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COVER FEATURE

The Apple (left), a standard black-and-white and a shadow-mask color tube.

how the apple tube works

By H. R. COLGATE*

THE Philco Apple† tube is a 21-inch single-gun rectangular color picture tube. The face on which the picture is viewed is coated with a repeating array of red, blue and green stripes arranged vertically. Each stripe is .010 inch wide and is separated from the next color by .010 inch so that in every inch across the face of the picture tube there are about 17 red stripes and an equal number of blue and green ones. The chemicals used in each of the stripes are selected so that when all three stripes are lighted at once, the resultant color is white. When each stripe is lighted separately, the resultant colors are red, blue or green. When red and blue are lighted together, the color is magenta. Blue and green produce cyan and red plus green makes yellow.

The magenta, yellow and cyan secondaries could be produced by lighting up the appropriate primary colors either in rapid sequence or simultaneously by making the spot hit the required color stripes at the same time. Secondary colors are produced on the Philco tube by making the spot hit the required color stripes at the same time. Colors in between primaries and secondaries are made by carefully controlling the amount of each color that is illuminated.

This type of colorimetry requires that the circuits which are processing the incoming broadcast signal information always know *exactly* where the picture writing beam is as it scans across each color stripe. If beam position is known to a high degree of precision, the beam can be modulated as it crosses a red stripe when there is red in the broadcast picture. When there is yellow in the broadcast picture, the beam can be turned on as it crosses the red and green stripe. For white, the beam is left on while it crosses all three stripes. It is possible with this tube, then, to make any color that can be produced by mixing appropriate amounts of red, blue and green light. Each color that can be produced may be reproduced 17 times per linear inch or 550 times per square inch.

The Apple tube provides the color processing circuitry with exact beam-position information by producing a marker signal every time a green stripe is crossed. Thus the circuits know when the beam is crossing green and that shortly thereafter it will cross the blue, then red. Obviously some time is required to receive the marker signal from the tube and some time is required to process the broadcast signal, so the marker signal is fed into circuits that predict where the beam will be a short time later and then makes use of this information to modulate the beam correctly.

Fig. 1 is a cutaway of the picture tube, as viewed from above. The red, blue and green phosphor stripes are printed directly on the glass faceplate. The phosphor stripes are backed with an aluminum coating. On the gun side of the aluminum coating and behind each green stripe is the marker, or index stripe. This marker stripe is made of a material that produces a signal every time it is crossed by an electron beam.

The marker stripe produces a signal only if it is being scanned. Since picture content is sometimes black or minus green, the beam that is producing the color picture cannot be depended on to produce a continuous signal from the marker stripe. A second beam produces marker signal only.

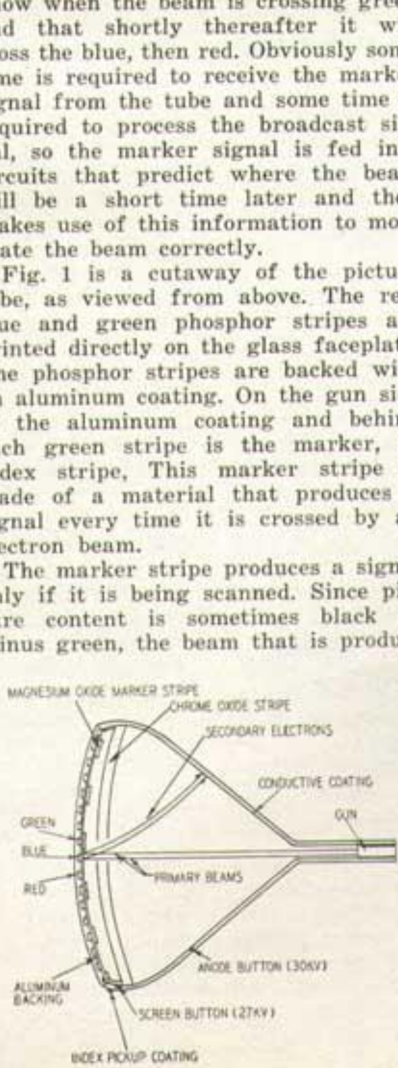

Fig. 1—Cross-section of the Apple tube, as viewed from above.

One beam, then, is used for "writing" the color picture and the second only for obtaining the beam-position information. The marker beam is so aligned that it always strikes the same color stripe as the picture writing beam.

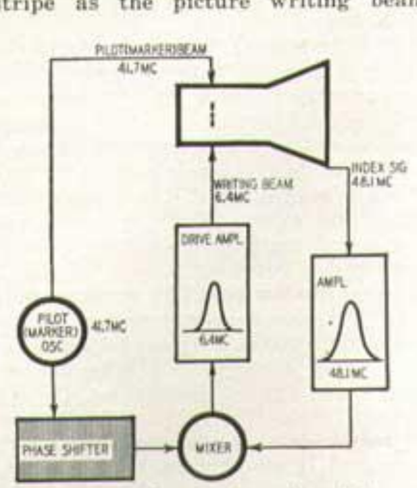

Fig. 2—How the marker signal is produced and processed.

It is modulated at a frequency—the "pilot carrier frequency"—which is above the video and color frequency range so that frequency-separation techniques can be used to separate marker-beam information from picture-beam signal.

The marker beam is always on and operates at a very low current level. It is also advantageous to operate the marker beam so that it produces a signal that is easy to distinguish from the miscellaneous signal produced by the picture writing beam as it hits the marker stripe during the course of picture writing.

The marker-signal production and processing are shown in the block diagram of Fig. 2. The marker signal from the screen of the picture tube must be amplified, combined with instructions from the transmitter and restored to picture writing frequency;

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† The term "Apple" does not refer to any characteristic of the tube—was simply the secret code name of the Philco color tube development project.

that is, the frequency at which the beams cross phosphor stripes, are amplified and fed to the electron-gun writing beam grid to produce color. An oscillator at 41.7 mc drives the marker-beam grid. This, plus the 6.4-mc scanning frequency (the rate at which both beams cross the marker stripes), produces a signal from the marker stripe whose frequency at 48.1 mc is easy to separate cleanly from writing signal. The output at 48.1 mc is amplified and then goes to a mixer. In the mixer it it heterodyned with the pilot oscillator output, producing the necessary 6.4-mc signal for the writing grid.

To change color, it is necessary only to change the time relationship between receipt of marker information and time that the writing grid is pulsed on. This time relationship between receipt of marker information and writing grid conduction is known as phase; thus, to produce blue the phase shift required would be 120° (since the marker stripe is behind green) and for red 240°.

To make the system of Fig. 2 show complete color pictures instead of a solid field of color, it is necessary to vary dynamically the phase and amplitude of the pilot oscillator signal entering the mixer.

To make use of the system chosen in Fig. 2, the 3.58-mc color signal must be converted to a 6.4-mc writing signal. Fig. 3 shows how this is done. The 3.58-mc color signal and a 3.58-mc reference signal are fed into mixers, each of which is hooked to the output of a 38.1-mc oscillator. The 41.7-mc signal from the mixer containing color information at 3.58 mc and the 38.1-mc pilot carrier are filtered and mixed with a 48.1-mc output from the index signal amplifier. The resultant 6.4-mc signal is used to drive the writing beam of the picture tube. The output of the mixer that has been fed 3.58-mc reference and 38.1 pilot carrier is used for marker beam at 41.7 mc.

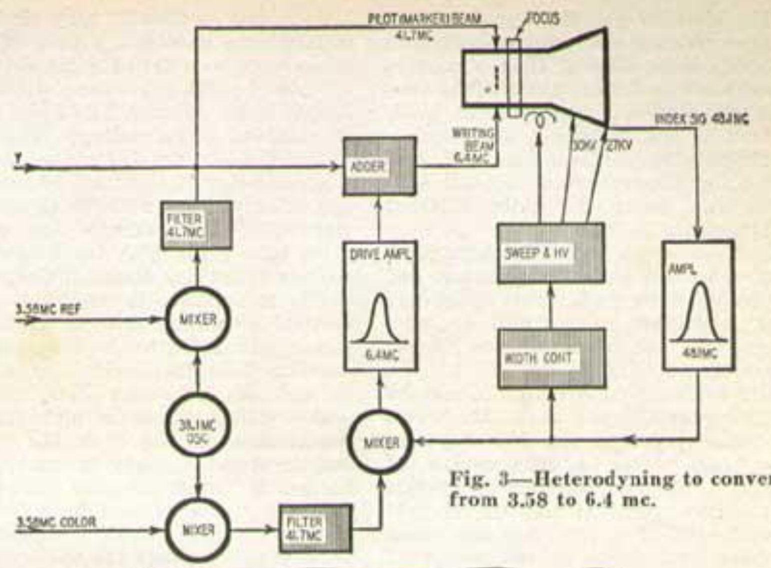

Fig. 3—Heterodyning to convert from 3.58 to 6.4 mc.

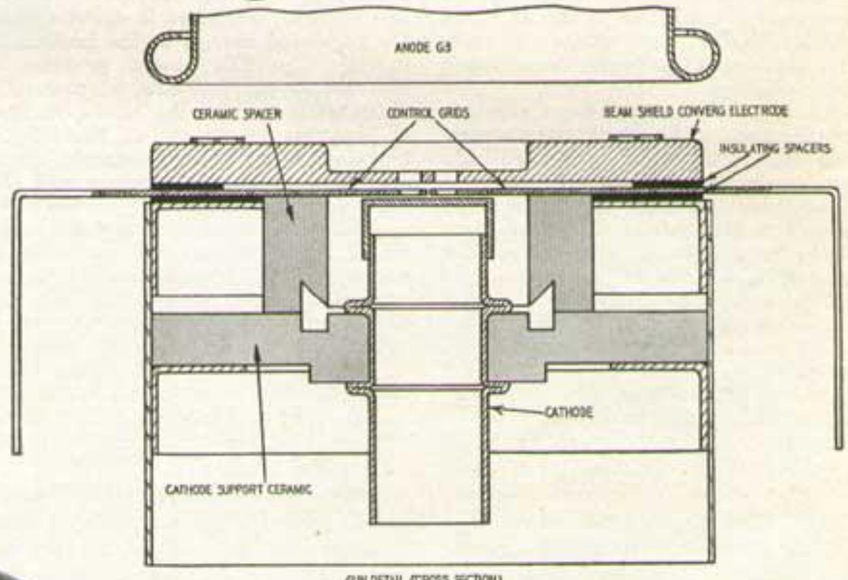

Fig. 4—Apple tube's "double-barreled" gun.

An experimental color receiver using the Apple tube.

The tube's construction

The picture tube, then, must meet several specific requirements. There must be a phosphor structure that, when selectively illuminated, will reproduce the color picture the camera sees. There must be a marker structure that produces a signal that will allow the circuitry to know exactly where the beam is at any instant. There must be an electron gun that has a picture writing beam and a marker beam.

Fig. 1 shows that there are three major components in each picture tube. There is the gun that produces the marker and picture writing beams, the screen structure composed of the aluminum-backed phosphor stripes and the graphite-coated glass that is the collector of the secondary electron signal.

The screen structure is operated at 27 kv. The anode or collector operates at 30 kv and is electrically separated from the screen by a stripe of chrome oxide. The 3-kv difference between the screen and the anode makes it possible to collect the secondary electron signal from the marker stripe and thus obtain beam-position information once that signal has been processed.

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