THE TELEVISION AGE

D. F. McLean[1]

Introduction

On 23rd February 2000, the United States National Academy of Engineering announced its top 20 Greatest Engineering Achievements of the 20th Century. They placed Radio & Television in 6th position, behind Electrification, the Car, the Aeroplane, Water Supply & Distribution and Electronics. At the press conference, Professor Neil Armstrong said, *"Engineering helped create a world in which no injustice could be hidden."* Interestingly, the engineering that landed him on the moon and explored our solar system and universe came in 12th place.

The word 'television' is now used right across every aspect of the medium: from the industry itself, to the occupation, the technical system to create it, the art form, the programmes we watch, right down to the 'TV' – the 'box' on which the pictures and sound appear.

Supported by the products of the Digital Communications Age, television's ability to bridge continents and bring into our homes images that can educate us, inform us, make us laugh or cry, horrify us, or even fool us, is unique. The power of the picture is awesome and we have seen how the use of television can be manipulated for major political influence, and how its graphic message can even play a major part in stopping wars, most notably Vietnam. Indeed President Lyndon Johnson said on that last point, *"historians must only guess at the effect that television would have had during earlier conflicts"*.[1]

The desire for 'seeing at distance' is probably as old as humankind itself. To be able to view some representation of a scene in a remote place has captured imaginations through the ages. No one person can take credit for the end result since the development of the concepts for 'distant vision' took place progressively. The earliest practical system for sending and receiving images was mechanically scanned facsimile. In that precursor to television, we see all the recognisable engineering functions such as scanning, synchronisation, and even digital transmission and digital coding.

Instead of sensing light reflected back off a document or picture, the earliest of facsimile systems used electrical conductivity. The first such systems created a binary-level picture. The two brightness levels occurred where there was either flow or no-flow of electric current – a digital image of sorts. Our conditioning on digital technology makes us think of digitally transmitted images as recent. Rather, they came *first.*

When light sensitive cells and valve electronics appeared, very long-range transmissions of continuous tone (i.e. smooth grey-scale or analogue) photographs became possible. Major events could be communicated around the world just a few hours after they happened. Prior to this, the only method of sending pictures was by despatch rider, train or ship. However, transmitting grey-scale photographs over long distances caused signal degradation and artefacts in the received picture. The answer was to convert the continuous tone analogue pictures into digitally coded images. One such system was the Bartlane system, the primary means for news picture transmission up until the start of World War II.

Mechanically scanned facsimile systems are now not limited to news pictures, weather charts or scanned images and documents. They include any capability of sending slowly scanned high-resolution images. Some of these images are the most impressive and revealing of modern times. Included in these are pictures of earth from weather satellites, of the surfaces of Venus and Mars, and of the outer planets sent over hundreds of millions of miles.

Origins of Television

Throughout the ages, and especially in the late Victorian and Edwardian periods, the various suggestions for television systems all displayed tremendous ingenuity and imagination. The biggest challenge was in the practical implementation of their ideas without the benefit of electronics. How could they convert a real-life scene to electricity, move the image from a remote place to the viewer using cable, or indeed the 'ether', and then reconstruct the image for viewing at a distant site – and all of this in an instant?

Mirroring Mother Nature, in modelling what the eye and brain did, became one of the dreams of the 19th century inventors. However, it became obvious that such an approach was just not practical. This would have entailed having the scene projected onto an array of several thousand photo-detectors. Each photo-detector would send its respective signal to an equivalent display system. The prospect of having several thousand detectors connected to several thousand pairs of wires across long distances simply failed the practicality test. Today we see that this concept was perfectly valid but almost one hundred years ahead of its time. From the 1970s, all solid-state television cameras have used exactly this idea: a matrix of separate light detectors (not several thousand but several *hundred* thousand) on the surface of a silicon chip, each separately 'wired' to its equivalent in a matrix of storage cells.

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[1] D. F. McLean is European Director of a consulting practice in a multi-national professional services company. He is a historian of early television and is the author of an IEE book "Restoring Baird's Image", to be published in summer 2000.

The alternative set the direction for television's development. This used scanning as already practised for facsimile. As with facsimile, the challenge was in getting the scanning sequence on both camera and display synchronised. Unlike facsimile, television needed a fast enough and sensitive enough photocell to generate enough pictures per second to render natural motion in a natural scene. One of the more practical devices for scanning – the Nipkow disc patented in 1884 – provided a simple and efficient means of sweeping the image over a single photo-detector. Without electronics to boost the faint signal, the Nipkow disc languished until, some forty years later, it became the method of choice for television scanning, used in some form or another by most of the early television pioneers.

The Paths to Television

The absence of technology did not stop the thought-experiments. The challenge of achieving practical television showed in the vast number of solutions proposed as being practical – if only they could be made to work. Most notable amongst these 'thought-pioneers' was a prolific Scottish-born inventor, Alan Archibald Campbell Swinton. He suggested in a letter to the science journal, 'Nature', in June 1908[2] a means to develop television using cathode ray tubes. What Swinton had done was to clear away the dead-end ideas and focus directly on the areas that needed research. His ideas remained the outline description of electronic valve-based television systems from the 1930s for the next 40 years. Today though, our advanced digital technology solutions for television have gone beyond the predictions of Swinton. His time is now past. Strangely, the concepts of the 19th century 'thought pioneers' have now become far more relevant to today's television.

In the 1920s, the spread of practical valve electronics opened the way for two paths to television. One path used the newly developed valve electronics to provide the long-missing link of amplification, strapped onto essentially a solution from the previous century. Such a solution was based on scanning the image opto-mechanically (using Nipkow discs, mirror-drums and other quaint Victorian inventions). The other path saw the new field of electronics providing the complete solution to television. Very little of this approach already existed, but the success of the cathode ray tube ensured its use as the display device.

The true challenge for both approaches lay in making a practical television camera. The mechanical approach already had several methods for scanning and merely needed a suitable photo-detector and amplifier electronics. The electronic approach was starting from scratch. Consequently, it had a long way to go before being practical and usable in a broadcast studio environment.

John Logie Baird

The path to implementing practical television starts in a quiet town on the south coast of England where a Scotsman was recuperating from his last business venture – selling soap. John Logie Baird was the first of many inventors to achieve practical television based on opto-mechanical scanning. He had his first crude television images – no more than shadowgraphs – by the end of 1923; very soon after electronic valves had become available and affordable to the public. Just over two years later on 26th January 1926, he gave the world's first demonstration of television of a live subject in continuous shades of brightness.

Baird's thinking from the outset was to envisage television as using the existing broadcast radio infrastructure, minimising development costs and costs to the consumer. All the consumer had to buy to get television would be a second medium-wave radio (to receive the vision signal) and a display attachment – the 'Televisor' – that would ideally have a Baird brand name on the front.

From 1926 to 1929, Baird focused on exploring his new medium through a series of demonstrations of its potential. His mechanical system of scanning and single photo-detector provided a level of flexibility that would not be possible in electronic television for decades to come. He experimented in video recording, demonstrated colour television, television in infra-red, 'telecine' (converting film to a television signal) and cinema television (projecting a television image onto a cinema theatre screen). However, whilst Baird was leading Britain into the new television age, the components for an electronic television system were being researched and developed in corporate laboratories around the globe.

Far too many have criticised Baird for not developing television into the electronic system it became. This is unnecessarily harsh on Baird. From his patents and demonstrations, Baird developed and implemented *solutions* to a problem, adapting existing technologies to meet his needs. In Baird, we see an innovative thinker, personally committed to developing television systems for the remainder of his life. If criticism can be directed, the Baird Company did not have the benefit of the research department of EMI at its disposal, which arguably held the greatest engineering capability in Britain at the time.

The first BBC Television Service started in 1932 on the only system readily available – Baird's 30-line system. By 1932, the system was mature and of a high professional quality. Its benefits to the BBC were that it was fully developed and used only an additional broadcast radio frequency on the medium wave. All that was needed was the camera and electronics from Baird in the studio, and an additional medium wave radio and a television display in the home. With this system, the BBC explored their artistic ideas and learned how to adapt to the immediacy, and sheer

openness of television, pioneering the techniques of live television programme making.

It is a popular misconception that the BBC's first Television Service had only 30-lines per picture because that was all a mechanical system could do. In reality, the only available radio frequency transmitters and receivers in the early 1930s were on the medium and short wave bands, and 30-lines was around the maximum allowable number of lines transmittable in one channel. Broadcasting television on the medium wave meant that coverage was exceptional: programmes from London were watched from as far away as Scandinavia and Madeira. Routinely, amateurs in Britain received television from Germany and Italy.

Electronic Television

The electronic camera took many years to develop. It made its first appearance in the UK in the mid-1930s as an individually handcrafted experimental device. The narrowed view we have today is that EMI succeeded in developing an electronic camera and that the Baird Company failed because they stuck with mechanical television. The story suffers in its abbreviation.

In truth, by the early 1930s, the Baird Company, the newly formed (in 1931) EMI and many other companies were involved in *all* aspects of high definition television. The camera was the key but equally important was the entire infrastructure for broadcast television – none of which existed at the start of the 1930s. For high definition television, this meant not just the camera, but also the special cables, the signal amplifiers, the vision switching, distribution and, most important of all, a special broadcast transmitter. Without the wide-band transmitter, high definition television would remain a curiosity. At the receiving end, there were the self-contained receiving sets for vision and sound. This would be where the manufacturers would *really* make their money.

Those developments in electronic television led to the launch of a high-definition television service by the BBC in late 1936, with an on-air competition between the high definition offerings of the Baird Company and EMI. EMI's all-electronic 405-line system was selected in February 1937 as being simply better all round. With a stable television format, the BBC exploited the latest developments in electronics to create a service that was able to meet the demands and needs of television broadcasting for at least the next 30 years.

At the start of the service in 1936, the scale of the change in cost, scope and systems totally overshadowed all the excellent and professional work that had been done before. After just three years, less than the duration of the BBC's 30-line Television Service, the 405-line service shut down for the duration of the Second World War. When it re-started in 1946, the Television Service began a long period of stability of its offering, whilst great strides were being made in corporate laboratories in developing video recording and television in colour.

Colour

From ideas that originated at the beginning of the 20th century, Baird first demonstrated colour television in 1928. The method he used was to send images in each of the component colours rapidly one after the other. This, the frame-sequential technique, became the preferred method until 1951 in the USA. For this method, a rotating colour disc was spun in front of the camera and the receiver. It had serious problems, not the least of which was the lack of compatibility with existing monochrome receivers. The USA pushed forward with a compatible approach and by 1953, the NTSC (National Television Standards Committee) had set the standard for colour television transmission that was to form the basis of the world's colour television systems. From the NTSC standard, the European enhanced systems, PAL and SECAM, were, much later, derived. These systems produce simultaneous colour television: a monochrome vision signal with the colour information modulated onto a high frequency carrier.

On occasions, the old technology can supply the only suitable solution to a problem. Few people realise that when we watched colour television from the Apollo lunar landings (1969-72), the cameras capturing the images were frame-sequential, with spinning colour filter discs in front of a monochrome TV camera. Mechanically scanned television even made it to the moon.

Cinema versus Television

In Britain in the early 1950s, the lower costs of television receivers together with national coverage caused a massive adoption of television in the home presenting a serious threat to the cinema. Nowadays, the cinema is merely an alternative means of entertainment to television that is focused on the major benefit of showing 'first-run' movies. With the advent of affordable 'home cinema' systems and movies on DVD, the cinema's technical edge is narrowing. In cinema theatres today, we are seeing an increasing convergence with television through using common technology.

The technology that allows presentations from computer to be projected in a lecture theatre also presents films from video. In small cinema theatres, video projectors fed by broadcast-quality videotape have already replaced the movie film projector. Cinema Television, one of the more enduring dreams of Baird from the 1930s, has only now come of age. This technology is moving into home theatre systems. As more and more homes are equipped with such hardware, the threat to such cinema offerings grows.

In late 1999, 'Toy Story 2' was presented in a few theatres in the USA and Europe using a new approach, entirely in the digital domain. The movie was held on computer hard disc and projected using a device

comprising 4 million mechanically scanned mirrors. Though the technology is new, the method seems archaic and reminiscent of some of the wild imaginings of Victorian inventors and would undoubtedly have attracted ridicule even thirty years ago.

We see convergence with the technology for television even in stills photography with the appearance of 'cross-over' consumer products. Starting in the late 1990s, video camcorders could record digital stills on videotape, whilst digital photographic cameras could also record short video sequences onto its storage device. We find it so easy to keep Photography and Video Recording separate in our minds – but they are simply different technology solutions to capturing images.

Technological solutions are appearing that can perform in an alternative and, at times, superior fashion to existing traditional images on celluloid, whether for photography or the cinema. The long-term danger to conventional film is real. Fundamentally, if it becomes more cost-effective to have digital movie presentations, then capturing images on celluloid will in the future become outdated. Looking many years in the future, creating, distributing and even presenting 'digital movies' will undoubtedly be the way forward, whatever the means for doing it is. The sobering thought is that for movies on DVD, that time is already here.

Recorded vision

Today, we switch on our TV sets, select our favourite channel and sit down to watch… videotape. Television has become largely scheduled replays of videotaped material. This is especially true for most of the cable and satellite TV channels. Even CNN, the epitome of instant round-the-world news, relies heavily on videotape. As a result, we benefit today from the best features of television: instant communications for timely events and a programmed schedule for high quality entertainment. The initial reason for developing video recording was (and largely still is in broadcasting) to time-shift an event to be more convenient for broadcast schedules.

Baird in 1927 and 1928 made the first recordings of television with a different need in mind. These recordings were experimental, made in support of the development of a consumer video playback and display device – the 'Phonovisor'. The recording process, called 'Phonovision' attempted to capture the vision signal in a manner that would preserve the timing information, simplifying playback.[3] The experiments were not successful, but the publicity surrounding them led the way for radio amateurs to record the BBC Television signal onto domestic audio recorders in the early 1930s. Discovered and restored in the late 1990s, these now provide a remarkable insight into what people watched and what 30-line BBC Television was *really* like.[4] The results challenge the long-accepted belief that 30-line television was poor quality with amateurish performances. Though the quality was constrained by having only 30-lines, these recordings show that the productions and performances were no less professional than that of the subsequent BBC 405-line Television service.

The move to high-definition (405-line) television from 1936 onwards was not matched by the technology for broadcast video recording for almost 20 years, until the 1950s. Practical home video recording systems would have to wait a further 20 years.

Live Pictures

Television operated as a 'real-time' live system from its beginnings. As it began to be used to relay major news events, the first being the 1937 Coronation, there came the need to create some archive of the event, other than by sending newsreel cameras to film alongside the television cameras. A stop-gap was 'tele-recording' – the process of synchronised filming of a precision television display. In the UK, television continued to be predominantly 'live' until the 1960s.

For some time, magnetic tape was seen to provide the answer to recording television. The problem was how to move the tape past the recording heads at the speeds necessary for capturing video. The RCA, Crosby and later the BBC approaches used stationary heads and moved the tape at high speed – a linear video recorder. These solutions all had mammoth tape reels and 'battleship engineering' to move kilometres of tape in just a few minutes at a precisely controlled speed. Consequently, the programmes were extremely short and media costs were high.

Practical video recording takes off

In 1956, Ampex announced the world's first truly practical video recorder. They had turned the problem round by moving the heads rapidly past the slowly moving tape. In their production systems, they used wide 2in (50mm) tape, mounted four heads equally around a disc and spun the disc at high speed across the width of tape. Mechanical scanning for television made a comeback.. so to speak. The four-head arrangement gave rise to the name for this type of recorder – the 'Quadruplex'. Such a segmented approach was necessary due mostly to limitations in the magnetic tape formulation and the video record/playback heads. The ideal approach was for one head to scan across the tape in the time for one picture, avoiding breaks in the picture area. This is helical scan recording, pioneered by Toshiba in the late 1950s[5] and used to this day in all analogue video recorders.

As new video products appear, new formats are developed which are often incompatible with older formats of which there have been many. The main domestic formats in the 20th century were: ¾-inch U-matic, Philips VCR, Betamax, VHS (and S-VHS), V2000 and the camcorder formats, VHS-C, Video-8 (and Hi8 and Digital8) and DVC. The obsolescence of format affects us as consumers, though we have been spared for nearly 25 years with JVC's VHS (Video

Home System). Its continued popularity and low cost-of-ownership outweigh its low technical quality when compared with newer contenders.

Videodisc Technology

Disc is a more convenient video format than tape: it provides access to any part of the recording very rapidly and is handier to use and store. In addition, pre-recorded programmes are far easier to mass-produce on disc than on than tape. Starting with Baird's Phonovision in 1927, pre-recorded videodisc formats have been a series of commercial failures to varying degrees, at least until the advent of the currently highly successful DVD.

As soon as DVD was released in the late 1990s, there was a rapid adoption of the new format. Players capable of both CD and DVD playback became cheaper than dedicated CD players, became 'big-sellers' in supermarkets, and the discs themselves hit the market only slightly more expensive than audio CDs. DVD looks to be the format of choice for pre-recorded video material for some years to come.

The inventors, developers and operators of videotape and videodisc systems throughout the years thought that what they had was, at the time, the 'last word' in such systems. In reality, we can always be sure that something new will come up, rendering the latest and greatest obsolete overnight. It is all too easy to be caught up in the progressive upgrade path and salivate over the next offering from the manufacturers. The epitaph for technology is that it is yesterday's vision, today's market opportunity and tomorrow's junk-pile / museum exhibit / collector's item.

The End of Media?

When we want to see a movie in our homes, we can watch a scheduled broadcast, or buy or rent a pre-recorded tape or disc and show it in a dedicated playback machine. We do not really need the tape or the disc. That is after all simply the packaging. We want the movie itself.

This concept has led some visionaries into believing that in the future we will have no need of these devices in our homes. As an alternative to conventional broadcasting or 'pay-per-view' programming, we should be able to 'download' all our entertainment from the equivalent of an Internet computer server. 'Pay-per-download' from the Internet is already being pioneered for software and more recently for music. Data download on demand (for video and audio) is undoubtedly the future, but is dependent on the development of a home mass storage system and high bandwidth low-cost digital communications into the home. Both of these technologies are feasible now and will be affordable soon.

A Digital Viewpoint on Television

To date, the views of television history have become stagnant, based on research and writings made in a time of stability for the technology. Even the latest edition of the Encyclopaedia Britannica describes television in terms of valve camera tubes. Times have changed and television and its associated technologies are in a stage of rapid development. The changes are so rapid that it can be difficult to get an overall view of where we are and where the technology is leading us.

In late 1998, the BBC launched a Digital Television service, starting a new era in television's history. That is what history will probably attempt to record in 'sound-bite' fashion. Alternatively, history could record that after 25 years of migrating their studio hardware – their cameras, recorders and editing equipment – from analogue to digital, the major television networks around the world improved the communications hardware for broadcasting and reception of television with digital technology. In Britain in 1998, digital television made only that small step.

Broadcasting in Britain needs to embrace further improvements to the service. Just having the additional quality of digital broadcasting is insufficient for the public to go and buy the latest hardware en masse – particularly if they are savvy enough to understand that further changes are due – even overdue.

Already the extra features on DVD movies hint at the next steps: Internet-like mark-up languages and Internet browser solutions to replace ageing Teletext systems, six-channel Dolby Digital and DTS audio to replace existing NICAM digital stereo, interaction with the programme material and multiple camera angles. In addition, we are transitioning to digital video recorders for capturing and time-shifting all of this at broadcast quality. These changes are nowhere near what we have already seen in television in Britain: NICAM digital stereo audio in 1986, Teletext in 1974, PAL colour in 1967, 625-line in 1964 and, above all, the 'high definition' (405-line) television service opened by the BBC in 1936.

End of the Tube?

Yet, even at the beginning of the 21st century, at the heart of our television set receiving digital images from satellite or DVD, is a relic of a bygone age – a thermionic valve. This valve – the cathode ray tube, CRT, or just the 'Tube' – houses glass and metal in a vacuum with high voltage electron beams that continually paint our television picture in a technology solution from one hundred years ago, at the start of the 20th century. This single remaining valve in our television receivers lingers on chiefly due to it remaining more cost-effective than any alternative. There is of course no nostalgia associated with keeping the 'tube' in our receivers. It is complex to manufacture, requires high voltages and analogue circuitry.

As soon as a cheaper and better alternative becomes available, we will see the last of valve-technology and analogue processing. We would then have a television system comprising chip-based cameras, digital communications sending encoded blocks of data rather than lines, all received and shown on flat-screen displays. Not too far in the future we will have a television system that will have far more in common with the thought-experiments of people in the late Victorian period than that of any of the early 20th century pioneers.

We have reached the unique vantage point in time of being able to look *back* at analogue television and see it as history. We see it now as yesterday's technology. Those engineering developments appear now to be no more than stepping-stones in the development of television, a development that will continue with that of the supporting technologies. This vantage point allows us to gain a far better appreciation of the impressive developments made by the early television pioneers, and especially those in the days of mechanical scanning.

The Future

There are widely different views on television with some even arguing that it is already dead,[6] killed off by the Internet. This comes from taking a culturally centred view and ignoring the real performance differences between the demand-based Internet and broadcast television. The image quality of video across the Internet is currently poorer than that of Baird's 30-line system despite the technology being used to achieve it. This is no more than a consequence of not only the low performance of the computer connection to the Internet but also congestion of the network caused by having as many video feeds as there are demands for them.

In our future, television may remain a broadcast service, become a demand-based service or, most likely, end up as the central display for an integrated home entertainment system. None of these detracts from its short and feature-packed history. The future is for speculation, but the past can be both fascinating and informative – especially when trying to understand how we got to the present, and how we can fulfil the dreams of the thought pioneers of the 19th century. Although what we have today is beyond their wildest imaginings, those pioneers also dreamt of possibilities that have yet to be realised.

Those ideas, which they labelled television, are much more than that. They are ideas for new ways of enhancing lifestyles, such as buying goods and doing tax returns from the home, that have more to do with the interactive nature of the Internet than television.

With new approaches for the Internet, improved technologies for digital communications, increased affordability of digital mass storage systems and computer technology, and new display systems, we are merely at the beginning of a new age for information and entertainment systems, of which television's central role is assured.

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[1] WHEEN, F.: 'Television', (Century Publishing, 1985), p65

[2] SWINTON, A. A. CAMPBELL: 'Distant Electric Vision', *Nature*, **78**, 18th June 1908, p151

[3] MCLEAN, D. F.: 'Computer-based analysis and restoration of Baird 30-line television recordings', *Journal of the Royal Television Society*, **22/2**, April 1985, pp87-94

[4] MCLEAN, D. F.: 'Looking In', *Electronics World*, **104**, No 1752, December 1998, pp 1031-1034

[5] SAWAZAKI, N., 'Helical Scan: the Early Years', from '25 Years of Video Tape Recording', compiled and edited by D. KIRK, May 1981, for 3M UK Ltd

[6] BBC Horizon, "Television is Dead, Long Live TV", 1996, director. Andrew Chitty