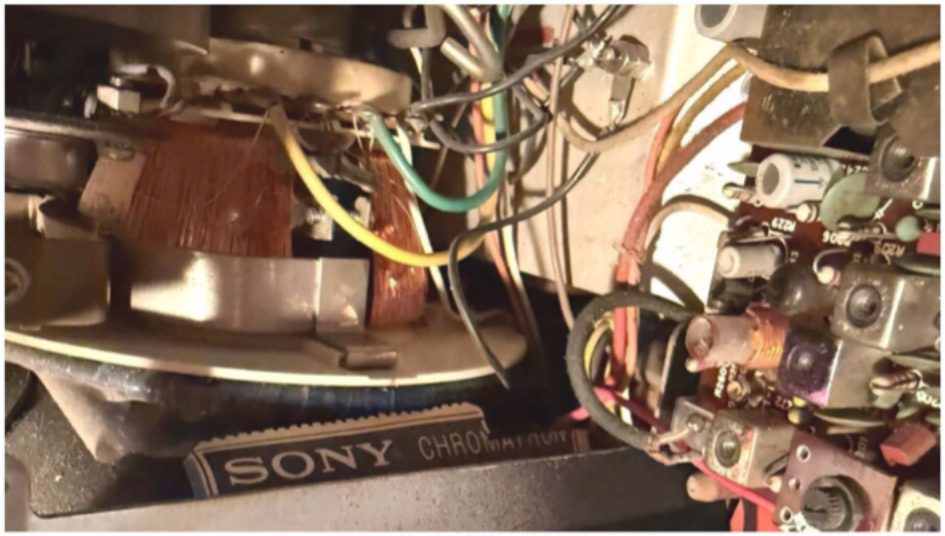
The Sony Chromatron:

Snatching Success from the Jaws of Failure - A Brief (pre) History of the Sony Trinitron

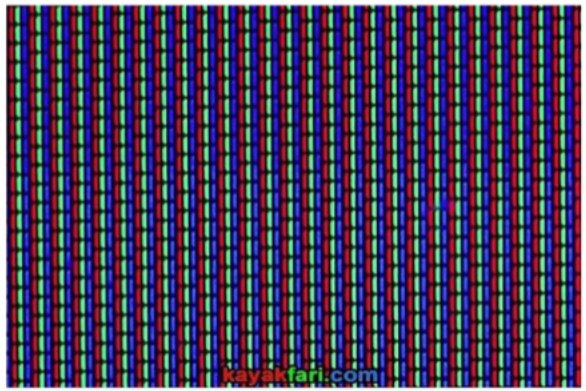


A Presentation by Matthew D'Asaro
for the 2025 Early Television
Foundation Convention

How Color TV Works – A Brief Review

- The human eye sees three colors – red, green, and blue. Thus, to display a full color picture, we must somehow superimpose a red, a green, and a blue picture.
- In order to superimpose three images on one CRT face, tiny dots or stripes of red, green, and blue phosphor are used. When viewed from a distance the dots are invisible and a full color picture appears.
- The problem is that electrons have no "color" – it is really hard to control which color of phosphor the electrons hit!

Color Image



Individual Phosphor Dots

Images From Kayakfari (https://kayakfari.wordpress.com/kayakfari-art/art-of-primary-colors-the-rgb-on-my-crt/)

RCA's Shadow Mask

- In 1954 RCA released the CT-100, their first color TV set.
- That set, and most that followed, used RCA's **patented** shadow mask CRT.
- Aside from the high patent licensing costs, because of the small holes in the shadow mask, most of the electronics were blocked, making for a relatively dim picture. It was also hard to adjust the three beams to "converge" at the same spot across the whole screen.

Example of Extreme Convergence Error

Image Repair Wiki
(https://repair.wiki/w/CRT_Picture_Adjustment_Common_Issues_and_Fixes)

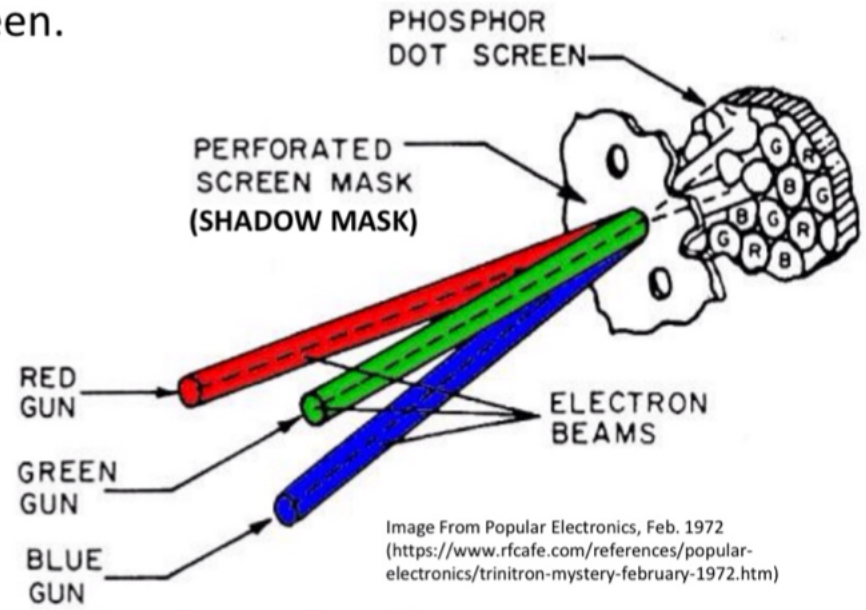


Image From Popular Electronics, Feb. 1972
(https://www.rfcafe.com/references/popular-electronics/trinitron-mystery-february-1972.htm)

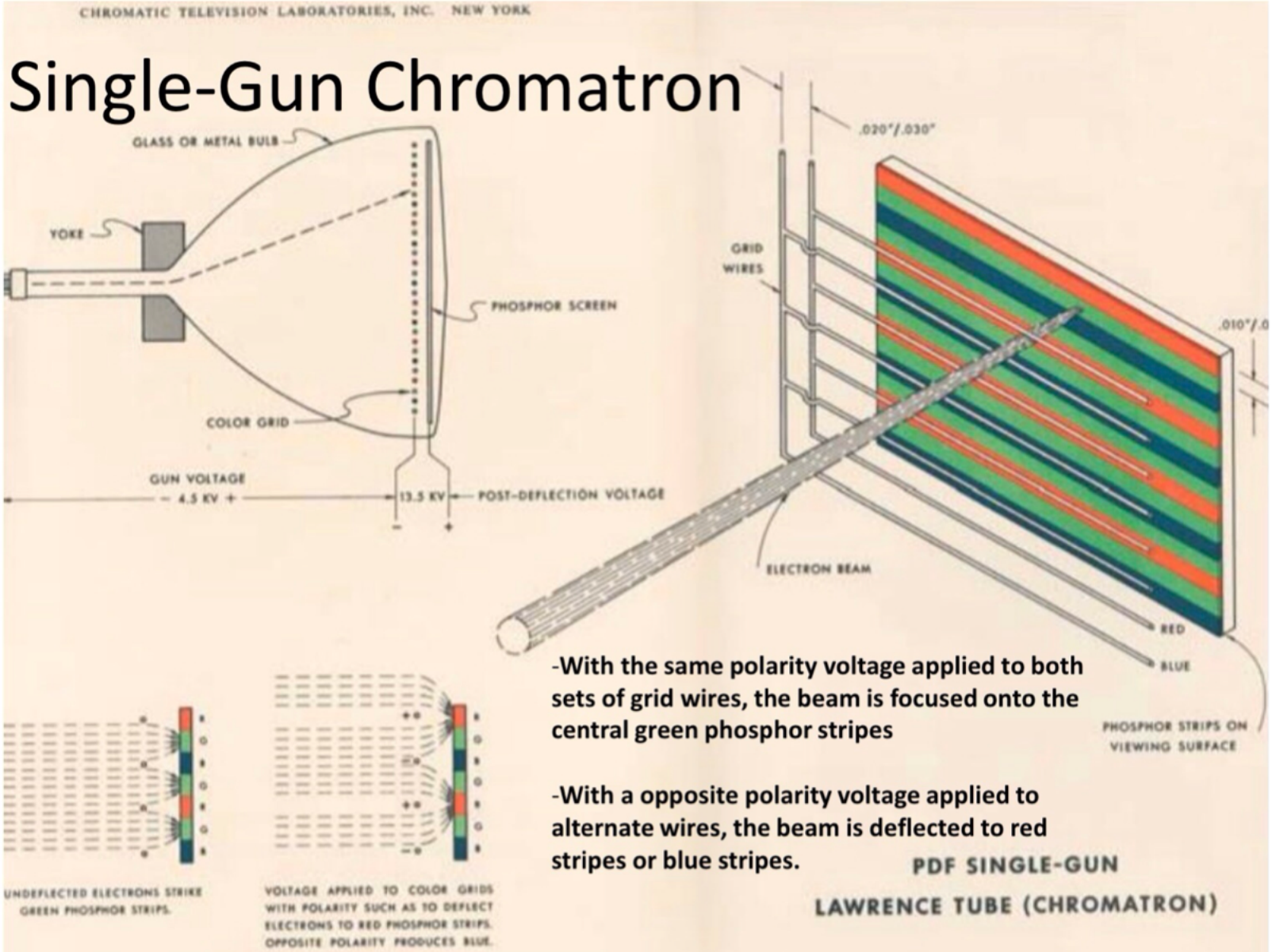
RCA's shadow mask design:
Three electron guns arranged in a "Delta" Pattern

The Chromatron Concept

- Invented in 1951 by Ernest Lawrence, Nobel Laureate and namesake of Lawrence Livermore National Laboratory.
- Avoids RCA's patent
  - Uses one electron gun for all three colors (red, green, and blue)
  - Uses stripes of color phosphor instead of dots
  - Directs the single electron beam to the desired color phosphor stripe with an array of charged wires behind the phosphor
  - Intensity of electron beam is adjusted in real-time to achieve the desired brightness of each color
- No problems with convergence
- Seemingly simpler design

Image From Visions 4 Net Journal (https://visions4netjournal.com/422-2/)

Single-Gun Chromatron



-With the same polarity voltage applied to both sets of grid wires, the beam is focused onto the central green phosphor stripes

-With a opposite polarity voltage applied to alternate wires, the beam is deflected to red stripes or blue stripes.

Image From a Brochure for the Chromatron, National Archives at San Francisco, reproduced by Physics Today, March 2019
(https://visions4netjournal.com/wp-content/uploads/2020/03/Larence-Chromatron-edit.pdf)

Three-Gun Chromatron

- Although less well known than the single-gun version, an original 1953 IRE paper published by Chromatic Television Laboratories, Inc. also describes a three-gun version of the Chromatron based on the ideas of Ernest Lawrence, but (presumably) developed later by employees of Chromatic Television Labs.
- Still avoids RCA's patent
  - Uses three electron guns like a conventional shadow-mask CRT
  - Still uses stripes of color phosphor instead of dots
  - Still has an array of vertical wires running parallel with the stripes of phosphor.
  - However, the voltage on the wires is constant – the beams are directed to the correct color phosphor mechanically by their different angles as with a conventional shadow mask design – not electronically as with the single-gun Chromatron
- Simplified convergence (vs. shadow mask)
- No rapid switching of beam or wires as with single gun, simplifying the electronics and reducing interference

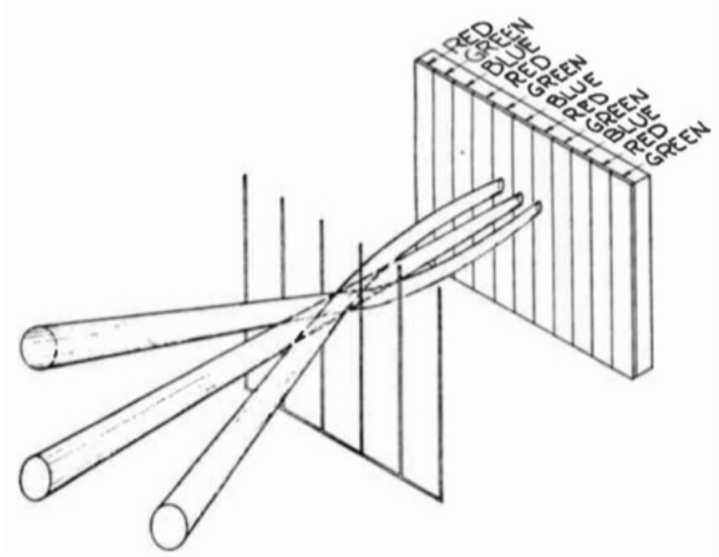


Image From July 1953 proceedings of the IRE (https://www.worldradiohistory.com/Archive-IRE/50s/IRE-1953-07.pdf)

Early Chromatron Work

- In 1951, Earnst Lawrence invented the Chromatron principle as a professor at Stanford University.
- Financed by Paramount Pictures, and in collaboration with the university, Chromatic Television Laboratories, Inc. was founded to develop the technology and sell the rights to it.
- In 1952 and 1953 Chromatic Television Laboratories built and demonstrated prototype tubes.
- As the field sequential color system (CBS system) was still the leading color TV technology at the time, the Chromatron made a lot of sense – the beam would only have to be switched between colors once per field – 60 times per second.
- In 1953 Chromatron CRTs were even used experimentally to broadcast the coronation of Queen Elizabeth II in field sequential color!
- However, with the NTSC system, where all three colors were displayed simultaneously, the single gun Chromatron required that the grid wires be switched at RF frequencies and the amount of RF power needed to do this (~50 Watts) caused an unacceptable amount of interference.

FIGURE 3. ERNEST LAWRENCE, EDWIN MCMILLAN, AND LUIS ALVAREZ (left to right) admire a finished Chromatron.

Image From Ernest O. Lawrence papers, Bancroft Library, University of California, Berkeley, reproduced by Physics Today, March 2019 (https://visions4netjournal.com/wp-content/uploads/2020/03/Larence-Chromatron-edit.pdf)

Sony Enters the Picture

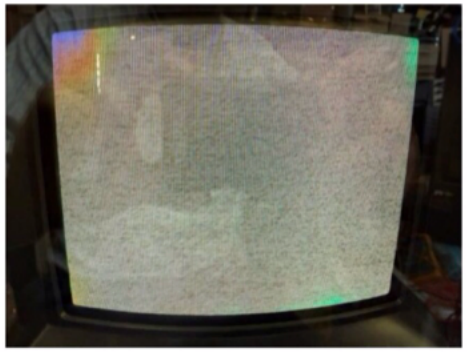
- Sony's first TV was the 1960 TV8-301, the world's first direct-view all solid-state TV (the 1959 Philco Safari used a projection system.)
- It was clear that color TV was the future, but Sony co-founder Masaru Ibuka wanted an alternative color CRT design. He did not want to pay RCA for their patented shadow mask for both financial reasons and an intense belief that the shadow mask was a poor design compromise that could be improved on.
- In 1961, while visiting an IEEE show in New York, Nobutoshi Kihara (a Sony engineer who would later develop the Walkman) discovered the booth of Chromatic Television Laboratories. Before the end of the day, Sony co-founder Akio Morita had negotiated a license to build the tubes and use them in TV sets.
- By 1963, and despite insistence from Chromatic Television Laboratories engineers that the design was hopeless, Sony negotiated to outright own the Chromatron technology, close Chromatic Television Laboratories, and move the entire operation to Japan.
- By September of 1964 Sony produced a 17" prototype single-gun Chromatron TV.

This view of the Colornetron beam-switching tube used in Japanese Yaou sets shows the three high-voltage electrode connections. The center pin is for the focusing grid, which gets 6.3 kv. The outer pins connect with the beam-switching grid, which gets 4.7 kv peak to peak.

Image From https://visions4netjournal.com/422-2/

Manufacturing an Expensive Failure

- Despite the initial optimism of Masaru Ibuka and his team, the Chromatron design was unsuccessful.
- The single-gun Chromatron, when used on the NTSC system, required that the electron gun and, critically, the color selection grid wires be switched between colors at RF frequencies which created an unacceptable amount of interference. Worse, the larger the screen, the more phosphor stripes it would need to have and the faster the switching had to occur, leading to more high frequency interference. Only prototypes of the single-gun design were ever made – none were sold.
- To get around this, the team focused on the three-gun Chromatron. They scaled up production of a 19" design with three guns arranged in a delta pattern and sold about 18,000 sets in Japan, but each was sold at a large loss, costing twice as much to make as they could be sold for, despite excellent picture quality.
- The root cause of the problem was applying the phosphor stripes accurately to the screen. The method of applying color phosphor to a traditional shadow mask CRT is to use a light source in place of each electron gun. Because of how the shadow mask works, the light will only hit the screen where electrons from that same gun will. Thus by using a light-sensitive chemical process, phosphor can be precisely applied. However, the wires in a Chromatron CRT bend the electron beams before they reach the screen, so they will not end up following the same path that light will.
- Instead of the photochemical method, each stripe of phosphor had to be applied individually with each stripe taking 40-minutes to an hour to apply. Even once complete, the yield on the CRTs was only 3 good tubes out of 1000 made (at least by some reports)! In the others, the placement of the stripes was imperfect meaning that the electron beams would not hit the intended stripes and poor color purity would result.



Left: Imperfect color purity was the biggest challenge with the Chromatron design. Small magnets are glued by hand to the envelope of the tube in my set try to correct this!
Right: The Chromatron grid wires bend the electron beams before they reach the screen, so they do not travel along a linear path.

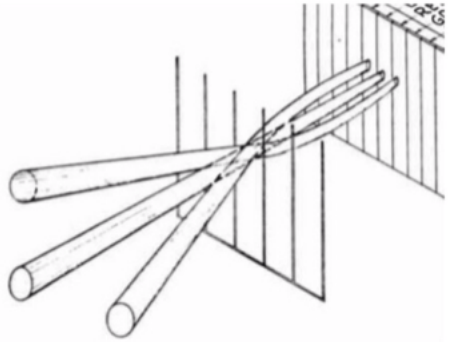
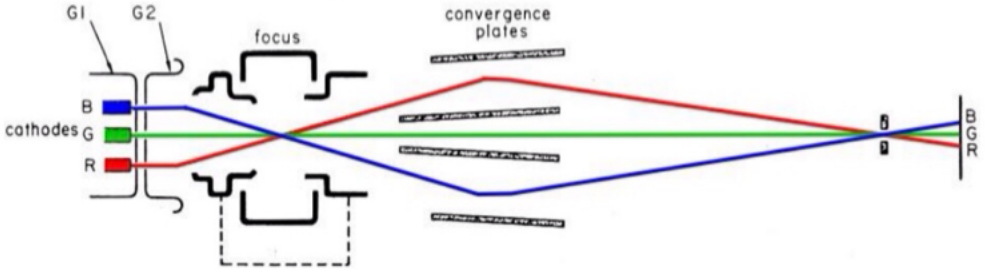


Image From July 1953 proceedings of the IRE
(https://www.worldradiohistory.com/Archive-IRE/50s/IRE-1953-07.pdf)

The Trinitron - Snatching Success from the Jaws of Failure

- By summer of 1966, Sony was on the verge of financial collapse from the investment in the expensive and unprofitable Chromatron.
- Sony co-founder and engineer Masaru Ibuka visited the US and examined the General Electric PortaColor which uses three electron guns arranged in a line and vertical stripes of phosphor, but doesn't think the design would be able to be scaled up to large screen sizes.
- Ibuka and his team, inspired by the General Electric Porta-Color, developed a single electron gun which produced three electron beams with three separate cathodes, but all other elements shared. In an odd twist of fate it was the skeptical Yoshida Miyaoka, leader of the Chromatron team, and one of its strongest advocates who developed the first working gun of this design!
- They were able to repurpose the Chromatron grid wire structures and the equipment used to make them into an "aperture grille", an array of vertical wires that works essentially as a linear shadow-mask.
- The fine wires didn't block nearly as much of the electrons as a conventional shadow mask did, leading to a brighter picture.
- Unlike in the Chromatron, the wires are not charged, so they do not alter the trajectories of the electrons that pass through them and thus the phosphor screen can be fabricated accurately using the conventional photochemical technique based on light following the same path that the electrons do.



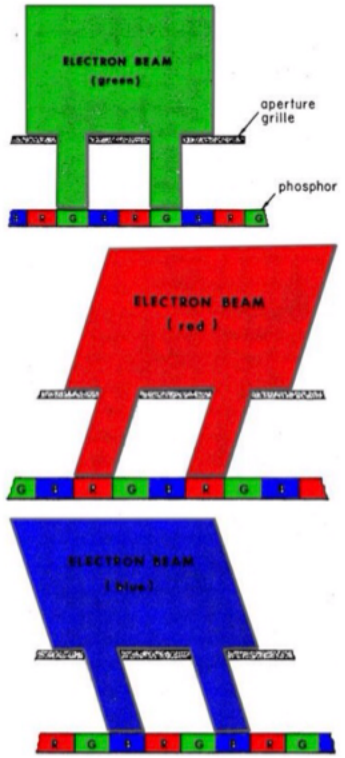


Image From Popular Electronics, Feb. 1972 (https://www.rfcafe.com/references/popular-electronics/trinitron-mystery-february-1972.htm)

Sony's design: Note that the aperture grill, shown as bars, is actually made of fine wires.

Sony Color TV Timeline

- September 1964 – Sony produces a 17” prototype single-gun Chromatron TV based on the technology licensed from Paramount pictures. The single-gun prototype design was never sold to the public.
- May 1965 – The 19C-70 a 19” three-gun Chromatron design is put on sale in Japan only.
- 1965-1967 – Sony sells a variety of 19” Chromatron models in Japan. Only about 18,000 were sold with each sold at a large loss. This nearly bankrupted Sony and led to the development of the Trinitron.
- April 1968 - The KV-7010U is put on sale in the US with a 7” “Chromagnetron” CRT.
- May – June 1968? (date unknown) - The KV-7010U is replaced with the KV-7010UA which uses a conventional Trinitron CRT.
- October 1968 - The KV-1310 is put on sale in Japan with a 13” conventional Trinitron CRT.
- Spring 1969 – The KV-1310 is brought to the US, under the models KV-1200, KV-1210, and KV-1220 differing from each other and the Japanese version only in naming, tuner, and case style.

19C-70 Chromatron - 1965

Image: Tequipment (https://www.tequipment.net/Hakko470B.html)

KV-7010U - 1968

KV-1210U - 1969

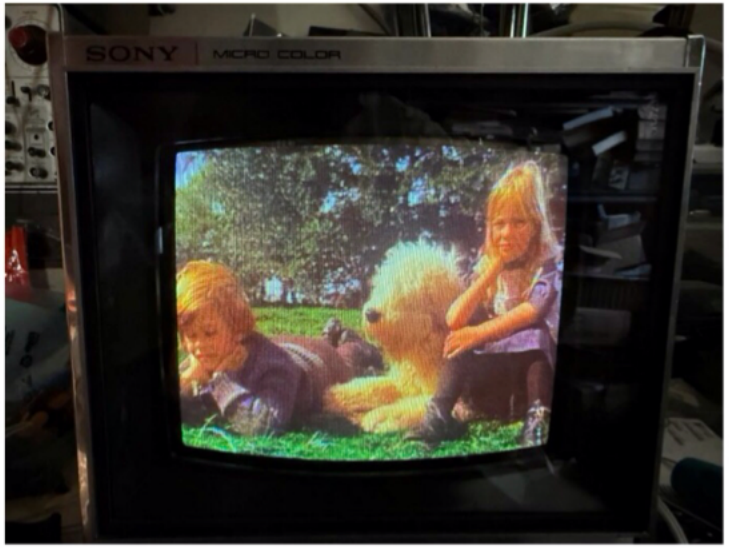
My Rare Find – A 1968 Sony KV-7010U

- Originally found at an estate sale near Los Angeles, CA
- I purchased it on eBay in February of 2025
- One of only two KV-7010U televisions publically known to exist, the other being in a private collection.
- “Worked” as found, but was very slow to warm up, and would only display a dim off-color picture.

KV-7010U – 1968 – eBay Listing Photo

Screen Image as Received

Final Results – It Works!



- Despite a somewhat weak CRT (the screen grid control is set for a maximum brightness, brightness is all the way up, contrast is all the way up, etc.), the set produces a spectacular vivid sharp color picture.
- This is due to the Chromatron grid wires focusing the electrons post-deflection so none are lost to an aperture grille or shadow mask and the effects of a defocused beam partially counteracted.
- Come see it in person right here at the Early Television Museum – **The only working Chromatron on public display in the world!**

Acknowledgement and Thanks

Thank you so very much to:

- Steve McVoy and the Early Television Foundation board of directors for all their hard work preserving the history of television and specifically for agreeing to display my set at the museum.
- Marshall Wozniak, of Visions4 Magazine, for his amazing site documenting the history of the Chromatron and his helpful correspondence on my set.
- And last, but certainly not least, my lovely (and very tolerant) wife Kayla who let me buy an expensive broken obsolete television, spend weeks fixing it, and then fly across the country to talk about it. I love you Kayla!

My Sony KV 7010-U all cleaned up and on display on our kitchen table with LEGO flowers.

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Early Television Convention

2025 Convention - Matthew D'Asaro

The Sony Chromatron: Snatching success from the jaws of failure - A brief (pre) history of the Sony Trinitron

In this presentation Matthew D'Asaro will be describing the history behind the museum's latest exhibit, a working Sony Chromatron TV. The Chromatron, originally invented by Nobel laureate and Manhattan Project physicist Ernest Lawrence, is an alternative color CRT design. Initially worked on by Paramount Pictures, the rights were bought in 1961 by Sony who planned to mass produce it. The effort nearly bankrupted Sony, but ultimately lead to the development of the wildly successful Trinitron. This history will be explored in more depth along with internal photographs and details of the Chromatron on display at the museum.

Matthew D'Asaro, PhD, is a collector and amateur historian of technology based near Seattle, WA. A long-time contributor and now board member of the Early Television Foundation, Matthew is committed to understanding and preserving the history of the technologies that have shaped our world. He is employed by Sea-Bird Electronics where he designs instrumentation for deep-ocean science and exploration.