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SOME THOUGHTS ON NEW APPLE SYSTEMS

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INTRODUCTION:

The following is based on the material discussed at the second group meeting on Advanced Apple. Most of the statements should he considered as thoughts rather than facts. Any comments on this material would be appreciated.

1. Position Modulation Writing vs. Amplitude Modulation Writing

The writing technique used in present Apple systems is a typical example of a.m. writing. The picture brightness is limited by the maximum brightness of primary colors (particularly red) that can be obtained without excessive desaturation. Using the present writing technique, the average beam current is 1/4 the peak beam current when saturated primaries are being reproduced. If p.m. writing (in the form of ideal skip scan) were used, the beam need not be turned off at any time during a triplet period, This, of course, would result in a 4:1 increase in brightness on primaries. Another factor that works to the advantage of p.m. writing is that, since the spot remains in the center of a color line throughout essentially the entire triplet period when primaries are being reproduced, there is no increase in effective spot size due to spot travel during "on time” as there is in the present writing techniques. It is estimated that this results In an additional brightness factor of 2 or 3 in favor of ideal skip scan.

Putting these two factors together, one concludes that an ideal p. m. writing system would have a brightness advantage of (8 or 12) : 1 over present Apple when producing primaries having the same degree of desaturation. Quite obviously, all of this advantage cannot be realized in practice due to the difficulty of making an ideal skip-scan horizontal deflection system The answer as to how much of the (8 or 12) : 1 advantage that can be realized will depend on the results of experimental work

It should be pointed out too, that all of the advantage of p.m. writing would not necessarily be used to obtain increased brightness on primaries. Some could be traded for better saturation on primaries, lower anode voltage (less sweep power) or increased tolerances

2. Perpendicular vs. Parallel Scan

One of the strong arguments against parallel scan systems has been that due to the necessarily narrower color lines demanded for parallel scan (approx. .55 the width of perpendicular lines) spot size would limit the brightness of primaries excessively. However, by taking advantage of p. m. writing, and also taking some liberty with the electron optics, this argument loses much of its strength. The maximum allowable spot dimensions are defined in one direction (perpendicular to color lines) by maximum allowable desaturation on primaries, and in the other direction (parallel to color lines by resolution considerations. On this basis, the "area” of the spot can be approximately the same for perpendicular or parallel scan. However, the form factors are quite different, for perpendicular scan being of the order of 2:1 and for parallel scan of the order of 8:1. If the amount of current that can be put into spots of different form factors is proportional to the ”areas" of the spots, then there is no basic primary-brightness advantage for perpendicular scan. If the current is proportional to the 2.5 power of the minimum dimension, perpendicular scan would have, approximately, a 4:1 advantage, Exactly how well a parallel scan system would compare in primary brightness to an equivalent perpendicular scan system depends on answer to electron-optical problems that are, as yet, unknown. However, it would seem that 1:1 is an extremely optimistic guess, and 4:1 is somewhat pessimistic. Wherever in this range, the real value lies, it appears that p.m. writing would allow at least as much primary brightness in a parallel scan system as present Apple has, and possibly over twice as much.

Comparing parallel and perpendicular scan on some other points:

a. Horizontal sweep linearity: Not critical for parallel scan.
b. Vertical sweep linearity: Not critical for perpendicular scan, line start control necessary for parallel scan.
c. Loop time delay: Considerably more time delay may be allowable in parallel scan systems if full advantage is taken of distorting the color lines to match sweep distortions.
d. P. M. Waveforms: Parallel scan systems needs no p.m. waveform to make primaries, perpendicular scan systems need none to make white.
e. Dynamic focus: Parallel scan demands a 15 kc. dynamic focus waveform.

3. General Classification of Systems

Numerous possible systems have been discussed recently. The writer has attempted to classify many of these on the basis of:

a. The orientation of color lines
b. Writing Technique
c. The number of beams and/or their uses.

The following seven classes, while not including all possible systems, does include most of the systems that have received serious consideration lately:

Class 1.0: Perpendicular scan, a.m. writing, two beams (one a pilot beam)
Class 2.0: Parallel scan, a.m. writing, two beams (one a pilot beam)
Class 3.0: Perpendicular scan, a.m. writing, single beam
Class 4.0: Perpendicular scan, p.m. writing, single beam
Class 5.0: Parallel scan, p.m. writing, single beam
Class 6.0: Parallel Scan, a.m. writing, three writing beams.
Class 7.0: Perpendicular scan, p.m. writing, two beams (with separate vernier deflection control of at least one beam, one beam a pilot beam).

4.Specific system classification

Some specific systems have been assigned numbers by the writer and others have been assigned to classes as follows:

(1.1) Present Apple system

(1.2, 1.3, etc.) Present Apple with modifications such as: subharmonic index, 21 mc. horizontal wobble, photo electric index, etc.

(2.1, 2.2, etc.) Various schemes involving parallel scan, two beams and continuous vertical wobble waveform (not a function of transmitter instructions).

(3.1) The photoelectric, trichromatic, clean index system described by Partin in the first group meeting on Advanced Apple.

(3.2) Same as 3.1 except index system is a hue servo.

(4.1) Perpendicular scan, with p.m. writing where the p.m. waveform is 7 mc. skip scan modulated by a saturation signal (preferably with compliment detection). Trichromatic-index hue servo.

(4.2) Same as 4.1 except p.m. waveform is 7 mc. skip scan plus a TDT waveform.

(5.1) Parallel scan, single beam, p.m. writing where p.m. waveform is simply a high frequency vertical wobble modulated by an inverse saturation signal. Trichromatic-index hue servo.

(5.2) Same as 5.1 except replacing trichromatic with diagonal index.

(5.3) Same as 5.1 except that p.m. waveform is a TDT waveform.

(5.4) System described in Kallman's fifth report, (Same as 5.3 except for special indexing method).

(5.5) System described in Kallman's sixth report. (Same as 5.4 except for special indexing method).

(6.1) Parallel scan, three beams modulated by $E_r^{1/\partial}$, $E_g^{1/\partial}$, and $E_b^{1/\partial}$. Trichromatic Index with hue servo,

(6.2) Same as 6.1 but with diagonal index.

(6.3) Same as 6.2 but without hue servo, pilot carrier on one beam.

(7.1) Perpendicular scan, two beams, pilot carrier on one, independent p.m. on the other (phase and amplitude controlled skip scan).

Any comments on the above method of system classification would be appreciated. If this classification is considered to be generally useful, it can be expanded to include many more possible systems.

5. System block diagrams

Block diagrams of several possible new systems are shown which illustrate some new ideas in Apple tube operation. Each system illustrated is characterized by single-beam, p.m. writing and hence fall in Class 4.0 or 5.0.

System 4.1. Refer to Fig. 1. The hue servo block is largely self explanatory. The three 30 mc. sinusoids mix with the video frequency components of the R, G, B light outputs to produce a color carrier of similar form to the transmitted color carrier. The phase of this locally generated color carrier defines the hue being reproduced. It is phase compared with the transmitted color carrier phase (transmitter hue instructions), and the error signal is made to control the horizontal deflection in such a sense as to minimize the error. Thus, if the p.m. waveform causes the reproduced color to have other than zero saturation, the hue servo will operate to make this color the correct hue. Therefore, the p.m. waveform controls only the saturation of the reproduced color. The p.m. waveform shown consists of a triplet frequency sawtooth that opposes the normal horizontal deflection. Its amplitude is a function of saturation and, on primaries, is sufficient to cause the spot to be stationary for as large a portion of each triplet period as possible, and then to jump to the next triplet. On complements and desaturated colors, it is of lower amplitude so that the spot "coasts" across a segment of a triplet before jumping to the next, and on white, it is of zero amplitude so that the spot moves at constant speed across the entire triplet. With this p.m. waveform, it would be possible to produce all values of saturation up to the point where spot size or sawtooth waveform imperfections impose a maximum. The main problem, excepting this, would be secure the proper relationship between transmitter saturation instructions and sawtooth amplitude. To ease this task, nearly contiguous stripes would probably be necessary.

A disadvantage of the arrangement shown is that, under certain circumstances, small displacements of portions of the picture could occur. Assume that a color sequence R, G, B, R, G, B occurs in the transmitter instructions. With each color shift, the spot will be advanced one color line from its uncontrolled position. This process, continued would result in the spot being several triplets off from its uncontrolled position. If another portion of the picture does not have this same color sequence, the spot will not be shifted as far. This trouble would be avoided if the hue error signal were made to control the phase of the "triplet frequency oscillator" rather than the horizontal deflection. However, this would probably result in a longer loop time delay. In order to control hue with transmitter instructions via the hue servo as shown, a loop time delay of the order of 0.3 μsec. is necessary.

Desired p.m. waveforms generally are of high fundamental frequency and rich in harmonics, as in the 7 mc. sawtooth in this case. The generation and application of these waveforms will be one of the biggest problems in these systems. Since the deflection angles involved are very small, of the order of .05°, the auxiliary deflection can be either magnetic or electrostatic. The desired deflection amplitudes could be obtained by about 25 ma thru a 20 turn (80µh) probe coil, or by about 10 v. across electrostatic deflection plates having less than 1 µµf. From this it would appear easier to design for electrostatic deflection unless, for the particular p.m. waveform desired, the magnetic circuit has a particular advantage.

System 4.2 and the TDT Waveform: System 4.2 is identical to 4.1 except that the skip scan waveform is continuous, at primary amplitude, and a TDT waveform (at triplet frequency) is added to it. The advantages of this are:

a. It becomes a quantized system.
b. Hue is changed primarily by the p.m. waveform, thus avoiding the small displacements possible in 4.1 and allowing a longer loop time delay.

The TDT waveform is one that deflects the spot in steps such that it remains in the centers of the R, G and B color lines for periods of time that are in the ratio of the R, G and B contributions to the desired color. One method of generating the TDT waveform is shown in Fig. 2. The upper clipper produces a positive pulse, the duty cycle of which is the percent contribution of red to the desired color. The lower clipper produces a negative pulse (1/2 period away from the positive pulse) the duty cycle of which is the percent contribution of blue to the total color. The portion of the period not occupied by either of these pulses is, obviously, the percent contribution of green, so that when these two pulse chains are added, the desired TDT waveform is produced.

The circuit shown will theoretically, produce a TDT waveform that will give proper color reproduction when driven by the un-gamma corrected signals, R, G and B. If it is driven by gamma-corrected signals, $E_r^{1/\delta}$, $E_g^{1/\delta}$, and $E_b^{1/\delta}$, chromaticity distortions would result. This could be corrected partially by using the peaked triangular waveform shown at the bottom of Fig. 2 instead of the pure triangle.

The clipping arrangement shown in this circuit would have to have same remarkable qualities. The amplitude of the triangular waveform, (R + G + B) would vary over a 60:1 range from peak white to a dim primary, 1/20 the brightness of a maximum brightness primary. If, on the dim primary, the clipper takes a slice out of the triangle that is 1/10 the height of the triangle (which is reasonable for good saturation) we would be asking it to take a slice 1/600th the peak triangle height on peak white. Since the triangle fundamental frequency is 3 - 7 mc, this would appear impractical. A more complex circuit would be needed, possibly cascaded clippers with a circuit preceding those shown which would compress the contrast range in the composite signal.

<u>System 5.1</u> The upper block diagram shows the simplest form of parallel scan, p.m. writing system. The p.m. waveform is simply a vertical, sinusoidal wobble of sufficient amplitude to produce the desired desaturation when properly registered with the color lines. The vertical position of the sinusoid center is controlled by a hue servo. The p.m. waveform amplitude is zero on primaries, so that excellent saturation should be attainable. The wobble amplitude is maximum on white and its particular value would be a white balance adjustment.

There are several fundamental disadvantages to this system which rule it out as an Apple X system possibility:

a. The hue servo loses control on white. The scanning path would then wander across color lines causing a desaturated rainbow effect on white.

b. Certain transmitter instructions would cause the scanning path to wander into adjacent triplets (analogous to the small displacements possible in System 4.1). In this case the subjective effect would be more objectionable since it would result in scanning sections of some triplets twice, and completely missing sections of others.

These two objections are partially overcome by using a TDT waveform instead of the desaturating sinusoid and by using contiguous, equi-angle stripes. This operation corresponds to system 5.3.

<u>System 5.2 and diagonal index</u> Diagonal index, with associated circuits, produces two signals (I, and I_2 in Fig. 3, bottom) which define the hue being reproduced by their phase difference. Since they are generated by scanning across diagonal or perpendicular index stripes, they change frequency with horizontal sweep speed. A hue servo made with diagonal index is shown in block form in Fig. 3. Two possible diagonal index patterns are shown in Fig. 4. In Fig. 4A, the pattern consists of two stripe sets of separable photo-index phosphors. The scanning spot generates two light signals of frequency, f, whose phase difference goes through 360° as the scanning path moves vertically one triplet. Fig. 4B shows a single-component, diagonal index pattern. Here two signals are

generated at frequencies f/3 and f/2. These can be separated by band-pass filters. The phase difference between the third harmonic of f/3 and the second harmonic of f/2 define the vertical position of the scanning path as in the previous example.

From the system viewpoint, the use of a diagonal index hue servo or a trichromatic index hue servo are not much different. System 5.2 has the same fundamental disadvantages as 5.1, and a diagonal index, TDT system could be hypothesized that would be similar to System 5.3.

<u>System 5.4. 5.5 and others</u> There is a group of parallel scan, TDT system possibilities which would not lose index on white. Some of these are:

a. Systems 5.4, 5.5

b. System 5.3 where the 30 mc. modulated with transmitted color carrier that is introduced in the hue servo is replaced by 30 mc. phase modulated in 120° steps by the TDT waveform.

c. The equivalent of (b) with diagonal index.

The difficulty with these systems appears, at present writing, to be that the index material, and index structure period (if present) need to be fast with respect to the TDT period.

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Encl.

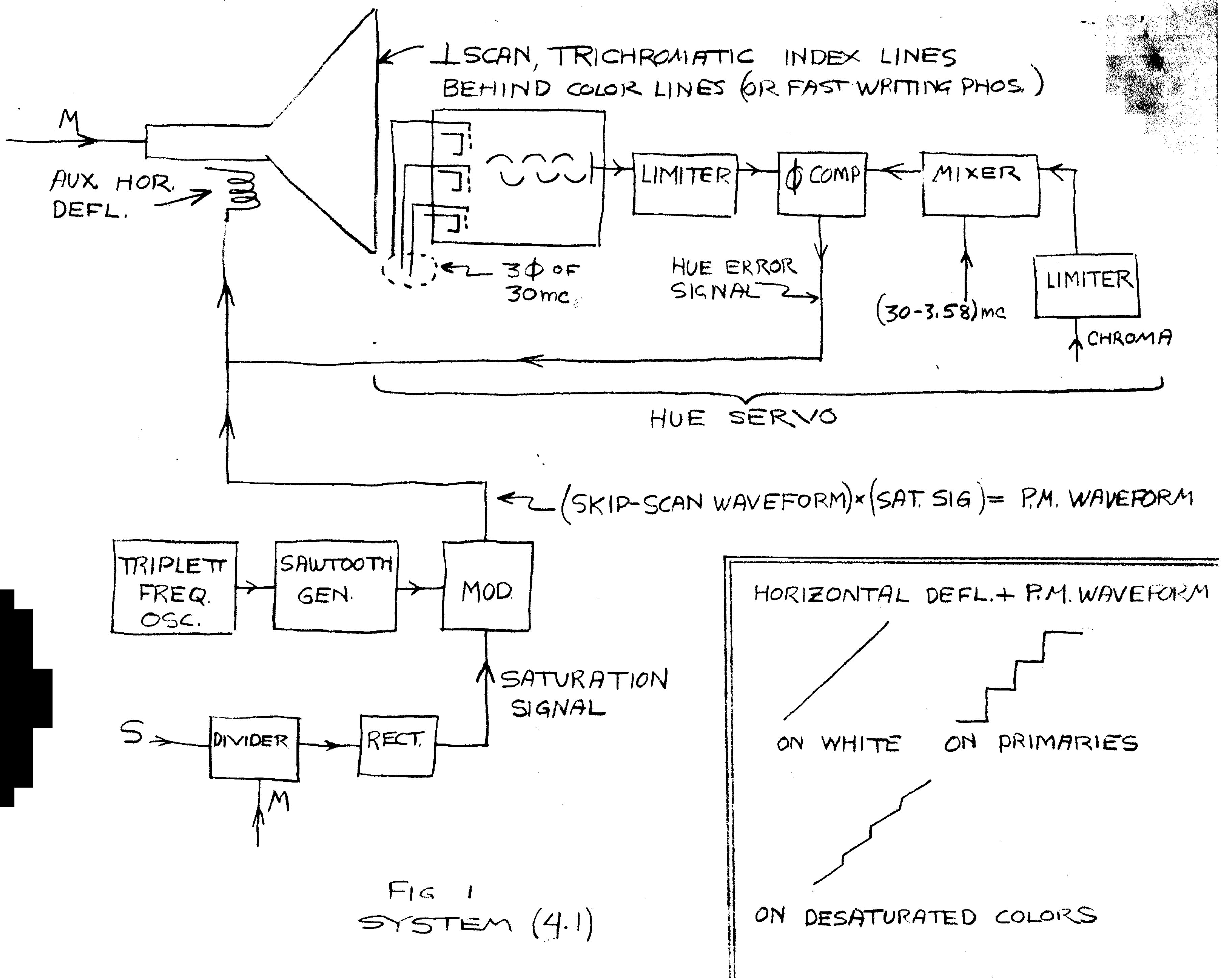
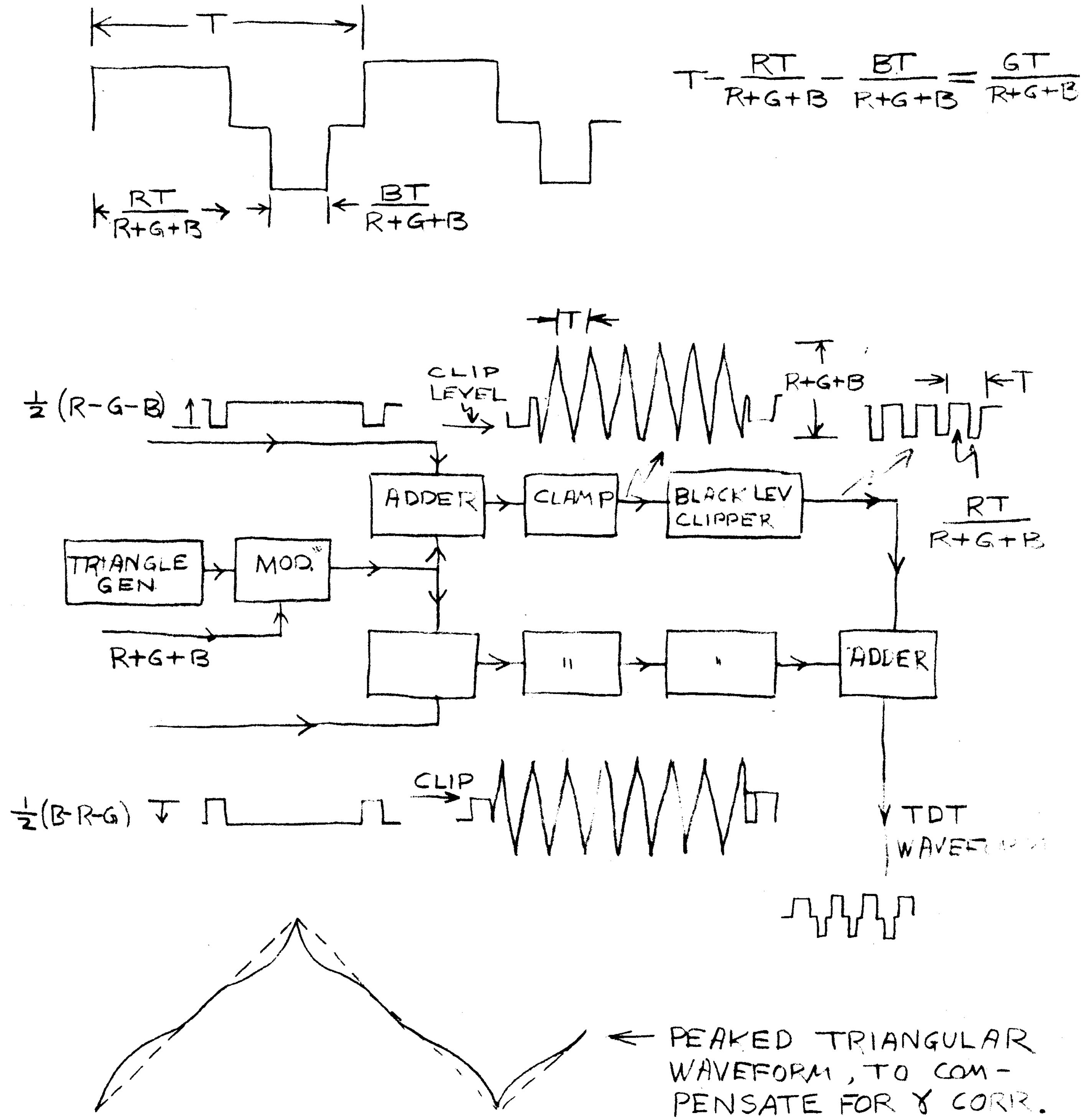


FIG 1
SYSTEM (4.1)

- TDT WAVEFORMS -

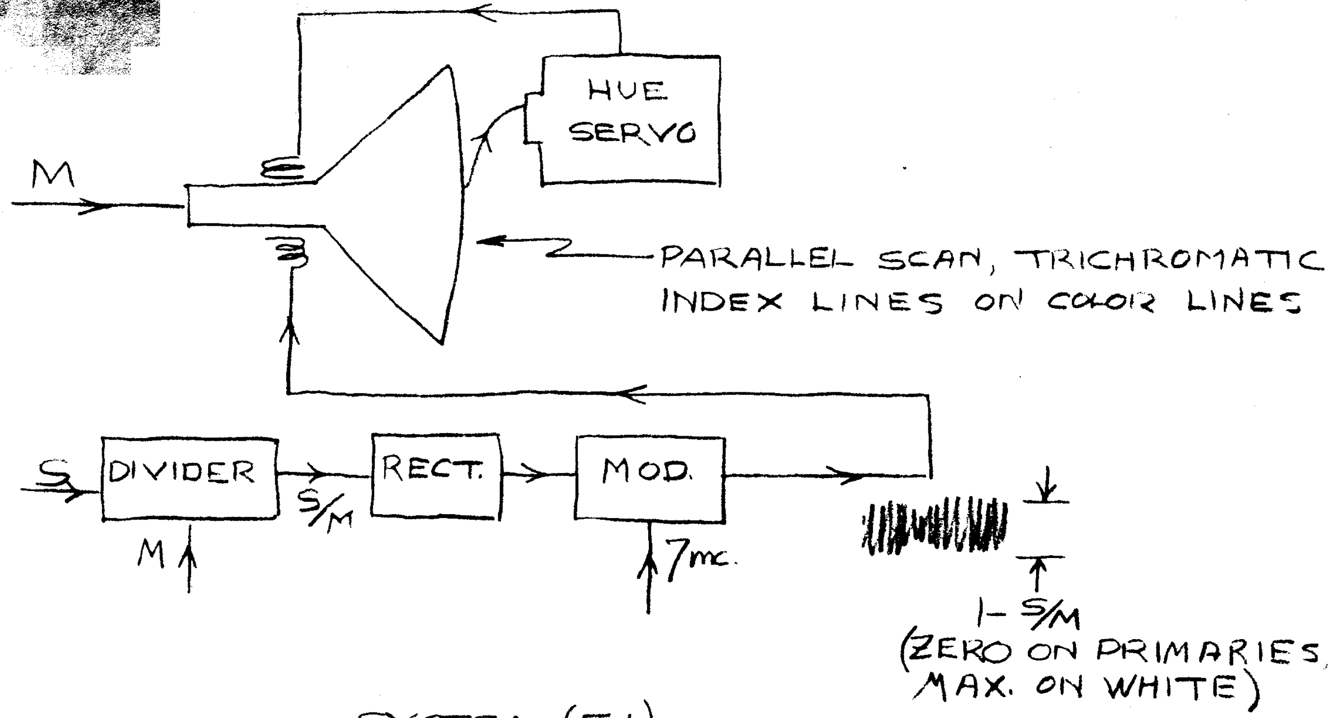


$$T - \frac{RT}{R+G+B} - \frac{BT}{R+G+B} = \frac{GT}{R+G+B}$$

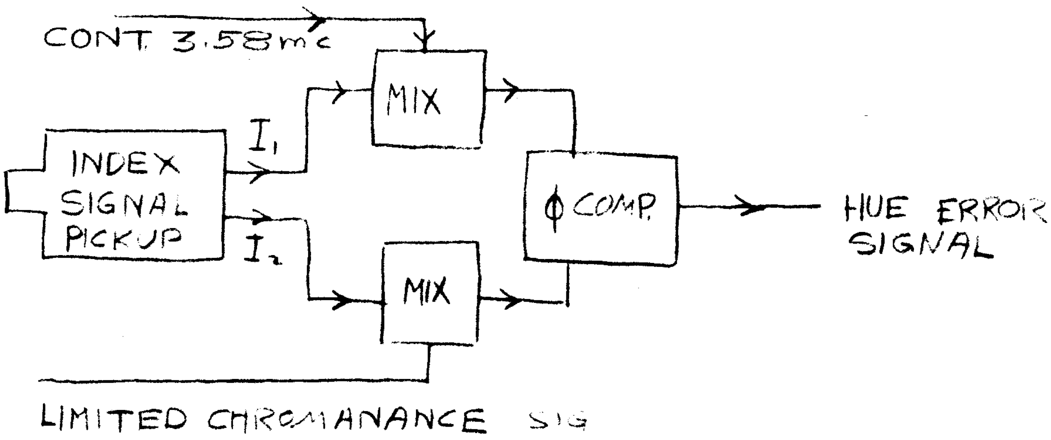
← PEAKED TRIANGULAR WAVEFORM, TO COMPENSATE FOR γ CORR.

FIG. 2

[redacted]



SYSTEM (5.1)



DIAGONAL INDEX LOOP TO
REPLACE HUE SERVO IN SYSTEM 5.1
MAKING SYSTEM 5.2

FIG 3

[redacted]

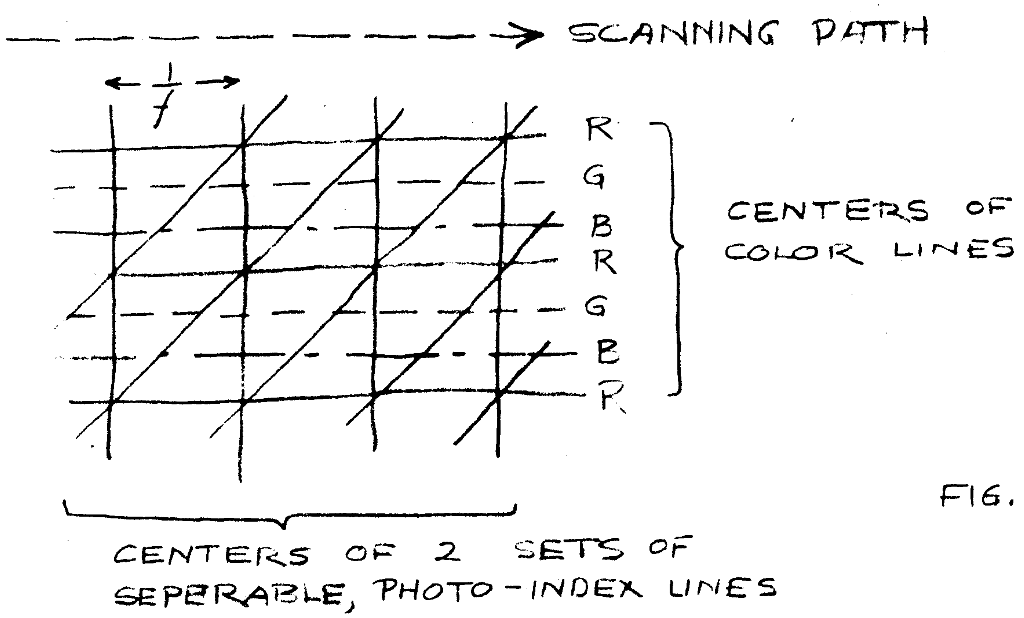

SCANNING PATH
1/f
R
G
B
R
G
B
R
CENTERS OF COLOR LINES
CENTERS OF 2 SETS OF SEPERABLE, PHOTO-INDEX LINES

FIG. 4A

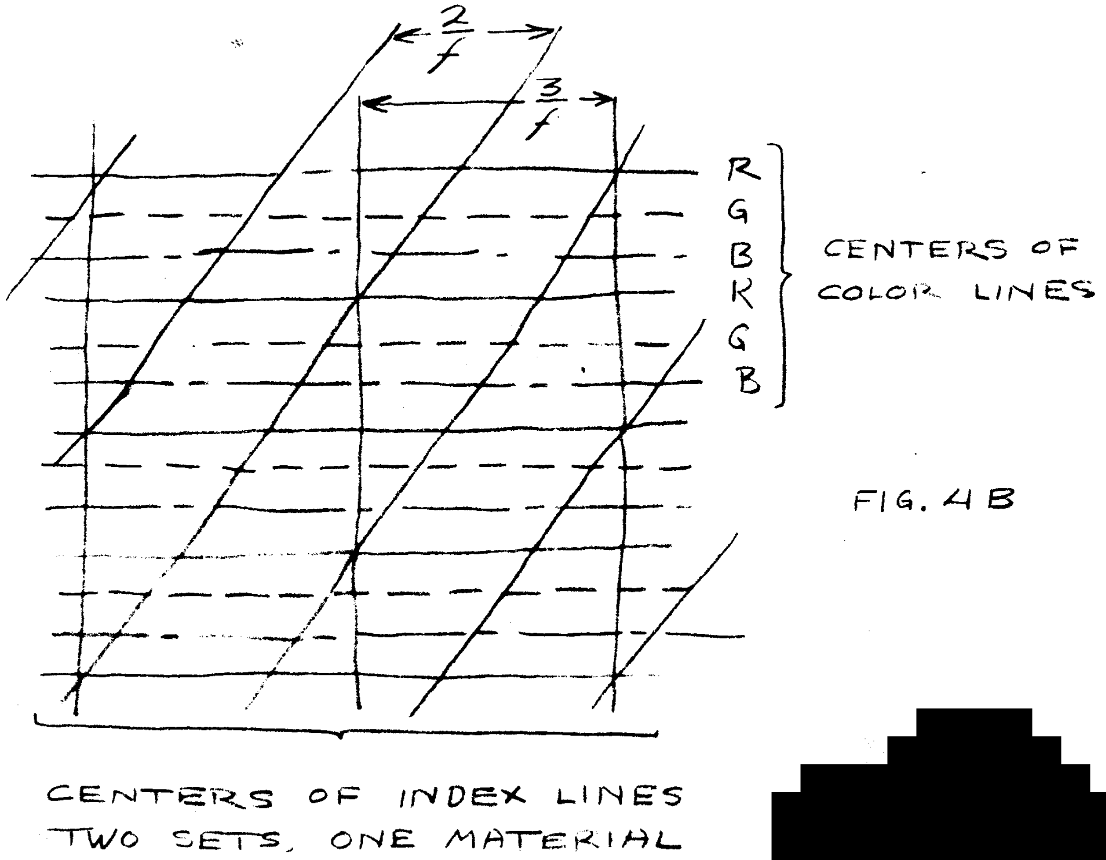

2/f
3/f
R
G
B
R
G
B
CENTERS OF COLOR LINES
CENTERS OF INDEX LINES TWO SETS, ONE MATERIAL

FIG. 4B

APPENDIX

1. Amplitude Modulation Writing

Refers to systems wherein transmitter instructions affect only the intensity of the CRT beam current.

2. Asynchronous Writing

In perpendicular scan systems, a method of writing whereby the writing frequency is controlled by the horizontal sweep speed.

3. Diagonal Index

An index structure, applicable to parallel scan systems, which consists of one or two kinds of index material deposited in two sets of lines, neither of which are parallel to the lines of writing phosphor. Positional information is derived from the phase relationship of the two signals generated by the spot as it sweeps over the two sets of index lines.

4. Dominant Hue Writing Systems

Writing systems wherein the pattern of electrons impinging on the screen is one line per triplet. Differing colors are produced by varying the width and position of these lines with respect to the viewing phosphor lines. This type of writing is characterized by the fact that any error in index has a direct effect on the reproduced hue.

5. Hue Servo

An indexing and hue controlling arrangement wherein the reproduced hue is controlled by an error signal that is the result of comparing transmitter hue instructions with index information.

6. Inverse Saturation Signal (with or without Complement Detection)

The reverse of a saturation signal, it has zero amplitude on primaries and maximum amplitude on white.

7. Position Modulation Writing

Refers to systems wherein transmitter instructions affect the instantaneous position of the writing beam.

8. Quantized Writing Systems

Writing systems wherein the pattern of electrons impinging on the screen consists, ideally, of lines centered on the color lines regardless of the color being reproduced. Differing colors are produced by varying the relative intensities of these lines. This type of writing is characterized by the fact that small errors in positioning of the electron pattern result in substantially no error in reproduced hue.

9. Saturation Signal

A signal that is zero on white and increases with increasing saturation, this is a function of chromaticity only, and is independent of intensity. An example of a saturation signal would be "S/M" where ″S" is amplitude of an equi-angle subcarrier and "M" is monochrome signal amplitude.

10. Saturation Signal with Complement Detection

A saturation signal that has a smaller amplitude on saturated complements than on saturated primaries.

11. Saturated White Brightness

In a given display, the maximum brightness of a saturated primary divided by the luminance contribution coefficient of that primary.

12. Skip Scan

A method of horizontal scanning applicable to perpendicular scan systems that entails the addition of a high frequency sawtooth component to the horizontal deflection in a sense that opposes deflection during the majority of its period. It can be either triplet frequency or line frequency.

13. Synchronous Writing

In perpendicular scan systems, a method of operation whereby the chromaticity information is introduced at constant frequency and the horizontal deflection is controlled to make the electron pattern register with the color lines.

14. Trichromatic Dwell Time Waveform (TDT)

A high frequency waveform applied to the deflection that causes the spot to remain in the center of each of the phosphor stripes in a triplet for periods of time that are in the same ratio as the R, G, and B components of the color being reproduced. For example, in a parallel scan system, the TDT waveform might be applied to the vertical deflection and would be a three-step step wave. The widths of the steps would be RT/(R+G+B), GT/(R+G+B) and BT/(R+G+B), where T is the period of the TDT waveform.