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A Mirror for Brunelleschi

THE ISSUE OF THE IMPACT OF TECHNOLOGY on the arts is more than a question for cultural historians and aestheticians. It has direct and particularly vexing implications for all who support the arts, particularly patrons. It poses a central problem for the development of arts policy because technological applications constantly strike at the fundamental idea of artistic creation, at least as that is traditionally conceived. Our basic confusion about the definition and history of technology is perhaps nowhere better examined than in this context.

Paul Klee's *Angelus Novus*, as interpreted by Walter Benjamin, perfectly illustrates the ambiguities that we experience in the contemplation of technology. Benjamin writes:

> A Klee painting named *Angelus Novus* shows an angel looking as though he is about to move away from something he is fixedly contemplating. His eyes are staring, his mouth is open, his wings are spread. This is how one pictures the Angel of History. His face is turned toward the past. Where we perceive a chain of events, he sees one single catastrophe, which keeps piling wreckage upon wreckage and hurls it in front of his feet. The angel would like to stay, awaken the dead, and make whole what has been smashed, but a storm is blowing from Paradise. It has got caught in his wings with such violence that the angel can no longer close them. This storm irresistibly propels him into the future to which his back is turned, while the pile of debris before him grows skyward. This storm is what we call Progress.[1]

There are two views that one can take of technological progress in our contemporary culture. One can assume that technology, like History in Benjamin's description, is a catastrophe; or one can believe

that it is an ever-growing pile of discrete and wonderful events moving society toward some sort of utopia. Of course, lesser variants on either of these positions are possible. Cognitive dissonance allows one to hold to both positions simultaneously.

TECHNOLOGICAL IMPACTS

Looking at the world of technology as it affects the arts reveals that recent developments in electronic media (computing and videotape) have made it possible for artists to develop forms of expression that were previously inconceivable. To see the matter in this way is to take the optimistic view of technology. This optimism is perhaps best expressed in the work of Nam June Paik, who can reasonably claim to be the father of video art. His *Lake Placid 80*, for example, a video commissioned by the National Fine Arts Committee of the Lake Placid Winter Olympics in 1980, illustrates the range of possibilities that video has made available.

Nam June Paik's frenetic deconstructionalist mode reveals the old truth that yesterday's avant-garde filters down endlessly into more general currency. Today, there is a whole television channel of music videos that look as if, on one level at least, they have been composed either by Nam June Paik or by his close disciples. This filtering effect should not be forgotten when assessing the impact of new technologies any more than when new art in general is considered.

Beyond such pleas for openmindedness, video art in particular suggests how our vision as human beings is being expanded by the impact of new technology. A piece by Woody Vasulka, an impressionistic vision of the relationship between Berlioz and Paganini, has images whose effect is achieved by digitalization, by breaking the picture up in ways that would have been inconceivable before the advent of electrical signaling systems involving computerized information processing. Televisions and computers may be cross-fertilized to create absolutely new visions of the world.

At one level, such new media are just that: new media. They create new ways of seeing and hearing; more than that, they have a direct impact on traditional forms, and that impact may be amazingly enhancing. This is not to make the clearly erroneous, McLuhanite point that in some mysterious way they replace older forms. Rather,

it is to emphasize the different dimension that a new medium can give to an older form.

Consider *Locale*, for example, a film about the Merce Cunningham Dance Company made by Charles Atlas in 1979. Atlas, the camera operator, wears a Steadicam, a device that requires little high-level technology. It simply involves mounting a camera on a human being and using gyroscopes so that the camera remains absolutely steady, no matter what the body does. The Steadicam, in Atlas's capable hands, allows him to join the dance in ways that are clearly impossible with traditional large camera tripods and mobile mounts.

But there is another point to all such work. Film and video have an important retrieval use—especially video, which artists find more accessible. These media allow for the preservation of previously unrecordable performances of dance and other performing arts. In other words, the medium is not only being used as a medium, but also as a means of creating archives of unprecedented richness. Those who point to this archival enrichment are also able to claim that in music, at least, technology has borne equally lush fruit, and not only in the matter of recordings.

We tend to look at things that are familiar to us as being in some way natural, whether it be the way that news is presented nightly on television, or the instruments used by the classical orchestra. In fact, there is not much that is natural about either. The instruments, for example, all have histories. They were invented by people and have developed over time. If there is great hesitation today about electronic instruments, synthesizers, and the like, one wonders where that leaves us when we come to contemplate the contribution of Dr. Sax to the benefit and joy of mankind. Computers are simply helping us to create today's saxophones.

Computers are found everywhere in the arts. In architecture, for example, computer technology is clearly on the verge of a new age. Today a computer and video interface can create nonexistent spaces. It is possible to see what a reconstructed Times Square would look like; it is easy to project what the shadow patterns of buildings are likely to be. We appear to be on the edge of true holographic imaging, which will allow a viewer to walk through all three dimensions of a nonexistent space.

All this is intended to describe the positive vision of art and technology, the enthusiastic reception that is given everything from fabric design by computer to the creation of verse by computer. Many of these applications are unproblematic. That architects today are able to use computers to avoid the mundane task of endlessly reproducing building details on plans is clearly to be welcomed. Yet despite these unquestionable advantages, another view is possible—that implied by Benjamin's vision of the chaos building up at the angel's feet—an essentially pessimistic view.

The first element of this pessimism involves the sense of being overmastered by the machine; machines can, for instance, design things better (or, at least, with greater complexity) than people can. Without the human element, the whole sense of artistic enterprise begins to slip away. It is possible to go further, taking the view that technology is working toward the end of all live performance, and dehumanizing every process of artistic production in our culture. Technology means the end of art in any previously recognizable form; it offers instead soulless alternatives. In short, its introduction into the world of the arts must be watched very carefully.

The positive and negative visions of technological progress share many common assumptions. Both assume that modern technologies pose an unprecedented challenge to the arts; both accept the fact that technology is changing at an ever-faster pace; both see it as playing an increasingly important role in our lives.

TECHNOLOGICAL IMPACT: A NEW VIEW

It may be possible, however, to establish a new and different view of technology. Historically based, it might begin by denying the assumptions of both the utopians and the apocalyptists. Is it not possible that we are amnesiac about the pace at which technology develops and wholly ignorant of the forces that set its agendas? Is its history not largely hidden from us, scarcely qualifying as a discipline in the academy? It would probably surprise the vast majority of people on this planet, Western people especially, to learn that it has been 102 years since television was first patented;[2] that it has been 113 years since the invention of the first solid-state electronic device.[3] Technology progresses slowly; or, more accurately, technology progresses much more slowly than is commonly assumed.

Indeed, it is possible to take an even longer-range view. The history of television, for example, might appropriately be said to have begun with the discovery of phosphor in 1602.[4] The background of scientific understanding that made television possible developed steadily until the creation of the cathode-ray tube in 1897.[5] Cathode-ray tubes were standard equipment in all advanced physics laboratories at the turn of the century. Against this scientific achievement, the idea of television itself came from a French lawyer, M. Senlecq, in 1878.[6] The actual process of scanning a substance that gives off differing amounts of electricity in accord with the intensity of the light falling on it, the intensity of light translating into variations in a current of electricity, was developed by a German, Paul Nipkow. His patent was granted in Berlin in 1884.

In 1908, Alan Campbell-Swinton outlined the modern system of using cathode-ray tubes for scanning in a dismissive footnote to correspondence in the British scientific journal *Nature*.[7] In 1911, a Russian, Boris Rozing, managed to transmit the first actual television picture to a cathode-ray tube.[8] Vladimir Zworokin, a pupil of Rozing's, came to the United States at the end of the First World War, after the Russian Revolution, and went to work for Westinghouse and RCA. By 1923, he had translated Campbell-Swinton's basic idea into a working prototype of modern television.[9] This was refined by Philo T. Farnsworth and others during the next decade.[10]

All this work took place while corporate interests were paying little attention to television, principally because radio and sound films, the latter only recently diffused, were then being effectively exploited. Indeed, in the early 1920s, when Campbell-Swinton was asked how long he thought it would take to construct his television, he replied that if one of the industrial giants (such as General Electric) invested some money in it, perhaps six months.[11] But television researchers did not have money thrown at them.

Thus we come to that curious period in the television history of the United States that begins in 1936 and does not end until 1945. While standard histories suggest that television was not introduced earlier because of World War II, the war in fact occupied less than four years of that period. The classic histories also suggest that television was not ready to be diffused, at least in the opinion of the Federal Communications Commission. According to some, it did not work well enough yet. There is, however, one major problem with all

such accounts: American RCA-style television was then working in Berlin, and indeed in London, throughout these years.

So, while the FCC was arguing that television did not work, 20,000 sets were operating in Britain[12] and 180,000 people saw television images of the Berlin Olympics in 1936.[13] The constraints on the introduction of television into the United States were social, not technological. Such social constraints are associated with "the 'law' of suppression of radical potential."

This "law" implies that technologies are introduced into society only when they do not disturb preexisting arrangements of all kinds. We waited forty years for a baby computer, though the first computer in the world was exactly that. The "Baby Mark I" ran a factoring program for forty-five minutes at the University of Manchester in 1948. Its builders were testing a memory system, and since it worked, they set about building a "proper" computer.[14] What was a "proper" computer in 1948? One that American scientists, led by John von Neumann, declared to be a proper computer—a room full of tubes.[15] So, for forty years, we have waited for the smaller machine. That, in my view, is the "law" of suppression of radical potential at work.

The historical record does not support the proposition that technological change is at all fast. Nor is it possible to sustain the contention that it is getting faster. In consequence, the supposed effects of technology become much less obvious.[16] Indeed, it becomes possible to reenvision our relationship with technology: to abandon a philosophy of technological determinism, and to develop wholly new attitudes toward—and plans for—technological development. When it comes to the arts, it should be possible to establish an agenda to assess the impact of technology. This is a purpose worth pursuing.

WHAT IS TO BE DONE: SIX SLOGANS

I would suggest that six slogans ought to condition the establishment of such an agenda. The first slogan: "A bird in hand is worth two in the bush." In this context, it means that it is always important to look at the society at hand, rather than at the "birds," or technologies, that exist in some species of utopian bush.

For example, 40 percent or more of the people in the United States own videocassette recorders (VCRs); these are being sold at the rate

of over a million each month. All forms of serious film and video (including archival materials relating to the other arts) are difficult to access, especially for people living outside metropolitan areas. The pervasive presence of VCRs, however, and the ease with which cassettes can be shipped, allow us for the first time to conceive of a truly national audience for all these arts. The VCR is clearly "a bird in hand."

Conversely, various systems of writing on the television screen must still be considered "birds in the bush." These systems are either called videotext or teletext, depending on the techniques employed. There is a major problem with writing on a screen: the screen is filled with too many words, and it is difficult for the viewer to read them. For example, if a firm like Sears, Roebuck, and Co. uses teletext as a method of electronically delivering all its catalog material, each double spread of the book represents dozens of "pages" of teletext. The electronic "catalog" is thus many thousands of "pages" long. While an individual can look at the traditional printed catalog in one room and then carry it to another room to place a telephone order, he cannot do the same with the electronic version of the catalog. So for a company like Sears, Roebuck, the old-fashioned catalog remains a better system of information delivery than anything produced by writing on a screen. It is pointless, in my view, to begin from a position that says, "the technology makes this possible." Whether or not one is able to write on the screen is not the issue.

However, from the standpoint of an agenda for the arts, it is wrong to bury one's head in the sand. In the arts, there are cutting-edge issues involving expression and the creation of meaning that wait to be explored. To continue with the example of writing on the screen, the Center for Visual History, under Lawrence Pitkethly, is today involved in making a series of public television films about American poets called "Voices and Visions." In the series' film on Ezra Pound, the words of poems are often visible on the screen. The technology is a straightforward application of film superimposition and animation; it is used, however, in a novel way, to reveal both the structures of the poems and their other less obvious aspects. Thus, on the one hand, one may look at an attempt to replace print on the catalog page and correctly hypothesize that it will not work. On the other hand, one can see that technology is able to expand our appreciation of an art form such as poetry.

Now, for a second slogan: "Fear the Greeks." Technologists often tend, for marketing or other reasons, to take too little cognizance of whether the already existing mousetrap is sufficient for our needs. We are constantly being given better mousetraps, whether we want them or not. The "standards war" in the videocassette market is a perfect example of this. Perhaps 8 mm Video is superior to VHS or BETA, or perhaps it is not; that is almost beside the point. The question is how it meshes into a market already dominated by other formats.

In regard to this issue, the history of the videodisk provides a significant warning. RCA virtually bankrupted itself trying to market a disk that was clearly an inferior mousetrap from every point of view.[17] The laser-driven disk, by comparison, is a very different device from RCA's and is better in several ways. The laser disk allows instant access to any single frame, and has superior sound and picture quality. Above all, it is the most durable audiovisual format, with the promise of six centuries of perfect preservation. But societal and economic forces were such as to constrain its introduction. The laser disk struggles for acceptance, having already disappeared in one consumer format, though it is alive and well as the compact audio disk (CD).

Proponents of the laser disk had argued that it provides both a better picture and better sound. But this was irrelevant if the consumer had already spent four or five hundred dollars on a VCR. Though it is true that the VCR records and the disk does not, the disk's other advantages are incontestable. This does not prevent it from floundering. A similar scenario appears to be in store for 8 mm Video. The fact that a new device can do the job better means nothing if social uses and the market have already combined to close off new options.

Slogan number three: "*Festina lente.*" "Hurry slowly" suggests, as I have already indicated, that the pace of change is generally not very fast. The history of holography may be offered as an example. The scientific knowledge needed to make holograms had its origins in 1801 with Thomas Young's interference hypothesis, which allowed him to measure the wavelengths of different colored lights accurately. The idea for the hologram was in the mind of Nobel Prize winner Dennis Gabor by 1947. Lasers were suggested for the process in a paper written in 1958.[18] Holography should mesh easily into a society addicted to realism. We appear to be waiting for the

"smellies" and the "feelies,"[19] and so there is good reason to believe that a three-dimensional moving-image hologram will be accepted. The question, however, is when.

The first commercially available moving hologram was produced in 1975.[20] If money were now thrown at the project, we could almost certainly solve many of the remaining technological problems in a short time. These are mostly engineering problems; they have little to do with basic concepts. Will we actually do this? In my view, not immediately. If we glance at the agenda that the worldwide electronics industry has developed for the near future of this field, we first see television monitors with stereophonic sound. That market will have to be saturated. Digital television will come next, and then cathode-ray tubes will be abandoned in favor of flat screens. After that, we will start discussing changes in the pictures we look at, which are currently made up of 525 or 625 lines—the world's major standards. NHK, the Japanese state broadcasting company, has developed with Sony a 1,125-line picture known as high-definition television, or HDTV.

This HDTV proposal offers a perfect example of McLuhan's notion that we drive into the future with our eyes firmly fixed on the rearview mirror. The current television picture duplicates the resolution of 16-millimeter film. Why? Because in the twenties, television researchers wanted to deliver home movies; they felt they could hope for no better film than 16-millimeter,[21] which translates into the general range of lines of contemporary standards. Fifty years later, we are still tied to that standard. Today there is talk of a new standard, but will we leap to the electronic equivalent of 70-millimeter film and beyond? No, instead 1,125 lines are being proposed—the equivalent of the 35-millimeter film image.

HDTV will come, but almost certainly only after a time span of decades—a decade, probably, for stereophonic sound on monitors, another decade for digital sets, a decade or longer for the flat screen. HDTV or any other new, incompatible standard may well take two or three decades simply to diffuse. After all this, and perhaps much else, will come holographic television—possibly by the middle of the twenty-first century.

Does this mean that any contemporary artist who wishes to work in holography should be ignored? Certainly not. If artists suggest that it is vital to know how to handle this medium, and if they create

projects that can help us to understand its potentialities, they ought to be supported. "Hurry slowly" simply means that it is important to have a realistic overview of the technology in question, and to not be unduly influenced by the hype that too often surrounds it. Everything takes as long as it ever did.

Fourth slogan: "*Carpe diem.*" There are always opportunities to be seized, as in the history of computing, when Charles Babbage was discovered in the rooms of the Analytical Society at Cambridge dozing over his logarithmic tables. In his version of the tale, he was suddenly awakened and asked what he was dreaming about. His reply: "I am thinking that all these tables [pointing to some logarithms] might be calculated by machinery."[22] In an alternate version of the story, another member of the Analytical Society, his friend the astronomer Herschel, is said to have added, "Yes, by steam."[23] The year was 1812 or 1813; who, at that time, needed a computer? It was cheaper to hire a clerk. There were armies of clerks for such work.

Today there are no clerks—certainly not for the arts—so specific technologies, especially the personal computer, ought to be put to as many uses as possible. For arts organizations, the mundane possibilities of databases ought to be transformed into better ways of reaching audiences. Artists should certainly use cheap video-editing systems or any other devices that render a mode of expression more easily accessible. Indeed, all technological possibilities might well be dealt with in this way, including the timely holographic experiment previously mentioned. *Carpe diem.*

Fifth slogan: "Fight the good fight." It is impossible to deal with technology in isolation. One has to think about society, the collective experience, which also embraces all the artistic expressions that the culture has produced. Fighting the good fight means taking advantage of appropriate technology; for instance, pushing the limits of commercial exploitation of videocassettes for education and the raising of artistic awareness in both young people and adults. This fight is occasioned by the fact that the broadcasting industry fosters passivity in its audience. Doing otherwise in such a well-entrenched situation will never be easy, but that does not mean that new responses should not be encouraged.

In the supposed rush forward, in our obsession with progress, there are certain things that must not be allowed to fall by the wayside. The use of film as an avant-garde means of expression—a perfectly

legitimate use of the medium, as old as any other—is one that will never be supported by the marketplace. But if one considers how the human experience would be impoverished if we did not have those reels of celluloid and boxes of tapes made by artists from the earliest experimenters through Maya Deren to Nam June Paik and beyond, one can understand how important it is that such work be supported and preserved.

In the rush to the future we should not forget older technologies. Audiotape, for example, has played (and continues to play) a vital role in the preservation of folk forms, spoken and musical. Radio can return such preserved material to the community. Again, the limited range of radio broadcasts produced by the industry today ought to be seen as a challenge rather than as a sign that all is lost.

Newer and more glamorous technologies can also be made to serve. While no new technology seems less appropriate for exploitation by the artistic community than satellites, which are enormously expensive and both metaphorically and literally out of reach, individuals should try to make something of them in ways that the political and commercial creators of the system never intended. The "Deep Dish" project of "Paper Tiger" (an alternative television production group), which reached community television channels all over the United States via satellite, shows what is possible.

A final slogan: "Horses for courses"—the question of appropriate technology. How does one judge the artistic quality of enterprises in terms of cutting-edge, high-tech, or low-tech appropriateness? There is a tripartite division here. The newest work that interests Bell Laboratories and others like them is largely concerned with developments on the frontiers of technological understanding. This level of technology often has a double-edged effect in the world of the arts. It is the sort of technology that often overmasters the artist in the ways suggested earlier. Then there is state-of-the-art high technology; with this, the issue is not so much a loss of a creative sense as it is one of economics. In the video area, for example, many of the image-processing systems that artists might wish to use are not available to them; they simply cost too much. Finally, there is low technology, or devices that are easily and readily accessible.

Clearly, the last level of technology poses no problem; there are even creative ways of dealing with the middle level. In New York, for example, the state's arts council, in collaboration with other bodies,

has created programs to allow video artists to gain access to extremely expensive production facilities during off-hours. These support programs have contributed to productions that fit admirably into the avant-garde tradition and reflect the highest levels of technical accomplishment, made possible with the latest developments in technology. For example, "Double Lunar Dogs" was made by Joan Jonas in 1984 at a major New York production facility. While the latest experiments in art and technology, not grounded in social (including artistic) realities, ought to be approached with caution, it is vital that we be open to all technological opportunities.

ART AND TECHNOLOGY, NOT ART VERSUS TECHNOLOGY

We should not think in terms of art versus technology. Art has always interfaced with technology, whether in the ancient techniques of casting bronze, still with us, or in lithography, now in its third century, or in photography. Wonderful cross-fertilizations are possible when the new technologies interact with the old. Some scholars argue that Monet's *Boulevard des Capucines* is an image that would not have been painted before the advent of photography. Photography rendered a similar blurring of images, especially in the early decades when shutters and film stocks were slow. It is perhaps fitting that the world's first public film show took place on the same Parisian street captured in Monet's painting.

Art and technology are twins. They divide because we choose to divide all sorts of things that were not separated before the coming of the Industrial Revolution. We divide art and artisans, artists and scientists, art and technology. But there was a time when this was not so. Think, for example, of *Trinity* by Masaccio in the Church of Santa Maria Novella in Florence. I recall listening to a guide explain that when the bishop of Florence unveiled the painting, Masaccio's perspective rendering of the vaulted roof behind the crucifix was so astonishing that people rushed outside the church to see where it had been built. Whether true or not, the anecdote attests to the power of illusionism in culture. We would know a great deal more about how we function as human beings, as artists, and as a society if we knew the substance of the conversations shared by Donatello, Masaccio,

Alberti, Ghiberti, Brunelleschi, and the philosophers and mathematicians who were part of their circle in the first decades of the fifteenth century. Something quite remarkable happened in those years.

Brunelleschi painted what is generally regarded as the first modern perspective painting in Western Europe. But it had to be viewed in a peculiar manner. One peered through a hole drilled in a wooden board. On the board, facing away from the viewer, was the painting (depicting the baptistry). Facing the board was a mirror. Thus the viewer looked through the hole at the reflection of the image in the mirror.[24]

This was an extraordinary development—one of the most important in the history of European perception. The first modern perspective painting with a single vanishing point represented a fundamental change in art that had absolutely nothing to do with technology. Apparently, the Florentines simply invented it.

The Florentines were familiar with the first Arab treatise on optics and perspective, translated from Arabic into Latin as *Perspectiva*; they had been making *trompe l'oeil* bas-reliefs and funerary images for several centuries; they had been doing work like the very doors of the baptistry that Brunelleschi had painted, which had considerable elements of three-dimensional representationalism in them. And then, suddenly, it came together: perspective without any technology involved. But the issue of perspective was at the top of what we would clearly recognize as a scientific agenda today. The Florentine artist had much to do with what we would now call scientific work.[25]

In a biography of Alberti there is a brief but telling description of a camera obscura one hundred years before della Porta, who is normally credited with this invention.[26] What, then, of the astonishing moment of the Brunelleschi painting? If Alberti knew of this device, could not Brunelleschi have shared this knowledge? What is the viewer doing but looking through a hole into another space, the exact mark of those reprographic and photographic processes we normally associate with eighteenth-century camera obscuras and the emergence of photographic processes in the nineteenth century?

The West's "discovery" or "invention" of perspective may have been a moment as technologically driven as any other. It could have been born, in part, out of knowledge of the camera obscura. Just as Nam June Paik's work (or that of any contemporary artist) is technologically derived today, Brunelleschi's work may have been

derived from the technologies of his era. Contemplation of the relationship between art and technology leads to the realization that, as a society, we must be prepared to provide mirrors for our Brunelleschis.

ENDNOTES

This essay is based on a verbal report made to the New York State Council on the Arts (NYSCA) at the Whitney Museum of American Art, 9 September 1986. The author gratefully acknowledges the museum's kind permission to reprint it in this form.

The report on which this essay is based was part of a project initiated on behalf of the NYSCA by John G. Hanhardt, curator of film and video at the Whitney Museum of American Art. The purpose of the project was twofold: to examine the historical and theoretical issues of art and technology in our times, and to develop a better understanding of the practical implications of technological development for the creation and dissemination of the arts, in close relation to the policy issues raised for the council by new technology. The author wishes to thank Dr. Hanhardt, his staff, and Jacqueline Kain, the project's research officer, as well as the program directors of NYSCA, especially Dai Sil Kim-Gibson, director, Media Program, and NYSCA's executive director, Mary Hays, for their help and guidance.

[1]Walter Benjamin, "Theses on the Philosophy of History," in *Illuminations*, trans. Harry Zohn (New York: Schocken Books, 1969), p. 257ff.

[2]Patented by Paul Nipkow in Berlin, 1884. See G. Shiers, ed., *Technical History of Television* (New York: Arno Press, 1977) for a collection of papers on the earliest phases of television development.

[3]Frederick Braun's rectifier, in Marburg, 1874. See Ernest Braun and Stuart McDonald, *Revolution in Miniature* (Cambridge, England: Cambridge University Press), p. 11ff.

[4]By a Bolognese, Cascariola. See Brian Winston, *Misunderstanding Media* (Cambridge, MA: Harvard University Press, 1986), p. 39.

[5]By K.F. Braun. Ibid.

[6]G.R.M Garratt and A.H. Mumford, "The History of Television," *Proceedings of the Institute of Electrical Engmeers*, 99 (London: Institute of Electrical Engineering, 1952), p. 26.

[7]Ibid., p. 31.

[8]P.K. Gorokhov, "History of Modern Television," *Radioteckhnika (Radio Engineering)* 1961, in Shiers, *Technical History*, p. 75.

[9]F.C. Waldrop and J. Borkin, *Television: A Struggle for Power* (New York: William Morrow, 1938), p. 213.

[10]G. Everson, *The Story of Television: The Life of Philo T. Farnsworth* (New York: W.W. Norton, 1949), passim.

[11]A.G. Jensen, "The Evolution of Modern Television," *Journal of the Society of Motion Picture and Television Engineers* 63 (1954), p. 176.

[12]Bruce Norman, *Here's Looking at You* (London: BBC & Royal Television Society, 1984), p. 210.

[13]William Uricchio and Brian Winston, "The Anniversary Stakes," *Sight and Sound* 55 (4) (Autumn 1986), p. 232.
[14]S.H. Lavington, *Early British Computers* (Manchester, England: Manchester University Press, 1982), passim.
[15]John von Neumann, "First Draft of a Report on EDVAC," in B. Randall, ed., *The Origins of Digital Computers* (Berlin: Springer-Verlag, 1973), p. 359ff.
[16]See Winston, *Misunderstanding Media*, pp. 363–80.
[17]Margaret Graham, *RCA and the Video Disc* (Cambridge, England: Cambridge University Press, 1986), passim.
[18]By Charles Townes and A.L. Shawlow. See G.W.A. Dummer, *Electronic Inventions and Discoveries* (Oxford, England: Pergamon Press, 1983), p. 198.
[19]Robert Scholes and Robert Kellogg, *The Nature of Narrative* (New York: Oxford University Press, 1968), p. 85ff.
[20]Paul Walton, *Space Light* (Sydney: Doubleday, 1982), p. 47.
[21]G. Schlafley, "Some Comparative Factors of Picture Resolution in Television and Film Industries," *Journal of the Society of Motion Picture and Television Technicians* (January 1951), p. 50.
[22]Herman Goldstine, *The Computer from Pascal to von Neumann* (Princeton: Princeton University Press, 1972) p. 11.
[23]Stan Augerton, *Bit by Bit* (New York: Ticknor and Fields, 1984), p. 40.
[24]John White, *The Birth and Rebirth of Pictorial Space* (London: Faber & Faber, 1957), p. 114ff. I am grateful to Julia Keydel for introducing me to this literature.
[25]Kenneth Clark, "Leon Battista Alberti on Painting," *Proceedings of the British Academy* 30 (1944), p. 6.
[26]Alberti made "demonstrations" through a tiny opening in a little "closed box." From the *Vita anonyma* in William M. Irvins, Jr., *On the Rationalization of Sight* (New York: Da Capo, 1973), p. 16. See also the references to a "veil" placed between "the eye and the thing seen, so the visual pyramid penetrates through the thinness of the veil. This veil . . . always presents to you the same unchanged plane. . . . ," in Alberti's *Della Pittura*, translated by John R. Spencer as *On Painting* (New Haven: Yale University Press, 1966), p. 68ff. Jean Gadol, in *Leon Battista Alberti* (Chicago, University of Chicago Press, 1969), glosses this *velo*, or "ideal frame," as a " 'glass' " (p. 38). Regarding Brunelleschi's interest in machines and his general inventiveness, see Frank D. Prager and Gustina Scagla, *Brunelleschi: Studes of His Technology and Inventions* (Cambridge, MA: MIT Press, 1970), passim.

(1973), *Urban Decline and the Future of American Cities* (with Katherine L. Bradbury, 1982), and the *Revolution in Real Estate Finance* (1985).

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