PART I

TECHNICAL PREHISTORY AND THEORETICAL APPROACHES

Chapter 1

THE THIRD IMAGE

Contingencies and Ruptures in the Technological History of Television

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Seen from the viewpoint of the history of science, television history is marked by three breaks [*Zäsuren*], and it would certainly exceed the limits of this paper to trace each of them in detail. We may, however, at least give a brief sketch of them in order to explicate the context of the present chapter's thesis. This paper argues that television, the beginnings of which may be dated to 1939, depended on the technical construction and technological realization of a third image that has remained epistemologically largely ungrasped. This means that television begins its triumphal procession through history from just that point in time when the knowledge that makes it technically possible lags after the artifacts it has construed. In a certain sense, this knowledge lag persists even today.

With this, we have named one of the three breaks already—namely, the last up to now, which can be dated to the year 1939. In that year, the first comprehensive electronic television system in the world was presented to the world by RCA in New York at the world exhibition. Camera systems, production of receivers, and broadcasting chains were simultaneously launched. It was the last world exhibition before the atomic bomb, and also one of the largest and most forgotten, if one measures it against the illusions it generated. In the same year, its traces were effaced by wars in Europe and Japan. All that remained of its visions was television.

It may be surprising that—from the perspective of this essay—there have been no further caesuras, even in the domain of digital optics. In fact, the digital chip found since the 1980s in all cameras, whether for photography or TV, does not constitute a further epistemological caesura with regard to television. This digital CCD-chip, which admittedly opens completely new operative dimensions to our photography and films, is, from the point of view of industry history, itself the child of TV research, and thus presumes the medium of TV already. What digital images everywhere offer us today was developed as the optimization of an element already defined by electronic television in 1939, namely, the "stored picture," also named in some patents the "electrical image." The Charged Coupled Device (CCD-chip for short), first described in 1970, was the result of the organized research of an applied and developed domain of knowledge, the quantum mechanics of solid state physics. From the beginning this chip served the purpose of building a video or still-image storage for TV cameras. The electronic cameras of 1939 already contained a "stored image," i.e. a third stored image, albeit not in this now scientistically [*szientivisch*] perfectly conceived form of the CCD-chip.

In the image technology of the twentieth century, it is not digitalization that constitutes the decisive caesura, but rather the first, purely electronically produced image of television from 1939. Only in a further step, which is only logical from the point of view of the history of science, does one fall back on digitalization's concept and technology. (Digitalization, as a mathematical "sampling of frequencies," goes back to Fourier's work of 1823.)

Defining Technical Media

These introductory considerations have already given some preliminary hints about the concepts of contingency and caesura, which are decisive for understanding the history of technology. Since TV marks a very late medial caesura in modernity, a cursory look back at its origins may be helpful. Technical media emerge from the history of knowledge as a contingent caesura, usually as an act of considerable, surprising, and often completely unrecognized improbability. Precisely for this reason technical media are "technical." It would be imprecise, to say the least, to call the alphabetic script already a technical medium. Certainly the qualification of contingency and extreme improbability holds true for the formation of Western alphabets. But what we call knowledge first arose together with this last. If we declare the subsequent arisal of media from 1600 on to be contingent in the sense of a caesura of knowledge, then a concept of knowledge, structured and ordered according to book-form writing, is already assumed. We can only speak of technical media with reference to modern media [*Medien der Neuzeit*], which, as is well known, begin with book printing.

Niklas Luhmann is entirely right to maintain that book printing, circa 1450, would never have been able to expand without its embedding in an already developed money economy and a differentiated European trade system. Other cultures already had printed books, but precisely no book printing. In Europe, it took nearly 150 years for book printing as a medium to make its mark as a caesura in science. That process began around 1600 with the formatting of knowledge as a modern science, which is strictly coupled to this originary medium of the book to this day. The technical medium of book printing thus establishes an expanded frame for the contingency of all subsequent medial caesuras. From this point on, technical media mark caesuras not only in knowledge, but also, in the same way, in that formation of knowledge called science. This is especially true for the double invention of photography and telegraphy around 1830, with which—in the strict sense of a media-scientific marking of caesurae—modernity already begins. The contingence of this is first perceived when one identifies its entry into the field of knowledge and science, already stamped by book printing.

To use Luhmann's terms: technical media are, after their highly unlikely arisal, converted into the likelihood of preservation ensured by a culture of knowledge and science. Here it is a question neither of positive knowledge nor of scientific truth. In the case of telegraphy, for instance, it took decades to implement it in cultural, economic, and political terms as a superior form of communication, despite all its incomprehensible flaws and functional weaknesses. This was done without understanding, in the sense of a scientific truth function, why and how telegraphy actually functioned. Telegraphy functioned for decades—in fact, for almost the entire nineteenth century—as a "blind" knowledge, and produced within its force field a parallel discursive world in the form of "modern spiritism." To speak of contingent caesuras in knowledge means also to speak of caesuras in ignorance and uncertainty. It is a matter of contingencies that open up new contexts in which—without further grounds and often quite suddenly—"something" appears and exists and may be described on the level of perception and world, may be built and used while remaining at the same time scientifically "untrue," inconsistent, uncertain, and approximate. This "something" is technical, and it exists materially and functionally, but cannot be addressed with a truth function within the discourses coupled in the field of science. Nonetheless this "something" is anchored in a function, economically, militarily, and politically, and thus also in the memory of a culture. Modern media [*Medien der Neuzeit*] are, since they are contingent caesuras in knowledge, as irreversible as writing. Their entropy is irreversible and thus not a negentropy.[1] Culture as the memory of society would not exist without the contingency of the medial. Yet no one knows what this has achieved. Only one thing is sure: technical media can only be destroyed together with the culture and society in which they contingently arose. In this far-reaching sense, one can also call them artifacts of articulation or—in a narrow sense of history of science—"epistemic things," to use an expression of Hans-Jörg Rheinberger (1997).

First Caesura: Photography/Electricity/Telegraphy

The history of tele-media begins with just such an "epistemic thing," a completely contingent artifact. This beginning lies much further back in the past than most histories of television would have one believe. The first caesura that is decisive for television history is marked by what Georg Christoph Lichtenberg offered to the scientific world in 1777 in six sensationally illustrated essays—those peculiar figures of resinous dust that he found by chance, due to the presence of resinous dirt in his laboratory. The arisal of these figures is thus completely contingent. They show figures of positive and negative charges of static electricity.

These were images of the discharge of an electrophorus, a device well known in the scientific world of its day, and found in hundreds of labs in all of Europe. Through experiments with this electrophorus, Alessandro Volta, who worked closely with Lichtenberg, found his way quite logically to his discovery of the electrochemical production of a flowing current in 1800—that is, what we now call a battery. There is no space here to explicate the connection between electrophorus and battery, but it is anything but improbable or uncertain. Sooner or later, the discovery of small currents from electrolytic sources made by Volta would have been likely, as long as one refined the electrophorus as an instrument to measure atmospheric currents, as Volta and Lichtenberg did. But Lichtenberg's figures remained completely improbable, uncertain, not understood, and contingent, both in 1777 and afterward.

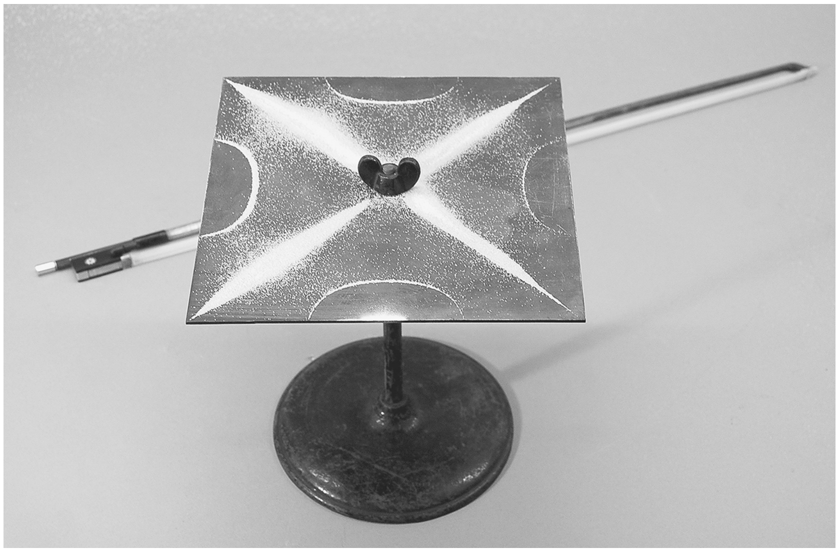

Figure 1.1. Vibrating plate of the kind developed by acoustician Ernst Florenz Chladni. Image courtesy of the Smithsonian Institution.

Twenty years later, Novalis included these figures of Lichtenberg in the "great ciphered writing" of nature's self-description, once the acoustician Ernst Florenz Chladni, following Lichtenberg, had placed the self-description of tones and sound on the agenda of Romantic philosophy of nature.[2] How could photography and telegraphy, the most important new media of the nineteenth century, arise in such temporal proximity to each other, almost simultaneously in the 1830s? One answer would be that they both sprang from the same insistent epistemological uncertainty, and mark their caesuras in it nearly at the same time. For, the uncertainty generated by Lichtenberg's figures from 1777 did not lead to their explanation. Only atomic physics could clarify and explain them in the twentieth century. The uncertainty of Lichtenberg's figures, and thus of a self-describing ciphered writing of nature, remained a constant in Romantic philosophy of nature, namely in the so-called speculative physics of early Schelling and German idealism as a whole. While searching for self-imagings of electricity and its polar, dual-dialectical qualities, Christian Oerstedt, a Romantic philosopher and physicist, discovered the electrodynamic effects of electrical currents in 1820. With this, the decisive epistemological precondition for telegraphy was found, namely that a constant electrical current has a magnetic effect.

The simultaneity of appearance of these two main media of the nineteenth century, photography and electricity, followed a characteristic tendency of Romantic philosophy of nature to self-similar[3] experiments with the uncertainty of techniques for nature's self-inscription. Thus Oersted discovered the electrodynamic effect that Andre-Marie Ampere immediately addressed[4] as the first electrodynamic law of modernity. From this there followed immediately the construction of the first pointer telegraph by Ampere himself. The self-similar experiment with the uncertainty of a self-transcribing nature is, however, also the reason why photography was brought into the world by the two leading scientific academies of Europe in 1839—in Paris, Daguerre's invention, presented by Arago; and in London, shortly thereafter so as not to be shown up, Talbot's invention, presented by Michael Faraday. For both the Paris Academy and the Royal Society in London, photography is above all a scientific medium, something since then all too often forgotten due to an overemphasis on culture and art.

This inner epistemological coupling of photography and telegraphy explains how the Scottish clockmaker and instrument builder Alexander Bain was already able in 1843, thus simultaneously with Morse's telegraph in the United States, to exhibit the first machine for transmission of images. Telegraphy was from the beginning not only a matter of writing and Morse code. Charles Wheatstone, the founder of the English telegraph system, had also already developed such a patent in 1940.

Here is—once more from the early years of telegraphy—the image telegraph of Frederick Bakewell from 1848. Its principle is the burning-in of a picture with nonconducting ink, which is then electromagnetically scanned in order to appear on the receiver's end as a stamped image.

The whole was perfected in the 1860s by the pan-telegraph of Giovanni Caselli, with which handwritten texts, written with nonconducting ink, could be transmitted, along with other images etched in copper.

Among the heirs of the uncertainty of Lichtenberg's figures in the knowledge of Romantic philosophy of nature, we may also count, of course, the connection between light and electricity. That which remained still unclear in Lichtenberg's figures was out of the question for photography. That photography was obviously due to a chemical light effect had been described by the academies in Paris und London. However, one had no explanation for the brute fact of it, as the secretary Arago had to admit.

Edmond Becquerel's discovery resulted inexorably from these self-similar, uncertain experiments with light and electricity that had been initiated by the Romantic philosophy of nature. His discovery of 1839 was that light causes a photovoltaic reaction. The incursion of light into a chemical flow cell brings forth a flowing current, which is very weak and thus unusable. But it belonged henceforth to the formatted knowledge of the community of researchers. It is the same effect that today converts light into electrical energy on our roofs, in the form of solar cells.

This all still belongs to that first large epistemological caesura to which TV owes its existence. TV arises, with regard to this first enabling caesura, from the coupling of uncertainty about the connection of light, self-ciphering of nature, and electricity. For the uncertainty about the origin of electrical currents in Becquerel's electrolytic apparatus was not greater than that in the electricity-theoretical origin of Lichtenberg's figures in 1777. Today it has been established in the history of science that the development of the theory of electricity did not arise from the certainties offered by the classical theories of Newton or analytical mechanics, but rather from the great and even catastrophic uncertainties occurring with the application of the medium of telegraphy. At the end of the 1860s, England had numerous oceanic cables at its disposal, crossing over the entire world, and could thus base its financial power and the Commonwealth-Empire upon this. These same ocean cables, however, functioned rather badly in a technical sense. Measured by today's standards, they were more or less dysfunctional. They operated with signal errors that could not be explained theoretically. Signals either disappeared or only arrived in weak and distorted form. The search for the causes of these defects—once again an operation in the realm of uncertainty—were what helped Maxwell's theory of electricity to its breakthrough at the end of the century. Generations of electricians and physicists were occupied with looking for the cause of bad transmissions from 1850 on, and one of them found a further building block that would be essential for the development of television—namely, selenium.

Selenium was first described in 1873 as a semiconductive metal that conducts a current especially well when sun shines on it and particularly badly when stored in the dark. Werner von Siemens developed a photometer from this, and we can imagine what significance this element would have for television.

The last and most significant element found through experimental research in the extremely uncertain context of light and electricity came from Heinrich Hertz. While systematically exploring a chance discovery that led finally to the discovery of radio waves, Hertz discovered that sparks discharged at the tip of a metal rod were especially strong and bright when ultraviolet light fell on them. Hertz could not explain this effect, but he described beyond all doubt how it occurred in his first publication of 1887. It was the experimental working out of this effect that would lead to the establishment of the completely electronic television in 1939. At first, however, smaller devices were built, called photocells, which technically exploited the effect. If light falls on the light-sensitive metal on the right side of the small glass bulb, a measurable current arises, which can be conducted out through the wire circle on the left side.

Second Caesura: Telephony and Mechanical TV

The second caesura to which television is due has a name from the history of technology: the "mechanical television." Mechanical television makes its entry onstage (via the elements just described) only when the telephone begins to conquer the world, after 1876 and no earlier.

Alexander Graham Bell was, however, anything but a physicist, as we should remember; instead he was an autodidactic researcher of deaf-mutes and a language teacher. The experimental history of the telephone is thus one of the most curious and improbable developmental narratives in the field of scientific uncertainty that the nineteenth century can offer us. Whoever wants to find out more precisely how extrascientific knowledge, confusions, and gross misunderstandings force their way into science and allow a scientific outsider the most improbable thing, namely the discovery of the telephone, should read Bell's lab books. When Bell presented his completed discovery, however, he thereby proved the theory of electricity that had previously been at once the most exotic and also the sole correct one, without himself having the slightest inking of it: the theory of James Clerk Maxwell. Only twelve years later did Heinrich Hertz prove the experimental validity of this theory. Shortly before his death, none other than Maxwell himself honored the teacher Bell in a great lecture. Bell suddenly became even more famous than Maxwell himself had been during his lifetime.

With the contingent "invention" of the Bell telephone, extrascientific knowledge (press articles, "public opinions") decisively intervened via the person of the inventor into the science and technology of the nineteenth century. After tele-hearing and tele-speech, which Bell introduced to physics and the history of technology, television became a relevant motivation and reason for research in a general cultural sense,

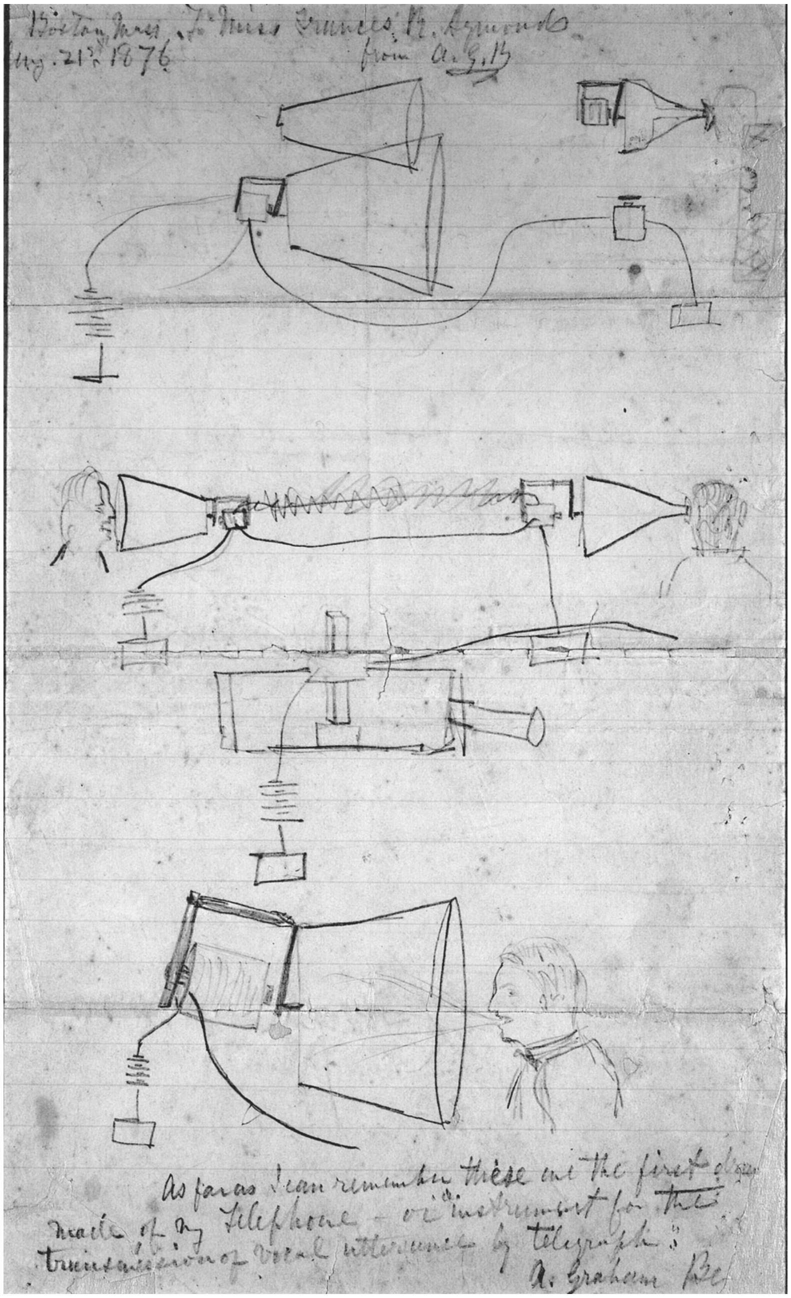

Figure 1.2. Early drawing of the telephone by Alexander Graham Bell, 1876. Image courtesy of the Library of Congress, Manuscript Division.

as we can see from Paul Nipkow's patent. Television became relevant in the sense of the construction of a telephone-like apparatus.

> Since the task of transmitting tones and even articulated sounds across vast distances has been solved in such an astonishingly simple way by Reis, Bell and other distinguished researchers, certain inventively gifted men have set themselves a further task well suited to arouse the same interest. It is the task of creating a device which, just as the telephone does for the ear, gives the eye the possibility of perceiving things far outside its natural sphere of activity. (Nipkow 1885)

To this end, he made use of "familiar things," such as perforated discs, which were only too familiar from acoustical physics since Seebeck's overtone experiments of 1841. Nipkow literally turned these acoustic discs around into the optical domain. The same device that was once built for hearing siren tones was now meant to enable the electromagnetic viewing of images.

Spiral-shaped holes are made on the Nipkow disc, rotating in front of the object to be transmitted, which in this way is sampled, hole for hole. Behind each hole that lets through a brief light pulse, selenium is mounted, which produces a current proportional to the strength of light, and then produced on the receiver's end by a light bulb. This receiving bulb must itself stand behind a perforated disc that revolves synchronously with that of the transmitter. Mechanical television, reckoned from its beginnings in 1884, remained for some fifty years—until the mid-1930s—the dominant paradigm of development. But even before World War I, scientists and engineers had described the instability of this undertaking clearly enough.

In order to reach a resolution that would produce a moving image sufficiently coherent for the human eye, the English electrical engineer Alan Archibald Campbell Swinton calculated in 1908 that one would need 160,000 synchronous sampling operations per second. Yet with even the best application of mechanical techniques, 160,000 sampling and reproductive operations could never be exactly synchronized via means such as rotating perforated irises and carefully worked out mirror reflex constructions. However, the mechanical epistemologies prevalent in England and Germany, and deeply ingrained in the minds of hundreds of thousands of engineers and scientists, were for long decades deaf to these objections. In the prevalent thinking about mechanics and ontology, Europeans continued for another quarter century to understand television as a pendant to telephony, trying to force their way towards it with mechanical means.

The Third Image: A Hidden Epistemological Paradox

This dead end was already corrected one year later, on the occasion of the Berlin Olympics, by the import of an American receiving tube called the Iconoscope. This latter had no mechanical parts. It constructed, purely electronically, a "third" image within the receiving tube of the TV camera. With this, we have arrived at the third and decisive caesura that enables TV in its present form. Its object is nonobjectivity, pure and simple.

We are speaking of the electron, that subatomic particle J. J. Thomson had discovered in 1897 in a cathode ray tube of the same type that Ferdinand Braun had presented to the world in Karlsruhe, at the same time. With this combination of measurable invisibility and an immeasurable effect of visibility, which is bound up with a logic and phenomenology of the non-unobservable, television arises. As concerns the electron, it was true from the day of its discovery that one could measure it and weigh it (as Thomson already did), and determine its charge, therefore its energy, along with its place, via the traces it left behind. But one cannot see the electron in question when measuring it. Its appearance is, according to our contemporary knowledge, a quantum effect, dependent on a probability function. It is certainly ironic that in the same year, in two different tubes in different places in the world, the electron's measurable existence and, parallel to this, its directable visibility became a part of our knowledge. One can only see the electron if one is not measuring it, and can thus only determine one of its local qualities. It was with the electron that Heisenberg proposed his uncertainty principle. This latter states that in the measuring process of the electron, at least one quality must remain undefined. For television and its technical arisal, the uncertainty principle plays no role. But for the epistemology of the particles, on the interdependency of which it is based, that principle indeed plays a part. Braun's invention described the cathode ray tube as a screen, a describable and paintable surface, which produces as its effect a cathode ray that is free of inertia and magnetically directable. With this, we still watch television today. Braun had put fluorescent materials on the inner right edge of the bulb that briefly made the discharge ray of the cathode tube glow. Thomson's discovery had the same tube as Braun's, but not prepared for seeing, rather for measuring. There is nothing to see here.

Thomson measured the energy of the ray that he sent through the tube and determined through its various angles of deflection the energy and mass of the particles of which it consisted. It was a brilliant experiment, but within the knowledge of the science of which Thomson was the child, it was only consequential and logically determined. It was only the result of this experiment that made an epistemological world first crumble and then collapse. For from now on, since 1897, seeing meant measuring, and the ontology of the electric meant that either the measurable exists, or nothing at all. Around the turn of the century, we might say, a constructed world began to dawn. It is in the process of losing its basis in being, if in an important part of its knowledge seeing is replaced by measuring (and without alternative)—or, in simple English, if the world disappears in favor of a construction of the world through observation. This is not to maintain that constructivism is established in intellectual history around 1900. Precisely through not asserting this, we can point to the unimaginably huge and destructive forces in the intellectual and cultural world of the first half of the twentieth century. Eccentricity, madness, suffering from alienation, the excesses of death and destruction, but also that otherworldly force of the avant-garde in art—this may be explained by the fact that from 1900 on, there is a rupture in epistemology that remained unremarked for decades, up to the 1950s, although it is based already in this rupture in Thomson's experiment.

Thomson introduced an energetically exactly measurable and almost inertia-free particle into the world of science and technology around 1900. This particle was nonetheless easily manipulable according to traditional laws of electrical currents, while remaining invisible, and interacting with light—the matter of the visible—in the most exquisite fashion. A hectic activity arose among the physicists who were concerned with photographic cells. Could light actually produce electrons from metals? Yes, it could, as Philipp Lenard, the assistant to Heinrich Hertz, already definitely proved in 1910. Before World War I, the two fundamental empirical laws of photoelectrics were already founded on his measurements, which were in no way inferior to Thomson's:

1. The number of electrons per temporal unit that stream out of a photoelectric surface is proportional to the intensity of light.
2. The energy, i.e., speed of the electrons given off by a photoelectric surface is not dependent on light intensity, but rather on its frequency, thus on its color.

With these two laws, electronic television could be realized. We owe the medium of 1939 to a Russian who had immigrated to the United Staets, Vladimir Kozmich Zworykin.[5] Zworykin, a deeply educated physicist from the school of Thomson and Lenard, had on the basis of both of Lenard's laws already written a patent in 1923 that would make television possible. It is the patent for the third image, an image stored between the others and constructed from electrons, which must arise in order that distant light become televisual light. If one proceeds determinedly enough to construct the visible from the invisible, the structure of Zworykin's camera is quickly understood. Light rays from an image fall through a lens onto a very fine mosaic of photocells. There are roughly 370,000 small cells on this mosaic, to be precise: silver drops containing cesium. These droplets react to light by discharging electrons (according to Lenard's laws), and they flow over the signal plate. Now the cathode ray tube comes into play, set up at an open angle to the plate of droplets. In precisely two seconds, it sweeps exactly 525 times over the plate of droplets, from left to right, with millimeter precision, and leads the electron charge they had lost from the light back to the droplets with a deft switching. Proportional to this, the discharged electrons flow out of the signal plate in the form of definite quantities of charge. On the receiver end, on the screen—that is, a Braun tube—a cathode ray sweeps, completely synchronous and at the same interval [*Takt*], 525 times every two seconds over the screen, line by line. In doing so, this ray is regulated with utmost precision by the outflowing charges on the camera's signal plate.

With this we have a televisual image based on the construction of a third, unseen image. Period. The World Exposition is opened. Contrast and sharpness may still be improved. Quantum effects play no role in any of this. In Zworykin's books, which explain his invention in detail for anyone else to reconstruct, there is no mention of quantum mathematics. He had no need for them. Television does not need atomic physics. One need understand nothing of the double-slit experiment to understand television. One also need understand nothing of the uncertainty principle, nothing of Einstein, Bose, Fermi, or Dirac, in order to grasp how television in its epistemology radically calculates the electronic down to the electric, addresses electron flows as quantities of charge, and thereby gets by with nineteenth-century mathematics. This is the secret of its rapid success, for the armies of technicians around 1940, who had all been educated according the state of knowledge of telegraphic electricity from the nineteenth century, did not have to relearn in order to apply the characteristics of TV in hundreds of factories and workshops and to build televisions and cameras on an assembly line.

And yet there remains a break in the epistemology of the electronic. One can apply the mutual reactions of light photons and electrons and their reconversion into light impulses on the fluorescent screen without the slightest knowledge of the phenomenological lag that remains. This is the scandal of the epistemology of the electronic in the twentieth century. It permits and enables technique of medial image construction and thereby hides its epistemological impact at the same time. If one asks more closely, persistently, and fundamentally than is necessary for the foreground technical function of TV, why and exactly how light photons interact with silver electrons that are mixed with cesium atoms, then there is no getting around quantum mechanics and their foundation in quantum physics. But then one finds oneself epistemologically already amid the virulent argument between analytic philosophy and philosophy of science that still goes on today, as Richard Rorty (2000) resumed it in his speech for the hundredth birthday of Gadamer. The "techies," like Saul Kripke and David Lewis, view electrons and elementary particles as ontologically given, as irrefutable facts in nature, which are not given *de dicto,* but rather *de re.*[6] The "fuzzies," like David Putnam, Ian Hacking, Bruno Latour, and others, believe that the definition of elementary particles is a construction of observation and designation, to which one could add others that might be different, but equally valid. It is beyond dispute that the descriptions we now have of the electron are the only successful ones (in the sense of technical construction). The "techies" among American philosophers are thus downright enthusiastic about these successes and their consequences. They would like to enchant us with cosmologies of the Big Bang, or trouble us with possible conclusions as to really existing parallel universes. The "fuzzies," among them Rorty himself, practice a looser nominalism and look for a more balanced discourse, for anti-metaphysical consensus and linguistic solidarity.

In media epistemological terms, there are two consequences to be drawn from the considerations presented here. First, we may state again that the televisual image, as it arose in 1939, was based on the technical construction of a third image. Television's third image is a pure construction of electrical effects and thus no continuation of the image of the camera obscura. The light falling into the camera and the image that results no longer come out, nor do they cast any illumination or glow (in the sense of illumination) upon anything. What we see on the flickering screen of our sets is not that which enters the camera. It is rather the sampling and electrical measuring of an intermediary image, an invisible storage, a technical icon—to formulate it precisely, television operates as an electronic iconoscope. The constructors of this technology [*Technik*] turned *expressis verbis* away from the preceding attempts at mechanical television that still depended on the mechanistic idea of reproducing light at its source directly at the place of the distant goal. Zworykin always insisted, on the contrary, that his iconoscopic television was not mechanical, and that there could be no talk of a direct transmission of light and images. Zworykin's nonmechanical television, however, still pretends very convincingly that it is mechanical.

TV is the construction of a third image from electronic effects. These are due to a knowledge and an epistemology that is never troubled by the questions—paradoxical in a quantum-mechanical sense—of how the reciprocal effects between light photons and electrically charged particles might be described physically or even ontologically. Television is a technology that integrates a new knowledge about the fundamental constructedness of the world, but only by overlaying it with the application of an old knowledge about the natural continuity of reality.

Thus, in the case of TV, we have, in terms of a history of knowledge, to do with an overlaying that has a distortion as its consequence. For a long time, people thought they were transmitting a reality, since the invention is assembled by means of an epistemology that is completely satisfied by an idea of the continuity of world and nature. In fact, however, television is from its beginnings a construction and can thus only be understood by means of constructivist theories of perception and communication. The present remarks should contribute to a deconstruction of these, and to a keeping open of the folds of their discourses.

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Notes

Translated by Larson Powell.

1. Translator's note: the concept of entropy, originally from thermodynamics, was introduced into information theory by Claude Shannon; Hagen is however applying it

to the evolution of science. (Entropy has also been used as a sociological concept: see Bailey 1990.) It is typical of Hagen's version of media history that all three of these meanings are in play here.

2. Translator's note: compare the discussion of Chladni in Benjamin's *Ursprung des deutschen Trauerspiels* (1980).
3. Translator's note: Self-similarity (*Selbstähnlichkeit*) is the property of an object that preserves its structure even in expanded size; it is most familiar from fractal geometry (see Mandelbrot 1982).
4. Translator's note: the author intends "address" in the technical sense developed by media theory, meaning the destination of a discovery within scientific discourse (on this concept, see Andriopoulos, Schabacher, and Schumacher 2001). For media theory, the address (*Anschrift*) of a medium determines its content.
5. Translator's note: on Zworykin, see Abramson 1995.
6. Translator's note: for a discussion of this, see Soames 2015.