Tomorrow's Media

Tomorrow's Media:

Essays in Honour of Aleksandar Louis Todorović

Edited by

David Wood and Jelena Todorović

Cambridge Scholars Publishing

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Aleksandar Louis Todorović: Superstar of the Art and Science of the Media A Homily

David Wood

This volume is dedicated to the dear friend and colleague of many, who passed away in 2020, Aleksandar Louis Todorović. David Wood, who considers him a soulmate, writes the following about him.

I first met Aleksandar Louis Todorović in the early 1970s, when we worked together on a European Broadcasting Union (EBU) report about a new way to shoot news material: 'electronic news gathering' or ENG. I thought then that life was so unfair. Louis was a Renaissance engineer, who understood the technology well and what programme makers did and wanted; who spoke who-knows-how-many languages; and who had great personal charm. How could he not be successful in broadcasting, or whatever he wanted to do? By the way, ENG took over the newsrooms of the world, and this may have been microscopically due to our report.

Back then, and for decades afterwards, the EBU–the grouping of Europe's national broadcasters–was the most powerful force in the broadcast-technology world. It was there that many key broadcast formats and standards were discussed and decided. Louis realised that this was the place to be if you wanted to change the media landscape. He became a leading member of the groups dealing with systems and standards for television-production equipment. At the same time, based in Belgrade, he was the Secretary General of the grouping of broadcasters in what was then Yugoslavia.

The 1980s saw the birth of digital television, and the first step was to convert programme production to a form that could take advantage of digital tools. Once the basic form of the digital signal was agreed, to make digital programme making a reality, two key elements were needed. One was the ‘digital interface’ for programme-making equipment. This was developed in the EBU and International Radio Consultative Committee[1] under the leadership of Canadian Ken Davies, who passed away in 2019. The other was the format for recording digital programmes. Louis led the team in the EBU that agreed the format for the first professional digital tape recorder, called (what else could it be?) the D1 format.

Another of his career highlights was chairing the EBU Technical Committee, the EBU’s most senior governing body for technology. The Committee took decisions that shaped the fate of the media across the world, and were in very good hands with Louis – always a diplomat, and always understanding the technical and creative implications of each of their actions.

With the breakup of Yugoslavia in the mid-1990s, Louis took on a new challenge: to establish and serve as Principal of the International Academy of Broadcasting, a postgraduate school in Montreux, Switzerland. Louis’s revolutionary aim was to teach both the technical and creative skills of television, and to foster a new generation of media staff who would have the same kind of cross-industry skills as he had. I taught one of the many courses there, in my case, on how to evaluate television picture quality. I am still not sure how to do it; but the students – and Louis – taught me a lot. Sadly, after some years, a change in the tax laws in Switzerland made it no longer viable to continue the school, and finally Louis returned to Belgrade.

Into retirement, Louis continued to lecture and write. He was a wizard at explaining technology to non-engineers, and his books were widely published and won awards.

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[1] The agency of the United Nations responsible for worldwide media standards, usually known by its French initials, CCIR.

He will always be remembered by his many dear friends, including George Waters and Paolo Zaccarian, who together with Louis were, for the author, the three MTMs (Media Technology Musketeers). Louis has left us a great legacy of how to bridge the creative and technical worlds of the media. He was always a pleasure to meet and have discussions with, and many is the media man who is left with great memories of his time.

Zbogom Louis.

Aleksandar Louis Todorović at the EBU Technical Assembly in Munich 2013.

NOTES ON THE CONTRIBUTORS

Christoph Dosch After graduating from the Technical University Munich in 1976, he started his career as scientific engineer with Munich's Institut für Rundfunktechnik (IRT): the research and development arm of the public-service broadcasters of Germany, Austria and Switzerland. He served as project leader in digital HDTV and a series of further R&D projects covering terrestrial, cable and satellite broadcasting, as well as multimedia and interactive services such as HbbTV. In the 1990s, his interests turned to aspects of general networking and accessibility to linear and interactive television services for people with special needs. In 2014, Dosch retired, having served IRT as its General Manager, Collaborative Research for almost two decades. From 2014 to 2021, however, he continued as IRT's liaison officer to the International Telecommunication Union (ITU) and EBU, mainly with respect to spectrum use and frequency planning. In 2007, he was elected Chairman of ITU Study Group 6 (Broadcasting Service), and served in that role until 2015. Currently, he is its Vice Chairman.

Paul Kafno is a graduate of Oxford University. He taught in Swaziland before joining the BBC as a radio producer, and subsequently moved to BBC TV, where he directed and produced a wide range of Arts and Drama programmes. At ITV, his theatre and music productions won the Prix Italia and Royal Television Society, Golden Gate and Prix Gemini awards, and were widely seen throughout the world. He pioneered the use of digital with his Stravaganza dei Medici programme, and later set up HD Thames, which produced the first high-definition coverage of the Olympics and world ice-skating, as well as plays and musicals. He continued to develop new technologies for the creative industries, including the distribution of live theatre and opera performances to UK cinemas. While on the Council of the International Broadcasting Convention he was President of the Nombre d'Or competition. He is currently a Director and Chair of CTVC.

Ulrich Reimers is a retired university professor of communications technology. After studying at Technische Universitaet Braunschweig, he worked as a researcher at its Institute for Communications Technology. Leaving the university as a Dr.-Ing., he joined the industry and became responsible for the development of HDTV studio equipment when that technology was still in its infancy. He then became Director of Technology for Norddeutscher Rundfunk, one of Germany's public broadcasters. During this phase of his career, he co-founded the Digital Video Broadcast (DVB) consortium, which went on to provide standards for digital television for many countries, including the UK. As Chairman of the DVB Technical Module for 20 years, he was responsible for the development of these standards. In 1993 he was asked to become a full professor at his alma mater, and the managing director of its Institut fur Nachrichtentechnik (IfN); and for the last eight years, he has served as a vice president of that university. Prof. Reimers, often called the 'Father of DVB', has received numerous international and national awards, including the J. J. Thomson Medal of the Institution of Electrical Engineers of the UK. He is currently working on the development of 5G broadcasting, together with a team of researchers at IfN.

Aleksandar Louis Todorović After graduating from Belgrade University's Department of Electrical Engineering, he spent more than 40 years of his professional life in various areas of broadcasting. His diverse posts included Director of Television Production, Editor-in-Chief of Special Programmes, and Director of Research and Development at Radio Television Belgrade, and Executive Director of Yugoslav Radio Television. In parallel with his broadcasting activities, he had a notable academic career at the University of the Arts in Belgrade, and from 2006, at the Mediterranean University in Montenegro. From 1993 to 2001, he was Director and Dean of the International Academy of Broadcasting in Montreux, Switzerland. Prof. Todorović was a Chairman of the Technical Committee of the EBU, Vice-Chairman of Study Group 11 of the International

Telecommunication Union, and at the time of his death in 2020 was a member of the Council of the IBC and Honorary Chairman of the EBU's Technical Assembly. He was a Life Fellow of the Society of Motion Picture and Television Engineers (SMPTE) and received the IBC award and the Gold Medal for Creativity from the World Intellectual Property Organisation. He published widely on the subjects of broadcasting and the relation between the arts and technology, including several important books on these subjects.

Jelena Todorović (BA, Faculty of Philosophy Belgrade, MA and PhD, UCL London) is a Full Professor of early modern European culture at the Faculty of Fine Arts, *University of the Arts in Belgrade* and the Vice-Dean for International Cooperation. Since 2006 she runs the project of the *State Art Collection in Belgrade*, the work for which she received European Union Award for cultural heritage in 2018. Although an art historian by training, her interests have always been more directed towards early modern cultural history, as well as the curatorial work and the history of collecting in the first half of the 20th century.

Simon Tuff read Electrical and Electronic Engineering at the University of Bradford and, after a short spell in the defence and computer industries, joined the BBC in 1988. There, he was able to pursue his passion for broadcast audio, which he acquired 14 years earlier as a boy chorister whilst recording radio programmes for the BBC's schools output. Since then, he has been fortunate to work on the engineering of all forms of the BBC's audio output, from local radio to the World Service, and from the introduction of TV surround sound to codec developments with BBC R&D. He is currently active in the field of next-generation audio technology, both as a creative programme-making tool and as a means of enhancing audience experiences.

George Waters graduated from University College Dublin in 1956, earning an MBA from the same institution 10 years later, and a doctorate from Trinity College Dublin in 1990 with a thesis dedicated to HDTV. He joined Raidió Teilifís Éireann (RTÉ), the Irish public broadcaster, in 1956 and was on the team that prepared the launch of

Irish television in 1961. Following a stint as RTÉ's Director of Engineering, he became its Director General in 1978, serving in that role for seven years. In 1985, he joined the headquarters of the EBU as Director of the Technical Department, and stayed there until 1997. Dr Waters was intimately involved with the standardisation of broadcasting systems throughout the world, and worked closely with standardisation bodies like ITU and ETSI. He was a member of the DVB project, and in 1993, co-founded the International Academy of Broadcasting in Montreux with Aleksandar Louis Todorović, and served as its President. Over the years, Dr Waters's work has been recognised with numerous awards, including from IBC, the National Association of Broadcasters (USA), and the SMPTE. He is a Life Member of the SMPTE, and currently involved in research on the history of broadcasting.

Janet West has spent more than 40 years in various broadcasting roles, including early HDTV development. In 2008, she obtained a master's degree in Environmental Strategy, with a view to helping the digital connected world develop ways to address sustainability. Her early career was as a commercial pilot, and her thesis addressed the factors affecting emissions by airliners, high-speed trains, standard trains, and cars. She has since lectured at Skema in France and at Anglia Ruskin University on the impacts of a connected world, lifecycle assessment, the built environment, and the ethics of sustainability. She also worked at BBC R&D on the environmental impact of broadcasting; at Warwick University on the impact of the internet; at the University of Bologna on changing student views of sustainability; and at the University of Valencia on climate change's impact on water quality.

David Wood has spent a lifetime in broadcasting, working for the BBC and Independent Broadcasting Authority in the UK, and for the EBU in Brussels and Geneva. The author of many technical papers on digital television and media quality evaluation, he has received a number of awards, including the SMPTE's highest: the Progress Medal. He was educated at the University of Southampton in the UK and the Popov Institute in the Ukraine. He is currently a technology and innovation consultant to the EBU.

Paolo Zaccarian has spent a lifetime in media technology. He worked for many years for Radiotelevisione Italiana, the national broadcaster of Italy, including as its Director, before joining CBS in the United States. He has led two technical groups of the EBU Technical Committee: Working Party G, concerned with programme production, and Sub-Group G2, with videotape recording. Included in this work was the development of the world's first professional digital tape recorder format, D1, undertaken in partnership with Aleksandar Todorović. Zaccarian also led various study groups in the ITU, charged with preparing technical standards for television and radio broadcasting. He has participated in most of the major media-technology standards discussions of the past 50 years.

CHAPTER 1

MILESTONES IN THE EVOLUTION OF RADIO AND TELEVISION

GEORGE T. WATERS

The genesis

The *Encyclopaedia Britannica* defines the word broadcasting as ‘the electronic transmission of radio and television signals that are intended for general public reception’. We will soon be celebrating the centenary of the first public broadcasting system. Over the years since its introduction, many improvements have enabled broadcasters to provide the varied and excellent services offered to the public today. These milestones in the development of the medium are the subject of this chapter.

Following the First World War, there was a great interest in radio, brought about by the success of wireless telegraphy: a fundamental resource used by both sides in the conflict. As a result, there developed a strong amateur movement, members of which operated transmitters and receivers to exchange greetings and personal messages. Many were involved in experimental research, and their experience added to the accumulated knowledge of the propagation and reception of radio signals. Collectively, they supported the demand for continuous public services. Groups of amateur operators, pejoratively termed ‘hams’ by their professional counterparts, were particularly well represented in the United States and Britain.

Seeing a great commercial opportunity and anxious to promote sales of receivers, industry leaders appealed to governments to license public radio services. Initially, schedules of programmes confined to short hours of transmission were licensed, and radio services were limited in coverage to local areas. These services stimulated demand for wider areas of coverage and increased hours of transmission. The radio receiver (known then as the 'wireless set') gradually replaced the gramophone as the centre of entertainment in the home.

The crystal set

In the early days of radio, the crystal set **(Fig. 1-1)** was the only means of reception. It was a very basic device consisting of no more than four components: the crystal itself, which was typically a small piece of the mineral *galenta*; a short piece of wire called the 'cat's whisker'; an aerial, usually consisting of a length of copper wire between 3 and 50 metres long, depending on the distance from the transmitter; and a pair of sensitive headphones. No power supply was required, as the power of the received signal was sufficient to operate the headphones. In later variants of the device, tuned circuits provided station selectivity.

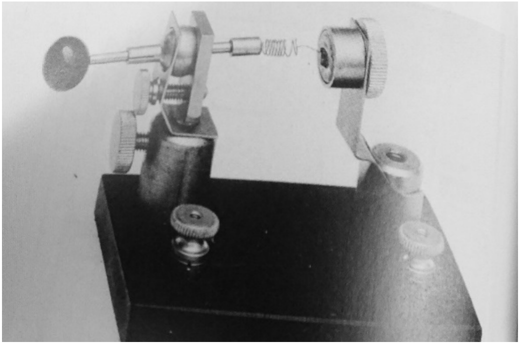

Fig. 1-1 Crystal set, Wikimedia commons

As a very primitive device, the crystal set of course had a number of drawbacks. These notably included its very low audio volume, the fact that only one person could listen to it at a time, and its reception, which was only satisfactory within an area in close proximity to the transmitter. It was, however, very popular because of its low cost and novelty value.

The triode valve

When combined, inventions by John Ambrose Fleming and Lee de Forest brought about a fundamental change in the manufacture of receivers, and hence the development of radio. Fleming, building on the invention of the electric light bulb by Thomas Edison in the 1870s, conceived the idea of the electronic valve. The diode, as constructed, was made of an evacuated glass valve containing two electrodes, called the cathode and the anode, and passed current in one direction only.

Lee de Forest invented the triode by adding a third electrode within the glass container. This electrode, called the grid, controlled the amount of current passing through the valve at any given time. This device was capable of detecting and demodulating a modulated radio frequency.

The triode was probably the greatest innovation in the history of radio, and was certainly a milestone in the evolution of broadcasting more generally **(Fig. 1-2)**. As a result of its incorporation into the design of radio receivers, it stimulated a veritable explosion in public demand for radio receivers, and hence the manufacturing of them. The domestic radio industry was born. The radio receiver was now developed into an instrument that incorporated amplifiers (also using valves) and loudspeakers, allowing multiple people to listen at the same time. However, such receivers required power, and in practice, this was either from mains electricity or from batteries.

The highly competitive industry soon spread worldwide, with manufacturers such as Cossor, Bush, Murphy and Burndept **(Fig. 1-3)** becoming household names in Britain. In the United States, Philco, Atwater-Kent and Zenith were very popular valve receivers. There were many more brands of radio made by a plethora of companies situated in a number of countries.

Fig. 1-2 Transistor, valve, Wikimedia commons

Fig. 1-3 Burndeptradio receiver, circa 1940, Wikimedia commons

Regulation

Radio transmitters grew like mushrooms, without any frequency coordination. This laissez-faire practice resulted in a situation where many transmitters in close proximity to each other caused mutual interference, which made reception very difficult. Transmitters on the same or even on adjacent frequencies made reception impossible except in very close proximity to the transmitter. This, of course, reduced the coverage area of the transmitter. The situation was almost out of control when the International Telecommunications Union (ITU) decided to convene a World Radio Conference in Atlantic City, New Jersey in 1947. The Conference, in turn, recommended that an International Frequency Registration Board (IFRB) be established, to regulate and manage the assignment and use of frequencies within the radio spectrum, and hence prevent indiscriminate use of the airwaves.

The Federal Communications Commission had already been established to regulate broadcasting and other uses of the spectrum in the United States. The designated radio-frequency spectrum, part of the overall electromagnetic spectrum, stretches from 30 Hertz (30Hz) at the lower end to 300 GigaHz (GHz) at the upper end, accommodating most of the requirements of electronic communication. This range of frequencies is divided into several bands, those used for terrestrial broadcasting being as follows: low frequency (LF); medium frequency (MF); high frequency (HF); very high frequency (VHF) and ultra high frequency (UHF) **(Fig. 1-4)**.

In the early days of radio, transmissions were largely confined to the LF, MF and HF bands. Each band has its own propagation characteristics, and the MF band was initially used for broadcasting. As an Irish storyteller would say ‘things rested so’. But, of course, in broadcasting, development is ongoing, with new ideas and new devices appearing continuously. For thirty years or so, the valve receiver reigned supreme and served the industry well but then came the transistor.

Fig. 1-4 Radio dial showing a large number of stations, Wikimedia commons

The transistor

The transistor revolutionised the electronics industry by rapidly replacing the vacuum tube with a solid-state device many times smaller and more efficient. It was invented by a team of scientists at the Bell Laboratories in New Jersey – John Bardin, Walter Brattain and William Shockley – who patented it in 1947 and received the Nobel Prize in Physics in 1956.

The first transistor used germanium as its main component, but this was later replaced by silicon. The transistor greatly changed the electronics industry and had a fundamental effect on broadcasting. It was instrumental in facilitating the manufacture of portable receivers that were battery operated. The transistor radio revolutionised radio broadcasting, upending the group-or community-listening 'living room' model that had developed after the crystal-set period, and again enabling listening that was personal – but also portable.

Photography

In the nineteenth century, Henry Fox Talbot in England and Louis Daguerre in France had independently and almost simultaneously proposed the first systems of photography. Despite being very elementary, and firmly studio-based due to the long exposure time required to register an image, their inventions sparked immense interest and activity.

In time, the photographic plate replaced the primitive paper screen on which a photographic image appeared. These plates were made of glass, coated with a light-sensitive chemical substance which, when developed, retained the image.

The Kinetoscope, designed by Thomas Edison, was a means of showing moving pictures through a binocular optical viewer. Films of around 45 seconds in length were shot specifically to be viewed on these machines, usually in coin-in-the-slot machines installed in fairgrounds and amusement arcades. However, the novelty of watching these short films soon wore off, and the Kinetoscope soon became redundant.

Motion pictures

It was not long before the movie industry provided the world with a new entertainment medium. The Lumière brothers, whose family ran a photographic-plate factory, invented a motion-picture process that was demonstrated for the first time in Paris in 1895. Realising that Edison's Kinetoscope was a very cumbersome machine to use, with viewing being confined to one person at a time, the brothers devised a system that recorded images onto a long strip of photographic film, made from celluloid, coated with a light-sensitive chemical, which could then be used to project the images onto a large screen. The apparatus they used to record and project their movies was called the *Cinématographe*. After their first public screening received a very favourable public reaction, the Lumières opened cinemas in many cities in Europe, and the cinema became the most popular mode of entertainment during the following half-century. By the time television viewing became well-established, a large archive of motion-picture material existed and, in time, this provided very welcome fodder for television programmers.

Television

The development of television cannot be attributed to any one individual, but rather to a succession of engineers, either working alone or collaborating in groups. John Logie Baird demonstrated it for the first time in Selfridges' Department Store, London, in 1925. His initial system used the Nipkow scanning principle. This consisted of a rotating disc perforated with a number of small holes in spiral succession near its edge, which was placed in front of an illuminated image. The reflected light passing the rotating spiral holes created a series of lines, with each line corresponding to a hole. Because the holes were arranged in a spiral, the lines appeared close and parallel to each other, and the full scan corresponded to a raster. Thus, scanning was established as a method to reproduce images. This basic method of scanning has been used in television ever since, although in more sophisticated forms. Even though Baird's system was not adopted by the BBC for public broadcasting, Baird is nevertheless often called 'the father of television'. He formed the Baird Television Development Company in 1928 and, over the next few years leading up to the BBC's competition to decide on what television system to adopt for Britain, Baird improved his proposal by increasing the number of lines and enhancing picture quality.

Electronic television

While Baird was pursuing his mechanical systems, an enthusiastic team of engineers employed by the Marconi-EMI company was busy developing an electronic version of television. It was fortuitous that, contemporaneously, great strides were being made in the development of electronic devices.

The team at Marconi-EMI, headed by Isaac Shoenberg, a Russian immigrant to Britain, adopted as its fundamental picture generator the iconoscope camera tube developed by Dr. V. K. Zworykin of RCA in the United States. By coincidence, Zworykin was also a Russian immigrant.

Baird was probably the last of the great individual inventors. From the mid-1930s onwards, developments in electronic media have generally been carried out by teams of engineers working in laboratories run by manufacturers, broadcasters, and universities. Many, indeed, were international collaborative projects shared by a number of laboratories. This was to some extent due to the ever-increasing complexity of electronic systems. Although the team headed by Shoenberg at EMI produced the 405-line system in Britain, the RCA team under Zworykin probably contributed to their work because RCA, at that time, had a financial interest in EMI **(Fig. 1-5)**.

Fig. 1-5 Early cathode-tube television set, Wikimedia commons

In 1936, the British Government instructed the BBC to carry out comparative tests on the Baird and EMI systems. Transmissions were carried out during alternate weeks until, in the end, the EMI electronic system was adjudged to be superior and adopted as Britain's television standard. This effectively put an end to the Baird system. Although regular television transmissions commenced in Britain in 1936, they were short-lived, due to the outbreak of the Second World War.

In Germany, television broadcasting continued for some time after the outbreak of the war, although viewing was in community halls rather than in the home, and it is thought that there were no more than 1,000 receivers in existence. Inevitably, however, transmissions ceased as the conflict in Europe became more intense. The first television pictures broadcast in Germany were of the 1936 Berlin Olympics, and used 180-line scanning. As such, their quality did not match that of pictures produced using the 405-line British system. An estimated 150,000 people watched the Olympics' coverage in 28 viewing rooms set up around Berlin.

A total of 21 camera types existed in this early period but the most impressive – at least in terms of size – was called the 'television cannon'. It used the pick-up tube designed by Zworykin in the United States, and at about two metres in length was very heavy and cumbersome in use. One of its operators was a young man named Walter Bruch, who in later years proposed the Phase Alternate Line (PAL) system adopted for colour television in most countries of Europe, Africa, Asia and Australasia.

Following the end of the Second World War, the BBC reintroduced its public television service. Its founding Director-General, Lord Reith, had left the Corporation in 1938, but the BBC continued to adhere to his maxim from the early days of radio, that public service broadcasting should provide 'entertainment, information and education'. To this day, it has fulfilled this remit.

The public responded enthusiastically to the new television service and it was not long before other countries in Europe began to establish their own. The British lobbied hard for their 405-line Schoenberg system to be adopted throughout Europe but this was not to be. The superior 625-line standard pioneered in Russia was adopted across the continent, and in the fullness of time, in Britain itself.

Magnetic tape recording

Although the first audio tape recordings were made in Germany by Fritz Pfleumer in 1928, his technique was never perfected, probably because of its primitive nature. Thirty years earlier, however, a Danish engineer named Valdemar Poulsen had already produced a wire recorder that was the true predecessor of the tape recorder. Poulsen's device utilised a spool of ferric wire that was transported over a recording head to a take-up spool. The wire, as it passed over the head, was subjected to a series of magnetic impulses corresponding to the audio information to be recorded. The Webster Company of Chicago eventually commercialised a reel-to-reel audio wire recorder and marketed it in the 1940s and '50s. Its commercial life was short-lived, however, as it was succeeded by the much more efficient tape recorder.

During the Second World War, German engineers at the company AEG produced the Magnetophone, which used a long ribbon of plastic tape coated on one side with a layer of ferrite. The tape was passed from a dispensing reel over a recording head to a take-up reel, which then held the recorded material.

The introduction of magnetic tape recording into radio production in the 1940s and 1950s had a profound effect on the services offered. Until then, all radio programmes were studio-based, except where special transmission lines could be installed between the transmission centre and venues such as sporting fields and concert halls. The tape recorder liberated radio producers to cover events by recording them on tape for transmission at a later time. It also allowed for the editing of the tape, and for archiving.

In time, smaller, more easily portable tape recorders further liberated broadcasters far more, by allowing recordings to be made at any location. This development was particularly appreciated by journalists and led to marked improvements in the production of news and current affairs programmes in particular.

Video recording

Because of bandwidth considerations, it was generally considered in the early days of taped radio programmes that the same technique could never be applied to television. But as the saying goes: 'never say never'.

The film star Bing Crosby, being accustomed to the ‘stop-start’ nature of film production, intensely disliked live television, with its lack of second chances and the associated requirement for strict self-discipline by performers. Indeed, his dread of live performances was such that he financed research and development work on magnetic video recording.

This work, carried out under the direction of John T. Milton, culminated in the development of a video tape recorder in the late 1950s. Known as the Crosby Tape Transport. Although it was never released commercially, a team headed by Charles Ginsbergat, at the newly formed Ampex Corporation of Sunnydale, California, continued to develop the technology. Parallel work was also in progress at RCA. The unveiling of the Ampex VR-1000 Video Tape Recorder at the 1956 annual convention of the National Association of Broadcasters (NAB) marked another milestone in broadcasting history.

International exchange of programmes

Initially, television networks were designed to provide national coverage and bound by international agreement to respect national boundaries (although in the United States they were planned on a state-by-state basis). In Europe, each country was allocated a set of frequencies and transmitter power levels, designed to minimise interference within the territory of its neighbours.

Then, in 1950, a unique experiment changed the face of European television forever. A group of English and French engineers installed a microwave link across the English Channel and pictures transmitted from Calais to the English coast were broadcast in Britain by the BBC. This was followed by reciprocal broadcasts and the overall success of the venture led to the development of a system of international programme exchanges, by the European Broadcasting Union (EBU), eventually called Eurovision. Over the years since, it has brought all the great moments in contemporary history, tragic and joyful, into our homes - for instance, the building of the Berlin Wall in the early 1960s, and some thirty years later, its destruction. The first moonwalk, when Neil Armstrong and Edwin Aldrin arrived via Apollo 11 was relayed live on 20 July 1969. Armstrong's iconic words still echo around the world: 'One small step for man, one giant leap for mankind.' And so, it came about that news, sport, and events such as the annual Eurovision Song Contest dominated the Eurovision Network.

The communications satellite

One of the most important contributions to modern telecommunications has been the communications satellite. Famed science-fiction author Arthur C. Clarke, who co-wrote the film *2001: A Space Odyssey* based on one his short stories, accurately forecast in a 1946 article in *Wireless World* that a satellite in equatorial orbit 22,000 miles above the Earth would appear stationary to an observer on the ground and could therefore be used as a space station to receive and transmit radio signals. Today, of course, the equatorial orbit is studded with satellites, many of them beaming television programmes either for direct reception in the home or for relay by cable or terrestrial networks. The Eurovision Network, which was originally composed of thousands of kilometres of terrestrially based microwave links, now operates a satellite system spanning the whole of Europe, the Middle East, and North Africa, and intercontinental circuits connect to North America, Asia, and other parts of the world.

Colour television

Baird, using his primitive apparatus, demonstrated the first colour television in 1928. He used three synchronised and superimposed rasters of red, green and blue to produce a colour image. Each raster was generated by a Nipkow disk. The 1960s heralded the introduction of colour television in Europe. By then, it was already well established in the United States and Japan.

The aim of arriving at a single, global set of colour television standards was discussed during the meetings of the ITU's International Radio Consultative Committee (CCIR) in Vienna in 1965 and Oslo in 1966. However, an agreement did not materialise, and in the end, there were three standards in contention: the NTSC standard as in use in the United States; the SECAM standard proposed by the French; the PAL standard proposed by Germany. It was, finally, agreed to ratify all three proposals leaving it up to individual countries to adopt whichever one they wanted. Most nations in the Americas, along with Japan, South Korea, and a handful of other Asian countries, adopted NTSC. France stuck with SECAM, which was also adopted in much of Francophone Africa and Russia, while most other countries throughout the world use PAL. Incidentally, the PAL system was devised by Walter Bruch of the Telefunken company, who many years before had operated the lead camera at the 1936 Berlin Olympics, including its opening ceremony by none other than Adolf Hitler **(Fig. 1-6)**.

Fig. 1-6 Telefunken Iconoscope camera, 1936, Wikimedia commons

The direct broadcast satellite

For many years, communication satellites have provided an indispensable resource for the distribution of television content to cable networks and broadcasters alike, and in this capacity, they are nowadays essential, particularly in the production of current affairs programmes and news bulletins. For instance, as noted above, the Eurovision Network was radically transformed by the introduction of satellite circuits. Eurovision members exchanged news items twice per day and were thus able to keep the public informed about news topics from around the world.

Direct reception of satellite signals in the home commenced in North America in the late 1970s. There, it was of particular importance, as vast areas were inaccessible by terrestrial means. Television services offered by Direct TV and EchoStar in the United States, and by Star Choice and Express VU in Canada, were initially called DTH (direct-to-home) systems, but later became known as DBS (direct-broadcast satellite).

By 1982, the first DBS service in Europe had been established. Originating in the UK and called Satellite Television Ltd, it eventually became BSkyB. DBS became feasible when receivers using gallium arsenide field effect transistors (FETs) became available, because they allowed smaller receivers to be manufactured. The resulting dish antenna is now a familiar sight in almost every town and village in Europe. Satellite television remains the most convenient and least expensive method of providing programming to rural areas, most of which cannot be covered by terrestrial means.

High-definition television

Ever since the Baird proposal, television engineers have aspired to improve picture quality. In fact, Sir Maurice Hankey, in a report commissioned by the British Government as early as 1943, noted:

In view of the inherent limitations of a television system based on 405 lines definition, it is essential […] that vigorous research work, with the aim of producing a radically improved system of television should begin immediately staff can be made available […] [W]e think that television definition should eventually be of the order of 1,000 lines.

After the Second World War, when television production and broadcasting recommenced in the UK, the monochrome system adopted included the 405-line raster with an aspect ratio of 4:3. No doubt with the Hankey Report in mind, the system was changed to one of 625 lines. This gave an improvement in picture quality, but it was still a long way off 1,000 lines. Ideally, a television system should be transparent to the medium, producing pictures identical in all respects to the scene being televised. For more than fifty years, research and development laboratories in many countries strove to produce a system that could be called ‘high definition’.

The credit for the development of the present standards for HDTV must go to Nippon Hoso Kyokia (NHK), the Japanese national broadcasting organisation, which in 1970 commenced research on the subject in its laboratories in Tokyo. This development effort was headed by Dr Takashi Fugio, and went on for many years. The first demonstration of HDTV in Europe took place in Killarney, Ireland in 1982.

There followed a great debate about the transmission standard, initially in the hope that a single worldwide standard could be agreed. Today, the HDTV standard of 1,080 is universally used, and is near enough to Sir Maurice Hankey’s wartime prognostication.

Assuming its pixels are square, a system of 1,080 lines and a 16:9 aspect ratio gives 1,920 pixels in the horizontal direction, and hence a raster of 2,074 pixels. This is commonly referred to as ‘2k’. More advanced systems, of 4k and even 8k, are being tested at present.

The television receiver

Since the beginning of the twenty-first century, there has been a profound change in home viewing. The tried and trusted cathode ray tube television receiver has been largely replaced by flat-panel receivers with light-emitting diode (LED) displays **(Fig. 1-7)**. This has come about because of a demand for bigger screens and better-quality pictures, and because of new technologies that make the manufacture of larger flat-panel displays possible. We have moved from viewing pictures measuring 35 centimetres from corner to corner on cathode ray tubes at the beginning of television, to displays of 254 centimetres or more on flat panel displays. Since the introduction of HDTV, demand for bigger pictures has been inexorable, and the industry has responded to it. The creative production industry also