CHAPTER 7

Technological Platforms

INTRODUCTION

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Technological systems are dynamic entities, the stability of which relates to temporary *convergence* phenomena[1] within a cultural set that establishes the media system, based on industrial and communication standards and protocols. The dynamics of convergence do not only relate to the physical and technical identity of media, they also work in terms of individual and social imagery. In this sense, the aesthetic experiment in the arts *sub specie* technology has always worked as much on technological innovations as it has on protocols.[2] The protocols (like standards and recommendations) are the results of an economic and socio-cultural negotiation; they are a place for the redefining of the convergence or divergence between different kinds of media. Furthermore, when the new technology is up and running, operations are activated (an example being aesthetic finality) which explore the characteristics and the potential of the new arrivals.

The technological innovations are a starting point for talking about mapping with regards to sensory factors and therefore invoke activity to produce sensory remapping and expressive training practices, which are useful in the reconfiguration of what Derrick de Kerckhove has called *brainframes* around this new technology (Kerckhove, 1991).

In chapter 7, some of the operations and the modes that distinguish the aesthetic actions from cinema technology and analogue and digital video will be highlighted. The first "place" in which the aesthetic practices of research operate is *techniques* (Altman, 2001), which can be interpreted as an *alchemi-*

cal, *laboratory*, or *handmade* environment for using the technology available and the human and corporal reclaiming of technology. The place of technique requires choices, solutions and decisions that bypass and anticipate the supposed linear nature of the use of the technology, systems, and materials.

The aesthetic decisions about the use of the technology can at the same time be informed by actions that look beyond the normal use of the object and the immediacy of a functional representation. They are practical operations on the technology and materials of a reflexive nature, aimed at creating aesthetic planning, which means a project that is not immediately useful, a "planning forecast of many possible aims." From this point of view, aesthetic experimentation is to be understood as "a mainly *meta-operational* activity" (Garroni, 1977).

The *breaking practices* (Shand, 2008) are other sensitive stimulating cultural points of techno-aesthetic experimentation. The error and breakdown become features that allow for the recognition and reconfiguration of the basic aesthetic and technological project and the subjectivity that produced it, revealing the astonishment and the sense of uncanny that hides behind the habituation to technological innovations (Gunning, 2003).

Aesthetic experimentation has always interacted with the category and modes of amateurship (Zimmerman, 1995; Ishizuka and Zimmerman, 2007; Shand, 2008) for financial reasons, for the opportunities of control upon the process and the possibility of creating flexible use, exchange and communication protocols. In addition, amateur film can be considered as a liminal space of transit and continuous experimentation. Therefore, the amateur area functions as a place where innovations can be checked and also as a place where the starting utopian potential of technology can be maintained. The astonishment and unawareness that amateur film maintains as a *reserve* and a *resource* is something "out of place" that must be considered as an *unintentional* approach, which is preparatory and complementary to what is "out of mode," revealed by obsolescence as a precondition for the discourse *intention* and action of reinventing the medium (Krauss, 1999).

The obsolescence includes its opposite, the industrial structures of production and reproduction (preservation and transmission) that affect and guide artworks and preservation arenas. The changes of standards produce obsolescences, remains, and destruction. Damage and decay are included in the language as aesthetic idiolect, as indicators of a "breaking" practice. The aesthetic aspect establishes the possibility of its own existence, too, in the dialectic created by technology between "product" and "process," between norms and the deviation, "industry" and "craftsmanship," and between "professional" and "amateur."

7.1 THE HISTORY AND TECHNOLOGICAL CHARACTERISTICS OF CINEMATOGRAPHIC PRODUCTION AND RECEPTION DEVICES

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Standard 35mm Film

In the first decade of the 20th century, Edison's perforated 35mm film and the aspect ratio of 1:1.33 was the format that was establishing itself and would be taken on as the industry standard from 1909. Between 1923 and 1924, the standards for the negative (BH) and positive (KS) perforations were set, together with the positioning settings for full-frame. With the introduction of the optical soundtrack, halfway through the 1930s, the standards for sound film were achieved (the Academy format, 1:1.37) and during the 1950s, panoramic and anamorphic formats and magnetic sound were introduced.

The physical characteristics of film were used at an expressive level. For more than just a few filmmakers (including George Landow, Peter Tscherkassky, Paolo Gioli) the perforations, the area of the soundtrack, and the frameline became expressive visual and audio elements. The physicality of the film became material for aesthetic practices derived from the collage and from found objects, and operates within a dialectic between norm and deviation, between use (functionality) and out of use (breaking), between the invisibility of the technical standards and the exhibition of protocols and structures.

From this point of view, Tscherkassky's trilogy *L'Arrivée*, *Outer Space*, and *Dream Work* from the end of the 1990s is exemplary. Through the use of cinemascope, the artist achieved three objectives from his own experimental research: making structural elements of the film such as the perforations visible, thus working on the concept of "outer space"; using a "classic" cinematographic format in an experimental context where paradoxically filmmakers have often not considered alternatives to the 1:1.33; placing in the contemporary transition a format, which imposed itself on a previous moment of transformation and crisis of cinema (the introduction of electronic television images) (Bardon, 2001).

Substandard Film

The evolution of photography from a practice of only professional photographers to a personal and common experience – think of George Eastman and his motto, "You press the button, we do the rest"[3] – and the birth of amateur cinema offer various analogies. In both cases, the easy-to-use instrument was essential in making photography and cinematography an everyday affair.[4]

The first attempts were linked to the reduction from 35mm format to 17.5mm, and the production of the first film cameras such as Birtac (1898) and Biokam (1899), for example, as well as different experiments such as Gaumont's Chrono de Poche (1900), 15mm.

The introduction of the safety film (cellulose diacetate) together with the Pathé Kok 28mm format (1912) gave life to the first system for cinema at home. The 28mm combined safety and ease of use, good quality, the possibility to project films from a dedicated library, and to have a camera specifically designed for home cinema purposes.

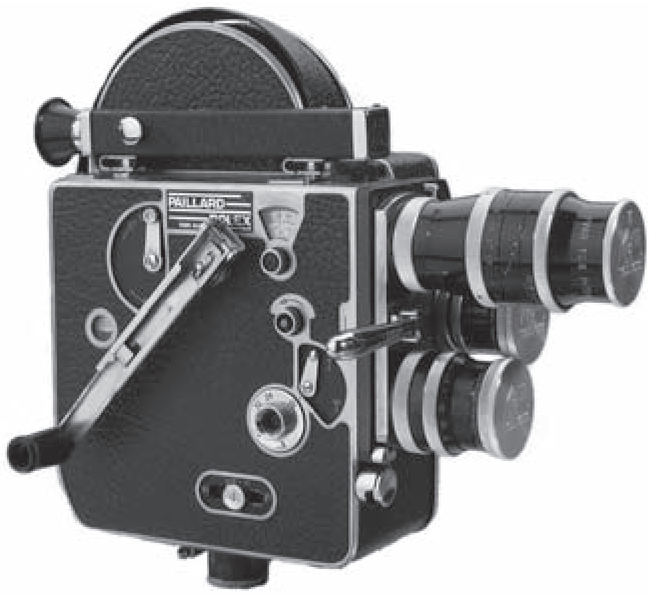
Amateur cinema therefore had to satisfy two requirements – practicality and security – to which a third would later be added: the use of reversal material. These requirements would form the basis for the first small and popular models: the 9.5mm Pathé Baby and the 16mm Kodak.

In 1922, Pathé put the 9.5mm on the market. Pathé's slogan was "Petit, simple et bon marché." As well as the miniaturization, a key factor in the growth and development was the accessory kit: tools to print and do the film processing by themselves; rotary discs with color filters to "simulate" the colors; and accessories to "extract" and enlarge single frames.

In 1923, Kodak put the 16mm on the market, although it was too expensive for many people. These were heavier cameras (4.5 kilograms compared to Pathé's camera which was barely one kilogram). It was possible to load the camera with 30 meters of film (compared with the French format's nine meters). The loading of the spools required greater skill than the loading of the 9.5mm's "cartridge." The 16mm was a more troublesome system, reserved for the elite but also aimed at semi-professionals in schools and institutions. The 16mm was an open system: the cameras were not the exclusive preserve of Kodak, instead, the patent was made available to many different brands (Bell & Howell being one noteworthy example) which would bring improvements and developments. The double perforations guaranteed remarkable frame stability. At the beginning of the 1930s, with the introduction of sound,[5] one row of perforations would be sacrificed to leave space for the soundtrack. From the 1950s onwards, the spread of the magnetic medium would allow for easier shots and sound recording.

The 16mm format started to be used at the end of the 1930s by Len Lye and Norman McLaren. In the 1950s, amateur filmmakers, visual artists, students from art schools, and ordinary fans used the completely manual 16mm cameras because their extreme versatility allows for a lot of experimentation (think of the Bolex-Paillard H16). Much of the Underground Cinema and New American Cinema of the time was made with such cameras (Maya Deren,

7.1
Paillard Bolex H16 with turret with three lenses. Source: Archivio Nazionale del Film di Famiglia – Associazione Home Movies.



Gregory Markopoulos, Harry Smith, Kenneth Anger, Jonas Mekas, Stan Brakhage, and Robert Breer).

In 1932, Kodak put a new format on the market, known as 8mm (Standard 8 or Double 8). It was 16mm film which was seven-and-a-half meters long, with twice the usual number of perforations; the spools were mounted in metal casing to be loaded and exposed twice. In the area of the 16mm frame, after the processing and before the lengthways cut, four images were printed. From the cut and spliced film, fifteen meters were left, which corresponded to about four minutes of film at sixteen frames per second.

The miniaturization of the filming and projection equipment would make the format the most popular until the middle of the 1970s. From the 1950s onwards, the Kuchar brothers would work on Kodachrome's chromatic capacity and the Standard 8 format's grain. Brakhage also used the format for filming as well as for hand-painting the film.

From 1965, Kodak started to sell Super 8, which was the same size as the 8-mm format; the improvement was made by redesigning the film, increasing the area by 40 percent, thanks to the modifications of the perforations. At the same time, a new emulsion was released: Kodachrome II. Kodak aimed it at family cinema. Amateur filmmakers remained loyal to the Standard 8 for a long time (as long as stock remained available). In contrast, the Super 8 was also the format of self-awareness, of the affirmation of the film diary, for example *Walden* (1969) by Jonas Mekas.

Cameras

The artistic use of the film camera started with its basic elements, working around its optical and mechanical principles. The early avant-garde movements used many effects created with the camera; some of these included optical distortions in *La Folie du Docteur Tub*e (1915) by Abel Gance, as well as multiple overlays, kaleidoscopic multiplications, positioning of the filters, and surfaces in front of the lens, and slow and fast motion in *Emak Bakia* (1927), *L'Etoile de Mer* (1928) by Man Ray, *Ballet Mécanique* (1924) by Fernand Léger, and *Filmstudie* (1926) by Hans Richter.

In the experimental context, the cameras were chosen according to their characteristics. The range of possibilities offered by Bolex-Paillard (speed and variable shutter, interchangeable optical systems, rewinding of the film for double exposures and fading) allowed many tricks to be carried out on the camera: from slow motion and animation to time-lapse and pixilation. For this reason, these cameras could be found in many of the American art schools and they were used in television for reporting. Beaulieu was another important brand in the construction of 16mm film cameras. The R16 resumed Bolex's tradition, compactness and versatility, not to mention the Angenieux 12-120 high quality zoom, which made it an instrument that was valued for difficult filming in mainstream production.

In the experimental context the cameras were freed from normative constraints (Deren, 1965) or they were constrained with set movements or kept still (as with certain structural and pop cinema). Finally, they were liberated from human presence, as was the case for the camera in continuous and automatic movement at the core of *La Région Centrale* (1971) by Michael Snow, a film that took conceptual action to its limits: the moving devices and the mobility that was created in the 1960s with the transfocal lenses, the dolly, the spider, and the camera-car; and in the 1970s firstly with the *louma* and then with the Steadicam.

Film cameras could then be recognized as complete craftsmanlike or idiosyncratic devices, for example: Alexandre Alexeieff's pin-screens or tools; László Moholy-Nagy's Light-Space Modulator, precursor to kinetic machines, whose movements and light games were the basis for *Lichtspiel* (1930). Another example was the "infernal machine" made to shoot Oski's painting that was the basis of Fernando Birri's *La verdadera historia de la primera fundación de Buenos Aires* (1959).

Film cameras were also related to their original and fundamental role in the camera obscura, like the example of Gioli's "pinhole camera" (a small empty metal rod with holes that was pulled manually) in *Film Stenopeico* (*L'Uomo senza Macchina da Presa*, 1973-1981-1989).

7.2
Camera mounted on rotating arms and automatically moving counterweights for Michael Snow's *La Région Centrale* (1971). Courtesy Michael Snow.

The liberation of film from the camera's "dictatorship" involved abstract, painted, and artistic cinema with drawing, painting, collage, engraving, rayographic practices (Christian Schad, Man Ray, and László Moholy-Nagy), and abstract animation (Len Lye, Norman McLaren, Stan Brakhage, Marcel Thirache, Harry Smith, Aldo Tambellini, Thorsten Fleisch, and Ian Helliwell).

In addition to finding the first attempts at cameraless cinema[6] in Man Ray's rayograms, as in the case of Barbel Neubauer, there was also the *post-production* or archival cinema that used material that had already been exhibited, hidden, and found in assemblages that had roots in photomontage (John Heartfield, Alexander Rodchenko). A practice that was also tied to the development of editing and optical printers and therefore also the possibility of revising and reframing the film. This was a practice that was put in motion in a way that was not dissimilar to "archival impulse" (Foster, 2004) and continued as an analytical, mnemonic, and imaginative exercise on various visual repertoires (Dziga Vertov, Joseph Cornell, Ken Jacobs, Ernie Gehr, Al Razutis, Martin Arnold, Gustav Deutsch, Tscherkassky, and Douglas Gordon).

Emulsion – Base

At the beginning of the 20th century, different cinematographic emulsions began to appear together with the first emulsions dedicated to the printing of copies (in 1908 Kodak's "Regular Positive"). Early in the second decade, orthochromatic film increased the zone of sensitivity, to the radiation of the visible spectrum. The spread of filming and projecting techniques that were not professional became associated with the use of safety film. The difficulties in the development of a stable safety film base and guarantee of basic conditions of transparency, resistance and flexibility persist, and a mixture of acetate, butyrate, and nitrate was used until the 1930s and 1940s, even for smaller formats. The beginning of the 1920s saw the spread of panchromatic emulsions, the majority of film production companies included pre-tinted stock materials. Around halfway through the 1920s, fine grain emulsions started to arise, able to produce positive and negative duplicates from which the final copies could be obtained. The reversal process was successful in cinema thanks to the 9.5mm, 16mm, and 8mm substandard formats. The substandard format experience was a fundamental forerunner and, in 1965, Fuji put the Single 8 on the market, the first polyester film. After the Second World War, the cellulose triacetate base spread, destined to replace cellulose nitrate as the standard for 35mm films from 1951 onwards. Around halfway through the 1970s, the polyester base replaced the triacetate in perforated magnetics, and then took over as the base for 35mm prints in the second half of the 1980s.

The use of negative or intermediate film or mixed elements in projection was widespread in the experimental field, for example, the use of the negative in *The Very Eye of the Night* (1958) by Maya Deren; *Berlin Horse* by Malcolm Le Grice (1970); in the works of Maurice Lemaître, Douglas Gordon, and Peter Tscherkassky; the structural, pop, flickering elements in *T.O.U.C.H.I.N.G.* (1968) by Paul Sharits; the interposition between negative and positive in *Film Feedback* (1972) by Tony Conrad; or the use of negative, positive, black and white, and color in the multi-cameras and multi-screens of *After Manet* (1973) by LeGrice.

From the beginning of the 20th century, reproducing natural colors was experimented with in different ways (Lumière, Urban's Kinemacolor in 1906, Chronochrome Gaumont in 1913). In 1905, Pathé introduced Pathé Color for the coloring of positives with a mechanical system for color application. The system was in use until early in the 1930s, but the techniques that asserted themselves up until the end of the 1920s, in terms of symbolic and referential representation, were tinting and toning. As the 1920s approached, the production of subtractive systems began. In 1922, the American film *The Toll of the Sea* gave the first example of a color film created using the second Technicolor system, and 1935 saw the use of the fourth Technicolor system, with the film *Becky Sharp* – this was a subtractive system with three colors that would remain in use until the end of the 1970s.

The first color systems beneficial for smaller film formats were Kodacolor and Agfacolor, interesting but complex systems that were available from early in the 1920s until halfway through the 1930s on 16mm format. During the 1930s the first systems of lenticular color reproduction began to spread. At the start of the 1930s, Dufaycolor was also available on the Pathé Baby format. But it was with Kodachrome (1935) and Agfacolor Neu that remarkable results were obtained, firstly on 16mm and then on 8mm. The single-layer subtractive Kodachrome emulsion for reversal film was the first real trichrome monopack. Initially designed for 16mm, it was soon applied to 35mm slides, and 8mm slides in 1936. The emulsion was cheap, with great chromatic stability, it was much loved, had great success and did not go out of production until 2009. The 1950s were the decade that saw color assert itself with monopack by Eastmancolor in 1950, Ferraniacolor in 1952, and Fujicolor in 1953.

The color system found a fertile testing ground in experimental cinema, for example *Composition in Blue* (1935) by Oskar Fischinger, which used Gasparcolor (Fischinger himself helped to develop it), a system then used by Len Lye and Alexandre Alexeieff. Another example was *Colour Separation* (1974) by

7.3
Reproduction of a frame from Isidore Isou, *Traité de bave et d'éternité* (1951).

Chris Welby, based on the color separation process. The experimentation with color then went in many different directions, from filters to flashing, from toning to all artistic cinema, experimental animation, and the early avant garde, for example, *Das Wunder. Ein Film in Farben* (1922) by Walter Ruttmann, colored by hand.

The transforming action of the photo-chemical characteristics of film was also at the root of alchemic practices (bleaching, modification to the processing and printing of the film, over- and underexposure) and went as far as favoring the visionary lyricism and the ready-made of chemical physical decay (the decay of nitrate and certain colors) and to propose an idea of cinema as art of destruction, for example: *Trasferimento di modulazione* (1969) by Pierfrancesco Bargellini, and the works of Jürgen Reble's Schmelzdahin group. The layers of emulsion were also subjected to scratching, engraving, and heating (Brakhage, Isidore Isou, Lemaître, Olivier Fouchard, Karl Lemieux, Yves-Marie Mahè, Jürgen Reble, and Thorsten Fleisch).

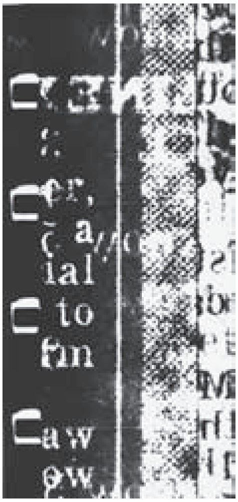
Sound on Film

From the beginning there were many experiments in synchronized sound recorded onto a disc, including Kinetophone, Phono-Cinéma-Théatre, and Chronophone. The techniques for the recording and photoacoustic reproduction of sound on film had their first important event in 1904 with Eugène Lauste, when the practice of live musical accompaniment would have great success, emphasizing cinema's performative characteristics.

At the end of the First World War, the experimentation began to intensify. In 1918, the German Joseph Engl, Hans Vogt and Joseph Massolle began to develop the variable area. In 1919, Lee De Forest started testing recording at variable density, creating the Phonofilm system in 1922. Between 1926 and 1930, the final phase of development in optical sound on film was started and the system with separate negatives and variable area gradually came to dominate for variable density and disc systems. In 1935, Gance presented the sound and stereo version of *Napoléon* and, in 1940, Walt Disney made the full-length feature *Fantasia*, in color and with stereo sound on the *fantasound* magnetic multitrack system. The electronic technology continued to spread in cinema, through recording and post-production of the sound on the magnetic tape. The main instrument for this practice was the Nagra-Kudelski recorder (1951).[7] This, and similar systems, laid the foundation for the live recording of sound that would spread in the following decades, until in the 1970s Dolby Stereo was introduced.

"Graphical" or "drawn" sound was an interesting experimental practice. In the conversion period towards sound film, there was a rise in experimentation and practices that mix optical sound, graphics and animation, and synthetic music in many contexts and different countries; ranging from the abstract films of Hans Richter, Viking Eggeling, to those of Walter Ruttmann. At the end of the 1920s in the Soviet Union, the experiments and research of Alexander Shorin, Arseny Avraamov, and Evgeny Sholpo stood out. The practice of utilizing graphic signs evoked an ornamental, synthetic, artificial, and graphic idea of sound. Oskar Fischinger moved in a similar direction with the "sound ornaments" in *Experiments in Hand-drawn Sound* (1931-32), as did Rudolph Pfenninger, Moholy-Nagy with *ABC of Sound* (1933), Norman McLaren, Len Lye, and the Whitney brothers with *Variations* (1941-42).

In many other cases, from the Letterists to much experimental cinema from the 1960s onwards, the area of the soundtrack was engraved, scratched, and the perforations encroached onto the area of playback to become an expressive noise. The printing or insertion of images on the track connects the audiovisual media and the cinematographic manufacture to graphic media and the typographic manufacture, the visual writing of the sound, and the orality of the graphics. There are examples of this in *Halftone* (1966) by David Perry, who utilized the halftone screens used by newspapers to construct the image of the sound; *Soundtrack* (1969) by Barry Spinello with the characters and typographic symbols of the Letraset transferred onto a clear film stock. *Dresden Dynamo* (1972) by Lis Rhodes and *Newsprint* (1972) by Guy Sherwin contained typographic characters inserted in the area of the image and the sound. Sherwin would then film daily objects and images, printing and inserting them into the soundtrack in *Musical Stairs* (1977) and *Railings* (1977).



7.4
Graphical sound: filmstrip from Guy Sherwin, *Newsprint* (1972). Courtesy LUX.

Multiscreens, Installations, and Cinematic Systems

Edison's Kinetoscope (1891) can be seen as a model for a system for individual viewing of moving images recorded on film, whilst the Lumière brothers' Cinématograph (1895) can be taken as the successful model for projection and collective viewing of images on a surface. From the beginning, the limits of vision were extended thanks to experiments with stereoscopy (Friese-Greene, Lumière).

In 1927 Henry Chretien's *Hypergonar,* in the anamorphic format with a 1:2.66 projection ratio, allowed for the expansion of images and screens, ideally complemented with the multiscreen "polyvision"[8] of Abel Gance's *Napoléon* and followed by the Fox Grandeur 70 mm format, in 1929. In 1952, the first Cinemascope film appeared (with Fox perforations, four magnetic tracks, 1:1.27/1:2.44 ratio), then standardized as Standard Cinemascope with a 1:2.35 screen image and with an optical track. The senses extend toward the third dimension during the "golden age of three-dimensional cinema" (during the first half of the 1950s).

The panoramic and anamorphic formats multiplied (Vistavision, Technirama, 65mm and 70mm) and, with them, new experiments and experiences appeared that continued for the whole of the 1960s (Circarama, Magirama by Gance, Cinemiracle, Circle Vision, Kinopanorama, and Circular Kinopanorama). The experimentation of the projection device went in many directions, which cannot be easily summarized in its entirety.[9]

MULTISCREENS

In 1927, Abel Gance first applied polyvision with his *Napoléon*. Even before this first application in mainstream film, the early avant-garde movement had already happily imagined (the futurists) or articulated (Moholy-Nagy) polyvision; they had also partly put the film in "situation" (Dada). At the end of the 1940s, Luigi Veronesi invoked "absolute films, projected by themselves or simultaneously, in space, on multiple transparent screens, on different layers, on screens of gas, permeable to bodies and colors" (Medesani, 2005).

The perceptive relationship between spectator and the projected image was the main issue of a lot of structural cinema's research practices, for example, through test effects, stroboscopy, and image flickering. *Razor Blade* (1965-1968) by Paul Sharits is an example that unites the stroboscope effect with a synchronized projection of two films on two identical screens (or on two identical portions of screen). *Globe* (1971) by Ken Jacobs, can be mentioned as an example of stereoscopy, a film that exploited the Pulfrich effect, an illusion of three-dimensionality that was obtained by decreasing luminosity on one eye (in this case through a polarized screen).

With "polyvison," a narrative and aesthetic practice was introduced that needed more surfaces as an alternative to, and an extension of, the classic text editing and limitations that showed itself in the multiple and simultaneous projections that would find later examples (Glauber Rocha, Malcome Le Grice, Isaac julien, Eija-Liisa Ahtila, Douglas Gordon, and Gary Hill).

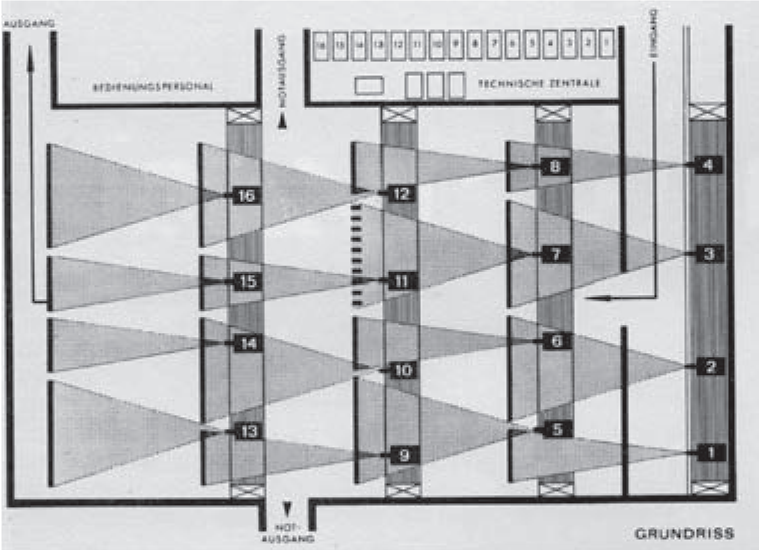
MULTISCREEN INSTALLATIONS

In 1952 with *Le film est déjà commencé?* Maurice Lemaître and the Letterist movement began to break down the centrality of the film as object, film as work, and the traditional modality of cinematic experience by putting the film in "situation." The screen became a target for objects, and lost its centrality, whilst the film was projected in other places (on spectators, walls, or ceilings). The protocol faded in favor of a *happening, a situation* in which everyone was required to take on an unusual role. Lemaître's following production was also exemplary in this way, with screens full of strange objects, slides projected everywhere within a room, putting the same screen in movement and invoking films that did not show themselves in their own materiality but only in the minds of the viewers, called upon to imagine and represent them.

The expansion and multiplication of the screens began from the "panoramic," environmental, and "ecological" idea that in 1896 gave life to the first *Cinerama* – ten projectors arranged in a circle for the Exposition Universelle in Paris (Crary, 2005): an exemplary experience that tied together the exceptionality and the ephemerality of these systems, the conception of environmental and open installation. Sound experimentation, loops, and the multi-polyvision was represented by *Varia Vision* (1965) by Edgar Reitz (Fig. 7.5).

The majority of these multiscreen installations were confined to temporary exhibitions, but for this reason they were perfect for the experimentation and expansion of cinema away from its usual environment, in many cases continuing a well-established tradition with theatrical (set design and lighting) and kinetic-plastic origins applied to large spaces.

At the Montreal Expo in 1967, the set designer and theater director Josef Svoboda presented the multiscreen installation *Polyvision*, composed of cinematographic and slide projections on three-dimensional moving objects.[10] Also at the Expo in Montreal, the installation (35mm and 70mm) *In the Labyrinth* included simultaneous projections on five screens that were able to combine multiple images into one like the tesserae of a mosaic. The installation was conceived and codirected by Roman Kroitor, who in the



7.5
Installation plan, seen from the top, for Edgar Reitz, *Varia Vision* (1965). Copyright: Edgar Reitz Filmstiftung.

same year co-founded the society which in 1970 would become the IMAX Corporation.

Another type of installation practice was concerned with the traditional duration of the projection. *Cinématon* (1978-2009) by Gérard Courant, is a 154-hour film, made using Super 8 and composed of single shots (portraits of art and culture personalities) assembled together. *Holes* (started in circa 1990) by Ian Helliwell, on the other hand, is a never-ending movie composed of pieces of unwanted footage in Standard 8 that the director continues to splice and add to with every new finding.[11]

VISIBLE PROJECTION SYSTEMS

The projected image can also be made up of many superimposed levels, like the 16mm *Altergraphies I* (1981) by Fréderique Devaux which included the projection of the film on an *écran hypergraphique* achieved by projecting a slide. The graphic superimposing of the screens was added to the sculptural nature of projection machines. Another example of superimposing was represented by Marcel Broodthaers' screens as typographical backgrounds onto which the 16mm *Le Corbeau et le Renard* (1968) was projected.

Further experiments could be found in the performances that place absorbent, masking surfaces and reflecting surfaces between the projector and the screen as was the case of the body and the mirror in Guy Sherwin's *The Man with the Mirror* (1976). The projection surfaces also vary according to their materiality: bodies, solid, liquid, and gas objects. Anthony McCall's *Line Describing a Cone* (1973) outlined – through the projection of a line in a dark environment, immersed in a gaseous atmosphere produced by a smoke/fog-machine – the space of the room as a space progressively shaped by the line that can be freely traveled over (see Fig. 1.5 in color section). On the contrary, the room of the Invisible Cinema, conceived by Peter Kubelka in 1970, became a ritual space of pure, orthodox and disciplined vision.

It is worth mentioning some of the obsolete and post-media machines (harking back to the initial utopia of Bauhaus and the Avant-garde movements of the 1920s), such as *Megatherm* and *Hellioptical* by Helliwell, which work on a Super 8 loop. Other recent works reuse obsolete devices whose functioning was based on circular and repetitive dimensions of the duration such as the Kodak Carousel, or elements from pre-cinema (Phenakitoscopes) and from its origins (Kinetoscopes).

Digital and Electronic Cinema

At the end of the 1970s, the electronic image became commercially viable: starting with Michelangelo Antonioni's experiences with electronic color correction in *Il mistero di Oberwald* (1980) and Francis Ford Coppola's *One from the Heart* (1982), and Zbigniew Rybczynski, pioneer in the convergence between cinema and video, and experimentation in high definition. It is also worth mentioning experimentation carried out firstly by Jean-Luc Godard and Peter Greenaway and then by Aleksandr Sokurov, Lars von Trier, and David Lynch.

At the end of the 1980s, non-linear editing devices became widespread, devices which had been in development since the beginning of the 1970s, for video. In 1987 Sony introduced the Digital Audio Tape for the recording of digital audio tracks and at the beginning of the 1990s, multichannel audio coding systems spread in cinemas: the Digital Theatre System, Dolby Digital (1992), and Sony Dynamic Digital Sound (SDDS) introduced in 1993. Computer-generated imagery (CGI) and computer-generated animation (CGA) constructed digital worlds, mixing real and virtual scenery, reinventing and restoring images from history and the history of cinema in a way never seen before. The need to mix analog and digital images in post-production inspired a renewed use of previously obsolete formats for filming and post-production such as the 35mm Vistavision and the 70mm.

The spread of both “light” and “heavy” digital hardware and software, in terms of cost and production, made way for two experimental possibilities: the aesthetic and expressive research, that is therefore limited, but also widespread and fundamental in practical terms; the research of spectacular and global simulation in terms of its impact, though limited to a few centers due to high costs. For the first situation see Abbas Kiarostami’s *ABC Africa*, for the second see *Star Wars: Episode II – Attack of the Clones* by George Lucas, both films using digital means in 2001.

The second half of the 1990s saw the introduction of digital intermediate process and digital grading. In more recent years the technology of projection has seen innovations in the area of digital light processing (DLP). Three-dimensional vision has also been brought back, made with 3-D digital cinema. Digital cinema had to take on agreements, standards ,and protocols (such as the digital cinema initiative, or DCI, 5, as well as JPEG 2000 and digital cinema packaging, or DCP). Standards and protocols which aimed to include backward compatibility, able to correctly reassert the aspect ratio, frame rate, and speed of archive film.[12] Finally, there are more and more born-digital films, which are created with digital audiovisual recording equipment, from the digital cameras on mobile phones to the new professional cinematographic cameras (such as Arri Alexa, Red Camera, Panavision Genesis, CineAlta, Canon, Viper, and Fusion).

Today the digital cinema workflow is complete: starting in post-production (since the 1980s), and continuing with the production of professional digital cameras and projectors, the digital workflow is now running in a complete way, from digital capture and digital screening via the digital post-production phase. The digital intermediate workflow, with digital film scanning and sometimes re-recording the digital frames onto analog film stock, will still remain, mainly for the preservation and exhibition of film heritage.

7.2 THE HISTORY AND TECHNOLOGICAL CHARACTERISTICS OF VIDEO PRODUCTION AND RECEPTION DEVICES

Alessandro Bordina

The video system cannot be studied and described as a single technological development but, according to Paul Conway's analysis (1996), must be understood as an open and interconnected set of various related technology *subsystems* (for example, the screens and the equipment for viewing, the encoding of the signal, the cameras, the devices and the equipment for recording and reproducing). Each subsystem is subject to its own cycles of technological change and obsolescence, which therefore leads to different system structures over the years. The following description of the evolution of the devices for the production and reception of electronic images will focus on the three main subsystems that make up the "video technology set": the display equipment, the encoding and broadcast of the signal, and the equipment for recording and reproduction.

1. Viewing Equipment

CATHODE RAY TUBE SCREENS

The construction of equipment for receiving live images is based on the research William Crookes did and products he made between 1858 and 1897, as well as successive experiments by Ferdinand Braun. Representing the cathode ray tube's "ancestor," the instrumentation created during this research period (known as the Crookes tube and the Braun tube, respectively) was not designed for the reproduction of electronic images, but for the study of electron flux behavior.

In 1906, Max Dieckmann and Gustav Glage were the first to develop research into the cathode ray tube (CRT) project, specifically for viewing the electronic image. The images obtained using this method were not captured using cameras, but drawn onto a Cartesian axis with a special pen that sent an electronic signal to a 1¼ -square inch CRT display (Magoun, 2007: 10).

The creation of a functioning reading and recording system, based on the mechanism known as the "Nipkow disk," took place between 1925 and 1928. In this phase the television equipment was based on both electronic and mechanical components, but the low quality of the images obtained, and the difficulty in overcoming problems connected with the amount of illumination necessary in recording, made for an unlikely commercial exploitation of the television system.

The first, very limited, commercialization of electro-mechanic screens happened in 1928, when Charles Jenkins got his experimental license for the transmission of video signal from the Federal Radio Commission (FRC) for Washington DC's W3XK station. In 1929 Jenkins could rely on there being 30 viewers as his daily program of animated silhouettes was transmitted with a definition of 48 lines at 15 frames a second. Various other transmission tests would follow in the 1930s, especially as a result of the Radio Corporation of America (RCA) and the development of television systems. In Europe, the first electro-mechanic broadcasts, made by the Baird Company, were launched by the BBC in September 1929.

The first public presentation of completely electronic viewing systems took place in Japan in 1926 with the work of Kenjiro Takayanagi, and the following year, Philo Farnsworth demonstrated how his electronic screen prototype worked.

In the United States, in concordance with the transmission standard defined by the National Television Systems Committee (NTSC) in 1941, the first real mass commercialization of television equipment began; however, it was soon interrupted by the Second World War. The production of television screens was restarted in 1946 with the introduction of two new RCA models (630TS with seven- and ten-inch screens), which were much more affordable compared with pre-war commercial equipment.

Despite later developments, the viewing mechanism of the electronic signal, based on the output and orientation of electronic beams, remained the working principle from the 1920s until the later developments that saw CRTs replaced with plasma screens and liquid crystal displays (LCD).

The technology of television's first forays into the artistic world was concerned with the use and modification of the viewing equipment. The video signal would be altered by means of the manipulation of the signal's viewing system, for example in *TV-Dé-coll/age* by Wolf Vostell (1961) the images broadcast were deformed using magnets which interfered with the direction of electron flow. Similarly, Nam June Paik modified various TV sets in his *Exposition of Music-Electronic Television* (1963), distorting the flow of electrons generated by the cathode ray by using magnets and integrating the audio and video signals to create abstract forms (*Zen for TV,* 1961).

The changes to and the combination of television screens were fundamental aspects of the video art process, also in the output that followed. Monitors became the basic element for the construction of installations (for example, associated with the body in *TV Bra for Living Sculpture*, Nam June Paik, 1969 or *Inasmuch As It Is Always Already Taking Place*, Gary Hill, 1990) or they were deconstructed until their working mechanisms were stripped bare (*Between Cinema and a Hard Place*, Gary Hill, 1991), or used in a more sculptural way that was not related to the viewing signal (*Family of Robot*, Nam June Paik, 1986; *Filz-TV*,[13] Joseph Beuys, 1966).

VIDEO PROJECTION

For at least 30 years of commercial use, the CRT remained the only way of exploiting the video signal on the mass market. However, the desire to make use of the electronic system in environments outside homes led various companies to investigate the possibility of a projection system that also used to broadcast videos in the cinematographic circuits (Kitsopanidou, 2003).

Research relative to the construction of equipment for video projection dates back to the early 1940s and the experiments in electronic image projection with RCA's CRT projector (1940), and Fritz Fischer's Eidophor (1943) and Scophony (1936). Although the Eidophor system attracted the interest of various companies in the 1950s,[14] it would be the CRT system that became the commercial standard for video projection, especially due to the launch of the Advent Videobeam 1000 and 1000A (Advent Corporation) in 1972. The projector was made up of three cathode ray tubes, each of which projected the image in one of the primary colors, the beams of light converged to compose the final image on the screen, whose dimensions were four and a half feet by five and two thirds.

The CRT projection system remained dominant until 1989 when the Sharp Corporation[15] put the first LCD projector onto the market (Sharpvision XV100). The XV100 projector allowed for the construction of an image that was 100 inches wide and, compared to CRT, was smaller, cheaper, and lasted longer.

The use of video projectors in artistic techniques eliminated the sculptural element that had been created by screens, favoring integration between audio-visual components and performance (see *Interface*, Peter Campus, 1972). If on one hand video projection returned the electronic image to cinema (for example in *24 Hour Psycho*, Douglas Gordon, 1993), on the other hand it allowed for more interaction with other materials (*Judy*, Tony Oursler, 1994) or with urban environments (see *Projektion X*, Imi Knoebel, 1971; *Projection on South Africa House*, Krzysztof Wodiczko, 1985). As had happened with cathode ray screens, some artists altered how the signal was viewed by altering the electronic or mechanical components of the video projector (one such example being *One Candle/Candle Projection*, Nam June Paik, 1988).

LCD AND PLASMA SCREENS

The third key step in the technological innovation of viewing equipment was the introduction of LCD and plasma screens. In May 1968, RCA announced research on a new type of electronic display that would be lighter, cheaper, and structurally very different, compared to CRTs. George Heilmeier's research for RCA attracted the interest of the Sharp Corporation, which decided to invest in the possibility of using liquid crystal technology for the production of lighter, more portable calculators. In 1973, Sharp presented the Elsi Mate EL-805 pocket calculator, the first device to use liquid crystal technology in a viewing system. After this first achievement, LCD technology was applied and adapted to various kinds of products (alarm clocks, radios, watches). In 1988, Sharp presented the first 14-inch LCD television.[16]

In 1969 at the University of Illinois, at the same time as RCA's research into LCD, Donald Bitzer, H. Gene Slottow, and Robert Wilson were making the first experiments for the plasma display panel (PDP). The University of Illinois's research attracted the interest of the Japanese television network NHK and the companies Fujitsu, Hitachi and Mitsubishi. The first commercial application was in 1983 when IBM produced a 19-inch monochrome display that used plasma technology for the PLATO computer. It was Fujitsu, on the other hand, that introduced the first 21-inch full-color television screen in 1992. The PDP system went through a large expansion at the end of the 1990s, exploiting its technological superiority in larger screens (in 1997 Fujitsu put the first 42-inch screen onto the market). Despite the rise in plasma screens, companies' investments in LCD products increased in the first years of the new millennium, allowing for an increase in the performance of the liquid crystal display, so much so that many companies abandoned research into plasma systems.

The continuous abandonment of CRT viewing devices obviously signaled a change in the way works of art were displayed. The reduction in the depth of the screen allowed for more choice in the positioning and arrangement of the monitors, which in some cases mimicked the material characteristics of paintings and photographs (*The Actor*, Marty St. James, Anne Wilson, 1990; *Provenance*, Fiona Tan, 2008).

2. Encoding and Signal Transmission

The second technological subset to be taken into consideration relates to the encoding of the signal.[17] The first experiments in transmitting a television signal were undertaken in the 1920s, using an electromagnetic system for recording and for the viewing of the signal. A few months later there was the public presentation of the first television, held by John Logie Baird in 1925 at Selfridge's Department Store in London, and the American Charles Francis Jenkins broadcast the silhouette of a toy windmill from five miles away in a naval station in Maryland to his Washington laboratory. In 1928, the Baird Company sent the first transatlantic signal from London to New York and at the end of the 1920s, a number of different electromagnetic television companies arose.

The demonstration of a completely electronic television system occurred at the same time as the spread of the electromechanical television. Before 1930, the only people who had completed an entirely electronic system for the production of a television image were Philo Farnsworth with the image dissector and Vladimir Zworykin with the launch of the iconoscope on behalf of RCA.

Without a shared standard for the quality of the broadcast, the television market had difficulties in developing. In the United States, the main hardware manufacturers such as Philco, Zenith, and DuMont pushed for a legislative definition for broadcast standards in order to avoid a monopoly in the sector. Towards the end of the 1930s, early negotiations about the standard that should be adopted began between producers, but it was not until 1941 that a definitive agreement was reached through the constitution of the National Television Systems Committee. In May 1941, the FCC gave the go ahead for 18 channels, using a six MhZ bandwidth and a signal of 525 lines at 30 frames per second.

In Europe in the 1930s there were three main systems for broadcasting a television signal: the Marconi-EMI (405 lines, 25 frames per second, five MHz of bandwidth) adopted in 1936 by the BBC Television Service; the system of 441 lines (25 frames per second, four Mhz of bandwidth) introduced in Germany in 1937; the system of 819 lines developed by René Barthélemy became the standard for broadcast in France in 1948.

The definitive standardization of the European broadcast signal arrived in 1956 with the introduction of the standard SECAM in France and PAL in the rest of Europe, which was developed in Germany by Telefunken in 1963. The two standards provided a definition of 625 horizontal lines at twenty-five frames per second, and the bandwidth for broadcast was seven MHz.

Although a large part of video art production existed outside the usual broadcasts, there were some examples of works designed specifically for network television (*This Is a Television Receiver*, David Hall, 1976; *The TV Commercials* Chris Burden, 1973-1977). Over the course of the 1970s the spread of video art production was also happening through public and specialized television channels, the latter of which, in addition to broadcasting programs made up of video works, collaborated in the production (examples in the United States being the television station WNET-3, New York; WGHB-TV, Boston; LBMA, Los Angeles; and in Europe included SWR, Baden-Baden; SFB, Berlin; WDR, Cologne) (Huffman, 2008; Tamblyn 1987).

SATELLITE TRANSMISSION

Over the course of the 1940s, two modalities for encoding/sending/receiving video were developed, two alternatives to radio frequency: broadcasting through cable and via satellite. Both types of channeling technology redefined the television signal allowing for an increase in the number of channels available to the viewer and the development of pay per view. The first large investment for the development of satellite technology was started by a multinational consortium that was made up of AT&T, Bell Telephone Laboratories, NASA, the British General Post Office, and the French National PTT. On 23 July 1962, the Telstar satellite sent the first satellite video signal for civilian purposes, visible in Europe through Eurovision[18] and in the United States through NBC, CBS, ABC, and CBC channels. The commercial spread of satellite television happened towards the end of the 1970s but it was the 1980s that saw its large expansion. In an artistic field, the first attempt in using the satellite broadcast came with Sherrie Rabinowitz and Kit Galloway's dance performance, *Satellite Arts Project: A Space with No Geographical Boundaries* (1977), which was followed by Paik's collaborative experiences in the 1970s and 1980s (for example, the opening of documenta 6 in 1977 broadcast in 25 countries with performances by Paik, Charlotte Moorman, Joseph Beuys, and Douglas Davis; but also the later examples *Good Morning, Mr. Orwell*, Nam June Paik, 1984 and *Bye Bye Kipling*, Nam June Paik, 1986).

DIGITAL SYSTEMS

The third turning point for the development of encoding and broadcast technology was the switchover from the analogue system for encoding the video signal to digital technology. Research on the development of digital television began at the end of 1950s and was carried out by Richard Webb for the Colorado Research Corporation on behalf of the National Security Agency, which was funding a system for encrypted broadcast. In 1961, the first working prototype for digital video communication (AN-FXC-3 (ZE-1)) was installed in the White House, between the President, the Central Intelligence Agency, and Camp David. The images transmitted had a resolution of 405 lines and used a six

Mhz bandwidth. In the public sphere, the development of a digital television system was left to the commercial competition for high definition television (HDTV). At the end of the 1980s, the spread of the analogue MUSE HDTV system, developed by Nippon Hoso Kyokai (NHK), forced American developers to follow a method of processing a high definition signal that would not render the satellite and cable market obsolete.

In 1990, VideoCipher developed a system to digitalize the television signal that allowed for four digital channels on the same bandwidth used for the transmission of one analogue channel. This innovation led various companies to develop a completely digital HD system. In 1993 the FCC created the Grand Alliance (GA), a consortium of manufacturers for the definition of a digital standard. In 1996, the ATSC standard was approved for the United States. In Europe the definitive standardization of digital television took place in 1997 when the DVB-T standard was published, which would remain the standard throughout Europe between 2000 and 2011.

The transition to the digital encoding of the signal had important consequences for the production and consumption methods of works made in the video medium. The possibilities of editing and non-linear manipulation of the signal increased the repertoire of techniques and modes of expression available to artists. Describing his transition towards using digital video, Chris Meigh-Andrews remembers:

> I was then able to mix multiple videotape sources, produce video frame grabs […] and perform image flips […]. Not only these new image effects extended the visual complexity of my work at this time, they also opened up my ideas to embrace new themes and ideas, particularly those related to the nature of electronic imagery and its potential relationship to visual perception and the flow of thought (2006: 264-265).

Since the 1990s, the use of digital video has led to greater interaction between the audio-visual and information technology components, impelling many artists to make interactive audio-visual works (*Alchemy*, Simon Biggs, 1990; *Tavoli (perché queste mani mi toccano?)*, Studio Azzurro, 1995).

3. Recording and Reproduction of the Electronic Analogue Signal

Research on the production of a recording system for electronic images on a magnetic device began in 1951 at the RCA laboratories and the Ampex research centers. The main problem the two laboratories needed to resolve was optimizing the use of the space on the magnetic device in such a way that it was able to record the largest amount of information on the smallest amount of tape possible. The first recording prototypes of the signal needed a large quantity of tape that had to pass over the reading/recording heads at high speed. In 1956, Ampex was able to present the first commercial recording system to CBS, ABC, the Canadian Broadcasting Corporation, and the British Broadcasting Corporation. The Ampex VRX-1000 was equipped with four rotating heads for recording and reproduction using tranverse scanning of the signal on a 2-inch tape. The tape was 4,800 feet long (1,500 meters) and was capable of recording an hour of video.

In 1965, Ampex produced the first system (known as 1 inch Type A by SMTPE) that used 1-inch tape and that performed helical scanning of the tape. The recording on 1-inch tape became the standard for television stations, big industry and governments over the course of the 1970s. In 1976 the type C system, developed by Ampex in collaboration with Sony, would become the most widespread format in broadcasting.

In the 1960s, whilst RCA and Ampex competed for leadership in the production of video recording systems aimed at broadcasting, Sony concentrated its research on the domestic market of video reproduction systems using magnetic tape. In 1965, Sony put two video recorder models (CV2000) on the market, designed by Nobutoshi Kihara and aimed at the mass market. The CV system used two rotating heads for the recording and helical scanning of a ½-inch tape with a diameter of seven inches, capable of recording up to one hour of video. Sony's ½-inch system opened up a market of similar consumer products that used the same sized tape (Panasonic NV-8100, Concord VTR-600-1) or smaller (such as the Akai VTS-100 that used a ¼-tape), but based on encoding and recording standards that were different for different companies. In 1968 the Electronic Industries Association of Japan introduced the EIAJ-1 shared standard for video recorders which used tape that was ½-inch (among the most common systems to use EIAJ-1 were Sony's AV and Panasonic's NY3130). A few years later the EIAJ-2 was developed for color videos.

The year before the EIAJ standard was defined, Sony had launched the first portapack system. The Sony CV-2400 Video Rover was made up of a smaller camera and a compact VCR that used the standard helical CV scanner weighing ten pounds and thirteen ounces (around five kilos). Two years later (1869) Sony launched an EIAJ portapack (AV-3400) which had great commercial success and would go on to be one of the most used items in production, outside broadcast.

Despite the commercial success of the EIAJ system, public demand called for a more reliable system that was less complicated to use and this influenced Sony to direct its research towards the development of a video recorder that used closed cassettes as recording devices, rather than open reels.[19] In 1968 Kihara made the first U-matic working prototype, which would be made commercial in September 1971. The system, which took its name from a peculiar way of loading the tape (U-loading), used cassettes that contained tape that was ¾ inch wide. Compared to the open-reel systems, the U-matic recorders offered higher quality and were more reliable both in the recording and the reproduction phase. However, the higher system costs,[20] the size and the excessive weight of the players (60 pounds) hampered the spread to the domestic market. The U-matic system would have success in the education sector, small businesses and television stations, gaining reputation as a semi-professional standard over time.[21]

If projects with television stations are excluded (for example the many projects broadcast by stations such as WNET-3, WGHB-TV, LBMA, SWR, SFB, and WDR), the majority of video art originally comes from the use of domestic video recorders, (mainly the ½-inch system until the mid-1970s, and on the U-matic format after that). The low cost of the equipment and the ease in production and copying of the tape allowed the artists to work at the limits, or outside the norms of television broadcast production.

Video was also approved as a suitably ephemeral medium, existing only when animated by an electric current and capable of being copied, recopied, and disseminated like any other mass-produced merchandise. In spite of now having to negotiate the more recent traditions of broadcast media, video artists felt they were working on a clean sheet of paper (Elwes, 2005: 6).

The "amateur" characteristics of the systems used influenced and conformed to the aesthetic exploration of the video medium in this first phase of video art production. The absence of editing systems that were cheap to use with consumer video technology was evident (see Vito Acconci's first video works), it also led to a lack of editing in the camera. In some cases, artists decided to modify the hardware themselves, manipulating the recording mechanisms during the recording (*Tape I*, Bill Viola, 1972), or creating complex systems for recording and reproduction using more than one recorder at the same time (such as Woody and Steina Vasulka's video feedback).

The development of equipment and the manipulation of the signal (image processor and video synthesizer) designed by the same artists, gradually increased the possibility of altering the electronic image both in the recording and the post production stages. At the end of the 1960s and the beginning of the 1970s, several artists created their own devices for distorting and transforming the video signal. Amongst the most well-known was the Paik-Abe Synthesizer, constructed in 1969 and used to produce "Video Commune," broadcast by WGBH in 1970. Paik and Abe's synthesizer was a seven-channel mixer/colorizer able to change the chrominance information and make up to seven image layers. In 1970 Stephen Beck created the Direct Video Synthesizer at the National Centre for Experiments in Television. Unlike Paik and Abe's machine, Beck's synthesizer was designed as an instrument for live performance and was not able to change images recorded on video camera. Being generated directly from the equipment to the CRT color screen, through electric impulses, allowed images and abstract patterns to be viewed. In 1974 Bill Etra and Steve Rutt produced the Rutt/Era Scan Processor which would be used to produce some of Steina and Woody Vasulka's videos (for example *C-Trend*, 1974; *Time/Energy Structure of the Electronic Image,* 1974-1975). The possibilities of changing the electronic image, created by Rutt and Era's device, were far superior to those previously synthesized. Thanks to a scan processor it was possible to control the positioning of the lines on the screen, creating animations and video wave forms and creating images from the sound signal and audio through the video signal. Using Rutt and Era's synthesizer, the production of artists such as Vasulka became focused around the deconstruction of the electronic image. In 1975, Woody Vasulka remembers that:

> Compared to my previous work on videotape, the work with the scan processor indicates a whole different trend in my understanding of the electronic image. The rigidity and total confinement of time sequences have imprinted a didactic style on the product. Improvisational modes become less important than an exact mental script and a strong notion of the frame structure of the electronic image. Emphasis has shifted towards a recognition of a time/energy object and its programmable building block – the waveform (Vasulka and Nygren, 1975: 9).

7.3 COMPUTERS AND DIGITAL RECEPTION DEVICES: HISTORY AND TECHNOLOGICAL CHARACTERISTICS

Tabea Lurk and Jürgen Enge

From a curatorial perspective, the history of the computer and the development of technological reproduction and computing machines are two quite distinct stories. Both formally and intentionally, they fall under different collecting categories and respond to different methods of display. They are also subject to historical change. Today, "technological cultural goods" are not only found in technology, science, and communication museums but have long become an integral element of media art. The resulting interaction between the two spheres has an impact both on the reception of history as well as on how the objects of the relevant field of research are presented and preserved.

Until recently, technology museums emphasized the object-like character of technological devices. The apparatus assumed the function of a (silent) witness of the past and its position in the history of technological development was contextualized with the help of descriptive explanations and (audio)visual models.[22] Nowadays, however, museums are expected to keep the machines operational and to exhibit them while still in service. Furthermore, curators have recently taken to illustrating the cultural position and development from the perspective of the history of technology with the help of artworks that make use of such devices (technology > art).

Where art is concerned, however, the meaning of technological instruments is considered less important than the general artistic / aesthetic intention of the artwork (art > technology). While it was common practice up until the turn of the millennium to merely replace or repair defect technical equipment, and the reproduction on specific hardware was rarely documented, the instruments that are condemned to obsolescence are nowadays frequently considered an integral part of the artwork, thus undermining the notion of their interchangeability.[23]

It seems, then, that the areas of interest of technology and culture have begun to overlap. In the following, we wish to further explore this phenomenon against the background of strategies of conservation.

History of Technology As Cultural History?

Going back to the dawn of the computer age, we find several prominent large-scale computers that are of sufficient historical interest to merit preservation.

These include computers such as the IBM 601 (1935, USA), the Z3 by Konrad Zuse (1941, Germany),[24] Colossus, the first computer programmable from memory (1943, UK), Howard Aiken's relay computer Mark I Computer (1944, USA), the ENIAC 1, developed by John Mauchly and J. Presper Eckert (1946, USA), and, finally the Electronic Numerical Integrator and Computer, to name but the most prominent rarities (Da Cruz, 2005; Cray-Cyber, 2006). Each of these has found a place in public and private special collections where they illustrate and document the history of technology.

Because many original devices were destroyed or lost during World War II, replicas of mainframe computers were constructed with the help of historic plans, including, for example, the replica of the Z1 (1937; 1989) in the German Museum of Technology (Berlin) and the famous Turing Bomb (1943; 2007) in the Museum Bletchley Park (London) which was designed to decode Enigma's radiograms (1917). The use of replicas is especially interesting in cases where a device's mechanical mode of operation is visible – that is, primarily in periods preceding the introduction of integrated circuitry – or in cases where a result that is computed in real time conveys cultural or historical values.

The Fascination of Computer Automation

Beginning in the 1960s, some of the instruments developed by computer scientists were introduced into the civil environment and were also made available as "multiprogramming devices." Large-scale computers found their way into the realms of scientific computation, research, and office automation (business and administration).[25] In the early 1960s, moreover, artists became increasingly fascinated with the laws of logic (concrete art) as well as with the unpredictability of chance which encouraged the creation of the first works of computer art, mainly on university campuses with the help of mainframe computers, but also occasionally with the help of machines at industrial computer centers. In some cases, the computer scientists themselves dabbled in art, such as Frieder Nake and Georg Nees in Stuttgart on the Grafomat of the Z64, Herbert Franke in Vienna on an ER56 computer (SEL programming), and Michael Noll and Bela Julesz at Bell Laboratories in New York (Herzogenrath and Nierhoff-Wielke, 2007; Anon, 2009). In other instances, designers commissioned computer-based calculations and then translated the results into sculptures and paintings. This approach was pursued by, for example, Gottfried Honegger (starting in 1970 at the ETH Zurich), Karl Gerstner (starting in 1982 at IBM Stuttgart), and Alfred Beuler (1969/1982ff).[26]

Because the majority of these works assumed a material shape of some sort, such as a sculpture, a painting, or a graphic, and only used the computer for calculation purposes, anyone wishing to preserve the heritage of this first generation of "computer art" must distinguish between the preservation of the material works (graphics, paintings, and sculptures: classical conservation) and the history of the development of their programs. The latter is usually documented by providing a short text describing the program as well as excerpts of the program's text (Klütsch 2007). The punch card and the original programming, however, have mostly not been preserved, not to mention the software or the relevant reproducers.

Unlike the first generation, many works of the transition period since the early 1970s required running computer programs. Thus the PDP computers that were manufactured by Digital Equipment Corporation were used for artistic purposes. Hans Haacke and other artists were already using the PDP-8, built in 1963, by the late 1960s. Several such devices were employed at legendary exhibitions such as "Cybernetic Serendipity" (1968, ICA London) and "Software" (1970, Jewish Museum NYC) that also served to blur the boundaries between computer art and robotics or cybernetics. Only very few objects and applications of this period survived, although some of them were described for scientific purposes. While it is possible to imitate the functions of these obsolete applications with the help of certain technological devices (legacy approach) or to program the original artistic concept on present-day platforms (hardware + operating system) (reprogramming), museums mostly rely on text-, image- or video-based documentation.

Using Computers in the Home

We mostly associate the early age of the personal computer with IBM, the corporation that in 1974 introduced the IBM 5100 and in 1981 ushered in the standardization of PC components with its IBM 5150, thus allowing for platform-independent operating systems. Similar computers were manufactured by Apple (since 1976),[27] Commodore (since 1977),[28] Tandy Corporation (the TRS-80, 1977), Atari (1979-92),[29] Texas Instruments (e.g., TI-99, 1979), Sinclair Radionics (e.g., MK14, 1982), Amstrad (Alan M. Sugar Trading, e.g., CPC464, 1984), and, later, various portable calculators, for example, by Toshiba. Earlier developments also proved significant, such as the use of cathode ray tube (CRT) monitors starting in the early 1960s, which at first visually reproduced the results of the calculating operations as glass teleprinters, or the invention of the computer mouse in 1968 by Douglas C. Engelbart and William English.[30]

With the emergence of the first 8-bit home and office computers in the late 1980s, artists were now able to use these instruments for their ends without having to rely on an institution. At first, they worked directly on the code and made collages of programming elements that were then published in computer journals. Besides Andy Warhol's famous sales campaign for the Commodore Amiga Product Launch (1985), where he used the Amiga to portray the actress Debbie Harry as part of a live performance, it was above all the TI99 / A4 (1981) that gained cult status among artists, before Apple's product lines became the market leader in the field of graphic design. While Herbert Franke with his art program "Mondrian" (1979) managed to make the transfer from the TI99 to more up-to-date operating systems (Windows XP), many works of this early period have only survived through their documentation, such as Alexander Hahn's *A Young Person's Guide to Walking Outside the City* (1988).

Another genre of "computer-based" art (as it was now commonly referred to) that survived from the late 1980s and early 1990s were interactive works and installations, some of which remain fully functioning to this day. These works not only involved the use of computers, but also incorporated computer equipment such as matrix printers and ink jet printers as well as extremely elaborate, self-made interfaces that were particularly popular in the mid-1990s. While independently working artists had to make do with whatever they had at their disposal – which is why their works reflect something like a status quo at a particular time in a particular country – other artists working at university research labs were able to launch much more complex developments. Everyday items such as plants, bicycles, suitcases, and many others were frequently turned into digital input devices with the help of self-soldered analogue digital converters, thus expanding the realm of experience of computer-based communication (Schwarz, 1997; Frieling and Daniels, 1997 and 2000; Wilson, 2002; Paul, 2003). The technological devices continued to produce artwork in real time (by means of feedback) but it was nevertheless the case that technology, metaphorically speaking, was considered less important than the experience of observing the artwork. Where artists were awarded grants for research stays at specific computer labs such as the MIT in Boston or later the Centre Pompidou or the Institute for Visual Media of the ZKM – Center for Art and Media Karlsruhe, they often had access to large-capacity computers made by SGI – Silicon Graphics International (1981-1996), a company that developed specific procedures for an accelerated representation of three-dimensional images which could be used to animate two- or three-dimensional spaces.

Besides the professional SGI line, it was once again IBM that defined the central standards for graphics cards with regard to home computers: the monochromatic representation of text with the monochrome display adapter (MDA) mode became available with the first PC in 1981, along with the color graphics adapter (CGA) graphics card (1981, resolution: 320x200 pixels in four-color mode / 640x350 pixels in two-color mode); in 1984, these were replaced by the enhanced graphics adapter (EGA) standard (resolution: 320x200 and

640x350 pixels in sixteen-color mode) and, in 1987, by the video graphics array (VGA). With a 256-bit color depth and an initial resolution of 320x200 pixels, the latter was capable of displaying around 250,000 colors. In the mid-1980s, the most common graphics cards (next to the IBM line) were those manufactured by HGC – Hercules Graphics Card (1982, resolution: 720x348 pixels, 2 colors: on / off). The graphical representation of image material and later also of colors was a special luxury unique to Apple computers, and these became standard features with the introduction of the microcomputer Apple II (1977); their processing power increased with every subsequent version. The Apple II had its own digital graphics and character generator (resolution: 40x48 or, in the high-resolution variant, 280x192 pixels, in 15 colors). From the mid-1990s onwards, 3-D graphics boards became available for the home sector (e.g. voodoo graphics boards manufactured by 3dfx) whose development was promoted mainly by the games industry.

Although product lines proliferated in the 1970s and 1980s, it is still possible to purchase original versions of most early home computers. Collecting specific types of devices, components, or series (e.g., of computer games, Apple Macintosh collections, etc.) has now become a culture of its own which is why the conservation and restoration of museum artworks relies not only on the reparation principle (where electrical engineers replace or repair individual components) but also, and especially, on what is known as the "storage principle." To this end, museums buy and store hardware that matches their pieces and then use this to replace or repair individual components if a malfunction occurs (ideally documenting the process). By contrast, museums have shown less interest in preserving and cultivating a passion for collecting software. Subcultures such as the gamer scene and the "demo scene" are an exception to this rule, having not only amassed many historical machines but also developed and promoted very intricate emulators, thereby practicing the "encapsulation principle" of original software components.[31]

From Hardware to Software

With the growing interest in "computer operating systems," historians of technology and media archaeologists now no longer restrict themselves to collecting and maintaining computing machines and other machine-like devices, but increasingly wish to expand the scope of relevant collections to include control technology and software development. In this context, it seems especially fascinating that present-day system architecture still bears traces of some of the groundbreaking innovations in the historical development of computer systems.

Thus in the early days of computer technology, electrophysical processes of the circuit path took place above the physical hardware, which was then still activated directly (e.g., the relay in the Z1), and its mode of operating was determined by the Von Neumann architecture (see Von Neumann, 1945). Since that time, data and programs use the same shared storage device, and their specification (header) identifies the type of information that was being processed.

With the development of procedural programming languages such as FORTRAN (1957), BASIC (1964), and C (1972), it became possible to address the individual memory locations to generate values, which in turn generated control commands for the hardware. The communication between programs and hardware thus became much easier. The procedures were executed in a linear fashion.

Beginning with C++, the 1980s saw the broad adoption of object-oriented programming languages that could compile data and functions into objects. At the same time, modularization, that is, the collection of commands in software libraries, made for easier programming, as certain functions / commands could be used repeatedly and did not have to be included in every program. With the introduction of the platform-independent programming language Java in the 1990s, a computer's operating system was finally no longer dependent on its hardware.

Other innovations, which we can only mention briefly, took place in the field of communication technology and the development of nets; the Petri net, for example, was based on a generalized automata theory, and one of its features was the concurrent execution of processes. The introduction of addressable addresses TCP/IP (1984, transmission control protocol and Internet protocol)[32] was another important innovation, as was the introduction of hypertext transfer protocol (HTTP, 1993), a description language which helped usher in the Internet age with its graphical user interfaces.

While artists only rarely questioned the system architecture itself, instead preferring to develop artistic programs and applications or creating artistic works with the help of the computer, the Internet age that began in 1993/1995 allowed them to explore completely new artistic practices. These spawned a new genre that came to be known as "net art," and, while it passed its zenith with the dot.com crisis of March 2000 and has since been reduced to a rather diffuse existence, net art nevertheless remains a productive field. Net artists mostly either draw on web services such as Google images, Amazon, Wikipedia, and others, or they provide – en route to the cloud – communicative structures of action.

Going beyond the Western art world, moreover, it seems likely that artists will increasingly make use of coding technologies. In this context, the asynchronous, cryptographic coding of contents, such as the RSA (1977), can be considered a milestone.[33]

As for reproduction devices, it seems as if there are no longer any limits – artists avail themselves of new technologies as soon as they come on the market, or they continue to develop specific interfaces in research laboratories if the available ones do not meet their needs. Large-scale projections, where liquid crystal display (LCD) and occasionally digital light processing (DLP) projectors have replaced the old CRT beamers, now exist alongside with reproduction modes for classical screens (from the CRT screen to the LCD monitor) as well as portable end devices such as smart phones.

Since manufacturers do not offer much information about the durability of this new generation of consumer devices, there is no way of telling how long they will last. Nevertheless, it seems likely that the conservation and restoration of these artworks will become much more complex in the future, especially with regard to art forms such as App art that operate with closed systems and codes.

Conclusion

Now more than ever, scholars recognize the critical importance of technological developments when examining innovations in media art, sometimes emphasizing the artistic aspect, while at other times applying concepts of media studies, the history of technology, or, more recently, media archaeology.

However, because many technology-based art forms are somewhat similar to reproduction techniques, curators have tended to neglect the conservational aspects, believing it was possible to simply "reproduce" the material. We now know that a technical apparatus that actually looks quite robust can be especially fragile, a feature that scholars usually refer to as "obsolescence."[34] Instruments age and thereby become a weak point in the system.

But access to digital information is also fragile. It is, of course, possible to make lossless, identical reproductions of digital information – unlike print graphics or photomechanical or magnetic negatives / data carriers that are prone to mechanical abrasion. But we have long ago reached new limits of preservation: the problem of the readability of old data carriers, software-based components, dysfunctional software libraries, the interlinking between programs and operating systems, and, finally, active memorization efforts. In many cases, we can no longer intuitively operate vintage machines. Instead, where a machine has been out of use for a long time or had some corroded batteries replaced, a user must simply be aware of certain basic functions and occasionally even settings, for example, of erasable programmable read-only memory (EPROM) programming, in order to get it started again. A computer's operating mode is not self-explanatory, that is, it cannot be logically deduced from the mechanics of the individual components.

The practical preservation of computer-based products has thus far mainly focused on two areas, namely the preservation of the object itself and the preservation of its function. Where object preservation is concerned, we may distinguish between, on the one hand, the preservation of the computing machines, of their mechanical and electronic elements (printers, monitors, input, and output devices) as well as the technological components (all technological cultural goods) and, on the other hand, the preservation of the paper- and plastic-based information and data carriers. Regarding the physical preservation of the latter, we may distinguish between the preservation of the data carriers and the preservation of information. Preventive conservational measures slow the natural degradation of the material substance. Objects must be stored in a constant climate[35] and protected against electromagnetic radiation, dust, sunlight, and mechanical wear, as well as against negligent handling. Furthermore, the contents/information are often transferred to a new platform (operating system + hardware), while occasionally recoding the data that is to be preserved.[36] Finally, emulators are also an option: contents are encapsulated in a digital environment pretending to be the original environment (Lee et al., 2002; Humanities Advanced Technology And Information Institute, 2009). Here, the preservation of information is similar to the preservation of functions. In contrast to the migration paradigm that is common in archive management, art conservators are more concerned with an artwork's specific authenticity.[37]

Surveying the field of preservation strategies from a museological perspective, it seems as though the traditional difference of content and form is repeating itself. While an emphasis on the preservation of contents focuses on a machine's functions, software components, and digital information, the material preservation is more concerned with maintaining its casing, thus placing greater emphasis on formal characteristics.

7.4 OBSOLETE EQUIPMENT: ETHICS AND PRACTICES OF MEDIA ART CONSERVATION

Gaby Wijers

The relationship between artistic intentions and technical equipment used is of crucial importance in the conservation of media art, where sustainability of artworks is threatened by an ever-shortening lifecycle of playback formats and equipment for playback and display. In their joint research project *Obsolete Equipment*, *Preservation of Playback and Display Equipment for Audiovisual Art,* (1 July 2009 – 30 June 2011), the Netherlands Media Art Institute (NIMk, Amsterdam) and PACKED vzw (Brussels), together with several Flemish and Dutch museums, investigated the lifecycle, storage, maintenance, and replacement of equipment in media art installations in order to provide best practices and guidelines.

This contribution highlights two of the eighteen cases studied in the Obsolete Equipment project: *Oratorium for Prepared Videoplayer and Eight Monitors*, a video installation made in 1989 by Belgian artist Frank Theys[38] and *I/Eye*, a computer-based installation made in 1984 by Dutch artist Bill Spinhoven van Oosten.[39] These cases provide insight into two divergent approaches explored in the project. The first case demonstrates what we call the "original technology" approach, in which storage is the key preservation strategy, and the second case is an example of the "updated technology approach" where emulation (as well as virtualization, in this case) is the principal strategy.

Introduction

Media art installations, whether they are film-, video-, or computer-based, have extremely diverse characteristics. Aspects including variability, reproduction, performance, interaction, and being networked are incorporated in many works. Media art is not one static, unique object, but often a collection of components, hardware, and software which together create a time- and process-based experience. Ready-made answers for preserving and re-exhibiting these works do not exist. Here, finding solutions for preservation or exhibition problems requires research, preferably conducted in interaction with the artist. The only accurate way to test if we have understood, documented, and transferred the constituent parts of a work of art and the work itself is by re-installing the work. The general research approach, therefore, is to conduct case studies and interviews with artists and other key figures involved in the work. This approach was adopted for the Obsolete Equipment project by the Netherlands Media Art Institute, NIMk, Amsterdam[40] and PACKED vzw, Brussels.[41] Eighteen case studies from the art collections of Flemish and Dutch institutions and two artists were investigated, documented, and reinstalled in order to gain insight in the requirements regarding storage, migration, emulation, and virtualization, to identify the obsolescence of presentation equipment and storage formats.[42] Furthermore, research was done into the ethical and technical requirements to which the preservation strategies must adhere, both in relation to the original state of the artwork and with regard to its (future) presentation. Experts from Zentrum für Kunst und Medien – Karsruhe (ZKM), Tate – London, Imal – Brussels, and Bern University of the Arts – Bern (BUA) shared their expertise and gave feedback on the process.

Change and Challenges in Media Art Conservation

Since the end of the 1990s, media artworks and the obsolescence of the equipment associated with them have received considerable attention in conservation research and literature. Two divergent approaches can be distinguished: the "purist/original technology" approach, and the "adapted/updated technology approach". The first approach highly values the use of original technology and wants to preserve the work as it originally appeared. With this approach, the storage of old equipment and spare parts is key, and the lifecycle of the work is related and limited to the lifecycle of the equipment. The second approach highly values the use of new technologies and is known for the dynamic appearance of the work. With this approach, migration and emulation are essential, and the eventual loss of authenticity and historicity in relation to functionality and concept is part of the discussion about the possible strategies. Both approaches are valid but a suitable approach somewhere between these two has to be found. It would be an error on the part of collecting institutions to give up too quickly on old technology. Although storage is the usual museum conservation approach, it has never been common practice to collect all the equipment related to media artworks. Frequently, all the equipment required for an installation is no longer available and/or the equipment pool is used to display a number of artworks. In order to effectively deal with the problem of obsolescence, it is necessary to collect relevant and dedicated equipment including spare equipment and spare parts and to organize proper storage and regular maintenance. The equipment is necessary for purposes of exhibition and research, as a reference for defining an artwork's original appearance and as starting point for emulation.[43]

Once an artwork is no longer functioning properly, the next step is to analyze the root cause and select an appropriate conservation approach. There are some common acknowledged forms of conservation in the case of obsolescence:

- Storing/restoring/repairing the original equipment
- Acquiring spare equipment:
  - Historical copy: replacing the equipment with the same model or a type from the same period with the same or similar functions
  - New copy: replacing the equipment with the same model or type from a later period, i.e., a more recent model with the same or similar functions
- Migration: Reconstructing the equipment with contemporary technology
- Emulation: Reconstructing the equipment with contemporary technology while retaining the original look and feel[44]
- Re-interpretation: Replacing the equipment with contemporary equipment each time the work is recreated
- Reconstruction: A complete reconstruction of the work based on available information

Two key approaches that deal with the problem of transferral are migration and emulation. Case studies have shown that migration, transferring data to a new carrier, is a rather simple process of continual upgrade and does present a viable solution, assuring a high level of access and interoperability. In other case studies, emulation has proven quite effective at producing an aesthetically authentic iteration of art objects, evoking the "look and feel" of the original. These studies have also shown that emulation is always a temporary solution and, since time-consuming and complex, best suited for circumstances that justify a high investment (see Rothenberg, 2006). In order to circumvent the fact that emulation is only a temporary solution, in *Obsolete Equipment* we also explored the process of virtualization. Virtualization involves running software within a virtual environment.[45]

Despite all efforts to collect and preserve it, current technological equipment will wear out and become obsolete, which means that decisions have to be made about whether and how to update it. The main question is how to formulate specific requirements for the emulation process, taking into account both the original appearance of the artwork and its future accessibility. Pip Laurenson proposes an approach that involves assigning significance to display equipment, its relation to the work's identity based on conceptual, aesthetic and historical criteria, and the role the equipment plays in the work. She sees identifying functional significance as an initial step to understanding the importance and use of the equipment (Laurenson, 2004).[46] The key questions are:

- Is the equipment purely functional or is it (also) conceptually important?
- Can the function of the equipment be mapped without discernible change?
- Is the equipment visible or hidden from view?
- Is the equipment mass produced, tailor made, or modified (by the artist)?

The significance of the equipment can be deduced from the meaning and value of the work. Some of the components may have significance beyond a purely functional level. The case studies in the Obsolete Equipment project demonstrated a clear distinction between the significance of playback and display equipment. The general tendency is to replace equipment or components with the same mass-produced model or with equipment that has the same functionality. The consensus is that, in most cases, the playback equipment can be upgraded without causing too many problems. Display equipment is more problematic, however. Replacing monitors and interactive features have the most greatest impact on the appearance of the artwork.

Choosing from all the various conservation strategies can be simplified by answering a series of questions using a decision tree developed by DOCAM.[47] This tool helps users focus on those aspects of a work that relate to its integrity and authenticity, while reflecting on how these aspects are impacted by the work's technological components. Besides the collection, preservation, or emulation of the playback equipment, the future preservation of works such as the cases studied in the Obsolete Equipment project requires collecting knowledge on the skills needed to service and maintain this equipment.

This brings us to another important aspect in media art conservation: documentation. Due to their many variations in technology, effects, and form, media artworks tend to follow a dynamic life cycle and require specific types of documentation ranging from the documentation produced by the artists and their collaborators in the production process to its use by conservators, curators, and critics in the mediation, dissemination, and history of the artwork and its life cycle of exhibition, preservation, and restoration. Eventually, documentation elements might come to compensate for the loss or deterioration of a work. As stated in the DOCAM Documentation Model: "Ultimately, it is the documentation that will survive the work, becoming its historical witness and sometimes supplementing any remaining fragments or relics."[48]

In Obsolete Equipment we conducted research, interviews, and case studies to gain knowledge on equipment for video- and computer-based installations from the 1980s and early 1990s in order to develop guidelines for emulation, migration, replacement, and storage of obsolete equipment. The project resulted in a strong research network that will help us to face the complex challenge of digital sustainability in media art.

Case study one: *Oratorium for Prepared Videoplayer and Eight Monitors* by Frank Theys, 1989 (M HKA)[49]

The primary focus of this case study was to determine what is important for the preservation of this artwork, and what an adequate conservation strategy would be (see Fig. 7.6 in color section).

The word "Oratorium" ("Oratory") in the title has two meanings: "Oratory" stands for a choral work usually of a religious nature consisting chiefly of recitatives, arias, and choruses without action or scenery, and is also the name for a prayer room with a small altar. In Frank Theys' installation, this small altar takes the shape of a U-matic deck installed on top of a bass guitar amplifier with speakers. Around these two stacked devices, eight video monitors placed on custom-made iron stands are facing each other in a circle. Each monitor displays a black-and-white close-up of a man playbacking the song You'll Never Walk Alone, the famous anthem of the Liverpool Football Club. The soundtrack is a polyphonic version of this song performed by the male choir of the Catholic University of Leuven (Belgium). The ¾-inch U-matic videotape, on which the two-minute-long sequence has been recorded more than once, has been taken out of its cassette and is looped. The loop runs in a circuit both inside and outside the player, physically extending the tape in the space of the installation. In this way, Theys uses the form of a video installation to create a sacred space in which ritual and alienation meet. At the same time he also pokes fun at grand emotions such as patriotism and rivalry. Because the work is installed in the exhibition space in a transparent way, viewers can understand how this video installation functions. They can walk around the circular installation and observe the videotape running as a loop in and out of the ¾-inch U-matic player. They can see how this ¾-inch U-matic player transmits the video signal through a set of cables to the eight cathode ray tube (CRT) monitors, and the audio signal to the audio equipment (and the CRT monitors). The display equipment transforms the signals into image and sound. Positioned in a circle around the video loop, with their screens facing the center, the CRT monitors seem to "encourage" their own support/carrier. After all, the image and the music cannot exist without the support/carrier (the ¾-inch U-matic tape).

THE EQUIPMENT

The equipment used for this work comprised a ¾-inch U-matic top loader modified by the artist, eight identical CRT monitors, a guitar amplifier including the speaker and the ¾-inch videotape. The Sony VP2030 used in *Oratorium* belongs to one of the first generations of U-matic players. The deck's casing is made of wood, metal, and plastic and has a top-loading system. To allow the tape to go out the player, Theys modified the original U-matic player. Aside from the fact that the later models of U-matic players look very different from the VP2030, they also cannot be modified to run the work: their front-loading systems do not allow the tape to go out. One of the main issues with the functionality of *Oratorium* is the wear resulting from its use in working order. The U-matic player is not designed for several months of non-stop operation during eight-hour-long days.

The original master tape was shot and edited on a U-matic BVU cassette. In 2010, Theys made a digital sub master of the video in DV format and provided a copy to M HKA. This video file is now the duplication master used to make new U-matic copies each time the work is installed. To be able to make new loops in the future, M HKA would have to create a stock of blank U-matic tapes and to keep at least one good U-matic recorder and spare heads (both no longer in production).

The current monitors, Profiline TV8121, are 15-inch black-and-white monitors designed for video surveillance systems. In order to preserve the work's integrity, it is essential that each of the eight monitors are identical and that they each fit on the metal stands made specifically by M HKA for this work, following the artist's instructions. For Theys, the minimalist, sculptural look of the current monitors and their grey color fits well with the work.

The amplifier currently used is a Marshall 4150 Club and Country Bass 100W 4x10 Combo Compressor Bass Amp. It has a dark brown covering and a beige grill cloth with a Marshall logo. The amplifier's physical presence and its historical reference conveys an image of rock music, and is visually very present in the installation. The electrical and video/audio cables restrict the size of the installation and the distance between the elements. The cables have to hang one meter from the floor.

CONSERVATION STRATEGY

At the beginning of the project, simulating the functionality of the installation and its equipment was considered as a possible way to preserve the artwork. A dummy tape would have been running in the installation while a digitized version of the video displayed from a hidden player. Later, when discussing this with the artist, it became clear that this was not an acceptable solution; hiding how the video image appears from the audience would go against the original intent of the work, which was to precisely reveal its own mechanisms. The visual connection between the video image and its carrier, as well as the various video dropouts generated by the unstable tape path would be lost. The variable vacillation of the image due to the unsteady transmission of the video signal thus should be seen as an integral part of the work, which contributes to its "magic", especially today, in our "binary world". Furthermore, when attempts to digitize sequences of the video loop were made, the capture software was not able to catch all the different video artifacts visible on the screen. The continuous connection between image and support and the inherent analog quality of *Oratorium* render impossible any attempt to migrate or modernize its components, making the storage of spare equipment and tapes the only possible strategy for long-term preservation.

Collecting stocks of spare equipment, parts, and tapes, creating proper storage conditions and ensuring maintenance – including preventive measures such as a regular survey of the critical devices and available resources in terms of technical services – represents a continuous effort, but will help to avoid future expenses for repair or searching for equipment. Above all, these measures will push back the fateful moment when the equipment will no longer be available, meaning that the work can no longer be displayed and can only be partly experienced through documentation. *Oratorium* has been actively exhibited since 2010, and will soon be shown in China. This is the right occasion to make the necessary investment in equipment and expertise in order to show the work not only at this time but also in the future.

Case study two: *I/Eye* by Bill Spinhoven van Oosten, 1984 (NIMk)[50]

The primary focus of this case study was to determine what is needed for the preservation of this artwork and in particular to investigate if emulation and virtualization would be adequate conservation strategies (see Fig. 7.7 in color section).

I/Eye (1993/2011) is a software-driven installation in which the involvement of the viewer is essential. The artwork consists of a video monitor, a camera placed on top of the monitor, and a computer. The monitor shows a full-screen, watchful human eye that is triggered by the viewers' movements recorded by the camera. The eye on the monitor follows the viewer's movement, turning the observer of the work into the one being observed. If, for some seconds, there is motion, the eye will continue to “look,” but if there is no movement at all for some time, the eye will close completely. The closed eye suggests it is sleeping. Meanwhile, the eye moves slowly up and down suggesting breathing.

As formulated by the art historian and critic Jorinde Seijdel, the encounter with *I/Eye* provokes an overwhelming and unnerving experience within viewers as “it challenges their own secure position as observers.” According to Seijdel *I/Eye* makes people aware that they are constantly being monitored and observed by others: “Big Brother is watching you” (Seijdel, 1997). According to Spinhoven, the artwork exists in at least two or three versions, and the hardware (monitor, camera, computer) was used in more than one version of the work. Spinhoven still continues to develop further versions of *I/Eye* and sees the project as an open-ended process. He is currently planning a web-based version.

EQUIPMENT

The aesthetic appearance and functionality of *I/Eye* has remained the same since its first exhibition in the window of NIMk’s predecessor, the Montevideo Gallery in Amsterdam, in 1993. The equipment has changed over time, however, and was malfunctioning at the start of this research project. Spinhoven has emulated and virtualized the hardware and software at NIMk and compared the results of both strategies.

The early monitor (probably a spherical Philips monitor) was only used once and was soon replaced by a Sony Cube Monitor PVM 2130. The monitor shows a full-screen, black-and-white human eye (the artist’s own), composed of five stills.

The camera on top of the monitor is equipped with a special fish-eye lens to have a wider registration area and an automatic iris lens to control light intensity. These lenses have been attached to the camera by the artist with tape. There are no specific requirements as to the model – it can be a web cam or FireWire camera – but it should have a show driver in order to connect it to the software. The current camera used for the presentation at NIMk in 2011 is a Monacor surveillance video camera type TVCCD-2000 CCD plus lens.

Through software processing, the computer recognizes the sense of displacement, thus causing an output image that gives the impression that the eye, the iris, is following the passers-by. The artist wrote the software using BASIC V Assembler language, which works on Acorn Archimedes Operating’s systems and RISC OS. He stores the software on a Risc PC 600. Some modules have been added to the hardware; this implies that the original performance of the computer has been modified.

One of the main issues to keep *I/Eye* working is the threat of obsolescence of the hardware and software used. Generally speaking, with every new computer type its performance is enhanced and its processing becomes faster. The behavior and functionality of *I/Eye* has a strong relationship with the specific computer architecture. The first computer type implemented was an Acorn Archimedes 410 home computer and the operating system Acorn RISC OS, versions from 3.0 to 6.0. Due to the obsolescence of various components in the case study research, we decided to reuse the Acorn Risc PC. The program creates an eye with a pupil on the basis of motion detection and pre-programmed behavior. The artist encountered a number of setbacks while attempting to activate the software. The cause was found in the digitizer, responsible for capturing the camera image, which turned out to have been corrupted. After replacing it with an identical one, the problem was solved. Incorrect settings and the timing of its horizontal and vertical refresh rate caused differences between the historical display of the *I/Eye* and the current one. Once the functionality of one of the initial versions was recovered, the artist decided to develop an emulator for the program.

CONSERVATION STRATEGY

The hardware of this installation was emulated based on an analysis of its technique and functionality in a different way compared to the “original” hardware and software. The emulation does fully replace the original hardware and software. The re-installation of *I/Eye* in 2011 implied a balance between the formal technical principle of the artwork and its core concept versus the functionality of its components. Re-staging the artwork involved a number of practical questions and deep understanding concerning the obsolescence and (in)availability of the operating system, the hardware, and the display equipment, as well as the (in)operability and correct functionality of the software.

A major part of the experience of this installation relies on the viewer’s participation, which can only be achieved if the installation is fully functional. For Bill Spinhoven, an artwork should have the possibility to grow and change by using new tools or equipment instead of trying to keep the old versions alive. Spinhoven still continues to develop further versions of *I/Eye* and he considers emulation to be more important than the authenticity and historicity of the equipment. The artist emulated and re-installed the work to a fully functioning condition.[51]

The recovered version is an assemblage of various historical hardware elements running the historic operating system, Risc PC. In this context, we could speak about emulation of the old installation with the help of available historic parts from other computers. In this conservation of *I/EYE*, emulation and migration go hand in hand. Migration of the data was and will be necessary to assure the work's functionality. The emulation side of the conservation of this work can be comprehended in various ways dependent on the point of departure. Emulation of the installation as a whole may be conducted by means of extracting the data from the old system and implementing them on a newer one. To perform the work's previous functionality, though, the old version of the computer should be replaced by a similar version that closely imitates it. This process might be classified as emulation of the first version of the equipment, along with the migration of the data. In relation to the virtualization of computer systems, *I/Eye* demonstrates that once the crucial components of the artwork are isolated from the system and are stabilized, they can be enclosed in a virtual environments of any given virtual machine software. Potentially, they can be transferred an almost infinite amount of times, maintaining the work's logic and functionality.[52]

NOTES

* Chapter 7.1 was jointly written by Simone Venturini and Mirco Santi. Together, they wrote *Cameras, Emulsion - Base*; Simone Venturini wrote *Standard 35mm, Film Sound on Film, Multiscreens, Installations, and Cinematic Systems, Digital and Electronic Cinema* and Mirco Santi wrote *Substandard Film*.

1 See Jenkins (2006) and Thorburn, Jenkins, and Seawell (2003).

2 With "protocols" I have in mind the interpretation given by Lisa Gitelman in *Always Already New Media, History, and the Data of Culture* (2006).

3 It was George Eastman's advertising slogan, used in 1888 to promote his revolutionary photographic equipment: Kodak camera.

4 Eastman also had the idea of making photography (and later cinema) a mass phenomenon.

5 Regarding the unusual effects of the introduction of sound on the film multiplicity and plurality, see: Durovicova (2004); Bock and Venturini (2005); Quaresima and Pitassio (2005).

6 "Zelluloid – Films ohne Kamera", is the title of a recent exhibition that was held at the Schirn Kunsthalle in Frankfurt (2 June-29 August 2010), dedicated to the cameraless cinema.

7 Nagra III NP was introduced in 1958. From 1962 onwards, with the neo-pilottone synchronization system, Nagra became the standard in sound recording in film, and it was the standard up until the end of the 1980s.

8 Abel Gance's polyvision consisted of three 35mm cameras that were filming and three 35mm projectors that were projecting. Compare the name and concept of simultaneism with the polyvision conceived and theorized by László Moholy-Nagy.

9 A reference for the proper revival of the different formats and systems in modern projection environments is Sætervade (2006).

10 In addition, see another of Svoboda's inventions, the Polyecran, made of 112 moving cubes, each containing a pair of Kodak Carousels. It was shown in 1958 for the first time and presented at the 1967 Montreal Expo.

11 Regarding the widespread utilization of the loop, see for example *Sleep* by Andy Warhol, but also Martin Arnold, Bruce McClure, and Douglas Gordon.

12 See chapter 8.1 in this volume, "Operational Practices for Film Preservation and Protocols for Restoration."

13 Filmed on 16mm, the performance is a part of *Identification* created by Gerry Schum, broadcast on 15 November 1970 by the channel, Südwestfunk Baden-Baden (SWR).

14 The Eidophor system is used in cinemas, schools and various governmental organizations (such as NASA).

15 For the history and description of how LCD video projection works, see Hornbeck (1998).

16 The Sharp model mentioned was one of the first to be widely commercially available; before that, other LCD monitors had been produced but they were much smaller, such as the 2-inch screen made by Masataka Matsuura in 1983 (see Kawamoto, 2002).

17 An analogue video signal is made up from a low-voltage electrical impulse that contains information relating to the brightness of the pixels which form the electronic image's horizontal lines and those relating to the synchronization of the signal with the viewing equipment.

18 Eurovision is a European television consortium, the majority of which consists of state channels; it was founded in the 1950s with the aim of sharing public service broadcasting.

19 See the Sony site http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/index.html. Last access: 11 November 2011.

20 The price fluctuated around $1,300 for a recorder and $30 for a cassette.

21 The system was also used by television stations especially in reporting. In 1974, CBS covered Nixon's visit to Moscow using the U-matic recording system.

22 The preservation, documentation and exhibition of a historical computer usually includes a brief account of its technological development (genesis), a compilation of technological data (classification, market introduction (+ original price), processor, pulsing, RAM / ROM, operating system, mass storage device, input and output devices (keyboard, mouse, printer, screen / terminal), graphics (text, image), sound), an explanation of its capacities and modes of operation, an analysis of data input and output, and a reference to the machine's place in the cultural history of complex computing machines.

23 A good example is the research project *Obsolete Equipment. The Preservation of Playback and Display Equipment for Audiovisual Art* by Platform for the Archiving and Preservation of Audiovisual Arts (PACKED) and the Netherlands Media Art Institute (NIMk), see http://nimk.nl/eng/obsolete-equipment.

24 The Z3 is considered the first programmable, fully automatic computer that was capable of floating point binary arithmetic. It replaced the Z1 (1938, a mechanical computer for the calculation of floating-point numbers) and the Z2 (1939 with electromagnetic relay technology), parts of which were developed during the same period.

25 The transition from relays to the microchip took place in the course of four computer or technology generations: first there were relays and tubes (until around 1958), then came transistor circuits with transistors and magnetic cores (1958-1966), followed by integrated circuits (1966-1975), and finally highly integrated circuits (since 1975), also called large scale integration (LSI) (cf. Computer Sciences Collection Erlangen Friedrich-Alexander University of Erlangen Nuremberg, http://www.iser.uni-erlangen.de/). Regarding the home computer, relevant factors include, for example, the bus width (8, 16, 32, and 64 bit) which determines

the storage size (RAM), the processor's clock rate, which increased from 1-4 mHz to, at one point, 4-5 GHz and then decreased due to the use of multiple cores, as well as the parallelization of the CPU.

26 Lurk (2009a, 2009b, and 2010a). For the British history of computer art, see Brown et al. (2008).

27 Apple I (1976) with an integrated screen, Lisa (1983), the compact calculator Apple SE (1987) that features in several interactive artworks, and many more (cf. http://www.apple-history.com/).

28 PET 2001 (Personal Electronic Transactor, also known as CBM, 1977), VC20 (actually VIC – Video Interface Chip, 1980), the legendary C 64 (Commodore 64, with 64 kilobytes of main storage, 1982), and the Amiga 500 (1986).

29 The first one being the Atari 2600 games console (1977), followed by the Atari 400 and 800 (1979), the Atari ST (since 1985) and Atari TT (since 1990).

30 For the development of the graphical (reproduction) interfaces, see the Webbox History: http://www.webbox.org/cgi/_timeline60s.html.

31 For information about computer games in this context, see the website of the *Computerspielemuseum* Berlin (http://www.computerspielemuseum.de/index.php?lg=en); for the "demo scene," see Botz (2011).

32 While TCP controls data transmission, delivers the application's data stream, and, where necessary, takes measures against data loss, the addressable address (IP) ensures that the data packet reaches its destination.

33 The procedure was named after the initials of its founders Ronald L. Rivest, Adi Shamir, and Leonard Adlemen.

34 This is contrasted with concepts of longevity, cf. Howard Besser, *Information Longevity* – http://besser.tsoa.nyu.edu/howard/longevity/.

35 The recommendations for the preservation of data carriers are: a maximum temperature of 19-25°C, a maximum relative humidity of 40-50%, UV protection, and the use of acid-free protection films. In addition, data carriers should never be stored horizontally on top of each other or on uneven surfaces (due to danger of distortion and scratches), and direct handling of the reflective surface of optical data carriers should be avoided. Finally, objects should be cleaned using a soft cloth and a mixture of water and isopropyl alcohol (70%) (guidelines according to Lurk (2010a), Matters in Media Art (2008), State Archives of Florida (2009), Swiss National Sound Archive (2008)).

36 Common migration procedures are:

- Refreshment of the readability and data carriers.
- Replication, i.e., context checking the different information systems and checking the short cuts for proper operation.
- Repacking information if the refreshment was not successful.
- Transformation, i.e., transfer to new storage media and systems.

37 See chapter 8.2 by Jürgen Enge and Tabea Lurk in this volume.

38 Collection Museum of Contemporary Art, Antwerp (M HKA).
39 Collection NIMk, Amsterdam.
40 http://www.nimk.nl.
41 http://www.packed.be.
42 Participating institutions: the Netherlands Cultural Heritage Agency (RCE), the Kröller-Müller Museum (KMM), the Museum of Contemporary Art (M HKA), the Netherlands Media Art Institute, Amsterdam (NIMk), the Municipal Museum of Contemporary Art (SMAK), and the Stedelijk Museum Amsterdam. The case studies, interviews, guidelines, and other resources collected during the project are published at http://www.obsolete-equipment.org/?q=nl/content/obsolete-equipment.
43 A collection of representative cameras, players, recorders, computers, monitors, etc., is difficult to acquire and maintain. Attempts to build up such a collection have been made by the Bern University of the Arts (BUA) and the ZKM (Centre for Art and Media) in Karlsruhe.

44 In the realm of digital media, emulation has a specific definition. An emulator is a computer program that "fools" the original code into assuming that it is still running on its original equipment, thus enabling software from an outdated computer to run on a contemporary one, see http://www.docam.ca/glossaurus/view_Label.php?id=108&lang=1. In conservation vocabulary, to emulate an artwork is to imitate and upgrade it while still retaining the original look and feel of the work, as a facsimile.
45 Virtual environments are created when operating systems and desktop applications are emulated and made independent from physical hardware. Virtualization seems to be the next step in preservation of computer based art. Virtualization as conservation strategy is explored by Tabea Lurk and Jürgen Enge; see http://www.aktivearchive.ch/fileuploads/pdfs/Virtualisation_Summary.pdf.
46 See also Jürgen Enge and Tabea Lurk's contribution to chapter 8 of this volume.
47 http://www.docam.ca/en/restoration-decisions/a-decision-making-model-the-decision-tree.html (last access: 18 September 2012).
48 http://www.docam.ca/en/documentation-model.html (last access: 3 May 2012). See also Annet Dekker's contribution to chapter 6 of this volume.
49 The description of this case is heavily based on the case study report "Oratorium voor geprepareerde videoplayer en acht monitoren (Oratory for Prepared Video Player and Eight Monitors) by Frank Theys, 1989" by M HKA and PACKED, 2011, and Lorrain (forthcoming).
50 The description of this case is strongly based on the case study report "*I/Eye* Bill Spinhoven" by NIMk, 2011 – http://www.obsolete-equipment.org/sites/default/files/case_studies/ieye_bill_spinhoven_case_study_report_0.pdf (last access: 18 September 2012), and Hölling (forthcoming).

51 Emulation of Spinhoven's work *Albert' s Ark* (1990) was researched in the project Inside Installations by NIMk and RCE. See Wijers (2011).

52 The work logic identifies the core components of the artwork and describes the interlocking of the digital modules involved. This is documented in terms of how it is anchored in the system environment and in relation to the overall artistic aesthetic concept. Lurk (2010b).

REFERENCES

Altman, Rick. "La parola e il silenzio. Teoria e problemi generali di storia della tecnica." In *Storia del cinema mondiale, vol. V, Teorie, Strumenti, Memorie,* edited by Gian Piero Brunetta, 829-854. Turin: Einaudi, 2001.

Anon. "Frieder Nake." *CompArt database Digital Art (daDA)*, 2009. Http://dada.compart-bremen.de/node/751. Last access: 18 September 2012.

Bardon, Xavier Garcia. "Entretien avec Peter Tscherkassky." Published on *brdf.net*, November 2001. Http://www.brdf.net/interviews/interview_peter_tscherkassky.htm. Last access: 16 September 2010.

Bock, Hans-Michael, and Simone Venturini (eds.). *Multiple and Multiple-Language Versions II/Version multiples II*. Milan: Il Castoro, 2005.

Botz, Daniel. *Kunst, Code und Maschine. Die Ästhetik der Computer-Demoszene*. Bielefeld: Transcript Verlag, 2011.

Brown, Paul, Charlie Gere, Nicholas Lambert, and Catherine Mason (eds.), *White Heat Cold Logic. British Computer Art 1960-1980*. Cambridge, MA: MIT, 2008.

Conway, Paul. *Preservation in the Digital World*. Report, published at the website of the Council on Library and Information Resources, Washington DC, 1996. Http://www.clir.org/pubs/reports/conway2/reports/conway2/index.html. Last access: 11 November 2011.

Crary, Jonathan. "Géricault, il panorama e i luoghi della realtà nel primo Ottocento." In *Il luogo dello spettatore. Forme dello sguardo nella cultura delle immagini*, edited by Antonio Somaini, 93-118. Milan: Vita e Pensiero, 2005.

Cray-Cyber. *Cray-Cyber.org Knowledge Base*. Http://www.cray-cyber.org/wiki/, 13 May 2006. Last access: 18 September 2012.

Da Cruz, Frank. *Columbia University Computing History. A Chronology of Computing at Columbia University*. Http://www.columbia.edu/cu/computinghistory/, 2005. Last access: 18 September 2012.

Deren, Maya. "Amateur Versus Professional." *Film Culture* 39 (1965): 45-46.

Durovicova, Natasa (ed.). *Multiple and Multiple-language Versions I/Versions multiples I*. Milan: Il Castoro, 2004.

Elwes, Catherine. *Video Art. A Guided Tour*. London: I.B.Tauris & Co., Ltd, 2005.

Foster, Hal. "An Archival Impulse." *October* 110 (2004): 3-22.

Frieling, Rudolf, and Dieter Daniels (eds.). *Media Art Interaction. The 1980s and 1990s in Germany*. Vienna: Springer, 2000.

—. *Media Art Action. The 1960s and 1970s in Germany*. Vienna: Springer, 1997.

Garroni, Emilio. *Ricognizione della semiotica*. Rome: Officina, 1977.

Gitelman, Lisa. *Always Already New Media, History, and the Data of Culture*. Cambridge, MA: MIT Press, 2006.

Gunning, Tom. “Re-newing Old Technologies. Astonishment, Second Nature and the Uncanny in Technology from the Previous Turn-of-the-Century.” In *Rethinking Media Change. The Aesthetics of Transition,* edited by David Thorburn, Henry Jenkins and Brad Seawell, 39-60. Cambridge, MA: MIT Press, 2003.

Herzogenrath, Wulf, and Barbara Nierhoff-Wielke (eds.). *Ex Machina – Frühe Computergrafik bis 1979. Die Sammlungen Franke und weitere Stiftungen in der Kunsthalle Bremen. Herbert W. Franke zum 80. Geburtstag*. Berlin: Deutscher Kunstverlag, 2007.

Hölling, Hanna Barbara. “Versions, Variation and Variability: Ethical Considerations and Conservation Options for Computer-Based Art.” *The Electronic Media Review, Volume Two*. Washington, DC: American Institute for Conservation of Historic and Artistic Works, forthcoming.

Hornbeck, Larry J. “From Cathode Rays to Digital Micromirrors. A History of Electronic Projection Display Technology.” *TI Technical Journal* July–September (1998): 7-46.

Huffman, Kathy Rae. “Art, TV and the Long Beach Museum of Modern Art.” In *California Videos. Artists and Histories*, edited by Glenn Phillips, 279-284. Los Angeles: The Getty Research Institute, 2008.

Humanities Advanced Technology and Information Institute (HATII). *Report on Emerging Digital Art Characterisation Techniques*. Unpublished report, Planets project, University of Glasgow, 30 November 2009. Http://www.planets-project.eu/docs/reports/Digital_Art_Characterisation_Techniques.pdf. Last access: 18 September 2012.

Ishizuka, Karen L., and Patricia R. Zimmermann (eds.). *Mining the Home Movie. Excavations in Histories and Memories*. Berkely etc.: University of California Press, 2007.

Jenkins, Henry. *Convergence Culture. Where Old and New Media Collide*. New York and London: New York University Press, 2006.

Kawamoto, Hirohisa. “The History of Liquid-Crystal Displays.” *Proceedings of the IEEE* 90 (2002) 4: 460-500.

Kerckhove, Derrick de. *Brainframes. Technology, Mind and Business*. Utrecht: Bosch & Keuning, 1991.

Kitsopanidou, Kira. “The Widescreen Revolution and 20th Century-Fox’s Eidophor in the 1950s.” *Film History* 15 (2003) 1: 32-56.

Klütsch, Christoph. *Computergrafik. Ästhetische Experimente zwischen zwei Kulturen. Die Anfänge der Computerkunst in den 1960er Jahren*. Vienna: Springer, 2007.

Krauss, Rosalind E. "Reinventing the Medium." *Critical Inquiry* 25 (1999) 2: 289-305.

Laurenson, Pip. "The Management of Display Equipment in Time-based Media Installations." In *Modern Art, New Museums. Contributions to the Bilbao Congress 13-17 September 2004*, edited by Ashok Roy and Perry Smith, 49-53. London: The International Institute for Conservation of Historic and Artistic Works, 2004.

Lee, Kyong-Ho, Oliver Slattery, Richang Lu, Xiao Tang, and Victor McCrary. "The State of the Art and Practice in Digital Preservation." *Journal of Research of the National Institute of Standards and Technology* 107 (2002) 1: 93-106. Available online – http://nvlpubs.nist.gov/nistpubs/jres/107/1/j71lee.pdf. Last access: 18 September 2012.

Lorrain, Emanuel. "Anatomy of the Analogue. The Preservation of Frank Theys' Video Installation *Oratorium for Preparated Videoplayer and Eight Monitors* (1989)." *The Electronic Media Review, Volume Two*. Washington DC: American Institute for Conservation of Historic and Artistic Works, forthcoming.

Lurk, Tabea. "Lagerungsbedingungen für digitale Datenträger." Unpublished report, Bern University of the Arts, 2010a. Http://www.hfg.edu/textarchive/Lagerungsbedingungen_2010.pdf. Last access: 24 September 2012.

—. "On the Aging of Net Art Works." In *Owning Online Art. Selling and Collecting Net-based Artworks*, edited by Markus Schwander and Reinhard Storz, 51-65. Basel: FHNW, Hochschule für Gestaltung und Kunst, 2010b. Available online – http://www.ooart.ch/publikation/inhalt/PDF/06-Tabea-Lurk-e.pdf. Last access: 18 September 2012.

—. "Programmes as space for thoughts? Annotations to the origins of Swiss computer art." In *India Habitat Centre's Arts Journal*, edited by Alka Pande and Nils Röller, 50-63. New Delhi: India Habitat Center, 2009a. Available online – http://www.prohelvetia.in/fileadmin/pro_helvetia_india/docs/New_Media_Journal.pdf . Last access: 18 September 2012.

—. "ComputerKunstGeschichte Schweiz." In *Computergeschichte Schweiz. Eine Bestandesaufnahme/ Histoire de l'ordinateur en Suisse. Un état des lieux*, edited by Peter Haber, 165-206. Zurich: Chronos Verlag, 2009b.

Magoun, Alexander B. *Television, the Life Story of a Technology*. Westport, London: Greenwood Press, 2007.

Matters in Media Art. "Condition Report Guidelines." Guidelines published at the website of the Matters in Media Art project, Tate, London/Museum of Modern Art, New York/SFMOMA, Los Angeles, 2008. Http://www.tate.org.uk/about/projects/matters-media-art/condition-report-guidelines. Last access: 24 September 2012.

Medesani, Angela. *Le icone fluttuanti. Storia del cinema d'artista e della videoarte in Italia*. Milan: Mondadori, 2005.

Meigh-Andrews, Chris. *A History of Video Art. The Development of Form and Function*. Oxford and New York: Berg, 2006.

Paul, Christiane. *Digital Art*. London: Thames & Hudson, 2003.

Quaresima, Leonardo, and Francesco Pitassio (eds.). *Multiple and Multiple-language Versions III/Version multiples III*. Milan: Il Castoro, 2005.

Rothenberg, Jeff. "Renewing *The Erl King*." *Millennium Film Journal* 45/46 (2006): 20-51.

Sætervade, Torkell. *The Advanced Projection Manual. Presenting Classic Films in a Modern Projection Environment*. The Norwegian Film Institute, Oslo 2006.

Schwarz, Hans-Peter (ed.). *Media-art-history. Media Museum. ZKM, Center for Art and Media Karlsruhe*. Munich: Prestel Verlag, 1997.

Seijdel, Jorinde. "I/Eye." In *The Second. Time Based Art from the Netherlands*. Catalogue of the eponymous exhibition, Netherlands Media Art Institute, Montevideo-TBA, Amsterdam, 24 January-9 April 1997. Amsterdam: NIMk, 1997.

Shand, Ryan. "Theorizing Amateur Cinema. Limitations and Possibilities." *The Moving Image* 8 (2008) 2: 36-60.

State Archives of Florida. "Preservation and Conservation. Protect your video and audio tapes, and floppy disks." Guideline published at the website of the Florida Department of State, Division of Library and Information Services, Tallahassee, FL, 2009. Http://dlis.dos.state.fl.us/archives/preservation/magnetic/index.cfm. Last access: 24 September 2012.

Swiss National Sound Archive. "Archiving conditions. The ideal archive." Guideline published at the website of the Swiss National Sound Archive, Lugano, 2008. Http://www.fonoteca.ch/yellow/archivingConditions_en.htm. Last access: 24 September 2012.

Tamblyn, Christine. "Video Art. An Historical Sketch." *High Performance* 37 (1987): 33-37.

Thorburn, David, Henry Jenkins, and Brad Seawell (eds.). *Rethinking Media Change. The Aesthetics of Transition*. Cambridge, MA: MIT Press, 2003.

Vasulka, Woody, and Scott Nygren. "Didactic Video. Organizational Models of the Electronic Image." *Afterimage* 3 (1975) 4: 9-13.

Von Neumann, John. *The First Draft of a Report on the EDVAC*. Unpublished report, Moore School for Electrical Engineering, University of Pennsylvania, 30 June 1945. Http://virtualtravelog.net.s115267.gridserver.com/wp/wp-content/media/2003-08-TheFirstDraft.pdf. Last access: 18 September 2012.

Wijers, Gaby. "To emulate or not." In *Inside Installations. Theory and Practice in the Care of Complex Artworks*, edited by Tatja Scholte and Glenn Wharton, 81-89. Amsterdam: Amsterdam University Press, 2011.

Wilson, Stephen. *Information Arts. Intersections of Art, Science, and Technology*. Cambridge, MA: MIT, 2002.

Zimmermann, Patricia R. *Reel Families. A Social History of Amateur Film*. Bloomington, in: Indiana University Press, 1995.