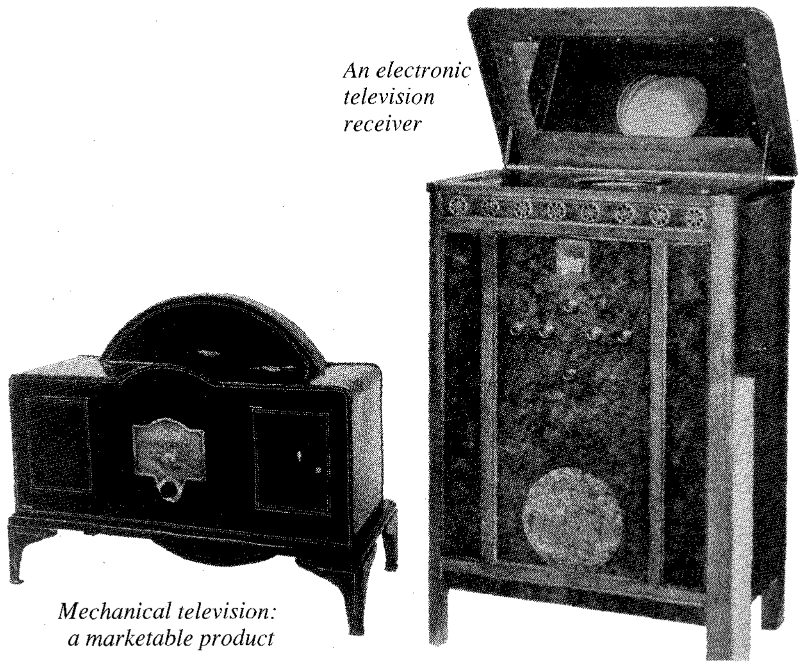
JAN VAN DEN ENDE, WIM RAVESTEIJN, AND DIRK DE WIT

# Shaping the Early Development of Television



An electronic television receiver

Mechanical television: a marketable product

Few of the billions of today's television viewers are aware that their early predecessors were served by a mechanical form of television. The central element in this early television was a rotating disc with a spiral series of perforations, called the Nipkow disc, after its Russian inventor Paul Nipkow. Two such discs were needed, one in the camera and one in the television itself. Rotating Nipkow discs, lamps, and light-sensitive elements together formed a means of recording and displaying television images.

Today the mechanical television is usually regarded as a historical curiosity; a cumbersome machine with a large, motor-driven wheel, a window, and flickering, blurred images: at best, merely a technological precursor to electronic television. However, we believe that there were once important incentives supporting mechanical television in its rivalry to electronic television. The electronic television gained preeminence not because of purely technical considerations, as is so often assumed, but also because of social ones. The programming that the television public wanted to see (the "software") influenced the choice in television technology (the "hardware"), and the institutional incorporation of television also played an important role.

Received wisdom on the early history of television originates from writers who have largely focused on technical aspects. This material conforms to the traditional approaches to the history of technology, which explained the development of technology mainly referring to technical factors and the ideas of inventors. We will address these approaches with the usual term "internalist," although it has been demonstrated

*This article is an adapted and translated version of a piece entitled "Waarom geen Nipkowschijf in elke huiskamer? De sociale constructie van televisie" which appeared in Het Jaarboek Mediageschiedenis, 1993 [1].*





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**Today, few viewers are aware that a mechanical form of television served their predecessors.**

that this concept has never been defined accurately, in contrast to its opposite "externalist" [2]. The internalist kind of historical study resulted in good narratives but offered little explanation for the direction of technological developments. The internalists assumed that the new technology was always superior to the old and took this as the self-evident reason for the spread of new technologies within society. In the case of television, according to this view mechanical television may well have enjoyed some success, but did not stand a chance against the newer, and therefore better, electronic television. Naturally, in a short while electronic television had gained complete superiority and mechanical television could be regarded as a historical curiosity. In hindsight, those involved could also be appraised accordingly: conservatives had held on to the mechanical system, those who had embraced electronic television early on were progressives.

It has since become clear that the internalist approach provides an insufficient explanation of technological development. For example, it gives no explanation of the fact that new technologies sometimes lie idle for years before coming into use, while others quickly displace the old. With regard to the history of television, an internalist approach fails to answer two questions. The first is, why was mechanical television so successful? Around 1930 the system was in widespread use in both Great Britain and the United States. In America, numerous broadcasting stations were in operation; in England, the BBC broadcasted regular programs. For many years the system underwent continuous development and in 1936, when an extensive comparison between the mechanical and the electronic systems was organized in England, it was still not clear which was better. The second question is, why did the development of television technology run such different courses in the United States and in Great Britain? In the U.S., development was discontinuous; around 1930 a "television boom" saw the use of mechanical television grow strongly, then stagnate around 1933. Electronic television subsequently came slowly into more widespread use. In the U.K., the development was more gradual; the use of mechanical systems continued right up to a national comparison in 1936, after which they were replaced by electronic systems.

Besides the internalist approach, a second type of historical perspective on the growth of television is provided by media history. In this, the social infrastructure necessary for television, such as broadcasting organizations, actors, and press offices, is held to be central. Media historians also pay attention to programming and to public evaluation. However, the television itself is kept out of the discussion; in practice it is regarded as a "given" technology, the implementation of which (in the form of television programs) is socially determined.[1] Media historians therefore regard the choice between mechanical and electronic television systems as a technical issue. Nevertheless, media historians would throw more light onto the subject were it not for the fact that they are primarily concerned with the later, rather than the earliest, stages in the development and spread of television.

Despite all criticism on internalist and other traditional approaches of technology development, they persist in recent literature, while new social-constructivist approaches, until now, have not led to a satisfactory alternative theoretical framework.[2] Basically, the new approaches stress the interaction between internal and external (or contextual) factors in technology development. We support this notion in regard to the early development of television. We do so on the basis of materials largely extracted from writers who focused on the technical history of television.[3] We see that it may be difficult to demonstrate the role of contextual influences in the history of television, but hope our analysis contributes in indicating that such influences indeed existed, even on the basis of existing materials.[4]

We focus on the choice between mechanical and electronic television systems. We analyze this choice from a broad perspective, with attention to social and technical factors and their interaction. We employ social-constructivist notions, especially the insight that several choices are always present in the historical development of a technology (see [6], [26]). Fur-

[1] This standpoint is explicitly embodied in [3].

[2] Even one of the main protagonists of social constructivist approaches, Wiebe Bijker, states this in [4].

[3] There are some exceptions of publications that focus on the social context, for instance J. Udelson's, *The Great Television Race, a History of the American Television Industry 1925-1941* [5].

[4] Citing M.J. Mulkay, Wiebe Bijker *et al.* explicitly state that it is difficult to apply contextual approaches on the history of television. See [6]. See also [7]-[10].

thermore we take upon the idea that social groups, according to the meanings they attribute to the technology, can influence the course of this development.[5] We understand social groups, not on the social-constructivist basis of the meanings attached to a given technology, but in the more traditional sociological sense. We also include individuals, organizations, and the relationships between them in our deliberations (see also, [29]).

In contrast to social-constructivism, we accord a specific role to technological factors. In our approach, a given technology has a certain objective reality that circumscribes the meanings that can be attributed to it (see also [30]). This is one of the reasons that agreement often exists between different parties on the given attributes of a new technology, even when they have different preferences with regard to the technology itself. We shall see that both mechanical and electronic television had strong and weak points that were recognized by most of those involved. Moreover, we hold that to a certain extent technological innovations do indeed have their own dynamic. Physical reality puts constraints and offers opportunities for technological development. For instance, technical limitations in 1930s Britain made it very difficult to develop a mechanical camera for outside broadcasts. Moreover, innovations developed for a specific application create opportunities in other fields. The invention of the vacuum tube, which made the development of electronic television possible, forms an example.

We concentrate our attention on developments as they took place in two of the leading countries in this field, Great Britain and the United States, with only a passing comment on a third front runner, Germany. The Netherlands provide us with an illustration of developments in a "subsequent" country; although the choice between the two television systems was strongly influenced by events abroad, the contest between mechanical and electronic television was also fought on Dutch soil. In fact, the unique social situation in the Netherlands gave developments a specific character.

## Early History

The nineteenth and first half of the twentieth century saw a large number of new ideas and inventions having to do with sending images over long distances. In hindsight, many of these can be seen as having formed part of the history of television; however, the inventors often had other applications in mind, such as a "picture telegraph," film, or "picture telephone."

A number of historical moments come immediately to mind [6]. Firstly, the invention of the selenium cell, whose photo-electric characteristics were accidentally discovered by an English telegrapher in 1873. In 1875, the American G.R. Carey was the first to suggest that it might be possible to send images by electricity: he talked of "seeing by electricity", in analogy to "hearing by electricity" with a telephone. The telephone inventor, Alexander Graham Bell, also thought that an image could be added to the sound.

At that time, researchers saw the main problem as one of being unable to send an entire image over just one line. Between 1880 and 1925, therefore, various scanning devices were proposed to allow the image to be sent, piece by piece, over one line. One of the most important of these was devised by Paul Nipkow, whose invention formed the basis for many subsequent mechanical television systems. While still a student at the University of Berlin in 1884, Nipkow had come up with the idea of a television that employed rotating perforated discs. The camera would consist of such a disc, a number of lenses, and a selenium cell. It would work as follows: a light source illuminated the object; lenses projected the reflected light onto the rotating disc; the disc allowed one point of the projected image at a time onto the selenium cell, so that for each complete rotation of the disc the entire image had been projected, a bit at a time, onto the selenium cell; the cell transformed this varying light intensity into an electrical current, and thereby turned the image into a series of consecutive electrical impulses. In the television receiver, the process would be reversed: the electrical signal would be amplified and connected to a lamp situated behind a synchronously rotating Nipkow disc, so that the lamp

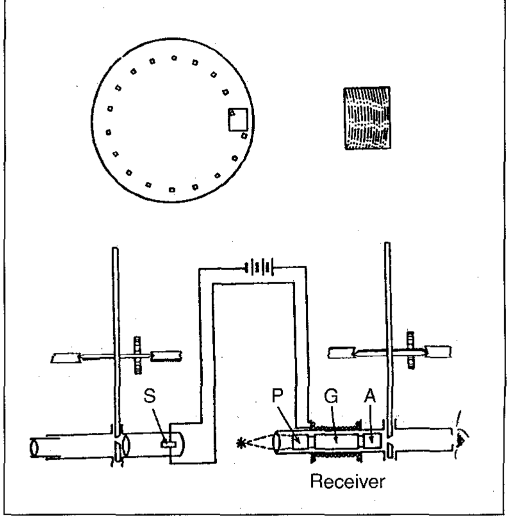


*Fig. 1. The operation of mechanical television.*

[5] Our approach shows similarities to Patrick C. Carbonara who also focuses on the circle of interdependence between players that affected the dispersion of monochrome and color television in [28].

flickered with an intensity corresponding to the electrical signal generated by the selenium cell. The image would then be visible on the face of the disc. Nipkow never built a prototype: the first fully operational model based on his principles was not produced until 1925.

Fig. 1 shows the operation of mechanical television.

### ▾ Operation of mechanical television

Around 1910, the Russian Boris Rosing developed a television system in which the function of the Nipkow disc was performed by

> **Received wisdom on the early history of television focuses on technical aspects.**

rotating mirrors. His television receiver, however, employed a cathode ray tube, developed in 1897 by Karl Ferdinand Braun at the University of Straatsburg. In this tube a glowing cathode radiated electrons which were then guided towards a light-emitting screen by means of an electromagnetic field. In 1911 Rosing succeeded in producing an image consisting of four lines using this method. Rosing called his system the "electric telescope." Rapid developmental progress was prevented by problems in directing the cathode rays. Tragically, Rosing himself was arrested in the turmoil of the Russian revolution, exiled, and never heard of again.

At about the same time as Rosing, the Englishman A.A. Campbell Swinton devised a completely electronic television system. In recording, the image was projected onto a photo-electric surface within a vacuum tube, and an electron beam scanned this surface. Campbell Swinton never succeeded in building a working model, but his work was to form the basis of the first patent application for a fully electronic television in 1929.

The following years also saw improvements in many of the elements of the mechanical system. In 1913 the German physicists Julius Elster and Hans Geitel made progress with the selenium cell and in 1917 D. McFarlan Moore developed a neon lamp capable of the rapid flickering required of the light source in the television receiver.

So by 1920 various ideas existed for television systems. Designs existed for a system using mechanical cameras and receivers (using Nipkow discs), a system employing a mechanical camera (with rotating mirrors) and an electronic receiver, and a system employing both an electronic camera and an electronic receiver. None of these systems could yet boast of a working prototype; but this was to change fast.

### ▾ Mechanical Television in Great Britain: Baird

Thanks to the work of John Logie Baird, Great Britain can be called the birthplace of mechanical television.[6] Baird was trained as an electrical engineer at the Royal Technical College in Scotland and was a born innovator. After a number of failures, which included a jam factory in Trinidad, in 1923 he began developing a mechanical television system based on Nipkow's principles [10]. Within a year he had succeeded in sending shadowy images from a camera to a television receiver along an electrical wire. In April 1925, Baird gave the first public demonstration of his television system. The television produced eight image lines. It was a primitive affair; the Nipkow discs were made of hatbox lids.

Nevertheless, the demonstration was a success. A London *Times* journalist described the images as being faint and blurred but nevertheless sharp enough to be able to distinguish facial expressions. Baird was able to obtain financial support from a number of sources which enabled him to continue his research. He formed Baird Television Ltd. and in 1926 was able to present his new "televisor" to members of the Royal Institute and *The Times*. The pictures were still of a person's head and shoulders, but Baird was now working with thirty lines; a neon lamp illuminated the disc in the television, and the discs in the camera and the receiver were electrically synchronized [11]. Moreover, he now used a new lighting method, the "spotlight" method, in which he changed the positions of the light source and photocells. The light source was behind the disc and the photocells in front, trained on the object. It was the object that was illuminated piece by piece. By employing more photocells, the total effective light intensity could be raised and this method also prevented the object from being excessively strongly lit.

There were three main technical problems. Baird himself complained constantly about the quality of the lenses and the photocells, his employees pointed to the imperfect signal amplification, and according to spectators the mechanical aspects, the cardboard discs, the wires and strings were shoddy. In an attempt to improve the working of the photocell he even

[6] For the history of television in Great Britain, we have made extensive use of [9].

considered using a human eye; a surgeon obtained one for him but after a crude dissection with a razor he gave up and threw it into a canal.

Baird wanted to provide an integrated system, that is, he wanted to provide programs as well as equipment. He was not interested in collaborating directly with the national broadcasting company, the BBC. He wanted to finance his research out of the sale of television sets and his programs out of advertising. However, the organization responsible for controlling broadcasting, the General Post Office (GPO), objecting to the low image quality, refused Baird permission to use his transmitters. In the meantime, he devised a number of remarkable firsts, for example, the *Noctovisor* (1926), an invention employing infrared light which ensured, as had the "spotlight" method, that actors were not subjected to excessive lighting intensities. With transatlantic transmission (1923) and color television (1929) Baird succeeded in attracting publicity. He needed it badly; his good contacts with supportive patrons were vital, since as long as he could not transmit and sold no television sets, Baird had no other income.

In 1929, Baird finally received permission to employ a medium-wave radio frequency for his transmissions. He worked with thirty lines and 12.5 images/s. The reason for the GPO's change of mind was that television had now become an issue of national prestige, and Baird had begun to establish international contacts (he also worked, for instance, with the German Fernseh AG) and had threatened to move to the United States if he did not receive a British transmission license. Though he marketed his television sets, or *televisors*, himself, they were manufactured by a number of other companies and were not immediately available; it would be six months before they would be on the market. In this first period the transmissions were mostly intended for amateur enthusiasts. Two radios were needed, one tuned to the audio signal, the other to the image signal; the loudspeaker output of the second formed the input signal for a homemade television receiver.

Baird's television sets cost £25, an average monthly wage. The DIY kit versions that he also marketed cost between £12 and £16 pounds. All models had a screen measuring 5 cm by 10 cm. Estimates of the number of television sets in use varied widely. In January 1931 Baird reported to the GPO that he had sold 1000, but at the end of 1932 he stated that 500 were in use. An unknown number of homemade sets were also sold. In addition, other companies, such as Electrical Music Industries (EMI), began to develop mechanical television systems. In 1933 the BBC put the figure of television sets in use at 8000. Slowly but surely, mechanical television was becoming a success.

Baird was now working on improving the image quality by increasing the number of image lines, but this was no simple matter. It meant increasing the diameter of the Nipkow disc, increasing the number of its perforations and reducing their size. In 1933, Baird managed to increase the number of lines to 120, and in 1936 to 240. By this time the perforations were so small that dust was blocking them and so Baird switched to a camera employing revolving mirrors. He also brought larger, more expensive television sets onto the market, with a screen measuring 10 cm by 22 cm; these varied from £50 to £75 in price. Few if any of these sets were ever sold.

### ▼ *Electronic Television in Great Britain: A Gradual Takeover*

The development of electronic television in the U.K. made use of American inventions and patents. One organization, in particular, was involved: the specially-formed company Marconi-EMI, of which the aforementioned EMI was one of the founders. The new company was given access to diverse American patents, including one for an electronic camera, the *iconoscope*, developed for the American company RCA by the Russian Vladimir K. Zworykin. He had studied under Rosing in Russia. The heart of the iconoscope was a vacuum tube, in which the image was projected onto a light-sensitive surface. Each point on this surface formed a small capacitor together with the metal plate situated immediately behind it. An electron beam scanned the surface vertically and horizontally, and the discharge current, which varied with the degree of illumination at each scanned point, provided the television signal.

However, the range of the transmitters was smaller for electronic television. The reason for this was that an increased amount of information per second could be transmitted only on higher radio frequencies, particularly in the VHF band, whose range was only about 50 km. Mechanical television mostly employed short- and medium-wave frequencies which had much greater ranges. Of course, it was not necessary for electronic television to have larger number of image lines and a higher amount of information per second than mechanical systems. Electronic television could also be employed with similar numbers of image lines, and then the same frequencies could be used and the same geographic range be reached. However, in that case the potentials and advantages of the electronic system compared with the mechanical one would not exist, whereas the electronic system still had the disadvantage of a higher price. So in practice, the amount of information of electronic was indeed higher. The eventual solu-

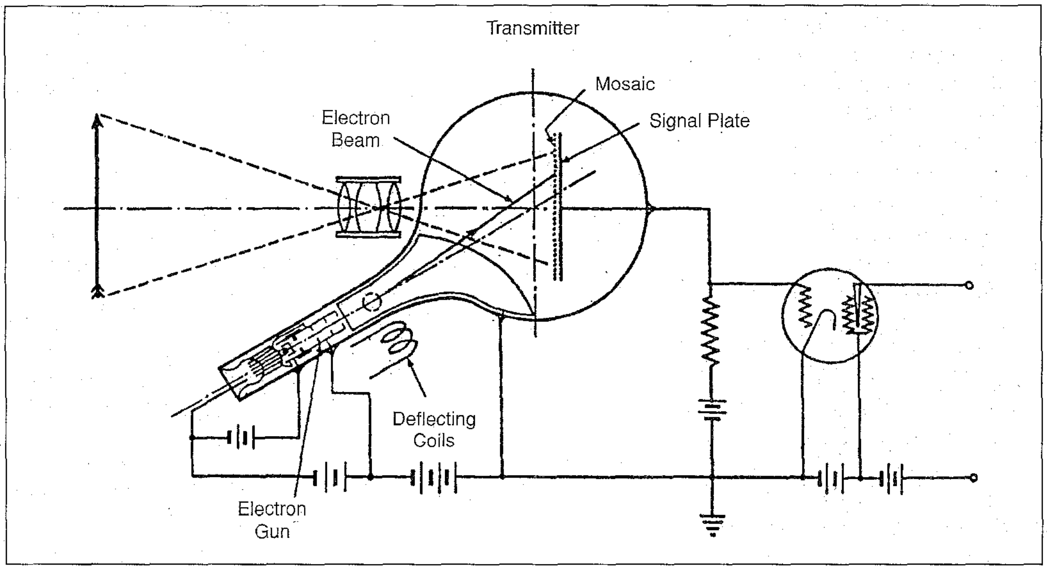


*Fig. 2. The operation of electronic television.*

tion for electronic TV broadcasts was the construction of relay stations that allowed the VHF signal to be heard further afield.

Fig. 2 shows the operation of electronic television.

In England, Marconi-EMI developed a camera, the *emitron*, based on Zworykin's principles, and which the company displayed at the 1935 annual radio exhibition. The *emitron* had an improved image quality and was also mobile. A number of other television systems were also on show. The electronic television sets were more expensive than the mechanical ones; at about £100 they represented an average Englishman's three months' wages, but the price did nothing to dampen the public's enthusiasm. Only for films (where the object was relatively small and could be perfectly lit) was Baird's mechanical system still considered more attractive. Baird tried to improve his system further, and even started to do research into electronic television.

In 1936, the Television Advisory Committee, which comprised representatives of the GPO and the BBC, created a two-year period to decide which system was better. Numerous television system manufacturers put themselves forward but only Baird and Marconi-EMI made it to the final round. Baird only participated with mechanical systems in the contest. He was now working with 240 lines and had two recording systems. For close-ups and studio work he used a conventional mechanical camera. For outside broadcasts he had developed a special process: the object was first filmed, the film automatically ran on through a developing machine, and the developed film was then broadcast using a special scanner. The whole process took only forty seconds. The purpose was to circumvent the mechanical camera's inadequacy in weak light. Baird's mechanical outside-broadcast camera had important disadvantages; it was large and difficult to transport, and the fragility of the film only increased the chances of an accident. Moreover, the whole process was extremely expensive. Baird's troubles took a turn for the worse when Crystal Palace burnt down in 1936; his company was housed there and much of his equipment was lost.

EMI was already demonstrating the emitron when the two-year trial period was introduced. The machine used 405 lines, and the television screen was now 30 cm by 30 cm. The screen tube was so long that it was mounted vertically, with a 45° mirror providing the final viewing screen. Even before the trial period was over, the machine was declared the best available; the image quality was better, the system was relatively reliable, and the emitron camera, being truly portable, was better suited to outside broadcasts than were Baird's mechanical cameras.

In January 1937 the BBC — which the GPO had accorded a television broadcasting monopoly, as it had in radio broadcasting — began transmitting regular broadcasts using an electronic television system with 405 lines. At first, few television sets were sold but a month later EMI dropped the price from £100 to £60. Six months after broadcasts had begun, 1500 sets (of all makes combined) had been sold. The spread of electronic television had begun.

## Social Shaping

The development of mechanical television in the U.K. involved a number of different social groups and organizations: the manufacturers (Baird and his company), the supervising governmental body (the GPO), the broadcasting company (the BBC), actors, amateur television enthusiasts, and the viewing public. Each group attributed different meanings to television.

For Baird, mechanical television was a means to set up and run a company. Television, for him, was a marketable product; his desire to produce his own programs was part of his marketing strategy. This was made possible in 1929 when the BBC first allowed him to use a transmitter. His broadcasts were mostly made up of studio entertainment, educational programs, and films. In this period, while he was broadcasting on a small scale and sold no television receivers, he depended on financiers to sponsor his activities. This makes clear why he put so much effort into coming up with new inventions; they would convince his patrons of the viability of the medium.

To start with, the BBC showed extreme caution; the broadcasting company would only be interested in talks about transmission, let alone participation, when an acceptable image quality could be guaranteed. Cinema film quality was informally taken as a standard. The difficulty of making outside broadcasts with the mechanical system also formed a problem for the BBC. Baird's solution to this problem, using an intermediary film stage, had its own problems; the camera was practically immobile, and the time delay that the film development produced was another possible problem.

At first the GPO was reluctant to give Baird a broadcasting license. Their argument was the same as the BBC's: Baird"s inability to guarantee a satisfactory image quality. Only when Baird threatened to leave the U.K. and set up in business abroad was he finally given a license—for England could not afford to lose Baird's company; television had become an issue of national importance.

Actors, too, had problems with mechanical television, for it depended on intolerably intense studio lighting. Baird's "spotlight" method was only a partial solution to this problem; the process put the actors into flickering light with the rest of the studio in utter darkness, so that they could read their parts only with difficulty and could not see the director. The system also left the actors precious little freedom of movement. At one point the BBC feared that actors would refuse to extend their cooperation to any mechanical television broadcasts.

Electronic television promised to solve most of these problems, but only by introducing a new problem, that of the extremely limited range of the existing VHF transmitters; many viewers would be left without a signal. To tackle this problem, an entire network of new VHF transmitters had to be set up. In 1934, when the BBC was considering replacing the mechanical system with the electronic, letters arrived from listeners in Scotland and the north of England, protesting that the change would leave them with no television signal at all. Electronic television, they argued, would divide British television viewers into two geographical halves: those within reach of VHF transmissions, and those without. The price of electronic television sets was probably another obstacle to the consuming public; they were much more expensive than the mechanical model.

Amateur television enthusiasts also found difficulties with the electronic version. VHF frequencies could not be picked up on ordinary radios, and the electronic television was too complex to build at home. And finally, electronic television of course brought Baird a big problem: it formed a threat to the continuation of his company.

## Mechanical Television in the United States: A "Boom"

Baird had an American counterpart. It was another inventor, Charles Francis Jenkins, who gave America its first mechanical television.[7] In June 1925 he was able to show pictures of a Dutch windmill turning; the images had been taken from a film screen. Jenkins' camera used two ground glass discs, that formed prisms, which deflected the beam of light in one direction as the discs rotated. He called his system *radiovision* because the system was wireless, preferring to reserve the term *television* for transmissions that took place over electrical cables, in analogy with the telephone and the telegraph. He envisaged numerous applications, such as film shows, theater shows, and sporting contests [5]. Like Baird he formed a company, but unlike Baird's it was supported by the banks.

It was not long before other large concerns began to show interest. AT&T's Bell Laboratories started work in this field in 1925 and General Electric also carried out research into mechanical television around this time. AT&T saw the device's potential as a "picture telephone," and between 1925 and 1929 the company poured over $300 000 into research into mechanical television. Two hundred engineers and scientists were put to work. By 1927 Bell was able to demonstrate two systems. One employed a large screen measuring 60 cm by 75 cm, the other a small screen measuring 5 cm by 6 cm. The latter was intended for installation in a "picture phone." In June 1929, exactly four years after Jenkins' original television, AT&T demonstrated a mechanical color television,

[7]For the history of the mechanical television in the United States we have made extensive use of [7]] and [12].

which worked using three color filters and three photocells, each photocell being connected via one of three transmission cables to a separate neon lamp in the television receiver.

From 1928 to 1932, mechanical television in the USA prospered — these were the years of a "television boom." Dozens of television stations started broadcasting, having been granted "experimental broadcasting licenses" by the Federal Radio Commission (FRC), the body that had been set up to regulate the use of radio waves. In 1931, 31 television stations were in active service and Chicago alone had an estimated 8000 television sets. Thereafter most of these stations disappeared, except for three from universities in the Chicago area that continued to broadcast educational programs using the mechanical system until 1937. Although the depression may also have been of influence, after this initial period it gradually became clear that the mechanical television system was not a viable option in the United States. We shall shortly examine the reasons below. Jenkins' company went bankrupt, and other manufacturers had it no easier.

## Electronic Television in the U.S.: A Slow Start

The first patent application for an entirely electronic television system came from the above-mentioned Zworykin. In the 1920s he worked at Westinghouse in the U.S., where at first little interest was shown in his activities but where he was later given a free hand. In 1923, Zworykin applied for a patent on his device, although the machine had yet to produce more than the shadowy image of a cross.

Six years later Zworykin was able to present a working cathode ray tube television set. Around this time he went to work at RCA, a company that had set up a central radio research laboratory in which researchers from various RCA companies were at work. In 1930 Zworykin was made head of the laboratory, and under his direction in 1933 it produced the iconoscope, the electronic camera.

The higher image quality of electronic television was due, in Zworykin's terms, to the "storing of electrical charges." In the mechanical camera, an increase in the number of screen image lines reduced the amount of light falling onto the selenium cell at a given moment; since the cell's low-light sensitivity was limited, at a certain point this began to create problems. In the electronic camera, the light sensitive plate was permanently illuminated, and in raising the number of screen lines, only the scanning speed was increased [13]. This allowed the electronic camera to operate in lower light levels than the mechanical camera.

Zworykin's successes encouraged RCA to invest a million dollars in television in 1935 alone. The concern built a new television transmitter on the Empire State Building in New York City and a special TV studio was built at the National Broadcasting Company (NBC), the RCA broadcasting organization. Although the company still had no official license to transmit TV commercially, in 1936 RCA began a campaign to attract potential TV advertisers. RCA's efforts to gain advantage over its competitors by building a patent portfolio became obstructed by the efforts of one man, who started with a single invention, Philo T. Farnsworth.

Farnsworth was responsible for the invention of another electronic television system. Farnsworth started working on what he called his television system in the mid 1920s. He managed to get several Californian businessmen, especially George Everson, interested in his ideas. In the fall of 1927 Farnsworth succeeded in a laboratory demonstration. Within a year his television system was made public with an article in the *San Francisco Chronicle* describing Farnsworth' camera, the *image dissector*, as ordinary jars that housewives used to preserve fruit. Farnsworth' achievements did not go unnoticed. In 1930 RCA tried to acquire "Television Laboratories Inc.," an offer that was declined by George Everson. After a brief liaison with Philco, Farnsworth continued on his own account with the Farnsworth Television Inc. The company soon became entangled in a patent conflict with RCA, which argued that Zworykin's iconoscope was the first camera.

Commercialization of television in the U.S. was delayed by the fight over patents. Farnsworth could not license his patents in the U.S. as long as his patents were under contest. In 1934 Farnsworth received an invitation from Baird Television for a patent license in England. Baird was at that stage forced by his financial backer, British Gaumont, to turn his mechanical television into an electronic system, because BBC had advised him to stop working on his experiments. With the money from this license Farnsworth could continue the perfection of his television system.

Electronic TV broadcasts took place in the U.S. on a limited scale after 1932. A number of stations that had employed mechanical equipment continued with electronic. RCA, which had broadcast with mechanical and shortly with a hybrid mechanical/electronic system, in 1933 set up a network of transmitters for all-electronic television. In this way the company offset the limited VHF signal range. In 1935 AT&T produced the coaxial cable, the first of which was laid between New York and Philadelphia. Nevertheless, electronic television made slow progress over the next few years. This was partly caused by the fact that companies such as Philco and Dumont, which were not yet able to produce a complete system themselves, convinced the Federal Communications Commission (FCC), the successor of the FRC, that no consensus yet existed within the industry on an "ideal" television system. It was not until Farnsworth entered into a cross-licensing agreement with AT&T in 1937 that could have left RCA out of commercial television altogether, that RCA and Farnsworth began the negotiation of cross-licensing agreements. In 1939 RCA was obliged to reach a licensing agreement with Farnsworth before they could market their television. In the meantime the agreement between AT&T and Farnsworth convinced the Columbia Broadcasting System (CBS) that commercial television had become viable.

In 1939 television became "official" when President F.D. Roosevelt initiated the first television broadcast at the New York World's Fair. In the next week the first television sets went on sale. Commercial television was within reach, but the World's Fair only started a new phase of experimentation in which the public was to be included through the sale of a handful of receivers. Not even RCA had permission to sell commercial time to advertisers until the FCC decided on standardization. However, the FCC delayed standardization since it demanded unanimity within the industry. FCC's concern for consensus became the catalyst for the Federal Government to establish the National Television System Committee (NTSC), which operated under the auspices of the branch organization of the industry, the Radio Manufacturer's Association. The NTSC reached consensus soon after the outbreak of World War II, and in 1941 standards were established. But now the war would prevent the commercialization of television.

## Social Shaping of Television in the United States

The U.S. media infrastructure differed greatly from the British, a situation dating from the radio age. In the early years of radio development, various companies energetically competed for and contested patent and broadcasting rights. In setting up NBC in 1926, RCA brought a number of these companies together; the radio stations belonging to the RCA, General Electric, Westinghouse, and AT&T were now operated by a single organization. AT&T was now responsible only for the transmission itself.

As had also been the case for radio, mechanical television equipment was produced by a number of different manufacturers, including Jenkins, AT&T, and General Electric. A number of these companies also undertook broadcasting activities; one of these was the RCA's own NBC. Most of the manufacturers saw mechanical television as a broadcasting medium, but AT&T concentrated on the potential for a "picture phone."

During the radio age, government and industry had reached an agreement embodied in the Radio Act of 1927. Government's primary aim had been to prevent the formation of monopolies in the broadcasting, programming, and television manufacturing industries. Secondly, it sought standardization, so that every radio could receive every station. It also expressed the view that the development of radio should remain a matter of private initiative; radio manufacturers and broadcasting companies should finance themselves. The governmental Federal Radio Commission was formed to confer licenses and to allocate radio frequencies, but was not to concern itself with the canvassing of advertising, nor with most aspects of programming. With the subsequent introduction of television, the FRC — later to become the FCC — was also the regulatory body.

Television broadcasts were dominated by singing, cabaret, educational programs (which included, for instance, a course on bookbinding) provided by the universities, and the occasional film or sporting contest. In Chicago a television station was run by a newspaper together with a television manufacturer. It televised little news, though; most of the programming consisted of cartoons.

In the U.S., too, amateur television receivers formed a significant social group. Special DIY televisions, which were considerably cheaper than the electronic sets, were brought onto the market.

What specific problems were faced by the various social groups using mechanical television in the U.S.? The FRC was faced with three problems; first, it was unsatisfied with the image quality and therefore only conferred temporary licenses. Secondly, there was still no transmission standard. Different stations employed different standards with regard to the number of lines and the number of images per second. In choosing between different standards, television buyers ended up effectively choosing between stations. Later the FCC therefore advocated standardization. Thirdly, station frequencies regularly overlapped. Here, too, the FRC wanted to sort things out.

For the broadcasting companies, the main problem was one of income. A temporary license did not allow a station to broadcast advertisements, and this denied them an important source of income. A third social group, the actors, had the same difficulties with the lighting as they did in the U.K. Finally, for the consumer public, the absence of technical standards and the overlapping of broadcast frequencies were the greatest problems.

How did this compare with the situation for electronic television? For the most important manufacturers of electronic television (RCA, Farnsworth, and Philco) patent rights formed a problem; as we have seen, RCA was eventually obliged to come to a licensing agreement with Farnsworth. The FCC, on the other hand, had to decide on certain technical standards that would unavoidably hinder the introduction of later technical improvements. Nevertheless, after the establishment of the NTSC, in 1941 a set of standards was agreed to. In other countries, such standards were only drawn up much later, and this explains why to this day the U.S. has a technically less sophisticated television system.

**Social groups, according to the meanings they attribute to the technology, can influence the course of its development.**

The broadcasters employing electronic television were by and large the same companies that had employed mechanical television. The main problem was the limited VHF transmission range. To begin with, reception was limited to the larger cities, and only after 1933 was a solution provided by a wider network of transmitters. By the end of the 1930s broadcasters and manufacturers joined forces after the FCC, in order to promote technical improvements, decided to confer broadcasting licenses only to those companies actively engaged in research into such improvements.

Since from the mid-1930s onwards broadcasters were allowed to carry advertisements, advertisers gradually became another important social group involved in electronic television. Initially, however, low viewing figures made these advertisers cautious.

The viewing public, meanwhile, was pleased that electronic television made it possible to broadcast events that took place outside the studio: sport and news. However, the absence of transmission standards was a problem for consumers, as in all probability was the expense of an electronic television set: in 1939 a set cost between $200 and $600. Again, part of the mechanical television viewing public was not reached by electronic television broadcasts. The conviction that areas outside the large cities should also have the benefit of television played a large part in the FCC's decision to allow the three universities that employed mechanical television to continue doing so for many years.

Finally, American amateur enthusiasts had the same problems with electronic television as did their British counterparts: its overwhelming technical complexity and the greater technical differences with ordinary radio reception.

## Mechanical Television in the Netherlands: Hat Shows

For a short time, mechanical television enjoyed a certain popularity in the Netherlands, although this was less the case than in either the U.K. or the U.S.[8] Just as had been the case in these two countries, it was an individual pioneer, the Eindhoven radio amateur Freek Kerkhof, who got Dutch television off the ground. In 1924 he decided to develop a television system using Nipkow discs, but it was 1927 before he could demonstrate his ten-line system, and little more than shadowy images could be discerned. Philips followed developments in image transmission from 1925 onward. Between 1928 and 1931, radio and newspapers showed considerable interest in mechanical television.

Philip's first experiments date from this time. Although its research laboratory's directors had resisted mechanical television from the start, under commercial pressure they presented, in 1928, a television image made up of 48 lines, employing Nipkow discs, a photocell, and a neon lamp. The device was able to radiotransmit an image of static objects a distance of 400 m. Philips had two aims in mind for these demonstrations of mechanical television: first to show that it was interested in the medium, and second to demonstrate its shortcomings. For all its sophistication, the Nipkow television was a large, cumbersome and susceptible machine and Philips saw little future for it in Dutch households.

In the first half of the 1930s, Dutch broadcasters showed little interest in the medium of television. One, the Vereniging van Arbeiders en Radio Amateurs (VARA), was an exception; in 1931 it transmitted an experimental broadcast using a thirty-line machine obtained through the German television manufacturer Telehor AG.

[8] A small number of Dutch publications have appeared on the development of mechanical and electronic television. Sources for the study of mechanical television are [14]-[16]; see also [17].

The 3 cm by 4 cm viewing screen was enlarged by means of an enormous lens. The broadcast lasted 15 min and was accompanied by widespread publicity. Radio magazines and newspapers described the limitations that thousands had witnessed for themselves. The portrait of a woman, they reported, had been indistinct and shaky; "one moment she was visible, and the next moment it looked more like a film of railway tracks shaken by the passage of a highspeed train" [18]. Not surprisingly, the public was warned not to expect too much of the new medium.

Kerkhof, in the meantime, continued his experiments. By 1935 he was able to demonstrate a thirty-line system, comprising a mechanical mirrordisc camera and three receivers, to the Dutch National Society of Radio Amateurs. The program showed Mrs. Kerkhof, busily displaying one hat after another. This demonstration was followed up in 1936 when Kerkhof started regular Sunday morning transmissions for Eindhoven amateurs using homemade 30-line receivers. A year later Kerkhof had built a second transmitter for the accompanying sound signal. He had also begun using cathode ray tubes in his cameras, which resulted in a considerably improved image contrast. After other improvements were made in the studios, he was able to start transmissions employing well-known artists, and these broadcasts continued until his transmission license was withdrawn as the result of Dutch war mobilization in 1939.

## Electronic Television in the Netherlands: Philips and the Government

Philips began building an experimental electronic television system in the 1930s.[9] Their research laboratory experimented with camera recordings in the studio, outside broadcasts, and with film shows. In 1937 Philips began to give public demonstrations; systems were available using 405 and 567 lines. In the Utrecht trade fair held in the spring of 1938, Philips demonstrated a number of 405-line television sets and also a large-screen set called the *protelgram.* The yellow-reddish image of the mechanical TV set had now given way to the sepia-greenish image of the electronic ones.

For all this, Philips was not actually very interested in television, a view the company retained right up to the 1940s. Philips directors saw the limited range of VHF transmitters and the high cost of television sets as serious obstacles to their successful marketing. Neither did they expect the public to be satisfied with a blurred image measuring only three by seven centimeters. And Philips did not expect the glass industry to suddenly come up with a large enough image tube.

Philips concentrated on two alternatives to television: the *huiscineac* and the above-mentioned *protelgram*, which was first shown at the Radiolympia in England in 1937. With the *huiscineac* (literally, "home cinema") viewers could project films at home, but the process was ultimately never exploited commercially. With the *protelgram*, Philips was reacting to the fact that many people found the picture of the first generation receiver disappointingly small: the *protelgram* projected a small, intense electronic screen image, by means of a large spherical mirror and a correcting lens, onto a screen or wall [22]. The image was then 40 cm by 50 cm, but its clarity left much to be desired. In 1937 Philips sold several sets, but shortly afterwards was proposing to take them back because the tube life was unacceptably low.

Philips also suffered an unpleasant and unexpected side effect from its experiments with television; the "picture radio" led to a stagnation in demand for ordinary radios [17]! In 1938, Philips therefore embarked on a rather unusual campaign; staff traveled throughout Europe ostensibly demonstrating televisions but actually concentrating on promoting the sale of radios. For Philips too, the start of the World War II, put a lengthy stop to further activities [23].

The radio broadcasting companies had not ignored these developments. In 1935, three of these companies submitted an application to jointly run a television station. This application led to the formation of the Television Commission, which was to seek information and to advise on the technical, legal, and economic aspects of mechanical and electronic television systems. The existing administrative structure with regard to radio served as a guideline. The Commission was composed of broadcasters and the PTT, the Dutch Post Office, which had a role in the provision of communication cables.

The Commission examined the situation in various countries, and it watched experimental transmissions of the German Olympic Games. Its interim report expressed reservations about costs and program content, and the Commission felt that the difficulties were serious enough to warrant deferring a regular television service for the time being. However, the rapid course of developments abroad made an experiment with electronic television imperative, a conclusion which was repeated in the Commission's definitive report published in December 1937. Broadcasters and the PTT would take care of the technical side of such an experimental transmission; television receivers would be situated in

[9] The section on Dutch electronic television is primarily based on [19]-[21].

public places, with the expectation that they would later appear in private houses. Philips declared itself prepared to supply apparatus, and after the broadcasters had acknowledged themselves prepared to make the programs and foot the bill for the transmissions, the Commission announced that everything was ready for a trial television service. At this point, World War II intervened and the experiment was postponed.

After the war, the various groups involved took matters up once more. Philips still had the American marketing of its own *protelgram* high on its agenda; the company was still convinced that television would spread only slowly in the Netherlands. Nevertheless by 1947 Philip's experimental research laboratory Natlab had produced a television transmitter, and its receiver was almost ready for mass manufacture. When a Philips manager in America sent a telegram strongly urging his colleagues to increase their television activities (the *protelgram* was all very well, but it looked like the future lay in television), Philips changed course [24].

The company was given a license to transmit within a radius of 40 km, and began experimental broadcasts to a select public. Three times per week Philips employees, local worthies, and radio dealers were treated to ninety minutes of television. Philips television receivers operated at a standard 625 lines, in contrast to France's 819 lines and Britain's 405 [25], [26]. Together with the PTT, Philips began to lobby government for permission to start more frequent broadcasts. One of its arguments was that a good domestic market was crucial to the sale of television sets abroad. However, party political and broadcasting companies' reservations held back the introduction of an experimental television service until 1951.

## Social Shaping of Television in the Netherlands

In the Netherlands too, various social groups and organizations influenced the development of both mechanical and electronic television: television amateurs, broadcasting companies (especially the VARA), Philips, government, and the PTT. As elsewhere, mechanical television was most important to the amateur enthusiasts. Kerkhof called for their comments on the programming. Ultimately, however, they formed no important pressure group in defense of mechanical television, and this had much to do with Kerkhof's attitudes. Unlike Baird, Kerkhof did not try to wring commercial profit out of television but aimed only to provide the best possible quality given the means available to amateurs.

Broadcasting companies were quick to lay claim to television, perhaps in order to prevent the medium from being stolen by other organizations. The VARA's 1931 experimental broadcasts gave an important boost to the development of mechanical television, but as a whole the broadcasting companies' involvement in these experiments was short-lived. The same can be said of Philips; though the company began experiments with mechanical television in the 1920s, it appears that these experiments were not considered of great importance. Government involvement was represented by the formation of the first Television Commission, representing the broadcasting companies and the PTT, and which appears to have been equally unenthusiastic about mechanical television.

> **Electronic television was more suited to the broadcasting of live outdoor events, where good image quality was vital.**

By and large, the same groups were involved in the growth of electronic television. Philips was still barely interested; when the company began demonstrating this equipment in the late 1930s the main purpose was to stimulate the sale of ordinary radios. Moreover, Philips was principally interested in a medium for the domestic reproduction of large-screen films, and was therefore more preoccupied with its *protelgram*. Still, its apparent disinterest in television ought not to be exaggerated; a significant portion of Philips' patent applications in 1934 and 1935 had to do with television.

In an important sense radio was the medium of the 1930s, and since the same parties were involved this was reflected in the development of both mechanical and electronic television. Practically everyone was content to wait and see what television had to offer; this also had much to do with the limited television programming of the time. The widespread opinion was that if television had anything to offer beyond adding images to a radio signal, it was the showing of films. Neither did Philips' attitude do anything to stimulate the further development of mechanical television.

After the Second World War the Netherlands opened an intense debate on the introduction of electronic television. Most of the parties who had been involved before the war reappeared and it was remarkable how many of them had changed their minds completely in the meantime. Philips' vacillation had been replaced by an almost aggressive approach, after the company had been put onto the scent by developments abroad. Having also gained the support of the PTT, Philips argued in terms of employment opportunities, export opportunities, and national prestige, and that these would first require a secure position for Philips in the Dutch market. The broadcasting companies, too, had modified their views; they were prepared, primarily from a protective standpoint, to work with experimental television broadcasts.

Government adopted no very clear position but did raise a number of financial and cultural objections. Political and broadcasting representatives (who in the Dutch social system were already strongly aligned) shared a certain hesitancy with respect to television which yielded to the pressure being generated by Philips, the PTT, and Nozema, a regulatory government installed office. Administrative structures that had evolved in the age of radio went on to determine the way in which television was used; indeed, in programming terms, television was initially little more than radio with pictures.

## Social Factors an Influence

In considering the developments recounted here, the choice between mechanical and electronic television can be perceived as having been the result of a combination of technical and social factors. Technical factors had to do with the advantages and disadvantages of each system. Mechanical television was cheap and TV sets could be constructed by amateurs themselves, all sorts of technical extensions (such as the use of color, image recordings, and large screens) were easy to put into practice, and as a consequence of low information density, the transmitters could have a long range. However, the image quality was poor and the system was best suited to studio work and film shows; it proved impossible to develop a practical camera for outside broadcasts. Electronic television on the other hand had a high image quality and was well suited to outside broadcasts, but the technique was expensive and not within easy reach of amateurs. Moreover, electronic television could only exploit its advantages in image quality if a higher number of image lines was applied. This required transmission on a VHF bandwidth with a low geographical range.

The choice between these two systems cannot, however, be attributed to these technical factors alone. Social factors also played a role. Different meanings were attributed to television by the various agents in its development: some wanted to see it used for public broadcasts, others for "picture phones." Its use in broadcasting was itself subject to differing appraisals: some saw it as a medium for film shows, others saw its potential as a news broadcaster, and still others noted its educational possibilities. In a social process involving a number of different social groups and organizations, the use of television for broadcasting purposes became predominant. With regard to programming, live events, and sports contests in particular, seem to be considered important. This appears, for instance, in the use of the 1936 Olympic Games in Berlin as a test between the two television systems in Germany. Electronic television was more suited to the broadcasting of such live events, as good image quality was vital and these events normally took place outdoors.

However, had another set of connotations predominated, for instance if television had been a medium of studio recordings and video telephony alone, then mechanical television would have stood a better chance. Certainly, in such applications its image quality would not have reached that of the electronic television, but the difference would have been smaller in these applications, and its advantages in other respects would probably have improved its overall acceptance. Although mechanical television had the advantage of a head start on electronic television, its early success largely resulted from the fact that studio recordings and video telephone were originally perceived as important purposes. Had there been a need for transmissions with worldwide reception (a need which is now met by satellites), mechanical television would also have had advantages. It is possible that other interpretations also played a part in the eventual choice for electronic television; actors, we may recall, had many difficulties with the strong lighting required by mechanical television.

In other words: internalist historical accounts take the importance of the image quality criterion for granted. In contrast to this, our approach to the early history of television reveals that in the course of a social process, image quality and the possibility of making outside broadcasts became dominant criteria.

The difference between historical developments in Great Britain and the United States must be attributed to the financial structures of the broadcasting organizations in each country. In the U.S., broadcasting companies had to meet their costs by selling advertising. Since they were given only experimental transmission licenses which stipulated that no advertising could be carried, they were deprived of this income and many eventually folded. In Britain, the BBC had a more secure future and the development of mechanical television became part of the national interest. Another explanation for the difference may lie in the fact that American mechanical television was faced with more problems, thanks to the large number of broadcasting companies, the lack of standardization, and limited radio frequencies. The reason that American universities continued to use mechanical television for so long is that it suited their purposes reasonably well; they broadcast mainly studio programs.

While the Netherlands was no television pioneer, it was no slow starter either. Early on, a mechanical system was developed that remained in use until 1939. Later, Dutch television fell behind the field. Philips, the most important Dutch electrical goods manufacturer, was only moderately interested in electronic television, and until 1947 it was more concerned with the alternatives to television. Developments abroad finally persuaded Philips to change tack.

A note should be made of the relationship between television and its predecessor, radio. We have seen that the organizations, set up by government and industry in all three countries, responsible for supervising radio broadcasts, were also given (or assumed) responsibility for television. Television did not develop in a political or industrial vacuum. Significantly, the organizational structure of radio was simply grafted onto television, though the technical system chosen was one less compatible with radio as far as frequency and type of technology was concerned.

Overall, our broad, technical-social perspective gives a better understanding of the early history of television than earlier one-sided approaches. Our analysis reveals, for example, that screen image quality and the possibility of making outside broadcasts became dominant criteria in the course of a social process. However, our analysis also shows that we cannot rub out technical factors, as some new approaches tend to do, thus in fact introducing a new type of bias. Perhaps, researchers busy in constructing new approaches should not polish off the older ones too soon, but try to find more embracing perspectives.

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