From Japan, a startling new color tv set

With a single gun tube and solid state circuitry, this 7½-inch set boasts economy and simplicity of design

By Yasumasa Sugihara, Hisao Ito, and Akira Horaguchi
Yaou Electric Co. Ltd., Kanagawa, Japan

There's big news in the small all-transistor color television set developed by the Yaou Electric Co. of Japan. Called the Colornet, it is the first such set in the world. Both its 7½-inch color picture tube and its method of color presentation are markedly different from those of conventional color receivers.

The picture tube, for example, has one electron gun that presents the red, blue and green information sequentially. Conventional three-gun shadow mask tubes present all three colors simultaneously. With the exception of the high voltage rectifiers and picture tube, the new receiver has no vacuum tubes. Power consumption has been held to 30 watts from an a-c supply, 20 watts when operated from d-c. Shadow mask sets use about ten times more power.

Two views of the 16-pound receiver are at the right. The color picture tube, called the Colornetron, is one version of the Lawrence tube developed independently at the Kobe Kogyo Corp. Yaou gets its Colornetron tubes from Kobe Kogyo. Another version of the Lawrence tube, the Chromatron, is used in the Sony Corp.'s color tv sets. However, Sony manufactures its own color tubes.

Problem of purity

Like the Chromatron, the Colornetron has one electron gun which horizontally scans very narrow vertical stripes of red, blue, and green phosphors. The voltage across two coplanar fine-wire grids behind the stripes switch the electron beam to the appropriate phosphor.

Differences between the Colornetron and the Chromatron are primarily in the method of fabrication and the method of assuring color purity [Electronics, June 1, 1964, p. 86].

In the Chromatron, to guarantee purity—which means to assure that the electron beam will always
hit the right phosphor—the tube’s own electron beam is used to bake each phosphor in the appropriate position. For instance, to deposit the red phosphor, the inside of the tube is coated with phosphor, and then evacuated. The voltage representing red is then applied to the color switching grid and the electron beam is made to scan the screen. The red phosphor will stick only on that portion of the screen that has been scanned. For each color, the tube must be evacuated to deposit a phosphor and then opened again to wash out the excess phosphor.

Kobe Kogyo eliminates this expensive process by depositing the phosphors on an auxiliary glass plate outside of the tube and using masked ultraviolet light to bake on the phosphor stripes. They solve the problem of purity with a special wire focusing grid directly behind the color switching grid. The focus grid makes each electron’s angle of approach to the screen the same, regardless of the angle of beam deflection. The illustration at the left shows how the focus grid works.

The screen—7½ inches across—is installed in a standard, inexpensive, 9-inch, 90° bulb (shown at the left) commonly used in Japanese black and white sets.

**Change of center**

Originally, Colornetron tubes had a red-centered color stripe pattern; that is, every other stripe was red. Color order was red-blue-red-green-red-blue-red-green. But a red-centered pattern will not give a truly white level for black and white picture reception. Instead, the screen tends to have a low color temperature resembling warm-white fluorescent bulbs.

Yaou feared that its customers might not accept a picture that differed greatly from the normal blue-white of conventional sets. The red fluorescent phosphor was changed from a low-efficiency zinc-phosphate phosphor to a higher efficiency zinc sulphide phosphor. As a result, Colornetron tubes now have a blue-centered pattern.

**Switching the colors**

With the blue-centered pattern, color switching grid wires lie over the red and green stripes. There is one terminal for the wires over the red stripes and another for those over the green stripes. The voltage applied between these two terminals determines which color the electrons will strike.

Red, green and blue signals are sampled sequentially to modulate the electron beam. In the same sequence, the voltage between the grids is switched so that each color signal illuminates only its respective colored phosphor.

The Colornetron is operated line sequentially. That means that color is switched after a line is scanned. The colors are scanned in the order, red, green, blue, as shown in the diagram (left). The solid lines represent the first field, the dotted lines the second field.

In the Sony Chromatron set, color switching is
Handling the signal

Three circuit branches work on the received signal after it is amplified in the first video amplifier. The first branch directs the signal through a delay line and a notch filter, which removes the 3.58 Mc chrominance signal, and a second video amplifier to the cathode of the Colornetron tube. The signal on the cathode is the luminance or monochrome part of the signal, $E_v$.

The second circuit branch filters out all but the synchronization pulses (represented by H) which control horizontal and vertical beam deflection. The horizontal sync pulses also generate the sawtooth and staircase waves which control the line sequential circuitry.

The third circuit branch contains a bandpass amplifier that passes only the 3.58 Mc chrominance signal and the 0.5 Mc sidebands on either side of the suppressed subcarrier. In this branch, $E_v$ is filtered out. The chrominance signal is then amplified and demodulated in a synchronous detector. There, the phase of the reinserted local subcarrier determines which color information is recovered. The subcarrier phase shifts 120° before every horizontal line scan so that demodulation of each of the three difference-signals, $E_y - E_v$, $E_y - E_r$, and $E_y - E_b$ takes place in turn. The recovered difference signal is amplified again and fed to the grid of the electron gun where it is added to $E_v$ to reproduce a red, green or blue signal.

The subcarrier generated by the crystal oscillator is shifted in phase in a phase modulator that, in turn, is modulated by a sawtooth wave generator.

In the phase detector, the phase of the crystal oscillator is compared with the reference color burst. Any difference between them creates an error signal in the reactance tube. The error signal is fed back to the oscillator. The comparison is triggered every third horizontal line by a gate signal that originates in the staircase wave generator. The staircase wave is a three-step voltage that—when amplified in the color-switching amplifier—biases the color switching grids to deflect the electron beam to the proper colored phosphors.

done at the rate of 3.58 megacycles. Because of this high rate of sampling, the system is known as dot sequential.

Keeping power requirements down

Neither shadow-mask nor Chromatron picture tubes are well suited for transistor tv sets. Not only are small shadow-mask tubes extremely difficult to manufacture but the shadow mask itself stops most of the electrons. It takes high voltages and currents to produce a satisfactorily bright image. Colornetron brightness is about 100 footlamberts, more than twice that of the average shadow tube.

The one-gun Chromatron has the disadvantage of needing a 3.58-Mc power source for its color switching grid. Transistors, which work well in conventional deflecting circuits, are unable to handle the Chromatron's color switching requirements.

Another disadvantage of the Chromatron's dot sequential system is that on-time is about half that of a line-sequential system, producing a relatively dimmer screen.

Furthermore, the color switching grid wires, which have a capacitance of approximately 1,000 picofarads between them, have high losses when operated at 3.58 Mc. Switching power required for a dot sequential tube is about 20 watts.

Because the color switching frequency of the Colornetron is low, the total power used by the color switching circuits is only 2 watts. This, together with the low deflection power requirements of the Colornetron, removes difficulties that might
be encountered with transistorized circuits. Also, unlike the dot sequential Chromatron picture tube, there is no problem of spurious radiation from 3.58-Mc switching.

**Phosphor spacing**

Low power dissipation in the switching grids reduces the possibility that grid wires will heat up and expand. An expanded wire is susceptible to vibration that may cause the wire to bow away from its normal position. A displaced wire may affect color purity or short-circuit neighboring wires.

Even in the Colormetrotron, grid bowing is a problem that limits the picture definition of the tube. The spacing between phosphor stripes on the screen is limited by the necessary spacing between grid wires. Monochrome resolution, which is approximately 200 lines, is limited by the spacing between phosphor stripes rather than by the bandwidth of the receiver. This can be seen in the photograph of the screen above. In a color picture, the lack of definition is a lot less noticeable.

The Colornet receiver uses many special circuits not found in other color sets. The operation of the complete receiver is described on page 83.

**One color demodulator**

Hue information phase-modulates the transmitted color subcarrier which is then suppressed at the transmitter. The hue information is then transmitted as the phase angle of the chrominance signal. The constant phase of the color burst, transmitted during the blanking period, serves as a reference. To recover any one color at the receiver, the subcarrier generated in a local oscillator, must be reinserted at the demodulator; and its phase must be shifted to the angle which represents that color. The phase displacement of the local subcarrier is known as the demodulation axis.

An important feature of the Colometricron TV set is the use of only one demodulator rather than two.
or three as in conventional color sets.

In a simultaneous color set, to recover all colors, there must be either two demodulators whose axes are at right angles or three demodulators whose axes are at the angles which represent the red, green and blue difference signals.

The Coloret, however, is sequential and only one color need be demodulated at a time. With one demodulator (shown below), the axis is made to change for every horizontal line to recover each primary color.

A major design feature of the Yaou receiver is the simplicity and economy with which the local subcarrier phase, and hence the demodulation axis, is shifted every line.

**Rotation**

The local crystal oscillator does not reproduce the transmitted subcarrier frequency exactly. Instead it generates the subcarrier frequency plus one-third the horizontal scanning frequency, ½ H. (That is, 3,579,545 plus 5250 cps or 3,584,795 cps).

The resulting oscillator output advances 120° in phase each period H with respect to the fixed phase of the color burst. The burst and the local oscillator will, however, be in phase every third line. This is illustrated below.

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**One color demodulator** recovers close approximations of all three difference signals in sequence. This is done by impressing the color signal with the local subcarrier which is advanced 120° in phase each line.

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**Crystal oscillator output** (line AC) advances continuously 120° in phase during each horizontal line (time H) with respect to the transmitted reference subcarrier burst, (line AB). The oscillator’s output phase, however, must be kept constant during each time H (as shown by the dotted line and the phasors) to provide axes for demodulation. This is done by phase modulating the oscillator output in the opposite direction to its phase advance for a period H.

Line AC and phasor AC represent the oscillator output phase which advances counter clockwise at the rate of one revolution per 3H with respect to the fixed reference color burst AB. However, to demodulate one color per line, the phase must be held constant during each horizontal line scan as shown by the dotted lines. Holding the phase constant for period H establishes axes for demodulation.

To keep the phase of AC constant for one horizontal scan, the oscillator output is retarded clockwise in a phase modulator at the same rate that it is advancing counterclockwise with respect to AB. The input to the phase modulator is a sawtooth wave whose period is H, as shown on page 84. The rise of the sawtooth retards AC to a maximum of 120° during horizontal scanning. The second part of the sawtooth advances AC quickly to its unmodulated position during beam retrace. In this way AC moves in 120° steps with respect to AB.

The Yaou receiver, therefore, demodulates the chrominance signal each horizontal line along axes which are 120° apart. These are very close approximations of the axes of the original difference signals.

The small difference in frequency between the local oscillator and the transmitted reference subcarrier does not affect the demodulation process. If the oscillator reproduced the exact subcarrier frequency, the receiver would require a phase modulator for the local subcarrier capable of shifting the phase by a maximum of 240° to provide the three demodulation axes. In its present form, the phase modulator need only shift the phase of the local subcarrier a maximum of 120°, resulting in much simpler circuitry.

The authors have built an experimental receiver which operates at the same frequency as the subcarrier and which demodulates exactly on the color difference axes. The experimental receiver, though considerably more expensive, did not perform significantly better.

The color switching circuitry, which switches the voltage on the color grids, consists of a staircase wave generator whose output wave shape is shown in the photograph on page 84 and an amplifying circuit that raises the voltage change to 100 volts per step. The amplified staircase rides on a 4.5 Kv d-c voltage. The staircase wave generator also generates the 3H gate pulse used to synchronize the oscillator.

**No degaussing necessary**

Of major concern to manufacturers of portable color tv sets are the effects of the earth’s magnetic field. In the Coloret receiver, the phosphor is deposited in the form of vertical stripes. As the set is moved in a horizontal direction the earth’s magnetic field causes a slight deflection of the electron beam in the vertical direction. Thus, the entire image slides a very small amount in a vertical direction. This effect is not noticeable, so the set may be moved around at will.