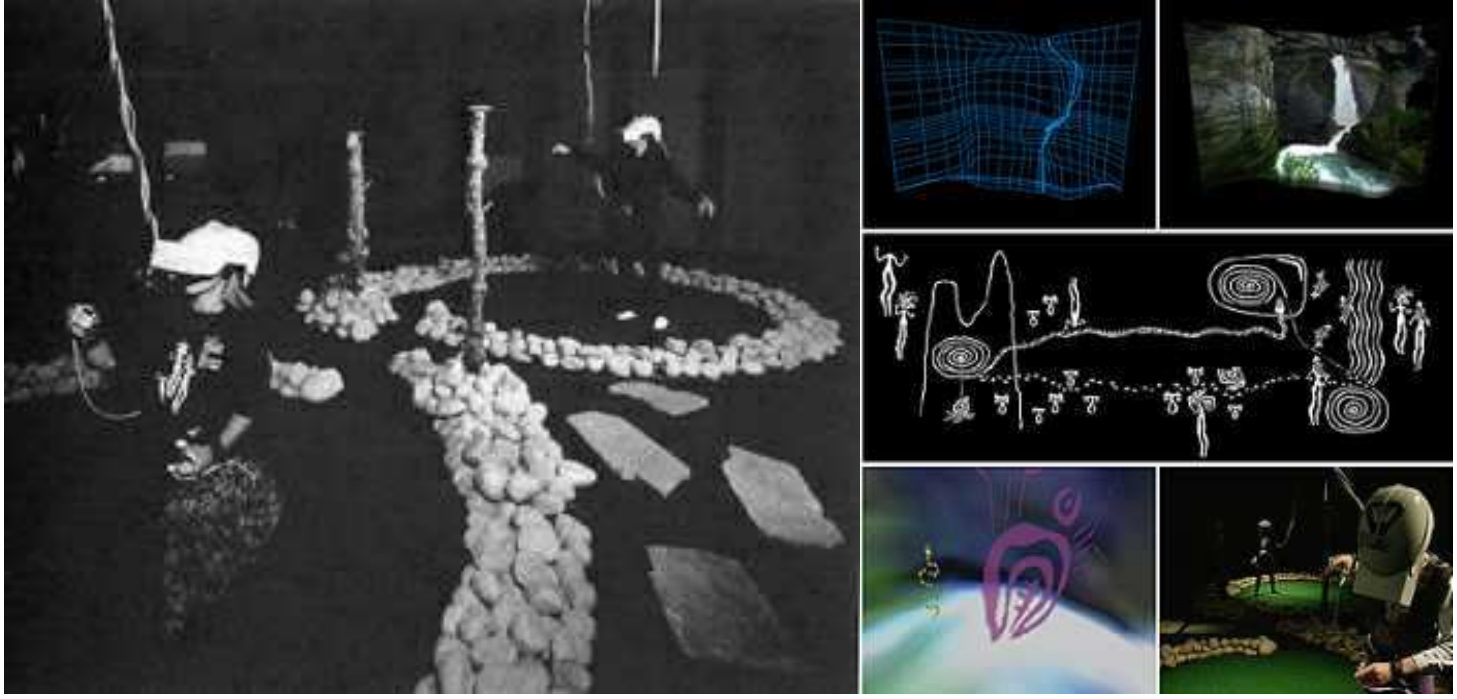
V.2 Seamless Total Simulation versus Interface Architecture

The goal of presentations with head mounted displays and data gloves was to design the interface to virtual reality as seamless as possible. As it is usual in their daily life´s body coordination, observers move their bodies in a gravitational world meanwhile they orientate themselves visually in a gravitationless simulation. 1 Observers should be able to move in simulated worlds as if they were real, nevertheless they should be able in the virtual reality to coordinate operations transgressing the body actions under gravitational conditions.



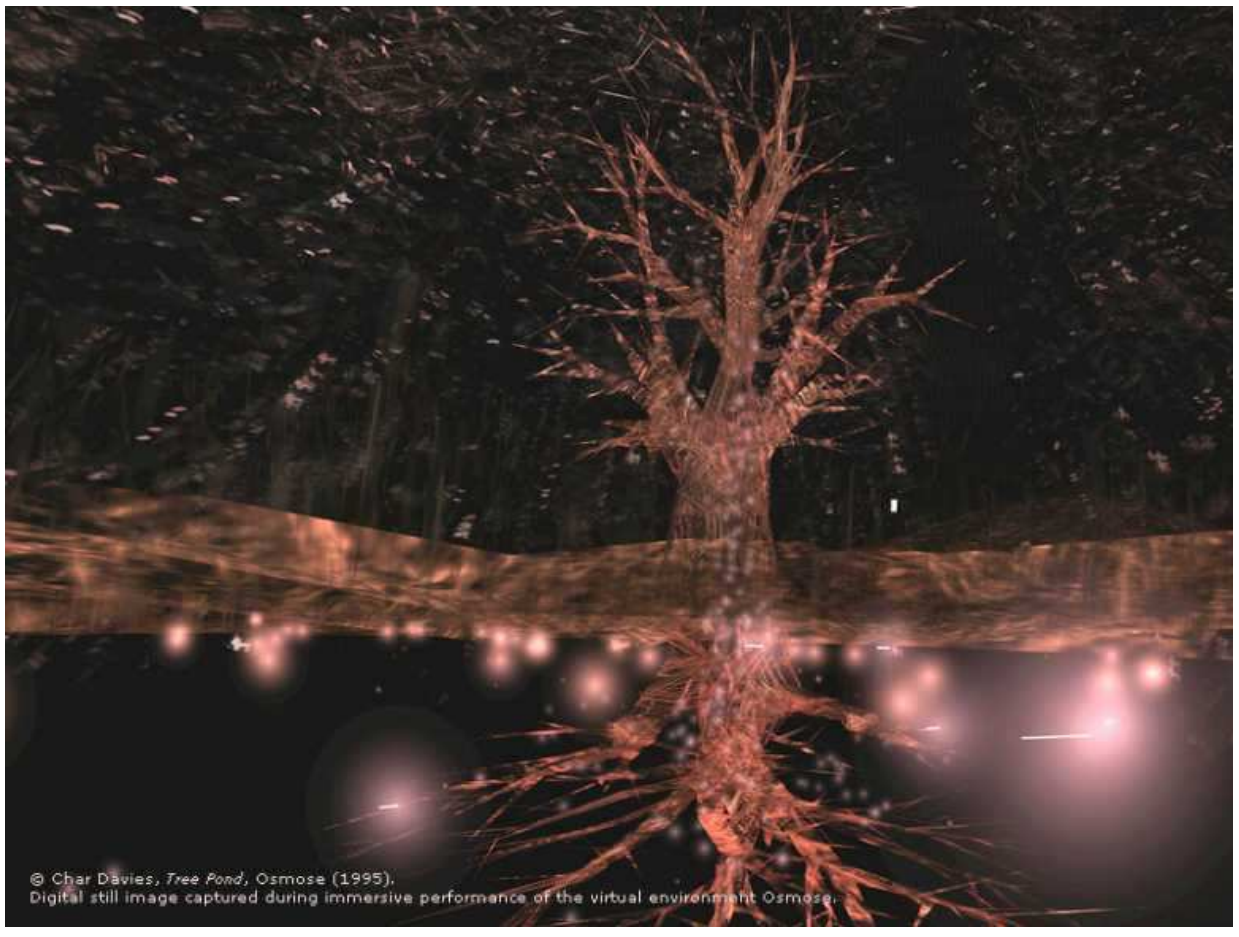
Fleischmann, Monika/Strauss, Wolfgang: Home of the Brain, virtual reality installation, 1991/92 (Kluszczynski: Data 2011, p.70).

In installations like "Home of the Brain" (1991/92) by Monika Fleischmann and Wolfgang Strauss 2, "Placeholder" (1993) by Brenda Laurel and Rachel Strickland 3 and "Osmose" (1995) by Char Davies 4 observers can enter and explore the spaces of images with motions of feets, hands and eyes in using virtual reality (VR) interfaces for heads and hands. The installations for data helmets and data gloves need a limited real space enabling observers to act obstacle-free in exploring the simulated worlds. In "Placeholder" the spaces for the actions of two observers with data helmets and data gloves are enframed by stones. By tactile means observers gain knowledge of the limited gravitation-bound area for their actions in a gravitationless virtual world binding the capabilities for visual perception. 5



Laurel, Brenda/Strickland, Rachel: Placeholder, virtual reality installation, 1993.

On the opposite to these "inclusive environments" with `seamless entrances´ to simulations the "responsive environments" by Krueger, Shaw or Weibel (see chap. V.1) offer observers thechnical interfaces as `seams´ between the gravitation-bound real space and the simulated worlds. 6 The `seam´ as a technical (interface 1) and cognitive interface (interface 2, see chap. VIII.2) can be a subject of the observation models realised by artists and programmers as "responsive environments". 7

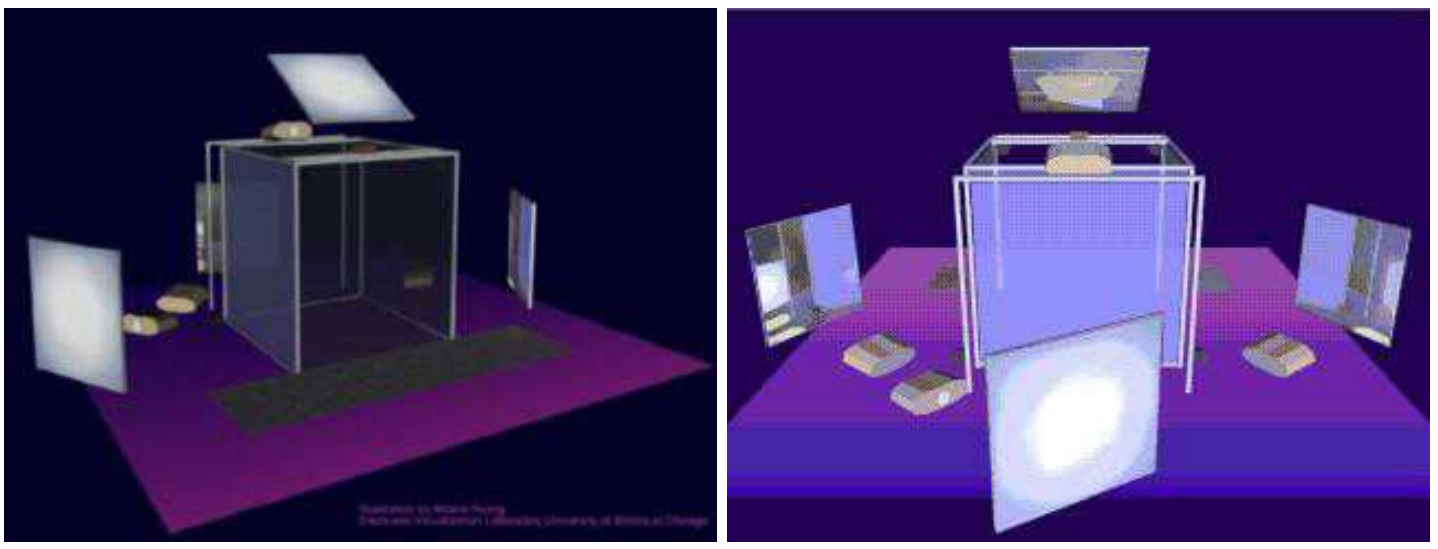


Davies, Char: Osmose, virtual reality installation, 1995.

From 1991 to 1993 Daniel J. Sandin, Thomas A. DeFanti and Carolina Cruz-Neira developed "CAVE" (Cave Automatic Virtual Environment) at the Electronic Visualization Laboratory (University of Illinois, Chicago). In the 3 x 3 meter large room of this technical platform computer animations can be presented by video beamers as rear projections on three up to six walls. The animations can be abstract model worlds as well as a panorama-like simulation of a world or a state of a world (for example reconstructions of a destroyed monument´s original state). Observers wear stereo glasses (LCD shutter glasses) with sensors (between both glasses) recording their location and

the head´s motions. Perspective distortions in oblique views on the projection walls are corrected:

> Therefore, as the viewer moves around in the environment, the off-axis stereo projection is calculated according to his/her position with respect to the walls. 8



Sandin, Daniel J./DeFanti, Thomas A./Cruz-Neira, Carolina: CAVE, reactive installation, Electronic Visualization Laboratory (University of Illinois, Chicago), 1991-93.

The installations of different works programmed for the "CAVE" can require the mounting of other interface equipments for the observers´ navigations. In "ConFIGURING the CAVE" (1996) by Jeffrey Shaw, Agnes Hegedüs and John Lintermann observers are enabled to navigate in seven visual worlds by moving a puppet´s limbs. 9 Observers switch from one visual world to another by moving the hands of the puppet to its eyes.



Shaw, Jeffrey/Hegedüs, Agnes/Lintermann, John: Con FIGURING the CAVE, reactive installation in the CAVE, 1996.

The visitors are on the one hand `external observers´ exploring the programming of the virtual world and reconstructing its `internal observer´. 10 On the other hand the observers are already included in an environment trying to immerse `seamlessly´ into its simulated world. But the real space used as a facility for simulations has a limited size (10' x 10' x 9'/3,05 x 3,05 x 2,74 meter) and a projected simulation remains an inaccessible world of optical illusions. In the little cube the observers´ area for body motions is limited, and in the navigation through the projected space its illusion of depth has to be remembered for the body coordination as being part of an inaccessible `mirror world´ behind the projection walls.

Dave Pape´s "Crayoland" (1995) 11 provokes observers to turn around if they want to follow the landscape panorama being drawn with crayons and then scanned. The margins of the virtual space (200´ x 200´/60,56 x 60,56 meter) and the limits of the real space are coordinated with each other. In contrary to the "Crayoland" is in "ConFIGURING the CAVE" the depth of illusion constituting the space of the images blocked by repeated patterns of sign configurations or abstract forms: The forward driving navigation in the virtual space is replaced by an observer behavior coordinating the puppet´s limbs to explore the possible modifications of the animation´s four sides: The seeker of the depth effect (immersion) is replaced by a sliding observer.



Pape, Dave: Crayoland, reaktive Installation im CAVE, 1995.

Parallel to the navigation within the virtual world the observers use their memory for self-orientations in a narrow real space prohibiting them to walk more than some steps in one direction. But with operations on the technical interface observers can move in virtual reality as if they walk in a much wider space than in the real space of the "CAVE": Observers `walk´ in simulated worlds often meanwhile they stand still in the real space. If observers turn around to see the simulated space on walls, floor or ceiling then they act out a `standturn´ (they turn the body without walking) to move in the virtual

world in circles: They move with their eyes in the virtual world in another radius than their body in the real space. A `seam´ between the real space and the projection is the precondition for a `seamless´ navigation in the virtual world(s).

No training is necessary for the coordination of motions with the tracker and one´s own body to navigate with the technical interface of the "CAVE" in virtual worlds. For observers this interface can seem to be an easy and intuitively usable entrance to the virtual world, but it is not `seemless´ like the navigation in virtual reality installations with data helmets and data gloves: The technical interface (interface 1) and the cognitive interface of the observer for his coordination of body motions (interface 2) have to be approximated to each other for cognitive intermediations (interface 3, see chap.VII.2.2, VII.2) between the real and virtual spaces with their different constituents. These intermediations for the development of adequate observing operations (action plans and schemes) can result in requirements to further exploratory actions with the feet, the head and the tracker. These characteristics allow to describe the "CAVE" as a navigable panorama with moving images (steuerbares Bewegtbild-Panorama). 12

Maurice Benayoun´s "CAVE" installation "World Skin" (1997-2003) shifts the observer in the position of war zones´ tourists. Observers can´t see the spatial depth of the war zones because it is blocked by the simulation of soldiers, tanks and ruins. The technical interface included a navigation interface for one observer and for further observers three little devices hanging from the ceiling. These hanging devices are prepared for a camera-like use. Observers click with a camera imitation on one of the war motifs projected on three walls. Then the photographed `frozen´ moments of war scenes turn into white planes with the outlines of the motif `clicked away´. After observers activated the sound of the camera clicks several times the background noises of war activities are replaced by the sound of rifle fire.



Benayoun, Maurice: World Skin, reactive installation in the CAVE, 1997-2003.

Benayoun creates the paradox of unmoved scenes of a warzone `vivified´ by 3D animation. With it the artist developed a narrative as well as a conceptual context being especially appropriate for the technical platform CAVE. To expectations concerning an immersion provoked by the allround simulation of the CAVE responds Benayoun in thematising the expectations of warzone tourists to experience the horrors of the past as illustrative as possible but not too `close´. The cardboard-like presentation of war scenes prohibits heroisation and thematises expectations to simulations of historical constellations (location and events). 13

Meanwhile in installations with data helmets and data gloves obervers combine their coordination of body motions under the gravitational force `seamless´ with the simulation of weightless objects in an illusory space, the observers in a "CAVE" simulation orientate themselves at a junction (`seam´) because only a part of their motions in the narrow real space serves the navigation in the virtual space with a usually wider simulated depth.

In "responsive environments" (see chap. V.1) observers have to accomodate their body motions to technical interfaces with installation-specific designs for explorations of the programmed possibilities to navigate in the spaces of images. "Responsive environments" can not be explored without cognitive reconstructions (observing operations, interface 2) of the consequences that the navigations in the spaces of images have for the body coordination at or on the technical interface (interface 1): The `seam´ as the coordination of a technical interface with the cognitive interface (for the self orientation and the coordination of body actions) provokes the coordination of different requirements of the space of the image and the image space. The coordination of the two ways of self orientation via switches from real spaces to spaces of images and from spaces of images to real spaces (Raumbild/Bildraum, Bildraum/Raumbild) demands a processual observation of the works modificating cognitive reconceptualisations several times to integrate new experiences: The body coordination on the technical interface and the orientation in the space of the image are recoordinated in observing operations to accomodate the mental reconstruction of an installation´s functions to new experiences and to develop new explorative procedures as consequences from arising questions about the installed work. This recoordination constitutes interface 3 in mediating between interface 1 and interface 2 (see chap. VII.2.2, VIII.2).

The what and how of observations is presented in the three kinds of installations explained above (`seam´ in "responsive environments", `seamless´ in virtual reality, `seam´/`seamlessness´ in the CAVE") as an interface problem posing different requirements for observing operations mediating between the orientations in the real space and the space of the image (interface 3).

Annotations

1 Davies/Harrison: Osmose 1996, chap. The Effect Osmose Has on Participants: "They [the immersants] seemed to involve an altered mind/body state. In this state, it seems they paradoxically feel both disembodied (because of the visual aesthetic, being able to float and pass through things) and embodied (due to reliance on breath and balance), simultaneously."
On techniques of virtual realities and its use in "inclusive environments" (see ann.6): Dinkla: Pioniere 1997, p.57-60; Grau: Art 2003, p.161-173; Halbach: Interfaces 1994, p.170,187-214; Hattinger/Russel/Schöpf/Weibel: Ars Electronica 1990; Heim: Realism

1998, p.98-107; Hünnekens: Betrachter 1997, p.54s.; Krueger: Reality 1991, p.65-76; Lovejoy: Currents 1997, p.203-208. back

2 "Home of the Brain" thematises in its virtual world the discourse on virtual reality via statements of Joseph Weizenbaum, Marvin Minsky, Vilém Flusser und Paul Virilio. These four computer scientists and philosophers of media inhabit four houses arranged around a "forum". The "techno-imaginary" (see chap. IV.2.1.4.4) is articulated in a medium presenting and reflecting its own characteristics. This virtual space was used by observers with physical disabilities to realise motions being impossible under gravitational forces for visitors without disabilities (hardware: Computer von Silicon Graphics und Apple, VLP-Dataglover, Eyephone. Software: Stew, Wavefront, In-House SW). Lit.: Fleischmann: Jetztzeit 1996, p.401s.; Grau: Art 2003, p.217-231; Kluszynski: Data 2011, p.14s.,24,26,41s.,66-73. back

3 Hardware: Silicon Graphics Onyx Reality Engine, 2 personal computer ("PC clones") with 2 Crystal River Engineering Convolvotrons, Macintosh II computer with Sample Cell Audio Processing card, 2 Silicon Graphics VGX computer, NeXT computer, Virtual Research VR helmets, Sony microphones, Yamaha sound processors, sensor system "the Grippees" (developed by Steve Saunders for "Placeholder"). Programmers: Raonull Conover, Glenn Fraser, Graham Lundgren, Catherine McGinnis, Douglas McLeod, Michael Naimark, Chris Shaw, Rachel Strickland, Rob Tow, Lloyd White. Software: C, UNIX, Minimal Reality Toolkit, ALIAS animation software, TCP. Lit.: Hayles: Virtuality 1996, p.15-21; Heim: Realism 1998, p.68-72, fig.3.5-3.7; Laurel/Strickland: PlaceHolder 1994; Laurel/Strickland: Placeholder 1996; Laurel/Strickland/Tow: Placeholder 1994; Lovejoy: Currents 1997, p.204s. back

4 Observers obtain VR interfaces outside of the installation´s chamber: In the chamber the observers move with this interface in the simulations of ceiling, clouds, water, branches and plants via inhaling and exhalation, among other actions. In the virtual space these operations cause up- and downward movements. Hardware: Silicon Graphics Onix Reality Engine 2, Division DVisor HMD, Polhemus Fastrak for the measurement of head positions and the backbone gradients. A respiratory waistcoat serves for the measurement of the chest´s elongation and contraction. Animation: Georges Mauro with SOFTIMAGE 3D ("SoftImage SAAPHIRE and DKIT development libraries...SGIs Performer and GL graphics libraries." (Davies/Harrison: Osmose 1996, chap. Technical Details)). Custom Software: John Harrison. Sound: Rick Bidlack, Dorta Blaszczak with MIDI on a Macintosh computer. Localisation: Crystal River Acoustetron. Lit.: Davies/Harrison: Osmose 1996; Grau: Art 2003, p.193-201; Hansen: Bodies 2006, p.108-113,135; Heim: Realism 1998, p.162-167,171, fig.6.1-6.4; Lunenfeld: Davies 1996; Manovich: Language 2001, p.261; Paul: Digital Art 2003, p.126s. back

5 Via data helmets the observers are transfered to three places – a cave, a waterfall, a river valley – in the ennvironment of the Banff National Park in Alberta/Canada. There they appear optionally as "Spider, Snake, Fish, and Crow." (Heim: Realism 1998, p.71; Laurel/Strickland/Tow: Placeholder 1994. Cf. Hayles: Virtuality 1996, p.17). back

6 "Inclusive environments": Bricken: Worlds 1991, p.364.
"Responsive environments": see chap. II.3 with ann.14. back

7 The use of the terms "seam" and "seamless" was inspried by Mark Chalmers´ use of the terms "seamful" and "seamless" (Chalmers/MacColl: Design 2003). Cf. Strauss/Fleischmann: Architektur 2003, unpaginated, chap. Das Verschwinden der Interfaces: "The new interfaces between humans and machines can´t be taken as barriers anymore, because they are interfaces with tendencies either to disappear or to become

invisible."
"The interface as a location of seams" ("Die Schnittstelle als Nahtstelle"): Neitzel/Nohr: Spiel 2006, p.16. back

8 Cruz-Neira/Sandin/DeFanti: Surround-Screen 1993, p.137. Technical equipment: Cruz-Neira/Sandin/DeFanti: Surround-Screen 1993, chapter 1.3, p.136ss. Cf. Grau: Art 2003, p.3s.,238,247,299; Heim: Realism 1998, p.99-107; Kacunko: Circuit 2004, p.111,642; Robbin: Shadows 2006, p.123-127. back

9 Shaw: Movies 2002, p.271s.; Paul: Digital Art 2003, p.128s. back

10 The "internal observer" is constituted by the possibilities programmed for (external) observers being enabled by the technical interface to activate functions of the system (Dreher: Weibel 1997, p.60, ann.49). back

11 Pape: Crayoland 2002. back

12 Vgl. Heim: Realism 1998, p.98-107 on the differences between the "perceptive immersion" in "HMD VR" and the "apperceptive immersion" in "CAVE VR". back

13 At the end of "CAVE" peresentations the visitors of the Ars Electronica Center in Linz received colour prints of the motifs photographed by them. Hardware: Two Silicon Graphics Onyx Reality Engines. Programmers: Patrick Bouchaud, Kimi Bishop and David Nahon. Sound: Jean-Bapiste Barrière. Lit.: Benayoun/Barrière: World 1998; Grau: Immersion 2004, p.268; Hansen: Bodies 2006, p.88-94, fig.1.8; Wilson: Information 2002, p.705ss. back

VI. Net Art: Networks, Participation, Hypertext
VI.1 Computer Networks

VI.1.1 From Timesharing to the Internet

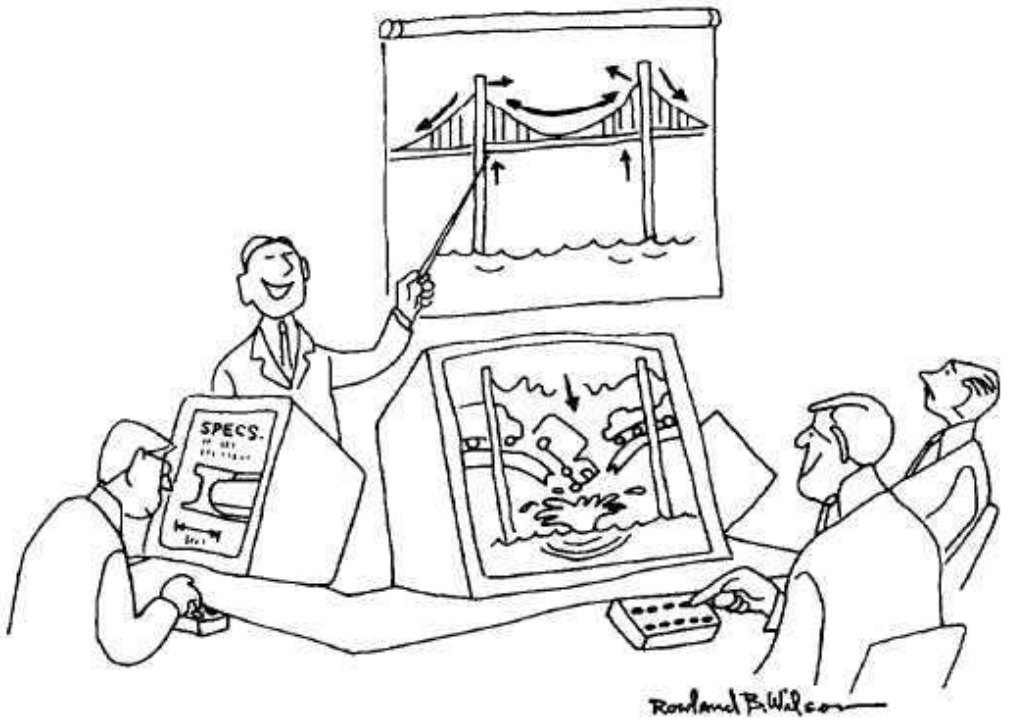
In the sixties and seventies American scientists asked if computers can´t be used for other purposes than for calculation tasks. The quest for alternative functions led to efforts to develop adequate interfaces for terminals serving as accesses to central mainframe computers and as a means to communicate with participants on other terminals (see chap. VI.2.1).

After the development of solutions for "multi-tasking" by dividing a processor´s capacities the computer researchers worked out "multi-access". It offers accesses from several terminals or "operators" to a central computer:

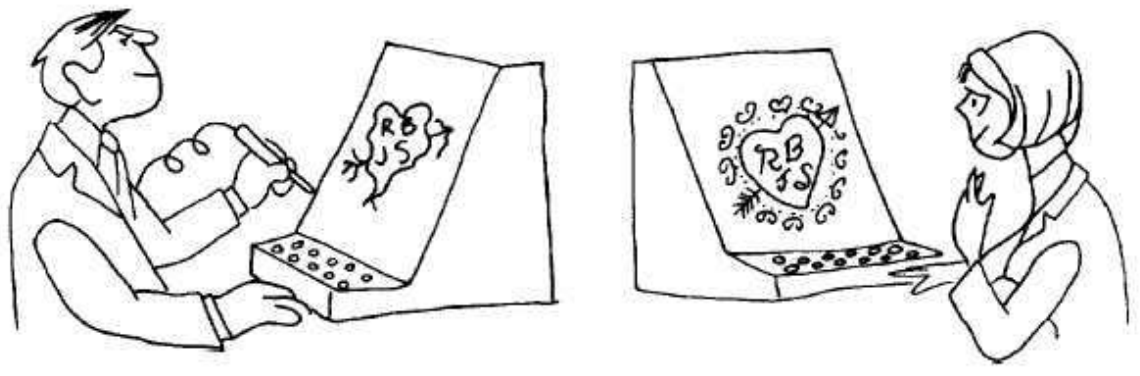
> ...during the normal running of the machine several operators are using the machine during the same time. To each of these operators the machine appears to behave as a separate machine. 1

Between 1957 and 1959 the concept for timesharing was developed to ameliorate the use of the computing power. Timesharing made possible a better utilisation of computer capacities being accessible from various terminals. Since 1964 the first workable timesharing systems were realised. 2 These systems subdivided the computing time of a computer in sections lasting milliseconds and distributed these sections to the programmes started by the participants on the terminals. The time needed by a computer to response via timesharing to requests by terminals rested within the "timespan of seconds". 3

In the sixties Joseph Carl Robnett Licklider and Douglas Carl Engelbart conceptualise the interface between humans and computers as a cooperation of several participants using the same "intelligence augmenting tool" 4 for operations with "symbols" 5: to store character strings, to retrieve documents from the memory, to process these data and to store the processed data. 6 A keyboard and an electronic pen or a mouse are the means to process characters presented on a monitor. With these means functions can be easily activated. 7 Computers formerly used as calculators can be used with these forerunners of menus´ icons dominantly to process text and graphics.



At a project meeting held through a computer, you can thumb through the speaker's primary data without interrupting him to substantiate or explain.



A communication system should make a positive contribution to the discovery and arousal of interests.

Wilson, Roland B.: Cartoons for Joseph Carl Robnet Licklider´s and Robert W. Taylor´s "The Computer as Communication Device", 1968 (Licklider/Taylor: Computer 1968/1990, p.26).

During the sixties and the seventies the development of the human-computer interface and the development of computer networks are joined: The terminals connected with mainframe computers via timesharing are replaced by computers connected to networks via high performance cables. The interfaces of these computers (keyboard, mouse, desktop, see chap. VI.2.1, VII.2) anticipate the interfaces being usual by the personal computers since the eighties.

Since the end of June 1970 the XEROX Palo Alto Research Center is formed as a private research organisation. There William K. English, Alan C. Kay, Robert M. Metcalfe, George E. Pake, Robert W. Taylor, Larry Tesler, John Warnock and others develop networks between microcomputers, the Alto (1972/73) as a precursor of the eighties personal computers. 8 After the local area networks with terminals connected to mainframe computers 9 the ARPANET was first installed in 1969 as a new development

of networks. It connected the computers of American universities working on military projects via cable systems (Ethernet) using dedicated lines faster than telephone cables. 10 In the eighties further networks were installed for specific research projects like MILNET (Military Network, since 1983), BITNET (Because It's Time NETwork), WSFNET (National Science Foundation Network) and CSNET (Computer Science Network). 11

A technical precondition of the internet developed Paul Baran with his concept for "packet switching" dividing digitised elements in packets and adding informations being necessary for the recombinations after the posting of the packets via varying connections (cables and hosts) to the target computer. "Nodes" (hosts) receive the packets and send them to the next well-functioning "node" ("rapid store-and-forward design"). Non-functional "nodes" are circumvented. With this concept Baran formed in 1964 the basis for decentral networking. 12 Between 1968 and 1970 the members of the Internet Message Processing (IMP) Group Will Crowther and Dave Walden solved the routing problems of the "packet switching" for the ARPANET with only 150 instructions in machine language. This was only one tenth of the number of commands determined as acceptable in the definition of the framework conditions for the ARPANET´s development. 13

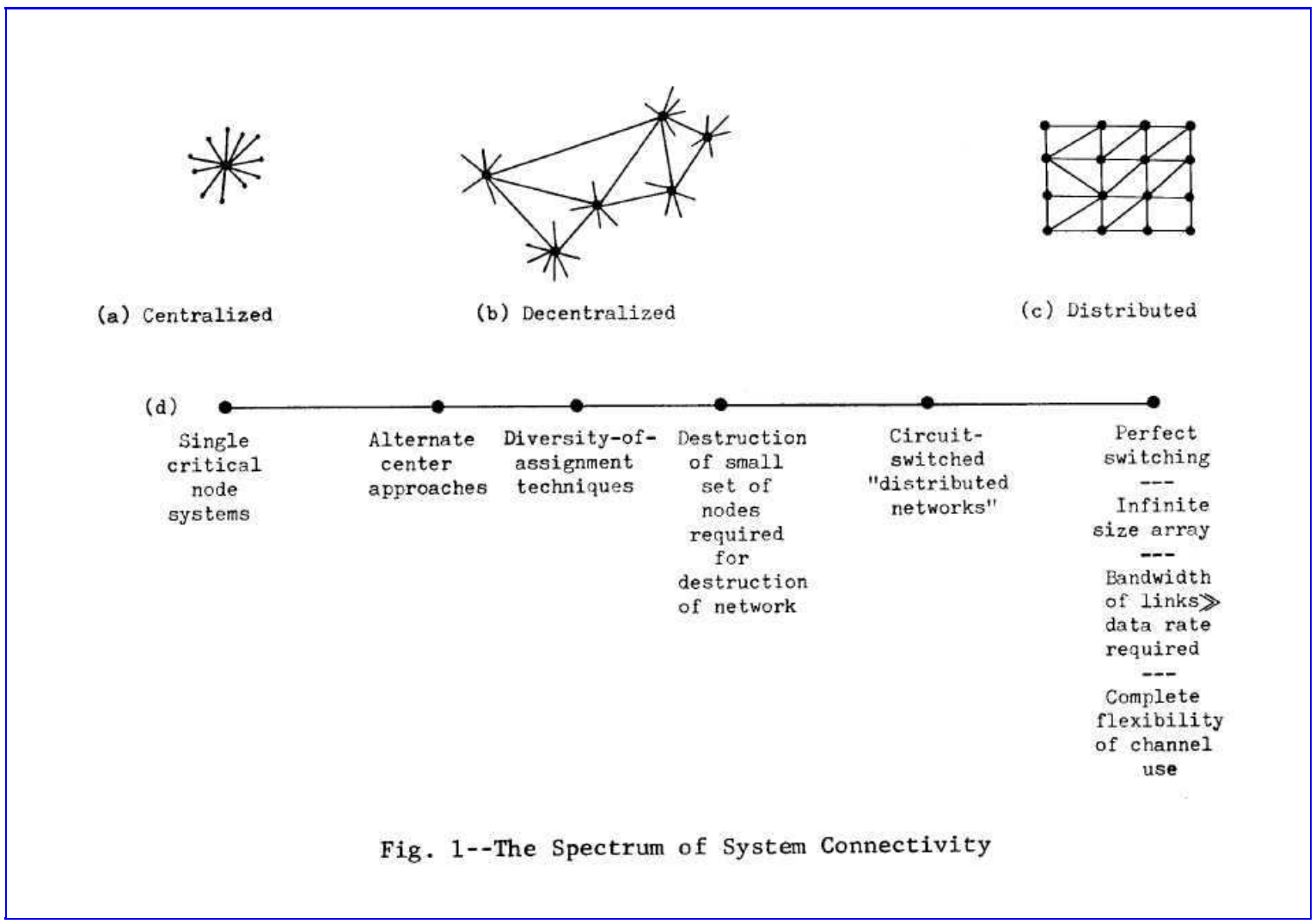


Fig. 1--The Spectrum of System Connectivity

Baran, Paul: The Spectrum of System Connectivity, 1964
(Baran: Communications V 1964, p.6, fig.1).

Protocols code and decode the data packets. In 1970/71 the transfer of data from one computer to another was made possible by the file transfer protocol (FTP). 14 In the ARPANET the TCP/IP protocol (Transmission Control Protocol/Internet Protocol) coordinated the transfer of data packets between networks. This protocol constituted the fundament of the later developed internet and its protocol layers. 15

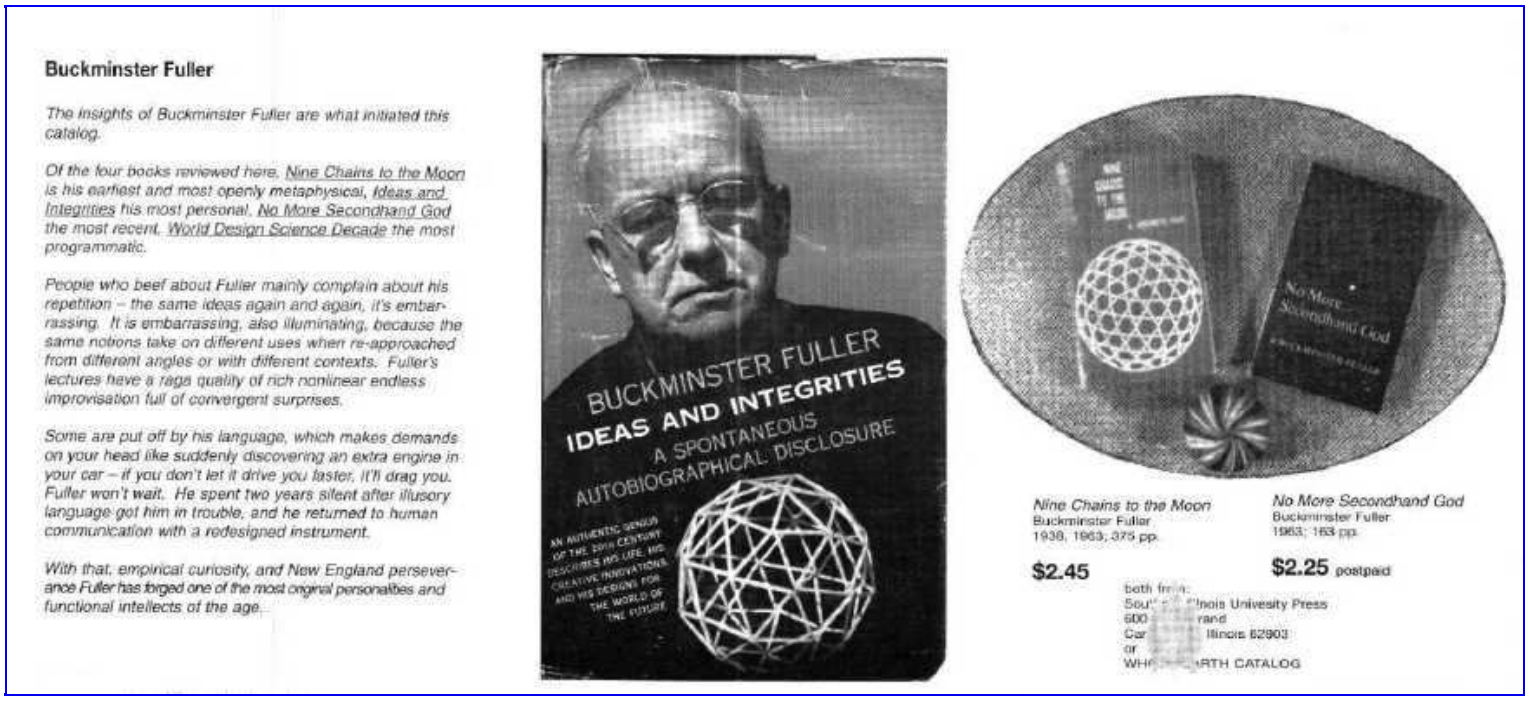
Beside the high capacity cables of the ARPANET networks were built in the eighties connecting personal computers via telecommunication in using modems with acoustic

coupler on which the telephones´ handsets had to be placed. The dial-in procedures with the program MODEM to bulletin board systems, newsgroups and MUD´s [16] were complicated. Before the Mosaic Browser (since 1993) was developed for the World Wide Web [17] participants operated in the internet in using commands that had to be learned. [18] Since 1980 the timesharing services being offered on universities´ computers were used to built the first nodes between the networks. These nodes constituted the fundament for the server structure of the internet being extended in the nineties. [19]

During the eighties and the early nineties the participants of Bulletin Board Systems (BBS) developed an awareness of "virtual communities" [20] communicating with each other in writing from remote places without time delay. The free and open software of networks constantly developed further as well as the abolished division between readers and authors (see chap. VI.1.2) are cornerstones of the demand for a free, unrestricted data exchange initiating the start of net activism. In the nineties activists rejected efforts to restrict web accesses through censorship, copyright, charges and other barriers. [21]

In 1985 the network The WELL (the Whole Earth ´Lectronic Link) started in Sausalito/California. Its system was based on a BBS programme for video conferences (PicoSpan für Unix) offering all participants access to a database. [22] The WELL was an online proceeding of the information exchange constituting the core of the "Whole Earth Catalog". After its first print in autumn 1968 Stuart Brand edited updates until 1994. This `catalogue in progress´ featured books and technologies inspiring people living in the Bay Area´ s surroundings of the commune keepers and the grassroots activism. Buckminster Fuller´s all-encompassing world view was the main inspiration:

> The insights of Buckminster Fuller are what initiated this catalog. [23]



Brand, Stewart (ed.): Whole Earth Catalog. Fall 1968: Buckminster Fuller (Brand: Earth 1968, p.3).

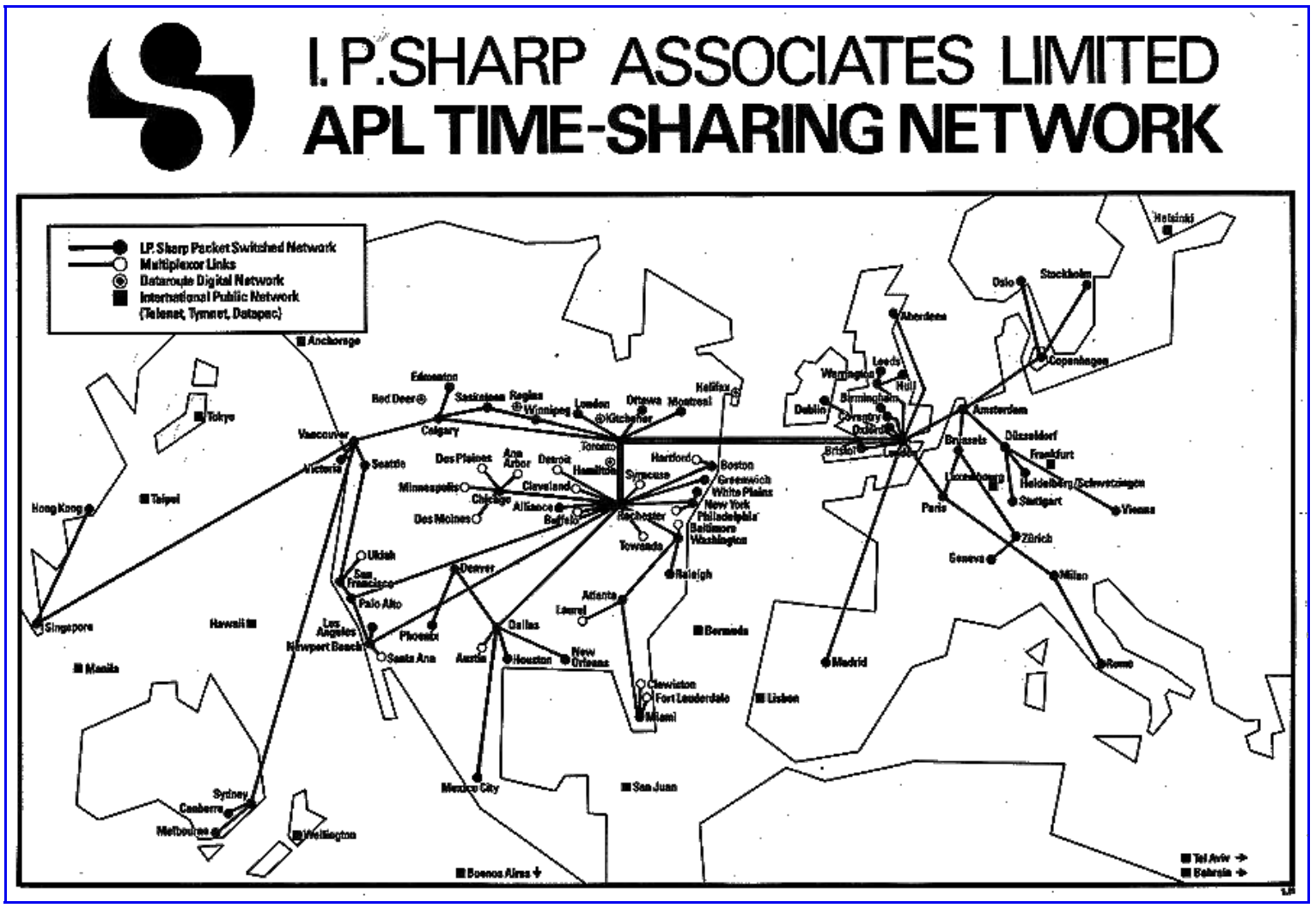
The transformation of the print version into The WELL included fora being open for the readers´ propositions and contributions. The "network forum" for the communication between the authors of the print versions was developed further into public conferences and newsgroups. [24]

Following Fred Turner the counterculture of the sixties ´ New Communalist movement with estimated between two and six thousand communes in the U.S.A., many of them located in the Bay Area, was converted in the eighties in "virtual communities" by The WELL. [25]

One of the public conferences on The WELL was the Art Com Electronic Network (ACEN, see chap. VI.1.2). 26

VI.1.2 Participation in Networks of the Eighties

The I.P. Sharp Associates Network (IPSANET) offered clients accesses to its mainframe computers. With acquirable network-specific terminals clients were able to reach nodes being connected with transocean cabels and a "packet switching" transmission technique. 27 In April 1979 I.P. Sharp Associates Network put capacities at the disposal of artists communicating with each other for two hours in a Computer Communications Conference from terminals in 19 towns of America, Australia, Japan, Canada and Austria. 28 Since 1980 artists could employ a mailbox system developed by Gottfried Bach for ASCII e-mails in the I.P. Sharp Associates Network. In 1982 this "Artbox" developed further to ARTEX (Artists´ Electronic Exchange Program). Until 1990 30 artists used ARTEX in projects with participants operating on terminals located in several places. 29



Nodes of the I.P. Sharp Associates Network.

ARTISTS' ELECTRONIC EXCHANGE SYSTEM

DESCRIPTION

ACCEPT	ACCEPT AND ERASE ONE OR MORE INCOMING MSGS. (E.G., ACCEPT 234 432 WILL CAUSE THESE MSGS TO BE ACCEPTED AND ERASED).
ALL	DISPLAY ALL INCOMING, OUTGOING AND SAVED MSG NUMBERS.
CC	CARBON COPY OPTION. 'QPQ,QPO' CC 234 SENDS A COPY OF MSG NUMBER 234 (WITH A NEW MSG NUMBER) TO USER CODES QPQ AND QPO. NOTE THAT SINGLE QUOTES (') MUST ENCLOSE THE RECIPIENT CODES.
DIRECTORY	PRINTS THE CODE, NAME AND A SHORT DESCRIPTION OF EACH USER IN 'ARTEX'.
INCOMING	DISPLAY ALL INCOMING MSG NUMBERS.
OUTGOING	DISPLAY ALL OUTGOING MSG NUMBERS.
PRINT	DISPLAY A SPECIFIC MSG. (E.G., PRINT 234 WILL CAUSE MSG NUMBER 234 TO BE DISPLAYED).
READ	DISPLAY ALL INCOMING MSGS. THERE WILL BE A PAUSE BETWEEN EACH MSG WITH A PROMPT (?:) FOR ACCEPTANCE OF THE MSG, TO BE ANSWERED WITH Y (YES) OR N (NO).
SAVED	DISPLAYS ALL SAVED MSG NUMBERS.
SEND	PROMPTS FOR CODE(S) OF RECIPIENT(S) (TO:), FOLLOWED BY A PROMPT FOR THE MSG (:). TO END MSG PROCEDURE TYPE STOP OR ENTER 'SPACE/RETURN' AS INPUT. TO SEND THE MESSAGE, ENTER SEND OR SE .
TRANSMIT	SIMILAR TO CC (ABOVE) BUT DOES NOT INCLUDE COMPLETE DATA OF THE ORIGINS OF THE MESSAGE.
UNREAD	DISPLAY ALL INCOMING, OUTGOING AND SAVED MSGS BY NUMBER AND CODE OF SENDER OR RECIPIENT.
USERS	DISPLAY ALL VALID USER CODES.
WHOIS	PRINTS A DETAILED DESCRIPTION OF THE USER SPECIFIED. (I.E. WHOIS 'JRA' WILL DO THIS FOR THE USER WITH THE COD
WITHDRAW	DELETES YOUR MESSAGE(S) WITH THE SPECIFIED NUMBER(S). (E.G., WITHDRAW 56 58 WILL DELETE THE MESSAGES 56 AND 58 FROM YOUR OUTGOING OR SAVED LIST). 'WITHDRAW' IS THE ONLY WAY TO DELETE A 'SAVED' MSG.

*

MESSAGES MAY BE 'SAVED' BY USING THE 'CC' OR 'TRANSMIT' FUNCTION, BY SENDING A COPY OF THE MSG TO YOURSELF. THIS WILL CAUSE THE MSG TO APPEAR WITH A NEW NUMBER, ON YOUR 'SAVED' MSGS LIST.

AT ACTION PROMPTS (?:), YOU CAN ENTER THE FOLLOWING UTILITY COMMANDS:

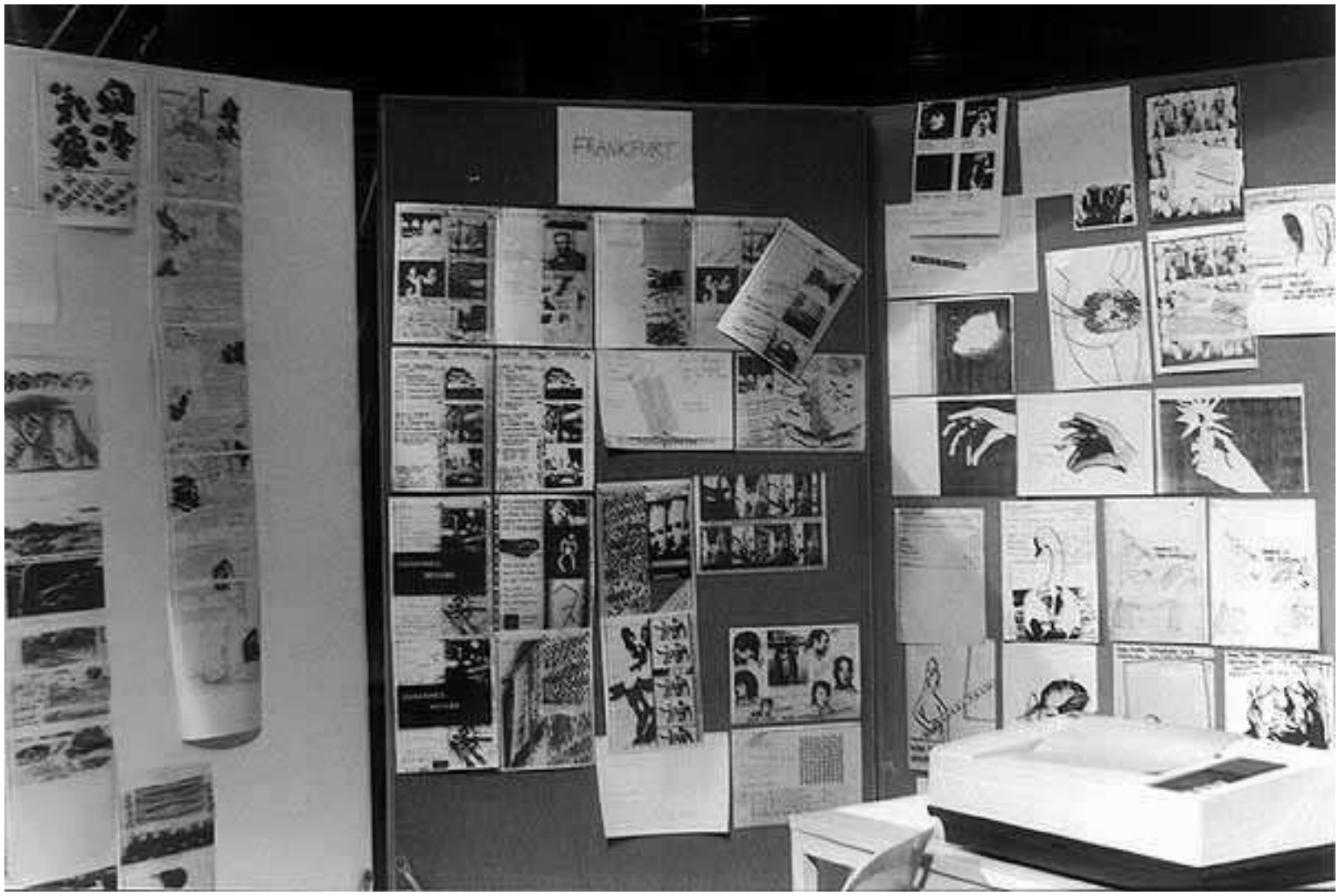
HELP OR HE - WILL CAUSE A LIST OF CORRECT RESPONSES TO THAT PROMPT TO BE DISPLAYED.

STOP OR ST - WILL MOVE BACK TO THE PREVIOUS PROMPT, OR EXIT THE FUNCTION IF THERE IS NO PREVIOUS PROMPT.

User manual for ARTEX in the I.P. Sharp Associates Network, November 1982.

"14 artists or groups" living in 15 cities (Amsterdam, Athen, Bath, Florenz, Frankfurt, Honolulu, Istanbul, Pittsburgh, San Francisco, Sydney, Tokyo, Toronto, Vancouver, Wellfleet, Vienna) participated in the project "The World in 24 Hours". In 1982, during the Ars Electronica Festival in Linz, Robert Adrian X administrated the telephone connections to the I.P. Sharp Associates Network. At 12.00 a.m. local time people in the participating cities could get in contact with the organisation centre in Linz. In their changes from place to place during 24 hours the participants followed the midday sun around the globe. Participants in Linz had three telephone lines to interchange faxes and videos with varying participants. For a telephone long distance transmission a Slow Scan TV Transceiver transformed videos into audio signals. They had to be retransformed into

video signals on the receiver side. I.P. Sharp Associates Network provided "Artbos and Confer programs" as well as opportunities to transmit computer graphics. Via the Confer program the participants in 15 cities were connected to the organisation centre in Linz. Many participants used the "Computer Timesharing (I.P. Sharp APL/Network)" as well as telefax and slow scan television. In Linz the resulting output was presented on partition walls installed in the foyer of the ORF-Landesstudio Oberösterreich. "Connectivity" 30 was the main feature of "The World in 24 Hours". 31



Adrian X, Robert: The World in 24 Hours. Österreichischer Rundfunk (ORF), Landesstudio Oberösterreich, Linz 1982: posting up of telefacsimiles from Tokyo, Frankfurt and Wien.

In 1983 Roy Ascott organised a collaborative writing project: Participants in Bristol, Honolulu, Paris, Pittsburg, Sidney, Vancouver and Vienna cooperated in writing text contributions for the roles of a "planetary fairytale". On projections in the Musée d´Art Moderne de la Ville de Paris visitors of the exhibition "Elektra" could follow the writers developing «La Plissure du Texte» in the e-mail network ARTEX. 32



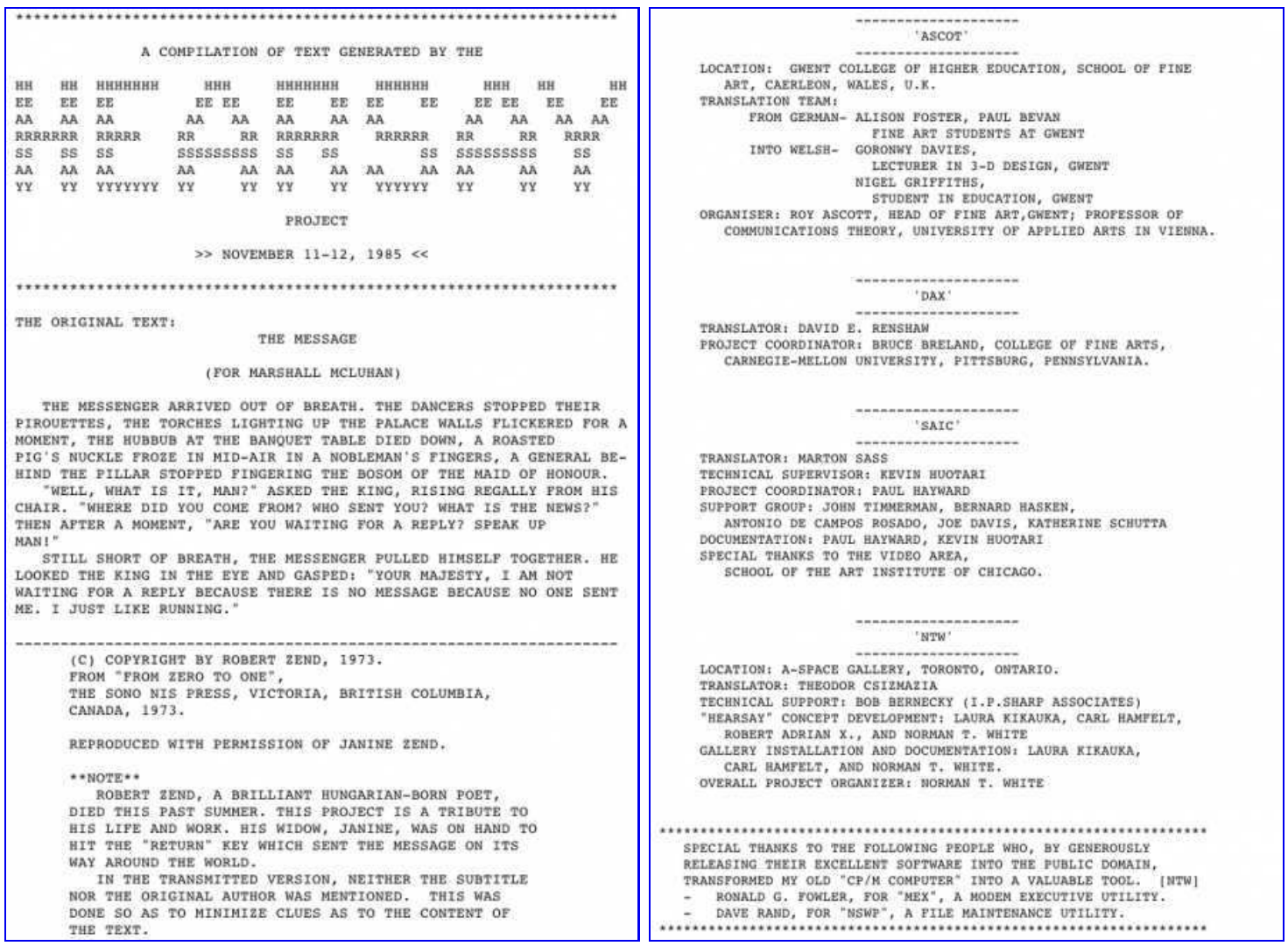
Ascott, Roy: La Plissure du Texte, 1983. Tom Klinkowstein and Greg McKenna at a terminal for the I.P. Sharp Associates Network in La Mamelle, San Francisco.

```
FROM FRONT TO NEXUS SENT 05.04 12/12/1983
LA PRINCESSE.
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                                      * ***** *
                                    * *********** *
                                    * *********** *
                                  * ***************** *
                                  * ***************** *
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                            * ***************************************** *
                            * *************    OEIL    ************** *
                            * ************* D'ETAIN  ************** *
                             * ************  DE TON  ************* *
                             * ************ CERCUEIL ************* *
                              * ***********  DIVIN   ************ *
                               * ******************************** *
                          * **********PENCHES-TOI  OH  ESPRIT MALIN******** *
                          * ************SUR  CE BREUVAGE  ANODIN*********** *
                          * **********ET  PAR  TES  ONDES ALCALINES******** *
                          * ************RENDS  LA  MAGIE  DIVINE*********** *
                                 * ******************************** *
                                * ***********  ASTRE   ************ *
                               * ************    DE    ************* *
                              * ************* L'AURORE ************** *
                             * **************  QUE LA  *************** *
                            * ***************    BOUE   *
                                          *  DEVIENNE  *************** *
                           *OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR
                               *OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*
                                   *OR*OR*OR*OR*OR*OR*OR*OR*OR*OR*
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FROM FRONT TO NEXUS SENT 06.21 12/12/1983
LA PRINCESSE
LE FIL DES JOURS TISSAIT SA TOILE.ET DU ROYAUME DE MENTHE NE SUBSISTAIT
PLUS QUE DESOLATION.LEUR PRINCESSE ETAIT PARTIE ET LA BETE FURIEUSE DE
NE N'AVOIR POINT PAS TROUVER CHLOROPHYLE ET AVAIT DETRUIT LE VERT ROYAUME
VERT DE GRIS SOUVERAIN DU ROYAUME S'ETAIT TOURNE VERT D'ESPOIR VERS SON
```

Ascott, Roy: La Plissure du Texte, 1983. Text contribution (detail) from Vancouver for La Princesse.

In 1985 Norman White initiates a translation chain in "Hearsay": Within 24 hours Robert Zend´s "The Message (For Marshall McLuhan) " (published in Zend´s "From Zero to One", 1973) was sent on I.P. Sharp Associates Network from one participating centre to the next and translated. The eight participants in eight centres in England, America, Canada and Japan modified the text from one translation to the next. For comparisons the following quotes offer the English versions from the start and the end of the chain: "...a General behind the pillar stopped fingering the bosom of the maid of honour" is changed into "The king sat calmly on his festive chair, his hand on a woman´s breast." 33



```
**********************************************************************

                A COMPILATION OF TEXT GENERATED BY THE

HH   HH  HHHHHHH     HHH     HHHHHHH    HHHHHH      HHH   HH      HH
EE   EE  EE          EE EE    EE    EE   EE    EE   EE EE   EE    EE
AA   AA  AA         AA   AA   AA    AA   AA         AA   AA   AA  AA
RRRRRRR  RRRRR    RR     RR  RRRRRRR    RRRRR    RR     RR   RRRR
SS   SS  SS       SSSSSSSSS  SS   SS         SS  SSSSSSSSS    SS
AA   AA  AA       AA     AA  AA    AA   AA    AA  AA     AA    AA
YY   YY  YYYYYYY  YY     YY  YY    YY   YYYYYY   YY     YY    YY

                              PROJECT

                        >> NOVEMBER 11-12, 1985 <<

**********************************************************************

THE ORIGINAL TEXT:
                              THE MESSAGE

                        (FOR MARSHALL MCLUHAN)

   THE MESSENGER ARRIVED OUT OF BREATH. THE DANCERS STOPPED THEIR
PIROUETTES, THE TORCHES LIGHTING UP THE PALACE WALLS FLICKERED FOR A
MOMENT, THE HUBBUB AT THE BANQUET TABLE DIED DOWN, A ROASTED
PIG'S NUCKLE FROZE IN MID-AIR IN A NOBLEMAN'S FINGERS, A GENERAL BE-
HIND THE PILLAR STOPPED FINGERING THE BOSOM OF THE MAID OF HONOUR.
   "WELL, WHAT IS IT, MAN?" ASKED THE KING, RISING REGALLY FROM HIS
CHAIR. "WHERE DID YOU COME FROM? WHO SENT YOU? WHAT IS THE NEWS?"
THEN AFTER A MOMENT, "ARE YOU WAITING FOR A REPLY? SPEAK UP
MAN!"
   STILL SHORT OF BREATH, THE MESSENGER PULLED HIMSELF TOGETHER. HE
LOOKED THE KING IN THE EYE AND GASPED: "YOUR MAJESTY, I AM NOT
WAITING FOR A REPLY BECAUSE THERE IS NO MESSAGE BECAUSE NO ONE SENT
ME. I JUST LIKE RUNNING."

----------------------------------------------------------------------
      (C) COPYRIGHT BY ROBERT ZEND, 1973.
      FROM "FROM ZERO TO ONE",
      THE SONO NIS PRESS, VICTORIA, BRITISH COLUMBIA,
      CANADA, 1973.

      REPRODUCED WITH PERMISSION OF JANINE ZEND.

      **NOTE**
         ROBERT ZEND, A BRILLIANT HUNGARIAN-BORN POET,
      DIED THIS PAST SUMMER. THIS PROJECT IS A TRIBUTE TO
      HIS LIFE AND WORK. HIS WIDOW, JANINE, WAS ON HAND TO
      HIT THE "RETURN" KEY WHICH SENT THE MESSAGE ON ITS
      WAY AROUND THE WORLD.
         IN THE TRANSMITTED VERSION, NEITHER THE SUBTITLE
      NOR THE ORIGINAL AUTHOR WAS MENTIONED.  THIS WAS
      DONE SO AS TO MINIMIZE CLUES AS TO THE CONTENT OF
      THE TEXT.
```

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                        --------------------
                              'ASCOT'
                        --------------------
LOCATION:  GWENT COLLEGE OF HIGHER EDUCATION, SCHOOL OF FINE
   ART, CAERLEON, WALES, U.K.
TRANSLATION TEAM:
      FROM GERMAN- ALISON FOSTER, PAUL BEVAN
                     FINE ART STUDENTS AT GWENT
      INTO WELSH-  GORONWY DAVIES,
                     LECTURER IN 3-D DESIGN, GWENT
                   NIGEL GRIFFITHS,
                     STUDENT IN EDUCATION, GWENT
ORGANISER: ROY ASCOTT, HEAD OF FINE ART,GWENT; PROFESSOR OF
   COMMUNICATIONS THEORY, UNIVERSITY OF APPLIED ARTS IN VIENNA.


                        --------------------
                              'DAX'
                        --------------------
TRANSLATOR: DAVID E. RENSHAW
PROJECT COORDINATOR: BRUCE BRELAND, COLLEGE OF FINE ARTS,
   CARNEGIE-MELLON UNIVERSITY, PITTSBURG, PENNSYLVANIA.


                        --------------------
                              'SAIC'
                        --------------------
TRANSLATOR: MARTON SASS
TECHNICAL SUPERVISOR: KEVIN HUOTARI
PROJECT COORDINATOR: PAUL HAYWARD
SUPPORT GROUP: JOHN TIMMERMAN, BERNARD HASKEN,
   ANTONIO DE CAMPOS ROSADO, JOE DAVIS, KATHERINE SCHUTTA
DOCUMENTATION: PAUL HAYWARD, KEVIN HUOTARI
SPECIAL THANKS TO THE VIDEO AREA,
   SCHOOL OF THE ART INSTITUTE OF CHICAGO.


                        --------------------
                              'NTW'
                        --------------------
LOCATION: A-SPACE GALLERY, TORONTO, ONTARIO.
TRANSLATOR: THEODOR CSIZMAZIA
TECHNICAL SUPPORT: BOB BERNECKY (I.P.SHARP ASSOCIATES)
"HEARSAY" CONCEPT DEVELOPMENT: LAURA KIKAUKA, CARL HAMFELT,
   ROBERT ADRIAN X., AND NORMAN T. WHITE
GALLERY INSTALLATION AND DOCUMENTATION: LAURA KIKAUKA,
   CARL HAMFELT, AND NORMAN T. WHITE.
OVERALL PROJECT ORGANIZER: NORMAN T. WHITE

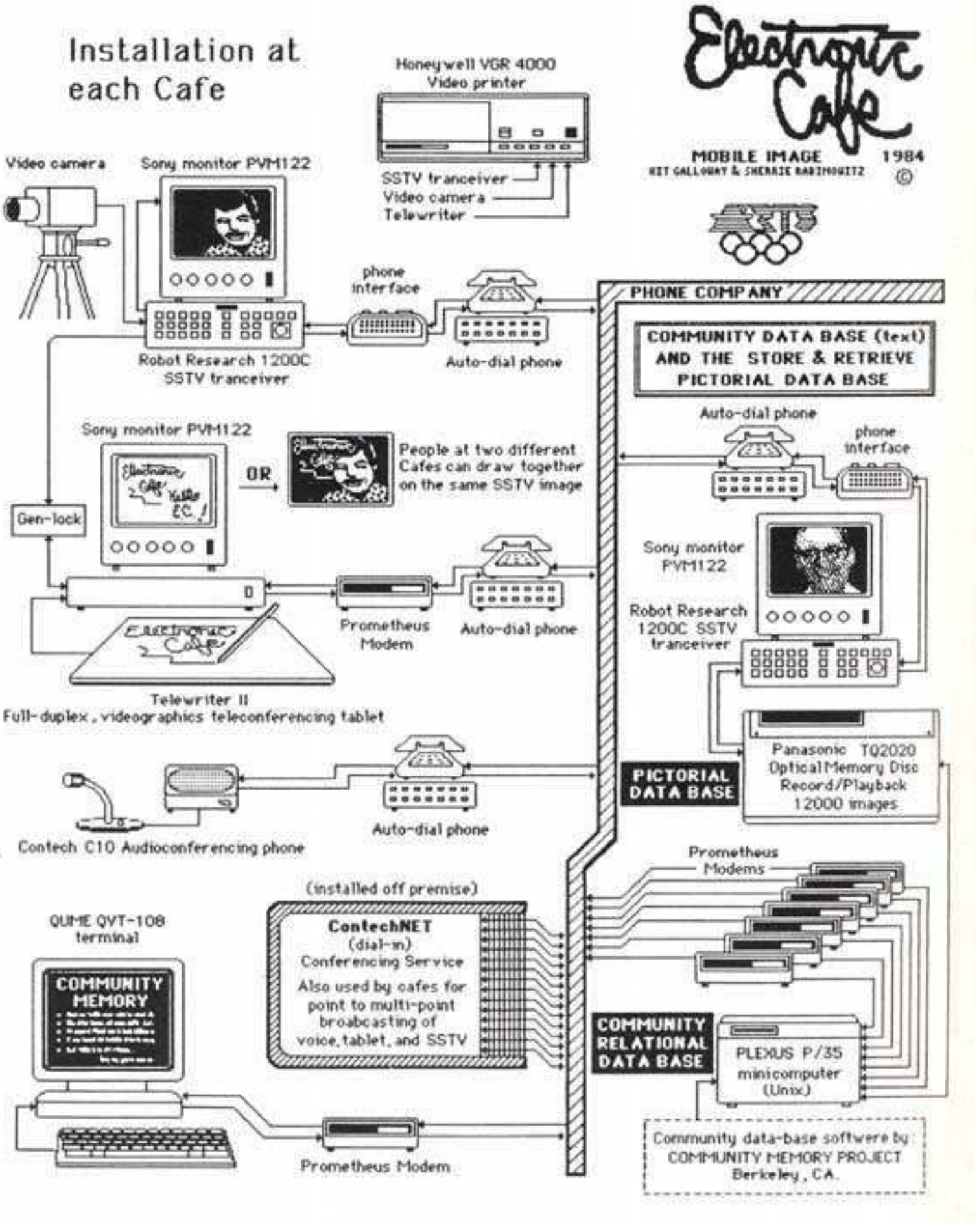

**********************************************************************
   SPECIAL THANKS TO THE FOLLOWING PEOPLE WHO, BY GENEROUSLY
   RELEASING THEIR EXCELLENT SOFTWARE INTO THE PUBLIC DOMAIN,
   TRANSFORMED MY OLD "CP/M COMPUTER" INTO A VALUABLE TOOL.  [NTW]
   -   RONALD G. FOWLER, FOR "MEX", A MODEM EXECUTIVE UTILITY.
   -   DAVE RAND, FOR "NSWP", A FILE MAINTENANCE UTILITY.
**********************************************************************
```

White, Norman: Hearsay, 1985. Left: the start of the web documentation. Right: the end.

Within the I.P. Sharp Associates Network the costs of a connection did not change with different distances of recipients. With Bulletin Board Systems like The WELL (see chap. VI.1.1) "it was almost impossible to link networks across the oceans due to the slow modem speeds and high phone costs... 34

In the projects for the I.P. Sharp Associates Network mentioned above the participation was limited to invited guests working within the context of art. These projects presented the participants´ contributions successively. But this is not a use of the connectivity as a precondition for a participation in favor of the interactions´ social aspects – in contrast to Kit Galloway´s and Sherrie Rabinovitz´s Los Angeles based project "Electronic Cafe". In 1984 the café of the Museum of Contemporary Art and four cafés in districts with publics of different ethnic groups offered to their visitors terminals with connections to the bulletin board of the Community Memory in Berkeley. The navigation in the Bulletin Board was designed as simple as possible. The Bulletin Board System included a database with texts and photos created by participants. A telewriter could be used by participants as a pen to make up handwritten documents – texts and drawings – and to post them. Video prints could be transfered via a Slow Scan Video System (SSTV). Participants on terminals of two different cafés could draw simultaneously on an image, store it in the database for images and publish it. 35 For the first time a Laser Optical

Disk Recorder was used as a database for images in a network. [36]



Galloway, Kit/Rabinovitz, Sherrie: Electronic Café, Los Angeles 1984. Diagram of the installation´s functions as they were installed in each café (Youngblood: Raum 1986, p.298).

The project can be understood as a "prototype of all internet cafés" as well as of the "context-based systems" [37], the platforms of the nineties´ internet refering to urban contexts. Gene Youngblood writes on the "Electronic Café":

> ...the information environment as commons, equally accessible to everyone. [38]

Youngblood features the inclusion of image documents into the network, the openness of the Bulletin Board unedited for contributions of all kinds and the possibility to send contributions anonymously as characteristics of the "Electronic Café":

> Democracy is threatened if we can´t participate anonymously in communities defined by telecommunication, not geography. 39

With the usability of terminals for participants of different income groups and the urban context of Los Angeles as a social reference framework the "Electronic Café" anticipates in 1984 "context-based systems" of the nineties like "De Digitale Stad" in Amsterdam (since 1993) and the "Internationale Stadt" in Berlin (1994-98) 40 using the availability of personal computers and telecommunication networks in efforts to build a new community. The social and libertarian aspirations of the sixties and seventies were combined in the eighties and nineties with the widely distributed personal computers 41 in ways offering virtual and urban communities to complement each other.



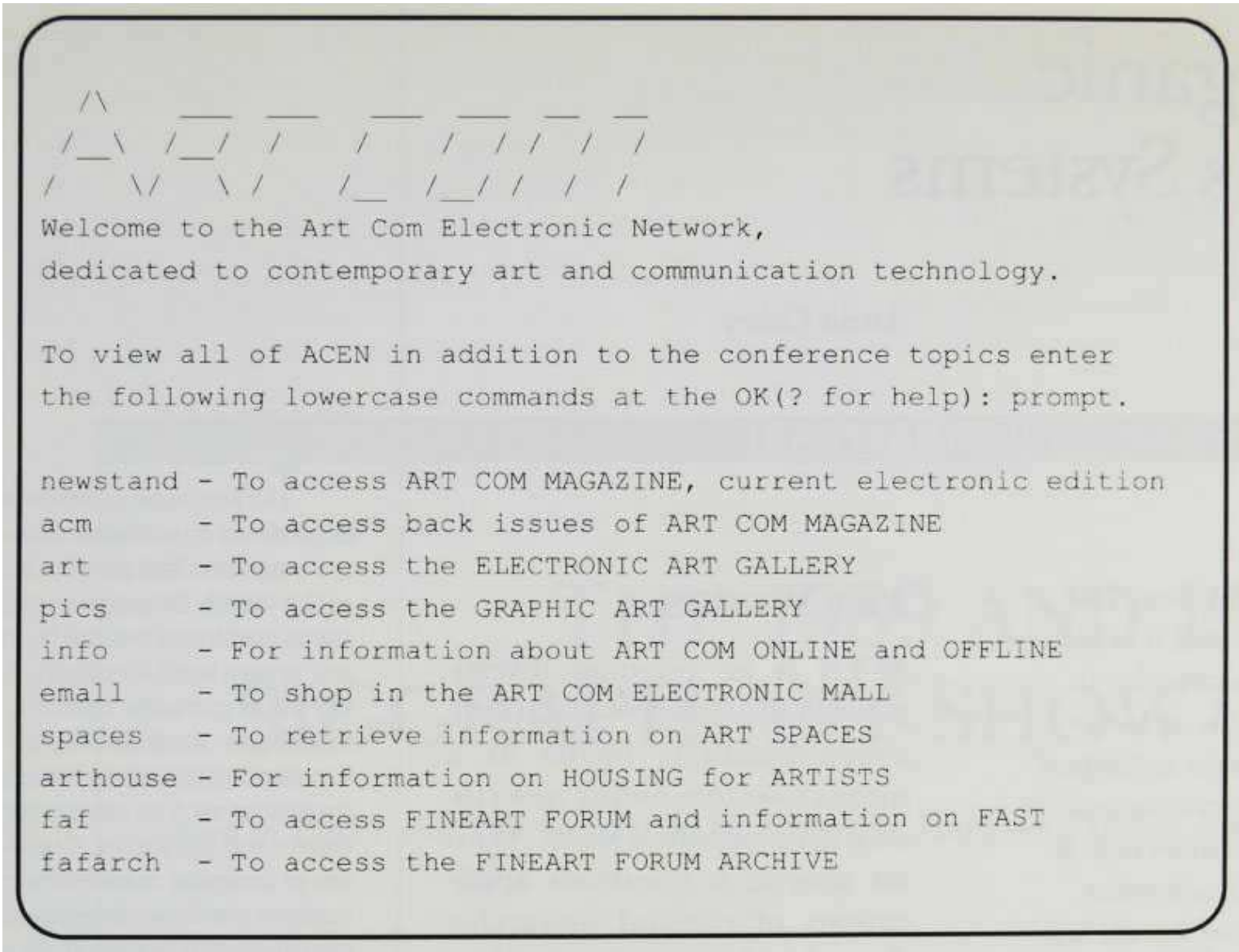
Galloway, Kit/Rabinovitz, Sherrie: Electronic Café, Los Angeles 1984.
Links: Videoprints. Rechts: Telewriter.

In spring 1986 the artists´ group Art Com opened a "public conference" on the Bulletin Board System The WELL (see chap. VI.1.1). In 1986 Carl Eugene Loeffler, Lorna and Fred Truck, Anna Couey and others installed the Art Com Magazine on The WELL and as a newsgroup on USENET informing their readers on current developments of the art, computer technology and networks. The readers are invited to post comments and to engage themselves as editors:

> *Art Com Magazine* attempts to realize publishing as a creative (art publishing as art work) and communicative medium shaped by the community that reads it. 42

Anna Couey´s invitation to participate takes up the openness for cooperation being usual in The WELL: In Bulletin Board Systems a reader reacts to existing contributions with his own comments and with them he offers impulses to other readers for a continuation of the dialogue. Couey´s conception of the art work as a "communication system" takes up the sixties and seventies developments of an engaged art and anticipates the later collaborative writing projects. George Landow and others address the later emerging change of a person´s roles between reader and author and designate it as "wreader"

(writer/reader). With it they mark the changeover from a participative action art to direct social interactions between remote participants. [43]



Art Com Electronic Network: Start Menu, since 1990
(Couey: Art Works 1991, p.128, fig.1).

In 1989 Anna Couey, Carl Eugene Loeffler and Fred Truck installed the Art Com Electronic Mail for the distribution of books, videos and software by and on artists. On the one hand the Whole Earth Catalog was extended in the Art Com Electronic Mail by product descriptions for the section media art. On the other hand a precursor of contemporary webshops was installed with a "checkout cashier".

VIRTUAL
MUSEUM OF
DESCRIPTIONS OF
ART

Welcome to the Anna Couey Virtual Museum of Descriptions of Art.

Founded in 1990 by Patrons of the Arts M and Peter Normal, the Couey Virtual museum is a home for a growing collection of descriptions of art. To augment the collection, describe in detail the experience of viewing a specific work of art. Please include location of artwork (museum name or collector name) and location within the building. Multiple descriptions of individual artworks encouraged.

All descriptions will be compiled into a true virtual museum in the future.

Topic 498: The COUEY virtual museum of Descriptions of Art.

1: Patrons of the Arts (normals)
Sun, Mar 4, '90 (20:08) 20 lines
Work: Etant Donnes
Location: Philadelphia Museum of Art.
Far end of museum's Duchamp Area.

It is placed at the far end of the D. collection in an empty, unlit room. When you walk to the doorway, the title is on the wall. When you look through the doorway you see a carpeted room and to the left about 10 feet in is a wooden wall. Maybe if you are brave enough to step on what may be an art carpet, and walk down it 10 feet, and get right up close to the wall, and aren't afraid to touch what may be an art wall, and stick yer eyes in the two peepholes you may see it. While we were there several people viewed the collection, but did not enter the room. Finally in disgust we drug in a guy, stuck him in front of the wall, pointed at the peepholes, and told hime to look. This was a total loss . . . the guy said, 'I can see why they keep it back here.' . . . the piece forces the participant to break several museum taboos.

The Normals: Couey Virtual Museum of Descriptions of Art, Art Com Electronic Network, since 1990 (Couey: Art Works 1991, p.129, fig.2).

In 1990 a Bulletin Board was started and organised as a Virtual Museum containing descriptions of art works written by the authors´ group "the Normals" (with Anna Couey). The "Couey Virtual Museum of Descriptions of Art" could be extended by new contributions from "wreaders". The Virtual Museum was open for descriptions of concepts for works either waiting to be realised or being notations independent from realisations:

> Users variously describe their experience of seeing a work of art, or create their own through description. 44

Some collaborative projects by ACEN anticipating future forms to use the internet for literature were "The Heart of the Machine" of Dromos Editions (Ian Ferrier and Fortner Andersen, since 1987), "Das Casino" by Carl Eugene Loeffler and Fred Truck (1987-88) as well as "Exquisite Corpse" by Gil Mina Mora (since 1988). "In the Heart of the Machine" was a novel in instalments. In preparing the next chapters the authors incorporated biographies sent by participants. "Das Casino" was a "bulletin board topic" with participants writing a dialogue in a "conceptual game of roulette". The topic included the fictive money Casinobux and a program generating random numbers. An alternative to this "participatory text performance" offered Mora´s "Exquisite Corpse" in transforming the surrealist strategy of a collaborative successive creation of drawings («cadavre exquis») into a text-producing strategy: Participants could not read more than the last line of the newest contribution. The 69th contribution was chosen as the end of the text. 45

In the internet the cyberspace frequently invoked in the eighties was not an illusionary space for the observers´ immersion but a space for dialogues and discussions. The internet was described by initiators of ARTEX projects like Robert Adrian X and Roy Ascott as an information room with worldwide accesses. 46 ARTEX participants could use the oversea cables of the I.P. Sharp Associates Network meanwhile the participants of The WELL constituted locally limited communities like ACEN on the West Coast of the U.S.A. by the reasons mentioned above. Their members could meet each other if the result of written dialogues was the fixation of a date for a direct communication on the complicated navigation in the internet. 47

The "Electronic Café" was constituted by the telecommunications between population groups living apart from each other in the urban context. The telecommunication can be used in a local context to undermine social and racial barriers being kept alive in urban spaces. Contrary to such locally based works the projects of Ascott and ACEN integrate remote participants in experiments transgressing established literary forms.

In the seventies the journal "Radical Software" offered a forum to video artists to exchange informations about new video techniques and various kinds to use them. The articles published in "Radical Software" could point out the juxtaposition of two cultures – social-critically engaged on one side and experimental formal on the other side – but not mediate between them (see chap. IV.1.1). In networks these both sides are connected tighter to each other because in public conferences a distributed authorship is practiced deconstructing hierarchies between authors and recipients. The experiment is the practice of distributed authorship: Social engagement and intelligent uses of media are no longer artistic strategies complementing each other in no other way than by "Radical Software ´s" contextualisation within an alternative culture encompassing both sides unconnected. The one-way communication of cinema and television got its *first alternative* in the seventies´ Community TV via cable or radio. 48 In the eighties a *second alternative* is added by a two-way communication in fora being part of projects like the boards and topics of ACEN. In web projects since the nineties video engagement and discussion fora

complement each other. In this *third alternative* media experiments and social criticism are no longer opposites (see chap. VI.3.4). 49

Annotations

1 Strachey: Time Sharing 1960, p.340. Cf. Bunz: Geschichte 2009, p.39s.; Friedewald: Computer 2009, p.128-137. back

2 An example for an early Time Sharing system: "The Sumerian Game" by BOCES and IBM, in 1965/66 tested by students (see chap. VII.1.3.2). back

3 Friedewald: Computer 2009, p.129. back

4 "Intelligence augmenting tool" ("intelligenzverstärkendes Werkzeug"): Friedewald: Computer 2009, p. 122,130s. Cf. Bardini: Bootstrapping 2000, p.1,10ss.,19ss.,23s.,28-32,36s.; Engelbart: Intellect 1962, p.72s; Licklider/Taylor: Computer 1968/1990, p.26s. back

5 Bardini: Bootstrapping 2000, p.13; Engelbart: Intellect 1962, p.22s. back

6 Engelbart/English: Research 1968; Licklider/Taylor: Computer 1968/1990; Rheingold: Community 1994, chap.3.
Licklider: Symbiosis 1960/1990, p.5: "Severe problems are posed by the fact that these operations have to be performed upon diverse variables and in unforeseen and continually changing sequences. If those problems can be solved in such a way as to create a symbiotic relation between a man and a fast information-retrieval and data-processing machine, however, it seems evident that the cooperative interaction would greatly improve the thinking process."
Engelbart: Intellect 1962, p.6: "In such a future working relationship between human problem-solver and computer 'clerk', the capability of the computer for executing mathematical processes would be used whenever it was needed. However, the computer has many other capabilities for manipulating and displaying information that can be of significant benefit to the human in nonmathematical processes of planning, organizing, studying, etc. Every person who does his thinking with symbolized concepts (whether in the form of the English language, pictographs, formal logic, or mathematics) should be able to benefit significantly."
Ebda, S. 37: "These new ways of working are basically available with today's technology--we have but to free ourselves from some of our limiting views and begin experimenting with compatible sets of structure forms and processes for human concepts, human symbols, and machine symbols." back

7 Engelbart: Intellect 1962, p.69s.; Licklider/Taylor: Computer 1968/1990, p.25,29s. Cf. Friedewald: Computer 2009, p.132 with ill.29, p.136s. back

8 Bardini: Bootstrapping 2000, p.149,153,158 (Alto Ethernet interface, end of 1973); Friedewald: Computer 2009, p.250,257,260-269,275-292,337s.; Matis: Wundermaschine 2002, p.269s.; Rheingold: Community 1993, chap.3. back

9 Engelbart: Intellect 1962, p.72. back

10 ARPANET: Bunz: Geschichte 2009, p.83-91; Roberts: ARPANET 1995; Warnke: Theorien 2011, p.29-41.
ARPANET until the end of 1972: 24 sites were connected. Among them are American universities, the Department of Defense, the National Science Foundation, NASA and the Federal Reserve Board. Until 1977 the ARPANET connected 111 mainframe computers. It was abandoned in 1990 (Stewart: ARPANET 1996-2012). back

11 Matis: Wundermaschine 2002, p.309; Rheingold: Community 1993, chap.3. back

12 Baran: Communication 1964; Baran: Communications I 1964; Bunz: Geschichte 2009, p.57-63; Rheingold: Community 1993, chap.3; Warnke: Theorien 2011, p.20-26.
In 1968 Donald Watts Davies developed a packet switching procedure at the British National Physical Laboratory independent from Baran. The developers of the ARPANET knew the proposals of Baran and Davies on packet switching (Hafner/Lyon: Wizards 1998, pdf p.41ss.; Matis: Wundermaschine 2002, p.306; Roberts: ARPANET 1995; Warnke: Theorien 2011, p.26-29). back

13 Hafner/Lyon: Wizards 1998, pdf p.64,73; Pias: Computer 2010, p.122s.
On the technical implementation of the "packet switching" in the ARPANET: Mutis: Wundermaschine 2002, p.306s.; Roberts: ARPANET 1995. back

14 Rheingold: Community 1993, chap.3; Scheller/Boden/Geenen/Kampermann: Internet 1994, p.47-70. back

15 Bunz: Geschichte 2009, p.100-108; Warnke: Theorien 2011, p.43-47,76-86. back

16 Bulletin Board Systeme, since 1978: Rheingold: Community 1993, Introduction.
Newsgroups: Usenet News, ab 1980: Arns: Netzkulturen 2002, p.17s.; Rheingold: Community 1993, chap. 4.
MUDs: Multi-User Dungeons (since 1979/80). Among others, "Adventure Games" were played in MUDs. In these games questions were presented and the players are asked for the right answers. Rheingold describes the addictive character of the MUDs´ fictional worlds (Rheingold: Community 1993, chap.5). back

17 Berners-Lee: Web 1999, p.68-71,79,99; Scheller/Boden/Geenen/Kampermann: Internet 1994, p.282-293. back

18 Rheingold: Community 1993, chap.2 and 4. back

19 Rheingold: Community 1993, chap.4. back

20 Rheingold: Community 1993, Introduction; Turner: Counterculture 2006, p.159-162. back

21 Arns: Netzkulturen 2002, p.24-29; Barbrook/Cameron: Ideology 1996; Barlow: Cyberspace 1996; Stallman: Copyright 1996; Stallman: Software 2002; Lessig: Code 1999. back

22 Rheingold: Community 1993, chap.2; Turner: Counterculture 2005, p.499; Turner: Counterculture 2006, p.3,141s.,144. back

23 Brand: Earth 1968, p.3. Vgl. Turner: Counterculture 2006, p.57. back

24 Rheingold: Community 1993, chap.2 and 4; Turner: Counterculture 2005, p.496,499; Turner: Counterculture 2006, p.7,79s.,84,86,89,142,151s. back

25 Turner: Counterculture 2005, p.487,503; Turner: Counterculture 2006, p.5s.,63s.,142,146ss.,158s.,161s. back

26 Couey: Cyber Art 1991; Couey: Art Works 1991; Loeffler: Telecomputing 1989, p.129; Rheingold: Community 1993, chap.2. back

27 Moore: History 2005.
In 1991 Robert Adrian X said about the terminal: "I had a terminal at home. I even have it at home, now it is an object for a museum collection. It looks like a big portable typewriter. It contains only a keyboard with a 300 baud acoustic coupler, and it printed everything on thermal paper. People without terminal had to visit one of I.P. Sharp´s offices. The equipment was quiet expensive at that time – circa 2000 $ for a new unit. I bought my machine second hand for circa 600 $." (Baumgärtel: Interview 1997) back

28 Interplay, 4/1/1979, from 8.00 to 10.00 p.m., organised by Bill Bartlett (Adrian X: Kunst 1995, p.10; Breitwieser: Re-Play 2000, p.300). back

29 Adrian X: Kunst 1995; Braun: Video 2000, p.4s.; Breitwieser: Re-Play 2000, p.300; Couey: Cyber Art 1991. back

30 Ascott/Loeffler: Connectivity 1991. back

31 Duration: from 9/27/1982, 12.00 a.m., to 9/28/1982, 12.00 a.m. (Linz, local time). Lit.: Adrian X: Raum 1989, p.142,145; Adrian X: Welt 1982 (quotations, p.146); Braun: Adrian X 2001, p.114-119; Arns: Interaction 2004, chap. Electronic Space as "Communications Sculpture"; Braun: Video 2000, p.421s.; Breitwieser: Re-Play 2000, p.302; Daniels: Engineering 2010, p.21; Grundmann: Art 1984, p.86-99. back

32 Berry: Thematics 2001, p.66: "The result of this collaborative endeavor...is like a very extensive `corps exquis´ (played without the element of concealment) mixing languages, role playing, and rambling narratives in such a way as to make it nearly impossible for an outsider to follow." Lit.: Adrian X: Kunst 1995, p.11; Ascott/White et al.: Plissure 1983; Braun: Video 2000, p.422s.; Breitwieser: Re-Play 2000, p.304; Daniels: Engineering 2010, p.22; Grundmann: Art 1984, p.24,35s.,59-68; Heibach: Literatur 2003, p.88s.; Popper: Art 1993, p.124,134. back

33 Baumgärtel: Immaterialien 1997, chap. Freude am (ASCII-)Text; White: Hearsay 1985. back

34 Adrian X: Interview 2001, p.63. back

35 Youngblood: Raum 1986, p.298. back

36 Software: Lee Felsenstein and his former colleagues of the Community Memory Networks, Berkeley (since 1973, Slaton: Community Memory 2001). back

37 Arns: Interaction 2004, chap. Social Networking, Participation. back

38 Youngblood: Raum 1986, p.357. back

39 Youngblood: Raum 1986, p.358.
Rheingold: Community 1993, chap.2 on the opposite practice of The WELL: "Nobody is anonymous." It was not possible to disconnect "pseudonyms" from the "real userid". back

40 Arns: Netzkulturen 2002, p.52-55; Baumgärtel: Internet 1998, chap 2.1. back

41 Stewart Brand, founder of The WELL (see chap. VI.1.1), to Howard Rheingold: "The personal computer revolutionaries *were* the counterculture." (Rheingold: Community 1993, chap.2) back

42 Couey: Art Works 1991, chap. Art Com Magazine. back

43 The "wreader" is thematised by scholars as reader eliciting relations in hyperfictions. There are transitions from an active reading of hyperfictions to the participation in collaborative writing projects (Heibach: Literatur 2003, p.50 with ann.86; Landow: Hypertext 2004, chap. Animated Text; Rau: Wreader 2001; Simanowski: Tod 2004, p.87). The reader is mentally activated by multilinear links (see chap. VI.2.2). A wreader acts in virtual fora similar to authors of public letters when he tries to provoke with his own remarks other readers to react critically to his contribution. back

44 Couey: Art Works 1991. back

45 Couey: Art Works 1991 (quotations); Couey: Cyber Art 1991; Gangadharan: Mail Art 2009, p.292ss.; Loeffler: Art Com Electronic Network 1988, p.321; Loeffler: Telecomputing 1989.
Judy Malloy´s hyperfiction "Uncle Roger" (1986-87) is featured in chap. VI.2.2. back

46 Adrian X: Kunst 1984, p.79 (ARTEX): "If artists´ telecomm is to have any reality it must seek to operate on a global basis...Artists who really want to operate in the electronic space of telecommunications...must take into account the equipment available to their partners in other parts of the world..."
Ascott: Art 1984, p.35s. (ARTEX): "...the act is indifferent to the geographical location of its contributors...There can be this sense of out-of-body experience, joining up with others in the aetheric, electronic, and totally timeless space." back

47 Rheingold: Community 1993, chap.2. back

48 Taesdale: Videofreex 1999; Dreher: Radical Software 2004, chap. video and TV. back

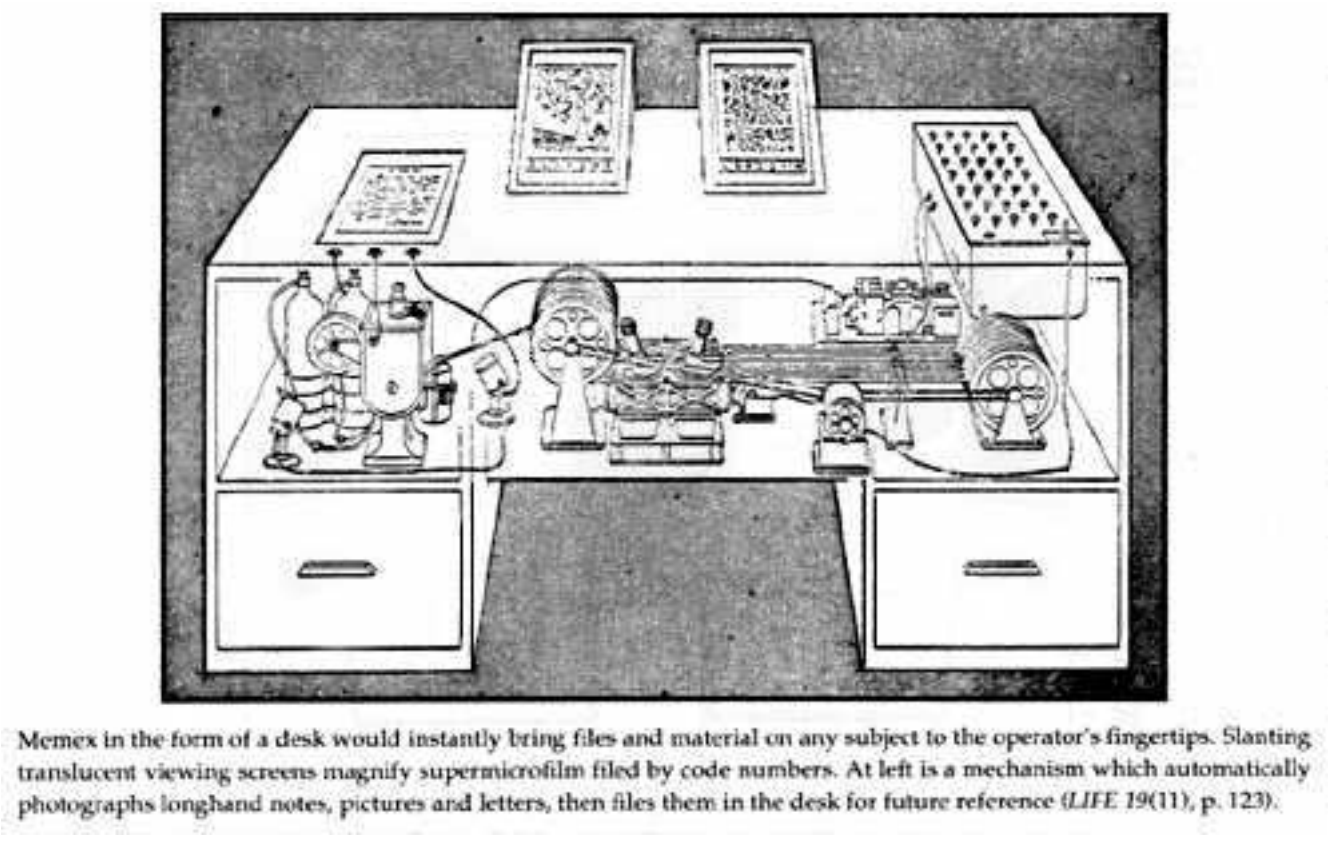
49 Dreher: Participation with Camera 2007, chap. TV-Programme and Participation, with ann.9 and 10; Dreher: Radical Software 2004, chap. Documentation and Intervention, Mapping & Acting. back

VI. Net Art: Networks, Participation, Hypertext
VI.2 Hypertext

VI.2.1 "As We May Think": From Vannevar Bush to Ted Nelson

Hypertext and networks had their own prehistories before they grew together in the web. Hypertext, especially the link as a concatenation of texts and text passages, became a central form of web presentations. The next chapters retrace the history of exploring computers connected by telecommunication and hypertexts as parts of one fabric (web). [1]

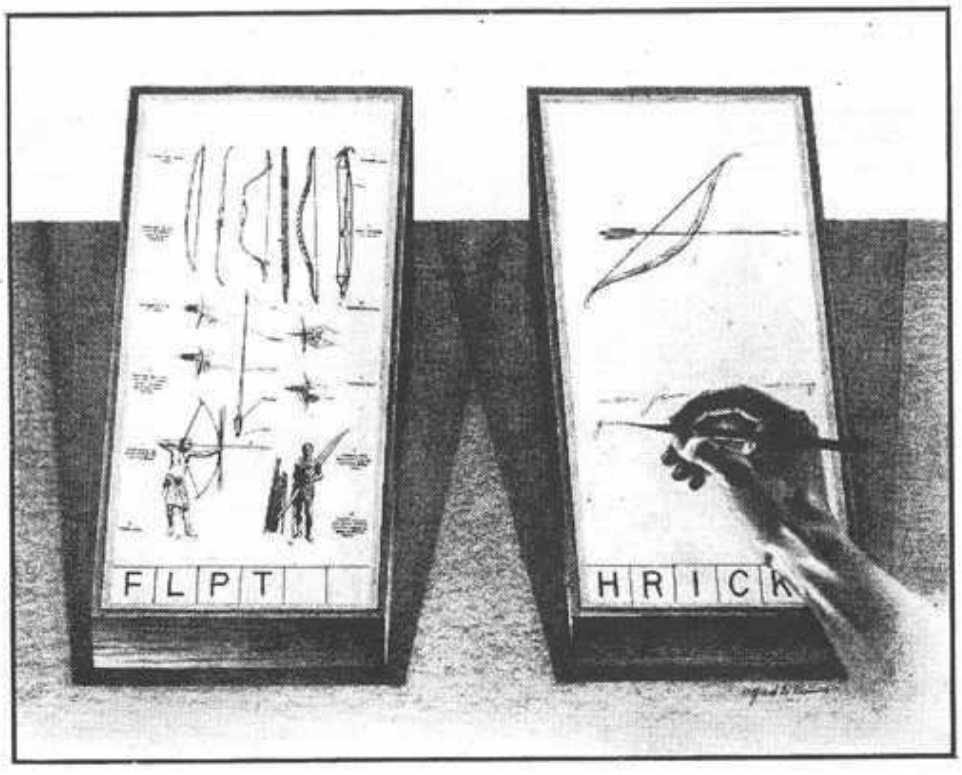
In 1945 Vannevar Bush combined in "As We May Think" [2] the technics to store bits of knowledge with possibilities to retrieve them and to work out connections between the stored data. In his concept for "Memex" – a precursor of a computer – Bush thematised the problems to store images and texts. He pointed to possibilities, how the stored data can be recalled, and developed an intelligence augmenting tool: A researcher should be enabled to use "Memex" as an "enlarged intimate supplement to his memory". [3]



Memex in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicrofilm filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference (*LIFE* 19(11), p. 123).

Bush, Vannevar: Memex, 1945, illustration (Life, 10th September 1945, p.123).

In Bush´s concept comparisons between parts of more encompassing documents are made possible by two viewing screens being mounted on a table. The screens enable the researchers to view data stored on microfilms. To store further documents on microfilms they have to be placed on a glass plate to photograph them.



Memex in use is shown here. On one transparent screen the operator of the future writes notes and commentary dealing with reference material which is projected on the screen at left. Insertion of the proper code symbols at the bottom of right-hand screen will tie the new item to the earlier one after notes are photographed on supermicrofilm (*LIFE 19*(11), p. 124).

Bush, Vannevar: Memex, 1945, illustration (Life, 10th September 1945, p.124).

"Memex" enables its users to set up and store connections between parts of different documents: The table contains a keyboard enabling researchers to control the linkage mechanics. With this equipment chains of links can be stored and recalled as "trails". Bush´s mechanical assistant for thought processes enables researchers to work out connections between different sources and to recall them as often as wanted.

In his concept for a memory machine Bush presents "associative indexing" 4 as a technically augmented cognitive procedure to work out connections. With his unrealised machine Bush anticipated concepts for human-computer interaction. Machines developed to augment human cognitive capabilities are established in contemporary research procedures as indispensable means. 5

At the Augmentation Research Center (Stanford Research Institute, Menlo Park/Kalifornien), directed by Douglas Carl Engelbart since 1959, researchers develop Bush´s concept of a memory machine since the sixties on terminals being equipped with graphical displays (on cathode ray tubes), keyboards, key set and mouse (since 1963). The terminals are connected via timesharing (see chap. VI.1.1) to the computing capacities of a mainframe computer. 6



Augmentation Research Center, Stanford Research Institute, Menlo Park: terminal with monitor, keyboard, keyset and mouse, ca. 1964.

In 1960 preliminary concepts were developed by Joseph Carl Robnett Licklider. He reflects in "Man-Computer Symbiosis" on the project-related organisation of a team with participants cooperating on terminals. 7 In 1962 Engelbart explains in "Augmenting Human Intellect" how a structure for databases and the accesses to them on terminals can be created in using the contemporary technical possibilities as adequate as possible to facilitate the working out of research subjects. Engelbart adds to Benjamin Lee Whorf´s key assumptions on the conditioning of thinking by languages 8 a further assumption on the influence of the means for data processing on cognition. 9 The interfaces and the database structures should be constructed to cause cognition-augmenting effects:

> By "augmenting human intellect" we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems. 10

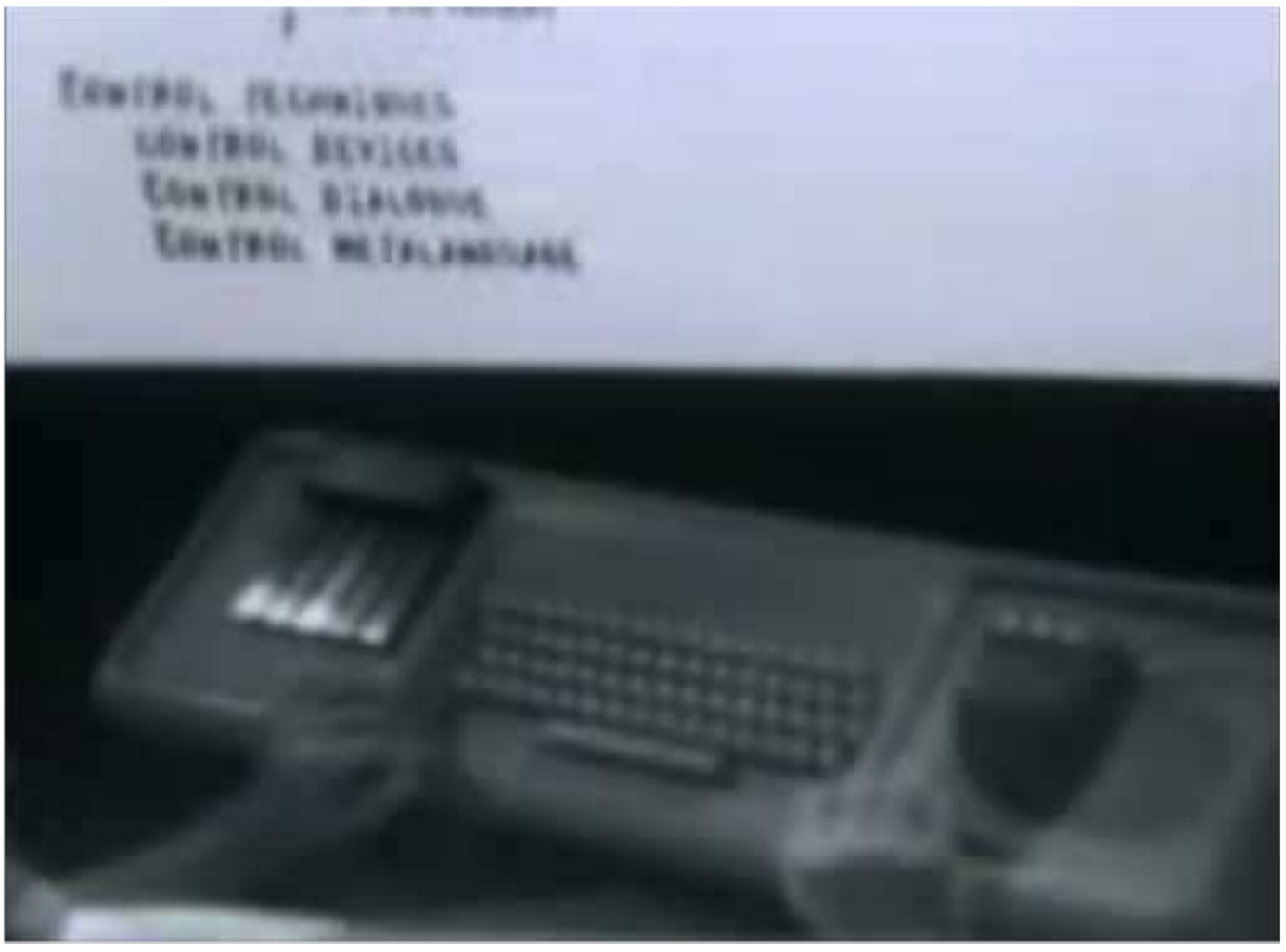
According to Engelbart the cognitive capability to manipulate symbols can be coordinated with the capabilities of computers to find ways of enabling humans to develop with computing processes more complex hierarchical structures. 11

Engelbart mentions cards with notches as a predigital ancillary system. As a further development of this mechanical thinking via "edged-notched-system" Engelbart introduces a digital "notedeck" presenting the next element of an "associative trail" automatically. 12 An "electronic computer equipment" can facilitate the administering of "thought kernels" via "linkages to other statements" for the development of "new concepts" 13 in a more helpful manner than mechanical systems with card boxes are able to do 14:

> It takes a repertoire of surprisingly few such primitive processes [which a particular machine can execute] to enable the construction of any symbol-manipulation process that can be explicitly described in any language. 15

Lists can be subdivided into "string[s] of substructures". Engelbart refers to propositions of several authors 16 to coordinate cognitive affordances being posed by the "manipulation of list structures" with the capabilities of computers to store symbols and to simulate "dynamic systems". 17 In 1962 Engelbart picks these propositions up and explains possibilities to represent links and their recalls on a monitor. 18 He conceptualises links `directional´ in levels of "substructures": "A network of lines and dots that looked something like a tree" constitutes a graphical structure for "antecedent-consequent links that have been established." 19

The scientists of the "Research Center for Human Intellect" (AHI) within the Stanford Research Institute used "bootstrapping" 20 as a method to work out the "oN-Line System" (NLS) for cooperations on several terminals. On the 9th December 1968 Engelbart presented this system being called the first hypertext system in his lecture lasting 90 minutes at the "ACM/IEEE-Computer Society Fall Joint Conference" (Brooks Hall, San Francisco). Engelbart used a keyboard to present NLS in its then comtemporary development stage. On a large projection the spectators followed Engelbart´s moves between the substructures of NLS. He demonstrated the concatenation of texts and text passages via "jump to link" command. 21 As an example Engelbart presented the "dictionary cross reference" in a "glossary of the NLS documentation." 22 Live presentations of scientists showing parts of NLS at the Augmentation Research Center in Menlo Park were inserted into Engelbart´s presentation in San Francisco via videoconferencing. In this lecture the interrelationships between the development of a database´s structure and collaboration became evident. 23



Engelbart, Douglas: Lecture, ACM/IEEE-Computer Society Fall Joint Conference, Brooks Hall, San Francisco 1968. Screenshot of Engelbart´s keyset, keyboard and mouse from YouTube.

In 1965 Theodor Holm Nelson defines the term "hypertext" 24 in "A File Structure for the Complex, the Changing, and the Indeterminate":

> Let me introduce the word "hypertext" to mean a body of written material or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper. It may contain summaries, or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it. 25

The link as a "connector, designated by the user, between two particular entries" concatenates parts of different "lists". With cross references between links Nelson loosens Engelbart´s hierarchy of "substructures". If "items" are concatenated by links then they can constitute a "trail". Comments can be added to the "trails". Via links series of list entries ("sequences") can be transferred between lists. Nelson´s "file structure" is determined by "entries", "lists", "links" and "sequences". 26

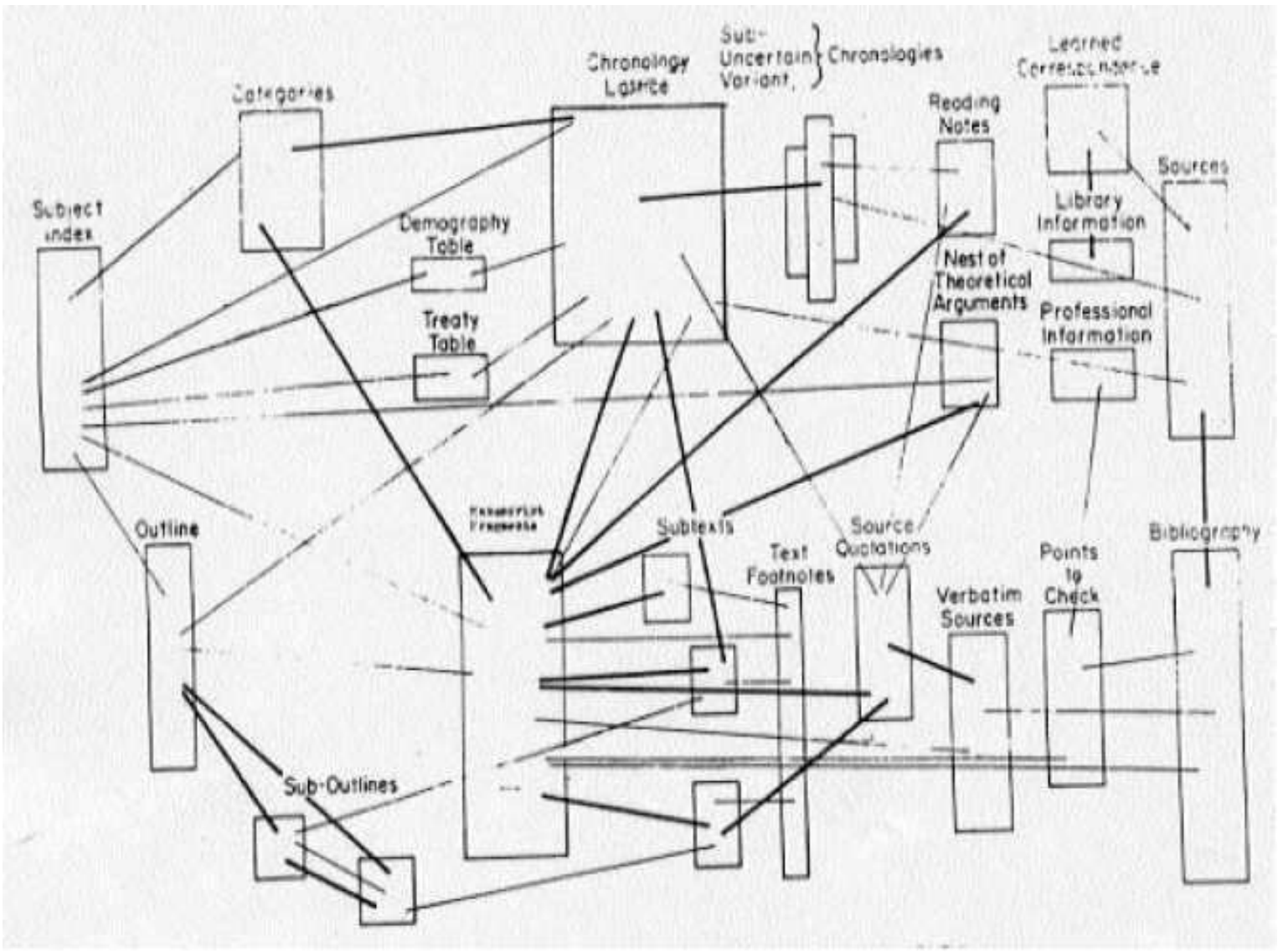


Figure 11.4. ELF's capacity for total filing: hypothetical use by historian. (A thin line indicates the presence of links; a heavy line indicates that some linked entries are identical.)

Nelson, Theodor Holm: Hypertext links in ELF ("Evolutionary List File"), diagram, 1965 (Nelson: File 1965/2003, p.142).

In 1970 Nelson and Ned Woodman installed "Labyrinth: An Interactive Catalogue" in the exhibition "Software – Information Technology: Its New Meaning for Art" curated by Jack Burnham for the Jewish Museum in New York. The "interactive catalogue" contained a restructuring of the exhibition´s catalogue. The restructuring was implemented on a DEC (Digital Equipment Corporation) PDP-8 (since 1965). Visitors of the exhibition could find out ways between the linked parts of the catalogue and received a print with a directory of their "trail" from link to link. 27

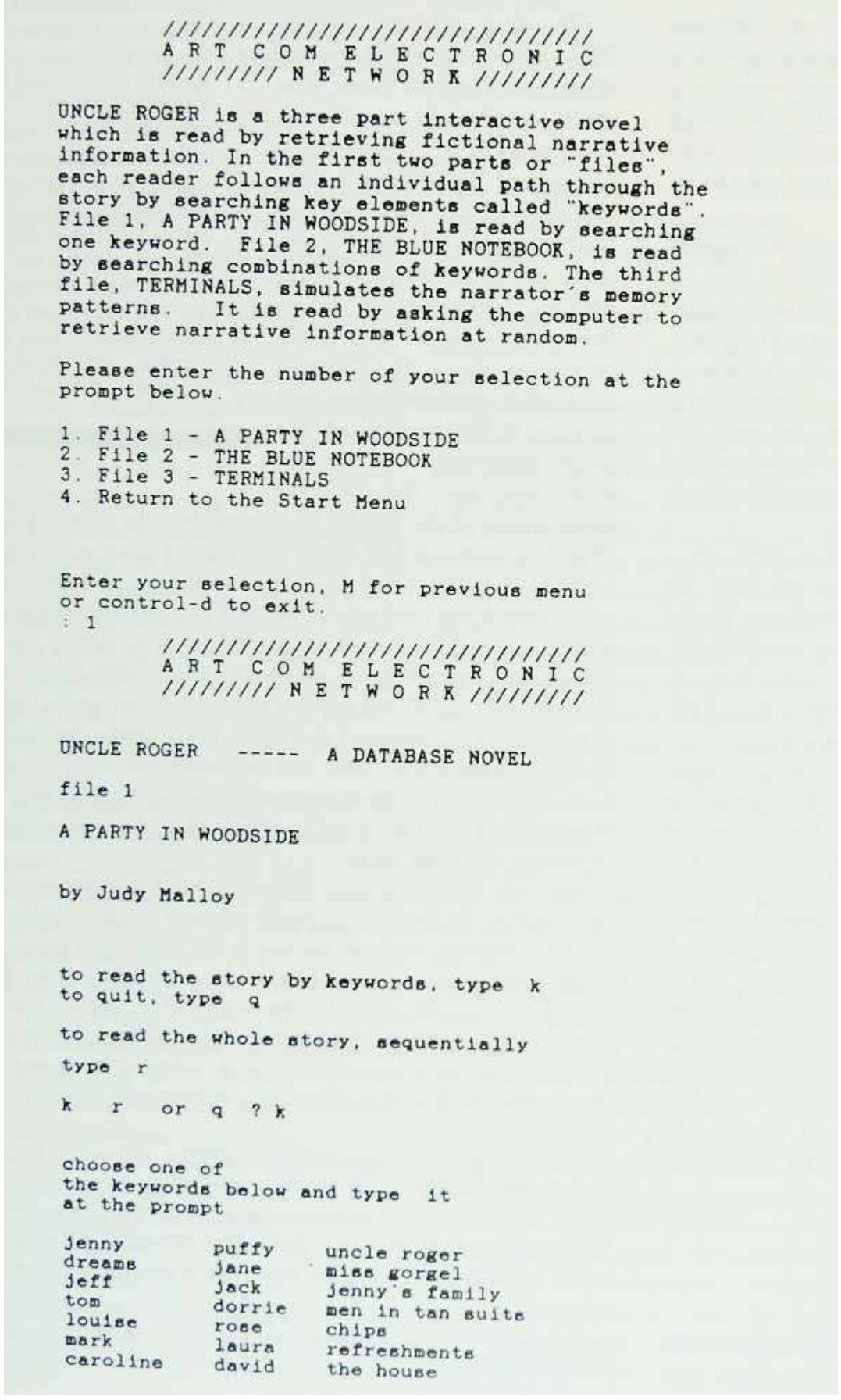
In the "non-linear systems" of hypertexts "annotations, additions and footnotes" 28 can be integrated and concatenated by "jump-links" as they were used in the "Labyrinth". 29 According to Nelson concatenations proove the connectedness of everything with everything else. In 1974 he writes in "Computer Lib/Dream Machines":

> Everything is deeply intertwingled. 30

This connectedness was for Nelson a proof of "the wholiness of the human spirit". 31 This "wholiness" was technically reconstructed by the web as hyperlinks, constructing a fabric of documents from concatenation to concatenation. Following the links from a start document principally all other files in the web can be reached. 32

VI.2.2 Hyperfiction for CD-ROM and the Web

Basic elements of hypertexts are "lexia" 33 with "labels" (or titles) and a description or explanation. Index cards can be placed one behind the other or beside each other from edge to edge meanwhile the sequences of the cards follow the semantic fields of the labels. By way of derogation from this principle of index cards it is possible to concatenate not only labels of lexia but parts of their descriptions, too. 34 This hypertext practice recured in hyperfictions of the late eighties and nineties. They were constructed with programmes like HyperCard or Storyspace and stored on disks. Also web projects of the nineties take up this hypertext structure (see chap. VI.2.3). Nevertheless several hyperfictions were realised for the internet before this kind of literature was distributed on disks (see chap. VI.1.1).



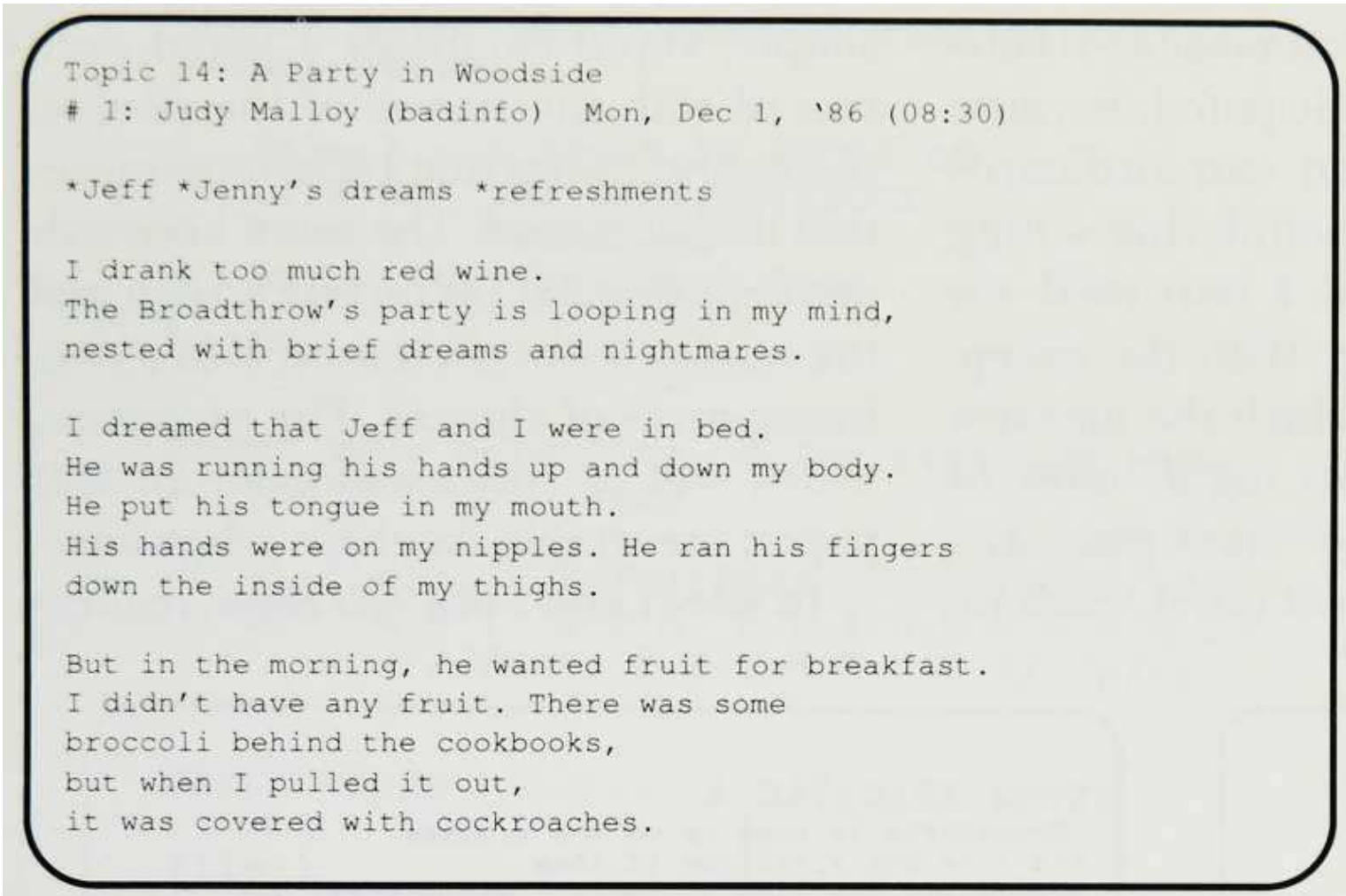
Malloy, Judy: Uncle Roger, File 1: A Party in Woodside, Art Com Electronic Network Datanet Artwork, 1987 (Malloy: Narrabase 1991, p.196, fig.1).

Under "topic 14" of ACEN´s public conference Judy Malloy uploaded her literary text "A Party in Woodside" – "a story about Silicon Valley" – between 1st December 1986 and 29th January 1987 as "records" containing from 1 to 18 text lines to be called up by participants of the Bulletin Board System The WELL (see chap. VI.1):

> Everytime I logged on to the WELL, I uploaded one record of the story. Each record was posted with a keyfield where the keywords were listed so that readers could download the story if they choose and put it into any commercial database. 35

Once the lexia were readable in the sequence of their downloads Malloy constructed "Uncle Roger" in 1987 as hyperfiction for the ACEN Datanet beginning with "Party in Woodside" as the first of three parts. Each part contained a "collection of keyword links

that produced chains of linked lexias..." 36 Either an observer read "A Party in Woodside" in the same sequence as in "topic14" or he selected a "keyword" from an index and followed the links between lexia being offered to him. If readers looked for other links then they could return to the index with "keywords". Judy Malloy characterises "Uncle Roger" as "a filmic novel written by a visual artist, a collection of memories that exist between the speech and the pre-speech level." 37



Topic 14: A Party in Woodside
1: Judy Malloy (badinfo) Mon, Dec 1, '86 (08:30)

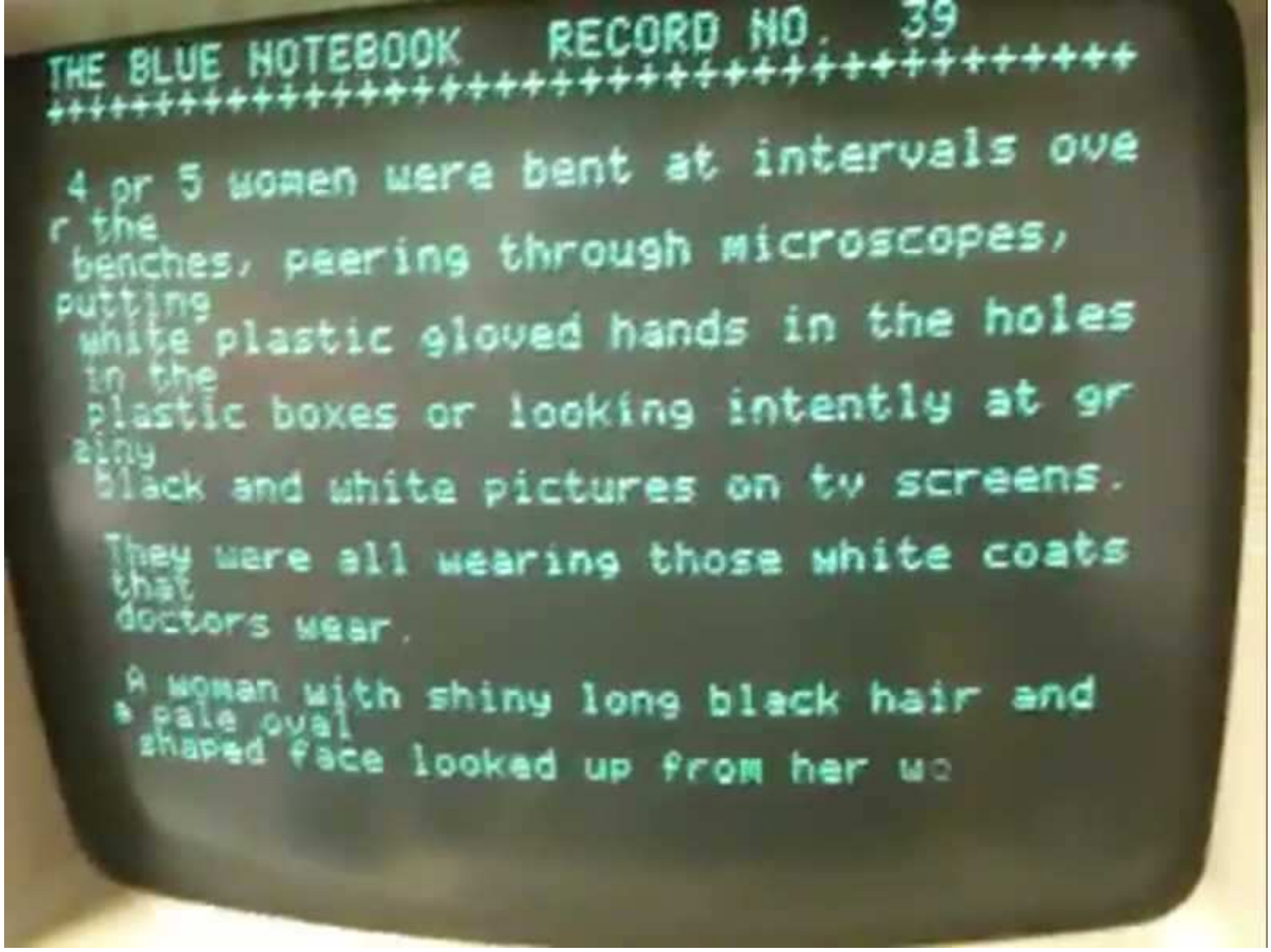
*Jeff *Jenny's dreams *refreshments

I drank too much red wine.
The Broadthrow's party is looping in my mind,
nested with brief dreams and nightmares.

I dreamed that Jeff and I were in bed.
He was running his hands up and down my body.
He put his tongue in my mouth.
His hands were on my nipples. He ran his fingers
down the inside of my thighs.

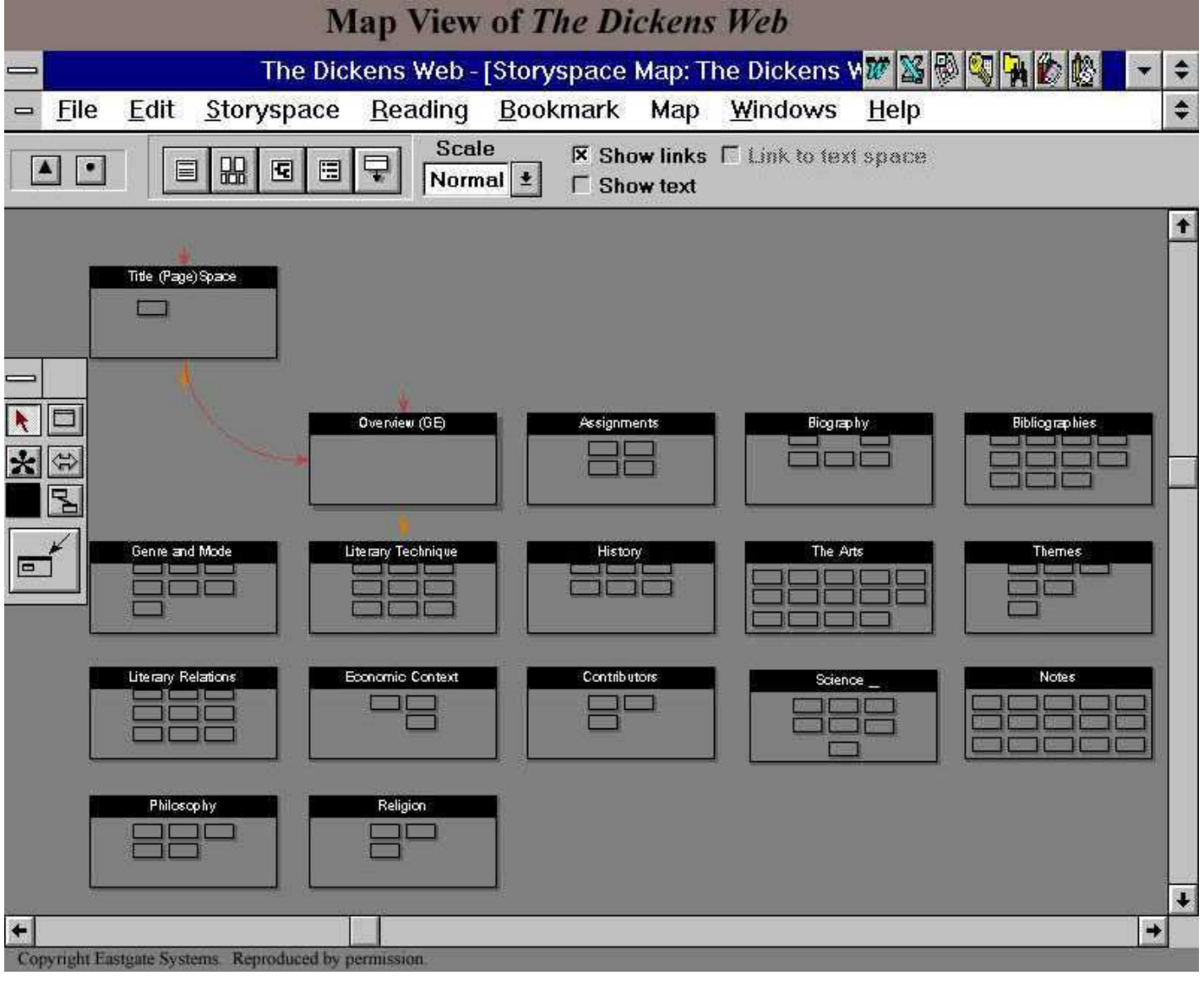
But in the morning, he wanted fruit for breakfast.
I didn't have any fruit. There was some
broccoli behind the cookbooks,
but when I pulled it out,
it was covered with cockroaches.

Malloy, Judy: Uncle Roger: A Party in Woodside, Entry 11 in Art Com Electronic Network, Topic 14, 1986 (Malloy: Narrabase 1991, S.198, Fig.4).

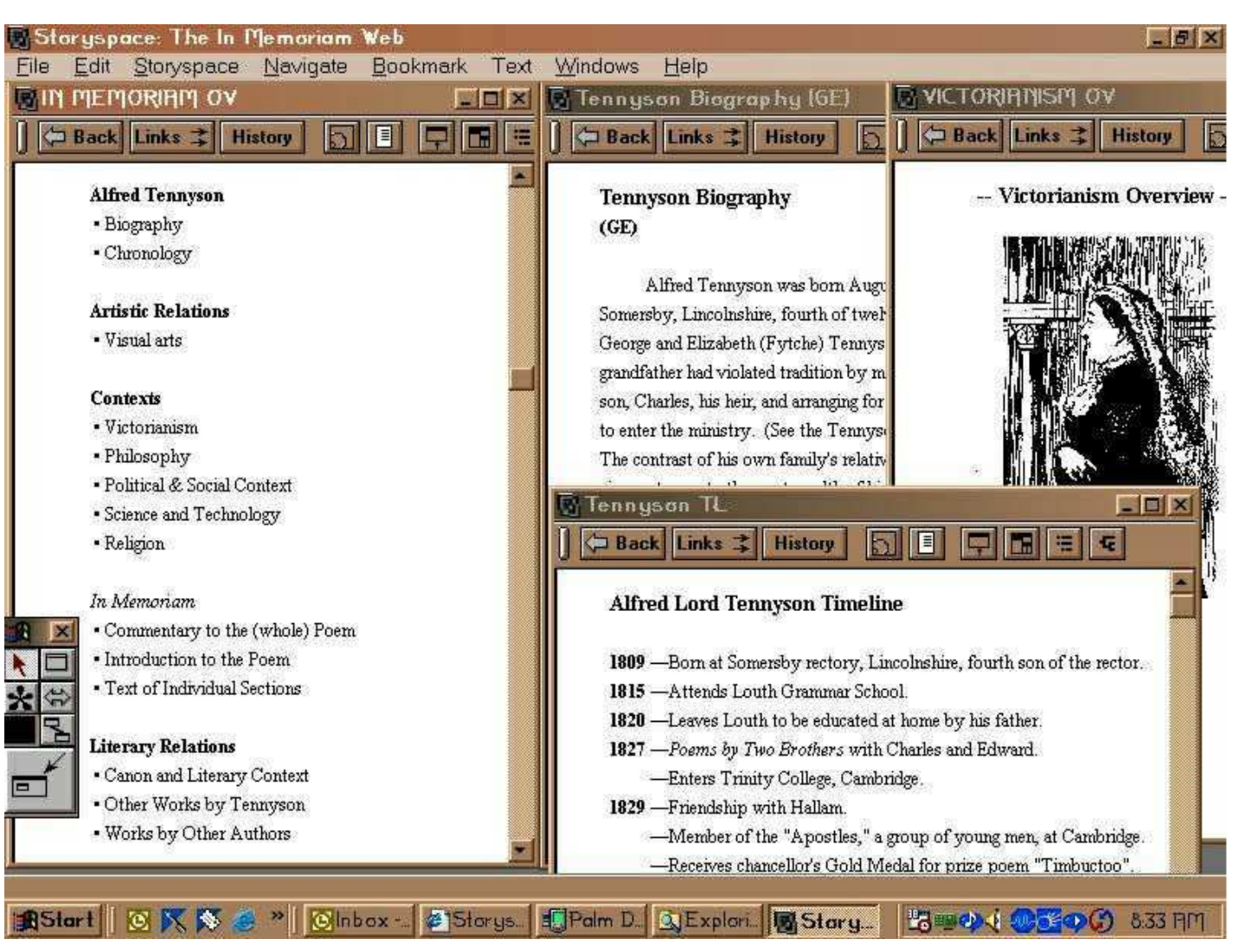


Malloy, Judy: Uncle Roger: The Blue Notebook, Record No.39, 1986, monitor presentation (screen shot of a short film by Dene Grigar).

In 1987 Jay David Bolter and Michael Joyce presented the programme "Storyspace" during the First Hypertext Conference being held at the University of North Carolina (Chapel Hill). The programme for personal computers (with the operating systems Macintosh or Windows) is a tool to create "interactive fiction[s]". 38 Three manners to navigate between connected lexia can be selected: "tree map, chart view, or Storyspace map." 39 The "storyspace map" visualises the concatenations as arrows and the concatenated lexia as writable cards ("writing spaces") spread loosely within a window. Links from and to parts of lexia are represented as fold-up cards containing only the relevant text part. The "Storyspace Roadmap Feature" indicates the links of a lexia and the reader´s link trail. 40 Furthermore "Storyspace" can be used as an editor to integrate several lexia as windows with their own menus on one monitor presentation: This structure was mostly used in didactic hypertext projects. 41

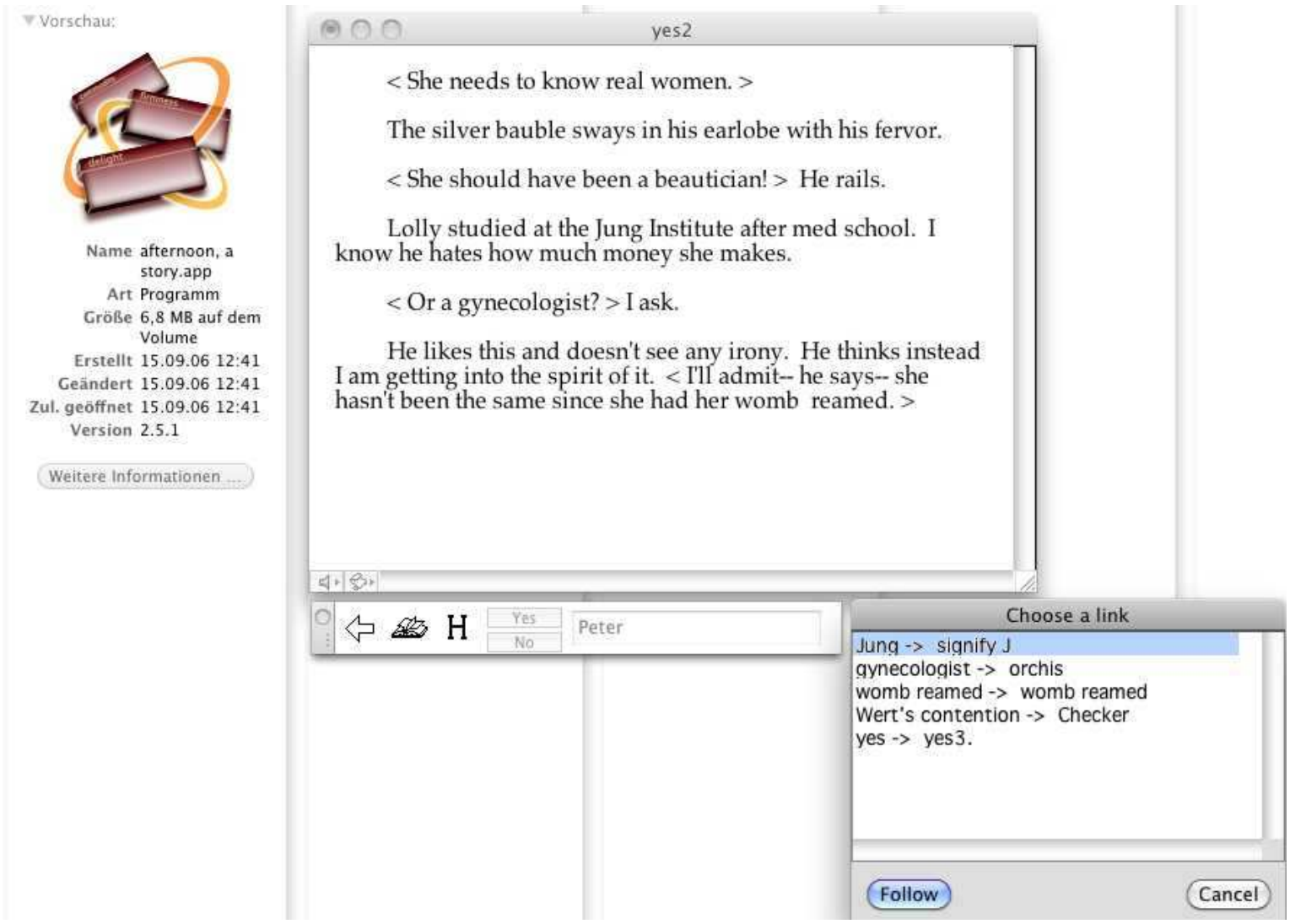


Kahn, Paul/Landow, George Paul/Launhardt, Julie/Peter, Ronnie: The Dickens Web, Storyspace Map, 1992, disk, Eastgate Systems, Inc.



Landow, George Paul/Lanested, Jon: In Memoriam Web, 1992, disk, Eastgate Systems, Inc.: lexia as windows with their own menus.

In 1987 Michael Joyce created "afternoon: a story" with "Storyspace" for a disk (today available on CD-ROM) edition of Eastgate Systems. The text divided in 539 lexia with 905 links provokes readers to explore the relations between the parts as well as to guess which person of the text is identical with the person guiding the readers (the narrator). 42 Readers can find their paths through the story with search entries in Storyspace´s navigation bar. Lexia with irritating labels (the key words in the light gray bar) can be `flipped through´ in a predetermined sequence via enter/return key.



Joyce, Michael: afternoon: a story, 1987, disk, Eastgate Systems, Inc. (illustration: CD-ROM version for Intel Mac, 2011).

Up to the 36th lexia a story is unfolded that seems to be told mostly by the poet Peter, as the connections between the lexia suggest. 43 Peter meets his employer Werther. During the dinner Peter reflects his relation to Werther´s firm and to his wife Lolly.

Peter is confused: He believes to have seen an accident involving his former wife Lisa and his son Andy. Peter´s efforts are not successfull to find Lisa and Andy via phone calls. By the end of the linear sequence determined up to the 36th lexia readers are forced to explore the links between lexia in using other functions than the return key. A window containing a selection of further leading links can be opened with a click on the icon for browsing designed as an opened book. Readers can use this function as well as click on words with (non marked) links in the lexia to find passages through the story. Readers can choose different paths to search out the course of the story: "Afternoon" "is not nonlinear, but multilinear." 44

A reader choosing links can not avoid to cross the same lexia at different paths. 45 Nevertheless the connections between lexia point to a final solution of the conflicts. The concatenations provoke the readers to search investigatively the relations between persons, especially what happened to Lisa and Andy. However readers don´t receive an answer to this question 46 – despite Lolly´s guess that Peter was the driver who caused his son´s death after an irritiation by seeing Lisa in "Werth´s truck". 47

Espen J. Aarseth argues against an understanding of "Afternoon" as a "a reconfiguration of narrative". He pleas for hyperfictions becoming "ergodic" by the reader´s efforts to explore the story in selecting paths between the heterarchical structured links 48:

> A hypertext such as Afternoon has all three: description ("Her face was a mirror"), narration ("I call Lolly") and ergodics (the reader´s choices). Unresolved here...is the conflict between narration and ergodics, between narrative and game. 49

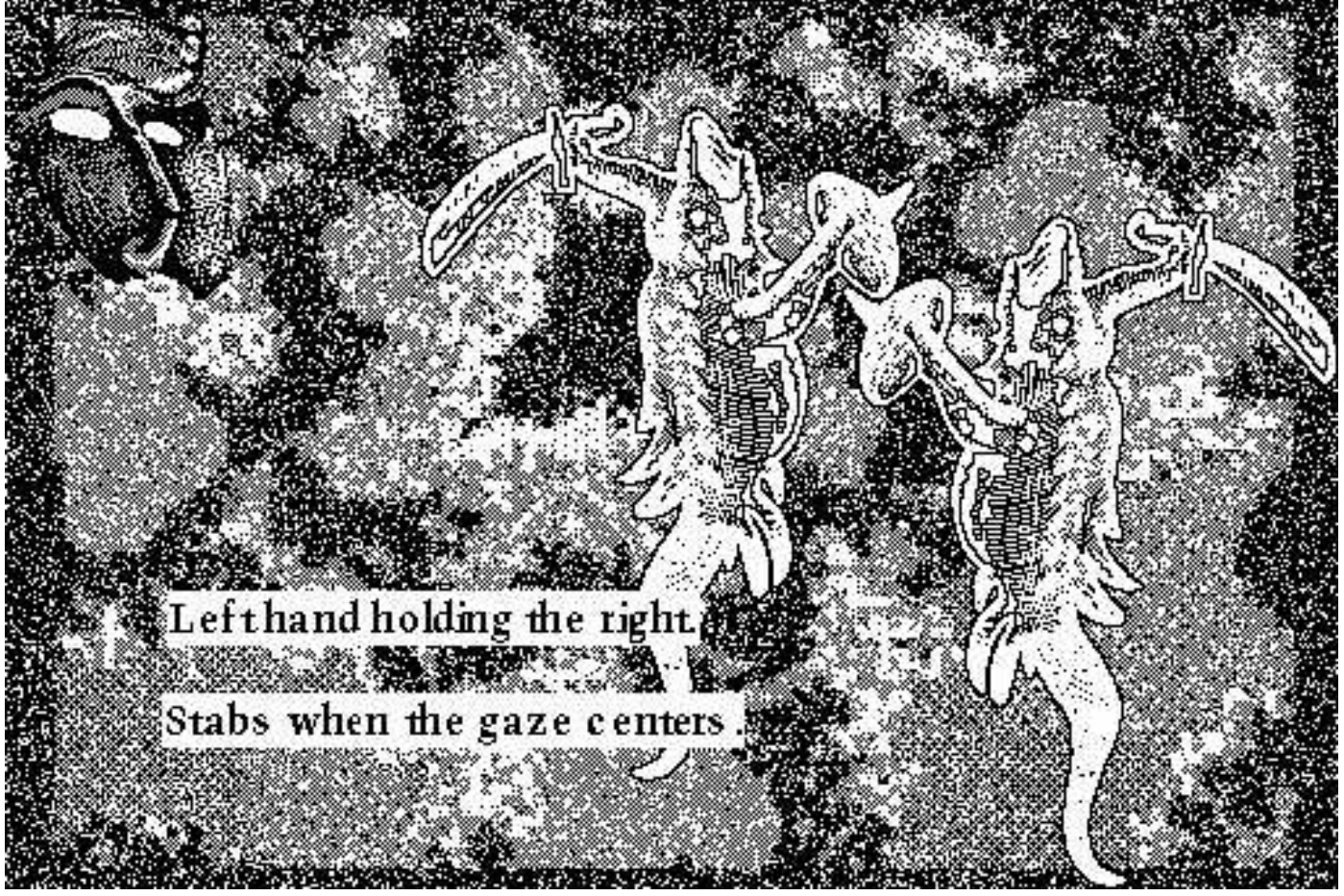
"Ergodic" are the functional elements – in "Afternoon" the links being selectable and activatable by the reader. According to Aarseth the "ergodic" and narrative aspects of "Afternoon" should not be played off against each other: He characterises Joyce´s hyperfiction as "an important limit text, on the border between narrative and ergodics". 50 Deviating from Aarseth "Afternoon" can be characterised as containing mutually supportive ergodic and narrative elements: a complementary relation versus the assumption of a "border".

From 1987 to 1992 each Macintosh computer was delivered together with the programme HyperCard. The basic elements were "stacks" with virtual cards. The caracteristics of all cards could be defined on a background layer. The content of the cards could be created with the object-oriented, easy applicable programming language HyperTalk. An editor made it possible to add texts and simple graphical elements to each card. Also, the creation of larger databases was made possible by HyperCard. 51

Examples for Hypermedia with HyperCard are Amendent Hardiker´s "Zaum Gadget" from 1987 and William Dickey´s "Zenobia, Queen of Palmyra" from 1988. Hypermedia are hypertexts augmented by graphical and audible media. 52

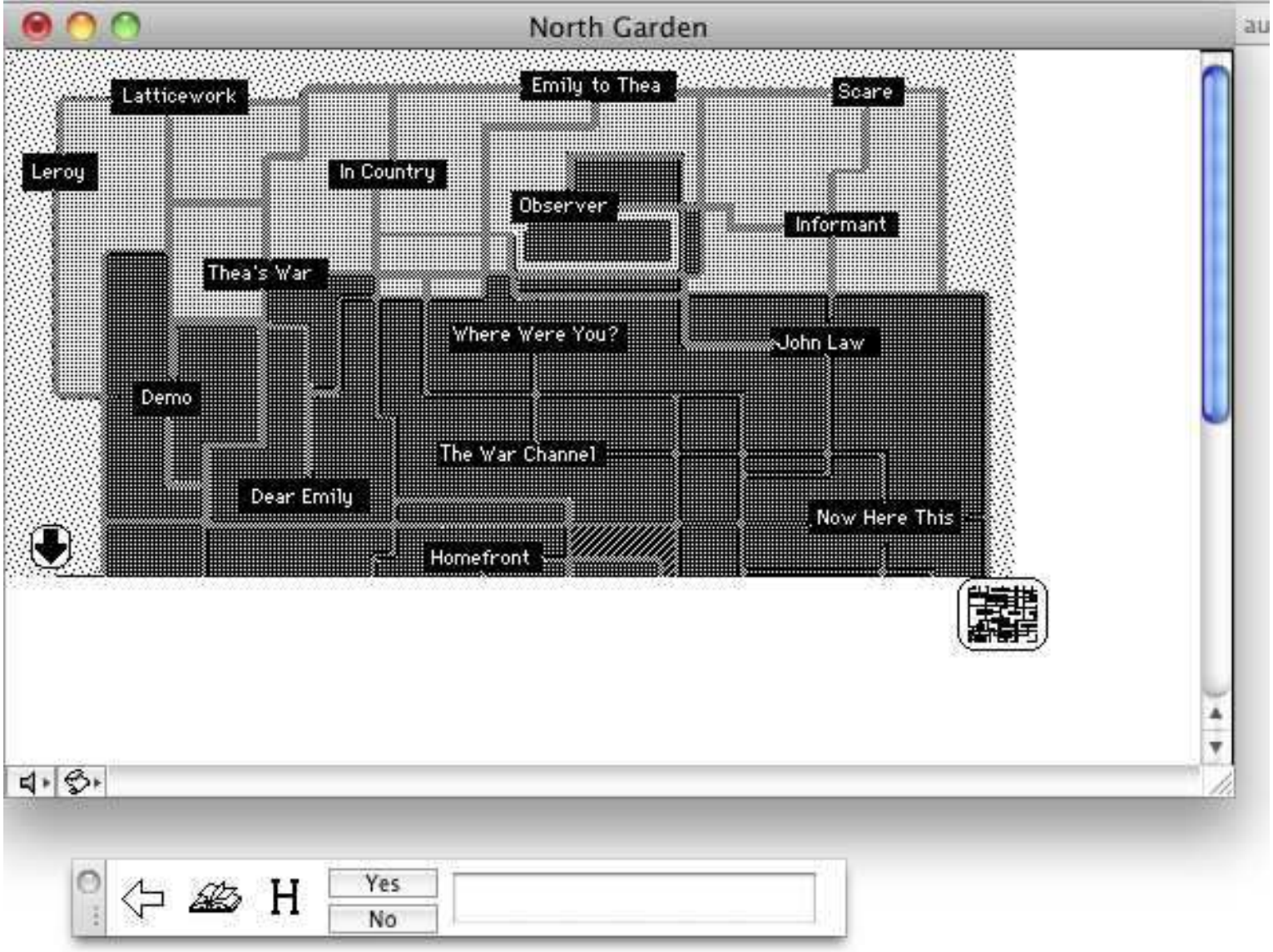
In "Zaum Gadget" the text material for the lexia stems from an English translation of the manifest "The Letter as Such" (1913) by Viktor Vladimirovich Khlebnikov and Alexei Kruchonych. Links to other lexia are marked graphically.

Into the lexia Hardiker integrates images and sounds. The sounds start automatically or they are activated by mouseover. Between the text parts of a lexia appear static or moving images. Furhtermore in some lexia pop-ups and dialog boxes are prompted to setup. 53



Dickey, William: Zenobia, Queen of Palmyra, 1988, disk.

Dickey combines in his hypermedia works text, images and audio files with navigation functions. "Zenobia" 54 contains not only unmarked and difficult to find click fields with links connecting to further cards. Links can be located in a part of a card as indications to relations between concatenation cards. In their efforts to find the links readers should expore "Zenobia´s" textual and graphical elements. Links can be located in parts of cards in ways that can indicate relations between concatenated cards. "Card 3" presents two graphics: a mirror-inverted repeated swordsman and the head of a bull. This head on the upper left corner contains a link meanwhile the lower left part shows the following text: "Left hand holding the right/Stabs where the gaze centers." According to Deena Larsen the "button...on the bull´s head emphas[es] the importance of Dickey´s use of the word "gaze" in the text. 55

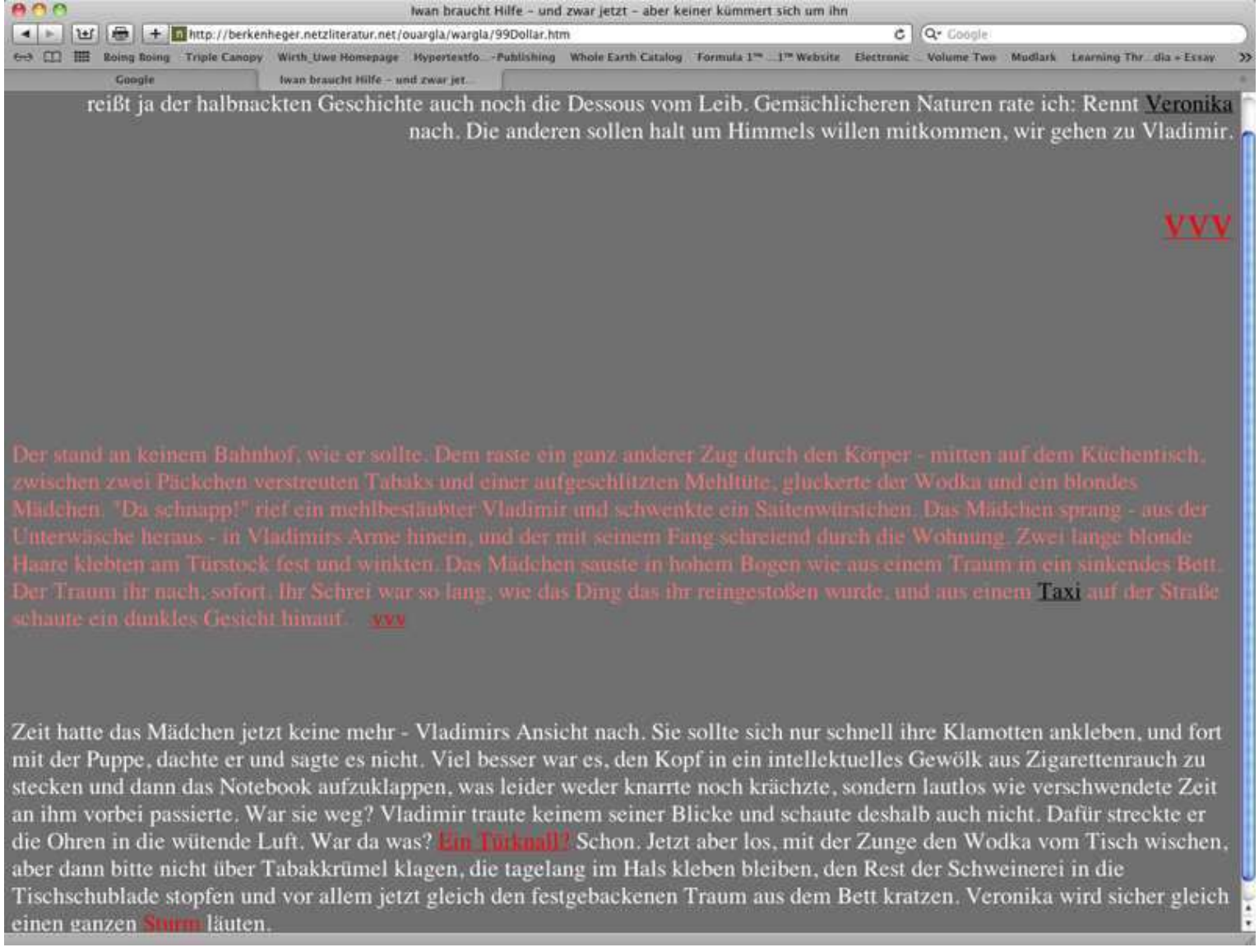


Moulthrop, Stuart: Victory Garden, 1991, North Garden, disk, Eastgate Systems, Inc. (illustration: CD-ROM version for Intel Mac).

In 1991 Stuart Moulthrop created "Victory Garden" with Storyspace. Since 1992 it was distributed on disks (now available on CD-ROM) by Eastgate Systems (1992). 993 lexia can be either called up in a predetermined sequence or the navigation between the links is possible in the same manners as in Joyce´s "Afternoon" with its 2804 links. In "Victory Garden" most of the lexia contain dialogues. The network of relationships being unfoldable across the links narrates the relations between American individuals of two generations in 1991, during the first golf war. The navigation page offers accesses to this network of individuals. It consists of a survey map divided in three further maps for the north, the centre and the south. These maps of a garden provide access to 39 paths between the lexia. 56 According to Beat Suter the maps offer a "certain kind of a labyrinthian garden with crossing ways" and demonstrate "the spatial text structure in a persuading manner." Contrary to Joyce´ s "Afternoon" a reader of "Victory Garden" finds many accesses and a limited amount (six) of alternative ends of the story. 57

Internet hyperfictions with a source code following the HTML standards defined by the World Wide Web consortium (W3C) contain much less links than Joyce´s "Afternoon" and Moulthrop´s "Victory Garden". 58

In "Zeit für die Bombe"/"Time for a Bomb" (1997) Susanne Berkenhager is content with 102 lexia and not more than four links on each webpage (plus anchors). On webpages with several links the text is divided in various blocks with letters in different colours. Between the blocks the perspectives of the actors change – mostly Veronika, Vladimir or Iwan – and in the blocks the links lead to text parts continuing the story from the same perspective. Between jumps and arrivals of links appear automatically and for a short time sentences with no other characteristics than to transport: They enforce the reader´s impression of a story moving forward rapidly in whatever perspective he may choose.



Berkenheger, Susanne: Zeit für die Bombe/Time for a Bomb, 1997, hyperfiction on the web.

Berkenheger offers a love story `with bomb´: To meet Vladimir Veronika travels to Moscow. At the station Veronika encounters Iwan instead of Vladimir who has fun with Blondie in the meantime. When Veronika finally meets Vladimir then she notices the absence of the bag with the bomb that she has brought with her for him. Iwan, abondoned by Veronika, sits before this bag and reflects what he can do with the bomb. After the readers were called by Iwan to follow him they get the chance to fire by clicks the bomb from afar. The readers get the chance to do the same a little bit later with the hand grenade. The author does not represent these detonations as explosions appearing on monitors but as a change in the tale´s progression. The paths of some links lead to Iwan´s death at the end of the story – and the next link brings the reader back to the start.

Common to Berkenheger´s "Zeit für die Bombe" and Joyce´s "Afternoon" is the multilinearity as a constituting part of the dynamics of the story´s progress. 59 In Berkenheger´s work nothing else than the links underlining some words and letters lead to further webpages meanwhile in the hyperfictions by Joyce and Moulthrop mentioned above the reader not only clicks on parts of the lexia leading further but on pathways, too. These pathways appear in a specific window denoting alternatives to other lexia.

The hypertextual procedures of net literature and the permutational procedures of computer literature with its further developments in the web can be distinguished. Permutational uses of texts presented Christopher Strachey´s "Love Letters" (1952, see chap. III.1.2) and the stochastic texts of Theo Lutz (1959, see chap. III.1.3) or Gerhard Stickel (1965, see chap. III.1.3). They demonstrated the results of algorithmic syntax reductions and the fillings of variable syntax positions with stored textual elements. These databases contain words being selected to be used as material for the programmed accesses.

This separation of programmed functions and databases with (parts of) texts is recurring in newer works like, for example, Simon Bigg´s "The Great Wall of China" (1996). Biggs selects Franz Kafka´s story "The Great Wall of China" ("Beim Bau der Chinesischen Mauer", 1917) as the word material for a syntactical oriented generation of sentences. The web project shows to observers fragments of Kafka´s text – four lines with four words each – in the left column. Biggs divided Kafka´s story in ten chapters. The small central column includes Chinese characters as icons of bottoms being usable to switch between the chapters. The right column presents the generated sentences: with an adequate syntax but provoking question marks concerning its semantic conclusiveness.

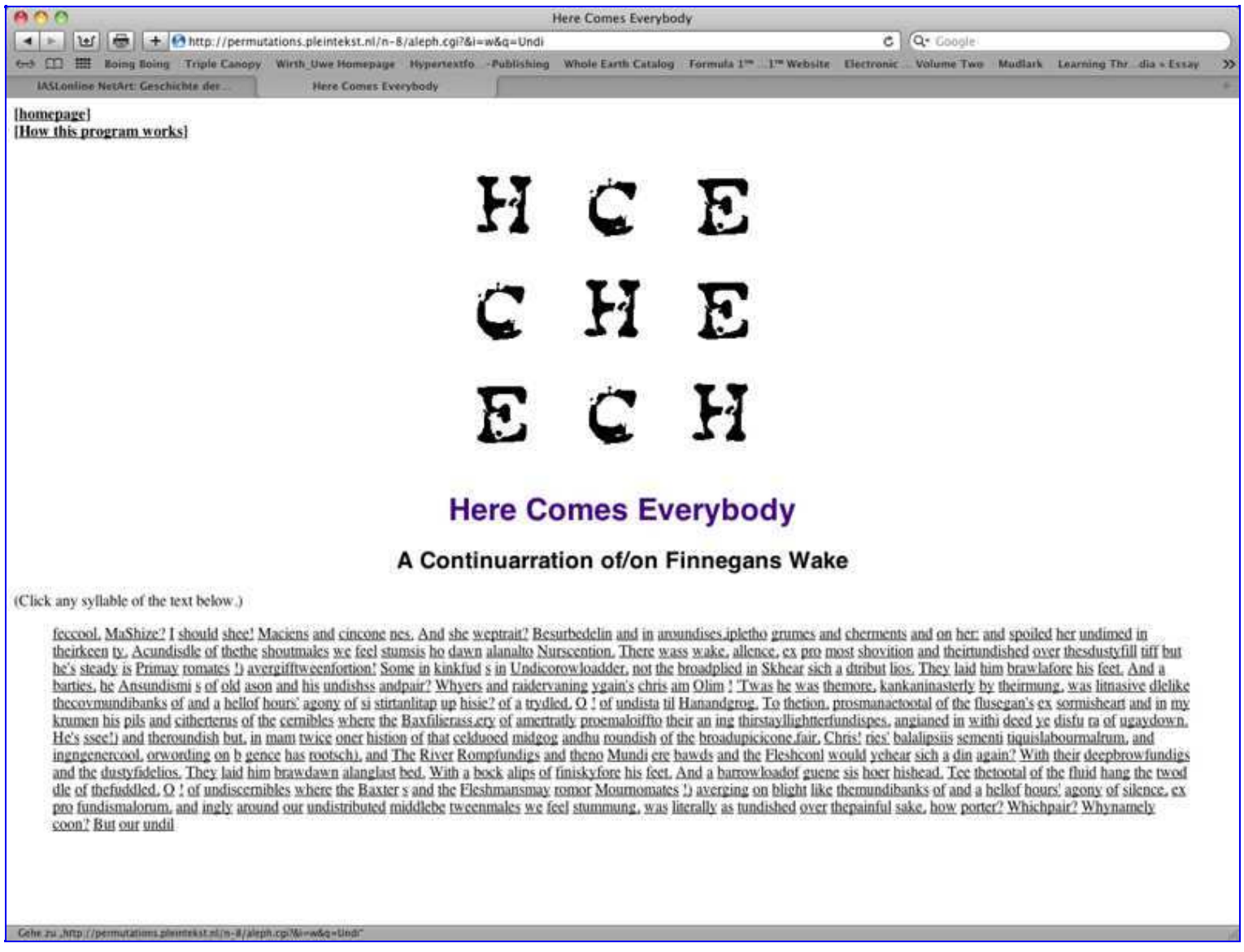


Biggs, Simon: The Great Wall of China, 1997, web project.

Mouse movements across the three columns provoke new generations. The generating processes are executed fast – too fast for observers to be able to read them. A static positioned cursor effects only a localisation of the text motion but doesn´t stop it. The generating process can be stopped by positioning the cursor on the central column or on the image: Only in this way the generated text is legible. According to Anna Munster "everything becomes pure movement, pure transmission". For Christiane Heibach the text motion creates a "text wall" ("Textmauer") being interpretable as a comment on Kafkas story. But Biggs´ far-reaching efforts to program the generation of texts are only justifiable if readers undermine the "text wall" effect and stop the text motion (see above): Often the generated texts repeat words within one sentence. The relations between syntax and semantics appear mostly absurd as if the elements need to be brought into a new sequence. The generating process evolves presentations provoking the readers ´ selecting cognition: The generating process does not substitute the reader´s cognition. 60

Florian Cramer offers on his web site "Permutations" (1996-98) web reconstructions via Perl scripts containing instructions for data processings to be executed on servers. The project permits to elicit digital reconstructions of works like "Systema infinitum" (Anonymous, 1717) and Raymond Queneau´s «Cent mille milliards de poèmes» (Paris 1961) in a game-like manner. In "Here comes everybody" a text automat generates combinations of syllables as an inventor of words. An initial text includes syllables, combinations of syllables, words and word combinations. The syllabels of these text parts contain links. A click on a syllable starts a process of selecting sentences with words containing the clicked syllable out of a digitised "Finnegans Wake" by James Joyce (London 1939). The words of the selected sentences are disassembled in syllables. The syllables for combinations are chosen by stochastic criteria how often certain

syllables follow one after another (see chap. II.1.2). To the resulting text the programme adds the links being relevant for repetitions of this sentence generation. [61]



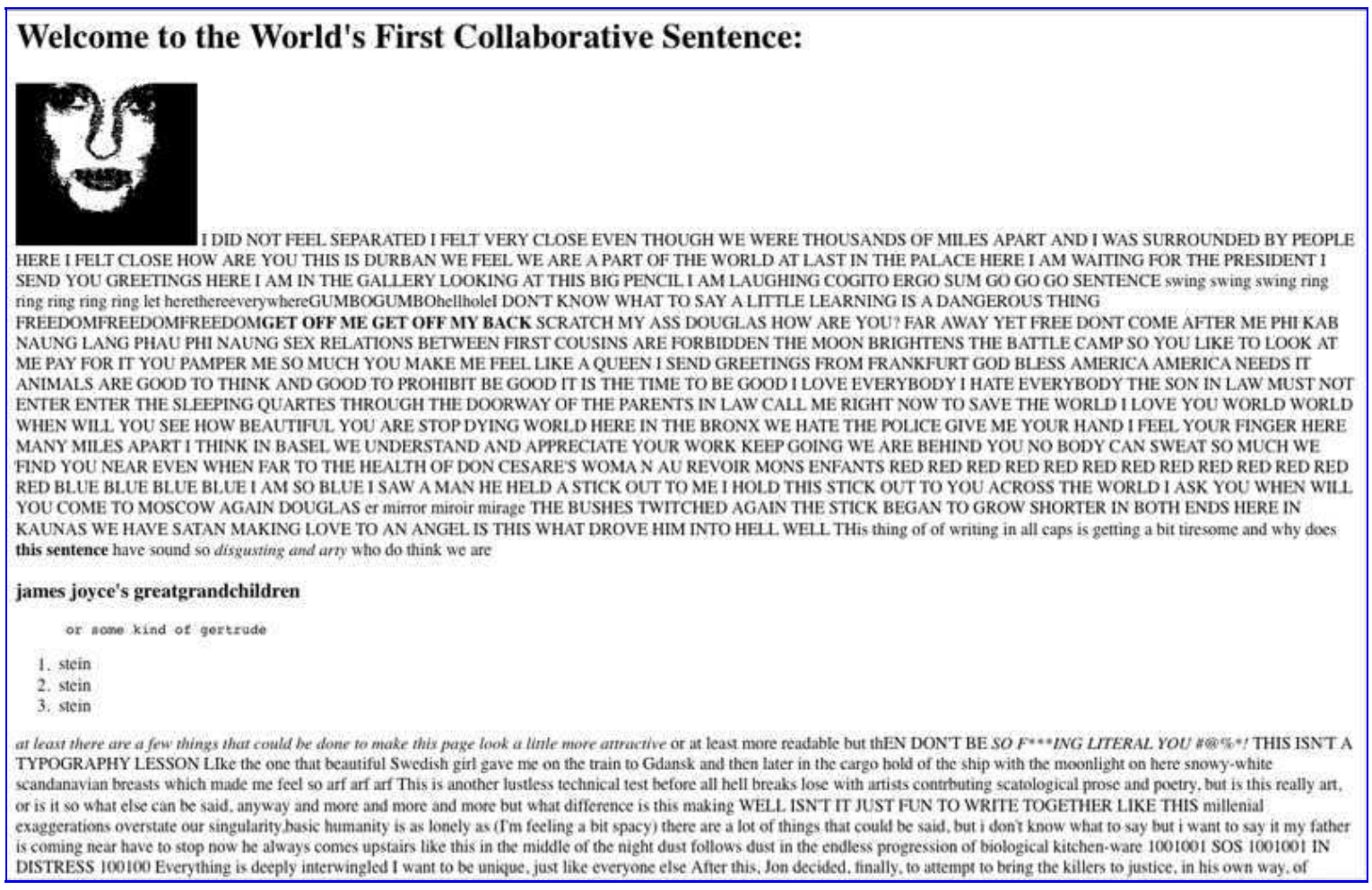
Cramer, Florian: Here Comes Everybody, permutations, 1996-98, web project.

Without activations by observers the system of "Here comes everybody" does not start computing processes using the results of elder processes as initial points, meanwhile in Generative Art computing processes usually unfold algorithms autonomously and sometimes observers can use their selections for interventions in not more than subordinated computing processes (see chap. IV.3.2-IV.3.3). The autonomous life of a continuously running or a stepwise activable system offers changing presentations as output to surprised observers or provokes reactions of indifference or helplessness. However hypertextual organised net literature does not decompose narrative elements but splits them multilinear, and – compared to printed books – it modificates the possibilities to (re)construct semantic relations in using media technologies. A search for layers of meaning is in generative literature only accidentally successful, meanwhile hypertexts are determined by the human control of semantics.

In hypertexts each of the links between texts and their parts is chosen by humans and stored digitally. These links can be inserted into the functions programmed for databases and their organisations of lexia. Several authors can contribute to the development of text archives based on such databases. The text archives can be kept open for actualisations and expansions. So the archives of such collaborativre writing projects remain works-in-progress. Participants of scientific research projects can use an "abductive" digressing reading [62] supported by "associative indexing" (see chap. VI.2.1) in their common search for new approaches (see "nic-las", chap. VI.2.3).

VI.2.3 Collaborative Writing Projects in the Web

In December 1994 Douglas Davis installed "The World´s First Collaborative Sentence" in the web, technically assisted by Robert Schneider and Gary Welz. This early web project of an artist presented a writable field and asked for contributions.The text contributions of participants were published one after another on a webpage. After a growing number of contributions they were partitioned and published on several web pages. In 2003 the amount of pages grew up to 23. 63 A program was installed to prevent the use of full stops in contributions. But already the punctuation marks on the first web page prove the circumvention of the programmed full stop prohibition by contributors.



Welcome to the World's First Collaborative Sentence:

I DID NOT FEEL SEPARATED I FELT VERY CLOSE EVEN THOUGH WE WERE THOUSANDS OF MILES APART AND I WAS SURROUNDED BY PEOPLE HERE I FELT CLOSE HOW ARE YOU THIS IS DURBAN WE FEEL WE ARE A PART OF THE WORLD AT LAST IN THE PALACE HERE I AM WAITING FOR THE PRESIDENT I SEND YOU GREETINGS HERE I AM IN THE GALLERY LOOKING AT THIS BIG PENCIL I AM LAUGHING COGITO ERGO SUM GO GO GO SENTENCE swing swing swing ring ring ring ring ring let herethereeverywhereGUMBOGUMBOhellholeI DON'T KNOW WHAT TO SAY A LITTLE LEARNING IS A DANGEROUS THING FREEDOMFREEDOMFREEDOM**GET OFF ME GET OFF MY BACK** SCRATCH MY ASS DOUGLAS HOW ARE YOU? FAR AWAY YET FREE DONT COME AFTER ME PHI KAB NAUNG LANG PHAU PHI NAUNG SEX RELATIONS BETWEEN FIRST COUSINS ARE FORBIDDEN THE MOON BRIGHTENS THE BATTLE CAMP SO YOU LIKE TO LOOK AT ME PAY FOR IT YOU PAMPER ME SO MUCH YOU MAKE ME FEEL LIKE A QUEEN I SEND GREETINGS FROM FRANKFURT GOD BLESS AMERICA AMERICA NEEDS IT ANIMALS ARE GOOD TO THINK AND GOOD TO PROHIBIT BE GOOD IT IS THE TIME TO BE GOOD I LOVE EVERYBODY I HATE EVERYBODY THE SON IN LAW MUST NOT ENTER ENTER THE SLEEPING QUARTES THROUGH THE DOORWAY OF THE PARENTS IN LAW CALL ME RIGHT NOW TO SAVE THE WORLD I LOVE YOU WORLD WORLD WHEN WILL YOU SEE HOW BEAUTIFUL YOU ARE STOP DYING WORLD HERE IN THE BRONX WE HATE THE POLICE GIVE ME YOUR HAND I FEEL YOUR FINGER HERE MANY MILES APART I THINK IN BASEL WE UNDERSTAND AND APPRECIATE YOUR WORK KEEP GOING WE ARE BEHIND YOU NO BODY CAN SWEAT SO MUCH WE FIND YOU NEAR EVEN WHEN FAR TO THE HEALTH OF DON CESARE'S WOMA N AU REVOIR MONS ENFANTS RED RED RED RED RED RED RED RED RED RED RED RED RED RED BLUE BLUE BLUE BLUE I AM SO BLUE I SAW A MAN HE HELD A STICK OUT TO ME I HOLD THIS STICK OUT TO YOU ACROSS THE WORLD I ASK YOU WHEN WILL YOU COME TO MOSCOW AGAIN DOUGLAS er mirror miroir mirage THE BUSHES TWITCHED AGAIN THE STICK BEGAN TO GROW SHORTER IN BOTH ENDS HERE IN KAUNAS WE HAVE SATAN MAKING LOVE TO AN ANGEL IS THIS WHAT DROVE HIM INTO HELL WELL THis thing of of writing in all caps is getting a bit tiresome and why does **this sentence** have sound so *disgusting and arty* who do think we are

james joyce's greatgrandchildren

```
or some kind of gertrude
```

1. stein
2. stein
3. stein

at least there are a few things that could be done to make this page look a little more attractive or at least more readable but thEN DON'T BE *SO F***ING LITERAL YOU #@%*!* THIS ISN'T A TYPOGRAPHY LESSON LIke the one that beautiful Swedish girl gave me on the train to Gdansk and then later in the cargo hold of the ship with the moonlight on here snowy-white scandanavian breasts which made me feel so arf arf arf This is another lustless technical test before all hell breaks lose with artists contrbuting scatological prose and poetry, but is this really art, or is it so what else can be said, anyway and more and more and more but what difference is this making WELL ISN'T IT JUST FUN TO WRITE TOGETHER LIKE THIS millenial exaggerations overstate our singularity.basic humanity is as lonely as (I'm feeling a bit spacy) there are a lot of things that could be said, but i don't know what to say but i want to say it my father is coming near have to stop now he always comes upstairs like this in the middle of the night dust follows dust in the endless progression of biological kitchen-ware 1001001 SOS 1001001 IN DISTRESS 100100 Everything is deeply interwingled I want to be unique, just like everyone else After this, Jon decided, finally, to attempt to bring the killers to justice, in his own way, of

Davis, Douglas: The World´s First Collaborative Sentence, 1994, web project.

Many contributions are written as stream of consiousness. In part several fonts were used and image files were inserted. Media being not pastable into the writeable field were uploaded by Susan Hoeltzel, the director of the Lehmann College Art Gallery, and Douglas Davis. 64

Douglas Davis realised participation projects like the TV programmes "Elektronik Hokkadim" (1971) and "Talk-Out: A Telethon" (1972). Spectators could react to the already broadcasted parts of the show by telephone comments. These reactions were transmitted on TV as parts of the live show. 65 At the beginning of the seventies artists´ participation projects in TV broadcasts transgressed the "one-way communication" being usual in contemporary mass media (see chap IV.1.1 with ann.12).

In 1994 Davis used the opportunity to receive server space and technical support to be able to install on the web a project for remote participants. More than twenty years after his first TV projects Davis could use the web for a public "two-way communication". 66 The collaborative writing project was not protected against spam and asocial contributions. After a longer while of trouble-free working of the system for collaborative writing it became nevertheless necessary to overwrite contributions with the term "censored".

Collaborative writing projects were just realised by members of ACEN on "The WELL" (see chap. VI.1.2). Gil Mina Mora´s "Exquisite Corpse" (1988, see chap. VI.1.2) was constituted by a continuation of the writing process from one participant´s contribution to the next contribution of another participant and so forth. This project anticipates Davis´ collaborative writing project for the web. Participation projects as alternative TV were modificated for the internet and web by Mora and Davis. The contemporary possibilities of a remote communication became technically constitutive for projects realising "two-way communication" 67 for the emancipation from the passive comsumption of a culture determined from a few purportedly for the people ("one-way communication"). 68

After Davis´ collaborative writing project from 1994 other collaborative writing projects were installed on the web for the creation of novels by distributed authorship. 69 Deviations from such collaborative writing projects with mostly linear evolving narratives without links between their parts are participation projects with "associative indexing" (see chap. VI.2.1) as a key feature.

Since 1999 Dragan Espenschied and Alvar Freude offer the "Assoziations-Blaster" for contributions first in German, then in a further version in English. It simplifies a sliding between links across disparate contents. In 27th October 2002 the popular collaborative writing project stored already 327900 contributions and 23682 keywords. 70 Espenschied and Freude take up the hypertext model of cards with labels and texts with links (see chap. VI.2.2), but they add a space for the writing of contributions.



Espenschied, Dragen/Freude, Alvar: Der Assoziations-Blaster, first contribution: Wurzelgnom, January 1999, web project.

The links are automated: If the text of a contribution includes words being part of the keyword archive then they are linked automatically. For a keyword with several contributions the system chooses one of them as a link.

A filter can be adjusted to present only the contributions being rated with a certain amount of points (user rating). If the filter is adjusted to let pass more than one contribution for a keyword than the programmed selection of contributions uses pseudo-random procedures.

After participants wrote three contributions to the keywords already stored then they can

enter new keywords. The system scores the contributions: Criteria for the awarding of points are for example the length of the participants´ texts and the valuations of other participants. A participant´s point account grows with his activities and the valuations of the others. This point account can be used by participants to valuate other contributions.

The "Assoziations-Blaster" has no keyword register. Instead of such a register the "Blaster" offers several accesses to the collectively created and changing text labyrinth. The homepage presents a selection of five keywords as accesses. Furthermore readers can choose the last contribution and a keyword being fed by a random procedure. Alternatives to dig in the "Blaster" offer the search for labels and words being used in the explanations of the labels.

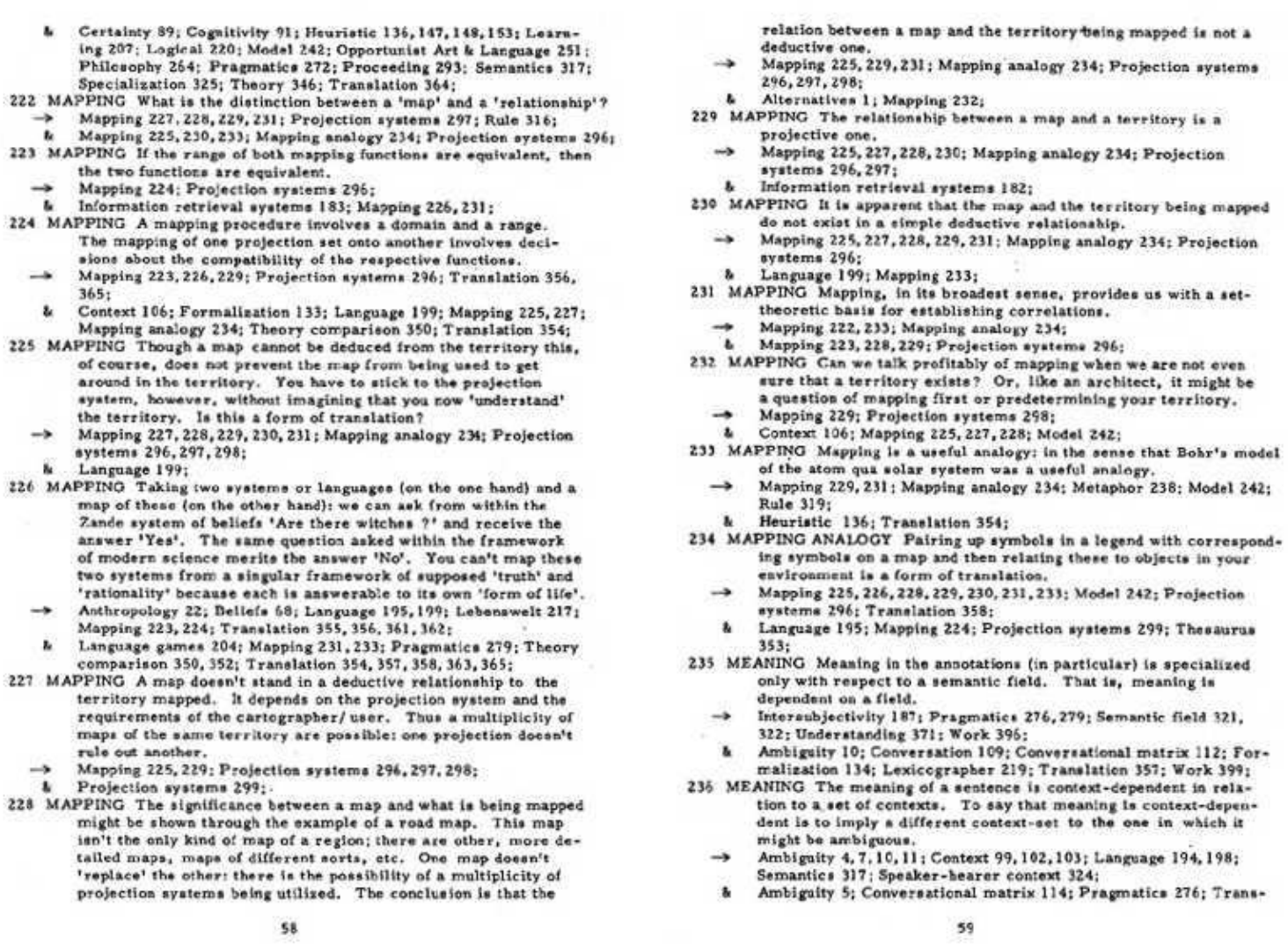
Via "Web-Blaster" words in texts of any webpage can be linked with contributions in the "Blaster´s" database: The automated links of the "Web-Blaster" are transferred to external texts. So the "Web-Blaster" offers further accesses to the lexia of the "Assoziations-Blaster".

Readers can escape a dead end of links by choosing "get away links" ("Flucht-Links").

The "Assoziations-Blaster" refers to the "meaning potentials" 71 of a word so far as they are grasped by contributions and links. The concatenation by automated links illuminates, lets unexplained or doubts the text semantics of a contribution in facing it with other contributions. 72

Since 1999 Joachim Maier and René Bauer develop "nic-las" ("nowledge integrating communication-based labeling and access system") offering a systematisation of the ways to create association fields cooperatively. "Stalker" is a version of "nic-las" without a predetermined theme and open for all participants. The already written contributions were embedded by participants in the functions offered by "nic-las" for the creation of relations between lexia. Participants can integrate further contributions into the growing hypertext system.

Research groups can use "nic-las" as a closed system: Such groups can get their own versions of the system for contributions by invited participants being bound to themes and to mutually agreed frameworks.



& Certainty 89; Cognitivity 91; Heuristic 136, 147, 148, 153; Learning 207; Logical 220; Model 242; Opportunist Art & Language 251; Philosophy 264; Pragmatics 272; Proceeding 293; Semantics 317; Specialization 325; Theory 346; Translation 364;

222 MAPPING What is the distinction between a 'map' and a 'relationship'?
→ Mapping 227, 228, 229, 231; Projection systems 297; Rule 316;
& Mapping 225, 230, 233; Mapping analogy 234; Projection systems 296;

223 MAPPING If the range of both mapping functions are equivalent, then the two functions are equivalent.
→ Mapping 224; Projection systems 296;
& Information retrieval systems 183; Mapping 226, 231;

224 MAPPING A mapping procedure involves a domain and a range. The mapping of one projection set onto another involves decisions about the compatibility of the respective functions.
→ Mapping 223, 226, 229; Projection systems 296; Translation 356, 365;
& Context 106; Formalization 133; Language 199; Mapping 225, 227; Mapping analogy 234; Theory comparison 350; Translation 354;

225 MAPPING Though a map cannot be deduced from the territory this, of course, does not prevent the map from being used to get around in the territory. You have to stick to the projection system, however, without imagining that you now 'understand' the territory. Is this a form of translation?
→ Mapping 227, 228, 229, 230, 231; Mapping analogy 234; Projection systems 296, 297, 298;
& Language 199;

226 MAPPING Taking two systems or languages (on the one hand) and a map of these (on the other hand): we can ask from within the Zande system of beliefs 'Are there witches ?' and receive the answer 'Yes'. The same question asked within the framework of modern science merits the answer 'No'. You can't map these two systems from a singular framework of supposed 'truth' and 'rationality' because each is answerable to its own 'form of life'.
→ Anthropology 22; Beliefs 68; Language 195, 199; Lebenswelt 217; Mapping 223, 224; Translation 355, 356, 361, 362;
& Language games 204; Mapping 231, 233; Pragmatics 279; Theory comparison 350, 352; Translation 354, 357, 358, 363, 365;

227 MAPPING A map doesn't stand in a deductive relationship to the territory mapped. It depends on the projection system and the requirements of the cartographer/user. Thus a multiplicity of maps of the same territory are possible: one projection doesn't rule out another.
→ Mapping 225, 229; Projection systems 296, 297, 298;
& Projection systems 299;

228 MAPPING The significance between a map and what is being mapped might be shown through the example of a road map. This map isn't the only kind of map of a region; there are other, more detailed maps, maps of different sorts, etc. One map doesn't 'replace' the other: there is the possibility of a multiplicity of projection systems being utilized. The conclusion is that the relation between a map and the territory being mapped is not a deductive one.
→ Mapping 225, 229, 231; Mapping analogy 234; Projection systems 296, 297, 298;
& Alternatives 1; Mapping 232;

229 MAPPING The relationship between a map and a territory is a projective one.
→ Mapping 225, 227, 228, 230; Mapping analogy 234; Projection systems 296, 297;
& Information retrieval systems 182;

230 MAPPING It is apparent that the map and the territory being mapped do not exist in a simple deductive relationship.
→ Mapping 225, 227, 228, 229, 231; Mapping analogy 234; Projection systems 296;
& Language 199; Mapping 233;

231 MAPPING Mapping, in its broadest sense, provides us with a set-theoretic basis for establishing correlations.
→ Mapping 222, 233; Mapping analogy 234;
& Mapping 223, 228, 229; Projection systems 296;

232 MAPPING Can we talk profitably of mapping when we are not even sure that a territory exists? Or, like an architect, it might be a question of mapping first or predetermining your territory.
→ Mapping 229; Projection systems 298;
& Context 106; Mapping 225, 227, 228; Model 242;

233 MAPPING Mapping is a useful analogy: in the sense that Bohr's model of the atom qua solar system was a useful analogy.
→ Mapping 229, 231; Mapping analogy 234; Metaphor 238; Model 242; Rule 319;
& Heuristic 136; Translation 354;

234 MAPPING ANALOGY Pairing up symbols in a legend with corresponding symbols on a map and then relating these to objects in your environment is a form of translation.
→ Mapping 225, 226, 228, 229, 230, 231, 233; Model 242; Projection systems 296; Translation 358;
& Language 195; Mapping 224; Projection systems 299; Thesaurus 353;

235 MEANING Meaning in the annotations (in particular) is specialized only with respect to a semantic field. That is, meaning is dependent on a field.
→ Intersubjectivity 187; Pragmatics 276, 279; Semantic field 321, 322; Understanding 371; Work 396;
& Ambiguity 10; Conversation 109; Conversational matrix 112; Formalization 134; Lexicographer 219; Translation 357; Work 399;

236 MEANING The meaning of a sentence is context-dependent in relation to a set of contexts. To say that meaning is context-dependent is to imply a different context-set to the one in which it might be ambiguous.
→ Ambiguity 4, 7, 10, 11; Context 99, 102, 103; Language 194, 198; Semantics 317; Speaker-hearer context 324;
& Ambiguity 5; Conversational matrix 114; Pragmatics 276; Trans-

Art & LanguageNY (Burn, Ian/Corris, Michael/Heller, Preston/Menard, Andrew/Ramsden, Mel/Smith, Terry): Blurting in A & L: an index of blurts and their concatenation (the Handbook)..., New York/Halifax 1973, p.58s.

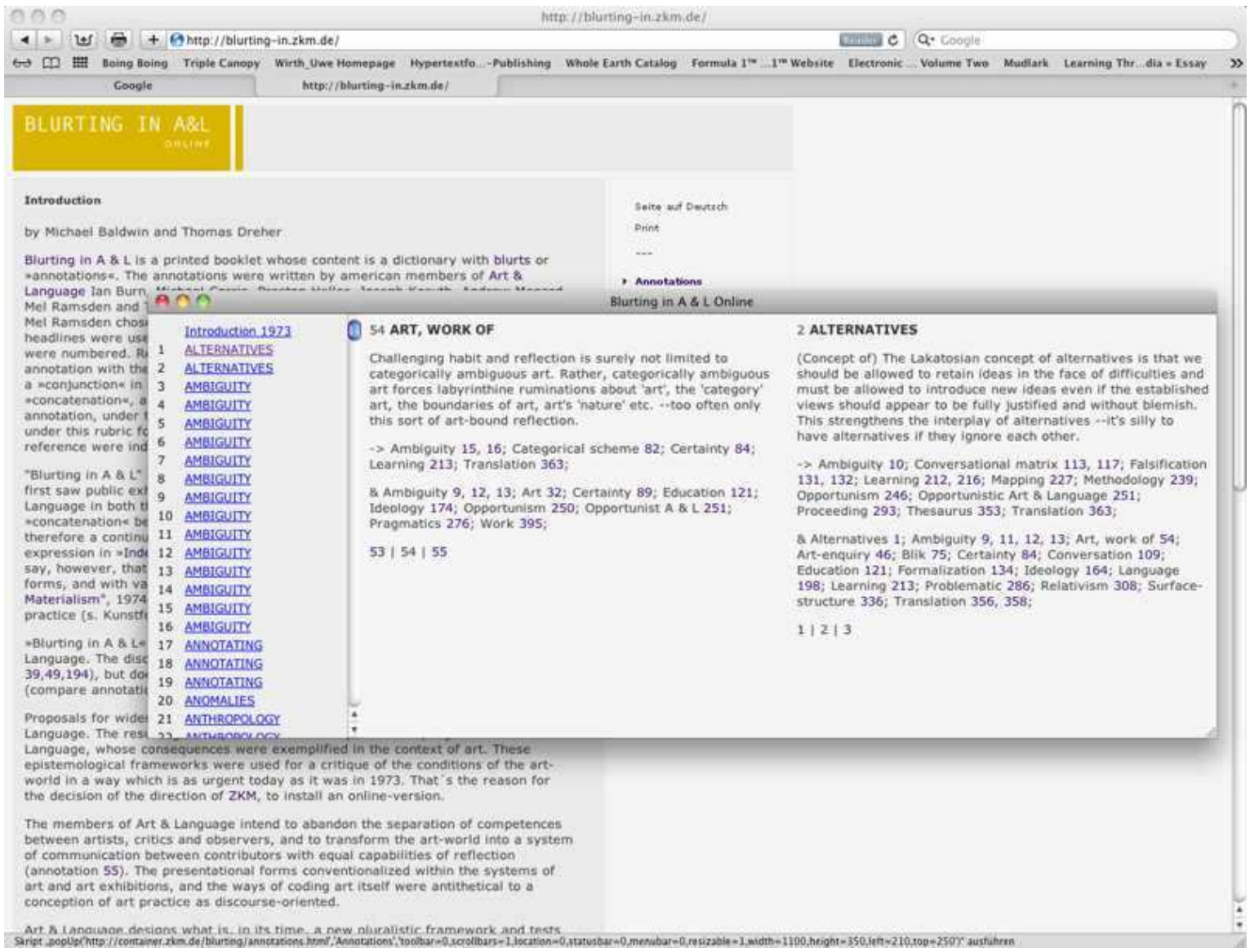
In 1973 a precursor of hypertext systems for a discourse by a group of participants was published in print: In the booklet "Blurting In A & L" 73 American members of the artists´ group Art & Language resystematised the content of their own texts. They divided members´ contributions for "The Annotation", an only vaguely defined project, into sections and attributed labels to them. They added not seldom the same label to several sections. The sections were sorted and numbered according to the alphabetical order of their labels.

In "Blurting In A & L" the lexia were tagged with "typed concatenations" 74: An arrow or an "&" marked two concatenation types. The arrow designates concatenations between more closely related units. This concatenation type can be semantised as "`...because of..." or "`...in order that...´", meanwhile "&" marks open relations leading out of the narrower relations designated with an arrow. The introduction proposes for "&" semantisations like "`...and then...´", "`...and so...´", "`...and next...´", but also "`either...or...´" or "`...but...´". Both concatenation types can be connoted as `annotative´ (arrow) and `associave´ ("&"). 75 For each of these two concatenation types lists with numbers of other lexia are added to each lexia. The members of the artists´ goup decided about the labels relevant for the wider ("&") and closer (arrow) contexts of a lexia and about its two concatenation lists.

An index lists the labels of lexia alphabetically. The numbers of the lexia are indicated to the right of their labels. On the next 72 pages follow the 408 lexia with the numbers indicated in the index. So a reference system was constructed by accesses for readers to the semantic network either via the index or via accidental hits by browsing through the pages and by reading across lines, labels and pages.

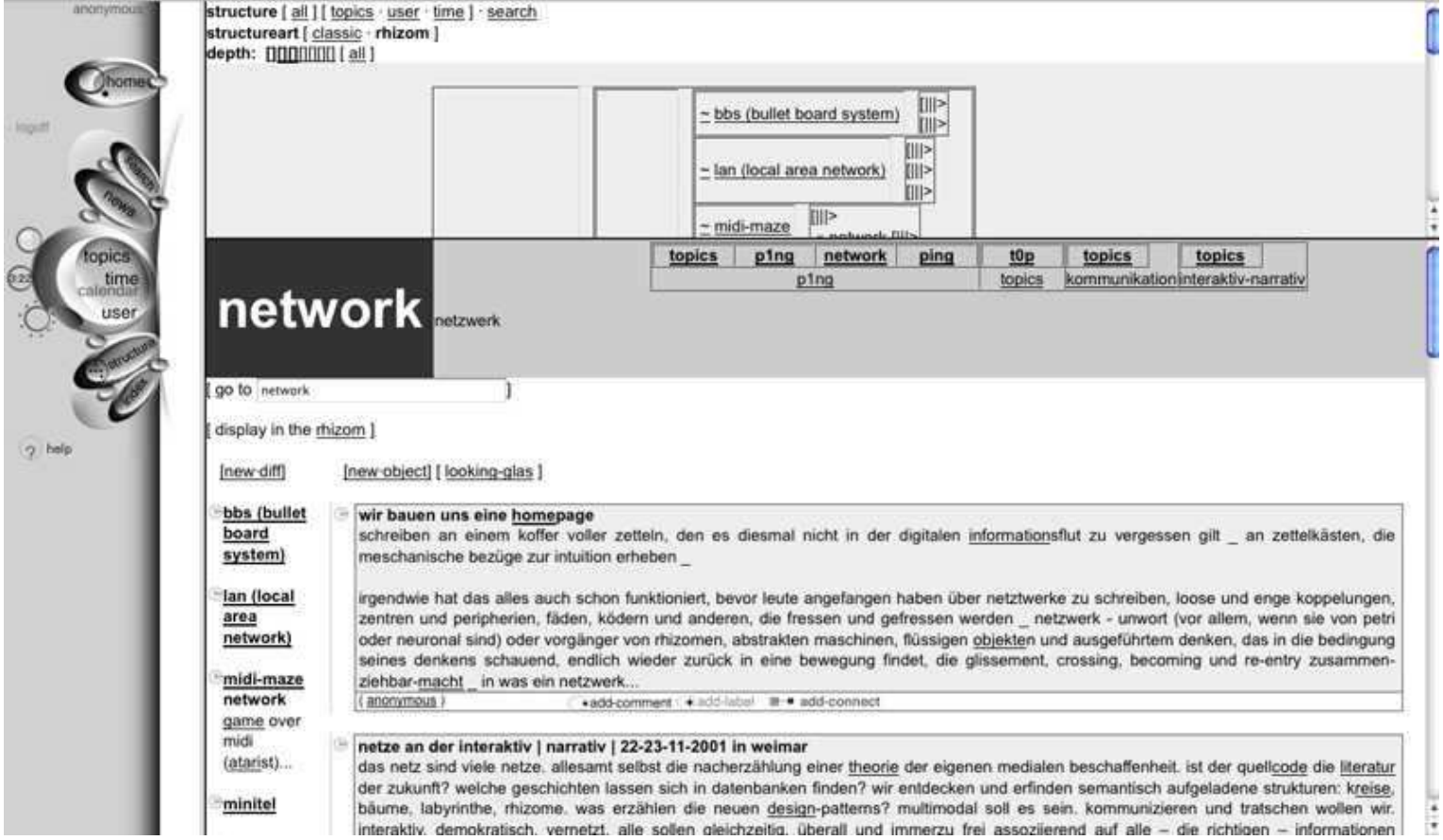
The published print of "Blurting in A&L" was readable like a cut through the ongoing

dialogue between the members of Art & Language. They wanted to demonstrate an intermediate result and with it an intermediate stop in their discourse process: a stop pointing to a going-on. With their open debate on the problem to develop a concept of art reacting to contemporary evolutions of theories in several disciplines the members of Art & Language contradicted the established paradigm of the art object as an immediately perceptible unique object of an author. Art & Language substituted the fixation of the art world and established art theories on portable objects with questionable modes of ascribing the status of art to them by a printed presentation of a discourse investigating these fixations and ascriptions as dubious concepts.



Art & LanguageNY (Burn, Ian/Corris, Michael/Heller, Preston/Menard, Andrew/Ramsden, Mel/Smith, Terry): Blurting in A & L: an index of blurts and their concatenation (the Handbook)..., New York/Halifax 1973/Online version. ZKM 2002.

The Online-Version developed in 2002 at the Center for Art and Media in Karlsruhe (ZKM) presents the index with the labels of the 408 lexia in the left column. On the right of the index two columns are placed beside each other. Each column shows one of the lexia. After a click on one of the numbers with links the linked lexia can be read on the other column. This online presentation makes it possible to compare the linking and the linked lexia. This comparison made possible by the web version offered the print version only then when the concatenated lexia were printed on the same double page.



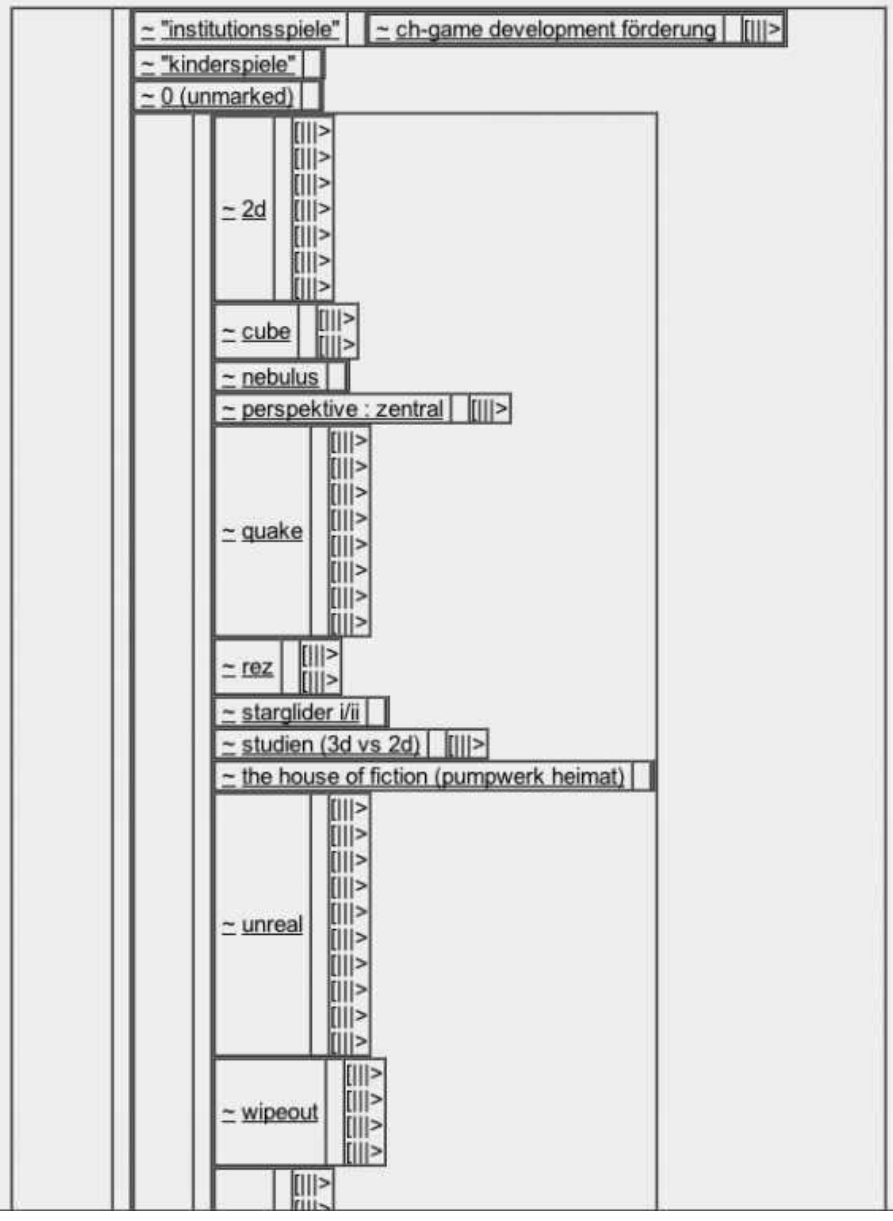
Bauer, René/Maier, Joachim: nic-las, Stalker, since 1999, web project.

Compared to "Blurting in A & L" "nic-las" offers a dynamic system open for further contributions and with more complex possibilities to structure a network of semantic fields. With collaborative writing systems like "nic-las" members of Art & Language could have been enabled to invite participants and to publish the ongoing discourse.

In "nic-las" cards with labels (see chap. VI.2.2) are developed further to "digitale Zettel"/"digital notes" including contributions of several auhors to one label. Each card contains writing spaces for comments. The comments will be presented within the commented "Zettel"/"note".

Contributions entered as "local objects" are figured under one lebel only, meanwhile "the dynamic objects" reappear in several "digital notes". Terms in the texts of "digital notes" are linked automatically with further "digital notes" being labelled with the same terms.

Within a "nic-las" project participants can install "digital notes" with new labels ("new diff"). These labels can be integrated into "topics" containing relations between labels. The "topics" can be called up as "digital notes" and as parts of a "structure". The "structure" of a project is presented above a horizontal band containing the label. Participants can choose between the "structure" with hierarchical formations above the horizontal band and an alphabetical list in the left column under the band. Furthermore the horizontal light grey band includes the "topics" on the right side in extracts of the "structure" facilitating to recognize how the labels are situated in the structure.



Bauer, René/Maier, Joachim: nic-las, Stalker, rhizomatic structure, since 1999, web project.

The graphic presentation of the "structure" is designated as "rhizomatic". The form of this structure shows from left to right and from top to bottom descending hierarchies. A label in a higher position of the hierarchy can be repeated under a label in a lower position. The system does not exclude cases with higher positioned labels including themselves as lower elements. 76 Therefore the hierarchy is not a logical, but a graphical form to visualise relations.

Each "note" includes a section called "unbewußte"/"unconscious". This "Irritationswerkzeug"/"irritation tool" either passes "deleuzianisch"/in a manner named "deleuzian" a selection of contributions to the reader, or it lets recur "Freudianisch"/"Freudianic" deleted texts.

With "Looking-Glass" external web pages can be commented and integrated into a project without to copy and store them as "Textbaustein"/"textual component". The now defunct section "subvisual" showed material found in the web: Java applets took links and images from the search engine Google. With each activation of a "digital note" new discoveries were shown. The digital "unconscious" and the "subvisual" expanded "associative indexing" (see chap. VI.2.1) as a source for inspirations to gain further proposals.

The members of a research group can inspire themselves mutually in using "nic-las" with or without agreed subject. The project "Stalker" in "nic-las" demonstrates a system with expanding digital notes without mandatory subject and only dependent from interests of

the participants. The participants´ plurality of writing styles must not undermine the interplay between entries but rather can create an increasingly dense network of "intertexts" 77 provoking to write further entries and new "digital notes" if contradictions and gaps in argumentations are recognisable.

Research goals can be crystallised in the course of a cooperation on a "nic-las" project in using the intertext relations as auxiliary means. A research group can appear as an `intertext implicit author´ 78 via the efforts of its members to create coherent argumentation lines. That does not exclude multifarious ruptured dialogues distributed over "topics" and "digital notes" with efforts recognisable for readers to gain a plausible argumentation.

"Nic-las" fulfills the demands to computing systems defined in Douglas Carl Engelbart´s concept of the "augmented intellectual worker" with a digital "card index box" serving "as a memory machine". 79 The private card index box of scholars like Johann Jacob Moser (1701-1785), Georg Friedrich Wilhelm Hegel (1770-1831) or Niklas Luhmann (1927-1998) is replaced by a memory machine being easier to handle: The cards with references noted by hand are superseded by a digital medium with an administration of stored documents and automated links.

The system "nic-las" with its selectable modes for the integration of links in a "structure" and its automated links demonstrates how programmed system requirements and concatenations chosen by participants following semantic criteria can be combined. The storing of files according to choices following individual criteria and the processes generated algorithmically – hypertextual as well as automated procedures – penetrate each other in digital memory machines and create semantic nets being open for further developments by one or several authors. 80

The concepts of hypertext developed by Vannevar Bush, Douglas Carl Engelbart and Theodor Holm Nelson (see chap. VI.2.1) are realised in the "Assoziations-Blaster" as an endless digression and in "nic-las" as a possibility to densify interpenetrating problem fields to structured semantic nets. Both net projects are examples for a successful convergence of hypertext and participation – for different requirements.

The projects of Computer Art provoke to differentiate `uncommon implementations of programs´ from `uncommon programs´: `systems with strange behaviours´ versus `strange systems´. `Strange systems´ are integrated in art, philosophy and natural sciences as unusual models being able to challenge common mindsets, meanwhile a conspicuous output of computing processes can be designated as `strange behaviours´ directed by programmes constructed in usual manners.

"Nic-las" offers hypertext to the participants of a project as a concatenation of indications, remarks and ideas being useful in cooperations for creations of new approaches, methods and mindsets. Symbolic interactions as insightful communications avoiding `strange behaviours´ are indispensable but the strength of "nic-las" is to facilitate in scientific cooperations the search for new aspects, problems and themes without being bound to established expertise limits. If participants´ `strange behaviours´ stimulate discussions then they can provoke challenges and new developments of systems.

The manner of "nic-las" to install hypertext is more than only a strange, new implementation: It is a `strange system´ with possibilities to avoid the disturbances in communications caused by `strange behaviours´ of participants and to integrate such aberrations as inspirations: The `strange system´ facilitates the collaborative jump out of the "normal science" to a "paradigm-shift-off". 81

Annotations

1 Warnke: Theorien 2011, p.155. back

2 Bush: Think 1945. Cf. Gere: Culture 2008, p.69s.; Idensen: Schreibweisen 2001, p.229-233; Landow: Hypertext 1993, p.14-18; Warnke: Theorien 2011, p.144-147. back

3 Bush: Think 1945, Chapter 6. back

4 Bush: Think 1945, Chapter 7. Cf. Gere: Culture 2008, p.70; Idensen: Schreibweisen 2001, p.231ss.; Landow: Hypertext 1993, p.15s. back

5 Hayles: Literature 2008, p.47-57; Licklider: Symbiosis 1960, p.4. back

6 Bardini: Bootstrapping 2000, p.29-32,60-86,95-102; Engelbart: Intellect 1962, p.68ss.,72s. back

7 Licklider: Symbiosis 1990. Cf. Engelbart: Intellect 1962, p.105s. back

8 Bardini: Bootstrapping 2000, p.40s.,45s.; Engelbart: Intellect 1962, p.21s.,24; Whorf: Language 1956. back

9 Bardini: Bootstrapping 2000, p.34-41; Engelbart: Intellect 1962, p.29. back

10 Engelbart: Intellect 1962, p.1. back

11 Engelbart: Intellect 1962, p.42. back

12 "Notedeck": Engelbart: Intellect 1962, p. 59s.
"Associative trail": Engelbart: Intellect 1962, p.51 with an explicit reference to Vannevar Bush´s "associative indexing". back

13 Engelbart: Intellect 1962, p.61ss. back

14 Krajewski: Zettelwirtschaft 2002, p.162-170. back

15 Engelbart: Intellect 1962, p.64. back

16 Engelbart: Intellect 1962, p.65s. back

17 Engelbart: Intellect 1962, p. 65ss. back

18 Engelbart: Intellect 1962, p.85-89. back

19 Engelbart: Intellect 1962, p.87s. back

20 In "bootstrapping" the developers employ themselves as model users and extrapolate from these experiences concepts for programming (Bardini: Bootstrapping 2000, p.143-147). back

21 Bardini: Bootstrapping 2000, p.138. back

22 Warnke: Theorien 2011, p.148. back

23 Bardini: Bootstrapping 2000, p.138-142; Engelbart/English: Research Center 1968; Warnke: Theorien 2011, p.147s. back

24 Ted Nelson´s earliest use of the term "hypertext" in a lecture at Vassar College (Poughkeepsie/New York) on February 1965 is documented in: Wedeles: Professor Nelson 1965. back

25 Nelson: File 1965/2003, p.144. back

26 Nelson: File 1965/2003, p.138s. Cf. Nelson: Computer 1974/2003, p.330s. on "collateral structures". back

27 Burnham: Software 1970, p.18s. New in: Montfort/Wardrip-Fruin: Media 2003, p.250s. back

28 See the quotation above (with ann.25). back

29 Nelson: Machines 1981/2003, p.452s. back

30 Nelson: Computer 1974/2003, p.307,329. back

31 Nelson: Computer 1974/2003, p.306s. back

32 Landow: Hypertext 1993, p.35. back

33 Landow: Hypertext 1993, p.52s. back

34 Bolter: Space 2001, p.35s.; Kuhlen: Hypertext 1991, p.84s.,89s.,96s.,333s.; Landow: Hypertext 1993, S.4,7,9,23. back

35 Malloy: Uncle Roger o.J. back

36 Malloy: Uncle Roger 2012. In 1997 Judy Malloy used "UNIX shell scripts" to programme "Uncle Roger" for the ACEN database (Malloy: Narrabase 1991, p.200; Malloy: Uncle Roger 2012). back

37 Malloy: Narrabase 1991, p.197. back

38 Bolter/Joyce: Hypertext 1987. back

39 Funkhouser: Poetry 2007, p.153 with ann.8. back

40 Landow: Hypertext 1993, p.111. back

41 Tan: Storyspace 2002.
The most famous example: Kahn, Paul/Landow, George Paul/Launhardt, Julie/Peter, Ronnie: The Dickens Web. Eastgate Systems, Inc. 1992. Lit.: Landow: Hypertext 1993, p.48,96-100; Landow/Kahn: Hypertext 1992 with chap. 2.2 (p.151ss.) on the first version realised in 1989 with Intermedia and its reprogramming until March 1992 with Interleaf World View (for Windows) and Storyspace (for Macintosh). back

42 Aarseth: Cybertext 1997, p.88; Douglas: End 2000, p.96,102; Suter: Hyperfiktion 1999, p.123. back

43 Douglas: End 2000, p.98. back

44 Bolter: Space 2001, p.128. back

45 Douglas: End 2000, p.98; Walker Rettberg: Piecing 1999, Chapter "Nietzschean Repetition?" back

46 Bachleitner: Formen 2010, chap.1.4, p.25ss. back

47 Douglas: End 2000, p.100ss.,104ss.; Walker Rettberg: Piecing 1999, Chapter "Nietzschean Repetition?" back

48 Aarseth: Cybertext 1997, p.1,85,89. back

49 Aarseth: Cybertext 1997, p.95. back

50 Aarseth: Cybertext 1997, p.94s. back

51 Kuhlen: Hypertext 1991, p.V; Needle: Rumors 1987; Nielsen: Multimedia 1995, p.57-62. back

52 Funkhouser: Poetry 2007, p.157; Nelson: File 1965/2003, p.144. back

53 Funkhouser: Poetry 2007, p.158. back

54 Montfort/Wardrip-Fruin: Media 2003, CD-ROM: 1980s, [Poems by William] Dickey 1988-90. back

55 Larsen: Preface 2003. back

56 Bolter: Space 2001, p.130-137. back

57 Zitate: Suter: Hyperfiktion 1999, p.160, cf. p.124.
Accesses and alternative endings: Bootz: Basique 2006, chap. Que sont les hypertextes et les hypermédias de fiction, 2.3.2; Douglas: End 2000, p.40. back

58 Suter: Hyperfiktion 1999, p.54,124. back

59 Bachleitner: Formen 2010, chap. 1-6, p.38ss.; Hautzinger: Buch 1999, chap.5.4, p.107-114; Simanowski: Berkenheger 1999; Simanowski: Interfictions 2002, p.130s.; Suter: Hyperfiktion 1999, p.111ss. back

60 Simon Biggs: Introduction 1996: "The inspiration for this project began with the short story of the same name by Franz Kafka. The database for the work consists of all the individual words in the original Kafka story. There are no linguistic structures stored in the system beyond the individual words. All sentences and grammar structures are formed `on the fly´ through object oriented and behavioural programming techniques, based on pattern recognition, redundancy algorithms and Chomskian Formal Grammars. Formal Grammars are used at the sentence level to generate individual sentences and ensure a degree of correctness in syntactical formation. This basic grammar system is augmented with many small ad hoc functions for dealing with plurality, conjugation, tense, etc. Most of these functions operate at the word level, but depend on `self-reading´ texts and backtracking techniques. Pattern recognition techniques are used at the higher level of content generation and contextualisation. This strategy has been employed as it was the objective to avoid having any form of `story-telling´ model in the system. The artist also wished to avoid using behavioural (Artificial Life) or Agent (for example,

modelling a `story-telling´ agent) based techniques, as the intention has been to create a system where the story, its subjects, actions and context, would emerge from the formation of the language itself, as something simultaneously written and read. Although at this point this technology is still in early development it does lead to a prose form that is very open, unexpected in its results and poetic."
Lit.: Bachleitner: Formen 2010, chap. 3.2, p.96s.; Heibach: Literatur 2003, p.222ss. (quote p.222) and CD; Heibach: Texttransformation 2000, chap.2,3,5; Munster: Media 2006, p.175s. (quote p.176); Simanowski: Aleatorik 2002. back

61 Cramer: per.m]utations 1998. back

62 Wirth: Gedanken 1999. back

63 In ca. 2005 many of the last entries were substituted by repetitions of the term "censored". In June 2007 it was impossible to call up the participants´ entries on the website of the Lehmann College of Art Gallery (According to informations published on the website Whitney Museum of American Art the collaborative writing project was installed on the web site of the Lehmann College of Art Gallery. There it was open for new entries from 1994 to 2005). In October 2010 these entries were found stored in the Internet Archive. Since July 2011 or earlier the archive informs about the blocking of accesses to the stored documents of the project. In 6/25/2012 the website of the Whitney Museum contained a documentation of the contributions to Davis´ "The World´s First Collaborative Sentence" on 21 web pages. In (between 9th June and 28th August) 2013 a "Restored Historic Version" and a "New Live Version" were installed on the Artport-Site of the Whitney Museum. back

64 Baumgärtel: net.art 2.0 2001, p.60ss.; Heibach: Literatur 2003, p.173ss.; Idensen: Schreibweisen 2001, p.253s.; Stallabrass: Internet 2003, p.60-63. back

65 Dreher: Radical Software 2004, chap. Video and TV with ann.19. back

66 "one-" and "two-way communication": Paik: Untitled 1971. Quote in: chap. IV.1.1 with ann.13. back

67 see ann.66. back

68 This is a variation of Carl Andre´s statement "Art is what we do. Culture is what is done to us." (Rose/Sandler: Sensibilities 1967, p.49). back

69 Example: Klinger, Claudia: Beim Bäcker, 1996-2000.
Lit.: Heibach: Literatur 2000, p.324s.,329; Heibach: Literatur 2003, p.168s.; Simanowski: Bäcker 2000; Simanowski: Interfictions 2002, p.27-34. back

70 Statistics of the German version from 10/27/2002. Statistics of the same version from 6/16/2012: 1046527 contributions to 77566 keywords. back

71 Halliday: Explorations 1973, p.59,64; Norén/Linell: Meaning 2007, esp. chap.3, p.389s. back

72 Heibach: Literatur 2000, p.330s.; Heibach: Literatur 2003, p.178-181; Idensen: Schreibweisen 2001, p.255-258; Ortmann: Netz 2001, p.67-72; Simanowski: Leichtigkeit 2000; Simanowski: Interfiction 2002, p.46-53,163. back

73 Art & LanguageNY: Blurting 1973. back

74 Dreher: Art & Language 2002, chap. III.2 with ann.29; Kuhlen: Hypertext 1991, p.34,106,111,118,246,339. back

75 Art & LanguageNY: Blurting 1973, p.5s.; Dreher: Art & Language 2002, chap. III.1. back

76 This contradicts Russell: Principles 1903, chap. X, §100s. back

77 Bauer: Intertext 2009, chap. 3, p.18-42; Idensen: Schreibweisen 2001, p.263. back

78 Dreher: Mitschreibeprojekt 2002/2004, chap. intertextimpliziter Autor. back

79 "Augmented intellectual worker": Engelbart: Intellect 1962, p.103 (see chap. VI.2.1). "System of notes as a memory machine"/"Zettelsystem als Gedächtnismaschine": Krajewski: Zettelwirtschaft 2002, p.141,151. back

80 Bauer: Intertext 2009, chap. 5.3, p.67-79; Dreher: Mitschreibeprojekt 2002/2004, chap. intertextimpliziter Autor and chap. Wen kümmert´s wer schreibt?; Idensen: Schreibweisen 2001, p.258-262; Suter: Literatur 2005, p.215-219. back

81 "Normal science": Kuhn: Structure 1996, esp. p.11,25,27,30,34-38,42ss. "Paradigm-shift-off": Atkinson/Baldwin: Post-War 1972, p.167 (Terry Atkinson and Michael Baldwin are English members of the group Art & Language. Cf. Dreher: Blurting in A & L 2002, chap. II.1). back

VI. Net Art: Networks, Participation, Hypertext
VI.3 Net Art in the Web

VI.3.1 Web: Hypertext, Protokolle, Browser

In the first half of the nineties a number of developments were crucial for the evolution from the internet to the web. These developments yielded prerequisites for net art.

Until 1993 Gopher and the web were competing internet systems. When the University of Minnesota decided to introduce an annual fee for the Gopher software then the CERN (Conseil Européen pour la Recherche Nucléaire) in Geneve released their competing WEB Software as public domain software: The internet participants chose the open web software. Open Source became a fundamental condition for a far reaching distribution of the web.

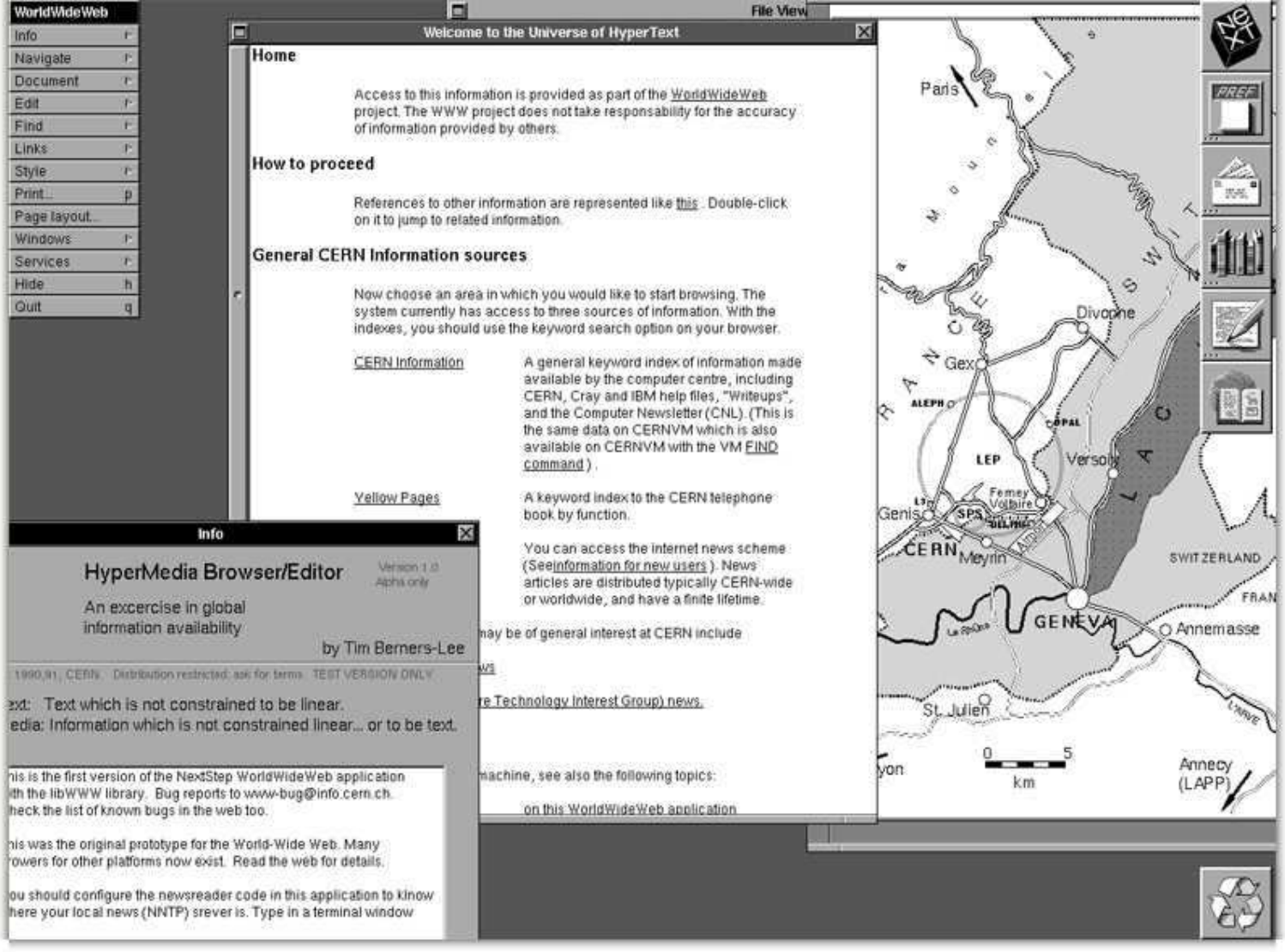
A consequence of the developments facilitating the access to the internet, the surfing and the setting up of a website – the web browsers and the definition of web standards (protocols) – was a sharp increase of internet participants in the nineties. In 1993-94 the developments from the internet to the web culminated in the web browser "Mosaic", the formation of the W3 (WWW) Consortium for the definition of standards and the reports in newspapers and journals on the growing number of participants from 2,63 millions in 1990 to 9,99 millions in 1993. In December 1995 the number grew to 15 millions. In June 1993 130 sites were stored on servers. Two years later pages of 23.500 sites could be called up online. 1

A proposition for a new project provided the impulse for a chain of developments resulting in the web: In 12th November 1990 Tim Berners-Lee and Robert Cailliau presented in "World Wide Web: Proposal for a HyperText Project" the plan for a web constituted by linked hypertext documents to be stored by the European Organization for Nuclear Research on several servers of the CERN:

> HyperText is a way to link and access information of various kinds as a web of nodes in which the user can browse at will. It provides a single user-interface to large classes of information (reports, notes, data-bases, computer documentation and on-line help). We propose a simple scheme incorporating servers already available at CERN.

Berners-Lee and Cailliau suggested that the implementation of simple browsers on "the user´s workstations" provides accesses to the "Hypertext world". Furthermore applications were planned enabling web participants to add documents. 2 This and the definition of protocols as binding guidelines for networks between components of different types 3 constituted a framework for the construction of a network between the CERN´s various servers: The Web arose from a project of the European research center.

From 1990 to 1991 the Web Browser WorldWideWeb (December 1990), the first version of the Hypertext Transfer Protocol (HTTP version 0.9, 1991, see below) and the tags of the Hypertext Markup Language (HTML tags, 1991, see below) were developed at the CERN. 4



Berners-Lee, Tim: Browser WorldWideWeb, 1990. Screenshot of a NeXT Computer, CERN.

The browser "WorldWideWeb" was a means to store and open files in formats (PostScript, films, sound files) supported by the NeXT system (for computers made by NeXT). Files stored on FTP- and HTTP-servers could be called up with "WorldWideWeb". The browser contained a WYSIWYG (What You See Is What You Get) editor usable to open pages in separate windows, to edit and to link them. If web participants wanted to control presentations of the browser then they had to define the properties of "basic style sheets" in using the "style editor".

Pei-Yuan Wei was inspired by HyperCard when he developed the browser "Viola WWW". In 1992 he presented the finished version for Unix´s X Windowing System. In 1993 Marc Andreessen and Eric Bina offered "Mosaic" as a browser easy to install on the operating systems Windows, Mac OS and Commodore Amiga. "Mosaic" became the most used browser followed already at the end of 1994 by Andreessen´s "Netscape Navigator". These are steps of the prehistory leading to the "browser war" between Netscape and Microsoft. In 1998 the last one won the competition with the "Internet Explorer". 5



Andreessen, Marc/Bina, Eric: Browser NCSA Mosaic 1.0, 1993. Screenshot of an Apple Computer with the operating system Mac OS 7.1.

Technical standards are the precondition of the internet´s data traffic. These standards are defined by protocols. The File Transfer Protocol (FTP) was already used in the ARPANET since the seventies as a part of the TCP/IP (Transmission Control Protocol/Internet Protocol) family of internet protocols and defines now the technical standards for the uploading of files to servers. 6

For the Open Systems Interconnection (OSI) Reference Model the International Organization for Standardization (ISO) defines since 1983 the functions of seven layers, from the physical layer to the application layer. The fourth layer defines the segmentation of the data stream and the avoidance of the traffic congestion: The TCP determines the function of the transport layer and offers a uniform technical basis for the upper application-oriented layers (from the fifth to the seventh layer). These layers are liberated by the flow control of the transport layer (the fourth layer) from the transport tasks controling the physical connection (the first layer), the transmission between nodes (the second layer) and the routing to the destination layer (the third layer). For the transmission with different systems of networking and telecommunication the transport layer (the fourth layer) organises the segmentation of data packets so that the application-oriented layers (from the fifth to the seventh layer) process only byte streams similar to a computer´s data transfer of a file from a hard disk or from a storage medium to the working memory. 7

OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data
		5. Session	Interhost communication
	Segments	4. Transport	End-to-end connections, reliability and flow control
Media layers	Packet/Datagram	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing
	Bit	1. Physical	Media, signal and binary transmission

The seven layers of the OSI reference model (Yao: OSI 2011).

The data transfer between computers is regulated by the Hypertext Transfer Protocol. It was defined in 1996 by the W3 Consortium and the Internet Task Force (IETF) in HTTP V 1.0. When the computer of a web participant starts a request then the Transmission Control Protocol establishes a connection to an HTTP server via a port (usually Port 80) and finishes this process with either an error message or a connection. 8

The Uniform Resource Identifier (URI) consists of a locator (URL), marking the location of the computer storing the HTML document to be found, and the name (URN) of this file. 9

Since 30th September 1998 the Domain Name System (DNS) is coordinated by the Internet Corporation for Assigned Names and Numbers (ICANN). 10 The URL addresses consist of letters and are stored and managed in a big database. The DNS system coordinates the URL addresses with the IP addresses constituted by ten digits. The IP addresses are the basic elements of the TCP/IP standards. The providers´ DNS servers receive automatically the actual informations being necessary for the coordination of URL addresses with IP addresses. The DNS servers´ translations from the established URL addresses to the IP addresses offer opportunities for censorship: By this intervention not only specific webpages but all contents of a website are blocked. 11

The source code with commands for browsers to present webpages is a further component of the web. The "Standardized Generalized Markup Language" (SGML) was the basis of the format that was used in documents at CERN (SGMLguid). In 1991 Tim Berners-Lee defined in "HTML Tags" 20 HTML elements: Many of them were influenced by SGMLguid. 12 In November 1995 Tim Berners-Lee and Dan Connolly determined the first official standard HTML 2.0. In this document HTML is described within point 3 as "an application of SGML". 13 The tags between angle brackets as marks for commands and the oblique strokes for the ends of commands reoccur from SGML to HTML – in Tim Berners-Lee´s own words:

> SGML was being used on CERN´s IBM machines with a particular set of tags that were enclosed in angle brackets, so HTML used the same tags wherever possible. 14

HTML and its extension to XHTML 15 became the standard types for documents to be presented in web browsers. Film, image and sound files can be integrated into these document types. 16 Net artists thematise since 1995 HTML in web projects (see chap. VI.3.2) and problematise since 1997 the browser presentations of documents and links (see chap. VI.3.3).

VI.3.2 HTML Art

Tim Berners-Lee wrote on his browser/editor "WorldWideWeb":

> I never intended HTML source code...to be seen by users...But the human readability of HTML was an unexpected boon. To my surprise, people [at the CERN] quickly became familiar with the tags and started writing their own HTML documents directly. 17

It is easy to learn to operate with the HTML code. This facilitates the construction of web pages in writing the source code. It is not necessary to write the sign combinations for links, anchors and other commands, because they can be called up per mouse click with easy to use and freely downloadable editors. If editors offer simple to use interfaces as work surfaces hiding the source codes then they can cause traces in the source code demonstrating the user´s inability to control the code. The source codes presented by the browsers show the traces of editors as these include, for example, unnecessary code elements or copyright informations of the programming firm.

In comparison to the hyperfictions for CD-ROMS (see chap. VI.2.2) early web projects by artists expose new scopes as results of the possibilities to control the browser presentations of webpages via their source codes. These include functional and graphical elements like cells, frames and layers as well as possibilities to integrate files stored on distant servers into one webpage. These codes include affordances to observers to explore the functions embedded in browser presentations and to reconstruct their programming. With this open relation between code and presentation the web projects presented below contradict the "dictatorship of the beautiful appearance" 18 determined by the "Graphical User Interfaces" (GUI) shown on the screens of personal computers: The browsers include possibilities to call up the source code and editors are means to modificate it in contrast to code hiding interfaces with buttons for clicks activating functions. The internet in times of the World Wide Web provokes doubts about the achievements of the personal computers with their desktops and possibilities to produce documents not only in a simplified manner but in a manner predetermined by the programmers of the GUI.



Friese, Holger: unendlich, fast..., 1995, web project (screenshot 2010).

Holger Friese´s "unendlich, fast..."/"nearly infinite..." (1995) consists of a browser field with a nearly complete blue surface. In the source code bgcolor="#000088", the RGB value for "Navy/low blue", determines the colour and its extension is organized by repetitions of the command
, the code for line breaks. In scrolling the blue plane in the browser up and down two white signs can be found several times repeated within a narrow field: There are stars and three lines with equal length arranged parallel above each other. These signs can be called up neither as signs of the alphabet nor as keys on manuals. Into the blue plane Friese integrated a screenshot of a postscript file (file name: "ende.gif"). He writes on this screenshot:

> And that´s the true reason why the background is blue, it is a screenshot of a Postscript file (the data structure that´s sent to a laserprinter to draw a lemniscate) which had a blue background on a very old DOS operated computer. 19

The signs constitute "a lying eight, the sign for infinity, in a form readable by computers." 20 The white signs of the image file appear on the monochrome plane isolated and subtracted from their former context. The "infinite" blue apears only "nearly" infinite, as the title says, because it is interrupted by these white signs and has a finite height and width.



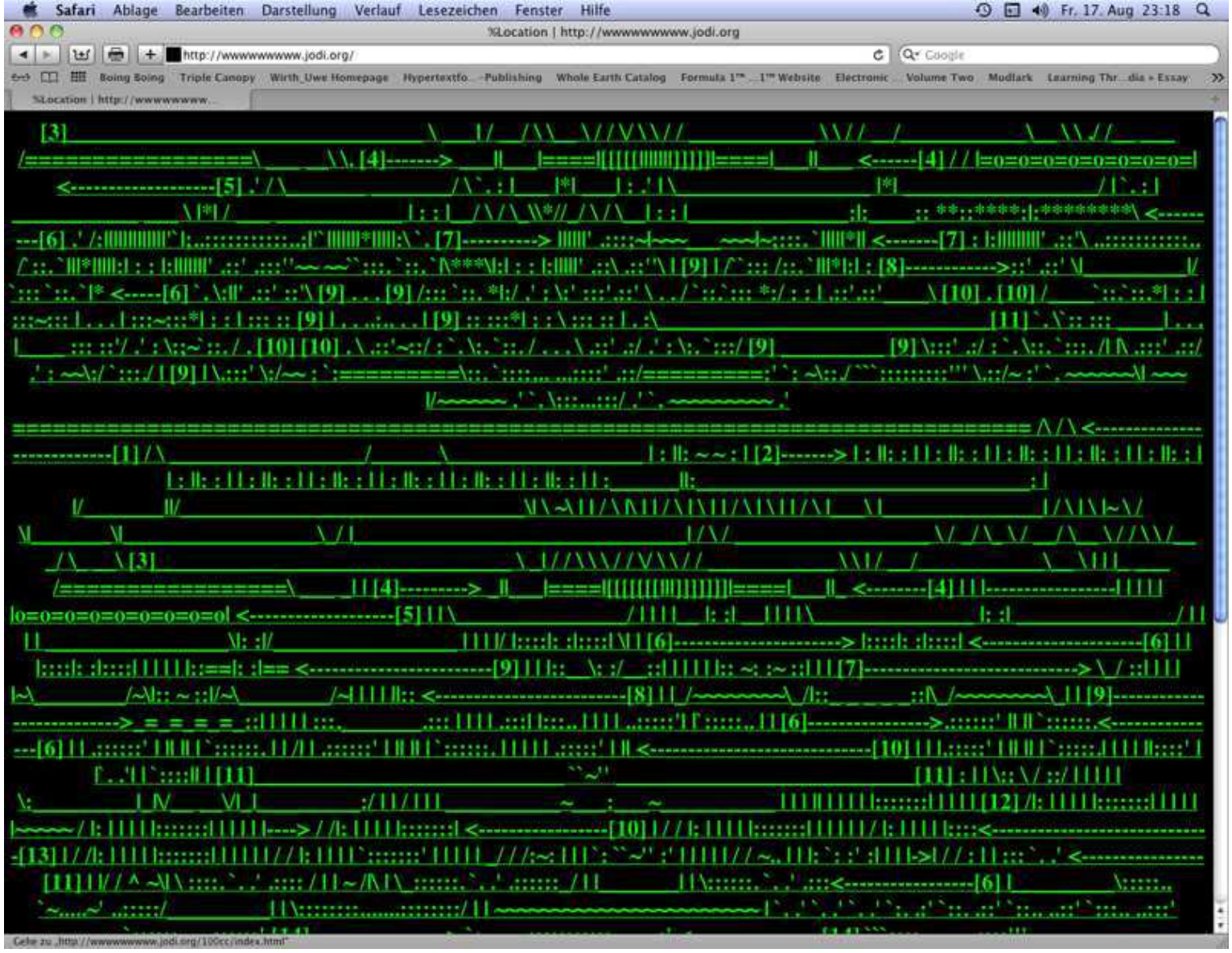
Jodi: wwwwwwwww.jodi.org, 1995, web project (screenshot 2012).

Jodi (Joan Heemskerk and Dirk Paesmans) connect in wwwwwwwww.jodi.org (1995) graphically unusual designed webpages containing some text elements with links often being recognisable only via cursor movements. Many pages present repeated images. Some of the images or image series contain links opening new images. The images are only seldom made with a digital camera. More often two-dimensional computer graphics are presented, and sometimes animated.gifs are shown. The HTML code is used to call up the same stored images several times within a webpage. Text elements can be components of the images as well as parts of the HTML document. HTML functions like <blink> or javascript like the "function scrollit" (automated scrolling) as well as photo sequences in animated gifs are means to control the `moving´ monitor presentations of the webpages. Some links are designed via the tag <form action> as buttons with the forms of formulars.



Jodi: wwwwwwwww.jodi.org, 1995, web project: text becoming visible after being marked by mouse-over (screenshot 2012).

"Accept" buttons are located under "agreement" declarations parodying copyright regulations and disclaimers. The remark "Texts for bots only" can be found in the source code of a page whose browser presentation shows nothing more than the text "Worm food" with an "accept" botton located below. The source code includes word sequences like "hackcrackphreakwarez" and hints to the culture of sharing open content ("warez") and the hacker scene. If someones moves the cursor over the black field between the "Worm Food" headline and the "accept" button then he can read the text of the source code in black letters on blue background as a part of the browser presentation.

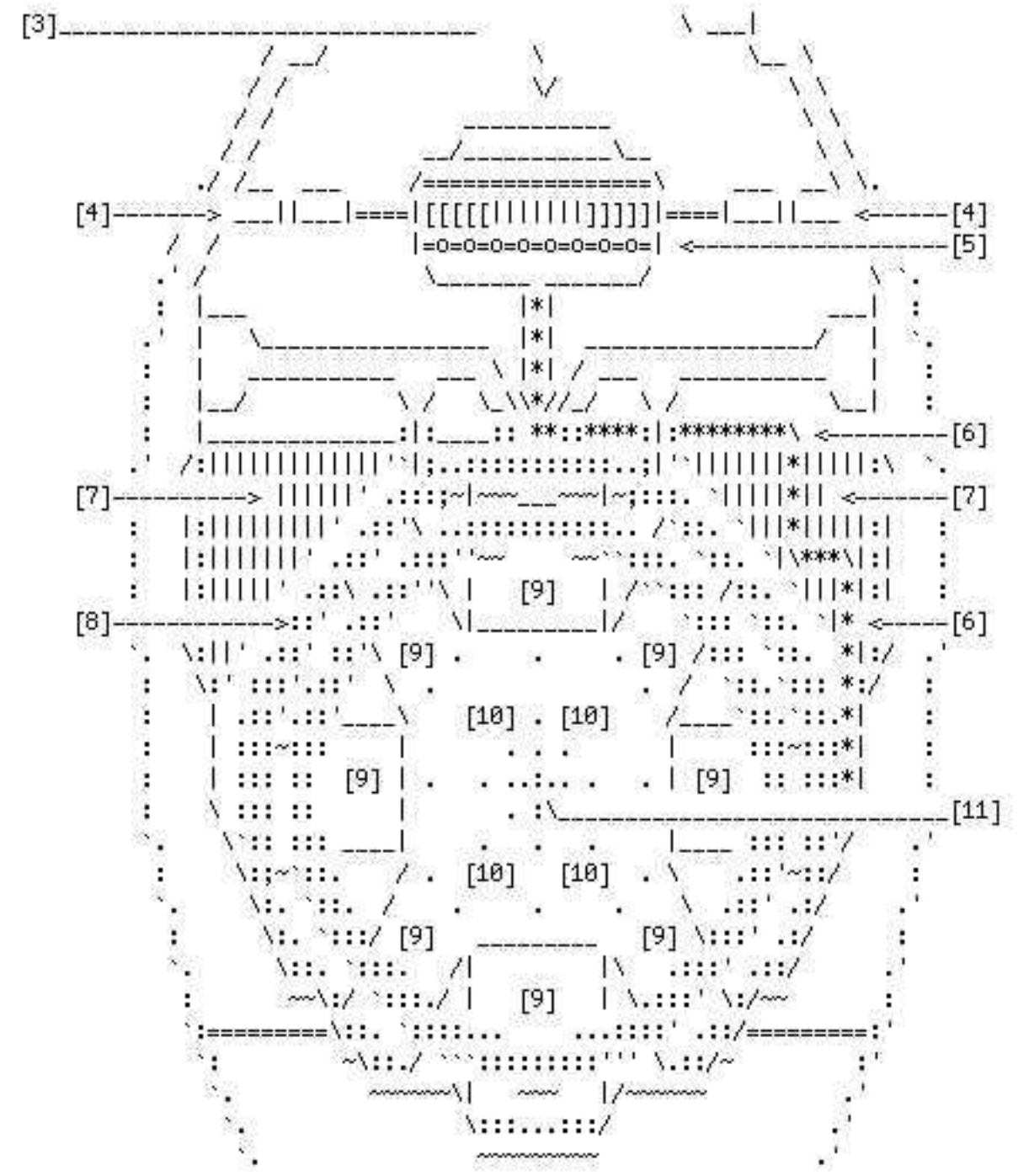


Jodi: wwwwwwwww.jodi.org, 1995, web project: browser presentation of the source code written in ASCII (screenshot 2012).

The first page presents in some browsers a source code in ASCII flashing (not all browsers `blink´). ASCII is an abbreviation for "American Standard Code for Information Interchange" substituting letters by number combinations. Platforms for ASCII Art collect and store typograms created with ASCII elements forming patterns sometimes looking either like diagrams or sometimes like pictures. Jodi uses the browser to dissolve the configuration of ASCII elements with a figurative contour on the level of the source code into an irritating sequence of signs: lines, dashes, points and cyphers in repeating sequences and variations. The whole field of this code presentation contains a link leading to another page of this web project.

```
<html><title> %Location | http://wwwwwwwww.jodi.org </title>

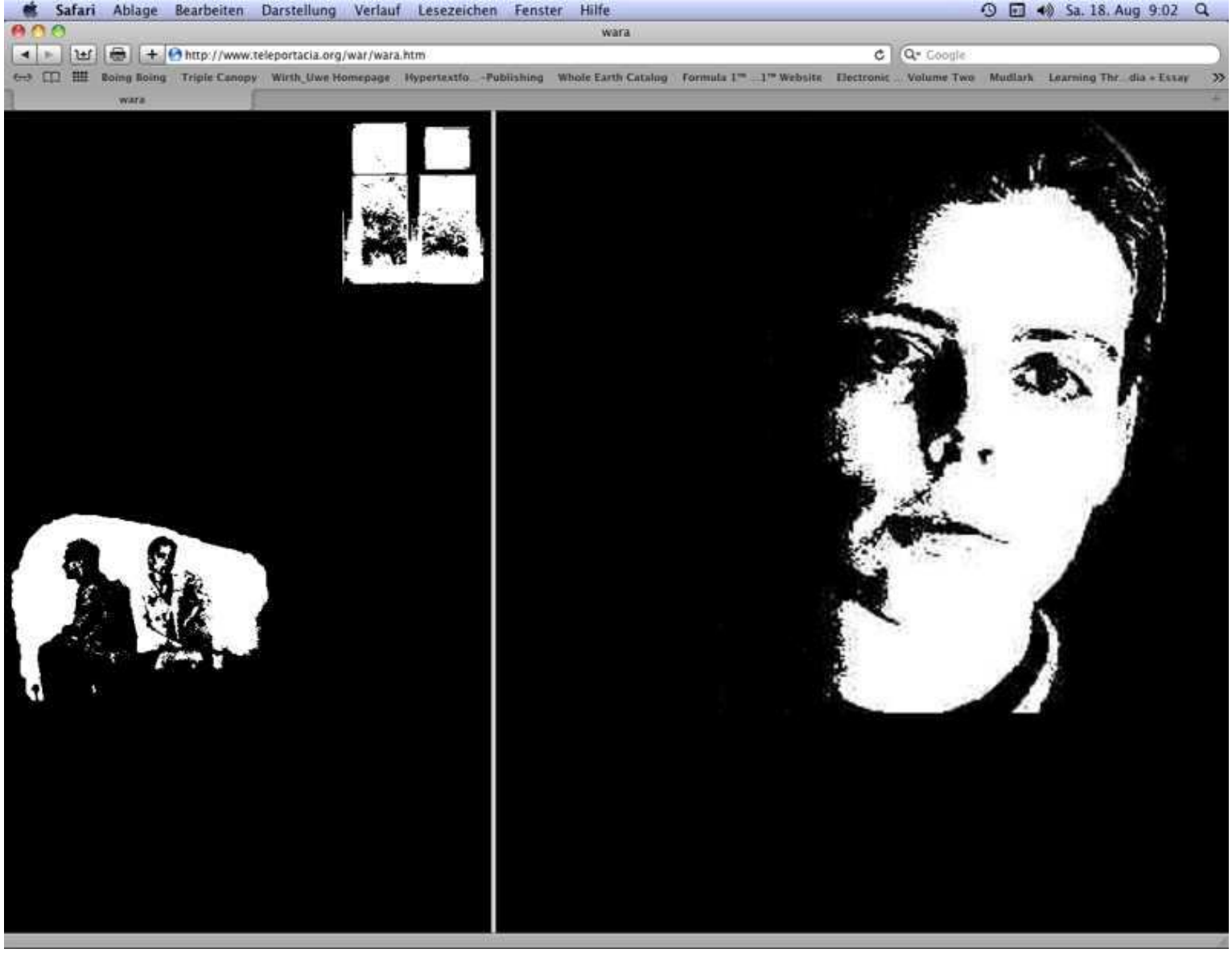
<BODY BGCOLOR="#000000"
TEXT="#00ff00" LINK="#00ff00" VLINK="#00ff00" ALINK="#ffffff">
<font size=5><CENTER><blink><b>
<A HREF="100cc/index.html">
```




```
==========================================================================
```

Jodi: wwwwwwwww.jodi.org, 1995, web project: a detail of the first page´s source code (browser presentation, Screenshot 2012).

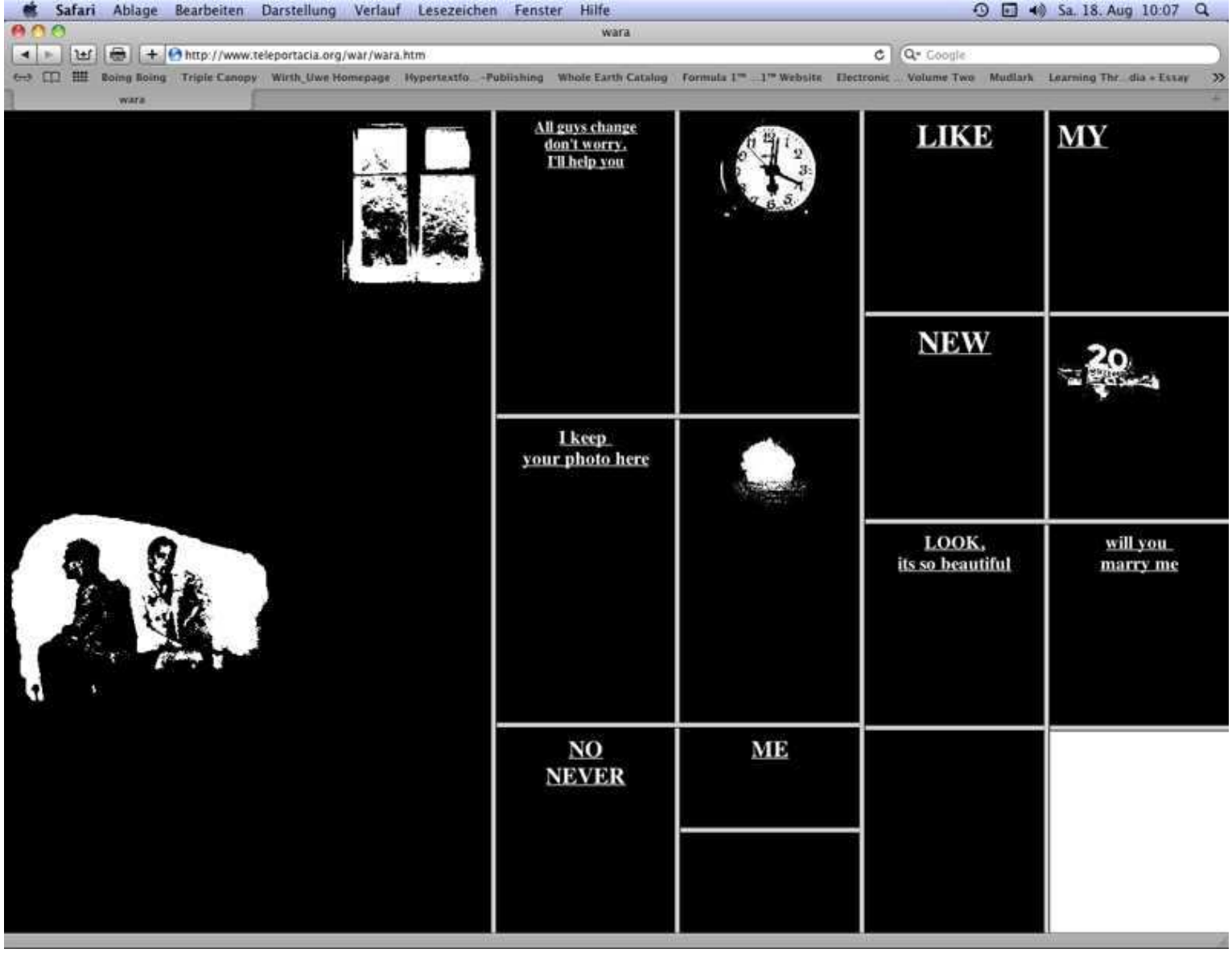
If these webpages and the relations between them refer to a common concept then it is the variation of forms, not seldom irritating because of the overall impression of repleteness. Jodi´s manner to explore the possibilities to design webpages must have been a provocation for observers interested in contemporary web design. 21



Lialina, Olia: My boyfriend came back from the war, 1996, web project (screenshot 2012).

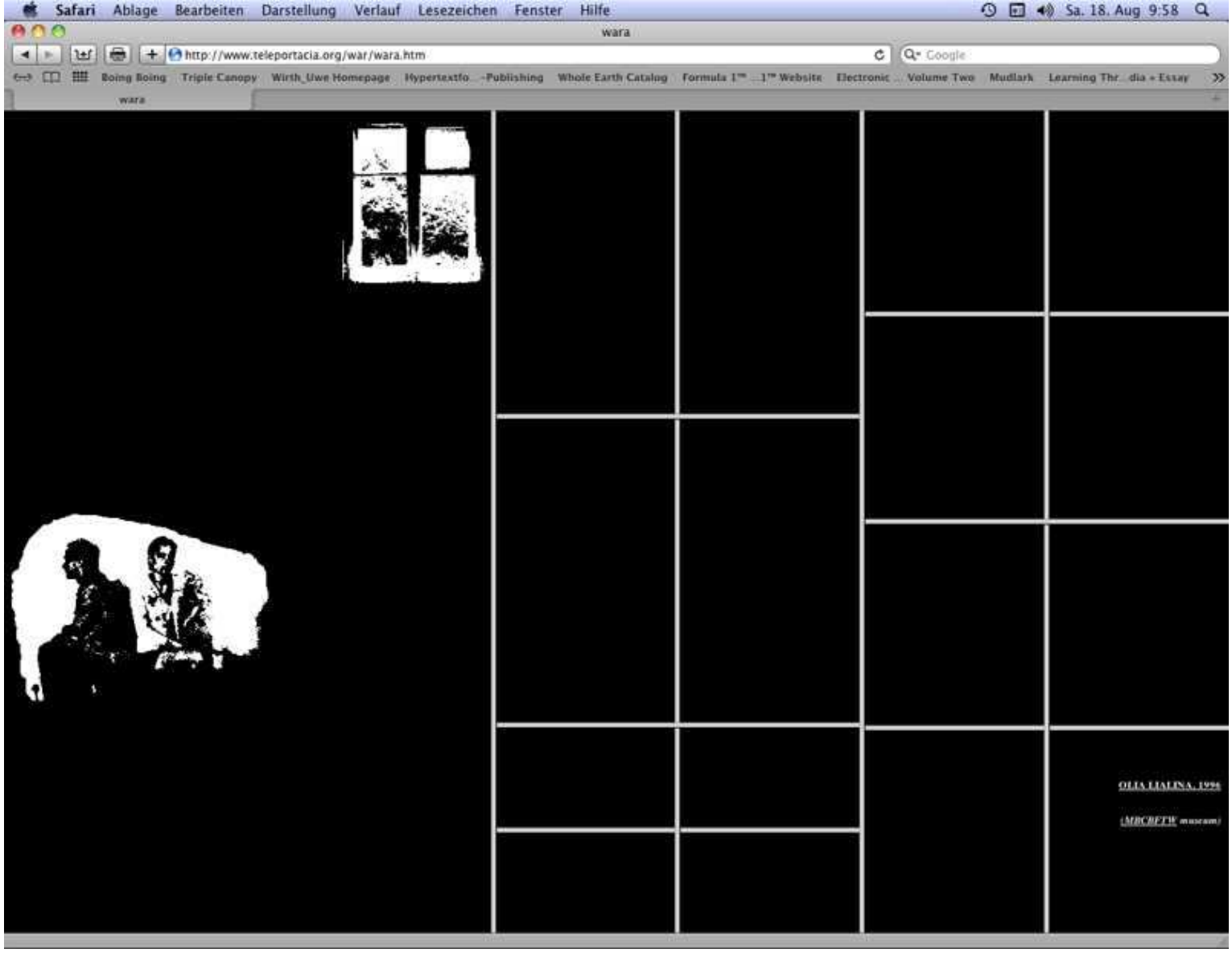
In "My boyfriend came back from the war" (1996) Olia Lialina contitutes a hyperfiction in concatenating webpages via frames (without scrollbars). The frames enclose words, word combinations or sentences. Only a few frames include images (without text), in one case also an animated gif. The frames are divided up into `frames in frames´: In clicking on texts or images within the frames links are activated causing the opening of new pages. In the meantime the webpage is divided into further frames.

In comparison to Douglas Carl Engelbart´s predigital model of notched cards stringed together edge-to-edge (see chap. VI.2.1 with ann.12) the cards or the contents of the frames in "My boyfriend came back from the war" are digitally set `into motion´: from adjacent card edges to a grid constituted by grey frames whose contents on black backgrounds become `mobile´. The notches are substituted by Lialina´s selection of links on fields within frames opening further frames within linked fields.



Lialina, Olia: My boyfriend came back from the war, 1996, web project (screenshot 2012).

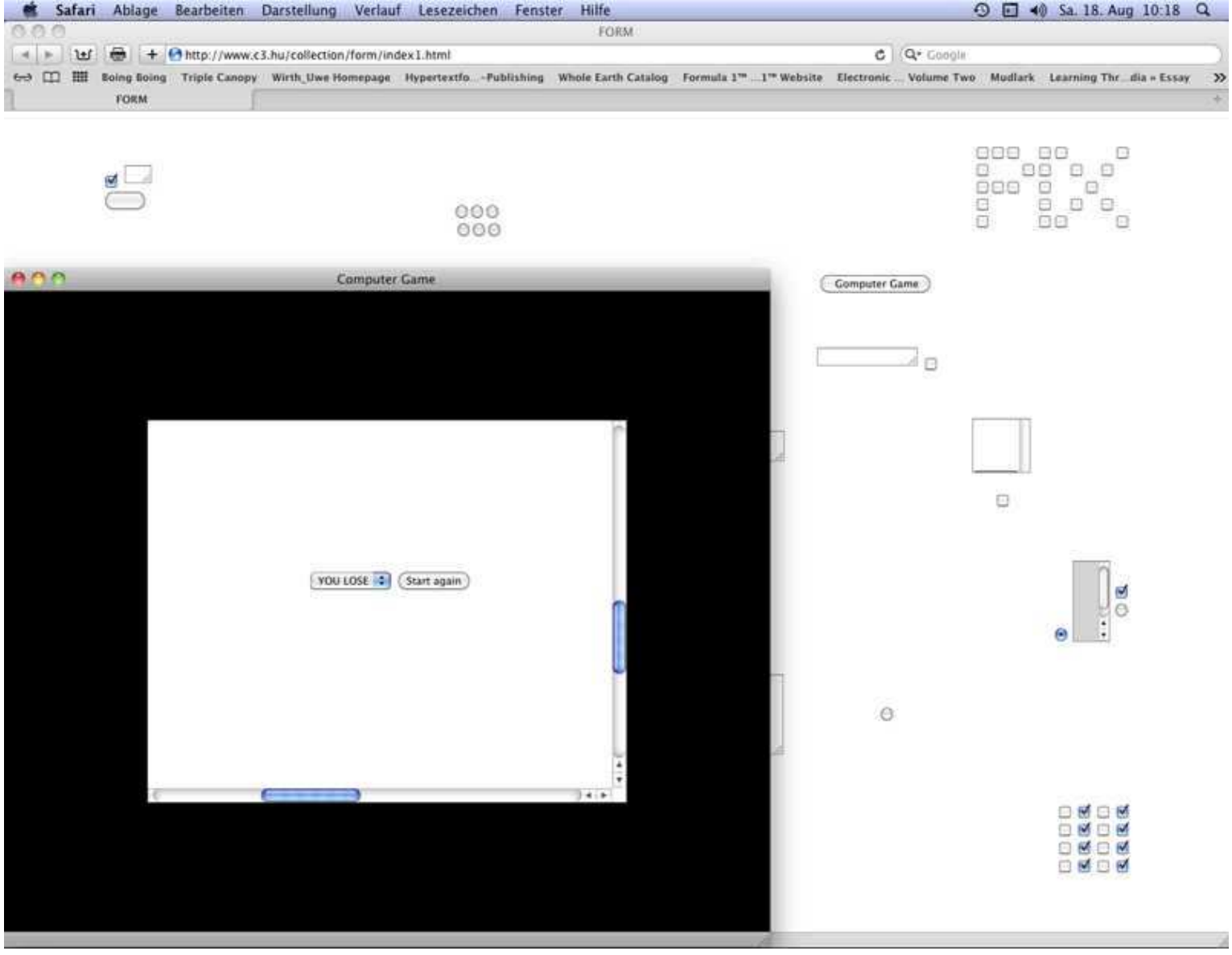
At the beginning the first frame fills the screen over the entire height and contains an image of a window at the top right as well as an image of a couple at the lower left. 22 After a click on the first frame´s couple appears on the right side a second frame with a front view of Lialina´s face. The left frame includes no further leading concatenation, meanwhile the right frame is divided from click to click in further frames with texts and images. Clicks on one of these frames cause at first changes in the frame content (images or texts) and then a division of the frame in two or four further frames. The end of the click sequences on frames causing their divisions is marked by monochrome black fields as frame contents. At the lower right appears not a further black field but instead a white frame presenting – as the source code tells – the text "LOOK, it´s so beautiful" in white letters on a white blackground. The text became visible in the browser Netscape 4 by mouse over for a short time. Lialina wrote to Roberto Simanowski about this presentation: "It was made invisible to be an invisible link. You can see it if you select it." 23 A click on this white frame leads to a frame with a mailto-function to Lialina´s e-mail address, and – in the actual version (2012) – on a line under the mailto-function to a link leading to the platform "Last Real Net Art Museum" offering copies, variations and alternatives to Lialina´s "My Boyfriend came back from the war" being programmed by artists from 1998 to 2012.



Lialina, Olia: My boyfriend came back from the war, 1996, web project (screenshot 2012).

The history of a woman wanting to marry a soldier is laid out by Lialina in a multi-branched but nevertheless sequential manner from left to right and from top to bottom. Words in several adjacent frames point to narrative interrelationships or yield parts of sentences being dissolved in further clicks.

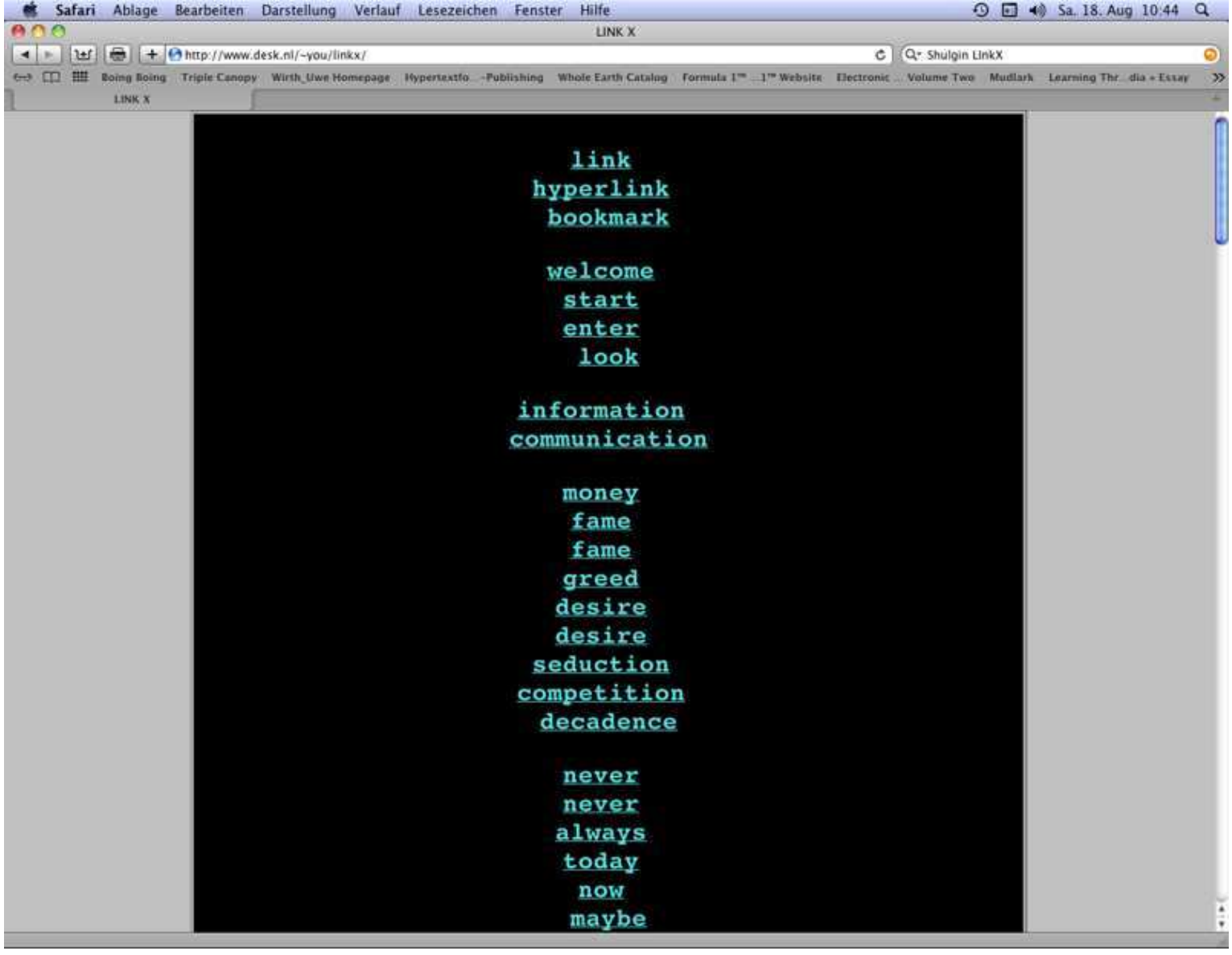
The artist matches her narrative strategy with the permutational possibilities of the frame combinations: The frame permutations and the combinations of sentence fragments are coupled. Lialina uses a frame-hypertext narrative strategy resulting in possibilities to play with semantically occupied fields provoking readers to follow the prearranged narrative direction. 24



Shulgin, Alexei: Form Art, 1997, web project (screenshot 2012).

Source codes built for purposes are showcased by Alexei Shulgin purposeless in browser presentations. The title "Form Art" (1997) recalls the HTML command for web forms (<form>). Shulgin utilizes input fields, control bottons and checkboxes in a HTML art augmented by Javascript and Java. These elements are distributed on webpages. Clicks on the control bottons and checkboxes open new browser windows demonstrating again constellations with input fields, control boxes and checkboxes. 25 In "Form Art" the forms are not used to send data to a server for further processing but to activate functions of the artistic project´s webpages like a marquee constituted by checkboxes.

The examples presented above are the results of experiments with the possibilities of programming browser presentations with HTML: The relevant browsers were Netscape Navigator 1 through 3 and Internet Explorer 1 through 3. The web projects presented below use uncommon link strategies to thematise the internet as a developing public archive.



Shulgin, Alexei: Link X, 1996, web project (screenshot 2012).

Alex Shulgin in "Link X" (1996) and Heath Bunting in "_readme – own, be owned, or remain invisible" (1998) selected words for the construction of URL addresses: The artists set "www." before the self chosen (Shulgin 26) or found words (Bunting 27) and added the top level domain ".com" used world wide for commercial sites. Contrary to Heath Bunting´s concentration on URL addresses ending with ".com" Shulgin changes between ".org" and ".com" and the resulting URL addresses lead in some cases to various websites. The words combined with links in the way described led in the time of the projects´ creations only seldom to documents meanwhile around 2000 unused URL addresses became rare. The words readable in the browser presentations deliver materials for the construction of links that can be used to explore the web as data space. In the early phase of the web this strategy was an interesting investigative attitude towards the arising data landscape.



Bunting, Heath: _readme – own, be owned, or remain invisible, 1998, web project (screenshot 2012).

URL addresses with the top-level domain .org are provided for organisations. Despite nonexisting restrictions this top-level domain is used mostly by organisations with charitable aims. The URL addresses of the top-level domain .com are reserved for the e-commerce. Among them are the websites of firms, often internationally operating corporations. If owners of websites occupied URL addresses similar to firm names then either they could receive money es a result of an out of court settlement for a voluntary cession, or they were faced with claims and lawsuits.

In 1999 eToys, the American shipment of toys, tried to force the Swiss artists´ group etoy in an out of court settlement to hand over their URL address etoy.com. After an interlocutory injunction the firm Network Solutions deleted etoy.com from the main register of URL addresses in December 1999. Network Solutions was responsible for the administration of .com addresses. Not only etoy´s website was not accessible any more but their mailbox, too. This sanction was not covered by the court decision.

After several negotiations without agreement the members of the Electronic Disturbance Theater and RTMark followed a strategy putting eToys under pressure at several levels until the management withdraw the lawsuit at the beginning of 2000.

During the Christmas season in 1999 virtual sit-ins were realised with the tool "FloodNet" to prevent sales on the website eToys.com for a short time. With the use of the software "FloodNet" developed by members of the group Electronic Disturbance Theater not the content of a website being the target is changed but the access is slowed down and blocked in extreme cases. A java applet runs reload calls: In three parallel frames a website is loaded in three-seconds-cycles. The server of a website is asked for a non-existent URL address and the "server error log" indicates its non-existence to web

participants. Simultaneous FloodNet calls by many web participants can cause an overload of the "server error log". In these cases the accesses to targeted websites are blocked. 28

The virtual sit-ins were combined with a successful press campaign. Both together damaged the image of eToys. The share price decreased dramatically and in February 2001 eToys filed for bankruptcy protection after disappointing Christmas sales. The "ToyWar" demonstrates the appropriation of the data space by corporations. 29 Bunting´s textual instrument exploring the segmentation of the commercial data space anticipates the problems causing etoys´ self defence.

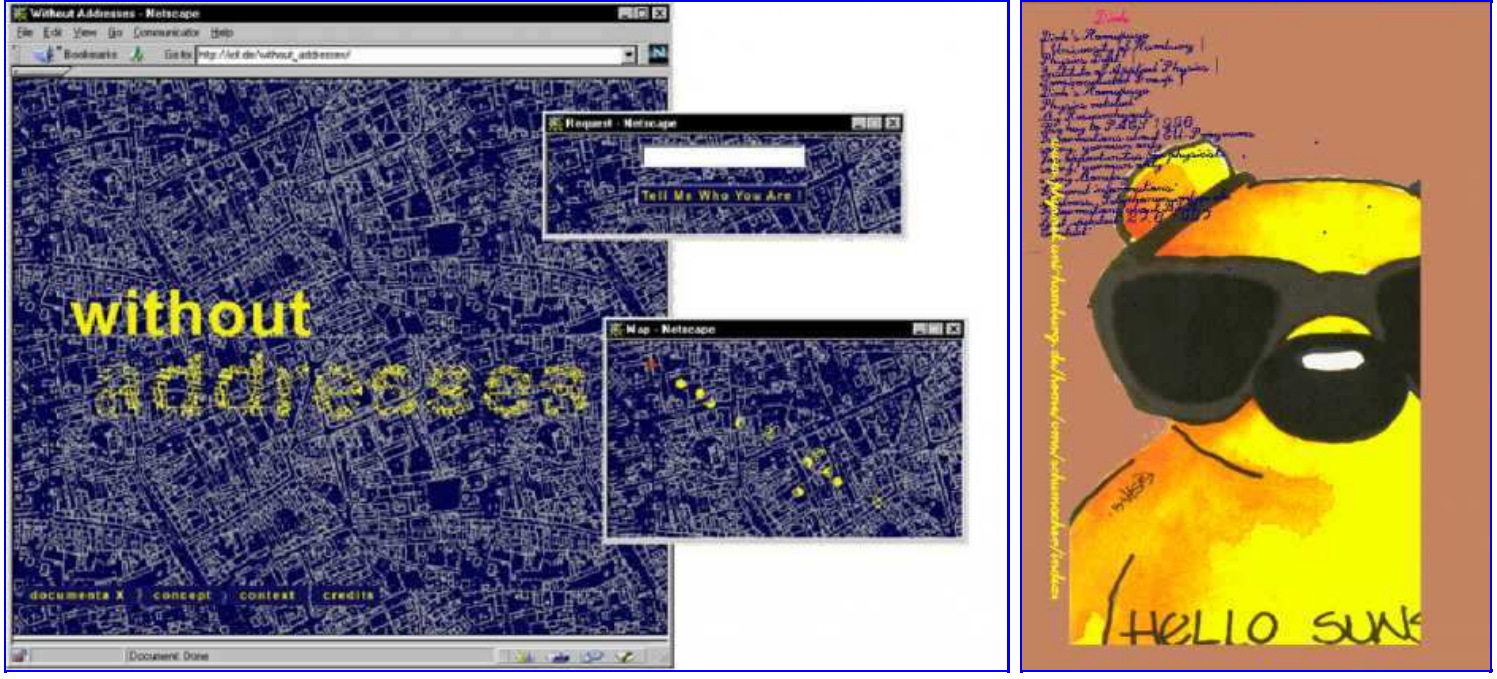
The examples of HTML Art presented above explore web fundamentals and lead the attention of web participants to HTML as a basic tool to create webpages. The possibilities to use the web must not be prefabricated by platforms such as social networks following frameworks mostly guided by commercial interests, and it is not necessary to use only these platforms. In the context of the web 1.0 e-commerce and the free exchange of informations were opposites, meanwhile in the web 2.0 platforms support and promote the exchange of informations between registered users because this boosts the profit of the platform owners: For advertisers and platform owners the users became game balls.

Contrary to that in the web 1.0 the net participants, while building their own websites and using tactical tools like "FloodNet", understood themselves as acting on their own behalf and according to their own benchmarks. If these actors wanted to resist restrictions then they organised campaigns and looked for participants. They used and use means resulting from the tactical possibilities offered by the free web distribution of informations and by activistic web tools being free of charge.

VI.3.3 Browser Art

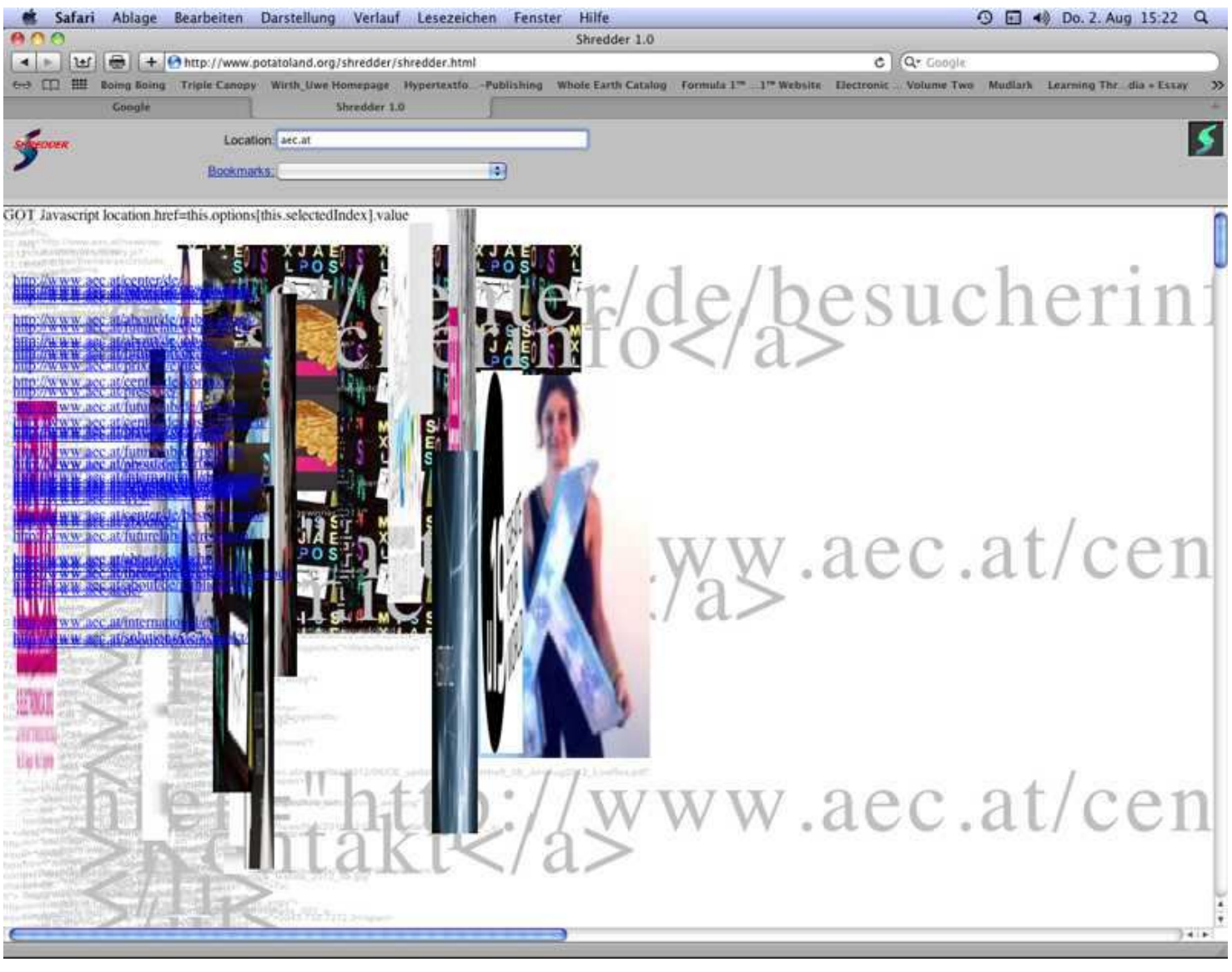
The examples presented in chapter VI.3.2 demonstrate the programming for browser presentations and the use of links as accesses to site-external webpages. The examples chosen for this chapter bring these two aspects together in their ways to thematise browser functions: They present not only browser functions (art for browsers) but also alternatives to popular web browsers (art as browser) being offered by Netscape and Microsoft (Internet Explorer).

The Web is used as a resource for data accesses in "without addresses" (1997) by Joachim Blank and Karl-Heinz Jeron 30 as well as in Mark Napier´s "The Shredder" (1998). 31 These projects offer web participants possibilities to select accesses to documents stored on servers connected via the internet, but both projects do not offer ways to influence the modification of these webpages. Meanwhile Napier makes the input of an URL address possible, "without addresses" provokes web participants with the question "tell me who you are" to write entries. Then it uses these entries as keywords in search systems (Altavista und Yahoo), selects a webpage and constructs with it a new webpage. The selected URL address is noted on the transformed document. This document is stored in an archive.



Blank, Joachim/Jeron, Karl-Heinz: without addresses, 1997, web project (illustrations of the project documentation by Blank & Jeron).

Modified webpages are stored in "The Shredder´s" archive. In contrast to the access to these files in "without addresses" a blue-white map offers a controlled access to the archive´s recently stored and transformed webpages. If a web participant moves the cursor over the map (without street names) partitioned in fields then the line in a text box changes. This text line consists of an IP address of the web participant and his entries.



Napier, Mark: The Shredder, 1998, web project (screenshot 2012).

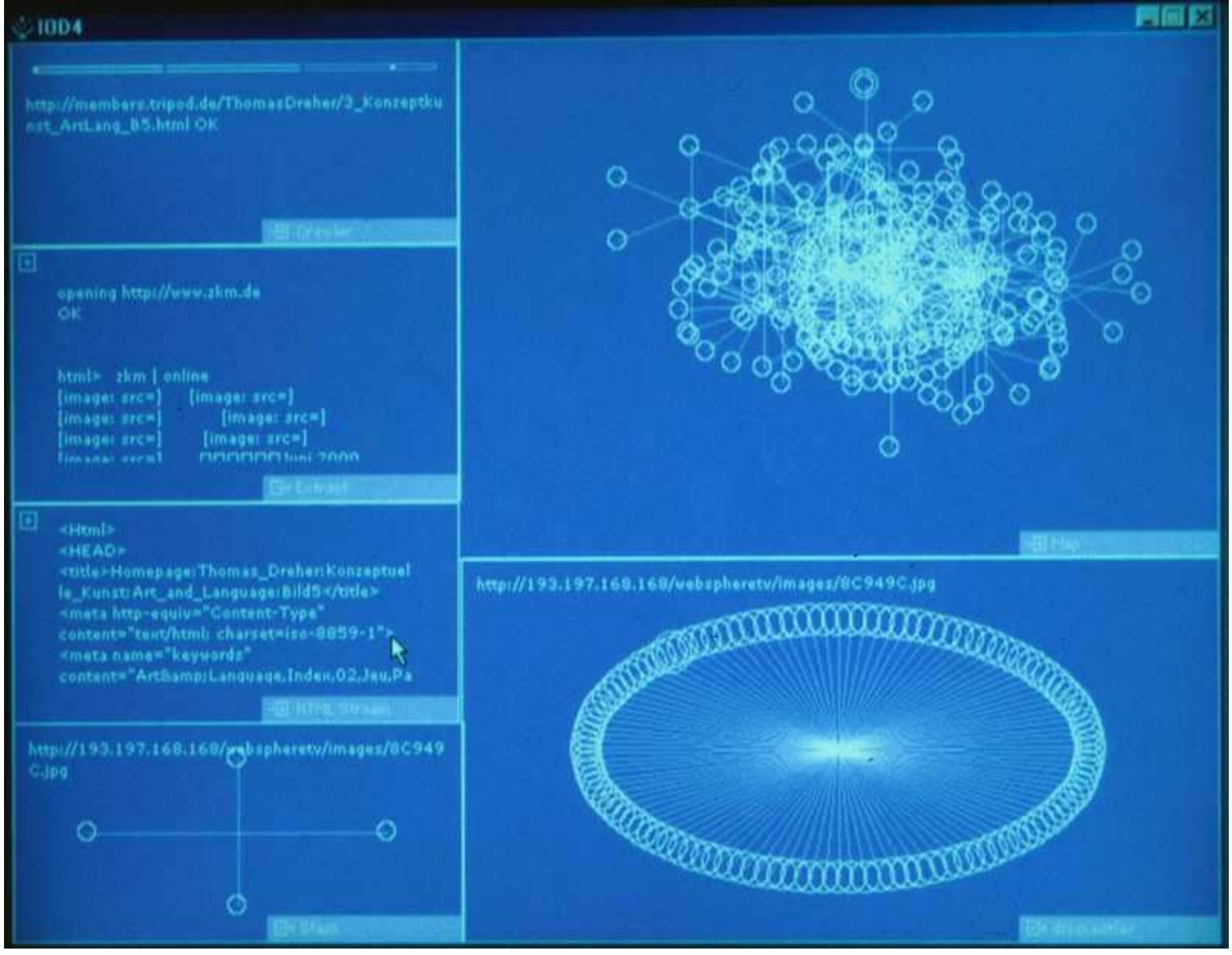
In "without addresses" the answers to the question "tell me who you are" are used to generate and store entries of the map fields´ virtual habitants. Mouse clicks on the map fields´ orange points open the files containing the informations on the virtual habitants.

The files generated by an algorithm using the input of web participants contain the pseudo-identities of a fictive town´s inhabitants.

"Without addresses" and "The Shredder" transform the lay-out of the found webpages. In "without addresses" the text found via search systems and transformed in a digital handwritten-like font overlies a picture taken from the source document. From the webpages being called up by net participants in entering URL addresses "The Shredder" shows on the top left side of the transformed webpage the links included in the source document as lines overlapping each other. This column presenting links overlies the images shown distorted and overlapping: With the measures of length and width the proportions of the images are changed. In these distorting manner the illustrations are integrated into the transformed webpage. The source code is shown in little and overlapping letters on the left column. Fragments of the source code appear in big letters in a second column moved to the right. These letters lay over the letters of the left column.

"Without addresses" and "The Shredder" use arbitrary documents called up in the net as basic materials for the computing processes controlled by algorithms. The results of the computing processes on servers controlled by Perl partially still allow to reconstruct the orignal elements. The two projects by Blank & Jeron and Napier demonstrate the relation between the source code and the browser presentation as depending on a modifiable technical configuration. The following projects add to the browsers for presentations of webpages alternative browsers presenting aspects of the data traffic.

Projects modifying webpages on the server side like Napier´s "The Shredder" are labeled as "art browsers" and distinguished from "browser art" like Shulgin´s "Form Art" (see chap. VI.3.2). 32 But then it is impossible to designate the alternative browsers as "browser art". The most obvious and in the following chosen way out of the resulting terminology confusion is to designate only projects as "art browsers" making alternative browsers available for download: Projects by Blank & Jeron and Napier modifying presentations within available browsers are not categorised as "art browsers".



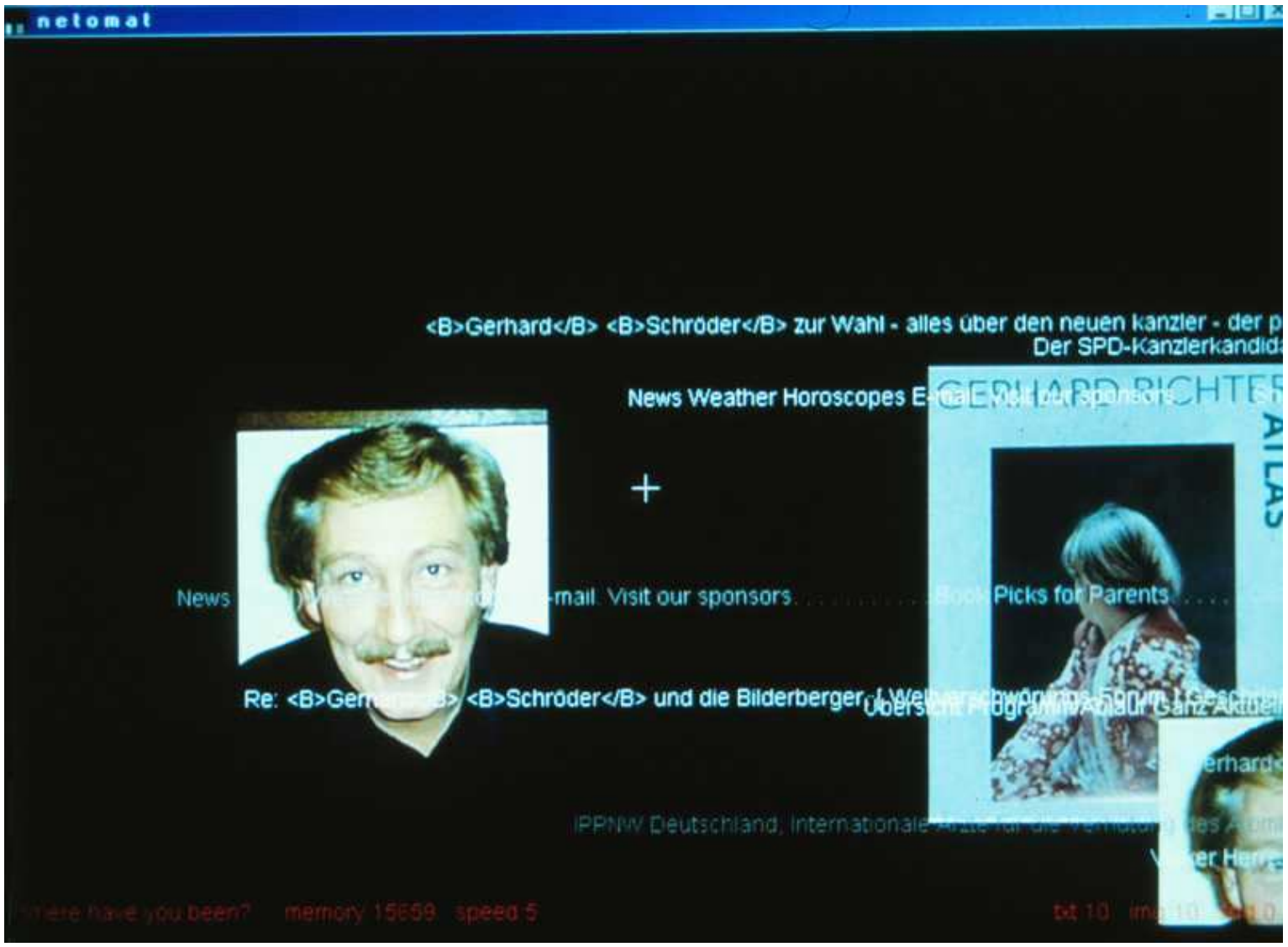
I/O/D: Web Stalker, 1997, browser (photo from the monitor, August 2000).

The art browsers "Web Stalker" by I/O/D (Matthew Fuller, Colin Green, Simon Pope, 1997) 33 and Maciej Wisniewski´s "Netomat" (1999) 34 thematise the data flow provoked by links and search systems. They addressed aspects not presented by the most used contemporary browsers (Internet Explorer, Netscape Communicator): the data traffic between servers initiated by the URL addresses in links. "Web Stalker" visualised the relations between linked webpages diagrammatically as an ongoing process capturing the documents from link to link via crawler, meanwhile in "Netomat" links of search systems are used to present the found files with their contents as a data stream of findings.

After the "Web Stalker" was downloaded and opened, a void, monochrome black or selectable purple or blue window appears. Users drag rectangles and correlate them with the functions described below. Each user cares for visual clarity in selecting the windows ´ functions, sizes and locations.

After the input of an URL address "Web Stalker" starts to look for the links of this webpage, then follows the links of the linked webpages, and so forth. A diagram ("Map") visualises this link structure as an ongoing computing process. Webpages are represented as circles and the links as lines. With the growing amount of links the circles become brighter. The "crawler" shows the URL address it is dealing with actually. A scale visualises how much of a webpage´s source code the "Web Stalker" has investigated. "HTML stream" presents the source code as a part of the dataflow grasped by the crawler and directed by the links from document to document. The "Dismantler" enables users to draw circles out of other windows (drag and drop). The "Dismantler" preserves the link structure of an URL address, as it is presented in the diagram with circles and lines. Users can select via clicks on circles the URL addresses indicated at the upper side of "Dismantler´s" and "Stash´s" rectangles. If such a circle is dragged into "Extract" then a

text is presented being the result of a readout of the source code and the computing processes initiated by this code. This text can be stored as .txt file. If circles are dragged into "Stash" then the URL addresses can be stored in a text file. These addresses can be copied and called up with an usual web browser.



Wisniewski, Maciej: Netomat, 1999, browser (photo from the monitor, October 2000).

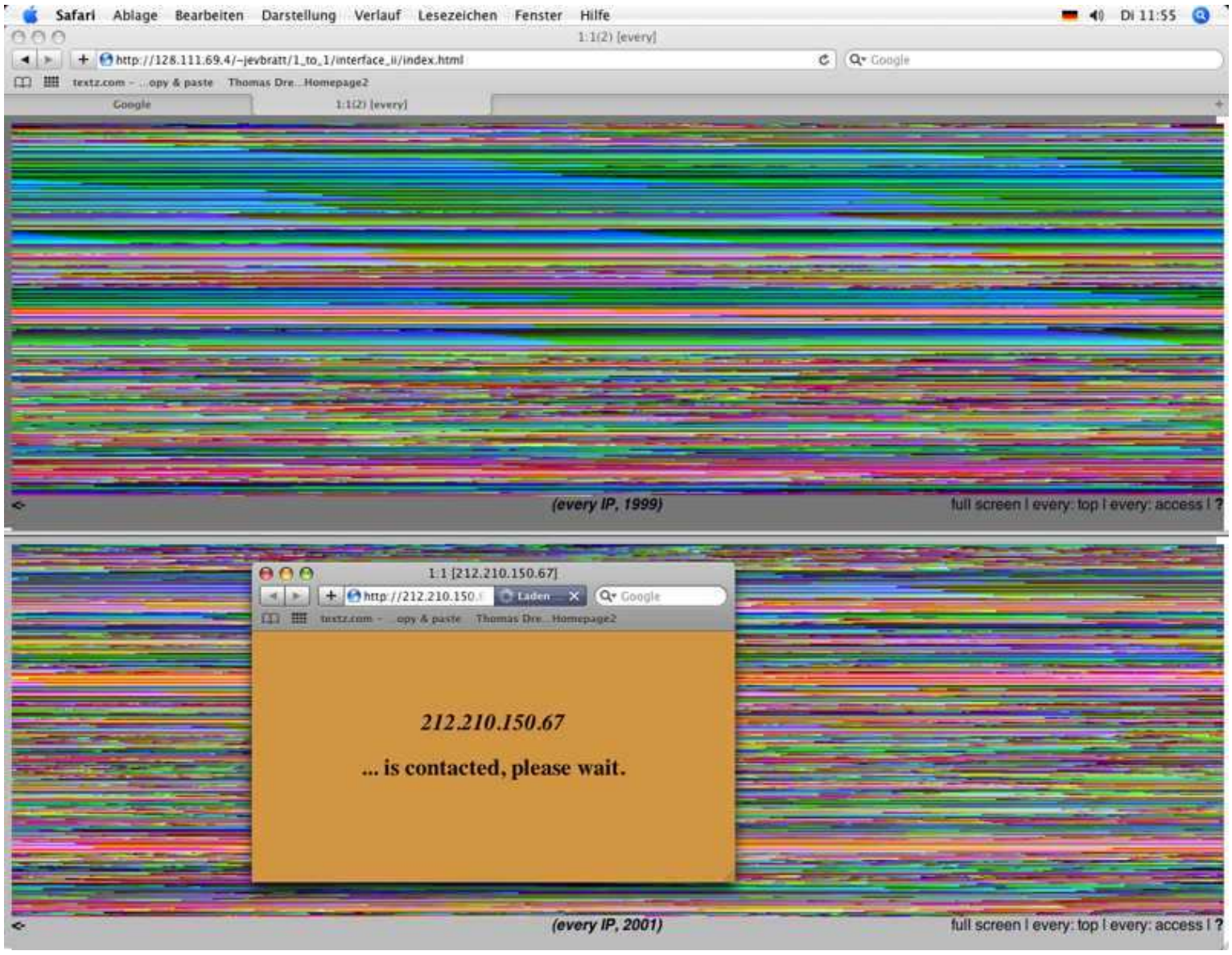
"Netomat" shows a data stream of images (ignored by the "Web Stalker") and text fragments. 35 If the "Netomat" is started after the activation of a web connection then the art browser begins its data access. In the browser window on the bottom right "Netomat" informs how many text, image and sound files are activated. The direction and speed of the data flow on the browser presentation can be modified with cursor movements. If the cursor position is directed from the centre to an edge then the presentation of the data stream is accelerated. The flow direction changes contrary to the cursor movements. A text input in the bottom line starts a new data stream after the Enter key is pressed. Because the memory function can´t be stopped the files indicated in elder data streams don´t disappear after the start of a new stream. Appearing text fragments can supply suggestions to further text inputs provoking the integration of new documents in the visualisation of memorised elements.

Wisniewski prevents directed data access. Text input causes surprise findings without enabling users to select elements out of the data stream and to recontextualise them: The browser surface presenting the data stream does not contain click functions.

"Netomat´s" use of documents found in the web dissolves the data constellations being defined by the source codes for the browser presentations of webpages: Texts are fragmented and pictures isolated. The "Netomat" substitutes the usual browser presentation of static webpages by the presentation of a data flow. This flow doesn´t loose its character to pass found web documents over to the user while he is tipping further text fragments: The surprising findings – the images and texts – can´t be

substituted by results of a targeted search for specific topics.

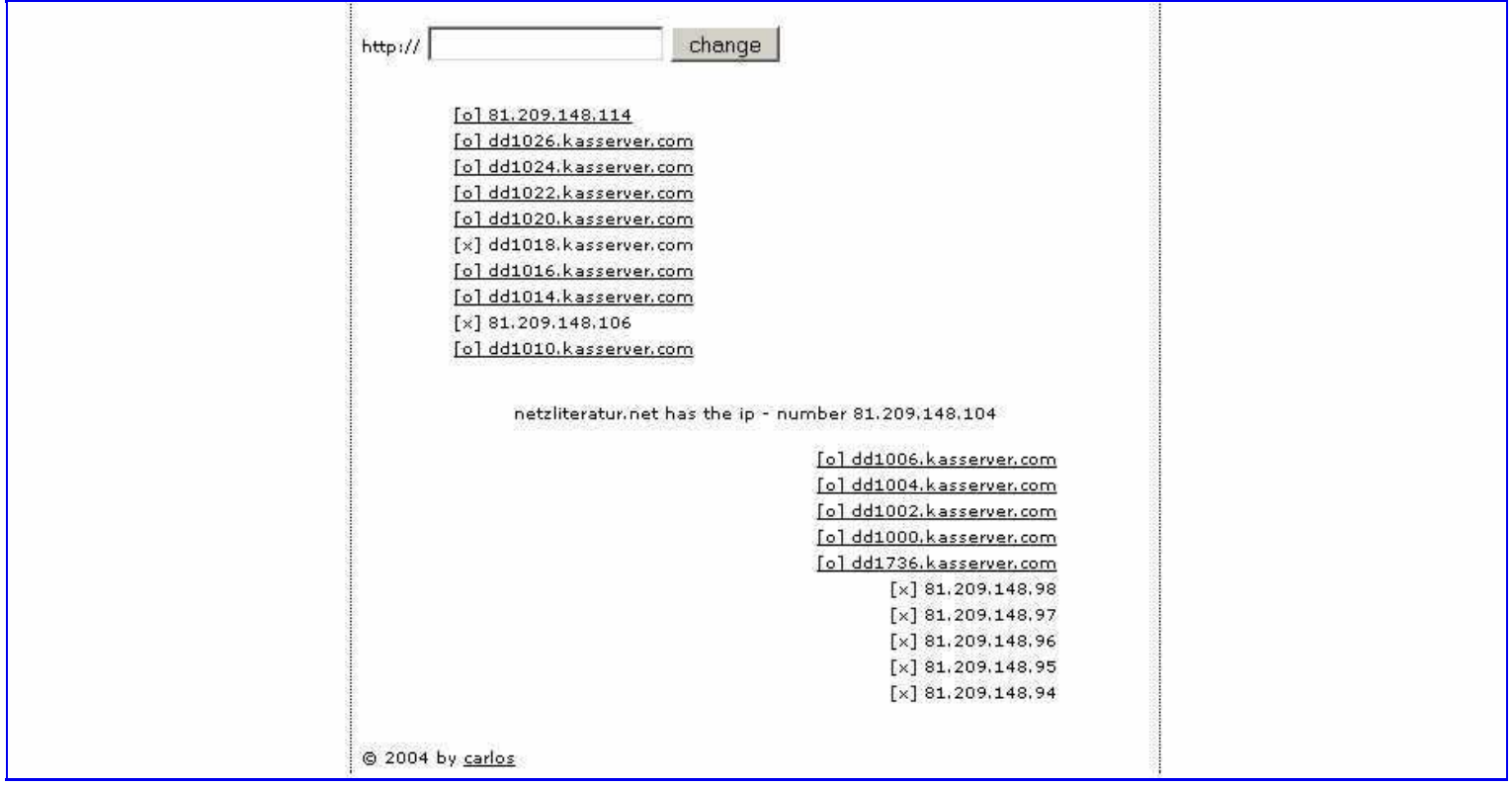
Instead of the "Netomat´s" exploration of the content of webpages, the "Web Stalker" visualises the dial-up progressing from link to link: The computing processes for the connection buildup cause progressing diagram configurations.



Jevbratt, Lisa: 1:1, every IP, 1999, 2001-2002, web project (screenshot 2009).

The web as an expanding archive of files linked to each other is tapped by the "Web Stalker" only partially starting with an URL address chosen by a web participant. Lisa Jevbratt´s 1:1 (1999, actualised in 2001-2) visualises the IP addresses of homepages found by crawlers. The overview demonstrates a Web 1.0 with an amount of websites that could seem to be not too big for a data visualisation of them all. Nevertheless in 1999 a crawler needed too much time to capture all available IP addresses of homepages. A crawler of the artists´ group C5, with Jevbratt as its member, gathered "two percent of the spectrum and 186,100 sites were included in the database." 36 In Jevbratt´s visualisations of the accessable homepages, for example in "every IP", the clarity of the visual arrangement and its combination with functionality (the links to the webpages) suffer from the mass of found IP addresses.

DNS servers translate the URL addresses of websites in IP addresses (see chap. VI.3.1). Jevbratt´s visualisations present the IP addresses of homepages as a dataspace with its own `geography´: The IP addresses with 10 numbers make it possible to define `distances ´ – close and distant relations – between them.



Katastrofsky, Carlos: Area Research, 2004, web project (screenshot 2007).

The projects "Neighbourhood Research" and "Area Research" (2004) by Carlos Katastrofsky (Michael Kargl) thematise the proximity or distance of IP addresses in searching for nearby IP addresses to the URL addresses inputted by web participants. In Katastrofsky´s projects the process of searching can be repeated by the input of further URL addresses, meanwhile Jevbratt visualises the results of two finished crawler actions (1999, 2001-2). The projects by Jevbratt and Katastrofsky complement the aspects of web data traffic shown by the art browsers "Web Stalker" and "Netomat".

The art browsers "Web Stalker" and "Netomat" are yielding for experimental more than for instrumentalising and target-oriented observation-manners. Aspects of the semantic web (as a vocabulary used by humans in speach acts and connected to semantic fields) are of primary importance in collaborative writing projects with databases as stores for contributions (see chap. VI.2.3), meanwhile the art browsers show technical procedures. The two levels of information in a technical and semantic context thematised in cybernetics (see chap. II) and information aesthetics (see chap. III) remain important aspects of a "problematic". 37

VI.3.4 Net art, Context Art and Media Activism

The relation between cybernetic models (see chap. II.2) and cybernetic sculptures (see chap. II.3) can be understood as a prefiguration of the relation between models of a net practice and net art: Just as the cybernetics´ concept of models defines a relation between theoretical statements and a built model (model level 1) and demonstrates with it possibilities to artists how they can install machining processes gaining the status of models as exemplary realisations (models level 2), so the net art tries to realise a net practice being exemplary in a non-commercial information context as net activists defended it against hazards: The free information exchange in a deterritorialised data world becomes a model (model level 1).

In the web the term "art" does not signify a status declared by institutions and defined within discourses but a provision of models being technically successful as well as an offer for the observation of net conditions: They are models for an exemplary net practice (model level 2). Net activists feel themselves obliged to react to critical observations of

net conditions in demonstrating who how and with which interests determines these conditions or tries to change them. This causes net art to demonstrate the consequences of the confrontations of interests and power structures.

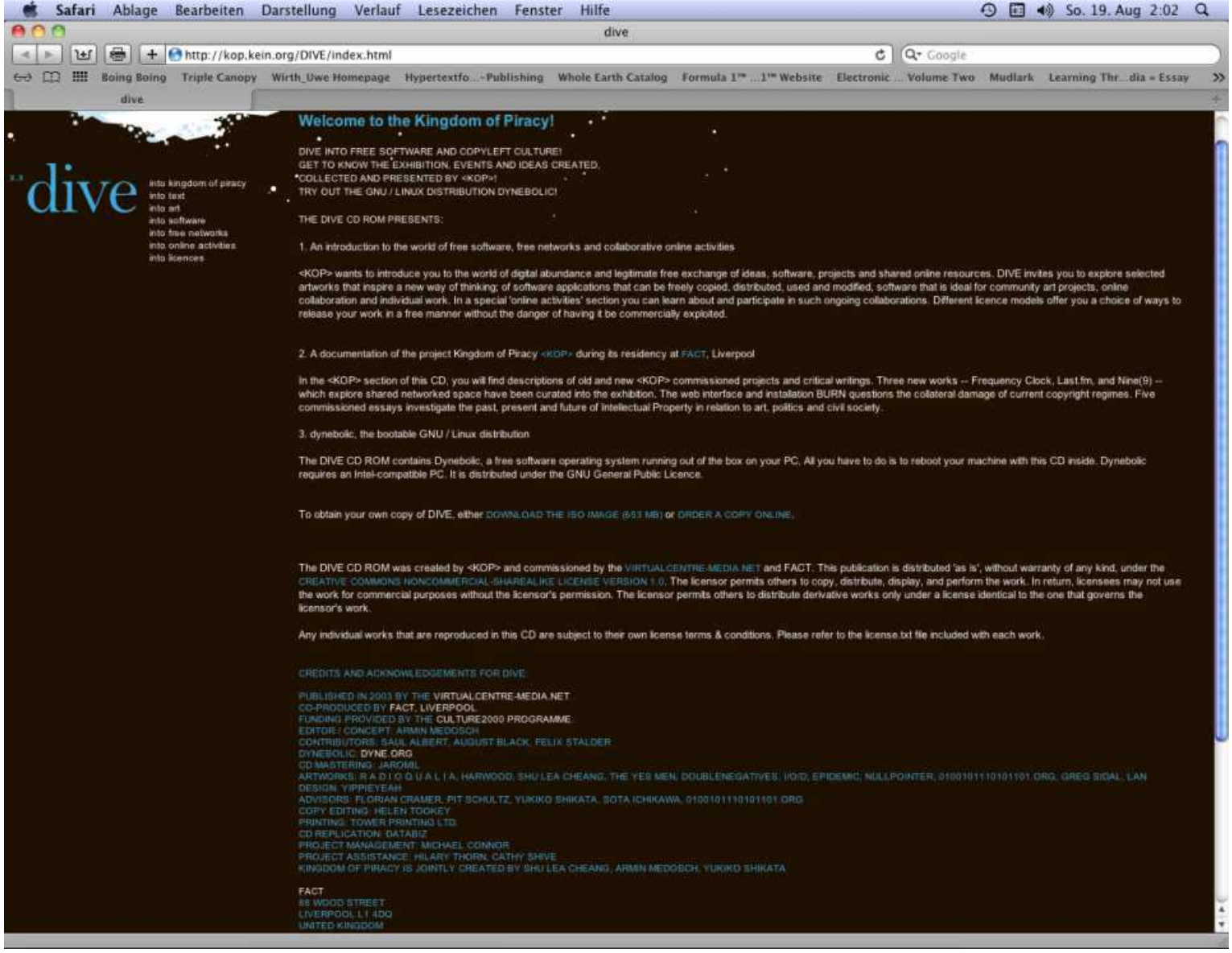
Collaborative writing projects (see chap. VI.2.3) and alternative browsers (see chap. VI.3.3) offer web practices provoking net observations (as reflexions). Either the daily routines of web participants calling up prepared unchangeable contents are questioned by models of participation, or the preconditions are created for critical observations of the net conditions being basic for the quotidian supply of documents.

In the context of the experimental video culture in the seventies Dan Sandin and Phil Morton extended the "Analog Image Processor" to an open platform for developers and provided with the "Copy-It-Right-Licence" an early example for Open Source and Open Content (see chap. IV.1). This open form to distribute products integrated artists of the demoscene in the eighties into their common ways to develop the programming of personal computers (see chap. IV.2.1.4.3) and to use later the internet´s possibilities for a no-cost distribution of their animation codes.

In comparison to elder media the web facilitates works-in-progress for the development of software (Open Source) or for the construction of knowledge systems (Open Content) meanwhile commercial oriented producers try to establish closed systems in the form of scarce and costly final products. On the one hand the barrier between producer and consumer vanishes in the gift economy, on the other hand this barrier is uphold by the distributors and salesmen. One of the effects of the web is a wider gap between the open source model with an unlimited distribution and a cooperative production on the one hand and, on the other hand, the commercial distribution models now augmented by e-commerce with a digital rights management based on software for copy-restriction mechanisms to be installed on the computers of the customers.

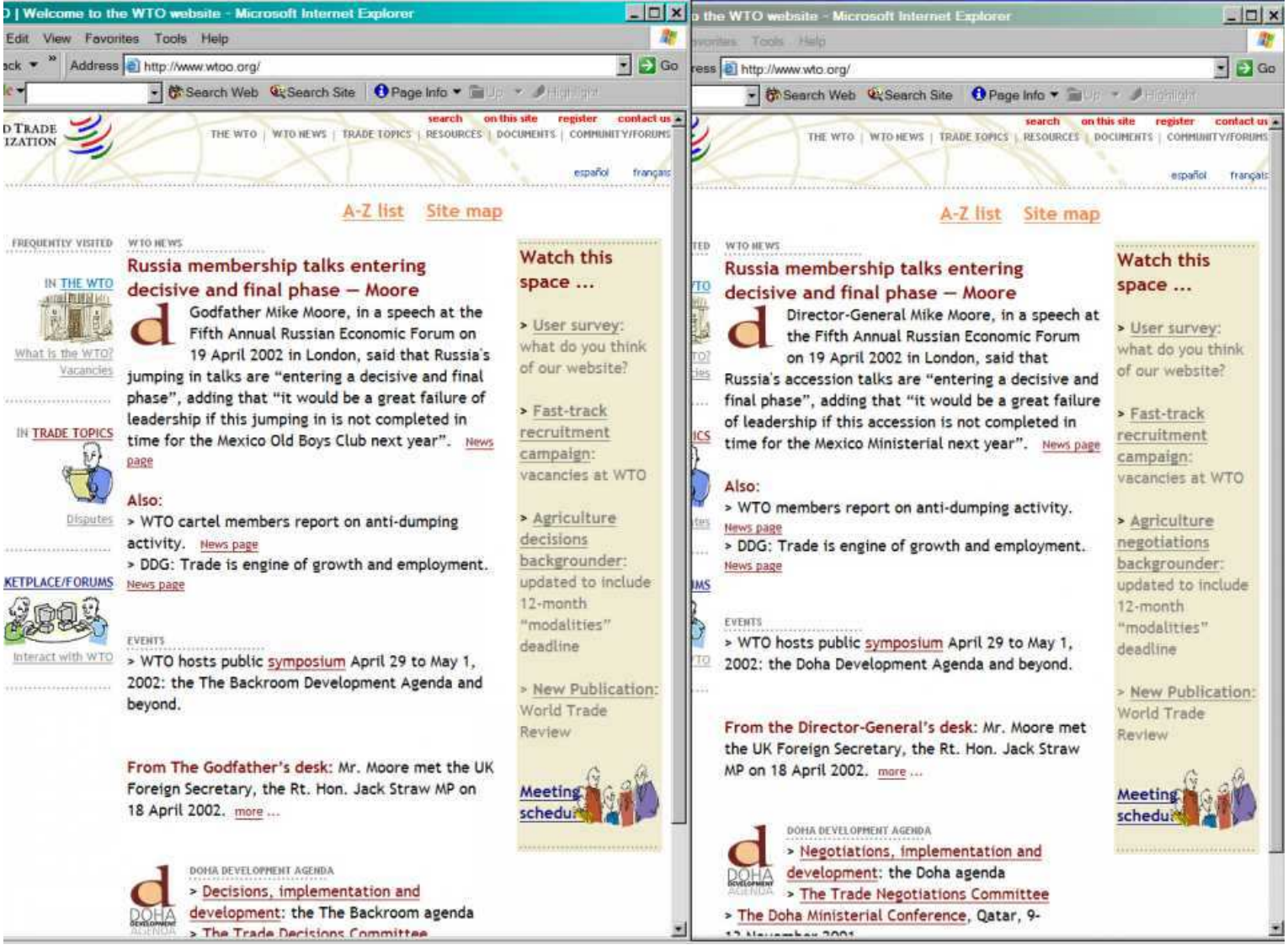
Since 1999 the relations between Open Source, Open Content and new distribution models were discussed on four Oekonux conferences. Richard Stallman, Eric Steven Raymond, Richard Barbrook, John Perry Barlow and Lawrence Lessig became in the eighties and nineties the most famous net activists writing on Open Source and Open Content.

In net activism restrictions for further developments of software and its distribution by copyright and patent laws were and are discussed as barriers blocking a free exchange of data and a cooperative development of software. This activism fights against economic, juridical and technical obstacles restricting a free data exchange. Platforms like "Illegal Art" (2002-6, now only parts of the original web contents are stored in the Internet Archive: sound, video) and "Kingdom of Piracy" (2002-6) show how artists thematise basic problems of web usage and their working conditions restricted by copyright and patent laws. The technical, economic and legal conditions for the accesses to data as well as for the downloads, modifications and distributions of files constitute an important part of net art´s context. If projects of net artists show web conditions in an exemplary manner and demonstrate the tensions between technical possibilities and restrictions by proprietary practices then the projects become either a part of net activism (Negativland/Tom Maloney, see below) or they transgress – for example by the provision of tools (model level 2) – the limits of art towards activism (The Yes Men, see below).



Medosch. Armin (Hg.): DIVE: An Introduction into the World of Free Software and Copyleft Culture, FACT in Liverpool, 2003, web plattform (screenshot 2012).

The comprehensive project "DIVE: An Introduction into the World of Free Software and Copyleft Culture" was integrated into the platform "Kingdom of Piracy". "DIVE" focuses on relations between software development and a free distribution (Open Source) without the restriction practices supported by copyright and patent laws. With "DIVE" "Kingdom of Piracy" became in 2003 the most comprehensive and most concise platform for relations between free software, net activism and net art.



The Yes Men/Detritus/Doll, Cue P.: Reamweaver Version 2.0, tool, 2002. Screenshot of the creation of a pseudo-mirror site of the World Trade Organization´s website.

One of the activistic projects of the platform was "The Yes Men´s Reamweaver". In 2002 Gladwin Muraroa of The Yes Men, Nickie Halflinger of Detritus and Cue P. Doll (Amy Alexander) developed "Reamweaver Version 2.0" with Perl. If the tool for automated modifications of sites was installed via FTP access on a server than it enabled web participants to create parodying pseudo-mirror sites (They seem to be a `mirror´ or the copy of a site with another URL address but with their modifications they comment the copied sites). "Reamweaver" was launched by RTMark and supported by interested web participants. 38 Fakes of the World Trade Organization´s (WTO) site are examples of the tool´s uses. 39 When critical pseudo-mirror sites are censored then "Reamweaver" enables web participants to create in a short time-span new counterfeits with further critical and parodying statements.



First page of a two-page invitation of the Media Tank to "Illegal Art Extravaganza", the special events to the travel exhibition "Illegal Art: Freedom of Expression in the Corporate Age", Old City´s Nexus Gallery, Philadelphia 2003.

Carrie McLaren, editor of the "Stay Free Magazine", curated the travel exhibition "Illegal Art: Freedom of Expression in the Corporate Age". The exhibition and its site presented many examples from art, film and music showing repetitions and modifications of copyright protected sources. Legal protection was provided by the Chilling Effects Clearinghouse. In this association the Electronic Frontier Foundation and the law schools of five American universities collaborated (Berkman Center for Internet & Society/Harvard University, Stanford Center for Internet & Society, Samuelson Law/Technology and Public Policy Clinic, University of California, University of San Francisco Law School, University of Maine School of Law).

The copyright does not protect authors against the exploiters of their rights. Rather the copyright is used by exploiters as a means to establish connections between the exploit of rights and jurisdiction in a strategically calculated manner disempowering authors (Links to the webpage "Copyright Articles" connected to texts about abuses by the copyright industry).

The website of the exhibition presented film extracts, animations, musical works and artworks in different media – partially with their history of jurisdiction: Some lawsuits were not completed by a judgement in the time of the travel exhibition´s presentations. The complaints ("cease-and-desist-orders") of the copyrights´ owners and exploiters disregard often "Fair Use" (see below), nevertheless the defendents frequently relent before a lawsuit starts because these lawsuits last long and the financial expenses are high.

The curator´s intention was to present to a broad public the misuse of the copyright as a restraint of artistic creativity instead of its protection 40 and to disturb the copyright industry´s lobbying and accusatorial practice. The exhibition offered to authors of newspaper reports an occasion to discuss the perversion of the copyright into a Corporate Right. 41 Beside the San Francisco Museum of Art no other museum with a wider collection of 20th century art exhibited "Illegal Art", even though they are affected by the effects of an accusatorial practice disregarding "Fair Use": Neither Marcel Duchamp´s L.H.O.O.Q. (1919) nor Pop Art could be created under contemporary legal relationships.

The copyright industry stigmatises takeovers of some parts of an art work protected by copyright as piracy, as intellectual property theft. "Illegal Art" exhibits examples of the ways artists use procedures to copy and quote with – mostly ironic – defamiliarizations or alienations. This "recombinant theater" 42 parodies and comments the contemporary mass culture by its manners to pick specific objects up. The technical possibilities of precise digital copies without losses in quality are used in procedures of appropriation and modification to articulate criticism of the mass media´s spectacle organisation. Procedures of quotation, plagiarism and transformation are used for an unveiling, exaggerating or alienating criticism of economic and social conditions; takeovers "for purposes such as criticism, comment..." permits the "Fair Use Doctrine" of the US law. 43 Entertaining modes of recycling and activistic-critical recombining strategies are (combinable) takeover practices to intervene in strategies of the copyright industry (corporations and their lawyers) to control the use and distribution of the mass culture´s signs. On this point we are faced with artistic and activist (re-)appropriations.

The website of "Illegal Art" itself was an example for the procedures of a "communication guerilla" 44 using strategies of (re-)appropriation ironically: When the homepage was opened then a window started presenting the following text: "ELECTRONIC END USER LICENSE AGREEMENT FOR VIEWING ILLEGAL ART EXHIBIT WEBSITE AND FOR USE OF LUMBER AND/OR PET OWNERSHIP". As soon as a reader of this parody of a license clicked on "I agree" then the contract and the homepage disappeared.

"Illegal Art" was conceived as a plea for an extension of the "Fair Use Doctrine´s" applicability. This extension is a conclusion drawn from the practices of the (re-)appropriation culture. Negativland outlined applications of the "Fair Use Doctrine" being adequate from their point of view:

> ...we would have the protections and payments to artists and their administrators restricted to the straight-across usage of entire works by others, or for any form of usage at all by commercial advertisers. Beyond that, creators would be free to incorporate fragments from the creations of others into their own work. 45



Negativland/Maloney, Tim: Gimme the Mermaid, film, 2000/2002.

Negativland and the former Disney film animator Tim Maloney assembled different sources in creating Gimme the Mermaid (2000/2002, an exhibit of "Illegal Art") as a comment on the behaviours of owners and administrators of copyrights. Copyrights protect properties and property is an important part in an economic-based power structure: Copyrights save property and property is power. A telephone voice of a lawyer for the music industry was visualised as the speech of the mermaid Arielle (the figure was a part of a Disney production) and was set to music in creating a cover version of Black Flag´s Gimme Gimme Gimme: "I own it or I control it...You can´t use it without my permission." The decision on the appropriation of a copyright protected "it" is not taken by the critic but by the criticized person: That´s the situation the "Fair Use Doctrine" should prevent. The barriers for the downloads and further processing created by one-sided interpretations of the copyrights and the "Digital Millenium Copyright Act" (DMCA) 46 threaten the net architecture created for free access.

Art forms and their distribution in legal, economic and media contexts determine each other. Because the production of art can´t be separated from production conditions as artists thematise them via critical self-embedding. If Tim Maloney shows the strategies of copyright administrators with the means the administrators tried to prevent then he needs a good defender. In "Illegal Art" the practice to bundle activist efforts is organised as legal assistance for artists creating test cases for legal proceedings. After the verdicts for or against the works featured in "Illegal Art" it is possible in comparable cases to anticipate future verdicts.

Annotations

1 Arns: Netzkulturen 2002, p.21s.; Berners-Lee: Web 1999, S.69,72ss.,79,97ss; Gere: Culture 2008, p.152s.; Warnke: Theorien 2011, p.49,52; Weiß: Netzkunst 2009, p.30s.
On the growth of the amount of users from 1995 to 2002 and the number of websites from 1993 to 2002: Matis: Wundermaschine 2002, p.312s.; Warnke: Theorien 2011, p.48s. Cf. Hyperakt/Vizzuality/Google Chrome Team: Evolution (2012): In 2011 2.27 milliard participants used the web. back

2 Berners-Lee/Cailliau: WorldWideWeb 1990. back

3 Berners-Lee: Web 1999, p.33-37. back

4 Berners-Lee: Web 1999, p.28-31,38-45. back

5 Browser "WorldWideWeb": Berners-Lee: Web 1999, p.45s.; Berners-Lee: WorldWideWeb Browser o.J.; Matis: Wundermaschine 2002, p.311; Wikipedia: WorldWideWeb 2012.
Other browsers: Berners-Lee: Web 1999, p.56s.,64,67; Matis: Wundermaschine 2002, p.315s. back

6 FTP: Warnke: Theorien 2011, p.36.
TCP/IP: Plate: Grundlagen 2012, chap. 11: TCP/IP; Warnke: Theorien 2011, p.43-46,51. back

7 Bunz: Speicher 2009, p.100-106; Kahnwald: Netzkunst 2006, p.49s.; Plate: Grundlagen 2012, chap. 11: TCP/IP; Weiß: Netzkunst 2009, p.37ss.,41s. back

8 HTTP V 1.0: Request for Comments/RFC 1945. Warnke: Theorien 2011, p.86-90. back

9 Since 2002 defined in RFC 3305. Precursor: RFC 1630, 1994 and others. Executing scientists: W3 Consortium/IETF (Berners-Lee: Web 1999, p.36s.,39s.). back

10 Warnke: Theorien 2011, p.64; Weiß: Netzkunst 2009, p.36. back

11 Postel: Domain 1983 (RFC 881); Warnke: Theorien 2011, p.62-76; Weiß: Netzkunst 2009, p.33-36.
Censorship with DNS filter, an example: Dreher: Link 2002-2006, chap. ODEM. back

12 Berners-Lee: Web 1999, p.41s.; Palmer: History undated; WWW Consortium: HTML 1992. back

13 Berners-Lee/Connolly: Hypertext 1995 (RFC 1866). back

14 Berners-Lee: Web 1999, p.42 (quotation),41-44. back

15 XHTML 1.0, January 2000, reformulation of HTML 4.01: WWW Consortium: XHTML 2000/2002. back

16 Warnke: Theorien 2011, p.96s.; Weiß: Netzkunst 2009, p.50.
back

17 Berners-Lee: Web 1999, p.42. back

18 "Dictatorship of the beautiful appearance"/"Diktatur des schönen Scheins": Stephenson: Diktatur 2002 (German title of Stephenson: Beginning 1999).

In a lecture Holger Friese demonstrated the recognizable traces of the "Großes Data Becker Homepage Paket": "Das kleine Homepagepaket", shift e.V., Berlin, 1/23/1999 (Dreher: Unendlich 2001). back

19 Friese: Selection 2008, p.24s. back

20 Friese: Artworks 2008.
Lit.: Dreher: Unendlich 2001; Rinagl/Thalmair/Dreher: Monochromacity 2011; Vannucchi: Friese 1999. back

21 Berry: Thematics 2001, p.84s.; Cramer: Discordia 2002, p.71,75,78; Cramer: Statements 2011, p.235ss.,243; Greene: Internet 2004, p.40s.; Kerscher: Bild 1999, p.110. back

22 Lialina and a filmmaker at Moscow´s film club "CinePhantom". Further pictures are based on stills "from the Hollywood film `Broken Arrow´" (Baumgärtel: [net.art] 1999, p.129). back

23 Simanowski: Hypertext 2001, part 4; Simanowski: Interfictions 2002, p.95s. back

24 Compare the opposite explanations of the relation frame – narration by Julian Stallabrass and Roberto Simanowski: According to Stallabrass the observers click "through screens without orientation" (Stallabrass: Internet 2003, p.58s.), meanwhile according to Simanowski the "reading process follows the [narrative] linearity fairly close" (Simanowski: Interfictions 2002, p.93. Cf. Berry: Thematics 2001, p.80ss.; Manovich: Language 2001, p.324s.). back

25 With scripts developed by Laszlo Valko. Lit.: Greene: Internet 2004, p.80s. with ill.54; Weiß: Netzkunst 2009, p.203-235, 375ss. back

26 Greene: Internet 2004, p.42s. with ill.23. back

27 Heath Bunting repeats the text of the following newspaper article: Flint, James: The Power of Disbelief. In: The Daily Telegraph, 4/8/1997 (on Heath Bunting). Lit.: Arns: Netzkulturen 2002, p.67s.; Arns: Readme 2006; Berry: Thematics 2001, p.196-199; Greene: Internet 2004, p.42-45; Heibach: Literatur 2003, p.110s.; Stallabrass: Internet 2003, p.29s. back

28 Dreher: Radical Software 2004, chap. Electronic Disturbance: Tools, Sites & Strategien. back

29 "Toywar": Arns: Netzkulturen 2002, p.62-65; Arns: Toy 2002, p.56-59; Drühl: Künstler 2006, p.283-293; Greene: Internet 2004, p.125ss.; Grether: Etoy 2000; Gürler: Strategien 2001, chap. Toywar; Paul: Art 2003, p.208s.; Richard: Anfang 2001, p.213-223; Richard: Business 2000; Stallabrass: Internet 2003, p.96-101; Weiß: Netzkunst 2009, p.199,254-265; Wishart/Bochsler: Reality 2002. back

30 "Without addresses" is no longer stored on a web server. It was "programmed with Perl and Postscript. The resulting Postscript file was rendered to a GIF file in using pbmplus." (Karl-Heinz Jeron, e-Mail 8/15/2012, in German) Lit.: Blase: Street 1997; Dreher: Stadt 2000, chap. without addresses; Gohlke: Go o.J.; Huber: Browser 1998, chap. 4.1 Joachim Blank/Karl-Heinz Jeron: without addresses. back

31 "The Shredder" was programmed in Perl and Javascript. Lit.: Greene: Internet 2004, p.99ss.; Kahnwald: Netzkunst 2006, p.18s.; Napier: Shredder 1999; Napier: Shredder

2001; Simanowski: Interfictions 2002, p.151,161; Stallabrass: Internet 2003, p.47. back

32 Kahnwald: Netzkunst 2006, p.7-11. Cf. Galloway: Browser 1998; Simanowski: Interfictions 2002, p.165,151 (Simanowski labels "The Shredder" and I/O/D´s "Web Stalker" presented below as "art browsers"); Maciej Wisniewski in Hadler: Informationschoreographie undated: "The `Netomat´ is no longer a browser art but rather an art browser."
Overviews on alternative browsers were offered by the Browserdays being organised in different cities (Amsterdam, Berlin, New York) and in 2001 at the "Browsercheck" presented in Berlin at "raum 3" "under everyday conditions". back

33 "Web Stalker" was developed in Lingo, the programming language for Macromedia Director. Lit.: Baumgärtel: Browserkunst 1999, p.88,90; Baumgärtel: [net.art] 1999, p.152-157; Dreher: Politics 2001, chap. I/O/D: Web Stalker; Fuller: Means 1998; Gohlke: Software 2003, p.58s.; Greene: Internet 2004, p.78,84-87; Heibach: Literatur 2003, p.213s.; Kahnwald: Netzkunst 2006, p.16ss.; Manovich: Language 2001, p.76; Paul: Art 2003, p.118s.; Simanowski: Interfictions 2002, p.165s.; Stallabrass: Internet 2003, p.21,23,39,55,126; Weibel/Druckrey: net_condition 2001, p.276s.; Weiß: Netzkunst 2009, p.235-242. back

34 Dreher: Informationschoreografie 2000, chap. Netomat; Fourmentraux: Art 2005, p.86s.; Greene: Internet 2004, p.131; Heibach: Literatur 2003, p.214; Kahnwald: Netzkunst 2006, p.21s.,40s.; Manovich: Language 2001, p.31,76; Stallabrass: Internet 2003, p.126; Weibel/Druckrey: net_condition 2001, p.80s. back

35 In 2000 the author could not call up the sound files on Windows 98. According to Wisniewski it was possible to call the sound files with fast connections, meanwhile low connections required to deactivate the sound function. Wisniewski offers not any more the download of "Netomat" on netomat.net. Also the documentation offered by Wisniewski on this site is no longer available. back

36 Jevbratt: 1:1 2002. Cf. Jevbratt: Infome 2003, chap. abstract reality: "1:1 was originally created in 1999 and it consisted of a database that would eventually contain the addresses of every Web site in the world and interfaces through which to view and use the database. Crawlers were sent out on the Web to determine whether there was a Web site at a specific numerical address. If a site existed, whether it was accessible to the public or not, the address was stored in the database. The crawlers didn't start on the first IP address going to the last; instead they searched selected samples of all the IP numbers, slowly zooming in on the numerical spectrum. Because of the interlaced nature of the search, the database could in itself at any given point be considered a snapshot or portrait of the Web, revealing not a slice but an image of the Web, with increasing resolution." Lit.: Baumgärtel: [net.art 2.0] 2001, p.192-197; Munster: Media 2006, p.82ss.; Paul: Art 2003, p.181s. back

37 «Problématique»/"problematic": Althusser: Marx 1969, p.32,34ss.; Art & LanguageNY: Blurting 1973, p.68, Nr.282.
The data visualisation "Small Talk" (2009) by Use All Five, Inc. maps a social network ("Twitter") according to semantic critieria. back

38 RTMark: Reamweaver 2002: "The Reamweaver software...allows users to instantly `funhouse-mirror´ anyone's website in real time, while changing any words that they choose." back

39 From http://www.wto.org to http://www.gatt.org (8/5/2012) and to http://www.wtoo.org/ (12/14/2003, not found any more in 8/5/2012. Screenshot of the

creation with "Reamweaver" in the NETescopio database: URL: http://netescopio.meiac.es/ proyecto/ 0220/ reamweaver_ samples/ wtocompare.jpg (3/9/2014)). back

40 Heins: Progress 2003. back

41 F.e. Dawson: Art 2003; Lotozo 2003; Nelson: Exhibition 2003. back

42 Critical Art Ensemble: Disturbance 1994, Chapter 4. back

43 Without author: United States Code undated (Title 17: Copyrights, Chapter 1, Section 107). back

44 Autonome a.f.r.i.k.a. gruppe/Blissett, Luther/Brünzels, Sonja: Handbuch 1997/2001. back

45 Negativland: Fair Use undated. back

46 Without author: U.S. Copyright 1998. back

VII. Games
VII.1 Computer and Video Games

VII.1.1 Early Computer Games

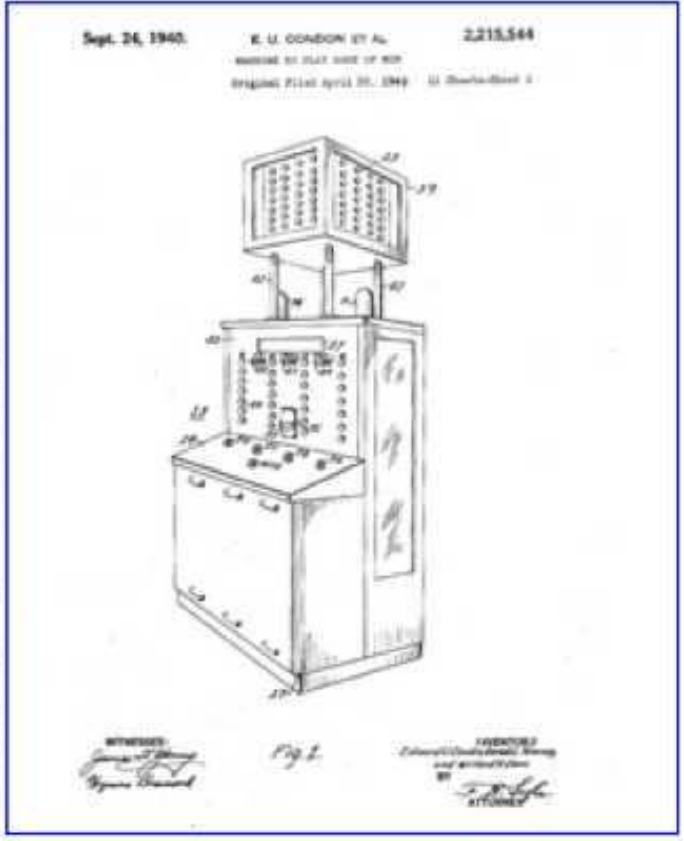
Since the beginning of the 16th century the game "Nim" is known in Europe. Two players alternate in their efforts to remove matchsticks from a series of matches. The players decide how many matches they remove. According to the agreement about the goal of the game each player tries either to cause or to prevent the situation to hold the last matchstick.

When in the thirties Patrick Michael Grundy and Roland Parcifal Sprague used Nim as a model case to investigate conditions of impartial games then they discovered independently from each other the Sprague-Grundy-theorem now fundamental to the mathematical game theory. 1 This model status exposed Nim beside chess: Both games offered points of departure for further far-reaching developments from which computer games emerged.

Since 1940 machine versions of Nim players were realised. They are variants of early electronic games processing a classic games´ set of rules (see below). The goal of the Nim machines was a reconstruction of the game logic. In the meantime, in 1948, inventors started with the "Cathode Ray Tube Amusement Device" (see below) 2 a development line constructing machines for the game action of hitting.

In 1940 Edward U. Condon, Willard A. Derr and Gereld L. Tawney received the U.S. Patent 2,215,544 for a Nim machine being able to play the two game strategies following the rules of either the "normal case" or the "reversed case" against a human competitor. In spring 1940 the machine called "Nimatron" was realised by the firm Westinghouse for the New York World´s Fair. "Nimatron" had a weight of more than a ton "and [the circuit] ma[de] extensive use of relays". 3





Condon, Edward U./Derr, Willard A./Gereld L. Tawney: Nimatron, 1940.
Left: Realisation by the Westinghouse Electric & Manufacturing Company, spring 1940, New York World´s Fair (source: The American Mathematical Monthly. Vol 49. January 1942, p.42ss.) .
Right: Illustration of U.S. Patent 2,215,544.

In 1948 Raymond Redheffer presented a Nim machine realised with "simple electrical circuits" weighing "about five ponds". The machine can not only be used to play with four rows of matchsticks but also for an arbitrary amount of them. According to Redheffer a precursor of this machine was just planned in 1941-42 for a realisation with relais. 4

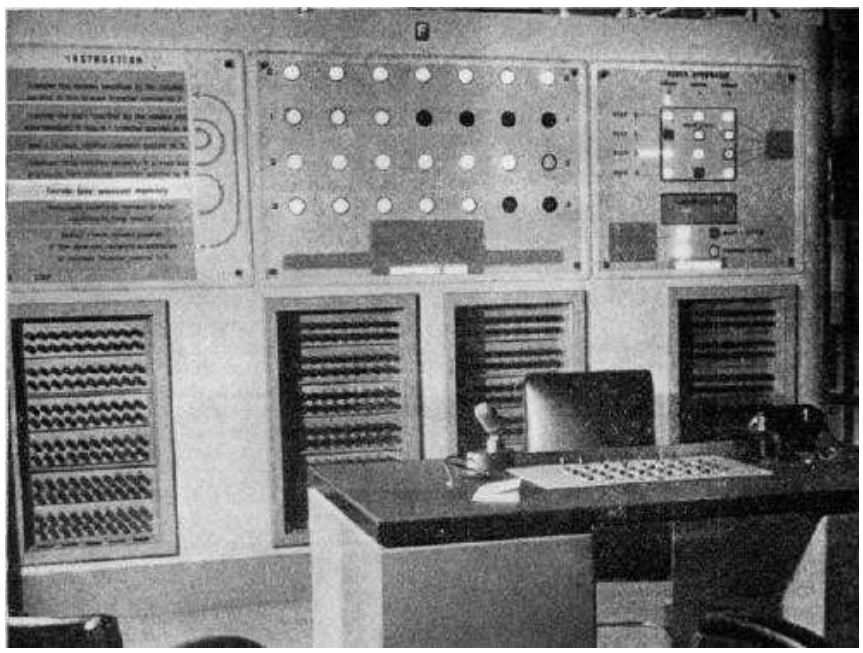


Redheffer, Raymond: Nim, box realised in using blue plexiglass, signed with "Raymond Redheffer MIT" (film by Mike Mozart, including some not quite correct informations according to the current level of knowledge). Screenshot from YouTube.

A box made with blue plexiglass was found at antique markets being signed with "Raymond Redheffer MIT" (Massachusetts Institute of Technology, Cambridge/Massachusetts). This box was named "Nim". This box seems to be one of the realisations of Redheffer´s concept.

When in 1951 the "Exhibition of Science" was a part of the "Festival of Britain" in London, then one of the exhibits was a game computer constructed by John Bennett and Raymond Stuart-Williams. The exhibition was installed in a new wing of London´s Science Museum in South Kensington. The Ferranti Nimrod was a digital computer consisting of 480 tubes to play Nim with a human competitor. A table contained buttons and lights to control computing processes. A demonstrator sat at this table turning his back to the computer, meanwhile a visitor sat at the other side of the table facing the front side of the Ferranti Nimrod. This front included three slabs with control lights: A list with the steps of the computing process (left), the score (center) and the computing processes for the rows of game elements (right) were displayed. 5





Bennett, John/Stuart-Williams, Raymond: Ferranti Nimrod, 1951.
Left: Industrial Exhibition, fair grounds, Charlottenburg/Berlin, opening day 6th October 1951, Federal Minister of Economic Affairs Ludwig Erhard (left bottom, at the centre) plays against Nimrod and looses three times (Borchers: Jahre 2001. Source of the images: Heinz Nixdorf MuseumsForum, Paderborn).
Right: Exhibition of Science, Science Museum, South Kensington/London, Part of the Festival of Great Britain, London 1951.

Within the exhibition parcours leading from physics, chemistry and biology to the outer space the computer was placed in the center of the fifth and last room. Jacob Bronowski wrote for the booklet of the exhibition:

> You are plunged headlong through these five rooms into the structure of matter, and are now ready to see, in a more leisure way, how we come to know about it. 6

The Ferranti Nimrod acts in the last exhibition space as an example for the "electronic brain". Beside the cosmic space, stars and lightbeams "which reach us from outer space" the "electronic brain" is mentioned as one of "a range of subjects from the electronic brain to the processes and structures on which life is based". 7

In a further booklet "NIMROD" the Ferranti Nimrod is compared with the mainframe computer Ferranti Mark I (1951, see chap. III.1) by the Manchester University. The booklet points to Ferranti Nimrod´s computing capacity to solve "quite complex

problems" despite its "small memory" in comparison to the mainframe computer. The digital Nim game is presented to demonstrate the computing capacities of the Ferranti Mark 1.

In the booklet on "NIMROD" the term "electronic brain" is explained as not useful because it provokes false expectations concerning autonomous thinking capacities of machines:

> [Automatic computers] do `think´ after a fashion but only in the manner that their designer and the person controlling the machine allow. 8

The Nim game presented a model of the mathematical game theory (see above) and it was used as a test case for the capacities of "automatic computers". 9

In the last space of the "Exhibition of Science" the imagination of a scientific cosmos was provoked by exhibits exemplifying games, mathematics, electronic calculation and cosmic space. As its contribution to the "Festival of Britain" the "Science Museum" offered to its visitors a parcours showing glimpses into the scientific cosmos. On its exhibition fairground at London´s South Bank the festival offered a collection of the best British achievements in industries, arts and sciences. Beside this exhibition area further exhibitions in areas within and outside London were installed.

The festival of achievements did not seek direct comparisons for example between Great Britain and the United States of America in cases like the machine-made Nim competitors Ferrant Nimrod and the little box developed at the MIT (see above).

In 1950 Claude Elwood Shannon presented guidelines of a chess program for computers. He explored ways to analyze chess and to use it as a precondition to develop a program. Because the possible moves were too many for the contemporary computing capacities Shannon proposed to reduce them so far that they still enable the program to unfold "a skillful game, perhaps comparable to that of a good human player." 10 Shannon explained the problems to be solved in programming:

> Our problem is to represent chess as numbers and operations on numbers, and to reduce the strategy decided upon to a sequence of computer orders. 11

In 1951 Dietrich G. Prinz developed a chess program for the Manchester Mark I (since 1949) analysing all possible moves. Because of the computer´s limited memory capacity the program could not solve more than some of the problems a player has to solve if a checkmate is possible in two moves. The computing with the program needed more time to find a solution than a human player. 12

In 30th July 1951 a program for a checkers game, developed by Christopher Strachey, was installed on the Pilot ACE of the National Physical Laboratory in Teddington/Middlesex (1950-55, see chap. III.1.2). But the memory capacity of this mainframe computer was too small. In consequence, Strachey rewrote his program of a checkers game in October 1951 using the machinic game of the Manchester Mark I, the precursor of the Ferranti Mark I. 13

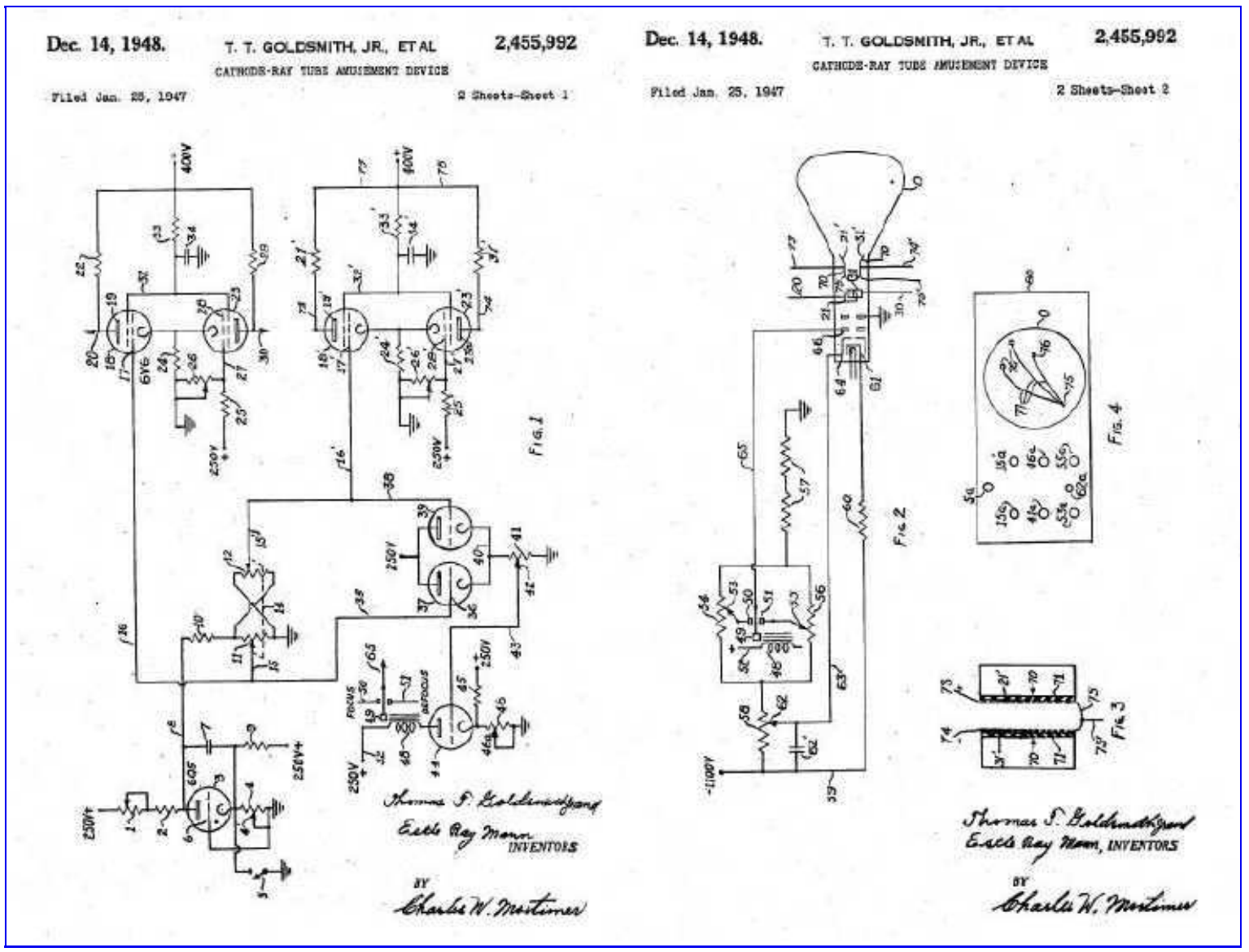
The programs and machines presented above are a part of the video and computer games´ prehistories. The presented games take up characteristics of elder games like the logics of rules structuring the progression of plays. Apparently in the English context of the Manchester University and Ferranti Ltd. as well as in the U.S.A. at the MIT (Redheffer´s employer) and at the Bell Telephone Laboratories (Shannon´s employer) scientists treated problems of programs for games as if they were solvable tasks.

Shannon wrote about the significance of chess programming:

> Although perhaps of no practical importance, the question is of theoretical interest, and it is hoped that a satisfactory solution of this problem will act as a wedge in attacking other problems of similar nature and of greater significance.

Games offer developers test cases to be used in the creation of "modern general purpose computer[s]". So for Shannon chess was sufficiently complex and in its structure with goal-oriented steps it was particularly suitable for the exploration of the "digital nature of modern computers". 14

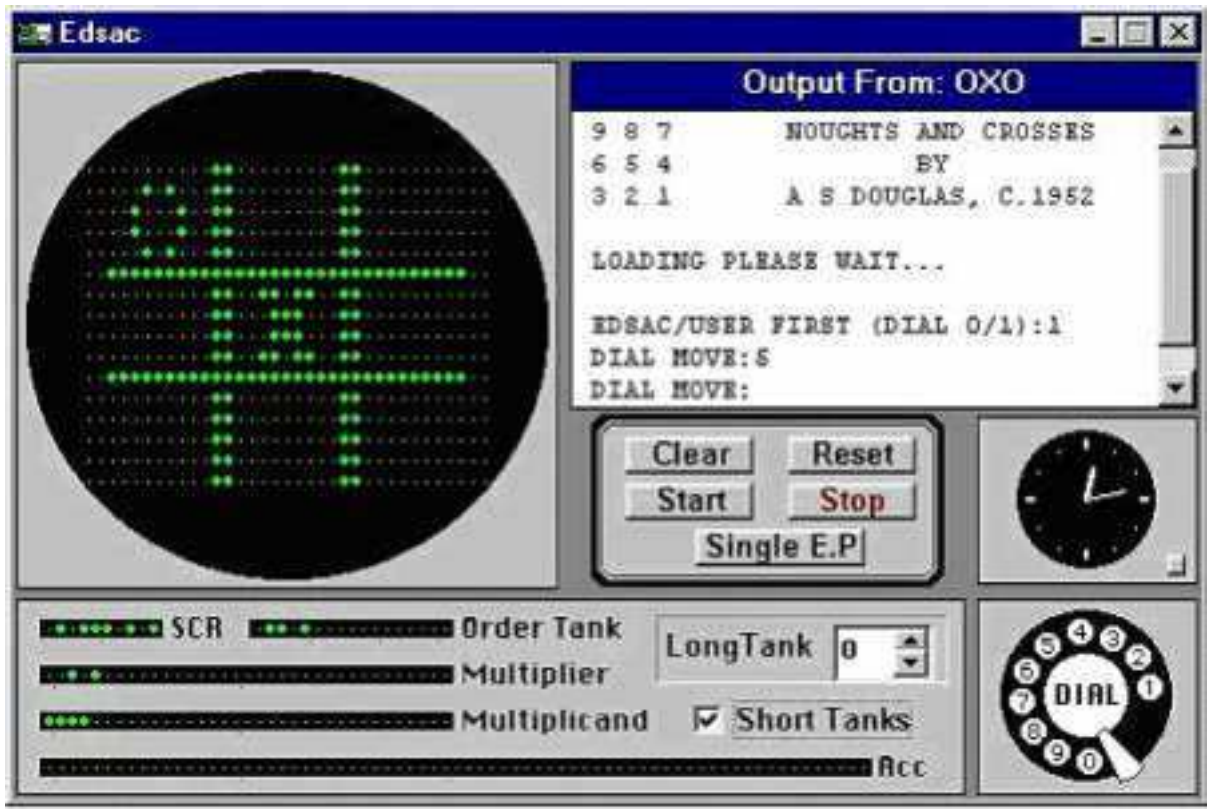
In 1948 Thomas T. Goldsmith Jr., Cedar Grove and Estle Ray Mann received the U.S. Patent #2,455,992 for their invention of a "Cathode Ray Tube Amusement Device". This never realised device was designed to change the course of a point on a cathode ray tube via knobs. The moving point should constitute a curved line and the knobs should serve to navigate the point to a target. The target should be marked by an overlay on the tube: For a player the moving point should be a bullet hitting or missing a plane. The "Amusement Device" was already a concept for a shooting game. 15



Goldsmith Jr., Thomas T./Grove,Cedar/Mann, Estle Ray: Cathode Ray Tube Amusement Device. U.S. Patent #2,455,992. 1948, Sheets 1 and 2, fig.1 - 4.

At the University of Cambridge (Cambridge/Cambridgeshire, England) Alexander S. Douglas wrote a doctoral thesis on the human-machine interaction. In 1952, as a demonstration of his thesis, he developed a program to play "Tic Tac Toe" on the mainframe computer EDSAC (Electronic Delay Storage Automatic Calculator, Mathematical Laboratory, University of Cambridge, since 6th Mai 1949). EDSAC´s three cathode ray tubes (with 35 x 16 pixels) presented the game with its basic division in

nine fields. With a telephone dial the fields could be marked with "X" or "O" on a rotational basis by the player or the computer. When a player or the computer succeeded to set his or its mark in three fields beside each other – in a horizontal, vertical or diagonal order – then the winner of the game was found. [16]



Douglas, Alexander S.: Tic Tac Toe, 1949, game for the mainframe computer EDSAC (illustration: Tic Tac Toe in the EDSAC Emulator).

Contrary to the patent by Goldsmith, Grove und Ray (see above) Douglas´ game is not an electronic game with new rules. Nevertheless the development of computer games containing the monitor presentations as an important part of the interface (as the access of the player to the game system) started in 1949 with Douglas´ version of "Tic Tac Tow". After the rules and moves of classical games have been programmed the next important step in the evolution of computer games was to develop games for monitor presentations.

The nuclear physicist William Alfred Higinbotham was the director of the Instrumentation Division at the Brookhaven National Laboratory in the U.S. Department of Energy (DOE, Upton auf Long Island). For the visitors´ day at 18th October 1958 Higinbotham invented an exhibit provoking visitors to interactions. With his object he reacted to the lack of interest "in static exhibits" as visitors demonstrated it in earlier public presentations. [17]



Higinbotham, William: Tennis for Two, 1958, Systron Donner Analog Computer, Germanium transistors, oscillograph (diameter: 5 inches), 2 boxes with turning knobs and press keys. Exhibited at the visitor´s day of the Instrumentation Division at the Brookhaven National Laboratory, U.S. Department of Energy, Upton/Long Island ("Tennis for Two" is presented enlarged in the wider circle. Image source: Brookhaven National Laboratory).

When reading the instruction book of a Systron Donner Model 30 analog computer (1954-60) Higinbotham found a description "how to generate various curves on a cathode-ray tube of an oscilloscope, using resistors, capacitors and relays. Among the examples...were the trajectories of a bullet, missile and bouncing ball all of which were subject to gravity and wind resistance." Higinbotham reminded the instruction book´s game ball of a tennis game. In constructing "Tennis for Two" he combined the little analog valve computer with an oscillograph (with a diameter of 5 inches) and two portable boxes, each of them with a turning knob and a press key.



Higinbotham, William: Tennis for Two, 1958, Systron Donner Analog Computer, Germanium transistors, oscillograph (diameter: 5 inches), 2 boxes with turning knobs and press keys. Screenshots from YouTube.

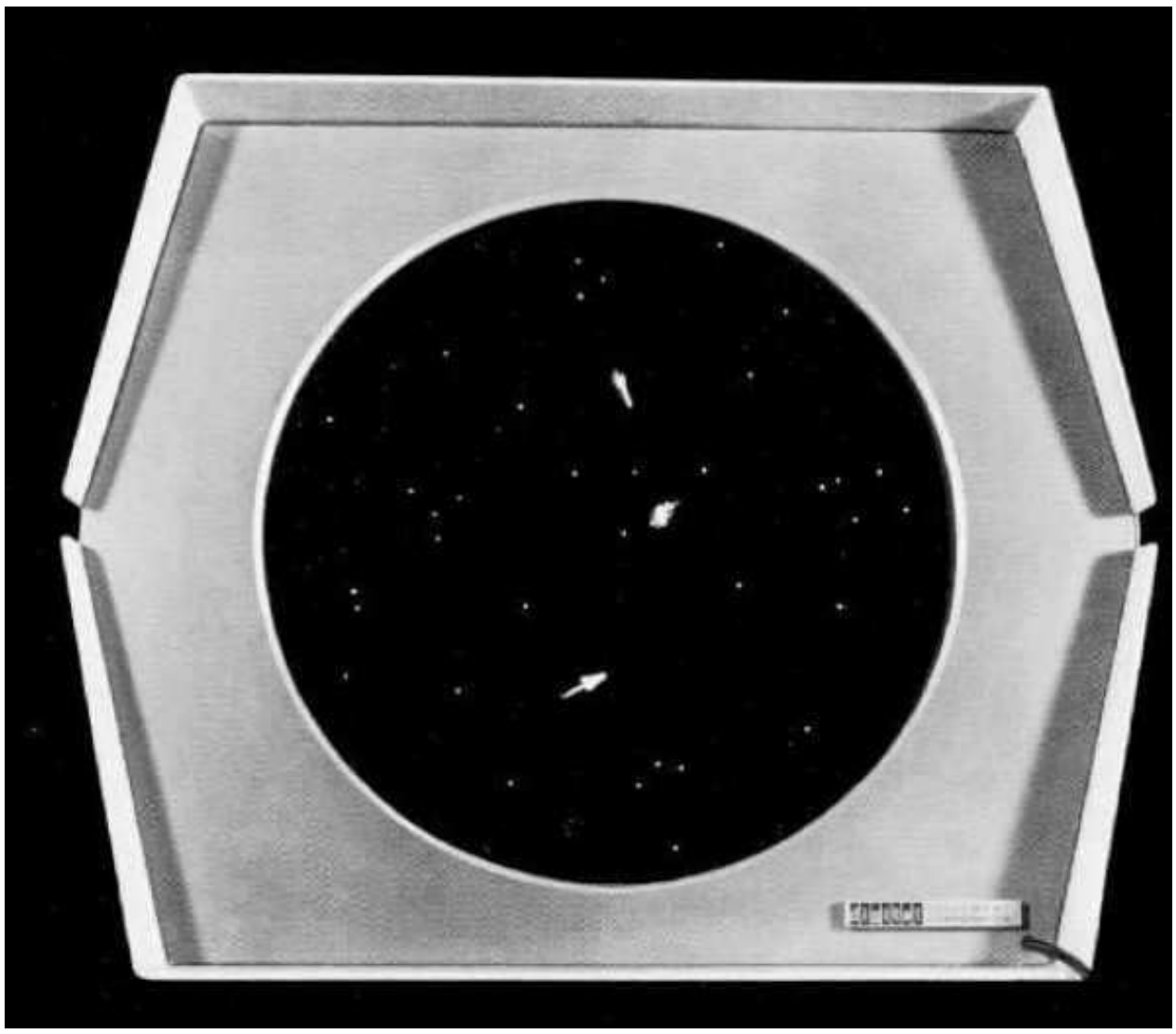
The oscillograph showed the vertical plan of a tennis court: A long horizontal floor line was interrupted in its middle by a short vertical line representing the tennis net. The players could influence the curve of a point in using the turning knobs on the boxes. The press key caused the racket to push the ball. The racket was reduced to a movable short

vertical line. The rackets appeared on both sides of the tennis court´s vertical plan. Higinbotham and Robert V. Dvorak, the executing "technical specialist", accelerated the moving parts with Germanium transistors. They were available only since recently:

> At that display rate, the eye sees the ball, the net, and the court as one image, rather than as three separate images. 18

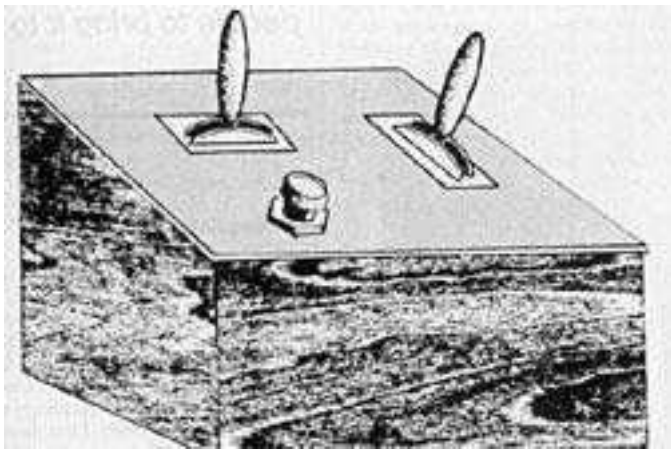
For "Tennis for Two" non-sporty games were selected no longer as a base, as it was the case in the development of former computer games´ programs (see the examples above), rather the idea of a point moving on a cathode ray tube – as it was anticipated in the patent by Goldsmith, Grove and Ray – was taken over for a reduced representation of a game play borrowed from sport. "Tennis for Two" was not yet able to record, store and indicate the score.

In 1961 J. Martin Graetz, Stephen R. Russell and Wayne Wytanen were employed in the Littauer Statistical Laboratory of the Harvard University (Cambridge/Massachusetts). According to Graetz´s report from the summer of 1961 he became acquainted with the transistor-equipped mainframe computer TX-0 (1955/56, developed at the MIT Lincoln Laboratory) at the MIT (Massachusetts Institute of Technology, Cambridge/Massachusetts) Electrical Engineering Department. Graetz got to know demonstrations realised for the TX-0 and its interface with a mouse, a console and a lighting pen. 19 These demonstrations inspired the development of a computer game´s programme for the minicomputer DEC (Digital Equipment Corporation) PDP-1 (since 1960) and its vector screen. In a room the PDP-1 was placed next to the TX-0. Alan Kotok, member of the TX-0 research group, as well as Dan Edwards and Peter Sampson, co-workers at the artificial intelligence research team, contributed to the development of "Spacewar!".



Edwards, Dan/Graetz, Martin J./Kotok, Alan/Russell, Stephen R./Sampson, Peter/Wytanen, Wayne: Spacewar!, 1962, computer game for the minicomputer PDP-1, screen with two spaceships.

In February 1962 the first version of "Spacewar!" was installed on the PDP-1. It consisted of two spaceships. Their forms presented on screens of cathode ray tubes are described by Graetz as "needle and wedge space ship outlines". The players used a knob on their "control boxes" to direct the rotation of the ships. 20 Beside the turning knob for the spaceship the box had a further turning knob with a double function: In moving the knob back the rocket was accelerated, meanwhile in pulling the knob forward the hyperspace function was started. Players could activate this function if they didn´t recognize another way to escape in fields anywhere between adversaries and the gravitational centre. The function could be used three times. After the escape the spaceship returned to arbitrary places on the playing field – in the worst case to the later developed gravitational centre (see below). The push button of the "control box" made it possible to start a torpedo consisting of small square points of light. This "torpedo" could be used to kill the adversary.



Edwards, Dan/Graetz, Martin J./Kotok, Alan/Russell, Stephen R./Sampson, Peter/Wytanen, Wayne: Spacewar!, 1962, computer game for the minicomputer PDP-1, console.

For a more interesting gameplay a gravity field was developed for the centre of the monitor and located in the area surrounding a star with flashing beams: Not moving spaceships were drawn into this centre of gravity.

The spaceships had to be moved to evade the projectiles of a competitor (who behaves like an enemy in the case of "Spacewar!") and not to be drawn into the centre of gravity. To reduce the necessary computing capacity the projectiles are not subjected to the forces of gravity. The authors tried to explain this absence of gravity with the makeshift explanation to connote projectiles as "photon bombs." 21

The statistics of points made it possible to limit the duration of a game to the time span necessary to reach a determined number of points.

At the end of April 1962 the second version of "Spacewar!" was installed. In May 1962 it was presented to the public at the day of the "Science Open House".

The Digital Equipment Corporation delivered the PDP-1 with "Spacewar!" as a program to be used to test the performance of the processor and the screen. 22

With "Spacewar!" the development of the computer games converged with the contemporary technology of minicomputers: The pioneer of minicomputers was the DEC PDP-1 being delivered since 1960. "Spacewar!" is the first shooter game for a monitor display, and its interface prefigures joysticks.

In the seventies the commercially successful successors of the shooter game consisted of simplified game systems (see chap. VII.1.2). The distribution of "Spacewar´s" game

system as open source code points to another cultural context as the one of the entertainment industry determining the development of the video games (see chap. VII.1.2). 23

VII.1.2 Arcade Games and Consoles

In the fifties and sixties games for mainframes and minicomputers were only able at public demonstrations to reach an audience larger than the circles of academic experts trained in the use of computers (see chap. VII.1.1). In the seventies the "arcade games" became electronic games in coin-operated machines accessable for a wider public in amusement halls 24, meanwhile the consoles for televisions transformed the living rooms – (since the sixties) the usual site for television – into a place for gaming. 25

The first arcade game "Computer Space" was sold since 1971. Nolan Bushnell developed it for Nutting Associates. Ralph Baer constructed "Odyssey" as a console connected with television. Magnavox distributed "Odyssey" since January 1972. "Spacewar!" (see chap. VII.1.1) was transformed in "Computer Space" into a game machine with a TV monitor in a futuristic designed fibreglass housing and an protruding keyboard, meanwhile the tennis game of the "Odyssey" console changed Higinbotham´s "Tennis for Two" (see chap. VII.1.1) into a `living room game´. 26



Bushnell, Nolan: Computer Space, Nutting Associates, 1971, arcade game. Left: the case. Right: the screen.

Baer transformed Higinbotham´s sideview of a tennis game into a top view. A small square represented the ball. It was moved between two big squares symbolising the rackets. A transparent foil contained a vertical line representing the tennis net.

The "Odyssey Home Entertainment System" included a control unit and two boxes with knobs used in the tennis game for moves with the rackets. The black/white graphics could not present other elements than points and lines. It was not yet possible to store and indicate stores.



Baer, Ralph: Tennis, one of the twelve games included in the Odyssey Home Entertainment System, Magnavox, 1972. Players with the console being connected to the TV.

Six movement patterns and twelve screen foils were the elements of twelve games, among them the tennis game described above. The movement patterns were installed in selecting one of six plugs interconnecting "conductors". 27



Baer, Ralph: Odyssey Home Entertainment System, Magnavox, 1972, console for twelve games, presentation in a TV Commercial, Carol Burnett Show, 10th February 1973. Screenshot from YouTube.

The sales of "Computer Space" and "Odyssey" fell short of their producers´ expectations: The technology of the arcade games and consoles became successful with later developed products mainly consisting of simplifications.



Nishikado, Tomohiro: Space Invaders, Taito, 1979, arcade game. Screenshot from YouTube.

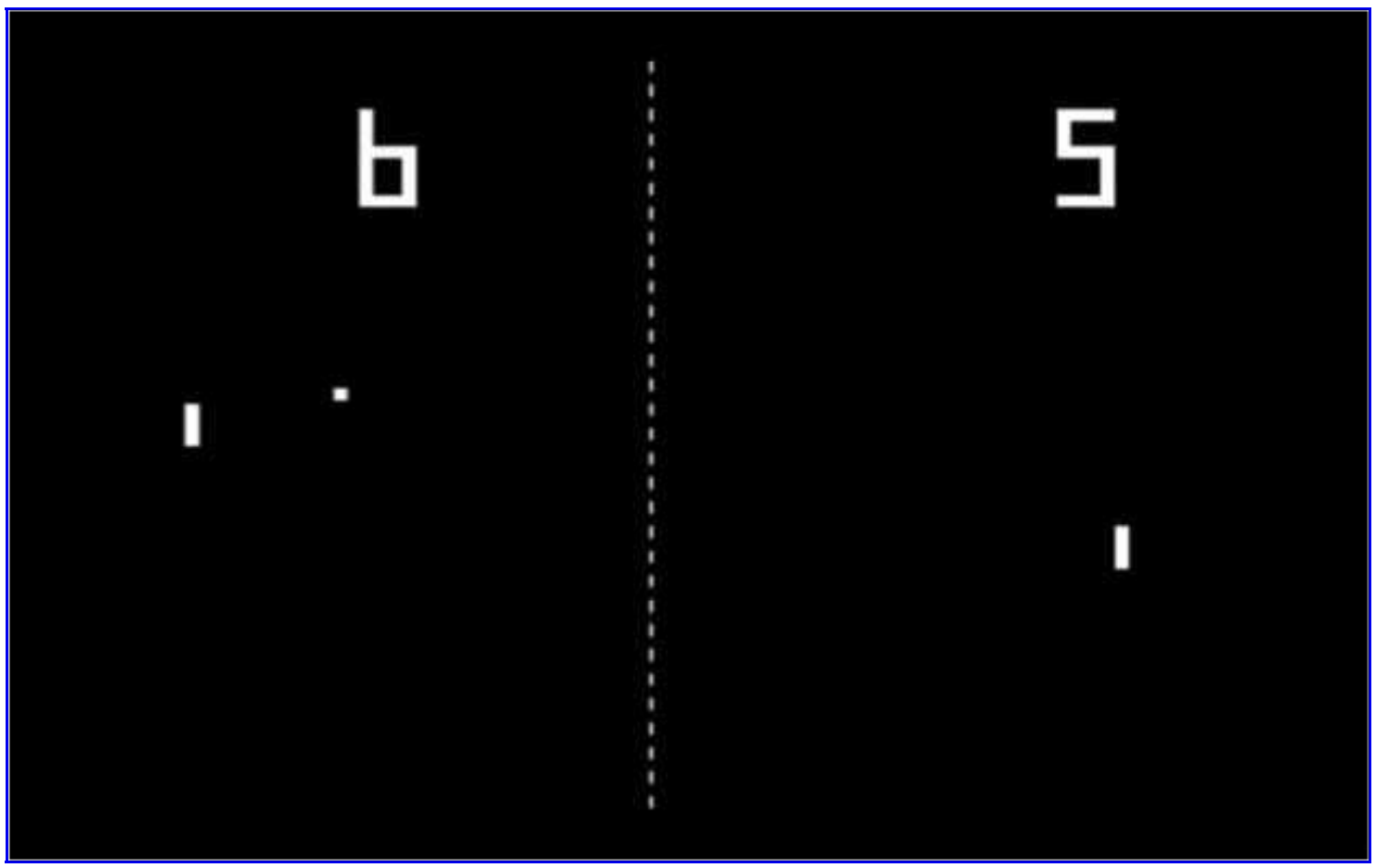
The adaptation of "Spacewar´s" gravity in the arcade game "Computer Space" and its thick user´s manual were reduced in "Space Invaders" (1978, Taito/Midway) 28 and "Asteroids" (1979, Atari) 29 to simple shooter games with one "source of risk". 30



Rains, Lyle/Logg, Ed: Asteroids, Atari, 1979, arcade game.

After the "Odyssey Home Entertainment System" for several games a market arose for game consoles with hard-wired components for only one game. Since 1976 multifunctional consoles were available. They were made with chip technology for games on "cartridges": If a cartridge were inserted into the console than another game could be started. 31

Among the arcade games "Pong" (1972, Atari) became the most widely played tennis game. Like "Odyssey" it was a successor of "Tennis for Two", but it included a score. "Pong" belongs to the first successful games of Nolan Bushnell´s firm Atari.



Alcorn, Allan: Pong, Atari, 1972, arcade game. Screenshot from YouTube.



Alcorn, Allan: Pong, Atari, 1972, arcade game. Photo by ProhibitOnions.

The Atari engineer Allan Alcorn divided the vertical lines representing tennis rackets in eight sections. If the square used as a ball hit the midst of the racket line then the square was bounced off at a right angle to the racket but diagonally (at a 45 degree angle) in all other sections. After longer playing times the ball moved faster. 32

Three month after the first delivery of "Pong" Atari was faced with the first imitators. 33 With "Home Pong", made available on the toy market since Christmas 1975, Atari started its engagement as a producer of consoles. 34 Since 1977 Atari´s multi-game console VCS/2600 (VCS = Video-Computer System) was sold successfully. 35



Alcorn, Allan/Brown, Bob/Lee, Harold: Home Pong, Atari, 1975, game console.

In Christmas 1977 the video game market suffered a crisis because too few interesting games were offered for the deliverable consoles. Atari survived the crisis without the financial problems of other game producers. With new games Atari initiated between 1979 and 1982 the reinvigoration of the games industries. In these times Japanese producers like Taibo, Namco and Nintendo rushed to the market hitherto dominated by American firms. 36

After its original delivery in 1982 the personal computer Commodore 64 (1982-94) became famous as a game platform. In this function it overcame its rivals produced by Apple and Atari. 37 Because of stronger computing capacities initially the consoles were more appropriate for games affording fast player movements but this advantage vanishes with further developed technology of personal computers. After the game industry´s second crisis from 1983 to 1985 personal computers and consoles were competing platforms for games. 38

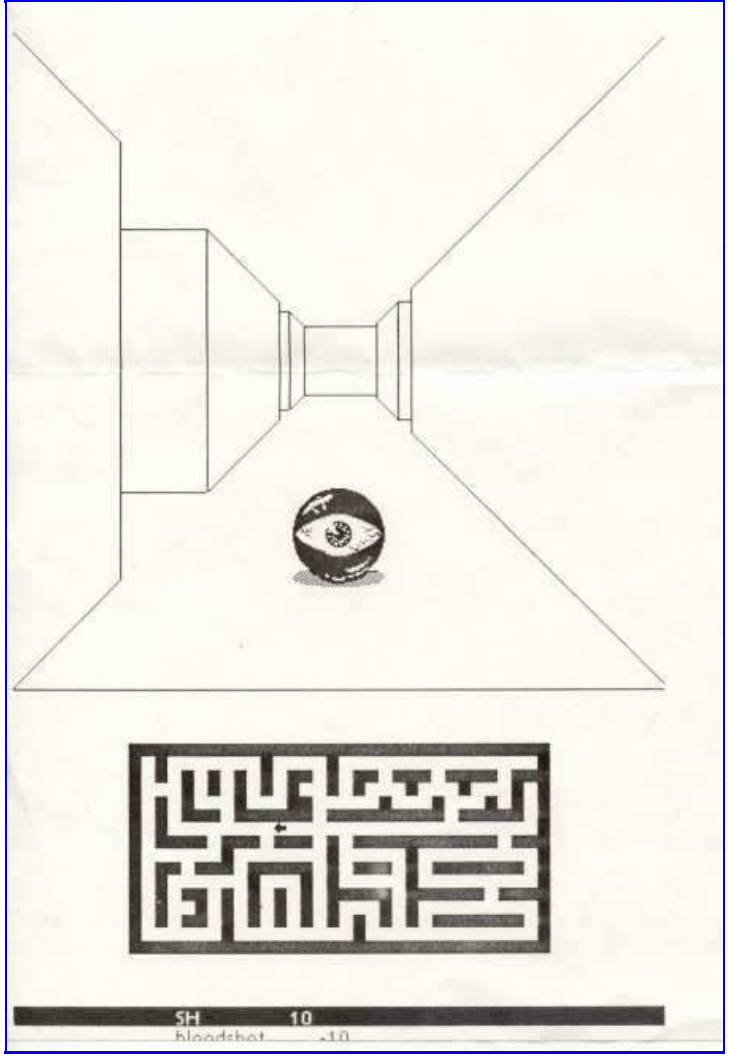
VII.1.3 First Person Shooter & Third Person View

VII.1.3.1 Ego Shooter

In the eighties and nineties the shooting games were developed further offering to the player a simulation of a weapon in the lower field of the screen. After having recognised ennemies the player shoots with his weapon on his run through three-dimensional animations simulating sequences of spaces (First Person Shooter or Ego Shooter). In the game genre "Management Simulation" not the affordance to shoot constitutes the primary goal of players but the selection of elements and properties constituting a game world with affordances to make further decisions (Third Person overview of God Games, see chap. VII.1.3.2).

In 1973 Steve Colley was confronted with the task to develop a program for simple 3D animations, among them line displays of labyrinths, and to implement it on the minicomputer Imlac PDS-1 (since 1970, with a vector graphics coprocessor) of the NASA/Ames Research Center (Computation Division, Moffet Field/Kalifornien).

A result of the communications between Colley, Howard Palmer and Greg Thompson was the plan, to program a labyrinth for humans moving in it. Considering the limited computing capacity Palmer proposed a labyrinth allowing only movements in a 90 degree angle. For this kind of navigation Colley programmed a labyrinth.





Colley, Steve/Palmer, Howard/Thompson, Greg: Maze War, 1973-74, game for the minicomputer Imlac PDS-1.
Left: printout of a screenshot (from an implementation on the personal computer Xerox Star 8010), 1985-86.
Right: child playing Maze War on an Imlac PDS-1, 30th Maze War Anniversary Event, DigiBarn Computer Museum, Mountain View/California 6th-7th November 2004.

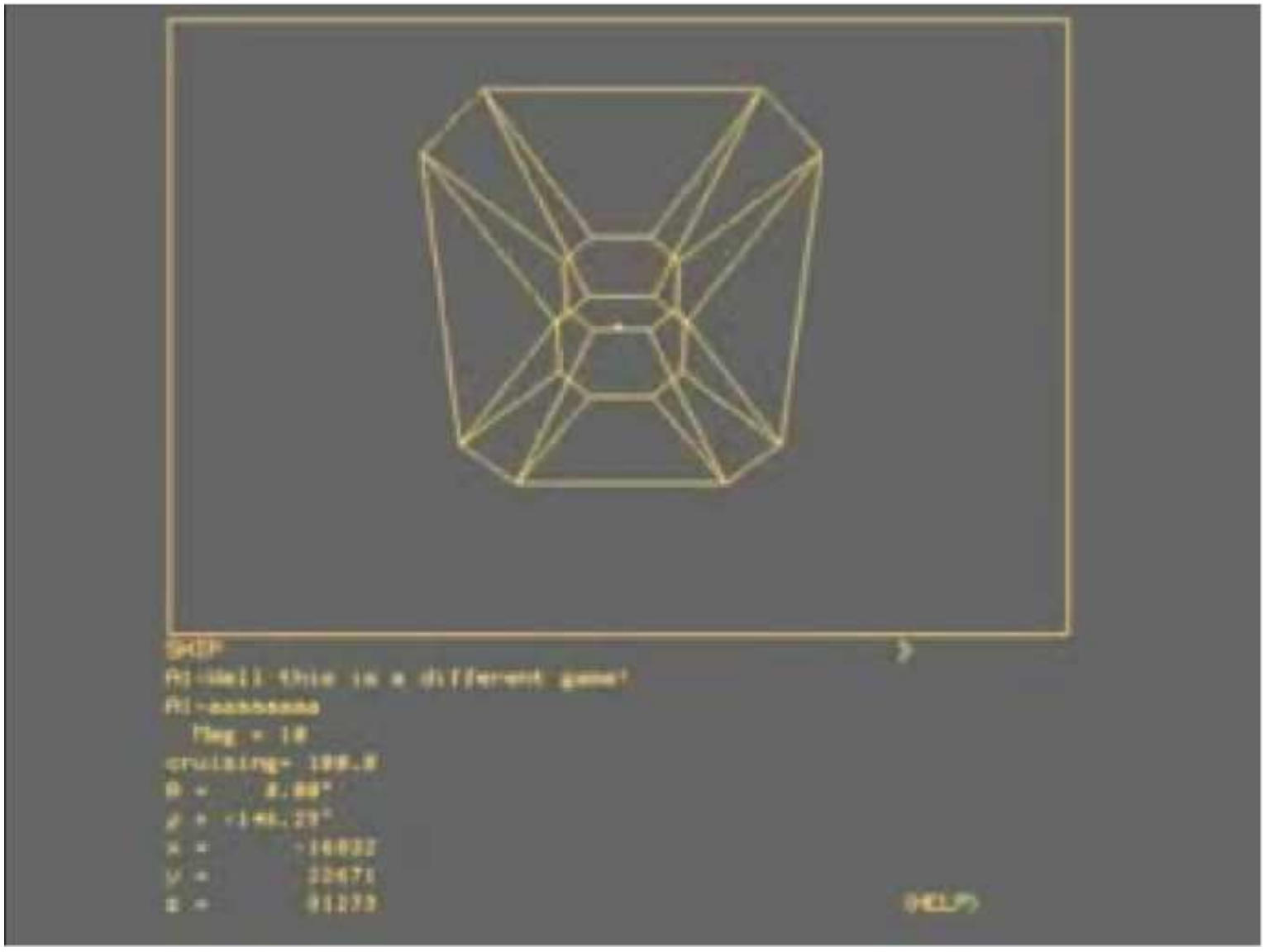
The moves of two players in the labyrinth were recorded in "using the serial ports" (Colley) of two Imlac PDS-1 computers connected by a local area network. In "Maze War" the players´ moves were presented on monitors. 39 They could see their position in a 3D animation presenting the edges of the walls as lines and on a floor plan of the labyrinth. The floor plan showed only the position of the player without the competitor, meanwhile the 3D animation presented the game state. In this view the competitor was presented as a ball with an eye. The position of the eyeball indicated which player hit the other one.

Players navigated through the labyrinth in using five keys of the keyboard: four keys for the navigation in four directions and one key for shooting. When a player entered new rooms then he could look around for a short time before he had to shoot.

This version was realised from 1973 to 1974 and in 1974 expanded by Greg Thompson to include a system for many players: When Imlac computers were connected via the ARPANET (see chap. VI.1) with a server (DEC PDP-10, 1964-83) then eight players could compete with each other in "Maze War". 40

Although "Maze War" as well as "Spasim" (1974) are said to be the origins of the game genre ego shooter, both 3D games did not yet include a simulation of the player´s weapon. "Spasim" was a space game representing starships and four planetary systems only as wireframe models meanwhile "Maze War" already eliminated the hidden lines. From January to March 1974 James Allen Bowery programmed "Spasim" for the PLATO (Programmed Logic for Automated Teaching Operations) system. Since 1960 the

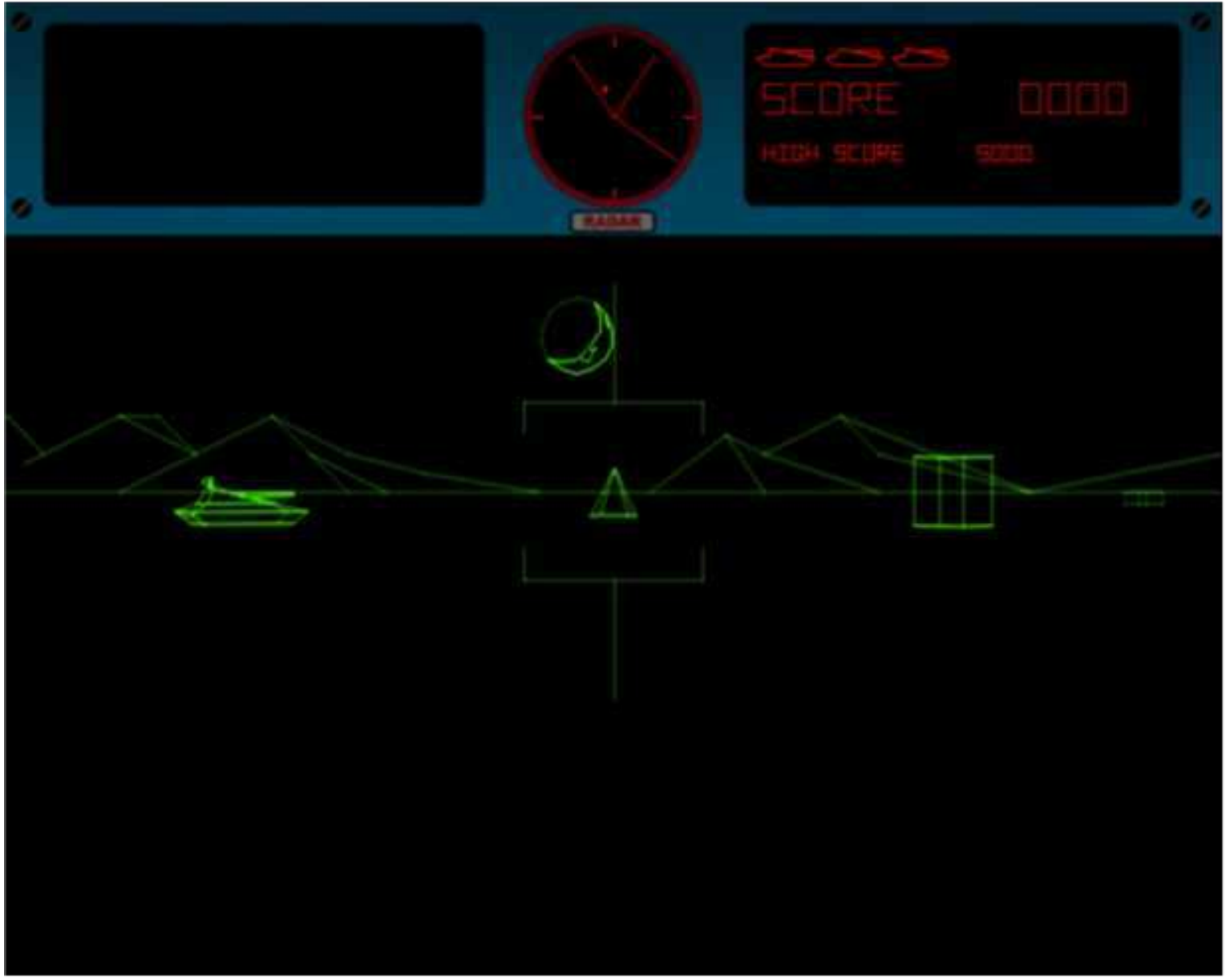
PLATO system was developed and evolved by the Control Data Corporation for e-learning.



Bowery, James Allan: Spasim, 1973-74, multiplayer online game for the PLATO (Programmed Logic for Automated Teaching Operations) system. Screenshot from YouTube.

Up to 32 participants could play "Spasim". In PLATO IV terminals with monochrome plasm screens were connected to the mainframe computer CDC Cyber 6400 of the Computer Based Education Research Laboratory (CERL, Urbana/Illinois), like the earlier 2D game "Empire" being programmed by John Daleske for 8 players in April/May 1973. Since July 1973 players of "Spasim" could change their point of view in using the keys QWEADZXC for 8 directions. Also players could use the "+" and "-" keys for acceleration and speed reduction. In the game world players are represented as starships. In each planetary system eight team players could shoot with "phasers-and-photon-torpedos". 41

Also the simulation in Attari´s arcade game "Battlezone" (November 1980) consisted of wire frame models. A player had to fire on a tank. This task had to be fulfilled successfully before the tank changes his tour between both sides of the screen, turns his front in the player´s direction and fires on him. The ennemy´s weapons included slow standard tanks as well as faster tanks and anti-tank missiles.



Rotberg, Ed/Hoff, Morgan: Battlezone, Atari, 1980, arcade game. Screenshot of Atari´s web version.

The player targeted with a linear representation of a gun sight indicating the periscope of a tank. Players could only fire straight ahead. Because no other function than shooting was offered for the game play "Battlezone´s" action functions are reduced compared to "Spasim".

The vector graphics presenting wireframes (based on polygon elements) become brighter from back to front. The animation is supported by green and black overlay transparencies. The representation of a periscope´s cross-hair was supplied by a transparency on the black-white monitor. The transparency simplified the cognition if and when ennemy objects appeared in the target area. With the representation of the cross-hair as a part of the player´s weapon "Battlezone" got an important element of future ego shooters that was not yet included in the 3D animations of "Maze War" and "Spasim".

Players navigated with two joysticks comparable to a tank driver´s control sticks. A radar screen shown at the center of the top presents targets as points. Already "Maze War" combined a perspective view with a top view of the game space (see above). This combination will be repeated in "Doom" (1993, id Software, see below). 42

In the ego shooters for home computers "The Eidolon" (1985, Lucasfilm) and "MIDI Maze" (1987, Hybrid Arts) the wireframe models were substituted: in the first named game by fractals and in the second game by coloured flat areas.



Kellner, Charlie/Seleme, Lance: The Eidolon, Lucasfilm Games/Epyx, 1985, computer game.

In "Eidolon" the player navigates in caves suggested by dotted lines and shoots on helicopters, fireballs, dragons and other monsters, meanwhile an instrument panel at the bottom of the screen indicates the score.

In "MIDI Maze" (1987) the players´ computers (Atari ST, 1985-93) are connected with each other via a MIDI (Musical Instrument Digital Interface) network. In a labyrinth the players navigate in four directions and they target at competitors represented as smileys (yellow icons presented as faces). The weapon is presented only as a red target rectangle. The players try to direct this red rectangle onto the smileys. 43



Xanth Software F/X: Midi Maze, Hybrid Arts, 1987, computer game. Screenshot from YouTube.

In "Wolfenstein 3D" (1992, id Software, computer game) the maze-like sequences of rooms limited by vertical planes representing walls were taken up from "Maze War" and "MIDI Maze" and constitute the game space for a player´s run through a sequence of rooms in fighting against ennemies. The player acts in the role of the fictive American soldier William "B.J." Blazkowicz being imprisoned in the NS-Ordensburg Wolfenstein. His fighting path out of the Ordensburg is limited by vertical planes simulating stone masonry and decorated with Nazi emblems as well as Hitler portraits. In these rooms he is confronted with German soldiers, SS men and shepherd dogs. They are the ennemies to fight against in actions of shooting (In 1994 the game was confiscated in Germany because of infringements against the penal code´s § 86a Section 1 Nr. 4 prohibiting the use of forbidden organisations´ signs).



id Software (Romero, John/Carmack, John/Hall, Tom): Wolfenstein 3D, Apogee Games, 1992, computer game.

In Wolfenstein 3D, as before in "MIDI Maze", the rooms are simulated without ceilings: Both games contain animations of maze-like sequences of spaces limited at the sides and in the depths by walls of the same height. In "Wolfenstein 3D" the weapon protrudes in these rooms. Because of the lamps with green shades the monochrome dark grey horizontal upper areas become readable as ceilings. The floor appears monochrome grey, too. But the floor is more light-coloured than the ceiling.

The 3D animation in "Wolfenstein 3D" is based on polygons. This animation was realised in using "Raycasting". "Raycasting" algorithms are developed to remove the surfaces of simulated objects being hidden from the player´s perspective. With this "rendering technique" a "pseudo-3D" imagery is calculated with data from two-dimensional maps. The walls of the ground plan are scanned with light rays from one point of view in one image line. These rays became the basics for the calculation of occlusion. Because of the specified geometric rules the ground and the walls have always the same height. No other walls than the ones with right angles are represented. In using these rules John Carmack realised in "Wolfenstein 3D" an early example for "Raycasting". 44 The walls got their textures with "sprites" being set by a graphic processor in the programmed image position. 45 In 1992 the increased capacities of computers with processors being cheaper than ever before paved the way for the programming of "Wolfenstein 3D´s" graphic engine.



id Software (Romero, John/Carmack, John/Hall, Tom): Doom, Cdv Software Entertainment, Pearl Agency, 1993, computer game.

In 1993 the design team of id Software (John Romero, John Carmack, Tom Hall) presented "Doom" (computer game), and with its graphic engine they set a new standard for 3D graphics. Like its predecessor "Wolfenstein 3D" the engine of "Doom" was based on "Raycasting": In "Doom" floors are not more than horizontal planes and the walls are only vertical. Now the walls of "Doom" have different heights and touch each other at whatever angle. The planes and ceilings of the combat rooms are created with textures. Ennemies, weapons and other objects were integrated as two-dimensional sprites into the virtual environments. 46 Meanwhile in "Wolfenstein 3D" the possible moves were restricted to two axes, they where enlarged in "Doom" to three axes. Sometimes a well visible hand lifts the weapon high into the image field.

The representations of labyrinths from "MIDI Maze" to "Wolfenstein 3D" is superseded in "Doom" by corridors widened to rooms with forking corridors. Several times the game architecture includes prospects on landscapes.

The player can find weapons during his passage through the sequence of rooms, and he can take them up in passing the find sites. These weapons can be hidden in parts of the game architecture making it difficult to find them. In searching such sites the player can switch into the map view: The indicated past paths of the player can serve him to find out unresearched places. 47 To proceed his path in running and fighting the player has to solve riddles, too.

"Doom" included four episodes, each of them contained nine levels. Each level offered to players rooms with ennemies and obstacles for running and fighting. "Doom" is an early example for the classical structure of ego shooters consisting of an environment´s exploration, fighting and task solving. 48

The narrative framework to these paths for running fighters came from a science fiction stored in the "Doom Bible" by Tom Hall until Cormack decided to give it up. Cormack explains the status this story can have for players:

Doom didn´t need a back story. It was a game about fight or flight. 49

The speed necessary to react in "Doom" to shooting ennemies causes players to run on each level as fast as possible. In "Speed Runnings" veterans of "Doom" reduced the time necessary for all levels to the record of five minutes. The courses of matches could be stored on a demo file. Players could distribute these files on the internet and communicate about their skills. 50

If the perspective of a game´s figure is identical with the view of a player on the screen then it is comparable to the "subjective shot" (also "point of view shot" or "POV shot") in films, as Britta Neitzel and Alex Galloway have shown in their game research. 51



Montgomery, Robert: Lady in the Lake, 1947, movie. Screenshot from YouTube.

In 1947 Robert Montgomery made the movie "Lady in the Lake" based on an adaptation of Raymond Chandler´s novel of the same name. In this film viewers follow the action in detective Philip Marlowe´s perspective: If persons turn their bodies in speech acts to Marlowe then they speak to the camera. Film presentations in cinemas provoke the impression of actors turning their bodies to the projection space and speaking to the movie goers. The observer gets involved in the story by the scenic constellation (immersion) and is pointed to the border between the filmed space and the projection space, because he can´t control the filmed actions nevertheless he locates himself like Marlowe in the filmed space. Marlowe remains another mostly invisible body who sees and calls implicitly the viewers to follow his perception: The camera and the viewers share Marlowe´s point of view, and the camera immerses the viewers of its images into Marlowe´s scenic context. The viewers are confronted with performative elements of Marlowe´s role play (his speech) as well as with absent elements (his performance in situations when the camera does not present him as a part of a mirror´s reflections).

In the first person shooters the game affordances at the technical interface (interface 2,

here consisting of keyboard, mouse, joystick and monitor) result in the observer´s self-localisation as an actor within the 3D game space: The actor in a real space (the cognitive access to the world including the coordination of the body, world-interface/interface 1, cf. chap. V.2, VII.2.2, VIII.2) locates himself at the technical interface under game conditions. 52 The imagination of observers doesn´t transform the real space into an expansion of the game space but players act on technical interfaces in real spaces and in their navigation they transpose themselves into the game space with its simulations of corridors and rooms narrowing down the possibilities to fight against moving programmed ennemies. The "incorporeal vision" 53 in Montgomery´s movie is changed into observation processes integrating the `pre-reflective body coordination´ (see chap. V.2, VII.2.2, VIII.2) of the hands on the technical interface into an immersive game play. The player´s immersion is not only a blending out of his surroundings and a plunging into the game world, as if he acts in it, but also a mediation between the technical interface and the cognitive interface (game-interface/interface 3; cf. chap. V.2, VII.2.2, VIII.2): This mediation – like a switch from the real space into the game world – enables players to fulfill game affordances with successful moves.

The cognitive interface (interface 1/world-interface as the access to the world, coordinating mind and body) can be adjusted to game affordances in processes of refinements of former refinements of the reactions trained at the technical interface. With their trials to coordinate the cognitive and technical interfaces players start a training developing strategies for game affordances. The world-interface for the self-positioning in an environment (interface 1) using prereflexive schemata for the body coordination is turned by players to the technical interface (interface 2) of a game to develop a game-interface (interface 3) for the plunging into the game world (immersion). In the case of ego shooters the game-interface (interface 3) is a self-organized learning process combining the acting self-orientation constituting the world-interface (interface 1) with the technical interface (interface 2). This combination is experienced in the game play as direct although it is the result of mediations.

VII.1.3.2 God Games

The solving of tasks is the central demand of strategy and simulation games in the "third person overview". 54 The difference to battle games involving players in the "first person perspective" (see chap. VII.1.3.1) is explained in the following at examples of god games with players deciding like an imperator, leader or planning organiser about the constitution of fictive social systems. 55

From 1962 to 1964 the Center for Educational Services and Research of the Board of Educational Services (BOCES, Northern Westchester/New York) cooperated with IBM at the realisation of two computer games for learning purposes. Three terminals (IBM 1050, since 1963) were connected via Dataphone to an IBM 7090 mainframe computer (since 1959). William McKay (IBM) programmed both games in FORTRAN (Fortran Assembly Program/FAP) for a timesharing system (see chap. VI.1.1 with ann.3).

SAMPLE PRINTOUT FOR SUMERIAN GAME

Hello! Before we begin, will you please type your name, first name first, then your last name, and then press the Return key.

Ed Smith

Now, Ed, you are ready to operate the Sumerian Economic Model.

Imagine that you have just been made Ruler of Lagash, a City-State of Sumer, in the year 3500 B.C. Twice yearly your Royal Steward, Urbaba, will report to you the economic condition of the kingdom. Guided by these reports, you will decide the use of your grain and other resources, trying to keep your population stable and well fed. Between reports, your court advisor will come to you with news of your kingdom.

The Steward will use the typewriter to report and ask for your decisions. When the "Proceed" light comes on, type your answer in figures and press "Return." (If you make a mistake, press "Cancel" instead and try again.) Good luck!

Initial Economic Report made to the New Ruler of Lagash by his Humble Steward:

Total population now	500
Total farm land under cultivation, acres	600
Total grain in inventory, bushels	900
one season old	900
two seasons old	0
three seasons old	0
Total grain just harvested, bushels	13000
Total resources, harvest + inventory	13900

You must now decide how to use your resources.
How many bushels of grain do you wish to FEED your people?

4000

How many bushels of grain do you want PLANTED for the next crop?

9000

This means that zero bushels must be removed from storage. Is this all right?
Do you wish to 1 – let your decisions stand or 2 – revise them?

1Resulting inventory	900

The steward will execute the royal commands and return in 6 months.

Sir, I am sorry to report that 225 bushels of grain have rotted or been eaten by rats this past season.

Economic Report of the Ruler's Steward for the SPRING Season in the year 1 of Luduga 1.

Population at previous report	500
Change in Population	–55
Total population now	445

The quantity of food the people received last season was far too little.

Harvest last season	13000
Harvest this season	14396
Previous inventory	900
Change in inventory	–225
Present inventory	675
Total resources, harvest + inventory	15071

You must now decide how to use your resources.
How many bushels of grain do you wish to FEED your people?

5000

How many bushels of grain do you want PLANTED for the next crop?

9000

This means that 396 bushels must be placed in storage. Is this all right?
Do you wish to 1 – let your decisions stand or 2 – revise them?

Center for Educational Services and Research of the Board of Educational Services (BOCES)/William McKay (IBM): The Sumerian Game 1962-64, computer game for a timesharing system (Wing: Economics 1966, p.33).

In the text based "Sumerian Game" players try to act in the role of a priest ruler in the city-state of Lagash (Mesopotamia, 3500 b.c.). The player receives a status report by the court advisor. The Royal Steward asks the player how many bushels of grain should be stored in the inventory and how many of them should be "planted for the next crop". The player has to make further decisions in using the consequences of his earlier decisions as

they are determined by the game system. The player can come to grips with the evolution of the city-state in three steps from a trading dominated by agricultural products to the evolution of crafts up to the development of the barter trade. In 1965/66 25 students tested the game (Mohansic School, Yorktown Heights/New York). 56

In 1968 the text based "The Sumer Game" was programmed in FOCAL and sometimes Doug Dyment, sometimes Richard Merrill are named as authors. When in 1968 the last one developed FOCAL (Formula Calculator), then he enabled PDP-8 minicomputers (since 1965) by DEC (Digital Equipment Corporation) with the interpreter FOCAL 68 to read his program and to process data.

The player is put into the position of the steward of Hammurapi, the sixth king of the First Babylonian dynasty in the 2nd millenium before Christ (1792-1750 b.c). In an introductory presentation the economic situation of the Babylonian population is explained. Criteria concerning the land, grain, population and adverse circumstances should be taken into consideration by players before they answer the questions in entering numbers. Who sells too large shares of the harvest will starve out the population. If players take bad decisions of this kind as stewards then they will be chosen to leave their offices: That will be the end of the game. The players explore the program in experiencing its reactions to their entries. Conclusions provoked by experiences with bad decisions can be brought in by players in repetitions of the game. 57

David H. Ahl developed a version in BASIC for a ten years lasting administration. Players have to develop strategies for the benefit of the population and the land for an administration avoiding self-caused catastrophes within the next ten years and reacting to preprogrammed emergency situations. For every task four variables are offered to the players to be substituted by self selected dates. 58

```
                HAMURABI
CREATIVE COMPUTING  MORRISTOWN, NEW JERSEY

TRY YOUR HAND AT GOVERNING ANCIENT SUMERIA
FOR A TEN-YEAR TERM OF OFFICE.

HAMURABI:  I BEG TO REPORT TO YOU,
IN YEAR 1 , 0 PEOPLE STARVED, 5 CAME TO THE CITY,
POPULATION IS NOW 100
THE CITY NOW OWNS 1000 ACRES.
YOU HARVESTED 3 BUSHELS PER ACRE.
RATS ATE 200 BUSHELS.
YOU NOW HAVE 2800 BUSHELS IN STORE.

LAND IS TRADING AT 24 BUSHELS PER ACRE.
HOW MANY ACRES DO YOU WISH TO BUY? 10

HOW MANY BUSHELS DO YOU WISH TO FEED YOUR PEOPLE? 2000

HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 990

HAMURABI:  I BEG TO REPORT TO YOU,
IN YEAR 2 , 0 PEOPLE STARVED, 5 CAME TO THE CITY,
POPULATION IS NOW 105
THE CITY NOW OWNS 1010 ACRES.
YOU HARVESTED 3 BUSHELS PER ACRE.
RATS ATE 16 BUSHELS.
YOU NOW HAVE 3019 BUSHELS IN STORE.

LAND IS TRADING AT 21 BUSHELS PER ACRE.
HOW MANY ACRES DO YOU WISH TO BUY? 25

HOW MANY BUSHELS DO YOU WISH TO FEED YOUR PEOPLE? 2000

HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 1000
HAMURABI:  THINK AGAIN.  YOU HAVE ONLY
 494 BUSHELS OF GRAIN.  NOW THEN,
HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 500

HAMURABI:  I BEG TO REPORT TO YOU,
IN YEAR 3 , 5 PEOPLE STARVED, 5 CAME TO THE CITY,
A HORRIBLE PLAGUE STRUCK!  HALF THE PEOPLE DIED.
POPULATION IS NOW 52
THE CITY NOW OWNS 1035 ACRES.
YOU HARVESTED 1 BUSHELS PER ACRE.
RATS ATE 0 BUSHELS.
YOU NOW HAVE 744 BUSHELS IN STORE.

LAND IS TRADING AT 17 BUSHELS PER ACRE.
HOW MANY ACRES DO YOU WISH TO BUY? 0
HOW MANY ACRES DO YOU WISH TO SELL? 25

HOW MANY BUSHELS DO YOU WISH TO FEED YOUR PEOPLE? 1000

HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 500
HAMURABI:  THINK AGAIN.  YOU HAVE ONLY
 169 BUSHELS OF GRAIN.  NOW THEN,
HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 300


HAMURABI:  I BEG TO REPORT TO YOU,
IN YEAR 4 , 2 PEOPLE STARVED, 12 CAME TO THE CITY,
POPULATION IS NOW 62
THE CITY NOW OWNS 1010 ACRES.
YOU HARVESTED 1 BUSHELS PER ACRE.
RATS ATE 0 BUSHELS.
YOU NOW HAVE 319 BUSHELS IN STORE.

LAND IS TRADING AT 23 BUSHELS PER ACRE.
HOW MANY ACRES DO YOU WISH TO BUY? 0
HOW MANY ACRES DO YOU WISH TO SELL? 500

HOW MANY BUSHELS DO YOU WISH TO FEED YOUR PEOPLE? 500

HOW MANY ACRES DO YOU WISH TO PLANT WITH SEED? 230

YOU STARVED 37 PEOPLE IN ONE YEAR!!!
DUE TO THIS EXTREME MISMANAGEMENT YOU HAVE NOT ONLY
BEEN IMPEACHED AND THROWN OUT OF OFFICE BUT YOU HAVE
ALSO BEEN DECLARED NATIONAL FINK!!!!

SO LONG FOR NOW.
```

Ahl, David H.: Hammurabi (Ahl: BASIC 1978, p.78).

In the seventies variants of "The Sumer Game" were developed. They augment the strategy game and transfer it to other countries and epochs. 59

In the game "Utopia" (1981, Mattel Electronics 60) for the console Mattel Intellivision (since 1980) the multi-button keypad of the controller facilitated the choice of alternatives to take the best decisions for an island and its population. In the areas of agriculture, industry, fish farming and army a player could act alone or against a ruler of

another island. Two-dimensional graphics were used to illustrate the consequences of decisions. The player´s time for his efforts to win levels was limited.



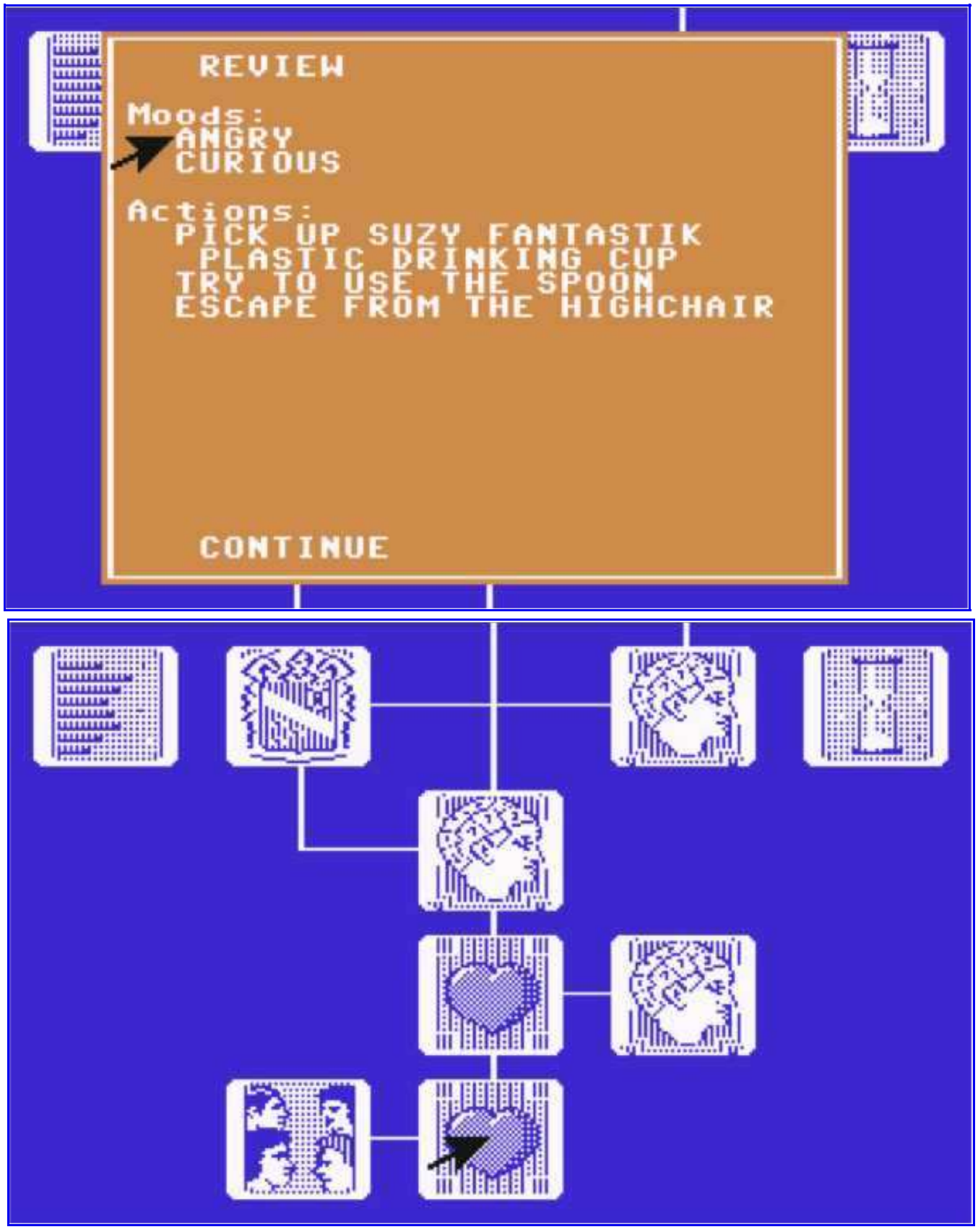
Daglow, Don: Utopia, Mattel Electronics, 1981, game for the console Mattel Intellivision (since 1980). Screenshot from YouTube.

Conflicts like the natural catastrophes and the piracy did not allow to understand the name "Utopia" as a designation for a game world showing an ideal state. Rather the conflicts point to deficits like missing answers to catastrophes and thieves. 61



Crane, David/Gold, Rich: Little Computer People, Activision, 1985, computer game.

In the eighties the strategy games are modified into games for the organisation of private lives at first in "Little Computer People" (David Crane and Rich Gold for Contemporary, Activision 1985, computer game 62) and "Alter Ego" (Peter J. Favaro for Contemporary, Activision 1986, computer game 63). In "Little Computer People" the living on several floors of a house is represented in vertical plans, like cuts through the `inner life of a house´. In contrast to the "Little Computer People" "Alter Ego" is a text-based game: It describes the actions of a house´s inhabitants. The player makes selections from the offered scope for actions and receives a description of its effects.



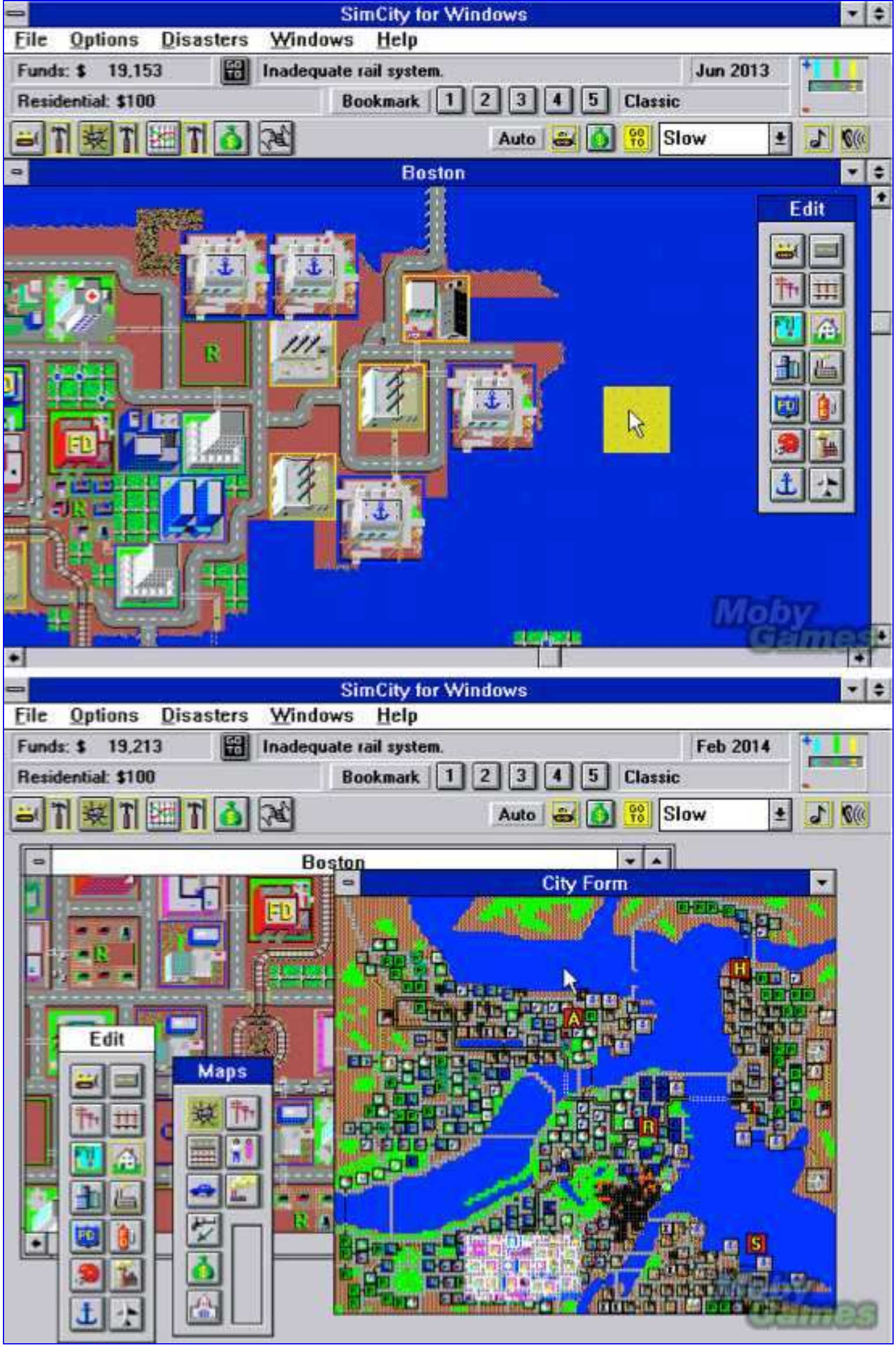
Favaro, Peter J.: Alter Ego, Activision, 1986, computer game.

In contrary to this organisation of private lives the real-time strategy game "Populous" (Peter Molyneux for Bullfrog Productions, Electronic Arts, 1989, computer game) offers a player the role of a deity directing the fortune of a population against another god in 500 worlds. The player can observe the consequences of his decisions in isometric views. The game world and its events can be influenced in pressing the buttons integrated into the floor panels being a part of the 3D simulation. 64



Bullfrog Productions: Populous, Electronic Arts. 1989, computer game.

When Will Wright developed "Sim City" (Maxis, Electronic Arts 1989, computer game) he was inspired by colleagues having constructed "Little Computer People". 65 However Wright takes up again the auctorial role of a player as a ruler of wider social entities: As before in "The Sumer Game", the city is the basic unity of the oversight made possible by top views in different windows. Later versions of "Sim City" offer isometric views. 66



Wright, Will/Maxis: Sim City, Electronic Arts, 1989, computer game.

The manual describes the player´s role as a "combination Mayor and City Planner". Players take decisions for all issues of their city, this includes the fire brigade, the police and the traffic. When players determine the infrastructure then they follow constraints

and consequences resulting from their earlier decisions. For zoning and the determination of an infrastructure the gaming system subtracts more than the expenses they cause for a municipal administration to install them. So the game´s affordances can cause players to prefer the perspectives of a land owner or a property investor more than the perspective of a mayor. 67

In 1991 Sid Meier and Bruce Shelley developed "Civilization" as a redesign of an identically named board game designed by Frances Treshan (Hartland Trefoil, 1980). "Sim City´s" urban perspective was expanded in "Civilization" to a perspective on a civilisation: In a constructed history of a civilisation (from 4000 B.C. to 2020 A.C.) with elements taken from the course of the real history players act from the perspective of a leader.

Players choose the degree of difficulty. They can shift from a top view of the selected land to boards with icons. With these icons and text windows players can select further elements determining the course of a game. Informations, inquiries from foreign rulers, war news and elements to be constructed are presented in windows.



Meier, Sid/Shelley, Bruce: Civilization, Micro Prose, 1991, computer game.

After an abandoned walkthrough players can resume the game on various levels and plan their next paths. 68

In "Bombs, Bavarians, and Backstories" David Myers shows the differences between the inevitable ideological implications of the background story and the strategies of players not wanting to follow an Eurocentric perspective 69 affirming the technical progress. How ever much "Civilization" implicates an Eurocentric perspective, nevertheless the game is complex enough to give skilled players chances to find for example strategies for moves from an Indian perspective more promising than the American perspective determined by the European civilisation and favored in the manuals and the promotion 70:

> ...among dedicated game players, the more barbarian-like `Indians´ (e.g. Iroquois) are usually considered more advantageously played than the (assumedly) less barbarian-like Americans.

In "Civilization" players can benefit from Indian concepts of nature in developing their views of environmental pollution. The negative connotation of non-European cultures as "Barbarian" is questionable if players use so-called Barbarian elements successful in specific phases of their efforts to build cultures:

> Rather than treating (and valuing) the barbarians as an oppositional force, dedicated game players are much more likely to attempt to develop their early civilizations with the barbarians´ aid. 71

The players of "Civilization" have to find their own ways between the technical possibilities of the game system and the social semantic fields of its signs. Myers finds "the aesthetics of play" in the technical and semantic possibilities being offered to players by more complex games to deviate from guidelines restricting semantic fields and to resist Eurocentrism. 72

Players of "god games" like "Sim City" and "Civilization" move in

- a distanced "third person perspective" not as directly involved as in ego shooters (see chap. VII.1.3.1),
- a "dispersed" perspective when acting on several levels and triggering actions,
- an "intradiegetic" perspective assigning the player an authorial role on the level of the operational activity. 73

Contrary to the players of "ego shooters" (see chap. VII.1.3.1) navigating under time pressure in the battle zones of game worlds the players act in strategy and simulation games simultaneously from points of view `above´ the action field and within it. This offers skilled players chances to develop their own strategies in the interplay between technical functions and semantic specifications. The preprogramming of a game can contain tensions between the possible technical functions of the game system and ideological perspectives restricting the semantic fields. 74

For a walkthrough players of strategy games choose between programmed possibilities. With this choice in an authorial position for the determination of elements depending from each other players are set by strategy games in positions affording to explore the possibilities of the game system in taking decisions over the activation of processes. With their explorations of the game system´s possibilities the players actualise functions of the programmed internal model player.

The intention of a game developers´ project is made manifest in the coding of a computer

game´s system: "God 1" is the team of the programming developers and "god 2" is the player set in an authorial position and enabled to dispose over components in selecting them as parts of an evolving game world. The player adopts an "external" position in reconstructing the program and the intentions of "god 1", meanwhile he occupies as "god 2" an "internal" position within the programmed game world, but this is a privileged position. 75

The players of "god games" move on the interface between the "external" and the "internal" position, between efforts to reconstruct the game system produced by "god 1" and playing as "god 2" selecting a constellation of the game world: On the one hand he can fail in an "internal" position (and he can loose his position in "The Sumer Game"), on the other hand he can select one of the possible constellations of the game world in an external reconstructing perspective, and in this position he can choose interdepencies with regards to enable himself in the internal position to win the game.

"Immersed" 76 in game conditions players of "ego shooters" act under time pressure and activate practiced action patterns at the technical interfaces. However players of "god games" train to concentrate themselves at the interface connecting "internal" and "external" points of view, between the programmed possibilities installed by "god 1" and further moves as decisions taken from the perspective of "god 2". The continuation of this concentration on the fulfillment of tasks is facilitated by augmented experiences with the game´s system.

With a more detailed realism of simulations players follow easier at the technical interface the ego shooters´ elements trying to immerse them into the "navigable space" 77 (see chap. VII.1.3.1), whereas the strategy and simulation games "involve" 78 the player with his distanced actions at the interface between external and internal points of view, between decisions for the actualisation of programmed parts and the screen´s simulation of the game world.

Players of "god games" ameliorate their game-interface (cognitive access to the game world, interface 3, see chap. V.2, VII.2, VIII.2) in correcting permanently at the technical interface (technical access to the game world, interface 2, see chap. V.2, VII.2, VIII.2) their mediations between their own social experiences (world observation, interface 1, see chap. V.2VII.2, VIII.2) and the acquired knowledge of the game system´s reactions to entries.

Annotations

1 Grundy: Mathematics 1939; Sprague: Kampfspiele 1935. back

2 Cohen: Cathode Ray Tube undated. back

3 Borchers: Jahre 2001; Goodeve: Nimatron undated; Redheffer: Machine 1948, p.343 (quotations). Patent: Condon/Derr/Tawney: Machine 1940. back

4 Redheffer: Machine 1948, p.343. back

5 Donovan: Replay 2010, p.5; Goodeve: Nimrod undated; Smith: Priesthood 2014. back

6 Bronowski: Story 1951. back

7 Bronowski: Story 1951. back

8 Without Author: NIMROD, Part 1: Electronic Brains 1951.
In 1954, as the Ferranti Nimrod was presented at the "Berliner Industrieausstellung" (exhibition of industrial products in Berlin) with the inscription "Elektronengehirn" ("electronic brain"). The clarification in the booklet on NIMROD did not prevent a bold use of the term "electronic brain" in exhibitions (Borchers: Jahre 2001; Donovan: Replay 2010, p.6). back

9 Cf. Donovan: Replay 2010, p.5s.
Also Grey Walter´s light searching robots (see chap. II.2.3) were shown in the last room of the exhibition, as a part of the department "How We Know" (Bronowski: Exhibition 1951 with the catalogue number ES106 "Machina Speculatrix"). back

10 Shannon: Programming 1950, chap.2 (pdf p.4). back

11 Shannon: Programming 1950, chap. 5 (pdf p.8). back

12 Bell: Games 1972, chap.5; Copeland: Intelligence 2000, chap. Early AI programs. back

13 Copeland: Intelligence 2000, chap. Early AI programs. However, the programming was not finished before July 1952 (Link: Enter 2012, p.23; Smith: Priesthood 2014).
In 1952 Arthur Lee Samuel started to develop a program to play draughts against the mainframe computer IBM 701 (1953). The program was improved in the course of the fifties. These upgrades caused versed players of draughts to estimate their chances to win against the technical opponent as not high but also not impossible. The methods of the program to learn from the opponent´s moves became important elements of artificial intelligence (Donovan: Replay 2010, p.6s.; Schaeffer: Jump 2009, p.87-97; Sutton/Barto: Reinforcement 1998, chap. 11.2, p.267ss.). back

14 Shannon: Programming 1950, chap.1 (pdf p.1). back

15 Patent: Goldsmith/Grove/Ray: States 1948. Lit.: Cohen: Cathode Ray Tube undated; Dixon: Computer 2006, chap. History of Computer Games: The Beginning; Günzel: Zeit 2010, p.91s. back

16 Koubek: OXO 2009, chap. OXO – Strategie auf dem EDSAC (pdf p.1-3); Winter: Noughts undated. back

17 Quotation: William Higinbotham. In: without author: Video Games 1981. back

18 Gettler: Video Game undated. Lit.: Donovan: Replay 2010, p.8s.; Kushner: Masters 2003, p.8; Mäyrä: Introduction 2008, p.40,58; Malliet/Meyer: History 2005, p.23; Pias: Computer 2010, p.13s.; Pias: Pflichten 2005, p.321ss.; Wirsig: Lexikon 2003, p.456. back

19 Graetz: Origin 1981, chap. I. Before Spacewar: "You Mean That's All It Does?" back

20 Quotations: Graetz: Origin 1981, chap. II Spacewar! Begun: The Hackers meet Spacewar!, chap. III Spacewar! Complete: The Control Boxes.
The levers of the control units came from the collection of the MIT´s Tech Model Railroad Club (TMRC. Botz: Kunst 2011, p.37,40; Graetz: Origin 1981, chap. III Spacewar! Complete: The Control Boxes). back

21 Graetz: Origin 1981, chap. III Spacewar! Complete: The Heavy Star. back

22 Brand: Spacewar 1972, chap. Spacewar; Donovan: Replay 2010, p.9ss.; Graetz: Origin 1981; Herz: Joystick 1997, chap. One; Kent: History 2001, p.17-21; Koubek: OXO 2009, chap. Spacewar! – Action auf der PDP-1; Mäyrä: Introduction 2008, p.41s.,58; Malliet/Meyer: History 2005, p.24; Manovich: Language 2001, p.253; Manovich: Space 1998, chap. Computer Space; Myers: Nature 2003, p.9s.; Pias: Computer 2010, p.84ss.; Wirsig: Lexikon 2003, p.427s. back

23 Brand: Spacewar 1972.
On the term `video game´: The term´s narrower semantic field encompasses game automats and consoles (see chap. VII.1.2) with a technical equipment constructed to play specific games (Neitzel: Geschichten 2000, p.163s.). back

24 Huhtamo: Slots 2005, p.14s.; Liebe: Dispositive 2008, p.83ss.; Neitzel: Geschichten 2000, p.163 with ann.3, p.203s. back

25 Liebe: Dispositive 2008, p.85s. Cf. Warnke: Situation 1979, p.685s. (television and couch corner). back

26 Donovan: Replay 2010, p.19ss.,22s.; Forster: Spielkonsolen 2009, p.14s. ("Odyssey" is "constituted by capacitors, resistors, transistors and diodes"); Herz: Joystick 1997, p.62s.; Kent: History 2001, p.31-34; Malliet/Meyer: History 2005, p.25,26; Manovich: Space 1998, chap. Computer Space; Yagoda: Nutting undated. back

27 Forster: Spielkonsolen 2009, p.14s.; Herz: Joystick 1997, p.33s.; Neitzel: Geschichten 2000, p.168s.; Pias: Computer 2010, p.109s.; Wirsig: Lexikon 2003, p.338. back

28 Kent: History 2001, p.116ss.; Mäyrä: Introduction 2008, p.62-66; Malliet/Meyer: History 2005, p.8s.; Neitzel: Geschichten 2000, p.172-175; Wirsig: Lexikon 2003, p.424s. back

29 Kent: History 2001, p.131s.; Malliet/Meyer: History 2005, p.30; Neitzel: Geschichten 2000, p.171s.,174s. back

30 Neitzel: Geschichten 2000, p.166 with ann.8. back

31 Forster: Spielkonsolen 2009, p.16,24-32,40 et al.; Kent: History 2001, p.98ss.; Malliet/Meyer: History 2005, p.26s.; Neitzel: Geschichten 2000, p.171; Wirsig: Lexikon 2003, p.82s. back

32 Günzel: Egoshooter 2012, p.34; Herz: Joystick 1997, p.63; Kent: History 2001, p.40-48,51-54; Mäyrä: Introduction 2008, p.41,58ss. (with a reference to the "transistor-transistor logic, TTL"),66,72; Neitzel: Geschichten 2000, p.169ss.; Pias: Computer 2010, p.112ss.; Wirsig: Lexikon 2003, p.366s. back

33 Kent: History 2001, p.58,60-64. Atari had to come in turn to a licence contract with Magnavox: Magnavox advocated Ralph Baer´s licence rights, including a patent for a console containing "Ping-Pong". Atari missed the money necessary for a legal dispute with Magnavox and got the licence at favorable conditions (Kent: History 2001, p.46ss.). back

34 Kent: History 2001, p.80-83; Malliet/Meyer: History 2005, p.26s.; Pias: Computer 2010, p.112ss. back

35 Forster: Spielkonsolen 2009, p.24-27; Neitzel: Geschichten 2000, p.171. back

36 Malliet/Meyer: History 2005, p.27s. back

37 Forster: Spielkonsolen 2009, p.18-22,34-38,62-66.
On the Commodore C64´s importance in the eighties´ cracktro- and demoscene : see chap. IV.2.1.4.3. back

38 Dixon: Computer 2006, chap. 1980s; Forster: Spielkonsolen 2009, p.48s.; Malliet/Meyer: History 2005, p.33-37. back

39 Colley: Story 2004. Cf. Palmer: History 2004: "...we had been experimenting with adhoc LANS for the Imlacs as part of our more serious work." back

40 Colley: Story 2004; Günzel: Egoshooter 2012, p.46s.; Palmer: History 2004.
"Maze War" versions for other platforms: Colley: Story 2004; Wadlow: Xerox 1981, chapt. The Network. back

41 Bowery: Spasim 1974; Shahrani: Feature 2006, chap. The Beginning – 1974 to 1991. back

42 Günzel: Raum 2008, p.124s. Lit.: Donovan: Replay 2010, p.84,131,250; Günzel: Egoshooter 2012, p.138,207; Kent: History 2001, p.149; Shahrani: Feature 2006, chap. The Beginning – 1974 to 1991; Wirsig: Lexikon 2003, p.53. back

43 "The Eidolon": Brigadoon: Eidolon undated.
"MIDI Maze": Lederer: Jahre 2007. back

44 For "ray casting" a designer develops geometric rules (like the walls of "Wolfenstein 3D" always at a right angle to the floor) for groups of rays meanwhile in "ray tracing" each beam is calculated for itself (see chap. IV.2. with ann.37. Lit.: Permadi: Ray-Casting 1996, esp. chap. Ray-Casting and Ray-Tracing). back

45 Sprites: little graphical elements to be drawn over the screen without necessity to be deleted in their last location and to be stored on their new location. The videochip "administers" the sprites "separately" (Botz: Kunst 2011, p.49).
Lit. about "Wolfenstein 3D": Donovan: Replay 2010, p.258ss.; Günzel: Egoshooter 2012, p.135,139,146,235s.; Hitchens: Family 2009, chap. 1-2; Kent: History 2001, p.400,458s.; Kushner: Masters 2003, S.92-101,106-122; Lederer: Jahre 2007; Malliet/Meyer: History 2005, p.40s.; Myers: Nature 2003, p.102s.; Shahrani: Feature 2006, chap. Evolution of the Engines; Wirsig: Lexikon 2003, p.499s.
Lit. about "Wolfenstein 3D": Castle Wolfenstein (1982, Muse Software, arcade game. Lit.: Myers: Nature 2003, p.100s.; Wirsig: Lexikon 2003, p.83); Catacomb 3D (1991, id Software, Computerspiel. Lit.: Kent: History 2001, p.458, Kushner: Masters 2003, p.89). back

46 Wikipedia: Doom Engine 2012. back

47 Mäyrä: Introduction 2008, p.105; Neitzel: Geschichten 2000, p.194; Nohr: Raumfetischismus 2007, p.71s. back

48 Mäyrä: Introduction 2008, p.105; Wikipedia: Doom 2012, chap. Handlung. back

49 Kushner: Doom 2003, p.132.
The narrative frame being disabandoned because of a lack of connections with moves

programmed in the game´s system: A portal to hell was opened by experiments with teleportation on two moons of the planet Mars. After the research institutes on the Marsmoon Phobos were liberated from demons the player teleports himself to the Marsmoon Deimos. This moon was carried out of its Mars orbit to the "hell dimension". From there the fighting ways lead to the hell to fight against the centre of the demonic invasion (Hall: Doom 1992). back

50 Players were enabled to design levels by "Doom´s" level editor (Neitzel: Geschichten 2000, p.142, ann.28, p.196, ann.35; Shahrani: Feature 2006, chap. Evolution of the Engines; Wirsig: Lexikon 2003, p.135).
In 1997 the source code for the operating system Linux was published and released for noncommercial uses. In October 1999 the source code was published again in using the copyright regulations of the GNU General Public Licence (Doom wiki: Doom 2011; Mäyrä: Introduction 2008, p.112).
Lit. about "Doom": Aarseth: Allegories 2004, p.161; Donovan: Replay 2010, p.259-262; Günzel: Raum 2008, p.124; Kent: History 2001, p.459s.; Kushner: Doom 2003, p.126-138,141-153; Mäyrä: Introduction 2008, p.101-106, 108-112; Manovich: Language 2001, p.244s.; Manovich: Space 1998, chap. Doom and Myst; Myers: Nature 2003, p.104-111; Neitzel: Geschichten 2000, p.194ss.; Neitzel: Point 2007, p.12,21p.; Shahrani: Feature 2006, chap. Evolution of the Engines; Wirsig: Lexikon 2003, p.134s. back

51 Galloway: Gaming 2006, p.43-46; Günzel: Egoshooter 2012, p.182s.; Neitzel: Geschichten 2000, p.196-200. back

52 Neitzel describes the player while immersed in the game world as expecting to be attacked from behind (Neitzel: Point 2007, p.22). The player does not forget his reduction of the body coordination in his concentration on the screen when acting at the technical interface with manual, mouse and joystick: Under game conditions the player mentally cuts out the environment in his concentration on the coordination of his moves while looking on the screen. The surrounding around the body is excluded by the player ´s reduction of his actions on the self-conditioned reflexes at the technical interface (joystick, manual). back

53 "Incorporeal vision" ("körperloses Sehen") : Neitzel: Geschichten 2000, p.126; Neitzel: Point 2007, p.22. back

54 "Third Person Total Overview": Malliet/Meyer: History 2005, p.42.
Strategy and simulation games: Kücklich: Computerspielphilologie 2002, p.35ss.; Wolf: Medium 2002, chap. 6: Genre and the Video Game on the "management simulation". back

55 Kücklich: Computerphilologie 2002, p.36s.; Malliet/Meyer: History 2005, p.37,42; Wirsig: Lexikon 2003, p.192s. back

56 Wing: Economics 1966. The second game was the "Sierra Leone Development Project". It was developed for students. back

57 Lange: Hamurabi 2008; Rosenberg: Code 2007, chap. 0, p.1s.; Wikipedia: Hamurabi 2012. back

58 Ahl: BASIC 1978, p.78s.; Myers: Nature 2003, p.43ss. The net version offers tips to players to find ways to get into the game easier. back

59 Merrill, Richard/Ahl, David/Schneider, Lee/Voros, Todd et al.: Dukedom, 1976, computer game (Ahl: Dukedom 1984); Storer, James A.: King, Creative Computing,

Morristown/New Jersey 1978, computer game (Ahl: BASIC 1978, p.96ss.); Fong, Weyman: Dynasty, Apple Core, 1978, computer game for personal computer (Apple II); Blank, George: Santa Paravia en Fiumaccio, Softside 1978, computer game for personal computer (Apple II); Schneider, Lee/Voros, Todd: Kingdom, Atari 1980, computer game for personal computer (Atari 800). back

60 Console Mattel Intellivision, since 1980. Lit.: Forster: Spielkonsolen 2009, p.40ss. back

61 Cassidy: Utopia 2004; Donovan: Replay 2010, p.190s. back

62 Grannell: Computer 2001; Wirsig: Lexikon 2003, p.276s. back

63 Gnome: Ego 2007; Wirsig: Lexikon 2003, p.21s. back

64 Donovan: Replay 2010, p.323s.; Herz: Joystick 1997, p.31,217; Wirsig: Lexikon 2003, p.367s. back

65 Wright: Chat 2000. back

66 Günzel: Raum 2008, p.125; Malliet/Meyer: History 2005, p.37; Wardrip-Fruin: Effects 2006, chap. The Sim City Effect; Wirsig: Lexikon 2003, p.412s. back

67 Friedman: Sense 1995, chap. Simulation and Subjectivity. Further lit.: Donovan: Replay 2010, p.191,193ss.; Günzel: Egoshooter 2012, p.257s.; Herz: Joystick 1997, p.218-223; Lobo: Life 2007, S.207ss.; Wirsig: Lexikon 2003, p.412s. back

68 Myers: Bombs 2005, chap. Play and Replay. back

69 Galloway: Gaming 2006, p.106; Poblocki: Becoming-State 2002, p.175. back

70 Poblocki: Becoming-State 2002, p.166,168,171s. back

71 Myers: Bombs 2005, chap. Barbarous Treatments. back

72 Myers: Bombs 2005, chap. A Theoretical Interlude, In the Back of the Backstories. Further literature on the first version of "Civilization": Carr: Trouble 2007; Donovan: Replay 2010, p.196; Galloway: Gaming 2006, p.95s.,99,101s.; Günzel: Egoshooter 2012, p.257s.; Mäyrä: Introduction 2008, p.95-101; Myers: Nature 2003, p.131ss.,135s.,140s.; Reichert: Government-Games 2008; Tyler: Test 2009; Wirsig: Lexikon 2003, p.90. back

73 Neitzel: Geschichten 2000, p.217s.; Neitzel: Point 2007, p.23-26. back

74 Myers: Bombs 2005, chap. Saving, Reloading and Replay. back

75 Neitzel: Narrativity 2005, p.237; Ryan: Myth 2001, chap. VR narrative, and the myth of the Holodeck.
About the distinction between internal (resp. model) player and implicit player: Dreher: Weibel 1997, p.39,49s. with ann.49 (with an adaptation of Umberto Eco´s distinction between the implicit, the internal and the external reader. In: Eco: Lector 1990, chap. 3.6, p.76-82). The terminology proposed here differs from Aarseth: Cybertext 1997, p.120,124,127 and Neitzel: Narrativity 2005, p.240s. back

76 Cf. the discourse on "immersion": Mäyrä: Introduction 2008, p.108ss.; Ermi/Mäyrä: Components 2005; Neitzel: Medienrezeption 2008, p.100ss.; Neitzel/Nohr: Spiel 2006, p.16s.; Schmidt: Illusion 2007. back

77 Manovich: Space 1998. back

78 Neitzel: Medienrezeption 2008, p.102s. back

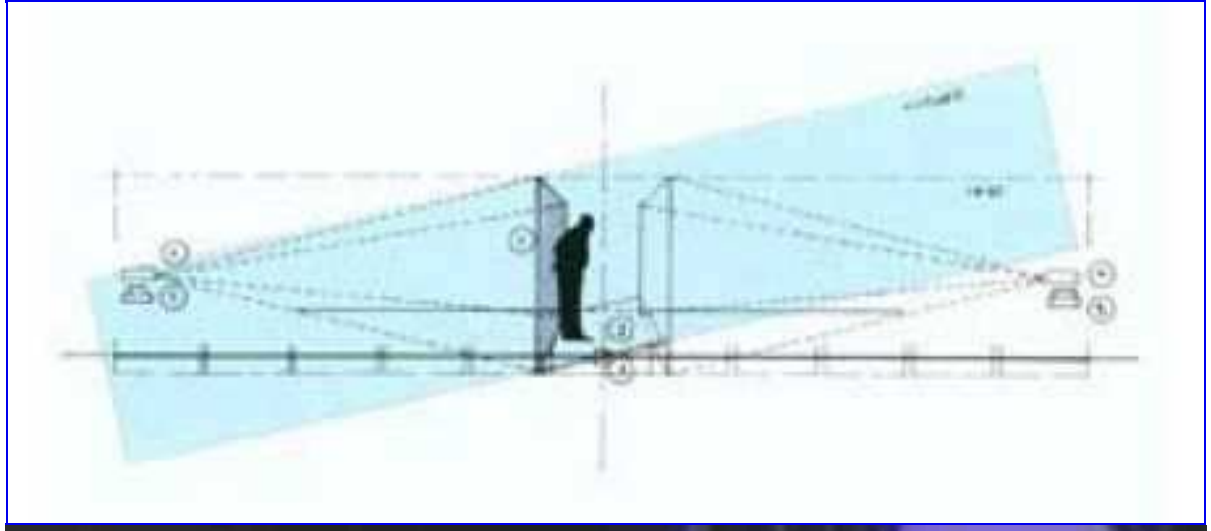
VII. Games
VII.2 Pervasive Games

VII.2.1 Spatialization

With the ego shooters "immersion" (see chap. VII.1.3.2, ann.76) became one of the important factors determining the history of computer games, as is shown in chapter VII.1.3: The players "involve" themselves actively ("involvement", see chap. VII.1.3.2, ann.76) into the game world with their actions and orientations between the input elements of a technical interface and the monitor presenting an immersing simulation. Players train their cognition of the relations between the monitor´s presentation of the game world and the possibilities offered by consoles, joysticks, mouses and/or keyboards to fulfill game affordances and to exploit the chances to win.

The exclusion of body parts not used for the input on technical interfaces and for the control of the screen´s output (technical interface) repeats the reduction of working processes to uses of eyes and hands. 1 After the Second World War the mechanically organised reduction of working processes to few involved body parts was developed further, and the reduction was continued by the digitalisation of organisational processes. Nevertheless the reactive installations of the first half of the nineties, as they were presented in chapter V, offer interfaces for a coordination of more parts of the body: The moving body is integrated into the installation no longer only with the coordinated movements of hands and eyes.

In Christian Möller´s "Space (im)Balance" (1992) 2 the observers move on a bridge-like platform. They change the bridge´s gradient in transferring their body weight. With their modifications of the bridge´s gradient observers activate the interface to two projections of a 3D animation. The projections on two adjacent long sides of the bridge present spheres moving in a simulated corridor. These movements depend on the bridge´s gradient. If observers want to maintain their upright posture then they have to react to changing gradients with balancing movements. Observers try to coordinate their balance adjustment with their efforts to influence the sphere´s movements between both projections. If observers change their position on the bridge to follow the sphere´s moves between the two projections then they modify the gradient of the bridge, too: With the indivisible relation between movements on the bridge and the image simulation the visitors´ possibilities to observe the sphere´s moves are restricted. If visitors modify the bridge´s gradient by motions to be able to follow the sphere´s movements from another point of view, then they change the sphere´s motion: In acting on the bridge visitors cause the following changes of the sphere because they initiate modifications of the projection with each correction of their body position made with the intention to ameliorate their angle of view.



Möller, Christian: Space (im)Balance, 1992, pavilion with reactive installation in the interior space, Donaulände, Linz.
Top: vertical plan (Möller: Space 1992, p.158).
Bottom: The pavilion´s interior with one of the two projections and an observer standing on the platform with a modifiable gradient.

Möller´s bridge is transformed in "Sonic Pong" by Time´s Up (1999) into an interface constituted by two little panels whose gradients can be modified with the feet. The 2D tennis game presentation of Atari´s classic "Pong" (1972, see chap. VII.1.2) is changed into a light projection of three signs – two beams for the two racquets and a circle for the ball – accompanied by sounds. The switching elements for the tonal control by hands are mounted on a board. The sound is emitted by a row of loudspeakers being placed between the two interfaces for inputs by hands and feet. Between the loudspeakers the sound follows the projection of the ball.



Time´s Up: Sonic Pong, 1999, reactive installation.

Meanwhile players control the Pong projection they react to gravitational forces in their efforts to maintain their upright posture. Above the panels the boards are mounted on vertical bars and can be used by players as opportunities to hold themselves with their hands, to balance and to keep their upper bodies upright.

When players ask themselves if the tonal control was the goal of the developers, then they recognise the necessity to proceed with the game play for a continuation of the sound production using sampled sounds of old computer games. The sound production can be controlled by two rocker levers and a pressure switch. The produced sounds are of an interesting kind and can provoke an understanding of the modified Pong elements as an interface to the sound production. 3

The development of internet games is followed by a further phase of the spatialization of games. Many participants play against each other in Massively Multiplayer Online Games (MMOG) 4 on several servers storing variants in different languages. The online role game "Neverwinter Nights" (Massively Multiplayer Online Role Game 5, 1991-1997) offered in 1991 still to 200 participants, then in 1997 up to 500 participants a platform to play against each other alone or in teams with a game master. The 3D simulation represented the fantasy game world in the "third person overview". In June 2001 "World War II online" was presented as a "first person shooter" (see chap. VII.1.3.1) with characteristics of role playing games, as they were featured earlier in online games like "Ultima Online" (since 1997) from a "third person overview". 6



Battleground Europe: World War II online, 2001, MMOG.

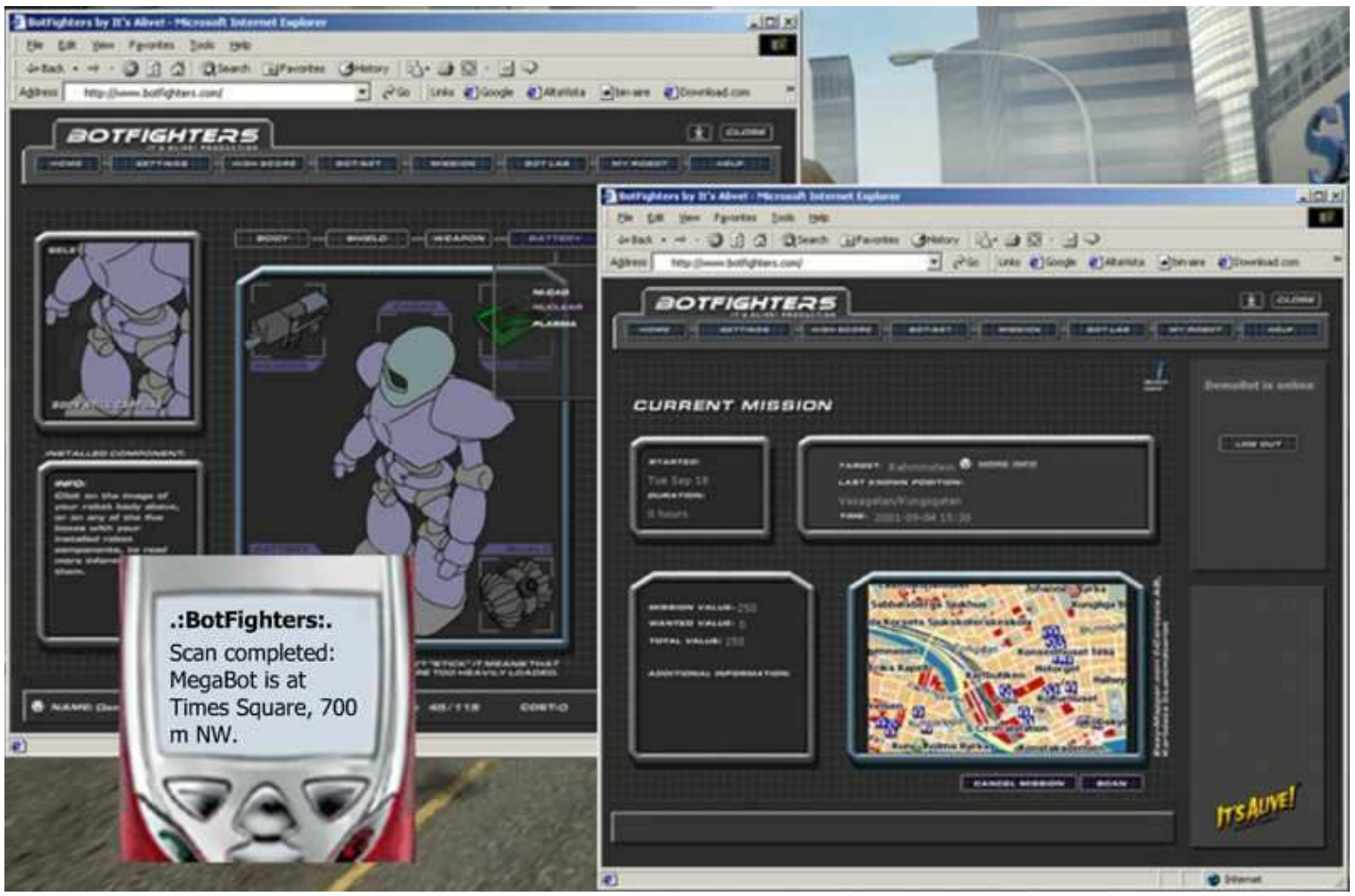
Already in April 2001 – and thus two months before "World War II online" – It´s Alive releases the pervasive game "BotFighters" for mobile telephones presenting the locations of opponents on a 2D display. With its offer to combatants to choose their role in one of the camps (rebels against "Global nations") "BotFighters" anticipates the combination of shooters and the elements of role playing in "World War II online", but it reduces the 3D simulation on the mobile phone´s display to a diagrammatic 2D view of game fields with icons representing the avatars of players. In the science fiction game "BotFighters" the ego shooters´ perspective of players is substituted by the players moving in the real space.



It´s Alive: Botfighters 1, since April 2001, the screen of the mobile telephone.

The diagrammatic screen presentation is an element of the technical interface delivering informations that the players can coordinate with their orientation and actions in the

world (world observation): The technical interface of the mobile phone (interface 2) and the world observation (interface 1) are mediated with each other by the players in the coordination of their `game moves´ (interface 3, see chap. VII.2.2). The coordination of movements in the real space and the virtual game world presupposes the player´s parallel self-orientation in the real world and the virtual combat zone: Thereby the mobile phone is simultaneously a scoreboard and the virtual part of the battlefield. For the game system only specific aspects of the orientation and motion in the real space are relevant, but nevertheless the player has to mobilise all capabilities for orientations and body coordinations to organize his movements in the real space.



It´s Alive: Botfighters 1, since April 2001, pervasive game, illustrations from the web site and the screen of the mobile telephone.

The localisation of players in cells uses mobile telephony´s cell-ID positioning technology. If opponents are located in the same mobile cell, then the game system informs them via SMS. At each day or night time a player can start a fight by ringing the combatant´s mobile phone. In the fights between rebels and "Global Nations" a player can try to enhance his account on the side chosen.

The account and the score-dependent hierarchy of the players are shown on the "BotFighter´s" website. 7 Players can also ameliorate the equipment of their avatars on the site of the commercial game. 8

The mobile screen with a 2D data visualisation presents to players the informations necessary for their coordinations of actions in the real space. More informations or even a virtual world worked out as a 3D animation 9 may be disturbing for the players´ efforts to coordinate their game moves in the urban traffic: Meanwhile moves at the consoles of computer games are coordinated by players "immersed" in virtual spaces and thus "involved" in 3D game worlds, the players of pervasive games use informations delivered by the screens of mobile gadgets to orientate themselves in the real space in a game-oriented functional way for the coordination of their strategies and moves. But the transfer of the navigation in simulated spaces back to the real spaces doesn´t cause a return of the self-orientation to strategies in street games. 10

In the course of the development of pervasive games after "BotFighters" the adaptation of computer games´ characteristics was at first deepened 11, until the developers overcame such dependencies.

At the pilot test of "Frequency 1550" (2/7-9/2005) eleven and twelve-year-old pupils of the course IVKO (Individueel Voorgezet Kunstzinnig Onderwijs) by Amsterdam´s Montessori Scholengemeenschap (association of Montessori schools) form six teams, each with four participants. Two players of a team stay in the head quarter at De Waag (the former city gate Sint Antoniespoort, 1488). The two other team members take over the role of pilgrims wandering in 1550 as penitents to the Hostie van het Mirakel in Amsterdam.



Waag Society: Frequency 1550, February 2005, pervasive game, pilot test.

In 15th November 1345 a sick man received a host before he dies. This host was found in the residues of his estate after it burnt to cinders. The place of this miracle became a destination of pilgrimages and led to the edification of a chapel as well as to a procession repeated annually. After the conversion of Amsterdam to the protestantism in 1578 the procession was continued. Since 1871 catholics organised the procession as a quiet walk, and the participants don´t carry any religious attributes.

In their role as penitents the participants pursue the goal to refind the (in the game) vanished host and to build a cloister. Only as citizens of Amsterdam they can receive a building permission. With the points received in accomplishing the tasks the players approach their goal to be recognised as citizens of Amsterdam.

A city map of the 16th century (from the collection of the Gemeentearchief Amsterdam) is divided in game sectors. The teams are assigned to specific sectors. Each team is equipped with two mobile phones: A mobile phone Nokia 6600 GPRS presents the city map of Amsterdam on its screen. The videostreams containing informations on the tasks of the game – a user manual and questions – are sent via UMTS and presented to each team on a second mobile, a Sony Ericsson Z 1010. In the urban space the teams get the instruction via GPRS on the first mobile phone to receive their next tasks via UMTS on their second mobile phone.

The street players carry GPS receivers. They are connected wireless by bluetooth to the GPRS mobile telephones being used to send the data to the game server. After the data are processed by the game server then they are sent to the GPRS mobile phones of the street players. On their screens the GPS localisation is presented on the city map of Amsterdam made in the 16th century.

In the head quarter a laptop presents the locations of all participants. The participants stationed at the head quarter can follow the paths of the teams on an actualised city map(in Flash) and they can switch to the map of the Gemeentearchief. While the participants of a team act in Amsterdam´s streets they compare the old city map on the screen of their GPRS mobile phone with the actual states of the urban environment. Especially the filled channels as well as the demolished and new bridges pose problems to the players´ efforts to orientate themselves in the actual city with a map of the 16th century.

The players located in the head quarter can help the other members of their team when questions concerning the current course of a street arise, and they can try to help to solve tasks as fast as possible (via input to search systems on the web). From the outdoor spaces the players send photos and films of solved tasks as e-mails with attachments via UMTS to the head quarter.

For the duration of 10 minutes competitors can deactivate with "GPS-boobytraps" the localisation being integrated into the game system via the GPRS mobile telephones. In these cases the view of the map remains intact. If the deactivated localisation can´t prohibit the participants of a team to arrive at a specific location before the end of the blocking period, than this period ends earlier.

The game´s pilot test had a duration of two days. In De Waag a third day was used to examine if the players memorised the informations they received on the history of Amsterdam in the first two days. It is told that the result of the test exceeded the expectations. 12

The test offered players to learn how the history of religions influenced the city as a growing field of forces integrating different structures (religions, urban planning, traffic, and others).

In the pervasive games described below changes in the states of the players´ moving bodies deliver the input to the carried mobile equipment. This equipment records dates and then processes or transports them in networks to servers. The screens of the mobile gadgets indicate to players if their movements remain within the programmed limits or if they transgress them.

Players coordinate the technically implemented part of the game´s rules with the non-implemented parts. To follow their game strategy and to fulfill the tasks the players try to accomodate their body movements to the informations indicated on the screens of the mobile equipment. In urban spaces the players have to care for their self coordination in traffic situations affording attentions not seldom simultaneously in times when the screens of the mobile equipments require this attention, too. The impossible simultaneous direction of the attention to the screens and the urban traffic has to be transformed into a sequentially structured observation, often under time pressure.

In "´Ere by Dragons" (2005) 13 the player´s attention is directed to his pulse because the mobile equipment reacts to it and switches itself off after two minutes lasting heart rates being either too high or too low.

Participants are equipped with PDAs (Personal Digital Assistants by Hewlett Packard : HPiPAQ), GPS receivers and a heart rate monitor (measures heart rates per minute). Two electrocardiograms (ECG contacts) of an ECG monitor are attached to a belt. They are strapped around the waist. A light weight sensor bus (Science Scope Sensor Slave) coordinates the connection of the two input systems GPS and ECG with the PDA. The ECG monitor (by Science Scope) is connected wirelessly with the sensor bus.



Active Ingredient/Lansdown Centre for Electronic Arts und London Institute for Sport and Exercise, Middlesex University, London/Mixed Reality Laboratory, Nottingham Trent University: ´Ere be Dragons, project, Nottingham, Februar und Dezember 2005/Singapore, November 2005/Berlin, October 2006.

A flash program reacts to the heart rate measured by the ECG in constructing isometric views of vegetative worlds. They are presented on the screen of the PDA to the players. The views coordinate specific motifs of landscapes with specific locations: If a player repasses the same location then the screen presents the same landscape motif.

The heart rate being adequate for each player and his age has to be ascertained before the game starts. The technical equipment is tuned to each player´s optimal heart rate. As long as a player sustains his optimal heart rate the screen of the PDA shows a landscape with grasses, trees and flowers. At a low rate the screen shows a desert, meanwhile a high rate is indicated by the presentation of an impermeable forest. When the player leaves the optimal heart rate, then a warning and, after two minutes, the deactivation follows. If players have to care about the traffic and are disabled to observe the screen, then audio signals facilitate the control of the pulse. A "client-server system" delivers the informations needed on the locations of other players.

The game intended for the activation of the body and as a means against obesity follows the concept of the "open play": "...it is up to the player to decide how they want to play." [14]

The equipment of Jonas Hansen´s (former: Jonas Hielscher) game "Wanderer" (2005) [15] reacts to the player´s speed. The players have to react to instructions like "too fast, go slower" or "too slow, go faster".

A player walks with laptop, GPS receiver and headphone. GPS localisations deliver the basic input for the indication of a player´s speed. A beat of bleeps makes it easier to players to accomodate their speed (walking pace: 3-4 km/h). Obstacles have to be

circumvented fast. Players increase their point account by following the instructions for direction changes (f.e. "Turn left now"), as they are generated by the game system´s chance operations, and by circumventions of obstacles lasting only a few seconds. Skilled reactions to game affordances and movements circumventing obstacles in the real space are rewarded in "´Ere by Dragons" and "Wanderer".



Hansen, Jonas: Wanderer, September 2005, pervasive game. Screenshots from Vimeo.

The development from games in exhibition spaces to games in urban spaces evolved from "Sonic Pong´s" spatialization of "Pong" to "BotFighters´" transfer of a MMORPG into the real space. Meanwhile in "BotFighters" and in "Frequency 1550" the game play is determined by two levels (the urban space and the game system) with affordances to the players to coordinate these levels with each other, in "´Ere by Dragons" and "Wanderer" the players integrate the states and actions of their bodies into their game strategies mediating between the urban space and the technical equipment.

A player´s reactions to situations in the urban traffic by a too much reduced or accelerated walking tempo and by increased heart rates are registered by the technical equipment. The registrations of his reactions cause in turn the player to correct his further movements: If a player integrates his body into the control of game moves in using the criteria indicated by the technical interface, then he integrates changes of his body in the same manner as he does it with other changing conditions of the environment. The player acts in this way as a controller of the organization of game moves (game-oriented world-interface, interface 3), but nevertheless in his organisation of further game moves he has another impact on conditions of his body as he has it on his adaptation to traffic conditions and other obstacles (*internal environment*/*external environment*). The part of the mobile equipment sustaining recursions of body states and actions to the game-oriented interface (interface 3) can be integrated into the body coordination like an artificial limb. The mediation between the body coordination for movements and orientations in the real space (world interface, interface 1) on the one hand, and the body coordination for the input to the mobile equipment (technical interface, interface 2) on the other hand, is realised by the coordination of the adaptable action schemes and plans (the cognitive body coordination) with measurable body effects (the biologic state). Players fulfill a *two-fold reorientation* concerning changing conditions of the environmental conditions and the changing informations about their own body: The game-oriented world observation (interface 3) is forced to mediate permanently in processes of reorientations between the self localisation by orientations within an environment (interface 1) on the one hand, and, on the other hand, the game´s rules and the affordances of the technical equipment (interface 2).

VII.2.2 Game-oriented World-Interface

When players develop strategies for pervasive games then they take into consideration their body coordination in the real space as well as their handling of the technology and their use of the rules to play: The `interface 1´ is constituted by the interface of the observer to the world, and the `interface 2´ by the relation between the technical equipment and the rules to play (as they are not always technically implemented). The `interface 3´ consists of the players´ efforts to develop strategies coordinating their orientation in an environment including the traffic conditions (world-interface, interface 1) with the game´s affordances (interface 2).

The `world-interface´ or `interface 1´ is the interface between the inner and outside world, between cognition, proprioception and sensomotor functions on the one hand and, on the other hand, fields of action in changing environmental conditions.

Observers coordinate their movements in an environment and constitute their conceptions of the environmental conditions in collecting experiences by walking around: The observer acts within the world he is observing (world-internal observer). 16 The observer operations of body movements within the world are fed back to the observing operations coordinating the actions. 17 The observing operations are cognitive

in the sense of knowledge, interest and attention as well as neurobiologic in the sense of a pre-reflective body coordination as it is presupposed, for example, by walking: Not each single step has to be coordinated, but only the direction and the speed. If wider brain areas are damaged then the trial to substitute the cancelled pre-reflective body coordination by intact brain areas causes a conscious and exclusively visually organized coordination. This requires a high concentration to be able to organise simple movements and excludes a body coordination after dark. 18 In activating the nerves being sensitive to audible, tactile and visual stimuli the body supplies input from the external environment and transfers these informations via the nerves to the brain areas being able to process these data in specific ways. In the brain environmental dates are integrated into the world observation in constructing "stimulation patterns", "schemes" and "turning markers". 19 Changings in these constructions cause modifications in the ways to control the body coordination for further movements in the world. The recursions of a body´s movements being made to collect new informations on the environment/world to the formation of world conceptions constitute the `interface 1´ respectively the interface of an observer to the world.

The `interface 2´ or `game-interface´ is constituted by the game rules that can be partially or fully implemented as parts of the technical game system. In games with technical systems implementing all rules players acting without knowledges of the game´s rules can use reactions of the game system to recognise if they follow or act contrary to these rules. Also in games integrating environmental factors only selectively, players make recourses to their `world-interface´ in its full extent for being able to supply the game system with the required dates obtainable by actions in the environment: For players it is impossible to act in real spaces if they did not develop their world observation, and, with it, their capabilities for self orientations and for the navigation of actions (interface 1). Strategies for the game play are results of plans for reactions to events in urban spaces under the conditions of the game. In game moves the strategies are executed under the conditions found in the environment (f.e. the traffic). 20

A walking player can keep his attention focused on a screen only for a short time, because he needs for walking straight ahead repeated visual checks of his own body and its relation to the environment 21: The design of pervasive games should take into account the body coordination and the ways it relates proprioception and outer perception.

The `interface 3´ or the `game-oriented world-interface´ consists of strategies developed by players for expected environmental conditions to realise chances to win via adequate moves. In ways to (sign-) act ("Spiel(zeichen)handeln" 22) between the signs of the game and the urban space the players develop a game-oriented world observation in intermediating `interface 1´ and `interface 2´. With Charles Sanders Peirce these mediations can be understood as mediations of "a first and second" in a "third":

> Third is the conception of mediation, whereby a first and a second are brought into relation. 23

Pervasive games provoke players to relate `interface 1´ and `interface 2´ with each other in `interface 3´ by "embeddings, functionalizations, reductions, hierarchisations, recursions and determinations". 24

Annotations

1 On the "body-hand-builder model" ("Kopf-Hand-Baumeistermodell") of modern times: Neusüß: Kopfgeburten 1985, p.63-73,105s.,119,131ss.,155. (review by Mies: Köpfe 1985; Schönbucher/Seitz: Neusüss 1985). back

2 Ars Electronica 92, Linz, Donaulände, 1992. In: Möller: Architektur 1994, p.31ss.; Möller: Space 1992. back

3 Time´s Up: Sonic 2006. back

4 Kücklich: Worlds 2009. back

5 Massively Multiplayer Online Role Game (MMORPG): Oliver: Eye 2002. Neverwinter Nights: Medar: Neverwinter undated. back

6 Wikipedia: Ultima 2012. back

7 Respectively they were shown on the now-unavailable site of the game. back

8 Dreher: Games 2008, chap. Examples 1: Games with Virtual Spaces; Dreher: Sammeltipp 2, Teil 1 2005-2008 . back

9 Cf. Neitzel: Point 2007. back

10 Cf. the "New Games Movement" of the seventies and its aim to use games "as the vehicle for change" and to direct the players´ attention away from the competition to the cooperative play actions. Lit.: Flanagan: Play 2009, p.183s.; Fluegelman: Games 1976; Pearce/Fullerton/Fron/Morie: Play 2007, chap. 2; Salen/Zimmerman: Rules 2004, p.528s.; Turner: Games 2006. back

11 See the adaptations of PacMan using new technologies: Mixed Reality Lab: Human Pacman, Singapur, 2003-2004 (Dreher: Sammeltipp 2, Teil 1 2005-2008); New York University´s Interactive Telecommunications Programme: Pac Manhattan, New York, April 2004 (Dreher: Sammeltipp 2, Teil 2 2005-2008); InfoLab21, Department of Communication Systems, Lancaster University: Pac-Lan, Bailrigg/Lancaster, Dezember 2005-Februar 2006 (Dreher: Sammeltipp 2, Teil 3 2005-2008). back

12 A server connected via internet was used as the center of all dates. This server was programmed with KeyWorx, a software platform developed by the Waag Society in Amsterdam. The software was open to use it free of charges in non-commercial projects if the developing group was named (Triple license Mozilla Public License/ GNU GPL/ Creative Commons 1.0 Niederlande). Lit.: Dreher: Sammeltipp 2, Teil 2 2005-2008. back

13 By Active Ingredient/Lansdown Centre for Electronic Arts and London Institute for Sport and Exercise, Middlesex University, London/Mixed Reality Laboratory, Nottingham Trent University, Nottingham. Lit.: Dreher: Sammeltipp 2, Teil 2 2005-2008. back

14 Cooke/Davis/Jacobs/Moar/Riddoch/Watkins: Ere 2006, p.159s. back

15 Dreher: Sammeltipp 2, Teil 3 2005-2008. back

16 The "world-internal observer" being able to gain knowledge about the world only relative to his observer position: Dreher: Games 2008, chap. Endophysics: The World as an Interface and chap. World-Interface (Interface 1). back

17 "Observing/observer operations"/ "Beobachtungs-/Beobachteroperationen": Dreher: Performance 2001, p.20ss. back

18 Dreher: Games 2008, chap. Game-oriented World-Interface (Interface 3) with ann.42,43; Gallagher: Body 2005, esp. p.43ss.,74. back

19 Dreher: Games 2008, ann.34-36. back

20 Dreher: Games 2008, chap. From the Game to the Gamer´s Move. back

21 Gallagher: Body 2005, p.76: "...there is cortical integration of information concerning self-motion, spatial orientation, and visuomotor functions." back

22 "Sign-acting in games"/"Sprach(zeichen)handeln": Dreher: Games 2008, chap. World-Interface (Interface 1) with ann.40. back

23 Peirce: Architecture 1891, p.175. back

24 Dreher: Games 2008, chap. Types of Mediation of (Levels of) Interfaces (with examples and analyses). back

VIII. Summary
VIII.1 Three Modes

VIII.1 Three Modes

In what follows three modes are presented as characteristics of procedures used in computer art: Relations between the humans at interfaces, programming and computing processes are shaped by *generative, hypertextual and modular procedures*.

In Evolutionary Art (see chap IV.3.1, IV.3.2) the selections in the course of a basically infinite computing process are executed either as parts of the programmed selections between possibilities, or, alternatively, by the observers when they take over the selection in the manner provided by the program. 1



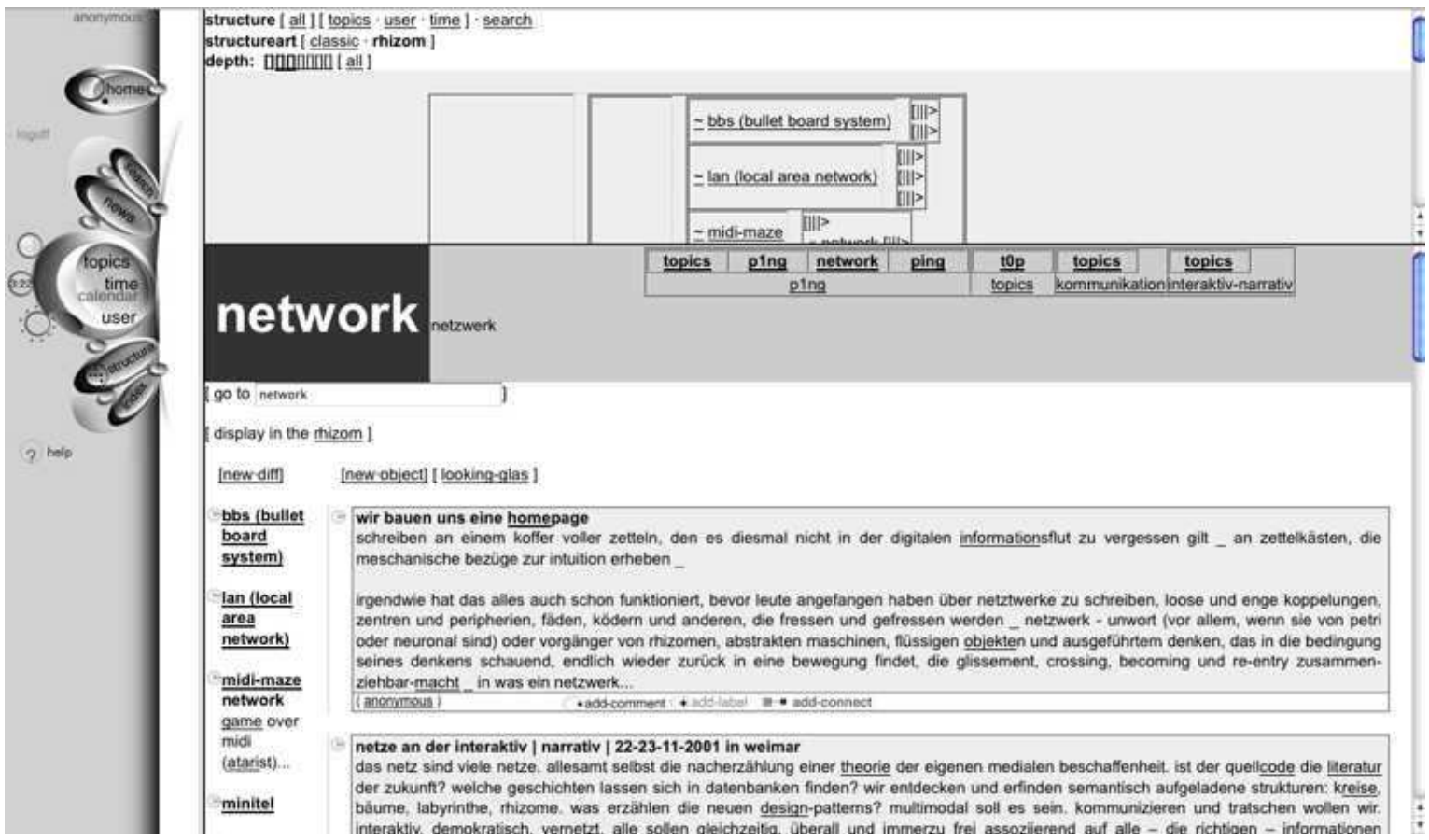
Draves, Scott: Electric Sheep, computer network, internet, screensaver, 1999. Screenshots of phases following one after another (November 2012).

The programs consist of systems determining the generative procedures. In Evolutionary Art the results of preceding processes are transformed in the course of the computing and alternatives are offered to the following generating phases. The output media present these processes in the time dimension (time-based media) and offer observers interfaces

to select alternatives. Despite these chances for selections by observers the programmed computing process remains the leading "agent": The observer is enabled only to select one of the alternatives preconditioned by the programmed generative procedure. In cases when observers don´t intervene the system selects one of these alternatives. If an observer takes the role of an "agent" then he does not interrupt the computing process but becomes an initiator co-determining the following generations. Observers monitor the largest portion of the generating process as "patients" (as passive observers of the computing process). 2

Evolutionary Art is a variant of Generative Art. The term `generative´ designates transformative procedures without determined end: The process of the transformations of the transformed is the path and the goal.

In the structures of databases for hypertexts observer operations (see chap. V.1 with ann.1) are integrated as the actions of cooperating participants (see chap. VI.2.3) deciding on the selection of texts. Their division of texts in sections are saved on cards or "nodes". These parts are designated by "labels" or "topics" and connected by links. 3 These processes are stored on servers. On terminals the stored parts can be recalled and participants can add new parts. The participants are "agents", and the database is the collective memory of the participants. The machine memory of a hypertext database is "patient" until the database-external "agents" activate it to open stored data and to store new inputs. A machine memory with digital writing systems initiates, modificates and augments the participants´ cognitive capabilities: "Augmenting Human Intellect". 4



Bauer, René/Maier, Joachim: nic-las, Stalker, since 1999, web project.

In the hypertextual procedure the roles of "agent" and "patient" are distributed contrary to the generative procedures: The main actor of hypertextual procedures is the observer connecting himself with other participants. Compared to elder writing systems and established uses of language the participants of hypertext systems use their language competence and the database in a modified communication system. For the participants their coordinations of signs with meanings continue to be a fundamental factor during all their actions on terminals. In contrary to the hypertextual systems, in generative projects the computing processes intitialised by codes cause the output media to confront observers with a machine independently producing changing formations. Toward this

generating "agent" and its output observers behave "patient": They try to reconstruct the scale of the output possibilities meanwhile they follow several phases of the generation process.

Meanwhile in hypertextual systems codes are used to connect stored text characters with regard to semantic fields established by the everyday language use, generative procedures are constituted by a computing process being controlled by a program: The programming code contains either no signs being precoded in computer-external contexts, or it uses code elements either to integrate precoded signs into the generation process as moving signs or to transform the signs´ outlines with desemantising effects.

In hypertextual systems the "algorithmic signs" 5 are used in links, anchors, etc. and integrated in texts as a means of the coordination of semantic fields, meanwhile the "algorithmic signs" are fundamental in programs initialising generative computing processes controlling output media. Observers can investigate the time-based output of generative projects concerning the relations between the program and its realisations: The recursion to the technical configurations is a plausible observing operation (see chap. V.1 with ann.1) to be able to follow the ouput of generative procedures, meanwhile hypertextually organised databases sustain the semantics and the participant´s memory function. The results of computing processes initialised by generative programs are not made to fulfill always the observers´ expectations. The output either provokes indifferent and wait-and-see observing operations, or it causes disturbing and investigating familiar perception patterns challenging the observers´ cognitive capabilities, meanwhile the hypertexts simplify and augment the uses of "semantic webs" 6 integrating precoded semantic fields as they were established in elder communication media.

Today three-dimensional simulations can be developed on personal computers with animation programs. The programs include elements as modules like the ones presented in the chapters IV.2.1.2 and IV.2.1.3. Designers construct 3D objects in using these program modules. Then for these objects points of views are selected for inclusions in film sequences. 7 In the development of a film animation designers choose and test different states of an object meanwhile they follow artistic criteria and the storyboard´s notations: Its hand-made sketches (see chap. IV.3.1) present the specifications for the planned image sequences. In realising the sequences of a storyboard designers mediate the modular possibilities of an animation program with the patterns used in human perception to recognise objects and movements.

In the eighties an animation designer chose the perspective and sizes of a three-dimensional object processed with programs for frame models, polygon surfaces and with methods to smooth the polygons as well as for surface qualities like texture, colour, light reflections and shading. Since the midst of the nineties animation programs for personal computers integrate these procedures together with further image editing procedures in one system. Since then the designers of film animations use frequently two-dimensional image templates as basic elements. Designers can variate the selection possibilities of an animation program´ s modules in their efforts to follow cinematographic and aesthetic criteria in the process to find the best variants as realisations of storyboards. When a designer jumps back and forth between the visual perception of provisional results and an adjusting control of the program´s modules then also the roles of "agents" and "patients" change between the designer and the computer. This change is typical for working processes with "modular" procedures on which Lev Manovich focused his investigation of "Info-Aesthetics". 8

For the animations of computer games designers include processed 3D elements in the game engine´s databases and program possible courses of gameplays by following the

criteria of immersion (see chap. VII.1.3 with ann.76). Meanwhile the spectators of films with computer animations view the results of a modular organized production in the position of "patients" only, players of computer games explore the 3D worlds and `meet´ the simulated bodies and objects from several sides and points of view (see chap. VI.1.3.1): The modular procedure is a precondition for the playing "agent" enabling him to view objects in different angles and to experience some of these objects as ennemies (f.e. EverQuest, Massively Multiplayer Online Role-Playing Game by Verant Interactive, 1999).



Verant Interactive: EverQuest, 1999, MMORPG. Screenshot from YouTube.

In modular procedures the software supports possibilities to develop virtual worlds step by step and from decision to decision by following artistic criteria, meanwhile in Generative Art artistic criteria can only be a part of decision-making processes in programming, and – beside some possibilities for selections by observers – are excluded when the programmed algorithms are unfolded by computing processes. However in hypertextual procedures the links are placed by interventions in texts: For links and anchors the codes controlling connections and concatenations are inserted by participants between (parts of) texts adhering to semantic criteria. In hypertexts the effects of functional elements are decisive on a semantic level, meanwhile in Generative Art the focus of the observer´s attention is directed to the relations between the code and the presentations of output media being generated in computing processes. Hypertextual procedures are activated by human interventions into text structures: Hypertexts don´t surprise observers by an unfolding of computing processes without human interventions, in contrary to Generative Art and its predecessor, the permutational computer literature (see chap III.1.2, III.1.3, VI.2).

Modes	Computer	Human
generative	agent	patient
modular	agent-patient	agent-patient
hypertextual	patient	agent

Agent-patient-relations for the three modes to use computing processes in Computer Art.

Annotations

1 Cf. Sims, Karl: Generative Images, 1993, reactive installation, in: see chap. IV.3.2 with ann.22-25; Draves, Scott: Electric Sheep, 1999, computer network, internet, screensaver, in: see chap. IV.3.3. back

2 Seifert: Co-Evolution 2008, p.12: "Agent and patient are defined as relata of the action relation. In an action relation `x acts upon y´ the relatum x is called `the agent´ and y `the patient´, if x acts upon y...As exemplified by Mario Bunge´s definition of terms such as `action´ and `interaction´, the meanings of `action´ and `interaction´ encompass human and non-human actions." (Cf. Bunge: Science 1998, p.41,310,463s.) back

3 Labels ("Etiketten")/topics: Kuhlen: Hypertext 1991, p.87,89s.; Bolter: Space 2001, p.29.
Node: "A node is something through which other things pass, and which is created by their passage." (Slatin: Hypertext 1991, p.162). back

4 Engelbart: Intellect 1962, see chap. VI.2.1. back

5 Dreher: Art 2005/2007, chap. V.2; Nake: Zeichen 2001. back

6 Trunk: Netze 2005, esp. p.19ss. back

7 Cf. Lev Manovich on "After Effects" (since 1993): Manovich: After Effects Part I & II 2006; Manovich: Software 2008, Part 2, Chapter 3, p.110-193. back

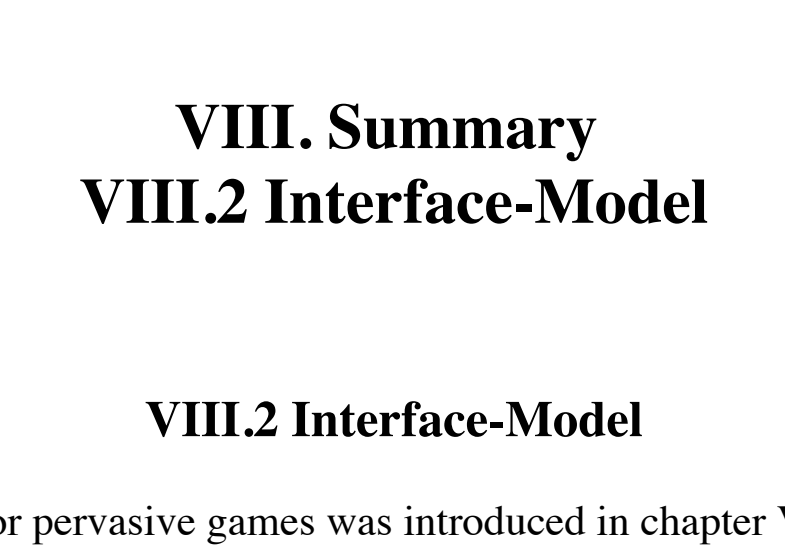
8 Manovich: Software 2008, Part 2, Chapter 4, p.212: "...the animator sets the initial parameters, runs the model, adjusts the parameters, and repeats this production loop until she is satisfied with the result...the animator maintains significant control."
Info-Aesthetics: Manovich: Info-Aesthetics 2001.
Modularity: Manovich: Language 2001, p.30s.,136-141,289; Manovich: Software 2008, Part 3, Chapter 5, p.246-261. back

VIII. Summary
VIII.2 Interface-Model

VIII.2 Interface-Model

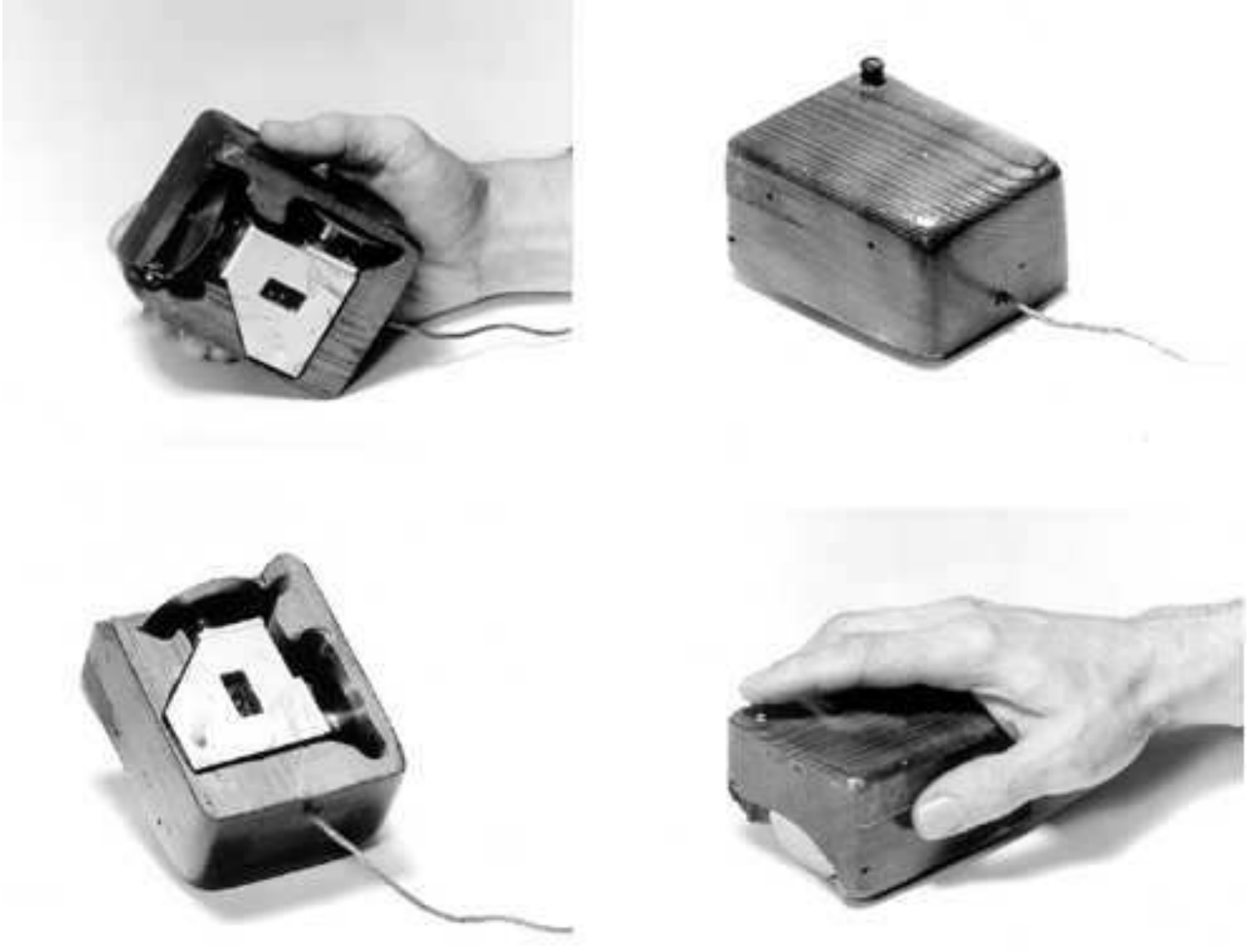
An interface-model for pervasive games was introduced in chapter VII.2. This model features players developing strategies of gameplay by mediations between their world-interface (interface 1) and the "game interface" ("interface 2") to constitute the "game-oriented world-interface (interface 3)". Below a modification of this model is sketched out to be applied to the interfaces of personal computers and reactive installations.

The cognitive access to the world 1 and the pre-reflective body coordination for actions in the world 2 constitute the `interface 1´ as a world-interface. The `interface 2´ contains the technical interface used by humans to control the output of a system via input in using for example the interface components of a computer (Human-Computer-Interface, HCI). `Interface 3´ is constituted by humans mediating their cognition and their body coordination (interface 1) with a technical interface (interface 2). `Interface 3´ is constituted by the human abilities to develop ways to use technical interfaces as well as a technically oriented world-interface – for the use of technologies as specific ways to explore the world, or to deal with the world-interface in specific ways depending on the technologies available for a use quite similar to protheses.



Sholes, Christopher Latham: Typewriter Keyboard Patent Drawing. U.S. Patent No. 207,559. 27th August 1878, fig.3.

For typewriters the key arrangement called "QWERTY" became a standard in English-speaking countries and in some other languages. On each of these typewriters the first six keys in the second row have the order "QWERTY". For computer keyboards the "QWERTY typewriter keyboard" was taken over and became a standard, too. The ten finger typing skills learnt in typewriting courses could be used again for the input to the `interfaces 2´ of computers. 3



Augmentation Research Center: First computer mouse, ca. 1964.

In the sixties the mouse and alternative interfaces were developed at the Augmentation Research Center (ARC, a department of the Stanford Research Institute, Menlo Park/California) under the direction of Douglas Carl Engelbart. This variety provoked investigations which kind of a gadget can be used beside keyboards as a further part of the technical interface to computers for a tactile control allowing a simultaneous concentration of the visual perception on monitors. 4 For the evaluation of the mouse´s acceptance only sporadic tests with contradictory results were integrated into the development of prototypes (see chap. VI.2.1 with ann.6). With these tests researchers at the ARC tried to explore the human capabilities to use the body coordination for a tactile control of gadgets without seeing them and permitting in this way an independent view on the monitor. Compared with a device controlled by a knee and other alternatives the mouse seemed to be a construction of equal value. 5





Augmentation Research Center: Left: A knee-operating pointing device as an alternative to a mouse, 1967 or earlier. Right: Grafacon, movable gyro-style pointing device as an alternative to a mouse, c. 1965.

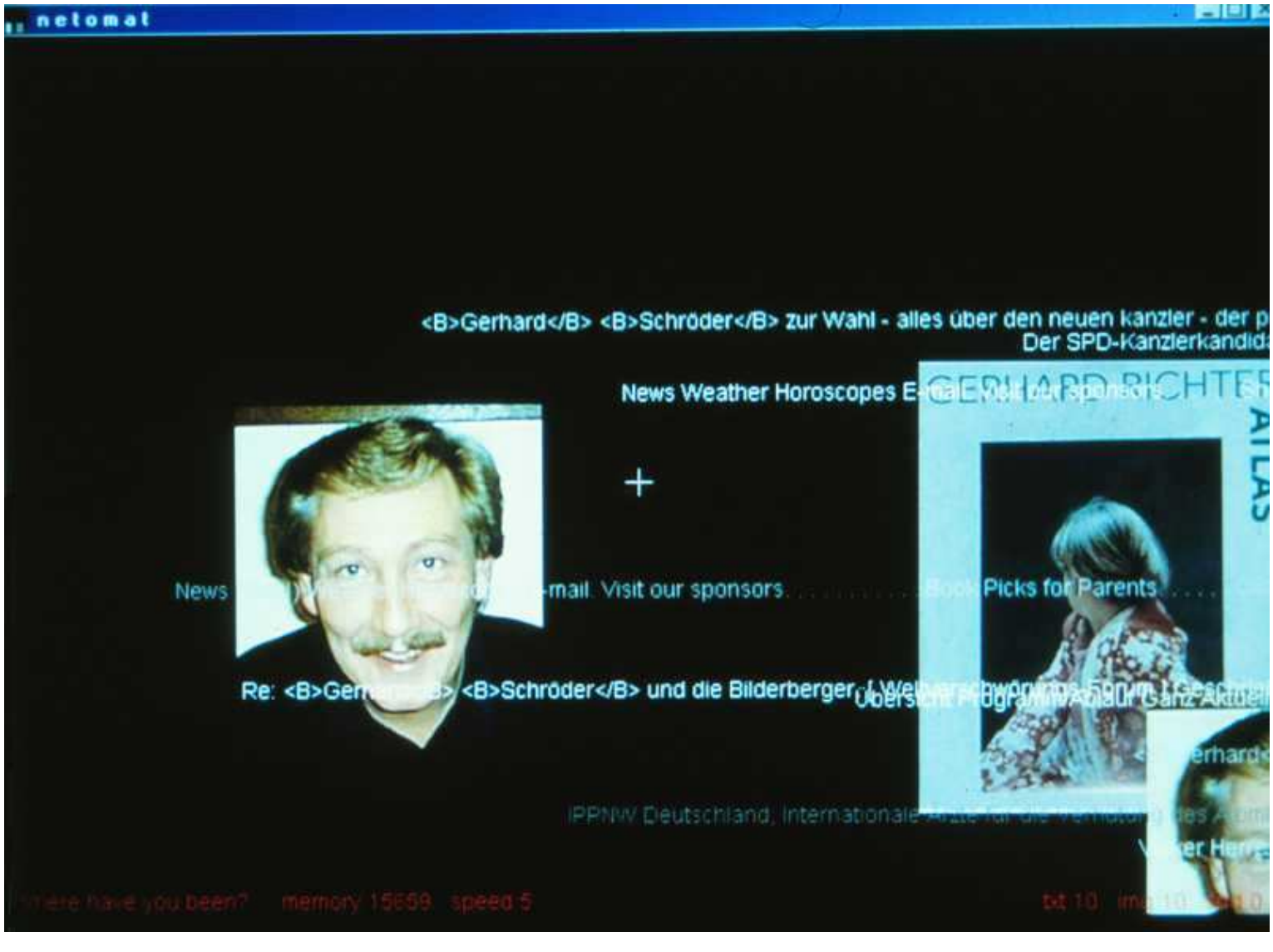
As a possible use of the technical interface combining monitor, mouse, keyboard and keyset (it became not an accepted part of the standard interface) the researchers at the ARC developed hypertextual procedures augmenting the uses of texts in writing systems. In using these technical interfaces (interface 2) and concatenation techniques a project´s participant gets access to hypertextual procedures. These procedures can provoke changes in an observer´s way to activate his language competence (interface 1) for his efforts to understand texts (see chap. VI.2.1 with ann. 8-19). With this modified understanding of texts participants of hypertext projects constitute an `interface 3´ containing concepts of the planning and implementing of "semantic webs" (see chap. VIII.1 with ann.6).



Augmentation Research Center: Prototype of an interface for computers with monitor, manual, keyset (left) and mouse (right), 1967.

On the one side the (self-)trained ways to surf the web in using hands and eyes on a keyboard, a manual, a mouse (or a touch screen) and a browser can be described on the level of the `interface 3´. On the other side on this level observers are enabled to explore and communicate the provocations produced by some projects of browser art (see chap. VI.3.3). Such an investigation using the provocations of browser art on the level of the `interface 3´ explores the informations being hidden by standard browsers, and the accesses to data being prohibited by these web interfaces (interface 2): Standard browsers convert a data stream to webpages with a design not unlike printed pages. 6 The data stream is fed from files being stored on several servers located at different places. These files consist of film, photo, audio and text formats. The files are put together in a browser presentation of a web page. After users installed Maciej Wisniewski´ s browser "Netomat" (see chap. VI.3.3) on a personal computer with one of the operating systems being used in 1999 and typed in a keyword then they could retrieve simultaneously text elements as well as audio and film files. The files stored on different servers were presented in "Netomat" without the functions controlled by the source code to execute the web page presentation of the usual web browsers putting together the files to the defined web page lay-out. To the observers´ advantage a simultaneity of different informations on a keyword was presented on the screen. The direction of the data stream on the monitor was influenceable by cursor movements.

An observer of browser art can´t rely on the reacting movements being trained by himself in using the established webbrowsers: The usual retrieving of web pages and links is called into question. For observers the relations between the input on a keyboard, monitor presentations and the functions controlled by mouse moves appear in a new light.



Wisniewski, Maciej: Netomat, 1999, browser (photo of the monitor presentation, October 2000).

The ego shooters (see chap. VII.1.3.1) force players to execute trained coordinations

between the perception of the simulated game world and hand movements as fast as possible on the technical interface (interface 2 with joystick, mouse, keyboard and monitor): On this interface (interface 2) the perception and body coordination (interface 1) is trained by the player to enable himself to react to the game world simulations with tactical moves (interface 3) eliminating obstacles with a minimum of delay. The immersive effect is caused by joystick navigations into the simulated spatial depth of the game world, the simultaneous concentration on ennemies coming out of this depth and the executions of the gameplay-trained modes to react. For the evolution of an `interface 3´ consisting of modes to operate against ennemies players enable themselves to the execution of fast moves by coordinating their perceptions of the game world with their hand operations at the joystick. After several successful actions realising strategies of the gameplay (`interface 3´) these fast moves provoke the impression of a speedily continuable movement in and through the game world.



id Software (Romero, John/Carmack, John/Hall, Tom): Doom, Cdv Software Entertainment, Pearl Agency, 1993, computer game.

The reduction of the body coordination on the games´ technical interfaces to hands (for the uses of keyboards, mouses and joysticks) and eyes (for the perception of monitors) is a consequence of the development of the standards for technical interfaces (interface 2, see chap. VII.2.1 with ann.1). In opposition to this reduction of the body to hands and eyes the affordances to the body coordination (interface 1) for the control of unusual technical interfaces are augmented: Reactive installations (see chap. V, VII.2.1) and pervasive games (see chap. VII.2) mobilise several parts, if not the whole body, of a moving observer as a human acting to move technical interfaces. Artists dissolve the reduction of human actions to a few body parts by an integration of wider parts of the `interface 1´ to control unusual `interfaces 2´. With these works artists enable observers to explore the possibilities to develop an `interface 3´ in mediating the unusual `interfaces 2´ with unusual activations of the `interface 1´. So artists transgress the established technical interfaces. The experimentation with interface alternatives leads observers to possibilities transferring common recursions between output and input in new concatenations of computing, thought and action processes.



Time´s Up: Sonic Pong, 1999, reactive installation.

After 2000 the increasing "interconnectedness" of various transmission and communication systems (GPS, mobile telephony, fixed-line network) with stationary and mobile devices 7 provokes the participants of projects to reconceptualise their reactions to requirements sometimes simultaneously posed by technical interfaces and the environment. The `interface 3´, constituted for this purpose by the participants´ observing operations, includes partially not easy to fulfill demands to coordinate self localisations and orientations in environments (interface 1) with the reception of informations indicated by the screens of mobile terminals (interface 2): In strategies for the gameplay simultaneous requirements by devices on the one side and environments on the other side lead to a partition of operations in phases with switches of the attention (interface 3) between both sides: At times the player directs his attention from the urban traffic to the screen and vice versa (see chap. VII.2.2).

Annotations

1 With "conceptual schemes" and "action plans": Dreher: Performance 2001, p.22s.,404s.; Dreher: Games 2008, ann.35. Cf. chap. VII.2.2. back

2 See chap. VII.2.2 with ann.18. back

3 Bardini: Bootstrapping 2000, p.67-80; Rehr: QWERTY undated. back

4 Bardini: Bootstrapping 2000, p.79-102,107-114. back

5 Bardini: Bootstrapping 2000, p.103-107, 112ss. back

6 Kahnwald: Netzkunst 2006, p.61-64,75-78. back

7 Dreher: Games 2008, chap. "Interconnectedness" and Mobile Devices with ann.1. back

IX. Bibliography

All abbreviations for texts used in the annotations present first the last name of the author or editor, then – after a colon – the first noun of the title. If the first noun of a title is a part of a designation containing more than one word (like Contextual Art), then the abbreviation includes the designation with all words. If titles present a first name as the first noun then the abbreviation contains first and last name. If titles contain no noun then the first word will be used in the abbreviation. The third part of the abbreviation constitutes the year of the publication.
Another abbreviation: t.o.f.p. = title of the first print in the author´s language.

Aarseth, Espen J.: Allegories of Space. The Question of Spatiality in Computer Games (2004). In: Eskelinen, Markku Markku/Koskimaa, Raine (ed.): CyberText Yearbook 2000. Research Centre for Contemporary Culture, University of Jyväskylä. Jyväskylä 2001, p.152-171. New in: URL: http://cybertext.hum.jyu.fi/articles/129.pdf (9/8/2012).
Aarseth, Espen J.: Cybertext. Perspectives on Ergodic Literature. Baltimore 1997.
Ackers, Susanne/Arns, Inke/Hunger, Francis/Lillemose, Jacob (ed.): The Hartware Guide to Irational. Cat. of exhib. PHOENIX Halle Dortmund 2006/Frankfurt am Main 2006.
Adams, Dan: The State of the RTS (2006). In: URL: http://www.ign.com/ articles/ 2006/ 04/ 08/ the-state-of-the-rts (9/8/2012).
Adrian X, Robert: Elektronischer Raum. In: Kunstforum. Vol.103. September/Oktober 1989, p.142-147. New in: URL: http://90.146.8.18/ de/ archiv_ files/ 19891/ 1989_142.pdf (2/24/2012).
Adrian X, Robert: Interview. In: Gehrmann, Lucas (ed.): Robert Adrian X. Cat. of exhib. Kunsthalle Wien 2001, p.46-67.
Adrian X, Robert: Die Kunst der Kommunikation/Communicating/L´Art de Communiquer. In: Grundmann, Heidi (ed.): Art Telecommunication. Vancouver/Vienna 1984, p.77-80.
Adrian X, Robert: Kunst und Telekommunikation 1979-1986. Die Pionierzeit. In: Springer. Vol.1/Nr. 1. April 1995, p.10s. (in English: Art and Telecommunication 1979-1986. The Pioneer Years. In: URL: http://telematic.walkerart.org/ overview/ overview_adrian.html (5/22/2012)).
Adrian X, Robert: Die Welt in 24 Stunden/The World in 24 Hours. In: Stadlmayr, Horst/Leopoldseder, Hannes (ed.): Ars Electronica im Rahmen des Internationalen Brucknerfestivals Linz. Cat. of exhib. Brucknerhaus. Linz 1982, p.145-157. New in: URL: http://90.146.8.18/ en/ archiv_ files/ 19821/ E1982_155.pdf (5/24/2012).
Ahl, David H.: BASIC Computer Games. New York 1978. New in: URL: http://atariarchives.org/ basicgames/ (9/8/2012).
Ahl, David H.: Big Computer Games. Morris Plains/New Jersey 1984. New in: URL: http://www.atariarchives.org/ bigcomputergames/ (9/8/2012).
Ahl, David H.: Dukedom. In: Id.: Big Computer Games. Morris Plains/New Jersey 1984, p.11-16. New in: URL: http://www.atariarchives.org/ bigcomputergames/ showpage.php?page=11 (9/8/2012).
Ahl, David H.: Hammurabi. In: Id. (ed.): BASIC Computer Games. New York 1978, p.78s. New in: URL: http://atariarchives.org/ basicgames/ showpage.php ?page=78 (9/8/2012).
Alsleben, Kurd: Aesthetische Redundanz. Abhandlungen über die artistischen Mittel der bildenden Kunst. Quickborn 1962.
Alsleben, Kurd/Eske, Antje/Idensen, Heiko (ed.): Felix Aestheticus. Konversationskunst.

Cat. of exhib. Zentrum für Kunst und Medientechnologie (ZKM)/Center for Arts and Media. Karlsruhe/Norderstedt 2011.
Althusser, Louis: For Marx (t.o.f.p. Pour Marx. Paris 1965). London 1969.
Anfam, David: Abstract Expressionism. London 1990.
The Architecture Machine Group: Seek 1969-70. In: Burnham, Jack: Software – Information Technology. Its New Meaning for Art. Cat. of exhib. Jewish Museum. New York 1970. New in: Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003, p.252s. New in: URL: http://www.manovich.net/vis242_winter_2006/ New%20Media%20Reader%20all/ 17-software-03.pdf (10/9/2011).
Arns, Inke: Interaction, Participation, Networking. Art and Telecommunication. In: Daniels, Dieter/Frieling, Rudolf (ed.): Media Art Net 1: Survey of Media Art. Vienna and New York 2004. URL: http://www.medienkunstnetz.de /themes/ overview_of_media_art/communication/ scroll/ (7/28/2013).
Arns, Inke: Netzkulturen. Hamburg 2002.
Arns, Inke: _Readme – Own, Be Owned Or Remain Invisible. In: Ackers, Susanne/Arns, Inke/Hunger, Francis/Lillemose, Jacob (ed.): The Hartware Guide to Irational. Cat. of exhib. PHOENIX Halle Dortmund 2006/Frankfurt am Main 2006, p.12,80.
Arns, Inke: This is not a toy war. Politischer Aktivismus in Zeiten des Internet. In: Münker, Stefan/Roesler, Alexander (ed.): Praxis Internet. Kulturtechniken der vernetzten Welt. Frankfurt am Main 2002, p.37-60. New in: URL: http://www.projects.v2.nl/ ~arns/Texts/ Media/ notoywar.html (8/1/2012).
Art & LanguageNY (Ian Burn, Michael Corris, Preston Heller, Andrew Menard, Mel Ramsden, Terry Smith): Blurting in A & L: an index of blurts and their concatenation (the Handbook)...New York/Halifax 1973.
Ascott, Roy: Art and Telematics. In: Grundmann, Heidi (ed.): Art Telecommunication. Vancouver/Vienna 1984, p.25-58.
Ascott, Roy/Loeffler, Carl Eugene (ed.): Connectivity: Art and Interactive Telecommunications. In: Leonardo. Vol.24/No.2. Cambridge/Massachusetts 1991, p.113-240.
Ascott, Roy/White, Norman et al.: La Plissure du Texte (1983). In: URL: http://www.normill.ca/ Text/ plissure.txt (5/24/2012).
Ashby, William Ross: Design for a Brain. The Origin of Adaptive Behavior. New York 1952/Second Revised Edition 1960. New in: URL: http://www.archive.org/ download/designforbrainor00ashb/ designforbrainor00ashb.pdf (9/30/2011).
Ashby, William Ross: Homeostasis. In: Foerster, Heinz von/Mead, Margaret/Teuber, Hans Lukas (ed.): Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transaction of the Ninth Conference. March 20-21, 1952, New York, N.Y. Josiah Macy, JR. Foundation. New York 1952, p.73-108. New in: Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy-Conferences 1946-1953. Volume/Band I: Transactions/Protokolle. Zürich und Berlin 2003, p.593-619.
Ashby, William Ross: An Introduction to Cybernetics. London 1956/Second Impression 1957. New in: URL: http://pespmc1.vub.ac.be/ books/ IntroCyb.pdf (9/30/2011).
Ashby, William Ross: Requisite Variety and Its Implications for the Control of Complex Systems. In: Cybernetica. Vol. 1/Nr.2. 1958, p.83-99. URL: http://pcp.vub.ac.be/ Books/AshbyReqVar.pdf (9/30/2011).
Ashley, Robert: Perfect Lives. Champaign, London und Dublin 1991.
Atkins, Barry/Krzywinska, Tanya (ed.): Videogame, Player, Text. Manchester 2007.
Atkinson, Terry/Baldwin: Michael: Some post-war American work and Art-Language: ideological responsiveness. In: Studio International. April 1972, p.164-167.
Augarten, Stan: Bit by Bit. An Illustrated History of Computers. New York 1984.
autonome a.f.r.i.k.a. gruppe/Blissett, Luther/Brünzels, Sonja: Handbuch der Kommunikationsguerilla. Berlin/Hamburg/Göttingen 1997/4th edition 2001.
Auzenne, Valliere Richard: The Visualization Quest. A History of Computer Animation.

Cranbury/New Jersey 1994.
Bachleitner, Norbert: Formen digitaler Literatur 2.0 (2010). In: URL: http://www.netzliteratur.net/ bachleitner/ index.html (6/10/2012).
Balestrini, Nanni: Tape Mark I. In: Morando, Sergio (ed.): Almanacco Letterario Bompiani 1962. Le applicazioni dei calcolatori elettronici alle scienze morali e alla letteratura. Milano 1962, p.145-151. New in: URL: http://p-dpa.net/download/almanacco-letterario-bompiani_1962.pdf (9/14/2015). New in English: Higgins, Hanna B./Kahn, Douglas (ed.): Mainframe Experimentalism. Early Computing and the Foundation of the Digital Arts. Berkeley and Los Angeles/California 2012, p.266-274.
Balestrini, Nanni: Tape Mark I. In: Reichardt, Jasia (ed.): Cybernetic Serendipity. The Computer and the Arts. Studio International. Special Issue/Cat. of exhib. Institute of Contemporary Art. London 1968, p.55s. New in: URL: http://www.cibercultura.org.br/ videos/ cybernetic serendipity.pdf (10/4/2011).
Baran, Paul: On Distributed Communication Networks. In: IEEE Transactions on Communication Systems. Vol. CS-12/Nr.1. March 1964, p.1-9. New in: URL: http://www.cs.ucla.edu/ classes/ cs217/ Baran64.pdf (5/20/2012).
Baran, Paul: On Distributed Communications. I. Introduction to Distributed Communication Networks. Memorandum RM-3420-PR. Rand Corporation. Santa Monica/California 1964. New in: URL: http://www.rand.org/ content/ dam/ rand/ pubs/ research_memoranda/ 2006/ RM3420.pdf (5/20/2012).
Baran, Paul: On Distributed Communications. V. History, Alternative Approaches, and Comparisons. Memorandum RM-3097-PR. Rand Corporation. Santa Monica/California 1964. New in: URL: http://www.rand.org/ content/ dam/ rand/ pubs/ research_memoranda/ 2008/ RM3097.pdf (6/2/2012).
Barbrook, Richard/Cameron, Andy: Californian Ideology. In: Science as Culture. Vol. 6/Nr.26. 1996. Part 1, p.44-72. New in: URL: http://www.imaginaryfutures.net/ 2007/ 04/ 17/ the-californian-ideology-2/ (5/21/2012).
Bardini, Thierry: Bootstrapping. Douglas Engelbart, Coevolution, and the Origins of Personal Computing. Stanford/California 2000.
Barlow, John Perry: A Cyberspace Independence Declaration (1996). In: URL: https://w2.eff.org/ Censorship/ Internet_censorship_bills/ barlow_0296.declaration (5/21/2012).
Barron, Steve: Dire Straits´ Money for Nothing. In: Promo. July 2006, p.20s. New in: URL: http://www.steve-barron.com/ pdfs/ promo-magazine.pdf (3/25/2012).
Bartels, Klaus/Thon, Jan-Noël Thon (ed.): Computer/Spiel/Räume. Materialien zur Einführung in die Computer Game Studies. Hamburger Hefte zur Medienkultur. Nr.5/2007, p.8-28. New in: URL: http://www.slm.uni-hamburg.de/ imk/ HamburgerHefte/ HamburgerHeft_5.pdf (9/8/2012).
Baudrillard, Jean: Agonie des Realen. Berlin 1978.
Baudrillard, Jean: The Ecstasy of Communication. In: Foster, Hal (ed.): The Anti-Aesthetic. Essays on Postmodern Culture. Seattle/Washington 1983, p. 126-134.
Baudrillard, Jean: Simulacres et Simulations. Paris 1981. New in English ("Simulacra and Simulations". Ann Arbor/Michigan 1994) in: URL: http://www.egs.edu/ faculty/ jean-baudrillard/ articles/ simulacra-and-simulations-i-the-precession-of-simulacra/ (2/4/2012).
Baudrillard, Jean: Videowelt und fraktales Subjekt. In: Hattinger, Gottfried/Weibel, Peter (ed.): Ars Electronica 1988: Kunst der Szene. Kat. Ausst. Brucknerhaus Linz. Linz 1988, p.88s. New in Englisch with the title "Video World and Fractal Subject" in: URL: http://90.146.8.18/ en/ archiv_files/ 19881/ E1988_048C.pdf (7/28/2013).
Bauer, René: Der Intertext im Zeitalter seiner digitalen Realisierung. Vom impliziten zum expliziten und algorithmischen Intertext. Die Möglichkeiten neuer kollaborativer, konkreativer und kontextualisierender Aufschreibesysteme. Dissertation Deutsches Seminar der Universität Zürich 2009. In: URL: http://www.netzliteratur.net/ bauer/

Intertext.pdf (6/17/2012).
Bauknecht, Kurt/Brauer, Wilfried/Mück, Thomas A. (ed.): Informatik 2001. Wirtschaft und Wissenschaft in der Network Economy – Visionen und Wirklichkeit. Tagungsband der GI (Gesellschaft für Informatik e.V.)/OCG Jahrestagung 2001 (25th-28th September 2001, Universität Wien). Vol.II.
Baumgärtel, Tilman: Browserkunst statt Browserkrieg. In: Kuni, Verena (ed.): netz.kunst. Jahrbuch ´98/´99. Institut für moderne Kunst Nürnberg. Nuremberg 1999, p.88 - 91.
Baumgärtel, Tilman: Immaterialien. Aus der Vor- und Frühgeschichte der Netzkunst. In: Telepolis. 6/26/1997. URL: http://www.heise.de/ tp/ artikel/ 6/ 6151/1.html (5/4/2012).
Baumgärtel, Tilman: Das Internet als imaginäres Museum. WZB Discussion Paper FS II 98-110. Wissenschaftszentrum Berlin 1998. In: URL: http://duplox.wzb.eu/ texte/ tb/ (5/25/2012).
Baumgärtel, Tilman: Interview mit dem kanadischen Telekommunikations-Pionier Robert Adrian X (1997). In: URL: http://www.heise.de/ tp/ artikel/ 6/ 6181/1.html (5/22/2012).
Baumgärtel, Tilman: [net.art]. Materialien zur Netzkunst. Nuremberg 1999.
Baumgärtel, Tilman: [net.art 2.0]. Neue Materialien zur Netzkunst/New Materials towards Net Art. Nuremberg 2001.
Baumgärtel, Tilman/BüroFriedrich (ed.): Install.exe Jodi. Cat. of exhib. Basler Forum für Neue Medien [plug in]. Basel 2002.
Beck, Stephen: Beck Direct Video Synthesizer. Lecture Berkeley Art Museum, Berkeley/California 2000. In: URL: http://people.wcsu.edu/ mccarneyh/fva/B/BeckDirectVideo.html (12/17/2011).
Beck, Stephen: Direct Video: Electronic Artform for Color Television (undated). In: URL: http://www.experimentaltvcenter.org/ direct-video-electronic-artform-color-television-0 (12/17/2011).
Beck, Stephen: Illuminated Music (undated). In: URL: http://www.stevebeck.tv/ ill.htm (12/17/2011).
Beckstette, Sven: Produktive Bildstörung (2009). In: URL: http://www.artnet.de/magazine/ das-informel-als-geburtshelfer-der-medienkunst/ (11/21/2011).
Beeren, Wim (ed.): Sonsbeek `71. Cat. of exhib. Sonsbeek buiten te perken. Deel 1. Sonsbeek 1971.
Bell, Alex G.: Games Playing with Computers. London 1972. New in: URL: http://www.chilton-computing.org.uk/ acl/ literature/ books/ gamesplaying/overview.htm (8/31/2012).
Benayoun, Maurice/Barrière: World Skin. In: Leopoldseder, Hannes/Schöpf, Christine (ed.): Cyberarts 98. International Compendium Prix Ars Electronica 1998. Oberösterreichischer Rundfunk. Linz/Vienna 1998, p.70-75.
Benedikt, Michael (ed.): Cyberspace. First Steps. Cambridge/Massachusetts 1991.
Bense, Max: Aesthetica. Einführung in die neue Aesthetik. Baden-Baden 1965/second extended edition 1982.
Bense, Max: Der Begriff der Information. Hauptprobleme der Informationstheorie. Eine Einführung. In: Saarländischer Rundfunk Saarbrücken. 12/8/1963. New in: Id.: Radiotexte. Essays, Vorträge, Hörspiele. Heidelberg 2000, p.141-152.
Bense, Max: Einführung in die Informationsästhetik (1965). In: Ronge, Hans (ed.): Kunst und Kybernetik. Ein Bericht über drei Kunsterziehertagungen. Recklinghausen 1965 1966 1967. Cologne 1968, p.28-41.
Bense, Max: Einführung in die informationstheoretische Ästhetik. Grundlegung und Anwendung in der Texttheorie. Reinbek bei Hamburg 1969.
Bense, Max: Informationstheorie und Ästhetik (1963). In: RIAS Berlin, Abteilung Funkuniversität. 10/28/1963. New in: Id.: Radiotexte. Essays, Vorträge, Hörspiele. Heidelberg 2000, p.131-140.
Bense, Max: Radiotexte. Essays, Vorträge, Hörspiele. Heidelberg 2000.
Bensinger, Charles: The Video Guide. Second edition Santa Barbara/California 1981.

New in: URL: http://videopreservation.conservation-us.org/ vid_guide/ video_guide.pdf (1/7/2012).
Benthall, Jonathan: Edward Ihnatowicz´s Senster. Technology and Art 30. In: Studio International. November 1971, p.174. New in: URL: http://www.senster.com/ ihnatowicz/ articles/ SINov71.jpg (10/7/2011).
Berners-Lee, Tim: Weaving the Web. The Original Design and Ultimate Destiny of the World WideWeb by Its Inventor. San Francisco 1999.
Berners-Lee, Tim: The WorldWideWeb Browser (undated). In: URL: http://www.w3.org/People/Berners-Lee/WorldWideWeb.html (7/28/2012).
Berners-Lee, Tim/Cailliau, Robert: WorldWideWeb. Proposal for a HyperText Project (1990). In: URL: http://www.w3.org/ Proposal.html (7/28/2012).
Berners-Lee, Tim/Connolly, Dan: Hypertext Markup Language – 2.0 (1995). In: URL: http://tools.ietf.org/ html/ rfc1866 (3/2/2014).
Berry, Josephine: The Thematics of Site-Specific Art on the Internet. Thesis Faculty of Arts. University of Manchester. Manchester 2001. In: URL: http://www.metamute.org/ sites/ www.metamute.org/ files/ thesis_final_0.doc (8/16/2012).
Betancourt, Michel: The History of Motion Graphics. From Avant-Garde to Industry in the United States. Rockville/Maryland 2013.
Biggs, Simon: Introduction [to "The Great Wall of China", 1996]. In: URL: http://www.littlepig.org.uk/ wall/ greatwall.htm (12/6/2012).
Birkhoff, George David: Aesthetic Measure. Cambridge/Massachusetts 1933.
Bittanti, Matteo (ed.): Civilization: Storie Virtuali, Fantasie Reali. Milan 2005.
Blase, Christoph: Street Smarts. In: Artforum. July 1997, p.29.
Blinn, James Frederick: Simulation of Wrinkled Surfaces. In: Proceedings of SIGGRAPH `77. Computer Graphics. Vol.12/Issue 3. August 1978, p.286-292. New in: URL: http://research.microsoft.com/ pubs/73939/ p286-blinn.pdf (1/23/2012).
Blinn, James Frederick/Newell, Martin E.: Texture and Reflection in Computer Generated Images. In: Communications of the ACM (Association for Computing Machinery). October 1976, p.542-547. New in: URL: http://research.microsoft.com/ pubs/ 73935/ p542-blinn.pdf (4/6/2012).
Block, Friedrich W./Heibach, Christiane/Wenz, Karin (ed.): p0es1s. Ästhetik digitaler Poesie/The Aesthetics of Digital Poetry. Cat. of exhib. Kulturforum Potsdamer Platz. Berlin/Ostfildern-Ruit 2004.
Bluma, Lars: Norbert Wiener und die Entstehung der Kybernetik im Zweiten Weltkrieg. Eine historische Fallstudie zur Verbindung von Wissenschaft, Technik und Gesellschaft. Dissertation Fakultät für Geschichtswissenschaft. Ruhr-Universität Bochum. Bochum 2004/Münster 2005.
Bódy, Veruschka und Gábor (ed.): Video in Kunst und Alltag. Vom kommerziellen zum kulturellen Videoclip. Cologne 1986.
Bois, Yve-Alain/Cowart, Jack/Pacquement, Alfred: Ellsworth Kelly. Die Jahre in Frankreich 1948-1954. Cat. of exhib. Westfälisches Landesmuseum für Kunst und Kulturgeschichte. Münster 1992.
Bolter, Jay David: Writing Space. Computers, Hypertext, and the Remediation of Print. Mahwah/New Jersey 1991/second edition 2001.
Bolter, Jay David/Grusin, Richard: Remediation. Understanding New Media. Cambrige/Massachusetts 2000.
Bolter, Jay David/Joyce, Michael: Hypertext and Creative Writing. In: HYPERTEXT '87. Proceedings of the ACM (Association for Computing Machinery) Conference on Hypertext. New York 1987, p.41-50.
Bonacic, Vladimir: Mensch, Kunst, Wissenschaft – Ein Weg zur Kunst. In: Franke, Herbert W./Jäger, Gottfried: Apparative Kunst. Vom Kaleidoskop zum Computer. Cologne 1973, p.214-217.
Bootz, Philippe: Les Basiques: la littérature numérique. In: Leonardo/OLATS. Décembre 2006. URL: http://www.olats.org/ livresetudes/ basiques/ litteraturenumerique/

basiquesLN.php (6/27/2012).
Borchers, Detlef: Vor 50 Jahren fing alles an: das erste "Elektronenhirn" in Deutschland (2001). In: URL: http://www.heise.de/ newsticker/ meldung/ Vor-50-Jahren-fing-alles-an-das-erste-Elektronenhirn-in- Deutschland-51722.html (10/2/2012).
Borries, Friedrich von/Walz, Steffen P./Böttger, Matthias (ed.): Space Time Play. Computer Games, Architecture and Urbanism: The Next Level. Basel 2007.
Botz, Daniel: Kunst, Code und Maschine. Die Ästhetik der Computer-Demoszene. Bielefeld 2011.
Bowery, James Allan: Spasim (1974). The First First-Person-Shooter 3D Multiplayer Networked Game. New in: URL: http://web.archive.org/ web/ 20071203093009/ http://www.geocities.com/ jim_ bowery/ spasim.html (9/5/2012).
Brand, Stewart: For God´s Sake, Margaret. In: CoEvolutionary Quarterly. Issue No.10. June 1976, p.32-44. New in: URL: http://www.oikos.org/ forgod.htm (9/29/2011).
Brand, Stewart: Whole Earth Catalog. Access to Tools. Fall 1968. Menlo Park/California 1968. New in: URL: http://www.wholeearth.com/ issue-electronic-edition.php?iss=1010 (5/21/2012).
Brand, Stewart: Spacewar. In: Rolling Stone. 7th December 1972. New in: URL: http://wheels.org/ spacewar/ stone/ rolling_ stone.html (9/2/2012).
Braun, Reinhard: Robert Adrian X. One has to slide off into some other territory (Man muss in ein anderes Gebiet abgleiten). In: Gehrmann, Lucas (ed.): Robert Adrian X. Cat. of exhib. Kunsthalle Wien 2001, p.90-123.
Braun, Reinhard: Video, Fernsehen, Telekommunikation – Die frühen Projekte/Video. TV. Telecommunication – The Early Projects. In: Breitwieser, Sabine (ed.): Re-Play. Anfänge internationaler Medienkunst in Österreich. Cologne 2000, p.21-69, 401-438.
Breitwieser, Sabine (ed.): Re-Play. Anfänge internationaler Medienkunst in Österreich. Cologne 2000.
Bricken, Meredith: Virtual Worlds. No Interface to Design. In: Benedikt, Michael (ed.): Cyberspace. First Steps. Cambridge/Massachusetts 1991, p.363-382.
Brigadoon, Alex: The Eidolon. In: URL: http://www.zzap64.co.uk/ zzap10/ eidolon.html (9/6/2012).
Broeker, Holger (ed.): Gary Hill. Selected Works and Catalogue Raisonné. Cat. of exhib. Kunstmuseum Wolfsburg/Cologne 2002.
Bronowski, Jacob: Exhibition of Science. Festival of Britain 1951. Science Museum. London 1951. Excerpts in: URL: http://www.goodeveca.net/ science1951/ guide.html (8/30/2012); http://cyberneticzoo.com/ ?p=249 (8/30/2012).
Bronowski, Jacob: The Story the Exhibition Tells. In: Id.: Exhibition of Science. Festival of Britain 1951. Science Museum. London 1951. New in: URL: http://www.goodeveca.net/ science1951/ sg_ story.html (8/30/2012).
Brown, Paul/Gere, Charlie/Lambert, Nicholas/Mason, Catherine (ed.): White Heat Cold Logic. British Computer Art 1960-1980. Cambridge/Massachusetts 2008.
Buderer, Hans-Jürgen: Kinetische Kunst. Konzeptionen von Bewegung und Raum. Worms 1992.
Bülow, Ralf: SINN IST FERN – Wie die Computer dichten lernten/YOURS BEAUTIFULLY – How Computers Became Poets. In: Herzogenrath, Wulf/Nierhoff-Wielk, Barbara (ed.): Ex Machina – Frühe Computergrafik bis 1979. Die Sammlungen Franke und weitere Stiftungen in der Kunsthalle Bremen. Herbert W. Franke zum 80. Geburtstag. Cat. of exhib. Kunsthalle Bremen 2007, p.134-172.
Bürger, Peter: Theorie der Avantgarde. Frankfurt a. M. 1974.
Büscher, Barbara/Herrmann, Hans-Christian von/Hoffmann, Christoph (ed.): Ästhetik als Programm. Max Bense/Daten und Streuungen. In: Kaleidoskopien. Heft 5/2004.
Bunge, Mario: Social Science Under Debate. A Philosophical Debate. Toronto 1998.
Bunz, Mercedes: Vom Speicher zum Verteiler – Die Geschichte des Internet. Berlin 2008/second edition 2009.
Burnham, Jack: The Aesthetics of Intelligent Systems. In: Fry, Edward F. (ed.): On the

Future of Art. New York 1970/third printing 1973, p.95-122.
Burnham, Jack: Beyond Modern Sculpture. The Effects of Science and Technology on the Sculpture of this Century. New York 1968.
Burnham, Jack: Software – Information Technology. Its New Meaning for Art. Cat. of exhib. Jewish Museum. New York 1970. New in: http://monoskop.org/ images/ 3/ 31/ Software_Information_Technology_ Its_New_Meaning_for_Art_ catalogue.pdf (10/6/2012).
Burnham, Jack: Systems Esthetics. In: Artforum. Vol.7/Nr.1. September 1968, p.30-35. New in: URL: http://www.arts.ucsb.edu/ faculty/ jevbratt/ readings/ burnham_ se.html (10/22/2011).
Burtnyk, Nestor/Wein, Marcelli: Computer-Generated Key-Frame Animation. In: SMPTE (Society of Motion Picture and Television Engineers) Motion Imaging Journal. Vol. 80/No.3. March 1971, p.149-153.
Burtnyk, Nestor/Wein, Marcelli: Computer-Generated Key-Frame Animation. In: Halas, John (ed.): Computer Animation. London 1974, p.38-44.
Burtnyk, Nestor/Wein, Marcelli: Interactive Skeleton Techniques for Enhancing Motion Dynamics in Key Frame Animation. In: Communications of the ACM (Association for Computing Machinery, Inc.). Vol.19/Issue 10. October 1976, p.564-569. New in: URL: http://design.osu.edu/ carlson/ history/ PDFs/ burtnyk-wein.pdf (1/21/2012).
Bush, Vannevar: As We May Think. In: The Atlantic Monthly. July 1945. New in: URL: http://www.theatlantic.com/ magazine/ archive/ 1945/ 07/ as-we-may-think/ 3881/ ?single_page=true (6/7/2012)
Bussy, Pascal: Kraftwerk. Man, Machine and Music. London 1993/Reprint 2006.
Bute, Mary Ellen: Abstronics. An Experimental Filmmaker Photographs the Esthetics of the Oscillograph. In: Films in Review. Vol.5/Nr.6. June-July 1954, p.263-266. New in: URL: http://www.centerforvisualmusic.org/ABSTRONICS.pdf (8/4/2015).
Buxton, William: Interaction at Lincoln Laboratory in the 1960´s: Looking Forward – Looking Back. In: Proceedings CHI 2005 (Conference on Human Factors in Computing Systems): Technology, Safety, and Community. Portland/Oregon. April 02 - 07, 2005. New York 2005 (ACM 1-59593-002-7/05/0004), p.1162-1167. New in: URL: http://billbuxton.com/ LincolnLab.pdf (1/27/2012).
Cariani, Peter: Emergence and Artificial Life. In: Langton, Christopher G./Taylor, Charles/Farmer, J. Doyne/Rasmussen, Steen (ed.): Artificial Life II. Santa Fe Institute Studies in the Science of Complexity. Vol.X. Redwood City/Kalifornien 1991, p.775-797. New in: URL: http://homepage.mac.com/ cariani/ CarianiWebsite/ CarianiArtificialLife2.pdf (10/27/2011).
Cariani, Peter: To Evolve an Ear. Epistemological Implications of Gordon Pask´s Electrochemical Devices. In: Systems Research. Vol.10/Nr.3. 1993, p.19-33. New in: URL: http://homepage.mac.com/ cariani/ CarianiWebsite/ PaskPaper.html (10/27/2011).
Carlson, Wayne: A Critical History of Computer Graphics and Animation (2003). In: URL: https://design.osu.edu/ carlson/ history/ ID797.html (1/16/2012).
Carnap, Rudolf/Bar-Hillel, Yehoshua: An Outline of a Theory of Semantic Information. In: Research Laboratory of Electronics. Massachusetts Institute of Technology. Cambridge/Massachusetts. Technical Report No.247. October 27, 1952. New in: URL: http://www.survivor99.com/ lcg/ information/ CARNAP-HILLEL.pdf (11/3/2011).
Carpenter, Loren C.: Computer rendering of fractal curves and surfaces. In: SIGGRAPH '80. Conference Proceedings Supplement. Volume 14/Issue 3. July 1980, p.9-15. New in: URL: http://old.siggraph.org/ publications/ rarities/ carpenter-1980supp.pdf (7/27/2013).
Carr, Diane: The Trouble with Civilization. In: Atkins, Barry/Krzywinska, Tanya (ed.): Videogame, Player, Text. Manchester 2007, p.222-236. Draft version in: URL: http://playhouse.files.wordpress.com/ 2008/ 11/ carrcivproof.pdf (9/18/2012).
Cassidy, William: Utopia (2004). In: URL: http://www.gamespy.com/ articles/ 495/ 495918p1.html (9/9/2012).
Cassou, Jean/Habasque, Guy/Ménétrier, Jacques: Nicolas Schöffer. Neuchâtel 1963

(German version).
Castell, Suzanne de/Jenson, Jennifer (ed.): Proceedings of Changing Views – Worlds in Play. Digital Games Research Association (DIGRA)´s Second International Conference. Vancouver 2005. URL: http://www.digra.org/ dl/ db/ order_by_author? publication= Changing%20Views:%20Worlds%20 in%20Play (9/18/2012).
Cates, Jon: Copying-It-Right. Archiving the Media Art of Phil Morton (2008). In: URL: http://copyitright.wordpress.com/ 2008/ 11/ 06/ copying-it-right-archiving- the-media-art-of-phil-morton- joncates-2008/ (12/28/2012).
Cates, Jon: Copying-It-Right. Archiving the Media Art of Phil Morton. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.2. Bristol and Chicago 2014, p.599-616.
Cates, Jon: RYRAL – Tom DeFanti, Phil Morton, Dan Sandin and Bob Snyder 1976 (2009). In: URL: http://copyitright.wordpress.com/ 2009/ 02/ (12/18/2011).
Catmull, Edwin Earl: Computer Display of Curved Surfaces. In: Proceedings of the IEEE (Institute of Electrical and Electronics Engineers) Conference on Computer Graphics, Pattern Recognition and Data Structures (IEEE Cat. No. 75CH0981-1C) 1975. p.11-17.
Catmull, Edwin Earl: A Subdivision Algorithm for Computer Display of Curved Surfaces. Report UTEC-CSc-74-133. Dissertation Department of Computer Science. University of Utah. Salt Lake City 1974. New in: URL: http://www.pixartouchbook.com/ storage/ catmull_thesis.pdf (1/22/2012).
Chalmers, Matthew/MacColl, Ian: Seamful and Seamless Design in Ubiquitous Computing. In: Technical Report Equator-03-005, Equator. New in: URL: http://www.equator.ac.uk/ var/ uploads/ ChalmersTech2003.pdf (5/2/2012).
Claus, Jürgen: Das audio-visuelle Zeitalter. Edition Zentrum für Kunst und Medientechnologie (ZKM), Karlsruhe/Ostfildern 2008 (with DVD).
Claus, Jürgen: Expansion der Kunst. Beiträge zur Theorie und Praxis öffentlicher Kunst. Reinbek bei Hamburg 1970.
Cohen, D.S.: Cathode-Ray Tube Amusement Device – The First Electronic Game. In: URL: http://classicgames.about.com/ od/ classicvideogames101/ p/ CathodeDevice.htm (8/30/2012).
Colley, Steve: Story of the Original Maze (2004). In: URL: http://www.digibarn.com/ history/ 04-VCF7-MazeWar/ stories/ colley.html (9/5/2012).
Colpaert, Erik/Shaw, Jeffrey: The Legible City. Amsterdam 1990.
Condon, Edward U./Derr, Willard A./Tawney, Gereld I.: Machine to Play Game of Nim. United States Patent Office #2,2155,544. Patented Sept 24, 1940. New in: URL: http://1939nyworldsfair.com/ ftp/ MACHINE_TO_PLAY_GAME_OF_NIM.pdf (8/30/2012).
Conlan, Roberta: Understanding Computers. Computer Images. New York 1986. Chapter Science and the Silver Screen, p.75-90. New in: URL: https://design.osu.edu/ carlson/ history/ PDFs/ silver-screen.pdf (1/28/2012).
Conn, Peter: Multi-Media and Rock Promos. In: Forth Dimensions. Vol. V/Nr.1. May/June 1983, p.8s. Neu in: URL: http://www.forth.org/ fd/ FD-V05N1.pdf (3/20/2012).
Cook, Robert L./Carpenter, Loren C./Catmull, Edwin Earl: The Reyes Image Rendering Architecture. In: Computer Graphics. Vol. 2/Nr. 4. July 1987 (SIGGRAPH `87 Proceedings), p.95-102. New in: URL: http://graphics.pixar.com/ library/ Reyes/ paper.pdf (1/29/2012).
Cooke, Karl/Davis, Stephen Boyd/Jacobs, Rachel/Moar, Magnus/Riddoch, Chris/Watkins, Matt: ´Ere be Dragons: Heartfelt Gaming. In: Digital Creativity. Vol. 17/Nr. 3. 2006, p.157-162. URL: http://citeseerx.ist.psu.edu/ viewdoc/ download? doi=10.1.1.106.623&rep =rep1& type=pdf (12/1/2012).
Copeland, Jack: A Brief History of Computing (2000). In: URL: http://www.alanturing.net/ turing_archive/ pages/ Reference%20Articles/

BriefHistofComp.html (11/1/2011).
Copeland, Jack: What is Artificial Intelligence? (2000). In: URL: http://www.alanturing.net/ turing_archive/ pages/reference%20articles/what_is_AI/What%20is%20AI04.html (9/1/2012).
Couey, Anna: Art Works as Organic Communication Systems. In: Leonardo. Vol. 24/No. 2. Cambridge/Massachusetts 1991, p.127-130. New in: URL: http://www.well.com/ ~couey/ artcom/ leonardo91.html (5/24/2012).
Couey, Anna: Cyber Art: The Art of Communication Systems. In: Matrix (Matrix Information and Directory Services, Inc.) News. Vol. 1/Nr. 4. July 1991. New in: URL: http://eserver.org/ art/ art-of-comm-systems.txt (5/22/2012).
Craemer, Susanne: Zur Rechtfertigung der hypothetischen Natur der Kunst und der Nicht-Identität in der Objektwelt/On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World. In: Fleck, Robert (ed.): Peter Weibel. Zur Rechtfertigung der hypothetischen Natur der Kunst und der Nicht-Identität in der Objektwelt/On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World. Cat. of exhib. Galerie Tanja Grunert. Cologne 1992, p.5-23.
Cramer, Florian: Discordia Concors: www.jodi.org. In: Baumgärtel, Tilman/BüroFriedrich (ed.): Install.exe Jodi. Cat. of exhib. Basler Forum für Neue Medien [plug in]. Basel 2002, p.67-79. New in: URL: http://cramer.pleintekst.nl/ essays/ jodi_-_discordia_concors/ jodi_-_discordia_concors.html (7/30/2012).
Cramer, Florian: Exe.cut[up]able Statements. Poetische Kalküle und Phatasmen des selbstausführenden Texts. München 2011. New in: URL: http://netzliteratur.net/ cramer/ poetische_kalkuele_und_phantasmen.html (12/7/2012).
Cramer, Florian: per.m]utations (1998). In: URL: http://permutations.pleintekst.nl/ (6/12/2012).
Critical Art Ensemble: The Electronic Disturbance. London 1994. New in: URL: http://www.critical-art.net/ books/ ted/ (12/14/2003).
Crone, Rainer F.: Numerals 1924-1977. Cat. of exhib. Leo Castelli Gallery. New York 1978.
Crone, Rainer F.: Numerical Order and Structure: from Paul Klee to Mel Bochner. In: Crone, Rainer F.: Numerals 1924-1977. Cat. of exhib. Leo Castelli Gallery. New York 1978, unpaginated.
Cruz-Neira, Carolina/Sandin, Daniel J./DeFanti, Thomas A.: Surround-Screen Projection-Based Virtual Reality. The Design and Implementation of the CAVE. In: Computer Graphics (Proceedings of SIGGRAPH 93. ACM SIGGRAPH). August 1993, p.135-142. New in: URL: http://citeseerx.ist.psu.edu/ viewdoc/ download;jsessionid= DF46BB72F7CA40AFE0FF36EBE2ED8393?doi= 10.1.1.136.8630 &rep=rep1&type=pdf (5/14/2012).
Csuri, Charles/Shaffer, James: Art, Computers and Mathematics. In: Proceedings Fall Joint Computer Conference 1968 (AFIPS [The American Federation of Information Processing Societies] Conference Proceedings. Vol.33). Fall 1968, p.1293-1298. New in: URL: http://design.osu.edu/ carlson/ history/ PDFs/ FJCC-Csuri.pdf (1/19/2012).
Daniels, Dieter: Reverse Engineering Modernism with the Last Avant-garde. In: Daniels, Dieter/Reisinger, Gunther (ed.): Netpioneers 1.0 – Contextualising Early Net-based Art. Berlin-New York 2010, p.15-63. New in: URL: http://143.50.30.21/ static/ publication09/ np_daniels_09.pdf (5/25/2012).
Daniels, Dieter/Naumann, Sandra (ed.): Audiovisuology. Cologne 2010.
Daniels, Dieter/Reisinger, Gunther (ed.): Netpioneers 1.0 – Contextualising Early Net-based Art. Berlin-New York 2010.
Davies, Char/Harrison, John: Osmose. Towards Broadening the Aesthetics of Virtual Reality. In: Computer Graphics (ACM SIGGRAPH). Vol. 30/Nr.4. 1996, p. 25-28. New in: URL: http://www.immersence.com/ publications/ char/ 1996-CD-Comp_Graphics.html (5/13/2012).
Davis, Douglas: Art and the Future: A History. Prophecy of the Collaboration Between

Science, Technology and Art. New York 1973.
Davis, Douglas: Vom Experiment zur Idee (i.O.m.d.T. Art and the Future: A History. Prophecy of the Collaboration Between Science, Technology and Art. New York 1973). Cologne 1975.
Davis, Douglas: Talk Out. In: Radical Software. Vol.2/No.4, Autumn 1973, p.49. URL: http://www.radicalsoftware.org/ volume2nr4/ pdf/ VOLUME2NR4_0053.pdf (12/31/2003).
Dawkins, Richard: The Blind Watchmaker. New York 1986. New in: URL: http://www.terebess.com/ keletkult/ The_Blind_Watchmaker.pdf (4/14/2012).
Dawson, Jessica: Art without Cease, or Desist. In: The Washington Post, 5/8/2003. New in: URL: http://u2.interference.com/ f286/ 05-08-2003-negativlands-u2 -on-display-washington-post -76783.html (8/17/2012).
Daylight, Edgar G.: Dijkstra´s Rallying Cry for Generalization: The Advent of the Recursive Procedure, late 1950s – early 1960s. In: The Computer Journal. Vol.54/Issue 11. March 2011, p.1756-1772. New in: URL: http://www.dijkstrascry.com/ node/4 (11/5/2011).
Debord, Guy: La société du spectacle. Paris 1967/third edition Paris 1992. New in: URL: http://classiques.uqac.ca/ contemporains/ debord_guy/ societe_du_spectacle/ societe_du_spectacle.pdf (7/22/2012).
Decker, Edith: Paik. Video. Dissertation Kunstgeschichtliches Seminar der Universität Hamburg 1985/Cologne 1988.
Decker, Edith/Weibel, Peter (ed.): Vom Verschwinden der Ferne. Telekommunikation und Kunst. Cologne 1990.
Deecke, Thomas: Douglas Davis. Arbeiten/Works 1970-1977. Cat. of exhib. Neuer Berliner Kunstverein. Berlin 1978.
Delaunay, Paul/Landow, George P. (ed.): Hypermedia and Literary Studies. Baltimore 1991.
Deppner, Martin (ed.): Embedded Pictures. Krise des Bildes – Krise der Wahrnehmung. Bielefeld 2004.
Derrida, Jacques: Positionen. Graz and Vienna 1986.
Derrida, Jacques: L´écriture et la différence. Paris 1967. New in: URL: http://www.clas.ufl.edu/ users/ burt/ %20derrida%20pdfs/ ecriture_difference.pdf (10/9/2013)
Derrida, Jacques: Semiologie und Grammatologie. Gespräch mit Julia Kristeva (i.O.m.d.T. Sémiologie et grammatologie. In: Kristeva, Julia/Rey-Debove, Josette/Umiker, Donna Jean (ed.): Essays in Semiotics/Essais de Sémiologie. Mouton 1971, S.11-27). In: Ders.: Positionen. Graz and Vienna 1986, p.52-82. New in: URL: http://swiki.hfbk-hamburg.de:8888/ medienphilosophie/ uploads/ 5/ derrida_semiologie.pdf (3/26/2012).
Diederichsen, Diedrich: Kunstvideo versus Videoclip. In: Poschardt, Ulf (ed.): Video – 25 Jahre Videoästhetik. Cat. of exhib. NRW-Forum Kultur und Wirtschaft. Düsseldorf 2004, p.70-82.
Dietrich, Frank: Real Time Animation Techniques with Microcomputers. In: Proceedings IEEE (Institute of Electrical and Electronics Engineers) Symposium on Small Computers in the Arts. University of Pennsylvania. Philadelphia 1982, p.71-74. New in: URL: http://www.ballyalley.com/ documentation/ zgrass/ zgrass-uv-1_articles/ Real_Time_Animation.pdf (2/3/2012).
Dietrich, Frank: Visual Intelligence. The First Decade of Computer Art (1965-1975). In: Leonardo. Vol.19/No.2. 1986, p.159-169. New in: URL: https://design.osu.edu/ carlson/ history/ PDFs/ dietrich-leonardo.pdf (1/19/2012).
Dika, Penesta: Die Computerkunst Herbert W. Frankes. Diploma thesis, Faculty of Arts and Cultural Studies, University of Vienna. Berlin 2007.
Dinkla, Söke: Pioniere interaktiver Kunst von 1970 bis heute. Dissertation Universität Hamburg 1995/Karlsruhe 1997.

Distelmeyer, Jan/Hanke, Christine/Mersch, Dieter (ed.): Game Over!? Perspektiven des Computerspiels. Bielefeld 2008.
Dixon, John: Computer History. Tracing the History of the Computer – History of Computer Games and Online Gaming (2006). In: URL: http://www.computernostalgia.net/ articles/ HistoryofComputerGames.htm (8/30/2012).
Dobrin, Sid/Morey, Sean (ed.): Ecosee. Image, Rhetoric, Nature. New York 2009.
Döhl, Reinhard/Auer, Johannes/Block, Friedrich W.: Als Stuttgart Schule machte. Ein Internet-Reader, ab 2005. In: URL: http://www.stuttgarter-schule.de/ (11/26/2011).
Dolanova, Lenka/Vasulka, Woody: Woody Vasulka. Dialogue with the (Demons in the) Tool. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.1. Bristol and Chicago 2014, p.273-307.
Donovan, John J./Shields, Rosemary (ed.): ACM '72 Proceedings of the ACM (Association for Computing Machinery) Annual Conference. Volume 1. New York 1972.
Donovan, Tristan: Replay. The History of Video Games. Lewes 2010.
Doom wiki: Doom Source Code (2011). In: URL: http://doomwiki.org/ wiki/ Source_code (9/8/2012).
Dotzler, Gerhard (ed.): Computer Art Faszination. 10 Jahre Computer Art Faszination. Hersteller und Dienstleister 1999. Medien-Institut. Frankfurt am Main 1999.
Douglas, Jane Yellowlees: The End of Books – Or Books without End? Reading Interactive Narratives. Ann Arbor/Michigan 2000. New in: URL: http://141.211.86.200/ pdf/ 0472111140.pdf (6/9/2012).
Draves, Scott: The Electric Sheep Screen-Saver. A Case Study in Aesthetic Evolution. In: Rothlauf, Franz/Branke, Jürgen/Cagnoni, Stefano/Wolfe Corne, David/Drechsler, Rolf/Jin, Yaochu/Machado, Penousal/Marchiori, Elena/Romero,Juan/Smith, George D. et al. (ed.): Applications of Evolutionary Computing (EvoWorkshops, Lausanne 2005). Lecture Notes in Computer Science, Vol. 3449 (Springer LNCS 3449). Veinna/New York 2005, p.458-467. New in: URL: http://draves.org/ evomusart05/ evomusart05draves.pdf (4/16/2012).
Draves, Scott/Draves, Isabel Walcott: The Flame Algorithm and its Open Source Culture. In: Computer Graphics. Vol. 44/No. 3. August 2010. URL: http://www.siggraph.org/ publications/ newsletter/ volume-44-number-3/ the-flame-algorithm-and-its-open-source-culture (4/16/2012).
Draves, Scott/Reckase, Erik: Fractal Flame Algorithm (2008). In: URL: http://flam3.com/ flame.pdf (4/15/2012).
Dreher, Thomas: Art & Language & Hypertext. Blurting, Mapping and Browsing (2002). In: URL: http://iasl.uni-muenchen.de/ links/NAAL.html (6/16/2012).
Dreher, Thomas: Conceptual Art and Software Art: Notations, Algorithms and Codes (2005/2007). In: URL: http://iasl.uni-muenchen.de/ links/ NAKSe.html (12/26/2012).
Dreher, Thomas: Der Beobachter als Akteur in Happenings und umweltsensitiven Installationen. In: Zacharias, Wolfgang (ed.): Interaktiv. Im Labyrinth der Wirklichkeiten. Essen 1996, p.407-429. New in: URL: http://dreher.netzliteratur.net/ 4_Medienkunst_Text.html (4/30/2012).
Dreher, Thomas: Blurting in A & L: Art & Language and the Investigation of Context (2002). In: URL: http://blurting-in.zkm.de/ e/ invest_context (6/17/2012).
Dreher, Thomas: Valie Export/Peter Weibel. Multimedial Feminist Art. In: Artefactum Nr.46/December 1992-February 1993, p.17-20. New in: URL: http://dreher.netzliteratur.net/ 2_Export.pdf (2/4/2012).
Dreher, Thomas: Pervasive Games: Interfaces, Strategies and Moves (2008). In: URL: http://iasl.uni-muenchen.de/ links/ NAPGe.html (5/10/2012).
Dreher, Thomas: Informationschoreographie: Maciej Wisniewski (2000). In: URL: http://iasl.uni-muenchen.de/ links/ lektion7.html (8/3/2012).
Dreher, Thomas: Kontextreflexive Kunst. Selbst- und Fremdbezüge in intermedialen Präsentationsformen. In: Weibel, Peter (ed.): Kontext Kunst. Kunst der 90er Jahre. Cat.

of exhib. Neue Galerie am Landesmuseum Joanneum. Graz 1993/Cologne 1994, p.78-113.
Dreher, Thomas: Das Kunstwerk, Weltkunst und Intermedia Art. In: kritische berichte. Heft 4/2008 (special issue on Niklas Luhmann, edited by Sabine Kampmann), p.56-59. New in: http://dreher.netzliteratur.net/ Luhmann_Kunstwerk.pdf (4/17/2012).
Dreher, Thomas: Link, Filter und Informationsfreiheit: ODEM (2002-2006). In: URL: http://iasl.uni-muenchen.de/ links/ lektion12.html (7/29/2012).
Dreher, Thomas: Mitschreibeprojekt "nic-las": Die Rolle des Teilnehmers in Netzdiskursen (2002/2004). In: URL: http://iasl.uni-muenchen.de/ links/ NANL.html (6/17/2012).
Dreher, Thomas: Participation with Camera: From Video Cameras to Camera Phones (2007). In: URL: http://iasl.uni-muenchen.de/ links/ NAPKe.html (5/31/2012).
Dreher, Thomas: Performance Art nach 1945. Aktionstheater und Intermedia (Backes, Michael/Dreher, Thomas/Jäger, Georg/Jahraus, Oliver (ed.): Das Problempotential der Nachkriegsavantgarden. Grenzgänge in Literatur, Kunst und Medien. Vol.3). Munich 2001. New in: URL: http://digi20.digitale-sammlungen.de/ de/ fs1/ object/ display/ bsb00041413_00001.html (2/4/2012).
Dreher, Thomas: Politics of Classification: Matthew Fuller und Graham Harwood (2001). In: URL: http://iasl.uni-muenchen.de/ links/ lektion8.html (8/3/2012).
Dreher, Thomas: Sammeltipp 2: Spiele im Stadtraum, Teil 1 (2005-2008). In: URL: http://iasl.uni-muenchen.de/ links/ TippSammel2.html (12/1/2012).
Dreher, Thomas: Sammeltipp 2: Spiele im Stadtraum, Teil 2 (2005-2008). In: URL: http://iasl.uni-muenchen.de/ links/ TippSammel2B.html (12/1/2012).
Dreher, Thomas: Sammeltipp 2: Spiele im Stadtraum, Teil 3 (2005-2008). In: URL: http://iasl.uni-muenchen.de/ links/ TippSammel2C.html (12/1/2012).
Dreher, Thomas: From "Radical Software" to Netactivism (2004). In: URL: http://iasl.uni-muenchen.de/ links/ NARSe.html (5/26/2012).
Dreher, Thomas: Internationale Stadt Berlin und sero.org (Blank & Jeron) (2000). In: URL: http://iasl.uni-muenchen.de/ links/ lektion4.html (8/16/2012).
Dreher, Thomas: unendlich, fast...: Holger Friese (2001). In: URL: http://iasl.uni-muenchen.de/ links/ lektion10.html (7/29/2012).
Dreher, Thomas: Peter Weibel: Polykontexturalität in reaktiver Medienkunst. Das Duoversum Raumbild-Bildraum und die Pluralisierung der Bildräume. In: Schuler, Romana (ed.): Peter Weibel. Bildwelten 1982-1996. Vienna 1997, p.33-62. New in: URL: http://dreher.netzliteratur.net/ 4_Medienkunst_Weibel.pdf (4/30/2012).
Drewett, Michael/Hill, Sarah/Kärki, Kimi (ed.): Peter Gabriel. From Genesis to Growing Up. Farnham 2010.
Druckrey, Timothy: Lovers Leap. Taking the Plunge: Points of Entry...Points of Departure. In: Klotz, Heinrich/Shaw, Jeffrey (ed.): Artintact 2. CD-ROMagazine. ZKM Zentrum für Kunst und Medientechnologie/Center for Art and Media. Karlsruhe/Ostfildern-Ruit 1995. New in: URL: http://www.rogala.org/ LL_Druckrey_95.html (10/9/2011).
Drühl, Sven: Der uniformierte Künstler. Aspekte von Uniformität im Kunstkontext. Bielefeld 2006.
Drummond, Phillip et al. (ed.): Film as Film. Formal Experiment in Film 1910-1975. Cat. of exhib. Hayward Gallery. London 1979.
Dunn, David/Vasulka, Steina und Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/Eigenwelt.htm (12/17/2011).
Eco, Umberto: Lector in Fabula. Die Mitarbeit der Interpretation in erzählenden Texten (t.o.f.p. Lector in fabula. La cooperazione interpretativa nei testi narrativi. Milan 1979). München 1987/second edition 1990.
Ehrlich, George: "The Magic Theatre" Exhibition: An Appraisal. In: Art Journal.

Vol.29/No.1. Autumn 1969, p.40-44.
EMS (Electronic Music Studios LTD.): EMS Spectre – User Manual. Without place of publication, undated. New in: http://audiovisualizers.com/ toolshak/ vidsynth/ spectre/ manual/ spec_man.htm (8/4/2015).
Engelbart, Douglas Carl: Augmenting Human Intellect. A Conceptual Framework (SRI Summary Report AFOSR-3223. Prepared for: Director of Information Sciences, Air Force Office of Scientific Research, Washington 25, DC, Contract AF 49(638)-1024. SRI Project No. 3578 (AUGMENT,3906,). Stanford Research Institute. Menlo Park/California October 1962). New in: URL: http://www.dougengelbart.org/ pubs/ papers/ scanned/ Doug_Engelbart-AugmentingHumanIntellect.pdf (5/19/2012).
Engelbart, Douglas Carl/English, William K.: A Research Center for Augmenting Human Intellect. In: AFIPS Conference Proceedings of the 1968 Fall Joint Computer Conference. San Francisco/California. December 9, 1968. Vol. 33, p.395-410. New in: URL: http://www.dougengelbart.org/ pubs/ augment-3954.html (5/20/2012).
Enzensberger, Hans Magnus: Die Aporien der Avantgarde (1962). New in: Id.: Einzelheiten II. Poesie und Politik. Frankfurt am Main fifth edition 1980, p.50-80.
Enzensberger, Hans Magnus: Baukasten zu einer Theorie der Medien. In: Kursbuch, März 1970, p.159-186. New in: Id.: Baukasten zu einer Theorie der Medien. Kritische Diskurse zur Pressefreiheit. Munich 1997, p.97-132.
Enzensberger, Hans Magnus: Baukasten zu einer Theorie der Medien. Kritische Diskurse zur Pressefreiheit. Munich1997.
Ermi, Laura/Mäyrä, Frans: Fundamental Components of the Gameplay Experience: Analysing Immersion. In: Castell, Suzanne de/Jenson, Jennifer (ed.): Proceedings of Changing Views – Worlds in Play. Digital Games Research Association (DIGRA)´s Second International Conference. Vancouver 2005. URL: http://www.digra.org/ dl/ db/ 06276.41516.pdf (9/18/2012).
Eskelinen, Markku Markku/Koskimaa, Raine (ed.): CyberText Yearbook 2000. Research Centre for Contemporary Culture, University of Jyväskylä. Jyväskylä 2001.
Feinemann, Neil: Die Kunst des Musikvideos. In: Poschardt, Ulf (ed.): Video – 25 Jahre Videoästhetik. Cat. of exhib. NRW-Forum Kultur und Wirtschaft. Düsseldorf 2004, p.83-95.
Fifield, George: The Paik/Abe Synthesizer. In: Cat. of exhib. Not Still Art Festival. Micro Museum. Brooklyn/New York 2000. New in: URL: http://www.experimentaltvcenter.org/ paikabe-synthesizer-not-still-art-festival- 2000-catalog (12/27/2012).
Fildes, Jonathan: `Olde´ Computer Music Unveiled. In: BBC News. 6/17/2008. URL: http://news.bbc.co.uk/ go/ pr/ fr/ -/ 2/ hi/ technology/ 7458479.stm (11/1/2011).
Flanagan, Bill: Interviews with Mark Knopfler (undated). In: URL: http://victorian.fortunecity.com/ stanmer/ 288/ intervw/interv.htm (1/30/2012).
Flanagan, Mary: Critical Play. Radical Game Design. Cambridge/Massachusetts 2009.
Fleck, Robert (ed.): Peter Weibel. Zur Rechtfertigung der hypothetischen Natur der Kunst und der Nicht-Identität in der Objektwelt/On Justifying the Hypothetical Nature of Art and the Non-Identicality within the Object World. Cat. of exhib. Galerie Tanja Grunert. Cologne 1992.
Fleischmann, Monika: Jetztzeit: Now. In: Zacharias, Wolfgang (ed.): Interaktiv. Im Labyrinth der Wirklichkeiten. Essen 1996, p.396-406.
Flückiger, Barbara: Digital Bodies (2010. T.o.f.p. Visual Effects. Filmbilder aus dem Computer. Marburg 2008. Chapters Körper, Digitale Figuren, p.417-467). In: URL: http://zauberklang.ch/ BodiesFlueckiger.pdf (3/4/2012).
Flückiger, Barbara: Visual Effects. Filmbilder aus dem Computer. Marburg 2008.
Fluegelman, Andrew (ed.): The New Games Book. Garden City/New York 1976.
Flusser, Vilem: Kommunikologie. Frankfurt am Main 1998.
Flusser, Vilem: Umbruch der menschlichen Beziehungen (1973-74). In: Flusser, Vilem: Kommunikologie. Frankfurt am Main 1998, p.7-231.

Focillon, Henri: La vie des formes. Paris 1934.
Foerster, Heinz von/Mead, Margaret/Teuber, Hans Lukas (Ed.): Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transaction of the Eighth Conference. March 15-16, 1951, New York, N.Y. Josiah Macy, JR. Foundation. New York 1951. New in: Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy-Conferences 1946-1953. Volume/Band I: Transactions/Protokolle. Zürich and Berlin 2003, p.337-528.
Foerster, Heinz von/Mead, Margaret/Teuber, Hans Lukas (ed.): Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transaction of the Ninth Conference. March 20-21, 1952, New York, N.Y. Josiah Macy, JR. Foundation. New York 1952. New in: Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy-Conferences 1946-1953. Volume/Band I: Transactions/Protokolle. Zürich and Berlin 2003, p.529-679.
Forster, Winnie: Spielkonsolen und Heimcomputer 1972-2009. Utting third edition 2009.
Foster, Hal (ed.): The Anti-Aesthetic. Essays on Postmodern Culture. Seattle/Washington 1983.
Foucault, Michel: Dispositive der Macht. Über Sexualität, Wissen und Wahrheit. Berlin 1978.
Foucault, Michel: Le jeu de Michel Foucault (Interview). In: Ornicar. Bulletin périodique du champ freudien. Nr.10. Juillet 1977, p.62-93. New in: URL: http://1libertaire.free.fr/MFoucault158.html (10/31/2013).
Fourmentraux, Jean-Paul: Art et Internet. Les nouvelles figures de la création. Paris 2005.
Franke, Herbert Werner: Computergraphik Computerkunst. Munich 1971.
Franke, Herbert Werner: Grafik aus dem Analogrechner. Manuscript 2014.
Franke, Herbert Werner: Kunst vom Bildschirm/Art from the Screen. In: Leopoldseder, Hannes/Lorenz, Wolfgang (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986, p.11-23,29-36. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19862/ E1986b_029.pdf (1/28/2012).
Franke, Herbert Werner/Jäger, Gottfried: Apparative Kunst. Vom Kaleidoskop zum Computer. Cologne 1973.
Franke, Herbert Werner/Nierhoff-Wielk, Barbara: Experimentelle Ästhetik. Herbert W. Franke im Gespräch mit Barbara Nierhoff-Wielk. In: Herzogenrath, Wulf/Nierhoff-Wielk, Barbara (ed.): Ex Machina – Frühe Computergrafik bis 1979. Die Sammlungen Franke und weitere Stiftungen in der Kunsthalle Bremen. Herbert W. Franke zum 80. Geburtstag. Cat. of exhib. Kunsthalle Bremen 2007, p.108-117.
Friedewald, Michael: Der Computer als Werkzeug und Medium. Die geistigen und technischen Wurzeln des Personal Computers. Aachener Beiträge zur Wissenschafts- und Technikgeschichte des 20. Jahrhunderts, Vol.3. Berlin and Diepholz 1999/second edition 2009.
Friedman, Ted: Making Sense of Software: Computer Games and Interactive Textuality. In: Jones, Steven G. (ed.): CyberSociety. Computer-Mediated Communication and Community. Thousand Oaks/California 1995, p.73-89. New and revised in: URL: http://www.duke.edu/ ~tlove/ simcity.htm (9/9/2012) .
Frieling, Rudolf/Daniels, Dieter (ed.): Medien Kunst Netz. Medienkunst im Überblick/Media Art Net. Survey of Media Art. Vienna 2004.
Friese, Holger: Artworks (2008). In: URL: http://www.fuenfnullzwei.de/ art.html (7/29/2012).
Friese, Holger: Selection of Works 1995-2008 (2008). In: URL: http://www.fuenfnullzwei.de/ pdf/ Holger_Friese_Works.pdf (7/29/2012).
Fritz, Darko: The Work of Vladimir Bonacic. A Temporary Realization of the New Tendencies Program. In: Rosen, Margit (ed.): A Little-Known Story about a Movement, a Magazine, and the Computer´s Arrival in Art. New Tendencies and Bit International,

1961-1973. Cat. of exhib. ZKM/Center for Arts and Media. Karlsruhe 2008 and Cambridge/Massachusetts 2011, p.49-56.
Fry, Edward F. (ed.): On the Future of Art. New York 1970/third printing 1973.
Fuller, Matthew: Behind the Blip. Essays on the Culture of Software. New York 2003.
Fuller, Matthew: A Means of Mutation. Notes on I/O/D 4: The Web Stalker. In: URL: http://www.variant.org.uk/ 6texts/ Matthew_Fuller.html (8/3/2012). New revised and expanded in: Id.: Behind the Blip. Essays on the Culture of Software. New York 2003, p.51-67.
Funk, Walter: Animac. Analog 3D Animation. In: Veritas et Visus. 3rd Dimension. November 2010, p.53-62. New in: URL: http://www.hologlyphics.com/ Animac_Analog_3D_Animation.pdf (6/17/2014).
Funkhouser, Chris T.: Prehistoric Digital Poetry. An Archeology of Forms, 1959-1995. Tuscaloosa/Alabama 2007.
Furlong, Lucinda: A Manner of Speaking. An Interview with Gary Hill. In: Afterimage. March 1983, p.9-16. New in: URL: http://www.vasulka.org/ archive/4-30c/ AfterImageMar83(1005).pdf (1/8/2012).
Furlong, Lucinda: Notes [1] Toward a History of Image-Processed Video: Eric Siegel, Stephen Beck, Dan Sandin, Steve Rutt, Bill and Louise Etra. In: Afterimage, Visual Studies Workshop. Volume 11/Nos. 1 and 2. Summer 1983, p.35-38. New in: URL: http://www.vasulka.org/ archive/ 4-30c/ AfterImageSum83(1006).pdf (12/15/2011).
Furlong, Lucinda: Notes [2] Toward a History of Image-Processed Video: Steina und Woody Vasulka. In: Afterimage. Vol.11/No. 5. December 1983, p.12-17. New in: URL: http://www.vasulka.org/ archive/ 4-30c/ AfterImageDec83(5001).pdf (12/19/2011).
Galanter, Philip: What is Generative Art? Complexity Theory as a Context for Art Theory. In: 6th Generative Art Conference. Politecnico di Milano. Campus Leonardo. Faculty of Architecture. Milan 2003. URL: http://www.philipgalanter.com/ downloads/ ga2003_paper.pdf (11/10/2011).
Gallagher, Shaun: How the Body shapes the Mind. Oxford 2005.
Galloway, Alexander R.: Browser Art (1998). In: URL: http://audiolabo.free.fr/ revue1999/ content/ galloway_browser_art.htm (8/2/2012).
Galloway, Alexander R.: Gaming. Essays on Algorithmic Culture. Minneapolis/Minnesota 2006.
Gangadharan, Seeta Peña: Mail Art. Networking without Technology. In: New Media & Society. Vol. 11/No. 1-2. February-March 2009, p.279-298. New in: URL: http://nms.sagepub.com/ content/ 11/ 1-2/ 279.full.pdf+html (5/27/2012).
Gardner, James: Elephants in the Attic. London 1983.
Gehrmann, Lucas (ed.): Robert Adrian X. Cat. of exhib. Kunsthalle Wien 2001.
Gendolla, Peter/Schäfer, Jörgen (ed.): The Aesthetics of Net Literature. Writing, Reading and Playing in Programmable Media. Bielefeld 2007.
Gendolla, Peter/Schmitz, Norbert M./Schneider, Irmela/Spangenberg, Peter M. (ed.): Formen interaktiver Medienkunst. Geschichte, Tendenzen, Utopien. Frankfurt am Main 2001.
Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 92. Die Welt von Innen – Endo & Nano. The World from Within – Endo & Nano. Cat. of exhib. Brucknerhaus Linz. Linz 1992.
Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 93. Genetische Kunst – Künstliches Leben/Genetic Art – Artificial Life. Cat. of exhib. Brucknerhaus Linz. Vienna 1993.
Gere, Charlie: Digital Culture. London 2002/expandend second edition 2008.
Gettler, Joe: The First Video Game? Before 'Pong', There Was 'Tennis for Two' (undated). In: URL: http://www.bnl.gov/ bnlweb/ history/ firstvideo.php (4/4/2014).
Gibson, William: Count Zero. London 1986.
Gigliotti, Davidson: A Brief History of RainDance (2003). In: URL: http://www.radicalsoftware.org/ e/ history.html (12/13/2011).
Girl on Film: Happy 25th Anniversary, Money for Nothing by Dire Straits (2010). In:

URL: http://imagesofheaven.blogspot.de/ 2010/ 07/ happy-25th-anniversary-money-for.html (3/25/2012).
Glanville, Ranulph/Müller, Albert (ed.): Pask Present. Cat. of exhib. Atelier Färbergasse. Vienna 2008.
Glowsky, Janice M.: Charles A. Csuri. Beyond Boundaries, 1963 – present. Cat. of exhib. SIGGRAPH 2006. Boston/Massachusetts 2006. New in: URL: https://csuriproject.osu.edu/ index.cfm?fuseaction= collections.seeItemInCollection&CollectionID= 10a5e08e-9bf9-4b8f-a10d-f358abf90d1e&ItemID= fc3af706-4f4e-43fb-b636-d5cdabe1960e (1/21/2012).
Gnome: Alter Ego. The Retro Life Sim (2007). In: URL: http://www.gnomeslair.com/ 2007/ 02/ alter-ego.html (9/9/2012).
Götz, Karl Otto: Elektronische Malerei und ihre Programmierung. In: das kunstwerk. Jg. XIV/Nr.12. Juni 1961, p.14-23.
Götz, Karl Otto: Erinnerungen und Werk. Vol. II. Düsseldorf 1983.
Gohlke, Gerrit: Go for it (undated). In: URL: http://blankjeron.com/ sero/ index.html?color=0033ff (8/2/2012).
Gohlke, Gerrit: Software Art – Eine Reportage über den Code. Künstlerhaus Bethanien. Berlin 2003.
Goldsmith Jr., Thomas T./Grove, Cedar/Ray, Estle: United States Patent Office #2,455,992. Cathode Ray-Tube Amusement Device. Patented Dec 14, 1948. In: URL: http://www.google.com/ patents/ US2455992 (8/30/2012).
Goldstein, Robert A./Nagel, Roger: 3-D Visual Simulation. In: Simulation. Vol. 16/No. 1. January 1971. p. 25-31.
Goodeve, Pete: Nimatron (undated). In: URL: http://www.goodeveca.net/ nimrod/ nimatron.html (8/30/2012).
Goodeve, Pete: Nimrod (undated). In: URL: http://www.goodeveca.net/ nimrod/ index.html (8/30/2012).
Goodman, Cynthia: Digital Visions. Computer and Art. New York 1987.
Gouraud, Henri: Computer Display of Curved Surfaces. Doctoral Thesis. University of Utah, Salt Lake City 1971/New York 1979.
Gouraud, Henri: Continuous Shading of Curve Surfaces. In: IEEE (Institute of Electrical and Electronics Engineers) Transactions on Computers. Vol. C-20/No 6. June 1971. p.87-93. New in: URL: http://www.divms.uiowa.edu/ ~cwyman/ classes/ spring05-22C251/ papers/ ContinuousShadingOfCurvedSurfaces.pdf (1/25/2012).
Graetz, J. Martin: The Origin of Spacewar. In: Creative Computing. Vol.7/No.8. August 1981, p.56-67. New in: URL: http://spacewar.zorg.org/ origins-of-spacewar.php (10/8/2012).
Grannell, Craig: Little Computer People (2001). In: URL: http://www.lemon64.com/ ?mainurl= http%3A/ /www.lemon64.com/ reviews/ view.php %3Fid%3D77 (9/9/2012).
Grau, Oliver: Virtual Art. From Illusion to Immersion (t.o.f.p. Virtuelle Kunst in Geschichte und Gegenwart. Visuelle Strategien. Dissertation Humboldt-Universität zu Berlin 1999/Berlin 2001). Cambridge/Massachusetts 2003. New in: URL: http://documenta_pdf.jmir.dyndns.org/ GrauVirtual.Art_2003_R.pdf (9/14/2015).
Grau, Oliver: Immersion and Interaction. From Circular Frescoes to Interactive Image Spaces. In: Frieling, Rudolf/Daniels, Dieter (ed.): Medien Kunst Netz. Medienkunst im Überblick/Media Art Net. Survey of Media Art. Vienna 2004, p.268-313. New in: URL: http://www.medienkunstnetz.de/ themes /overview_of_media_art/ immersion/scroll/ (7/27/2013).
Greene, Rachel: Internet Art. London 2004.
Grether, Reinhold: Wie die Etoy Campagne geführt wurde (2000). In: http://www.heise.de/ tp/ artikel/ 5/ 5768/1.html (8/1/2012). New in English in: Weibel, Peter/Druckrey, Timothy (ed.): Net_condition. Art and Global Media. Cat. of exhib. Steirischer Herbst. Graz 1998/Zentrum für Kunst und Medientechnologie. Karlsruhe 1998. Cambridge/Massachussetts 2001, p.280-285.

Grünkranz, Daniel: Towards a Phenomenology of Responsive Architecture. Intelligent Technologies and Their Influence on The Experience of Space (2009). In: URL: http://www.orambra.com/ media/ phenonemology/ grunkranz.pdf (12/17/2010, no longer available on the Web).
Grundmann, Heidi (ed.): Art Telecommunication. Vancouver/Wien 1984.
Grundy, Patrick Michael: Mathematics and Games (1939). In: Eureka 2/1939, p.6ss. New in: Eureka 27. October 1964, p.9ss. URL: http://www.archim.org.uk/ eureka/ 27/ games.html (8/30/2012).
Guderian, Dietmar: Strukturelle Parallelen von Kunst und Mathematik. In: Maur, Karin von (ed.): Magie der Zahl in der Kunst des 20. Jahrhunderts. Cat. of exhib. Staatsgalerie Stuttgart 1997, p.321-327.
Günzel, Stephan: Egoshooter. Das Raumbild des Computerspiels. Habilitation Universität Potsdam 2010. Frankfurt am Main 2012.
Günzel, Stephan: Raum, Karte und Weg im Computerspiel. In: Distelmeyer, Jan/Hanke, Christine/Mersch, Dieter (ed.): Game Over!? Perspektiven des Computerspiels. Bielefeld 2008, p. 115-131. New in: URL: http://www.stephan-guenzel.de/ Texte/ Guenzel_Raum Computerspiel.pdf (9/6/2012).
Günzel, Stephan: Von der Zeit zum Raum. Geschichte und Ästhetik des Computerspielmediums. In: Rabbit Eye – Zeitschrift für Filmforschung. Nr.2/2010, p.90-108. In: URL: http://www.rabbiteye.de/ 2010/ 2/ guenzel_computerspielmedium.pdf (8/30/2012).
Gürler, Hayriye: Kollektive Strategien im Netz am Beispiel des Electronic Disturbance Theater (EDT) (2001). In: URL: http://web.uni-frankfurt.de/ fb09/ kunstpaed/ indexweb/ frankfurt/ referate/ guerl.htm (8/1/2012).
Gunzenhäuser, Rul: Zur Synthese von Texten mit Hilfe programmgesteuerter Ziffernrechenanlagen. In: mtw. Zeitschrift für moderne Rechentechnik und Automation. Nr.10/1963, p.4-9. New in: Büscher, Barbara/Herrmann, Hans-Christian von/Hoffmann, Christoph (ed.): Ästhetik als Programm. Max Bense/Daten und Streuungen. In: Kaleidoskopien. Heft 5/2004, p.170-182.
Habermas, Jürgen (ed.): Stichworte zur `Geistigen Situation der Zeit´. Vol.2: Politik und Kultur. Frankfurt am Main 1979.
Hadler, Simon: Informations-Choreografie als Netzkunst. In: ORF On Kultur. URL: http://www.orf.at/ orfon/ kultur/ 991217-2586/ 2588txt_story.html (9/30/2006, no longer available on the Web).
Hafner, Katie/Lyon, Matthew: Where Wizards Stay Up Late. The Origins of the Internet. New York 1998. New in: URL: ftp://ftp.fixme.ch/ free_for_all/ Ebook/ IT%20eBooks/ Entertainment/ Fiction/ Origins%20of%20the%20Internet, %20Where% 20the%20Wizards%20Stay %20Up%20Late.pdf (12/18/2013).
Halas, John (ed.): Computer Animation. London 1974.
Halbach, Wulf R.: Interfaces. Medien- und Kommunikationstheoretische Elemente einer Interface-Theorie. Dissertation Ruhr-Universität Bochum/Munich 1994. New in: URL: http://digi20.digitale-sammlungen.de/ de/ fs1/ object/ display/bsb00043415_00001.html (2/16/2012).
Hall, Tom: Doom Bible. Revision Number .02 (1992). In: URL: http://5years.doomworld.com/ doombible/ doombible.pdf (9/23/2012).
Halliday, Michael Alexander Kirkwood: Explorations in the Functions of Language. London 1973.
Hansen, Mark B.: Bodies in Code. Interfaces with Digital Media. New York 2006.
Haraway, Donna Jeanne: A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century. In: Id.: Simians, Cyborgs and Women: The Reinvention of Nature. New York 1991, p.149-181. New in: URL: http://www.stanford.edu/ dept/ HPS/ Haraway/ CyborgManifesto.html (2/5/2012).
Haraway, Donna Jeanne: Simians, Cyborgs and Women: The Reinvention of Nature. New York 1991.

Harrison III, Lee: We Started Out... In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992. p.92,94. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 092-095.pdf (12/17/2011).
Hartling, Florian: Der digitale Autor. Autorschaft im Zeitalter des Internets. Dissertation Philosophische Fakultät II. Martin-Luther-Universität Halle-Wittenberg 2007/ Bielefeld 2009.
Hatanaka, Minoru/Koizumi, Keiko/Sekiguchi, Masaki (ed.): Steina & Woody Vasulka. Video Works. ICC Collection. Cat. of exhib. NTT InterCommunication Center (ICC) Theater. Tokyo 1998. New in: URL: http://www.vasulka.org/ Catalogues/ PDFs/ Cat_Videoworks.pdf (12/18/2011).
Hattinger, Gottfried/Weibel, Peter (ed.): Ars Electronica 1988: Kunst der Szene. Cat. of exhib. Brucknerhaus Linz. Linz 1988. New in: URL: http://90.146.8.18/ de/ archives/ festival_archive/ festival_catalogs/ festival_catalog.asp? iProjectID=9054 (2/5/2012).
Hattinger, Georg/Russel, Morgan/Schöpf, Christine/Weibel, Peter (ed.): Ars Electronica 1990. Vol. II: Virtuelle Welten. Cat. of exhib. Brucknerhaus Linz und ORF-Landesstudio Oberösterreich. Linz 1990.
Nina Hautzinger: Vom Buch zum Internet? Eine Analyse der Auswirkungen hypertextueller Strukturen auf Text und Literatur. Mannheimer Studien zur Literatur- und Kulturwissenschaft. Band: 18. St. Ingbert 1999.
Hayles, N. Katherine: Electronic Literature. New Horizons for the Literary. Notre Dame/Indianapolis 2008.
Hayles, N. Katherine: Embodied Virtuality. Or How to Put Bodies Back into the Picture. In: Moser, Mary Anne/MacLeod, Douglas (ed.): Immersed in Technology. Art and Virtual Environments. Cambridge/Massachusetts 1996, p.1-28.
Heibach, Christiane: Literatur im Internet: Theorie und Praxis einer kooperativen Ästhetik. Dissertation Universität Heidelberg 1999. Berlin 2000. In: URL: http://www.netzaesthetik.de/ inhalt/ Aufsaetze/ heibach_diss.pdf (6/16/2012).
Heibach, Christiane: Literatur im elektronischen Raum. Frankfurt am Main 2003.
Heibach, Christiane: Texttransformation – Lesertransformation. Veränderungspotentiale der digitalisierten Schrift. In: dichtung-digital. Nr.11/2000. URL: http://dichtung-digital.mewi.unibas.ch/ 2000/ Heibach/ 30-Mai/ index.htm (6/12/2012).
Heim, Michael: Virtual Realism. Oxford 1998.
Hein, Birgit: Film im Underground. Von seinen Anfängen bis zum Unabhängigen Kino. Frankfurt am Main/Berlin/Wien 1971.
Hein, Birgit: The Structural Film. In: Drummond, Phillip et al. (ed.): Film as Film. Formal Experiment in Film 1910-1975. Cat. of exhib. Hayward Gallery. London 1979.
Heins, Marjorie: The Progress of Science and Useful Arts. Why Copyright Today Threatens Intellectual Freedom. A Public Policy Report (Second edition, 2003). In: The Free Expression Policy Project. URL: http://www.fepproject.org/ policyreports/ copyright2dexsum.html (8/5/2012).
Henning, Michelle: Museums, Media, and Cultural Theory. Maidenhead/Berkshire 2006.
Hermann, Hans-Christian von: Programmierung des Schönen. In: Büscher, Barbara/Herrmann, Hans-Christian von/Hoffmann, Christoph (ed.): Ästhetik als Programm. Max Bense/Daten und Streuungen. In: Kaleidoskopien. Heft 5/2004, p.154-163.
Herz, J.C.: Joystick Nation. How Computer Games Ate Our Quarters, Won Our Hearts and Rewired Our Minds. New York 1997.
Herzogenrath, Wulf/Nierhoff-Wielk, Barbara (ed.): Ex Machina – Frühe Computergrafik bis 1979. Die Sammlungen Franke und weitere Stiftungen in der Kunsthalle Bremen. Herbert W. Franke zum 80. Geburtstag. Cat. of exhib. Kunsthalle Bremen 2007.
Hess, Thomas Baer: Gerbils ex Machina: In: Art News. December 1970, p.23.
Higgins, Hanna B./Kahn, Douglas (ed.): Mainframe Experimentalism. Early Computing

and the Foundation of the Digital Arts. Berkeley and Los Angeles/California 2012.
High, Kathy: Mods, Pods and Designs. Designing Tools and Systems. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.2. Bristol and Chicago 2014, p.359-383.
High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. 2 vols. Bristol and Chicago 2014.
Hill, Christine: Attention! Production! Audience! Performing Video in its First Decade, 1968-1980 (1996). In: Video Data Bank: Surveying the First Decade: Video Art and Alternative Media in the U.S., 1968-1980. School of the Art Institute of Chicago. Chicago 1996. URL: https://www.vdb.org/ sites/ default/ files/ attention.pdf (11/15/2011).
Hill, Christine: Eric Siegel. Einstine. In: Video Data Bank. Surveying the First Decade: Video Art and Alternative Media in the U.S. 1968-1980. Video Data Bank School of the Art Institute of Chicago. Chicago 1996. In: URL: http://www.vdb.org/titles/einstine (7/26/2015).
Hitchens, Michael: B.J.s Family: A Survey of First Person Shooters and their Avatars. In: Ryan, Malcolm/Pisan, Yusuf (ed.): Proceedings of The Sixth Australian Conference, University of New South Wales. Sydney 2009. New in: URL: http://gamestudies.org/ 1103/ articles/ michael_hitchens (9/7/2012).
Hodges, Andrew: Alan Turing. The Enigma. Essex 1983/London 1992.
Hoggett, Reuben: CORA – the tortoise – M. Docilis (2009). In: URL: http:// cyberneticzoo.com/ ?p=172 (10/19/2011).
Hoggett, Reuben: 1956 – CYSP 1 – Nicolas Schöffer. In: http://cyberneticzoo.com/ ? p=815 (10/3/2011).
Hoggett, Reuben: 1969 – The Logo Turtle – Seymour Papert, Marvin Minksy et al. (American). In: URL: http://cyberneticzoo.com/ ?p=1711 (10/16/2011).
Hoggett, Reuben: M. speculatrix – a new species of animal – ELMER (2009). In: URL: http://cyberneticzoo.com/ ?p=65 (10/3/2011).
Holbrook, Bernard D./Brown, Stanley W.: A History of Computing Research at Bell Laboratories (1937-1975). In: Computing Science Technical Report. Bell Telephone Laboratories. No.99. 1982. New in: URL: http://design.osu.edu/ carlson/ history/ PDFs/ cstr99.pdf (1/17/2012) .
Holeczek, Bernhard/Mengden, Lida von (ed.): Zufall als Prinzip. Spielwelt, Methode und System in der Kunst des 20. Jahrhunderts. Cat. of exhib. Wilhelm-Hack-Museum. Ludwigshafen am Rhein 1992.
Holland, Owen: Grey Walter. The Pioneer of Real Artificial Life. In: Langton, Christopher G./Shimohara, Katsunori (ed.): Artificial Life V. Proceedings of the Fifth International Workshop on the Synthesis and Simulation of Living Systems. Cambridge/Massachusetts 1997, p.34-41.
Huber, Hans Dieter: Browser, Buffer, and bitslag. Kunstgeschichte im Internet. Vorlesung IX: Webprojekte von Künstlern II: Documenta X Internetprojekte (1997). In: URL: http://www.hgb-leipzig.de/ artnine/ lehre/ bbb/09/ index9.html (8/2/2012).
Hünnekens, Annette: Der bewegte Betrachter. Theorien der interaktiven Medienkunst. Cologne 1997.
Huhtamo, Erkki: Slots of Fun, Slots of Trouble. An Archeology of Arcade Gaming. In: Raessens, Joost/Goldstein, Jeffrey (ed.): Handbook of Computer Game Studies. Cambridge/Massachusetts 2005, p.3-21.
Huhtamo, Erkki/Parikka, Jussi (ed.): Media Archeology. Approaches, Applications, and Implications. Berkeley 2011.
Hyperakt/Vizzuality/Google Chrome Team: The Evolution of the Web 2.0 (2012). In: URL: http://www.evolutionoftheweb.com (8/13/2012).
Idensen, Heiko: Kollaborative Schreibweisen – virtuelle Text- und Theorie-Arbeit: Schnittstellen für Interaktionen mit Texten im Netzwerk. In: Gendolla, Peter/Schmitz, Norbert M./Schneider, Irmela/Spangenberg, Peter M. (ed.): Formen interaktiver Medienkunst. Geschichte, Tendenzen, Utopien. Frankfurt am Main 2001, p.218-264.

New (with modifications) in: URL: http://www.netzliteratur.net/ idensen/ Schnittstellen_Siegen.html (6/8/2012).
Ihnatowicz, Edward: Cybernetic Art. A Personal Statement. Without place of publication 1986. New in: URL: http://www.senster.com/ ihnatowicz/ articles / ihnatowicz %20brochure.pdf (10/5/2011).
Ihnatowicz, Richard: Forty Is a Dangerous Age. A Memoir of Edward Ihnatowicz. In: Brown, Paul/Gere, Charlie/Lambert, Nicholas/Mason, Catherine (ed.): White Heat Cold Logic. British Computer Art 1960-1980. Cambridge/Massachusetts 2008, p.111-117.
Jacobson, Dov: Human Vectors (2013). In: URL: http://rhizome.org/ editorial/ 2013/ aug/ 1/ dov-jacobson-human-vectors-1982/ (16.8.2015).
Jankel, Annabel/Morton, Rocky: Creative Computer Graphics. Cambridge 1984.
Jeudy, Henri Pierre: Die Welt als Museum. Berlin 1987.
Jevbratt, Lisa: 1:1 (2) Description (2002). In: URL: http://128.111.69.4/ ~jevbratt/ 1_to_1/ description.html (8/4/2012).
Jevbratt, Lisa: Coding the Infome. Writing Abstract Reality (2003). In: URL: http://dichtung-digital.mewi.unibas.ch/ 2003/ issue/ 3/ Jevbratt.htm (8/4/2012).
Johnson, Soren: Analysis: Turn-Based Versus Real-Time. In: Game Developer. Vol.16/No.7. August 2009. New in: URL: http://www.gamasutra.com/ php-bin/ news_index.php? story=25920 (9/21/2012).
Jones, Stephen: Synthetics. Aspects of Art and Technology in Australia, 1956-1975. Cambridge/Massachusetts 2011 (Thanks to Ian Milliss for directing my attention to this book).
Jones, Steven G. (ed.): CyberSociety. Computer-Mediated Communication and Community. Thousand Oaks/California 1995.
Joselit, David: Feedback. Television against Democracy. Cambridge/ Massachusetts 2007.
Julesz, Béla: Binocular Depth Perception of Computer-Generated Patterns. In: The Bell System Technical Journal. Vol. XXXIX/Nr.5. September 1960, p.1125-1162. New in: URL: http://www3.alcatel-lucent.com/ bstj/ vol39-1960/ articles/ bstj39-5-1125.pdf (11/18/2011).
Julesz, Béla: Dialoge über die Wahrnehmung (t.o.f.p. Dialogues on Perception. Cambridge/Masschusetts 1995, p.93-100). In: Weibel, Peter (ed.): Jenseits von Kunst. Cat. of exhib. Neue Galerie am Landesmuseum Joanneum. Graz 1997, p.137ss.
Julesz, Béla: Foundations of Cyclopean Perception. Chicago 1971.
Kac, Eduardo: Telepresence and Bio Art. Networking Humans, Rabbits, and Robots. Ann Arbor/Michigan 2005.
Kacunko, Slavko: Closed Circuit Videoinstallationen. Ein Leitfaden zur Geschichte und Theorie der Medienkunst mit Bausteinen eines Künstlerlexikons. Berlin 2004. Neu in: URL: http://www.slavkokacunko.de/uploads/media/cc_cd.pdf (10/20/2012).
Kahnwald, Nina: Netzkunst als Medienkritik. Neue Strategien der Inszenierung von Informationsstrukturen. München 2006. Neu in: URL: http://www.netart-datenbank.org/ nina_kahnwald/ magister.pdf (8/2/2012).
Kane, Carolyn L.: Chromatic Algorithms. Synthetic Color, Computer Art, and Aesthetics after Code. Chicago 2014.
Kent, Steven L.: The Ultimate History of Video Games. From Pong to Pokémon and Beyond – The Story Behind the Craze That Touched Our Lives and Changed the World. New York 2001.
Kerscher, Gottfried: Bild – Icon – Eyecatcher. Zur Bildstrategie im Internet. In: Kuni, Verena (ed.): netz.kunst. Jahrbuch ´98/´99. Institut für moderne Kunst Nürnberg. Nuremberg 1999, p.110-117.
Kersting, Hannelore (ed.): Sammlung Etzold – Ein Zeitdokument. Cat. of exhib. Städtisches Museum Abteiberg. Mönchengladbach 1986.
Klee, Paul: Das bildnerische Denken. Basel/Stuttgart second edition 1964.
Klotz, Heinrich/Shaw, Jeffrey (ed.): Artintact 2. CD-ROMagazine. ZKM Zentrum für

Kunst und Medientechnologie/Center for Art and Media. Karlsruhe/Ostfildern-Ruit 1995.
Klotz, Heinrich/Weibel, Peter (ed.): Jeffrey Shaw – a User´s Manual. From Expanded Cinema to Virtual Reality/Jeffrey Shaw – eine Gebrauchanweisung. Vom Expanded Cinema zur virtuellen Relität. Ostfildern-Ruit 1997.
Klütsch, Christoph (ed.): Computergrafik. Ästhetische Experimente zwischen zwei Kulturen. Die Anfänge der Computerkunst in den 1960er Jahren. Vienna 2007.
Kluszczynski, Ryszard W. (ed.): Performing Data. Monika Fleischmann & Wolfgang Strauss. Cat. of exhib. Narodowe Centrum Kultury. Centrum Sztuki Wspólczesnej Laznia. Warschau 2011. New in: URL: http://fleischmann-strauss.de/ resources/ Performing_Data_09_2011_ Monika_Fleischmann_ Wolfgang_Strauss.pdf (5/17/2012).
Knowlton, Kenneth C.: A Computer Technique for Producing Animated Movies. In: Proceedings of the Spring Joint Computer Conference (AFIPS [The American Federation of Information Processing Societies] Conference Proceedings. Vol. 25). Spring 1964, p.67-87. New in: URL: http://www.computer.org/ portal/ web/ csdl/ doi/ 10.1109/ AFIPS.1964.2 (1/19/2012).
Knowlton, Kenneth C. (ed.): Computer-animated Movies. In: Reichardt, Jasia (ed.): Cybernetic Serendipity. The Computer and the Arts. In: Studio International. Special Issue/Cat. of exhib. Institute of Contemporary Art. London 1968, p.67s. New in: URL: http://www.cibercultura.org.br/ videos/ cybernetic serendipity.pdf (10/4/2011).
Kostelanetz, Richard: Soho. The Rise and Fall of an Artists´ Colony: A Critical Memoir. New York 2003.
Koubek, Jochen: OXO, Spacewar!, Adventure – Ein handlungsorientierter Ausflug in die Geschichte der Computerspiele. In: LOG IN. Heft 157-158/2009, p.57-62. Preprint in: URL: http://medienwissenschaft.uni-bayreuth.de/ assets/ Uploads/ Koubek/ forschung/ KoubekSpielegeschichte.pdf (9/1/2012).
Kovács, Ilona: Béla Julesz. Entdecker der durch Zufallspunkte generierten Stereogramme. In: Weibel, Peter (ed.): Jenseits von Kunst. Cat. of exhib. Neue Galerie am Landesmuseum Joanneum. Graz 1997, p.134ss.
Krajewski, Markus: Zettelwirtschaft. Die Geburt der Kartei aus dem Geiste der Bibliothek. Berlin 2002.
Krauss, Rosalind: Sculpture in the Expanded Field. In: October. Nr.8. Spring 1979, p.30-44. Neu in: URL: http://newmediaabington.pbworks.com/ w/ file/ fetch/ 31643643/ Krauss%20-%20Sculpture %20in%20the%20Expanded%20Field.pdf (11/22/2011).
Kristeva, Julia/Rey-Debove, Josette/Umiker, Donna Jean (ed.): Essays in Semiotics/Essais de Sémiologie. Mouton 1971.
Krtilova, Katerina: Vilém Flussers Bild-Theorie: Zur Philosophie des technischen Bildes ausgehend von der Fotografie. In: Flusser Studies 10. November 2010. URL: http://www.flusserstudies.net/ pag/ 10/ krtilova-bildtheorie.pdf (2/5/2012).
Krueger, Myron W.: Articial Reality II. Reading/Massachusetts 1991.
Krueger, Myron W.: Computer Controlled Responsive Environments. The University of Wisconsin. Madison 1976. New in: URL: http://portal.acm.org/ citation.cfm? id=909177 (10/3/2011)
Krueger, Myron W.: Responsive Environments. In: Proceedings of the National Computer Conference (Dallas 1977). American Federation of Information Processing Systems (AFIPS). Vol.46. June 1977, p.423-433. New in: Stiles, Kristine/Selz, Peter: Theories and Documents of Contemporary Art. A Sourcebook of Artists´ Writings. Berkeley und Los Angeles 1996, p.473-486.
Krueger, Myron W.: "VIDEOPLACE". A Report from the ARTIFICIAL REALITY Laboratory. In: Leonardo. Vol.18/No.3. 1985, p.145-151. New in: URL: http://dada.compart-bremen.de/ public/ docUploads/ videoplace_paper.pdf (10/3/2011).
Krueger, Myron W.: VIDEOPLACE – Eine künstliche Realität. In: Kunstforum. Bd.103. September-Oktober 1989, p.210-215. New in: URL: http://90.146.8.18/ de/ archiv_files/ 19891/ 1989_210.pdf (4/29/2012).
Krull, Fred N.: The Origin of Computer Graphics within General Motors. In: IEEE

Annals of the History of Computing. Vol.16/Issue 3. September 1994, p.40-56. New in: URL: http://design.osu.edu/ carlson/ history/ PDFs/ CGatGM.pdf (1/18/2012).
Kücklich, Julian: Computerspielphilologie – Prolegomena zu einer literaturwissenschaftlich begründeten Theorie narrativer Spiele in den elektronischen Medien. Magisterarbeit. Institut für Deutsche Philologie. Ludwig-Maximilians-Universität. Munich 2002. In: URL: http://www.playability.de/ txt/ csp.zip (9/8/2012).
Kücklich, Julian: Virtual Worlds and Their Discontents: Precarious Sovereignty, Governmentality, and the Ideology of Play. In: games & culture. Vol. 4/No. 4. 2009, p.340-352. Draft in: URL: http://playability.de/pub/drafts/precarious.pdf (11/30/2012).
Kuhlen, Rainer: Hypertext. Ein nicht-lineares Medium zwischen Buch und Wissensbank. Berlin and Heidelberg 1991.
Kuhn, Thomas Samuel: The Structure of Scientific Revolutions. Chicago 1962/third edition 1996. New in: URL: http://moodle.eosmith.org/ pluginfile.php/3436/ mod_resource/ content/ 1/ The%20Structure%20OF %20Scientific%20Revolutions %203rd%20ed%20- %20Thomas%20Kuhn.pdf (1/21/2014).
Kuni, Verena (ed.): netz.kunst. Jahrbuch ´98/´99. Institut für moderne Kunst Nürnberg. Nuremberg 1999.
Kushner, David: Masters of Doom. How two guys created an empire and transformed pop culture. New York 2003.
Lambert, Nick: Computer Art Thesis. A Critical Examination of `Computer Art´. Thesis. Text submitted for the degree of Doctor of Philosophy (DPhil). University of Oxford. Oxford 2009. New in: URL: http://thesis.lambertsblog.co.uk/ ?page_id=54 (2/3/2012).
Landow, George Paul: Hypertext. The Convergence of Contemporary Critical Theory and Technology. Baltimore 1992/third edition 1993.
Landow, George Paul: Is this Hypertext any Good? Evaluating Quality in Hypermedia. In: dichtung-digital Nr.3/2004. URL: http://www.dichtung-digital.org/ 2004/ 3/ Landow/ index.htm (4/25/2012).
Landow, George Paul/Kahn, Paul: Where´s the Hypertext? The "Dickens Web" as a System-Independent Hypertext. In: Proceedings of the ACM ECHT '92 Conference on Hypertext. New York 1992, p.149-160. New in: URL: http://citeseerx.ist.psu.edu/ viewdoc/ download? doi=10.1.1.131.1974 &rep=rep1&type=pdf (7/12/2012).
Lange, Andreas (ed.): pong.mythos. Ein Spiel und seine Geschichte/A Game and Its History. Cat. of exhib. Württembergischer Kunstverein. Stuttgart 2006. In: URL: http://www.pong-mythos.net/index.php?lg=de (11/30/2012).
Lange, Bill: Hammurabi (2008). In: URL: http://www.codeproject.com/ Articles/ 30058/ Hammurabi (9/8/2012).
Langlois, Philippe: Pierre Schaeffer ou la quête de l´alchimie entre l´image et le son (2010). In: URL: http://www.ina-expert.com/e-dossier-de-l-audiovisuel-pierre-schaeffer-quel-heritage/pierre-schaeffer-ou-la-quete-de-l-alchimie-entre-l-image-et-le-son.html (4.8.2015).
Langton, Christopher G.: Artificial Life. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 93. Genetische Kunst – Künstliches Leben/Genetic Art – Artificial Life. Cat. of exhib. Brucknerhaus Linz. Vienna 1993, p.25-78. New in: URL: http://90.146.8.18/ de/ archiv_files/ 19931/ 1993_025.pdf (4/13/2012).
Langton, Christopher G./Shimohara, Katsunori (ed.): Articial Life V. Proceedings of the Fifth International Workshop on the Synthesis and Simulation of Living Systems. Cambridge/Massachusetts 1997.
Langton, Christopher G./Taylor, Charles/Farmer, J. Doyne/Rasmussen, Steen (ed.): Artificial Life II. Santa Fe Institute Studies in the Science of Complexity. Vol.X. Redwood City/Kalifornien 1991.
Lansdown, John: Not only Computing – but also Art. In: Computer Bulletin. March 1980. New in: URL: http://www.bbk.ac.uk/ hosted/ cache/ archive/ BCS/ Comp Bulletin 1980/ Computer Bulletin March 1980.pdf (1/19/2012).
Lansdown, John: Not quite Computing – almost Art. In: Computer Bulletin. December

1975. New in: URL: http://www.bbk.ac.uk/ hosted/ cache/ archive/ BCS/ Comp%20Bulletin%201975/ Computer%20Bulletin%20Dec%201975.pdf (1/20/2012).
Laposky, Benjamin Francis: Oscillons. Electronic Abstractions. A New Approach to Design. Cherokee/Iowa 1953. New in: URL: http://www.vasulka.org/ archive/ Artists3/ Laposky,BenF/ ElectronicAbstractions.pdf (11/15/2011)
Laposky, Benjamin Francis: Oscillons. Electronic Abstractions (1975). In: Leavitt, Ruth (ed.): Artist and Computer. New York 1976, p.21. New in: URL: http://www.atariarchives.org/ artist/ sec6.php (11/15/2011).
Larsen, Deena: Preface to William Dickey´s Poems. In: Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003, CD-ROM: 1980s: Dickey, Preface.
Laurel, Brenda/Strickland, Rachel: PlaceHolder. In: Leopoldseder, Hannes (ed.): Der Prix Ars Electronica. Internationales Kompendium der Computerkünste/International Compendium of the Computer Arts. Edition 94. ORF Landesstudio Oberösterreich. Linz 1994, p.124s. Neu in: URL: http://90.146.8.18/ de/ archives/ prix_archive/ prix_projekt.asp? iProjectID=11134 (5/3/2012).
Laurel, Brenda/Strickland, Rachel: Placeholder. In: Moser, Mary Anne/MacLeod, Douglas (ed.): Immersed in Technology. Art and Virtual Environments. Cambridge/Massachusetts 1996, p.297s.
Laurel, Brenda/Strickland, Rachel/Tow, Rob: Placeholder. Landscape and Narrative in Virtual Environments. In: ACM Computer Graphics Quarterly. Vol. 28/Nr. 2. May 1994. URL: http://www.tauzero.com/ Brenda_Laurel/ Severed_Heads/ CGQ_Placeholder.html (5/3/2012).
Leavitt, Ruth (ed.): Artist and Computer. New York 1976. New in: URL: http://www.atariarchives.org/ artist/ (11/15/2011).
Lederer, Mark: Vor 35 Jahren begann die Laufbahn des Ego-Shooters (2007). In: URL: http://www.heise.de/ tp/ artikel/ 25/ 25854/ 1.html (9/6/2012).
Le Grice, Malcolm: Computer Film as Film Art. In: Halas, John (ed.): Computer Animation. London 1974, p.161-168. New in: URL: http://www.luxonline.org.uk/ articles/ computer_film(1).html (1/20/2012).
Leopoldseder, Hannes/Lorenz, Wolfgang (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986. New in: URL: http://90.146.8.18/ en/ archives/ festival_archive/ festival_catalogs/ festival_catalog.asp? iProjectID=9249 (1/28/2012).
Leopoldseder, Hannes (ed.): Der Prix Ars Electronica. Internationales Kompendium der Computerkünste/International Compendium of the Computer Arts. Edition 94. ORF Landesstudio Oberösterreich. Linz 1994. New in: URL: http://90.146.8.18/ en/ archives/ prix_archive/ prix_start.asp? iProjectID=8 (5/3/2012).
Leopoldseder, Hannes/Schöpf, Christine (ed.): Computerkultur Tage Linz ORF-Videonal 86 im Rahmen der Ars Electronica 86. Österreichischer Rundfunk (ORF), Landesstudio Oberösterreich. Linz 1986. New in: URL: http://90.146.8.18/ en/ archives/ festival_archive/ festival_catalogs/ festival_catalog.asp? iProjectID=9249 (6/2/2012).
Leopoldseder, Hannes/Schöpf, Christine (ed.): Cyberarts 98. International Compendium Prix Ars Electronica 1998. Oberösterreichischer Rundfunk. Linz/Vienna 1998.
Leopoldseder, Hannes / Schöpf, Christine (ed.): Cyberarts 99. Internationales Compendium Prix Ars Electronica. Vienna/New York 1999.
Lessig, Lawrence: Code and Other Laws of Cyberspace. New York 1999.
Licklider, Carl Robnett: Man-Computer Symbiosis. In: IRE Transactions on Human Factors in Electronics. Vol. HFE-1. March 1960, p.4-11. New in: Taylor, Robert W. (ed.): In Memoriam of J.C.R. Licklider 1915-1990. Systems Research Center/Digital Equipment Corporation. Palo Alto 1990, p.1-19. New in: URL: http://memex.org/ licklider.pdf (5/20/2012).
Licklider, Carl Robnett/Taylor, Robert W.: The Computer as Communication Device. In:

Science and Technology. April 1968. New in: Taylor, Robert W. (ed.): In Memoriam of J.C.R. Licklider 1915-1990. Systems Research Center/Digital Equipment Corporation. Palo Alto 1990, p.21-41. New in: URL: http://memex.org/ licklider.pdf (5/20/2012).
Liebe, Norbert: Die Dispositive des Computerspiels. In: Distelmeyer, Jan/Hanke, Christine/Mersch, Dieter (ed.): Game Over!? Perspektiven des Computerspiels. Bielefeld 2008, p.73-94.
Light, Flash: Electronic Peristyle. James Seawright (2007). In: URL: http://www.solidstatelight.com/ flash/ searight.htm (10/8/2011).
Linehan, Thomas (ed.): SIGGRAPH `93 Visual Proceedings ACM (Association for Computing Machinery, Inc.). New York 1993.
Link, David: There Must Be an Angel. On the Beginnings of the Arithmetics of Rays. In: Zielinski, Siegfried/Link, David (ed.): Variantology 2. On Deep Time Relations of Arts, Sciences and Technologies. Cologne 2006, p.15-42. New in: URL: http://dada.compart-bremen.de/ public/ docUploads/ Link_MustBeAnAngel_2006C.pdf (11/30/2011).
Link, David: Programming ENTER. Christopher Strachey´s Draughts Program. In: Computer Resurrection. The Bulletin of the Computer Conservation Society 60. Nr.60/Winter 2012/3, p.23-31. New in: URL: http://www.cs.man.ac.uk/ CCS/ res/ res60.htm#f (9/14/2015).
Lobo, Daniel G.: Playing with Urban Life. How SimCity influences Planning Culture. In: Borries, Friedrich von/Walz, Steffen P./Böttger, Matthias (ed.): Space Time Play. Computer Games, Architecture and Urbanism: The Next Level. Basel 2007, p.206-209.
Loeffler, Carl Eugene: The Art Com Electronic Network. In: Leonardo. Vol.21/No.3. Cambridge/Massachusetts 1988, p.320s.
Loeffler, Carl Eugene: Telecomputing und die digitale Kultur. In: Kunstforum. Vol. 103. September/Oktober 1989, p.128-133. New in: URL: http://90.146.8.18/ de/ archiv_files/ 19891/ 1989_128.pdf (5/24/2012).
Lotozo, Eils: Private Intellectual Property: Keep Out! In: The Philadelphia Inquirer, 10/15/2003. New in: URL: http://www.riorevuelto.org/site/ip/ventana.php?id_articulo=790 (8/5/2012).
Lovejoy, Margot: Postmodern Currents. Art and Artists in the Age of Electronic Media. Upper Saddle River/New Jersey 1989/second edition 1997.
Lübbe, Herrmann: Zeit-Verhältnisse. Über die veränderte Gegenwart von Zukunft und Vergangenheit. In: Zacharias, Wolfgang (ed.): Zeitphänomen Musealisierung. Das Verschwinden der Gegenwart und die Konstruktion von Erinnerung. Essen 1990, p.40-49.
Luhmann, Niklas: Art as a Social System (t.o.f.p. Die Kunst der Gesellschaft. Frankfurt am Main 1995). Stanford/California 2000. New in: URL: http://monoskop.org/ images/ 2/ 28/ Luhmann_Niklas_Art_as_a_Social_System.pdf (9/14/2015).
Luhmann, Niklas: Soziale Systeme. Grundriß einer allgemeinen Theorie. Frankfurt am Main 1984/second edition 1987.
Lund, Cornelia und Holger (ed.): Audio.Visual – On Visual Music and Related Media. Stuttgart 2009.
Lunenfeld, Peter: Char Davies. In: Art + Text. No.53. 1996, p.82s. New in: URL: http://immersence.com/ publications/ 1996/ 1996-PLunenfeld.html (5/1/2012).
Lutz, Theo: Stochastische Texte. In: augenblick. Jg. 4. Heft 1. Oktober-Dezember 1959, p. 3-9. New in: Büscher, Barbara/Herrmann, Hans-Christian von/Hoffmann, Christoph (ed.): Ästhetik als Programm. Max Bense/Daten und Streuungen. In: Kaleidoskopien. Heft 5/2004, p.164-169; Döhl, Reinhard/Auer, Johannes/Block, Friedrich W.: Als Stuttgart Schule machte. Ein Internet-Reader, ab 2005. In: URL: http://netzliteratur.net/ lutz_schule.htm (11/3/2011).
McCormack, Jon/Dorin, Alan: Art, Emergence and the Computational Sublime. In: Second Iteration. Proceedings of the Second International Conference on Generative Systems in the Electronic Arts. Victoria, Australia, 5-7 December 2001. Centre for Electronic Media Art. Victoria/Australien 2001, p.67-81. New in: URL:

http://www.csse.monash.edu.au/ %7Ejonmc/ research/ Papers/art-2it.pdf (4/19/2012).
Machan, Kim: Robert Ashley´s "Perfect Lives". In: Leopoldseder, Hannes/Lorenz, Wolfgang (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986, p.217-220,323s. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19862/ E1986b_323.pdf (1/29/2012).
Mäyrä, Frans: An Introduction to Game Studies. Games in Culture. London 2008.
Magnenat Thalmann, Nadia/Thalmann, Daniel: Computer Animation. Theory and Practice. Tokio 1985/Second revised edition 1990.
Malliet, Steven/Meyer, Gust de: The History of The Video Game. In: Raessens, Joost/Goldstein, Jeffrey (ed.): Handbook of Computer Game Studies. Cambridge/Massachusetts 2005, p.23-45.
Malloy, Judy: From Narrabase to Hyperfiction: Uncle Roger. In: Leonardo. Vol. 24/No. 2. Cambridge/Massachusetts 1991, p.195-202. New and modificated in: URL: http://www.well.com/ user/ jmalloy/ rogpap.html (6/9/2012).
Malloy, Judy: Uncle Roger (undated). New in: URL: http://www.well.com/ user/ jmalloy/ cfp2.html (6/9/2012).
Malloy, Judy: Uncle Roger – World Wide Web Edition (2012). In: URL: http://www.well.com/ user/ jmalloy/ uncleroger/ partytop.html (6/9/2012).
Malloy, Judy (ed.): Women, Art, and Technology. Cambridge/Massachusetts 2003.
Manning, Ed: Blocpix (1975). In: Leavitt, Ruth (ed.): Artist and Computer. New York 1976. New in: URL: http://www.atariarchives.org/artist/sec17.php (3/11/2012).
Manovich, Lev: Alan Kay´s Universal Media Machine. In: Fetveit, Arild/Bang Stald, Gitte (ed.): Northern Lights 2006: Digital Aesthetics and Communication. University of Copenhagen. Copenhagen 2007. New in: URL: http://www.manovich.net/ DOCS/ kay_article.doc (1/18/2012).
Manovich, Lev: After Effects, or the Velvet Revolution. [Part I]. In: Millenium Film Journal. No.45-46. Fall 2006. New in: URL: http://mfj-online.org/ journalPages/ MFJ45/ Manovichpage.html (12/21/2012).
Manovich, Lev: After Effects, of Velvet Revolution. Part II (2006). In: URL: http://manovich.net/ DOCS/ ae_article_part2.doc (1/23/2012).
Manovich, Lev: Info-Aesthetics: Information and Form (2001). In: URL: http://www.manovich.net/ IA/ (12/22/2012).
Manovich, Lev: The Language of New Media. Cambridge/Massachusetts 2001. New in: URL: http://www.manovich.net/ LNM/ Manovich.pdf (4/29/2012).
Manovich, Lev: The Mapping of Space. Perspective, Radar, and 3-D Computer Graphics. In: Linehan, Thomas (ed.): SIGGRAPH `93 Visual Proceedings ACM (Association for Computing Machinery, Inc.). New York 1993, p.143-147. New in: URL: http://manovich.net/ TEXT/ mapping.html (1/21/2012).
Manovich, Lev: Navigable Space (1998). In: URL: http://manovich.net/ DOCS/ navigable_space.doc (9/8/2012).
Manovich, Lev: Synthetic Realism – The Mythology of Computer Graphics. In: Afterimage. Vol.20/No.2. September 1992, p.12ss. New in: URL: http://www.manovich.net/ TEXT/ assembling.html (4/13/2012).
Manovich, Lev: Software Takes Command (2008). In: URL: http://softwarestudies.com/ softbook/ manovich_softbook_11_20_2008.doc (1/18/2012).
Mason, Catherine: Bits in Motion. Early British Computer-Generated Art Film. British Film Institute. Programme Notes for the National Film Theater. London 2006. In: URL: http://www.catherinemason.co.uk/ pdf/ bitsinmotionprogramme.pdf (1/28/2012).
Mason, Catherine: A Computer in the Art Room. The Origins of British Computer Arts 1950-80. Norfolk 2008.
Masson, Terrence: CG 101. The Computer Graphics Essential Reference (1999). In: URL: http://www.cs.cmu.edu/~ph/nyit/masson/cgibookinfo.htm (1/31/2012).
Mathews, Stanley: From Agit-Prop to Free Space. The Architecture of Cedric Price. In:

URL:part 1: http://www.audacity.org/ SM-26-11-07-01.htm (10/9/2011); part 2: http://www.audacity.org/ SM-26-11-07-02.htm (10/9/2011); part 3: http://www.audacity.org/ SM-26-11-07-03.htm (10/9/2011).
Maur, Karin von (ed.): Magie der Zahl in der Kunst des 20. Jahrhunderts. Cat. of exhib. Staatsgalerie Stuttgart 1997.
Matis, Herbert: Die Wundermaschine. Die unendliche Geschichte der Datenverarbeitung – von der Rechenuhr zum Internet. Frankfurt am Main and Vienna 2002.
Medar: Neverwinter Nights (undated). In: URL: http://www.bladekeep.com/ nwn/ index2.htm?http%3A// bladekeep.com/ nwn/ main.shtml (12/1/2012).
Mehring, Christiane: Television Art´s Abstract Starts, Europe c. 1944-1969. In: October, Nr.125/Summer 2008, p.29-64.
Meigh-Andrews, Chris: Peter Donebauer, Richard Monkhouse and the Development of EMS Spectron and the Videkalos Image Processor. In: Leonardo. Vol.40/No.5. 2007, p.450s.,463-467.
Meigh-Andrews, Chris: A History of Video Art. New York 2006/second edition 2014.
Mies, Maria: Leiblose Köpfe – kopflose Hände. In: taz. 11/23/1985, p.9.
Miller Hocking, Sherry: The Grammar of Electronic Image Processing. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.2. Bristol and Chicago 2014, p.439-471.
Miller Hocking, Sherry: Rutt/Etra: Notes on Development (1986). In: URL: http://www.experimentaltvcenter.org/ ruttetra-notes-development (12/18/2011).
Miller Hocking, Sherry: Principles of Electronic Image Processing – Image Processing Systems (1978). In: Video History Project: Resources – Tools – Texts. Experimental Television Center Ltd., Bingham University, Newark Valley. URL: http://www.experimentaltvcenter.org/ principles-electronic-image-processing-image-processing-systems (12/12/2011).
Miller Hocking, Sherry: Two Texts Concerning Portable Video (1992). In: Video History Project: Resources – Tools – Texts. Experimental Television Center Ltd., Binghamton University, Newark Valley. URL: http://experimentaltvcenter.org/ two-texts-concerning-portable-video (12/11/2011).
Möller, Christian: Interaktive Architektur. Cat. of exhib. Aedes. Galerie für Architektur und Raum. Berlin 1994.
Möller, Christian: Space Balance. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 92. Die Welt von Innen – Endo & Nano. The World from Within – Endo & Nano. Cat. of exhib. Brucknerhaus Linz. Linz 1992, p.155-158. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19921/ E1992_155.pdf (12/16/2012).
Moles, Abraham André: Art et Ordinateur. Tournai 1971.
Moles, Abraham André: Information und Redundanz (1965). In: Ronge, Hans (ed.): Kunst und Kybernetik. Ein Bericht über drei Kunsterziehertagungen. Recklinghausen 1965 1966 1967. Cologne 1968, p.14-27.
Moles, Abraham André: Théorie de l'information et perception esthétique. Paris 1958.
Monkhouse, Richard: The Moving Art of Video Graphics – or How to Drive a Spectre. In: Video and Audio-Visual Review. December 1974, S.22-27. Neu in: URL: http://www.vasulka.org/ archive/ Institutions1/ London,EMS/ MovingArt.pdf (4.8.2015).
Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003. Neu in: URL: http://www.manovich.net/ vis242_winter_2006/ New%20Media %20Reader%20all/ (10/9/2011).
Moore, Roger D.: History of I P Sharp Associates Timesharing and Network (2005). In: URL: http://rogerdmoore.ca/ INF/ ERInstallationHistory.htm (5/22/2012).
Morando, Sergio (ed.): Almanacco Letterario Bompiani 1962. Le applicazioni dei calcolatori elettronici alle scienze morali e alla letteratura. Milano 1962. New in: URL: http://p-dpa.net/download/almanacco-letterario-bompiani_1962.pdf (9/14/2015).
Morrison, Michael: Becoming a Computer Animator. Indianapolis/Indiana 1994. New in: URL: http://www.danielsevo.com/ hocg/hocg_intro.htm (1/22/2012).

Moser, Mary Anne/MacLeod, Douglas (ed.): Immersed in Technology. Art and Virtual Environments. Cambridge/Massachusetts 1996.
Münker, Stefan/Roesler, Alexander (ed.): Praxis Internet. Kulturtechniken der vernetzten Welt. Frankfurt am Main 2002.
Munster, Anna: Materializing New Media. Embodiment in Information Aesthetics. Hanover/New Hampshire 2006.
Murphy, William Thomas: Television and Video Preservation 1997. A Report on the Current State of American Television and Video Preservation. Volume 1. October 1997. Report of the Librarian of Congress. In: URL: http://www.loc.gov/ film/ tvstudy.html (12/11/2011).
Myers, David: Bombs, Barbarians, and Backstories. Meaning-Making within Sid Meier´s Civilization (t.o.f.p. Bombe, barbari e antefatti. Progettazione e semantica in Civilization di Sid Meier. In: Bittanti, Matteo (ed.): Civilization: Storie Virtuali, Fantasie Reali. Milan 2005, p.165-183). New in: URL: http://www.loyno.edu/ ~dmyers/ F99%20classes/ Myers_BombsBarbarians_DRAFT.rtf (9/17/2012).
Myers, David: The Nature of Computer Games. Play as Semiosis. New York 2003.
Nabakowski, Gislind: "Kein Geld in der Bank". Interview mit Robert Ashley über seine Video-Oper "Perfect Lives". In: Kunstforum. Vol.77-78. Januar - Februar 1985, p.91-99.
Nadeau, James A.: The Medium is the Medium: the Convergence of Video, Art and Television at WGBH (1969). Master of Science in Comparative Media Studies. Massachusetts Institute of Technology. Cambridge/Massachussets 2006. In: URL: http://dspace.mit.edu/ bitstream/ handle/ 1721.1/ 39146/ 123349020.pdf? sequence=1 (12/30/2011).
Nake, Frieder: Ästhetik als Informationsverarbeitung. Grundlagen und Anwendungen im Bereich ästhetischer Produktion und Kritik. Vienna 1974.
Nake, Frieder: On Generative Aesthetics – Two Picture Generating Programs. In: Proceedings of the International Symposium Computer Graphics 70. Brunel University. Department of Computer Science. Uxbridge/Middlesex, 4/14-16/1970.
Nake, Frieder: Brief an Hans Joachim Etzold, Bremen 8/11/1973. In: Kersting, Hannelore (ed.): Sammlung Etzold – Ein Zeitdokument. Cat. of exhib. Städtisches Museum Abteiberg. Mönchengladbach 1986, p.224s.
Nake, Frieder: Die präzisen Vergnügen. Die frühen grafischen Blätter und neue interaktive Installationen. Cat. of exhib. Kunsthalle Bremen 2004.
Nake, Frieder: Algorithmische Zeichen. In: Bauknecht, Kurt/Brauer, Wilfried/Mück, Thomas A. (ed.): Informatik 2001. Wirtschaft und Wissenschaft in der Network Economy – Visionen und Wirklichkeit. Tagungsband der GI (Gesellschaft für Informatik e.V.)/OCG Jahrestagung 2001 (25th-28th September 2001, Universität Wien). Vol. II, p.736-742. URL: http://www.agis.informatik.uni-bremen.de/ ARCHIV/ Publikationen/ Algor.ZeichenWienText.pdf (12/26/2012).
Napier, Mark: The Shredder. In: Leopoldseder, Hannes / Schöpf, Christine (ed.): Cyberarts 99. Internationales Compendium Prix Ars Electronica. Vienna/New York 1999, p.46s.
Napier, Mark: The Shredder. In: Weibel, Peter/Druckrey, Timothy (ed.): Net_condition. Art and Global Media. Cat. of exhib. Steirischer Herbst. Graz 1998/Zentrum für Kunst und Medientechnologie. Karlsruhe 1998. Cambridge/Massachussetts 2001, p.76s.
Naumann, Sandra: Seeing Sound. The Short Films of Mary Ellen Bute/Die Kurhfilme von Mary Ellen Bute. In: Lund, Cornelia und Holger (ed.): Audio.Visual – On Visual Music and Related Media. Stuttgart 2009, p.40-54,277-281.
Needle, David: Rumors or Reality...(1987). In: URL: http://macgui.com/ usenet/ ? group=14&id =4827 (6/10/2012).
Nees, Georg: Generative Computergraphik. Berlin 1969/2006.
Nees, Georg: Künstliche Kunst. Wie man sie verstehen kann. In: Nierhoff, Barbara (ed.): Georg Nees. Künstliche Kunst: Die Anfänge. Cat. of exhib. Kunsthalle Bremen 2005, unpaginated.

Nees, Georg: Variationen von Figuren in der statistischen Grafik. In: Grundlagenstudien aus Kybernetik und Geisteswissenschaft. Bd. 5/ Heft 3/4. Dezember 1964, p.121-125.
Negativland: Fair Use. In: URL: http://www.negativland.com/fairuse.html (12/14/2003, no longer available on the Web).
Negroponte, Nicolas: The Architecture Machine. Toward A More Human Environment. Cambridge/Massachusetts 1970/Second Printing 1972. New in: URL: https://dl.dropboxusercontent.com /u/ 2163252/ negroponte-architecturemachine.pdf (9/13/2015).
Negroponte, Nicolas: Soft Architecture Machines. Cambridge/Masschusetts 1975. New in: URL: https://dl.dropboxusercontent.com/ u/ 2163252/ negroponte-softarchitecturemachines.pdf (9/12/2015).
Neitzel, Britta: Gespielte Geschichten. Struktur- und prozessanalytische Untersuchungen der Narrativität von Videospielen. Dissertation Fakultät Medien, Bauhau-Universität Weimar. Weimar 2000. In: URL: http://e-pub.uni-weimar.de/ volltexte/ 2004/ 72/ pdf/ Neitzel.pdf (9/2/2012).
Neitzel, Britta: Medienrezeption und Spiel. In: Distelmeyer, Jan/Hanke, Christine/Mersch, Dieter (ed.): Game Over!? Perspektiven des Computerspiels. Bielefeld 2008, p.95-113.
Neitzel, Britta: Narrativity in Computer Games. In: Raessens, Joost/Goldstein, Jeffrey (ed.): Handbook of Computer Game Studies. Cambridge/Massachusetts 2005, p.227-245.
Neitzel, Britta: Point of View and Point of Action. Eine Perspektive auf die Perspektive in Computerspielen. In: Bartels, Klaus/Thon, Jan-Noël Thon (ed.): Computer/Spiel/Räume. Materialien zur Einführung in die Computer Game Studies. Hamburger Hefte zur Medienkultur. Nr.5/2007, p.8-28. New in: URL: http://www.slm.uni-hamburg.de/ imk/ HamburgerHefte/ HamburgerHeft_5.pdf (9/8/2012).
Neitzel, Britta/Nohr, Rolf F.: Das Spiel mit dem Medium. Partizipation – Immersion – Interaktion. In: The same authors: Das Spiel mit dem Medium. Partizipation – Immersion – Interaktion. Zur Teilhabe an den Medien von Kunst bis Computerspiel. Marburg 2006, p. 9-17. New in: URL: http://ssl.einsnull.com/ paymate/ dbfiles/ pdf/ resource/ 727.pdf (5/15/2012).
Neitzel, Britta/Nohr, Rolf F.: Das Spiel mit dem Medium. Partizipation – Immersion – Interaktion. Zur Teilhabe an den Medien von Kunst bis Computerspiel. Marburg 2006.
Nelson, Chris: An Exhibition That Borrows Brazenly. In: New York Times, 1/7/2003. New in: URL: http://www.nytimes.com/ 2003/ 01/ 07/ arts/ an-exhibition-that-borrows-brazenly.html? pagewanted=all&src=pm (8/5/2012).
Nelson, Theodor Holm: Computer Lib: You can and must understand computers now/Dream Machines: New freedoms through computer screens – a minority report. Redmond/Washington 1974. New in: Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003, p.303-338. URL: http://www.manovich.net/ vis242_winter_2006/ New%20Media%20Reader%20all/ 21-nelson74-03.pdf (6/8/2012).
Nelson, Theodor Holm: A File Structure for the Complex, the Changing, and the Indeterminate. In: Association for Computing Machinery. Proceedings of the 20th National Conference 1965, p.84-100. New in: Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003, p.134-145. URL: http://www.manovich.net/ vis242_winter_2006/ New%20Media%20Reader%20all/ 11-nelson65-03.pdf (6/8/2012).
Nelson, Theodor Holm: Literary Machines. Sausalito/California 1981. Excerpts from chapter 2 in: Montfort, Nick/Wardrip-Fruin, Noah (ed.): The New Media Reader. Cambridge/Massachusetts 2003, p.443-461. URL: http://www.manovich.net/ vis242_winter_2006/ New%20Media%20Reader%20all/ 30-nelson-03.pdf (6/8/2012).
Neuhaus, Wolfgang: Als William Gibson den Cyberspace erfand...In: Telepolis 10/15/2006. URL: http://www.heise.de/ tp/ artikel/ 23/ 23727/ 1.html (1/23/2012).

Neusüß, Christel: Die Kopfgeburten der Arbeiterbewegung oder Die Genossin Luxemburg bringt alles durcheinander. Hamburg 1985.
Nielsen, Jakob: Multimedia and Hypertext. The Internet and Beyond. San Diego/California 1995.
Nierhoff, Barbara (ed.): Georg Nees. Künstliche Kunst: Die Anfänge. Cat. of exhib. Kunsthalle Bremen 2005.
Nierhoff-Wielk, Barbara: Ex machina – Die Begegnung von Computer und Kunst. Ein Blick zurück. In: Herzogenrath, Wulf/Nierhoff-Wielk, Barbara (ed.): Ex Machina – Frühe Computergrafik bis 1979. Die Sammlungen Franke und weitere Stiftungen in der Kunsthalle Bremen. Herbert W. Franke zum 80. Geburtstag. Cat. of exhib. Kunsthalle Bremen 2007, p.20-57.
Nohr, Rolf F.: Raum-Fetischismus. Topographien des Spiels. In: Bartels, Klaus/Thon, Jan-Noël Thon (ed.): Computer/Spiel/Räume. Materialien zur Einführung in die Computer Game Studies. Hamburger Hefte zur Medienkultur. Nr.5/2007, p.61-81. New in: URL: http://www.slm.uni-hamburg.de/ imk/ HamburgerHefte/ HamburgerHeft_5.pdf (9/8/2012).
Noll, A. Michael: The Beginnings of Computer Art in the United States. A Memoir. In: Leonardo. Vol.25/Nr.1. 1994, p.39-44. New in: URL: http://noll.uscannenberg.org/ Art%20Papers/ Memoir.pdf (11/6/2011).
Noll, A. Michael: Computer-Generated Three-Dimensional Movies. In: Computers and Automation. Vol. 14/No. 11. November 1965, p.20-23. New in: URL: http://noll.uscannenberg.org/ Art%20Papers/ 3D%20Movies.pdf (1/20/2012).
Noll, A. Michael: Computers and the Visual Arts. In: Design Quarterly. No. 66/67. 1966, p. 64-71. New in: URL: http://noll.uscannenberg.org/ Art%20Papers/ Computers%20Visual%20Arts.pdf (11/6/2011).
Noll, A. Michael: Human or Machine: A Subjective Comparison of Piet Mondrian's `Composition with Lines´ and a Computer-Generated Picture. In: The Psychological Record. Vol. 16/No. 1. January 1966, p.1-10. New in: URL: http://noll.uscannenberg.org/ Art%20Papers/ Mondrian.pdf (11/6/2011).
Noll, A. Michael: Patterns by 7090. In: Bell Telephone Laboratories. Technical Memorandum MM–62-1234-14. Filing Case No.38794-23. August 28,1962. New in: URL: http://noll.uscannenberg.org/ Art%20Papers/ BTL%201962%20Memo.pdf (11/6/2011).
Norén, Kerstin/Linell, Per: Meaning Potentials and the Interaction between Lexis and Contents. An Empirical Substantiation. In: Pragmatics. Vol.17/Nr.3. September 2007, p.387-416. New in: URL: http://www.liu.se/ikk/medarbetare/per-linell/list-of-selected-most-important-publications/1.454366/130_Meaning_potentials_KN_PL.pdf (1/14/2014).
Oelinger, Maria: Sinn für Interaktion. Lecture for Informatica Feminale 1999. In: URL: http://www.oelinger.de/ maria/ interact/ titel.htm (4/29/2012).
O´Grady, Gerald: Stan Vanderbeek´s "Violence Sonata" in and on Channels 2 and 44, WGBH-TV, Boston, January 12, 1970 (1970). In: URL: http://www.guildgreyshkul.com/ VanDerBeek/ _PDF/ ViolenceSonata_PDF_LORES.pdf (10/3/2008, no longer available on the Web).
Oliver, Julian Holland: The Similar Eye: Proxy Life and Public Space in the MMORPG. In: Proceedings of Computer Games and Digital Cultures Conference. Tampere 2002, p.171-184. New in: URL: http://www.digra.org/dl/db/05164.45486.pdf (11/30/2012).
Ortmann, Sabrina: netz literatur projekt. Entwicklung einer neuen Literaturform von 1960 bis heute. Berlin 2001.
Paik, Nam June: untitled. In: Beeren, Wim (ed.): Sonsbeek `71. Cat. of exhib. Sonsbeek buiten te perken. Sonsbeek 1971. Deel 1, p.84.
Palmer, Howard: The True Early History of Maze War (2004). In: URL: http://www.digibarn.com/collections/games/xerox-maze-war/index.html#palmer (9/4/2012).

Palmer, Sean B.: The Early History of HTML (undated). In: URL: http://infomesh.net/html/ history/ early/ (7/29/2012).
Pape, Dave: Crayoland (2002). In: URL: http://www.evl.uic.edu/ pape/ projects/crayoland/ (5/7/2012).
Parke, Frederick I.: Computer Generated Animation of Faces. In: Donovan, John J./Shields, Rosemary (ed.): ACM '72 Proceedings of the ACM (Association for Computing Machinery) Annual Conference. Volume 1. New York 1972, p.451-487. New in: URL: http://portal.ku.edu.tr/ ~ndereli/ article2.pdf (1/28/2012).
Pask, Gordon: An Approach to Cybernetics. New York 1961.
Pask, Gordon: A Comment, a Case History and a Plan. In: Reichardt, Jasia (ed.): Cybernetics, Art and Ideas. Greenwich/Connecticut 1971, p.76-99. New in: URL: http://pangaro.com/ pask/ Pask% 20Cybernetic% 20Serendipity% 20Musicolour% 20and% 20Colloquy% 20of% 20Mobiles.pdf (2/27/2014).
Paul, Christiane: Digital Art. London 2003.
Pearce, Celia/Fullerton, Tracy/Fron, Janine/Morie, Jackie: Sustainable Play. Towards a New Games Movement for the Digital Age. In: Games & Culture. Vol.2/No.3. July 2007, p.261-278. New in: URL: http://lmc.gatech.edu/ ~cpearce3/ PearcePubs/DACSustainablePlay.pdf (12/1/2012).
Peirce, Charles Sanders: The Architecture of Theories. In: The Monist. Vol.1/No.2. January 1891, p.161-176. URL: http://www.archive.org/ details/ monistquart01hegeuoft (12/1/2012).
Permadi, F.: Ray-Casting Tutorial For Game Development And Other Purposes (1996). In: URL: http://www.permadi.com/ tutorial/ raycast/ (9/7/2012).
Phong, Bui-Tong: Illumination for Computer Generated Pictures. In: Communications of ACM (Association for Computing Machinery, Inc.). Vol.18/Issue 6. June 1975, p.311–317. New in: URL: http://jesper.kalliope.org/ blog/ library/ p311-phong.pdf (4/4/2012).
Pias, Claus: Computer Spiel Welten. Zürich second edition 2010.
Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy-Conferences 1946-1953. Volume/Band I: Transactions/Protokolle. Zürich and Berlin 2003.
Pias, Claus: Die Pflichten der Spieler. Der User als Gestalt der Anschlüsse. In: Warnke, Martin/Coy, Wolfgang/Tholen, Georg Christoph (ed.): Hyperkult II. Zur Ortsbestimmung digitaler und analoger Medien. Bielefeld 2005, p.213-341.
Pickering, Andrew: The Cybernetic Brain. Sketches of Another Future. Chicago/Illinois 2010.
Piehler, Heike: Die Anfänge der Computerkunst. Dissertation Christian-Albrechts-Universität. Kiel 2000/Frankfurt am Main 2002.
Plate, Jürgen: Grundlagen Computernetze (2012). In: URL: http://www.netzmafia.de/skripten/ netze/ index.html (7/28/2012).
Poblocki, Kacper: Becoming-State. The bio-cultural imperialism of Sid Meier´s Civilization. In: Focall – European Journal of Anthropology No.39/2002, p.163-177. New in: URL: http://amu.academia.edu/ KacperPoblocki/ Papers/335927/ Becoming-State (9/17/2012).
Popper, Frank: Art of the Electronic Age. London 1993.
Popper, Frank et al.: Electra. L´électricité et l´électronique dans l´art au XXe siècle. Cat. of exhib. Musée d´Art Moderne de la Ville de Paris. Paris 1983.
Popper, Frank: Die Kinetische Kunst. Licht und Bewegung, Umweltkunst und Aktion. Cologne 1975.
Porr, Bernd: Systemtheorie und Naturwissenschaft. Eine interdisziplinäre Analyse von Niklas Luhmanns Werk. Wiesbaden 2002.
Poschardt, Ulf (ed.): Video – 25 Jahre Videoästhetik. Cat. of exhib. NRW-Forum Kultur und Wirtschaft. Düsseldorf 2004.
Poschardt, Ulf: Das Video als Laboratorium. In: Id. (ed.): Video – 25 Jahre Videoästhetik. Cat. of exhib. NRW-Forum Kultur und Wirtschaft. Düsseldorf 2004, p.9-32.

Postel, Jan: The Domain Name Plan and Schedule (1983). In: URL: http://www.rfc-editor.org/ rfc/ rfc881.txt (7/29/2012).
Price, Robert: A Conversation with Claude Shannon. One Man´s Approach to Problem Solving. In: Cryptologia. Vol.9/Nr.2. April 1985, p.167-175.
Prince, Patric D.: Women and the Search for Visual Intelligence. In: Malloy, Judy (ed.): Women, Art, and Technology. Cambridge/Massachusetts 2003, p.2-15.
Raessens, Joost/Goldstein, Jeffrey (ed.): Handbook of Computer Game Studies. Cambridge/Massachusetts 2005.
Rau, Anja: Wreader´s Digest – How To Appreciate Hyperfiction. In: Journal of Digital Information. Vol. 1/No. 7. 2001. New in: URL: http://www.netzliteratur.net/ rau/ rau_wreader.htm (5/25/2012).
Redheffer, Raymond: A Machine for Playing the Game of Nim. In: The American Mathematical Monthly. Vol. 55/No. 6. June-July 1948, p.343-349.
Reeves, William T.: Particle Systems – A Technique for Modeling a Class of Fuzzy Objects. In: Computer Graphics. Vol.17/Nr.3. July 1983, p.359-375. New in: URL: http://www.lri.fr/ ~mbl/ ENS/ IG2/ devoir2/ files/ docs/ fuzzyParticles.pdf (1/29/2012).
Rehr, Darryl: Consider QWERTY... In: URL: http://home.earthlink.net/ ~dcrehr/ whyqwert.html (12/29/2012).
Reichardt, Jasia: The Computer in Art. London 1971.
Reichardt, Jasia (ed.): Cybernetic Serendipity. The Computer and the Arts. In: Studio International. Special Issue/Cat. of exhib. Institute of Contemporary Art. London 1968. New in: URL: http://www.cibercultura.org.br/ videos/ cybernetic serendipity.pdf (10/4/2011).
Reichardt, Jasia (ed.): Cybernetics, Art and Ideas. Greenwich/Connecticut 1971. Vorwort neu in: URL: http://cast.ap.buffalo.edu/ courses/ f11/ arc619/ wp-content/ uploads/ 2011/ 09/ reichardt-CyberneticsArtandIdeas.pdf (10/13/2011).
Reichert, Ramón: Government-Games und Gouverntainment. Das Globalstrategiespiel Civilization von Sid Meiner. In: Nohr, Rolf F./Wiemer, Serjoscha (ed.): Strategie spielen. Medialität, Geschichte und Politik des Strategiespiels. Münster 2008, p.189-212. New in: URL: https://www.academia.edu/ 4873245/ Government-Games_und_Gouverntainment_Das_Globalstrategiespiel_Civilization_von_Sid_Meier_in_Rolf_Nohr_Serjoscha_Wiemer_Hg._Strategie_spielen_2008_ (5/2/2014).
Reichle, Ingeborg: Kunst aus dem Labor. Zum Verhältnis von Kunst und Wissenschaft im Zeitalter der Technoscience. Vienna 2005.
Reunanen, Markku: Computer Demos—What Makes Them Tick? Licentiate Thesis. AALTO University. School of Science and Technology. Faculty of Information and Natural Sciences. Department of Media Technology. Helsinki 2010. In: URL: http://www.kameli.net/ demoresearch2/ reunanen-licthesis.pdf (2/3/2012).
Rheingold, Howard: Virtual Community. Homesteading on the Electronic Frontier. Reading/Massachusetts 1993. New in: URL: http://www.rheingold.com/ vc/ book/ (5/20/2012).
Rheingold, Howard: Tools for Thought. New York 1985. New in: URL: http://www.rheingold.com/ texts/ tft/ (1/19/2012).
Richard, Birgit: Am Anfang war das Wort: Domain war´s!. In: Kunstforum. Bd.153. Januar – März 2001, p.202-229.
Richard, Birgit: Cool Business. In: Nettime, 12/5/2000. URL: http://amsterdam.nettime.org/ Lists-Archives/ nettime-l-0012/ msg00025.html (8/2/2012).
Rieser, Martin/Zapp, Andrea (ed.): New Screen Media. Cinema/Art/Narrative. London 2002.
Rinagl, Birgit/Thalmair, Franz (ed.): Content | Form | Im-Material. [Five Years of] CONT3XT.NET. Nürnberg 2011.
Rinagl, Birgit/Thalmair, Franz/Dreher, Thomas: Monochromacity as a Reflection of Computing Processes in Internet-based Art. In: Rinagl, Birgit/Thalmair, Franz (ed.):

Content | Form | Im-Material. [Five Years of] CONT3XT.NET. Nuremberg 2011, p.166-175. URL: http://cont3xt.net/ blog/ ?p=3424 (8/16/2012).
Robbin, Tony: Shadows of Reality. The Fourth Dimension in Relativity, Cubism, and Modern Thought. New Haven/Connecticut 2006. New in: URL: http://monoskop.org/log/?p=11555 (8/16/2015).
Roberts, Lawrence Gilman: The ARPANET & Computer Networks (1995). In: URL: http://packet.cc/ files/ arpanet-computernet.html (5/20/2012).
Roberts, Lawrence Gilman: Machine Perception of Three-Dimensional Solids. In: M.I.T. Lincoln Laboratory. Technical Report 315. M.I.T. Cambridge. May 1963. New in: URL: http://www.packet.cc/ files/ mach-per-3D-solids.html (1/26/2012).
Roch, Axel: Claude E. Shannon. Spielzeug, Leben und die geheime Geschichte seiner Theorie der Information. Berlin 2009.
Roch, Axel/Siegert, Bernhard: Maschinen, die Maschinen verfolgen. Über Claude Shannons und Norbert Wieners Flugabwehrsysteme. In: Schade, Sigrid/Tholen, Georg Christoph (ed.): Konfigurationen. Zwischen Kunst und Medien. Munich 1999, p.219-230.
Rödiger, Karl-Heinz (ed.): Algorithmik – Kunst – Semiotik. Hommage für Frieder Nake. Heidelberg 2003.
Rössler, Otto E.: Endophysik. Die Welt des inneren Beobachters. Berlin 1992 (in English, modified and expanded: id.: Endophysics. The World as an Interface. Singapore 1998).
Rötzer, Florian: Technoimaginäres – Ende des Imaginären? In: Kunstforum. Bd.97/November-Dezember 1988, p.64-74.
Rötzer, Florian: Technoimaginäres – Ende des Imaginären? In: Kunstforum. Bd.98/Januar-Februar 1989, p.54-59.
Rogers, Everett M./Valente, Thomas W.: A History of Information Theory in Communication Research. In: Schement, Jorge Reina/Ruben, Brent D. (ed.): Between Communication and Information. Information and Behavior. Vol.4. New Brunswick/New Jersey 1993, p.35-56.
Ronge, Hans (ed.): Kunst und Kybernetik. Ein Bericht über drei Kunsterziehertagungen. Recklinghausen 1965 1966 1967. Cologne 1968.
Rose, Barbara/Sandler, Irving: Sensibilities of the Sixties. In: Art in America. Vol.55/Nr.1. January-February 1967, p.44-57.
Rosen, Margit: "The control of control" – Gordon Pasks kybernetische Ästhetik. In: Glanville, Ranulph/Müller, Albert (ed.): Pask Present. Cat. of exhib. Atelier Färbergasse. Vienna 2008, p.130-191.
Rosen, Margit (ed.): Hiroshi Kawano. The Philosopher at the Computer. Exhib. Zentrum für Kunst und Medientechnologie Karlsruhe (ZKM)/Center for Arts and Media. Press photos. In: URL: http://container.zkm.de/ presse/ special_kawano_e.html (11/29/2011).
Rosen, Margit (ed.): A Little-Known Story about a Movement, a Magazine, and the Computer´s Arrival in Art. New Tendencies and Bit International, 1961-1973. Cat. of exhib. Zentrum für Kunst und Medientechnologie Karlsruhe (ZKM)/Center for Arts and Media. Karlsruhe 2008 and Cambridge/Massachusetts 2011.
Rosen, Margit: Die Maschinen sind angekommen. Die [Neuen] Tendenzen – visuelle Forschung und Computer. In: Weibel, Peter (ed.): bit international. [Nove] tendencije. Computer und visuelle Forschung. Zagreb 1961-1973. Neue Galerie Graz am Landesmuseum Joanneum. Graz 2007, p.32-57.
Rosen, Margit: A Record of Decisions. Envisioning Computer Art. In: Glowsky, Janice M.: Charles A. Csuri. Beyond Boundaries, 1963 – present. Cat. of exhib. SIGGRAPH 2006. Boston/Massachusetts 2006, p.25-46. Neu in: URL: https://csuriproject.osu.edu/index.cfm?fuseaction= collections.seeItemInCollection&CollectionID= 10a5e08e-9bf9-4b8f-a10d-f358abf90d1e&ItemID= fc3af706-4f4e-43fb-b636-d5cdabe1960e (1/21/2012).
Rosenberg, Scott: Dreaming in Code. Two Dozen Programmers, Three Years, 4,732 Bugs, and One Quest for Transcendent Software. New York 2007.

Ross, David: Douglas Davis. Events Objects Drawings Videotapes 1967-1972. Cat. of exhib. Everson Museum of Art, Syracuse/New York 1972.
RTMark: Reamweaver Answers the WEF (World Economic Forum). Press Release and Annual Report, Jan. 28, 2002. In: URL: http://www.rtmark.com/ wef.html (8/5/2012).
Russell, Bertrand Arthur William: Principles of Mathematics. Cambridge 1903. New in: URL: http://fair-use.org/bertrand-russell/ the-principles-of-mathematics/ (6/17/2012).
Rothlauf, Franz/Branke, Jürgen/Cagnoni, Stefano/Wolfe Corne, David/Drechsler, Rolf/Jin, Yaochu/Machado, Penousal/Marchiori, Elena/Romero, Juan/Smith, George D. et al. (ed.): Applications of Evolutionary Computing (EvoWorkshops, Lausanne 2005). Lecture Notes in Computer Science, Vol. 3449 (Springer LNCS 3449). Vienna/New York 2005.
Russell, Bertrand: The Principles of Mathematics. Cambridge 1903/New York 1996. Neu in: URL: http://fair-use.org/ bertrand-russell/ the-principles-of-mathematics/ (7/13/2012).
Russett, Robert/Starr, Cecile: Experimental Animation. Origins of a New Art. New York 1976/second edition 1988.
Rutt, Steve: What We Did...In: Dunn, David/Vasulka, Steina und Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.137s. In: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 136-139.pdf (12/17/2011).
Rutt, Steve/Etra, Bill und Louise Etra: RE Video Synthesizer Systems. Models RE 4A and RE 4B. Rutt Electrophysics Corporation. New York 1974. [user manual]. New in: URL: http://www.fondation-langlois.org/ html/ e/ docnum.php?NumEnregDoc=d00016290 (12/18/2011)
Ryan, Malcolm/Pisan, Yusuf (ed.): Proceedings of The Sixth Australian Conference. University of New South Wales. Sydney 2009. New in: URL: http://books.google.de/books?id=SYEzMIBe57kC&pg= PP1&lpg= PP1&dq= Proceedings+of+The+Sixth+Australian+Conference, University+of +New+South +Wales. +Sydney+2009&source= bl&ots= d64Loz_oJe&sig= kImRy2LdwgOmrG97RTXFND-HrAQ&hl=de&sa=X&ei= hEVJUJLzNoOe0QXCuoD4Cg&ved= 0CC4Q6AEwAA#v=onepage&q= Proceedings%20of%20The%20Sixth %20Australian %20Conference %2CUniversity %20of %20New %20South %20Wales. %20Sydney %202009&f= false (9/7/2012).
Ryan, Marie-Laure: Beyond Myth and Metaphor – The Case of Narrative in Digital Media. In: Game Studies. Vol.1/Issue 1. July 2001. URL: http://www.gamestudies.org/0101/ ryan/ (9/18/2012).
Sakane, Itsuo: Computer Graphics Art in Japan/Computergraphik in Japan. In: *Leopoldseder, Hannes/Lorenz, Wolfgang* (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986, p.158-161,203-205. New in: URL: http://90.146.8.18/ en/ archives/ festival_archive/ festival_catalogs/ festival_artikel.asp?iProjectID=9281 (8/17/2015).
Salen, Katie/Zimmerman, Eric: Rules of Play. Game Design Fundamentals. Cambridge/Massachusetts 2004.
Sandin, Dan: Distribution Religion. In: Dunn, David/Vasulka, Steina und Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Kat. Ausst. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.134. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 132-135.pdf (12/17/2011).
Sandin, Dan/Morton, Phil: Distribution Religion. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.1. Bristol and Chicago 2014, p.263-267.
Schade, Sigrid/Tholen, Georg Christoph (ed.): Konfigurationen. Zwischen Kunst und Medien. Munich 1999.

Schaeffer, Jonathan: One Jump Ahead. Challenging Human Supremacy in Checkers. New York 1997.
Scheller, Martin/Boden, Klaus-Peter/Geenen, Andreas/Kampermann, Joachim: Internet. Werkzeuge und Dienste. Von "Archie" bis "World Wide Web". Berlin 1994.
Schement, Jorge Reina/Ruben, Brent D. (ed.): Between Communication and Information. Information and Behavior. Vol. 4. New Brunswick/New Jersey 1993.
Schier, Jeffrey: Digital Image Processor. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.144ss. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 144-146.pdf (12/17/2011).
Schier, Jeffrey: Direct Video Synthesizer (Zero and One). In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.123ss. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 122-125.pdf (12/17/2011).
Schier, Jeffrey: Early Scan Processors – ANIMAC/SCANIMATE. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.94s. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 092-095.pdf (12/17/2011).
Schier, Jeffrey: Eric Siegel EVS Synthesizer. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.120s. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 116-121.pdf (12/1/2011).
Schier, Jeffrey: Image Processor (IP). In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.134s. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 132-135.pdf (12/17/2011).
Schier, Jeffrey: Multi-Level Keyer. In: Dunn, David/Vasulka, Steina und Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.131. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 130-131.pdf (12/17/2011).
Schier, Jeffrey: Paik-Abe Video Synthesizer. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.129. In: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 126-129.pdf (12/17/2011).
Schier, Jeffrey: Rutt/Etra Scan Processor. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.138s. In: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 136-139.pdf (12/17/2011).
Schmidgen, Henning: Das Unbewußte der Maschinen. Konzeptionen des Psychischen bei Guattari, Deleuze und Lacan. Dissertation Institut für Arbeits-, Organisations- und Gesundheitspsychologie, Fachbereich Erziehungswissenschaft, Psychologie und Sportwissenschaft. Freie Universität Berlin 1995-96/Munich 1997. New in: URL: http://digi20.digitale-sammlungen.de/ de/ fs1/ object/ display/ bsb00041069_00001.html (2/16/2012).
Schmidt, Florian: Use Your Illusion. Immersion in Parallel Worlds. In: Borries, Friedrich von/Walz, Steffen P./Böttger, Matthias (ed.): Space Time Play. Computer Games,

Architecture and Urbanism: The Next Level. Basel 2007, p.146-149.
Schöffer, Nicolas: Les apparitions de CYSP 1 en public (1997/2009). In: URL: http://www.olats.org/ schoffer/ cysppubl.htm (10/3/2011).
Schöffer, Nicolas: Le Spatiodynamisme (Lecture Sorbonne, Paris 6/19/1954). Editions Architecture aujourd´hui. Boulogne-sur-Seine 1955. Neu in: URL: http://www.schoffer.fr/images/digit/s/spatiod.pdf (10/30/2013).
Schönbucher, Katharina/Seitz, Werner: Rezension von Neusüss, Christel: Die Kopfgeburten der Arbeiterbewegung oder Die Genossin Luxemburg bringt alles durcheinander, Hamburg 1985. In: Widerspruch, Beiträge zur sozialistischen Politik, Heft 10, 1985, p.129-132. New in: URL: http://www.werner-seitz.ch/ pdf/ Rezension_1985%20Neususess.pdf (5/27/2014).
Schuler, Romana (ed.): Peter Weibel. Bildwelten 1982-1996. Vienna 1997.
Schulze, Holger: Das Aleatorische Spiel. Erkundung und Anwendung der nichtintentionalen Werkgenese im 20. Jahrhundert. Munich 2000.
Seawright, James: Phenomenal Art. Form, Idea, and Technique. In: Fry, Edward F. (ed.): On the Future of Art. New York 1970/third printing 1973, p.77-93.
Segeberg, Harro/Winko, Simone (ed.): Digitalität und Literalität: zur Zukunft der Literatur. München 2005, p.197-220. New in: URL: http://digi20.digitale-sammlungen.de/ de/ fs1/ object/ goToPage/ bsb00041567.html? pageNo=1&prox=true&phone=true&context= Computer+Games&ngram=true&hl= scan&fulltext=Computer+Games &mode=simple (9/9/2012).
Seifert, Uwe: The Co-Evolution of Humans and Machines. A Paradox of Interactivity. In: Seifert, Uwe/Kim, Jin Hyun/Moore, Anthony (ed.): Paradoxes of Interactivity. Perspectives for Media Theory, Human-Computer Interaction and Artistic Investigations. Bielefeld 2008, p.8-23. New in: URL: http://www.transcript-verlag.de/ ts842/ts842_1.pdf (12/14/2012).
Seifert, Uwe/Kim, Jin Hyun/Moore, Anthony (ed.): Paradoxes of Interactivity. Perspectives for Media Theory, Human-Computer Interaction and Artistic Investigations. Bielefeld 2008.
Shahrani, Sam: Educational Feature: A History and Analysis of Level Design in 3D Computer Games. Part 1 (2006). In: URL: http://www.gamasutra.com/ view/ feature/131083/ educational_feature_ a_history_and_.php?print=1 (10/2/2012).
Shanken, Ed: Art and Electronic Media. London 2009.
Shannon, Claude Elwood: Communication in the Presence of Noise. In: Proceedings of the Institute of Radio Engineers. Vol.37/Nr.1. January 1949, p.10-21. New in: URL: http://www.cqccedu.cn/ vod/ tongxinyuanli/ web/ kczy/ xnjd_1.pdf (11/14/2011).
Shannon, Claude Elwood: Communication Theory of Secrecy Systems. In: Bell System Technical Journal. Vol.28/Nr.4. 1949, p.656–715. New in: http://netlab.cs.ucla.edu/ wiki/files/ shannon1949.pdf (11/14/2011).
Shannon, Claude Elwood: Presentation of a Maze-Solving Machine. In: Foerster, Heinz von/Mead, Margaret/Teuber, Hans Lukas (Ed.): Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transaction of the Eighth Conference. March 15-16, 1951, New York, N.Y. Josiah Macy, JR. Foundation. New York 1951, p.173-180. New in: Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy-Conferences 1946-1953. Volume/Band I: Transactions/Protokolle. Zürich and Berlin 2003, p.471-479.
Shannon, Claude Elwood: Programming a Computer for Playing Chess. In: Philosophical Magazine. Series 7. Vol.41/No.314. March 1960, p.256-275. New in: URL: http://archive.computerhistory.org/ projects/ chess/ related_materials/ text/ 2-0%20and%202- 1.Programming_a_computer_for_playing_chess.shannon/ 2-0%20and%202-1.Programming_a_computer_for_playing_chess.shannon.062303002.pdf (8/31/2012).
Shannon, Claude Elwood: The Redundancy of English. In: Foerster, Heinz von (ed.): Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social

Systems. Transactions of the Seventh Conference. March 23-24. 1950, New York, N.Y. Josiah Macy, JR. Foundation. New York 1950, p.123-158. New in: Pias, Claus (ed.): Cybernetics – Kybernetik. The Macy Conferences 1946-1953. Volume/Band 1. Zürich and Berlin 2003, p.249-272.
Shannon, Claude Elwood/Weaver, Warren: The Mathematical Theory of Communication. Urbana and Chicago 1949/1998 (primary publication of Shannon´s text in two parts in: Bell System Technical Journal, Vol. 27/Nr.3, 1948, p. 379-423. New in: URL: http://www.alcatel-lucent.com/ bstj/ vol27-1948/ articles/ bstj27-3-379.pdf (9/29/2011); Vol.27/Nr.4, 1948, p.623-656. New in: URL: http://www.alcatel-lucent.com/ bstj/ vol27-1948/ articles/ bstj27-4-623.pdf (9/29/2011)).
Shaw, Jeffrey: @ Home with Jeffrey Shaw. In: @ Home. Conference Doors of Perception 2. Netherlands Design Institute/Mediamatic. Amsterdam RAI Convention Center. Amsterdam 1994. URL: http://museum.doorsofperception.com/ doors2/ transcripts/ shaw.html (4/30/2012).
Shaw, Jeffrey: Modalitäten einer interaktiven Kunstausübung. In: Kunstforum. Bd.103. September-Oktober 1989, p.204-209. New in: URL: http://90.146.8.18/de/archiv_files/19891/1989_204.pdf (4/29/2012).
Shaw, Jeffrey: Movies after Film – The Digitally Expanded Cinema. In: Rieser, Martin/Zapp, Andrea (ed.): New Screen Media. Cinema/Art/Narrative. London 2002, p.268-275.
Shaw, Jeffrey: The Virtual Museum. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 92. Die Welt von Innen – Endo & Nano. The World from Within – Endo & Nano. Cat. of exhib. Brucknerhaus Linz. Linz 1992, p.105-109. New in: URL: http://90.146.8.18/ de/ archiv_files/ 19921/ 1992_105.pdf (4/30/2012).
Sherman, Tom: The Primature Birth of Video Art. In: iDC Digest. Vol.27/Issue 17. 1/9/2007. URL: http://mailman.thing.net/ pipermail/ idc/ 2007-January/ 000949.html (1/21/2007).
Siedler, Jeffrey: EMS Spectron Video Synthesizer. PPT-file, undated. In: URL: https://www.facebook.com/ download/ 1647801288800026/ Spectron %20Grammar.pdf (8/4/2015).
Siedler, Jeffrey: Spectre. Colour Video Synthesizer. (undated). In: URL: http://www.audiovisualizers.com/ toolshak/ vidsynth/ spectre/ spectre.htm (8/4/2015).
Siegelaub, Seth: Artist´s Reserved Rights Transfer and Sale Agreement. In: Szeemann, Harald: documenta 5. Befragung der Realität. Bildwelten heute. Cat. of exhib. Neue Galerie und Museum Fridericianum. Kassel 1972, p.18.13-18-39.
Simanowski, Roberto: Aleatorik als Aufklärung. Mauerbau und Babelturm in Simon Biggs´ "Great Wall of China". In: dichting-digital. Nr.22/2002. URL: http://dichtung-digital.mewi.unibas.ch/ 2002/ 04-20-Simanowski.htm (6/12/2012).
Simanowski, Roberto: Beim Bäcker. In: dichtung-digital. Interviews. Februar 2000. URL: http://dichtung-digital.mewi.unibas.ch/ 2000/ Simanowski/ 15-Feb/index.htm (6/16/2012).
Simanowski, Roberto: Susanne Berkenhegers "Zeit für die Bombe". Die Tat des Lesers, die simulierte Zerstörung und die Redundanz der Animation. In: dichtung-digital. Nr.2/1999. URL: http://dichtung-digital.mewi.unibas.ch/ Simanowski/ 2-Juli-99/brief1_0_x.htm (6/20/2012).
Simanowski, Roberto: Russisch Hypertext. Olia Lialinas "My boyfriend came back from the war". In: URL: http://dichtung-digital.de/2001/06/10-Simanowski/ (7/30/2012).
Simanowski, Roberto: Interfictions. Vom Schreiben im Netz. Frankfurt am Main 2002.
Simanowski, Roberto: Von der Leichtigkeit des Links und dem Kampf um seine Freiheit. Interview mit Alvar C. H. Freude und Dragan Espenschied. In: dichtung-digital. Interviews. November 2000. URL: http://www.dichtung-digital.de/ Interviews/ Espenschied-Freude-6-Nov-00/ index.htm (6/16/2012).
Simanowski, Roberto: Tod des Autors? Tod des Lesers!/Death of the Author? Death of the Reader! In: Block, Friedrich W./Heibach, Christiane/Wenz, Karin (ed.): p0es1s.

Ästhetik digitaler Poesie/The Aesthetics of Digital Poetry. Cat. of exhib. Kulturforum Potsdamer Platz. Berlin/Ostfildern-Ruit 2004, p.79-91. New in: URL: http://www.p0es1s.net/ poetics/ symposion2001/ full_simanowski.html (5/25/2012).
Sims, Karl: Artificial Evolution for Computer Graphics. In: Computer Graphics. Vol.25/Nr.4. July 1991, p.319-328. New in: URL: http://www.karlsims.com/ papers/ siggraph91.html (4/14/2012).
Sims, Karl: Genetische Bilder/Genetic Images. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 93. Genetische Kunst – Künstliches Leben/Genetic Art – Artificial Life. Cat. of exhib. Brucknerhaus Linz. Wien 1993, p.401-407. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19931/ E1993_401.pdf (4/14/2012).
Sims, Karl: Interaktive Evolution/Interactive Evolution. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 93. Genetische Kunst – Künstliches Leben/Genetic Art – Artificial Life. Cat. of exhib. Brucknerhaus Linz. Vienna 1993, p.119ss. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19931/ E1993_119.pdf (4/14/2012).
Sims, Karl: Particle Animation and Rendering Using Data Parallel Computation. In: Computer Graphics. Vol. 24/Nr.4. August 1990, p.405-413. New in: URL: http://www.karlsims.com/ papers/ ParticlesSiggraph90.pdf (1/29/2012).
Sitney, P. Adams: Visionary Film. The American Avant-Garde. New York 1974.
Sklover, Thea: Manhattan Cable´s anchised area 380 000 homes. In: Radical Software. Vol.1/No.4. Summer 1971, p.22s. URL: http://www.radicalsoftware.org/ volume1nr4/ pdf/ VOLUME1NR4_full.pdf (12/12/2011).
Slatin, John: Reading Hypertext. Order and Coherence in a New Medium. In: Delaunay, Paul/Landow, George P. (ed.): Hypermedia and Literary Studies. Baltimore 1991, p.153-169.
Slaton, Joyce: Remembering Community Memory. The Berkeley Beginnings of Online Community. In: SFGate. 13th December 2001. URL: http://www.sfgate.com/ cgi-bin/ article.cgi?f= /g/ a/ 2001/ 12/ 13/ commmem.DTL&ao=all (5/27/2012).
Smith, Alex: The Priesthood at Play: Computer Games in the 1950s. In: URL: https://videogamehistorian.wordpress.com/ 2014/ 01/ 22/ the-priesthood-at-play-computer-games-in-the-1950s/ (9/14/2015).
Smith, Myron P.: Computers and the Art of Animation. In: Halas, John (ed.): Computer Animation. London 1974, p.148-158.
Spielmann, Yvonne: Analog to Digital. Artists Using Technology. In: High, Kathy/Miller Hocking, Sherry/Jimenez, Mona (ed.): The Emergence of Video Processing Tools. Television Becoming Unglued. Vol.2. Bristol and Chicago 2014, p.499-527.
Spielmann, Yvonne: Woody Vasulka. Artifacts, 1980 (2004). In: URL: http://www.fondation-langlois.org/ html/ e/ page.php? NumPage=489 (12/31/2012).
Spielmann, Yvonne: Video. Ein audiovisuelles Medium. In: Daniels, Dieter/Naumann, Sandra/Thoben, Jan (ed.): See This Sound. Exhib. Lentos Kunstmuseum, Linz 2009. Website "See This Sound". Ludwig-Boltzmann Institut. Linz 2009. URL: http://see-this-sound.at/ kompendium/ abstract/ 48 (12/18/2011). New in: Daniels, Dieter/Naumann, Sandra (ed.): Audiovisuology. Cologne 2010, p.315-325.
Spielmann, Yvonne: Video. The Reflexive Medium (t.o.f.p. Video. Das reflexive Medium. Frankfurt am Main 2005). Cambridge/Massachusetts 2008.
Sprague, Roland Parcifal: Über mathematische Kampfspiele. In: Tohoku Mathematical Journal. First Series. Vol.41/1935, p.438–444. New in: URL: https://www.jstage.jst.go.jp/ article/ tmj1911/ 41/ 0/ 41_0_438/ _article (8/30/2012).
Stadlmayr, Horst/Leopoldseder, Hannes (ed.): Ars Electronica im Rahmen des Internationalen Brucknerfestivals Linz. Cat. of exhib. Brucknerhaus. Linz 1982.
Stallabrass, Julian: Internet Art. The Online Clash of Culture and Commerce. London 2003.
Stallman, Richard M.: Reevaluating Copyright: The Public Must Prevail. In: Oregon Law Review. Spring 1996. New in: URL: http://www.gnu.org/ philosophy/ reevaluating-copyright.en.html (7/26/2012).

Stallman, Richard M.: Free Software, Free Society. Selected Essays. Boston 2002. New in: URL: http://www.gnu.org/ philosophy/ fsfs /rms-essays.pdf (5/21/2012).
Steenson, Molly Wright: Artificial Intelligence, Architectural Intelligence: The Computer in Architecture, 1960–80. Dissertation proposal 2010. Princeton University School of Architecture. Princeton/New Jersey 2010. In: URL: http://www.girlwonder.com/ blog/ wp-content/ uploads/ 2010/05/ steenson-dissertation-proposal.pdf (10/9/2011).
Steenson, Molly Wright: Cedric Price´s Generator (2007). In: URL: http://www.activesocialplastic.com/ architecture/2007/08/ (10/9/2011).
Stephenson, Neal: In the Beginning...was the Command Line. New York 1999. New in: URL: http://cryptonomicon.com/beginning.html (2/19/2004).
Stephenson, Neal: Die Diktatur des schönen Scheins. Wie grafische Oberflächen Computernutzer entmündigen (t.o.f.p. In the Beginning...was the Command Line. New York 1999). Munich 2002.
Stephenson, Neal:In the Beginning...was the Command Line. New York 1999.
Stewart, William: ARPANET -- The First Internet (1996-2012). In: URL: http://www.livinginternet.com/ i/ ii_arpanet.htm (5/20/2012).
Stiles, Kristine/Selz, Peter: Theories and Documents of Contemporary Art. A Sourcebook of Artists´ Writings. Berkeley and Los Angeles 1996.
Strachey, Christopher: The "Thinking" Machine. In: Encounter. Literature, Arts, Politics. Nr.3/1954, p.25–31.
Strachey, Christopher: Time Sharing in Large, Fast Computers. In: Information Processing. Proceedings of the International Conference on Information Processing. UNESCO, Paris 15-20 June 1959. Paris, Munich and London 1960, p.336-341.
Straßer, Wolfgang: Schnelle Kurven- und Flächendarstellung auf graphischen Sichtgeräten. Dissertation TU Berlin. Berlin 1974.
Strauss, Wolfgang/Fleischmann, Monika: Virtuelle Architektur und Imagination. In: film + arc 1. Katalog Internationales Festival Film + Architektur. Graz 1993, unpaginated. New in: URL: http://netzspannung.org/ cat/ servlet/ CatServlet/ $files/ 439657/ film%2Barc-VirtArchitektur%2B Imagination-WSMF1993.pdf (5/5/2012).
Stürner, Miriam: Von künstlicher und digitaler Poesie. Formen computergenerierter Poesie seit den 1960er Jahren. Magisterarbeit Universität Stuttgart. Philosophisch-Historische Fakultät. Institut für Neuere Deutsche Literatur. Stuttgart 2003. In: URL: http://www.netzliteratur.net/ stuerner/ stuerner.html (11/15/2011).
Sturken, Marita: Artifacts. In: Id. (ed.): Steina and Woody Vasulka. Machine Media. Cat. of exhib. San Francisco Museum of Modern Art. San Francisco 1996. New in: URL: http://vasulka.org/Catalogues/PDFs/Cat_MachineMedia.pdf (12/31/2011).
Sturken, Marita (ed.): Steina and Woody Vasulka. Machine Media. Cat. of exhib. San Francisco Museum of Modern Art. San Francisco 1996.
Sturken, Marita: TV as a Creative Medium. Howard Wise and Video Art. In: Afterimage. May 1984, p.5-9. New in: URL: http://vasulka.org/ archive/ 4-30c/ AfterImageMay84(1004).pdf (12/17/2011).
Sturman, David: The State of Computer Animation. In: ACM SIGGRAPH. Vol.32/No.1. February 1998. URL: http://www.siggraph.org/ publications/ newsletter/ v32n1/ contributions/ sturman.html (12/17/2011).
Suter, Beat: Hyperfiktion und interaktive Narration im frühen Entwicklungsstadium zu einem Genre. Zürich 1999.
Suter, Beat: Literatur@Internet – oder warum die Zukunft des Schreibens längst da ist. In: Segeberg, Harro/Winko, Simone (ed.): Digitalität und Literalität: zur Zukunft der Literatur. Munich 2005, p.197-220. New in: URL: http://digi20.digitale-sammlungen.de/ de/ fs1/ object/ goToPage/bsb00041567.html? pageNo=197&prox= true&phone= true&ngram=true&context= Computer+Games&hl=scan&mode=simple&fulltext= Computer+Games (9/9/2012).
Sutherland, Ivan Edward: Sketchpad, A Man-Machine Graphical Communication System. Massachusetts Institute of Technoloy. Cambridge/Massachusetts 1963. In: URL:

http://www.cl.cam.ac.uk/ techreports/ UCAM-CL-TR-574.pdf (1/17/2012).
Sutherland, Ivan Edward/Sproull, Robert F./Schumacker, Robert A.: A Characterization of Ten Hidden-Surface Algorithms. In: Computing Surveys. Vol. 6/No 1. March 1974, p.1-55. New in: URL: https://design.osu.edu/ carlson/ history/ PDFs/ ten-hidden-surface.pdf (1/22/2012).
Sutton, Gloria: Stan Vanderbeek´s "Poemfields". The Interstice of Cinema and Computing. In: Higgins, Hanna B./Kahn, Douglas (ed.): Mainframe Experimentalism. Early Computing and the Foundation of the Digital Arts. Berkeley und Los Angeles/California 2012, p.311-333.
Sutton, Richard S./Barto, Andrew G.: Reinforcement Learning: An Introduction. Cambridge Massachusetts 1998. New in: URL: http://webdocs.cs.ualberta.ca/~sutton/book/ebook/the-book.html (10/7/2012).
Szeemann, Harald: documenta 5. Befragung der Realität. Bildwelten heute. Cat. of exhib. Neue Galerie and Museum Fridericianum. Kassel 1972.
Taesdale, Parry D.: Videofreex America´s First Pirate TV Station. Hensonville/New York 1999.
Tan, Kenneth Paul A. S.-S.: Storyspace: Using Hypertext in the Classroom (2002). In: URL: http://www.technologysource.org/ article/ storyspace/ (6/9/2012).
Tasajärvi, Lassi: A Brief History of the Demoscene. In: Id. (ed.): Demoscene. The Art of Real-Time. Helsinki 2004, p.11-32.
Tasajärvi, Lassi (ed.): Demoscene. The Art of Real-Time. Helsinki 2004.
Taylor, Grant D.: The Machine That Made Science Art. The Troubled History of Computer Art 1963-1989. Thesis. The University of Western Australia. Perth 2004. In: URL: http://theses.library.uwa.edu.au/ adt-WU2005.0114/ (10/2/2011).
Taylor, Robert W. (ed.): In Memoriam of J.C.R. Licklider 1915-1990. Systems Research Center/Digital Equipment Corporation. Palo Alto 1990. New in: URL: http://memex.org/licklider.pdf (5/20/2012).
Theweleit, Klaus: Zur Frühgeschichte des Videoclips. In: Poschardt, Ulf: Das Video als Laboratorium. In: Id. (ed.): Video – 25 Jahre Videoästhetik. Cat. of exhib. NRW-Forum Kultur und Wirtschaft. Düsseldorf 2004, p.47-69.
Thiel, Tamiko: MACHINA COGITANS. Das visuelle Design der Connection Machines CM-1 und CM-2/MACHINA COGITANS. The Visual Design of the Connection Machine CM-1 and CM-2. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 93. Genetische Kunst – Künstliches Leben/Genetic Art – Artificial Life. Cat. of Exhib. Brucknerhaus Linz. Vienna 1993, S.186-194. New in: URL: http://90.146.8.18/ en/archiv_files/ 19931/ E1993_186.pdf (4/14/2012).
Time´s Up: Sonic Pong. In: Lange, Andreas (ed.): pong.mythos. Ein Spiel und seine Geschichte/A Game and Its History. Cat. of exhib. Württembergischer Kunstverein. Stuttgart 2006. In: URL: http://www.pong-mythos.net/index.php?lg=de&main=Time_s_Up-AT-&site=01:02:29 (11/30/2012).
Todd, Stephen: Techniques to Create the Non-existent. In: New Scientist. Issue 1701. January 1990. URL: http://members.fortunecity.com/ templarser/ latham.html (4/14/2012).
Todd, Stephen/Latham, William: Evolutionary Art and Computers. London 1992.
Torcelli, Nicoletta: Video Kunst Zeit. Weimar 1996.
Town, Elke: Video by Artists 2. Toronto 1986.
Trunk, Daniela: Semantische Netze in Informationssystemen. Verbesserung der Suche durch Interaktion und Visualisierung. Kölner Arbeitspapiere zur Bibliotheks- und Informationswissenschaft Band 51. Fachhochschule Köln. Fakultät für Informations- und Kommunikationswissenschaften. Institut für Informationswissenschaft. Cologne 2005. In: URL: http://www.fbi.fh-koeln.de/ institut/ papers/ kabi/ volltexte/ band051.pdf (12/26/2012).
Turing, Alan Mathison: Proposal for Development in the Mathematics Division of an Automatic Computing (ACE). Report to the Executive Committee of the National

Physics Laboratory [1946]. In: Id.: The Collected Writings of A.M. Turing. Vol.1: Mechanical Intelligence. Amsterdam 1992, p.1-86. New in: URL: http://www.alanturing.net/ turing_archive/ archive/ p/ p01/ p01-001.html (11/1/2011).
Turing, Alan Mathison: The Collected Writings of A.M. Turing. Vol.1: Mechanical Intelligence. Amsterdam 1992.
Turner, Fred: From Counterculture to Cyberculture. Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism. Chicago 2006.
Turner, Fred: When the Counterculture met the New Economy. The WELL and the Origins of Virtual Community. In: Technology and Culture. Vol.46/No.3. July 2005, p.485–512. New in: URL: http://www.stanford.edu/ ~fturner/ Turner%20Tech%20&%20Culture%2046%203.pdf (5/21/2012).
Turner, Fred: Why Study New Games? In: Games & Culture. Vol.1/Nr.1. January 2006, p.1-4. New in: http://fredturner.stanford.edu/ wp-content/ uploads/ turner-gc-why-study-new-games.pdf (12/1/2012).
Tyler, Christopher W./Clarke, Maureen B.: Autostereogram. In: Stereoscopic Displays and Applications, Proceedings SPIE. Vol. 1256/Nr.182. 1990, p.182-196. New in: URL: http://www.ski.org/ CWTyler_lab/ CWTyler/ TylerPDFs/ TylerClarkeAutosterSPIE1979.pdf (11/26/2011).
Tyler, Tom: The Test of Time. McLuhan, Space and the Rise of Civilization. In: Dobrin, Sid/Morey, Sean (ed.): Ecosee. Image, Rhetoric, Nature. New York 2009. p.257-77. New in: URL: http://www.cyberchimp.co.uk/ research/ pdf/ Tyler_Test_of_Time.pdf (9/18/2012).
Usselmann, Rainer: The Dilemma of Media Art. Cybernetic Serendipity at the ICA London. In: Leonardo Journal. Vol.36/Nr.5. October 2003, p.389-396. New in: URL: http://www.rainerusselmann.net/ 2008/ 12/ dilemma-of-media-art-cybernetic.html (10/4/2011).
Vanderbeek, Stan: New Talent – The Computer. In: Art in America. Vol.58. 1970, p.86-91. New in: URL: http://www.stanvanderbeek.com/ _PDF/ Poemfields_Computer %20generated %20imagery_Final.pdf (11/3/2015).
Vannucchi, Hélia: Holger Friese. Unendlich, fast...In: Kuni, Verena (ed.): netz.kunst. Jahrbuch ´98/´99. Institut für moderne Kunst Nürnberg. Nuremberg 1999, p.100ss.
Vasulka, Woody: Dan Sandin. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.132. New in: URL: http://vasulka.org/ Kitchen/PDF_Eigenwelt/ pdf/ 132-135.pdf (12/31/2011).
Vasulka, Woody: Sony CV Portapack Industrial, 1969. In: Dunn, David/Vasulka, Steina and Woody/Weibel, Peter (ed.): Eigenwelt der Apparatewelt. Pioniere der Elektronischen Kunst/Pioneers of Electronic Art. Cat. of exhib. Oberösterreichisches Landesmuseum Francisco Carolinum. Linz 1992, p.150. New in: URL: http://vasulka.org/ Kitchen/ PDF_Eigenwelt/ pdf/ 150-151.pdf (1/4/2012).
Vasulka, Woody/Hagen, Charles: Syntax of Binary Images. In: Afterimage. Vol.6/Nos. 1 & 2. Summer 1978, p.20-31.
Vasulka, Woody/Nygren, Scott: Didactic Video. Organizational Models of the Electronic Image. In: Afterimage. Vol.3/No.4. October 1975, p.9-13. New in: URL: http://www.vasulka.org/ archive/ 4-30c/ AfterImageOct75(5024).pdf (12/19/2011).
Vasulka, Woody/Weibel, Peter (ed.): Buffalo Heads. Media Study, Media Practice, Media Pioneers, 1973-1990. Cat. of exhib. Zentrum für Kunst und Medientechnologie (ZKM)/Center for Arts and Media. Karlsruhe/ Cambridge/Massachusetts 2008.
Virilio, Paul: Das öffentliche Bild. In: Kunstforum. Bd.98. Januar-Februar 1989, p.106f.
Virilio, Paul: Das dritte Intervall. Ein kritischer Übergang. In: Decker, Edith/Weibel, Peter (ed.): Vom Verschwinden der Ferne. Telekommunikation und Kunst. Cologne 1990, p.335-348.
Virilio, Paul: Véhiculaire. In: Berque, Jacques et al. (ed.): Nomades et vagabonds.

Véhiculaire Cause commune. Nr. 2. Paris 1975, p.41-68.
Wadlow, Thomas A.: The Xerox Alto Computer. In: BYTE Magazine. Vol. 6/No. 9. September 1981. New in: URL: http://www.wadlow.org/ xerox-alto.html (9/5/2012).
Wagner, Kirsten: Computergrafik und Informationsvisualisierung als Medien visueller Erkenntnis. In: Deppner, Martin (ed.): Embedded Pictures. Krise des Bildes – Krise der Wahrnehmung. Bielefeld 2004, p.14-28. New in: Image. Zeitschrift für Interdisziplinäre Bildwissenschaft. Ausgabe 1/2005, p.46-63. URL: http://www.gib.uni-tuebingen.de/ own/ journal/ pdf/ buch_image1.pdf (1/17/2012).
Wagner, Richard: Oper und Drama (1852). Stuttgart second edition 1994.
Walker Rettberg, Jill: Piecing Together and Tearing Apart: Finding the Story in Afternoon. In: Hypertext´99. Proceedings of the Tenth ACM (Association for Computing Machinery) Conference on Hypertext and Hypermedia: Returning to our Diverse Roots, Darmstadt 1999. New York 1999, p.111-117. New in: URL: http://jilltxt.net/ txt/ afternoon.html (6/9/2012).
Walter, William Grey: The Living Brain. London 1953/Middlesex 1961 (Reprint 1968).
Walther, Elisabeth: Max Bense und die Kybernetik. In: Dotzler, Gerhard (ed.): Computer Art Faszination. 10 Jahre Computer Art Faszination. Hersteller und Dienstleister 1999. Medien-Institut. Frankfurt am Main 1999, p.360. New in: URL: http://www.netzliteratur.net/ bensekybernetik.htm (11/2/2011).
Wardrip-Fruin, Noah: Three Play Effects – Eliza, Tale-Spin, and Sim City. In: Receiver Nr.17: Gaming and Playing. December 2006. New in: URL: https://docs.google.com/ viewer?a=v&q= cache:OKXfYplzr7gJ:citeseerx.ist.psu.edu/ viewdoc/ download? doi%3D10.1.1.105.2025 %26rep%3Drep1 %26type%3Dpdf +Wardrip-Fruin+Three+Play+Effects&hl= en&pid=bl&srcid= ADGEESizjPC5SS12AyvVPMsx-t25_slW7NFqgGvrqrQhTe05IQ5 tTi1J3pyUTa66TBqxeYgUsPgkqbgezS - Xn61FfTZfJcZk6xdot NCxhr9Eq_YAzsi2yPi9LulOFfL 9inIpxJry46UIc &sig=AHIEtbSELDbE8wX ocAdHCV1kJSk54_rXDA (9/29/2012).
Wardrip-Fruin, Noah: Digital Media Archeology. Interpreting Computational Processes. In: Huhtamo, Erkki/Parikka, Jussi (ed.): Media Archeology. Approaches, Applications, and Implications. Berkeley 2011, p.302-322. New in: URL: http://games.soe.ucsc.edu/ sites/ default/ files/ nwf-BC7-DigitalMediaArchaeology.pdf (11/26/2011).
Wardrip-Fruin, Noah: Playable Media and Textual Instruments (2005). In: Gendolla, Peter/Schäfer, Jörgen (ed.): The Aesthetics of Net Literature. Writing, Reading and Playing in Programmable Media. Bielefeld 2007, p.211-253. New in: URL: http://vectors.usc.edu/ thoughtmesh/ publish/ 107.php (9/29/2011).
Warnke, Martin: Zur Situation der Couchecke. In: Habermas, Jürgen (ed.): Stichworte zur `Geistigen Situation der Zeit´. Vol.2: Politik und Kultur. Frankfurt am Main 1979, p.673-687. New in: URL: http://www.uni-marburg.de/ fb03/ politikwissenschaft/ pi-nip/ texte/ quellen/ warnkecouchecke.pdf (9/2/2012).
Warnke, Martin: Theorien des Internet zur Einführung. Hamburg 2011.
Warnke, Martin/Coy, Wolfgang/Tholen, Georg Christoph (ed.): Hyperkult II. Zur Ortsbestimmung digitaler und analoger Medien. Bielefeld 2005.
Wedeles, Laurie: Professor Nelson Talk Analyzes P.R.I.D.E. In: Miscelany News. Vassar College. Poughkeepsie/New York 2/3/1965. New in: URL: http://faculty.vassar.edu/ mijoyce/ MiscNews_Feb65.html (6/8/2012).
Weibel, Peter: Der Ausstieg aus der Kunst als höchste Form der Kunst (Interview mit Sara Rogenhofer und Florian Rötzer). In: Kunstforum. Vol.98/Januar-Februar 1989, p.60-75. New in: URL: http://peter-weibel.at/ images/ stories/ pdf/ 1989/ 0329_DER_AUSSTIEG_AUS.pdf (2/5/2012).
Weibel, Peter: Die Beschleunigung der Bilder in der Chronokratie. Bern 1987.
Weibel, Peter (ed.): bit international. [Nove] tendencije. Computer und visuelle Forschung. Zagreb 1961-1973. Cat. of exhib. Neue Galerie Graz am Landesmuseum Joanneum. Graz 2007.
Weibel, Peter: Zur Geschichte und Ästhetik der Digitalen Kunst. Supplement zum

Katalog Ars Electronica ´84 (Brucknerhaus, Linz 1984). Linzer Veranstaltungsgesellschaft. Linz 1984. New in: URL: http://peter-weibel.at/ images/ stories/ pdf/ 1984/ 0204_ZUR_GESCHICHTE_UND.pdf (1/28/2012).
Weibel, Peter (ed.): Jenseits von Kunst. Cat. of exhib. Neue Galerie am Landesmuseum Joanneum. Graz 1997.
Weibel, Peter (ed.): Kontext Kunst. Kunst der 90er Jahre. Cat. of exhib. Neue Galerie am Landesmuseum Joanneum. Granz 1993/Cologne 1994.
Weibel, Peter: Konturen einer Geschichte der Wahrnehmungstheorie und -kunst in Österreich. In: Weibel, Peter (ed.): Jenseits von Kunst. Cat. of exhib. Neue Galerie am Landesmuseum Joanneum. Graz 1997, p.26-44. New in: URL: http://www.peter-weibel.at/ images/ stories/ pdf/ 1987/ 0280_VON_DER_VISUELLEN.pdf (1/29/2012).
Weibel, Peter: Postontologische Kunst: Virtualität, Variabilität, Viabilität. In: Schuler, Romana (ed.): Peter Weibel. Bildwelten 1982-1996. Vienna 1997, p.242.
Weibel, Peter: Von den visuellen Musik zum Musikvideo. In: Weibel, Peter/Bódy, Veruschka (ed.): Clip, Klapp, Bum. Von der visuellen Musik zum Musikvideo. Cologne 1987, p.53-164. New in: URL: http://www.peter-weibel.at/ images/ stories/ pdf/ 1987/ 0280_VON_DER_VISUELLEN.pdf (1/29/2012).
Weibel, Peter: Musik-Videos. Von Vaudeville zu Videoville. In: Bódy, Veruschka und Gábor (ed.): Video in Kunst und Alltag. Vom kommerziellen zum kulturellen Videoclip. Cologne 1986, p.24-41. New in: URL: http://www.peter-weibel.at/ images/ stories/ pdf/ 1986/ 0257_MUSIK_VIDEOS.pdf (3/9/2012).
Weibel, Peter: Pictorial Space in Electronic Art. In: Leopoldseder, Hannes/Lorenz, Wolfgang (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986, p.189-193. New in: URL: http://90.146.8.18/ en/ archives/ festival_archive/ festival_catalogs/ festival_catalog.asp? iProjectID=9249 (7/26/2013).
Weibel, Peter: Stimmen aus dem Innenraum. In: Hattinger, Gottfried/Weibel, Peter (ed.): Ars Electronica 1988: Kunst der Szene. Cat. of exhib. Brucknerhaus Linz. Linz 1988, p.135-148. New in English with the title "Voices from an Inner Space" in: URL: http://90.146.8.18/ en/ archiv_files/ 19881/ E1988_068.pdf (2/5/2012).
Weibel, Peter: Welt der virtuellen Bilder/The World of Virtual Images. In: Camera Austria. Nr.46/1994, p.42-51. New in: URL: http://peter-weibel.at/ images/ stories/ pdf/ 1994/0427_DIE_WELT_DER.pdf (5/1/2012).
Weibel, Peter: Welt von Innen – Endo & Nano. Über die Grenzen des Realen/The World from Within – Endo & Nano Over and Beyond the Limits of Reality. In: Gerbel, Karl/Weibel, Peter (ed.): Ars Electronica 92. Die Welt von Innen – Endo & Nano. The World from Within – Endo & Nano. Cat. of exhib. Brucknerhaus Linz. Linz 1992, p.8-12. New in: URL: http://90.146.8.18/ en/ archiv_files/ 19921/ E1992_008.pdf (7/26/2013).
Weibel, Peter/Bódy,Veruschka (ed.): Clip, Klapp, Bum. Von der visuellen Musik zum Musikvideo. Cologne 1987.
Weibel, Peter/Druckrey, Timothy (ed.): Net_condition. Art and Global Media. Cat. of exhib. Steirischer Herbst. Graz 1998/Zentrum für Kunst und Medientechnologie, Karlsruhe 1998. Cambridge/Massachussetts 2001.
Weiß, Matthias: Netzkunst. Ihre Systematisierung und Auslegung an and von Einzelbeispielen. Dissertation Philosophische Fakultät, Albert-Ludwigs-Universität Freiburg im Breisgau 2008/Weimar 2009. Nur-Text-Fassung in: URL: http://www.weisskunst.de/ mss/ 20100629mw_diss.pdf (8/2/2012).
White, Norman: Hearsay (1985). In: URL: http://www.normill.ca/ Text/ Hearsay.txt (5/24/2012).
Whitelaw, Mitchell: Metacreation. Art and Artificial Life. Cambridge/ Massachusetts 2004.
Whorf, Benjamin Lee: Language, Thought, and Reality. Selected Writings. Cambridge/Massachusetts 1956. New in: URL: http://openlibrary.org/ books/

OL6197196M/ LANGUAGE_THOUGHT_and_REALITY (6/8/2012).
Wiener, Norbert: Cybernetics or Control and Communication in The Animal and The Machine. New York 1948/ reprint Whitefish/Montana 2007.
Wiener, Norbert: I am a mathematician: the later life of a prodigy. An autobiographical account of the mature years and career of Norbert Wiener and a continuation of the account of his childhood in ex-prodigy. Garden City/New York 1956. New in: URL: http://de.scribd.com/ doc/ 27506099/ I-Am-a-Mathematician-1956 (7/11/2013).
Wiener, Oswald: der bio-adapter (prospekt 1965/66). In: Id.: Die Verbesserung von Mitteleuropa, Roman. Reinbek bei Hamburg 1969/second edition 1985, appendix A, S.CLXXV-CLXXXIII. New in: URL: http://personal.georgiasouthern.edu/ ~hkurz/ wiener/ ow-1.htm (2/5/2012).
Wiener, Oswald: Die Verbesserung von Mitteleuropa, Roman. Reinbek bei Hamburg 1969/second edition 1985.
Wikipedia: Amiga Software. In: URL: http://en.wikipedia.org/ wiki/ Amiga_software (2/3/2012).
Wikipedia: Doom. In: URL: http://de.wikipedia.org/ wiki/ Doom (9/8/2012).
Wikipedia: Doom Engine. In: URL: http://en.wikipedia.org/ wiki/ Doom_engine (9/7/2012).
Wikipedia: Hamurabi. In: URL: http://en.wikipedia.org/ wiki/ Hamurabi (9/8/2012).
Wikipedia: MTV Video Music Award. In: URL: http://de.wikipedia.org/ wiki/ MTV_Video_Music_Awards (2/1/2012).
Wikipedia: Looker. In: URL: http://en.wikipedia.org/ wiki /Looker (3/12/2012).
Wikipedia: Ultima online. In: URL: http://en.wikipedia.org/ wiki/ Ultima_Online (12/1/2012).
Wikipedia: WorldWideWeb. In: URL: http://en.wikipedia.org/ wiki/ WorldWideWeb (8/27/2012).
Wilson, Stephen: Information Arts. Intersections of Art, Science, and Technology. Cambridge/Massachusetts 2002.
Wing, Richard L.: Two Computer-Based Economics Games for Sixth Graders. In: American Behavioral Scientist. Vol.10/Nr.3. 1966, p.31-35.
Winter, David: Noughts and Crosses (undated). In: URL: http://www.pong-story.com/ 1952.htm (9/1/2012).
Wirsig, Christian: Das große Lexikon der Computerspiele. Spiele, Firmen, Technik, Macher. Von "Action" bis "Zork" und von "Activison" bis "Zipper Interactive". Berlin 2003.
Wirth, Uwe: Wen kümmert´s wer spinnt? Gedanken zum Schreiben und Lesen im Hypertext. In: Böhler, Michael/Suter, Beat (ed.): Hyperfiction. Basel and Frankfurt am Main 1999, p.29-42. New in: URL: http://user.uni-frankfurt.de/%7Ewirth/ Texte/ netzsymp.html (6/13/2012).
Wishart, Adam/Bochsler, Regula: Leaving Reality Behind. The Battle for the Soul of the Internet. London 2002.
Without author: The Ferranti Nimrod Digital Computer. Faster than Thought. Leaflet Festival of Britain. Science Museum. London 1951. New in: URL: http://www.goodeveca.net/ nimrod/ NIMROD_Guide.html (8/30/2012).
Without author: NIMROD. Part 1. In: Without author: The Ferranti Nimrod Digital Computer. Faster than Thought. Leaflet Festival of Britain. Science Museum. London 1951. New in: URL: http://www.goodeveca.net/ nimrod/ NIMG_1.html (8/30/2012).
Without author: Paik-Abe Video Synthesizer (undated). In: URL: http://www.audiovisualizers.com/ toolshak/ vidsynth/ paik_abe/ paik_abe.htm (12/12/2011).
Without author: Program Guide. In: Radical Software Vol.II/No.1. Winter 1972, unpaginated.
Without author: Scape-mates [by] Ed Emshwiller (undated). In: Catalogue EAI. URL: http://www.eai.org/ title.htm?id=2847 (12/17/2011).

Without author: Sony CV 2000 (undated). In: URL: http://experimentaltvcenter.org/sony-cv-2000 (1/8/2012).
Without author: Sony CV Series Video (undated). In: URL: http://www.smecc.org/sony_cv_series_video.htm (4/10/2012).
Without author: Sony DVK-2400/VCK 2400 Battery operated Videocorder/Camera Ensemble (undated). In: URL: http://www.experimentaltvcenter.org/ sony-dvk-2400vck-2400-battery-operated-videocordercamera-ensemble (1/9/2012).
Without author: SONY AV-3400 PORTA PAK (undated). In: URL: http://experimentaltvcenter.org/sony-av-3400-porta-pak (1/7/2012).
Without author: United States Code, Title 17: Copyrights, Chapter 1, Section 107: Limitations on exclusive rights: Fair Use (undated). In: URL: http://www.copyright.gov/title17/ 92chap1.html#107 (9/28/2011).
Without author: U.S. Copyright Office Summary: The Digital Millenium Copyright Act of 1998 (December 1998). In: URL: http://www.loc.gov/ copyright/ legislation/ dmca.pdf (12/14/2003).
Without author: User Notes on FORTRAN Programming (UNFP). (An open cooperative practical guide). Chapter 1-1: A Brief History of FORTRAN/Fortran (1996-98). URL: http://www.ibiblio.org/ pub/ languages/ fortran/ch1-1.html (11/5/2011).
Without author: Stan Vanderbeek´s "Violence Sonata" (Video Excerpt) (undated). In: URL: http://openvault.wgbh.org/ catalog/ ntw-mla000126-stan- vanderbeek-s-violence-sonata (12/13/2011).
Without author: Video Games – Did They Begin at Brookhaven? (1981). In: URL: http://www.osti.gov/ accomplishments/ videogame.html (9/1/2012).
Wolf, Mark J.P.: The Medium of the Video Game. Austin 2002.
Wright, Will: A chat about the "The Sims" and "SimCity" (2000). In: URL: http://edition.cnn.com/ chat/ transcripts/ 2000/ 1/ wright/ index.html (9/9/2012).
WWW Consortium: HTML Tags (1992). In: URL: http://www.w3.org/ History/19921103-hypertext/ hypertext/ WWW/ MarkUp/ Tags.html (7/29/2012).
WWW Consortium: XHTML™ 1.0 The Extensible HyperText Markup Language (Second Edition). A Reformulation of HTML 4 in XML 1.0 (2000/2002). In: URL: http://www.w3.org/ TR/ xhtml1/ (7/29/2012).
Yao, Colin: The OSI Reference Model (2011). In: URL: http://www.fiberoptics4sale.com/wordpress/ the-osi-reference-model/ (2/22/2014).
Yagoda, Marvin: 1972 Nutting Associates Computer Space (undated). In: URL: http://web.archive.org/ web/ 20090130053055/ http://www.marvin3m.com/ arcade/cspace.htm (10/2/2012).
Yalkut, Jud: The Electronic Video Synthesizer. Interview with Eric Siegel. In: Ohio Media. Vol.1/No. 2-3. December 1977/January 1978. New in: URL: http://eai.org/user_files/ supporting_documents/ evs.pdf (11/17/2011).
Youngblood, Gene: Expanded Cinema. New York 1970. New in: URL: http://www.vasulka.org/ Kitchen/ PDF_ExpandedCinema/ ExpandedCinema.html (1/2/2012).
Youngblood, Gene: Larry Cuba "Calculated Movements". An Interview with Larry Cuba. In: *Leopoldseder, Hannes/Lorenz, Wolfgang* (ed.): Ars Electronica 86. Computerkulturtage Linz. Vol. 2. ORF-Videonale. Neue Bilder – Neue Zeiten. Österreichische Rundfunk (ORF). Landesstudio Oberösterreich. Linz 1986, p.118-124,181-184. In: URL: http://90.146.8.18/ en/ archiv_files/ 19862/ E1986b_181.pdf (1/28/2012).
Youngblood, Gene: Der Virtuelle Raum. Die elektronischen Umfelder von Mobile Image/Virtual Space. The Electronic Environments of Mobile Image. In: Leopoldseder, Hannes/Schöpf, Christine (ed.): Computerkultur Tage Linz ORF-Videonale 86 im Rahmen der Ars Electronica 86. Österreichischer Rundfunk (ORF), Landesstudio Oberösterreich. Linz 1986, p.289-302, 351-358. New in: URL: http://90.146.8.18/ en/archiv_files/ 19862/ E1986b_351.pdf (5/24/2012).

Zacharias, Wolfgang (ed.): Interaktiv. Im Labyrinth der Wirklichkeiten. Essen 1996.
Zacharias, Wolfgang (ed.): Zeitphänomen Musealisierung. Das Verschwinden der Gegenwart und die Konstruktion von Erinnerung. Essen 1990.
Zielinski, Siegfried/Link, David (ed.): Variantology 2. On Deep Time Relations of Arts, Sciences and Technologies. Cologne 2006.
Zinman, Gregory: Analog Circuit Palettes, Carhode Ray Canvases. Digital´s Analog, Experimental Past. In: Film History. Vol.24/Nr.2. 2012, p.135-157. New in: URL: https://www.academia.edu/ 4259816/ Analog_Circuit_ Palettes_Cathode_Ray_ Canvases_Digitals_Analog_ Experimental_Past (8/4/2015).
Zivanovic, Aleksandar: SAM, The Senster and the Bandit: Early Cybernetic Sculptures by Edward Ihnatowicz. In: Proceedings of the Symposium on Robotics, Mechatronics and Animatronics in the Creative and Entertainment Industries and Arts, SSAISB 2005 Convention: Social Intelligence and Interaction in Animals, Robots and Agents, April 13, 2005, University of Hertfordshire, Hatfield 2005, p.1-7. New in: URL: http://www.aisb.org.uk/ publications/ proceedings/ aisb05/ 4_CreatRob_Final.pdf (10/5/2011).
Zivanovic, Aleksandar: Technical Info about the Senster (undated). In: URL: http://www.senster.com/ ihnatowicz/ senster/ senstercomputer/index.htm (10/6/2011).
Zivanovic, Aleksandar: The Technologies of Edward Ihnatowicz. In: Brown, Paul/Gere, Charlie/Lambert, Nicholas/Mason, Catherine (ed.): White Heat Cold Logic. British Computer Art 1960-1980. Cambridge/Massachusetts 2008, p.95-110.