MEMORANDUM REPORT

On

THE PRESENT STATUS OF
PHILCO
LINE-PHOSPHOR COLOR DISPLAYS

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Preface

This report was prepared by Jack Fogarty at the request of R. G. Clapp in order to summarize progress up to November 19, 1950 on the line-phosphor color displays being developed in the Philco Research Division. Information on the current status of the project and specific tube operation and special circuitry problems was gathered from individuals working on the various units in the Receiver Group.

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SUMMARY

The Philco line-phosphor color tube, utilizing indexed three color line phosphor triplets, shows promise of providing a relatively simple direct view tube for dot sequential or even field sequential color television receivers. Investigations have been made to determine the practicality of using the line phosphor structure in several types of display, each of which requires special circuitry. A perpendicularly-scanned display (using vertical color lines) requires either a synchronous type or resampling type of receiver; work on the synchronous type has been discontinued because of the extreme accuracy required of the horizontal beam deflection, which must be in exact synchronization with the transmitted dot color information. A parallel-scanned display (using horizontal color lines) requires a small auxiliary deflection field to wobble the beam vertically over the color triplet in sync with the color indexing. The report describes these display systems and the functions of the special circuits involved.

The operation of a tube using a flat screen composed of .007 inch color phosphor lines spaced .003 inches apart naturally poses several problems; the spot size must be less than .010 inch and uniform throughout an undistorted raster to avoid color crosstalk and misregistration. Index generation difficulties are the recognition of the weak secondary-emission difference signal from the green stripes, the elimination of video contamination of the index signals, and amplification of the index signal with negligible time delay. Progress on spot size measurements, dynamic focus, yoke astigmatism, geometrical distortion, and index generation is treated in the text.

The report also discusses circuitry problems involved in the construction of special units such as the color burst separator, desampler, resampler, cathode dottor, vertical deflection servo loop, and wobbulator. Although a number of these units have been packaged and ”knothole" patterns have been generated on color tube screens, no complete color display system has been assembled.

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THE PRESENT STATUS OF PHILCO LINE-PHOSPHOR COLOR DISPLAYS

I. INTRODUCTION

The Philco line-phosphor color tube screen consists of triplets of colored phosphor lines which incorporate an indexing system based on a difference in the secondary emission of the green stripe from the other stripes. This report summarizes the work on several types of indexing-tube color displays, none of which have been completed yet. The general characteristics of these display systems are reviewed in the next section before discussing the progress on tube operation and special component circuits. The r-f, i-f, video, sound, and deflection synchronizing circuits will not be considered as display problems.

II. COLOR DISPLAYS

A. Perpendicular Scanning

Figure la shows a block diagram of a synchronous type dot-sequential receiver using perpendicular scanning. The video information goes direct to the picture tube grid, and the cathode is dotted at the time of each color component maximum. The color sync phase, as obtained from the burst, is compared with the indexing phase, and the horizontal sweep is carefully servoed to keep exactly in synchronism with the transmitted colors. Although the vertical deflection is not, critical, the accuracy required of the horizontal deflection is extraordinary. An equivalent horizontal linearity of about 0.02% is necessary to prevent color crosstalk. For this reason and also because the tube structure is absolutely determined by the transmission system, work on the synchronous type of perpendicular-scan display was stopped.

The resampling type of color receiver for perpendicular scanning is shown in Figure 1b. In this receiver the video is separated into its three color components before it goes to the display, thereby making the display operation independent of the transmission system. The three color videos are fed into a remodulator unit which samples them in accordance with the indexing signal and feeds this time multiplexed information to the picture-tube grid. The cathode dotter is also tied by the indexing signal. Thus, the proper intensity information is on the grid and the beam is turned on exactly when it is passing over the right color stripe. With this method, the deflection characteristics are subject only to the circuit limitations of the other unit. A linear horizontal sweep, however, produces a constant-frequency indexing signal and is therefore very desirable for simpler circuitry in the rest of the equipment.

B. Parallel Scanning

While the Philco color tube was originally conceived for perpendicular scanning, the advantages offered by parallel scanning have not been overlooked. As shown in Figure 2, the scanning beam moves parallel to the phosphor stripes while a small auxiliary deflection field rapidly wobbles the beam up and down so that all three phosphors of the triplet group can be excited. The indexing signal derived from the screen can be used to keep the wobbled beam centered over the desired triplet. If this arrangement is used in a field-sequential system, no wobbling may be required. The prime advantage of parallel scanning is constancy of frequency and amplitude of the resampling carrier used, since this is not generated from the indexing signal. Of course, the vertical linearity is very important, but this is easier to control than the horizontal.

Color line indexing may be done at the left edge of the screen during horizontal blanking and may be discontinued during the active scanning time, provided that pincushion and other field distortion can be eliminated, Continuous indexing, on the other hand, could servo the sweep so that no special vertical pincushion correction would be needed. Before a complete picture can be demonstrated with parallel scanning, a new color tube is needed since the .010 inch stripe spacing on our available 16 inch samples does not permit all the lines to appear on the screen.

C. RCA Dot-Phosphor Display

Work has been started also on a complete dot-sequential receiver using an RCA three-gun dot-phosphor tube. The r-f, i-f, v-f, deflection, and color sync and gating units have been built, but the RCA dot-phosphor tube and the information needed to build the dynamic convergence unit it uses have not yet been received. Circuits are being designed to operate this receiver on CBS standards also.

III. TUBE OPERATION

A. Tube Deficiencies

The cathode life of the first color tube was definitely poor. The zero bias beam current decreased rapidly with use; this could have been caused by poisoning resulting from poor evacuation or from other manufacturing defects.

Spot size is a major factor in the operation of a line-phosphor indexing tube. Since the color stripes are .007 inch wide and spaced about .003 inch apart, the beam spot must be less than .010 inch wide if color crosstalk due to exciting more than one color-phosphor at a time is to he avoided. Also, good index signal from the screen depends on a small spot to produce a sharp current pulse as the beam passes over an index stripe.

A special tube with a TP400 gun was constructed by Lansdale for the purpose of measuring spot size. It consists of a 5 inch diameter bulb with the same neck length as the 16 inch color tubes. An aluminum signal plate at the end of the tube has a calibrated gold wedge deposited on it, so that a signal will be produced by secondary emission when the beam is swept across the wedge. Accurate measurements are not possible with this wedge, however, since the aluminum appears to have a slightly higher secondary emission ratio than the gold, which is contaminated with phosphor. Also, the wedge taper is too sharp for good calibration in the region of interest. Using this tube, an approximate figure for the best spot size obtainable was .010 inch. Any future measuring tube of this type should have a thinner wedge with a secondary emission which differs from that of the signal plate material by a greater amount.

The static spot size at the center of the screen is a matter of gun design, assuming a good focus field. It has been suggested that a successful projection tube gun design be copied in a scaled-up version for this 16 inch color tube, perhaps using a 2 inch diameter.

B. Focus

In a line-phosphor tube, it is essential that the spot be perfectly focussed all over the screen to avoid color crosstalk and mixing index information. Since the phosphor stripes are deposited on a flat plate, the distance between the screen and the electron crossover in the gun varies with the spot position on the screen. Perfect focus in this case requires dynamic focussing to change the field in accordance with beam deflection.

A dynamic-focussing unit has already been built and performs satisfactorily over the horizontal scan. All that remains for completion is the vertical portion of the unit. It is expected that the entire focussing operation will require four tubes. The greatest difficulty encountered is deflection yoke astigmatism.

C. Yoke Astigmatism

Yoke astigmatism produces a distortion of the spot as a function of deflection which cannot be corrected by the focus field. Spot elongation at the corners of the screen results in color crosstalk and poor index signals.

Static spot-size checks have been made with several types of yokes. The best yoke to date has been a hand-wound Schlesinger type; good results have been obtained with a production 70° cosine yoke operated with 50° deflection. The special two-inch diameter cosine yoke has not been satisfactory; Bocciarelli's group, however, is now working on a better two-inch yoke design.

Experiments are also being made to determine the field shape inside an entire yoke. Powdered iron is solidified in a plastic inside the yoke while current is flowing through the winding. Later, the plastic block is cut into sections to reveal the flux-line structure.

Deflection sensitivity has not been a problem, since 50° is the maximum required, and deflection circuits are available with ample current output.

Crosstalk between the yoke windings has been greatly reduced by balancing the horizontal winding to ground and bypassing the vertical for 15 kilocycles.

D. Pincushion Distortion

Geometrical distortion of the raster is mostly the result of using a flat screen and a linear angular deflection and, to a very small extent, a function of the deflection yoke. When perpendicular scanning is used, this pincushion distortion results in a higher indexing-signal frequency at the top and bottom of the raster than in the middle. With parallel scanning, rapid color changes are produced along the upper and lower scanning lines unless continuous indexing correction is used.

Calculations have been made showing the deflection waveshapes required to produce a rectangular raster on the flat screen. It is unlikely, however, that these waveshapes could be simply produced electronically with sufficient accuracy to eliminate completely the pincushion effects. It has also been suggested that the pincushion correction be made by using several permanent magnets placed around the tube and experimentally adjusted for the best results. With either electronic or magnetic correction a servo system using continuous indexing signal probably will be required.

E. Indexing Signal

In order to accurately present color information on a line-phosphor display tube, it is necessary to know where the beam is located with respect to the color stripes at every instant of time. The present Philco tube uses secondary emission from the green stripes to provide this indexing information.

One problem in the present method of index generation is low signal output. Formerly, the color phosphors had a thin aluminum backing on which a gold stripe .003 inch wide was deposited over the screen. The small difference in secondary emission between the screen and the index stripe made index recognition extremely difficult. The index signal at present is obtained from a magnesium oxide stripe deposited partly beneath and partly following the green stripe. Nevertheless, the index current is seldom more than 20% of the beam current under the best circumstances. What is needed is either an excellent emitter of secondary electrons or a screen with no secondary emission except for the index stripe. The use of impact conduction rather than secondary emission would greatly simplify the index problem.

The major problem of index recognition is cancelling out the video modulation necessarily superimposed on the indexing signals The superimposed video signal output may be 10 to 80 times the indexing signals. Broadly resonant circuits tuned to the index frequency were coupled to the screen and the collector ring, and their outputs were fed to a mixer. An inverting amplifier in the collector circuit corrected for the difference in signal amplitudes and phased the index pulses to add and the video component to cancel. However, the best method to date was tried before this one and performed successfully at low beam currents. Two capacitors with an inductor between them were used instead of the two tuned circuits between the screen and collector and ground, their values being adjusted for equal signal amplitudes across them. In these circuits, the capacitance between the screen and the collector ring partially mixes the video and indexing signal before they reach the circuits outside the tube. However, reducing area of the screen ring coating on the tube and putting iron oxide in the region between it and the collector ring reduced this capacitance about four to one. The index phase is affected by a transit time difference of about 30° of the color cycle between the electrons collected from the center of the screen and those collected from the edges.

Amplification of the indexing signal presents further complications. With perpendicular scan, the index frequency is proportional to the horizontal sweep speed. With good horizontal linearity, the amplifier bandwidth can be reasonably small. Transients in the horizontal sweep, however, can produce a two to one change, in the indexing frequency. Also, in order to keep the time delay down, Q's on the order of one are required in the amplifier. The change of sweep speed which can be tolerated without causing excessive change in the color presented on the screen is inversely proportional to the time delay in the indexing system.

The most recent attempt at indexing by secondary emission does not involve video cancellation or use the collector signal. When the secondary emission ratio is greater than unity, the screen signal will go positive; therefore index recognition becomes a matter of clipping to remove the video component from the desired signal. Static measurements show that the green secondary emission ratio is greater than unity, but dynamic measurements have not been made yet.

F. <u>Phosphor Color</u>

The first line-phosphor tubes tested showed a severe deficiency of red light output. The recent arrivals, however, exhibit a satisfactory color balance with the exception of some spray streaking, most often noticeable in the red.

Several methods have been used to check the individual colors. The most obvious method is simple microscopic examination of the screen. However, when perpendicular scanning is used, a better idea of the colors can be obtained by "knothole" patterns, which are generated by dotting the picture tube with a 7 mc signal produced by the index stripes or an oscillator cohered with the horizontal defection. In regions where pincushion distortion is small and the deflection is linear, the bands of color widen out into an area of solid color, resembling a knothole. By phasing the dotting signal, each color can be shown separately in the knothole. When parallel scanning is used, bands of color can he seen, the shape of the bands being dependent upon the vertical linearity and pincushion correction.

G. High Voltage Supply Regulation

The operation of a line phosphor display tube requires that the raster size and spot focus remain constant. One necessary condition for this is a regulated high-voltage supply. Equipment has been built which adequately fulfills the requirements. One circuit uses two tubes in the regulator section and gives 0.5% regulation out to 200 µa. Even better regulation is obtainable with another circuit.

IV. SPECIAL UNITS PROGRESS

The r-f, i-f, and video portions of receiver design will be omitted in this report. Mention has already been made of the items directly concerned with the color tube, so this section of the report will deal with special units needed for the displays.

A. Color Sync and Noise

The color sync program deals with color sync performance and burst transmission. This leads to the noise performance study of circuits and complete receivers. Crystal filter, locked oscillator, and AFC color sync generating circuits have been studied. Equipment is now being completed for a subjective evaluation of noise using the direct view trinoscope receiver with variable amounts of noise introduced into its video, color sync, and deflection circuits. So far, experiments have used a special black-and-white receiver with an i-f amplifier designed by Tellier's group for good phase and transient response. The results have shown that gating, assists color-burst separation.

B. Color Sampling

A demodulator unit has been completed for separating a dot-sequential video signal into three separate color components. This device uses pulse gating and filters the three outputs A color burst separator and sync generator unit is available for use with the demodulator.

Two types of remodulator were considered before building a unit for the display. A heterodyne remodulator is not limited by index frequency variations except in the phase response of its circuits. A double-heterodyne unit is more practical than a single one since the color sequence is maintained and adjustment is less critical. A straight resampler unit was chosen as a design adaptable to any display.

In order to reduce the bandwidth required, the completed remodulator unit utilizes sine-wave sampling instead of pulse gating. This means that a dotting unit is necessary at the picture tube if color crosstalk is to be eliminated. Since a constant phase-shift network was not available for phasing the sampling sine-wave to the modulator tubes, a constant time-delay network was used instead, leaving the remodulation operation highly sensitive to index frequency variations.

Construction of the cathode dotting unit has been started. It will be a sideband tripler circuit using the index signal. The problems involved are (1) obtaining adequate bandwidth at 21 mc to allow for index frequency variations, and (2) shielding the 180 volt (peak-peak) r-f signal from the other parts of the color receiver.

D. Horizontal Linearity

When work was begun on a synchronous type perpendicular-scan receiver, the main problem was the horizontal deflection. As has been mentioned, the operation of the synchronous display depended on the accurate positioning of the beam horizontally to produce the correct color at the time of its transmission. A breadboard deflection unit was constructed which employed a feedback loop to servo the yoke current to a reference voltage consisting of an accurate sawtooth independently generated plus the error voltage obtained from the indexing circuits. With no index error voltage added, the deflection produced was linear to about 3%. The beam position could be rapidly changed in accordance with the waveform applied to the error terminals, but no tests were made using indexing error because the index equipment was not completed before this display was shelved. For present displays a conservatively-designed horizontal deflection unit without feedback is available, giving a linearity within 5%.

D. Vertical Linearity

Work is progressing on a vertical deflection circuit employing a servo loop to provide the linearity necessary for a parallel-scanned display. A linearity of about 0.2% is needed for the 60° equivalent deflection on this present screen. The vertical current is duplicating a sawtooth plus sine-wave waveform which should give 1% linearity. The addition of a third harmonic component to the reference waveform would improve the linearity still further, but because of waveform inaccuracies throughout the unit, achievement of the proper linearity will require control from the indexing signal. Pincushion distortion and hum are also part of the vertical problem.

E. Vertical Wobble

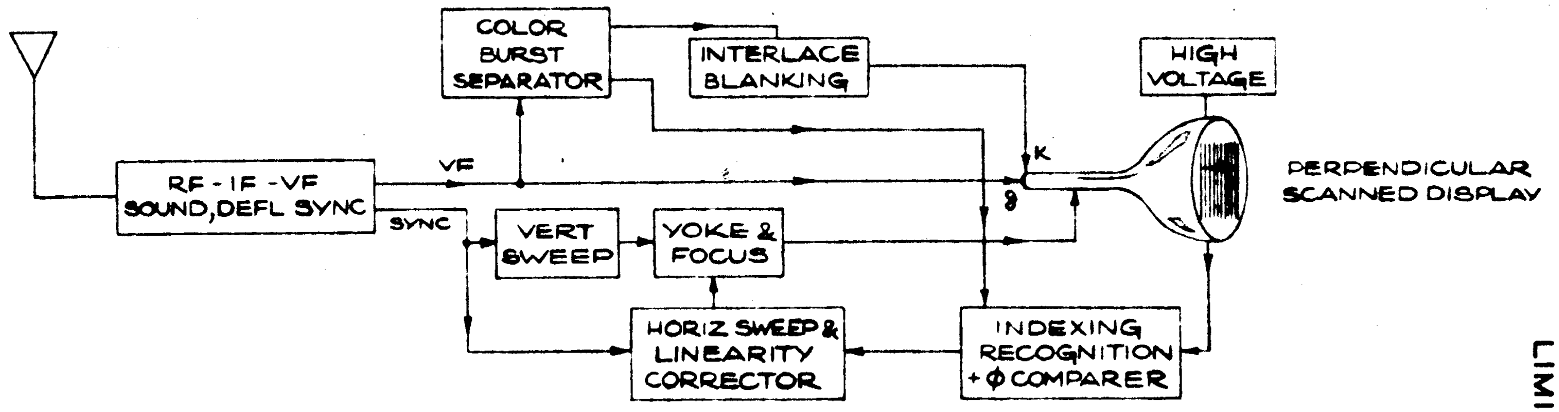
An investigation into a vertical wobbulator for parallel scanning has been started. The required auxiliary deflection is very small, and there is no trouble in producing it over the entire screen. There is some question of losses in the aquadag coating inside the tube at 7 mc, but this may be tolerable. While a sawtooth wobble waveform is preferable, it will probably have to be a sine wave for bandwidth reasons.

CONCLUSION

The Receiver Group has been investigating several different methods of using the Philco line-phosphor tube in a direct-view color display, so that no practical approach could be overlooked. While no complete display has been demonstrated, a number of the necessary units have already been packaged, and the work to date has proceeded satisfactorily.

HR 12-11-50

AOR53Y-1



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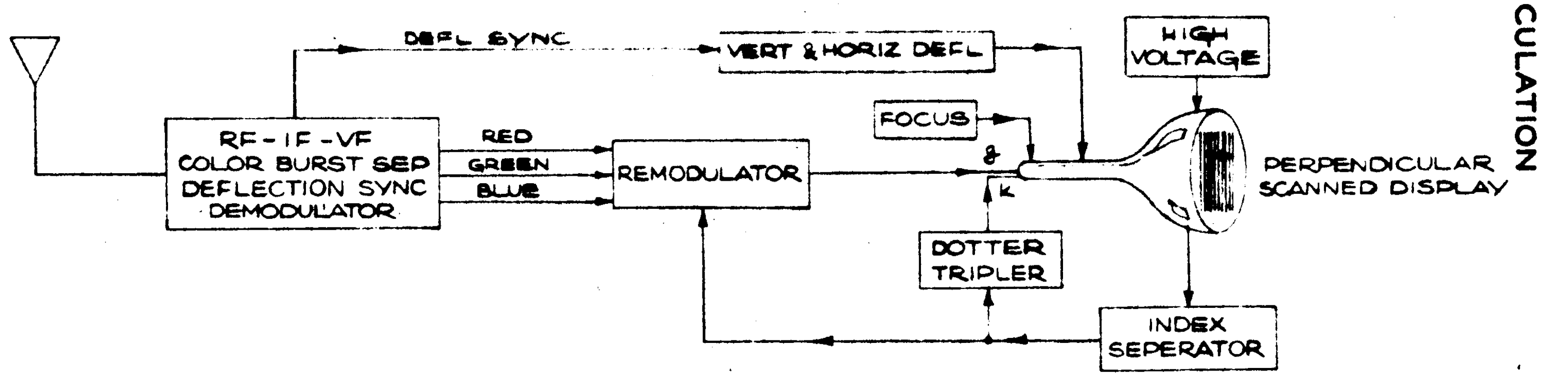


RESAMPLING TYPE
b

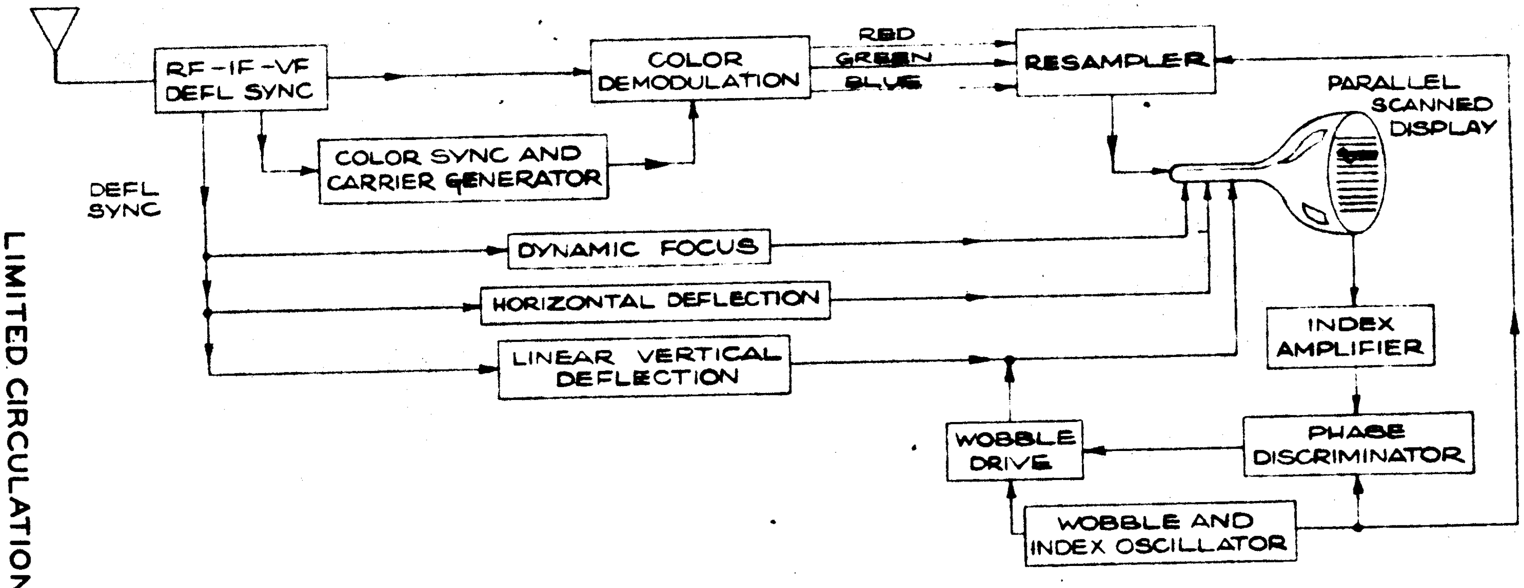
PERPENDICULAR-SCANNED DOT SEQUENTIAL RECEIVERS

FIGURE I

AOR53Y-2

HR 12-12-50

LIMITED CIRCULATION



PARALLEL-SCANNED
DOT SEQUENTIAL RECEIVER

LIMITED CIRCULATION

FIGURE 2