How the World Changed Television

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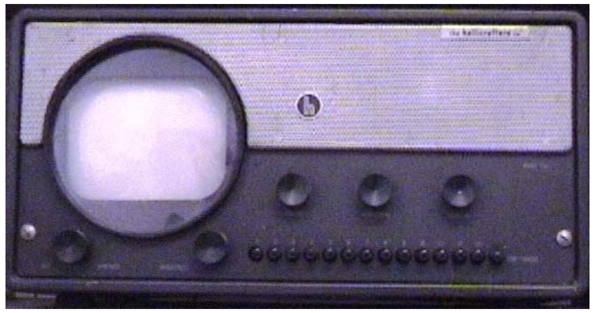
There has been any number of scholarly papers written about how television has changed the world, this paper casually looks however at the ways the world changed television. The modern television receiver is an electromechanical example of evolution and survival of the fittest that would likely meet with Darwin's approval. By being a product in an open marketplace the consumer and competition caused changes to sweep across the products brought to market without precedence in earlier radio manufacturing.

This note is written from a US perspective in an attempt to capture some of the elements which played a part in the evolution of domestic television receivers into the global commodity which is endemic over the planet.

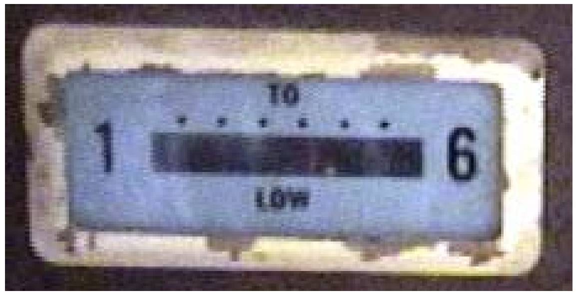
Post War televisions were essentially radios with built-in oscilloscopes

Until about 1948 almost all televisions were electrostatic deflection with tubes in the range of 3" to 9".



The whole process of multiple channel broadcast television was new to the world, The United Kingdom early to the TV marketplace had no need for tuners as there was one station in London and yet another in Birmingham on a different frequency. Their TVs had no tuners. A classic example of this is the Bush TV-10 (and 11) from the immediate Post War period.

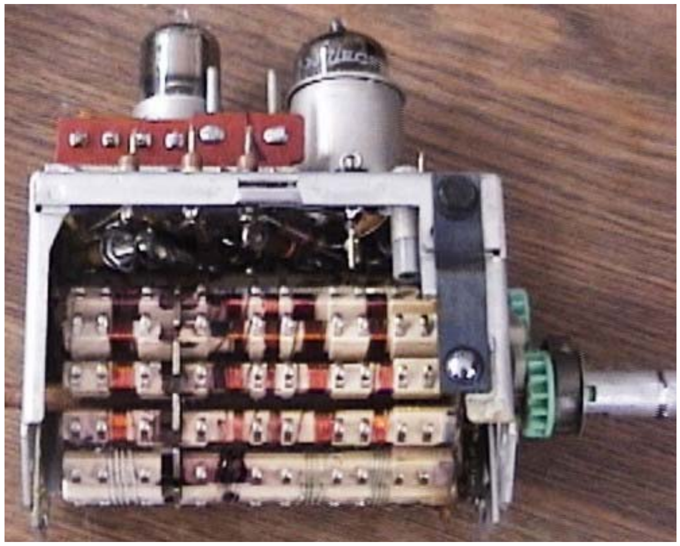
The US got off to a flying start by not ever agreeing on a channel plan. The area around 50 MHz was contested as Armstrong's FM band, Television's Channel ONE



and finally amateur radio's six meter band. All this happened in a brief two years.The hams won and have been punishing channel 2 ever since! Thereby forever leaving TV to start counting from two.

For a number of reasons most domestic television manufacturers chose not to build television tuners. The lion's share of tuners were built by three companies all in the Midwest. They were Oak, Standard Coil and Sarkes-Tarizan. The tuner was a bit of black magic and many receivers were sorely lacking in tuner performance opening a market for the "signal boosters" realized by Anchor, Regency and Blonder-Tongue and a few hundred others!

Tuners were mechanical devices with complex detent mechanisms ranging from turret drums to adaptations of phenolic rotary switches. Almost without exception early tuners comprised a pentode RF stage like a 6AG5 and a triode mixer and triode oscillator typically a 6J6. Noise figure varied from optimally 7-8 dB at Channel 2 to more typically 12-15 dB at Channel 13. And, that was 'before' they were cleaned and adjusted by TV repairmen…



As the television marketplace demanded larger viewing screens the first big evolution came with the move to electromagnetic scanning and an introduction of yokes to CRTs. This era was typified by the RCA 630 chassis using a 10” CRT.

These early display tubes needed an Ion Trap to keep the heavy ions from the filament from discoloring the center of the phosphor display. Strategic investments in Ion Trap manufacturing plants didn’t pan out as shortly a little trick known as the “straight gun” for the CRT eliminated their future requirement.

As screens got larger the need for higher accelerating anode voltages and greater sweep deflection powers also appeared. Purposely built as horizontal sweep tubes such as the 6BG6 and 6BQ6 entered the arena generally with a little mica trimmer called a 'drive adjuster' to preserve horizontal linearity and most importantly keep the sweep tube from getting red hot.

For a brief moment in time Ion traps made a renaissance. Under some conditions sweep tubes would manifest a magnetron like property and set up a sympathetic wideband RF generation at the horizontal scanning rate. This resulted in a vertically displayed interference line in the picture. This high minded property called the Barkhausen Effect was simply cured by the introduction of the repurposed ion trap around the sweep tube.

The vertical deflection system of early television receivers look a lot like an audio amplifier of the period generally using tubes like the 6V6 and 6K6 for vertical output stages, just like the sound channel. Prior to a adoption of the now classic VHF Channels 2 through 13 TVs used Intermediate Frequencies as low as 8 MHz or more correctly for that era, Mc./s. Most Post War TVs used 21 MHz as the IF soon followed by a move in the early 1950's to the 45 MHz system which survives today. The 45 MHz system uses a visual carrier positioned at 45.75 MHz positioned on a slope called a "Nyquist Filter" which effectively undoes the novel spectrum conserving properties of the vestigial sideband transmission used in all modern analog television transmission. US and North American TV transmission use an intercarrier spacing of 4.5 MHz between the visual carrier and the aural carrier where the aural carrier is higher in frequency than the visual. All television receivers place the local oscillator at a frequency above the desired channel resulting in an inversion of the incoming channel's spectrum thereby placing the aural (sound) carrier at 41.25 MHz.

Some early television receivers used a separate IF channel for reception of the sound transmission, not only was this an added cost, the performance suffered in that instabilities in the TVs local oscillator transferred into impairments in the received sound signal. The surviving system is known as intercarrier sound where the difference between the visual and aural carrier (in this case 4.5 MHz) is detected and subsequently processed.

Television receivers of yore needed lots of power to feed 20 or so vacuum tubes so that required big rectifiers. The popular 5U4 and some times two of ‘em served this purpose early on. TV receivers were early adopters of solid state rectification. Selenium rectifier stacks soon took over and not long thereafter silicon rectifiers in clip cartridges. Can anybody forget the smell of a selenium rectifier gone bad? Many dogs and spouses have taken a bum rap for the emanation of this horrific odor.

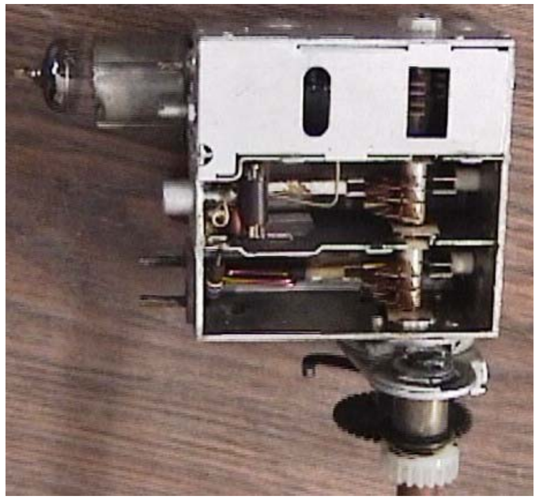
The ‘big change’ in the mid 50’s was the move away from historical transformer powering and filament architecture. The trend to series string filaments and the elimination of power transformers permitted significant weight reduction and prompted a move to ‘portable’ receivers. This move to series-string resulted in the profusion of every imaginable filament voltage being appended to classical tube designs. Receiver B+ was generated by a simple voltage doubler bringing “input condensers” and “fuse ohm resistors” on to the shelves of every TV shop. During the same period the art of building picture tubes (CRTs) responded to the market with rectangular displays more in line with the 4:3 aspect ratio of the NTSC standard. As the screen got bigger, higher angles of scanning deflection also emerged to keep overall receiver dimensions down.

By the mid 50’s the consumers desire to use television outside of a darkened living room drove the need for brighter displays. The aluminized phosphor CRT solved this requirement. Tired CRTs growing dim enjoyed a few months of additional life by the installation of picture tube boosters which raised the CRT’s filament by about 20% and coaxing a few more electrons into service. A more heroic measure was the picture tube zapper which operated by the devil-may-care TV repairman and might, with a purposefully generated internal arcing kick up some new cathode surface and resultant life or just as likely cause an internal failure from which no recovery was possible.

Synchronization of Vertical and Horizontal timing were a real problem in early receivers. Who can forget seeing Arthur Godfrey’s head beneath his feet or the picture flopping into diagonal obscurity just at the *good part*? RCA had a technique introduced about the time of the famous 630 chassis, which called synchroguide, made great strides in holding on to horizontal sync under marginal conditions. Vertical synchronization was first accomplished by blocking oscillators and vertical integrators where a novel series of horizontally timed pulses called ‘equalizing pulses’ set up the occasion for vertical sync generation. Today sync is derived from digital ‘count down’ processes yet the equalizing pulses remain in the vertical interval of all analog TV transmissions about as useful as your own appendix.

From the early 50’s experimentation with TV transmission at frequencies above the VHF spectrum occurred. The FCC opened up a Table of Assignments that permitted TV transmission from 470 to 890 MHz adding TV channels 14 through 83. Some TV markets were encouraged by regulatory fiat to use UHF channels exclusively which resulted in the need for receivers to tune these new channels. The degree of coverage afforded then by a typical UHF station was at best, terrible. Efficient transmitters of much power were difficult to realize at the UHF frequencies and TV receivers either had very modest UHF tuners inside or more typically a UHF converter on top with a bow-tie or loop antenna attached directly.

It was an uphill battle for early UHF television. The Congress, known for their keen insight and helpful ways, acted in the early 60’s to mandate the All Channel Tuner Act which prescribed that all TVs, going forward, must be capable of tuning channels 2 through 83. The industry responded with some very inept and shameful tuners which cheaply satisfied the mandate but did nothing to improve reception.



In a further attempt to gain parity for UHF television the FCC also permitted power levels up to 5 Megawatts for UHF stations. A VHF station, then as now, was permitted a maximum power level of 100 Kw or 314 Kw depending on its channel assignment.
The composite TV tuner covering VHF and UHF in a single entity did not emerge for several years. The foray of cable TV into the spectrum between channels 2 and 7, the so-called midband and especially the introduction of electronically tuned local oscillators caused separate tuners to merge. The elimination of tuning shafts and the mechanical functionality of TV tuners permitted the easy adoption of remote control. Today all TVs have remote control via Infrared of nearly every adjustable attribute of the receiver. During final test most receivers are brought into picture alignment by interaction with 'secret' set up screens accessed through the IR path. Lest we forget, today's ubiquitous remote control started out with visible light beams squirting at the corners of Zenith TVs and for many years remote control meant small motors to twist mechanical tuners.

In the 60's most remotes were controlled ultra-sonically with tuning bars tapped like a piano sending signals in the range of 20 KHz. The clinking of change in your pocket or a dog's metal collar would frequently be enough to change the channel!

The idea of color television had been around since the earliest TV experimentation in the 20's and 30s   Domestically, Walter Jenkins and in England, John Logie Baird each posited and even displayed methods of producing color TV. In the Post War era, CBS, with the work of Peter Goldmark, realized a mechanically rotated color wheel which in conjunction with a CRT produced a tenuous color system. This process was adopted by the FCC about 1950 and was the Law of the Land for a couple of years.

TABLE 17–1. UNITED STATES TELEVISION STANDARDS *

	Color	*Monochrome*
Scanning lines per frame	405	525
Frame frequency	72 per second	30 per second
Field frequency	144 per second	60 per second
Horizontal line frequency	29,160 cps	15,750 cps
Color frame frequency	24 per second	None
Color field frequency	48 per second	None
Color sequence	Red, blue, green	None

* See Table 1-1 for standards common to color and monochrome transmissions.

The manner in which the transmission characteristics of the standard field sequential color-television system differ from the more familiar monochrome system is summarized in Table 17–1.

[4] Fink, D. G., Color Fundamentals for TV Engineers, *Electronics*, Vol. 23, No. 12 p. 88 (December, 1950).

Very few (hundreds) of receivers were ever built using this Standard. In 1953 RCA was successful in persuading the FCC to adopt an all electronic color system which was compatible with the existing black and white technique. Goldmark did have his fifteen minutes of fame, in that the first color images of man on the Moon in 1969 used a subset of the old CBS system. The first commercial color TV using the new standard was the RCA CT-100 a 15" screen in a box about 3 foot square!

The RCA system produced a set of additional signals which were added to the monochrome signal, when suitably recovered they would in conjunction with the monochrome signal itself produce a signal that could reproduce color. The big change in the home receiver was the need for a new type of CRT display. The 'lighthouse' or shadow mask tube which materially survives today arranges red, blue and green phosphor patterns on a CRT screen so that they can be operated upon by individual red, blue and green electron guns. It is sort of like three separate picture tubes (red, blue and green) essentially occupying the same space and presenting on a common display surface. By decomposing the original scene into color equivalent electrical elements and a brightness element the signals can be transmitted within a single six MHz TV channel. The transmitted signal can be reconstructed into a color image at the receiver by adding controlled amounts of the color and brightness signals to the CRT. The degree of precision and practical realization of color television has dramatically improved in the intervening 50 years since its introduction. The underlying standard has however remained essentially unchanged. Wherever digital TV may take us in the coming years it will be hard to forget the contribution of analog NTSC on the television landscape.

By the middle 60's Stereophonic radio was being transmitted in the FM bands. An adaptation of that analog technique found its way in to US television by the mid 80's bringing stereo to otherwise 'one horned' TVs. Never pushing the science boundaries, US television always stayed focused on what can be built cheaply and sold widely. To wit, the BBC's NICAM provided a lovely 728 Kb/s stereo plus channel but somewhere between pragmatism and *Not Invented Here* NICAM never made its way state-side.

The ascent of the transistor and subsequently integrated circuits did much to change the complexion of television receivers. The first transistor to find its way into TV receivers was the UHF local oscillator from as early as 1960. In about 1962 Philco introduced a small all transistor portable TV called the Safari.

Shortly thereafter Sony and Motorola each had larger screen all transistor models. A less than obvious change in television receivers was reliability. Heat was a central factor in reliability and with vacuum tubes producing 75 or more Watts to generate horizontal sweep and high voltage coupled with dozens of Watts of filament burden made older television designs toasty to say the least. A midsize (17") black and white TV from the era might consume on the order of 150 Watts. The heyday of all tube color TVs, using 21" round CRTs, was 1965. These receivers usually were around 400 Watts of AC input. Another advancing factor was repeatability, when receivers relied on multiple vacuum tube stages, drift in alignment was commonplace. Today a technique call SWIF uses a Surface Wave Acoustical Filter (SAW) before large bulk IF amplification and the days of

IF alignment are now passé. Up until about 1966 most color TV sets were modeled after, what is called today, 'reference designs' from RCA, first with the proliferation on round tube designs based around the popular 21FBP22 tube. This best characterized by the RCA CTC-9.

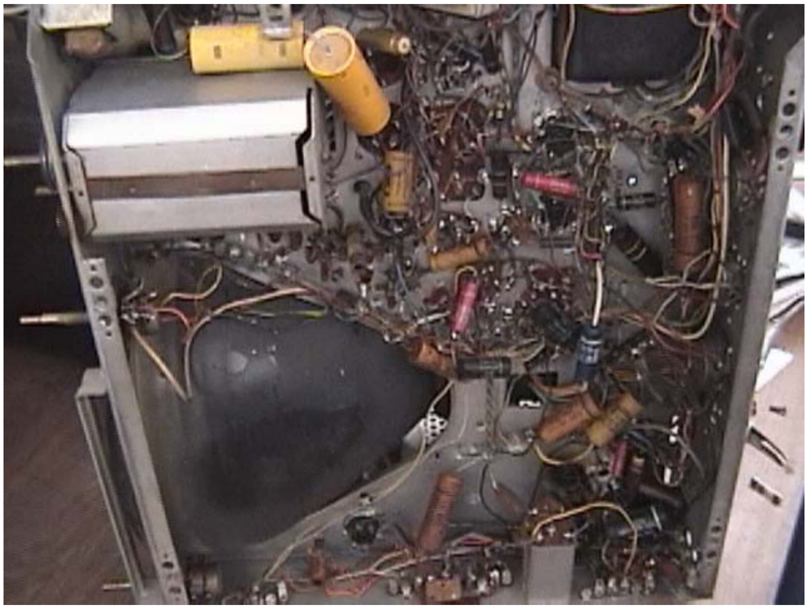
Until a Justice Department decree prevented it, RCA sold 'kits' of strategic parts (yoke, flyback transformer, convergence panel elements) to most competing manufacturers. This tactic had effectively stifled creativity and innovation in color design. As the rectangular tubes (such as the 25XP22) started to emerge in the 60s, RCA still commanded the market with chassis such as the very popular CTC-12.

Many retailers of receivers bought copies of this and similar circuits from manufacturers such as Warwick based in Chicago, a supplier to Sears & Roebuck, who also built many OEM (original equipment manufacturer) products.

The Curtis-Mathis was an example of a RCA ‘kit’ like receiver.

A footnote to the market strongly dominated by RCA, who effectively *owned* all aspects of color in the early days, is the first commercially available rectangular color TV. That distinction fell to Motorola and the TS 914 chassis that employed the 23FJP22. This set was introduced about 1964 but never quite found the market. It had a series of replaceable sub panels and coined the expression “works in a drawer”. Almost reluctantly Zenith came to the color party in about 1963 when they had found a way of breaking the RCA color demodulation Patents through the use of a ‘sheet beam’ demodulator (6HS8) evolved by Zenith’s Bob Adler, also acclaimed as the *Father* of the remote control. By the late 60s most manufacturers had broken ranks with the canonical RCA lead and design variants erupted, generally driven by cost reduction and trying to find a sweet spot in the consumer market.

It is hard to talk about television receivers and not discuss the migration from point to point circuit wiring to printed circuits. The classic radio (and television) construction technique of the early 50s employed tube sockets and terminal strips where circuits were accomplished by hook-up wire.



Both General Electric and RCA started working with printed circuits for certain sections such as IF and sound. Various manufacturers moved to a process that employed a terminal strip that was an insulated cone into which wires were poked and then soldered. Proudly trying to hold on to a dying past, Zenith would proclaim “an all hand-wired *chassis*” when, in fact a PC board was in the tuner.

The value of a TV receiver bears little relation to its cost. In the late 40’s an early adopter of 12” TV might spend $400. In about 1950 the Lowest price RCA 630 chassis based product Was about $200.

In the 60's a mid-range color set would cost $400, today a 27" color, stereo, remote control TV costs $300! It is that ***WalMartinizing*** of consumer electronics that drove the market forever offshore. Currently there are about 300 Million (analog) TV receivers in the USA, they continue to live and die and are, even now, replenished to the tune of about 25 million a year. In the 80's emerged the notion that televisions cost about $10 an inch, the world wide glut of television manufacturing and dumping of boat loads of products on our shore has violated this *Ciciora's Constant* to the extent that during the 2003 Christmas season 27" color receivers were seen domestically as low as $119!

The advent of MPEG digital processing while hugely influential in the marketplace is almost like a footnote to the fray that existed prior to the early 90's. Today bits of Silicon smoothly transcode MPEG encoded signals in to more than a dozen display standards. NTSC, PAL, SECAM (yes, even with bottles!) all produce their balkanized systems from a stream of MPEG ones and zeros by nothing more than grounding a pin on a worldwide, all seeing, all dancing MPEG chip. Native scan, which is the scan rate that a product is authored in or a display operates, is no longer a limiting factor. CRT, LCD, Plasma or DLP all get the message to squirt out a rational colorful image from the data stream.

Emil Berliner is generally attributed development of the disk phonograph (as I write these words, I can anticipate murmurs, did I hear Reis or Meucci mentioned). Invited back for a day and shown a hard-drive Emil would probably 'get it'. Call on Logie Baird to do a walk on and it would be hard to say where to start. In the 70's a popular song said, "look what they did to my song, mom." Yup, we did it driven every step of the way by bigger, brighter, cheaper.

It is interesting to reflect on the history of US television. No one can doubt the contributions (some good and some bad) that TV's influence has made on our society. Neither can we forget the images of JFK in Dallas, the Moon landing and 9/11 persistent on our human screen long after the electronic image faded, so yes, television has changed the world but technologically the world has indeed also changed television.

Lawyerly talk:

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Short Bio for Ted Hartson:

In 1992 Ted Hartson decided to work independently after some 30 years in telecommunications. Mr. Hartson was an executive with Time Inc., Capital Cities Communication and The Washington Post and has been involved with most aspects of broadcasting and wired communications in the US and abroad.

Hartson formed Scottsdale Television Labs in Scottsdale, AZ which was dedicated to support and independent research of RF properties in the 50 MHz to 2 GHz range. In 1995 Hartson founded EnCamera Sciences Corporation, which was a high tech start up engaged in the development of a highly advanced modulation technique for in inclusion of large amounts of digital data within a conventional analog television signal. EnCamera Sciences was sold in the Fall of 2000. The EnCamera technology and its many issued Patents is the basis of the MovieBeam system in use by the Disney Company in the US. After a period of consultancy with the new owners Mr. Hartson returned to propagation investigation within the framework of his originally formed Scottsdale TV Labs (STL).

STL maintains apparatus to conduct propagation analysis in the VHF UHF Microwave spectrum.

Ted spent his teen years working in a TV shop witnessing these waves of change firsthand.

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