Whatever Became of the Chromatron?

It's still very much around, though not in this country.
An improved version is appearing in Japanese sets.

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In the years since the spinning color-wheel gave way to the three-gun, all-in-one-tube color TV system, quite a few different approaches to color TV have been tried for a share in the success of the shadow-mask tube. But, only one fundamentally different color-CRT design shows real promise of commercial success: the "single-gun" Lawrence design, in its two versions, the Chromatron and the Colortron. (The reason for the quotation marks around "single-gun" will be explained in a moment.)

Before describing the Lawrence type tube in detail, we should note that one reason for the RCA shadow-mask tube's success is that it worked, and worked well. It still does, especially with recent improvements. At the moment, it is firmly entrenched in American industry; all US television manufacturers are using it, and no one has announced that it is seriously considering switching to the Lawrence or any other type of tube. The shadow mask tube has definite disadvantages, some of which the Chromatron and similar tubes are said to have overcome. But to become a factor in American color TV, the new type will have to prove itself significantly better or significantly cheaper than the shadow-mask.

Two principal drawbacks of the shadow-mask tube are the necessity for convergence, and the comparatively low brightness, a result of inefficient use of the electron beams.

The low brightness can be partially overcome by using brighter phosphors and higher beam currents, but the fact remains that about 85% of the electrons in the shadow-mask tube strike the mask and not the phosphor.

The three independent electron beams must be converged into a precise cluster before passing through the holes in the shadow mask and striking the trio of phosphor dots on the screen. Because of the construction of the tube, a beam cluster properly converged at the center is grossly misconverged everywhere else. So dynamic convergence signals tug magnetically at the beams along their axes to shift the point of convergence appropriately. Apart from circuit complexity, this means extra work during manufacture or installation. Every set must be converged individually, a time-consuming operation that calls for a bit of skill and a test generator.

Another problem is that the mask

Single-beam tube with its electrostatic focusing and color-selecting grid. You are looking down endwise at the strips and wires. Dc of several thousand volts applied to wires focuses beam into pinpoint. Superimposed 3.58-mc ac makes beam slightly left or right as it sweeps across, making it strike red, green or blue phosphor at the same instant it is being modulated by red, green or blue information.

Do it with one beam

Naturally, any approach to color-picture-making that uses only one beam will have no convergence problems, since there will be nothing to converge. The nuisance of "gaussed" shadow masks also disappears.

The Lawrence tube was only recently developed for commercial use (though it was invented in 1951). It is now manufactured and used as the Chromatron in sets by Sony of Japan. Its phosphors are arranged in parallel, vertical stripes instead of in dots. The single gun is modulated sequentially with red, green and blue information. The idea is that as the beam passes a green stripe, its intensity at that instant is determined by the green signal; as it passes a red stripe, it carries red signal information, and the same way for blue. The switching is done electronically, much in the same way as in a single-beam, multiple-trace oscilloscope. This is known as time division.

Making the beam strike only a green stripe when it is green-modulated calls for an additional bit of deflection (aside from the normal vertical and horizontal sweep), because the wires of the post-deflection focusing grid (see drawing) "hide" the blue and green stripes from the beam. It's a little like flicking your fingers this way and that as your arm swings back and forth. The second deflection must be exactly synchronized with the switching of the gun control grid from red to green to blue.

To accomplish this, the Lawrence tube's grid of vertical wires, parallel to the phosphor stripes and just behind the screen, is fed from a 3.58-mc switching voltage generator. (There are 400 wires, but only four are shown in the drawing. For illustration, they are numbered.) All even-numbered wires are interconnected in a single array, and the odd-numbered wires in another. The complete grid assembly thus has two connections, both fed from a 3.58-mc switching-voltage generator.

When there is no potential on the grid (or, actually, when all the wires are at the same potential—at the zero-axis crossing of the 3.58-mc sine wave), the beam shoots undeflected between the wires and strikes a point along a red phosphor stripe. During one half-wave excursion of the sine wave, the charge on the grid wires is such as to make the beam (electrons, remember—negative) deflect toward a green stripe. During the other half-wave, the relative charges are reversed and the beam swings the other way, toward a blue element.

Thus the beam can be modulated sequentially at the cathode with the R, G and B signals, and simultaneously deflected near the screen to the corresponding phosphor stripes.

So much for the raw theory. In actual practice, the grid is fed not only with the switching voltage, but also with a dc voltage about one half of the anode voltage. The effect of the dc voltage is to make the grid into an electrostatic lens and accelerator, which focuses the beam and intensifies it.

Note that, with the polarity of the grid unchanged, the beam will be directed oppositely as it passes between
the next adjacent space between wires, because, from the viewpoint of the beam, the positive and negative wires have been interchanged. The result is the sequence of stripes shown, with twice as many red stripes as green or blue.

This can be handled in two ways. One is to make the red gating interval half as long as the others, so that although the red stripes are carried by the electron beam twice as often as the blue or green stripes, the light output is the same. The other way assumes a less efficient red phosphor (which has been the case until the advent of the "euporium reds"). That is simply to let the red phosphor get more than its share of excitation, thereby bringing the red light output nearer the green and blue.

According to Japanese data, the 19-inch rectangular Chromatron tube has 400,000 red, 200,000 green and 200,000 blue picture elements (stripes times scanning lines); about 6% of the 525 scanning lines are lost. By comparison, the 21-inch shadow-mask tube has 350,000 color-dot triangles—that is, 350,000 color elements; but some are unused, lying in the dark space between scanning lines, so that the number of active color elements is roughly equivalent for both types of tubes.

A particular advantage of the Chromatron over the shadow-mask tube is in picture brightness. At least 80% of the beam is effective in the Chromatron, compared to only about 15% in the shadow-mask tube. Still, one gun is not sufficient to excite a large screen; therefore, recent commercial designs of the Chromatron use three electron guns—not in a different principle of operation, but simply to increase available electron current and brightness. So, in a literal sense, the present Chromatron is a single-beam, three-gun tube. The picture is 3 times brighter than the picture from a shadow-mask tube, and 70% brighter than that from a single-gun Chromatron, the manufacturer claims.

For black-and-white, the demodulator delivers the same signal voltage to all three outputs. The electronic switch and the second-deflection generator continue to function, but the beam receives the same (monochromatic) information at each "position" of the switch. It thus strikes all phosphor stripes with the same current, producing white light.

The first Chromatron receiver made by Sony has 27 tubes, so it is, if anything, more complex than American shadow-mask designs. Though convergence circuitry is gone, there is now electronic-switching circuitry and a second-deflection generator, which has to put out a fair bit of power. The capacitance of the deflection grid is about .001 μf, so the generator must push several amperes through that at 3.58 mc to maintain the necessary voltage. Radiation of this switching voltage, and resultant interference, has apparently been overcome.

Deflection power (for primary deflection, that is—to the yoke) is much smaller than for the shadow-mask tube—about the same as for a 90° black-and-white set. Ac power requirement for the whole set is about 290 watts.

The Colortron tube

An offshoot of the Lawrence de-

sign is also being made and used in Japan—made by Kobe Kogyo in Kobe and used by Yawu Electric. It is a 9-inch tube called the Colortron. It works much the same as the Chromatron, but is manufactured differently and has only one gun. At this writing, it is being used in a 9-inch, 90° portable color set. The set is virtually all solid-state; it has 47 transistors, 25 diodes and 6 thermistors. From a 12-volt battery, it draws 22 watts.

The Colortron differs from the Chromatron designs chiefly in two ways. First, the functions of beam switching and beam focusing are divided between two grids, one behind the other. Second, the phosphors are deposited on a flat, transparent plate which is then installed in the bell of the tube, rather than being deposited directly onto the curved faceplate of the tube. In the photo of the complete set, you can see the comparatively large masked-out area; this is part of tube, not part of the cabinet.

A recently described version of the Colortron uses a color switching frequency that is described as "very low", although all sources are very silent about what the frequency is (15,750 cycles would seem logical). One charge leveled against the Chromatron is the way it radiates 3.58 mc from its switching grid, though recent designs are said to have overcome that. A lower frequency, such as is apparently being used in the Colortron, would be one way to solve the problem.

Also noteworthy is the fact that the Yawu receiver, with the Colortron, uses offset-subcarrier demodulation. The offset subcarrier is commonly used in color generators to produce a complete sweep or "rainbow" of colors during each horizontal scan, but has not been used before (commercially, at least) in color receivers. The Yawu set operates with line sequential color switching, in which each horizontal scanning line is devoted to producing just one of the three primary colors. Beam switching is done during the horizontal retrace time, so there is no loss of brightness from "wasted moments" during the beam's travel across the screen. The line sequential method has not been popular because of a "crawling" effect in the picture; but the Yawu people claim that this is not visible on the little 9-inch screen.

Information on any of these tubes turned out to be extremely hard to come by. The situation led one of my "sources" to remark that "there must be something wrong with the idea, otherwise there'd be lots of them on the market."

In a future article, we hope to show the actual beam-switching and demodulation circuitry we've been talking about here.

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