Current Status of Apple Receiver Circuits and Components*

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Summary – This paper reviews the components and circuits of a developmental color television receiver utilizing the Apple type of display. The block diagram of the complete receiver is presented, together with detailed diagrams of circuits peculiar to the display, i.e., the index signal amplifier, color signal processing, high-voltage, horizontal sweep, and focus circuits. Photographs of the chassis layout and electron optical assembly are presented. The problem of integrating the circuits is outlined and typical receiver performance figures are stated.

INTRODUCTION

THE COMPANION papers have presented the groundwork from which a complete receiver design can be developed. A program of successive receiver designs has been carried on and this paper will describe a version of receiver number seven. Historically, it should be pointed out that early receivers were built to provide technical information and as such they included many alternate versions of circuitry. Unfortunately, this led to many now unrealistic "guesstimates" of receiver circuit complexity. A full gamut of pulse-type writing drives by remodulation and heterodyne methods, carrier drives (including equiangle sub-carrier correction), and many forms of sweep and high voltage circuits were explored. Only recently has an attempt been made to attack the receiver problem as a comprehensive design. The circuitry of this receiver was integrated early in 1955.

CONSTRUCTION

The construction of this receiver is shown in the accompanying illustrations. Fig. 1 is a front view of the receiver. The important features are the 260-square-inch rectangular screen, and the control locations. The customer-type controls in the control bar are horizontal sync, vertical sync, focus, contrast, hue, and chrominance. All required setup controls are accessible either through the slot below the control bar or at the rear of the chassis. The conventional adjustments are: 1) Horizontal oscillator frequency, 2) Width, 3) Parabola waveform for horizontal linearity, 4) Vertical linearity, and 5) Height. The special color receiver controls are: 1) Dynamic focus amplitude, 2) Sawtooth waveform for horizontal linearity, 3) Width modulation parabola waveform, 4) Width modulation sawtooth waveform, 5) Pilot carrier bias, and 6) Master hue.

Only six of these eleven setup controls are not found in a usual monochrome receiver. Of these six, only three appear to be required in future receiver designs.

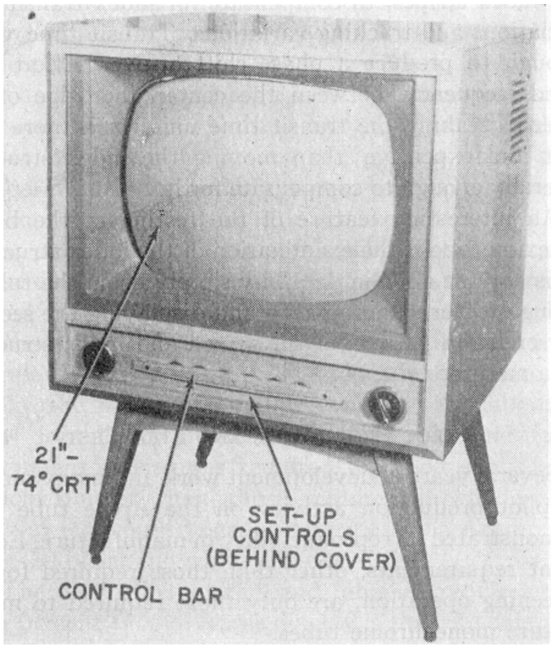

Fig. 1 – Front view of Philco color receiver.

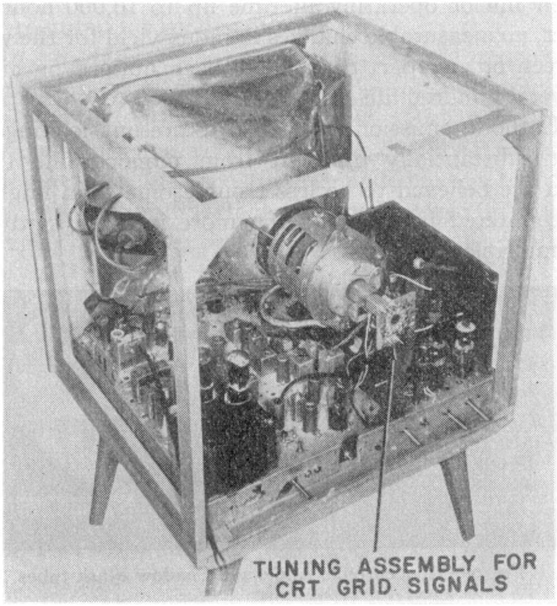

Fig. 2 – Rear view of receiver assembly.

Fig. 2 shows the rear view of the receiver assembly. A small plate, associated with the crt socket, provides a location for pilot carrier and writing grid circuits.

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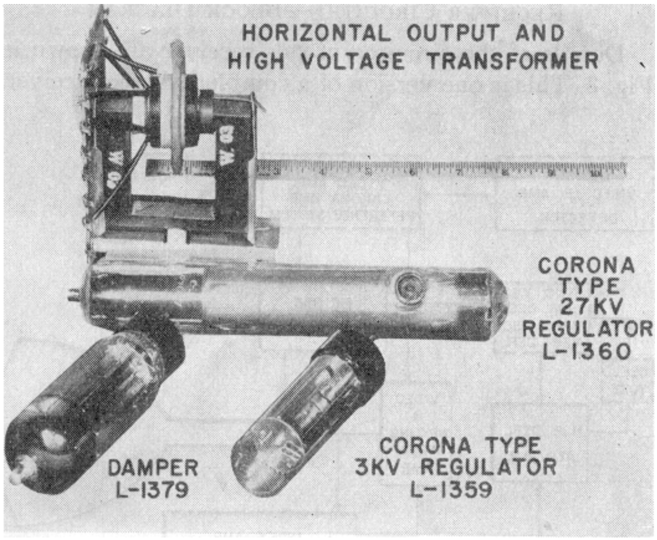

Fig. 3 – View of the experimental damper tube, 3kv regulator tube and 27kv regulator tube.

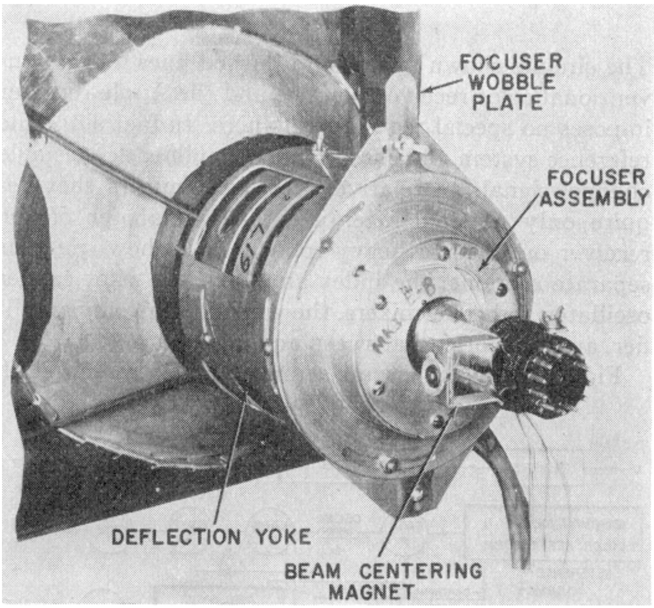

Fig. 4 – View of experimental yoke-focuser mount.

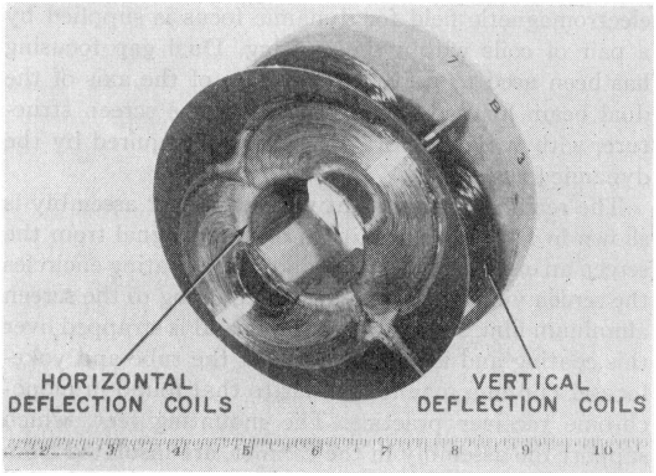

Fig. 5 – Details of the yoke

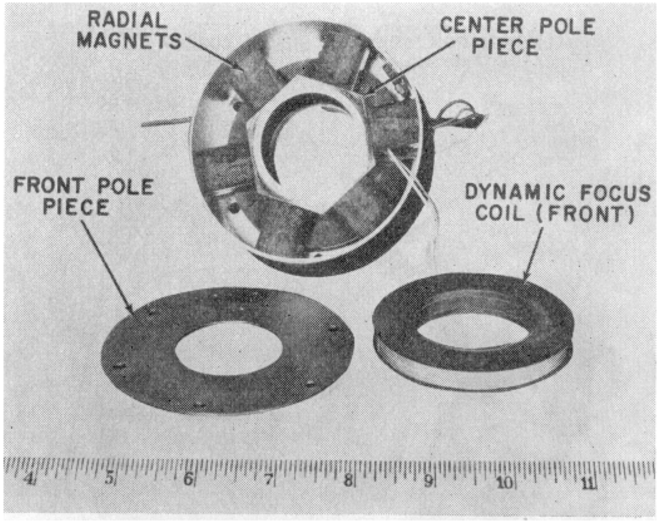

Fig. 6 – Construction details of the dual gap focuser.

The pilot carrier signal is coupled from the chassis on the coaxial lead shown. Writing-frequency signals are carried by open wire leads at present.

Obviously, good bonding of the chassis to the crt assembly is required. This is achieved by foil straps at front and rear of the chassis and crt. The chassis construction is conventional and the chassis size is 21 by 24 inches. The only nonstandard components associated with the chassis are the tubes in the sweep high-voltage section.

Fig. 3 shows the experimental damper tube, the 3-kv regulator tube, and the 27-kv regulator tube used in the receiver. The horizontal output transformer is included for comparison purposes.

Fig. 4 is a view of the experimental yoke-focuser mount. It is conventional, with the yoke centered from the tube neck and the focuser carried by a "wobble plate" in a plane normal to the tube neck. The focuser is mechanically aligned to the tube neck by adjusting the "wobble plate." A beam centering magnet is used to obtain writing beam alignment.

Briefly, the complete electron-optical alignment is as follows. First, with vertical deflection only, the yoke is rotated so that a vertical beam trace is aligned with the color stripes. Second, the centering magnet is adjusted to place the beam along the focuser axis. A modulation pattern obtained by 60-cycle connections to the dynamic focus coils determines the unique position of proper beam alignment. These two steps complete the alignment of the crt assembly.

Fig. 5 shows details of the yoke. The cylindrical windings have an inside diameter of two inches and a core length of 1½ inches.

Fig. 6 shows the dual gap focuser construction. The permanent magnet field is supplied by six radial magnets and provides 90 per cent of the focus strength. The electromagnetic field for dynamic focus is supplied by a pair of coils within the housing. Dual gap focusing has been used to prevent a rotation of the axis of the dual beam focused spots, relative to the screen structure, with variations of focus strength required by the dynamic focus action.

The remaining important part of the crt assembly is shown in Fig. 7. To obtain an indexing signal from the screen an external band of a conductive coating encircles the screen viewing area to form a coupling to the screen aluminum film. A metal mounting band is strapped over this coating and is used to support the tube and yoke-focuser cup in a manner similar to that found in monochrome receiver practice. The mounting feet, which support the assembly in the cabinet, are insulated from the metal mounting band, but are grounded to the foil shield. The circuit elements formed by the band, the Aluminized screen to which it is coupled, and ground, are tuned to resonance at the index sideband frequency. Index signal take-off is accomplished by a coaxial lead connected to the mounting band. To shield the index circuit from the external interference an aluminum foil shield is folded to cover the rim of the crt. In the figure one corner of this shield has been opened for purposes of illustration. The tube and circuitry do not appear sufficiently sensitive to magnetic fields to require any magnetic shielding or compensation for earth field effects.

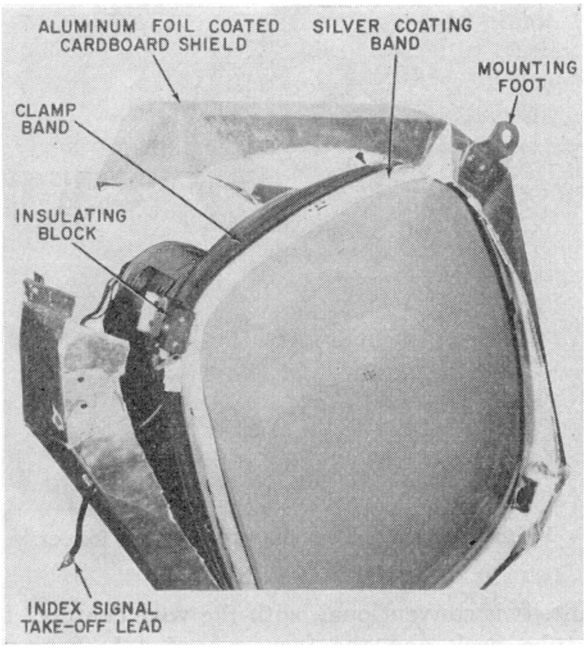

Fig. 7 – View showing details of crt mounting assembly

The foregoing explanation of the details of the crt assembly may give an understanding of recent practice in this area. Further simplification of the physical structures external to the crt are expected with operating requirements better known now than at the start of the receiver design.

RECEIVER CIRCUITRY – BLOCK DIAGRAM

Details of the circuitry of this receiver are shown in Fig. 8. This is one version of a complete Apple receiver.

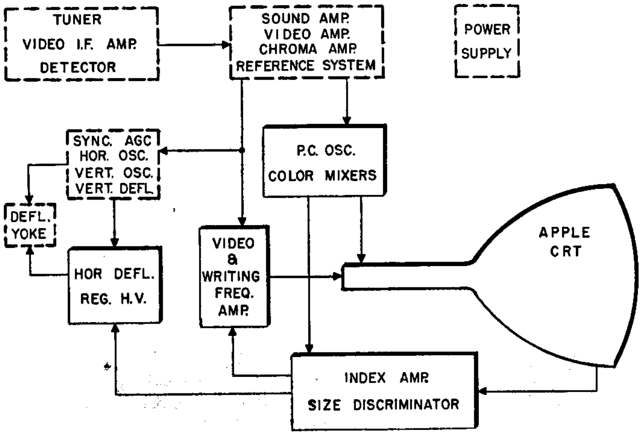

Fig. 8 – Block diagram of the Apple receiver

The circuits shown in the light dashed lines follow conventional color receiver practice and the Apple receiver imposes no special requirements here. In fact since the reference system and chrominance amplifier drive single channel signals to relatively low-level mixers they require only nominal attention. The remainder of the receiver outlined in heavy solid lines is shown in four separate sections: the index amplifier, the pilot carrier oscillator and color mixers, the writing frequency amplifier, and the horizontal sweep and high voltage.

Fig. 9 shows the circuit arrangement in more detail.

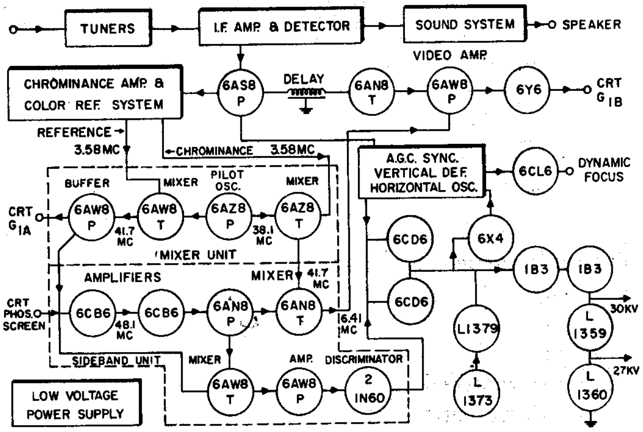

Fig. 9 – Functional diagram of the Apple receiver

The horizontal sweep-high voltage section is very similar to monochrome practice. To date, a pair of 6CD6 tubes have been used for the drive, and a special high-perveance diode, the L-1379, is the damper. The 30kv supply is obtained by a voltage doubler of 1B3's. Six special points about this circuit should be mentioned.

1) A “width” control, for the close but long time-constant control, of the average color writing rate, is obtained by controlling the average bias on the drive tube grids with the output of a writing frequency discriminator. This precludes grid leveling on the grid drive signal but is otherwise satisfactory control which has been found not to disturb the sweep linearity.

2) Sweep width modulation at the vertical scanning rate to match the raster pincushion to the color line pincushion is provided by a small amount of drive tube bias variation with vertical parabola and sawtooth components derived from the vertical output stage.

3) To aid in maintaining horizontal sweep linearity with changes in line voltage, and to maintain nearly constant picture height, it appears advantageous to derive the plate supply voltage for the horizontal and vertical oscillators from the regulated energy in the horizontal system. The 6X4 shown provides a 400-volt supply for this purpose.

4) An antiringing damper, the L-1373, is used to suppress transients of the output transformer which would otherwise appear as uncontrolled variations in the horizontal sweep linearity. This is a small tube requiring a rating of about 50 milliamperes average current and 1 kilovolt peak inverse voltage.

5) Vertical dynamic focus only is used in this receiver and for this a vertical frequency parabola is applied to a focus control tube.

6) The high-voltage supply must have two regulated outputs for reasons of maintaining optimum focus, horizontal sweep operation, and index. This regulation requirement has been accomplished by use of L-1359 and L-1360 all glass gas regulators developed by the Philco Lansdale laboratories. Although this type of tube has a somewhat clouded past history the newly developed types have been tested thoroughly and have been highly successful, giving no trouble in receiver operation. The three requirements for stability of width, linearity, and high-voltage regulation can be met by these circuits.

The mixer unit consists of two tubes whose triode sections accomplish nearly all the color signal processing required by the receiver. The functions of this section are to generate an unmodulated pilot frequency carrier, and to transfer the chrominance modulation to a second pilot frequency carrier. To supply the unmodulated pilot carrier signal, a pentode is used as a 38.1 mc oscillator. Oscillator output is mixed with 3.58 reference signal and the sum frequency of 41.7 mc is selected, amplified, and applied to the crt pilot signal grid where about 40 volts peak-to-peak are required. The pilot carrier bias control previously mentioned is a dc bias control on this crt control grid. Pilot oscillator output is also mixed with the receiver chrominance signal and again the sum derived to form the chrominance modulated signal of 41.7 mc. The essential requirements of this mixer section are nominal and may be summed up by the admonition, “Eliminate stray couplings.”

The mixing of index signal and pilot carrier beam current occurs at the crt screen and permits frequency separation of index information as a sideband of the pilot carrier from color writing information. The sideband unit is, at this moment, the largest special circuit group in the receiver but it is also the most straightforward. It comprises a 3-stage amplifier with a center frequency of 48.1 mc and 2-mc total bandwidth. Required selectivity is achieved in passive circuits associated with the index take-off circuit and ahead of the first amplifier. This amplifier has two outputs. One is mixed with the unmodulated 41.7 mc pilot carrier to form a color writing frequency difference signal that is applied to a discriminator to derive the width control signal previously noted. The second is mixed with the chrominance modulated 41.7-mc pilot carrier to form a chrominance modulated writing frequency signal which also includes the positional information of the index signal.

The functions of the video amplifier are normal. The luminance signal from the detector is amplified and applied to the crt writing grid. The chrominance signal from the sideband unit is amplified by the last two stages of the video amplifier, and with the luminance makes a composite video signal for the crt writing grid. About 150 volts of peak-to-peak signal, including the sync pulse, are desirable to achieve 40 foot-lambert highlight brightness pictures. The master hue control is located in the reference system for the purpose of aligning the phase of the final writing signal with crt screen structure.

The circuits shown in Fig. 9 comprise a fully operable receiver that is capable of making excellent pictures. However, many embellishments of the circuits of Fig. 9 are possible and indeed all of the following have been tested in prior receivers.

1) Monochrome correction of the “Y” signal to an “M” signal.[1]

2) Chrominance signal correction from the transmitted vector relationship to an equal angle signal.

3) DC restoration or dc coupling of luminance or chrominance signals.

4) Sundry writing frequency circuit processing for enhancement of saturation by control of writing frequency signal conduction angle.

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[1] The “M” signal is defined in the companion paper by R. G. Clapp, E. M. Creamer, S. W. Moulton, M. E. Partin, and J. S. Bryan, “A new beam-indexing color television display system.” p. 1108, this issue.

The action of these circuits has been found to be as one would predict, yet final usage in a receiver is not easy to establish since each added circuit has its draw-backs. The situation is not unlike dc restoration in monochrome receivers. In the present receiver design good colorimetry appears to depend more on the amplitude linearity of the circuits than on additional circuit functions.

OVER-ALL RECEIVER INTEGRATION

There are several points of over-all receiver operation which should be singled out for comment.

Amplifier Delay

There are two related requirements on the index and writing circuits of the Apple receiver.

1) Selectivity must be adequate to minimize crosstalk of writing beam information into the indexing signal.

2) Delay must be short enough to index the chroma writing information accurately to index beam position.

These somewhat opposite objectives are satisfactorily realized by localizing the major selectivity at the sideband amplifier input. Subsequent amplifiers, including the sideband mixer and the video stages handling chroma, are broad-band, typically 5 mc, to give an over-all circuit bandwidth of approximately 2 mc. In addition, all color processing is kept outside the index amplifier chain to minimize amplifier delay. The circuit delay of the Receiver 7 circuits is approximately 0.9 microseconds.

Sweep Velocity

With amplifier delay of this order the constancy of hue with scanning is affected by the constancy of the index frequency. Since the index frequency is produced by the horizontal scanning of the pilot beam over the vertical index line structure, realization of an essentially constant index frequency depends on the proper correspondence of sweep velocity and the screen index line geometry. Receiver 7 relies upon circuits similar to those found in monochrome practice and on component stability for its proper operation. The yoke current waveform is of exponential type realized with a developmental low-impedance damper tube, and the crt index line pitch along any horizontal scanning line is a matching exponential. With the average index frequency held accurately by discriminator control of horizontal scanning width, a match between crt color line geometry and raster geometry is achieved with resistive sawtooth and parabola waveform controls.

External Field Influences

It has already been noted that no magnetic shielding has been used in this receiver as the earth's field effects are negligible. In addition, experience has shown that unusual care to avoid hum fields in the vicinity of the crt is unnecessary. This results from the close proximity of writing and pilot beams which prevents an error-producing differential action from taking place.

TYPICAL RECEIVER PERFORMANCE

Several characteristics of the over-all receiver performance are of interest. In a manner similar to the makeup of the transmitted color signal, the color processing circuits are in no way required to make a monochrome picture. The colorimetric white point of the picture is determined by the crt screen and there is no static or dynamic white balance problem. Resolution is certainly not limited by spot size because the spot can be no more than ½ of a brightness picture element. The contrast ratio is excellent, since there is no secondary emission problem at the screen and the pilot beam current can be less than 1 per cent of the peak writing beam current. Screen face reflectivity is low due to the nonreflecting guard lines. Colorimetry can be as good as the circuitry one may wish to include in the receiver, and elementary circuitry has been found adequate.

To achieve a primary color, a color line must be resolved by a moving modulated spot and hence there is the requirement to make the screen structure (that is the phosphor stripe width) as coarse as permissible and to drive the beam to a current limited by the focused spot size. This determines the available highlight brightness on color pictures. The preceding paper and the preceding description of this receiver indicate that excellent results have been achieved in this area. The present receiver performance is 40 foot lamberts highlight brightness with good primary color saturation. Figs. 4 to 7 show the simplicity of the crt assembly and the list of receiver setup controls is complete. Circuit progress has led to chassis simplification such that the chassis of Fig. 2 is 21 by 24 inches and contains the complete receiver including the power supply. This receiver, as a developmental type, does not use an excess of dual section tubes, yet its complement is only eight tubes more than a shadow mask receiver containing the same nondisplay circuitry. In the foreseeable future this differential may be not more than five tubes. This seems a small price to pay, in so-called circuit complexity, to gain an electron-optical system requiring only two alignment adjustments and a cathode-ray tube completely free of static and dynamic white balance and magnetic field problems.

ACKNOWLEDGMENT

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