Oskar Blumtritt

The flying-spot scanner, Manfred von Ardenne and the telecinema

'I never *act*; I am always slightly surprised by what I do.'

Bruno Latour[1]

Introduction

If you were to visit the Deutsches Museum in Munich, Germany, and you were to enter the room on the third floor labelled 'Telecommunications', you would find a section dedicated to 'Television' and within it a subsection called 'Electromechanical and Electronic Television Systems' (Colour plate 7). Among the objects, texts, graphics, pictures, demonstrations and videos presented, the text on a label behind an assembly of six objects starts with the words: 'Experimental System of Fully Electronic Image Transmission/ Manfred von Ardenne, Berlin; 1931'. Of course, you could also look at (some of) the six objects without reading any of the labels mentioned.

Let us assume that you are interested in the history of television. What would you see, feel and learn if you looked at (some of) these objects? You might, for instance, be able to investigate some details, or to relate the entire assembly to the objects, texts, graphics, pictures, demonstrations and videos around it. But would it not have been more appropriate to go to the library or to the archives to learn more about the history of television? Or would you be impressed by their (assumed) authenticity and even design, or by the (assumed) fact that these objects are (technical) artefacts, i.e. human-made things, made to fulfil certain functions with the intention to make life more comfortable or more interesting? In other words, would the objects have any meaning to you and could they have meanings themselves; are they part of our history or part of a technological evolution, and do they have their own history?

This quite arbitrary series of assumptions and questions could be extended nearly ad infinitum. The aim of this paper is to bring some order to this sort of question. In doing so, it will concentrate on the role that artefacts can play in history and in historiography. Whereas historians are normally obliged to tell stories and therefore convey meaning with language, historically trained curators in a museum possess additional opportunities, such as artefacts, to deal with historical pertinence. So the main issue of this paper can be circumscribed as partaking in a historical reflection on the relations between humans and artefacts.

Some historiographical considerations

Historians rely on materials that they have to analyse and legitimatise as historical sources. Therefore they try to investigate the authenticity of the materials looked at and they use certain methods to bring these materials into a specific order. In writing about their investigations and analyses they ultimately aim both to disclose and to create meaning. However, the methods (including the terminology) as well as the choice of materials depend on accepted worldviews and on accepted scientific rules. But where do they come from? Why and how do they change? A historical work that claims to be a scientific one, that is, a reflexive one, should also ask these questions.

In the last 40 years or so, historians have become used to adapting ways of thinking that originated in neighbouring disciplines such as anthropology, sociology and archaeology.[2] However, in dealing with the questions of 'reality', such as the meaning of artefacts, environment, etc., historians are still troubled by the dominance of a language-oriented philosophy. In order to overcome some of the problems inherent in historical thinking and writing I would like to take up some of the ideas which the philosopher, anthropologist and sociologist Bruno Latour has developed over the last 15 years.[3] Thereby I intend to concentrate on topics that are related to the question of how a historian might be able to deal with artefacts.

In reflecting on the modern worldview through examples of scientific activities, Bruno Latour elaborates on what he calls the 'modern paradox':[4] the distinction between nature and society – or between object and subject – has successively become an incommensurability in the modern philosophical work of purification.[5] Where 'modern' historians are concerned, I would like to specify that this kind of work has led us to a loss of reality, because, as writing scholars, we have been imprisoned in a mental construct, surrounded by walls consisting of dichotomies such as subjects and objects, epistemology and ontology, mind and matter, humanities and natural sciences, and so on. The socio-constructive movement in sociology and the deconstructivist movement in philosophy have made great efforts in recent years to bridge the gap between construction and reality. But they could not free us because they have remained in a semiotic world and lack any connections with the material world.

Let me present just one example in order to show what I mean by this lack of reality in the field under discussion, i.e. in technohistorical studies. In their attempt to develop concepts of sociotechnical change, social constructivists such as Wiebe Bijker[6] claim to investigate the history of artefacts – seen as the hard contents of technology – by asking two questions: In what way does technology constitute society? and In what way does society constitute technology? Their analysis on a broad empirical basis leads them to a generalisation that suggests the following approach: first one has to find so-called relevant social

groups who attach to artefacts different meanings because of their different interests. The discussion on the respective meanings of the artefacts takes place in a technological framework in which the groups eventually establish a group of meanings related to the artefacts. The process of the establishment of meanings is finally interpreted as a form of 'power'. In this technological framework, the artefacts are reduced to entities that play a certain role in the process mentioned. For instance, it will be asked whether they can be seen as exemplary artefacts or not. Hence it is unimportant whether the technology is successful or not – a pattern normally used in the historiography of technology. Instead one has to follow 'interpretative flexibility'.

This heuristic approach is – as already mentioned – the outcome of a generalisation of the insights developed in microstudies. Taking a closer look at these microstudies, I have gained the impression that concepts such as 'relevant social groups', 'interpretative flexibility', 'technological frame' and 'power' were elaborated and valued differently in each of the microstudies. However, the heuristic approach is eclectically overlapped in different ways by inductive reasoning and hermeneutic approaches. Furthermore, in the practical aim of the social constructivists to explain conclusively processes of political decision-making, the artefacts disappear altogether. In other words, the artefacts – although they are claimed to be the starting point of the investigations and the 'hard content' of technology – take on a 'contextual' status for social groups and are called 'sociotechnical ensembles'. Thus a social constructivist hardly has to look at artefacts themselves; it is sufficient to look at texts, i.e. at texts in which some properties of technical artefacts or devices have gained some significance.

I think that these considerations fit the more general statements which Bruno Latour derived from his study of the development of the so-called social-studies-of-sciences movement.[7] The weakening of the dualism of nature and society by dividing each of them into 'hard' and 'soft' parts does not help to deconstruct it. And terms such as 'content' and 'context' belong only to one of the two sides. Being sympathetic with the intentions of the initiators of the movement just mentioned, Latour states: 'It is the glory of the Edinburgh school of social studies of science to have attempted a forbidden crossover. [...] They used the critical repertoire that was reserved for the "soft" parts of the nature to debunk the "harder" part, the sciences themselves!'[8] But: 'What had started as a "social" study of science could not succeed, of course, and this is why it lasted only a split second – just long enough to reveal the terrible flaws of dualism.'[9] In order to overcome the dualism between nature and society, Bruno Latour has to go one step further: one has to accept that in the so-called modern age there happened necessarily a growing proliferation of hybrids (that is humans *and* non-humans) which has to be seen as the non-modern dimension, a 'mediation'

alongside the modern 'purification'.[10] Instead of speaking of objects (or related terms) we should use the term 'quasi-objects'.[11]

On a more general level Latour suggests the notion of a 'factish', a combination of 'fact' and 'fetish'.[12] He emphasises that for the factish it 'is *because* it is constructed that it is so very real, so autonomous, so independent of our own hands.'[13] So humans and non-humans 'happen' to each other; there are no agents and no things in an outer world that have to be mastered. But there are events, where humans and non-humans have a history.[14] Latour adds that the use of the related terms humans and non-humans is not an attempt to overcome the philosophical–abstract subject–object dichotomy, but an attempt to bypass this dichotomy by looking at the praxis of collectives. So he opens a field of historical reflection where humans and non-humans can be seen as agents and as non-agents, respectively. The question of the meaning of the meaning – for instance, as treated so intensively by Jacques Derrida from the mind side, the words side – now becomes as obsolete as speaking about 'contexts', where the definitions and boundaries of 'texts' and 'contexts' never became clear. The things themselves have meanings and histories insofar as they refer to a social history of things as well as to a 'thingy' history of humans.[15] The methodological approach will therefore become more like the well-known network analysis.[16]

Because my aim here is not to deal with the possible philosophical implications on an abstract level, I will now switch to an historical microstudy in order to obtain a more concrete historical basis. I will return to the considerations presented so far in the conclusion.

The flying-spot scanner in the museum

How does the so-called experimental fully electronic television system of Manfred von Ardenne 'happen' to the visitors of the telecommunications exhibit in the Deutsches Museum? As already stated, visitors are confronted with some devices in the lower right-hand corner of a display case, flanked by a picture of a man and a text label, along with some other devices, texts, pictures and graphics in the same display case (Colour plate 8). Most visitors – insofar as they are non-professionals in both technology and history, but curious to learn something new – believe that these devices must have some importance, some meaning, because they have found their way into a museum of masterpieces of technology. In this way, the devices represent the fetishes of so-called technological progress and convey the myth of an ever-changing and improving modern world by the efforts of the *homo faber*.[17] And the museum designer has tried to underline the still undefined importance of the devices by displaying them attractively, emphasising their aesthetic values. But the wooden material combined with the glass tubes also evokes nostalgic feelings and the unfamiliar shape (to present-day eyes) of

this unique[18] ensemble of technical devices is capable of increasing the inquisitiveness of the visitor.

Mieke Bal, who deals with the discursive analysis of museums and displays, states: 'The thing on display comes to stand for something else, the statement about it. It comes to *mean*. The thing recedes into invisibility as its sign status takes precedence to make the statement. [...] The very fact of exposing the object – presenting it while informing about it – impels the subject to connect the "present" of the objects to the "past" of their making, functioning, and meaning. This is one of the levels on which exposition is narrative.'[19] Finally, these narratives tend to follow 'myth models'.[20] In other words, the relationship of 'thing' and 'subject' dissolves the object–subject dichotomy, at least partly, into a 'multimedialized' concept of discourse by introducing a third entity, the authority of the museum statement on the object.[21] In this respect, the visitor–device distinction, which seemed to have established itself, will be resolved in quasi-subjects that Bal just calls 'persons'.

With respect to the narrative aspect, one also has to realise that some of the visitors will even want to possess these devices, i.e. they will want to have them in their own collection. As Jean Baudrillard has shown, those devices regarded as mere 'objects' can arouse passion. Expressed in the traditional object–subject distinction, Baudrillard states that an object that is divested of its functions (that is, it does not direct people back to the world) refers back to a subject and constitutes a system of the personal microcosm.[22] Susan Stewart describes this behaviour as 'the social disease of nostalgia'.[23] She argues that the relationship of narratives to their objects comes into play: 'Narrative is seen [...] as a structure of desire, a structure that both invents and distances its object and thereby inscribes again and again the gap between signifier and signified that is the place of generation for the symbolic.' Latour's concept might help to cure this 'modern' disease.

The considerations made so far should illustrate that there are various forms of affections people may experience in dealing differently with things. And they lay bare, in my opinion, some of the shortcomings of the 'philosophems' that have been handed down. One of the 'reality problems', which was mentioned just briefly, is that of the functioning, i.e. the instrumentality of devices. It is still unsolved. A visitor cannot see this instrumentality immediately. On the contrary, the ensemble of devices is non-functional, the devices are not even connected to each other. And the display case produces an additional distance. A visitor might only suspect that a device presented in a technical museum will have been produced to execute some functions – and the knobs on some of the devices will encourage his or her supposition.

Allow me now to switch from the object–visitor relationship to the object–curator relationship in order to make my arguments more

straightforward. A curator has, of course, to legitimate why he or she directs his or her interest to a specific object and has to explain how and why it has been investigated, documented, collected, displayed and so on. The curator in a technical museum is normally trained in technology as well as in history and it is his or her task to promote the public understanding of technology as well as to preserve material heritage. Therefore, he or she is interrelated with different scientific communities, with various groups of variable commercial and political interests, with visitors having divergent interests and leanings, and so on. In other words, the curator seems to be in the ideal position to experience and to reflect on the various aspects of the human–non-human relationships.

Despite these complex connections, the curator has to deal with the initially isolated task of ascertaining what constitutes the so-called experimental fully electronic television system of Manfred von Ardenne. What the curator sees first, as already mentioned, can be described as a conglomeration of different materials of varying shapes, which is supposed to have functioned in a specific way. And he or she will believe – at least for the moment – that it did function in this way, and will have a closer look at the ensemble from an engineering point of view. When considering the glass tube with the white screen, one can surmise that the tube is able to generate a cathode ray, which is directed to a fluorescent screen, where it can produce a light spot. Horizontal and vertical deflecting plates make it possible for the cathode ray to be led across the entire screen. If one looks at the glass tube with the yellow screen, one will find a similar construction; only the material of the screen seems to be different. The wooden cases with the control and adjusting knobs contain valve circuits, which can be analysed as a mains connection unit and two sawtooth generators with different frequencies. One can also identify a device that is part of a cine projector and a black metal box containing a photoelectric cell and a circuit with an amplifier valve.

A thorough historical reconstruction would require that the curator restores these devices to a fully functioning condition and tests the possible operation modes of the ensemble. But this would be impossible in this case. For even a single test would destroy the respective device; and this contradicts the task of preserving the material culture. In addition, we would learn that the ensemble is not complete: the wiring is missing, as are the second mains connection unit, parts of the cine projector, the optical lens and parts of the photocell amplifier (Figure 1). Fortunately, we have sufficient evidence from photographs about the entire ensemble and from the literature about its operating principles and the problems and results the ensemble produced while operating. A critical analysis of this literature needs to refer, from time to time, to the devices themselves.

Figure 1 The complete photocell amplifier. (Deutsches Museum)

We can learn most from the writings Manfred von Ardenne produced during the development period or immediately afterwards.[24] His scheme of the ensemble (Figure 2) shows how it was supposed to operate.[25] On the transmitter side a mains connection unit feeds a cathode-ray tube which produces a light spot. The light goes through a lens and a transparent slide and finally meets the photoelectric cell. The cell converts the intensity of the light spot into an analogous electrical impulse that will be amplified and transferred to the cathode-ray tube on the receiver. According to the strength of the electrical impulse, the cathode ray in the receiver tube will produce a more or less intense light spot on the screen. The two sawtooth generators (horizontal sweep unit and frame sweep unit) connected in

Figure 2 Scheme of the experimental set: Bildkippgerät (frame sweep unit), Zeilenkippgerät (horizontal sweep unit), Normales Netzgerät (standard mains connection unit), Sender (transmitter), Diapositiv (slide), Zelle (photocell), Photozellenverstärker (photocell amplifier), Empfänger (receiver). (Deutsches Museum)

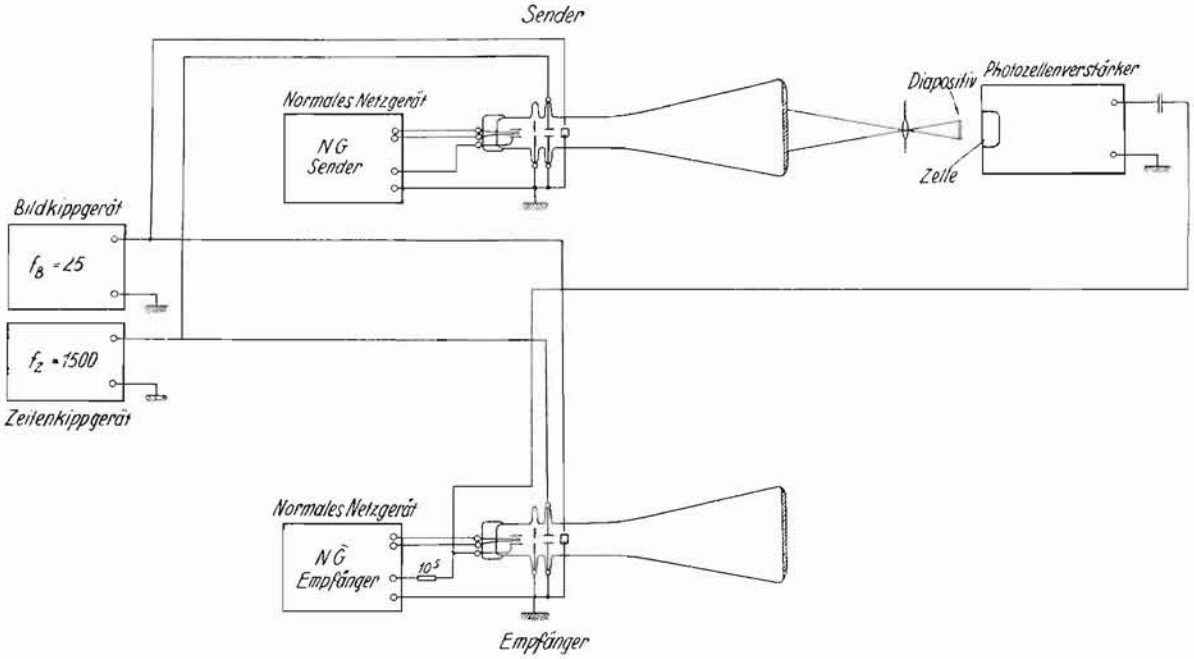


Abb. 1. Prinzipschaltung der Versuchsanordnung

parallel to the deflection plates of the tubes will lead both cathode rays synchronously over the screen, 25 times each second.

We are also dealing with books that contain texts, pictures and graphics. And they claim to have an author, Manfred von Ardenne, just as the ensemble claims to have a designer, also Manfred von Ardenne. But the abstract investigation of the functionality of the ensemble does not lead us much further. To reflect on the task of the curator and – more generally – on the history of things, we should now consider the 'thingy' history of Manfred von Ardenne.

Manfred von Ardenne and his devices

How did Manfred von Ardenne happen to construct, deal with, use and write about these devices and the entire 'system'? And how did these kinds of devices and 'systems' occur in the life of Manfred von Ardenne? A few biographical notes might help us approach an answer to this set of questions.

Manfred von Ardenne[26] was born in Hamburg in 1907, the first child of Egmont Baron von Ardenne and Adela Baronin von Ardenne (née Mutzenbecher). This upper-middle-class family of the Wilhelminian Empire and the Weimar Republic apparently lived a traditional German humanistic lifestyle.[27] Manfred's father had a respected position first as an officer and then in the government in Berlin, and he had some good connections with the best of Germany's military, industrial, scientific and political society. Manfred's mother looked after the household and took care of the five children. Manfred, as far as he could remember, was always keen to tinker with all sorts of things he found in the house, garden or elsewhere. When he lived in Berlin, his childlike interest in dealing with and investigating his material environment was supported by his parents and their friends as well as by a private teacher. After he entered the *Realgymnasium* at the age of 15 his interests were focused on physical and chemical experiments – at school, at home and at the Urania, the highly reputed institution to promote the public understanding of natural sciences and technology. The First World War seemed to have affected him only as far as it enlarged his experimental opportunities. He identified the postwar period with his growing fascination about wireless technology, combined with his experience of having only a limited budget to finance his comprehensive experiments. In December 1922 he made contact with Siegmund Loewe who ran a high-frequency laboratory. Loewe allowed him to participate in some of his experiments, and von Ardenne also learned how the former Telefunken engineer established his own company, Radiophon GmbH, founded on 2 January 1923. It is also worth noting that Loewe belonged to a circle which promoted public broadcasting and did his best to initiate what later became known as the radio boom.[28]

Because of his poor performance in the humanities, von Ardenne was urged to leave the *Realgymnasium* with the *Primareife*, i.e. a year before *Abitur*, the final school qualification. For about a year he worked as a trainee in a mechanical workshop to improve his practical skills. Alongside this, he continued his high-frequency experiments, held popular lectures, wrote two popular books on this topic[29] and applied for his first patents.[30] But he also learned that he needed more scientific skills to improve his experimental work. With the help of Graf von Arco and Walter Nernst he succeeded in being admitted to the University of Berlin. He studied there for two years, from 1925 to 1927. His now more scientific and systematically oriented work led him to construct a new valve type for an amplifier circuit.[31] It was the basis for a broadcast receiver that Loewe produced in his factory from 1926 on, of which about 1 million were eventually sold. Von Ardenne also developed components and circuits to achieve broadband amplification. These amplifiers were successful technically, but not commercially.

Nevertheless, the royalties von Ardenne received from the sale of broadcast receivers and other high-frequency equipment made him rather wealthy, and he decided to leave his parental home and establish a new laboratory. He bought a villa on a 5000-square-metre estate in Berlin-Lichterfelde in 1928. However, through this purchase he got into debt: the financial pressures of equipping and running his costly laboratory forced him to borrow money and come to an accommodation with the Loewe company[32] – to produce devices that were financially successful. He decided to concentrate the efforts of his '(Versuchs-)Laboratorium Manfred von Ardenne'[33] on cathode-ray oscillographs, that is, on widely used electronic measuring devices that still required highly sophisticated improvements. One of the first results was the construction of a 'melted down' (i.e. sealed) cathode-ray tube that operated at voltages over 1000 V. I should add that, at this time, von Ardenne employed about four collaborators: Walter Bruch, Kurt Schlesinger and Leonhard on a scientific or engineering basis and Emil Lorenz as glass-blower.[34] So at least the prototypes and demonstration models could be fabricated in the laboratory itself (Figures 3–5).

Successful work on oscillographs, as well as the failure to convince industry and the German Post Office to support his broadband technologies, led von Ardenne to direct his efforts towards the field of electronic television. Loewe was also experimenting in this area and must have encouraged von Ardenne to cooperate. Coming back to the so-called experimental fully electronic television system, we see that the construction of the electrode system of the cathode-ray tube is an element in the presupposition of its functioning well. An appropriate fluorescence layer also had to be found in order that the light spot would be as small and sharp as possible; on the transmitter side

Figure 3 Advertisement (c. 1932) for cathode-ray tubes for measurement and television purposes, produced by the Leybold and von Ardenne company. (Deutsches Museum)

especially, the spot had to disappear as fast as possible (no afterglow, i.e. as little inertia as possible). The cathode-ray tube turned out to be a complex system of features that had to be traded off against one another. For instance, an improvement in light gain achieved by high anode voltage reduced the deflection sensitivity of the cathode ray.

These physical, chemical and technological problems led von Ardenne and his staff to participate in an international network of people dealing with related topics. However, because this network of people was his competition, he had to withhold information about his patentable achievements.[35] Von Ardenne had always tried hard

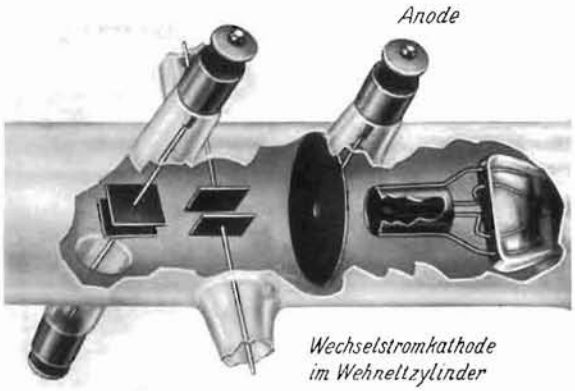


Figure 4 (above) Part of the sealed cathode-ray tube with cathode in a Wehnelt cylinder (responsible for control of the cathode ray), anode and deflection plates. (Deutsches Museum)

Figure 5 (right) Manfred von Ardenne (left), Emil Lorenz and a cathode-ray tube for television purposes, c. 1932. (Deutsches Museum)

to be accepted in the scientific community and therefore wanted to make public his inventions, even his future developmental goals. But this competition forced him to describe his results, in developing the oscillograph for example, in a rather odd way. He explained the properties of the fluorescent material used in detail, and said that, although one could achieve these properties principally by using calcium tungstate ($CaWO_4$), *he* had used a 'special material'.[36] In the patent regarding the 'process of scanning television images' of 1931 – held by the D S Loewe radio company – von Ardenne stated that for a suitable connection of the cathode-ray tube with the photocell amplifier one 'could' [sic] just use plaster.[37]

The problems with cathode-ray tubes at both the transmitting and receiving end were connected to a notion that in some circles in the 1920s took on symbolic meaning, concerning the terms 'electronic' and 'inertia'. Hartmut Petzold[38] has mapped out the development of the term 'electronics' from its origin in physics, in about 1904, to its progressive adoption in different technological fields, especially in communications engineering. I wish to add that this development meets the ideology of individual freedom and mobility that accompanied the technological as well as social development. Electronics – dealing with free electrons – is, at the very least, almost free of inertia; it symbolises the progress of society

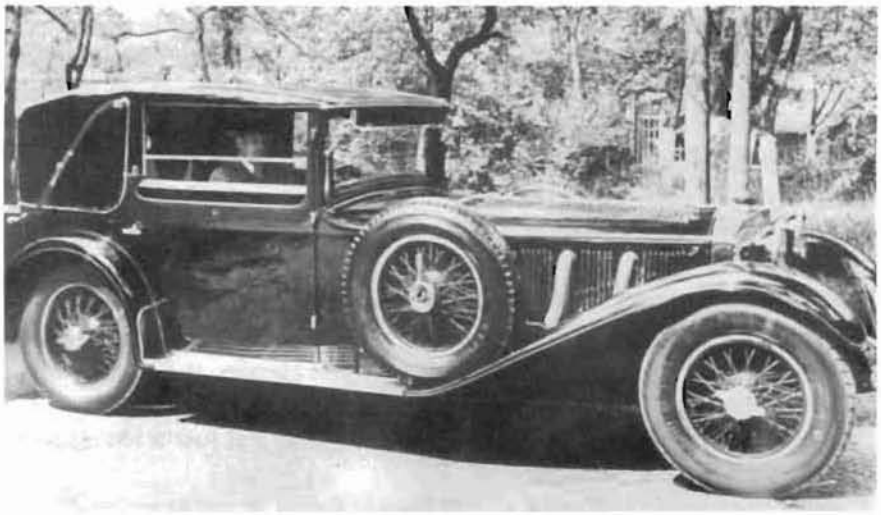


Figure 6 Manfred von Ardenne in his Mercedes-Benz SSK, 1930. About 35 examples of the SSK (Super-Sport-Kurz) car were built between 1929 and 1932. It had power of 125 kW (170 HP) and a maximum speed of 185 km/h (115 mph). (Deutsches Museum)

and the acceleration of technological progress and its mastering of nature. It also corresponds with what Joachim Radkau calls 'the age of nervousness'.[39] Let me try to show now how the ambitious Manfred von Ardenne fitted into these patterns (Figure 6).

As we already know, Manfred von Ardenne wanted and needed to direct all his efforts, skills and creativity towards obtaining pioneering technological results that had practical, commercial applications. At the same time, and this might be reminiscent of his humanistic-oriented parental home, he eagerly looked for acceptance not only in the scientific communities but also in politically influential society. An experimental research laboratory that he owned and led himself seemed to be his 'natural' place. His scientific reputation was partially earned by means of his production of highly sophisticated physical instruments, his oscillographs. Additionally, he asked (or even urged) highly reputed scientists and industrialists to meet him in his laboratory to discuss unsolved problems. His connection with and his dependence on the Loewe company made it seem reasonable to him to enter the new field of television. This also increased his integration in political circles, especially via the Imperial Post Office (Reichspostministerium) that was closely related to the German communications industry and to the German broadcasting corporations. The geopolitical implications of electrical and electronic communications brought additional tension into this both global and national enterprise.[40]

I do not want to argue that von Ardenne had been conscious of all these aspects at that time, but he definitely shared the commonly held belief in technological progress and individual freedom. Regarding his decision to enter the field of television, I should add that sound broadcasting had achieved a high profile, and was considered a valuable democratic instrument by 1930. Television, as an extension

of sound broadcasting, also promised to gain a considerable public reputation. What Joachim Radkau[41] maps out for the late nineteenth century is true for the 1920s too: the experience of technology was not only related to the status quo of technological development but also to the perspectives such a technology could bring. Hence we should look at the technologies that attempted to scan, transmit and reproduce moving pictures by means of electricity in those days.

Early television and telecinema

There exists extensive literature on the technical, economic and social development of television and broadcasting.[42] Herein, the telecinema, as it was then called, is mostly integrated into the emergence of television in the 1920s and 1930s. I want to pick out just a few aspects that illustrate my argument.

After the establishment of sound broadcasting in industrialised countries around 1925, the idea of developing broadcasting of moving images started to gain acceptance in engineering circles. The main technical problem, which arose and transcended then-known communications technologies such as telegraphy, telephony, sound broadcasting and picture telegraphy, was that a beam had to scan three-dimensional moving objects at very high speed, while another synchronised beam synthesised the picture of the object. In practical terms, very high speed meant very high frequencies and broad bandwidths. A reliable technology for dealing with these frequencies and bandwidths barely existed at that time. Only a few outstanding men, such as Manfred von Ardenne, as we have seen, tried to promote the idea of high-frequency and broadband transmission and to develop some appropriate devices. So the development of television sets proceeded in a different way. Most engineers were content to pick up and develop known optomechanical and electromechanical components that used only a small number of image lines. Electrically driven Nipkow discs, mirror wheels and, later, mirror screws (Figure 7) had their origins in experimental equipment for scanning. Photoelectric cells (Figure 8) on the transmitter side and discharge tubes on the receiving side converted light into electricity, and vice versa. Synchronisation required ingenious circuits that depended on the experience and creativity of the respective developer or inventor. Most of the televised images were displayed as silhouettes. What we now call low-density television was then referred to as mechanical television.

All these systems had their technical limits. For instance, increasing the number of lines by means of a mirror screw would only have accommodated a viewing distance too great for the eye to satisfactorily resolve detail.[43] But the attempt to improve each of the components of the so-called mechanical television system was exactly the way in which the German broadcasting and Post Office authorities supported

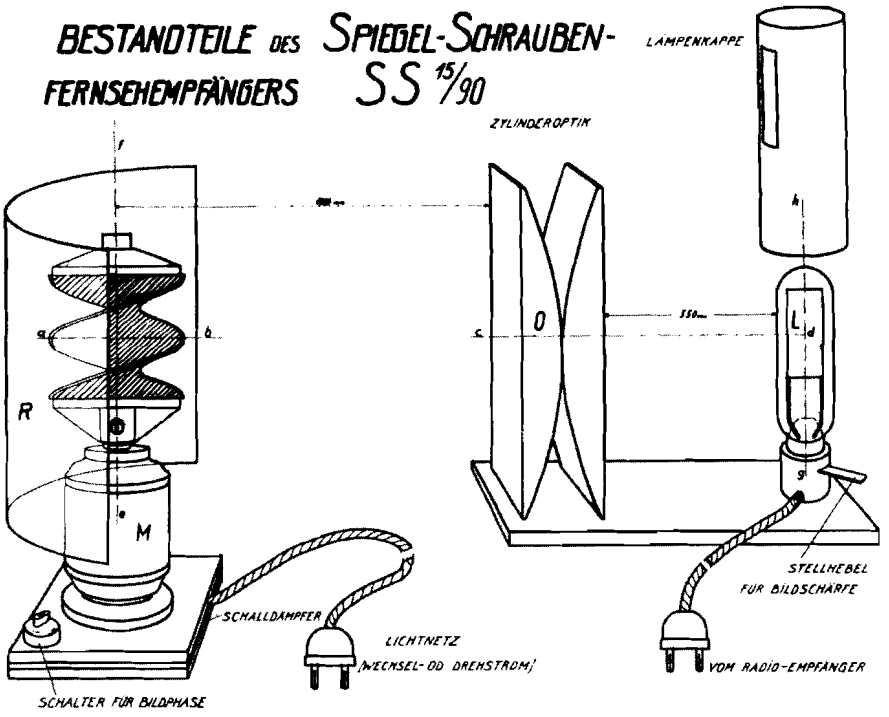


Figure 7 Parts of the mirror-screw television receiver SS 15/90 from Süddeutsche Telefon-Apparate-Kabel- u. Drahtwerke AG (TEKADE), 1932, operating at 15 images per second and 90 image lines. (Deutsches Museum)

the development of television.[44] They even went as far as adopting a (rather low) scanning standard in 1929:

- number of lines: 30, horizontally scanned
- number of pictures per second: 12.5
- aspect ratio (vertical/horizontal): 3:4.[45]

German industry and the Post Office kept an eye on the competition, especially in Britain and the United States, and therefore favoured a practical rather than a highly sophisticated television system, in the not too distant future. They presented their results from 1928 onwards to the public at the Funkausstellung (radio fair) in Berlin.[46] Siegmund Loewe and his company were also engaged in the development of television on a technical, commercial and political level. Among other things, Loewe held a share in Fernseh-AG, founded in 1929, which developed the mechanical system; but at the same time, he expected von Ardenne to produce some pioneering electronic components.[47]

During that time only a few engineers in different countries, but not in Germany, tried to solve the problems of picture transmission in a different way. On the transmitter side, these engineers attempted to store an entire picture in a camera tube and then scan it electronically. Best known were the principles of the image-dissector

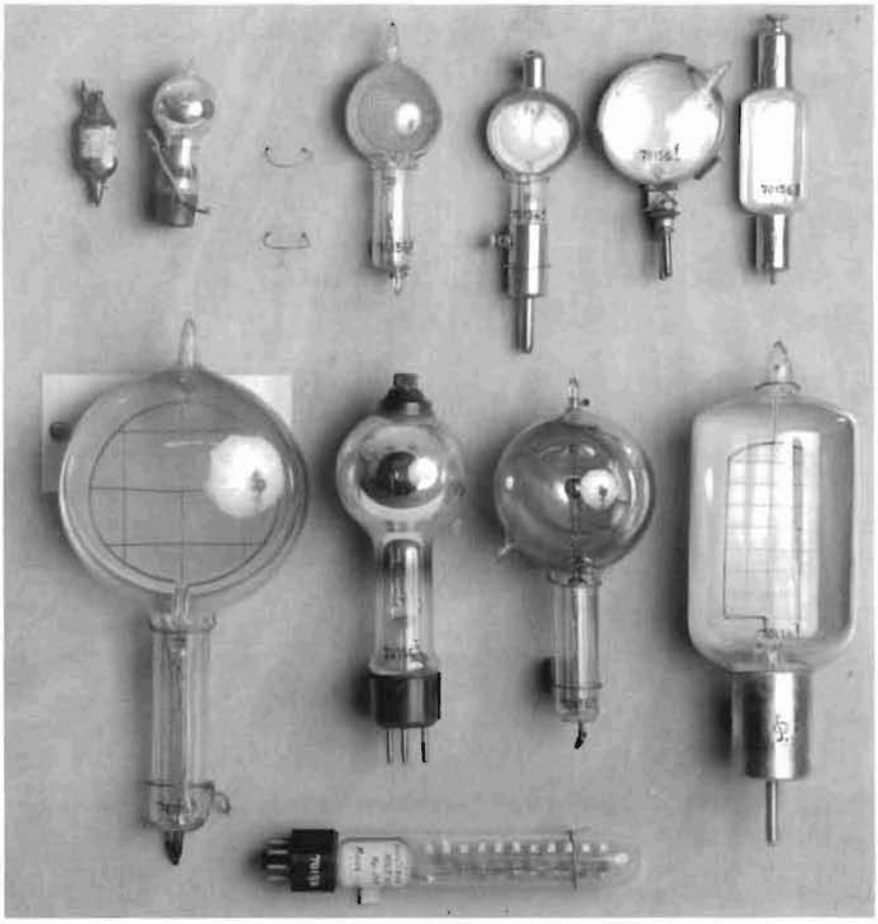


Figure 8 Assortment of photocells used for television purposes, 1930. (Deutsches Museum)

type of Farnsworth and the iconoscope of Zworykin, both from the United States; but these devices did not operate sufficiently well until the mid-1930s and were not presented in Germany until 1936.[48] In addition, a rather sceptical attitude towards rapid development of these electronic devices predominated in German industry and in the German Post Office in the early 1930s. Von Ardenne knew about all these developments, restrictions, assessments, etc. – for example from his international correspondence with scientists and engineers, such as Zworykin.[49] And he surely was aware that he and his small laboratory staff could not hope to gain the experience the others had – neither technically nor commercially.[50] But he also felt that he had to signal his presence in television developments and his ability to do pioneering work in this field.

His scanning, synchronising and synthesising ensemble was really an experimental set that he could put together in one hour.[51]

> Feverishly we [that is von Ardenne and Emil Lorenz] took from our stock two cathode-ray tubes, put together two apparatus for the production of

deflection voltage from the components of the low-frequency lab, prepared one of the wideband amplifiers, and borrowed from the optical lab a powerful lens and a low-inertia photocell.[52]

Of course, it took some time to stabilise and optimise the set – about two months.[53] But if you were to look inside the boxes containing the photoelectric cell or the frame-sweep (Colour plate 9) and line-sweep circuits they would give you, at first glance, the impression of an amateur radio set. However, a closer look, at the valves he used, for example, would convince you that von Ardenne had in fact used some of his highly sophisticated components. And the hand-written labels on most of the valves indicate that they date from his newest experiments in the field of high-frequency and broadband transmission.[54] The circuit he used for synchronisation, a connection in parallel, is simple but ingenious. However, it could only work on a laboratory scale with the transmitter and receiver connected directly by wires.

We have evidence from some contemporary witnesses that von Ardenne's system scanned, transmitted and reproduced images quite well.[55] But these assessments only relate to the use of transparent images, i.e. either slides or pictures from a cinema film. His attempts to televise three-dimensional objects did not produce good results. However, this hardly mattered, since all the television sets which were developed around 1930 had problems with live shooting. For instance, in 1929 the silent black-and-white film *Wochenende* (*Weekend*) was specifically made for the purpose of comparing different television sets. The film was used for scanning tests in the following years (Figure 9).[56]

Figure 9 Image from the film Wochenende, *photographed on von Ardenne's television receiver, 1931. (Deutsches Museum)*

The presentation of television at the Funkausstellung, which was devoted to celebrating technological progress, was not the success that industry and the postal authorities had wanted. The shadowy pictures which could be seen on the small screens could convince neither engineers nor the public – not even those who were well-meaning. Walter Bruch noted that, for example, the short-wave transmissions with an increased number of lines of 48 gave poor results because of echoes.[57] Generally speaking, a switch in the technical as well as in the popular technical literature took place in Germany in 1930/31: engineers and journalists began to speak of a necessary trend towards telecinema on the long road to the realisation of full television. The inventor and reputed populariser of communications technology Eduard Rhein wrote in his article 'Es ist ein weiter Weg ...' in 1930:

> Optimism about future things can be a gesture of mercy. [...] But optimism about the television! We all believe in it more than definitely exists, because we all long for the experience of this first hour of wonder. [...] Two years elapsed between the first and last disappointment. Even if some progress can be noted [...]: we do not *see* it.[58]

In the speeches given at the opening ceremony of the Funkausstellung in 1931, the representatives of the German Post Office, who were also responsible for the transmission of television signals, acted rather defensively. They praised broadcasting for its political and social value, and they also emphasised that it was true that there was some technological impetus to stimulate the progress of television. But they said that 'impoverished Germany' would still have to wait some time before television could be widely introduced.[59] The communications engineering industry held a similar attitude, but it expressed the hope that the broadcasting industry would bring about 'a freeing act to overcome the neediness'.[60] This mixture of technical, political, social and economic arguments, which successively led to a rather sceptical attitude towards 'technological progress', found its equivalent expression in popular technical journals. For example, some authors argued against intercontinental transmissions not only because of poor technical quality but also because the content was thought to be lacking in cultural terms.[61] Others stressed the fact that broadcasting had an enormous share in the national economy – despite the fact that some 'strong differences' in comparison with Britain and the United States could be seen.[62] In contrast to the technical journals, articles in the mainstream press still praised the 'technological progress'. So one can find columns called 'daily progress', in which the social and political value of improvements in communications engineering was especially emphasised.[63] Further articles hailed the 'wonders', 'miracles' and 'sensations' of the scientific and technical achievements in the field of high-frequency transmission.[64] With television, national pride was the basis for

Figure 10 Presentation of the experimental set in the laboratory, spring 1931. (Loewe Opta GmbH, Unternehmensarchiv, Kronach)

extolling developments, which at least pointed the way forward. In this way the very first steps towards colour television, as well as von Ardenne's 'fully electronic television system', were at the centre of discussion.[65] In the tradition of the struggle for the cultural acceptance of the engineering sciences, which dated back to the last decade of the nineteenth century, the young Manfred von Ardenne gained credit for devoting his life to science and technology.[66]

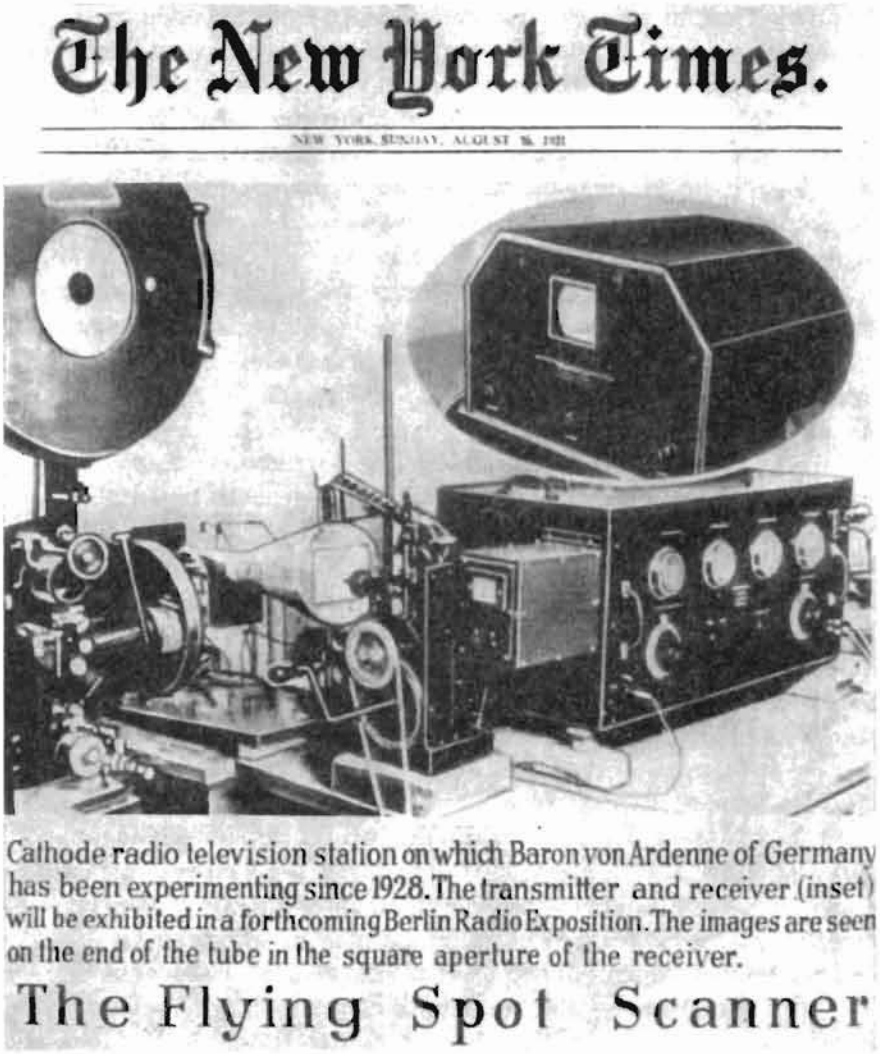
Flying-spot scanner versus fully electronic television system

Of course, Manfred von Ardenne was very proud of his results too. He carefully made notes about the events at which he had successfully presented his work on television, including the related apparatus and persons.[67] And he emphasised that his set should be seen as the 'first publicly presented experimental fully electronic television set'. The haste with which he had produced his set, which he presented to a selected circle in December 1930 (Figure 10), to the press in April 1931, and to the public during the Funkausstellung in Berlin in August 1931,[68] was purely a result of the opportunity to make such a statement – a statement that was neither true nor false. On the one hand, von Ardenne wrote in his scientific articles and books that his ensemble more properly belonged to efforts towards the telecinema. But on the other hand, he had to classify his telecinema set as an effort in the field of television, as a pioneering work in a forward-looking direction. Indeed, the use of cathode-ray tubes for transmitting and receiving made his set 'fully electronic', and provided features which could be used in television. In this way, his set could transcend the admittedly problematic differentiation between telecinema and

television. And the quite acceptable images, measuring 8 x 9 cm, showing the film *Wochenende* and an amateur film by von Ardenne about workers leaving the Loewe plant, did not provoke the spectators to ask critical questions. Rather the reverse, as the comparatively good images were represented in an experimental environment which suggested that even cinema films could now be reproduced 'by television' with promising quality.[69]

In his notes and memoirs von Ardenne even maintained that the spectators at his presentations saw a transmitted picture on a cathode-ray tube for the first time.[70] This is doubtful though, since we know about successful tests that had been carried out by many others some years earlier.[71] But von Ardenne, who became a master propagandist and also had the advantage of being a young outsider in both industry and the relevant political circles, fitted the image of the avant-garde technical pioneer. While the reputed expert Fritz Schroeter, director at Telefunken GmbH and one of the few promoters of an electronic television system in Germany, acted rather modestly in public, von Ardenne explained to different audiences some of the features of his cathode-ray tubes – especially their outstanding brightness. For instance, when von Ardenne gave a paper on this topic during a meeting at the Technische Hochschule in Berlin, on 14 January 1931, he also discussed the relevance of his developments for television.[72] Although he did not show any television pictures – this would have been impossible for a representative of the industry – the reaction he received was appreciative.[73] And he and Schlesinger, a member of his staff, could also publish articles on the fundamentals of electronic television receivers in the newly established technical journal *Fernsehen*.[74] Furthermore, his emphasis of the receiving side of television had become common practice – also in the United States, where Zworykin had presented his kinescope receiver as the crucial step towards all-electronic television.[75]

As we have already seen, an additional problem arose for von Ardenne because of his relationship with the Loewe company. In order to secure his possible patent rights, Loewe paid a great deal of attention to the things his young, ambitious and prestige-addicted collaborator tried to make public.[76] The transmitter, which made the television system 'fully electronic' and forward-looking, did not get much publicity at that time. Only the American press, reporting on the forthcoming Funkausstellung in Berlin in August 1931, emphasised the transmitter side of von Ardenne's ensemble: it set the 'flying-spot scanner' in the foreground and identified the achievement of von Ardenne with this component alone (Figure 11).[77] This was understandable insofar as the propaganda of the RCA had praised Zworykin's kinescope; the cathode-ray tube as receiver did not seem to be anything new. The oscillation between consideration of the receiver and of the transmitter, while ostensibly establishing an all-electronic


The New York Times.

NEW YORK, SUNDAY, AUGUST 16, 1931

Cathode radio television station on which Baron von Ardenne of Germany has been experimenting since 1928. The transmitter and receiver (inset) will be exhibited in a forthcoming Berlin Radio Exposition. The images are seen on the end of the tube in the square aperture of the receiver.

The Flying Spot Scanner

Figure 11
Announcement of Manfred von Ardenne's experimental set, shown at the radio fair in Berlin two days later, in the New York Times, 16 August 1931. (Deutsches Museum)

television system (or at least an ensemble for an all-electronic telecinema), also referred to still unsolved technical problems.

One of the main problems was the already mentioned control of the brightness of the tube, which also affected control of the picture lines and therefore the synchronisation of the transmitter and receiver. As Schlesinger expressed it in early 1930, the problem was the 'natural connection' of brightness and sensitivity in a cathode-ray tube, whereby either the velocity of the cathode ray or the amount of electrons had to be changed in order to get an acceptable result.[78] At that time, he suggested a highly sophisticated compensation circuit to solve this problem.[79] Von Ardenne surely profited from Schlesinger's theoretical and practical considerations. But in his own experiments, which embraced the entire system, von Ardenne eventually adopted a method for controlling the picture line that had been suggested by

Rudolph Thun in 1930.[80] Thun had changed from the commonly used constant scanning velocity and controlled cathode-ray intensity to a variable scanning velocity and a constant ray intensity. Von Ardenne discussed the advantages of this method, called line control, at great length.[81] In particular, the improved medium brightness and the simplicity of the cathode-ray tube on the transmitter side should compensate for the fact that the commonly used receivers were not yet able to be combined with such transmitters.[82]

Von Ardenne hardly had any problems developing the respective circuits on a laboratory scale. Loewe considered the development from a more practical, commercial point of view and therefore looked for easily producible receivers, such as the *Volksempfänger*. So he disagreed with von Ardenne's direction of development.[83] In his copy of von Ardenne's book *Die Kathodenstrahlröhre* he noted on the respective pages that he had tried to convince von Ardenne, even before the latter started his experiments, but he could not persuade him.[84] So Loewe asked Schlesinger to lead his company's television laboratory in 1930 and eventually, in 1932, he transferred the entire television work from von Ardenne's laboratory to his own.[85] Instead of the line-control method, he used the brightness-control method, referring to a US patent of Reginald Clay, which eventually became an international standard method in television.[86] Furthermore, he allowed von Ardenne to keep the patent on the line-control method – despite the contract between them.[87]

In spite of the fact that von Ardenne had insisted on the line-control method, he had been able to bypass this problem in his early television system by connecting the transmitter directly to the receiver, and using a special form of the common method of brightness control, namely control of the space charge.[88] It is conspicuous that in all the reminiscences and histories of contemporary television experts – such as Bruch,[89] Karolus and Schröter – one finds a similar interpretation: the outstanding achievement of von Ardenne was now seen as his construction of the transmitter, i.e. especially the scanner, which all authors referred to using the American expression 'flying-spot scanner'.[90] They ignored the fact that they had once also been impressed by the picture on the receiving cathode-ray tube. This might be because the presentations of von Ardenne's ensemble in 1931 'only' met the high end of a new unofficial television standard: 100 lines (the official RPZ norm was 48 lines), 25 pictures per second, and 10,000 image dots.[91] But these values, because they were compatible with cinema movies, allowed transmission of 'nearly any normal' movie at fairly high quality.[92] At this time 'nearly normal' meant that the scenes of the movie were rather long so as to 'give the eye time enough to recognise the things at all'.[93] In other words, von Ardenne could increase the number of image dots up to 10,000 per image during 1931 and thereby achieve an acceptable telecinema, but

this was not his real aim. As already stated, he wanted to prove that all his developments would have the potential to lead to successive improvements in the field of television, which could not be reached by the so-called mechanical systems.

One can accept this potentiality merely from an abstract technological viewpoint. But just as von Ardenne's prophecy about the line-control method did not hold, the principle of his flying-spot scanner would prove itself to be useful only for scanning movies (until the 1980s), and not for live shooting. From the mid-1930s, Farnsworth- and Zworykin-type tubes could demonstrate technical and economical advantages for this purpose. Loewe and von Ardenne cancelled their contracts in 1932 and von Ardenne reduced his experiments in television and concentrated on electron microscopy, although he continued to intervene in special topics – insofar as far as they proved his pioneering talents. It is possible to learn more about these interrelations by looking at the situation in the German Patent Office. All the applications for patents by the D S Loewe company and by von Ardenne from 1930 until 1932, which were related to all-electronic television, seemed to challenge considerably the staff of the patent office.[94] Just a few were granted, but only after at least five years. The patent letters on the flying-spot scanner by von Ardenne even indicate that the patent was applied for in March 1931 but not publicised until October 1944.[95]

Despite his modest manner in his technoscientific articles and books, where von Ardenne reduced his claim for his flying-spot scanner to a device applicable in telecinema, he always felt entitled to be regarded as the inventor of the first all-electronic television system, the only system that was forward-looking in both technical and commercial terms. Only occasionally did he state that his efforts in television had primarily a prophetic intent and that they were included in his propaganda of demonstrating the necessity of the use of higher frequencies and broader bandwidths. The ensemble of devices in the Deutsches Museum suggests these complex, seemingly contradictory relationships in a direct and concrete way. To put it more cautiously, it contains the flying-spot scanner as well as the receiver, parts of the cine motion projector, as well as broadband circuits. So it can evoke simultaneously questions about the meaning of both these devices and their correlations at the time when they were built, and afterwards. And the devices have always been parts of the events outlined above, like other non-humans and humans (Figure 12).

It has to be added that von Ardenne never participated in any discussion on the cultural value of television and his interest in cultural life or cultural affairs was never distinct.[96] In this sense he had no 'vision of television', but he did have intelligent practical and theoretical suggestions as to how to continue. He also regarded this epoch as the end of his apprentice years on his way to becoming a

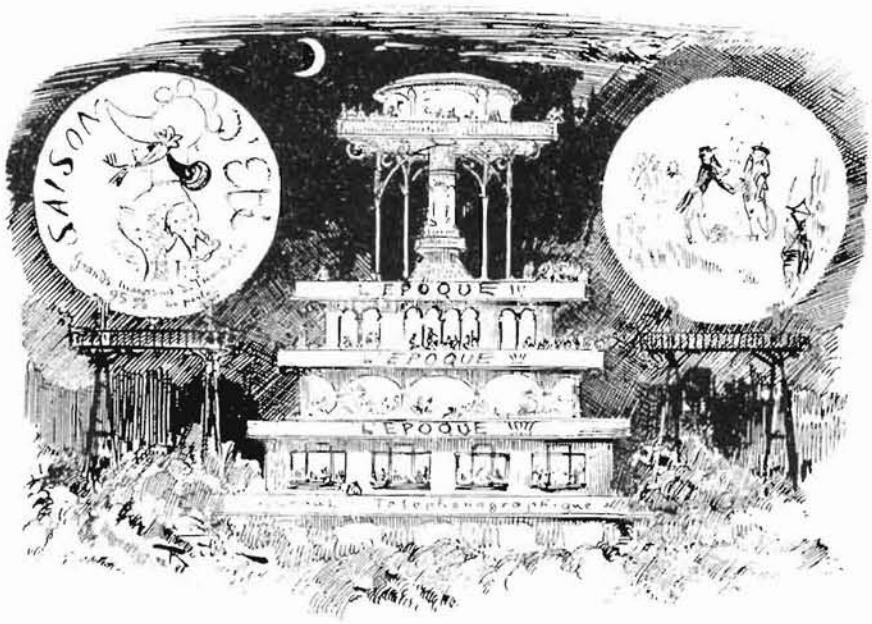


Figure 12 Writers began to speculate about television in the 1870s. This idea, from Albert Robida's novel Le Vingtième Siecle: Roman d'une Parisienne d'après-demain *(1883), shows the presentation of advertisements and news. (Deutsches Museum)*

reputed and wealthy man of science.[97] Just how original his career had been and how obstinate he had been can be surmised, for instance, from the fact that he never had contact with the Institute of Communication Engineering at the Technische Hochschule in Berlin in the 1920s or 1930s.[98] Neither television nor VHF technology had been the central topic of the professors there at that time.[99] The visionaries, in a purely techno-economic sense, were either outsiders, such as von Ardenne, or a small number of physicists in the industry, such as Schröter.[100] But whereas most of the experts concentrated on the development of television terminals, men like von Ardenne and Schröter never forgot their central aim: to develop and promote high-frequency and broadband technology.[101] It should be added that Schröter's work with VHF transmitters for television was sufficiently successful for Telefunken GmbH to be set up in 1932.[102]

Conclusion

In a letter to the Deutsches Museum in 1967, Professor Manfred Baron von Ardenne complained that the 'true' history of television was not correctly displayed in the museum.[103] Most of his contributions were missing. It is interesting to see that he started his list of missing items with his broadband amplifier of 1925 and his cathode-ray tube with brightness control of 1929. In 1938, a year after a temporary exhibition on television, by which time his electronic telecinema set had arrived at the Deutsches Museum, neither von Ardenne nor the curator even mentioned this topic.[104] And von Ardenne did not contradict the curator when the latter called the ensemble a 'line-control set'. At this time the ensemble represented a 'factish' to do

with pride in state-of-the-art national engineering in the new field of television, the then-implicit definition of a technical masterpiece. I can imagine that it would more likely have confused the curator, who surely knew about the problems of broadband amplification if he had had time enough to investigate all the parts and components of the ensemble, to demonstrate such wide interrelations.[105]

The social history of the electronic telecinema/television set has changed in the meantime, and we have also changed our attitude towards technology and technical artefacts. After futile attempts to construct some sorts of 'contexts', which tended to become open-ended and therefore countless in number, the ensemble is now presented in a way which can provoke aesthetic as well as nostalgic feelings and, in addition, a great variety of questions regarding functionality, history and so on (Figure 13). The short statement of the curator is unable to answer all the questions, or even to lead the visitor – whether layman, technician or historian – to all the different tracks. And in many instances this article, too, has had to settle for merely indicating what these tracks might be. So, on the one hand we have the situation that Bal has interpreted as a 'multimedialized' concept of a discourse of quasi-subjects. On the other hand we have, partly according to Bal, a narrative; but it derives from an incomplete

Figure 13 Pope Pius XI and Guglielmo Marconi (in the background) inaugurate the new Vatican radio station, 1931. Vatican City was and is the only state without a television transmitter of its own. (Deutsches Museum)

network analysis of various human/non-human nodal points and some of their connections.

The consequences for a museum have often been circumscribed with the metaphor 'cave' – by referring either to the CAVE (computer-aided visual environment) or to Plato's allegory of the cave.[106] I do not want to extend this topic here, so let me simply reiterate that the continuous expansion of museum collections in parallel with the diversification of media technologies has required a change in fundamental philosophy. There has been a shift from the consideration of a museum as a place of representation of collections or ideas towards a place where one can permanently observe the constitution of collections and ideas, i.e. the changes in museums themselves. The appearance and reality inside and outside the museum (the 'cave') are neither to be grasped by traditional 'philosophems' nor by museological procedures. So the construction as well as the selection of museum collections has to undergo a permanent process of reflection.

I would rather like to refer this kind of reflection back to the historiographical considerations at the beginning of this article. In my opinion, the basis of such a reflection should be the analysis of events where humans and non-humans met and affected each other.
Of course, the approach of Bruno Latour is primarily sociological, and not historical or philosophical. And neither the elements of his method nor his intention can be called entirely new. But his approach transcends both common sociological and philosophical practice by its consequent avoidance of pitfalls, which exist in the social sciences as well as in the humanities. If one looks, for example, into the anthology on the 'history from things' edited by Steven Lubar and David Kingery, one can find many hints that dealing with historical artefacts differs from the analysis of texts.[107] Nevertheless, the artefacts are essentially understood as 'primary sources' which can be 'read' like texts and which have 'contexts'. Even Robert Seidel, who surely is aware of the pitfalls and additionally tries to reconcile historians' and practitioners' interest in artefacts, recently came up with a similar vocabulary.[108]

The present predominance of a subject-based epistemology (and terminology) may not be maintained for the whole of the so-called modern epoch. The other extreme, an object-based epistemology, can be found, for instance, in the attitude of the late Victorian world, where individuals tended to see objects 'as the sites of meaning and knowledge' and 'many intellectuals regarded museums as a primary place where new knowledge about the world could be created and given order'.[109] The central concept here is, of course, the concept of meaning. Steven Conn, studying the late Victorians, suggests that we 'consider several levels on which people related to objects. At one of these, meanings are personal [...]. At another level, meanings derive from some kind of social interaction [...]. At a more abstract level,

meaning results when individuals engage in a deliberate, self-reflective act of symbolic action.'[110] Although I agree that this differentiation might be helpful in some historical investigations, I would doubt whether the still-supposed subject–object dichotomy would withstand further reflection. As we have seen from the 'thingish' history of Manfred von Ardenne and the personal/social history of the flying-spot scanner, all these 'levels' of human–non-human interactions can be found in the 'events' at the same time, and they have proved to be of the same value. As a consequence, I would like to suggest that we – that is historians, sociologists and philosophers – should not 'bypass' the problem of the meaning of the meaning, as Latour has done. We should rather continue to follow intended ideas which scholars such as Michel Foucault and Jacques Derrida have set forth. The well-known concept of Derrida's *différance*, the 'alliance of speech and Being in one word', the 'trace of a trace' – whereby the traces and the forces of breaching are inseparably intertwined in space and time – seems to me to be especially helpful.[111] In other words, the work of deconstructing epistemology as well as ontology – not to mention phenomenology – could lead to a 'reconciliation' of these until-now distinct philosophical disciplines. It goes without saying that dealing with texts is part of the work of both academic historians and curators. So careful use of terminology, for example the avoidance of 'more-or-less' metaphorical usage of terms such as 'contexts', 'reading artefacts', etc., should have a correlation with the philosophical reflection of language.[112] And this reflection would eventually be able to create a symmetry between (arte)facts and values, expressed in meanings.

The philosopher Andrew Feenberg, who, like Latour, intends to bridge the gap between 'technique and meaning', develops a political philosophy of technology.[113] He suggests that we 'add to the symmetry of successful and unsuccessful theories and devices, introduced by constructivism, and the symmetry of humans and nonhumans, proposed by actor network theory' a third symmetry: 'We must supplement these with the symmetry of program and anti-program, at least in those cases where the anti-program is taken up by actors able to build a new system around it. This third symmetry is the basis of a democratic politics of technological rationalization.'[114] In my opinion, this extension (like the symmetry of facts and values) would enable us to reflect on the historical aspect of the human–non-human interrelation. The politics of the German Post Office, for example, with regard to mechanical and electronic television and the respective actions and reactions of the scientists and engineers, including their instruments and devices, indicate the relevance of such a reflective approach.

I have to confess that, in my opinion, we are just at the beginning of the development of a historiography which reflects these symmetries in a sophisticated way.[115] So I have only tried to offer some plausible

arguments in order to show that it is worth taking up these hints in our future work. And I do hope that I can convince colleagues studying the history of technology, as well as those studying so-called 'general history', at least to a certain degree, that it is necessary to have a thorough look at artefacts, as nobody denies that they do affect us.

Acknowledgements

I wish to thank the staff of the archives mentioned in the notes and references. I am especially grateful to Kilian Steiner of the Loewe archives, who also read an early draft of the article and offered valuable comments. Finally, I am obliged to the referees, the editors and the publishers for all their work.

Notes and references

1 Latour, B, *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, MA: 1999), p381 (Latour's emphasis)
2 Cf., *inter alia*, Csikszentmihalyi, M and Rochberg-Halton, E, *The Meaning of Things: Domestic Symbols and the Self* (Cambridge, etc.: 1981).
3 My argument will rely on three of Latour's books, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: 1987); *We Have Never Been Modern* (Cambridge, MA: 1991); *Pandora's Hope: Essays on the Reality of Science Studies*, note 1.
4 Latour, B, *We Have Never Been Modern*, note 3, p58
5 The practice of purification 'creates two distinct ontological zones: that of human beings on the one hand; that of nonhuman on the other'. See Latour, B, *We Have Never Been Modern*, note 3, pp10ff.
6 Bijker, W E, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociological Change* (Cambridge, MA: 1995), especially pp269ff
7 Cf., for instance, Latour, B, *We Have Never Been Modern*, note 3, pp54ff; *Pandora's Hope: Essays on the Reality of Science Studies*, note 1, pp17ff, 91ff.
8 Latour, B, *We Have Never Been Modern*, note 3, p54
9 *Ibid.*
10 *Ibid.*, pp49ff
11 *Ibid.*
12 Latour, B, *Pandora's Hope: Essays on the Reality of Science Studies*, note 1, pp17, 272ff
13 *Ibid.*, p275
14 *Ibid.*, p282
15 *Ibid.*, pp16ff
16 Latour, B, *We Have Never Been Modern*, note 3, pp104, 117ff
17 Latour, B, 'Über technische Vermittlung: Philosophie, Soziologie, Genealogie', in Rammert, W (ed.), *Technik und Sozialtheorie* (Frankfurt am Main: 1998), pp29–81 (here pp63ff)

18 More precise would be 'nearly unique'. In Manfred von Ardenne's laboratory, some parts of the ensemble had been produced twice. See correspondence between Manfred von Ardenne and Deutsches Museum, from 1936 to 1937, in the Deutsches Museum records office. There was also a replica of the entire set, authorised by Manfred von Ardenne and displayed in the Museum für Deutsche Geschichte in former East Berlin. See Möbius, P, 'Erste vollelektronische Fernsehanlage der Welt: Erfindung von Manfred von Ardenne aus dem Jahr 1931 im Museum für Deutsche Geschichte', *Neue Museumskunde*, 20 (1977), pp162ff.

19 Bal, M, *Double Exposures: The Subject of Cultural Analysis* (New York: 1996), p4 (Bal's emphasis)

20 *Ibid.*

21 *Ibid.*, pp2ff

22 Baudrillard, J, 'The system of collecting', in Elsner, J and Cardinal, R (eds), *The Cultures of Collecting* (Cambridge, MA: 1994), pp7–24, especially pp7ff

23 Stewart, S, *On Longing: Narratives of the Miniature, the Gigantic, the Souvenir, the Collection* (Baltimore, MD: 1984), pIX

24 von Ardenne, M, 'Die Braunsche Röhre als Fernsehempfänger', *Fernsehen*, 1 (1930), pp193–202; von Ardenne, M, 'Die fotografischen Hilfsmittel beim Oszillografieren mit Braunschen Röhren', *Fernsehen*, 1 (1930), pp364–73; von Ardenne, M, *Funk-Empfangs-Technik: Bildübertragung, Fernsehen, Tonfilm* (Berlin: 1930); von Ardenne, M, 'Über Fortschritte beim Fernsehen mit Kathodenstrahlröhren', *Fernsehen*, 2 (1931), pp173–8; von Ardenne, M, 'Über neue Fernsehsender und Fernsehempfänger mit Kathodenstrahlröhren', *Fernsehen*, 2 (1931), pp65–80; von Ardenne, M, *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik* (Berlin: 1933)

25 von Ardenne, M, *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik*, note 24, p356

26 According to von Ardenne, M, *Eine glückliche Jugend im Zeichen der Technik* (Berlin: n.d., 1962) and von Ardenne, M, *Ein glückliches Leben für Forschung und Technik – Autobiographie* (Dresden: 1972 and following editions).

27 See also Herf, J, *Reactionary Modernism: Technology, Culture, and Politics in Weimar and the Third Reich* (Cambridge: 1984) and Rüdiger, H, 'Der dritte Humanismus', in Oppermann, H (ed.), *Humanismus* (Darmstadt: 1970), pp206–33.

28 For Siegmund Loewe, his companies and his connection to Manfred von Ardenne, see Steiner, K, *Die Loewe-Chronik – 75 Jahre Loewe Opta GmbH (1923-1998)* (n.p., Kronach: n.d., 1998).

29 von Ardenne, M, *Funk-Ruf-Buch* (Berlin: 1924); von Ardenne, M, *Des Funkbastlers erprobte Schaltungen* (Berlin: 1924)

30 'Verfahren zur Erzielung einer Tonselektion, insbesondere für die Zwecke der drahtlosen Telegraphie', German Imperial Patent DRP 427.342, applied for 14 October 1923, granted (and cancelled) 1 April 1926.

31 Dreifachröhre (three-unit tube) 3NF; one of these can be seen in the Deutsches Museum.

32 See von Ardenne's autobiography, note 26, and the draft by S Loewe of 18 August 1931, Loewe Opta GmbH Archives, 41.8.

33 The name sometimes changes from 'Versuchslaboratorium' to 'Laboratorium' and vice versa. The pleonasm 'experimental laboratory' was used by von Ardenne, in my opinion, to emphasise both his scientific claims and technical progressiveness.

34 Brachner/Eckert/Schubert interview with Manfred von Ardenne, Munich, 1984, archives, Deutsches Museum, audio collection.

35 Von Ardenne also had to consider the legal rights of the Loewe company.

36 von Ardenne, M, 'Die fotografischen Hilfsmittel beim Oszillografieren mit Braunschen Röhren', *Fernsehen*, 1 (1930), pp364–73 (here p366); von Ardenne, M, 'Über neue Fernsehsender und Fernsehempfänger mit Kathodenstrahlröhren', note 24, p66. Even in 1933, von Ardenne did not reveal his secret: see von Ardenne, M, *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik*, note 24, pp82ff, 358ff.

37 German Imperial Patent DRP 697.695, 'Verfahren zur Abtastung von Fernsehbildern', patented from 19 July 1931, publicised 19 September 1940

38 Petzold, H, 'Zur Entstehung der elektronischen Technologie in Deutschland und in den USA', *Geschichte und Gesellschaft*, 13 (1987), pp340–67

39 Radkau, J, *Das Zeitalter der Nervosität: Deutschland zwischen Bismarck und Hitler* (Munich: 1998), especially pp190ff

40 For these relationships see, for instance, Hugill, P J, *Global Communications since 1844: Geopolitics and Technology* (Baltimore, MD: 1999).

41 Radkau, J, note 39

42 See, for instance, Abramson, A, *The History of Television, 1880 to 1941* (Jefferson, NC: 1987); Burns, R W, *Television: An International History of the Formative Years* (London: 1998); Farnsworth, E, *Distant Vision: Romance and Discovery of an Invisible Frontier* (Salt Lake City, UT: 1990); Fisher, D E and M J, *Tube: The Invention of Television* (Washington DC: 1996); Goebel, G, 'Das Fernsehen in Deutschland bis zum Jahre 1945', *Archiv für das Post- und Fernmeldewesen*, 5 (1953), pp259–393; Holtschmidt, D, *Fernsehen: wie es begann* (Hagen: 1984).

43 Burns, R W, note 42, p266

44 *Ibid.*, p257

45 *Ibid.*, pp256ff

46 Riedel, H, *70 Jahre Funkausstellung: Politik, Wirtschaft, Programm* (Berlin: 1994); see also, for a British point of view, Beauchamp, K G, *Exhibiting Electricity* (London: 1997), pp216ff

47 Loewe, S, 'Wann kommt das Fernsehen?', manuscript, 18 August 1931, Loewe Opta GmbH Archives, 41.8

48 Burns, R W, note 42, p267

49 Abramson, A, *Zworykin: Pioneer of Television* (Urbana, IL/Chicago, IL: 1995), p148

50 For instance, the RCA spent a lot of money and manpower to promote Zworykin's ideas. See *ibid.*, pp82ff.

51 Interview with Manfred von Ardenne, note 34

52 Manfred von Ardenne interviewed by David and Marshall Fisher, in Fisher, D E and M J, note 42, p201

53 *Ibid.*

54 'Experimental system of fully electronic image transmission', 'Telecommunications' exhibit, Deutsches Museum
55 See, for instance, Loewe, S, memorandum, 25 April 1931, Loewe Opta GmbH Archives, 41.8.
56 Auer, P, 'Was Sie haben Bilder empfangen? Das können Sie doch gar nicht!', *Aus der Berliner Postgeschichte* (1985), No.4, pp7–55 (here pp24–8)
57 Bruch, W, notes, 1930/31, archives, Deutsches Museum, NL101
58 Translated from Rhein, E, 'Es ist ein weiter Weg ...', *Fernsehen*, 1 (1930), pp413–15 (Rhein's emphasis).
59 *Funkalmanach 1931 – Offizieller Ausstellungskatalog zur Grossen Deutschen Funkausstellung und Phonoschau Berlin 1931* (Berlin: 1931), p11; 'Funkausstellung 1931 – Die Schau für Technik und Kultur', *Funk* (1931), pp273ff
60 Speech by Erwin Michel, syndic of the radio industry, 1931, archives, Deutsches Museum, NL 101, 388 (audio tapes).
61 Band, L, 'Wert und Unwert der Amerika-Übertragungen', *Funk* (1931), pp275–6; Leers, P W, 'Neue Formen – neuer Inhalt: Ein Rückblick auf das Programm des Jahres 1931', *Funk* (1931), pp409–10
62 Antonine, H, 'Der Wirtschaftsfaktor Rundfunk: Vergleiche zwischen Amerika, Deutschland und England', *Funk* (1931), p278
63 For example, 'Tastsinn als Gehörersatz', *Reclams Universum*, 47 (1931), p332; 'Verbesserter Fernempfang in der Großstadt', *ibid.* p288.
64 For example, Coler, H, 'Wunder der Schwingungsforschung', *Reclams Universum*, 47 (1931), p326; Lillge, 'Sensation im Kurzwellenfunk', *ibid.* p618; Wagner, H, '"Hören Sie, meine Herren ...": Konferenz am Tele-Trans-Mitter', *ibid.* p259.
65 For instance, Rosen, H, 'Fernsehen in natürlichen Farben!', *ibid.* p134; Neuburger, A, 'Das Fernsehtheater kommt', *ibid.* pp974–5; 'Deutsche Funkausstellung', *ibid.*; Wagram, W, 'Manfred von Ardenne: der Entwicklungsgang eines jungen Erfinders', *Reclams Universum*, 48 (1932), pp602–3.
66 Wagram, W, note 65, p602
67 von Ardenne, M, notes, December 1932, Loewe Opta GmbH Archives, 41.8
68 In Hall III, Stand 331, i.e. the stand of the D S Loewe radio company. See *Funkalmanach 1931*, note 59, p163.
69 For example, Stoff, W, 'Pionierarbeit für das Fernsehen', 1969, manuscript, Loewe Opta GmbH Archives, 41.10.
70 von Ardenne, M, note 67
71 For example, Goebel, G, *Das Fernsehen in Deutschland*, note 42, pp270ff.
72 Kappelmayer, O, 'Braun'sche Röhre: Fernsehen der Zukunft?', *Berliner Lokalanzeiger*, 16 January 1931
73 For details see Goebel, G, 'Manfred von Ardenne führt das elektrische Fernsehen vor', *Funkschau*, 52 (1980), pp64–6 and 53 (1981), pp72–8.
74 von Ardenne, M, 'Die Braunsche Röhre als Fernsehempfänger', *Fernsehen*, 1 (1930), pp193–202; Schlesinger, K, 'Kompensation der Bildpunktverschiebung beim Fernsehen mit Braunschen Röhren', *ibid.*, pp202–9
75 For example, Neuburger, A, 'Das "Kineskop", ein neuer Fernseher', *Fernsehen*, 1 (1930), pp175–9.

76 Loewe, S, note, 25 April 1931, Loewe Opta GmbH Archives, 41.8
77 *New York Times*, 16 August 1931
78 Schlesinger, K, note 74
79 *Ibid.*
80 Thun, R, 'Grundsätzliche Systeme bei der Übertragung bewegter Bilder', *Fernsehen*, 1 (1930), pp267–73
81 von Ardenne, M, 'Über neue Fernsehsender und Fernsehempfänger mit Kathodenstrahlröhren', *Fernsehen*, 2 (1931), pp65-80; von Ardenne, M, *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik*, note 24, especially pp374–84
82 von Ardenne, M, *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik*, note 24, p375
83 See the advertising material of the D S Loewe radio company from 1932, Loewe Opta GmbH Archives, 41.8.
84 S Loewe's copy of von Ardenne's *Die Kathodenstrahlröhre*, pp347ff, in the Loewe Opta GmbH Archives, 621/386/7A.
85 Loewe, S, notes, 22 April 1932, Loewe Opta GmbH Archives, 41.8
86 *Ibid.*
87 German Imperial Patent DRP 624.849, 'Fernsehübertraungsverfahren unter Verwendung modulierter Kippspannungen (Liniensteuerungsverfahren)', 1930
88 von Ardenne, M, 'Die Braunsche Röhre als Fernsehempfänger', note 24, p200
89 Bruch had visited his former boss von Ardenne at the Funkausstellung in 1931, but it seems to have been just a courtesy visit. Cf. 'Niedersachsen Forum, Gast des Monats: Walter Bruch', VHS video, *c.* 1980, archives, Deutsches Museum, NL101, 525.
90 For example, Bruch, W, 'Kleine Geschichte des deutschen Fernsehens', manuscript, n.d., *c.* 1965; Karolus, A, 'Entwicklungsgeschichte der Fernsehtechnik', manuscript, n.d., 1967; Schröter, F, 'Aus dem frühen Entwicklungsgang des Fernsehrundfunks', manuscript, September 1973. All manuscripts in archives, Deutsches Museum, NL 101.
91 Burns, R W, note 42, pp262ff; Goebel, G, note 42, pp309ff; Riedel, H, note 46, pp47ff
92 von Ardenne, M, 'Über Fortschritte beim Fernsehen mit Kathodenstrahlröhren', note 24, p173
93 Rhein, E, 'Der erste Fernsehfilm wird gedreht...', *Fernsehen*, 1 (1930), pp157–9
94 See the lists of patents, including remarks from S Loewe, in the Loewe Opta GmbH Archives, 41.10, and German Imperial Patents DRP 624.849, 643.605, 652.905, 653.015, 697.695.
95 German Imperial Patent DRP 755.947, 'Fernsehsendeanordnung mit Braunscher Röhre', 1931
96 For example, *Am Anfang war der Amateur: Manfred von Ardenne*, television documentary (directed by Alfred Cube), transmitted on WDR, 1984.
97 von Ardenne, M, *Eine glückliche Jugend im Zeichen der Technik*, note 26, p81
98 von Ardenne, M, interviewed by the author, 17 December 1988
99 See 'Programme für das Studienjahr' of the Technische Hochschule Berlin during these years, Main Archives, Technische Hochschule Berlin. Only

Professor Kock had the task of dealing with the field of 'high-frequency transmission' as one of his topics.

100 For details see Schröter, F, note 90

101 *Ibid.*; see also von Ardenne, M, 'Zur Anwendung ultrakurzer Wellen für das Fernsehen', *Fernsehen*, 1 (1930), pp390–2; von Ardenne, M, 'Gehts mit Ultrakurzwellen?', *Fernsehen*, 2 (1931), pp28–31.

102 See, for example, Burns, R W, note 42, pp267ff.

103 von Ardenne, M, letter to Deutsches Museum, 21 December 1967, Deutsches Museum records office

104 von Ardenne, M, correspondence with Dr Fuchs, 9 April – 1 December 1938, Deutsches Museum records office

105 For the topics treated by the curator, see Fuchs, F, 'Die Fernsehsonderschau im Deutschen Museum zu München', *Radio/Bildfunk/Fernsehen für Alle*, 16 (1937), pp145–50; Fuchs, F, *Das Fernsehen* (Munich: 1937).

106 See also Fehr, M, Krümmel, C and Müller, M (eds), *Platons Höhle: Das Museum und elektronische Medien* (Cologne: 1995); Pearce, S M, *Museums, Objects and Collections: A Cultural Study* (Leicester/London: 1992).

107 Lubar, S and Kingery, W D (eds), *History from Things: Essays on Material Culture* (Washington/London: 1993)

108 Seidel, R W, 'Reconstructions, historical and otherwise: the challenge of high-tech artifacts', in Rojas, R and Hashagen, U (eds), *The First Computers: History and Architectures* (Cambridge, MA: 2000), pp33–52

109 Conn, S, *Museums and American Intellectual Life, 1876–1926* (Chicago, IL/ London: 1998), p15

110 *Ibid.*, p14

111 Derrida, J, 'Différance', in *Margins of Philosophy* (Chicago, IL: 1982), pp1–27

112 For the use of metaphors, see Derrida, J, 'White mythology: metaphor in the text of philosophy', *ibid.*, pp207–71.

113 Feenberg, A, *Questioning Technology* (London: 1999), ppviii, 188

114 *Ibid.*, p119

115 In the history of sciences one can find a more advanced discussion on such topics. See, *inter alia*, Rheinberger, H-J, *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford, CA: 1997)