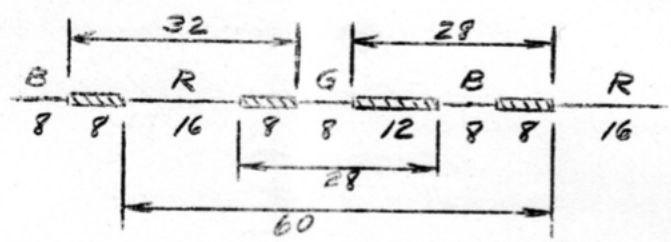
REPORT ON APPLE PAPERS AT THE IRE CONVENTION

Three Apple papers were presented by Philco engineers at the session on Color TV on March 20, 1957. The first two dealt with the Apple tube, recent modifications and characteristics. The third paper discussed some features of the model 8C receiver.

I. Recent Improvements in the Apple Beam Indexing Color Picture Tube - presented by Moulton

1. The most significant modification in the Apple tube is the change in stripe widths. The red stripe has been widened at the expense of blue and green to give a 60% increase in brightness. The tube originally used equal phosphor and guard band spaces of .010" giving a triad spacing of .060".

   The new stripe dimensions, given in thousandths, are shown below:



   It will be noted that the pitch is unchanged and that red is now twice as wide as blue or green. The white point is the same as the previous tube. With this arrangement, the green phosphor is used undiluted while blue is still diluted a small amount. The "tolerance band" on red (.032") is greater than on blue or green. A demonstration was given to show subjectively that green and blue have greater tolerance than red to contamination from the other primaries. It was stated that these results are not contrary to Mac Adam's minimum perceptible color difference chart because the demonstration was based on error the eye would tolerate as opposed to what the eye could perceive on a side by side comparison basis.

2. The second change in the tube concerns the relative configuration of the phosphor and index stripes for which new printing masters have been developed. The change eliminates the need for pin cushion correction which was accomplished by vertical modulation of the horizontal sweep.

3. The third improvement described is the choice of a new material for the guard band stripes. The new stripe is more opaque and has higher light absorption giving a darker face tube as seen by the viewer.

4. The fourth point discussed was a report of the latest life test data. It was stated that a 2000 hour life test of "almost 100 tubes" gave results comparable to monochrome. The speaker stated confidently that cathode loading is no longer a problem. A larger aperture and an improved cathode binder have contributed to longer cathode life.

II. Accuracy of Color Reproduction in the Apple System - presented by Chatten.

This paper described the accuracy with which the Apple tube can reproduce the chroma signal applied to its control grid. An excellent presentation was given that cannot be reported in detail here. A series of slides showing portions of the Maxwell triangle were displayed to show the desaturation that occurs as a function of beam current. The main points were as follows:

a. Saturation holds up quite well to 1 ma beam current.

b. The spot has a half power diameter of .016" at 1 ma beam current.

c. The tube will produce 60 ft. lamberts white picture at 1.3 ma. This would correspond to 650 ua on a flat red field.

III. An Advanced Color Television Receiver Using a Beam Indexing Picture Tube - presented by Moore.

This paper described the physical aspects of model 8C as well as some of the circuit simplifications that have been made. Photographs of the set complete with cabinet and with the side panels removed were shown. Cabinet dimensions for the table model were given as height 19", width 28", and depth 25". The single vertical chassis is mounted on the right side wall, as viewed from the front. Printed wiring is used throughout with the exception of the horizontal and high voltage circuits. The mechanical layout looked fairly clean indicating considerable product design effort.

The deflection circuits have been further simplified. Four tubes have been removed from this area. These changes are:

a. Horizontal driver reduced from 2 to 1.

b. Horizontal damper reduced from 2 to 1.

c. Elimination of the ringing damper.

d. Elimination of the horizontal discharge tube.

The set still employs two HV regulators for the 27 KV and 30 KV supplies. The focuser has been completely redesigned and no longer requires the control tube of 7A. The dc field is established with PM magnets while the parabolic vertical correction waveform is formed with passive networks from the vertical output stage.

Receiver 7A added Y and 6.4 mc chroma at low level followed by two stages of wide band amplification. Model 8C provides for separate amplification of these two signals and they are added at high level at the picture tube grid. Reasons for this change were not stated.

Preliminary evaluation of the effect of the circuit changes described above would indicate that our "crab apple" design could be reduced to about 31 tubes. A revised crab apple schematic is being drawn.

Philco reported on efforts to reduce the visibility of the vertical line structure by the use of optical filters. A curve of filter attenuation vs frequency was plotted that showed high transmission in the range of 0 to 4 mc with the attenuation rising rapidly at 6.4 mc.

The speaker summarized the main features of model 8C as follows:

1. Improved packaging.
2. Simplified circuits.
3. Improved setup and alignment.
4. Higher brightness
5. An optical filter to reduce line structure.

TV Zaloudek
Color TV Product Engineering
Room 303, Building 5

TVZ :erh
3/27/57

cc: JF McAllister
RB Dome
DE Harnett
DW Pugsley
DE Garrett
WE Good
GA Schupp
B Field
FG Cole
LC Maier
JC Nonnekens
EF Schilling
A. Letizia

APPLE VARIATIONS

The four systems just presented represent all that is available for today's color receiver. None of these systems in their present form appear to be capable of meeting our cost objectives even under an agressive product design program. However, it is our opinion that of these four types some variation of the Apple system has the best chance of eventually meeting our objectives through new developments. It is for this reason that we are negotiating with Philco for a technical exchange which would entitle us to current status know how of their Apple development. We have not seen their receivers for nearly two years. Our new look will either strengthen our opinion of the potential of this system or serve to remove it from our consideration.

The Apple variation category uses a single gun and vertical phosphor stripes, alternating red, green and blue. The phosphors are balanced to produce white light when scanned by a dc beam or one modulated with luminance information. Color selection is achieved by ensuring that the phase of the chrominance signal applied to the control grid corresponds at all times to the hue of light emitted by the particular stripe being excited. To maintain this correspondence between signal phase and spot position, there is generated at the screen an index signal that contains positional phase information of the spot as it is scanned horizontally.

The signal applied to the control grid is comprised of two separate components, the 0 to 3mc brightness information and the color writing signal. The color signal may be described as three equi-angle vectors each representing one of the primary components of the picture. These vectors represent a frequency fw, the rate at which the electron beam traverses complete color triads. The index signal so controls the phase of this vector system that the phosphor stripes properly sample the color signal to accurately display the chrominance component of the picture.

For proper operation it is essential that the index signal accurately describes the spot position relative to the phosphor stripes. Thus, the index information, its generation and processing, is the heart of any Apple variation system. The accuracy and inherent cost of the indexing method will make or break any proposed system. A number of methods have been proposed for the generation of this information. Four of these will be discussed.

1) Secondary Emission

The Philco Apple receiver uses secondary emission from magnesium oxide stripes placed in back of the color phosphors, spaced one per color triad. The secondaries are collected at the rim of the tube. This method of obtaining index is known to work. It has the disadvantage that the secondary transit time to the collector varies as a function of spot position, thereby requiring phase compensation. The level of signal available from the tube is low requiring considerable amplification in the receiver.

2) Combs

A large number of combs have been proposed for index generation. In this approach metallic stripes are deposited on the back of the phosphors. A large number of comb configurations are possible considering such variables as tooth width and spacing.

The feasibility of combs for index generation is not completely known. Deposition of combs having sufficient conductivity may represent a serious problem. The effect of secondary emission from the teeth on the signal to noise ratio of the index is unknown. The comb represents a serious problem to the tube manufacturer in that a single short between teeth or a break in a tooth would reject an otherwise good tube.

3) Ultra-Violet Radiation

The use of ultra-violet radiation from suitable phosphor stripes on the screen has been suggested for index generation. This method has no transit time or deposition problem. However, efficient ultra-violet collection and possible video signal contamination present serious drawbacks.

4) Primary Sensitive Photo Tubes

This method utilizes photo tubes each sensitive to one of the primary colors. Comments on this approach are similar to those for uv plus possible difficulties from ambient light sources.

Several references have been made to the accuracy of index and the possibility of video contamination. An unmodulated beam scanning an array of index stripes will produce an index signal that contains accurate positional phase information. Modulation of the beam with color writing signals, for example, will cause components of current to flow in the index circuit that may cause intolerable phase errors in the index signal. A phase error results in improper color reproduction. The writing frequency (6.4mc in Philco's Apple), harmonics, and their corresponding modulation components dominate a wide band of frequencies. For successful operation of any Apple system, some means must be found to reduce the effect of video contamination to a tolerable level. It is appropriate then, at this point to consider methods for minimizing these errors.

Index Generation in Philco's Apple

Philco's Apple uses an index signal of 7.5 times the writing frequency , thus placing the index in a "pocket" between two fairly high order harmonics where the level off video contribution is quite low. This index is obtained by modulating a pilot beam with a 41.7 mc sine wave. As this beam scans MgO stripes at a rate of 6.4 mc, product mixing occurs making available a signal at 48.1 mc. This signal contains the necessary spot position information and is sufficiently free of picture modulation. This method gives satisfactory performance, but is quite costly to achieve.

Phase Correction of the Index Signal

It has been suggested that index phase errors caused by the video signal can be corrected by the same video signal. Fundamentally, this is probably true. Suitable detectors and phase modulators could be used to operate on the index signal to make this correction. It does not appear to solve the cost dilemma, however. The non-linear characteristic of the picture tube would further complicate this system.

A Saturating Index System

Consider the writing beam of an Apple tube so restricted that its minimum current is adjusted to some low value, about 10 ua. This component of beam current could generate clean index. It would only be the video modulation on top of this minimum current that would cause trouble. Index could be taken off at writing frequency if the signal could be amplitude limited provided no phase distortion occured in the process. Because of the low levels involved considerable amplification is required. A very costly wide band amplifier would be needed to avoid phase distortion of the fundamental component while bringing the signal up to a suitable level for limiting.

However, it would appear that if the source of index, MgO for example, could be made to saturate at 10 uA, that a solution to the problem would be available. We are not aware of any known techniques to accomplish this saturation effect at low levels. This type of solution would materially reduce the receiver circuitry.

Several examples of Apple variations in block diagram form are appended to this report. While not complete, they will serve to illustrate some of the above considerations.

We believe that some form of Apple variation has a good change of beating out the other presently known systems. The relative simplicity of the picture tube is but one reason for this belief. The Apple tube most closely resembles the present monochrome tube. The signal processing appears to have the most potential for further simplification through additional fundamental contribution. Inexpensive index information, available at high level without video contamination could be the key to a successful Apple variation system.

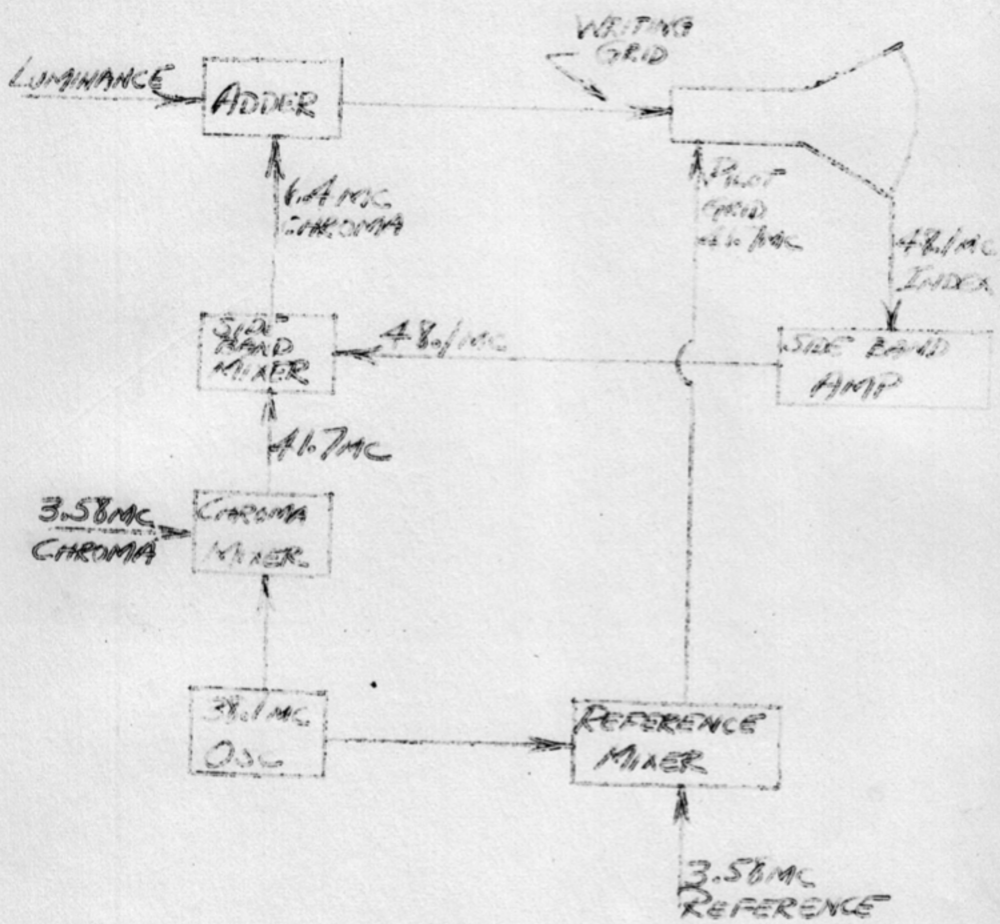
T.V. Zaloudek

TV Zaloudek

4/30/57

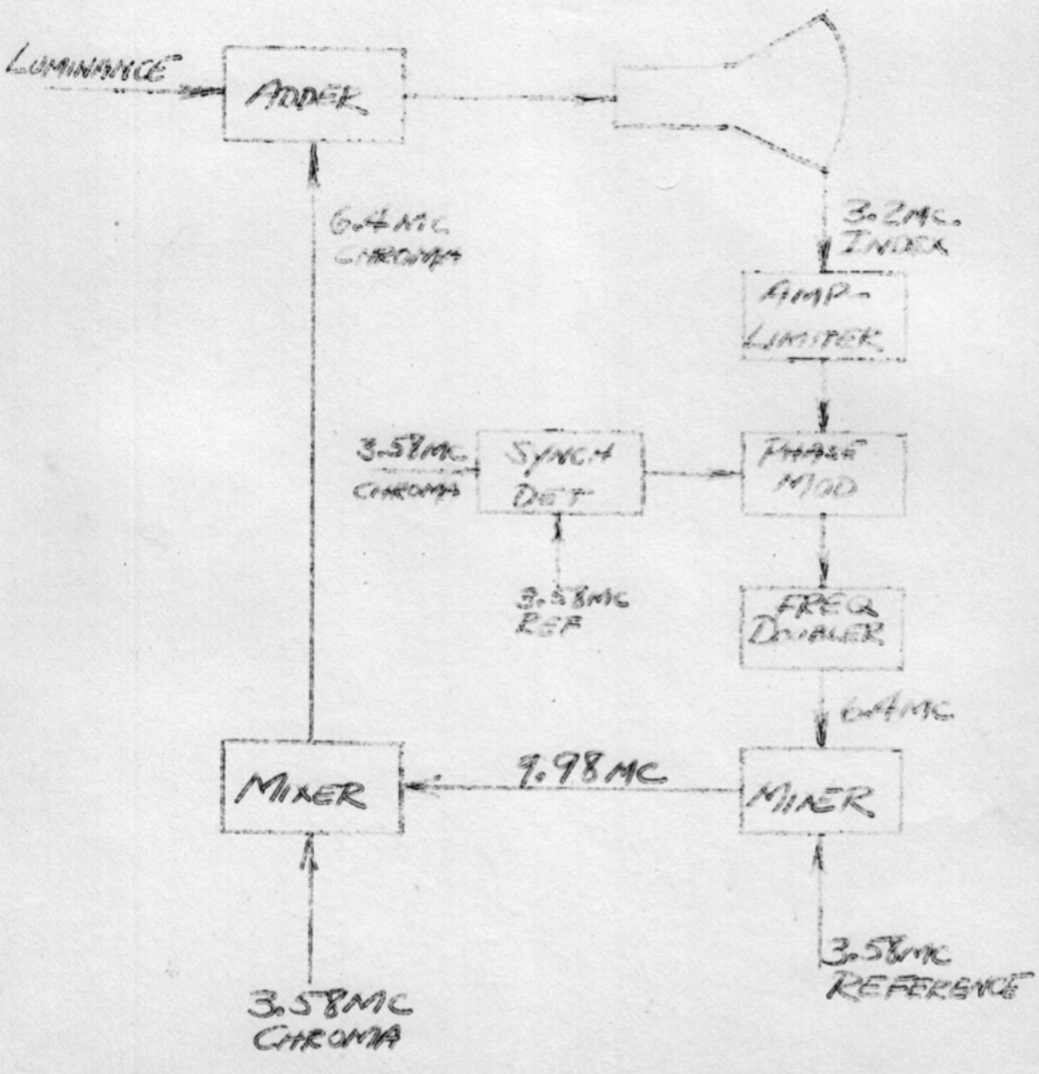
APPLE VARIATIONS

PHILCO'S APPLE SYSTEM

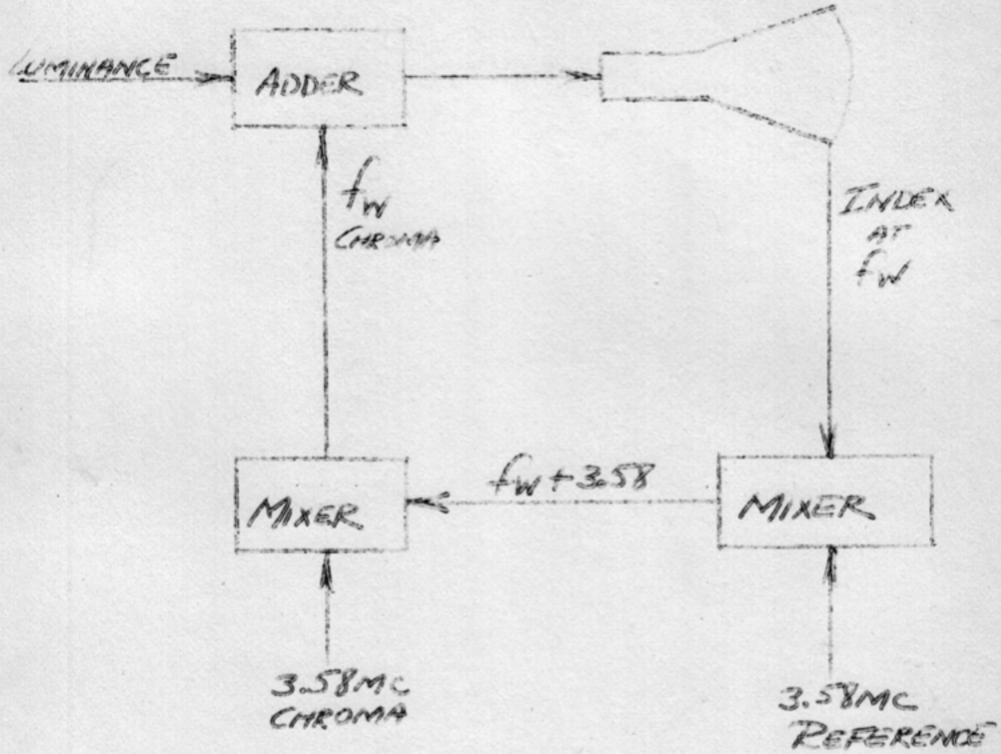


APPLE VARIATIONS

PHASE CORRECTION OF THE INDEX SIGNAL



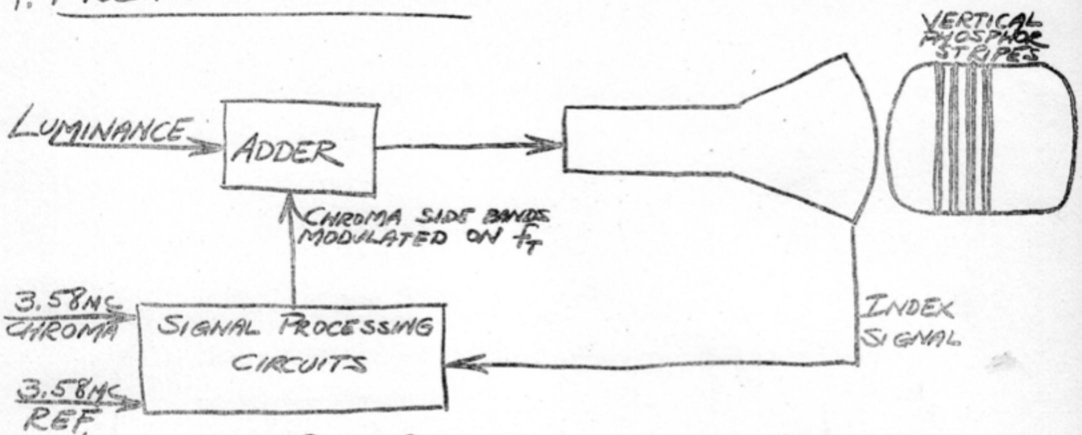
SIMPLEST FORM OF APPLE VARIATION THAT ONE MIGHT CONSIDER



f_W = RATE AT WHICH COLOR TRIADS ARE SCANNED

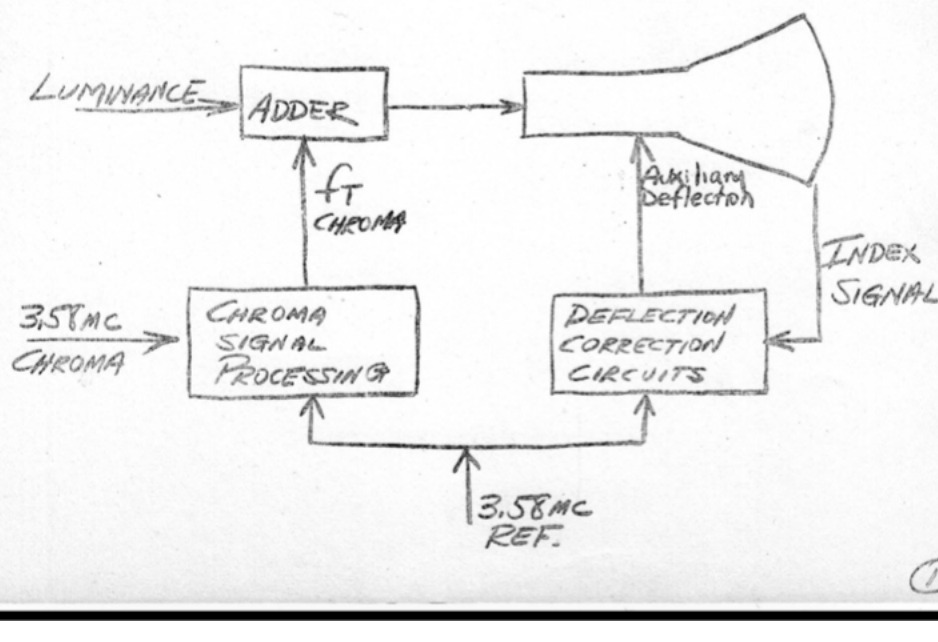
TWO BASIC FORMS OF APPLE VARIATIONS

A. MODIFIED SIGNAL



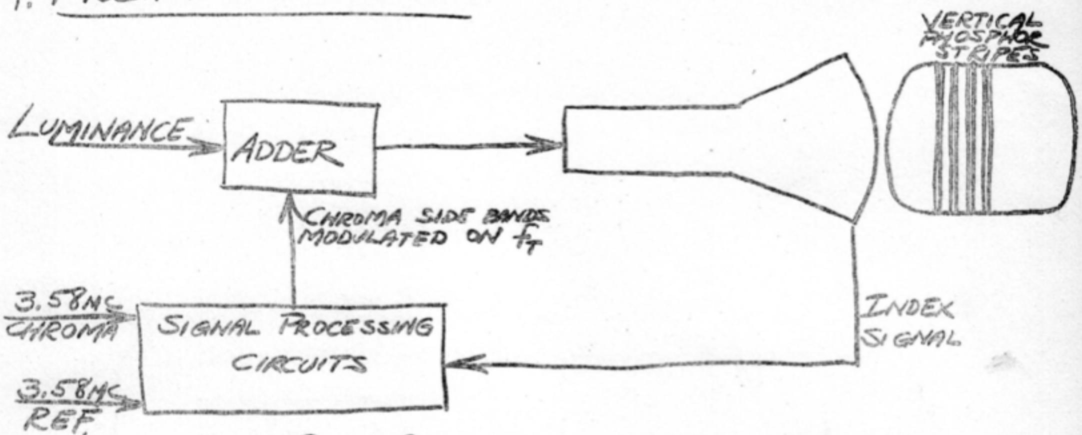
f_T = FREQUENCY AT WHICH BEAM SCANS THE TRIADS.

B. MODIFIED DEFLECTION



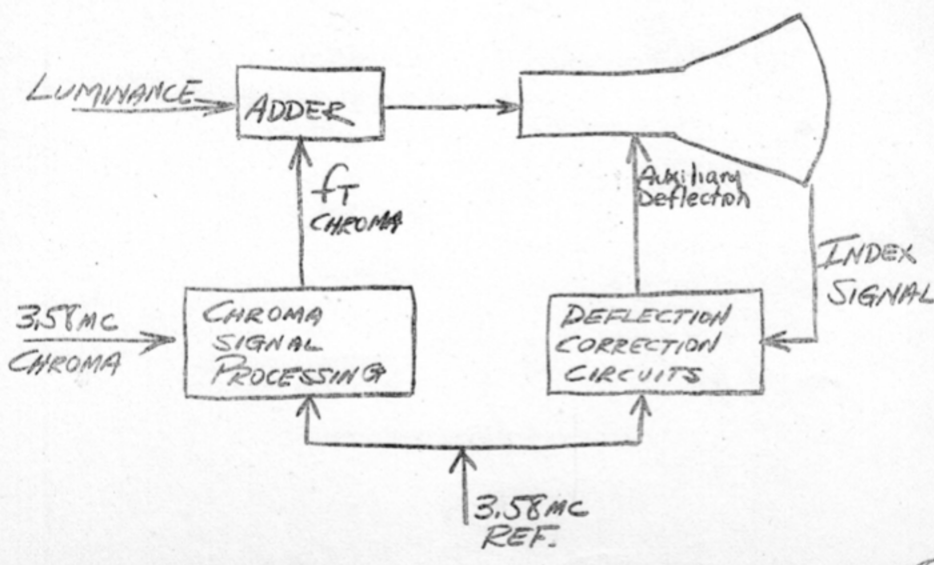
TWO BASIC FORMS OF APPLE VARIATIONS

A. MODIFIED SIGNAL

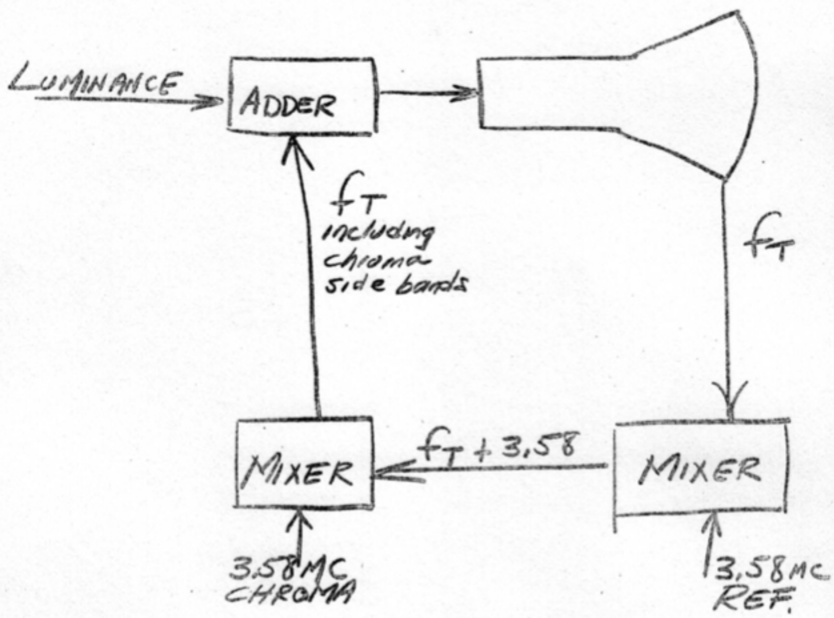


f_T = FREQUENCY AT WHICH BEAM SCANS THE TRIADS.

B. MODIFIED DEFLECTION



SIMPLEST FORM OF APPLE VARIATION THAT ONE MIGHT CONSIDER



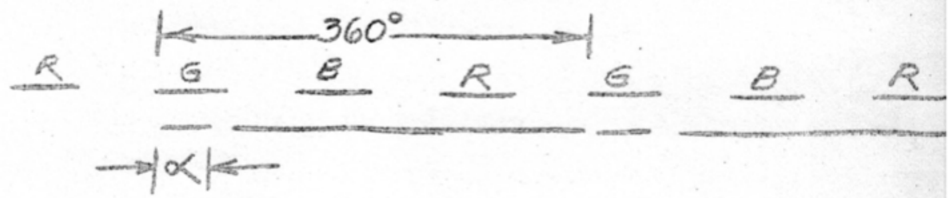
NOTES

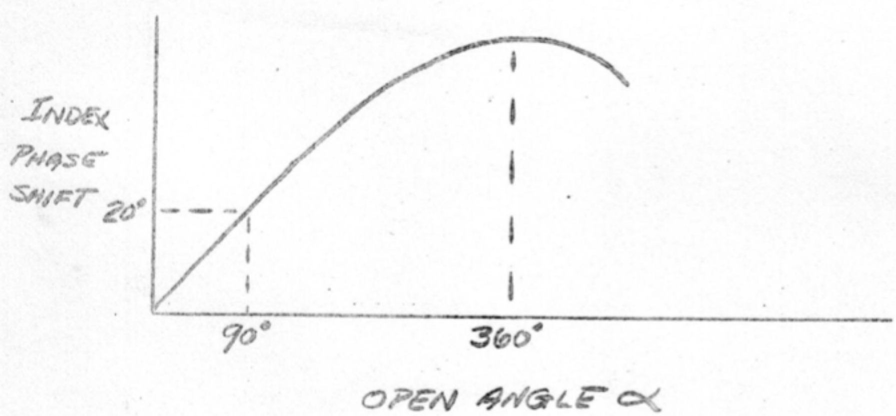
① f_T = RATE AT WHICH TRIADS ARE SCANNED

② BASIC REQUIREMENT: THAT PHASE OF f_T REPRESENT BEAM POSITION INDEPENDENT OF VIDEO MODULATION.

GROUP I — INDEX STRIPES SPACED TO GIVE $f_i = f_T$
SINGLE ENDED SIGNAL TAKE OFF

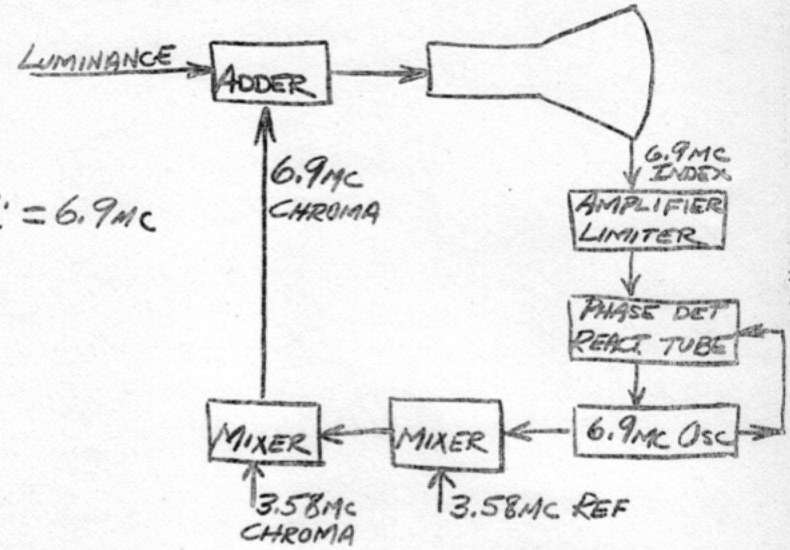
example: Dome's docket April 26, 1956





EXAMPLES OF GROUP I (NARROW SINGLE-ENDED COMB)

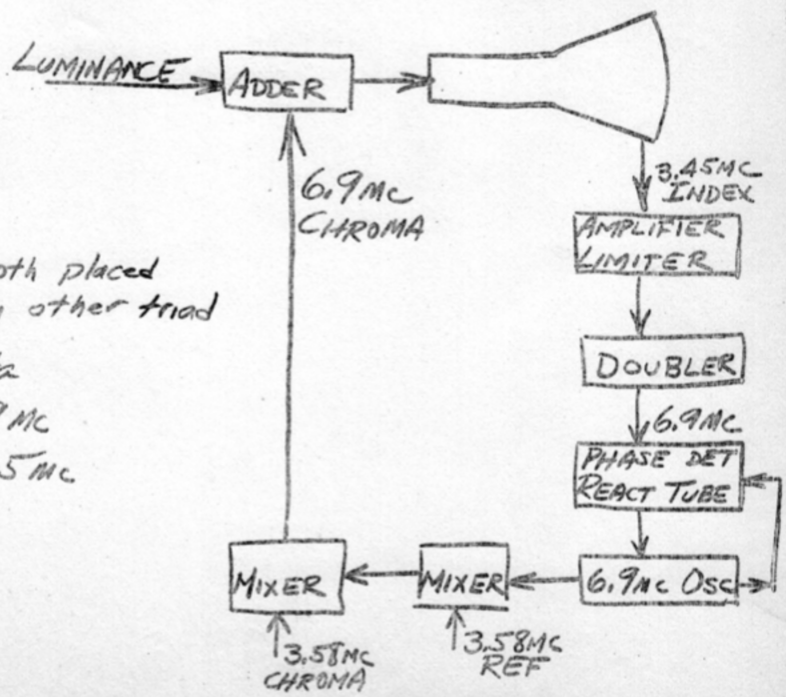
(1)



NOTES

$f_T = f_i = 6.9Mc$

(2)



NOTES

(a) Narrow tooth placed behind every other triad

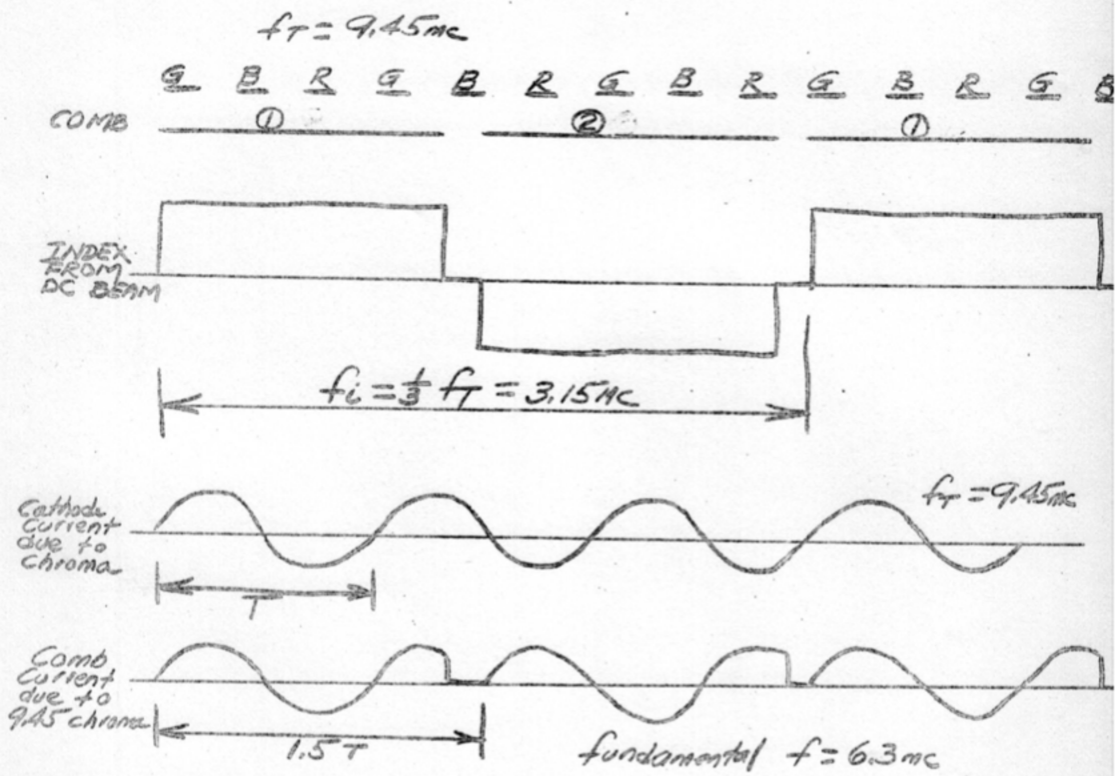
(b) Freq. data

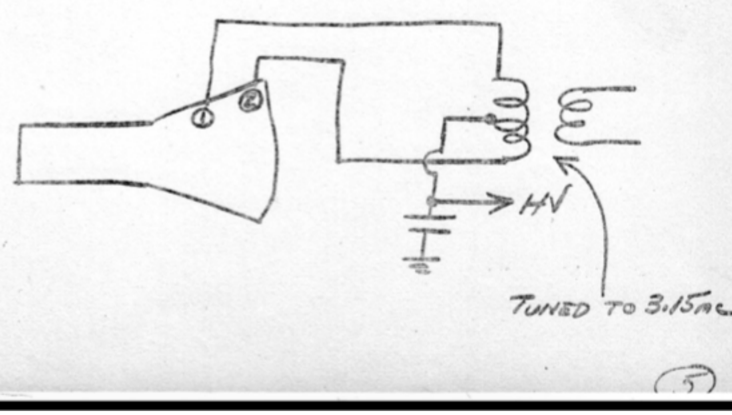
$f_T = 6.9Mc$

$f_i = 3.45Mc$

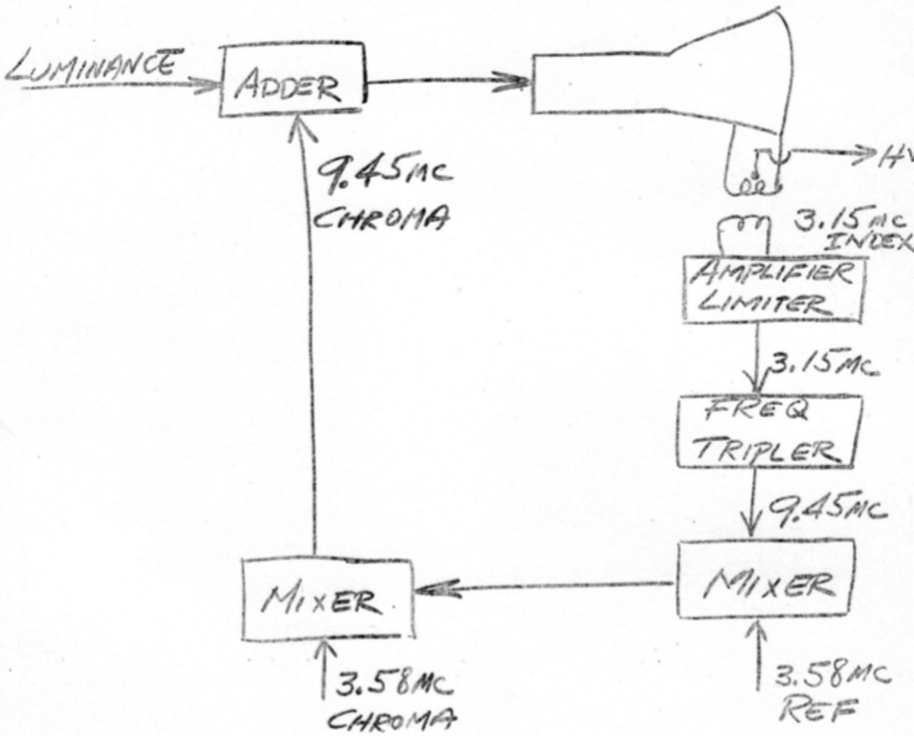
GROUP II PUSH PULL INDEX TAKE OFF

EXAMPLE 1 — KIM'S PROPOSAL (JAN 18, 1957 REVISED FEB 5, 1957)





KIM'S COMB SYSTEM (CONT)



NOTES

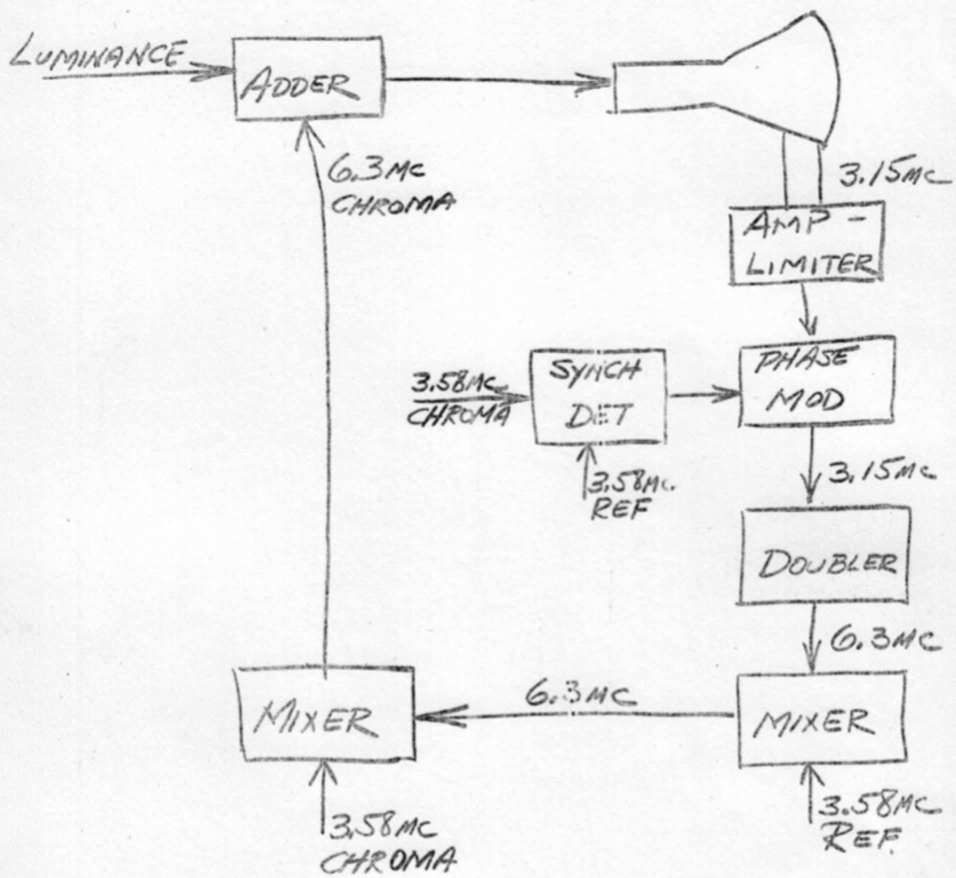
$f_T = 9.45$ MC

$f_i = 3.15$ MC

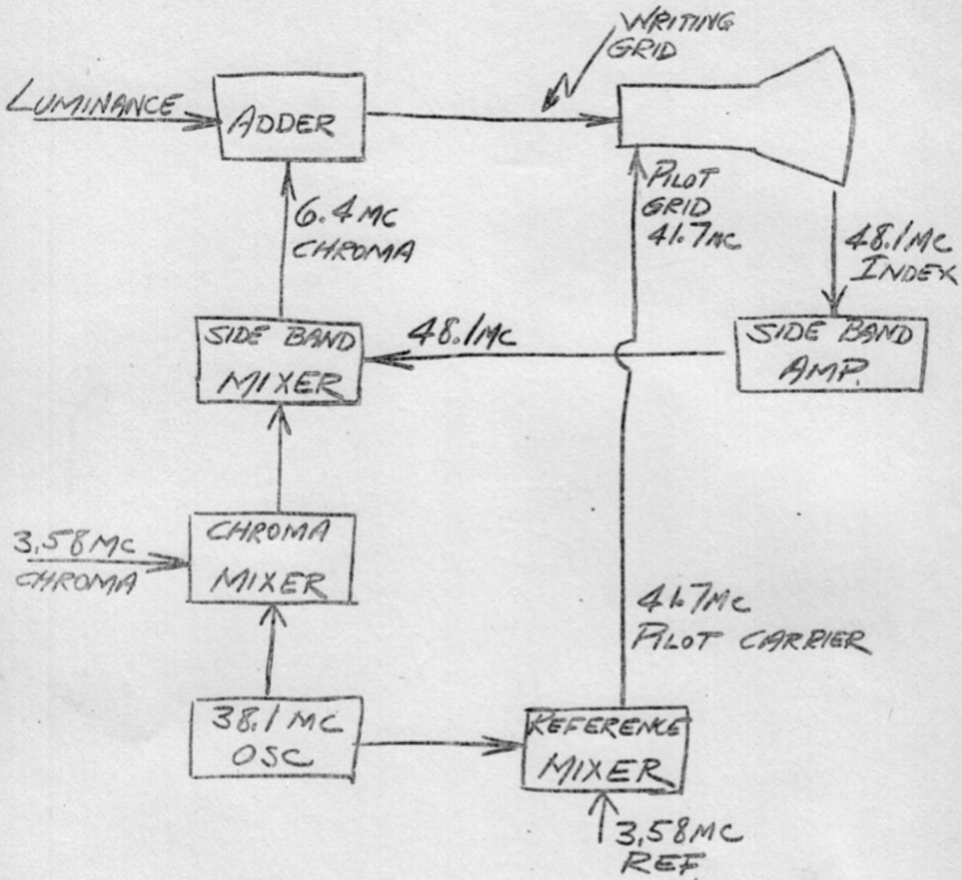
Push pull index take off.

GROUP II PUSH PULL INDEX TAKE OFF

EXAMPLE 2 — DOME'S PROPOSAL — Feb 14, 1957



① PHILCO'S APPLE SYSTEM



NOTES

① FREQ. DATA

$f_T = 6.4$ MC

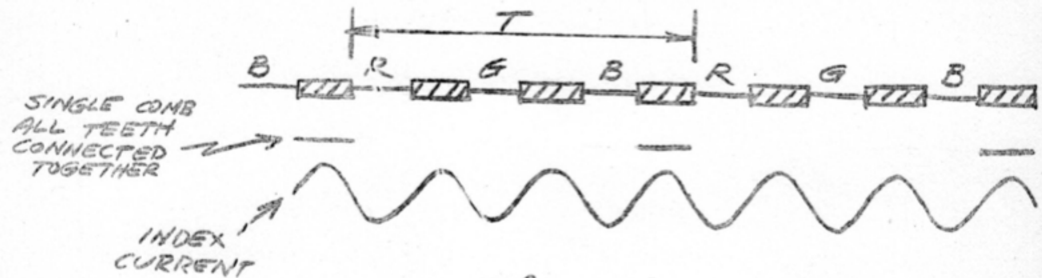
$f_i = 48.1$ mc

MgO freq = 6.4 Mc

② SINGLE GUN — 2 BEAMS

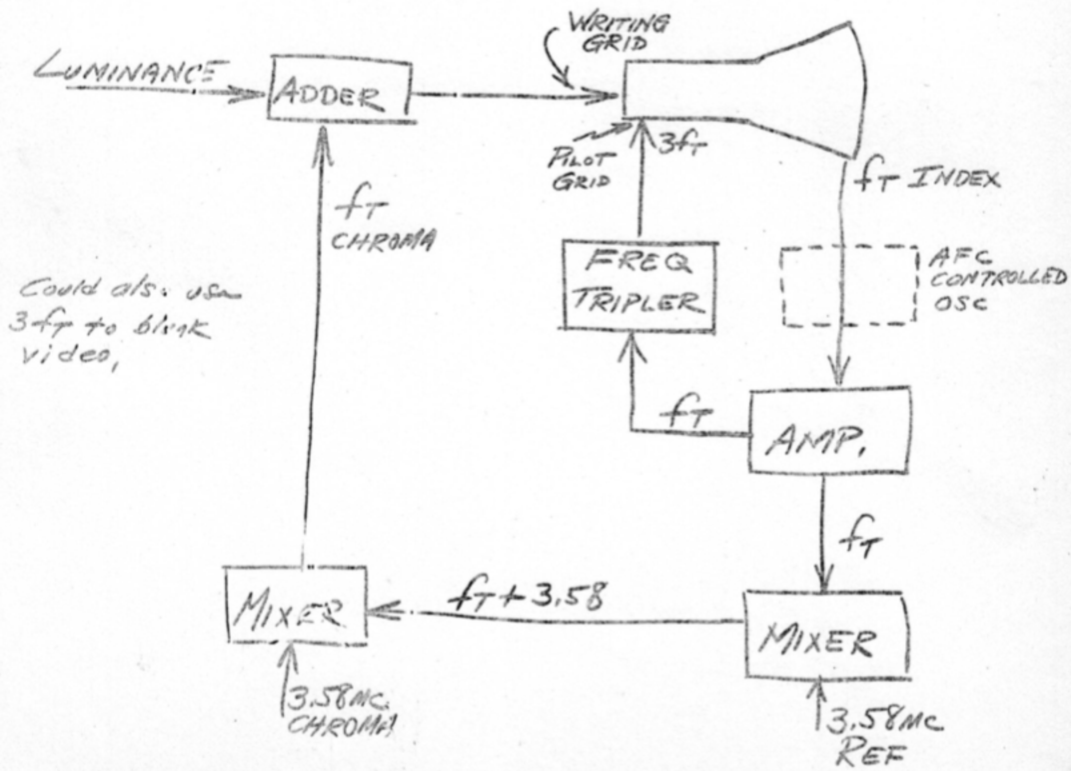
GROUP III EMPLOYING PILOT BEAM

(3) PROPOSED BY LYNCH + TRUE (VARIATION ON #2)



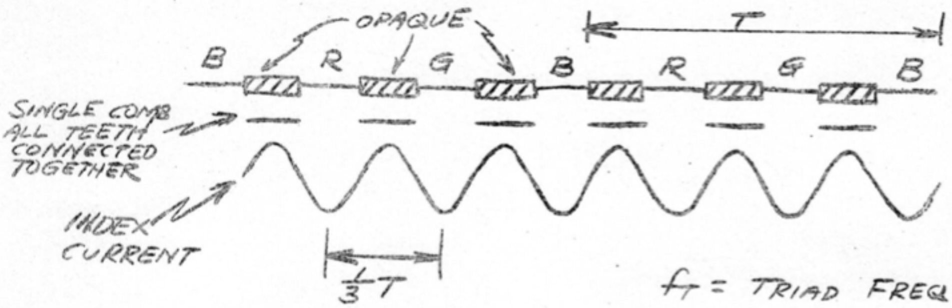
f_T = TRIAD FREQ

PILOT CARRIER = $3 f_T$



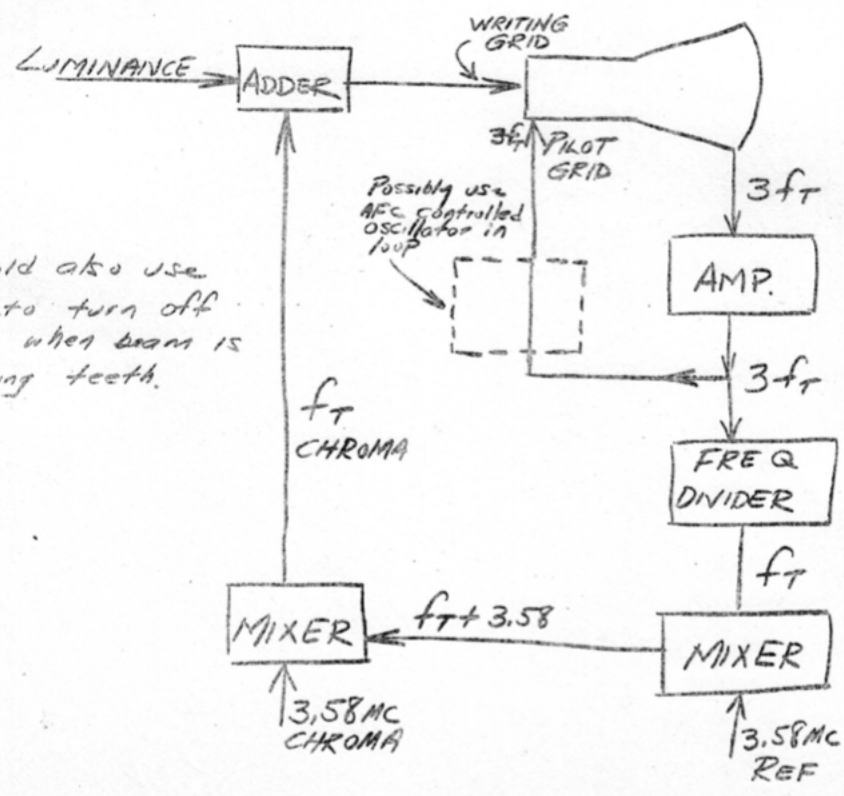
GROUP III EMPLOYING PILOT BEAM

② PROPOSED BY LYNCH and TRUE



f_T = TRIAD FREQ

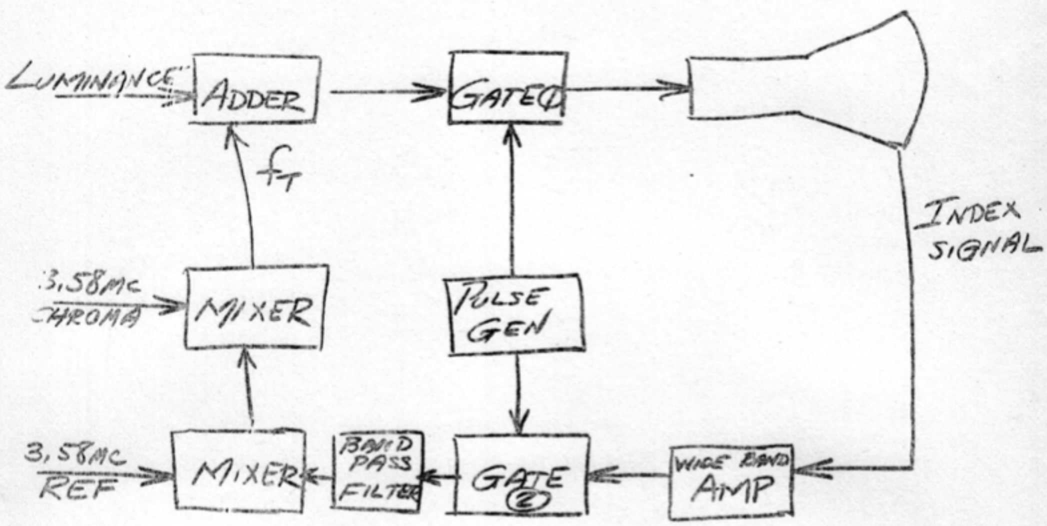
$f_i = 3 f_T$



Could also use $3f_T$ to turn off video when beam is scanning teeth.

GROUP IV TIME SHARING SYSTEMS

① PATENT #: 2,736,764 by BINGLEY Filed 6/29/53
Issued 2/28/56



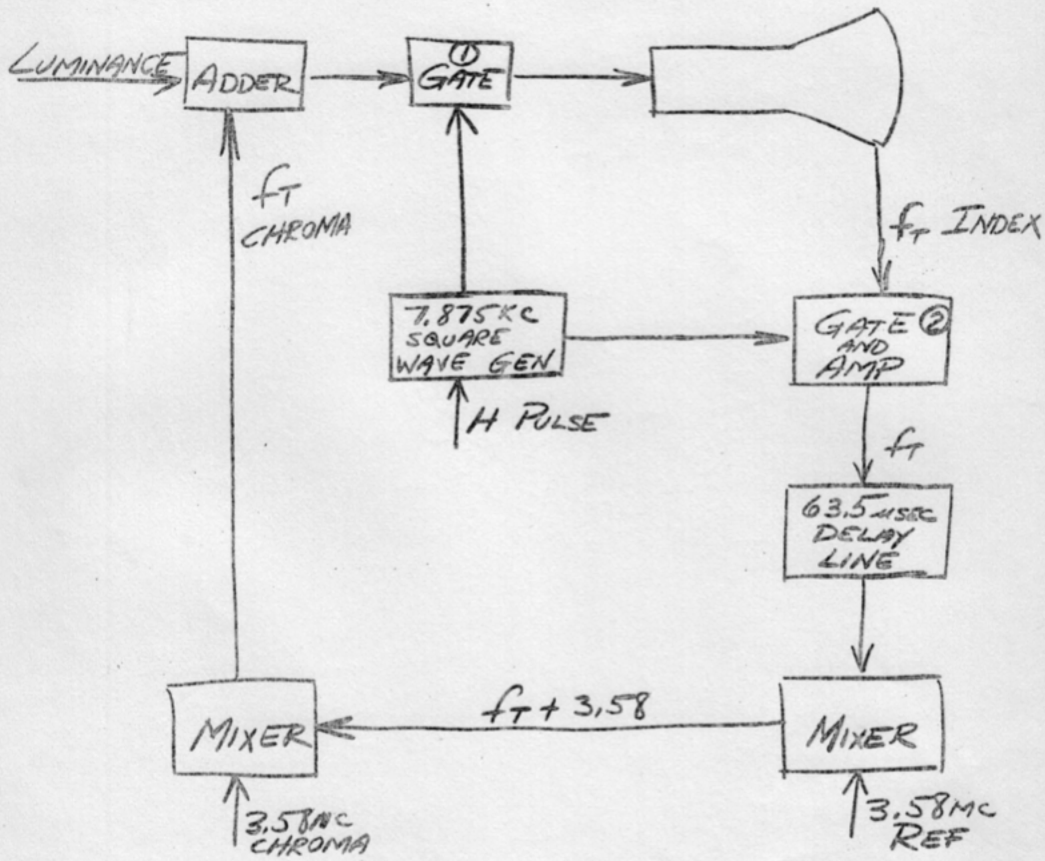
GATES ① and ② OPEN & CLOSE IN OPPOSITION.

INDEX STRIPES PLACED ONE PER TRIAD (MgO)

GATES OPERATED AT FREQ HIGHER THAN f_T.

GROUP IV TIME SHARING SYSTEMS

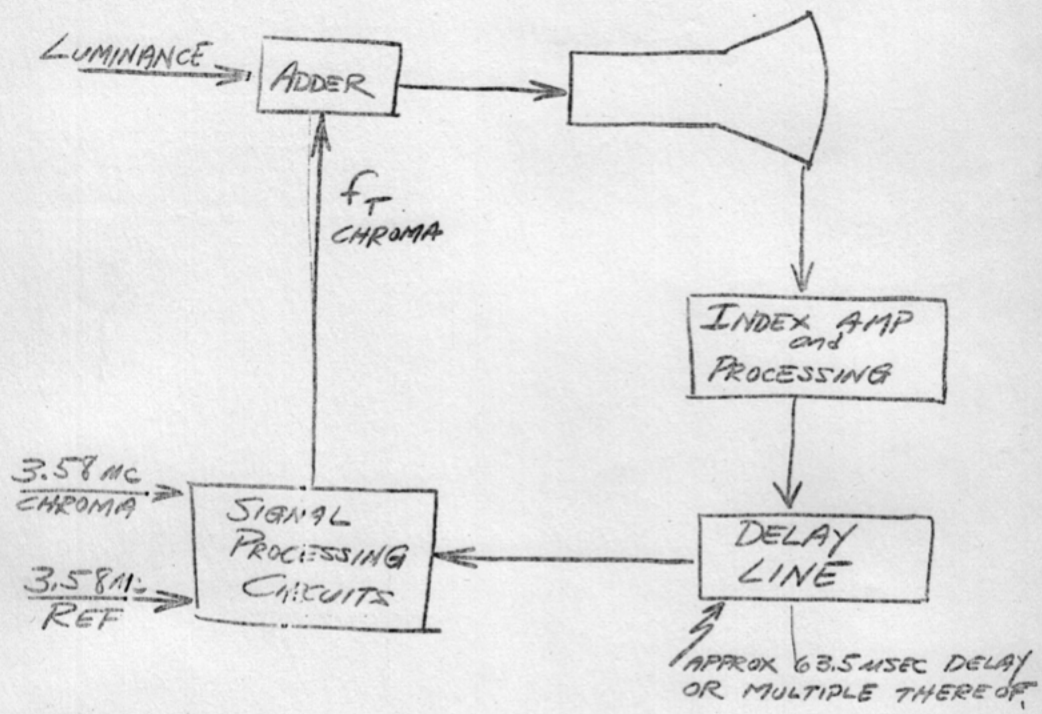
② PROPOSED BY FIELD and ZALOUDEK



GATES ① and ② OPEN + CLOSE IN OPPOSITION

GROUP V LINE TO LINE INDEXING

PROPOSED BY ZALOUDEK



DELAY LINE ADDED TO GENERAL APPLE VARIATION BLOCK DIAGRAM.

INDEX INFORMATION FOR LINE n IS GENERATED DURING A PREVIOUS LINE, SUCH AS LINE (n-1).

BASED ON ASSUMPTION THAT SWEEP AND PRINTING ERRORS ON ANY LINE ARE VERY SIMILAR TO THOSE EXISTING ON PRECEEDING LINE.

GROUP VI EMPLOYING STORAGE OF INDEX INFORMATION.

Per Bingley patent # 2,736,764.

Example ①

Uses storage tube scanned in synchronism with display tube. Periodically gates out video for 1/60 sec and stores complete raster of index information on storage tube. Then operates system for desired length of time receiving index from storage tube. Cycle is repeated at necessary intervals.

Example ②

Uses storage tube scanned horizontally only in synchronism with display tube. Stores index from display tube during horizontal retrace for use during next line scan.

Electronics Park, Syracuse
June 25, 1957

APPLE TUBE WITH PHOTO ELECTRIC INDEX

A calculation of the operating levels on the apple photo electric multiplier index system is shown herein to provide a full understanding of the system's operation.

PHOSPHOR OUTPUT

The phosphor to be used for index generation is the P16 phosphor which has an emission peak well into the ultra-violet region at 3750 angstroms. The lay down of the phosphor is in vertical stripes with a 1:6 duty cycle. The phosphor efficiency is approximately 1%, although density and thickness of the strip may raise this to as much as 5%.

The minimum level of beam current necessary for good index production, 7ua, is used in this calculation. The high voltage at the phosphor is 27,000 volts. The radiant energy output from the phosphor is calculated as follows:

Phosphor Radiant Energy Output =

(Electron Beam Power) (Phosphor Efficiency) (Duty Cycle) =

(7 ua) (27000) (.01) (1/6) =

314 uw

PHOTO MULTIPLIER ENERGY PICKUP OR INPUT

The photo multiplier to be used is the Dumont #6365. The photo cathode is .196 sq. inches in area and is located approximately 15 inches from the screen. An aluminum coating under the P16 phosphor reflects the radiant energy that would pass through the faceplace changing the radiation pattern from a sphere to a hemisphere. An aluminum coating on the inside of the bulb reflects additional energy towards the photo multiplier providing an improvement in energy pickup by a factor of three.

Calculation of the energy pickup is based on point source radiation of the phosphor radiant energy in a hemispherical pattern. The radiant energy pickup by the photo multiplier is calculated as follows:

Photo Multiplier Input =

(Phosphor output) (Photo Cathode Area/Hemisphere Area) (Reflection Imp.) =

$$(314\ \text{uw}) \left(\frac{.196\ \text{in}^2}{2\pi(15)^2}\right) (3) =$$

0.131 uw

PHOTO MULTIPLIER OUTPUT

The 6365 photo multiplier has a sensitivity at 3750 angstroms of 142 ua/uw. The output load is a dynamic load of 8000 ohms. The photo multiplier output is calculated as follows:

Photo Multiplier Output =

(Multiplier Input) (Sensitivity) (Load) =

$$142 \frac{ua}{uw} (0.131\ uw)(8000\ ohms) =$$

0.149 volts

This output is developed across a 9 mcs. tuned circuit in order to select only the 9 mcs fundamental component. The photo multiplier input waveshape is not completely known, therefore, the conversion from a pulse type input to a fundamental component sine wave output was not taken into account in calculating the above output.

This level of output should provide adequate index information.

Frank G. Cole

Frank G. Cole
Color T.V. Prod. Engineering
TELEVISION RECEIVER DEPARTMENT

FGC/mb

cc: JF McAllister
WE Good
DE Harnett
RB Dome
GA Schupp
Color TV Study Report

Miscellaneous Investigation Report #88
May 29, 1957

Development Engineering
Television Receiver Dept.

AN APPLE SYSTEM SIMULATOR USING A 6AR8 VACUUM TUBE

By: M. J. Palladino

Abstract:

This report discusses a closed loop simulated index signal and writing frequency signal "Apple System" using a 6AR8 vacuum tube.

The circuit was designed to provide an index signal similar to one obtained from a comb structure in a single gun Apple color TV tube. The 6AR8 plates simulate a comb in which both sets of teeth are effectively ungrounded; consequently, the output circuit is of the push-pull type or is balanced to ground, ground being at a center tap.

The purpose of the experiment was to verify the phase shifts calculated in an analytical survey made by R. B. Dome. In addition the experiment would indicate susceptibility to oscillations in the feedback loop.

Conclusions:

The results of this experiment substantiate the phase errors R. B. Dome calculated in an analytical survey. Mr. Dome presented his analysis in a letter to D. N. Timbie on Feb. 14, 1957.

In his letter, R. B. Dome calculated a maximum phase shift of 34.8° (pg. 11) when the index signal is a square wave. He further showed a maximum phase shift of 30° when the color signal is at an angular position of 150° and the index signal is sinusoidal (pg. 16, fig. 16). Compared to this, the experiment using the 6AR8 resulted with a maximum phase shift of 34°.

All phase angles measured in the experiment agreed within 10% of the phase angles calculated by R. B. Dome and tabulated in Table III pg. 11.

In addition the experiment showed that the loop can be closed without encountering violent oscillations. This statement can be applied to an actual comb-structure Apple tube only if the feedback loop of the experiment is representative of an actual system.

Discussion:

Figure 1 shows a schematic of the circuit used in this experiment. The two plates of the 6AR8 simulate two teeth of a comb structure. The plates are balanced to ground by a bifilar winding tuned to the fundamental index frequency. The 12AX7 is driven as a frequency doubler to provide the color carrier frequency. The variable delay line is inserted in the feedback loop to provide the variable phase relationship between the fundamental frequency driving the deflectors, and the color carrier frequency on G_1. G_1 of the 6AR8 is clamped by action of the diode and the cathode is by-passed for R.F. as well as low frequency components. For this experiment a 1 MC index frequency was used and, hence, a 2 MC color carrier frequency. Phase angles were measured with a 535 Tektronix oscilloscope which showed a maximum phase shift of 34°.

Michael J. Palladino

MJP:RFL
CC: WD Rublack - #6
JC Nonnekens - #6
EF Schilling - #6
LC Maier - #6
GA Schupp
TV Zaloudek
BA Field
FG Cole
JF McAllister
DE Garrett
RB Dome
DE Harnett
DW Pugsley
ME Cood
TT True
IE Lynch
M Graser
N Johannessen
HJ Vanderlaan

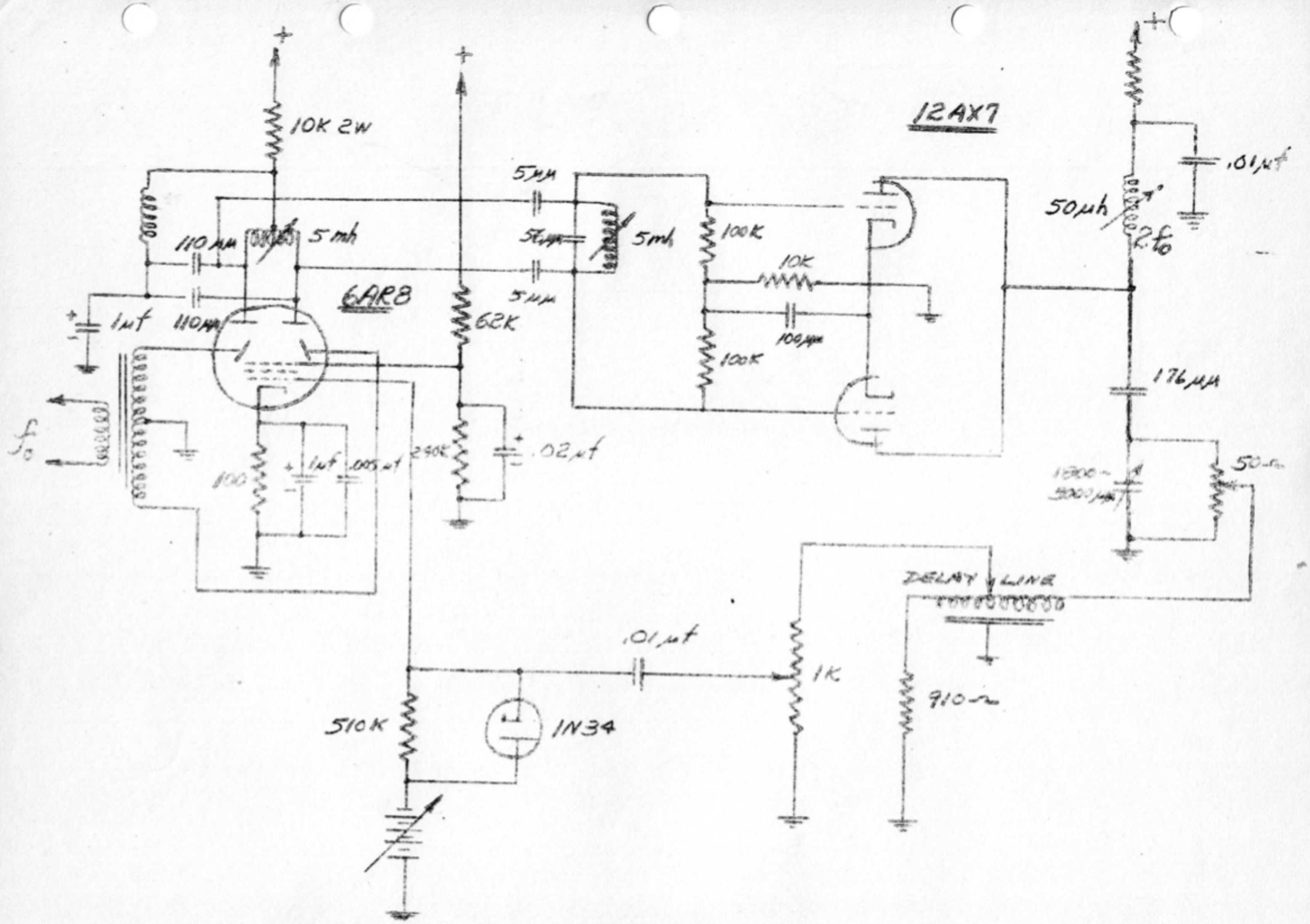


FIGURE 1
MISC. INVEST. #88

cc: JF McAllister
DE Harnett
WE Good
GA Schupp
B. Field
FG Cole

March 28, 1957

Mr. D.N. Timbie
Patent Section
Room 222, Building 5
Electronics Park

This disclosure deals with the broad category of single gun color systems know as "Apple variations".

BACKGROUND

These systems employ picture tubes having vertical phosphor stripes, alternating red, green and blue. Means are provided for deriving an index signal from the screen that contains positional phase information. The index signal is used in a variety of ways to modify the chroma signal applied to the picture tube control grid so as to ensure that the chroma information corresponds at all times to the color phosphor being excited.

Figure 1 shows the basic block diagram for apple variation systems.

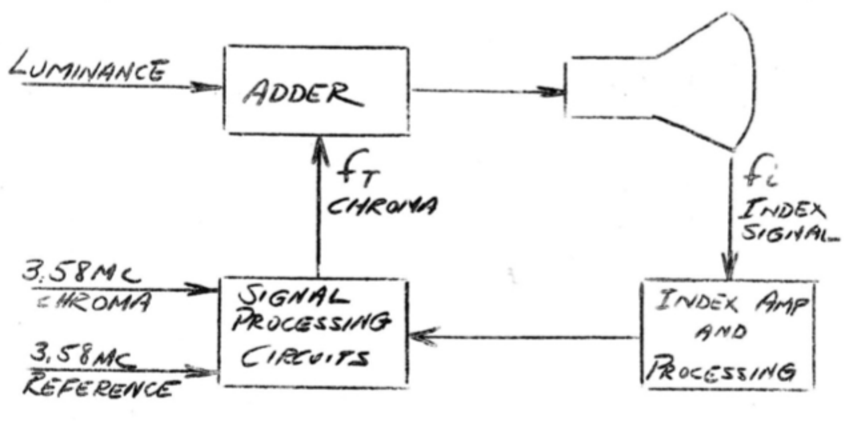


Figure 1

The luminance and chrominance signals are combined in an adder and applied to the control grid of the picture tube. The luminance component is the conventional 0 to 3 mc video signal. The chrominance information is contained as side bands on a carrier frequency, f_T, the rate at which the electron beam scans the phosphor triads. Signal f_T also contains both chroma reference and beam position phase information.

The principle function to be performed is the modification of the 3.58 mc chroma signal to the f_T chroma signal which contains the information mentioned above.

The index signal, f_i, is generated by the electron beam scanning index stripes which are a part of the picture tube screen assembly. The specific manner in which the index signal is made is not relevant to this disclosure. The tube may or may not have a separate pilot beam. Suffice to say that means are provided for the generation of an index signal the phase of which accurately describes the beam position relative to the phosphor stripes independent of video modulation. The manner in which f_i, 3.58 mc chroma, and 3.58 mc reference are combined to form f_T also is not relevant to this disclosure.

In the group of systems described by Figure 1, ideally, the phase of f_T would be corrected instantaneously if there were any variations in the phase of f_i due to printing errors or changes in sweep velocity. However, in practical circuits, the time delay in the loop is in the order of 1 usec so that in effect the chroma signal f_T matches the phase of f_i as measured 1 usec earlier. This delay imposes stringent requirements on screen printing and horizontal sweep linearity.

PRESENT PROPOSAL

This disclosure proposes a method applicable to any system in the apple variation group to greatly reduce the accuracy requirements referred to above. It is proposed that instead of trying to index with as little time delay as possible that the separate functions of index generation and index utilization be separated in time by a whole horizontal line. An index signal, f_i, generated by the scanning of line 1 would be delayed one line and used to control the phase of the chroma signal, f_T, on line 2. Similarly, index derived from line 2 would be used on line 3. Thus the process would be continuous, but with a one line time delay between the index generation and its use. Figure 2 shows how this could be accomplished in the general apple variation type of system.

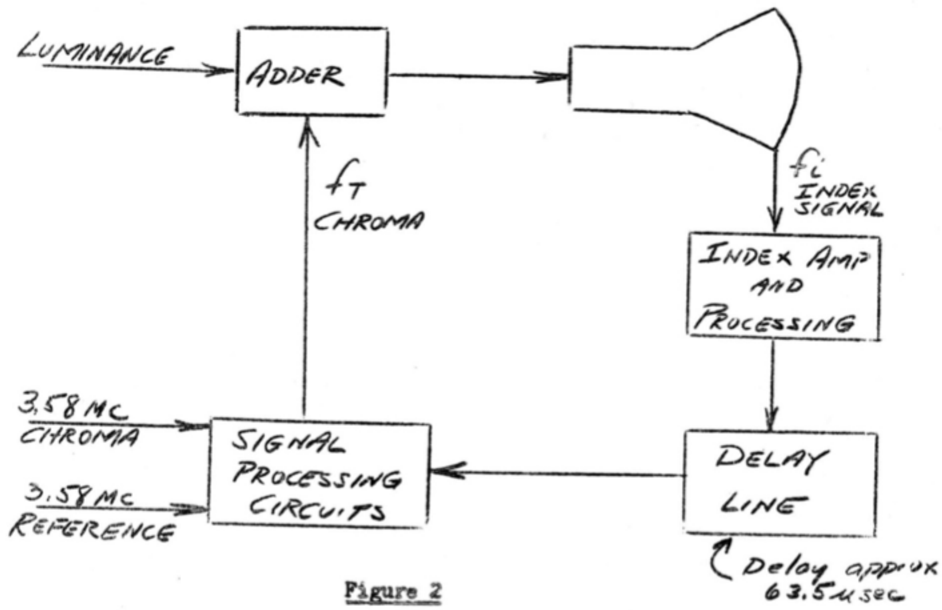


Figure 2

Figure 2 is the same as Figure 1 except that the delay line block has been added. The inserted time delay would be approximately 63.5 usec (one horizontal scan line). The delay would be adjusted so that the entire loop delay would be exactly one horizontal line.

This system assumes that the index requirements do not vary appreciably between any two successive lines. It is assumed, therefore, that printing errors and variations in horizontal sweep velocity will be virtually the same on any two adjacent lines. In this system any error in f_i caused by ringing in the sweep or errors in the printing of either phosphor lines or index stripes would not cause a chroma error 1 usec later as might be the case in present systems. Instead, these perturbations in the phase of f_i would be applied to the phase of f_T on the next horizontal line at a time when indeed, they would be required.

While a broad system application is claimed for this disclosure, it may be helpful to show how the principle could be applied to a specific system. Refer to figure 7 in R.B. Dome's disclosure to you dated February 14, 1957. Figure 3 shows how this sytem might be modified to embody the present proposal.

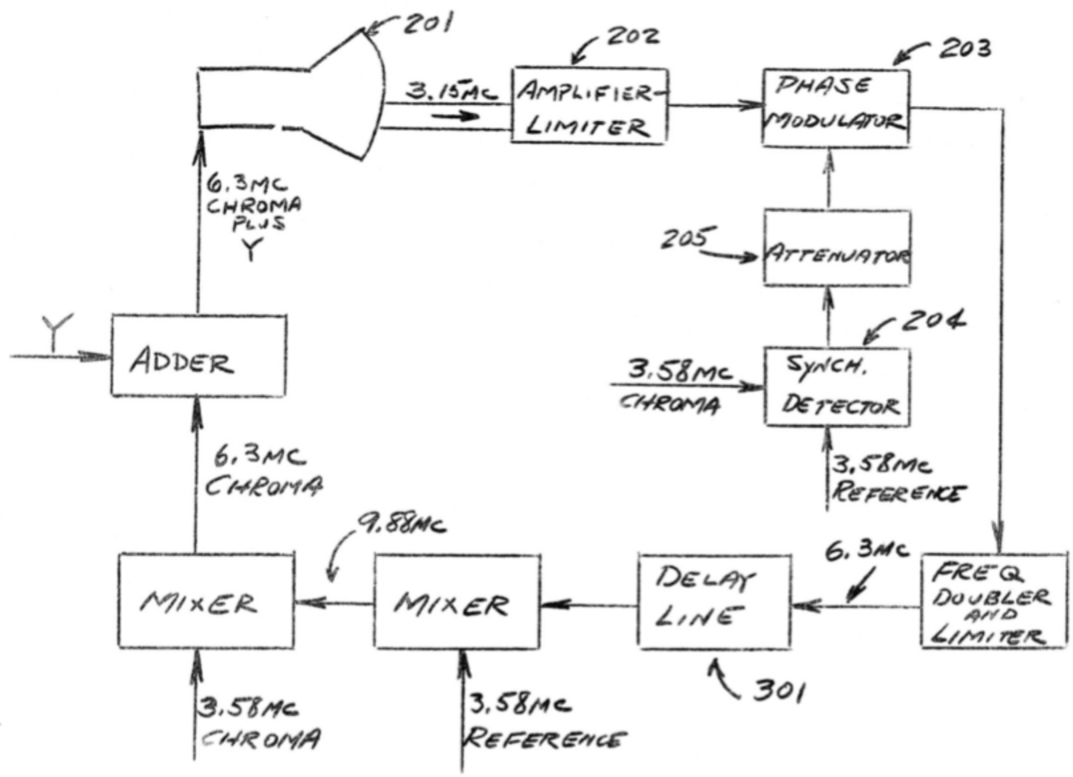


Figure 3

The delay line, 301, is shown inserted in the loop at a point where the index phase has already been corrected and the center frequency is 6.3 mc.

In summary, this disclosure proposes a different way to use the index information in any apple variation system. It assumes that the problem of index generation has been solved. It is proposed that accurate index, once derived, can be used more advantageously on the line following the one on which it was generated. The desired effect can be accomplished by the addition of a delay line in the index channel.

Will you please issue a docket covering this disclosure:

Signed________________

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