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AN EVALUATION OF COLOR TELEVISION DISPLAY SYSTEMS

by

The Engineers of the Television Receiver Dept.
and
the Cathode Ray Tube Dept.

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Abstract

The CRT-TVRD Color Study Group or Task Force was organized on November 30, 1956 with the goal of determining a marketable Color Television Display System.

The members of this group were:

TVRD	CRTD
J. F. McAllister	L. C. Maier
R. B. Dome	J. C. Nonnekens
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In addition, the following engineers were active in preparing or presenting information for this study:

F. G. Cole	I. E. Lynch
B. Field	M. J. Palladino
M. Graser, Jr.	W. D. Rublack
N. Johannessen	T. T. True

Sixteen discussion periods were held, including one presentation to the Research Laboratory people of the basic finds of the study.

This report contains the individual technical studies, their summary and the conclusions and recommendation of this group.

W. E. Good (Scribe)

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WEG/IEL/REL

M.I.R #99

AN EVALUATION OF COLOR TELEVISION DISPLAY SYSTEMS

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AN EVALUATION OF COLOR TELEVISION DISPLAY SYSTEMS

June 21, 1957

BY CATHODE RAY AND TELEVISION RECEIVER DEPARTMENTS

PART I - Summary

A. Purpose and Conclusion

This study was undertaken to determine the feasibility of designing a Color TV receiver consistent with cost and performance requirements as now established by marketing. These requirements are:

1. Ultimately profitable operation at list prices of $319.00 for table models and $350.00 for consoles. These prices reflect a $100.00 list price premium for color over good quality monochrome receivers. For adequate profitability, the permitted increase in manufacturing cost is $50.00. (The $100.00 list price increase for color may also be expressed, approximately, as a 30% premium over monochrome.)

2. The picture size must be 21".

3. The design must be eventually capable of utilizing all information present in the NTSC signal.

Consideration was given in this study to performance and cost. However, cost stands out as the limiting factor. No color system known today, or feasible in the light of today's materials, meets the $350.00 market criterion. To achieve this price, basic research level effort is necessary to provide invention in system and/or materials. There is one system, "Apple-Super Index", which with moderate development activity could achieve a manufacturing cost of $31.00 over objective.

It is recommended that GE proceed immediately to contribute to development of this system.

B. Cost Summary

Manufacturing Costs of a table model set are presented on Chart #1 (page 3) for the several systems studied. Inasmuch as the Aperture Mask Tube is the only tube actually in production, the chart begins by comparing 1959 estimated AM costs with 1961 estimated AM costs. It is assumed that TVRD would purchase the picture tube from RCA, so that provision for liquidation of tube development costs is not included.

As to alternative systems, tubes are not now available. Accordingly, for the purpose of this report, CRTD has prepared Engineering estimates which reflect the intrinsic cost differences between these and the aperture mask tube at comparable quantities and stages of development.

The systems are grouped as: "Known Today", "Feasible in Today's Technology", and "Basic Research Required". The objective manufacturing cost for color ($154) is noted in the last column. It is computed from the theoretical list price of a current monochrome wood table model, (Model 21T1543 less power tuning), which would list for $219.00. The objective list price for color, then, would be $319.00, requiring $154.00 as the manufacturing cost.

It is to be noted from the chart that the manufacturing costs of Aperture Mask, Post Acceleration, current Apple, and Chromatron are $100.00 and $50.00 in excess of the objective in the 100,000 and 1,000,000 quantities respectively, and so do not meet the marketing objective. In the second group of systems (feasible in today's technology) the costs are shown to be greater or equivalent to the known systems with exception of "Two-Color" and "Apple Super-Index". Two-Color is $29.00 higher than the objective; this system displays only two primaries, orange and cyan, and produces pictures which are similar to the "True Color" process of the movie industry. The other system, "apple Super-Index", is $31.00 higher than the objective manufacturing cost. This could yield a list price of $379.00, as opposed to the objective list of $319.00.

The hope of achieving cost compliance with objective is in the last group of systems. The variable color filter, or the light amplifier conceivably could yield a manufacturing cost consistent with objective. Basic research work is required to invent and develop materials for these systems. The cost figures presented are only an indication of what the cost might be if ideal materials are assumed, excluding the costs of research itself.

In summary, all today's known systems, or those feasible in the light of today's technology, exceed the cost objective. Apple Super-Index approaches it. New invention and basic research, alone, offer hope of achieving it.

Reference is made to Part II of this report for details on all systems studied.

C. <u>Recommended Program</u>

An engineering Advanced Development program is recommended in both CRT and TVRD to contribute to development of the Apple Super-Index system. An effort of 5-6 man years/year is recommended for TVRD to establish requirements and accomplish circuit and component improvements. It is further recommended that CRTD support this TVRD development with the required effort.

MANUFACTURING COSTS

TABLE MODEL

	SYSTEM	Mfg. Cost Quantity 100,000	Mfg. Cost Quantity 1,000,000 Add. Dev.	Color Objective Mfg. Cost
I	Known Today	1959	1961	
	a) Aperture Mask (AM) - RCA Type	267	209	154
	b) Post Acceleration (PA) - GE Type	261	203	154
	c) Apple - current Philco Type	258	213	154
	d) Chromatron - Paramount-Dumont Type	266	206	154
II	Feasible in Today's Technology			
	a) Aperture Mask Variation			
	1. Double Mask - 3 gun	Greater than AM		
	2. One Gun	Same as AM		
	3. In-line gun	Same as PA		
	4. Two-color (Gross type)	183		154
	b) Post Acceleration - Double Grille	Greater than PA		
	c) Lafferty	Same as AM		
	d) Penetron	Greater than AM		
	e) Gabor	Greater than AM		
	f) Projection	Greater than AM		
	g) Eidophor	Greater than AM		
	h) Apple Super-Index	218	185	154
III	Basic Research Required			
	a) Variable Color Filter		166	154
	b) Light Amplifier		166	

NOTE: To obtain list price multiply manufacturing cost by approximately two (32% discount; 10% excise tax; 19.2% gross margin).

CHART I

SUMMARY OF THE TECHNICAL REPORTS — AN EVALUATION OF COLOR TELEVISION DISPLAY SYSTEMS

By: W. E. Good

This summary covers the highlights of the detailed reports in Part III of this report, and the results of their individual consideration by the CRT-TVRD Color Study Group.

1. Over 68 color tube types or variations were stuided and the detailed reports or patent dockets are included in Part III.

2. Both the performance and the cost of these systems were compared and a breakdown of the results is included in Table I under Color Systems Evaluation.

3. Of the 68 types, 47 were considered to be technically feasible in the sense that it was theoretically possible to make such a system work. Fifteen were considered to be practical in the sense that the systems could be built in the laboratory and be made to function. Six systems appeared to have about the same cost potential as the Aperture Mask receiver. Six systems appeared to have the potential of costing less than AM - four of these were Apple variations (yet to be developed or proven practical), and two were in the "future" category. Nine systems were labeled as capable of adequate performance and 17 were pointed out as needing further study in order to determine their full potentiality.

Several different ways were used to classify these systems - the one used in Table I is by the function required to obtain color. In presenting this material to the Research Laboratory we found it more convenient to use, "Current Systems," "Alternative Systems Which May Be Feasible in Light of Present Technology" and "Future Systems Dependent Upon Major Development in Materials and Technology." Regardless of how the classification was made, we arrived at the conclusion that we had a complete classification. We feel that there are no basic gaps in the systems considered.

TABLE I
COLOR SYSTEMS EVALUATION

	TECHNICALLY FEASIBLE	PRACTICAL (ENGINEERING WISE)	COST LESS THAN A.M.	PERFORMANCE ADEQUATE	NEEDS FURTHER STUDY OR DEVELOPMENT
A. Accurate Beam Scanning					
1. Transverse scanning (vertical lines)					
a. Without sweep speed correction	Marginal	No	No	No	No
b. With sweep speed correction	Marginal	No	No	No	No
2. Parallel scanning					
a. Manual adjustment	Marginal	No	No	No	No
b. Servo controlled	Yes	No	No	No	No
3. "Checkerboard"	Marginal	No	No	No	No
B. Color Signal Controlled by Beam Scanning Position					
1. Apple	Yes	Yes	Same	Yes	Yes
2. Dome's comb	Unk.	Unk.	Pot L.	Unk.	Yes
3. Gethman's slave tube	Yes	No	No	No	No
4. Kim's tube	Unk.	Unk.	Pot L.	Unk.	Yes
5. U.V. phosphor tube	Yes	Yes	Pot L.	Yes	Yes
6. True's, Lynch's tube	Unk.	Unk.	Pot L.	Unk.	Yes
C. Adjacent Image					
1. Three monochrome tubes with					
a. American Optical System (Projection)	Yes	Yes	No	No	No
b. Trinoscope	Yes	No	No	No	No

Unk. - unknown
Pot L. - potentially less
Marg. - marginal

	TECHNICALLY FEASIBLE	PRACTICAL (ENGINEERING WISE)	COST LESS THAN A.M.	PERFORMANCE ADEQUATE	NEEDS FURTHER STUDY OR DEVELOPMENT
2. Two monochrome tubes with optical addition (two color)	Yes	No	Yes	No	No
3. One monochrome tube divided into three areas with Fresnel lens addition	Unk.	Unk.	Pot L.	Unk.	Yes
4. Baird two color tube					
a. One gun on each side of phosphor plane	Yes	No	No	No	No
b. Both guns on same side of phosphor plane	Yes	No	No	No	No
D. <u>Beam Control at Phosphor Screen</u>					
1. Insulated stripes with anode voltage alternately applied	No	No	No	No	No
2. Interleaved deflection plates or grill wires					
a. Lawrence - horizontal stripes	Yes	Yes	Same	Marg.	No
b. Lawrence - vertical stripes	Yes	Yes	Same	Marg.	No
c. Snyder deflection plates	Yes	No	No	No	No
3. Mesh grill tube controlling depth of beam penetration	Yes	No	No	No	No
4. Lafferty tube (reflection type)					
a. One gun	Yes	Yes	Same	Marg.	No
b. Three gun					
1. Inline guns at equal voltages	Yes	Yes	No	Marg.	No
2. Closely spaced with cathode voltages spread	Yes	Yes	No	Marg.	No
5. Lafferty tube (transmission type)	Yes	No	No	No	No
6. Dome's magnetic tube	No	No	No	No	No

	TECHNICALLY FEASIBLE	PRACTICAL (ENGINEERING WISE)	COST LESS THAN A.M.	PERFORMANCE ADEQUATE	NEEDS FURTHER STUDY OR DEVELOPMENT
E. <u>Direction Sensitive - Electron Shadowing</u>					
1. One gun P.A. using space displacement in the neck by:					
a. Magnetic field	Yes	No	No	No	No
b. Electrostatic field	Yes	No	No	No	No
c. Sheet beam cathode	Yes	No	No	No	No
2. Three gun P.A.	Yes	Yes	Same	Yes	Yes
3. Double grill P.A.	Yes	Yes	No	Yes	Yes
4. One gun AM with:					
a. Dot sequential beam rotation	Yes	No	No	No	No
b. Chroma rate beam movement	Yes	Marg.	No	Marg.	No
5. Three gun A.M.	Yes	Yes	Same	Yes	Yes
6. Single mask post acceleration A.M.	Yes	Marg.	No	Yes	No
7. Double mask post acceleration A.M.	Yes	Marg.	No	Yes	No
8. Three inlinegun A.M.	Yes	Yes	Yes	Yes	Yes
9. Gabor tube	Yes	No	No	No	No
Possible modifications:					
a. Unfolded neck	Yes	Yes	No	Unk.	no
b. Single gun	Yes	Yes	No	No	No
c. Reflection type shadow mask	Yes	Yes	No	No	No
10. Three gun P.A. with horizontal phosphor lines	Yes	No	No	No	No
11. Four phosphor - Zenith tube	Yes	No	No	No	No

	TECHNICALLY FEASIBLE	PRACTICAL (ENGINEERING WISE)	COST LESS THAN A.M.	PERFORMANCE ADEQUATE	NEEDS FURTHER STUDY OR DEVELOPMENT
F. Direction Sensitive Nonplaner Color Screen					
1. Baird three gun tube	Yes	No	No	No	No
2. Graser two gun modification	Yes	No	No	No	No
3. Phosphor pyramids	Yes	No	No	No	No
4. Perpendicular phosphor planes	Yes	No	No	No	No
5. Honeycomb structure	Yes	No	No	No	No
G. Velocity Sensitive					
1. Lafferty tube - three guns closely spaced	Yes	No	No	No	No
2. Three gun mesh tube listed under D 3	Yes	No	No	No	No
3. Penetron					
a. One gun					
1. Field sequential	No	No	Yes	No	No
2. Line sequential	No	No	Yes	No	No
3. Dot sequential	Yes	No	No	No	No
b. Three gun with different voltages	Yes	No	No	No	No
H. Color Filters					
1. "Porphyrite" - electrically controlled color filters	Yes	No	Pot Less	Pot Yes	Yes
2. McAllister proposal - light amplifiers	Yes	No	Pot Less	Pot Yes	Yes
3. Zaloudek proposal of color control by:					
a. A second electron gun excitation	Unk.	Unk.	Unk.	Unk.	Yes

	TECHNICALLY FEASIBLE	PRACTICAL (ENGINEERING WISE)	COST LESS THAN A.M.	PERFORMANCE ADEQUATE	NEEDS FURTHER STUDY OR DEVELOPMENT
b. U.V. light excitation	Unk.	Unk.	Unk.	Unk.	Yes
4. Mechanically moved filters	No	No	No	No	No
I. <u>Two and Three Color Line Sequential Proposals</u>					
1. Timbie - Devine proposal - field of green followed by field of red and blue line sequenced	No	No	Unk.	No	No
2. Dome proposal - green presented on each field, red and blue line sequenced on each field	Yes	No	Unk.	No	No
J. <u>Light Valves</u>					
1. Eidophor	Yes	No	No	Unk.	No
2. Scophony - Ultrasonically controlled	Unk.	Unk.	No	Unk.	No
3. Reflection or transmission controlled	Unk.	Unk.	Unk.	Unk.	Yes
K. <u>Others</u>					
1. Color by current density changes	Unk.	No	Unk.	No	No
2. P.O.W.	Unk.	Unk.	Unk.	Unk.	Yes
3. Spot hesitation (Lynch's docket)	Yes	Yes	Unk.	Unk.	Yes

Detailed cost analyses were made for the basic systems considered. These are summarized in Table II. The cost of each of the remaining systems was judged relative to the Aperture Mask receiver as indicated in Table I. Whereas the major consideration in this study was to find a system which would potentially sell for $350, there still needs to be an evaluation of performance. Performance was judged to be adequate if it fulfilled the basic needs of the NTSC signal and would eventually achieve the assumed brightness of 50 ft. Lamberts while using 50% Ultravision glass. (See Display Device Characteristics.) It was assumed that the AM tube represented "adequate" performance even though its brightness, registration and grey scale performance are open to question.

TABLE II

SUMMARY OF COST ANALYSES OF THE INDICATED COLOR SYSTEMS. THESE ARE MANUFACTURING COSTS ON THE BASIS OF A 21 INCH PICTURE IN A TABLE MODEL RECEIVER.

TV Receiver Type	Manufacturing Cost	
Monochrome	$104	
Color Objective	154	
Aperture Mask (AM) (1956-57 Production 3,900 units)	517	
Aperture Mask (AM Optimo) (a) (1958 for 100,000 (b) Later for 1,000,000 with cost reductions)	267	209
G.E. Post Acceleration (PA - Optimo) (Same Dates as AM)	261	203
Chromatron (Same Dates as AM)	266	206
Apple (Secondary Emission) or Ultra-Violet)	258	213
Apple (Ultimate possibility assuming much simplified indexing)	180 (approx)	
Two-Color Aperture Mask (Preliminary)	181	
Electrical Color Filter (Speculative - assumes $10 color filter and practical characteristics for the materials involved)	165	
Light Amplifier panel (Speculative - Same assumptions as Electrical Color Filters)	165	
Color Eidophor - (Speculative) (Materials cost only)	466	

The following systems were specifically judged to be greater in cost than the Aperture Mask Receiver: Lafferty tube, Penetron, Projection, Double Grille PA, Double Mask AM, Gabor flat tube and one gun AM.

Table II shows the relationship of the manufacturing cost of AM, PA, Apple and Chromatron color receivers and their potential variations. It is quite apparent that none of these systems meet the $150 manufacturing cost objective. Even if it is assumed that the Apple, single gun system, is technically improved until it is possible to take a high level index signal directly from the picture tube, thus eliminating all of the present index amplifiers and converters, the resulting optimistic cost is still $30 too high. The only systems that come tolerably close to the objective are the Light Amplifier and the Electrical Color Filter. However, both of these estimates were based on the existance of materials which are still unknown, so that these estimates are highly speculative.

A look at the performance of the more pertinent systems considered gives us some idea as to their future potential and possibily which one should be used if the price is permitted to rise.

CURRENT SYSTEMS:

Aperture Mask (AM) - The brightness of this tube is marginal. In fact, even if the holes in the mask were made as large as theoretically possible it would be difficult to achieve 50 ft. lamberts through Ultravision glass without further increasing the high voltage power. Table III shows the relative power required by each of these types. Standard AM requires 11 times the HV power as the equivalent monochrome set. Although reasonable registration is possible, it is clear that the triad gun arrangement is not as simple to converge as an in-line arrangement. Applying a double mask or using Post Acceleration on AM does not appear to be worthwhile. The grey scale stability of the three gun tube has not been completely evaluated. If the AM type were to be continued it would be in order to change to in-line guns, design the yoke to include the major dynamic convergence corrections, and enlarge the holes or slots in the mask. The result would be a brighter and better registered tube but still requiring a large amount of high voltage power.

TABLE III

RELATIVE VALUES OF HIGH VOLTAGE POWER REQUIRED FOR EACH COLOR SYSTEM TO EQUAL THE WHITE HIGHLIGHT BRIGHTNESS OF AN EQUIVALENT MONOCHROME RECEIVER WITH 50% ULTRAVISION.

	Monochrome	AM	PA	Apple	Chromatron
Relative HV Power	1	11	1.7	3 to 4	3

G.E. Post Acceleration (PA) - This tube has high electron transparency and requires only 1.7 times as much HV power as the equivalent monochrome tube. It requires an internal grille structure, accurately placed relative to the phosphor stripes, and a stable voltage ratio between the 7 KV grille and the 25 KV screen. The main difficulty in this tube is in making reproduceable or interchangeable grilles. Experience with the in-line gun arrangement indicates that all major convergence errors may be compensated by means of the yoke design. This leaves only minor adjustments to be made in the factory which should result in better and more stable registration. The haze problem resulting from secondary electrons from the screen appears to be capable of being solved. This tube in its present form would require a magnetic shield to reduce the effect of the earth's magnetic field on the soft beam. The tube is potentially capable of further improvement by use of a double grille. This would result in higher gun volrages which would improve spot size and reduce haze effects due to secondaries. If a solution is found for economical construction of a single grille PA then an evaluation of the double grille PA is in order. Two basic problems then remain - one, the difficulty in going to wider angle deflection with this tube and the fact that it has three guns (grey scale stability). Otherwise this tube appears to have the greatest potential of any three gun tube and could satisfy all of the performance requirements. If this tube should be considered at some future date, specific effort would be required in matching a yoke and gun design, haze reduction, resolving the three gun grey scale problem and in investigating double grille variations.

Apple - The secondary emission type Apple has two basic difficulties: (1) inability to obtain flat color fields (due to variation in secondary electron transit time and unreproduceable electrostatic-fields within the tube) and the difficulty in constructing the tube (M_gO secondary emission material vagaries and the difficulty of accurately placing the 27 to 30 KV boundary near the screen. The brightness of this tube is better than AM but still may not satisfy the requirements. The high frequency index requires special handling and the possibility of RF interference always exists. The present structure of 16 triads/inch is found to be objectionable to some. The HV power required of this type of display falls between three and four times that of monochrome.

New Apple with low frequency index - This Apple variation is truly a one gun (no separate index beam required) tube and in one form makes use of an Ultra-Violet emitting phosphor and a photo-multiplier tube pickup for indexing. Early indications are that this approach shows real promise compared to the one above, because of general simplification, i.e. no index beam required, no transit time variations and one HV potential which greatly reduces the voltage field variations within the tube. Work with this system and with variations may well lead to a practical and economical color system. The gun and yoke problem need particular attention due to the severe requirements placed on spot size and beam current.

Chromatron - This single gun (Lawrence Tube) tube selects color at the screen by applying a sine-wave (3.58 mc) to the double grille). It is faced with all of the problems of the G.E.- P.A. tube except for convergence. However, the burden on the single gun is very severe. It is required to deliver approximately 10 times the peak current of one of the PA guns. It also has the possibility for various moiré patterns depending upon whether the grille wires are vertical or horizontal. It requires approximately three times the HV power of monochrome plus 15 to 20 watts of RF switching power for the grille. The radiation problem is not negligible. It requires continuous switching even on white. This tube does not appear to have the performance or cost potential of P.A. or Apple.

It is apparent that the performance of all of these color tubes depends on the basic sensitivity of the colored phosphors and the ability of the electron gun to deliver sufficient current of the appropriate spot size to produce a given brightness. Further improvement in phosphor sensitivity would reduce the burden on the electron gun. In fact an improvement in the technique of laying down stripes or dots of phosphor could improve the effective sensitivity of the phosphor almost two to one. The ratios of HV power given above are based on the measured efficiencies of a settled powdered phosphor screen. In actual practice the required HV power is almost twice the value indicated.

The basic costs of the color tubes so far described is a direct function of the increase materials cost and the increase in the number of operations required during construction. This cost may vary from two to three times the cost of a monochrome tube. The new Apple may be closer to two times because it requires no internal structure and it may employ a monochrome-type bulb.

ALTERNATIVE SYSTEMS WHICH MAY BE FEASIBLE IN LIGHT OF PRESENT TECHNOLOGY

Apple variations, either of the U.V-photomultipler type or the conductive comb types, appear to be headed in the right direction for the development of truly one gun color tubes. They satisfy the desirable condition that no switching takes place on monochrome and the errors in reproduction are thrown into the color portions of the picture where they are likely to be more tolerable. Further study is required to determine the best one of these variations, the optimum index frequency, the possibility of an amplitude limited index signal, the limits in comb conductivity and performance and the value of spot hesistation techniques.

Accurate Beam Scanning Systems - These are essentially precision scanning systems (Apple - without servo) which require inordinately small position tolerances, (say 0.001 inches instantaneous position tolerance). This is especially true in the horizontal line type. Adding a servo to the horizontal line type is difficult because of the need of matching each raster line to a color triad. Apple seems to represent the logical development of this category.

Beam Control at the Phosphor Screen and Velocity Sensitive Types - Many of these types require complex or unrealizeable structures at or near the phosphor screen. The most practical of these are the Lafferty 45° reflection type Aperture Mask tube in either single gun, three gun direction or velocity sensitive types. It is now clear that this type of tube could have run a close race with the AM tube. However, at this date, its potential does not seem to be as great as "Apple" or "PA."

The Penetron type uses three layers of transparent phosphors and depends on beams with different velocities or penetration to achieve color. The single gun version requires some form of a grille along with switching voltages of the order of 5 kv peak to change colors. The phosphors are low in sensitivity and the proper colors are not yet available. The three gun penetron with three separate necks and yokes presents very severe registration problems. The penetron may provide a possible solution for two-color TV but three color TV is impractical at the present time.

The Gabor type of flat picture tube has this feature as its only virtue at the present time. The tube is in the research stage and presents no basic color advantages over AM, as presently conceived.

Projection systems which optically combine three color rasters require about the same HV power as the AM tube because the optical efficiency of the system is about the same as the electron efficiency of AM. The cost of the three tubes and the optics is greater than the AM tube. Also the performance of the projection screen is poor in both directivity and contrast. The chances of obtaining inexpensive optics, screen and picture tube do not look good at this time.

Direction sensitive tubes which use phosphor geometry (eg phosphor pyramids) at the screen were judged impractical due to the need of converging the patterns of three guns (with three yokes) which have relatively large angles between them.

Mechanical scanning systems, rotating mirrors etc. were not seriously considered in this survey because none of the systems which came to note appeared to have sufficient merit to overcome the inherent problems connected with mechnical and optical parts in motion.

SYSTEMS DEPENDENT UPON MAJOR DEVELOPMENT IN MATERIALS AND TECHNOLOGY

An Electrically Controlled Color Filter, in which such a filter is placed in front of a "monochrome" tube, was judged to be theoretically feasible but would only be practical with further development of electro-optic and fast decaying phosphor materials. With present materials it would require several kilowatts of 3.58 mc switching power to select colors. The basic principles of such a filter are well known but further study is required to develop application techniques which will place the minimum requirements on the materials. An experimental filter of small size could be constructed to check the proposed methods of using the filters. It is suggested that a preliminary study be made to determine the long range feasibility of this scheme and the required properties of the materials to be used in a practical system. There is no doubt about the attractiveness of a system of the type that selects color external to the picture tube and thus permits the use of a monochrome type tube as the source of light.

Light Amplifier applications fall in the same category as the preceding system of selecting color external to the picture tube. Various methods of using the light amplifier panel or panels are suggested which produce color by activating the color-producing elements in the screen in synchronism with the exciting light from the picture tube. Development of the characteristic of photo-conductors, electro-luminescent phosphors, and techniques are needed for this system. Work has been initiated towards the ultimate development of a monochrome light amplifying panel. This is certainly the first step to be taken in what appears to be a long-term development.

The P.O.W. or picture-on-the wall is a logical follow-up to the light-amplifier panel, with the additional complication of electrical scanning and brightness control. The electrical input P.O.W. appears to be farther in the future than the light amplifying panel.

The Color Eidophor could conceiveably be adapted to the home TV receiver if a suitable gel could be developed for the light controlling screen. However, even with the existance of such a material, the cost of such a system appears to be considerably more than AM.

Another suggested system takes the form of a light valve plate which is scanned by an electron beam and the transmittance or reflectance is thereby controlled picture element by picture element. It is intriguing to contemplate a reflecting type screen whose brightness is a function of the ambient illumination shining on the screen. Another scheme calls for phosphors whose colors are controlled by some secondary means of excitation, such as ultra-violet light of different frequencies.

LINE-SEQUENTIAL, FIELD SEQUENTIAL AND TWO COLOR CONSIDERATIONS

It is apparent that some of the display systems have been ruled out because it was impractical to select colors at the 3.58 mc rate required by the NTSC standards. There is no doubt that the NTSC standards do use the existing channel space more efficiently than the field sequential system, however, some consideration was given to the possibility of using field sequential switching in all of the systems investigated. This was done to determine if some system might show an outstanding advantage for field sequential switching. If such a system were found one might consider changing the signal standards or be tempted to build a "convertor" to change the NTSC signal to a field sequential signal. The conclusion to all of these suggestions was negative, except possibly for the "future" systems (i.e. light amplifiers and electrical color filters). Neither one of these is far enough along to warrant a decision concerning the standards at this time. A "convertor" is judged to be impractical and too costly.

Two color requires some additional remarks. Actual tests were made to determine if either field or line-sequential two color TV was subjectively acceptable. The required signals were derived directly from the NTSC signal. For field-sequential it was judged that the flicker was too great for saturated and semi-saturated orange and cyan colors. Line-sequential switching gave rise to a crawl and to a color breakup with vertical motion which was judged to be undesirable. A simultaneous two color picture gave a pleasing picture which most persons preferred over monochrome. So it could be concluded that two color simultaneous system would be marketable providing the cost was not much greater than monochrome and certainly less than the objective for three color. An estimate for a two color Aperture Mask set exceeded the three color objective. Only remotely possible for the future are the two color penetron and the electrical color filter system.

CONCLUSIONS

It has become quite clear that none of the systems studied can meet the marketing objective unless events take place (invention or a major technological step) that cannot now be foreseen. In spite of this, it is reasonably clear that there are a number of directions that development might take which could eventually lead to the marketable color TV receiver. Of all the possibilities it would appear that the single gun approach using a low frequency index is the most fruitful direction to follow. It is judged that this system has the potential for acceptable performance and that the potential for the cost to come down, with development and invention, is greater than any other basic system, at this time.

W. E. Good

6-26-57
WEG:REL

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THE COLOR STUDY GROUP

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a. Apple Analysis - W. Rublack

b. Apple Index Diagram - R. B. Dome

c. Apple Receiver - Model 7A - Block Diagram - T. V. Zaloudek

d. Report on Apple Papers at the IRE Convention - T. V. Zaloudek

e. Crabapple Block Diagram - B. Field

f. Crabapple Diagram - B. Field

g. Crabapple Cost Sheet - E. K. Jacobs

h. Super Index Apple Cost Sheet - E. K. Jacobs

4. Chromatron (Lawrence)

a. Lawrence Tube Investigation - M. J. Palladino

b. Moire Patterns in Lawrence Color TV Picture Tubes - M. J. Palladino

c. Chromatic Trip Report - W. E. Good

d. Optimum Chromatron Circuit Diagram - B. Field

B. Today's Color Tubes Comparison with Mono. - E. F. Schilling

VI Alternative Systems Which May Be Feasible in Light of Present Technology

A. Apple Variations

1. Apple Variations - General - T. V. Zaloudek

2. Two Basic Forms of Apple Variations - T. V. Zaloudek

3. Apple Tube with Photoelectric Index - F. G. Cole

4. Photoelectric Apple Circuit Diagram - B. Field

5. Single-Gun Picture Tube (Patent letter relating to comb structures to obtain indexing) - R. B. Dome

6. Apple System Simulator Using the 6AR8 Vacuum Tube — M. J. Palladino

7. Comb Structure Apple Systems (Two Patent Letters) — C. S. Kim

8. Capacitance and Resistance in Thin Metallic Combs, Used for Indexing in Color Television Tubes — N. Johannessen

9. Single-Gun "Apple Variation" (Patent letter relating to one horizontal line for indexing followed by a line of writing) — T. V. Zaloudek

10. Patent letter relating to continuous indexing and writing but with index signal delayed one line before use — T. V. Zaloudek

11. A Triad-Rate Indexing Color Tube and System with Index Beam Current Pulsing (Patent Letter) — I. E. Lynch and T. T. True

12. A Three-Times-Triad-Rate Indexing Color Tube and System with Index Beam Current Pulsing (Patent Letter) — I. E. Lynch and T. T. True

B. Accurate Beam Scanning

1. Horizontal Phosphor Lines with Servo Control — N. Johannessen

2. Four Beam Horizontal Line System with Continuous Servo — N. Johannessen

3. A Spot Hesitation, Precision Scan, Color System with an Indexing Servo (Patent Letter) — I. E. Lynch

C. AM and PA Variations

1. Single-Gun Aperture Mask and Post Acceleration Color Tubes — M. J. Palladino

2. The Use of Beaded Blass for Picture Tube Contrast Improvement (Patent Letter) — W. E. Good and I. E. Lynch

3. In-Line AM Gun Trip Report — G. A. Schupp

4. Double Grille PA Color Tube — T. T. True

D. Beam Control at the Phosphor Screen and Velocity Sensitive Tubes

1. General Discussion - R. B. Dome

2. A Grid-Controlled Color Kinescope - I. E. Lynch

3. A Magnetically Switched Color Tube (Patent Letter) - R. B. Dome

4. Letter to patent attorney relating to above magnetic tube. - H. J. Vanderlaan

5. A Discussion of the Lafferty-Sixty Degree Tube - I. E. Lynch

6. Penetron Color Picture Tubes - M. Graser, Jr.

E. The Gabor Tube

1. Investigation of the Gabor Color Television Display Device - M. J. Palladino

2. A Gabor Type Self-Sweeping Tube Employing a Lafferty Type Deflection Mask (Patent Letter) - I. E. Lynch

VII Systems Dependent Upon Major Development in Materials and Technology

1. Light Amplifiers for Color Television - M. Graser, Jr.

2. Light Amplifiers - T. T. True

3. Electrically Controlled Color Filters - W. E. Good

4. Evaluation of the Electrically Controlled Color Filter - W. E. Good and T. T. True

5. Variable Color Filter (Polaroid Type) Cost Sheet - E. K. Jacobs

6. Color Eidophor Theory - M. Graser, Jr.

7. Color Eidophor Receiver Including Block Diagram, Cost Sheet, and letter to W. E. Glenn - B. Field, - J. Nonnekens and - M. Graser, Jr.

8. Color Scophony - M. Gaser, Jr.

VIII Line-Sequential, Field-Sequential, and Two-Color Considerations

1. Field and Line-Sequential Two-Color - H. J. Vanderlaan

2. Picture Tubes and Systems Considerations Under Field-Sequential Operation including letter to Dr. L. R. Fink - F. G. Cole and I. E. Lynch

3. Conversion of the NTSC Signal to Field-Sequential or Line-Sequential Signals - T. T. True

4. Gross Two-Color Aperture Mask and Cost Sheet - E. K. Jacobs

IX Color TV Systems Patent Search - T. V. Zaloudek

I. E. Lynch
Development Engineering
Television Receiver Dept.

IEL:REL
6/24/57

Development Engineering
TELEVISION RECEIVER DEP'T

February 8, 1957

DISPLAY DEVICE CHARACTERISTICS

(A) Monochrome and Color Performance

1. Brightness

a. Produce 40 foot lamberts on crayon boy tablet after passing through 50% transmission untravision glass or equivalent. This is considered adequate for normal home viewing ambient levels.

2. Contrast Ratio

a. Large area = 50/1 measured in the dark. This is considered adequate for normal home viewing ambient levels. = 45/1 measured in a lighted room at an ambient level of 5 foot lamberts. The ambient light is the reflected light measured from a white card at the picture tube face.

b. Small area = 20/1 measured in the dark. This is considered adequate for normal home viewing ambient levels.

3. Resolution and Focus

a. Horizontal resolution = clearly define 325 lines for luminance signal.

b. Vertical resolution = at nominal brightness interlaced raster lines should be visible at a viewing distance of three times the picture diagonal.

4. Registration

a. 30 mils maximum error on the edges of a 21 inch picture tube.

b. Imperceptible error in center of tube at a viewing distance of three times the picture diagonal.

5. Phosphor Structure Visibility

a. No greater visibility than interlaced raster lines (monochrome and color).

6. Purity

a. Flat monochrome and color fields should have no more shading effects than a monochrome tube.

b. Saturated color fields shall not display any objectionable hue or intensity variations.

7. Suseptibility to External Fields

a. Purity and registration should remain within specified limits as the display device is rotated through 180°.

7. b. Imperceptible effects when the display device is placed in a 1/2 gauss peak to peak a.c. field.

   c. For any critical frequency the display device must not be susceptible to RF fields of 0.1 volt per meter.

8. Beats and/or Undersirable Patterns

   a. No objectionable moving or stationary patterns or flaws should be visible other than those inherent in the NTSC specifications.

9. Grey Scale and Color Temperature

   a. Display device must be capable of producing 4000° to 8000°K and maintain proper grey scale throughout contrast and brightness ranges.

10. Phosphor Decay Time

   a. Should not give rist to objectionable transient effects for moving objects.

   b. Flicker should be no worse than monochrome.

   c. No perceptible color break-up due to motion.

11. Radiated Interference

   a. Must meet FCC specifications for RF radiation.

   b. X-ray radiation must not exceed .75 m r per hour for a 40 hour week.

12. Saturation and Dominant Wave Length

   a. Red - minimum tolerable saturation of 79% with a dominant wave length of 611 mu.

   b. Blue - minimum tolerable saturation of 82% with a dominant wave length of 470 mu.

   c. Green - minimum tolerable saturation of 64% with a dominant wave length of 535 mu.

13. Stability

   a. Brightness should not fluctuate by more than ±5% nor vary by more than ±15% during a reasonable on-off cycle.

   b. Purity should remain within previously specified limits for short or long term durations. (Short term is considered a period of viewing and long term is considered as several months.)

   c. Grey scale should remain within previously specified limits for short or long term durations.

   d. Registration should remain within previously specified limits for short or long term durations.

   e. All other display device variables should remain within previously specified limits for short or long term durations.

February 8, 1957

DISPLAY DEVICE CHARACTERISTICS

(B) Physical Characteristics

1. Aspect Ratio

   a. Vertical to horizontal should be approximately three to four.

2. Picture Area (Masked Screen Area)

   a. Usable area should be equivalent to a monochrome 21 inch rectangular tube.

3. Face Plate Shape

   a. Flat

   b. Cylindrical

   c. Spherical

4. Length - short as possible but preferably no longer than a 21" - 90° monochrome tube.

5. Percent of Transmitted Picture area Displayed

   a. 91% minimum with no over sweep.

6. Filter Glass

   a. Should produce the equivalent of 50% transmission.

   b. Color should not deviate from neutral density in such a way to distract from the appearance of the set.

   c. Grey scale color temperature should not be visibly affected by ambinet light.

7. Cabinet size

   a. It would be desirable if the physical dimensions of the picture tube and assembly are comparable to those of a monochrome tube of equivalent picture area.

M. J. Palladino

MJP:REL
2/8/57

3-7-57

Classification of Color Tube Types

A. Accurate Beam Scanning

1. Transverse scanning - vertical phosphor lines.

    a. Without sweep speed correction

    b. With sweep speed correction servo

2. Parallel scanning - horizontal phosphor lines with vertical position correction made by use of deflector plates. Correction voltages may be obtained by:

    a. Circuit adjustments to correct errors observed visually. This system depends upon the generation and proper adjustment of a correction waveform (desirably approaching continuously variable) which is applied to deflection plates in the tube neck.

    b. Servo control by screen secondary emission or comb structures

3. "Checkerboard" color screen requiring accurate scanning in both sweep directions.

B. Color signal controlled by beam scanning position.

1. Apple

2. Dome's comb tube

3. Gethman's slave tube - uses second tube to perform the functions of the pilot beam without producing light haze

4. Kim's tube

5. U.V. phosphor tube - same principle as Apple tube but with ultra violet light pickup instead of secondary electrons.

6. True, Lynch tube using comb structure over guard band areas thus allowing high pilot beam currents

C. Adjacent Image

1. Three monochrome tubes with optical addition

   a. American Optical System - using Schmidt lenses to gather light from small tubes and project it to a ground glass. By using three such systems with color filters and proper registration, color pictures can be reproduced

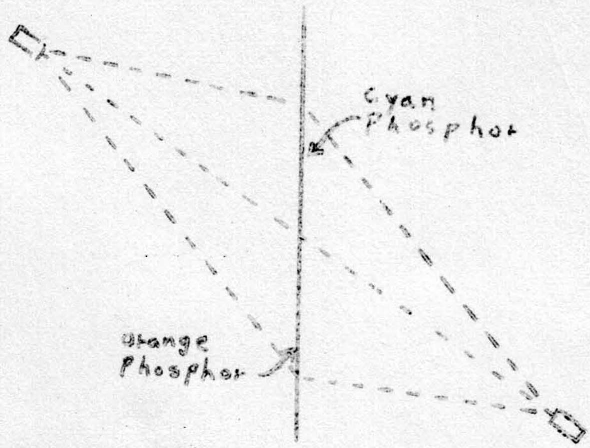
   b. Trinoscope

2. Two monochrome tubes with optical addition (two color)

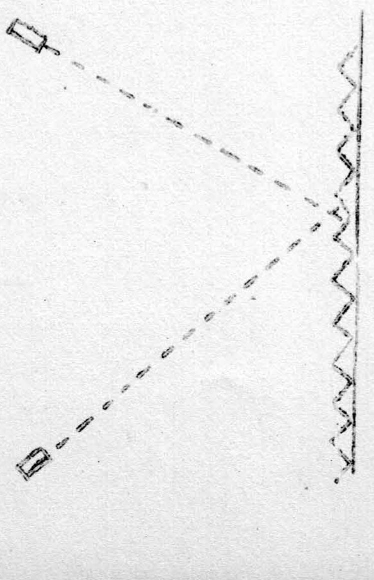
3. One monochrome tube divided into three areas with optical addition - Fresnel lenses.

4. Baird two color tube

   a. One gun and one phosphor on each side of a glass plate



   b. Graser's proposal



D. <u>Beam control at phosphor screen to produce color.</u>

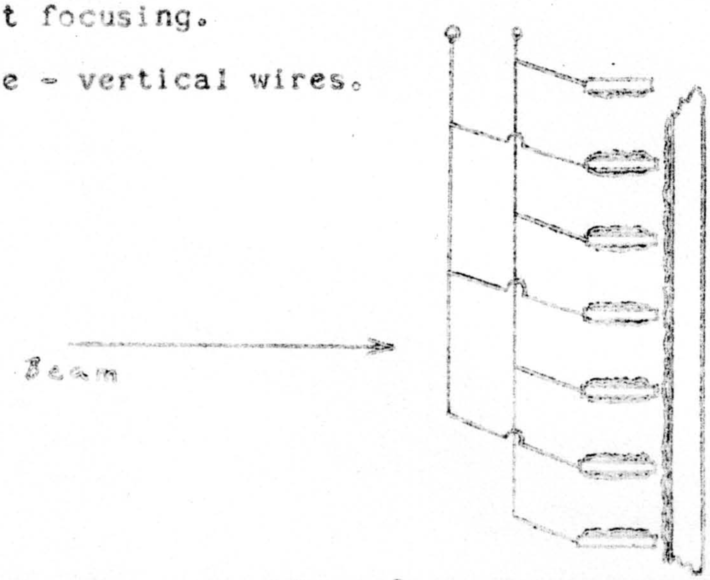
1. Insulated stripes with anode voltage switched to color stripes desired.

2. Interleaved deflection plates or grill wires at the screen. Chroma switching applied between alternate plates or wires.

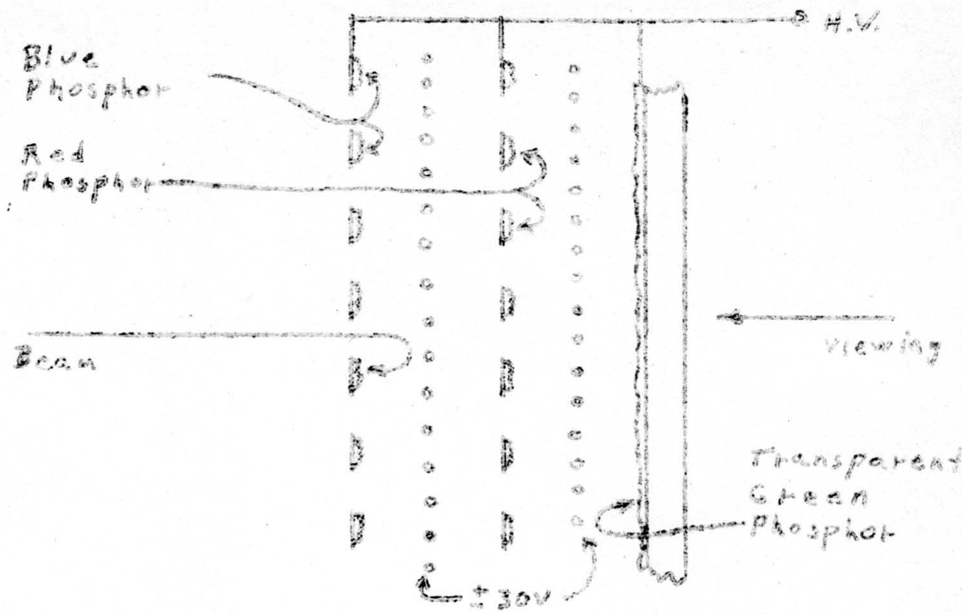
   a. One gun Lawrence - horizontal phosphor stripes and grill wires using post focusing.

   b. One gun Lawrence - vertical wires.

   c. Snyder proposal

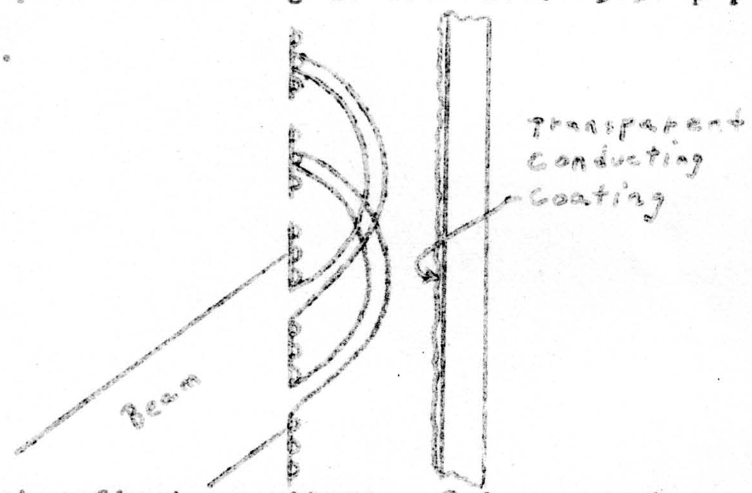


3. Fine mesh grids at phosphor assembly. Green transparent phosphor is placed on face plate. Behind this is a wire grill (#1) at ground potential (for a three gun tube). Behind this is a wire mesh (#2) upon which red phosphor is uniformly settled. This is again followed by a second grill (#3) (at about +60 volts for the three gun tube). The last mesh grid (#4) is coated with blue phosphor. The faceplate, mesh #2, and mesh #4, are at anode potential. Grids #1 and #3 control the depth of beam penetration and hence the phosphor layer to which the electrons return. This can be a one gun field sequential (grill #1 and #3 are switched) or a three gun dot sequential tube. In the three gun version, correspondence between guns and phosphors is controlled by different cathode voltages



4. Lafferty 45° or Weimer Tube

a. One gun with reflector plate switching at dot rate. 305v p-p required for switching.

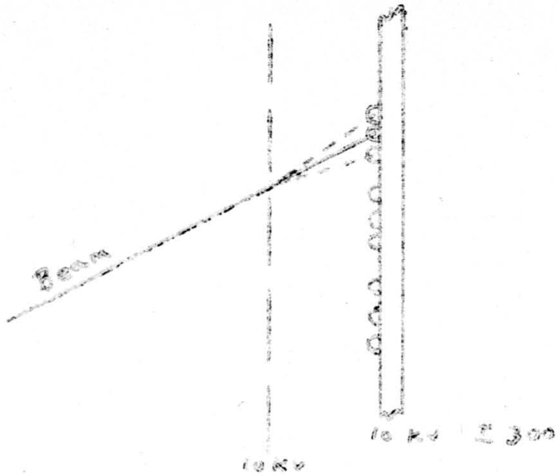


b. Three guns with constant reflector voltage. Colors may be selected by:

1. Three guns inline at equal cathode voltages.

2. Three guns closely spaced at different cathode voltages. A 190 volt spread in potential produced color fields in a 12 kv experimental tube.

5. Modified Lafferty 45 degree tube with separate aperture mask and phosphor on the gun side of the faceplate. Color is then obtained by switching the faceplate voltage 600 volts peak-to-peak around aperture mask and faceplate d.c. voltage.



6. Dome's magnetic tube

E. <u>Direction - sensitive color screen using electron shadowing.</u>

1. One gun P.A. using space displacement in the neck by:
    a. Magnetic field
    b. Electrostatic field
    c. Sheet beam cathode with control for moving spot back-and-forth
2. Three gun P.A.
3. Double grill P.A.
4. One gun A.M. with
    a. Spot rotation at constant radius from tube axis. Rotation is at constant angular velocity corresponding to dot sequential sampling.
    b. Spot movement at variable distance from tube axis to produce saturation changes. White would be produced with no beam color deflection (beam on tube axis hitting all the primaries at any instant. Color phase is controlled by direction of deflection. Color switching by deflection is at chroma rate (1.0 mc bandwidth).
5. Three gun A.M.
6. Single mask post acceleration A.M.
7. Double mask post acceleration A.M.
8. Three inline gun A.M. tube proposed by Reiches of the Park Products Company.

9. Three gun Gabor or Willys flat face tube with the following possible modifications

   a. Unfolded neck

   b. Single gun with electrostatic, electromagnetic, or sheet cathode color displacement of the beam.

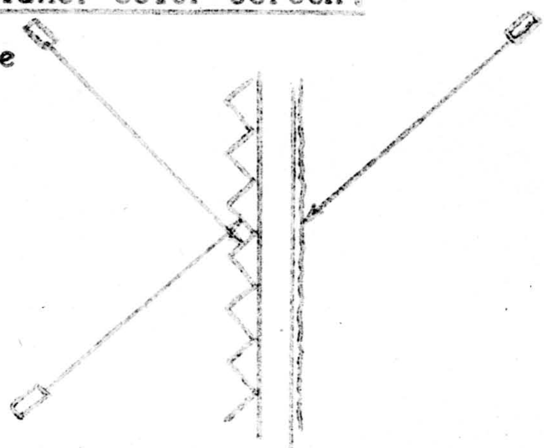
   c. Reflection type shadow mask similar to that in the Lafferty 45^0 tube.

10. P.A. three gun tube with the three guns inline vertically (horizontal phosphor lines).

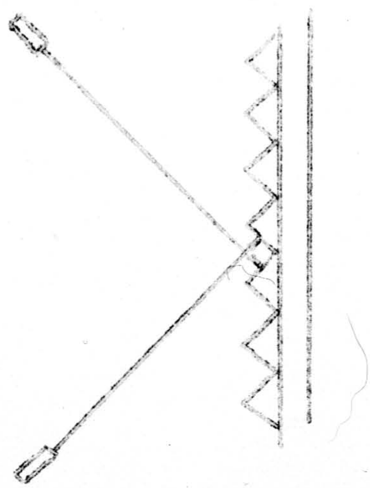
11. Four phosphor (three primaries plus white) - Zenith tube.

F. <u>Direction sensitive nonplaner color screen.</u>

1. Baird three gun tube

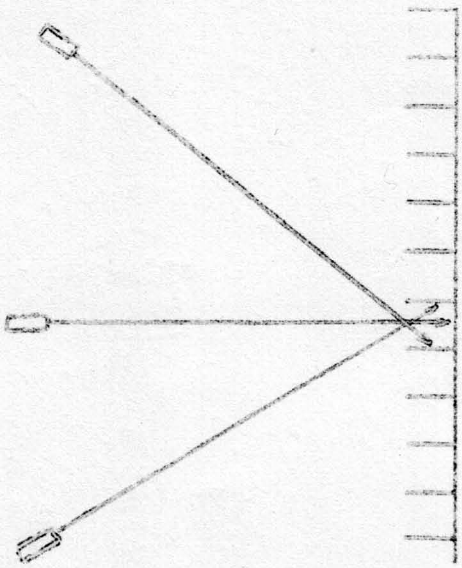


2. Graser proposal for modified form of Baird two color tube.

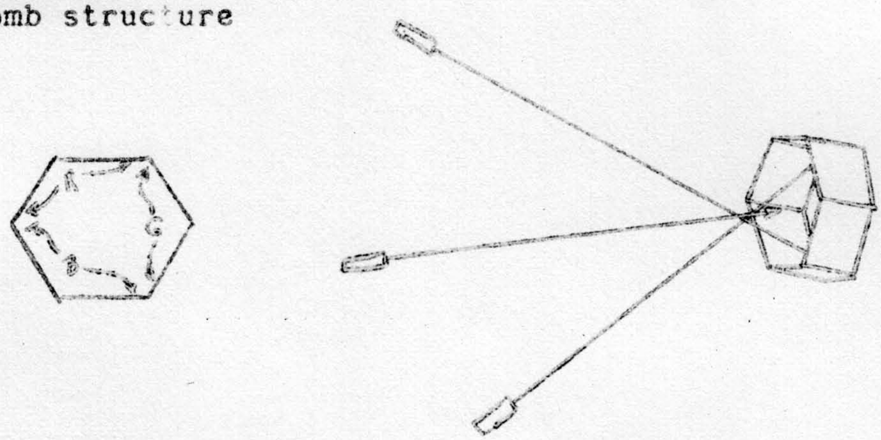


3. Phosphor pyramids for three color

4. Perpendicular phosphor planes



5. Honeycomb structure



G. <u>Velocity sensitive.</u>

1. Lafferty 45° three gun tube with cathode voltages different to make different beam velocities to common anode voltage.

2. Three gun version of mesh tube listed under D3. Cathode voltages would be spread with no switching in the mesh screen assembly required.

3. Penetron

   a. one gun

      1. field sequential

      2. line sequential

      3. dot sequential

b. Three gun with each at different cathode voltage (three yokes).

H. <u>Color filters.</u>

1. "Porphyrite" - electrically controlled color light absorbing filter.
2. McAllister's proposal
3. Zaloudek proposal of controlled color of tube screen light emission by:
   a. A second electron gun excitation
   b. Ultra-violet light excitation
4. Mechanically moved color filters

I. <u>Two and three color line sequential proposals.</u>

1. Timbie Devine Tube - one field of green followed by a field of red and blue line sequenced.
2. Dome Tube - green presented on each field with red and blue line sequenced. Patent disclosure letter May 18, 1953.

J. <u>Light Valves.</u>

1. Eidophor
2. Scopheny - Ultrasonially controlled light valve

K. <u>Others.</u>

1. Color changes produced by current density changes.
2. P.O.W.
3. Spot hesitation - beam sweep velocity modulated to cause beam hesitation on the color desired.

I E Lynch
I.E. Lynch

IEL/o'g

A NOTE ON LUMINOUS EFFICIENCY OF COLOR PICTURE TUBES
By: T. T. TRUE February 7, 1957

Similar color phosphors must be used in practically all tri-color display devices. It is therefore interesting to note the typical luminous efficiencies which can be achieved with known phosphors, and to calculate what efficiency the "ideal" display device would have when using these phosphors.

Consider the following phosphor characteristics:

Phosphor	Color Coordinate x	y	Luminous proportions required for Ill. "C"	Luminous eff. in 5 Q type* tube
Blue: GE 3-203P	.145	.060	.085	10
Green: GE3-253P	.235	.700	.640	37
Red: GE 1092-1	.670	.300	.275	7

The following table of efficiencies can be calculated from the above data:

Type of tube	Luminous efficiency when producing illuminant C field	
Ideal 3-gun tube (non-equalized phosphors)	15.3 FL/mw/cm^2	9.6 (Foot lamberts/watt for 21" tube)
Ideal 3-gun tube (equalized phosphors)	8.5	5.3
Ideal 1-gun tube (equalized phosphor - 50% guard band	4.25	2.6

In order to compare the efficiencies which are realized in actual color tubes with the "ideal" values given above, the following table is presented:

Type of tube	Luminous efficiencies for ill. C fields** L_E FL/mw/cm^2	L_E FL/watt for 21" tube
Monochrome tube	25.2	15.8
PA tube	8.65	5.4
AN tube	8.15(approx.)	5.1
Apple	2.73 (approx.)	1.7

*Luminous efficiency is expressed in Foot lamberts/milliwatt/cm^2

**These efficiencies are based on power <u>at the tube screen</u>, and light measured without safety glass.

Misc. Inv. Report #94
June 19, 1957

Development Engineering
Television Receiver Dept.

COMPARISON OF HIGH VOLTAGE POWER AND GUN REQUIREMENTS IN FOUR COLOR TELEVISION PICTURE TUBES

By: M.J. Palladino

ABSTRACT

The four tubes discussed in this report are Apple, Aperture Mask, Post Acceleration and Chromatron. The high voltage power and gun requirements are compared and normalized to a monochrome picture tube.

CONCLUSIONS

The conclusions that may be drawn from this report are not intended to show tube performance superiority, but to indicate relative power demands from the receiver and relative severity in gun demands.

Table 1 in the discussion shows the Aperture Mask tube imposes enormous demands in high voltage power as compared with monochrome. Even when the theoretical phosphor efficiencies are considered it requires in the order of 11 times the monochrome power. Consequently, on white, this tube requires the highest peak current to provide a picture with equivalent monochrome brightness. In overall gun demands, however, the Aperture Mask is not as severe as Apple or Chromatron. Apple is the most severe due to the small spot size requirement.

The Chromatron tube, due to very low duty cycles, demands the most current for color reproduction while Aperture Mask and Apple are nearly equal.

The Post Acceleration tube requires less high voltage power than any of the other three color tubes and 1.7 times the monochrome in theory. In fact, theoretically, only 0.6 of the monochrome peak current is necessary per gun to obtain the same brightness on white or color. In terms of overall gun demands the P.A. tube is not as severe as a monochrome tube.

To summarize, the Post Acceleration tube is least demanding in all respects. The gun requirements are less stringent because the low voltage beam is over compensated by the larger permissible spot size, non-limited duty cycle, and post accelerating field. In addition the low velocity beam requires less deflection and high voltage power.

DISCUSSION

In analyzing the performance of Apple, Post Acceleration, Aperture Mask, and Chromatron picture tubes it is desirable to compare the relative capabilities desired in the gun or guns. Table 1 shows the results of such a comparison.

	Monochrome	Equalized Phosphor Apple	Partially Equalized Phosphor Apple		Aperture Mask		Post Acceleration		Chromatron	
	THEORETICAL	THEORETICAL	THEORETICAL	MEASURED	THEORETICAL	MEASURED	THEORETICAL	MEASURED	THEORETICAL	MEASURED
Phosphor Efficiency ft.L/mw/cm^2	25	8.5	11.9	2.73	15.3	8.15	15.3	8.65	8.5	
Gun Potential	17 KV	27 KV	27 KV		25 KV		7 KV		7 KV	
Screen Potential	17 KV	27 KV	27 KV		25 KV		25 KV		22.5 KV	
Spot Size in Mils	20	8	8		30		30		30	
High Voltage Power at Screen Relative to Monochrome	1.0	4.2	3.0	6.5	11.1	20.1	1.7	2.9	3.0	5.3
Peak Current Per Gun for White Relative to Mono.	1.0	2.6	1.9	4.1	3.8	7.0	0.6	1.1	2.7	4.7
Peak Current Per Gun for Color Relative to Mono. for White		5.3	3.7	8.2	3.8	7.0	0.6	1.1	8.0	14.0
Figure of Merit for White	82.4	25.6	30.4	20.6	77.2	56.8	102.4	78.9	48.7	36.5
Figure of Merit for White Normalized to Monochrome	1.0	3.2	2.7	4.0	1.1	1.5	0.8	1.05	1.7	2.3
Figure of Merit for Color		14.8	21.4	14.5	77.2	56.8	102.4	78.9	28.1	21.1
Figure of Merit for Color Normalized to Monochrome		5.6	3.9	5.7	1.1	1.5	0.8	1.05	3.0	3.9

TABLE #1

In this table the first row indicates phosphor efficiencies in foot lamberts per milli watt per square centimeter of screen area. The "partially equalized phosphor" Apple was determined by taking the mean of equalized and unequalized phosphors. This was justified on the basis of an Apple tube with wider red stripes than blue and green. The measured efficiencies in the second row were selected from several sets of actual measurements.

The relative high voltage power required at the screen to provide 50 ft. lamberts on high light whites through 50% transmission ultravision glass or equivalent, was determined in the following manner:

THEORETICAL

Equalized Phosphor Apple

$$P_s = \frac{25\ ft.L./mw/cm^2}{8.5\ ft.L./mw/cm^2}\left(\frac{1}{0.50}\right) 0.707 = 4.17 \qquad (1)$$

where 0.50 = 50% guard bands

0.707 = 70.7% inherent ultravision

Partially Equalized Phosphor Apple

$$P_s = \frac{25\ (0.707)}{11.9\ (0.50)} = 2.97 \qquad (2)$$

Aperture Mask

$$P_s = \frac{25}{15.3(0.15)} = 11.1 \qquad (3)$$

where 0.15 = 15% transparency

Post Acceleration

$$P_s = \frac{25}{15.3(0.98)} = 1.67 \qquad (4)$$

where 0.98 = 98% front end efficiency

Chromatron

$$P = \frac{22.5}{8.5\,(0.98)} = 3.0 \qquad (5)$$

where 0.98 = front end efficiency

The figures for measured high voltage power were arrived at by similar calculations using measured phosphor efficiencies.

The peak current per gun required on white, relative to monochrome, was determined by multiplying the high voltage power by the ratio of monochrome screen potential to the specific color tube's screen potential. In the case of Post Acceleration and Chromatron this number must be divided by 0.92 and 0.85 respectively, due to grill transparencies. The average peak current per gun required on color was arrived at by assumptions. On Apple it was assumed the red gun required half the total current on white due to relative primary phosphor efficiencies; therefore, the figure for peak current on white was multiplied by two. The Aperture Mask and Post Acceleration require the same current per gun on color as they do on white. The Chromatron tube is operated with a 40° conduction angle, consequently the figure for white must be multiplied by a factor of three to obtain the figure for color.

The figure of merit is an arbitrarily factor intended to indicate the gun requirements, relative to monochrome, for producing a picture of equivalent brightness. This figure is calculated from the following formula:

$$F.M. = S.S.\sqrt{\frac{E_{sc}}{I_{pm}}} \qquad (6)$$

when FM = Figure of Merit

SS = Spot Size in Mils

E_{sc} = Screen Potential

I_{pm} = Peak Current relative to monochrome

Measured figures for high voltage power were not available for the Chromatron tube; therefore, it was assumed to differ from the theoretical by the same ratio as Post Acceleration measurements.

Michael J. Palladino

MJP:REL

Today's Color TV Systems

A Comparison in 1958 and in 1960+

There are four Color television receiver systems which have received major development activity by industry, notably the Aperture Mask, Post Acceleration, Apple, and the Chromatron. This discussion will deal with the current and future cost possibilities of these systems in the light of the objective costs presented by Jack McAllister. But before we begin discussing costs, let us review briefly how these systems work and what some of their performance difficulties are.

Aperture Mask

First the Aperture Mask System. This system, as you know, was promoted by RCA, and is the only system now in production. We have built several thousand of these sets in Syracuse.

The tube, now all glass, is composed of three electron guns, an aperture mask containing some 300,000 holes, and phosphors deposited on the face plate in the form of triads of red, green, and blue phosphor. The mask openings are placed such that the beam from the red gun can hit only the red phosphor, the mask shadowing the other two phosphors. The same for green and blue. The phosphor being excited then is a function of the angle of approach of the beam. Three video signals are necessary (R.G.B.) from the chassis.

Since the porousity of the mask is only 15%, the tube is limited in brightness. Since three beams are arranged in delta fashion, the registration or convergence of the three colored pictures is difficult and gives objectional fringing of color. Since three guns are used, a grey scale problem exists both in getting grey from black to white and in stability during the short and long time aging of the set. The chassis requires 26 tubes. For calibration a current monochrome set uses 17 tubes.

The performance limitations on any of the systems may not limit their success at all. Perhaps the aperture mask set of today can be sold in large quantities if the price is right.

Post Acceleration

Now let's look at the Post Acceleration System, which, you will recall, was developed by G.E. in Syracuse.

This tube is constructed with vertical phosphor lines of R.G.B., 28 triads to the inch. A vertical grill of fine stretched wire is located just behind the phosphors and run at a lower potential (7KV) than the screen (25KV). Three guns are used in an in-line arrangement. The field between the screen and the grill provides for post focusing action of the beams. Here again the angle of beam approach determines the phosphor excited. The porousity of the screen is high, 90%, giving good brightness. The video signals required are the same as in Aperture Mask.

Some of the limitations of this system are focus, since the beam potential is only 7KV; haze, caused by secondary electrons emitted from the phosphors (work in this laboratory has reduced this effect greatly). Grey scale is a problem as in any 3 gun system, and the earth's magnetic field has a great effect, since the beam is at a low potential. This chassis uses one less tube than AM or 25.

Apple

The third system under discussion is the Philco Apple System. We worked with Philco on Apple some two years ago, and are now negotiating a fresh look at their progress.

This system is a single gun system with vertical phosphor stripes arranged in a R.G.B. sequence. A wide red phosphor is used to enhance red due to its low efficiency. Opaque guard bands are placed between the phosphors. Behind the phosphor triads a stripe of MgO is placed to emit secondary electrons which are collected by the collector around the rim of the tube. Two beams are emitted from one gun. One is the writing beam containing Y and chroma information. The other is a fixed low level pilot beam. The secondary emission signal called index furnishes beam position information which is used to modify the chroma signal such that red information will be on the writing gun when the beam is crossing the red stripe.

This system is limited in that the triads, practically, must be wide - 16 to the inch, in order to achieve reasonable color saturation. This is a coarse appearing structure to some observers. This may possibly be optically filtered. The Apple set uses 33 tubes today.

Chromatron

The last system under consideration is the Chromatron. Now being actively pursued by Paramount and Dumont. We have not seen any late pictures, and only try to evaluate what we hear.

The tube is a single gun, post acceleration device with vertical phosphor stripes and a double grill. Color selection is accomplished applying the color subcarrier signal (3.58mc) to the double grill causing the post accelerated beam to bend between the grill and screen and hit the proper phosphor corresponding the chroma information of the NTSC signal at the gun. This system probably suffers most of the limitations of the other systems. Since one low voltage gun now does the work of three, as in our PA tube, brightness is limited by focus which is limited by low beam voltage. The haze problem should be the same as on our PA, as will be earths field effects. This chassis would contain 27 tubes.

Cost Comparison
1958

And so with this background in mind, let's proceed to our dilema, COST. Jack McAllister discussed with you the cost objective developed by our department. Briefly, a color set must be priced at no more than $100 more than its good quality monochrome cousin. This means approximately $50 in manufacturing cost. Here is a cost comparison chart showing the costs of the four systems based on what we could design for next year if the picture tubes were available. The costs here represent those of a table model of a total line of

100,000 quantity. The chart shows the costs of AM, PA, Apple, Chromatron, Monochrome, (for calibration) and the objective for color. The costs are shown in terms of Picture Tube, Labor and overhead, all parts including cabinet in Chassis, Other costs including engineering charges, tooling, warranty and royalty. These costs are summed under Manufacturing Cost. You may note here that all of the Manufacturing costs are within a few dollars and all over $100 from the objective. Just not in the same ball park! We may note that the Apple trades a simple picture tube with lower cost for a more complicated and expensive chassis. We may also note that if we took the picture tube out entirely the objective cost still wouldn't be reached. The picture tube costs will be discussed by the next speaker.

Moving on further to the List Prices we see that at the current table model price of $495, we are $175 from the objective. And even at this price we derive a substandard margin. The margin represents, in part only, the profit. Margin also includes administrative and promotional expenses. The figure shown under monochrome indicates small profit for the low end of the Monochrome line. The Color margins indicate loss or just break even.

To sum up briefly; the situation looks rather bleek for mass production of color television at a profit for the next few years.

Future Comparison
1960+

But let's not stop here in 1958, let's carry on further and try to factor in some product development that could possibly happen over the next few years. We may note first that a color set is composed of a monochrome section plus a color section. Any thing that reduces costs in the monochrome portion of the color set will also reduce the monochrome set costs, thereby reducing the objective for color. The amount we have to work with then is roughly 3/5ths of the current color set costs.

Let's take a look at what might happen to Aperture Mask. Let us open up the holes in the mask and thus increase the tubes' efficiency by, say 2:1, and take the resultant gain by reducing the expensive high voltage supply. Let us also consider some circuit cost reductions which will develop over the next few years. Let the quantity increase to, say, 1,000,000 and gain some quantity price advantage. The picture tube will drop in price from $75 to $53. All of the factors might reduce the Manufacturing cost to $213 from the previous $268. Even this dream leaves us $59 from the objective. Still quite a ways out of the ball park. Nowhere do these costs correspond to a List price which would achieve a market that would buy the quantity of sets necessary to achieve the price in the first place.

Let's look at P.A. The picture tube also reduces to $53. Let us, for instance, remove the expensive regulation circuit necessary to maintain the screen and grill ratio. Let us as before allow other circuit reductions and increase the quantity to 1,000,000. Here the manufacturing cost drops to $207 from the previous of $260. This figure is as with AM still a long way from the objective.

Taking the same approach with Chromatron yields the same results.

COST COMPARISON

1958

	AM	PA	APPLE	C'TRON	COLOR OBJECTIVE	MONO
CHASSIS	$130	122	141	120		66
PICTURE TUBE	75	75	54	84		19
LABOR AND OVERHEAD	30	30	30	29		11
OTHER COSTS - ENG, TOOLS WARRANTY, ROYALTY	33	33	33	33		8
MANUFACTURING COST	268	260	258	266	154	104
MARGIN %	11	13	14	12	19	19
LIST PRICE	495	495	495	495	319	219
QUANTITY	← 100 000 →					500 000

There may be only one faint glimmer on the horizon, in the guise of Apple. We have not explored the problem of indexing deeply enough to feel that a much cheaper system could not be developed. A later speaker will deal with this problem in detail. But if a simple index system could be developed the manufacturing cost might be reduced to $182, putting us in the ball park. But a basic invention is necessary.

We may conclude this discussion by saying that we do not have a system in hand that will meet the market requirements set forth by our department. And, furthermore, with the possible exception of Apple, we do not see that these systems can be developed over the next few years to meet these market requirements.

G. A. Schupp /ю

G. A. Schupp, Manager
Color TV Product Engineering

4-30-57

COPY

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4-22-57		Color - Optimum +

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION
21" Table Model - Mahogany W od
AM Color TV - Glass Pix Tube
Optimum + Chassis (25KV HV Supply)

MATERIAL			
CABINET		15.00	15.00
CABINET ACCESSORIES		8.03	8.00
CATHODE RAY TUBES		75.00	53.00
OTHER TUBES (25)		18.58	14.83
SPEAKER		.84	.84
CHASSIS ASSEMBLY		78.84	72.00
PACKING		2.26	2.26
TOTAL		198.55	165.93
FREIGHT 1%		1.99	1.65
SPOILAGE 2%		3.98	3.30
TOTAL MATERIAL		204.52	170.88
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION		9.00	
SPEAKER		.01	
ELECTRONIC REPRODUCER		.03	
GEN. DEVELOPMENT		4.57	
TOOL MAINTENANCE		3.00	
Gen. Tools		.69	
TOTAL P.E.C.E.		17.30	5.00
WARRANTY COSTS			
SET WARRANTY		2.34	1.89
PICTURE TUBE WARRANTY		4.00	2.12
TOTAL WARRANTY		6.34	4.01

LIST PRICE		495.00	395.00
DISCOUNT		32.3%	32.3%
DISTRIBUTOR COST		335.00	267.42
EXCISE TAX		33.50	26.74
NET G.E. SELLING PRICE		301.50	240.68
GROSS MARGIN — DOLLARS		34.50	31.24
GROSS MARGIN — PER CENT		11.4%	13.0%
QUANTITY		100M	1000M
COST SUMMARY			
MATERIAL		204.52	170.88
LABOR		12.00	10.00
I.M.E.		18.00	12.50
SHOP COST		234.52	193.38
P.E.C.E.		17.30	5.00
WARRANTY		6.34	4.01
EXTRA COST 2%		5.20	4.05
MFG. COST LESS ROYALTY		263.36	206.44
ROYALTY		3.64	3.00
TOTAL MFG. COST		267.00	209.44

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RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4-23-57		PA - Optimo Color
CLASS / ISSUE / BANDS: Preliminary	CHANNELS	MANUFACTURING PLANT

DESCRIPTION

PA-Optimo Color
21" CRT
Table Model - Wood Mahogany

MATERIAL			
CABINET	15.00	15.00	
CABINET ACCESSORIES	8.03	8.03	
CATHODE RAY TUBES	75.00	53.00	
OTHER TUBES (24)	15.72	15.72	
SPEAKER	.84	.84	
CHASSIS ASSEMBLY	75.13		
PACKING	2.26		
TOTAL	191.98	160.48	
FREIGHT 1%	1.92	1.61	
SPOILAGE 2%	3.84	3.22	
TOTAL MATERIAL	197.74	164.31	
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION	9.00		
SPEAKER	.01		
kr~~ELECTRONIC REPRODUCER~~tools	.03		
GEN. DEVELOPMENT 2%	4.55		
TOOLS ~~MAINTENANCE~~	3.00		
Gen. Tools 3%	68		
TOTAL P.E.C.E.	17.27	5.00	
WARRANTY COSTS			
SET WARRANTY 1%	2.28		
PICTURE TUBE WARRANTY	5.00		
TOTAL WARRANTY	7.28	4.00	

LIST PRICE	495.00	395.00	
DISCOUNT	32.3%	32.3%	
DISTRIBUTOR COST	335.00	267.42	
EXCISE TAX	33.50	26.74	
NET G.E. SELLING PRICE	301.50	240.68	
GROSS MARGIN — DOLLARS	40.47	37.89	
GROSS MARGIN — PER CENT	13.4%	15.7	
QUANTITY	100M	1000M	
COST SUMMARY			
MATERIAL	197.74	164.31	
LABOR	12.00	10.00	
I.M.E.	18.00	12.50	
SHOP COST	227.74	186.81	
P.E.C.E.	17.27	5.00	
WARRANTY	7.28	4.04	
EXTRA COST	5.05	3.92	
MFG. COST LESS ROYALTY	257.34	199.77	
ROYALTY	3.69	3.02	
TOTAL MFG. COST	261.03	202.79	

Psi
reg. 1.40

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E. K. Jacobs			

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RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4-22-57		Crab Apple (peeled)

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION: 21" Table Model - Mahogany wood

Apple Color TV

MATERIAL			
CABINET		15.00	
CABINET ACCESSORIES		8.60	
CATHODE RAY TUBES		54.00	41.00
OTHER TUBES	31	24.55	
SPEAKER		.84	
CHASSIS ASSEMBLY		84.00	
PACKING		2.25	
TOTAL		189.24	
FREIGHT	1%	1.89	
SPOILAGE	2%	3.78	
TOTAL MATERIAL		194.91	173.54
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION		9.00	
SPEAKER		.01	
ELECTRONIC REPRODUCER		.03	
GEN. DEVELOPMENT		4.38	
TOOL MAINTENANCE		3.00	
Gen. Tools		2.19	
TOTAL P.E.C.E.		18.61	5.00
WARRANTY COSTS			
SET WARRANTY		2.19	
PICTURE TUBE WARRANTY		3.38	
TOTAL WARRANTY		5.57	3.62

LIST PRICE		495	395
DISCOUNT		32.3%	32.3%
DISTRIBUTOR COST		335.00	267.42
EXCISE TAX		33.5	26.74
NET G.E. SELLING PRICE		301.50	240.68
GROSS MARGIN — DOLLARS		43.33	27.80
GROSS MARGIN — PER CENT		14.4	11.5%
QUANTITY		100M	1000M
COST SUMMARY			
MATERIAL		194.91	173.54
LABOR		12.55	11.00
I.M.E.		17.57	12.50
SHOP COST		225.03	197.04
P.E.C.E.		18.61	5.00
WARRANTY		5.57	3.62
EXTRA COST	2%	4.98	4.24
MFG. COST LESS ROYALTY		254.19	209.90
ROYALTY		3.98	2.98
TOTAL MFG. COST		258.17	212.88

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RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4-22-57		Crumbatron - Color

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION:

21" Table Model - Mahogany wood
Chromatic Color System

MATERIAL			
CABINET		15.00	
CABINET ACCESSORIES		8.03	
CATHODE RAY TUBES		84.00	58.00
OTHER TUBES (26)		17.42	
SPEAKER		.84	
CHASSIS ASSEMBLY		70.53	
PACKING		2.26	
TOTAL		198.08	163.58
FREIGHT 1%		1.98	1.64
SPOILAGE 2%		3.96	3.28
TOTAL MATERIAL		204.02	168.50
LABOR			
ASSEMBLY LABOR			
APPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION		9.00	
SPEAKER		.01	
Spkr. Tools		.03	
GEN. DEVELOPMENT 2%		4.59	
TOOLS		3.00	
Gen. Tools		.69	
TOTAL P.E.C.E.		17.32	5.00
WARRANTY COSTS			
SET WARRANTY 1%		2.30	1.89
PICTURE TUBE WARRANTY		5.00	2.32
TOTAL WARRANTY		7.30	4.21

LIST PRICE		495.00	395.00
DISCOUNT		32.3%	
DISTRIBUTOR COST		335.00	267.42
EXCISE TAX		33.50	26.74
NET G.E. SELLING PRICE		301.50	240.68
GROSS MARGIN	DOLLARS	35.46	34.61
	PER CENT	11.8%	14.4%
QUANTITY		100M	1000M
COST SUMMARY			
MATERIAL		204.02	168.50
LABOR		11.50	9.50
I.M.E.		17.25	11.88
SHOP COST		232.77	189.88
P.E.C.E.		17.32	5.00
WARRANTY		7.30	4.21
EXTRA COST		5.15	3.98
MFG. COST LESS ROYALTY		262.54	203.07
ROYALTY		350	300
TOTAL MFG. COST		266.04	206.07

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING
E. K. Jacobs			

COST REDUCED AM COLOR RECEIVER

This report presents the findings of the latest effort to reduce the cost of an aperture mask color receiver that will still meet minimum performance standards. The design philosophy used in this investigation is based on the experience gained in the design and manufacture of the current production receiver and the several sample runs which preceded it. The competitive performance of the latest RCA standard and deluxe sets was also considered.

Several assumptions regarding the development of components were made and are explained below. The timing of the design and the accompanying developments are keyed to possible production in 1958. A schematic diagram and cost estimate for this design are included as a part of this report.

The major design considerations and the philosophy behind them are as follows:

I. PICTURE TUBE

The design would use the new RCA AM round glass tube. This tube having no exposed HV metal other than the anode button requires no expensive insulation as in the present receiver. The announced price is unchanged from the metal tube. It is anticipated that by 1958 the light output efficiency will be improved by virtue of larger aperture mask holes. The likelihood of this tube being available in 1958 is fair. We understand RCA is working on this approach.

II. HORIZONTAL SWEEP AND HV

These circuits are based on a HV capability of 20KV at 0.6ma as compared to 24KV at 1ma in our present production and 20KV at 1ma in the RCA receiver. No high voltage regulator is planned, at least in the leader models. Tests conducted on the current receiver without HV regulation indicate that this operation may be satisfactory. Non-regulated HV performance is aided by the lower beam current indicated above and the use of AC coupling in the Y signal which limits the variation of HV load with picture content. Without regulation, the convergence will be impaired slightly more at low line voltage than with regulation. This characteristic needs to be evaluated further and possible compensation schemes investigated.

All of the above considerations are valid only on the basis of the higher efficiency picture tube mentioned earlier. It is anticipated that the set would have brightness comparable to present RCA production. This design would permit sizeable cost reductions in the horizontal sweep, HV, and low voltage power supply.

It is intended that both electrical and mechanical design considerations would include sufficient flexibility to permit the manufacture of a step-up model which would completely utilize the pix tube brightness capabilities.

III. CONVIRGENCE

This circuit contains developments which will provide improved operation over the present receiver. The convergence unit on the pix tube neck would be considerably cost reduced by improved design provided quantity justified the necessary tooling.

IV. BLACK AND WHITE PERFORMANCE

The monochrome performance of this design would be virtually identical to present color production. These considerations include picture quality, sensitivity, sync stability, weak signal performance, and video drive capability. As indicated in the HV discussion, it is intended to use AC coupling in the Y signal.

V. AUDIO PERFORMANCE

Audio performance would bo approximately the same as present production. The design utilizes the 6DT6 sound detector with quieting sensitivity and AM rejection roughly comparable to the 21T500. Audio output would be about 1.5 watts at 10% instead of the present 2 watts. The reduction in available power is due to the B+ stacking employed to effect power supply economy.

VI. CHROMA PERFORMANCE

The chroma performance will be comparable to or better than present production. It is intended that improvement will be made in the chroma transients. Chroma drive and reserve gain would be the same as the current receiver.

VII. AGC CIRCUIT

The AGC circuit employs an amplified AGC system instead of the present keyer. This circuit has been evaluated in a current receiver. Performance is good at some reduction in cost.

VIII. HORIZONTAL AFC CIRCUIT

High performance has been maintained in this circuit because of the requirement of accurate burst gating. Lack of high voltage regulation imposes some additional requirements on the horizontal AFC circuit which have been provided for.

IX. TUBE COUNT

The schematic included with this report shows a total of 25 tubes including the pix tube. Careful chassis layout will permit an additional tube combination which would reduce the count to a total of 24.

X. MECHANICAL LAYOUT

Because of the reduction in tube count, it is planned to utilize one chassis in place of the present two. Single sided printed board construction would be used and would include all circuits except the power transformer and the horizontal sweep and HV. Having the horizontal circuits off the printed board would give the required flexibility for two models as indicated in the discussion on HV.

XI. COMPARISON WITH MONOCHROME PERFORMANCE

The design of this receiver takes cognizance of the fact that it must be an integral part of the complete TV line fitting into a top-of-the-line slot next to the U2 chassis. Fundamental operational characteristics such as sensitivity, picture quality, sync stability and AGC performance have not been compromised and are consistent with the rest of the TV line.

XII. PRELIMINARY COST ESTIMATE

The current estimate of the 21T500 shows the manufacturing cost to be 562.98. The net GE selling price of this model is $301.50. This results in a negative gross margin of $261.48. A preliminary estimate of the design described in this report costed on the same basis as the current 21T500 gives a manufacturing cost of $517.20. On the net GE selling price of $301.50 this results in a negative gross margin of $215.70.

On a quantity of 100,000 the preliminary estimate shows a manufacturing cost of $270.71. On the GE selling price of $301.50 a gross margin of +$30.79 results. Extending the quantity to 1,000,000 sets, the manufacturing cost becomes $208.60. This gives a gross margin of +$32.08 on a net GE selling price of $240.68. More detailed cost information is included in the preliminary cost estimate included with this report.

The following assumptions were made in the preparation of this cost estimate:

1. The picture tube, for the 40 per day and 100,000 quantity estimates, was entered at the current price of $83.30. For the 1,000,000 quantity, the price was projected to $53.00.

2. The total engineering budget charged against the color line for 100,000 sets is estimated at $1,749,000.

3. Quantity discounts of purchased material.

4. Manufacture our own yoke, convergence assembly and metal parts.

5. Cost reduction of components made feasible by the large quantity.

6. That equipment used to manufacture such items as the yoke could be used on subsequent chassis, due to the large capital outlay that would be necessary.

A cost estimate of the U chassis Model 21T056 is included with this report for comparison. Note: This set utilizes a metal cabinet.

T.V. Zaloudek

TV Zaloudek
Color TV Product Engineering
Room 303, Building 5

TVZ:erh

COPY

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
2-9-57		COLOR - OPTIMUM

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION:

21" Table Model - Mahogany Wood
AM Color TV - Glass Picture Tube
Optimum Chassis
20 KV High Voltage Supply

MATERIAL			
CABINET	17.50	15.00	
CABINET ACCESSORIES	9.27	8.03	
CATHODE RAY TUBES	83.30	75.00	53.00
OTHER TUBES	14.83	14.83	
SPEAKER	.84	.84	
CHASSIS ASSEMBLY	100.75	76.79	
PACKING	2.26	2.26	
TOTAL	228.75	201.05	170.00
FREIGHT 1%	2.29	2.01	
SPOILAGE	4.58	4.02	
TOTAL MATERIAL	235.62	207.08	
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION	77.60	9.00	
SPEAKER	.01	.01	
~~ELECTRONIC REPRODUCER~~ Tools	.03	.03	
GEN. DEVELOPMENT 15%	49.80	4.75	
TOOL MAINTENANCE	33.90	3.00	
Gen. Tools 1%	3.32	.70	
TOTAL P.E.C.E.	164.66	17.49	5.00
WARRANTY COSTS			
SET WARRANTY 1%	3.32	2.37	1.93
PICTURE TUBE WARRANTY	5.00	5.00	2.12
TOTAL WARRANTY	8.32	7.37	4.05

	40/day		
LIST PRICE	495.00	495.00	395.00
DISCOUNT	32.3%	32.3%	
DISTRIBUTOR COST	335.00	335.00	267.42
EXCISE TAX	33.50	33.50	26.74
NET G.E. SELLING PRICE	301.50	301.50	240.68
GROSS MARGIN DOLLARS	215.70	40.92	32.08
GROSS MARGIN PER CENT	71.5%	13.6%	13.3%
QUANTITY	3900	100M	1000M
COST SUMMARY			
MATERIAL	235.62	207.08	170.00
LABOR	25.00	12.00	10.00
I.M.E.	70.00	18.00	12.50
SHOP COST	330.62	237.08	192.50
P.E.C.E.	164.66	17.49	5.00
WARRANTY	8.32	7.37	4.05
EXTRA COST	10.07	5.24	4.03
MFG. COST LESS ROYALTY	513.67	267.18	205.58
ROYALTY	3.53	3.53	3.02
TOTAL MFG. COST	517.20	260.58	208.60

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

RTD-458-A-12 (10-56) BACK

QTY.	CHASSIS MATERIAL	3900	100M	
1	POWER TRANS.	7.000	6.00	
1	METALLIC RECTIFIERS	.473	.43	
1	OUTPUT TRANS.	.654	.46	
3	FUSE	.177	.18	
	TUNING CAPACITOR			
11	ELECTROLYTICS	3.724	3.50	
(	PAPER CAPACITORS			
91(	MICA CAPACITORS	5.305	4.90	
	CERAMIC CAPACITORS			
	H.V. CAPACITORS			
	BULPLATES			
2	TRIMMERS	.562	.30	
124	FIXED RESISTORS	3.565	3.49	
14	POTENTIOMETERS	4.019	3.93	
2	SWITCHES	.319	.25	
1	HEAD END (S.C. Less Tubes)	10.970	9.95	
x	WIRE CUTTING LIST	2.194	2.19	
1	POWER CORD	.151	.15	
1	VIDEO DET. TRANS.	1.160	1.04	
1x	OSC. COIL xxxxx Grid	.103	.09	
1	R.F. COILS xxxx Input Filter	1.540	1.54	
2	I.F. COILS	.134	.12	
1	FIL. TRANS. xxxx Tun. Coil	.224	.20	
1	REACTOR	1.000	1.00	
1	CENTERING RING xxxxxx Purity	.390	.20	
1	ION TRAP Blue Gun Mag	.290	.20	
23	CHOKE COILS	2.035	1.85	
1	HORIZ. SWEEP TRAN.	5.500	2.60	
1	DEFLECTION YOKE	15.980	10.00	
1	FOCUS COIL Vert. B.O.	.357	.34	
1	LINEARITY COIL Delay Line	.638	.50	
1	HORIZ. OSC. COIL	.260	.24	
4	HORIZ. SIZE COIL Audio & Peak Coils	.430	.43	
1	VERT. SWEEP TRANS.	1.210	1.10	
1	Cent. Mag	2.300	1.50	
2	Trap Coils	.210	.19	
2	Conv. Coil Pk.	6.284	B.00	
1	Sound TO Coil	.360	.25	
6	Beam Magnets	4.746	3.10	
2	Ret. Output Tr.	.707	.62	
Total	Electrical	84.971	65.84	
X	MISC.	5.000	4.00	
	CHASSIS M.P.			
34	OTHER METAL PARTS xxx	4.552	3.25	
23	SOCKETS/BOARDS xxxx	1.100	1.10	
2	FIN. PLATES/ADAPT Bds.	5.000	2.50	
7	TERM. STRIPS	.129	.10	
	SCALE DRIVE			
Total	Mechan'l	15.781	10.95	
TOTAL	CHASSIS MATERIAL	100.752	76.79	

QTY.	CABINET ACCESSORIES			
	DIAL SCALE			
1	BACK	.430	.50	
1	CAP	.158	.12	
2	ESCUTCHEON Over-lay	1.572	1.25	
10	KNOBS	.352	.35	
1	GLASS Safety	3.260	3.26	
	ANTENNA			
	DIAL WINDOW			
1	GRILLE Baffle	.055	.06	
	GRILLE CLOTH			
	DUST SEAL			
1	MASK	1.130	.80	
x	TUBE MTG. ASM.	.548	.45	
2	NAMEPLATE	.039	.04	
	MISC. HD'WARE			
	MISC. U.H.P.			
4	Channels	1.234	1.20	
1	Vent	.487		
	TOTAL ACCESSORIES	9.265	8.03	

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			

D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

COPY

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
1-28-57	of parts 631	21T056

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
B	3			Syracuse

DESCRIPTION:

21" Table Model - Mahogany Finish - Metal Cabinet
"U" Chassis - 4" Speaker
12 Position Cascode Head End
90° Es. Alum. Tube 21BTP4
Dark Glass - Conventional Top Tuning

Line Rate 656/Day

MATERIAL	21T056		
CABINET Illinois	$ 8.43		
CABINET ACCESSORIES	5.75		
CATHODE RAY TUBES Apt	17.88		
OTHER TUBES 13	8.27		
SPEAKER 4	.72		
CHASSIS ASSEMBLY	36.13		
PACKING	1.20		
TOTAL	78.38		
FREIGHT 1½%	1.18		
SPOILAGE 1½%	1.18		
TOTAL MATERIAL	80.74		
LABOR			
ASSEMBLY LABOR	3.58		
UNAPPLIED LABOR	1.33		
COL 2½%	.12		
TOTAL LABOR	5.03		
P.E.C.E.			
D.A. LIQUIDATION	.45		
SPEAKER Specific	.01		
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT 1%	.93		
TOOLS MAINTENANCE	.75		
Tools Gen. 3%	.28		
Tools Speaker			
TOTAL P.E.C.E. 3%	.02		
	2.44		
WARRANTY COSTS			
SET WARRANTY 1%	.93		
PICTURE TUBE WARRANTY	.600		
TOTAL WARRANTY	$ 1.53		

	21T056	UHF Installed	UHF 21T056
LIST PRICE			
DISCOUNT			
Net Billing Price	126.72		144.54
EXCISE TAX	12.67		14.45
NET G.E. SELLING PRICE	114.05		130.09
Income From Sales DOLLARS	4.26		7.64
Income From Sales PER CENT	3.7%		5.9%
QUANTITY	15500		
COST SUMMARY			
MATERIAL	80.74		
LABOR	5.03		
I.M.E. 135%	6.79		
SHOP COST	92.56		
P.E.C.E.	2.44		
WARRANTY	1.53		
EXTRA COST 2%	1.93		
MFG. COST LESS ROYALTY	98.46		
ROYALTY	1.07		
TOTAL MFG. COST	99.53	11.21	110.74

Memo:

VHF	Dollars	Per Cent
Gross Margin	$14.52	12.7%
C & A Expense	$10.26	9.0%
UHF		
Gross Margin	$19.35	14.9%
C & A Expense	$11.71	9.0%

Labor content of components $1.35
IME content of components $2.73

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

RTD-458-A-12 (1-57) BACK

QTY.	CHASSIS MATERIAL	21T056		
1	POWER TRANS.	$ 3.740		
	METALLIC RECTIFIERS			
1	OUTPUT TRANS. Audio	.458		
2	FUSE	.155		
	TUNING CAPACITOR			
4	ELECTROLYTICS 7 Sect	1.738		
15	PAPER CAPACITORS	1.171		
1	MICA CAPACITORS	..081		
39	CERAMIC CAPACITORS	1.438		
1	XXXXXXGlob.Res.	.050		
3	BULPLATES	.189		
	TRIMMERS			
74	FIXED RESISTORS	1.439		
7	POTENTIOMETERS	1.150		
	SWITCHES			
1	HEAD END (S.C. Less Tubes)	9.180	(2 tubes-$1.613)	
105	WIRE CUTTING LIST	.769		
1	POWER CORD	.151		
1	VIDEO DET. TRANS.	.577		
	OSC. COIL			
	R.F. COILS			
3	I.F. COILS	.344		
	FIL. TRANS.			
1	REACTOR	.453		
1	CENTERING RING	.122		
1	ION TRAP	.084		
9	CHOKE COILS	.436		
1	HORIZ. SWEEP TRAN.	3.100	(1B3GT-$653.00)	
1	DEFLECTION YOKE	2.320	90° Make	
	FOCUS COIL			
	LINEARITY COIL			
1	HORIZ. OSC. COIL Stab. XXXXCoil	.129		
	HORIZ. SIZE COIL			
1	VERT. SWEEP TRANS.	.905		
2	Germ. Diodes	.440		
	Ratio Det.	.383		
1	47.25 T Coil	.135		
1	Vert.Bl.Osc.	.340		
1	Aud.T.O.Coil	.230		
242	MISC.	1.410		
	CHASSIS M.P.			
9	OTHER METAL PARTS	1.115		
14	SOCKETS/BOARDS	.567		
	PIN PLATES/ADAPT			
	TERM. STRIPS	.006		
	SCALE DRIVE			
2	Pr.Cir.Bds.	1.285		
1	Ant. Term Bd.	.036		
TOTAL	CHASSIS MATERIAL	$36.126		

QTY.	CABINET ACCESSORIES	21T056		
	DIAL SCALE			
1	BACK	.184		
1	CAP	.043		
1	ESCUTCHEON	.889		
6	KNOBS	.329		
1	GLASS T.Temp	1.870		
	ANTENNA			
	DIAL WINDOW			
	GRILLE			
	GRILLE CLOTH			
	DUST SEAL			
1	MASK	.538		
2	TUBE MTG. ASM.	.590		
1	NAMEPLATE	.035		
33	MISC. HD'WARE	.233		
	MISC. U.H.F.			
1	Cab.Support	.041		
4	Glass Channels	.680		
1	Vent	.316		
	TOTAL ACCESSORIES	5.748		

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			

D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

COPY

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4/2/57	of parts 1128	21T500

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
B	11			Syracuse

DESCRIPTION:

21" Table Model - Mahogany
AM Color TV - 21AXP22 Picture Tube
"H" Chassis
1956 - 1957 Program

Line Rate 40/Day

MATERIAL	21T500		
CABINET Bethlehem	17.50		
CABINET ACCESSORIES	9.30		
CATHODE RAY TUBES	83.30		
OTHER TUBES 25	17.86		
SPEAKER 5¼	.84		
CHASSIS ASSEMBLY	121.74	*	
PACKING	2.26		
Corona Reg.	7.50		
TOTAL	260.30		
FREIGHT 1%	2.60		
SPOILAGE 2%	5.21		
TOTAL MATERIAL	268.11		
LABOR			
ASSEMBLY LABOR	16.41		
UNAPPLIED LABOR	8.12		
VARIANCE	3.27		
TOTAL LABOR	27.80		
P.E.C.E.			
D.A. LIQUIDATION	77.60		
SPEAKER Specific	.01		
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT 15%	55.64		
TOOL MAINTENANCE	34.65		
Gen. Tools 1%	3.71		
Sprk. Tools	.03		
TOTAL P.E.C.E.	171.64		
WARRANTY COSTS			
SET WARRANTY 1%	3.71		
PICTURE TUBE WARRANTY	5.00		
TOTAL WARRANTY	$ 8.71		

		21T500	UHF Installed	UHF 21T500
LIST PRICE				
DISCOUNT				
Net Billing Price		$335.00		$354.00
EXCISE TAX		33.50		35.40
NET G.E. SELLING PRICE		301.50		318.60
GROSS MARGIN	DOLLARS	277.87		270.70
	PER CENT	92.2%		85.0%
QUANTITY		3900	All	Models
COST SUMMARY				
MATERIAL		268.11		
LABOR		27.80		
I.M.E.		75.00		
SHOP COST		370.91		
P.E.C.E.		171.64		
WARRANTY		8.71		
EXTRA COST		24.63		
MFG. COST LESS ROYALTY		575.89		
ROYALTY		3.48		
TOTAL MFG. COST		579.37	9.93	589.30

* Two tubes with total value of $1.66 are included in Chassis Assembly
Labor content of components is $2.23

FINAL ESTIMATE

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

458-A-12 (10-56) BACK

QTY.	CHASSIS MATERIAL		21T500	
1	POWER TRANS.		9.080	
1	Chroma Cl.		.473	
1	OUTPUT TRANS. Audio		.654	
6	FUSE		.526	
2	Germ. Diode		.440	
21	ELECTROLYTICS Sections		6.738	
39	PAPER CAPACITORS		3.748	
3	MICA CAPACITORS		1.977	
9	CERAMIC CAPACITORS		1.562	
1	H.V. CAPACITORS		1.900	
1	HV Resistor		.500	
4	TRIMMERS		.992	
155	FIXED RESISTORS		4.697	
9	POTENTIOMETERS		4.844	
2	SWITCHES		.319	
1	HEAD END (S.C. Less Tubes)		10.970	
x	WIRE CUTTING LIST		2.434	
1	POWER CORD		.151	
1	VIDEO DET. TRANS.		1.160	
1	Ratio Det.		.374	
1	Xtal Filter		1.540	
3	I.F. COILS		.484	
	Xtal Tun. Coil		.224	
	REACTOR		1.376	
1	Purity Ring		.390	
1	Blue Gun Magnet		.290	
29	CHOKE COILS		2.690	
1	HORIZ. SWEEP TRAN.		5.500	
1	DEFLECTION YOKE		15.980	
1	Vert. Blocking Osc.		.357	
1	Delay Coil		.638	
1	HORIZ. OSC. COIL		.260	
	HORIZ. SIZE COIL			
1	VERT. SWEEP TRANS.		1.210	
1	Centering Mag.		2.300	
3	Trap Coils		.307	
2	Converg. Coil & Pack		6.284	
1	Sound T.O. Coil		.360	
	Beam Magnets		4.746	
2	Ref. Output Trans.		.707	
	Total Electrical		99.182	
x	MISC.		5.352	
	CHASSIS M.P.			
33	OTHER METAL PARTS		4.696	
26	SOCKETS/BOARDS		1.200	
2	Prtd. Bds.		5.400	
7	TERM. STRIPS		.129	
1	Insul. Cone		2.290	
	Insul. Ring (Mag)		1.140	
1	Insul. Ring (Anode)		2.350	
	Total Mechanical		22.557	
TOTAL	CHASSIS MATERIAL		121.739	

QTY.	CABINET ACCESSORIES		21T500	
	DIAL SCALE			
1	BACK		.430	
1	CAP		.158	
2	ESCUTCHEON & Overlay		1.572	
10	KNOBS		.355	
1	GLASS Safety		3.260	
	ANTENNA			
	DIAL WINDOW			
1	GRILLE Baffle		.055	
	GRILLE CLOTH			
	DUST SEAL			
1	MASK		1.130	
x	TUBE MTG. ASM.		.548	
2	NAMEPLATE		.039	
8	MISC. HD'WARE		.034	
	MISC. U.H.F.			
4	Channel		1.234	
1	Vent		.487	
	TOTAL ACCESSORIES		$9.302	

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			
D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

COPY

KTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
4-2-57	of parts 1125	21C700

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
B	11			Syracuse

DESCRIPTION

21" Console Model - Mahogany
AM Color TV - 21AXP22 Picture Tube
"H" Chassis
1956-1957 Program

MATERIAL	21C700		
CABINET Bethlehem	$ 29.00		
CABINET ACCESSORIES	9.23		
CATHODE RAY TUBES	83.30		
OTHER TUBES 25	17.86		
SPEAKER 8"	1.79		
CHASSIS ASSEMBLY	121.74 *		
PACKING	2.63		
Corona Reg.	7.50		
TOTAL	273.05		
FREIGHT 1%	2.73		
SPOILAGE 2%	5.46		
TOTAL MATERIAL	281.24		
LABOR			
ASSEMBLY LABOR	16.41		
UNAPPLIED LABOR	8.12		
VARIANCE	3.27		
TOTAL LABOR	27.80		
P.E.C.E.			
D.A. LIQUIDATION	77.60		
SPEAKER Specific	.03		
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT 15%	57.61		
TOOLS MAINTENANCE	34.65		
Gen. Tools 1%	3.84		
Spkr. Tools	.05		
TOTAL P.E.C.E.	173.78		
WARRANTY COSTS			
SET WARRANTY 1%	3.84		
PICTURE TUBE WARRANTY	5.00		
TOTAL WARRANTY	$ 8.84		

	21C700	UHF Installed	UHF 21C700
LIST PRICE			
DISCOUNT			
Net Billing Price	$ 385.00		$ 404.00
EXCISE TAX	38.50		40.40
NET G.E. SELLING PRICE	346.50		363.60
GROSS MARGIN DOLLARS	249.35		242.18
GROSS MARGIN PER CENT	72.0%		66.6%
QUANTITY	3900	All	Models
COST SUMMARY			
MATERIAL	281.24		
LABOR	27.80		
I.M.E.	75.00		
SHOP COST	834.04		
P.E.C.E.	173.78		
WARRANTY	8.84		
EXTRA COST	24.93		
MFG. COST LESS ROYALTY	591.59		
ROYALTY	4.26		
TOTAL MFG. COST	595.85	9.93	605.78

*Two tubes with total value of 31.66 are included in Chassis Assembly

Labor content of components is $2.23

FINAL ESTIMATE

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

RTD-458-A-12 (10-56) BACK

QTY.	CHASSIS MATERIAL		21C700	
1	POWER TRANS.		9.080	
1	xxxxxxxxxx Chroma C.T.		.473	
1	OUTPUT TRANS. Audio		.654	
6	FUSE		.526	
2	xxxxxxxxxx Germ. Diode		.440	
21	ELECTROLYTICS Sections		6.738	
39	PAPER CAPACITORS		3.748	
33	MICA CAPACITORS		1.977	
39	CERAMIC CAPACITORS		1.562	
1	H.V. CAPACITORS		1.900	
1	xxxxx H.V. Resistor		.500	
4	TRIMMERS		.992	
155	FIXED RESISTORS		4.697	
19	POTENTIOMETERS		4.844	
2	SWITCHES		.319	
1	HEAD END (S.G.) xxxxxx		10.970	
x	WIRE CUTTING LIST		2.434	
1	POWER CORD		.151	
1	VIDEO DET. TRANS.		1.160	
1	xxxx Ratio Det.		.374	
1	xxxx Xtal Filt.		1.540	
3	I.F. COILS		.484	
1	xxxx Xtal Tun. Coil		.224	
2	REACTOR		1.376	
1	xxxxxxxx Purity Ring		.390	
1	ION TRAP Blue Gun Magnet		.290	
29	CHOKE COILS		2.690	
1	HORIZ. SWEEP TRAN.		5.500	
1	DEFLECTION YOKE		15.980	
1	xxxxxx Vert. Block Osc.		.357	
1	xxxxxxx Delay Coil		.638	
1	HORIZ. OSC. COIL		.260	
	HORIZ. SIZE COIL			
1	VERT. SWEEP TRANS.		1.210	
1	Centering Ring Mag.		2.300	
3	Trap Coils		.307	
2	Converg. Coil & Pack		6.284	
1	Sound T.O. Coil		.360	
6	Beam Magnets		4.746	
2	Ref. Output Trans.		.707	
	Total Electrical		99.182	
X	MISC.		5.252	
	CHASSIS M.P.			
33	OTHER METAL PARTS		4.696	
26	SOCKETS/BOARDS		1.200	
2	xxxxxxxx Printed Bds.		5.400	
7	TERM. STRIPS		.129	
1	xxxxxx Insul Cone		2.290	
1	Insul Ring (Mag)		1.140	
1	Insul Ring (Anode)		2.350	
	Total Mechanical		22.557	
TOTAL	CHASSIS MATERIAL		$121.739	

QTY.	CABINET ACCESSORIES		21C700	
	DIAL SCALE			
1	BACK		$ .430	
1	CAP		.158	
2	ESCUTCHEON & Overlay		1.572	
10	KNOBS		.355	
1	GLASS Safety		3.260	
	ANTENNA			
	DIAL WINDOW			
	GRILLE			
	GRILLE CLOTH			
	DUST SEAL			
1	MASK		1.130	
x	TUBE MTG. ASM.		.548	
2	NAMEPLATE		.039	
x	MISC. HD'WARE		.008	
	MISC. U.H.F.			
4	Channel		1.234	
1	Vent		.487	
1	Hole Cover		.004	
	TOTAL ACCESSORIES		$ 9.225	

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			

D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

COPY

RTD-458-12 (1-57) TELEVISION RECEIVER DEPT.	DATE 4-2-57			D.A. NUMBER of parts 1125		MODEL NUMBER 21C701
	CLASS B	ISSUE 11	BANDS		CHANNELS	MANUFACTURING PLANT Syracuse

DESCRIPTION:

21" Console Model - Walnut
AM Color TV - 21AXP22 Picture Tube
"H" Chassis
1956-1957 P

MATERIAL	21C701		
CABINET Bethlehem	$ 31.25		
CABINET ACCESSORIES	9.23		
CATHODE RAY TUBES	83.30		
OTHER TUBES 25	17.86		
SPEAKER 8"	1.79		
CHASSIS ASSEMBLY	121.74*		
PACKING	2.66		
Corona Reg.	7.50		
TOTAL	275.33		
FREIGHT 1%	2.75		
SPOILAGE 2%	5.51		
TOTAL MATERIAL	283.59		
LABOR			
ASSEMBLY LABOR	16.41		
UNAPPLIED LABOR	8.12		
VARIANCE	3.27		
TOTAL LABOR	27.80		
P.E.C.E.			
D.A. LIQUIDATION	77.60		
SPEAKER Specific	.03		
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT 15%	57.96		
TOOLS	34.65		
Gen. Tools 1%	3.86		
Sprk. Tools	.05		
TOTAL P.E.C.E.	174.15		
WARRANTY COSTS			
SET WARRANTY 1%	3.86		
PICTURE TUBE WARRANTY	5.00		
TOTAL WARRANTY	$ 8.86		

		21C701	UHF Installed	UHF 21C701
LIST PRICE				
DISCOUNT				
Net Billing Price (DISTRIBUTOR COST)		$395.00		$ 414.00
EXCISE TAX		39.50		41.40
NET G.E. SELLING PRICE		355.50		372.60
GROSS MARGIN	DOLLARS	243.31		236.14
	PER CENT	68.4%		63.4%
QUANTITY		3900	All	Models
COST SUMMARY				
MATERIAL		283.59		
LABOR		27.80		
I.M.E.		75.00		
SHOP COST		386.39		
P.E.C.E.		174.15		
WARRANTY		8.86		
EXTRA COST		24.99		
MFG. COST LESS ROYALTY		594.39		
ROYALTY		4.42		
TOTAL MFG. COST		$598.81	$9.93	$608.74

*Two tubes with total value of $1.66 are included in Chassis Assembly
Labor content of components is $2.23

FINAL ESTIMATE

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

RTD-458-A-12 (10-56) BACK

QTY.	CHASSIS MATERIAL		21C701	
1	POWER TRANS.		$ 9.080	
1	~~xxxxxxxxx~~ Chroma Cl.		.473	
1	OUTPUT TRANS. Audio		.654	
6	FUSE		.526	
2	~~xxxxxxxxxx~~ Germ. Diode		.440	
21	ELECTROLYTICS Sections		6.738	
39	PAPER CAPACITORS		3.748	
33	MICA CAPACITORS		1.977	
39	CERAMIC CAPACITORS		1.562	
	H.V. ~~CAPACITORS~~ Resistor		1.900	
1	~~DUMMIES~~		.500	
4	TRIMMERS		.992	
155	FIXED RESISTORS		4.697	
19	POTENTIOMETERS		4.844	
2	SWITCHES		.319	
1	HEAD END ~~xxxxxxxx~~		10.970	
x	WIRE CUTTING LIST		2.434	
1	POWER CORD		.151	
1	VIDEO DET. TRANS.		1.160	
1	~~OSC. COIL~~ Rat. Det.		.374	
1	~~R.F. COILS~~ Xtal Filt.		1.540	
3	I.F. COILS		.484	
1	~~xxxxx~~ Stal Tun. Coil		.224	
2	REACTOR		1.376	
	~~CENTERING RING~~ Purity Ring		.390	
1	~~ION TRAP~~ Bl. Gun Mag.		.290	
29	CHOKE COILS		2.690	
1	HORIZ. SWEEP TRAN.		5.500	
1	DEFLECTION YOKE		15.980	
1	~~FOCUS COIL~~ Vert. Bl. Osc.		.357	
1	~~LINEARITY COIL~~ Delay Coil		.638	
1	HORIZ. OSC. COIL		.260	
	HORIZ. SIZE COIL			
1	VERT. SWEEP TRANS.		1.210	
1	Centering Mag.		2.300	
3	Trap Coils		.307	
2	Converg. Coil & Pack		6.284	
1	Sound T.O. Coil		.360	
6	Beam Magnets		4.746	
1	Ref. Output Trans.		.707	
	Total Electrical		99.182	
x	MISC.		5.352	
	CHASSIS M.P.			
33	OTHER METAL PARTS		4.696	
26	SOCKETS/BOARDS		1.200	
2	~~PIN-PLATES/ADAPT~~ Printed Bds.		5.400	
7	TERM. STRIPS		.129	
1	~~SCALE DRIVE~~ Insul. Cone.		2.290	
1	Insul Ring (Mag)		1.140	
1	Insul Ring. (Anode)		2.350	
	Total Mechanical		$22.557	
TOTAL	CHASSIS MATERIAL		$121.739	

QTY.	CABINET ACCESSORIES		21C701	
	DIAL SCALE			
1	BACK		$ .430	
1	CAP		.158	
2	ESCUTCHEON & Overlay		1.572	
10	KNOBS		.355	
1	GLASS Safety		3.260	
	ANTENNA			
	DIAL WINDOW			
	GRILLE			
	GRILLE CLOTH			
	DUST SEAL			
1	MASK		1.130	
x	TUBE MTG. ASM.		.548	
2	NAMEPLATE		.039	
x	MISC. HD'WARE		.008	
	MISC. U.H.F.			
4	Channel		1.234	
1	Vent		.487	
1	Hole Oover		.004	
	TOTAL ACCESSORIES		$ 9.225	

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			

D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

CIRCUIT BY CIRCUIT COSTS - COLOR RECEIVER

("H" - CHASSIS)

6-5-57

This report is the result of the attempt which was made to proportion all costs of the "H" chassis production color receiver into individual circuits and further to show how much of each total properly was due to monochrome and to color. Previous cost analyses have been such that it was not possible to determine how much certain individual functions cost.

The basis for this analysis is the Cost Estimating Unit's cost sheet which is the result of very detailed unit costs. This cost sheet was based on 3,900 unit production. Using this cost sheet as a base, some price revisions were estimated by E.K. Jacobs and new costs determined under the following assumptions:

1. 1,000,000 unit production.
2. The high voltage regulator was deleted.
3. No picture tube insulation included (assumed glass tube).
4. Resistor prices were unchanged.
5. Potentiometers, coils, transformers and electrolytics were reduced 5% to 20%.
6. Stand-up capacitors were given the same cost as equivalent standard paper capacitors.

The costs are broken down into 16 different circuits. Each circuit has its cost broken down into three more areas. One is the electrical component cost, another the material cost other than electrical components and the last is all other costs. In addition each of these areas is broken down into monochrome costs and color costs. Since in some circuits all costs are either for monochrome or color, the total manufacturing cost of the receiver is distributed in about 70 different portions. This is sufficiently fine to allow a good analysis of circuit costs to be made.

Some explanation of how the costs were proportioned is in order. First, the electrical components were assigned to the proper circuits and further separated into monochrome and color portions. Percentages of each subdivision were calculated with respect to the total electrical component cost. Where certain costs were to be proportioned into only some of the 16 circuits, percentages were calculated with respect to the total electrical component cost of the circuits over which this proportioning was desired.

The following total amounts of money were distributed as indicated.

A. Material other than electrical components.

1.	Specific metal parts - assigned to specific circuits.	$1.65
2.	Specific wire cutting - assigned to specific circuits.	1.04
3.	Horizontal printed board - distributed proportionally into circuits 7, 8, 9, 10, 13.	1.25
4.	Vertical printed board - distributed proportionally into circuits 2, 3, 4, 5, 6, 11, 12.	1.21
5.	General metal parts and hardware-assigned proportionally into all circuits except 14 and 15.	5.64
6.	General wire cutting - assigned proportionally into all circuits except 14 and 15.	1.40

7.	Tube sockets - assigned @ $.03 each for all tubes except picture tube which is $.30.	$1.06
8.	Packing - assigned proportionally into all circuits.	2.26
9.	Cabinet - assigned proportionally into all circuits.	15.00
10.	Cabinet accessories - assigned proportionally into all circuits.	8.03
	Sub-total	$38.54
11.	Freight - 1% of sub-total plus cost of electrical components - assigned proportionally into all circuits.	1.85
12.	Spoilage - 2% of sub-total plus cost of electrical components - assigned proportionally into all circuits.	3.70
	Total	$44.09

B. All other costs

1.	Labor - assigned proportionally into all circuits.	$10.00
2.	IME (125%) - assigned proportionally into all circuits.	12.50
3.	PECE - assigned proportionally into all circuits except 1 and 14.	5.00
4.	Warranty - $2.12 assigned to picture tube - $1.93 assigned proportionally into all circuits except 14.	4.05
5.	Extra costs - assigned proportionally into all circuits.	4.03
6.	Royalty - assigned proportionally into all circuits.	3.02
	Total	$38.60

The results are summarized in the following block diagram. This shows the 16 circuits with the monochrome cost in the solid blocks and the additional for color in the dotted blocks. The total circuit cost is obtained by adding the amounts in the solid and dotted blocks for the circuit. The sheets following the block diagram give details on the circuits in each block.

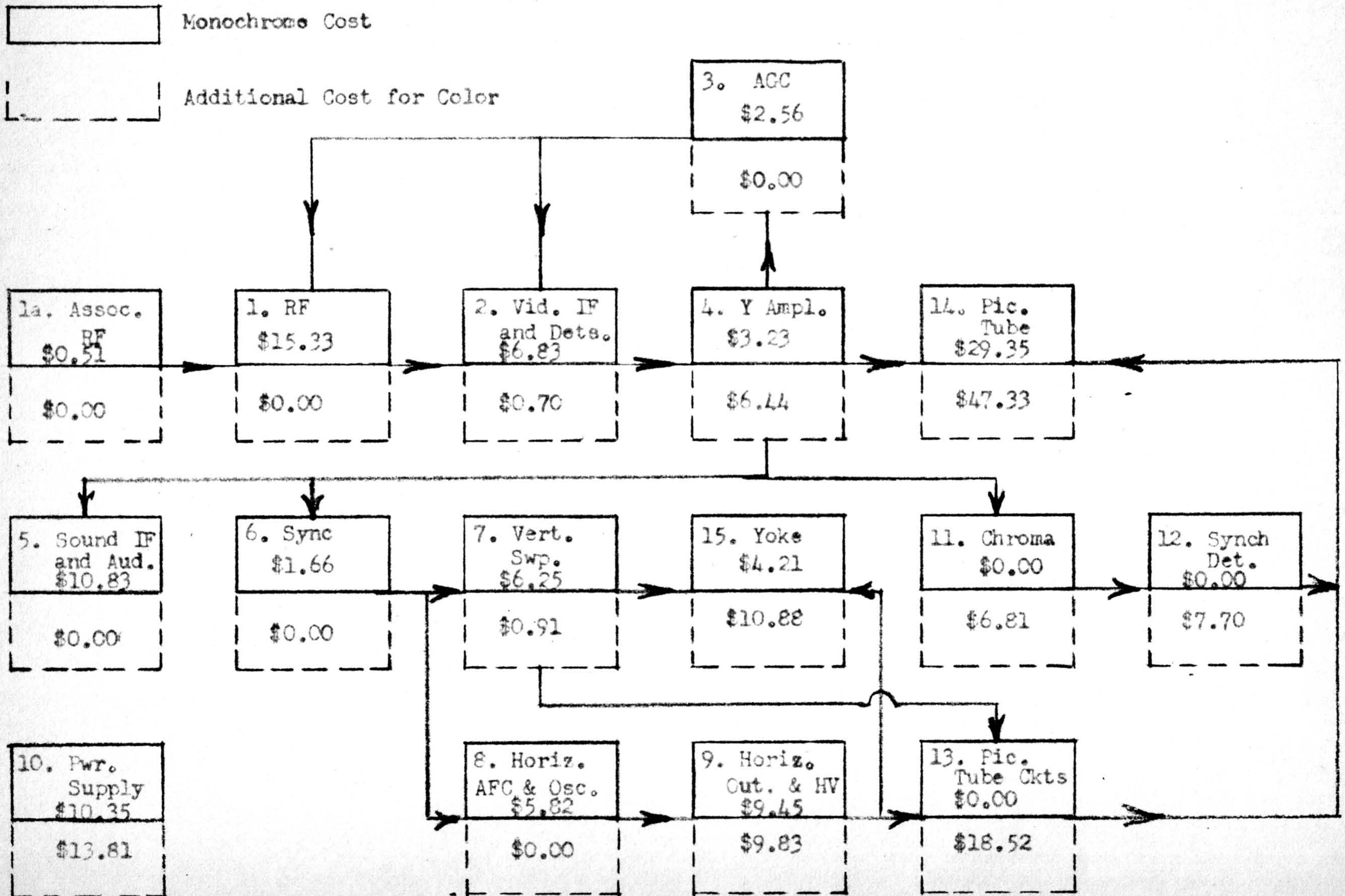
Finally, Table I shows how each circuit cost is broken down with respect to electrical components, other material and other costs. Table II shows total material and manufacturing cost.

JRL 6/5/57

J. R. Locke
Receiver Analysis Specialist

JRL:RFL

See attached sheets for more detailed content of blocks.



BLOCK DIAGRAM - COST BREAKDOWN

JRL 6/5/57

J. R. Locke
6/5/57

CONTENTS OF BLOCKS IN BLOCK DIAGRAM

1. RF Unit - This is the purchased part and is charged to monochrome.

1a. Associated with RF Unit - Includes the local - distance switch, attenuating resistors, antenna RC isolation and RF B+ filtering. All are charged to monochrome.

2. Video IF and Detectors - Includes all parts from output of RF unit through the two second detectors. All parts are charged to monochrome except those required for the 4.5 MC second detector and the additional 41.25 MC trap which are charged to color.

3. AGC - Includes all parts associated with AGC and all are charged to monochrome.

4. Y Amplifier - This includes all parts from the video second detector through to the cathodes of the picture tube. Those parts up to the grid of the cathode follower plus the brightness circuit are charged to monochrome and the remainder are charged to color (cathode follower, delay line, DC control circuit, contrast and drive controls, etc.).

5. Sound IF and Audio - This includes all parts from the 4.5 MC second detector load resistor through the speaker and all charges are to monochrome.

6. Sync - This includes all parts from the take-off at the cathode follower through the clipper-noise canceller circuit (6BY6) and all charges are to monochrome.

7. Vertical Sweep - This includes all parts from the clipper plate to, but not including, the yoke. All parts are charged to monochrome except ½ - 6BL7 and part of the sweep output transformer which are charged to color.

8. Horiz. AFC and Osc. - This includes all parts from the clipper plate to the output tubes grids and all charges are to monochrome.

9. Horiz. Output and HV - This includes all parts from the output tubes to, but not including, the yoke, plus the high voltage and focus circuits. One ouput tube, one damper, part of the sweep output transformer and part of the high voltage rectifier are charged to monochrome. One sweep output tube, one damper, part of the sweep output transformer, part of the high voltage rectifier and the focus circuit are charged to color. The H.V. regulator has been excluded from the cost.

10. Power Supply - This includes all parts, which are common to more than one circuit, which supply power at 400 V DC or lower. One rectifier tube, the CLC π filter for 250 V DC, the circuit from AC plug to the transformer primary and part of the power transformer are charged to monochrome. The remaining parts are charged to color (two rectifier tubes, the CLC filter for 400 V DC, part of the power transformer, some filament filtering and some RC filtering).

11. Chroma - This includes all parts for the chroma take-off, burst gate, crystal filter and the reference amplifier (not including the plate circuit) and all parts are charged to color.

12. Synchronous Detectors - This includes the plate circuit of the reference amplifier, the two synchronous detectors and the three color difference amplifiers, with their coupling circuits. All parts are charged to color.

13. Picture Tube Circuits - This includes all parts for convergence and controls, centering magnet, purity ring, blue gun positioning magnet, magnet assembly and G1 and G2 controls. All parts are charged to color.

14. Picture Tube - Part of the cost is charged to monochrome and the remainder is charged to color.

15. Yoke - Part of the cost is charged to monochrome and the remainder is charged to color.

JRL 6/5/57

J. R. Locke
Receiver Analysis Specialist

JRL:RL

Table I

Circuit	Electrical Components			Other Material Pack, Freight, Spoil.			All Other Costs		
	Mono	Add For Color	Mono & Color	Mono	Add For Color	Mono & Color	Mono	Add For Color	Mono & Color
1. RF Unit	$ 9.66	$ -	$ 9.66	$ 3.52	$ -	$ 3.52	$ 2.15	$ -	$ 2.15
1a. Assoc. RF Unit	.31	-	.31	.11	-	.11	.09	-	.09
2. Vid. IF & Det.	3.73	.41	4.14	2.05	.17	2.22	1.05	.12	1.17
3. AGC	1.44	-	1.44	.72	-	.72	.40	-	.40
4. Y Ampl.	1.90	4.07	5.97	.79	1.23	2.02	.54	1.14	1.68
5. Sound IF, Aud.	6.24	-	6.24	2.83	-	2.83	1.76	-	1.76
6. Sync	.97	-	.97	.42	-	.42	.27	-	.27
7. Vert. Swp.	3.73	.58	4.31	1.47	.16	1.63	1.05	.17	1.22
8. Horiz. to Out. Tube	3.47	-	3.47	1.37	-	1.37	.98	-	.98
9. Horiz. beyond Out. Tube	5.46	6.05	11.51	2.45	2.07	4.52	1.54	1.71	3.25
10. Power Supply	6.20	8.82	15.02	2.40	2.51	4.91	1.75	2.48	4.23
11. Chroma	-	4.04	4.04	-	1.63	1.63	-	1.14	1.14
12. Synch. Det.	-	4.76	4.76	-	1.60	1.60	-	1.34	1.34
13. Pic. Tube Ckt.	-	11.77	11.77	-	3.43	3.43	-	3.32	3.32
14. Pic. Tube	19.50	33.50	53.00	5.32	5.56	10.88	4.53	8.27	12.80
15. Yoke	2.70	7.30	10.00	.75	1.52	2.27	.76	2.06	2.82
Total	65.31	81.30	146.61	24.20	19.88	44.08	16.87	21.75	38.62

Table II

Circuit	Total Material			Mfg. Cost		
	Mono	Add For Color	Mono & Color	Mono	Add For Color	Mono & Color
1. RF Unit	$13.18	$ -	$ 13.18	$ 15.33	$ -	$ 15.33
1a. Assoc. RF Unit	.42	-	.42	.51	-	.51
2. Vid. IF & Det.	5.78	.58	6.36	6.83	.70	7.53
3. AGC	2.16	-	2.16	2.56	-	2.56
4. Y Ampl.	2.69	5.30	7.99	3.23	6.44	9.67
5. Sound IF, Aud.	9.07	-	9.07	10.83	-	10.83
6. Sync	1.39	-	1.39	1.66	-	1.66
7. Vert. Swp.	5.20	.74	5.94	6.25	.91	7.16
8. Horiz. to Out. Tube	4.84	-	4.84	5.82	-	5.82
9. Horiz. beyond Out. Tube	7.91	8.12	16.03	9.45	9.83	19.28
10. Power Supply	8.60	11.33	19.93	10.35	13.81	24.16
11. Chroma	-	5.67	5.67	-	6.81	6.81
12. Synch. Det.	-	6.36	6.36	-	7.70	7.70
13. Pic. Tube Ckt.	-	15.20	15.20	-	18.52	18.52
14. Pic. Tube	24.82	39.06	63.88	29.35	47.33	76.68
15. Yoke	3.45	8.82	12.27	4.21	10.88	15.09
Total	89.51	101.18	190.69	106.38	122.93	229.31

Report No. 57
11/1/56

Development Engineering
Television Receiver Dept.

Miscellaneous Investigation Report

Post Acceleration Color Tube Status on 10/30/56

By: W. E. Good

The status of the post acceleration color tube from an application and performance point of view, based on operating experience with both internal sandwich and phosphor on the face plate post acceleration color tubes, is as follows:

Brightness: 40 foot lamberts (Crayon Boy) can be obtained through a 50% ultra-vision glass at 25 KV - 230 ua (screen current; 280 ua cathode current; 5.8 W screen power + 0.4 W psi power). (80 foot lamberts through clear glass). (Aperture Mask - AM - 27 foot lamberts (Crayon Boy) @ 25 KV - 360 ua; 9 watts - screen and mask power). The post acceleration tube gives three times the brightness with less HV power than the AM tube.

Convergence or Registration: The post acceleration tube appear to be an easier tube to converge because of the in-line gun arrangement. This puts all corrections into perpendicular axes rather than in the triangular system of AM. It also permits some corrections to be built into the yoke. Today, only linear sawtooth voltages at horizontal and vertical rates are required for basic registration (raster size correction) and these are obtained directly from the yoke currents. Convergence, equal to or better than the AM can be obtained with the above two waveforms and a small amount of vertical parabola. Thus for dynamic convergence of PA, 5 adjustments are required; for AM 9 adjustments are required. Recent work by CRT on shielding the individual beams from the back yoke field shows promise of "building in" the basic raster size corrections so that the five adjustments will be reduced to second order ones which make them less critical and consequently more stable. An estimate of what may be achieved by optimizing yoke compensation and beam shielding, leads one to believe that the convergence of the red and blue rasters will be within 1/8 of an inch of the green raster before dynamic waveforms are applied.

Definition and Contrast Ratio (haze): Pictures on PA appear soft compared to AM. This now attributed primarily to the poor small-area contrast-ratio rather than to poor focus guns.

Small area contrast ratio measurements indicate PA to be half as good as AM. (PA 8 to 1 contrast ratio; AM 14 to 1 contrast ratio - typical condition, but not the most severe). The poor contrast ratio is due to the haze generated by high energy secondary electrons emitted from the phosphor screen and being returned to the phosphor screen by the post acceleration field. A halo extends out around each bright spot to a radius of about 1½ inches. Beyond this distance the large area or ultimate contrast ratio is comparable to AM (140 to 1).

Haze has other bad effects. In addition to reducing small area contrast ratio and reducing apparent definition, it causes desaturation of the primary colors due to its uniform illumination of all of the phosphor stripes. In fact, the color of the haze is determined by the relative efficiencies of the three phosphors. Colored haze (usually blue) degrades the colorimetry of the picture particularly in low brightness areas adjacent to bright areas. This one effect can be reduced by choosing the tint of the filter glass to equalize the effective phosphor efficiencies and make the haze grey. All measurements and observations indicate that the haze must be reduced by at least 2 to 1 and preferably 3 to 1 to be competitive. Experimental coating materials have been shown to be capable of a 3 to 1 improvement although none as yet have withstood the rigors of bake-out.

Little loss of definition is attributed to the presence of the grill or line structure (at 28 lines per inch) or to the secondary electrons from the grill itself.

Color Saturation: The saturation is poorer than the AM tube because of the effects of haze. Haze must be reduced at least 2 to 1 for equivalent and satisfactory performance.

Purity: Many of the hand made samples have been capable of producing three simultaneous pure color fields, with some minor fringing impurities at the very edges. This is certainly the first step but for commercial application of this tube we need at least half of the theoretical purity or psi tolerance, in order to take care of earth's magnetic field effects and for long and short time circuit variations. We should be able to live with a ≤ 2% psi tolerance. A simple magnetic shield will probably be required in addition to coils for controlling the vertical and axial field through the tube. No magnet belt is visualized at this time.

Grey Scale and Color Temperature: No basic difficulties, other than those attributable to the presence of haze, have been encountered in the adjustment of the grey scale and in setting a desired color temperature. The grey scale stability in later tubes has been good.

Grill Wire Vibration: Most of the tubes have had damper bars and wire vibration has been at a very minimum. Later samples show very small perceptability of the damper bar shadow itself.

Phosphor on the Faceplate: The phosphor on the faceplate version of PA gives a more pleasing picture than the internal sandwich tube. The POF tube will probably need no pincushion correction. The reduction of optical reflections is a definite advantage.

W. E. Good

WEG:REL
CC: JF McAllister
DE Harnett
RB Dome
GA Schupp
TV Zaloudek
DW Pugsley
DE Garrett

Syracuse - March 8, 1957

The purpose of this analysis is to develop a particular servo color system, the Apple System, in such a way as to provide some insight into the nature of the problem. Other servo systems will differ from the "Apple" chiefly in the mechanism used to obtain a position signal which can be fed back to the signal processing circuits in order to control color rendition.

This description is aimed primarily at those engineers such as the chemists who may not be familiar with circuit principles. To avoid an excessively long presentation it will be best if those readers who are unfamiliar with such topics as gamma correction for non-linear transfer characteristics, modulation and mixer action, and Fourier analysis get in touch with me for a brief blackboard session. This minimum background will be assumed in the text that follows.

The interesting development as given here by starting with a dot sequential system was suggested by a lecture series given in Bldg. 5.

W. Rublack

/fmd

W. Rublack

The color camera equipment is operated in such a manner that the signal voltages derived (E_r, E_g, and E_b) are of equal magnitude for a white field. In all that follows it is to be assumed that the signal voltages are gamma corrected. Although the signals are not transmitted in this form they could be resynthesized in the receiver if required. Let the reproducing screen consist of vertical stripes of red, green and blue emitting phosphors suitably balanced so that a d.c. scan produces a white field. The simplest scheme (in principle) is to sequentially sample the simultaneous color information as shown in Figure 1. For the present it must be assumed that some means is available to synchronize the sampling with the instantaneous beam position on the screen to maintain proper color rendition. The angular sampling frequency (ω_W) must be related to the writing period, that is, the time required for the beam to scan a distance equal to the screen pitch.

The signal obtained under ideal sampling conditions when only red information is present is shown in Figure 2. Fourier analysis of this signal, taken with respect to the center of a red stripe, yields the first series expression of equation (1),

$$\begin{aligned} E = \; & E_R\left[0.333 + 0.551 \cos(\omega_w t) + 0.276 \cos 2(\omega_w t) + \ldots\right] \\ & + E_G\left[0.333 + 0.551 \cos(\omega_w t - 120^\circ) + 0.276 \cos 2(\omega_w t - 120^\circ) + \ldots\right] \\ & + E_B\left[0.333 + 0.551 \cos(\omega_w t - 240^\circ) + 0.276 \cos 2(\omega_w t - 240^\circ) + \ldots\right] \end{aligned} \qquad (1)$$

If only green information were present, the series expression would be of the same form except for a phase delay of $2\pi/3$ or 120°. This yields the second term in (1). The signal in general which may consist of contributions of all three primary colors will be given by (1) in its entirety. For a monochrome field $E_R = E_G = E_B$ so that equation (1) reduces to,

$$E_M = 1/3(E_R + E_G + E_B) = E_R = E_G = E_B \qquad (2)$$

For a constant luminance white signal this implies a d.c. scan of constant magnitude.

It should be noted that the signal voltages are applied to the C.R. tube that is suitably biased to cut-off for zero signal. The voltage E is not the grid voltage but voltage above cut-off.

In order to produce the response shown an infinite bandwidth is obviously required. At the expense of screen efficiency, the use of a fractional duty cycle makes the square wave response unnecessary. As a first approximation assume that the upper limit of the bandwidth of the amplifier in Figure 1 is just sufficient to pass the fundamental (first harmonic) terms of (1). In the practical tube this writing frequency is approximately 6.4mc. The signal applied to the grid of the tube will have the reduced form,

$$\begin{aligned} E_1 = \; & E_R\left[0.333 + 0.551 \cos(\omega_w t)\right] \\ & + E_G\left[0.333 + 0.551 \cos(\;\text{"}\; - 120^\circ)\right] \\ & + E_B\left[0.333 + 0.551 \cos(\;\text{"}\; - 240^\circ)\right] \end{aligned} \qquad (3)$$

The reduced signals for a pure red field and also for a particular yellow (for which $E_R = E_G$) are shown in Figure 3. The light output indicated by the shaded areas differs in form from the grid signal due to the power law gun characteristic. It is obvious that desaturation has resulted even for a duty cycle of 1/2. We shall refer back to this expression (3) for signal E_1 repeatedly in what follows.

A better approximation is necessary if the desaturation due to limited bandwidth is to be reduced. The extent of desaturation depends not only on the gamma characteristic and the duty cycle but also upon the spot size and its growth with current. Therefore only the nature of the saturation correction will be dealt with here.

First consider an expression similar to (3) in which the coefficients of the fundamental terms have been increased from 0.551 to unity,

$$\begin{aligned} E_2 &= E_R\left[0.333 + \cos(\omega_w t)\right] \\ &+ E_G\left[0.333 + \cos(\omega_w t - 120^\circ)\right] \\ &+ E_B\left[0.333 + \cos(\omega_w t - 240^\circ)\right] \end{aligned} \qquad (4)$$

To obtain the sum of the fundamental terms expand them by using the usual formula,

$$E \cos(\omega_w t - \alpha) = E \cos\omega_w t \cdot \cos\alpha + E \sin\omega_w t \cdot \sin\alpha$$

The sum of the three terms can then be put in the form,

$$a \cos\omega_w t + b \sin\omega_w t$$

which is one term of a general Fourier series. It can be written as a single cosine function with a phase angle θ, in the form $S \cos(\omega_w t + \theta)$ where,

$$S = \sqrt{a^2 + b^2} \qquad \theta = -\tan^{-1}(b/a)$$

For equation (4) we have,

$$E_2 = 1/3\,(E_R + E_G + E_B) + S\cos(\omega_w t + \theta) \qquad (5)$$

where,

$$S = \sqrt{E_R^2 + E_G^2 + E_B^2 - E_R E_G - E_R E_B - E_G E_B} \qquad (6)$$

$$\theta = \tan^{-1}\left\{\frac{\sqrt{3}(E_G - E_B)}{2E_R - E_G - E_B}\right\} \qquad (7)$$

The amplitude (S) of the cosine term is a measure of the saturation since, from (6), it is zero for a white field. Also from (6) we see that S/3 is equal to the d.c. level for any pure primary color. If the quantity S/3 is subtracted from the right hand side of (5), the signal will be unaltered for white fields but the signal for

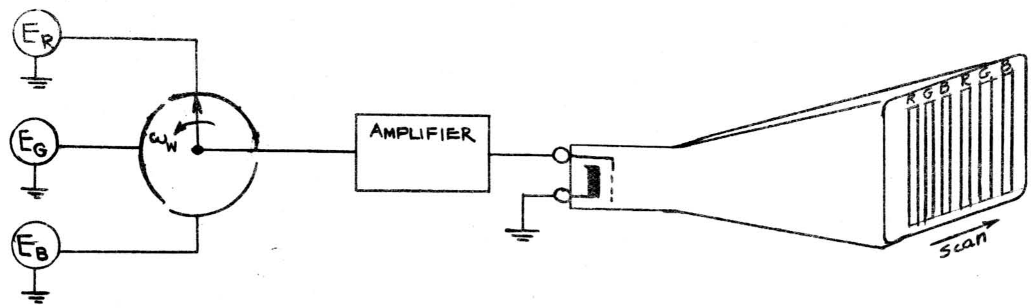


Figure 1 - Dot sequential sampling scheme.

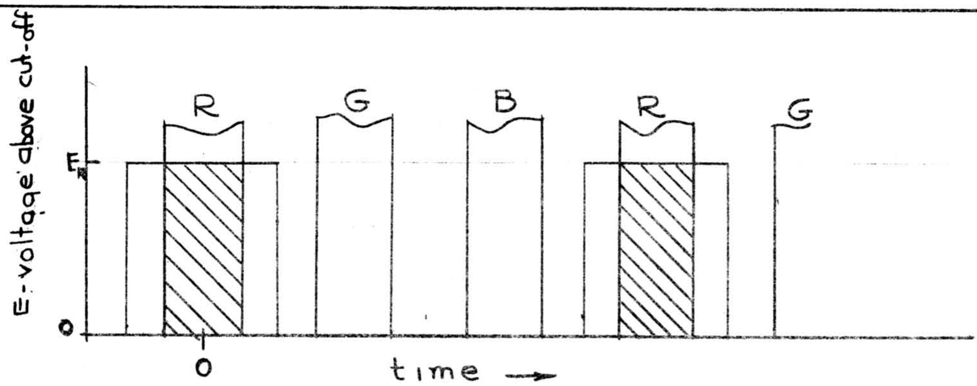


Figure 2 - Signal with ideal sampling conditions. Shaded areas represent light output.

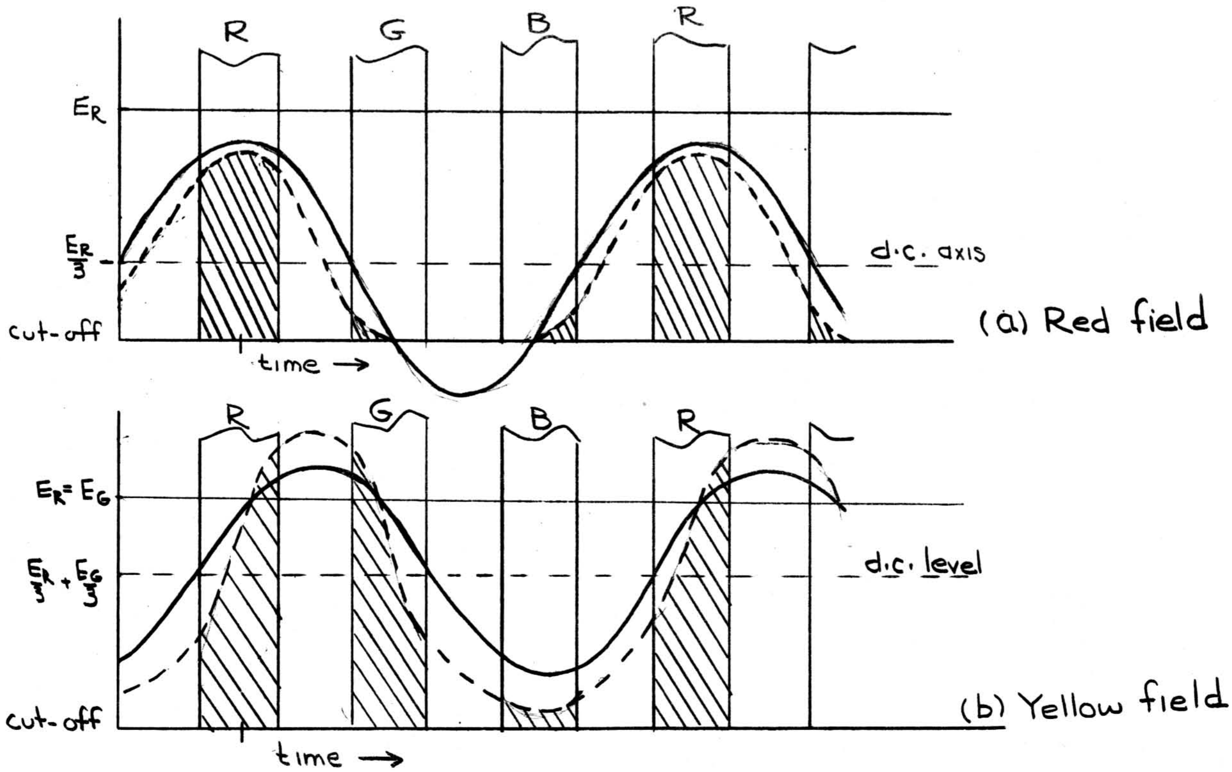


Figure 3 - Reduced signal E_1. Shaded areas represent light output.

a pure primary color will be a cosine function with zero d.c. level, ie, the d.c. level will occur at cut-off voltage if the tube is properly biased. The desired signal with the saturation correction becomes

$$E_2 = 1/3(E_R + E_G + E_B) + S \cos(\omega_w t + \theta) - 1/3\, S \qquad (8)$$

As before,

$$E_M = 1/3(E_R + E_G + E_B)$$

The signals and light output for a pure red field and a yellow field are shown in Figure 4. The required signal processing could be carried out as shown in Figure 5 where correction for the envelope function S is made.

Having developed the desired form of signal it is now necessary to determine how synchronization may be obtained. Our requirement is a position signal, that is, a sinusoid whose phase bears a known relation to the position of the scanning beam relative to the phosphor stripes. Such a signal will have the form $\cos(\omega_w t + \phi)$ where ϕ may be a function of the time.

Assume that index stripes of a high secondary emitting material are located in a known position relative to the red phosphor stripes but on the gun side of the aluminum film. If a d.c. beam were to scan normal to these stripes the secondary emission would display a series of pulses as a function of the time. The angular frequency of pulse recurrence would be ω_w. If the secondary current were collected and passed thru on impedance it would generate a voltage of the form,

$$E_S = a + a_1 \cos(\omega_w t + \phi) + a_2 \cos 2(\omega_w t + \phi) + \ldots \qquad (9)$$

If this signal were passed thru an amplifier and limiter of restricted bandwidth we would obtain the desired position signal $\cos(\omega_w t + \phi)$. Normally the phase angle ϕ would be function of the electron transit time which varies with the position of the beam on the tube screen. By proper design however, the transit time variation can be compensated for when developing the printing pattern for the index stripes.

In actual practice the writing beam which also contains a 6.4mc signal would contribute to the output and would contaminate the desired signal. Therefore it is necessary to modulate the pilot beam with a high frequency signal which is an odd multiple of one-half the writing frequency to minimize interference from the writing frequency or its harmonics which will be produced. The index structure of the tube then acts as a mixer and the output consists of the sum and difference components of the high frequency pilot beam and the position signal as shown in a general way in Figure 6. The extraction of the position signal from the sum component will be discussed later.

Having obtained the position signal, the processing shown in Figure 7 may be used to sample the color information. The proper sampling frequency is provided by the position signal itself and the maintenance of the proper phase insures desired hue control. The output of the scheme in Figure 7 will be the phase

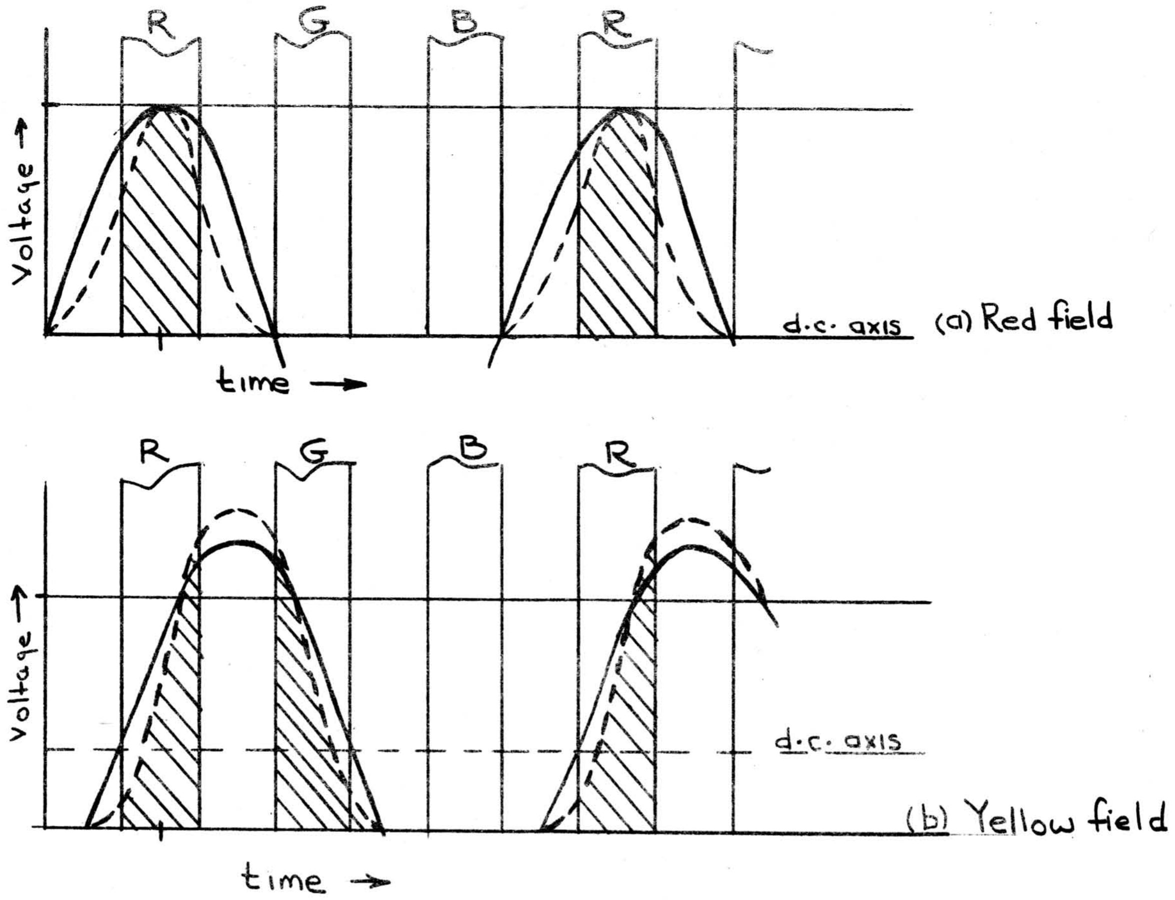


Figure 4 - Signals with saturation correction (E_2)

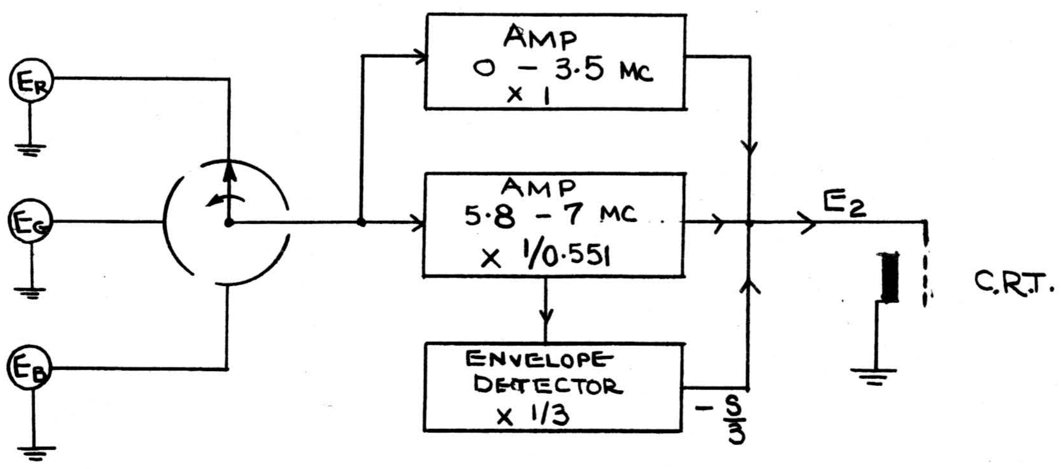


Figure 5 - Circuit used to obtain saturation correction.

corrected form of E_1, equation (3),

$$E_1 = E_R\left[0.333 + 0.551 \cos(\omega_w t + \phi)\right] + E_G\left[0.333 + 0.551 \cos(\omega_w t + \phi - 120^o)\right] + E_B\left[0.333 + 0.551 \cos(\omega_w t + \phi - 240^o)\right] \quad (10)$$

Applying the saturation correction to this signal will yield the phase corrected signal similar to (8).

The N.T.S.C. signal is not transmitted in the form $E_R + E_G + E_B$ but in the form,

$$E_{NTSC} = E_Y + E_Q \sin(\omega_c t + 33^o) + E_I \cos(\omega_c t + 33^o) \quad (11)$$

in order to provide a luminance signal E_Y for monochrome sets and to provide chrominance signals E_Q and E_I. These signals are defined in terms of E_R, E_G and E_B,

$$E_Y = .30\, E_R + .59\, E_G + .11\, E_B$$

$$E_Q = .48\,(E_R - E_Y) + .41\,(E_B - E_Y)$$

$$E_I = .74\,(E_R - E_Y) - .27\,(E_B - E_Y) \quad (12)$$

The chrominance signals E_Q and E_I modulate a subcarrier (of frequency $\omega_c/2\pi = 3.58$mc) in 90° phase quadrature. The N.T.S.C. signal could be expressed directly in terms of E_R, E_G, and E_B in the form,

$$E_{NTSC} = E_R\left[.300 + .632 \cos(\omega_c t)\right] + E_G\left[.590 + .593 \cos(\omega_c t + 137^o)\right] + E_B\left[.110 + .447 \cos(\omega_c t + 244^o)\right] \quad (13)$$

Thus the N.T.S.C. signal has a form very similar to signal E_1, equation (3), except for the d.c. terms, the carrier frequency and the sign of the phase differences. The latter two differences are easily resolved by proper circuitry and will be discussed later.

We may rewrite expression (13) as the sum of the luminance signal and the chrominance signal,

$$E_{NTSC} = E_Y = (.300\, E_R + .590\, E_G + .110\, E_B) \quad (14a)$$

$$+E_C = E_R[.632 \cos(\omega_c t)] + E_G[.593 \cos(\omega_c t + 137^o)] + E_B[.447 \cos(\omega_c t + 244^o)] \quad (14b)$$

Since the luminance signal required for balanced phosphors with N.T.S.C. coordinates is E_M, for accurate reproduction we must apply a luminance correction to the

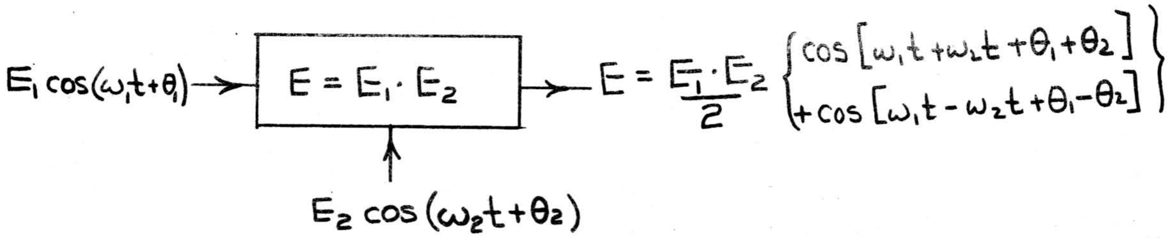


Figure 6 - Action of a mixer.

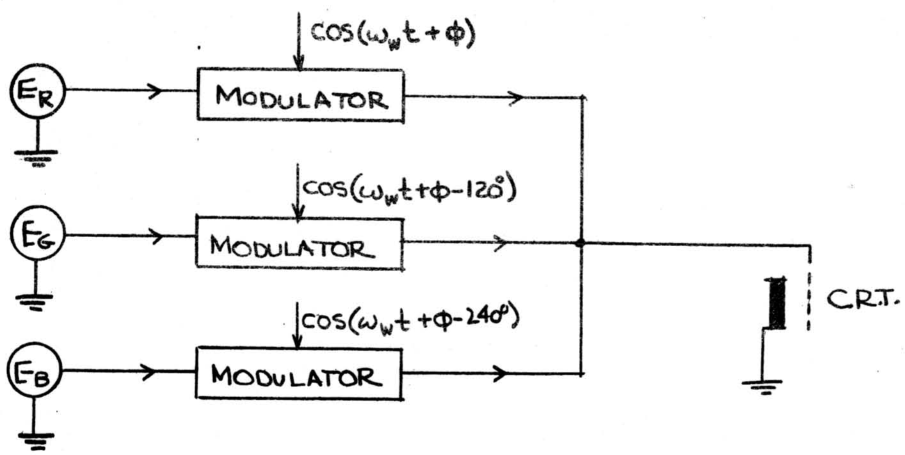


Figure 7 - Possible modulation scheme to obtain the harmonic terms of signal E_1'

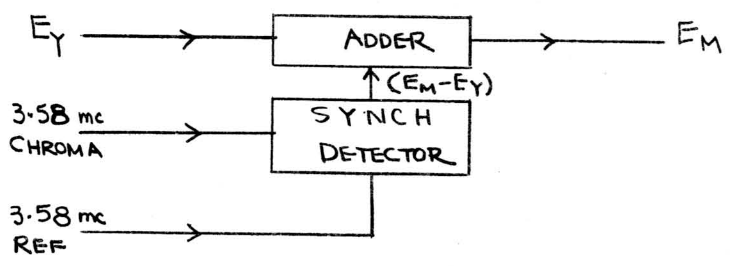
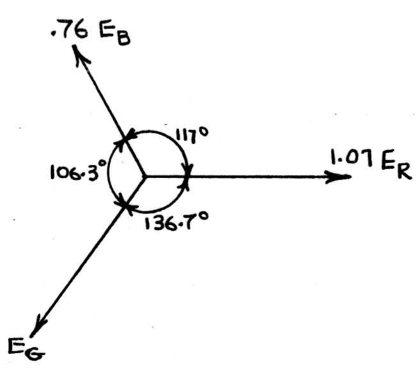
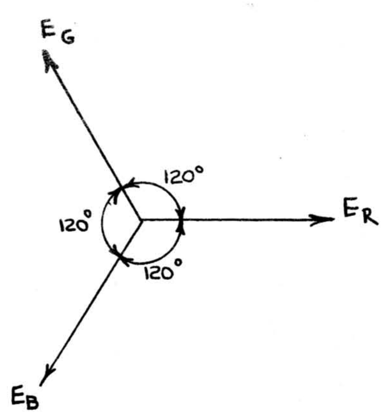


Figure 8 - Circuit for luminance correction



(a) NTSC Chrominance Signal
$\omega_c/2\pi$ = 3.58 MC



(b) Desired Signal
$\omega_w/2\pi$ = 6.4 MC

Figure 9

N.T.S.C. signal. This can be simply done by adding to E_Y the quantity $(E_M - E_Y)$ which can be made available by using a synchronous chroma detector. Since,

$$E_M = .33\ E_R + .33\ E_G + .33\ E_B$$

$$E_Y = .30\ E_R + .59\ E_G + .11\ E_B \quad (15)$$

we have

$$(E_M - E_Y) = .03\ E_R - .26\ E_G + .22\ E_B \quad (16)$$

The coefficients in (16) should sum to sero. Therefore we may subtract E_Y from each primary voltage in (16) and obtain,

$$(E_M - E_Y) = .03\ (E_R - E_Y) - .26\ (E_G - E_Y) + .22(E_B - E_Y)$$

Since the coefficients in (15) sum to unity we have,

$$0 = .30\ (E_R - E_Y) + .59\ (E_G - E_Y) + .11\ (E_B - E_Y)$$

or

$$(E_G - E_Y) = -.51\ (E_R - E_Y) - .19\ (E_B - E_Y)$$

Then,

$$(E_M - E_Y) = .16\ (E_R - E_Y) + .27\ (E_B - E_Y) \quad (17)$$

This signal can be obtained from the synchronous detector with a suitable matrix circuit as indicated in Figure 8. Note that the detected I and Q signals are $(E_R - E_Y)$ and $(E_B - E_Y)$ signals in disguise (see equation 12).

The chrominance signal E_c (14b) consists of three terms although chrominance information consists of only two quantities. The signal E_c is shown in vector form in Figure 9a. The three vectors cannot all be independent and an analysis of the vector diagram would show that any one vector is equal to a diagonal of the parallelogram defined by the other two. The desired chrominance signal is shown in Figure 9b. The angular deviations between the two signals are small and it is customary to neglect them. The deviations could be compensated for by printing the color stripes with corresponding irregularity.

Since the recent practice has been to meglect the luminance correction and the saturation correction they will not be included in the block circuit diagram about to be described. Since the saturation correction has been omitted, it implies that proper reproduction of saturated colors is not too important. Omission of the luminance correction does not alter reproduction of white areas since for white fields $E_Y = E_M$. Note that for this case there is no chrominance information so that the output (M-Y) from the synchronous detector must be zero. However in color rendition, blue fields (such as lake water) will be rendered too dark while green portions will be excessively bright.

The signal processing circuits of the Apple receiver are shown in Figure (10). A pilot oscillator is used to produce a high frequency signal ($\omega_p/2\pi$ = 38.1mc)

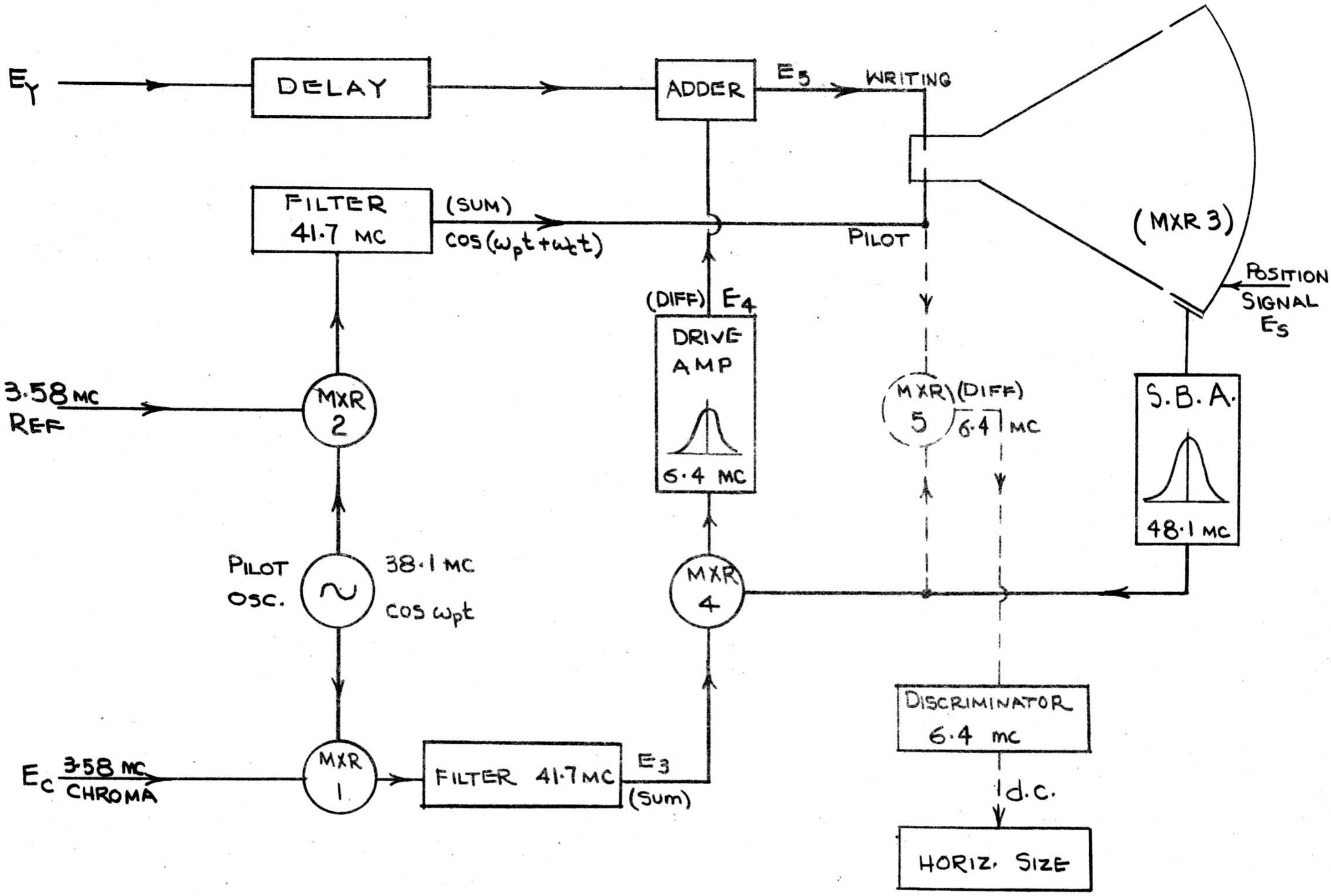


Figure 10 - Block diagram of Apple System signal processing.

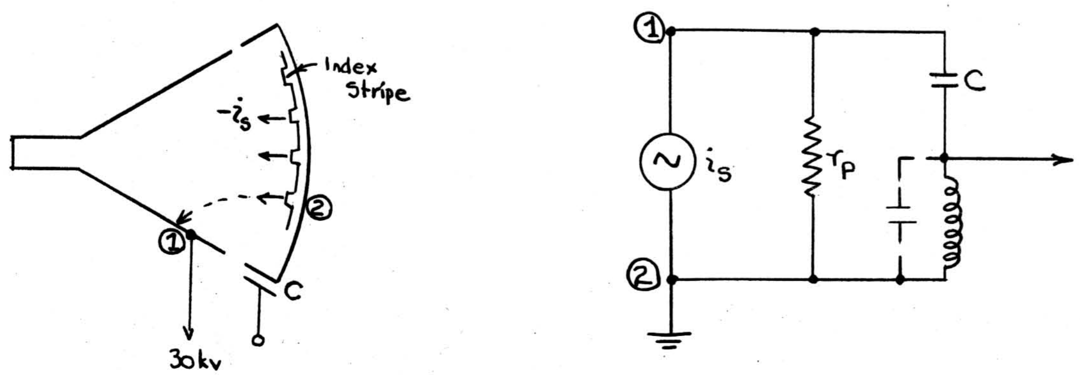


Figure 11 - Scheme for extracting the position signal.

of arbitrary phase θ_p. This is mixed with the reference subcarrier ($\omega_c/2\pi$ = 3.58mc) whose phase is controlled by a transmitter burst. The sum component $\cos(\omega_p t + \omega_c t + \theta_p + \theta_c)$ is fed to the pilot beam. Due to the mixing action of the stripe structure of the tube, the position signal (9) is injected. The sum component $\cos(\omega_p t + \omega_c t + \omega_w t + \theta_p + \theta_c + \phi)$ passes thru the sideband amplifier tuned to 48.1 ± 1mc. If the sideband amplifier is too sharply tuned it will produce a large phase error for small frequency deviations.

A separate pilot beam is necessary for several reasons. The high frequency pilot signal cannot be added to the video signal of the writing beam because the C.R. tube is a non-linear device ($i_p = e_g^{2.2}$). This would produce intermodulation distortion between the two signals and therefore could give rise to spurious frequencies which may be passed through the sideband amplifier. Furthermore, the writing beam will often swing below cut-off and it would be preferable to maintain the pilot beam at a fixed amplitude. This can be best carried out by having a separate beam.

The output of the pilot oscillator is also mixed with the N.T.S.C. chrominance signal E_c (14b) and the sum component is selected,

$$\begin{aligned} E_3 = \; & E_R\left[.632\cos(\omega_c t + \omega_p t + \theta_c + \theta_p)\right] \\ & + E_G\left[.593\cos(\omega_c t + \omega_p t + \theta_c + \theta_p + 137^\circ)\right] \\ & + E_B\left[.447\cos(\omega_c t + \omega_p t + \theta_c + \theta_p + 244^\circ)\right] \end{aligned} \tag{18}$$

The output of the sideband amplifier is mixed with E_3 and the difference signal is selected,

$$\begin{aligned} E_4 = \; & E_R\left[.632\cos(\omega_w t + \phi)\right] \\ & + E_G\left[.593\cos(\omega_w t + \phi - 137^\circ)\right] \\ & + E_B\left[.447\cos(\omega_w t + \phi - 244^\circ)\right] \end{aligned} \tag{19}$$

The signal has the proper frequency and contains the phase information. Except for the luminance terms it compares with the desired signal E_1 (10). Depending on the fidelity desired the signal E_4 can be added to either E_M or E_Y. In the latter case the signal becomes,

$$\begin{aligned} E_5 = \; & E_R\left[.300 + .632\cos(\omega_w t + \phi)\right] \\ & + E_G\left[.590 + .593\cos(\omega_w t + \phi - 137^\circ)\right] \\ & + E_B\left[.110 + .447\cos(\omega_w t + \phi - 244^\circ)\right] \end{aligned} \tag{20}$$

which is fed to the writing grid of the tube.

It is desirable to maintain the writing frequency as constant as possible so that the sideband amplifier which is tuned to this frequency introduces a minimum phase error. For this reason a stripe pattern should be used that compensates for the variation in sweep speed across the tube face. It is important that the sweep width remain constant in spite of line voltage fluctuations, etc. Therefore a width servo is introduced as shown by the dashed lines in Figure 10. The 6.4mc output of the mixer is fed to a discriminator which supplies a d.c. signal to control the horizontal size. If the frequency exceeds 6.4mc the horizontal size is decreased and vice versa.

The high frequency position signal is extracted from the C.R. tube by a conductive band applied onto the panel skirt which forms a capacitative coupling. This is fed to a tuned circuit across which the signal voltage is developed. This tube and its equivalent circuit (current generation) is shown in Figure 11.

THIRD ANGLE PROJECTION

REVISIONS	MATERIAL	PAT. MLD. DIE
	DRAWN BY R. B. Dome	
	INSPECTED 1-7-57	FIRST MADE FOR APPLE INDEX

FIRST CALLED FOR ON

MFG. PROCESS OR FINISH NO.

PRINTS TO

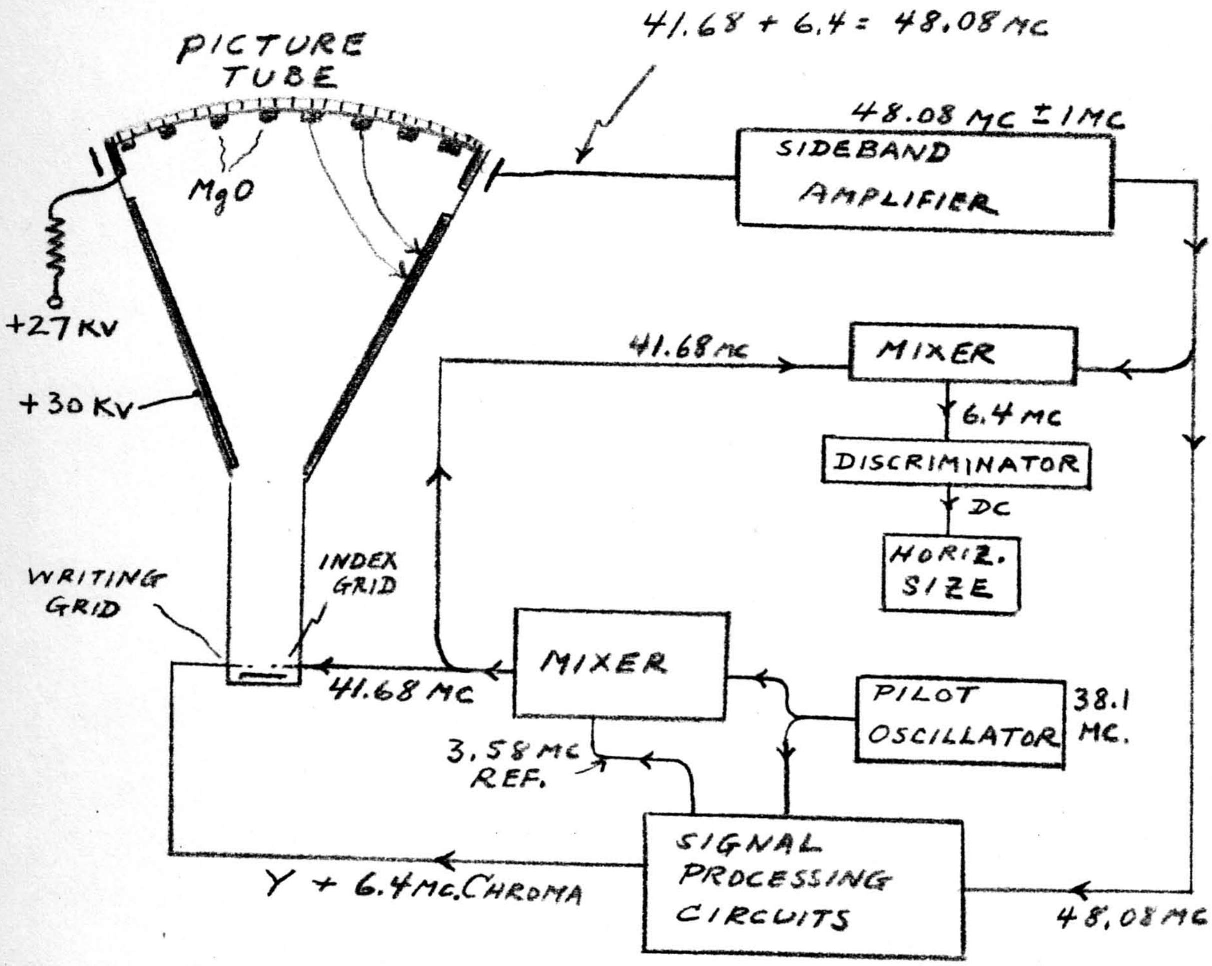


FIG. 1

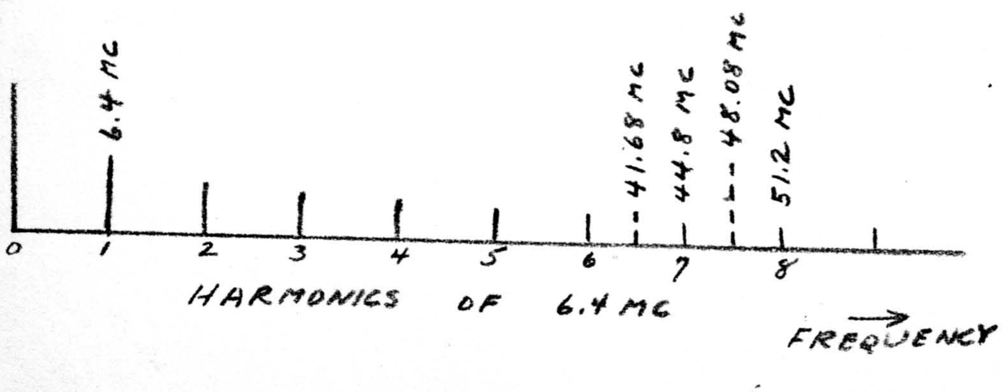


FIG. 2

GENERAL ELECTRIC

DIVISION

WORKS

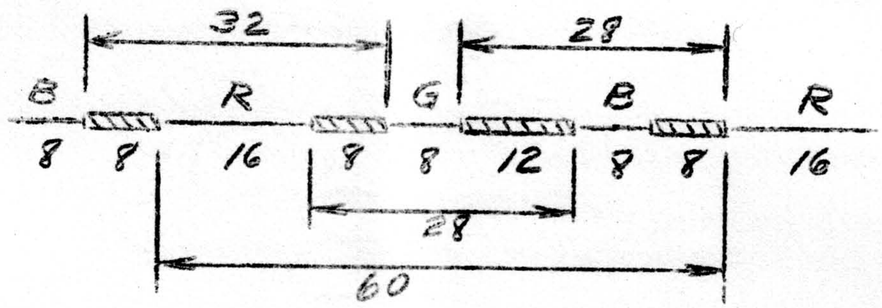
REPORT ON APPLE PAPERS AT THE IRE CONVENTION

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.

Report on Apple Papers

II. <u>Accuracy of Color Reproduction in the Apple System</u> - 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. <u>An Advanced Color Television Receiver Using a Beam Indexing Picture Tube</u> - 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.

Rreliminary 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

ETD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

COPY

DATE	D.A. NUMBER	MODEL NUMBER
3-12-57		Crabapple

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				Syracuse

DESCRIPTION:

Color TV
Crabapple Chassis
21" Table Model - Mahogany Wood

MATERIAL			
CABINET	19.00	16.25	
CABINET ACCESSORIES	10.05	8.60	
CATHODE RAY TUBES	62.00	48.00	41.00
OTHER TUBES	28.06	28.06	
SPEAKER	.84	.84	
CHASSIS ASSEMBLY	108.38	85.25	
PACKING	2.50	2.50	
TOTAL	230.83	189.50	
FREIGHT 1%	2.31	1.90	
SPOILAGE 2%	4.62	3.79	
TOTAL MATERIAL	237.76	195.19	180.00
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION	77.60	9.00	
SPEAKER	.01	.01	
ELECTRONIC REPRODUCER spkr. tools	.03	.03	
GEN. DEVELOPMENT 15%	50.29	4.53	
TOOL MAINTENANCE	33.90	3.00	
Gen. Tools 1%	3.35	2.26	
TOTAL P.E.C.E.	165.18	18.83	5.00
WARRANTY COSTS			
SET WARRANTY	3.35	2.26	2.03
PICTURE TUBE WARRANTY	3.75	3.00	1.65
TOTAL WARRANTY	$ 7.10	$ 5.26	$ 3.68

		40/Day		
LIST PRICE		$495.00	$495.00	$395.00
DISCOUNT		32.3%	32.3%	
DISTRIBUTOR COST		335.00	335.00	267.42
EXCISE TAX		33.50	33.50	26.74
NET G.E. SELLING PRICE		301.50	301.50	240.68
GROSS MARGIN	DOLLARS	219.94	42.09	21.28
	PER CENT	72.9%	14.0%	8.8%
QUANTITY		3900	100M	1[illegible]00M
COST SUMMARY				
MATERIAL		237.76	195.19	180.00
LABOR		27.50	13.20	11.00
I.M.E.		70.00	18.00	12.50
SHOP COST		335.26	226.39	203.50
P.E.C.E.		165.18	18.83	5.00
WARRANTY		7.10	5.26	3.68
EXTRA COST		10.15	5.01	4.24
MFG. COST LESS ROYALTY		517.77	255.49	216.42
ROYALTY		3.67	3.92	2.98
TOTAL MFG. COST		521.44	259.41	219.40

*Two tubes value $1.61 included in Chassis Assembly.

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

RTD-458-A-12 (10-56) BACK

QTY.	CHASSIS MATERIAL	3900	100M	
1	POWER TRANS.	$10.000	$ 8.50	
1	METALLIC RECTIFIERS	.450	.45	
1	OUTPUT TRANS.	.654	.46	
2	FUSE	.118	.12	
	TUNING CAPACITOR			
20	ELECTROLYTICS Sect.	4.080	3.84	
	PAPER CAPACITORS			
156	MICA CAPACITORS	9.048	8.30	
	CERAMIC CAPACITORS			
2	H.V. CAPACITORS	.520	.52	
	BULPLATES			
1	TRIMMERS	.100	.10	
179	FIXED RESISTORS	4.256	4.20	
18	POTENTIOMETERS	4.585	4.48	
2	SWITCHES	.319	.25	
1	HEAD END (S.C. Less Tubes)	10.970	9.95	
X	WIRE CUTTING LIST	3.000	3.00	
X	POWER CORD	.151	.15	
1	VIDEO DET. TRANS.	1.160	1.04	
	OSC. COIL			
1	R.F. COILS xxxxxXtal Filter	1.540	1.54	
2	I.F. COILS	.134	.12	
1	FIL. TRANS. xxxx XtalTun.C.	1.224	.20	
2	REACTOR	1.700	1.70	
	CENTERING RING			
1	ION TRAP xxxx FocusCoil	13.500	3.00	
19	CHOKE COILS	1.672	1.50	
1	HORIZ. SWEEP TRAN.	5.500	2.60	
1	DEFLECTION YOKE	15.980	10.00	
1	FOCUS COIL xxxxxBlockOsc.	.357	.34	
1	LINEARITY COIL xxxxxxxxDelayLine.	.638	.50	
1	HORIZ. OSC. COIL	.260	.24	
	HORIZ. SIZE COIL			
1	VERT. SWEEP TRANS.	1.210	1.10	
1	SoundT.O.Coil	.360	.25	
33	Misc. Coils	4.360	3.50	
TOTAL	ELECTRICAL	86.846	68.95	
x	MISC.	6.000	4.80	
	CHASSIS M.P.			
	~~OTHER METAL PARTS~~ Metal Parts	5.000	4.00	
x	SOCKETS/BOARDS	1.850	1.85	
2	~~PIN-PLATES/BOARDS~~ Prntd. Bd.	7.500	3.75	
10	TERM. STRIPS	.180	.15	
	SCALE DRIVE			
1	Electro-Static Shield	1.000	.75	
Total	Mechanical	21.530	15.30	
TOTAL	CHASSIS MATERIAL	108.376	85.25	

QTY.	CABINET ACCESSORIES			
	DIAL SCALE			
1	BACK	$ .470	$ .43	
	CAP	.158	.12	
	ESCUTCHEON Over Lay	1.700	1.35	
	KNOBS	.352	.35	
	GLASS	3.600	3.60	
	ANTENNA			
	DIAL WINDOW			
1	GRILLE Baffle	.055	.06	
	GRILLE CLOTH			
	DUST SEAL			
1	MASK	1.250	1.00	
X	TUBE MTG. ASM.	.548	.45	
2	NAMEPLATE	.039	.04	
	MISC. HD'WARE			
	MISC. U.H.F.			
4	Channels	1.350	1.20	
1	Vent	.530		
TOTAL ACCESSORIES		$10.052	$8.60	

LABOR DETAILS	ADL	UDL	TOTAL
SUB-ASSEMBLIES & FEEDER			
MAIN			
I.F.-R.F. TEST			
INSTRUMENT ASSEMBLY & TEST			
TOTAL LABOR			

D. A. SUMMARY			
SHOP WORK			
STYLING			
TOOLS			
E. & D.			
MISC.			
TOTAL D. A.			

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

COPY

DATE	D.A. NUMBER	MODEL NUMBER
4-22-57		Apple (super index)

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION:

Super index apple

Assuming invention of material to produce index from pix tube directly at index frequency

MATERIAL			
CABINET	12.00		
CABINET ACCESSORIES	8.00		
CATHODE RAY TUBES	41.00		
OTHER TUBES	18.60		
SPEAKER	.84		
CHASSIS ASSEMBLY	61.00		
PACKING	2.00		
TOTAL	143.44		
FREIGHT	1.43		
SPOILAGE	2.86		
TOTAL MATERIAL	147.73		
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION			
SPEAKER			
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT			
TOOL MAINTENANCE			
TOTAL P.E.C.E.			
WARRANTY COSTS			
SET WARRANTY	1.70		
PICTURE TUBE WARRANTY	1.25		
TOTAL WARRANTY	2.95		

LIST PRICE			
DISCOUNT			
DISTRIBUTOR COST			
EXCISE TAX			
NET G.E. SELLING PRICE			
GROSS MARGIN — DOLLARS			
GROSS MARGIN — PER CENT			
QUANTITY	1,000,000		

COST SUMMARY			
MATERIAL	147.73		
LABOR	10.00		
I.M.E.	12.50		
SHOP COST	170.23		
P.E.C.E.	5.00		
WARRANTY	2.95		
EXTRA COST	3.56		
MFG. COST LESS ROYALTY	181.74		
ROYALTY	2.26		
TOTAL MFG. COST	184.00		

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

MISCELLANEOUS INVESTIGATION REPORT #84
DEVELOPMENT ENGINEERING

ELECTRONICS PARK - SYRACUSE
MAY 2, 1957

COPY — LAWRENCE TUBE INVESTIGATION — COPY

by: M. PALLADINO

ABSTRACT

This report is concerned with the principles of operation of the Lawrence tube. Included is a comparison of various sampling methods, a discussion of moire problems, horizontal definition, and brightness limitations.

CONCLUSIONS

Precise equations have been formulated that indicate exact placement of phosphor stripes depending upon deflection angle, grille and screen potentials, and physical dimensions of the tube. With these equations it has been shown that a constant pitch for grill and phosphor stripes will not cause appreciable errors; therefore, in practice, the phosphor stripes are laid down with a constant pitch slightly larger than the grill pitch.

The grill capacity and switching potential may be determined from the physical dimensions of the tube. The horizontal stripe Lawrence tube requires 548 volts peak to peak to completely switch the beam from green to red and blue stripes with a grill capacity of 1950 uuf. The vertical stripe tube has a grill capacity of 2810 uu and requires approximately 1000 volts peak to peak switching potential.

The vertical stripe tube is capable of resolving 392 lines horizontal, thus the number of stripes are adequate to prevent deterioration of the arbitrarily established horizontal resolution.

The table on the following page compares various methods of switching and gating the Chromatron tube. The conduction angles indicated are the maximum realizable when the switching potential on the grill is adjusted for the peak deflections specified in each row. It should be noted that a 50% duty cycle can be realized only when a second harmonic is added to the switching voltage.

The low duty cycle of the Lawrence tube inflicts a fundamental limitation on the high light brightness capabilities. If simple sub-carrier switching is employed with a third harmonic gating pulse and a 40° conduction angle tolerated; than the high light brightness of the tube is limited to 32.8 foot lamberts per milliamp of cathode current. However, a three to one increase on white can be realized if the third harmonic gating pulse level is compelled to be proportional to the chroma information. In this manner the gate is removed when white information is present and a 100% duty cycle realized, hence 98.4 foot lamberts per milliamp of cathode current is realized.

One of the major problems associated with the Lawrence tube is the various moire patterns. There appears to be three basic moires. One is caused by the beat frequency between the 2nd harmonic of sub-carrier and the grille frequency. This is

GRILL SWITCHING WAVEFORM	PEAK DEFLECTION IN MILS	GATING FREQUENCY	SAMPLING SEQUENCE	MAXIMUM CONDUCTION ANGLES IN DEGREES				TOTAL DUTY CYLCE IN PERCENT OF PERIOD OF f_o
				θ_R	θ_B	θ_G	θ_T	
$A \sin \omega_o t$ $f_o = 3.58$MC	12	$3f_o = 10.74$ MC	(R-G-B)-(R-G-B)	23°	23°	29°	69°	19.2%
	15	$3f_o = 10.74$ MC	(R-G-B)-(R-G-B)	46°	46°	23°	69°	19.2%
	12.5	$3f_o = 10.74$ MC	(R-G-B)-(R-G-B)	28°	28°	28°	84°	23.3%
	12	$6f_o = 21.48$ MC	(R-G-B)-(B-G-R)	46°	46°	58°	138°	38.4%
	15	$6f_o = 21.48$ MC	(R-G-B)-(B-G-R)	92°	92°	46°	138°	38.4%
	12.5	$6f_o = 21.48$ MC	(R-G-B)-(B-G-R)	56°	56°	56°	168°	46.6%
	12	$4f_o = 14.32$ MC	(R-G-B)-G-(R-G-B)	83°	83°	58°*	116°	32.2%
	9.5	$4f_o = 14.32$ MC	(R-G-B)-G-(R-G-B)	37°	37°	74°*	148°	41.1%
$A \sin \omega_o t +$ $\frac{A}{2} \sin 2\omega_o t$ $f_o = 3.58$MC	15	$3f_o = 10.74$ MC	(R-G-B)-(R-G-B)	70°	70°	90°	210°	58.4%

* The sum of two equal sampling periods centered around $\omega_o t = 0°$ and $\omega_o t = 180°$

a moving 7.5 mc pattern which is not very visible. The second is an intensity variation in phosphor stripes due to shading effects of the grill wires, which produces a more pronounced pattern than the first. The third pattern appears to be the most noticeably and most difficult to explain. It is a function of the number of grill wires intercepted by the beam; so if the spot size is intercepted by a maximum of two wires during a sampling period, the moire pattern results. The effect is that eight phosphor stripes are alternately fully illuminated and not excited. This is repeated every 1.2 inches. The integrated results are vertical dark bands in saturated fields.

DISCUSSION

A. Principles of Operation

The Lawrence tube is a single gun tube which employs the principle of "Post Focusing." A double grill is placed in close proximity to the phosphor screen; the potential of this grill with respect to the screen determines the post accelerating field. The grill wires are placed behind the red and blue phosphor stripes. The wires associated with the red phosphor stripes are brought out to one electrode and the blue to another. Between these electrodes a coil is placed to resonate with the grill capacity at 3.58 mc. A push-pull amplifier drives the tank circuit to provide opposite phase sub-carrier switching. Thus the beam is deflected from green to red and blue stripes depending upon polarities. At zero and 180° phase of subcarrier the beam is undeflected and therefore is post focused on the green stripe.

In terms of the potentials applied and the geometry of the tube, the physical constants and drive requirements for the tube may be derived. The defining symbols for the physical dimensions and potentials are shown in Figure 1.

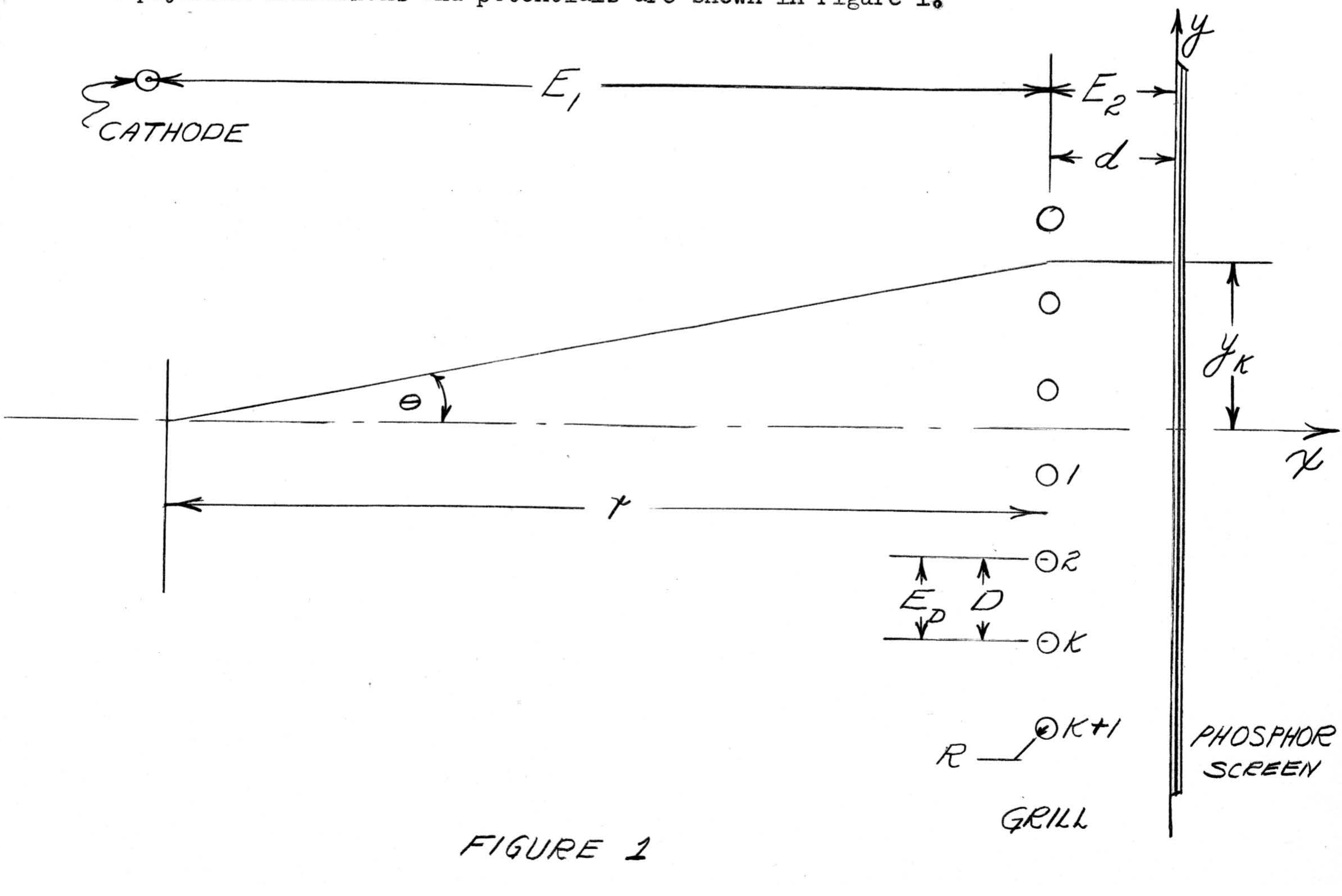


FIGURE 1

The mean velocity in the region between the wire grid and aluminum backing at any angle is:

$$v_x = \frac{1}{2}\sqrt{\frac{2e}{m}}\left[\sqrt{E_1}\ \cos\theta\left(1+\sqrt{1+\frac{E_2}{E_1\cos^2\theta}}\right)\right] \tag{1}$$

Defining v_y as the velocity of the electrons parallel to the grill in the same region and Δy as the displacement on the phosphor screen due to v_y, then

$$\Delta y = \left(v_y/v_x\right) d \tag{2}$$

$$v_y = \sqrt{\frac{e\cdot 10^7}{m}}\ \sqrt{2E_1}\ \sin\theta \tag{3}$$

$$\therefore \Delta y = \frac{E_1}{E_2}\left(d\sin 2\theta\right)\left[\sqrt{1+\frac{E_2}{E_1\cos^2\theta}}-1\right] \tag{4}$$

Equation (4) tells where an electron will strike the screen if it has been deflected by an angle θ and therefore determines the phosphor placement for the single gun tube. Also, if the grid wire spacing is uniform this equation is used to determine the electron arrival angle for the three-gun version of this tube. In actual practice, the phosphor stripes are laid down with a constant pitch slightly larger than the distance between wires of the grill. Figure (2) shows the pitch variation with deflection angle.

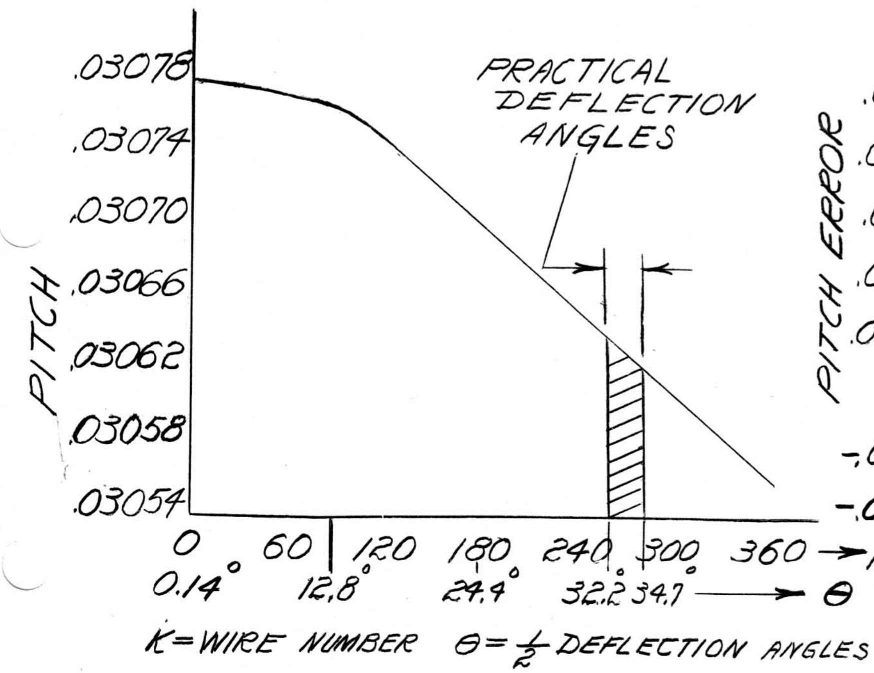


FIGURE 2

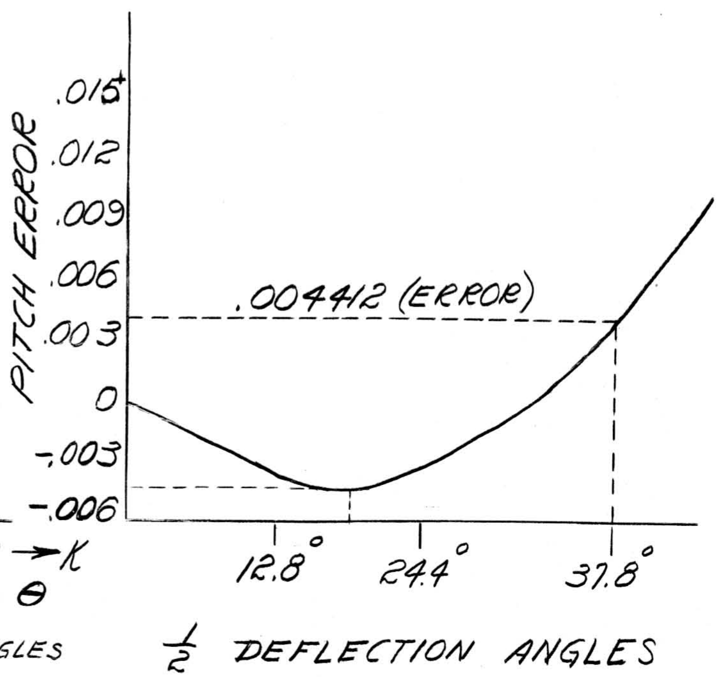


FIGURE 3

If the pitch is carefully chosen from this curve, the maximum errors in wire placement can be held to .0045" error. Figure (3) shows the variation of wire placement error versus deflection angle using a constant pitch determined from curve #2 for the 142nd wire.

B. Grill Capacity and Deflection Potentials

Referring to Figure 1, the switching potential required on the grill to deflect the beam to the red and blue stripes and the grill capacity may be determined. If adjacent grill wires are permitted to bear a change of +q and -q coulombs then by applying a modified Gauss' theorem and using a psi ratio of 3

$$C = \frac{\epsilon}{3.6 \ln D/R} \quad \mu\mu f/cm \tag{5}$$

$$E_D = \frac{2E_1}{\pi} \frac{D}{d} \ln \frac{D}{R} \tag{6}$$

where C = capacity per cm. of wire length

E_D = peak to peak deflecting potential

D = spacing between grill wires

d = grill to screen spacing

R = radius of grill wires

E_1 = d.c. potential of the grill

ϵ = dielectric constant

If these equations are applied to the horizontal stripe Chromatron picture tube of screen size 12 x 16 inches, grill spacing of 30 mils, 6 mil diameter wires, 320 mils grill to screen spacing and a 4 KV grill potential; the switching potential E_D = 548 v and total capacity C = 1950 uu.

Applying the same equations to the Chromatron vertical stripe tube: D = 24 mils, R = 1.5 mils and E_1 = 7.5 KV results in $E_D \cong$ 1000v and C = 2810 uu for a 14" x 19" screen.

C. Phosphor Lines and Horizontal Definition

The number of phosphor lines, when positioned at right angles to the direction of scan, determines the horizontal resolution of the tube. The number of changes along a horizontal line for a given bandwidth may be determined by the relationship:

$$H_R = 2\, t_{ha}\, f_{max}\, \frac{3}{4} \qquad (7)$$

where H_R = horizontal resolution

t_{ha} = active horizontal trace time

3/4 = aspect ratio

Each element thus defined along the horizontal line should have the possibility of being red, green or blue. Therefore the number of distinct phosphor lines per inch for a vertical stripe tube is given by:

$$PL/in = \frac{3H_R}{W}\,\frac{4}{3} = \frac{6\,t_{ha}\, f_{max}}{W} \qquad (8)$$

w = width of phosphor screen in inches

Assuming the Chromatron tube with 12 mil vertical stripes and a 14" x 19" phosphor screen, the maximum frequency the tube is capable of resolving is:

$$f_{max} = \frac{1}{.012}\,\frac{PL}{in}\,(19 in)\,\frac{1}{6.0(54 \mu s)} \qquad (9)$$

$$f_{max} = 4.9\ mc. \qquad (10)$$

The horizontal resolution is therefore limited by equation (7):

$$H_R = 2(54)(.75)(4.9) = 392\ Lines \qquad (11)$$

The specifications we have arbitrarily established for "Display Device Characteristics" dictate that the tube must clearly define 325 lines horizontal resolution for the luminance signal. Thus it may be seen that the number of vertical stripes are adequate to prevent deterioration of the specified desirable horizontal resolution.

D. Beam Switching and Gating Methods

The Chromatron picture tube is essentially a dot sequential display device. However, this term must be used with care, because it is often used with a specialized meaning. The color changing action in the various instances depends on the type and manner of operation of the one gun tube. One class of operation is called continuous color sequence because it is characterized by successive primary colors repeated in triad intervals. Graph #1A in the appendix shows a switching frequency of f_o (3.58 MC). Here it may be seen that R, G, and B are gated once in a period of f_o which provides the "Continuous Color Sequence": When the gating frequency is $3f_o$ (10.74 MC):

(R-G-B) - (R-G-B) . . . .

If the beam is gated with the 6th harmonic of sub-carrier, as shown in Graph #2A, then R, G, and B are each sampled twice in a period of 3.58 MC. This leads to a class of operation termed "Reversing Color Sequence". The significance of the nomenclature may be seen by selective placement of brackets in the color sampling sequence -

RR G BB G RR G BB G RR ....

R-(R-G-B) - (B-G-R) - (R-G-B) - (B-G-R) - R ....

Fourth harmonic gating is neither continuous nor reversing in their true sense. As seen in Graph #3A, the green is sampled twice in a period of f_o while red and blue are sampled once which results in the following "Sequence of Four":

(R-G-B) - G - (R-G-B) - G - (R-G-B)

The maximum realizable conduction angles depend upon the gating frequency and amplitude of the sub-carrier switching potential. In Graph #1A it is assumed that the peak amplitude of f_o deflects the beam to the center of the red and blue stripes. Since this deflection amounts to a complete stripe displacement, then the beam crosses over from the green to the red and blue stripes at half amplitude of f_o. ($A \sin \omega_o t = \frac{A}{2}$) occurs at 30°, 150°, 210° and 270°, therefore, this is an equal time shared system where the dwell time amounts to 120° for each stripe. The maximum realizable conduction angle, however, is limited by spot size if saturated colors are to be obtained. If we consider that the "post accelerating" field will focus the spot to a 6 mil width perpendicular to the stripe length; then the beam may not be gated on until the $\sin \omega_o t = 9/12$. (Assuming a 15 mil stripe width and a full stripe deflection by peaks of the switching potential.) Likewise, if the spot is to be restricted to the red stripe and not overlap into green, then the beam must be gated off at a sub-carrier phase angle of $180° - (\sin^{-1}\omega_o t = 9/12)$. The result is a possible conduction angle of 83° for red and blue. It would appear that, if pure sine wave gating is used, the fast transition across the green stripe would restrict the maximum conduction angle. This is not necessarily true; as shown in Graph #1, for saturated green the conduction angle $\theta_g = 180° \pm (\sin^{-1}\omega_o t = 3/12)$ therefore $\theta_g = 180° \pm 14.5° = 29°$. With $3f_o$ gating frequency peaks occur at $\omega_o t =$ 60°, 180° and 300° furthermore, for saturated red, the beam may not be gated on before $\sin \omega_o t = 9/12$ or $\omega_o t = 48.5°$; therefore the conduction angle for red, $\theta_R = 60° \pm (60° - 48.5°) = 23°$. Similarly the maximum conduction angle for blue, $\theta_B = 300° \pm 11.5° = 23°$. The preceeding shows that Red and Blue restrict the duty cycle of the tube to 6.4% per primary stripe.

The maximum deflection permissible is 15 mils, if saturated red and blue are to be maintained. With the sub-carrier switching potential adjusted accordingly, then $\theta_R = 60° \pm (60° - (\sin^{-1}\omega_o t = 9/15)) = 60° \pm 23° = 46°$, also $\theta_B = 46°$. The dwell time on green, however, has decreased so that $\theta_G = 180° \pm (\sin^{-1}\omega_o t = 3/15) =$ 23°; which shows the green dwell time to be the limiting factor. The preceeding analysis shows that an optimum conduction angle occurs for peak deflections of f_o between 12 and 15 mils. When the peaks of f_o cause approximately 12.5 mils deflection then the conduction angles for all three primaries are equal, $\theta_R = \theta_B = \theta_G = 28°$ so the maximum realizable duty cycle is approximately 7.8% per primary color.

In the vertical stripe Chromatic tube a 40° conduction angle is employed with a gating frequency of $3f_o$. If we assume that peaks of f_o deflect the beam 9.5 mils then the conduction period for red begins when the beam is deflected approximately 6.1 mils (9.5 sin 40°). Therefore, with a 3 mil wide spot size about half the beam overlaps into green at the beginning of the red conduction period. A similar analysis applies to the end of the blue conduction period. At the start of the green conduction period approximately half the spot overlaps into red and at the finish half overlaps into blue. Consequently, if saturated green is called for, 30% of each conduction period desaturation occurs due to the contribution of light from other primaries. Conversly, green contributes light for 15% of the red and blue conduction periods. From the standpoint of energy only 4% of the beam energy excites the green phosphor during the red and blue conduction angles and 8% of the energy is lost to the red and blue phosphors during the green conduction period.

In Graph #2 the sub-carrier switching potential is adjusted for 12 mil deflection at peaks of f_o and a sixth harmonic of f_o is used for gating the beam. With this gating sequence each primary color is sampled twice in a period of f_o; furthermore, since peaks of $6f_o$ occur at $\omega_o t = 60°$, 120°, 180°, 240°, 300° and 360°, then $\theta_{R1} = 60° \pm 11.5°$, $\theta_{R2} = 120° \pm 11.5°$, $\theta_{B1} = 240° \pm 11.5°$, $\theta_{B2} = 300° \pm 11.5°$, $\theta_{G1} = 180° \pm 14.5°$ and $\theta_{G2} = 0° \pm 14.5°$. The analysis is similar for any deflection due to peaks of f_o, therefore in every case the conduction angle per primary color is doubled over the $3f_o$ gating sequence. This resolves to a maximum conduction angle of 56° or a 15.6% duty cycle per primary color.

In Graph #3, a fourth harmonic of f_o is indicated as the gating frequency. Since peaks of $4f_o$ occur at $\omega_o t = 0° - 90° - 180° - 270°$, the dwell time on green will restrict the sampling angles for peak deflections greater than 9.5 mils. The conduction angles realized for this deflection are $\theta_R = 90° \pm [90 - (\sin^{-1}\omega_o t = 9/9.5)]$ or $\theta_R = 37°$; $\theta_B = \theta_R$ and $\theta_{G1} = 180° \pm (\sin^{-1}\omega_o t = 3/9.5) = 37°$ and $\theta_{G2} = 360° \pm (\sin^{-1}\omega_o t = 3/9.5) = 37°$. Thus the duty cycle for red and blue is approximately 10% each and about 20% for green; consequently the green phosphor would have to be diluted.

The efficiency of the Lawrence tube may be increased by adding a second harmonic to the fundamental sub-carrier switching potential. Graph #4 shows a switching potential of $E = A \sin \omega_o t + A/2 \sin 2\omega_o t$. Here peaks of the switching potential occur at 60° and 300° and the dwell time on the green stripe has increased considerably around $\omega_o t = 180°$, therefore a gating frequency of $3f_o$ is most desirable. Under this condition of switching the maximum conduction angle is realized when the beam is deflected as far into the red and blue stripe as possible. When the switching potentials are adjusted for 15 mil deflection on peaks $\theta_R \cong 25°$ to $95° \cong 70$, $\theta_B \cong 265°$ to $335° \cong 70°$, and $\theta_G \cong 134° - 224° \cong 90°$. This provides a duty cycle of 19.5% per primary stripe which is the only mode of operation, of those mentioned here, that will realize better than 50% duty cycle in a period of f_o.

The preceeding discussion is tabulated in the conclusions for quick reference and comparison between the various gating sequences.

E. Moire Patterns

In the Lawrence tube a moire pattern exists due to the difference in frequency between the equivalent frequency of the wire spacing and the second harmonic of sub-carrier frequencies. The effects of the fundamental and third harmonic of sub-carrier are small due to frequency interlace.

If we consider a vertical stripe Lawrence tube with 12 mil stripes, 24 mil wire spacing and a 19" horizontal width; then a linear sweep with 15% flyback time produces an equivalent wire frequency of:

$$f_W = \frac{(19)\frac{1}{24}}{(.85)\,63.5\cdot 10^{-6}} \cong 14.7 \text{ MC} \tag{12}$$

For this condition, the moire frequency is:

$$f_m = 14.7 - 7.2 \cong 7.5 \text{ MC} \tag{13}$$

and the moire spacing is:

$$S_m = \frac{14.7}{7.5} \times 0.024 \cong 0.047 \text{ inches} \tag{14}$$

Another moire pattern exists due to the interception of the beam by the grill wires. This pattern depends on the relative spot size of the beam entering the grill with respect to the diameter of the grill wires. The effect is an intensity variation in phosphor stripes as a function of grill interception. If the beam is wide, the comparative area shadowed by the grill wire is small and consequently the moire pattern becomes less apparent. The shadowed areas due to grill wires are not vertical bands but are staggered from line to line because of frequency interlace. Still a third moire pattern exists if the beam is not large enough, entering the grill wires, to assure that all stripes will be illuminated. For example, if we assume the following:

stripe width - 12 mils
diameter of grille wires - 3 mils and grill wiring
  grill wire spacing - 24 mils
conduction angle - 40°
spot size, entering the grill - 30 mils
switching frequency - 3.58 MC
gating frequency - 10.74 MC
active horizontal trace - 54 us and
  horizontal picture size - 19"

then during one period of 3.58 MC the beam traverses:

$$d_t = \frac{1}{3.58\times 10^{6}}\left(\frac{1}{54\cdot 10^{-6}}\right) 19'' \cong 100 \text{ mils/cycle} \tag{15}$$

for a 40° conduction angle the beam traverses:

$$d_c = d_t/9 \cong 11 \text{ mils} \tag{16}$$

with a 30 mil spot size the beam covers 41 mils during a conduction period. Consequently, only two wires maximum are intercepted by the beam during any conduction period. If a saturated red or blue field is desired, in every 1.2 inches there will be eight phosphor stripes alternately fully illuminated and not excited. Due to frequency interlace, the four non-excited stripes will be displaced by two stripes; therefore, the integrated effect is dark vertical bands in saturated fields. A detailed analysis of moire effects in the Chromatic tube will be given in another Miscellaneous Investigation Report.

F. Brightness Considerations

The Chromatron tube, since it has one gun, must utilize phosphors of equal efficiency or an appropriate filter glass to produce white.

The highlight brightness may be caluclated as follows:

Equalized phosphors = 8.5 ft.l./mw/cm²
Phosphor screen potential = 22.5 KV
Phosphor screen area = 14" x 19" or 1700 cm²
Grill wires (diameter = 3 mils spacing = 24 mils

$$\text{transparancy} = \frac{19 - \frac{19(.003)}{.024}}{19} = 87.5\%$$

If we consider the total phosphor screen area producing an illuminant C field then:

$$\text{Phosphor Efficiency} = \frac{8.5 \text{ ft.l./mw/cm}^2}{1700 \text{ cm}^2 \quad \left(100 \frac{\text{mw}}{\text{Watt}}\right)} = 5 \text{ ft.l/watt} \tag{17}$$

The power delivered to the screen depends upon the grill transparency and conduction angle. For a 40° conduction angle the total beam current is available for one-third of the time; therefore, the screen current, in terms of cathode current is

$$I_S = I_K(1/3)\,.875 \tag{18}$$

and the screen power is:

$$P_S = E_S I_S = I_K(1/3)(0.875)\,22.5\,KV \tag{19}$$

$$\therefore P_S = 6.56 \text{ watts per milliamp of cathode current} \tag{20}$$

consequently the high light brightness is given by:

$$H.L.B. = 6.56(5 \text{ ft.l/watt}) = 32.8 \text{ ft.l. per ma. of cathode current} \tag{21}$$

A major contribution to the Chromatron art is a circuit improvement which achieves a three to one improvement in high light white brightness. This is accomplished dynamically by controlling the level of the third harmonic gating pulse in proportion to the amplitude of chroma information. Chroma is detected by a diode detector and its output controls a suppressed carrier AM modulator. Therefore, on white, the third harmonic gating signal is zero and full gating is realized only for a saturated color. The resulting color distortions leave the flash area unchanged while greens go toward cyan and magentas toward red. When the gating pulse is suppressed, the one-third factor for duty cycle in equations 18 and 19 is eliminated, therefore, on high light white brightness, the tube produces 98.4 foot lamberts per milliamp of cathode current.

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MJP;rer

CC: RB Dome
DE Garrett
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JF McAllister
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N Johannessen
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MJ Palladino
TT True
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FG Cole
BA Field
GA Schupp
TV Zaloudek
LC Maier
JC Nonnekens
WD Rublack
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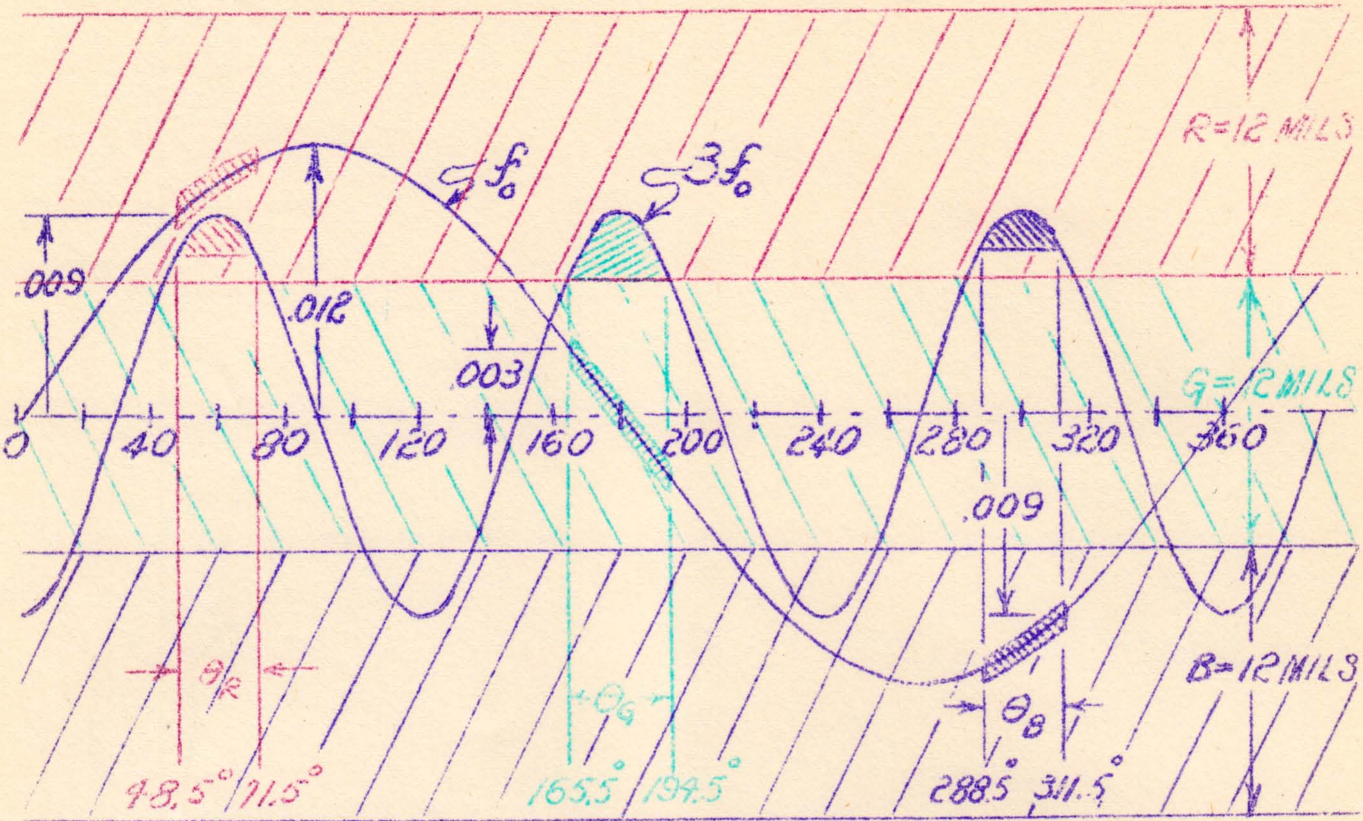
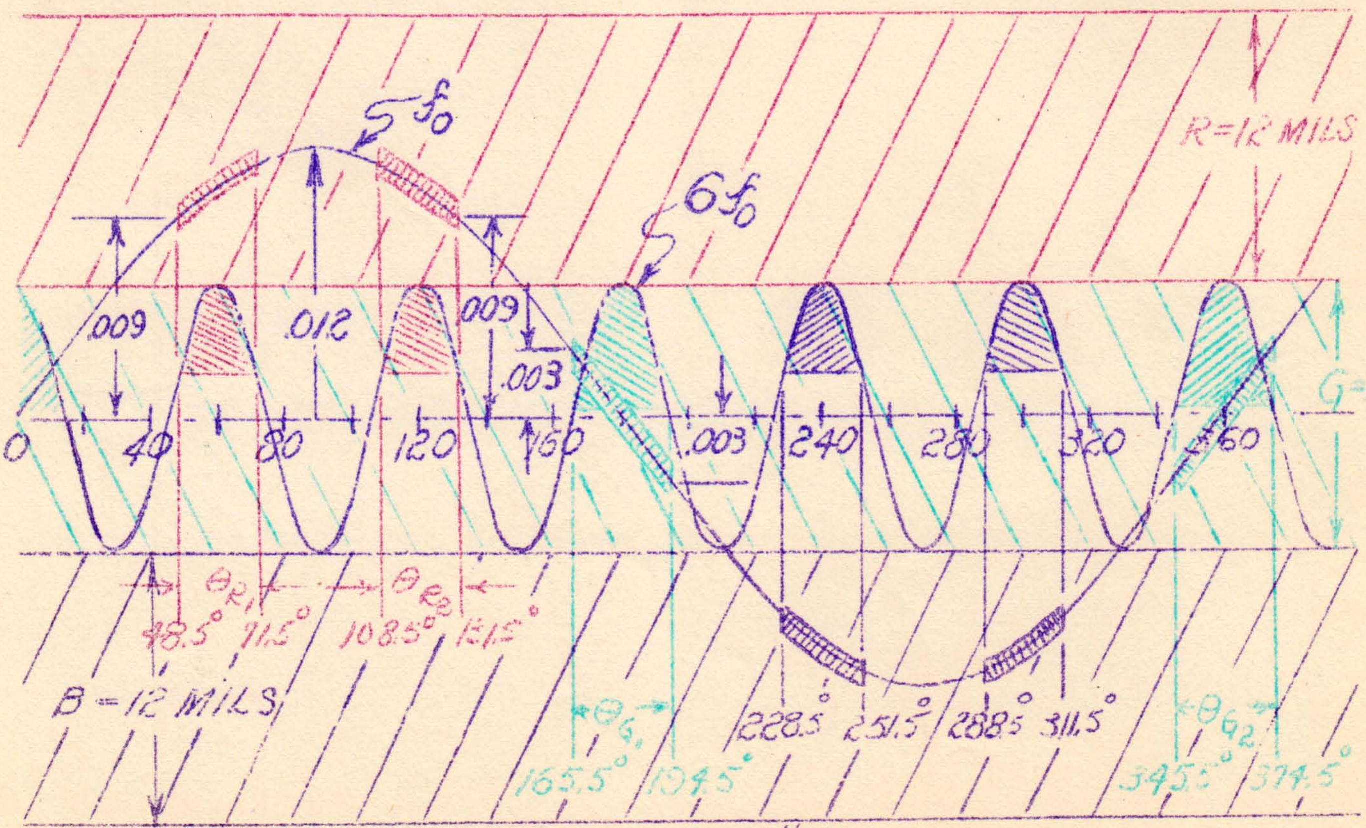
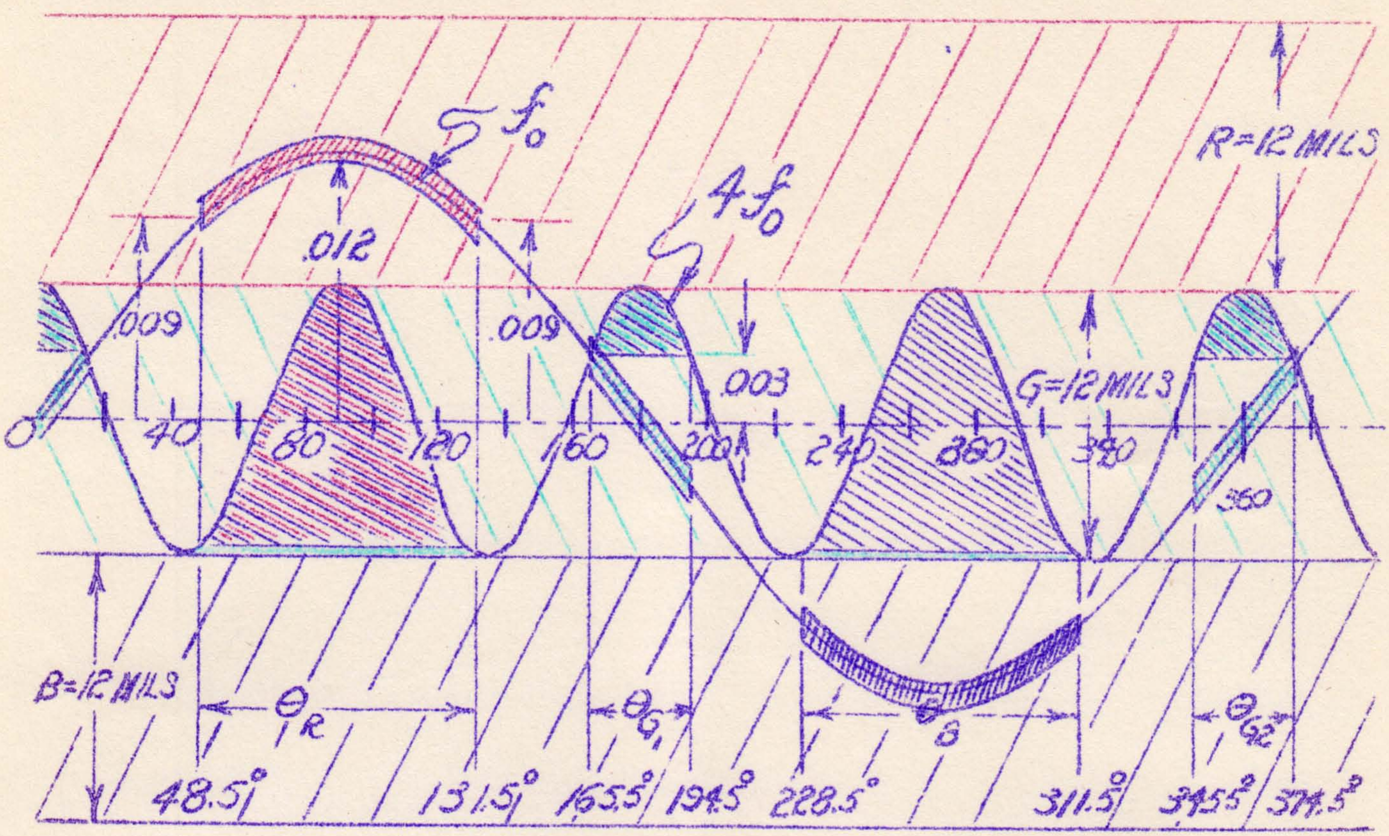


GRAPH #1



GRAPH #2

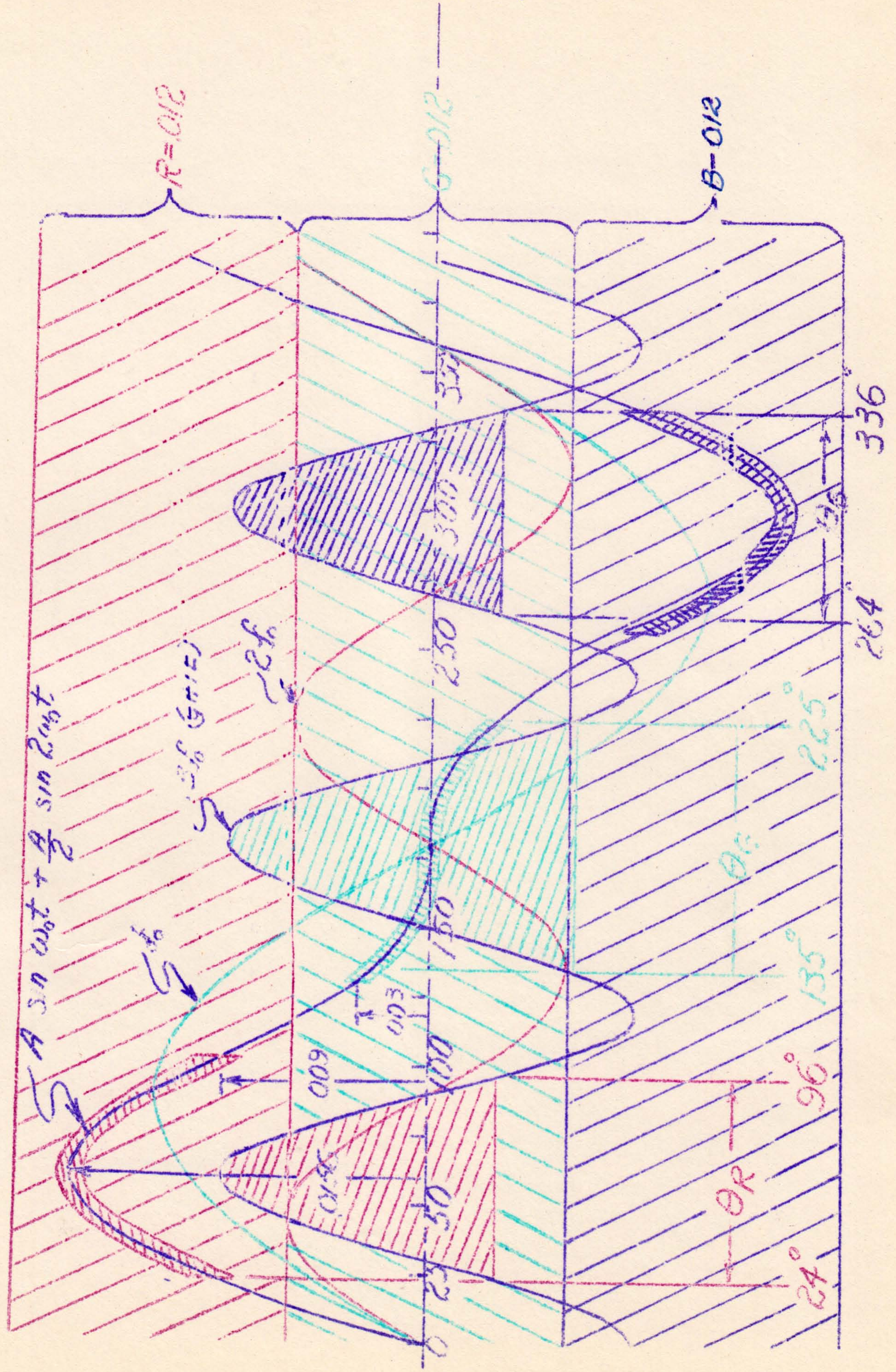


f_0
$4f_0$
R=12 MILS
.012
.009
.009
.003
G=12 MILS
0
40
80
120
160
200
240
280
320
360
B=12 MILS
θ_R
θ_{G_1}
θ_B
θ_{G2}
48.5°
131.5°
165.5°
194.5°
228.5°
311.5°
345.5°
374.5°

GRAPH #3

A-3

GRAPH #4


R=012
G-012
B-012
$A \sin \omega_0 t + \frac{A}{2} \sin 2\omega_0 t$
25
50
100
150
250
300
600
336
264
96
24°
96°
θR
135°
225°
θG

Miscellaneous Investigation Report #97
June 21, 1957

Development Engineering
Television Receiver Dept.

Moire Patterns In A Lawrence-Type Color Television Picture Tube

By: M. J. Palladino

Abstract:

This report discusses three basic moire patterns inherent in the Chromatic Color TV Picture Tube. The tube under discussion is a vertical stripe tube with specific stripe, grill, and spot size dimensions.

Conclusions:

There are three basic moire patterns that can be calculated. One exists due to the equivalent frequency of the wire spacing and the second harmonic of sub-carrier frequency. This leads to a moire frequency of 7.5 mc and a spacing of 0.047 inches.

The shading effect of grill wires due to beam interception is another pattern. It is reduced as the spot size increases at the grill. The moire is an intensity variation in phosphor stripes as a function of grill wires.

The third moire is the most prevalent and is due to grill wire spacing relative to conduction angle repetition rate. The result would probably appear as irregular and oscillating fine line intensity variation. In addition this moire pattern may flicker at a 60 ~ rate. The frequency of this moire is approximately 300 KC.

Discussion:

The version of the Lawrence tube suggested by Chromatic Laboratories and referred to as the Chromatron has several basic moire patterns. The specific tube under discussion has 12 mil wide vertical phosphor stripes, a 24 mil wire spacing in the grill assembly and a 19 inch horizontal width.

One of the moire patterns exists due to the "difference-frequency" between the equivalent frequency of the wire spacing (f_w) and the second harmonic of sub-carrier frequency. The effects of the fundamental and third harmonic of sub-carrier are small due to frequency interlace. If we assume a 15% flyback time the moire frequency is:

$$f_m = f_w - 2f_s = \frac{(19'')\frac{1}{.024''\text{ spacing}}}{(0.85)\,63.5\,\mu sec} - 2(3.6\text{ mc}) \qquad (1)$$

$$f_m \cong 14.7 - 7.2 \cong 7.5\text{ mc} \qquad (2)$$

and the moiré spacing is:

$$S_m = \frac{14.7}{7.5} \times 0.024'' \cong 0.047 \text{ inches} \qquad (3)$$

A second moiré pattern exists due to the interception of the beam by the grill wires. This pattern depends on the relative spot size of the beam entering the grill with respect to the diameter of the grill wires. The effect is an intensity variation in phosphor stripes as a function of grill interception. If the beam is wide, the comparative area shadowed by the grill wires is small, consequently, the moiré pattern becomes less apparent.

The third basic moiré pattern is the most severe. This pattern exists if the beam is not large enough, entering the grill wires, to assure that all stripes will be illuminated. In order to determine the effects of this moiré pattern the following characteristics are assumed for the tube and its operation:

stripe width - 12 mils
diameter of grill wires - 3 mils
grill wire spacing - 24 mils
spot size, entering the grill - 30 mils
switching frequency - 3.58 mc
gating frequency - 10.74 mc
active horizontal trace time - 54 u sec
horizontal picture size - 19 inches
conduction angle per primary color - 40°

then during one period of sub-carrier the beam traverses

$$d_t = \frac{1}{3.58 \cdot 10^6} \left(\frac{1}{54 \cdot 10^{-6}} \right) 19'' \cong 100 \text{ mils/cycle} \qquad (4)$$

during a 40° conduction angle the beam traverses

$$d_c = d_t \frac{40^\circ}{360^\circ} \cong 11 \text{ mils} \qquad (5)$$

Figure 1 shows how the third moiré pattern is generated. The 11 mil conduction period is indicated by the blanked portion of the shaded areas. The two circles, at each conduction period, indicate the position of the 30 mil wide beam at the beginning and end of each duty cycle. The rays from these circles to the phosphor stripes indicate how the electron stream is divided. The division of the

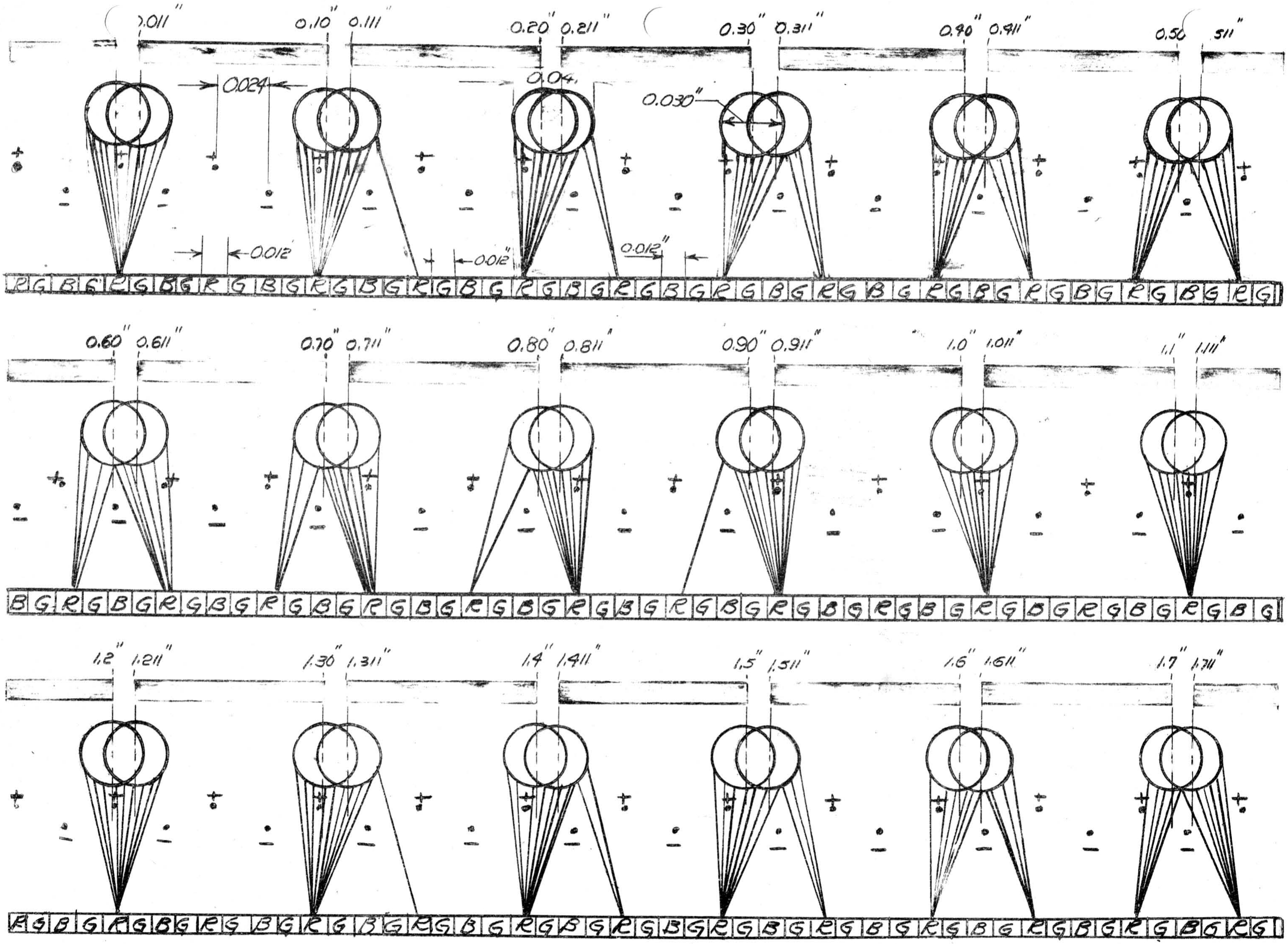


FIGURE 1
MISC. INVES. REPORT #97

beam depends on its position with respect to the oppositely charged grill wires. The diagram shows that the beam covers 41 mils of linear distance from the beginning to the end of a conduction period. Since the wires are spaced 24 mils the beam may fall between two negatively charged wires, two positively charged wires, or one of each depending on relative phases. If the beam falls between negatively charged grill wires, then only one stripe will be illuminated during a conduction period. If the beam falls between positively charged grill wires, then the beam will be almost equally divided between the phosphor stripes during a conduction period. If the beam strikes the grill between a positive and negatively charged wire then it will divide unequally between two stripes. The end result is that three out of twelve conduction periods only one stripe is illuminated; therefore, seven or eight stripes are alternately fully illuminated and not excited. This phenomena is repeated every 1.2 inches across a line. The frequency of the moire' (f_m) may be determined as follows:

$$f_m = \frac{d_h \frac{1}{S_m}}{t_{ha}} \tag{6}$$

where

d_h = horizontal linear distance

S_m = moire spacing

t_{ha} = active horizontal trace time

$$f_m = \frac{(19'') \frac{1}{1.2''}}{54\ \mu sec} = 293\ Kc \tag{7}$$

If the grill wire spacing is constant and the phase of the gating pulse does not vary; then, due to frequency interlace the stripes that were dark are fully excited and vice-versa. Since grill wire spacing and conduction periods are not integer multiples this pattern is displaced by one stripe. The integrated result would appear as vertical dark bands in a saturated field; however, since grill wire spacing probably is not absolutely constant and gating pulse phase not stable, the moire would be irregular and oscillating and could conceivably flicker at a 60 ~ rate.

Michael J. Palladino

Michael J. Palladino

MJP:REL

C O P Y   March 27, 1957

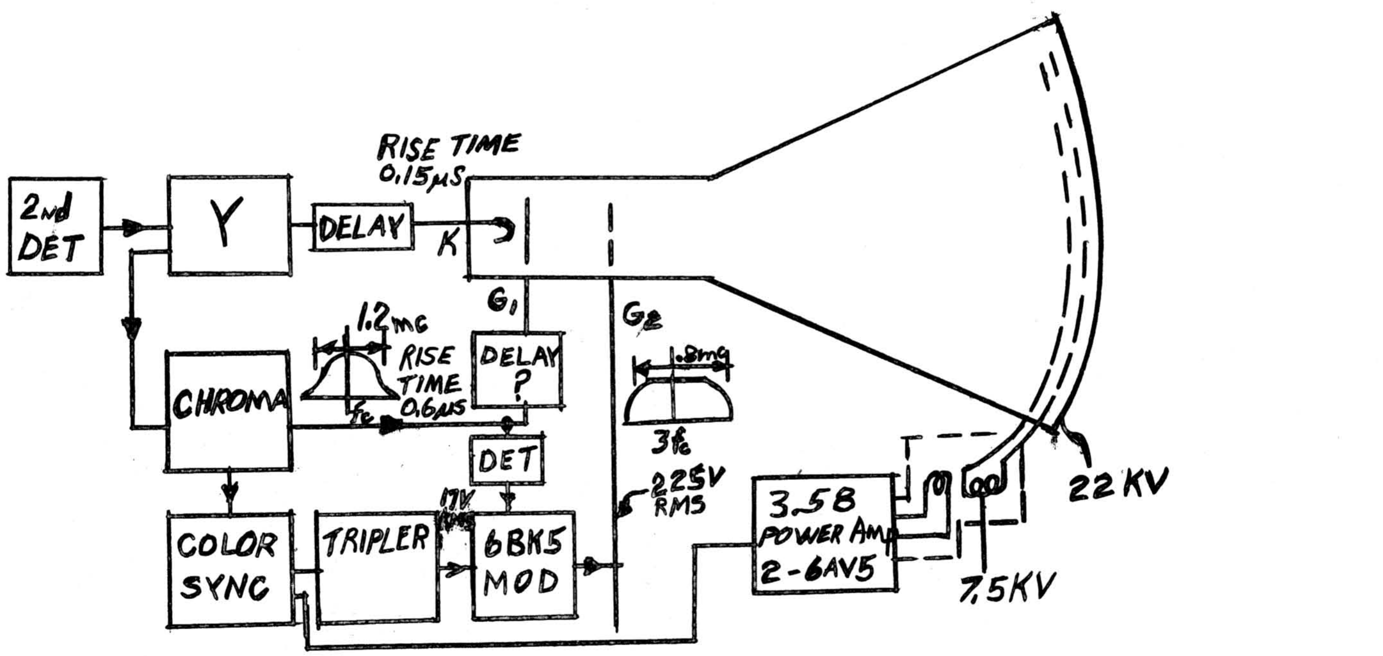
TRIP REPORT - W. E. GOOD - March 19, and 20, 1957

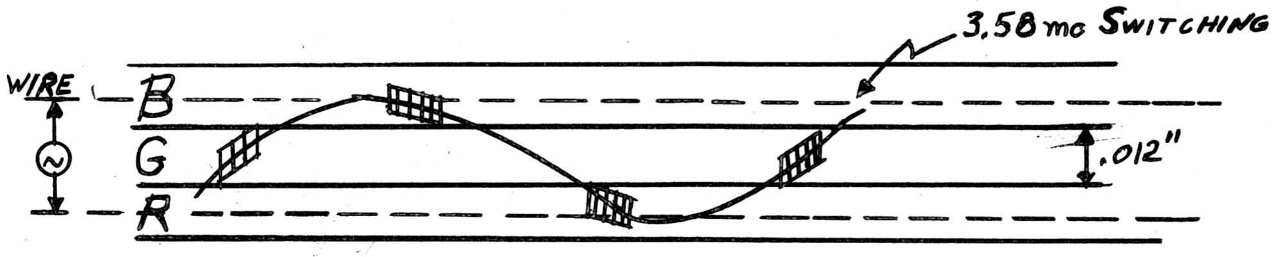
CHROMATIC OLOR TUBE

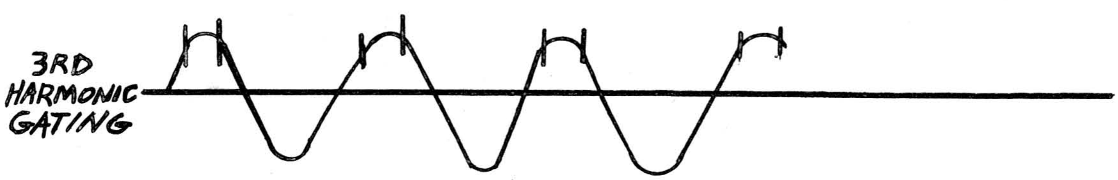
I spent two hours, on March 19, 1957, with Robert Dressler, Director of Research and Development, Chromatic TV Labs, Inc., New York City; and on March 20th listened to the Chromatic paper entitled "Brightness Enhancement Techniques for the Single-Gun Chromatron" by R. Dressler, P. Neuwirth and J. Rosenberg.

The major contribution to the Chromatron art is a circuit improvement which permits a three to one improvement in white highlight brightness. Dumont is taking over the production responsibilities for the tube and the West Coast Chromatic tube lab has been sold.

Dressler spoke of a 23 tube receiver which might go to 21. This receiver uses 3.58 mc sine wave switching at the grille from a push-pull 6AV5 amp with 30 watts DC input. Third harmonic gating is used at the G_2 grid. Chroma is applied to G_1 and Y to the cathode.







He claims the 3.58 radiation has been reduced to 3 μv/m at 100 feet by using a torroidal tank coil, twinex shielded cable with link coupling and shielding of the power amplifier. Other circuit points were: two high voltage rectifiers, one for 22 KV, one for 7.5 KV; no psi regulator; extra inductance in addition to the yoke for energy storage and stabilization of the psi ratio; three tube sound channel; pentode AGC; 18 db reserve chroma gain.

Normal operation of the Chromatron uses 3rd harmonic gating of G_2 resulting in a 40° conduction angle for each color, giving a 1/3 duty cycle for the single gun. This limits the white high light brightnesses to 15 or 20 foot lamberts. If the 3rd harmonic gating is removed, white highlights of 40 to 60 F.L. are obtained but the color performance is ruined. They achieve both conditions dynamically by causing the level of the third-harmonic gating wave to be proportional to the amplitude of the color signal. Chroma is detected by a diode detector and used as the controlling signal into a suppressed carrier AM modulator. Therefore, on white, the 3rd harmonic gating signal is zero. For a saturated color, full gating is present. The resulting color distortions leave the flesh area unchanged while greens go toward cyan and magentas toward red. Luminance errors were not mentioned except to point out that blacks were stretched giving a more pleasing picture with an overall γ of 1 or less. He claims no moiré troubles.

Their lab set up consists of a low power transmitter with facilities for test signals, color bards, slides and movies. They had two chromatron receivers and a hi-ball RCA Aperture Mask Receiver in the viewing room. The Chromatron tubes were internal sandwich type with horizontal wires and rectangular glass bulbs. They were not turned on during my visit.

Dumont plans to build a phosphor-on-the-face-plate type of tube with vertical wires. They are in preliminary contact with the glass companies. Dressler expected to have samples during the Summer (1957) and be ready to give public demonstrations in July or August.

He was agreeable to arranging a demonstration of their present set up, along with further disclosure of technical information providing we will sign an agreement to keep the information confidential for at least eight months.

William E. Good

William E. Good
Development Engineering
Television Receiver Department

WEG:REL

<u>COPY</u>

Comparison of Monochrome and Color Tube Costs

Abstract:

The cost of the 21" - 90° aluminized monochrome picture tube is compared with those of the Aperture Mask, Post Acceleration, and the Apple color tubes. Shown in chart form are comparisons of material content, number of process steps, shrinkages assumed and theoretical and actual tube costs at both the 300,000 and the 1,000,000 unit level. Also included, is a discussion of the major factors producing the cost differential. The figures used are in terms of 1956 dollars and as such do not allow for increased labor or materials costs. However, anticipated process improvements and cost reductions have been factored into the figures.

The tube cost data included in this study has been prepared by Cathode Ray Tube Engineering from the most recent material price estimates and the present concept of the manufacturing processes required to produce each of the types. The data has been reviewed with the Financial Section. It is their feeling that the shop cost and manufacturing costs are consistent with prior color tube cost studies. However, due to the lack of specific information and experience in providing facilities equipment, personnel and processes, the details of the costs can be no more than Engineering estimates.

Conclusion:

Summarized in Chart 1 are the results of this report. It is clearly indicated that display tubes, of the type mentioned, which must perform the color function within the tube will cost from two to three times that of an equivalent monochrome tube. This is due largely to the increase in both materials and processes and in the tolerances involved in providing for the color display.

Discussion:

The additional cost of the color tube is the result of having to produce means whereby color selection can be obtained. Whereas, in a monochrome tube the electron beam excites but a single phosphor, color tubes generally employ from one to three beams whose path must be controlled throughout their transit to the screen so as to be directed toward one of the three colored phosphors. Color selection for the Aperture Mask, Post Acceleration and Apple tubes is obtained in three different ways. The Aperture Mask tube employs a mask which shadows the electron beams. The Post Acceleration tube employs a grille which provides for electron optical shadowing and the Apple tube derives a signal from a different emitting material which indicates the position of the electron beam at the phosphor screen and consequently the color signal to be applied to the tube.

The fact that color selection is needed implies:

(a) Bulbs with tighter glass tolerances

(b) Tighter tolerances for the production of and control of electron beams

(c) A color selection mechanism

(d) The use of three colored (red, green and blue) phosphors deposited in a pre-determined geometrical pattern

Chart 2 summarizes the total number of glass and metal parts that are needed to provide color selection. Chart 3 indicates the number of process steps that are required in the various tubes. Note that the color tubes require about twice the number of steps as monochrome.

Chart 1

% of Color Costs over Monochrome

Units		Mono.	Apple	Aper Mask	Post Acc.
300,000	theoretical	100%	248%	328%	334%
	actual	100%	281%	355%	366%
1,000,000	theoretical	100%	205%	249%	251%
	actual	100%	232%	280%	276%

Chart 2

Metal and Glass Part Totals

	Mono.	PA	AM	Apple
Bulb	1	1	1	1
Gun	33	166	166	68
Mask or Grille	--	15	5	--
Total	34	182	172	69

Chart 3

Process Totals

Tube Type	Cap Prep	Fun. Prep	Tube Assly	Tube Finish	Mount Assly	Mask Grille	Totals
Monochrome	20	2	3	8	19	-	52
Apple	65	15	6	10	17	-	114
AM	43	8	6	8	33	22	120
PA	43	7	6	8	27	30	121

Chart 4

Shrinkage

21" - 90° Monochrome (considered excellent)

Bulb Prep.	80% yield	20% loss
Finishing	90% yield	10% loss
Overall	72% yield	28% loss

Color (shrinkage used in estimates)

Bulb Prep.	70% yield
Finishing	85% yield
Overall	60% yield

Chart 5

Comparison Theo. Color vs Theo. Monochrome Costs — 300,000 per year

Materials	Mono.	Apple	% over Mono	AM	% over Mono	PA	% over Mono
Bulb	$ 8.25	$ 12.00		$ 15.00		$ 17.00	
Gun	.34	.65		1.40		1.60	
Screen	.21	3.25		.88		3.25	
Misc.	.07	.08		.08		.08	
Dir. Mech.	----	2.10		12.00		5.00	
	8.87	18.08	204%	29.36	332%	26.93	304%
Direct Labor	.64	2.51		2.21		2.83	
Misc. (transport)	.28	.70		.70		.70	
IME	2.08	8.16		6.63		9.19	
	$ 11.87	$ 29.45	248%	$ 38.90	328%	$ 39.65	334%

Chart 6

Comparison Theo. Color vs Theo. Monochrome Costs — 1,000,000 per year

Materials	Mono.	Apple	% over Mono	AM	% over Mono	PA	% over Mono
Bulb	$ 8.25	$ 10.50		$ 14.00		$ 12.00	
Gun	.34	.65		1.60		1.40	
Screen	.21	.88		.88		.88	
Misc.	.07	.10		.08		.08	
Dir. Mech.	----	2.10		3.50		6.00	
	8.87	14.23	160%	20.06	226%	20.36	230%
Direct Labor	.64	2.21		2.21		2.21	
Misc. (transport)	.28	.70		.70		.70	
IME	2.08	7.18		6.63		6.63	
	$ 11.87	$ 24.32	205%	$ 29.60	249%	$ 29.90	251%

Chart 7

Comparison of Total Color vs Total Monochrome Costs — 300,000 per year

Materials	Mono	Apple	% over Mono	AM	% over Mono	PA	% over Mono
Bulb	$ 8.58	$ 13.20		$ 16.50		$ 18.70	
Gun	.49	.79		1.54		1.76	
Screen	.34	4.64		1.26		4.64	
Misc.	.08	.10		.10		.10	
Dir. Mech.	----	2.63		15.00		6.25	
	9.49	21.36	225%	34.40	362%	31.45	331%
Direct Labor	1.15	4.77		4.20		5.38	
Misc. (transport)	.32	.75		.75		.75	
IME	4.07	15.50		13.65		17.49	
	15.03	42.38	281%	53.36	355%	55.07	366%
Complaints, Royalties, Engineering, C & A	2.53	7.13		8.98		9.27	
	$ 17.56	$ 49.51		$ 62.34		$ 64.34	
Estimated Selling Price		$ 57.57		$ 72.49		$ 74.82	

Chart 8

Comparison of Total Color vs Total Monochrome Costs 1,000,000 per year

Materials	Mono	Apple	% over Mono	AM	% over Mono	PA	% over Mono
Bulb	$ 8.58	$ 11.55		$ 13.20		$ 15.40	
Gun	.49	.79		1.54		1.76	
Screen	.34	1.26		1.26		1.26	
Misc.	.08	.10		.10		.10	
Dir. Mech.	---	2.63		7.50		4.40	
	9.49	16.33	172%	23.60	248%	22.92	241%
Direct Labor	1.15	4.20		4.20		4.20	
Misc. (transport)	.32	.75		.75		.75	
IME	4.07	13.65		13.65		13.65	
	15.03	34.93	232%	42.20	280%	41.52	276%
Complaints, Royalties, Engineering, C & A	2.53	5.28		7.10		6.99	
	$ 17.56	$ 40.21		$ 49.30		$ 48.51	
Estimated Selling Price		$ 46.75		$ 57.32		$ 56.40	

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.

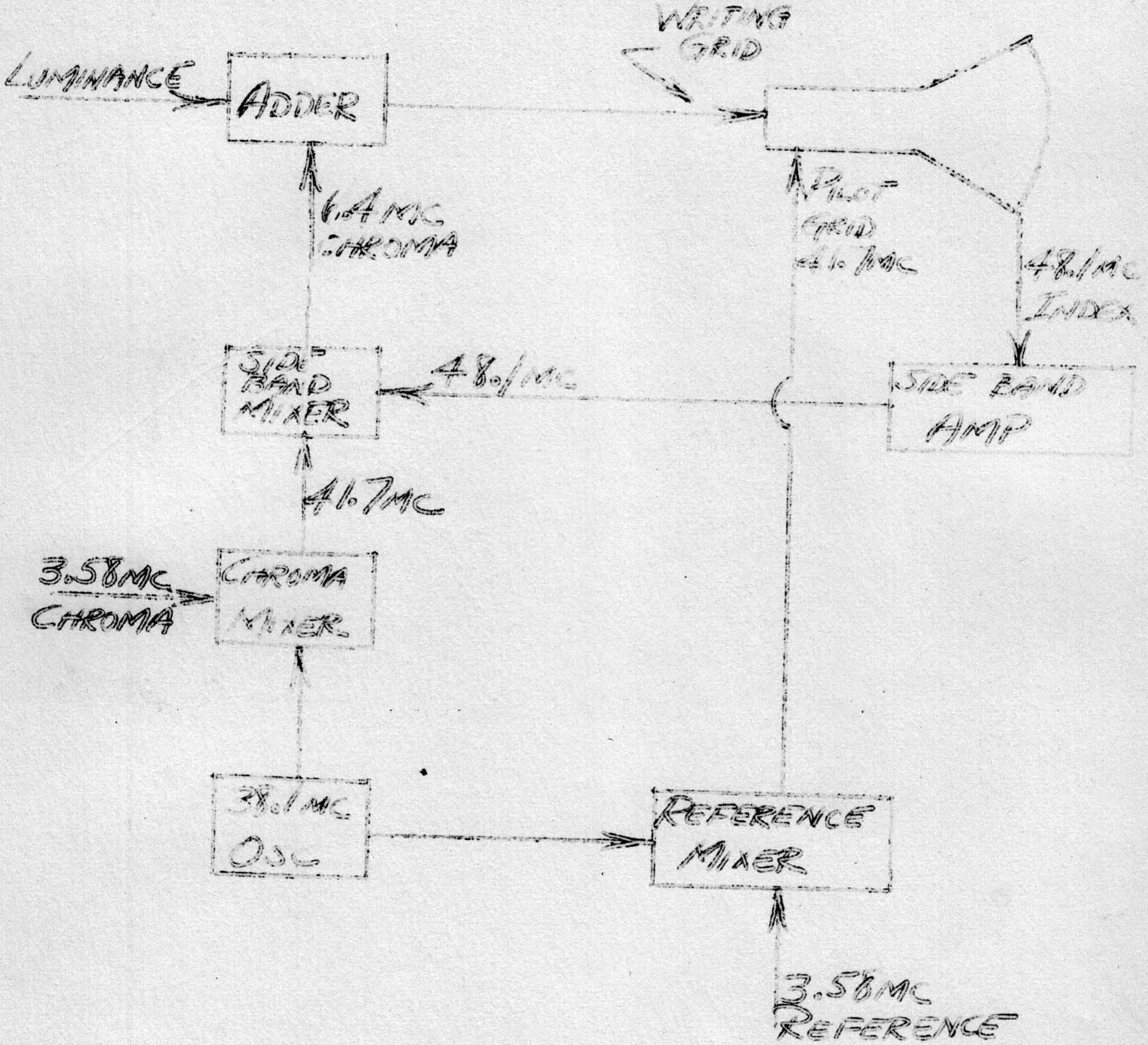
T. V. Zaloudek

TV Zaloudek

4/30/57

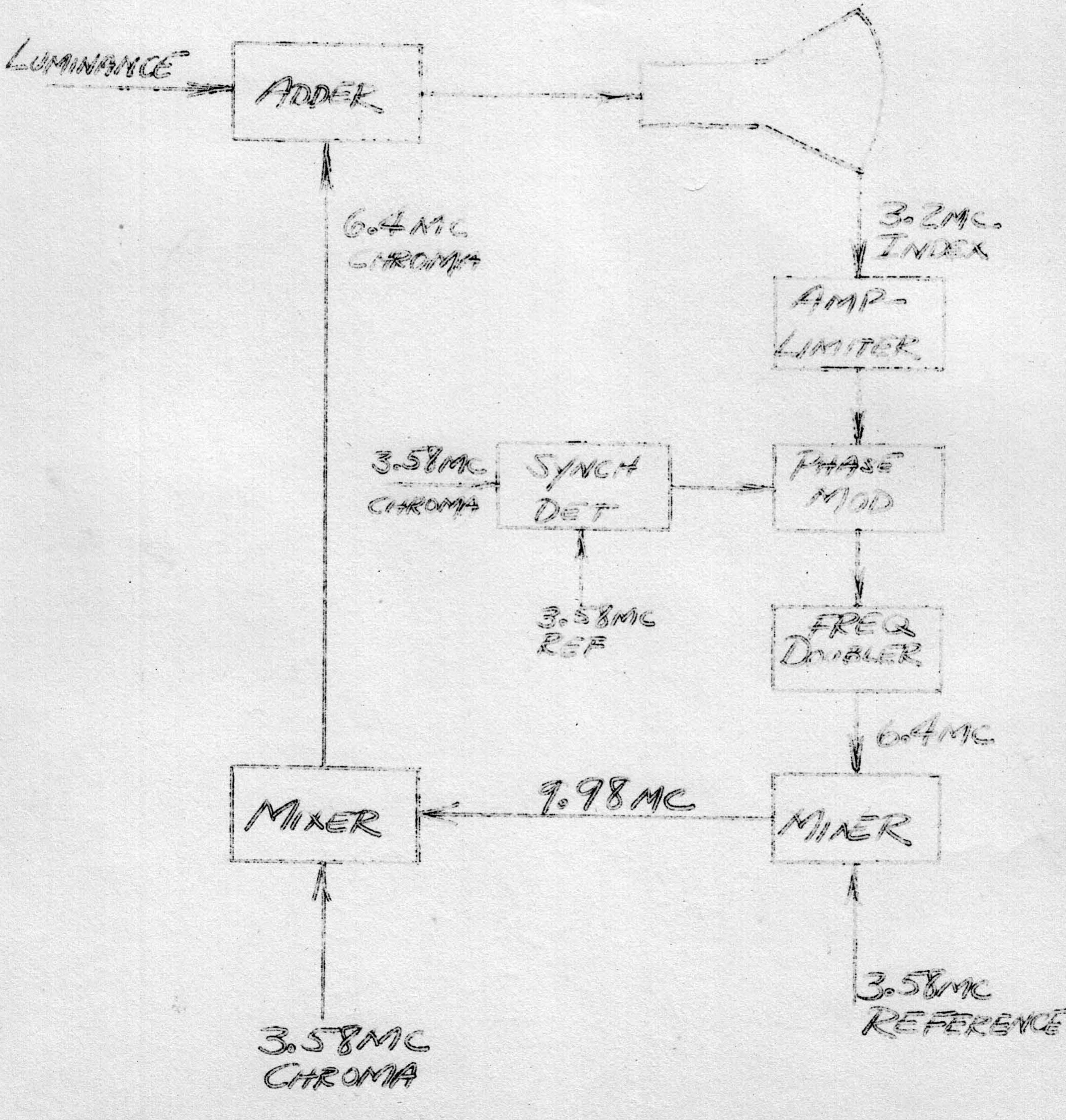
APPLE VARIATIONS

PHILCO'S APPLE SYSTEM

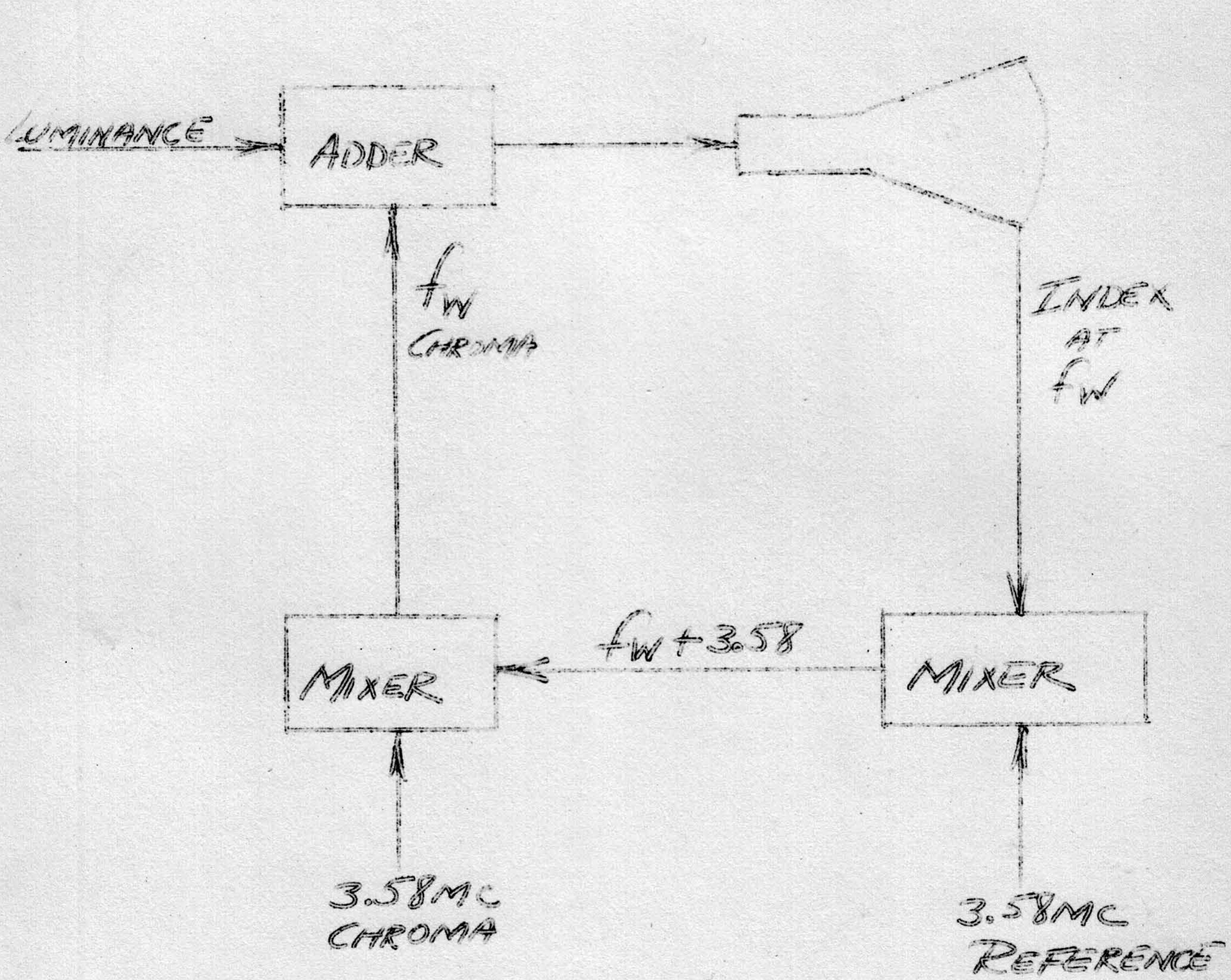


APPLE VARIATIONS

PHASE CORRECTION OF THE INDEX SIGNAL



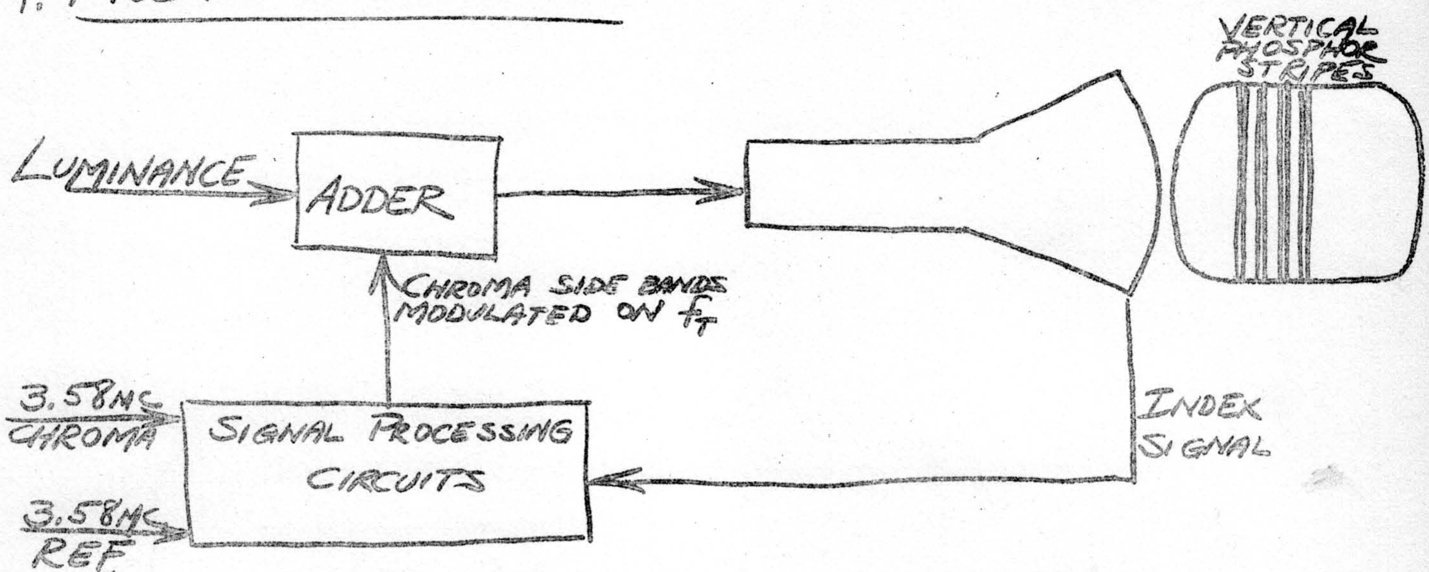
SIMPLEST FORM OF APPLE VARIATION THAT ONE MIGHT CONSIDER



f_W = RATE AT WHICH COLOR TRIADS ARE SCANNED

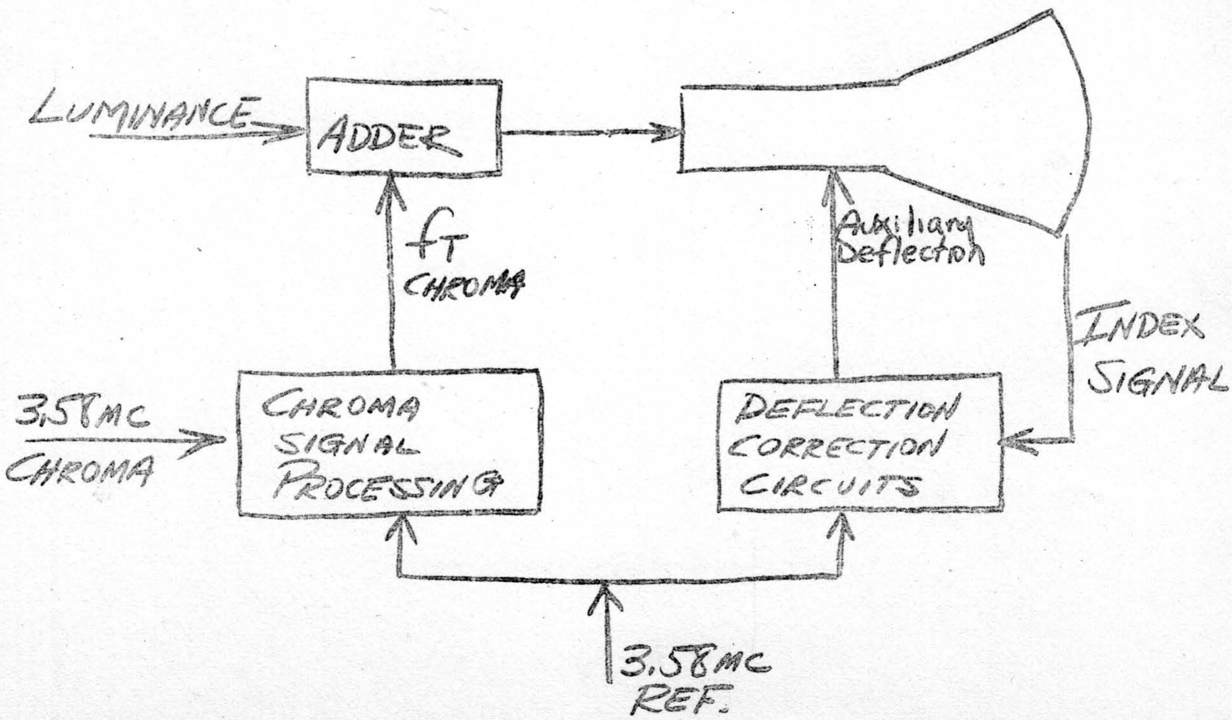
TWO BASIC FORMS OF APPLE VARIATIONS

A. MODIFIED SIGNAL

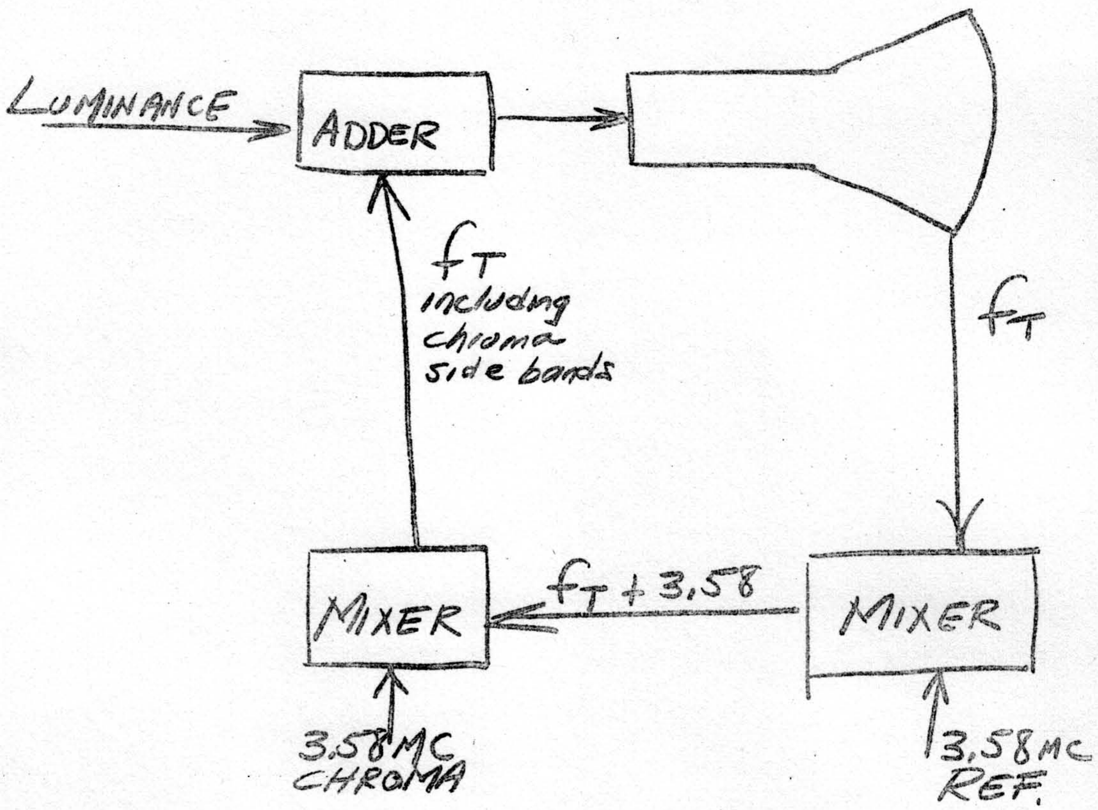


f_T = FREQUENCY AT WHICH BEAM SCANS THE TRIADS.

B. MODIFIED DEFLECTION



SIMPLEST FORM OF APPLE VARIATION THAT ONE MIGHT CONSIDER



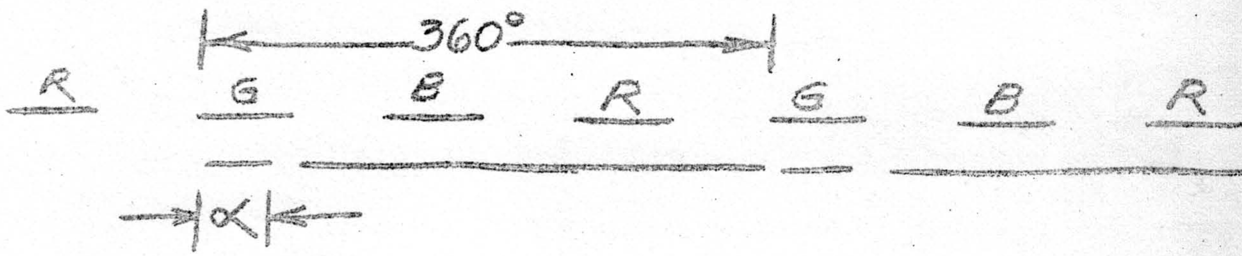
NOTES

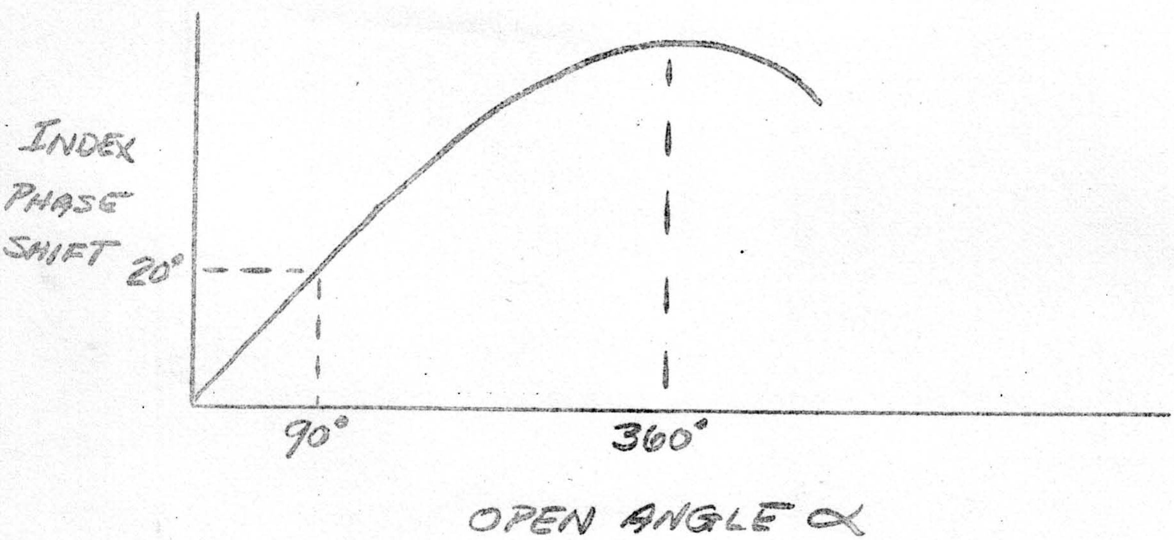
① f_T = RATE AT WHICH TRIADS ARE SCANNED

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.

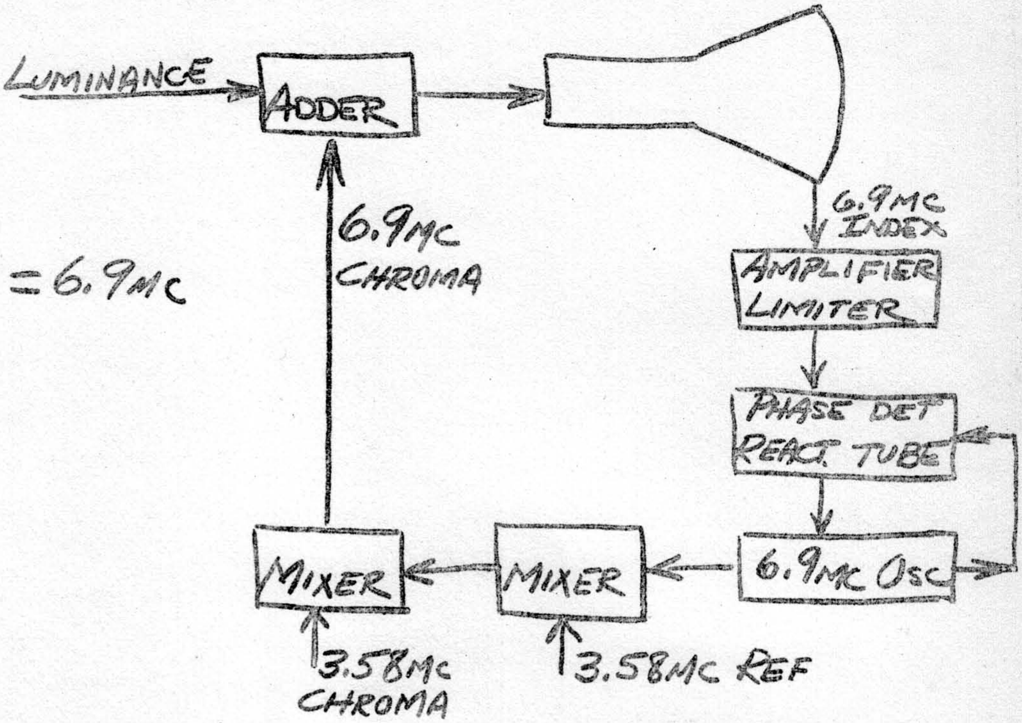
example: Dome's docket April 26, 1956





EXAMPLES OF GROUP I (NARROW SINGLE-ENDED COMB)

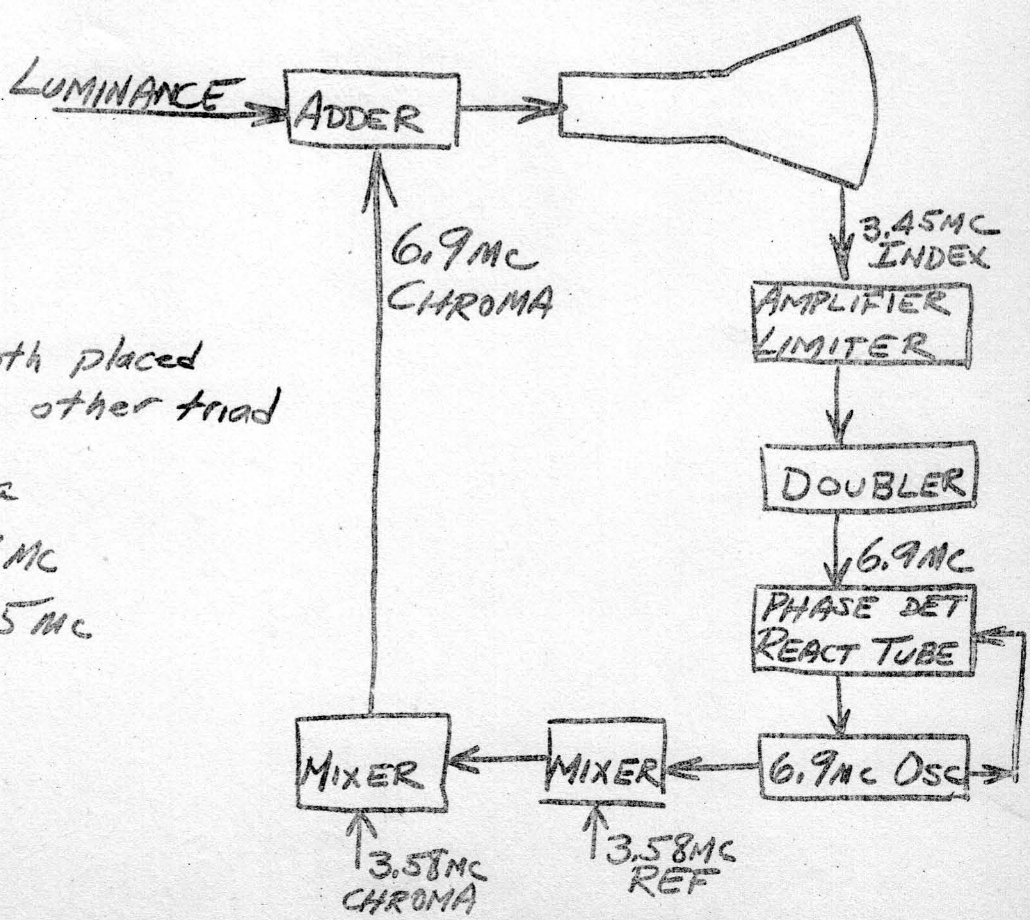
①



NOTES

$f_T = f_i = 6.9Mc$

②



NOTES

ⓐ Narrow tooth placed behind every other triad

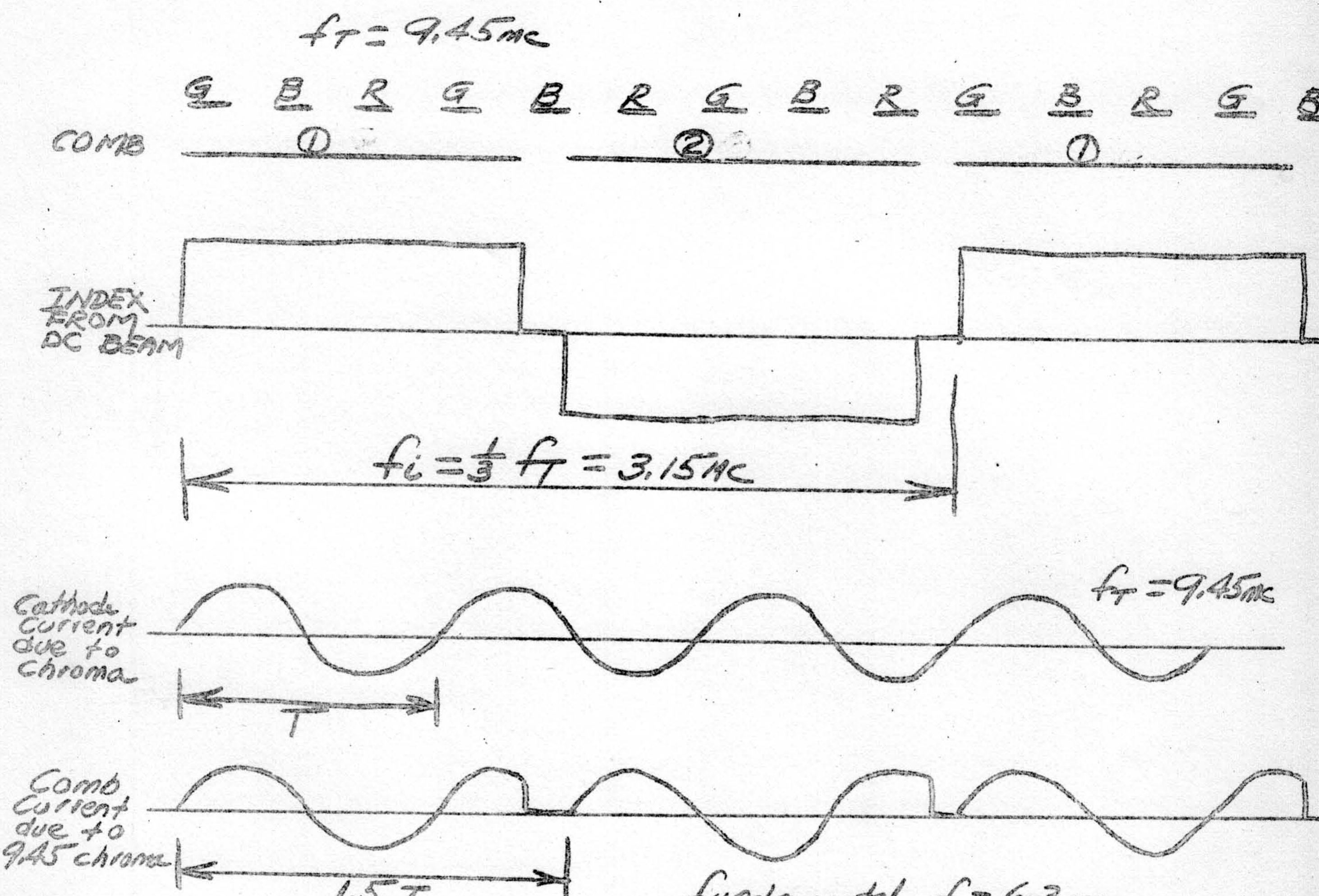
ⓑ Freq. data

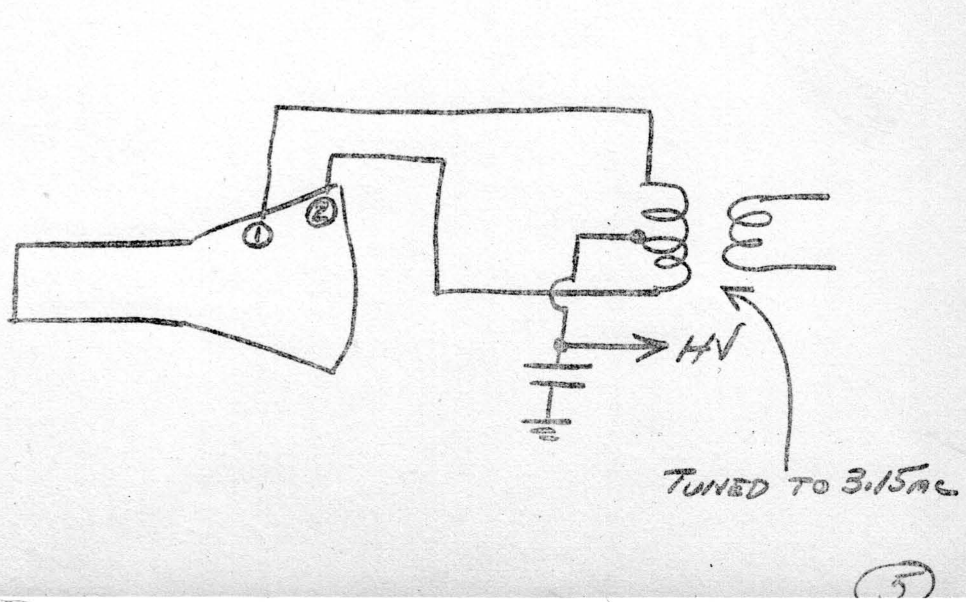
$f_T = 6.9 Mc$

$f_i = 3.45 Mc$

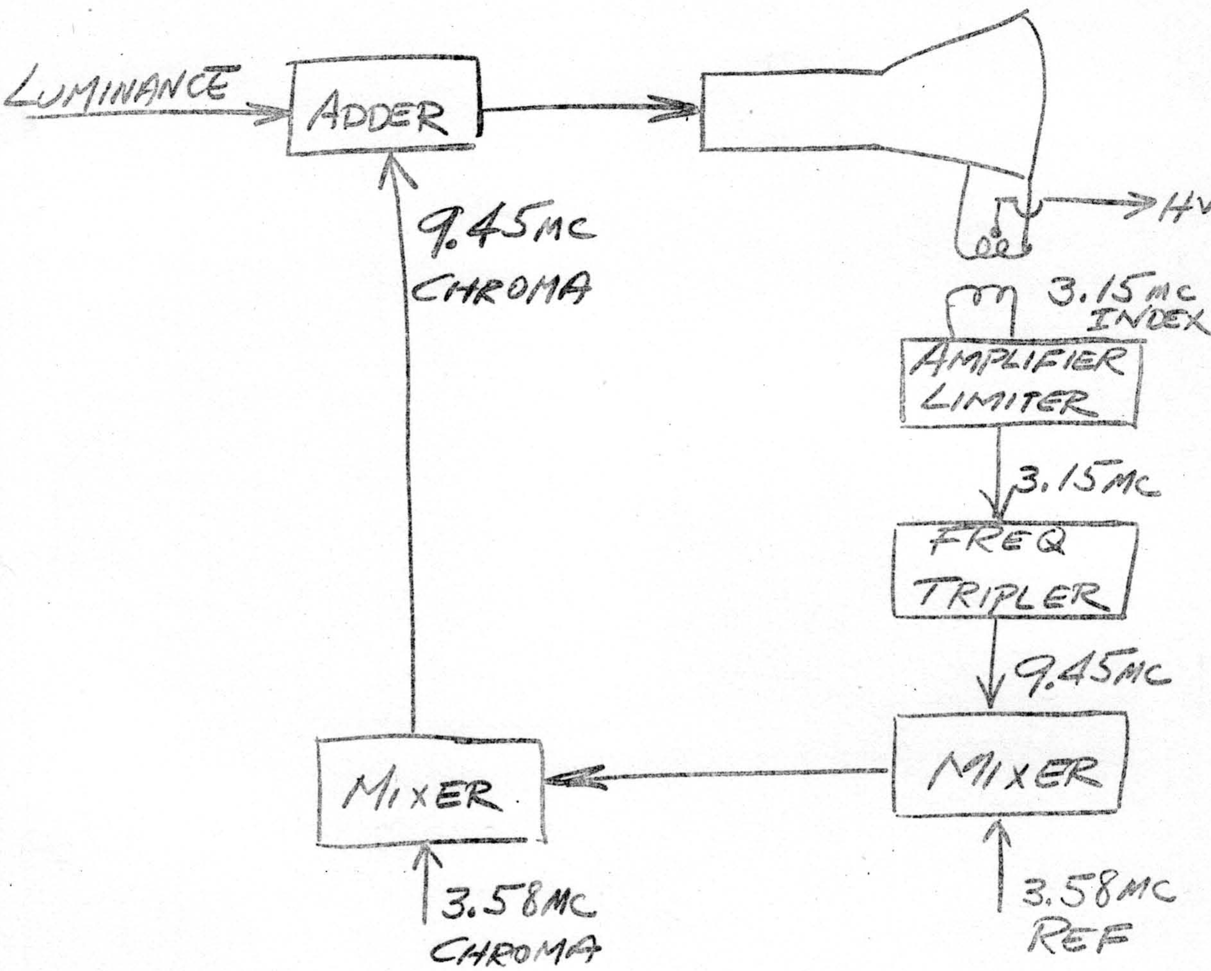
GROUP II PUSH PULL INDEX TAKE OFF

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





KIM'S COMB SYSTEM (CONT)



NOTES

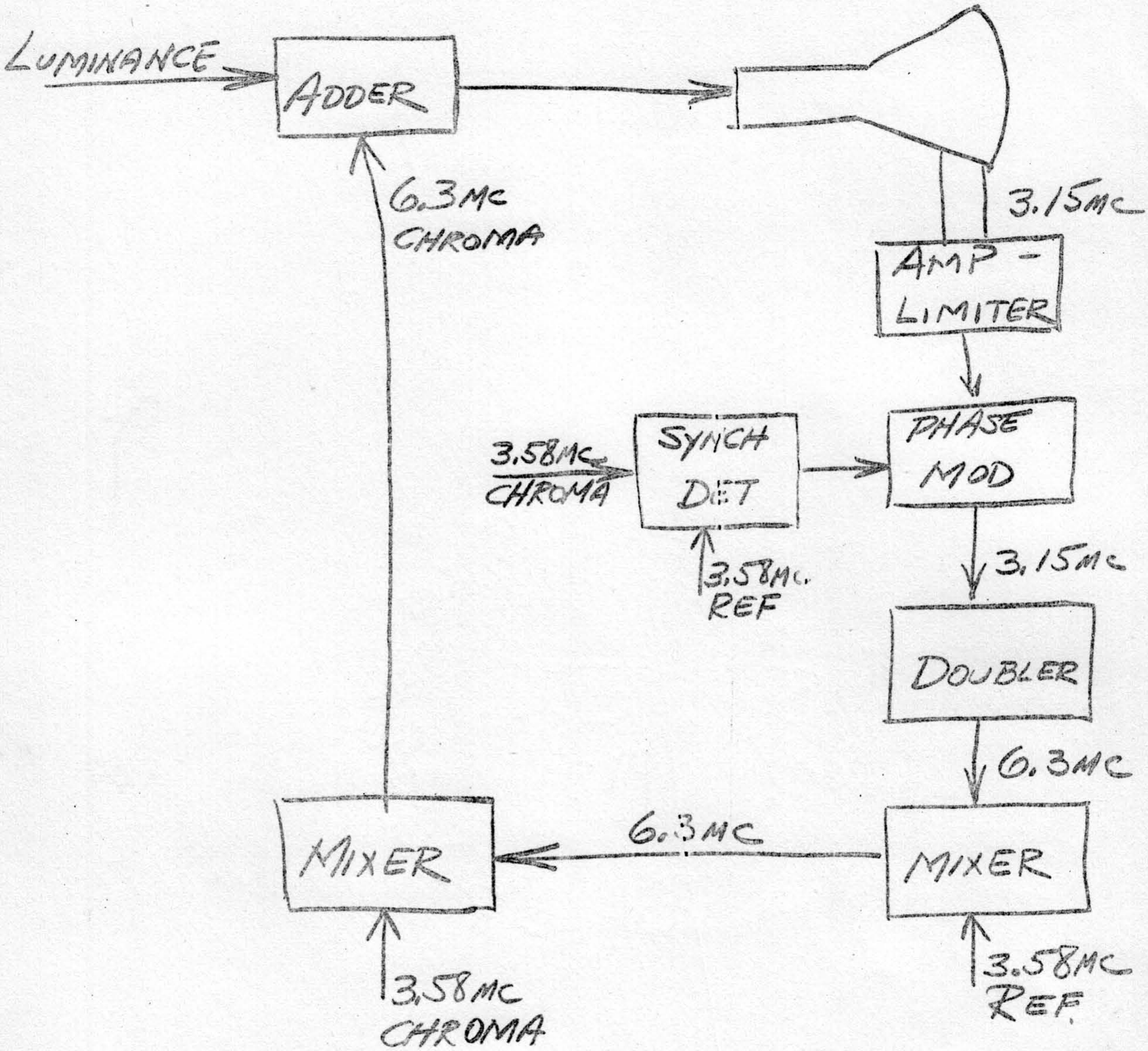
$f_T = 9.45$ MC

$f_i = 3.15$ MC

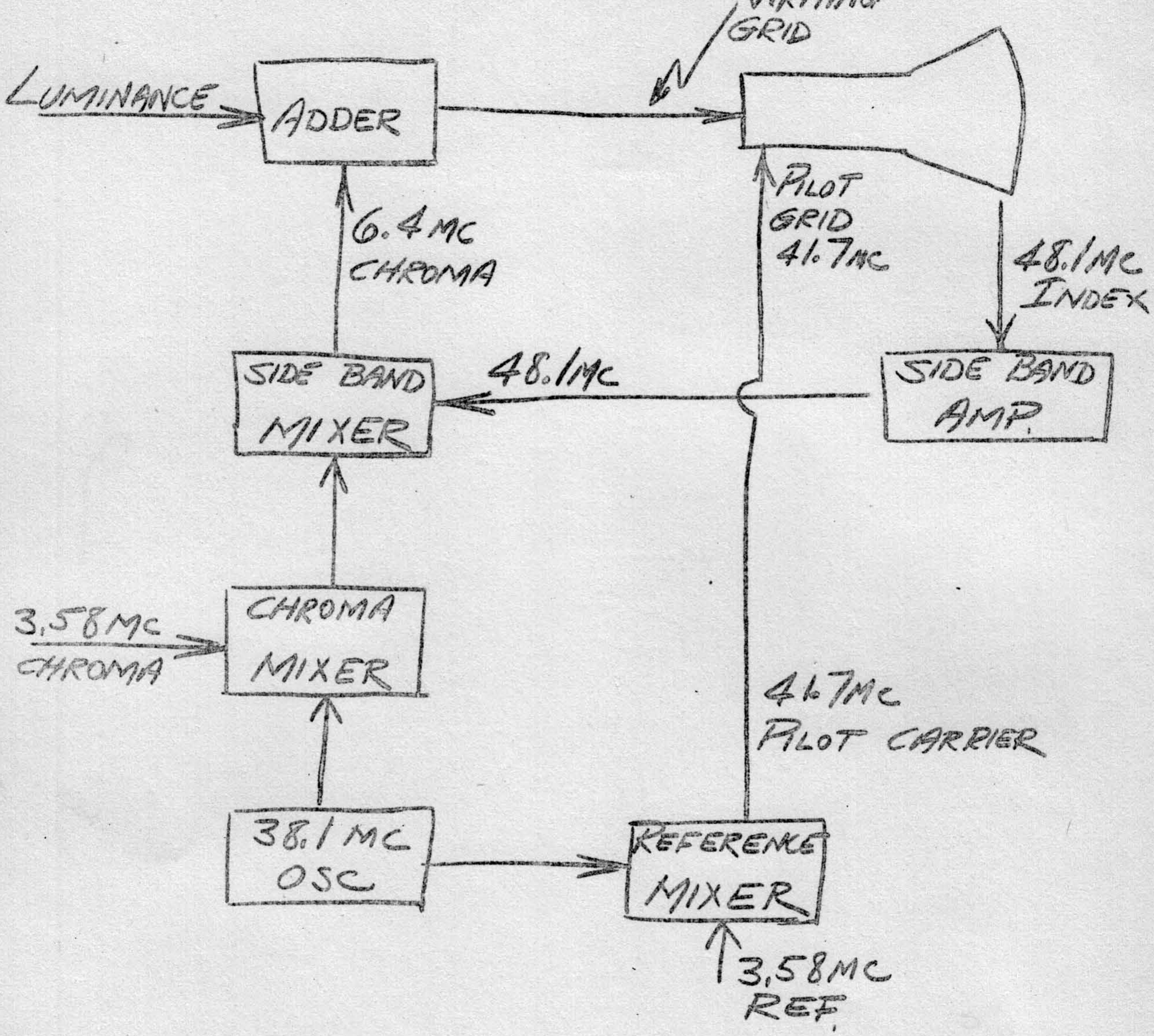
Push pull index take off.

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

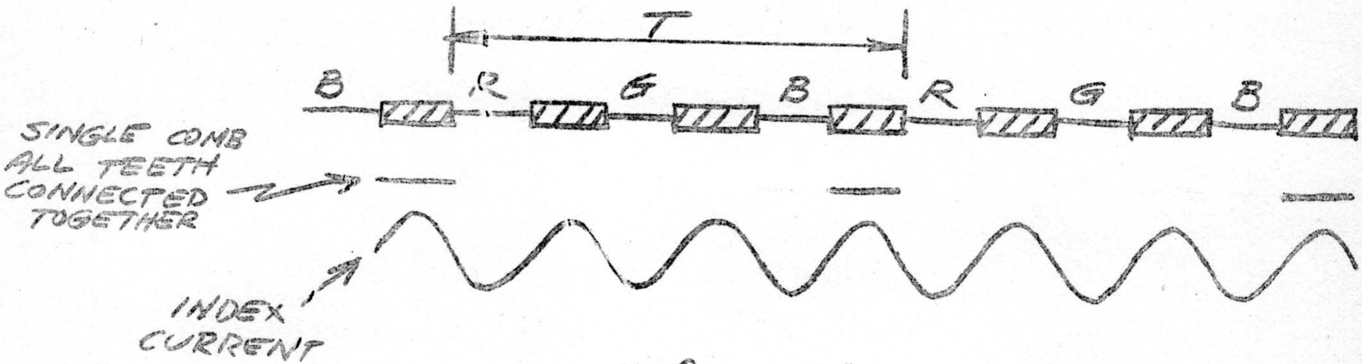
$f_i = 48.1$ MC

MgO freq = 6.4 Mc

② SINGLE GUN – 2 BEAMS

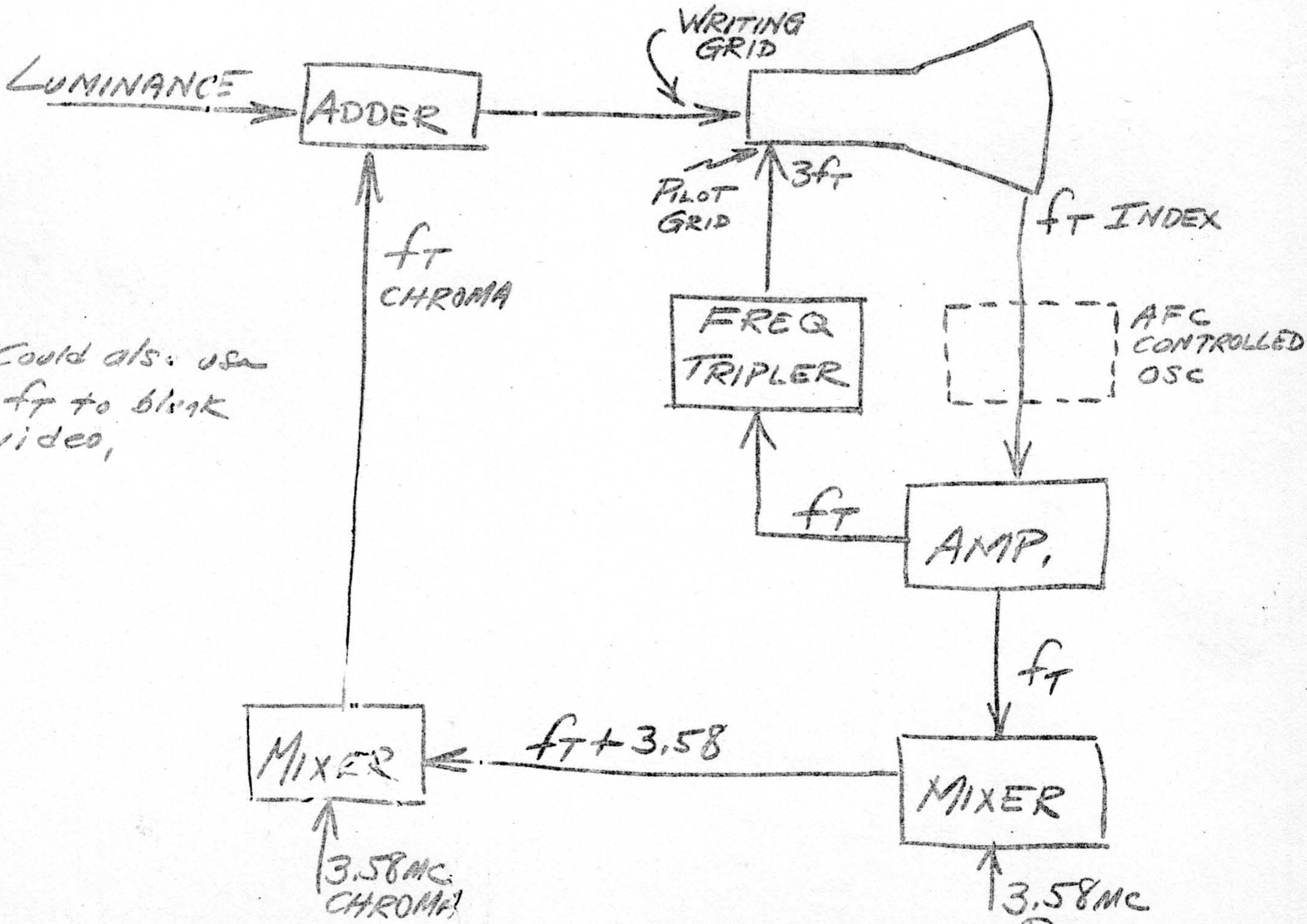
GROUP III EMPLOYING PILOT BEAM

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



f_T = TRIAD FREQ

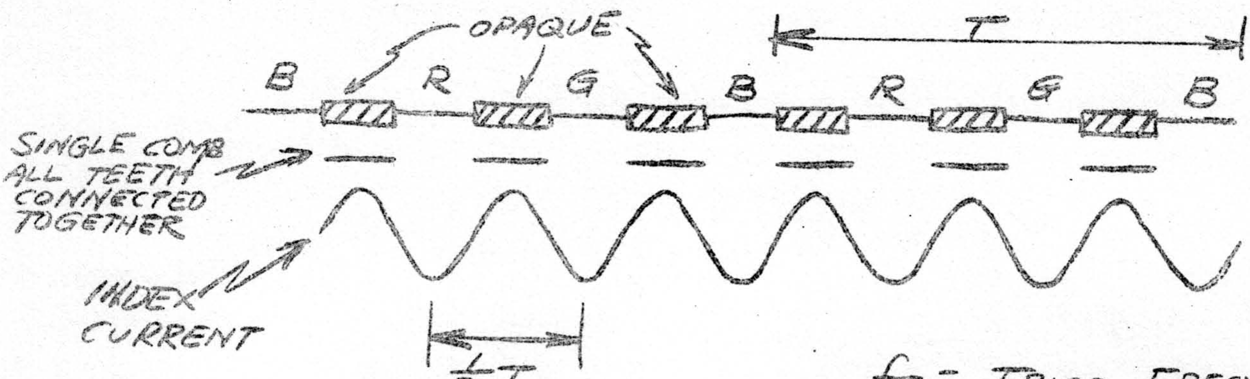
PILOT CARRIER = $3f_T$



Could also use $3f_T$ to blank video,

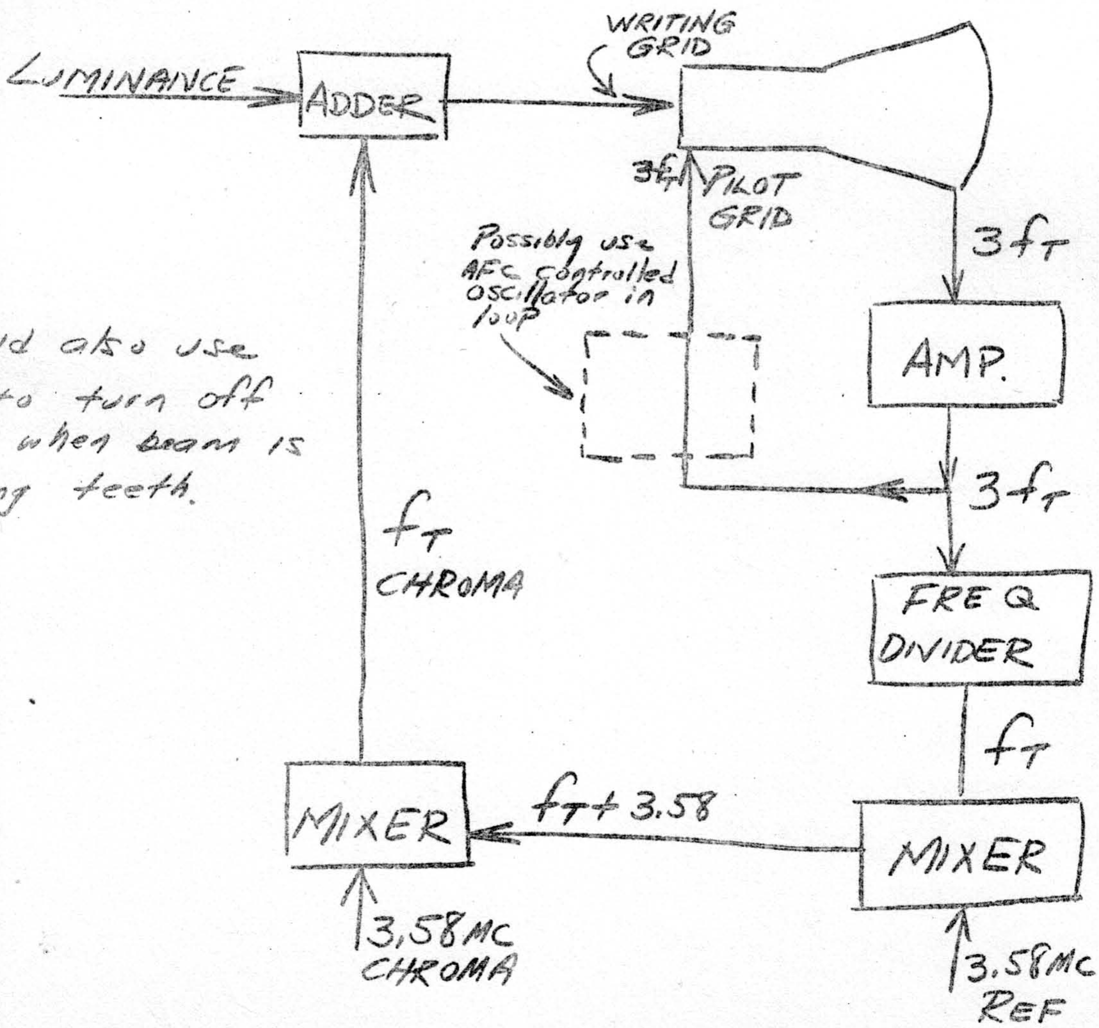
GROUP III EMPLOYING PILOT BEAM

② PROPOSED BY LYNCH and TRUE



f_T = TRIAD FREQ

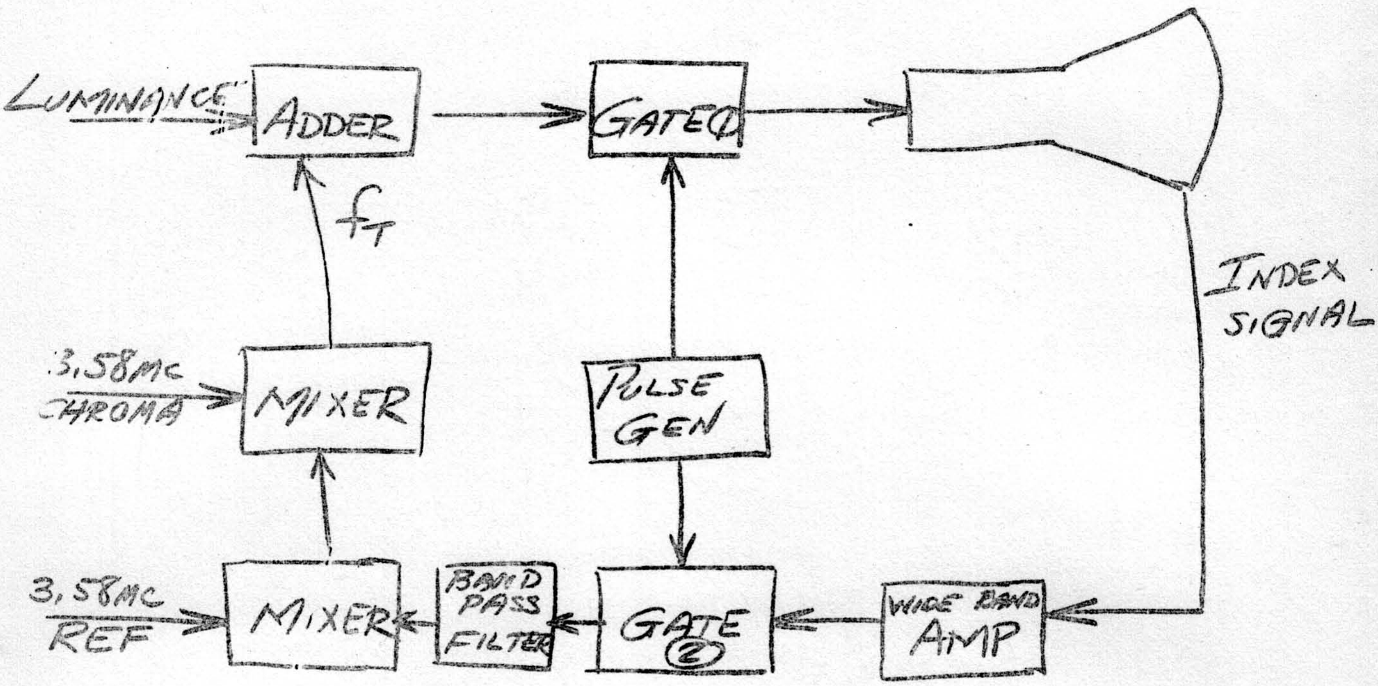
$f_i = 3 f_T$



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



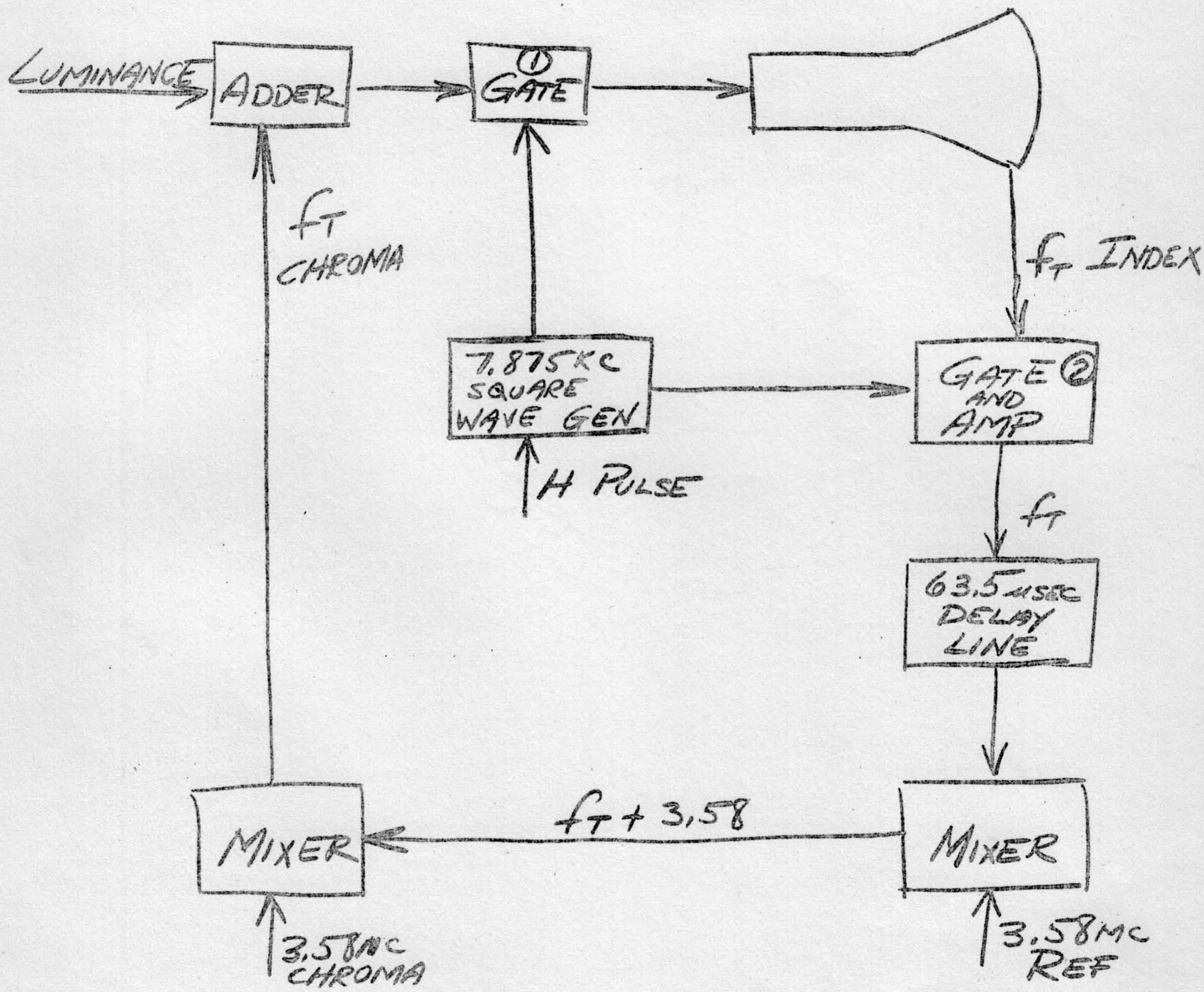
GATES ① and ② OPEN & CLOSE IN OPPOSITION.

INDEX STRIPES PLACED ONE PER TRIAD (MgO)

GATES OPERATED AT FREQ HIGHER THAN f_T.

GROUP IV TIME SHARING SYSTEMS

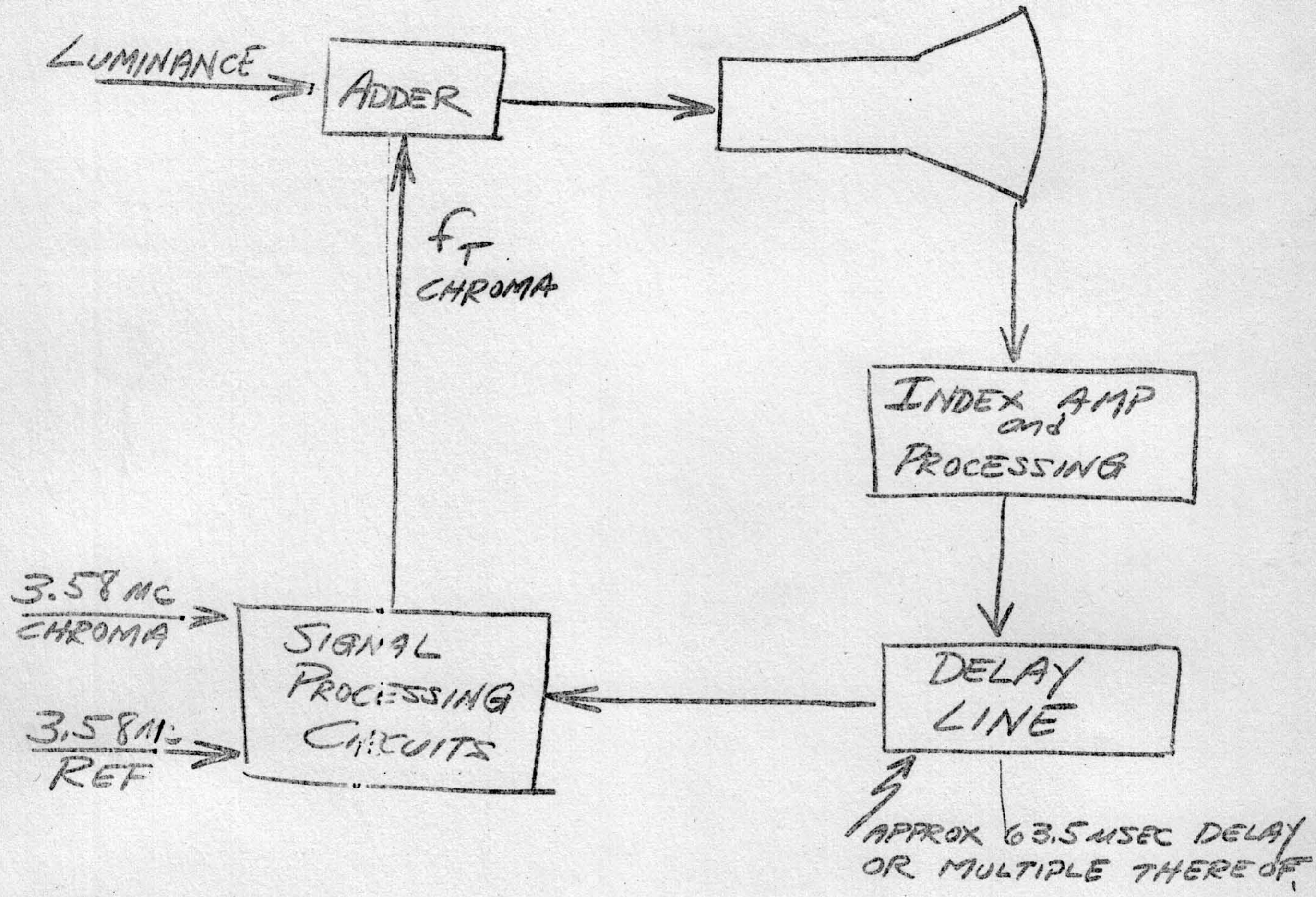
② PROPOSED BY FIELD and ZALOUDEK



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 recovering 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) =

<u>314 uw</u>

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.) =

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

<u>0.131 uw</u>

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) =

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

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

9.101 Single-Gun Color Picture Tube

Syracuse, New York
April 26, 1956

Mr. D. N. Timbie
Legal Department
Building 1
Electronics Park

This disclosure letter deals with the design of a single-gun color picture tube suitable for the reproduction of television images in full natural color.

Several designs of single-gun color picture tubes have appeared in the past. Some of these are:

1. The aperture mask type of RCA
2. The Lawrence tube with grill
3. The Lafferty 45° tube with aperture mask
4. The Philco "Apple" tube with indexing beam

Number 1 is very low in light output and is expensive to manufacture because of the mask. Number 2 requires a high r.f. switching voltage and can produce r.f. interference to other services and is expensive to manufacture because of the interleaved grill which has to be inserted in the tube before the face plate is attached. Number 3 requires keystone correction and is expensive to manufacture because of the mask. Number 4 is probably the least expensive tube to manufacture of the four but requires an auxiliary gun for indexing and requires rather complex additional circuitry.

The present proposal is for a tube somewhat like the Apple tube but differing therefrom in several respects. Only one gun and cathode-ray beam is used. No secondary emission stripes are used. Instead, the signal that indicates the beam position is taken from a special metallic coating deposited or evaporated on the back of the phosphor screen. This metallic coating is in the form of a fine-toothed comb as shown in Fig. 1.

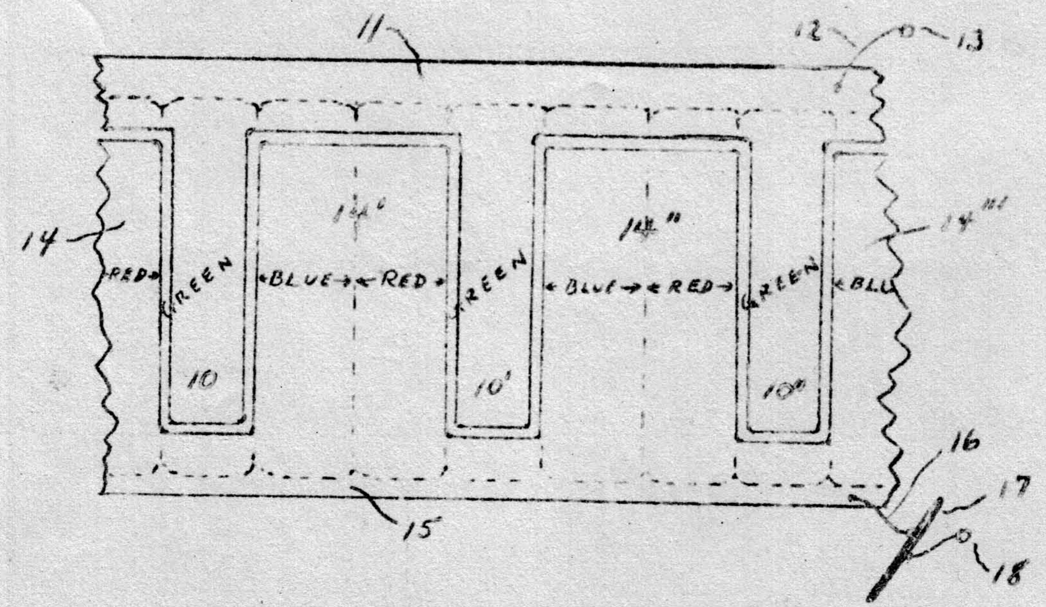


Fig. 1

The fine-toothed comb consists of teeth 10, 10', etc., connected to a strip 11 running horizontally across the top (or bottom) of the tube and which is connected to a conductor 12 leading to an external connector 13. The coarse-toothed comb consists of teeth 14, 14', 14", etc., connected to a strip 15 running horizontally across the bottom (or top) of the tube and which is connected by a conduction path 16 to the internal coating 17 on the funnel of the cathode-ray tube which in turn is connected to an external connector 18 on the side of the bulb.

Phosphor stripes are located as shown in Fig. 1, the order of which is arbitrary, but shown here as having the green light emitting phosphor in line with the fine teeth followed by blue and red light emitting stripes covering the coarse teeth so that the order is red, green, blue, red, green, blue, etc. A set of red, green, and blue stripes is known as a "triad". For the purposes of the analysis which is to follow shortly, it is assumed that the width of a single triad is 360° or 2π radians. Each of the three stripes of the triad is assumed to cover 120°, or $\frac{2\pi}{3}$ radians.

The picture tube is provided with a scanning means. As the beam of electrons is swept across the screen the electron current will flow into the fine-toothed comb either directly or indirectly by capturing secondary electrons from the phosphor powder, or by a combination of these ways, to cause a series of current pulses to flow into an external circuit connected to terminal 13. When the beam terminates on the broad teeth or on the phosphors beneath the broad teeth, no current flows in the circuit connected to terminal 13; instead, the current, consisting of broad pulses, flows directly to the source of high voltage to which terminal 18 is connected.

Now the series of impulses available at terminal 13 will be fed into an amplifier 36 coupled by tuned circuits, tuned to the frequency corresponding to the repetition rate of the pulses, and the output of the amplifier will be a sinsusoidal wave. This sine wave is supposed to indicate, by the time position of its peaks, the position of the ray as it strikes the screen. Ultimately the sine wave will control the ray at the intensity control electrodes of the gun to determine the color to be reproduced. This is done by modifying the phase of the sine wave in accordance with received chroma information so that if red is called for the wave is made to crest at a time so that the beam strikes the red phosphor, etc.

It is evident, then, that the pulses picked up by the fine teeth must contain a minimum amount of misinformation regarding the actual spot position. Misinformation can arise if the beam modulation changes its intensity in any unsymmetrical way as the beam is swept across a fine tooth. It is therefore an important aspect of the problem to determine the probable extent of such misinformation and to devise some means for minimizing it. In Fig. 2, a wave 20 indicates the electron beam intensity as a function of time or position as it moves across the screen. If a narrow tooth is crossed at an interval 21, the pulse center of gravity lies half way along the interval and no phase distortion results. The same can be said for an interval

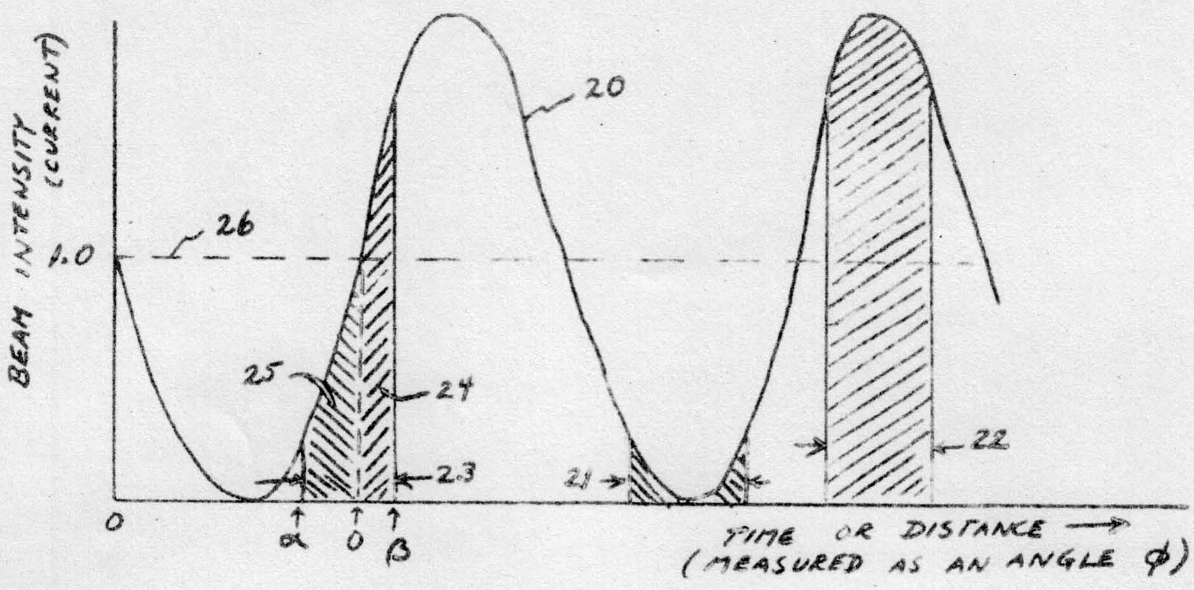


Fig. 2

crossed at position 22. But if an interval such as 23 is crossed where the beam intensity is not balanced with respect to the center of the interval, phase distortion will result because the center of gravity of the pulse 23 lies to the right of the center of the interval. The interval 23 is shown here divided into two separate cross-hatched sections with cross-hatching of opposite slopes. The cross-hatched areas are equal so that the center of gravity lies on the line identified by the angle 0. The boundaries of the right hand cross-hatched area 24 are 0 and β, while the boundaries of the left hand cross-hatched area 25 are α and 0.

It is evident by inspection that if the fine tooth can be made narrow enough, the center of gravity and the center of the interval 23 will coincide and no phase distortion results regardless of the beam modulation. But this limit is zero width for the tooth and so is not usable because the output would be zero. Consequently, it is necessary to use a finite tooth width or interval 23 width and to determine the relationship between interval width and phase displacement.

I have assumed that the probable worst modulation case is that shown in Fig. 2, namely, that of a sine wave fully modulating the beam current whose mean value is 1.0 (the horizontal dotted line 26). Thus, the mathematical expression for wave 20 would be

$$y = 1 + \sin \phi \qquad (1)$$

where ϕ is a variable

Now the center of gravity of pulse 23 will lie on the line identified by $\phi = 0$ if the area on the left is equal to the area on the right, or mathematically when

$$\int_0^\beta y \, d\phi = \int_\alpha^0 y \, d\phi \qquad (2)$$

Substituting for y the value given in eq. (1),

$$\int_0^\beta (1 + \sin\phi)\, d\phi = \int_\alpha^0 (1 + \sin\phi)\, d\phi \qquad (3)$$

Integrating,

$$(\phi - \cos\phi)\Big|_0^\beta = (\phi - \cos\phi)\Big|_\alpha^0 \qquad (4)$$

Substituting the limits in these terms,

$$\beta - \cos\beta + 1 = -\alpha - 1 + \cos\alpha$$

or,

$$\beta - \cos\beta = -\alpha - 2 + \cos\alpha \qquad (5)$$

This transcendental equation in β may be solved for β in terms of α by trial and error by direct substitution of a series of values for β for any α chosen. The following table of values was obtained in this way:

α in Radians	$\cos\alpha$	$-\alpha-2+\cos\alpha$	β in Radians	Open Angle $\beta-\alpha$ in Radians	$\beta-\alpha$ in Degrees	Shift of Pulse Center $=\frac{\alpha+\beta}{2}$ in Radians	Shift of Pulse Center $=\frac{\alpha+\beta}{2}$ in Degrees
0	1.00000	-1.00000	0	0	0°	0	0°
-0.1	0.99500	-0.90500	0.09086	0.19086	10.93°	-0.00457	-0.26°
-0.2	0.98007	-0.81993	0.16627	0.36627	21.0°	-0.01687	-0.97°
-0.3	0.95534	-0.74466	0.22919	0.52919	30.35°	-0.03554	-2.03°
-0.4	0.92106	-0.67894	0.28943	0.68943	39.4°	-0.05529	-3.16°
-0.5	0.87758	-0.62242	0.32518	0.82518	47.4°	-0.08741	-5.00°
-0.6	0.82534	-0.57466	0.3609	0.9609	55°	-0.1196	-6.85°
-0.8	0.69691	-0.50309	0.4129	1.2129	69.5°	-0.1935	-11.1°
-1.0	0.54030	-0.45970	0.4435	1.4435	83°	-0.2772	-15.85°
-1.57	0	-0.43	0.4642	2.0342	116.5°	-0.5529	-31.6°
-2.00	-0.41615	-0.41615	0.4737	2.4737	142°	-0.7632	-37°
-2.50	-0.79864	-0.29864	0.5525	3.0525	175°	-9.9738	-47.1°
$-\pi$	-1.00000	0.14159	0.8222	3.9638	228°	-1.1597	-67°
-4.00	-0.6494	1.3506	1.46	5.46	314°	-1.27	-72.5°
-4.50	-0.2079	2.2921	1.935	6.435	368°	-1.283	-73.5°
-5.00	0.2924	3.2924	2.50	7.50	430°	-1.25	-71.5°

TABLE OF PHASE SHIFT VS OPEN ANGLE

In the above table the pulse width is expressed as the "open angle", and corresponds to the width 23 in Fig. 2. The "shift of the pulse center" means the angular displacement of the midway distance across the pulse with respect to the center of gravity of the pulse and is therefore the phase shift of interest. The data is shown graphically on the attached curve sheet. Note that the shift reaches a maximum of about 73.5° for a sampling or open angle of 360° and then begins a slight decrease.

It should be pointed out that the curve represents about the maximum error that might be expected because of the 100 per cent modulation assumed. In picture areas where the light variations are not so pronounced the shift will be considerably less.

A sampling angle of 90° ought to be a good compromise; the maximum shift is then about 20° (from the curve) and the chances are good that for most of the picture the error will be 10° or less. If 90° is used, the 90° interval would be measured between the center lines of the spaces separating the fine teeth and the coarse teeth in Fig. 1 so that the fine teeth themselves would be slightly less than 90°, say 63°. An idea of the physical width of a fine tooth can be obtained by simple calculation. Suppose the trace length across the tube is 19 inches and that there are 380 triads. Then one triad would have a physical width of

$$W = \frac{19''}{380} = 0.050'' \qquad (6)$$

Since W corresponds to 360°, the width of a fine tooth would be

$$W = 0.050'' \left(\frac{63^\circ}{360^\circ}\right) \; 0.00875''$$
$$\text{or } 8.75 \text{ mils} \qquad (7)$$

The gaps separating coarse and fine teeth would be

$$d = 90^\circ - 63^\circ = 27^\circ \text{ each or } 3.75 \text{ mils} \qquad (8)$$

The width of the coarse teeth would be

$$D = 360^\circ - 90^\circ - 27^\circ = 243^\circ \text{ or } 33.75 \text{ mils} \qquad (9)$$

The method to be employed in laying down the comb may involve a photo-etch process. A continuous film of metal is first deposited or evaporated onto the phosphor screen. The surface is then photo sensitized and a photo image of the desired comb arrangement is exposed onto the surface. The surface is then developed by a suitable developer and a resist applied and then etched so as to remove metal corresponding to the required gaps, leaving the desired combs.

With 380 triads being crossed in 55 microseconds, the time of one horizontal scan, the fundamental frequency generated by the beam crossing the triads is

$$f = \frac{380}{55 \times 10^{-6}} = 6.9 \text{ MC} \qquad (10)$$

This output is fed into a phase detector 30 together with a local oscillator 31 at 6.9 MC, whereby the resultant phase detector output is used to set the local oscillator's phase and frequency to agree with that of the comb output. Fig. 3 shows this schematically by block diagrams. Detailed diagrams are not needed because these devices are well-known. The local oscillator is now mixed with the color reference subcarrier of 3.58 MC in a mixer 32 giving an unmodulated output at 3.58 MC ≠ 6.9 MC = 10.48 MC. This frequency is fed into another mixer 33 fed also with the 3.58 MC chroma sidebands to produce a frequency of 10.48 MC - 3.58 MC sidebands = 6.9 MC sidebands.

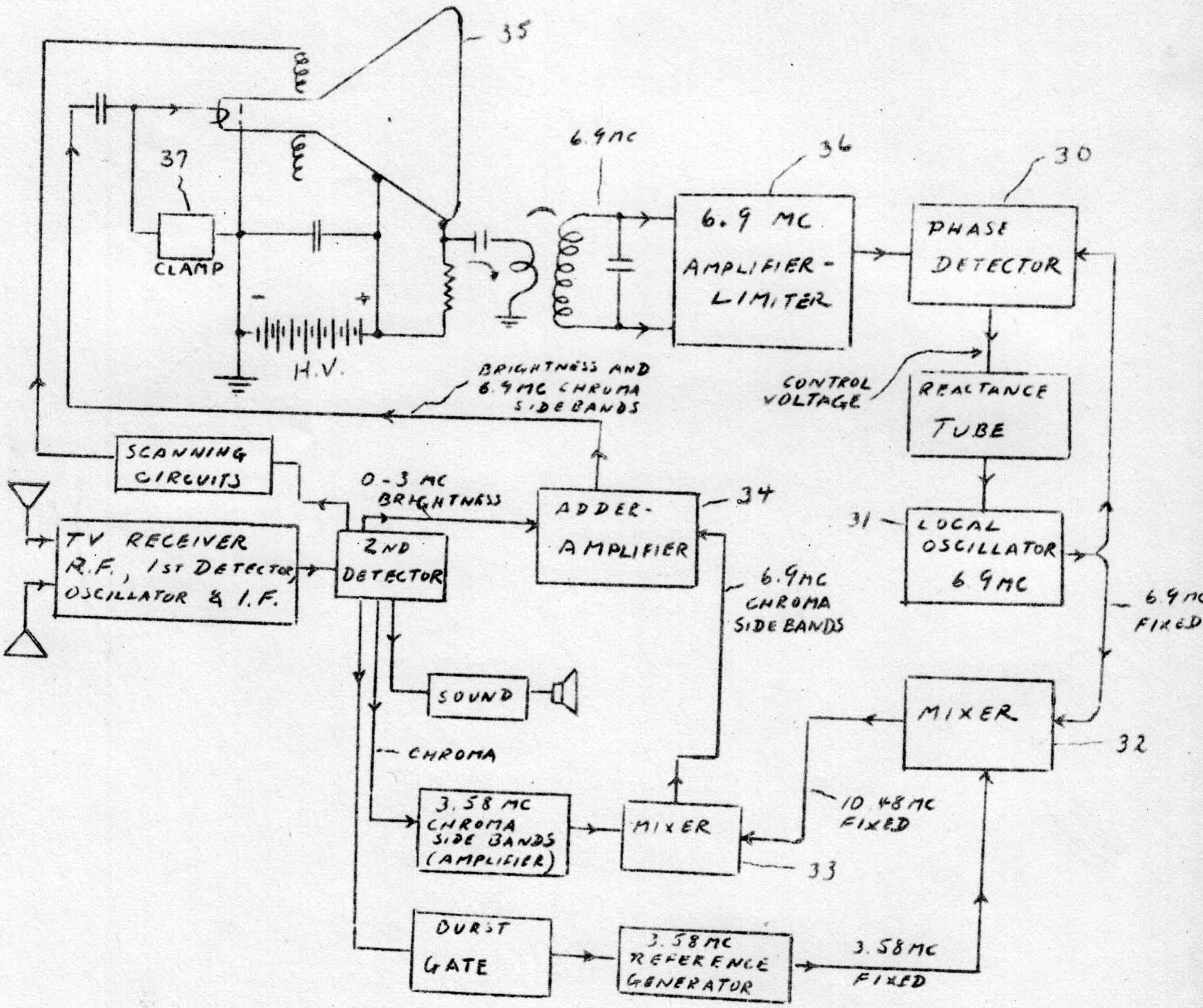


Fig. 3

These 6.9 MC sidebands are combined with brightness modulation in an adder 34 and the output used to excite the control of electrodes of my cathode-ray picture tube 35. A clamp 37 may be employed between the control electrodes of device 35 so as to prevent complete extinction of the spot except during flyback. In this way the flow of 6.9 MC pulses is not interrupted during the scanning cycle. Other parts of the receiver, not a part of the present invention, are shown but are not given symbols.

Some of the basic concepts of this invention are covered by an entry in my laboratory notebook #1009, pages 63, 64, 65, and 66, dated April 25, 1956, signed and witnessed on April 26, 1956.

Many variations of the proposed design will occur to those skilled in the art. For example, one question that may arise is: what is to prevent direct pickup of the 6.9 MC voltage present on the wires leading to the gun by the sensitive amplifier-limiter 36 input circuit tuned to the same frequency? Shielding and isolation are possible answers, but another scheme might be to place a fine tooth behind every other green stripe so as to produce half as many pulses per trip across the screen. The amplifier-limiter 36 would in the example given then be tuned to $\frac{6.9}{2}$ MC = 3.45 MC. The output of amplifier-limiter 36 is then fed into a frequency doubler to obtain the required 6.9 MC. No phase ambiguity will result from this manipulation and yet the sensitive amplifier at 3.45 MC will not be exposed to a strong field since the field in the picture tube is strong at 6.9 MC.

Will you kindly issue a patent docket covering this disclosure?

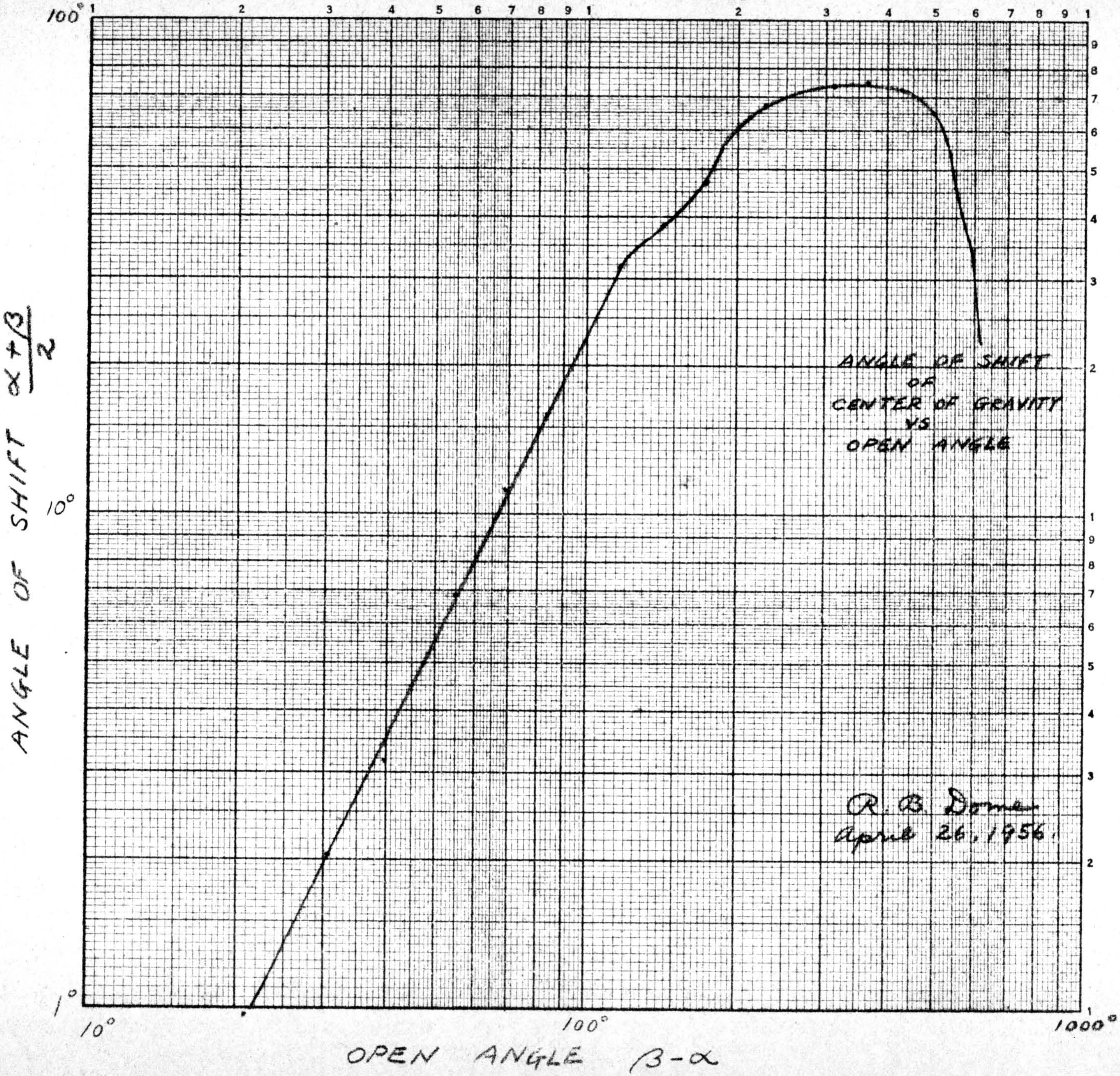
Signed ______________________

ated ______________________

Witness ______________________

Date ______________________

RBD/DL
Attached: 1 curve sheet
cc: JF McAllister
DE Harnett
DW Pugsley
GA Schupp
TV Zaloudek
LC Maier - Bldg 6
JR Locke



ANGLE OF SHIFT OF CENTER OF GRAVITY VS OPEN ANGLE
R. B. Dome
April 26, 1956.
ANGLE OF SHIFT $\frac{\alpha+\beta}{2}$
OPEN ANGLE $\beta-\alpha$
1°
10°
100°
1000°

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 Good
TT True
IE Lynch
M Graser
N Johannessen
HJ Vanderlaan

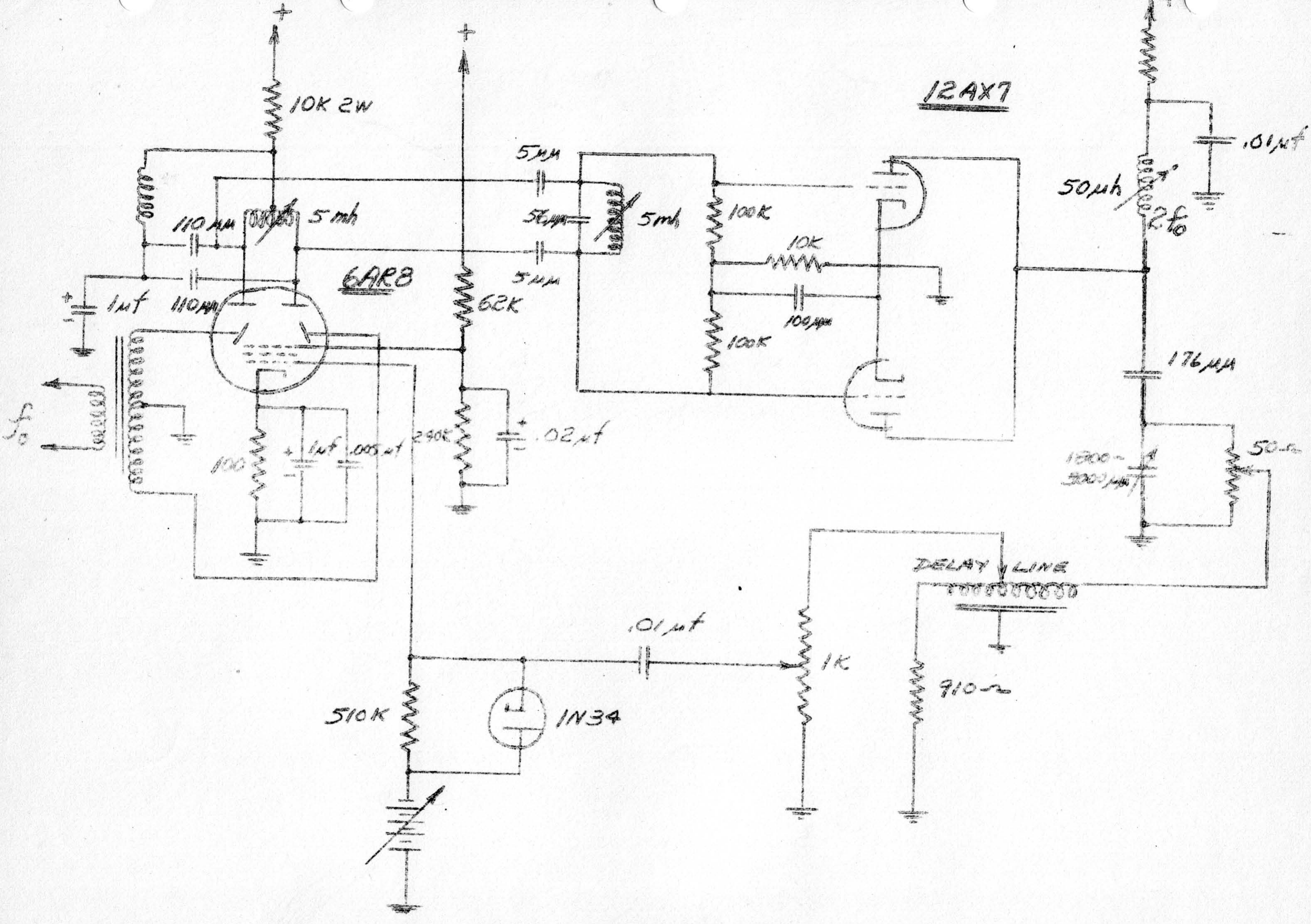


FIGURE 1
MSC. INVEST. #88

Room 201 Bldg. 6

V. C. Campbell
W. L. Jones
C. Dichter
W. S. Munday
J. C. Nonnekens
E. F. Schilling
L. E. Swedlund

Electronics Park
Syracuse, New York
February 5, 1957

Mr. R. J. Mooney
Legal Department
Room 11 Bldg. 1

In the disclosure letter of my invention of a new single gun color tube with associated circuitries of the receiver, dated January 18, 1957, it has been found that some modification is necessary. This is to disclose the necessary modification and to explain its functional characteristics.

The widths of group 10 and 11 of conductive stripes, which cover one triad and two triads alternately as shown in Figure 1 of the above mentioned disclosure letter, are modified in such a way that the width of the each conductive stripe group 10 and 11 are equal and become 1.5 triad widths as shown in Figure 5 of this letter. In addition to this, the tank circuit 30 in Figure 2 in the previous letter is also modified as shown in Figure 6. As a beam sweeps across the comb of conductive stripes, the beam lands alternately on group 10 and 11 of the comb, the comb acts as a beam switching tube, and the current in the tank circuit 30 changes its polarity with the rate of the beam switching. If this beam is a chroma signal of 9.45MC there will be a 3.15MC (f_i) component due to the beam switching provided that the comb is unsymmetrical as mentioned in the previous letter, and this is shown in Figure 7(b).

However, if the comb is symmetrical as shown in Figure 5, the lowest frequency component of the switching beam of 9.45MC chroma signal will be 4.725MC and there will be no frequency component of 3.15MC as shown in Figure 7(c).

In general, the chroma information is phase modulated on the subcarrier 9.45MC and, being the ordinary chroma band width of the order of less than 1MC, the side bands of the chroma signal are mostly concentrated around 9.45MC. Therefore, in the practical case, the frequency components of the side bands in the switching beam will not produce the 3.15MC component which could interfere with the index signal, and it is possible to obtain the index signal of the frequency 3.15MC from the D.C. beam.

Since thds conductive pattern leaves one stripe of one given color uncovered for every two that are covered, there might be noticeable difference in the luminance of the uncovered and covered stripes. If this was the case, by narrowing the gap between adjacent conducting stripe or adjusting the width of the stripes of this color, i.e. decreasing the width under the conductive stripe and increasing the width of the uncovered stripe, it is possible to correct the above luminance difference.

I will appreciate your including this letter into my previous submitted patent entry.

C. S. Kim

Signed: C. S. Kim

Edmund F. Schilling

Witnessed: E. F. Schilling

Att: 3 drawings

/fmd

Feb 5, 1957

Dated: February 5, 1957

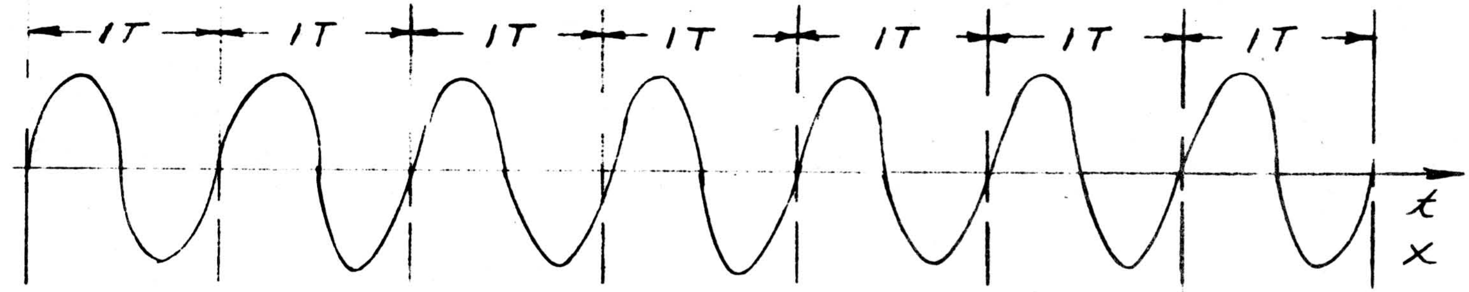


Fig. 7(a) Cathode Current Due To Chroma Signal

T: Triad Distance

t: Time

x: Distance

$f_i = \frac{1}{3T}$ Y sec.

: Index Frequency

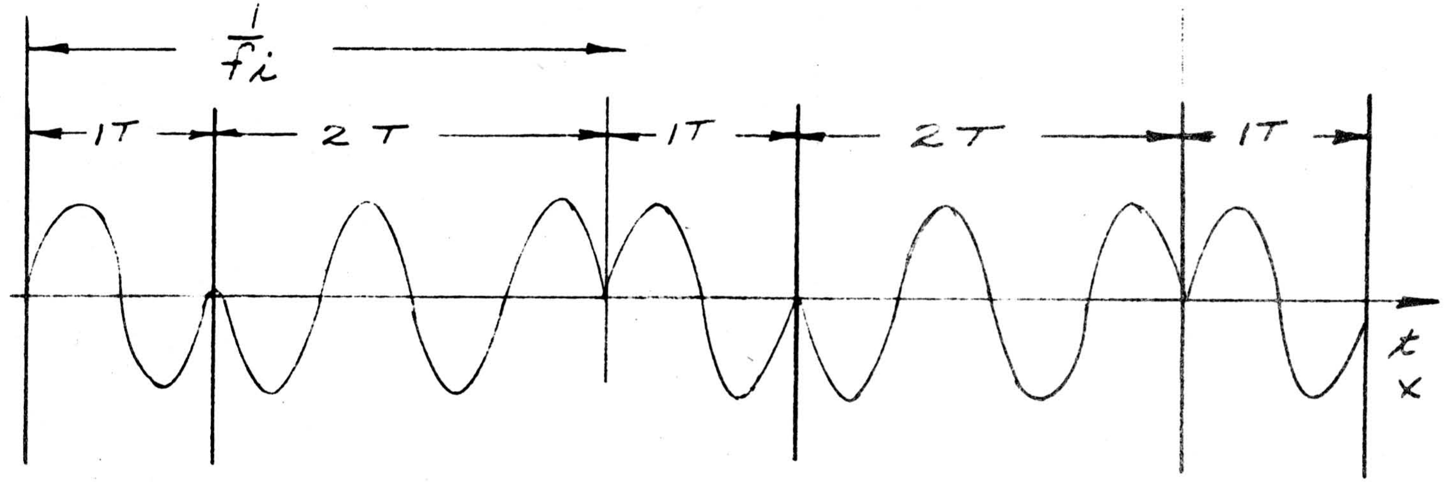


Fig. 7(b) Voltage Across Tank Circuit 30* For Unsymmetrical Comb (Give The Lowest Frequency fi)

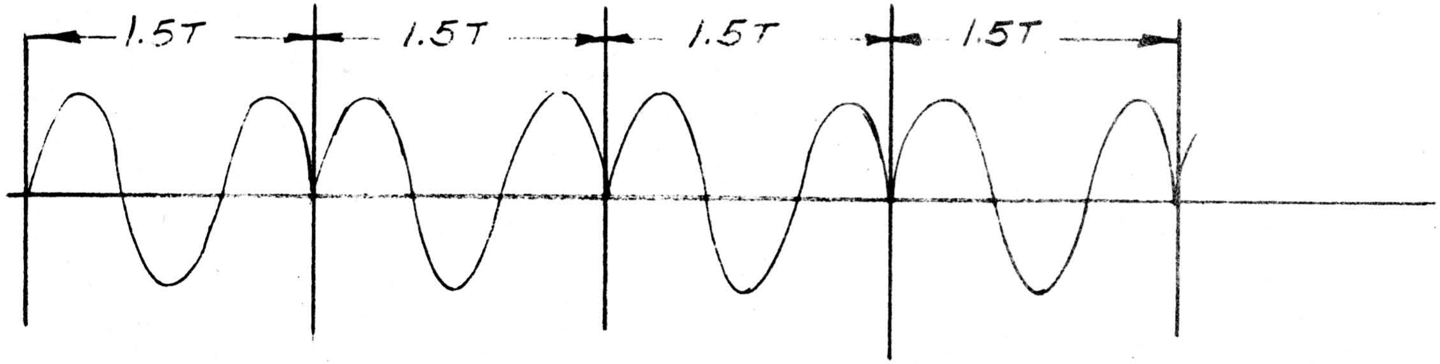


Fig. 7(c). Voltage Across Tank Circuit 30* For Symmetrical Comb (Give The Lowest Frequency 1.5fi)

* Consider Tank Circuit Impedance Is Resistive

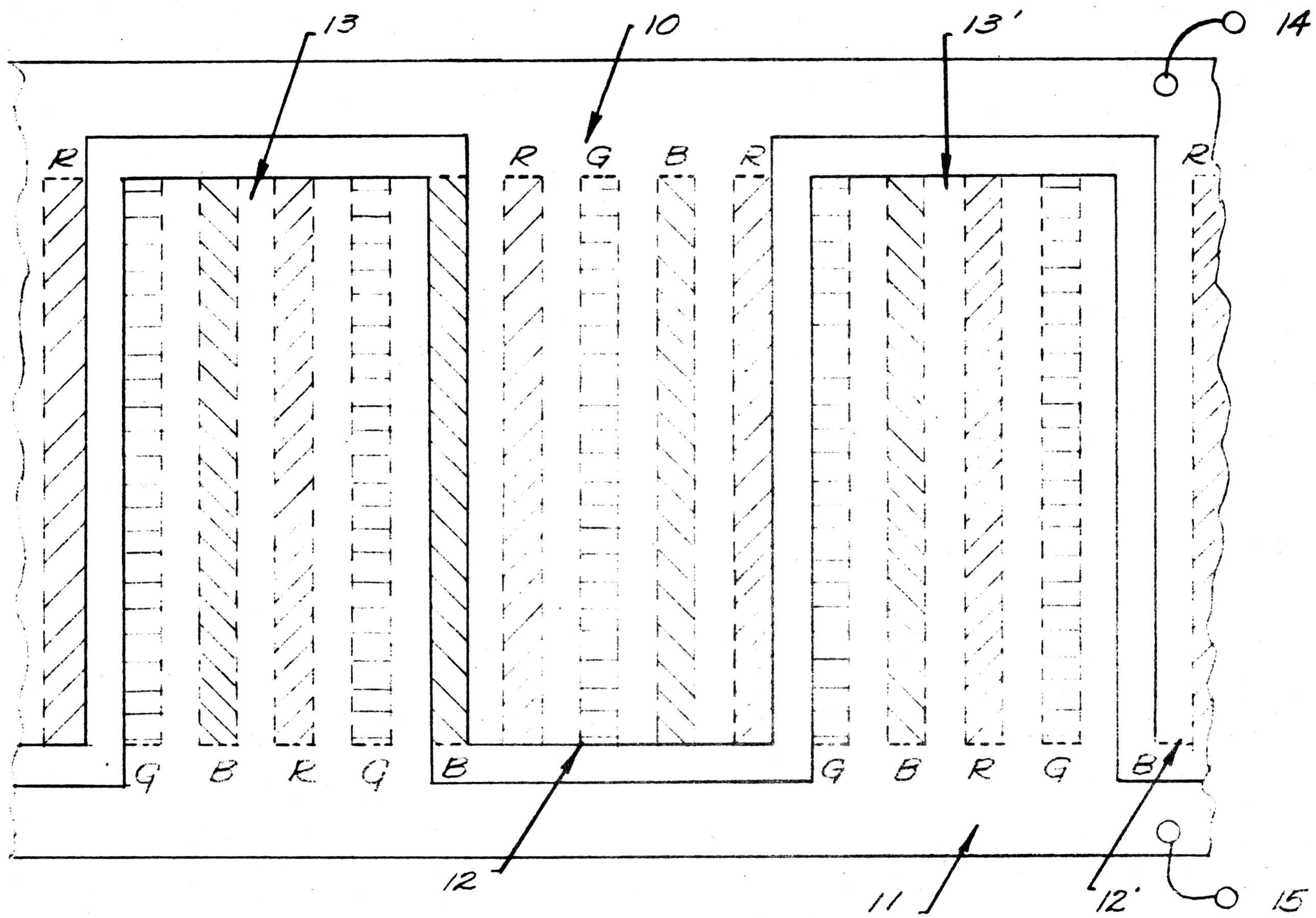


FIGURE 5

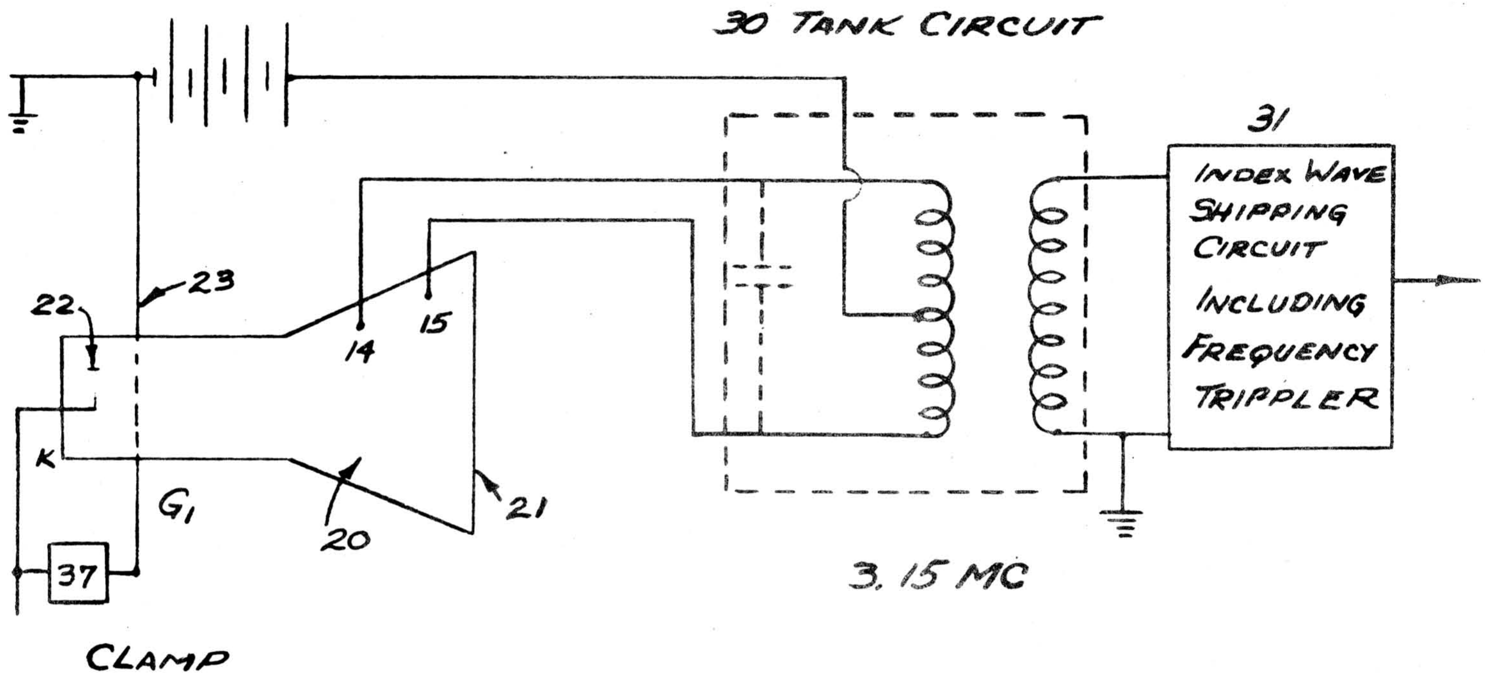

30 TANK CIRCUIT
31
INDEX WAVE SHIPPING CIRCUIT INCLUDING FREQUENCY TRIPPLER
22
23
14
15
K
G1
20
21
37
3.15 MC
CLAMP

FIGURE 6

J. W. Dreher
L. C. Maier
J. C. Nonnekens
E. F. Schilling

Syracuse - January 18, 1957

Mr. R. J. Mooney
Legal Department
Building 1

This entry is to disclose the invention of a new single-gun color tube with its associated circuitries of the receiver suitable for the reproduction of television images in full natural color. The primary investigations on this invention were covered by entries on pages 6, 7, 8, and 9, dated February 26, 1954, of my patent notebook #67 and on pages 51, 52, 53, and 54, dated November 20, 1956 and on page 55, dated January 10, 1957, of my patent notebook #38.

This new system applies the principle of obtaining information on the location of phosphor stripes and sampling the electron beam according with the above index information to reproduce proper color images somewhat like the Apple Tube. and Dome's tube, but differing therefrom in several respects.

As shown in Figure 1, conductive stripes such as aluminum stripes are applied back of the conventional vertical phosphor stripes on the screen 21 of a color tube 20, namely red, green and blue, such that one group, 10, of conductive stripes covers a set of red, green and blue stripes known as a "triad", and the other group, 11, of conductive stripes covers two triads in such a way that 10 & 12 are alternative in the horizontal direction and forms a comb. The toothed comb consists of teeth 12, 12' etc. of 10, and 13, 13' etc. of 11, which are electrically connected respectively to external terminals 14 and 15 and where 10 and 11 are electrically insulated from each other.

The comb 10 and 11 acts not only as the pick-up device of the index signal but also works as light reflectors as in an ordinary tube.

Let it be assumed that a D.C. beam is scanned over the screen. Then if the beam is on the teeth of 10 and no beam is on the other teeth of 11, there will be the voltage difference between 14 and 15 provided that there is a impedance across 14 and 15 as shown in Figure 2. Here if the spot size of beam on the screen is much smaller than the width of 12, and if the tank circuit 30 is tuned to the frequency f_i which is identical to the rate of the beam traveling on teeth, say 12, 12' etc., it is possible to obtain across 30 the maximum voltage of f_i which has the stripe index information having been phase modulated with the index stripes 10 and 11. Let f_i be 3.15MC with a small side band which contains the index information. The reason for selecting this value will be explained later. This index signal is tripled to the middle frequency of 9.45MC with index side bands and then amplified to a constant voltage using a limitter circuit through index wave shaping circuit 31. Then, as was done in Apple and Dome's system, the output of 9.45MC is fed to the mixer 32 with the other input of the 3.58MC reference signal of 34.

The 13.03MC output of 32 is then again introduced into another mixer 33 with the other input of the 3.58MC chroma. This 9.45MC output of 33 are added with 0 ~ 3MC brightness signal and amplified by 36. If it is necessary to cut down the 3.15MC which might be produced from the brightness signal, a trap circuit for 3.15MC can be introduced in 36 to ensure that no 3.15MC will interfere with 3.15MC of the tank circuit.

The output of 36 which contain brightness information and 9.45MC chroma and index information will be applied to the cathode of 22 through a clamp circuit 37 which is provided to prevent complete extinction of the spot except during flyback so that the index information can be maintained without interruption and the A.C. beam will be able to reproduce proper color image.

The advantage of this system is due to the fact that the voltage across the 15 from the A.C. beam scanning across the screen, has the components of 12.60MC, 9.45MC, 6.30MC and the fundamental frequencies of the brightness information of 0 ~ 3.0MC, but no 3.1MC, and these components will be filtered out by the tank circuit, so that the system becomes an open loop type circuit. Therefore it is possible to maintain good stability. The selection of the tank circuit tuned frequency of 3.15MC is now clear knowing the above mentioned filtering action of the A.C. components reproduced by the A.C. beam on the comb and noting the fact that 9.45MC of the tripled frequency of 3.15 of the index information is identical to the rate of traveling of the beam on color triads so that, if there is for instance, the red video only, the positive part of 9.45MC color signal will land on red stripes, having corrected the landing position of every third triad by the index signal. Of course the better color reproduction will be obtained by keeping the smaller spot size which is preferred to be smaller than the width of each color stripe.

A different system of a color receiver using the same color picture tube 20 is shown in Figure 3. Here the tank circuit and the index wave shaping circuit 31 are identical with that of the previous system. The output of 31 is so delayed that the index signal passing through 41 has the phase difference of the multiple of 180° electrical angle of 9.45MC with respect to red stripes 16 16' etc, of Figure 4 as the index signal makes the one complete loop starting from and ending at the screen, and at the same time that the phase difference of the inputs of 41, 42 and 43 is 120°. The components 41, 42, and 43 are identical mixer-clamps where 9.45MC index signal is amplitude modulated with a color video signal 51 and clamped in such a way that the negative half cycle 50 of the signal only is possible as shown in Figure 4. Let the signal 50 be called the sampling signal. Should greater amplitude of 50 be needed an amplifier with the center frequency of 9.45MC and the side bands for the index and the video information, can be placed between the mixer and the clamp of 41 etc.

The outputs of 41 etc, are fed into an adder 44 which not only superpose sampling signals of red, green and blue, but also filter out the frequencies which are lower than the lowest frequency component of 50. Then the output of 44 is finally introduced to the cathode 22 through the same clamp cirucit 37 of the previous system.

As mentioned in the previous system the voltage across 14 and 15, which is produced by the A.C. beam, has no component of 3.1MC and the system becomes a open loop type circuit. Since there is no low frequency component in the output of 44, there is no danger of having some higher harmonics of the video frequency which is in the range of 3.15MC, the tuned frequency of the tank circuit 30.

The widths of each phosphor stripe and guard band 19, the black spaces between two adjacent phosphor stripes are both kept to 60° electrical angle of 9.45MC as shown in Figure 4 and the angles between the center of, say, the red phosphor stripe to the edge of adjacent green and blue stripes become 90°. Therefore by placing the peak of 50 and the center of red strip at the same place in the time and distance domain as seen in Figure 4, there is no A.C. beam overlapping adjacent blue and green stripes provided that the spot size of the beam in infinitesimally small. However, in the actual case, the spot is not infinitesimally small and as a result some of the said beam could land on the adjacent green and blue, but since the light emission from these are are so small compared with that if red, the effect of this registration can be neglected.

Then finally superimposing red, green and blue sampling signals of 50, it is possible to produce the proper color image on the picture tube.

I will appreciate it if you issue a patent docket covering this disclosure.

Att: 4 drawings

Signed: C. S. Kim

Date: January 18, 1957

Witnessed: E. F. Schilling

/fmd

Date: January 18, 1957

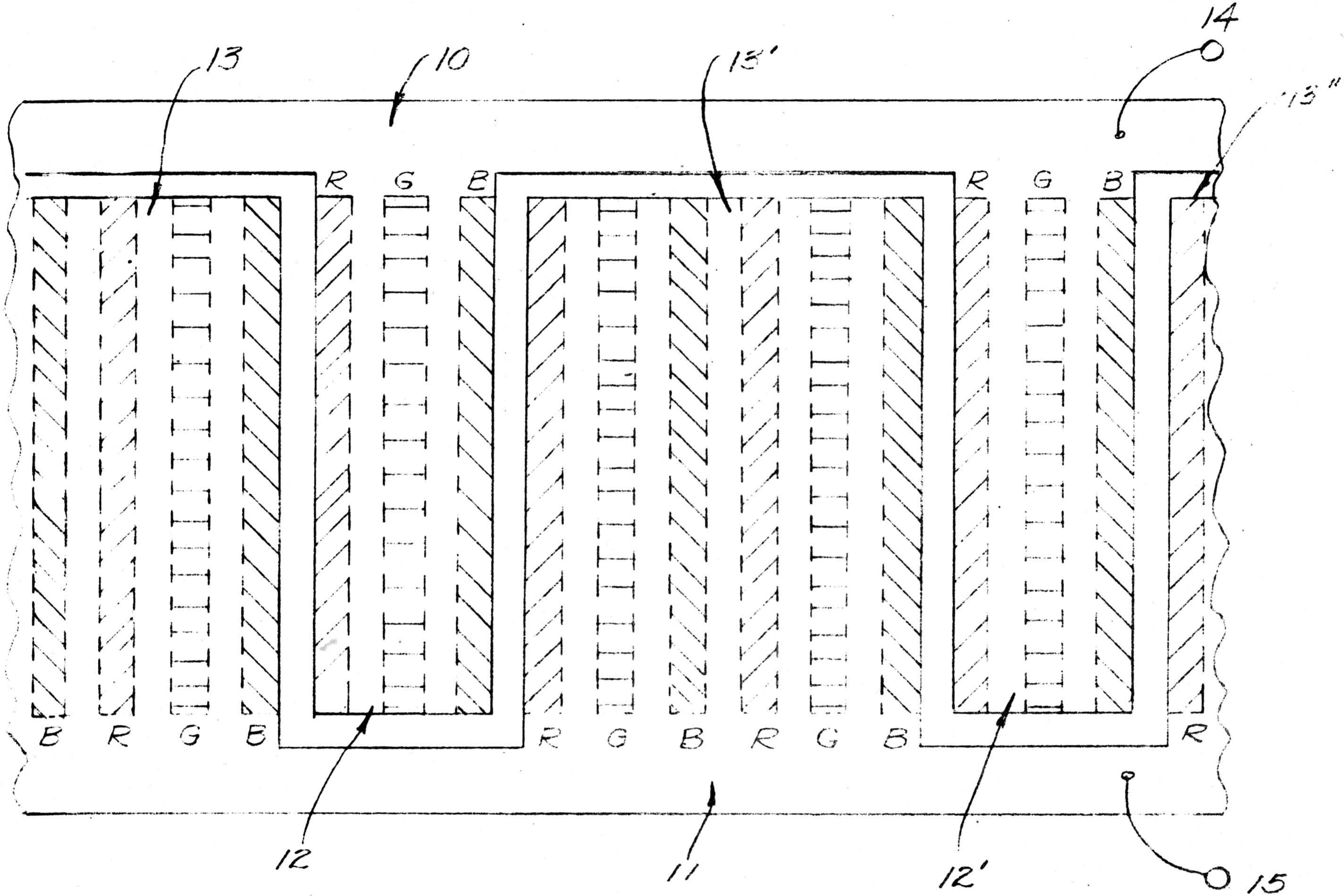


FIGURE 1

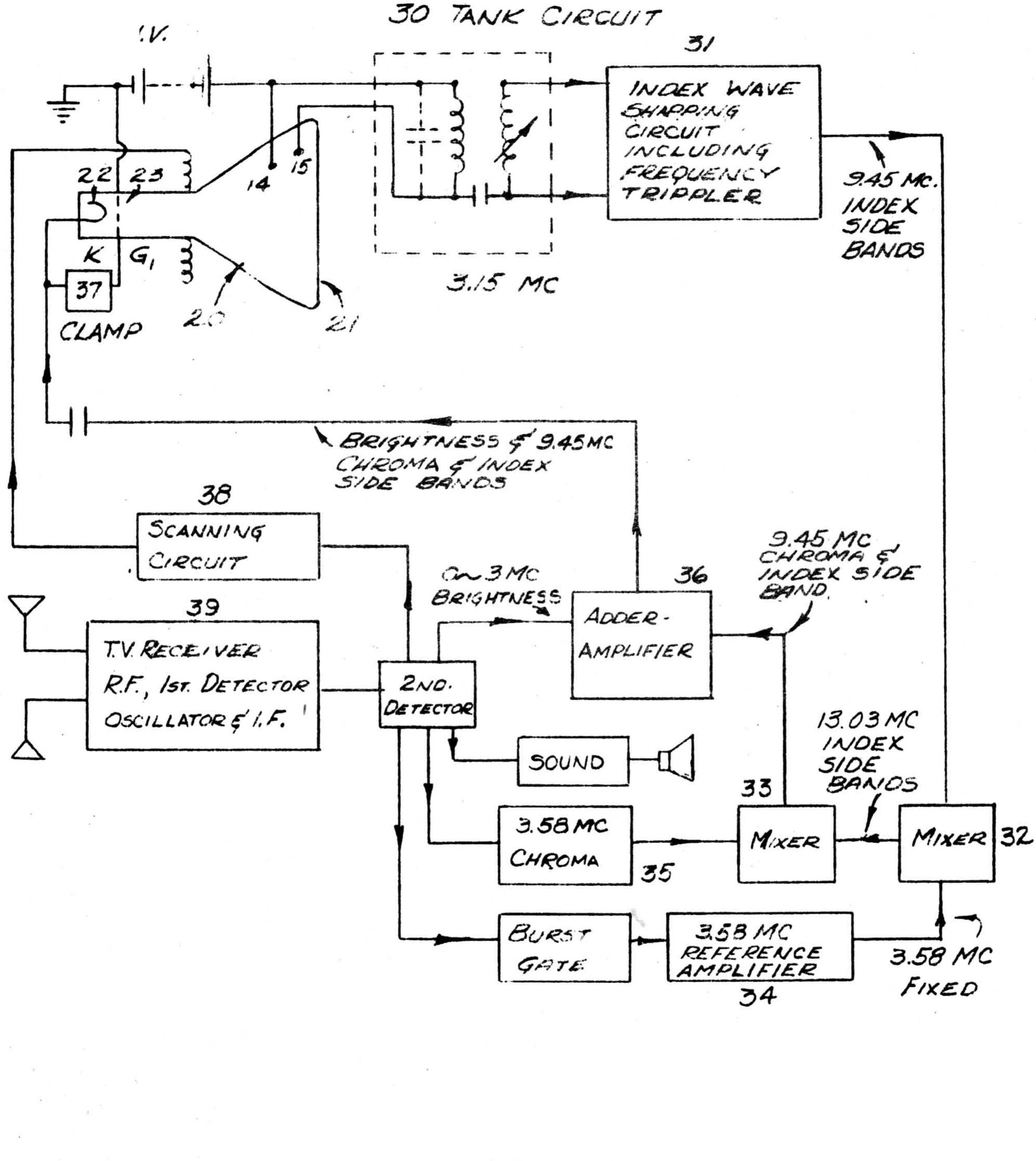

30 TANK CIRCUIT
31
INDEX WAVE SHAPING CIRCUIT INCLUDING FREQUENCY TRIPPLER
9.45 Mc. INDEX SIDE BANDS
3.15 MC
22
23
14
15
K
G1
37
CLAMP
20
21
BRIGHTNESS & 9.45 MC CHROMA & INDEX SIDE BANDS
38
SCANNING CIRCUIT
39
T.V. RECEIVER R.F., 1st. DETECTOR OSCILLATOR & I.F.
0~3 MC BRIGHTNESS
36
ADDER-AMPLIFIER
9.45 MC CHROMA & INDEX SIDE BAND
2ND. DETECTOR
SOUND
13.03 MC INDEX SIDE BANDS
33
3.58 MC CHROMA
35
MIXER
MIXER
32
BURST GATE
3.58 MC REFERENCE AMPLIFIER
34
3.58 MC FIXED

FIGURE 2

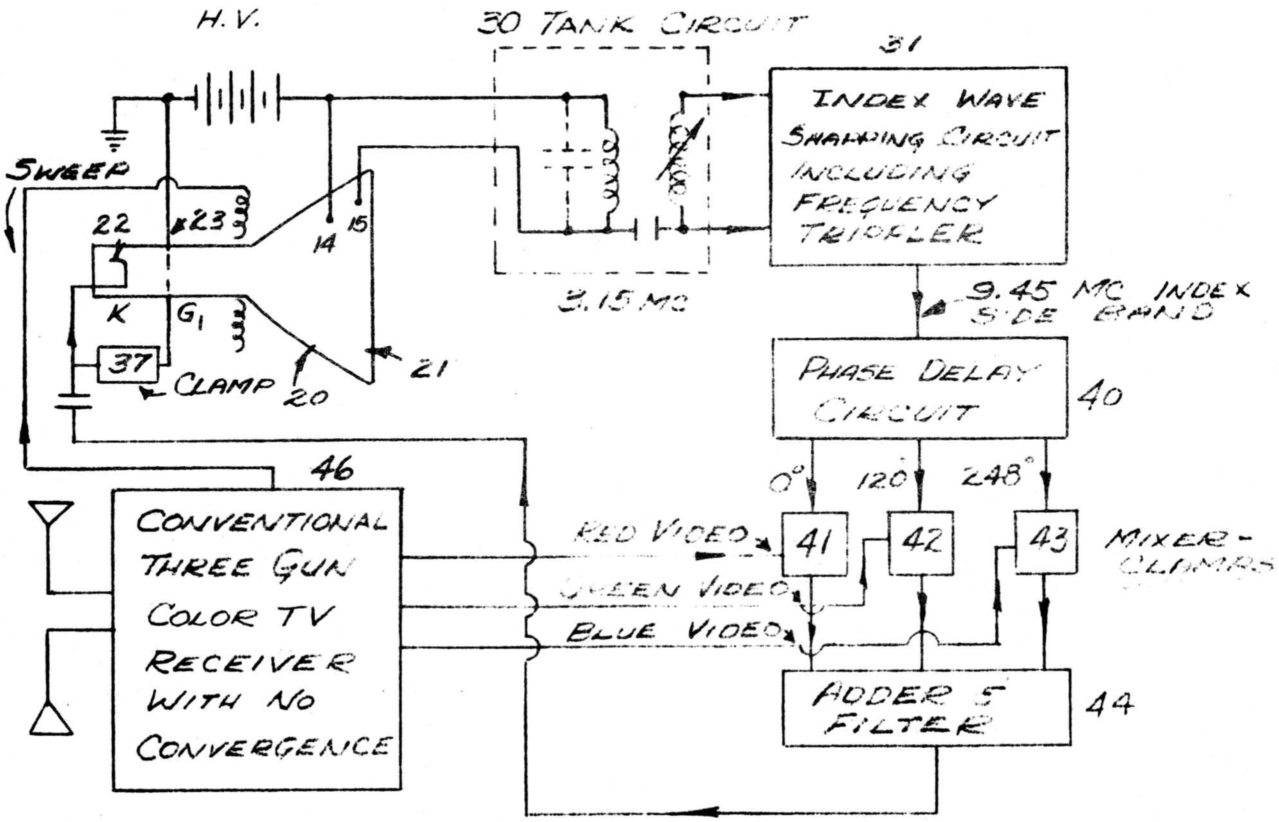
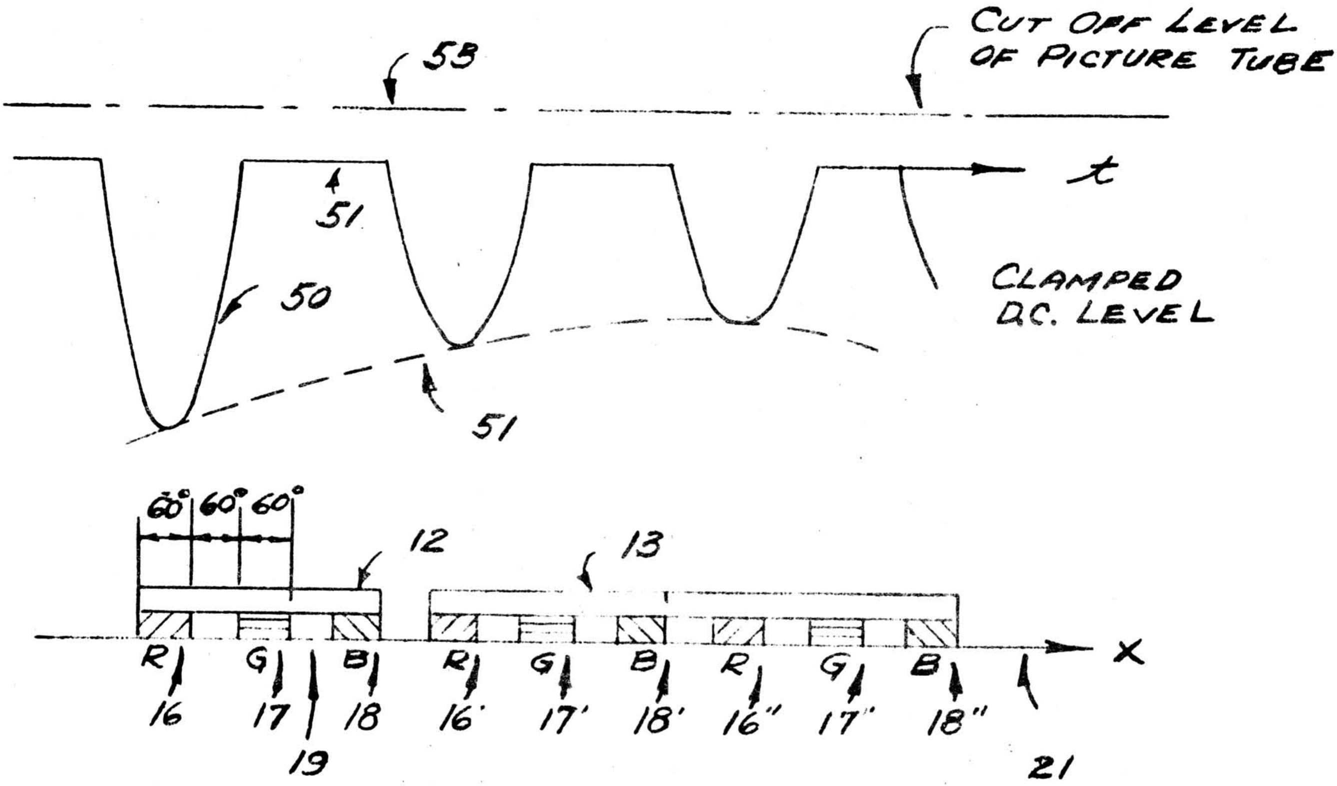

H.V.
30 TANK CIRCUIT
31
INDEX WAVE SHAPING CIRCUIT INCLUDING FREQUENCY TRIPLER
SWEEP
22
23
14
15
K
G_1
37
CLAMP
20
21
3.15 MC
9.45 MC INDEX SIDE BAND
PHASE DELAY CIRCUIT
40
0°
120°
248°
46
CONVENTIONAL THREE GUN COLOR TV RECEIVER WITH NO CONVERGENCE
RED VIDEO
GREEN VIDEO
BLUE VIDEO
41
42
43
MIXER-CLAMPS
ADDER & FILTER
44

FIGURE 3



t : TIME

X : HORIZONTAL DISTANCE ON SCREEN

FIGURE 4

J. W. Dreher
L. C. Maier
J. C. Nonnekens
E. F. Schilling

Syracuse- January 24, 1957

Mr. R. J. Mooney
Legal Department
Building 1

In the disclosure letter of my invention of a new single-gun color tube with associated circuitries of the receiver, dated January 18, 1957, it has been found that some printing errors were made. This is to correct these errors and the corrections are given as follows:

Location	Error	Correction
Sixth line of the third paragraph, page one	10 and 12	10 and 11
Third line of the second full paragraph, page two	but no 3.1MC	but no 3.15MC
Second line of the first full paragraph, page three	3.1MC	3.15MC
Eleventh line of the second full paragraph, page three	with that if red	with that of the red (the phosphors are balanced)

I will appreciate it if you provide the necessary corrections in my entry.

Signed: C. S. Kim

Date:

Witnessed: E. F. Schilling

Date:

/fmd

Miscellaneous Investigation Report #98
June 25, 1957

Development Engineering
Television Receiver Dept.

CAPACITANCE AND RESISTANCE IN THIN METALLIC COMBS, USED FOR INDEXING IN COLOR TELEVISION TUBES

By: N. Johannessen

Abstract

This report gives approximate values of capacitance and resistance for 3 mc and 6 mc index combs. Values are calculated for a comb sample, made by the Tube Dept., and the values are compared with those obtained by measurement.

Conclusion

The capacitance of index combs is found to be extremely high, 16,000 uuf for a 6 mc index, and 8,500 uuf for a 3 mc index. It will be necessary to divide the comb in several sections, and tune each section to resonance at the index frequency. The resistance of the 10 mils narrow teeth is found to be in the order of 900 ohms. In case the capacitance is not resonated, this resistance will cause phase variations of about 90°.

Discussion

There are several different suggestions of using metallic combs in color television tubes for generation of an index signal. The advantages of a comb index are:

1. No secondary electron transit time.
2. Extra beam for index is not necessary.

In the suggested systems, the index comb, at the same time, acts as the ordinary aluminizing on back of the phosphors. This means that the spacing between the comb teeth is limited to the width of the guard bands, (10 mils). The close spacing, and the large number of teeth, with phosphor and glass as dielectric, will result in a relatively high capacitance between the two sections of the comb.

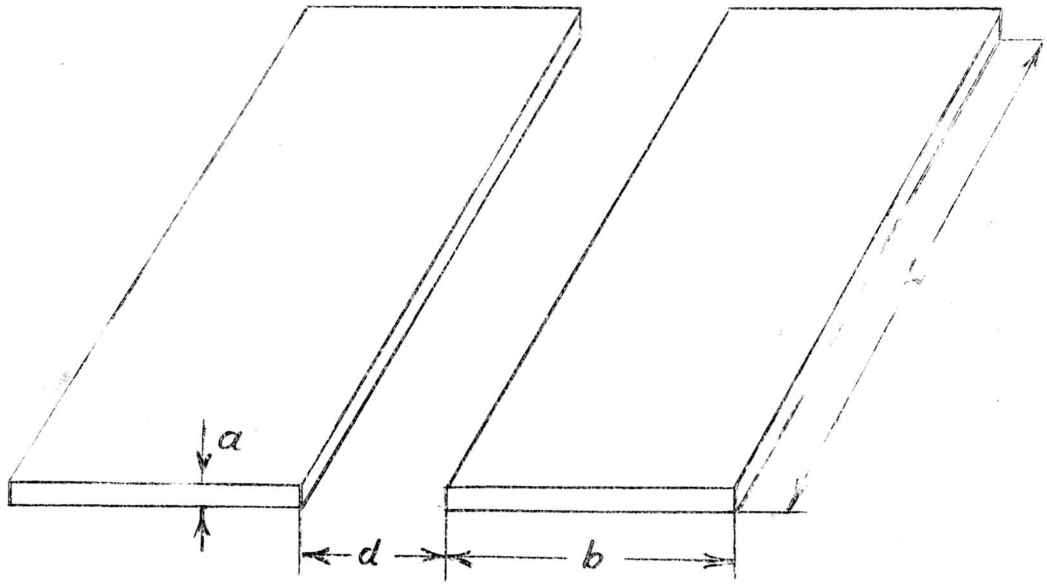


Fig. 1.

The capacitor formed by the comb teeth is of an unusual structure, the capacitance due to the uniform field between the two parallel areas is negligible because of the very thin aluminum layer (4,000 Angstrom). The total capacitance due to this effect is:

$$C = \frac{K a L}{4 \pi d} 2n$$

where K = dielectric constant $\cong$ 5

a = 4,000 Anstrom = 4×10^{-5} cm.

d = 10 mils = 25×10^{-3} cm.

L = 14 in. = 35 cm.

= number of triads = 325

$$C = \frac{5 \times 4 \times 10^{-5} \times 35 \times 2 \times 325}{4 \pi \times 25 \times 10^{-3}} = 14.5 \mu\mu f$$

The most capacitance is due to the edge effect. The capacitance for a 6 mc index comb is calculated below.

$$C = \frac{K \times L}{8 \pi^2} \left[\ln \frac{16 \pi (d+b)}{d^2} + \frac{b}{d} \ln \frac{d+b}{b} + 1 \right] 2n \quad \text{cm.}$$

where K = dielectric constant $\cong$ 5

b = stripe width = 10 mils = 25×10^{-3} cm

d = stripe spacing = 10 mils = 25×10^{-3} cm

L = stripe length = 14 in. = 35 cm

n = number of triads = 325

$$C \cong \frac{5 \times 35}{8 \pi^2}\left[\ln \frac{16 \pi\, 5 \times 10^{-2}}{6.25 \times 10^{-4}} + \ln 2 + 1\right] 650 \text{ cm.}$$

$$\underline{C \cong 14400 \text{ cm} = 16000 \mu\mu f}$$

For a 3 mc index comb, the capacitance will be between 8,000 and 9,000 uuf.

A comb sample with a structure as shown in Fig. 2 was made up by the Cathode Ray Tube Dept.

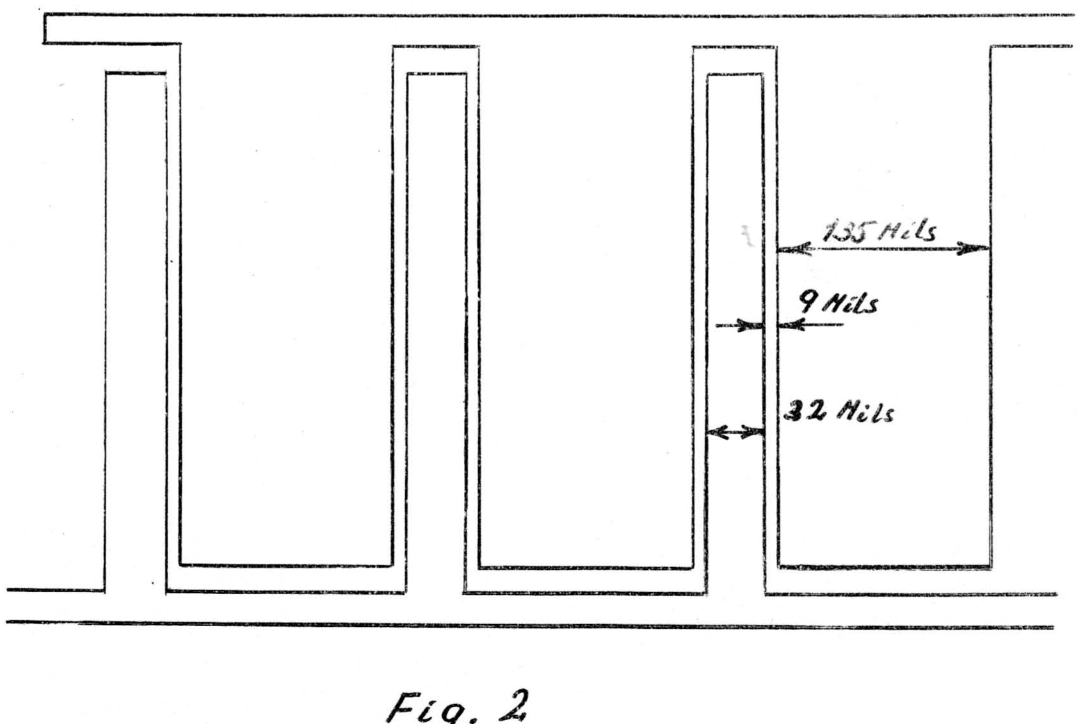


Fig. 2

On the sample, the teeth were deposited directly on a glass plate, the aluminized area measured 4" X 5", and there were 26 teeth on each part of the comb.

The approximate capacitance of the sample was calculated by use of equation 1.

$$C = \frac{5 \times 10}{8 \pi^2} \left[\ln \frac{16 \pi \times 0.103}{5.3 \times 10^{-4}} + 3.5 \ln \frac{0.103}{0.08} + 1 \right] 52 \text{ cm}$$

$$\underline{C = 366 \text{ cm} = 407 \mu\mu f}$$

The actual capacitance was measured to be 400 uuf. If the sample was caled up to 14" X 19", the capacitance would be $\frac{400 \times 14 \times 19}{4 \times 5} = 5{,}320$ uuf. This comparatively low capacitance id due to the small number of teeth (equivalent to 1.82 mc index frequency).

In order to determine the phase shift of the index signal, the resistance of the narrow teeth on the sample was calculated.

$$R = \rho \frac{L}{a \times b} \quad \Omega$$

where ρ aluminum = $0.0262 \ \Omega/mm^2/m$.

a = stripe thickness = 4,000 A = 4×10^{-4} mm.

b = stripe width = 32 mils = 0.8 mm.

L = stripe length = 4 in. = 0.1 m.

$$R = \frac{0.0262 \times 0.1}{4 \times 10^{-4} \times 0.8} = 8.2 \ \Omega$$

The resistance on the sample was measured to be 85 ohms or approximately 10 times the calculated value. During the measurements, it was made sure that the resistance in the contact points was less than 1 ohm. The resistance of the narrow teeth in a 6 mc comb, where $b = 25 \times 10^{-2}$ mm and $L = 0.35$ m

$$R = \frac{0.0262 \times 0.35}{4 \times 10^{-4} \times 0.25} = 91 \ \Omega$$

If it is assumed that the actual resistance (as found before) is 10 times the calculated value, the actual resistance of a 6 mc comb will be 910 ohms.

This resistance is in series with the comb capacitance, and will cause the phase of the index signal to change from 0° to almost 90° when the beam scans from top to bottom. In case the comb capacitance is tuned to resonance at the index frequency, the resistance will not cause any phase shift, but a very high attenuation of the index signal. The inductance necessary to resonate the comb, is 0.045 uh for a 6 mc index, and 0.28 uh for a 3 mc index. In both cases, it will be necessary to divide the comb in several sections, and tune each section individually.

N. Johannessen.
N. Johannessen

NJ:REL

Subject: Single Gun Color System

March 21, 1957

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

Many single gun picture tube color TV receiver systems has been proposed. One such group of systems is referred to as "apple variations". In this category, the picture is formed by scanning vertical phosphor stripes where the phosphor colors are alternated red, green and blue. Proper colors are displayed by ensuring that the color video information supplied to the control grid corresponds at all times to the color of phosphor stripe being scanned. An index signal is derived from the screen that contains beam position information relative to the phosphor stripes.

For all systems in this general category, the color accuracy is dependent to a large extent on the accuracy of the index signal. The index signal can be generated in any one of several ways such as secondary emission from appropriate stripes in back of the color phosphors, conducting combs that intercept the beam as it scans, ultra violet radiation from appropriate auxiliary phosphor in back of the color phosphor, etc. In any of these methods, it is necessary that the index signal contain beam position information whose phase is independent of video modulation placed on the electron beam. Many schemes have been proposed to insure the accuracy of the index information, but most of them become quite complex in their execution.

The purpose of this disclosure is to describe a method to obtain a clean index signal. The principle involved is simple and utilizes time sharing between presentation of video information and the generation of the index signal.

An index signal is generated periodically on certain selected horizontal lines. Video information is blanked and thereby not displayed on lines that are used to generate index. Similarly, index information is not generated on lines that display video. Thus, the index signals that are generated are absolutely free of video contamination.

Reference is now made to Figure 1 where one embodiment of this idea is shown in block diagram form.

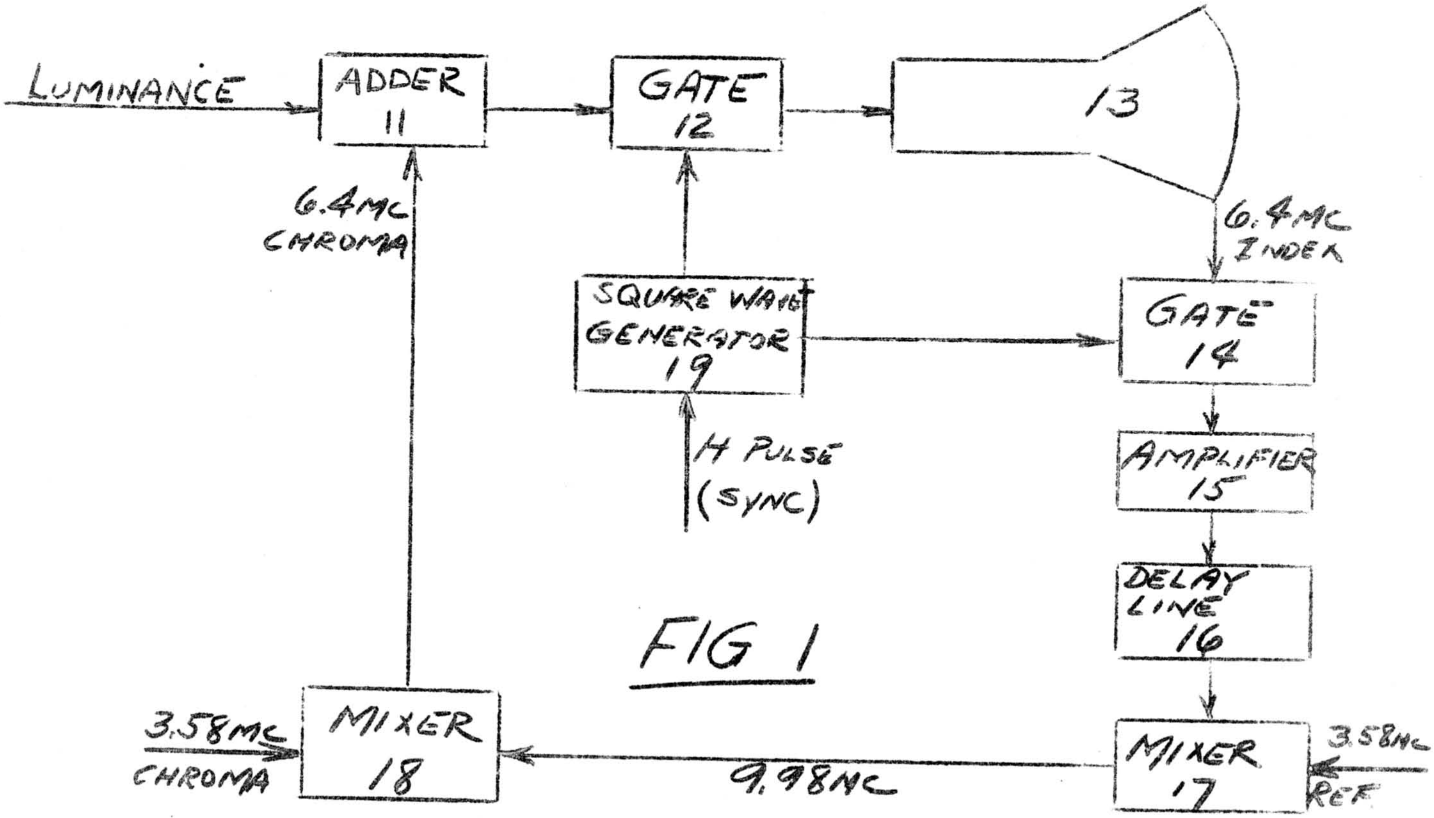


FIG 1

In this arrangement the vertical phosphor triads are assumed to repeat at a frequency of 6.4 mc when scanned by the electron beam. The index signal may be derived by means of a conducting comb, secondary emission, ultraviolet, or other suitable means by virtue of an appropriate index stripe placed one per color triad. Thus, the scanning electron beam produces an index signal whose fundamental frequency is 6.4 mc which is applied to gate 14.

The luminance and chrominance signals are combined in an adder 11 and applied to gate 12. Gates 12 and 14 are actuated by a square wave generator 19 which runs at one half the horizontal scanning frequency to which it is synchronized. Thus, the square wave generator operates at approximately 7.875 KC.

Output from the square wave generator 19 actuates gate 12 so as to apply composite video to the control grid of the picture tube 13 on alternate scanning lines, such as lines 1, 3, 5, 7 etc. On the other set of alternate scan lines, such as 2, 4, 6, 8, etc., no video is applied to the picture tube control grid. In this arrangement only half of the video information is applied to the picture tube. The resulting picture would be equivalent to a completely non-interlaced presentation. On lines where video is blanked (2, 4, 6, etc.) the beam current is held at some small value, about 10 microamperes, to be used to generate the index signal.

Gate 14 is so controlled by the square wave generator 19 that it passes the 6.4 mc index signal only on lines that contain no video signal, 2, 4, 6, etc. The output of gate 14 is applied thru an amplifier 15 to a delay line 16 whose time delay is approximately one line (63.5 usec). The exact time delay is adjusted so that the entire loop delay is exactly one horizontal scanning period.

The delay line output is combined with the 3.58 mc reference signal in mixer 17 where the output signal is 9.98 mc. This 9.98 mc signal is combined with the 3.58 mc chroma side bands in mixer 18 where the output signal is 6.4 mc. This 6.4 mc signal contains the chroma side bands in addition to color reference and beam position phase information.

Stated simply, this system derives index information during one horizontal line to be used on the next line. The assumption is made, therefore, that the index requirements will not change appreciably between two successive lines.

Variations on this basic idea are immediately apparent. For example, it would be possible to blank video on line 1 and allow gate 14 to pass index during this line. Video would then be applied to the picture tube during lines 2 and 3 by appropriate control of gate 12. Likewise gate 14 would stop the flow of index from the picture tube during lines 2 and 3. The index signal generated on line 1 would be delayed 63.5 usec for use during line 2. An additional delay of 63.5 usec of the same index signal would provide index for line 3. This additional 63.5 usec delay could be obtained with a separate line delay and appropriate switching circuits. It might also be obtained by a single delay line by using reflections in the line. Thus index for line 2 would be taken from the receiving terminals of the line and index for line 3 from the the driver end.

The process would be repeated by blanking video on line 4 in order to generate new index for lines 5 and 6. This scheme would throw away one third of the transmitted video instead of one half as in the original proposal. This system is based on the assumption that index requirements would not vary appreciably over any three successive lines.

Stated broadly, it is proposed that accurate index information can be obtained by either equal or unequal time sharing between index generation and video presentation where the time units involved are equivalent to whole scanning lines or multiples thereof. Index information obtained on one scan line can be made available on subsequent lines by the use of suitable delay lines.

Will you kindly issue a joint patent docket covering this disclosure?

TVZ:BF/erh

Signed ______________________

____

Date ______________________

Witness ______________________

Date ______________________

cc: JF McAllister
RB Dome
DE Harnett
WE Good
GA Schupp
FG Cole

Subject: A Triad-Rate Indexing Color Tube and System with Index Beam Current Pulsing

Syracuse, N. Y.
June 11, 1957

Mr. D. N. Timbie
Patent Section
Room 222 - Bldg. 5
Electronics Park

This disclosure letter describes a color tube and system operating by indexing and dot sequential presentation. Several techniques used here are similar to Apple Systems. Two basic new ideas are incorporated which improve performance and reduce cost.

The tube consists of vertically printed red, green, and blue, phosphor stripes with guard-bands. The guard-bands are composed of black non-light-reflecting material. This material will improve contrast over material which readily reflects light. Various possibilities now exist for the obtaining of indexing information. One of these would make use of secondary emission material as in the Apple tube. Another could employ a comb structure by which electrons are removed directly. In either case, the indexing structure is to be placed over a guard-band stripe and not over any light producing phosphor. This technique will allow beam current pulsing during the instant the beam is landing on the indexing area. By such operation, high indexing currents will be possible with no production of "haze" light which limits contrast ratio in the Philco Apple System. In all further discussions, comb structures will be referred to for simplicity although the same remarks apply equally well to secondary emission and ultra-violet light tubes.

In Fig. 1 is shown a possible configuration of the phosphor stripes, guard-band, and comb structure. The comb teeth have a repetition rate equal to the triad rate. Two possibilities exist for laying down the comb structure over the previously layed down phosphors and guard-band areas. One of these would consist of completely aluminizing the screen structure. This would then be followed by a layer of insulating material over which the conducting comb will be placed. Insulating material not covered by the comb can now be washed away. The second technique would be to aluminize the phosphor areas and possibly the guard-band areas not covered by comb teeth. This will now be followed by the placing of the comb structure directly on the proper guard-band material. Care must be exercised to insulate the comb from the aluminized phosphor. This technique is to be preferred over the first because of lower comb capacity.

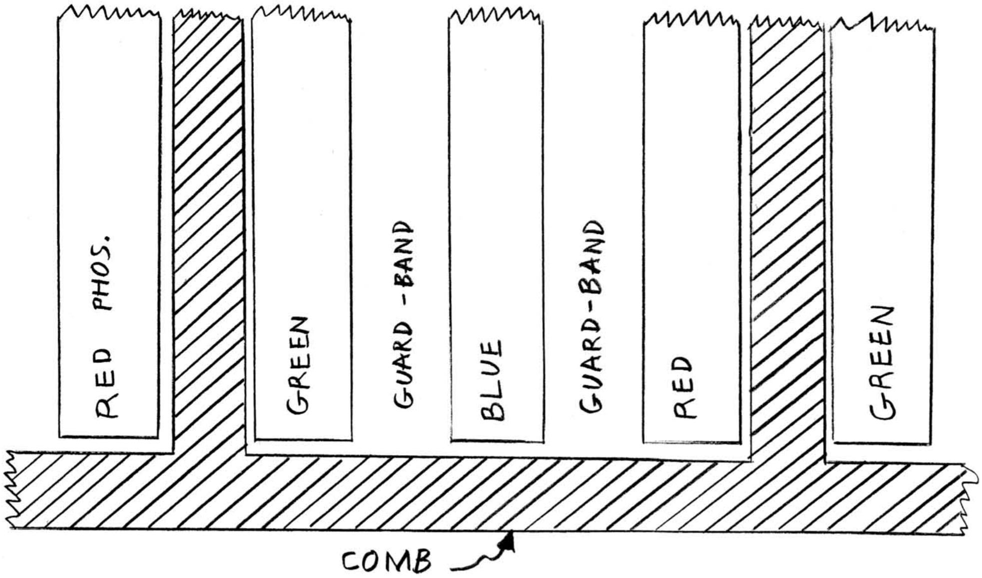


Figure 1

Fig. 2 gives a block diagram representation of the proposes system. The indexing signal is developed across a tank circuit of other impedance placed between

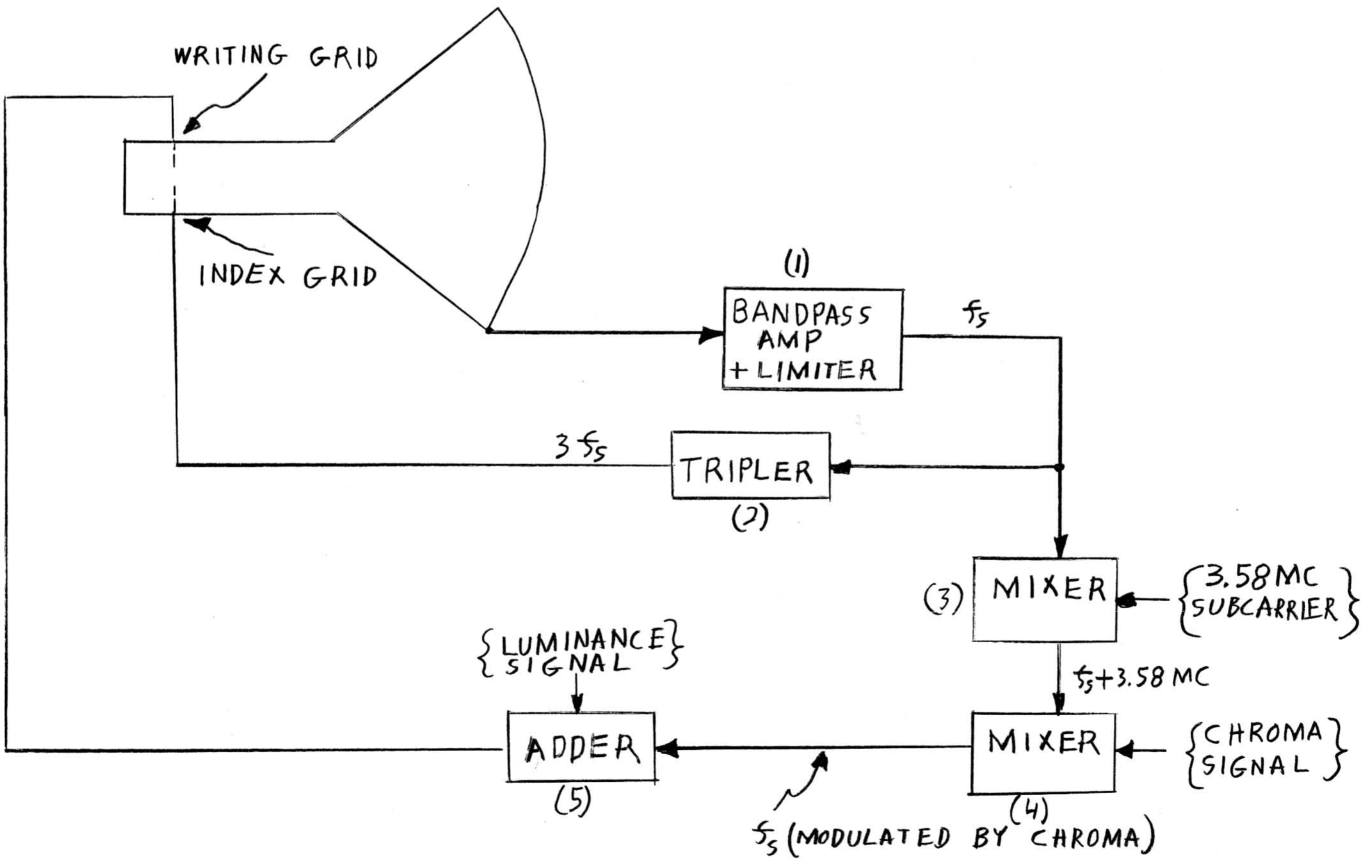


Figure 2

the comb structure and the anode voltage source. This triad rate signal f_s is fed to a bandpass amplifier and limiter (1). The limiter output (still f_s in frequency) is fed to a frequency tripler (2), the $3f_s$ output of which drives the picture tube pilot grid. The pilot grid waveform will be sinusoidal in nature and three times triad rate in frequency. The phase shift around this loop is adjusted such that the peaks of the index beam current will occur at the instant the beam is striking the guard-band areas. By proper biasing, the indexing beam current will be zero at times when it is passing over the phosphors. With such operation, high indexing currents are generated and possible since they produce no spurious illumination. High indexing current will reduce the bandpass amplifier requirements over any system where index beam pulsing is not used. This loop as now proposed represents an intentionally closed loop with positive feedback. This is desirable in that the indexing beam always operates at maximum peak current. However, near perfect limiting 'by (1)' will be required to prevent amplitude "squegging" of the loop. An alternate approach would be to replace the limiter by a phase or frequency controlled oscillator.

The signal control loop of the proposed system again includes the bandpass amplifier and limiter (1), the output of which is fed at f_s frequency to mixer (3). In mixer (3) the f_s signal is beat with the 3.52 mc reference carrier regenerated from the NTSC signal. The output of mixer (3) is the sum and difference of f_s and 3.58 mc. Only the sum is used. It is then fed to mixer (4) where it is beat with chroma information. The difference component is taken as the output of (4). It is an f_s carrier amplitude and phase modulated by chroma. By adding luminance signal in adder (5), a signal is generated which is dot sequential in form. It is applied to the signal writing grid of the picture tube. No "M" type correction of this dot sequential signal is shown. This correction could be provided if desired.

There are several advantages of the above system over previously proposed Apple type systems. The principal of these are as follows:

1. There is no background haze illumination caused by indexing. The index beam is cut off while passing over the phosphors. This will allow higher ultimate contrast.

2. Index beam pulsing will produce a much higher index signal output from the picture tube. Less amplification will thus be required in the index loop. Better signal-to-noise ratio will also be achieved.

3. Because of high index signal output, wider bandwidths may be possible in the index loop. This will speed up corrections for errors and will thus reduce requirements placed on sweep width and linearity.

4. One master can be used to print all phosphors and the comb structure making printing simpler.

5. Comb structures, ultra-violet light, and secondary emission materials, are all equally applicable to the proposed tube and system.

6. Circuitry is simplified and performance improved over conventional Apple by the elimination of the pilot oscillator and associated mixers.

7. Index stripes (regardless of material) of any thickness may be used since the electron beam does not have to reach light producing areas. Thus a high conductivity comb of high efficiency u.v. phosphor may be used.

8. The use of u.v. phosphor or comb structures will have no transit time problems.

9. Interference by outside signals should be low because of high indexing signal level.

10. No phase ambiguity (loss of gun-to-phosphor correspondence) can exist. Blemishes or momentary loss of indexing information will produce only momentary color errors. The system will always recover.

As an alternate to the above proposal, two techniques exist for operation with a single gun. The first of these would make use of a space-displaced electron beam from a single cathode. Two grid structures would be used with the beam being deflected from one grid to the other at three times triad rate. The second alternative would use a single gun. Time sequencing would be used at three times triad rate. This will produce a dot-rate writing signal when the beam is striking the phosphor, and a pulsed index signal when the beam is hitting guard-bands. Either of these two systems will eliminate crosstalk.

The ideas presented in this disclosure are described on pages 59 through 64 of I.E. Lynch's notebook #1018. Would you please docket this as a joint disclosure.

Signed: ____________________
I.E. Lynch

Date: ____________________

Signed: ____________________
T.T. True

Date: ____________________

Witnessed: ____________________

Date: ____________________

IEL/TTT/REL

Subject: A Triad-Rate Indexing Color Tube and System with Index Beam Current Pulsing

Syracuse, N. Y.
June 11, 1957

Mr. D. N. Timbie
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This disclosure letter describes a color tube and system operating by indexing and dot sequential presentation. Several techniques used here are similar to Apple Systems. Two basic new ideas are incorporated which improve performance and reduce cost.

The tube consists of vertically printed red, green, and blue, phosphor stripes with guard-bands. The guard-bands are composed of black non-light-reflecting material. This material will improve contrast over material which readily reflects light. Various possibilities now exist for the obtaining of indexing information. One of these would make use of secondary emission material as in the Apple tube. Another could employ a comb structure by which electrons are removed directly. In either case, the indexing structure is to be placed over a guard-band stripe and not over any light producing phosphor. This technique will allow beam current pulsing during the instant the beam is landing on the indexing area. By such operation, high indexing currents will be possible with no production of "haze" light which limits contrast ratio in the Philco Apple System. In all further discussions, comb structures will be referred to for simplicity although the same remarks apply equally well to secondary emission and ultra-violet light tubes.

In Fig. 1 is shown a possible configuration of the phosphor stripes, guard-band, and comb structure. The comb teeth have a repetition rate equal to the triad rate. Two possibilities exist for laying down the comb structure over the previously layed down phosphors and guard-band areas. One of these would consist of completely aluminizing the screen structure. This would then be followed by a layer of insulating material over which the conducting comb will be placed. Insulating material not covered by the comb can now be washed away. The second technique would be to aluminize the phosphor areas and possibly the guard-band areas not covered by comb teeth. This will now be followed by the placing of the comb structure directly on the proper guard-band material. Care must be exercised to insulate the comb from the aluminized phosphor. This technique is to be preferred over the first because of lower comb capacity.

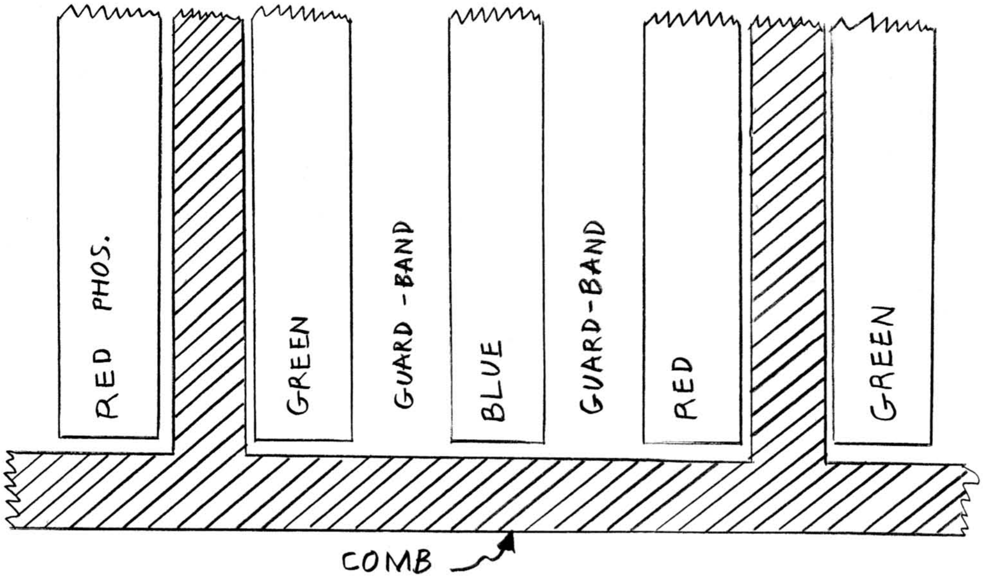

Figure 1

Fig. 2 gives a block diagram representation of the proposes system. The indexing signal is developed across a tank circuit of other impedance placed between

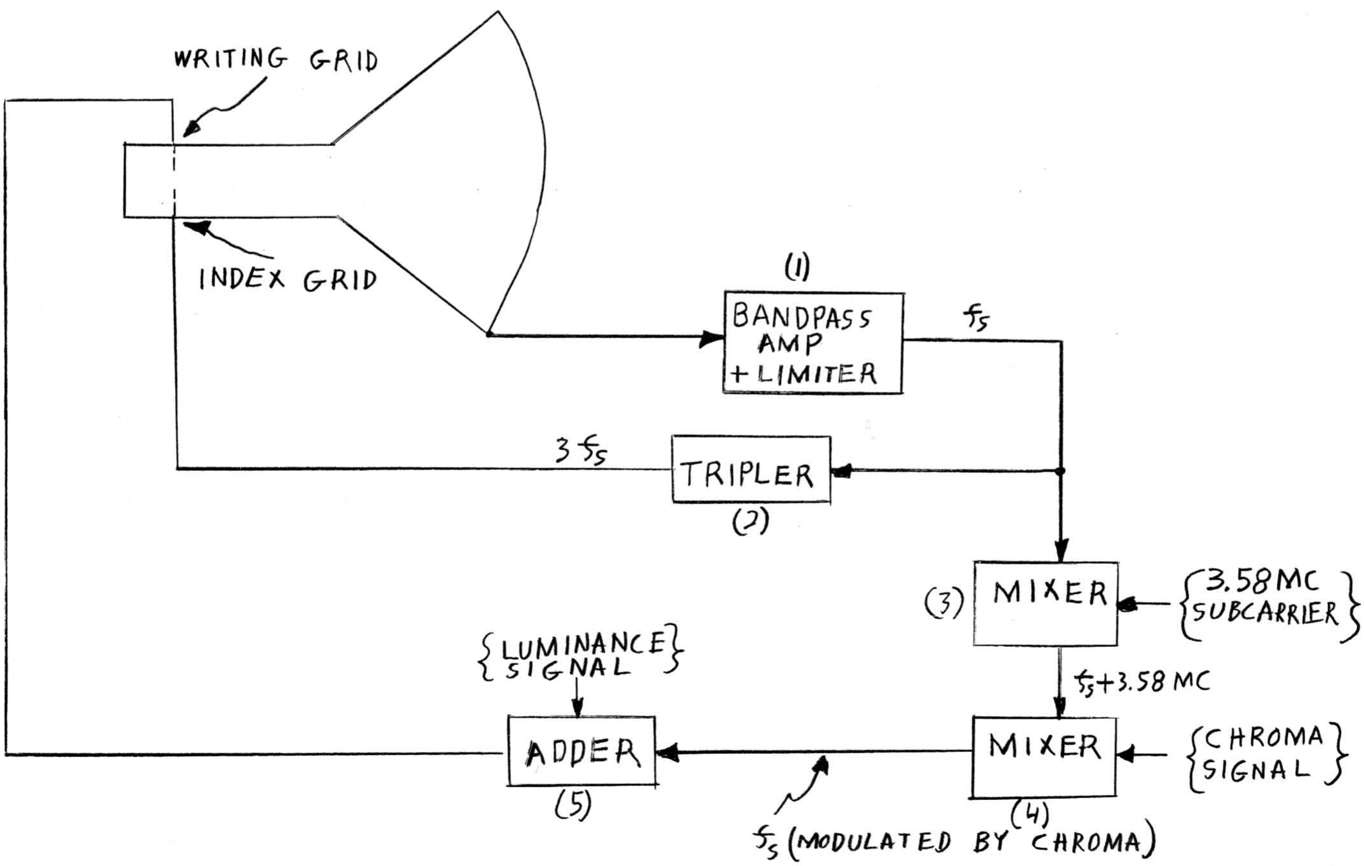

Figure 2

the comb structure and the anode voltage source. This triad rate signal f_s is fed to a bandpass amplifier and limiter (1). The limiter output (still f_s in frequency) is fed to a frequency tripler (2), the $3f_s$ output of which drives the picture tube pilot grid. The pilot grid waveform will be sinusoidal in nature and three times triad rate in frequency. The phase shift around this loop is adjusted such that the peaks of the index beam current will occur at the instant the beam is striking the guard-band areas. By proper biasing, the indexing beam current will be zero at times when it is passing over the phosphors. With such operation, high indexing currents are generated and possible since they produce no spurious illumination. High indexing current will reduce the bandpass amplifier requirements over any system where index beam pulsing is not used. This loop as now proposed represents an intentionally closed loop with positive feedback. This is desirable in that the indexing beam always operates at maximum peak current. However, near perfect limiting 'by (1)' will be required to prevent amplitude "squegging" of the loop. An alternate approach would be to replace the limiter by a phase or frequency controlled oscillator.

The signal control loop of the proposed system again includes the bandpass amplifier and limiter (1), the output of which is fed at f_s frequency to mixer (3). In mixer (3) the f_s signal is beat with the 3.52 mc reference carrier regenerated from the NTSC signal. The output of mixer (3) is the sum and difference of f_s and 3.58 mc. Only the sum is used. It is then fed to mixer (4) where it is beat with chroma information. The difference component is taken as the output of (4). It is an f_s carrier amplitude and phase modulated by chroma. By adding luminance signal in adder (5), a signal is generated which is dot sequential in form. It is applied to the signal writing grid of the picture tube. No "M" type correction of this dot sequential signal is shown. This correction could be provided if desired.

There are several advantages of the above system over previously proposed Apple type systems. The principal of these are as follows:

1. There is no background haze illumination caused by indexing. The index beam is cut off while passing over the phosphors. This will allow higher ultimate contrast.

2. Index beam pulsing will produce a much higher index signal output from the picture tube. Less amplification will thus be required in the index loop. Better signal-to-noise ratio will also be achieved.

3. Because of high index signal output, wider bandwidths may be possible in the index loop. This will speed up corrections for errors and will thus reduce requirements placed on sweep width and linearity.

4. One master can be used to print all phosphors and the comb structure making printing simpler.

5. Comb structures, ultra-violet light, and secondary emission materials, are all equally applicable to the proposed tube and system.

6. Circuitry is simplified and performance improved over conventional Apple by the elimination of the pilot oscillator and associated mixers.

7. Index stripes (regardless of material) of any thickness may be used since the electron beam does not have to reach light producing areas. Thus a high conductivity comb of high efficiency u.v. phosphor may be used.

8. The use of u.v. phosphor or comb structures will have no transit time problems.

9. Interference by outside signals should be low because of high indexing signal level.

10. No phase ambiguity (loss of gun-to-phosphor correspondence) can exist. Blemishes or momentary loss of indexing information will produce only momentary color errors. The system will always recover.

As an alternate to the above proposal, two techniques exist for operation with a single gun. The first of these would make use of a space-displaced electron beam from a single cathode. Two grid structures would be used with the beam being deflected from one grid to the other at three times triad rate. The second alternative would use a single gun. Time sequencing would be used at three times triad rate. This will produce a dot-rate writing signal when the beam is striking the phosphor, and a pulsed index signal when the beam is hitting guard-bands. Either of these two systems will eliminate crosstalk.

The ideas presented in this disclosure are described on pages 59 through 64 of I.E. Lynch's notebook #1018. Would you please docket this as a joint disclosure.

Signed: ____________________
I.E. Lynch

Date: ____________________

Signed: ____________________
T.T. True

Date: ____________________

Witnessed: ____________________

Date: ____________________

IEL/TTT/REL

Subject: A Three-Times-Triad-Rate Indexing
Color Tube and System with Index Beam
Current Pulsing

Electronics Park - Syracuse, N. Y.
June 17, 1957

Mr. D. N. Timbie
Patent Section
Room 222 - Bldg. 5
Electronics Park

This disclosure letter describes a system for producing color TV pictures which utilizes three-times-triad-rate indexing and index beam current pulsing. This system is similar in many respects to a system proposed in a previous letter entitled "A Triad-Rate Indexing Color Tube and System With Indexing Beam Current Pulsing." The major difference is that the indexing material in this proposal is placed over all guard-band stripes instead of just one per triad. This raises the fundamental indexing signal frequency from triad-rate to three times triad-rate. The two advantages of this system over the previous are: (1) increased indexing signal output by a factor of three and (2) higher frequency separation between video frequencies and the indexing signal frequencies. However, an additional factor which must be dealt with is the possibility of phase ambiguity.

Figure 1 gives a representation of the picture tube screen assembly.

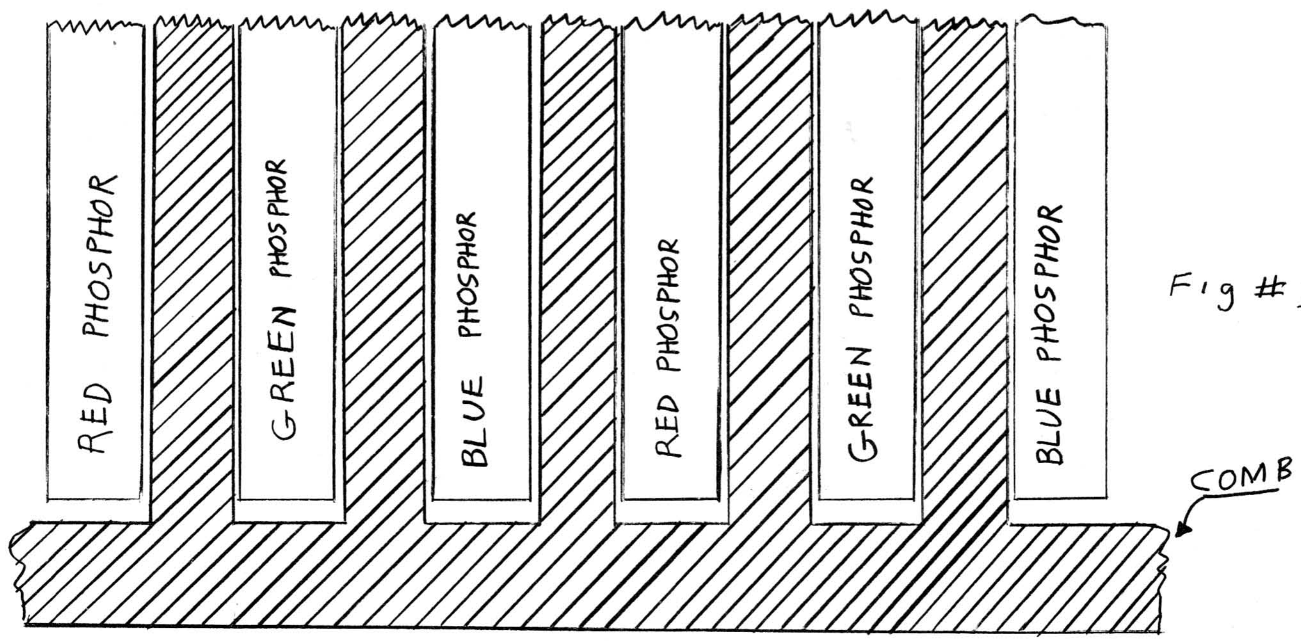

Fig #1

A comb tooth is seen to be placed over every black guard band stripe. Indexing voltage is developed between the comb teeth and the anode supply by use of a suitable series impedance. The indexing frequency will be three times triad-rate.

A block diagram of a system using the above tube is shown in Figure 2. In this system, three times triad-rate index signal ($3f_s$) is taken from tube (1) and fed to a band-pass amplifier and limiter (2). The output of the limiter (2)

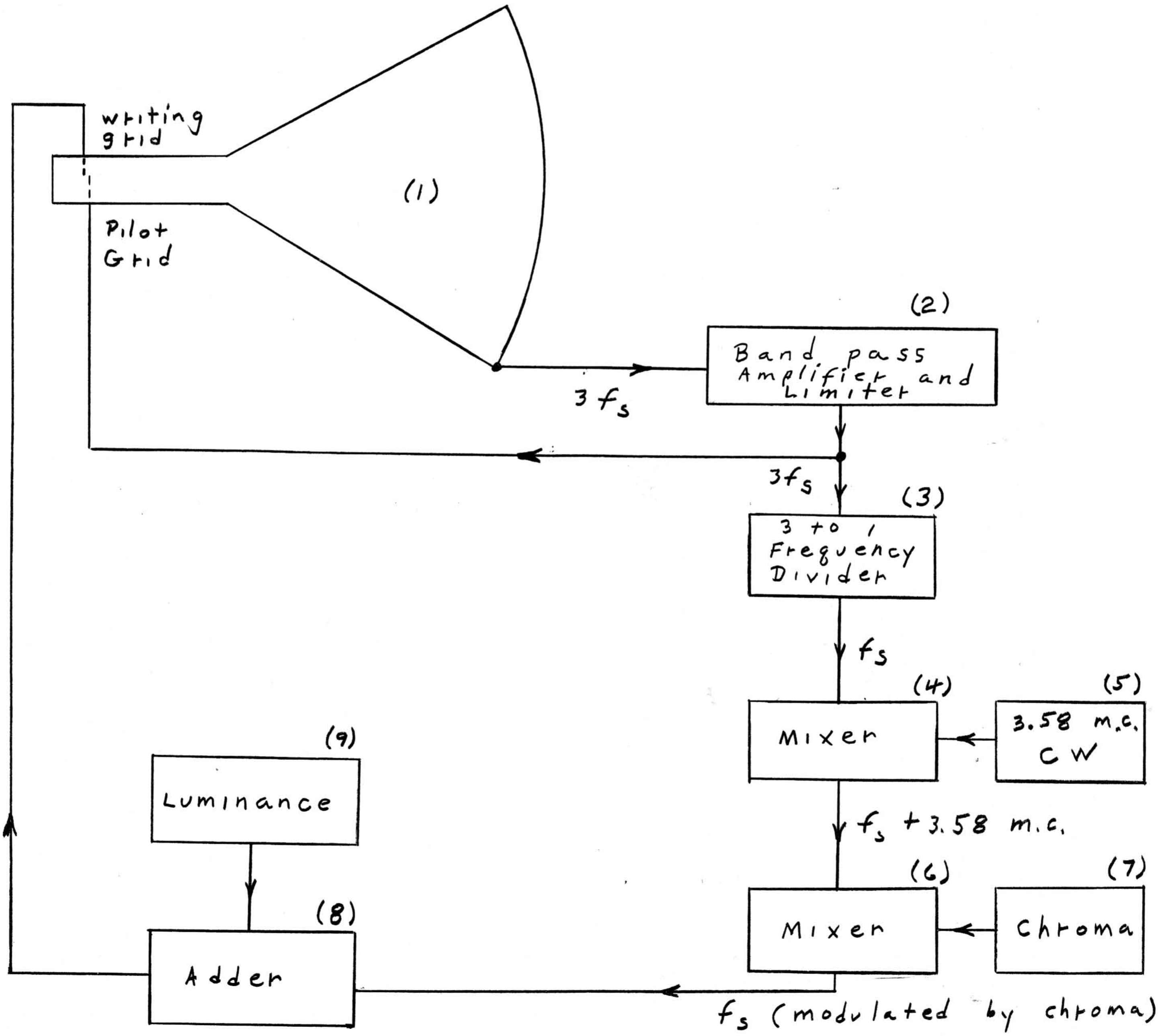

Figure # 2

is fed directly to the pilot grid of the picture tube (1). This completes the indexing loop. The phase shift of the loop is adjusted to pulse the index beam on whenever it is passing over an index tooth. Feedback is positive and the system will tend to be self oscillating. Extremely good limiting in this loop will be required if amplitude "squegging" is to be prevented. A frequency and/or phase controlled oscillator may be used in place of/conventional limiter (2) if necessary.

The $3f_s$ output frequency of (2) is also fed to a three-to-one frequency divider (3). This frequency division is necessary in order to obtain a proper dot-sequential writing signal for the picture tube. The output of the frequency divider (f_s) is beat with 3.58 mc color reference from generator (5) in mixer (4). The sum of f_s and 3.58 mc is taken as the output of mixer (4) and fed to mixer (6). In this second mixer, the output of (4) is beat with chroma information from (7). The difference of these two signals is taken as the output of mixer (6), and is composed of an f_s carrier amplitude and phase modulated by chroma. Addition of luminance information from (9) is made in adder (8). The output of (8) is in the form of a dot-sequential voltage which is applied to the writing grid of the tube.

In this three times triad-rate indexing system the possibility of phase ambiguity exists. Unless preventive steps are taken, color correspondence can be lost at the start of any line or following any indexing blemishes. Phase ambiguity at the beginning of a line may be prevented in either of two ways. The first would consist of always insuring that the first indexing tooth bears a fixed phase relationship with a given color stripe. The second would utilize only one indexing stripe per triad for several triads at the start of a horizontal line. This would allow proper correlation before starting the three per triad indexing stripes.

It should be noted that the system proposed above has several possibilities for the type of indexing material to be used. Among these are secondary emission, u.v., combs, infra-red, and possibly others. All would readily lend themselves to pulsed-type operation.

As an alternate to the above proposal, two techniques exist for operation with a single gun. The first of these would make use of a space-displaced electron beam from a single cathode. Two grid structures would be used with the beam being deflected from one grid to the other at three times triad rate. The second alternative would use a single gun. Time sequencing would be used at three times triad rate. This will produce a dot-rate writing signal when the beam is striking the phosphor, and a pulsed index signal when the beam is hitting guard bands. Either of these two systems will eliminate crosstalk.

Ideas relating to this disclosure are given on pages 59 through 65 of I.E. Lynch's patent notebook #1018. Would you please docket this as a joint disclosure.

Signed: ____________________
I.E. Lynch

Date: ____________________

Witnessed: ____________________

Signed: ____________________
T.T. True

Date: ____________________

Date: ____________________

IEL:TTT:REL

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.

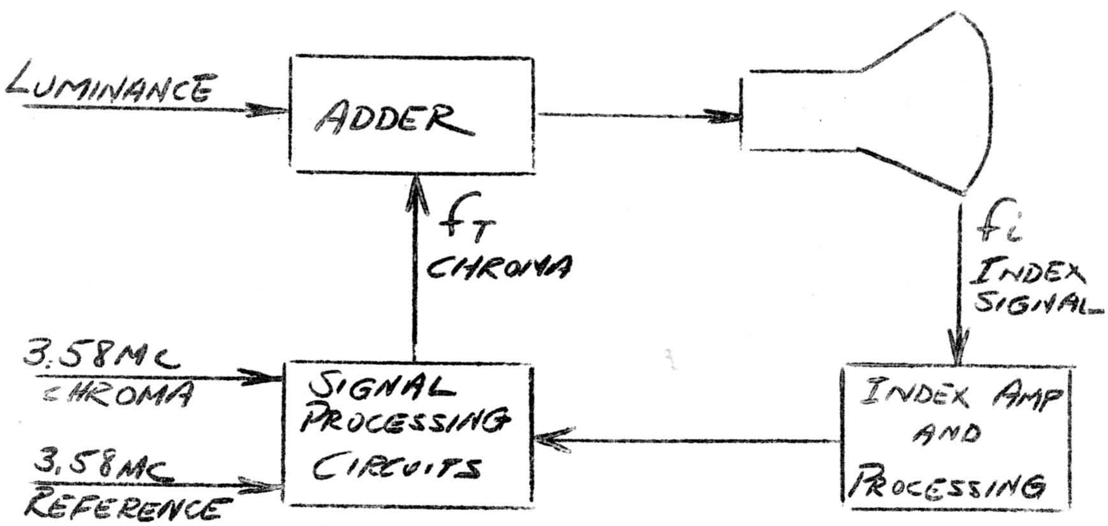

Figure 1

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.

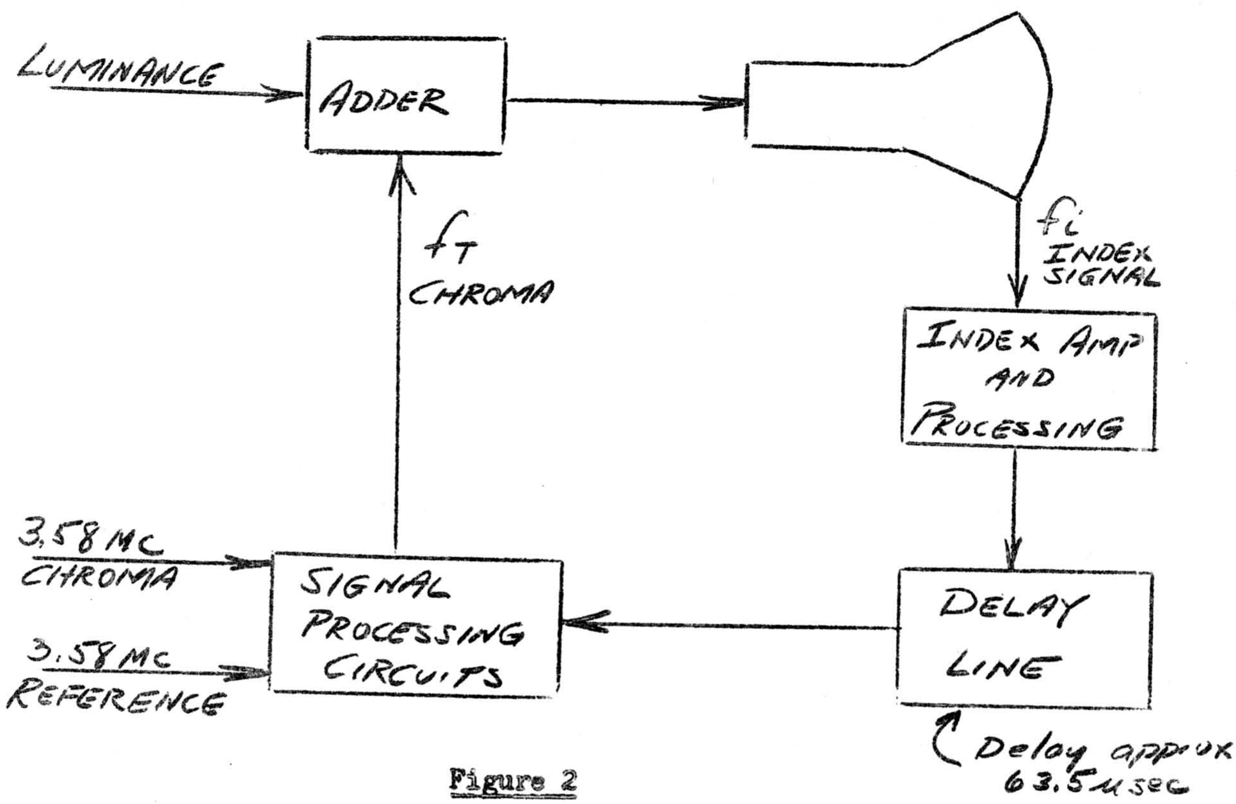

Figure 2

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.

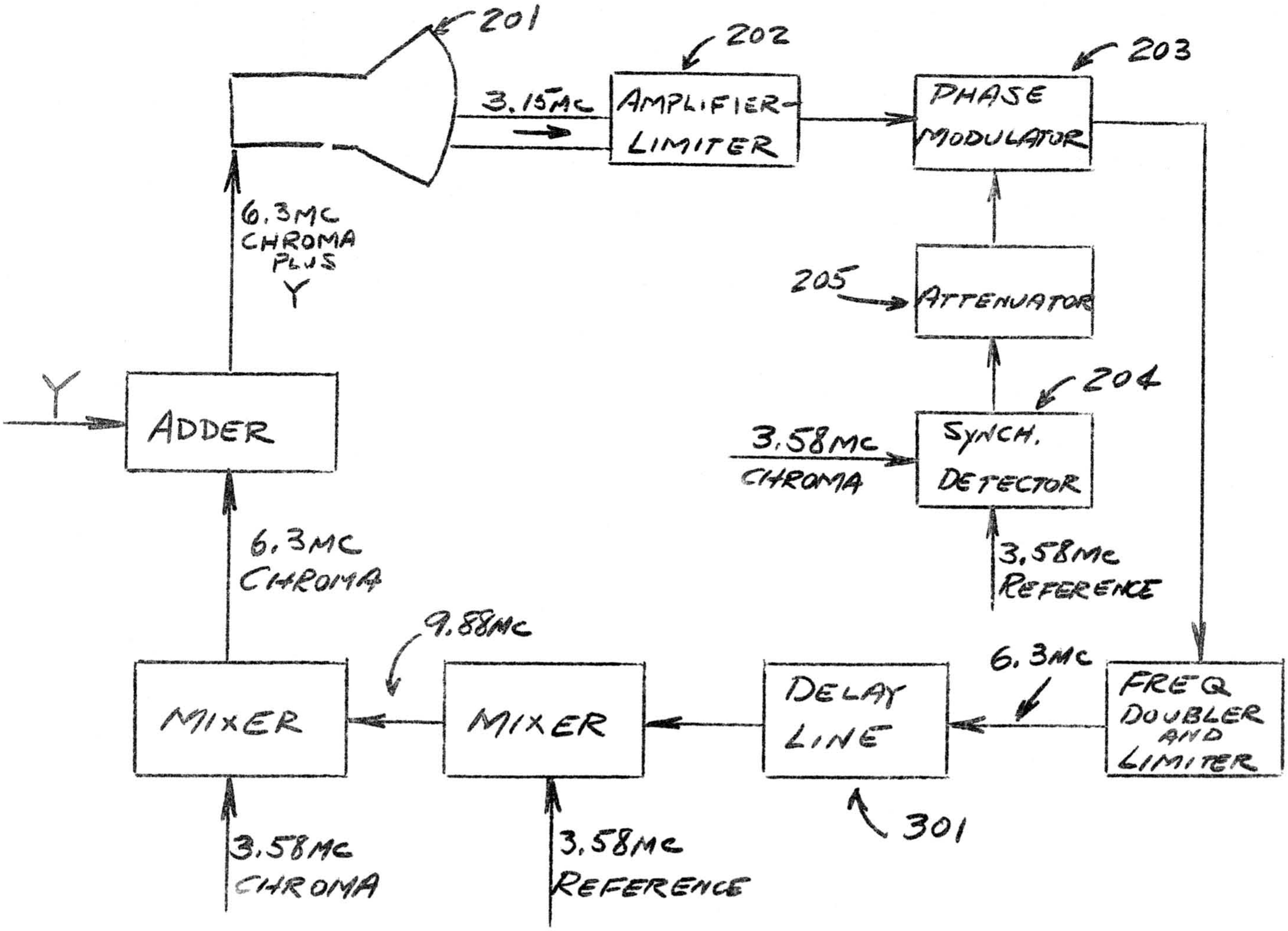

Figure 3

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____________________

TVZ:erh

Date____________________

Witness____________________

Date____________________

MISCELLANEOUS INVESTIGATION REPORT #81
APRIL 22, 1957

TELEVISION RECEIVER DEPARTMENT
COLOR DEVELOPMENT ENGINEERING

ACCURATE BEAM SCANNING
HORIZONTAL PHOSPHOR LINES WITH SERVO CONTROL

by: N. JOHANNESSEN

ABSTRACT

This report is a discussion of an accurate beam scanning color display device. In the discussed system, the precision in vertical deflection is obtained by feeding a correction voltage to a pair of electrostatic deflection plates. This voltage is obtained by an index structure on the phosphor screen.

CONCLUSION

The main limitation of this system seems to be the small spot size required to operate the tube, and difficulties in obtaining a index signal. Furthermore, the system requires extra circuits to prevent line jumping, and to obtain interlaced raster lines.

DISCUSSION

In an accurate beam scanning system, the orientation of the phosphor lines can be chosen in any desired direction.

If however, the phosphor lines are orientated in any angle between horizontal and vertical, precision scanning in both directions are required, so it appears to be most practical with either vertical or horizontal orientated phosphor lines.

The main limitation of a horizontal line system seems to be the dimensions of the picture elements. It takes one triad to form a picture element, so in a vertical line system, the width of a triad can be made equal to the horizontal width of a picture element. While in a horizontal line system, the width of a triad can be made equal to the vertical height of a picture element.

The ratio between the height "h", and the width "w", of a picture element is:

$$\frac{h}{w} = \frac{\text{Horizontal resolution X Aspect ratio}}{\text{Vertical resolution}} = \frac{325 \times 3}{480 \times 4} = 0.5$$

This shows that in a horizontal line system, all dimensions, such as triad width, line width and spot size, are restricted to one=half the dimensions necessary in a vertical line system. Because of this a certain amount of misregistration will cause twice as much desaturation in case of horizontal lines.

If we consider a 14" height picture tube with 480 interlaced scanning lines, the width of each triad will be 0.030". When a 50% guard band between phosphor lines is used, the width of each phosphor line will be 0.005".

In order to allow a reasonable error in the registration, it will be necessary to keep the spot size in vertical direction down to about 0.006". In horizontal direction it is desirable to keep the spot width as large as possible, in order to decrease the current density in the beam. From a standpoint of resolution, the spot width can be made up to six times the height, however, with such a wide beam, spot rotation can be a problem.

The requirements to the linearity of the vertical sweep will be very tight. If we assume a perfect stair step switching of the beam, and no servoing, the sweep has to be linear within 0.03%. It is obvious that this requirement to linearity can not be fulfilled by the deflection system, so the only way to keep the beam in register with the phosphor lines is by use of a servo system.

Generation of indexing signal:

The generation of indexing signal will be much more complicated than in a vertical line system. Secondary electron emitting stripes placed on back of the phosphor lines can neither indicate direction nor magnitude of error. In order to get this information, it will be necessary to place the secondary electron emitting material in certain patterns for example as shown in Figure 1. When scanning this type of pattern, a square wave voltage will be generated. It can be seen from Figure 1, that the duty cycle of this square wave carries both direction and magnitude information. With no error (the beam in position "a") the duty cycle will be 50%. When the error is towards red (beam in position "b") the duty cycle will be less than 50%, if beam is in position "c" (green error), the duty cycle will be higher than 50%. However, much distortion of this signal can be expected, due to the fact that the beam, in order to make colors, is deflected in vertical direction over one triad at chroma sub-carrier rate.

Another approach for generation of a indexing signal is the metallic comb deposited on back of the phosphor lines, known from Mr. R. B. Dome's version of the Apple tube*. In a horizontal line system however, the comb can not indicate magnitude of error, because of variations in beam current due to luminance information in the picture. Furthermore, a horizontal comb will have a very high capacitance, probably more than 20,000 uuf, and a resistance of about 200 Ω . These characteristics will limit the use of a comb type index for a horizontal line system.

Tracking Servo:

In a horizontal line system, the generated index signal can be detected, amplified, and then applied to the vertical sweep system, and in this way correct for an error in beam position. Due to inertia in a magnetic deflection system, beam position can only be changed at a slow speed. Considerable increase in speed can be obtained by feeding the error voltage to a pair of vertical electrostatic deflection plates.

It will be recognized that the servo system will only be able to track within one triad. This means that the largest amount of error that can exist before the beam jumps, will be less than one-half a triad width, or about 0.012". In order to assure that the beam will start each scanning line within this limit, the vertical sweep has to be linear within 0.09%. This requirement of sweep linearity can not be met in a commercial TV set.

Instead, the servo could be furnished with a memory circuit. This memory should be arranged in such a way that the error existing when the beam starts scanning one line, is stored in the memory, and is reapplied to the deflection plates at the beginning of the next scanning line. In this way the error voltage will be accumulated from line to line, and eliminate the use of precision scanning.

* Described in disclosure letter to Mr. D. N. Timbie - April 26, 1956.

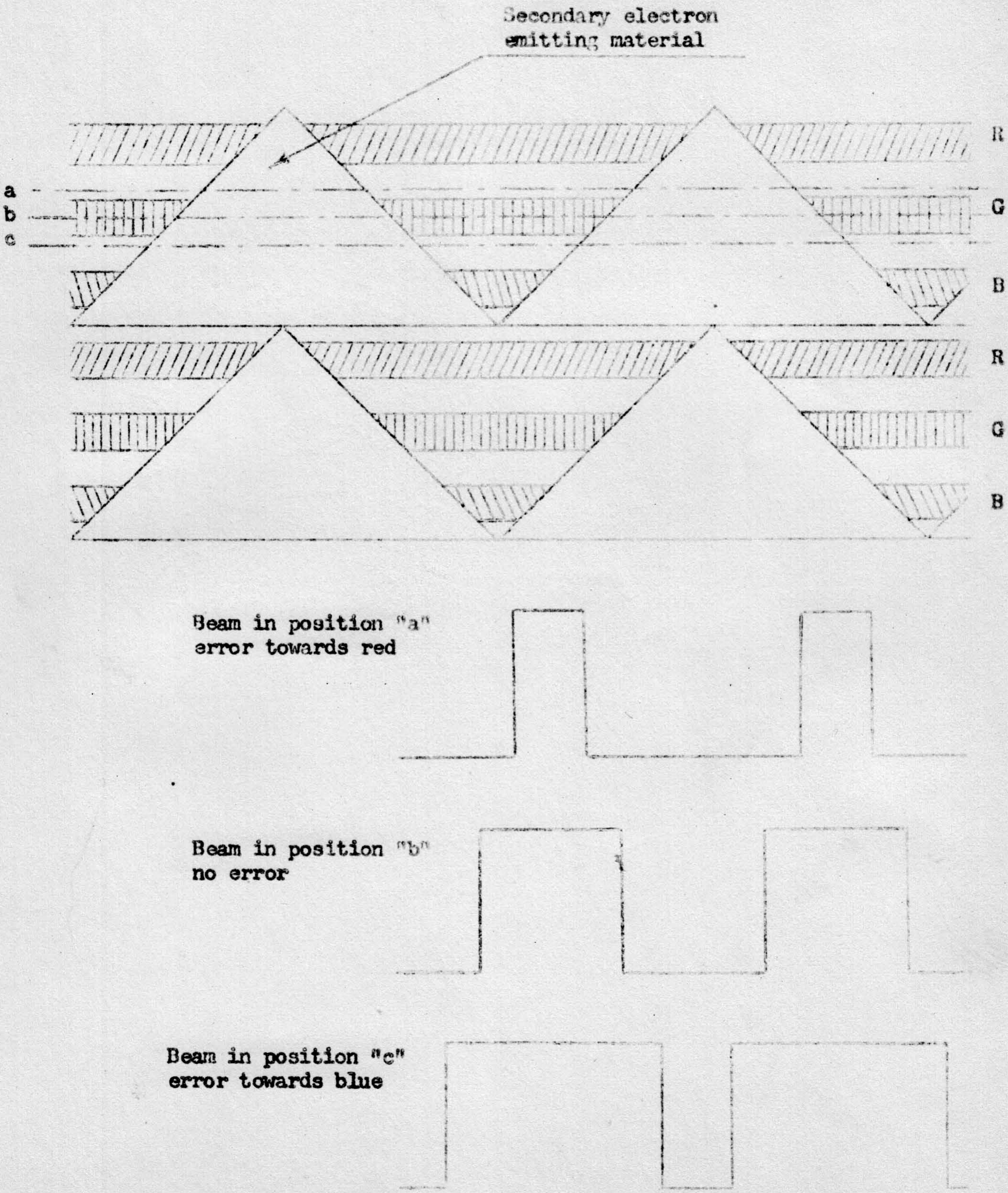
Secondary electron
emitting material
a
b
c
R
G
B
R
G
B
Beam in position "a"
error towards red
Beam in position "b"
no error
Beam in position "c"
error towards blue

Figure 1

The system will also require a circuit, which can start an even field on an even triad, and an added field on an added triad. This is necessary in order to obtain interlaced raster lines.

Niels Johannessen
N. Johannessen
Development Engineering
TELEVISION RECEIVER DEPARTMENT

NJ:rr
5-8-57

cc: RB DOME
DE GARRETT
DE HARNETT
JF McALLISTER
DW PUGSLEY
WE GOOD
M GRASER
IE LYNCH
MJ PALLADINO
TT TRUE
HJ VANDERLAAN
FG COLE
BA FIELD
GA SCHUPP
TV ZALOUDEK
LC MAIER #6
JC NONNEKENS #6
WD RUBLACK #6
EF SCHILLING #6

MISCELLANEOUS INVESTIGATION REPORT #91
JUNE 3, 1957

TELEVISION RECEIVER DEPARTMENT
COLOR DEVELOPMENT ENGINEERING

ACCURATE BEAM SCANNING FOUR BEAM HORIZONTAL LINE SYSTEM WITH CONTINUOUS SERVO

by: N. JOHANNESSEN

ABSTRACT

Advantages and limitations of a four beam horizontal line system are discussed. The descriped system has a common electron gun, through which the four closely spaced beams are passed.

CONCLUSION

The advantages of this system are:

1. Registration problems are minimized
2. Lower current density in beam
3. One beam available for indexing
4. Index beam can be operated at high current level.

The limitations are essentially the same as in the one gun system, namely:

1. Extremely high precision of gun is necessary
2. High capacitance of index comb
3. Gating and storage circuits are necessary to prevent line jumping.

DISCUSSION

The proposed electron gun has a common cathode in front of which an aperture mask, with four very closely spaced rectangular slots, is placed. Across each of these slots, is a thin wire which acts as control grids. The four cross over points, formed in this way, are now focused on the screen by a common lens; and thus appear on the screen as rectangular spots 5 by 30 mils, and 7 mils center to center spacing.

When an electron lens with a magnification factor of 5 is used, the dimensions of the slots in the aperture plate will be approximately 1 by 6 mils. with a center to center spacing of 1.4 mils. The tolerances on the dimensions and the position of the slots must be kept extremely small, about 0.1 mils. This is necessary because with the close beam spacing, none of the beams can be position corrected independently. It must be considered doubtful that an aperture plate with such a high degree of precision can be made in mass production. There are two methods by which these requirements for the aperture plate can be decreased: 1. By decreasing lens magnification factor to unity. 2. By use of a more complex lens, with two cross over points. However, both alternatives have their drawbacks. If the magnification of the lens should be decreased to unity, the tube would be so long that it would be impractical in a commercial TV set.

If a double cross over gun is used, the four beams will be separated more when passing through the yoke, and result in misregistration. Furthermore, some cross modulation can be expected due to the grid to cathode fields, and due to the fact that the four beams are traveling as one column over most of the distance from cathode to screen.

In Figure 1 is shown a lay out of the phosphor screen with index stripe. For a 14" high picture tube with interlaced raster lines, only 30 mils are available for each triad including the index stripe. This leaves 7 mils to each of the phosphor lines and 9 mils for the indexing.

The servo system has to be made in such a way that only the index beam can generate an error signal. In order to allow the index stripes to discriminate between the color writing beams and the index beam, it will be necessary to modulate the index beam with a certain frequency, which has to be higher than the highest video frequency, for example 10 MC. In the case where the index beam is centered on the comb (no error), an equal amount of index signal will be picked up by the two sets of teeth. These signals will cancel out in the primary of the take off transformer. In case of an error in one or the other direction, an error signal will be generated; the phase of this signal, with respect to that of the index oscillator, will indicate the direction of error. Due to the very close spacing of the comb teeth, the total capacitance between these will be in the order of 20,000 uuf. The inductance required to resonate this at the 10 MC index frequency will be approximately 12 muh, such low inductance will be very difficult to obtain in the take off transformer. One way the effect of the capacitance can be decreased is to divide the comb in several sections, and then tune each section individually.

A block diagram of the system is shown in Figure 2. The generated error signal is after amplification fed to a synchronous detector. The dc error voltage is now connected to a pair of vertical deflection plates through a push-pull amplifier.

When 7 mils phosphor stripes and 5 mils spot sizes are used, the maximum error there can be tolerated is 1.6 mils. This error will give the equivalent of a 10° change in color sampling angle. With a 2% geometric distortion of the vertical sweep, the time it will take to reach this error will be 88 usec. or 1.37 lines. This means that if distortion of the vertical sweep was the only source of error, the time constant in the servo system could be fairly long. However, there are many other possibilities for error, for example, pincushion, yoke rotation, spot rotation, distortion of spot shape and spacing, misprinting of triads, influence of external fields, and so on. If for example, due to pincushion, the tangent of the spot trace should reach an angle of 1° with respect to the phosphor lines, the maximum error of 1.6 mils, would be reached in just 0.26 usec. In practice several of these errors would occur at the same time, and an extremely large band width would be required in the servo system in order to correct the error at the proper speed.

Another serious problem is line jumping, it can be seen from Figure 1, that the maximum error there can be tolerated at the beginning of each line is 12 mils. With a 2% distortion of the vertical sweep this error will be reached in 660 usec. or 10 lines. A proposed scheme to prevent line jumping is to apply the integrated error signal to the magnetic deflection system. This, however, can not correct for errors introduced by pincushion or yoke rotation. In case of symmetry, the integrated error could be zero, while the error at the beginning of a line easily could exceed 12 mils. To insure correct start of all lines, the error which occurs at the beginning of a scanning line, should be gated out, stored, and then be reapplied at the beginning of the following line.

Likewise, some difficulties can be expected in obtaining interlaced raster lines.

N. Johannessen

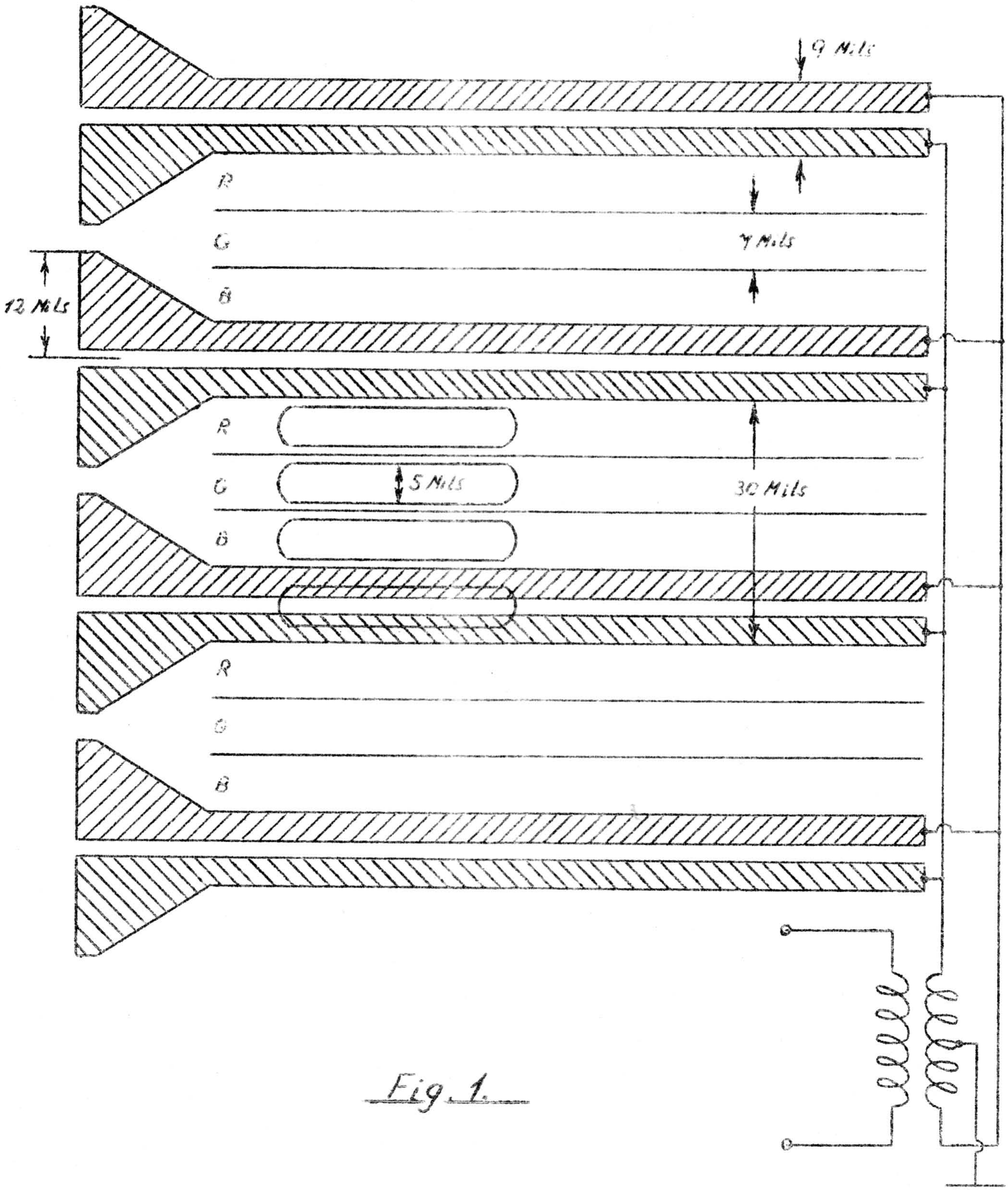

Fig. 1.

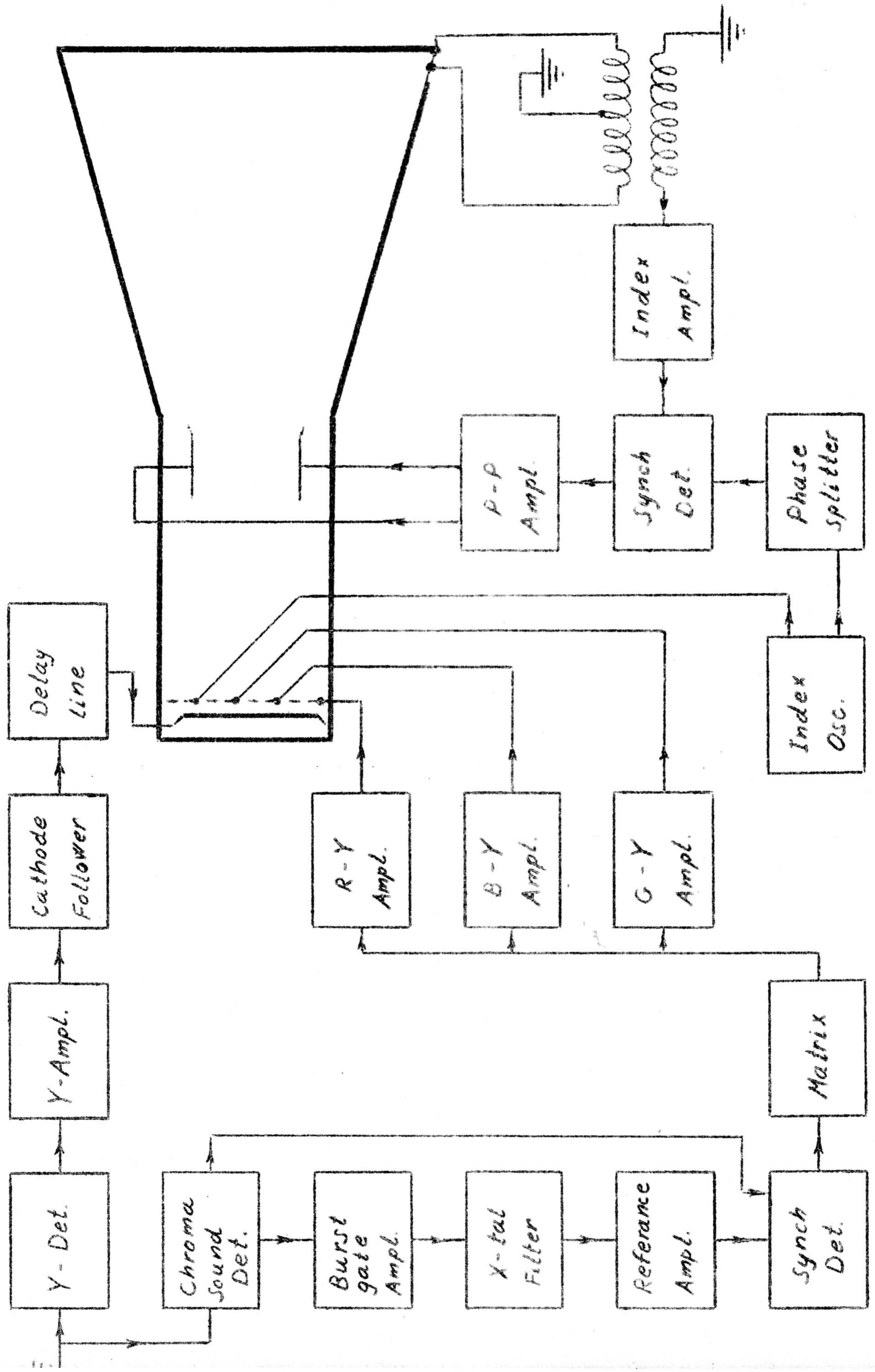
Y - Det.
Chroma Sound Det.
Burst gate Ampl.
X-tal Filter
Referance Ampl.
Synch Det.
Y-Ampl.
Cathode Follower
Delay line
R - Y Ampl.
B - Y Ampl.
G - Y Ampl.
Matrix
Index Osc.
P-P Ampl.
Synch Det.
Phase splitter
Index Ampl.

Fig. 2

Subject: A Spot Hesitation,
Precision Scan,
Color System with an
Indexing Servo

Electronics Park, Syracuse, N. Y.
June 6, 1957

Mr. D. N. Timbie
Patent Section
Room 222 - Bldg. 5
Electronics Park

This disclosure letter describes a system for producing color TV pictures which utilizes a vertical phosphor line tube and triad-period-spot-hesitation as a means of controlling color. The system has provisions for index servoing, and therefore may be classified as "precision scan with index servo."

A diagram of the screen assembly of the tube to be used in the proposed system, is shown in Figure 1. The phosphor, index area, and comb teeth are all arranged in vertical columns.

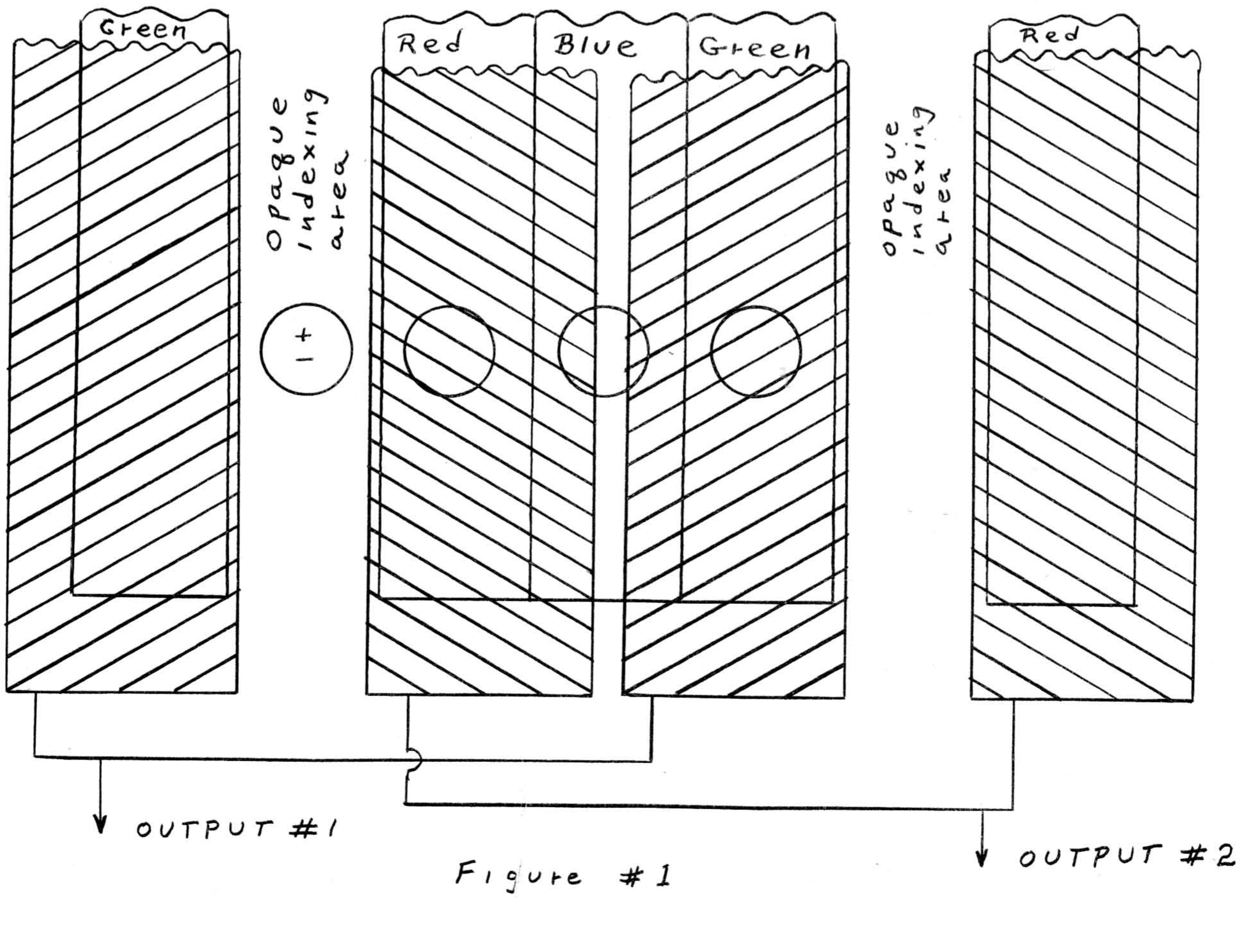

Figure #1

The comb teeth are represented by the diagonally shaded areas. One tooth is seen to be placed over a red and part of a blue phosphor stripe. A second tooth is placed over a green and the remaining area of the blue phosphor stripe. The comb teeth over red are all connected together giving an output. The teeth over green are also connected together giving a second output. Spacing must be provided between the red and green comb teeth for insulation purposes. It is not necessary for proper operation of the system, that the width of the teeth be equal. One set of teeth might cover the red and blue phosphors while the other set covers only the green. The phosphor stripe sequence (R, G, B) shown in Fig. 1 is also not necessary for operation of the system although there may be an optimum arrangement from the standpoint of color error minimization (smallest amount of light produced by the indexing beam and by writing beams hitting the wrong phosphor).

The indexing stripe for the proposed tube is located between the green and red stripes as shown in Fig. 1. This stripe will be black and non-light emitting. Any electrons hitting this area will produce no light and also no comb output. It should be noted that this is the only non-light producing area. No guard-band is indicated between the color stripes. Guard-bands could be used but in no way would improve performance unless the width of the index stripe is made less than a phosphor stripe. The reasons for this will become more apparent later in this discussion.

The gun used in the tube of the proposed system is to have four closely spaced beams. By having the beams closely spaced, convergence errors are minimized (all four beams pass through approximately the same yoke region). Any minor errors which may remain may be corrected by proper phosphor printing (change of triad pitch) to match the yoke being used. The actual gun used could consist of four closely spaced cylinders, four co-axial guns, or any new gun type with four individually controlled electron streams. Dr. W. E. Glenn of the Schenectady Research Laboratory thinks it should be possible to construct a long narrow cathode structure with the area separated into four areas. The emission from each area would be controlled by a separate single or double wire grid stretched across each of the four areas. The gun would be placed in a horizontal plane so that the beams would strike a triad as shown by the four circles of Fig. 1. Minor alignment may be required to provide equal beam spacing and proper landing on the triad.

Let us now assume that alignment is correct, and that the undeflected "beam bundle" is hitting a triad as shown in Fig. 1. If the index beam is now modulated with say a 24.15 mc sine wave, none of this signal will be developed at the comb output points (all current goes to the black stripe). The choice of 24.15 mc is based on a 3.5 times the assumed triad rate of 6.9 mc to give a frequency interlaced relationship. Several other possible frequencies exist such as 17.25 mc or 2.5 times triad rate. If now the beam bundle of Fig. 1 is displaced slightly to the left, a 24.15 mc output will be obtainable from comb group #1. Displacement to the right will cause index voltage output from comb group #2.

It remains now to sweep the proposed tube in such a manner as to maintain correspondence between index beam and index stripe, red beam and red stripe, and so on. Consider the sawtooth shown in Fig. 2a. This waveform represents the normal magnetic sweep to be used in the proposed system. If to this sweep we add a second sweep shown by waveform (b) we may realize a jumping sweep.

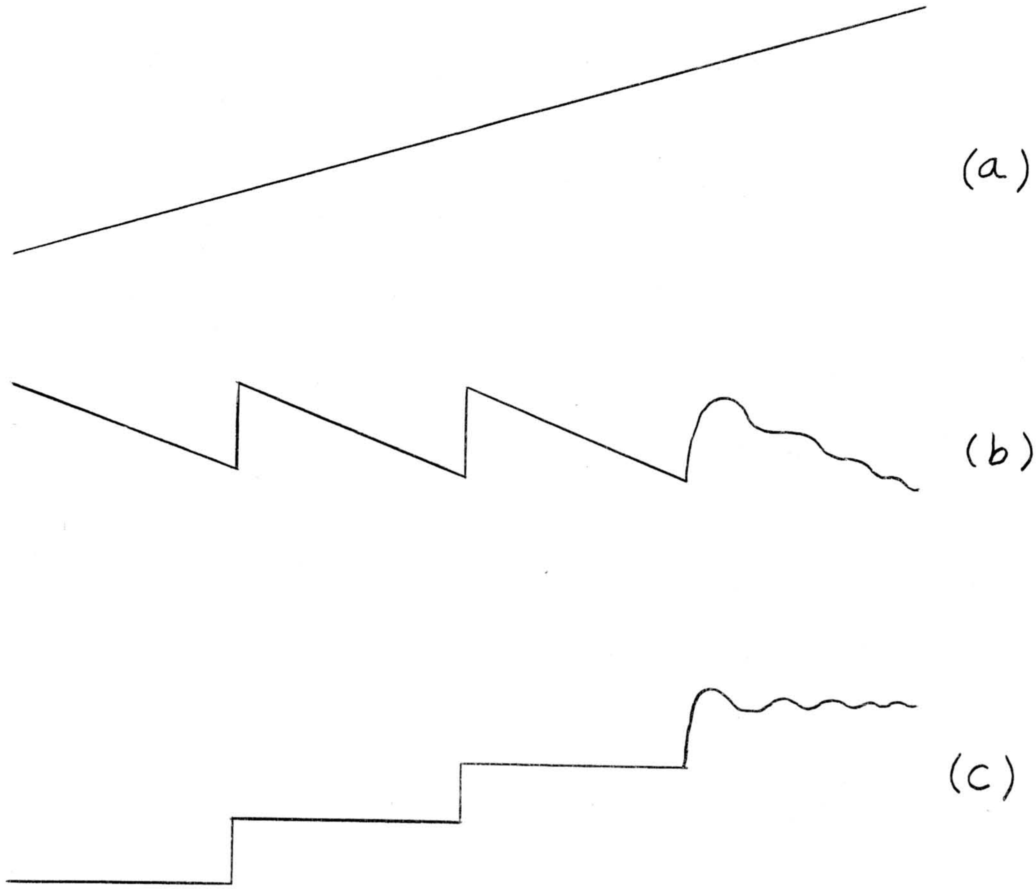

Figure # 2

The effect of waveform (b) is to be introduced by applying the signal to deflection plates in the tube neck. By making the magnetic sweep and the electrostatic sweep oppose each other (during the gradual slope portion of (b)) it should be possible to momentarily hold the beam bundle motionless on a triad. At the vertical discontinuities in waveform (b), this opposition ceases and the beam bundle will quickly jump to the next triad. The combined effect of waveforms (a) and (b) is shown by waveform (c). The amplitude, frequency, phase, and exact wave shape of waveform (b) must be controlled to insure proper beam jumping or color impurities (loss of gun-to-phosphor correlation) will result. The repetition rate of (b) will be 6.9 mc or the triad rate. The waveshapes shown on the right hand side of (b) and (c) represents a practical waveform which might be used.

A block diagram of the proposed system (includes sawtooth generation and phase control), is shown in Fig. 3. The two 24.15 mc output voltages from the picture tube (#1 and #2) (taken from the two sets of comb teeth) are fed to frequency selecting amplifiers. The output of these two amplifiers (3) and (4), is then separately fed to two amplitude detectors (5) and (6). These detectors are so arranged that (5) gives a positive dc output while (6) gives a negative output. The magnitude of these developed biases depends only upon the degree of indexing beam position error (assuming the index beam current to be constant). If now we assume

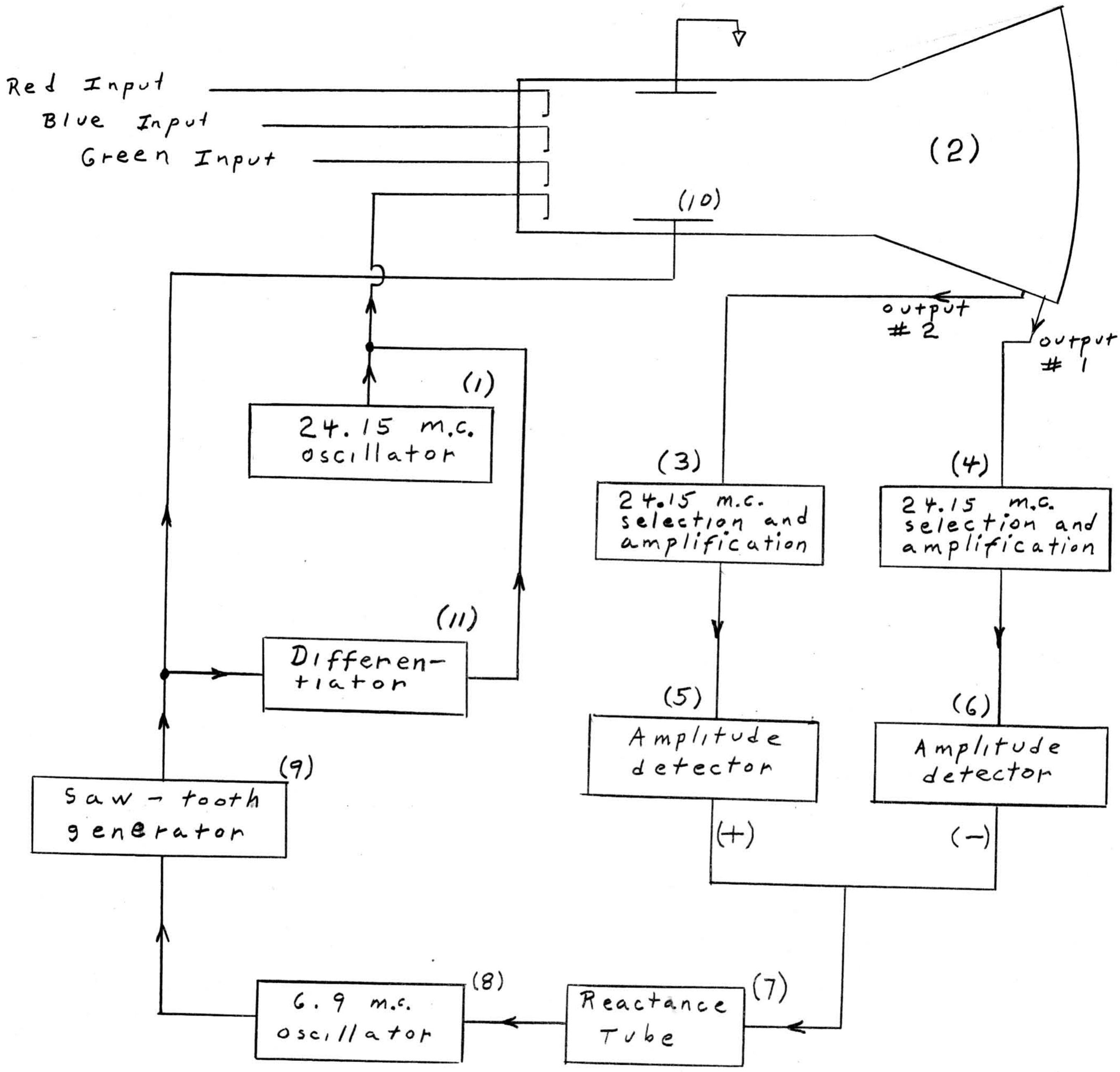

Figure # 3

that the index beam is in error to the left (hitting green) there will be a comb output at #1 and a negative bias developed. This negative bias is then fed to a reactance tube (7) which slows down the frequency of oscillator (8), delays the phase of the sawtooth generated by (9) whose output is applied directly to deflection plate (10). This delay of sawtooth phase on the plate causes the bundle to jump further on the next jump and the index beam to again strike the index stripe. If on the other hand, the index beam is hitting the red stripe, index output will come from comb group #2, the detector output will be positive, the oscillator frequency will be sped up, causing the sawtooth phase to change and index beam to again return to the index stripe. When the index beam hits the index stripe, no error voltage results so that the servo system may be considered to be of type #2 or one with no correction voltage when there is no error. This is different from the Apple System where a signal is always being fed back. This system also differs from Apple in that no modification of chroma by servo control is performed. Chroma and Y are detected, and fed to the three writing guns. Matrixing can be either external or in the picture tube.

An alternate approach to the maintaining of proper beam bundle jumping is possible. This would make use of varying the height of rise of the sharp discontinuities in waveform (b) of Fig. 2. The repetition rate of the sawtooth would be held constant (instead of the jump distance as before) and the jump distance would be increased or decreased depending on the direction of the error.

An additional refinement of the system is obtained by differentiation of the 6.9 mc sawtooth with (11) to give a pulse-shaped output. This voltage is applied to the indexing gun to blank it during the jump interval. This technique prevents the index beam from striking the comb structure during the jump and giving correction voltage where none is necessary. This feature is not required if the comb teeth are equal in area since equal positive and negative voltages will result at the reactance tube grid, and no correction will be initiated.

A final consideration relates to the possibility of incoherence or failure of gun-to-correct-phosphor at the start of a horizontal line. It is quite possible that the index beam might start off with the index beam hesitating half on the read comb and half on the green comb (directly centered on the blue stripe of Fig. 1). If this were to happen equal positive and negative voltages would result at the reactance tube grid, and no correction would be initiated. The system would hang with incorrect gun-to-phosphor correspondence. This condition or possibility of error can be prevented by moving the spacing between comb teeth to a second location (say between the red and blue phosphor) for the first few triads. If at the start of a horizontal line the system hangs, it will do so only to the point where the spacing changes. If it starts off other than in the hanging position, corrections will be initiated and completed before the point is reached where the spacing is shifted, and it will then be impossible for the system to hand at this point. It may be desirable to blank off an area to the left of the tube to insure proper correspondence before picture writing is started.

Several advantages are realized by the proposed system over Apple operation. Among these are: Low error illumination by the indexing beam provided the index stripe is black. Only 25% loss in screen area (for the index stripe) occurs as opposed to 50% for Apple guard-bands, and considerable improvement in efficiency and lessening of gun current capability requirements results. Assuming a 10%-of-triad time for jumping, the proposed tube will be 90% efficient while Apple is 50%. Also, if we assume a 40° conduction angle per color for Apple, only 16% on white and 12% on primary colors of the gun's capability can be used. With the proposed tube both of these numbers stay at 90%.

A discussion of the ideas presented here are given on pages 67 through 72 of my patent notebook #1018. Would you please docket this disclosure.

Signed: ____________________
I. E. Lynch

Date: ____________________

Witnessed: ____________________

Date: ____________________

IEL:REL

MISCELLANEOUS INVESTIGATION REPORT #85
MAY 9, 1957

DEVELOPMENT ENGINEERING
TELEVISION RECEIVER DEPARTMENT

SINGLE GUN APERTURE MASK AND
POST ACCELERATION COLOR TUBES
by: M. J. PALLADINO

ABSTRACT

This report relates a couple possible methods of operating a single gun Aperture Mask and Post Acceleration color tube. The manner of obtaining color and the deflection potentials required are discussed.

CONCLUSIONS

The single gun varieties in these tubes are not too encouraging. The major drawbacks are the high deflection potentials required to realize color, and the brightness limitations on high light white.

In the A.M. tube 3 KV P-P of chroma information is necessary to switch the beam on saturated colors. In the P.A. tube 720 volts of sub-carrier are required for a dot sequential presentation. In addition, the P.A. is restricted to low duty cycles, if saturated colors are to be realized. In this respect the A.M. tube has the advantage of a 100% duty cycle. However, to produce the equivalent brightness of the three gun A.M. tube, the single gun must be capable of three times the peak current of one gun in the three gun version.

Color purity on both tubes is sensitive to deflection potentials, and registration problems are similar to the three gun versions.

In the A.M. tube approximately 7% of the spot size strikes areas between phosphors when white is called for. When complimentary colors are desired approximately 14% of the spot lies in areas void of phosphors and about 6% lies on the undesired primary causing desaturation. If the energy distribution is considered constant across the spot area than, with equalized phosphors, 7.5% of the total luminance causes desaturation.

DISCUSSION
SINGLE GUN A.M. TUBE

A single gun could be utilized in an A.M. tube by designing two pair of horizontal and two pair of vertical deflection plates in the gun as shown in Figure 1.

Detected R-Y and B-Y information may be applied to the deflection plates in push-pull; therefore, in Figure 1, the beam will follow a path similar to that shown with the particular polarities indicated. The angle of entrance of the beam through the aperture mask is dependent upon the relative amplitudes of R-Y and B-Y on the deflection plates. Consequently, the tube operates similar to a "vector-scope" having an infinite number of color centers on the circumference of a circle. The radius of the circle is determined by the color base required for the particular phosphor dot spacing, in the present aperture mask tube it is 33 mils. The deflection potentials necessary to achieve this color base can be very closely approximated from the geometry of the picture tube.

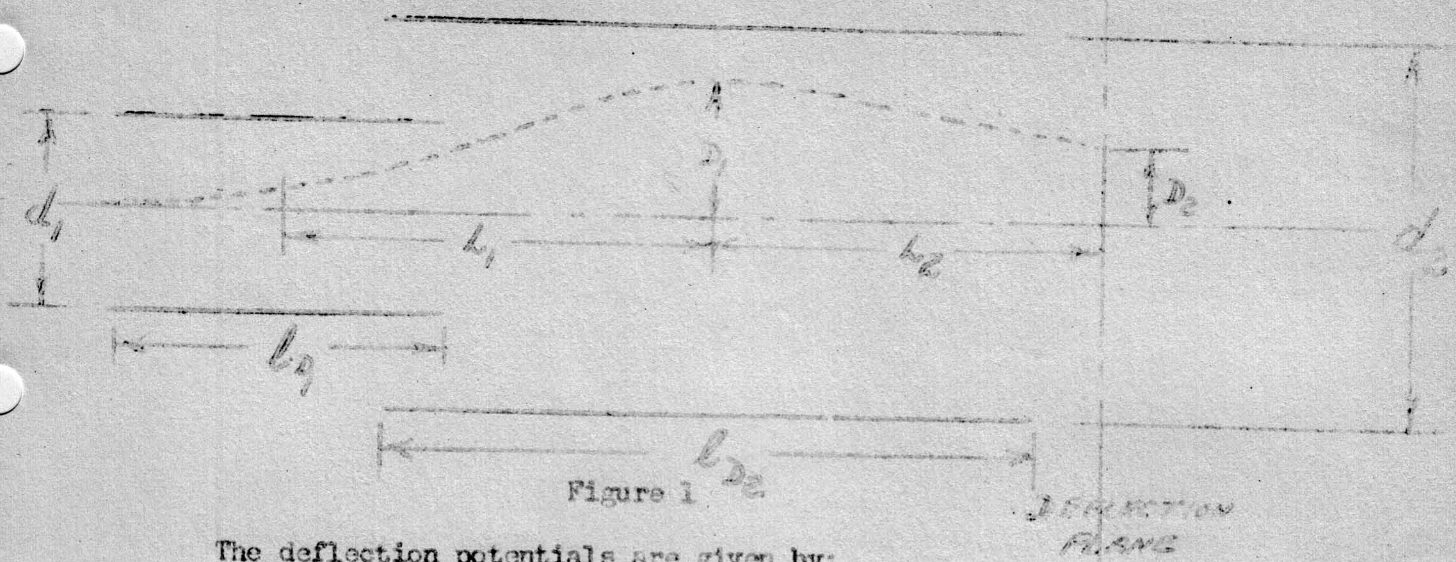

Figure 1

The deflection potentials are given by:

$$V_D = \frac{2D\ d\ V_a}{L\ l_d} \quad \text{--(1)}$$

Approximately three to four inches of space is available between the end of the gun and the yoke. The dimensions of Figure 1, may be varied accordingly; however, if we assign numerical values such that the four pair of plates require identical potentials than:

$$V_{D1} = \frac{2\ (0.36)\ (0.5)\ 25KV}{(1.5)\ (2.0)} = 3\ KV\ P\text{-}P \quad \text{--------------(2)}$$

$$V_{D2} = \frac{2\ (0.15)\ (0.9)\ 25KV}{(1.5)\ (1.5)} = 3KV\ P\text{-}P \quad \text{--------------(3)}$$

in equation 2	in equation 3
$D_1 = 0.36$ IN	$D_2 = 0.15$ IN
$d_1 = 0.50$ IN	$d_2 = 0.90$ IN
$L_1 = 1.50$ IN	$L_2 = 1.50$ IN
$l_{D_1} = 2.00$ IN	$l_{D_2} = 1.50$ IN

Fringing of the deflection fields has been neglected above, so that actual deflection potentials will differ from the theoretical values of Equations 2 and 3. It should be noted that magnetic deflection may also be used in which case the deflection is less sensitive to variations in the accelerating potential. However, it is more difficult to realize magnetic control; due to the small distance available between gun and yoke physical restrictions are automatically encountered.

Figure 2 indicates the position of the beam with respect to phosphor dots when white is called for. The percentage of spot size lost due to space between dots

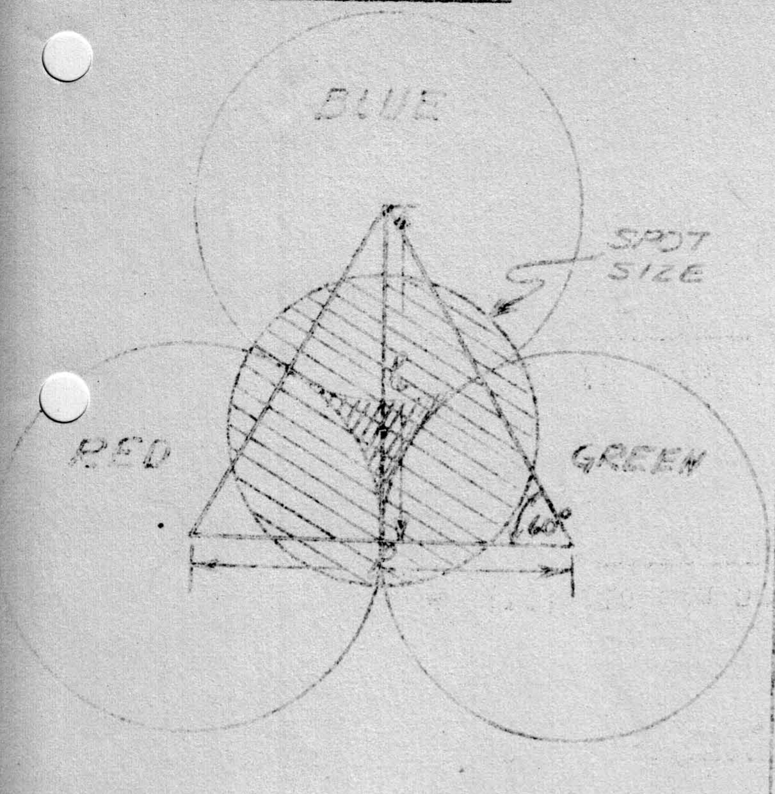

FIGURE 2

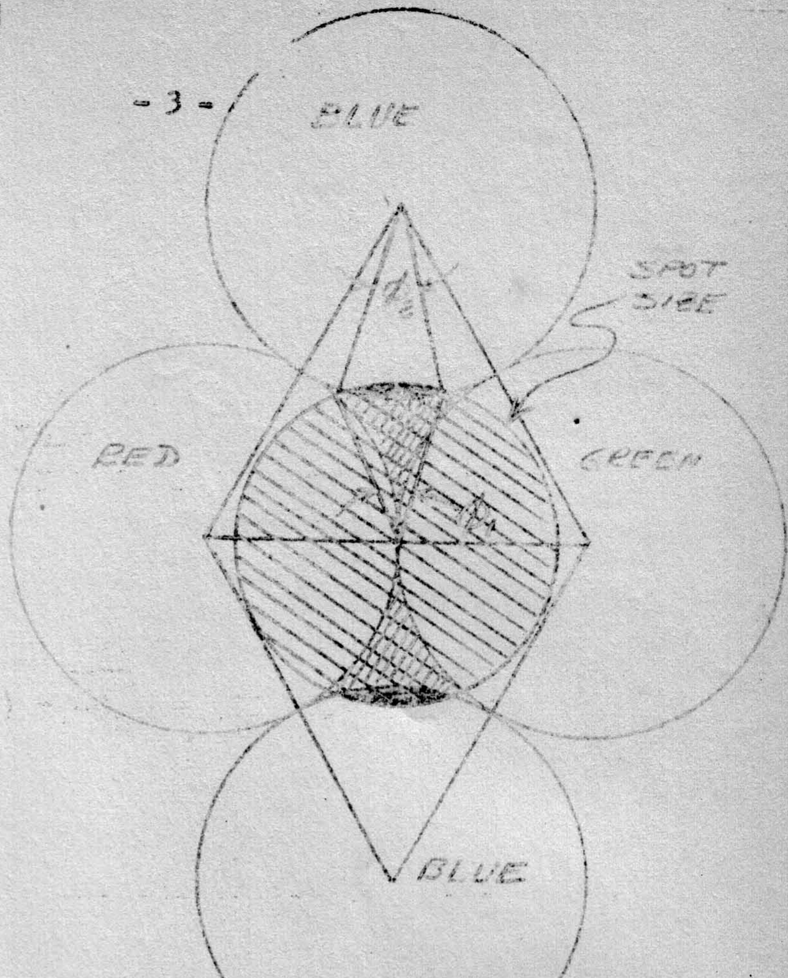

FIGURE 3

may be calculated from geometric considerations. The centers of the phosphor dots lie at the vertices of an equilateral triangle; therefore, the area of the space between the phosphors is equal to the area of the triangle less the area of three identical sectors subtended by 60° angles. Hence the lost area is given by:

$$A_L = \frac{bh}{2} - 3\left(\frac{\pi R^2}{6}\right) \qquad (5)$$

with 16 mil phosphor dots,

$$A_L = \frac{(16)(16 \sin 60^\circ)}{2} - \frac{\pi 8^2}{2} \doteq 11 \text{ mils}^2 \qquad (6)$$

This could be considered as the total lost spot area for a close appromimation, so that the percentage of spot size striking the area between phosphors with a 14 mil diameter round spot is:

$$\frac{A_{lost}}{A_{spot}} \cong \frac{11 \text{ mils}^2}{\pi 7^2} \cong \frac{11}{49\pi} \cong 7.15\ \% \qquad (7)$$

Figure 3 shows the location of the spot when yellow is desired. Under this condition about twice the percentage of spot size, or 14% strikes the areas between phosphor. The contamination of yellow due to electrons striking the blue phosphor is small. The percentage of the spot size striking blue can be calculated as follows:

The shadowed area on the blue phosphor is the sum of two segments of circles of radii = 7 and 8 mils. So, according to geometry, the shadowed area is:

$$A_T = 1/2\, R_1^2\,(\Phi_1 - \sin\Phi_1) + 1/2\, R_2^2\,(\Phi_2 - \sin\Phi_2) \text{ ---- } (8)$$

where:

$$\cos\frac{\Phi_1}{2} = \frac{7 - 1/2\,[7 - (16\cos 60 - 8)]}{7} = 0.916 \text{ -- } (9)$$

therefore:

$$\Phi_1 = 47^\circ \text{ ---------------------------------- } (10)$$

similarly:

$$\cos\frac{\Phi_2}{2} = \frac{8 - 0.575}{8} = 0.930 \text{ ---------------- } (11)$$

and

$$\Phi_2 = 43^\circ \text{ ---------------------------------- } (12)$$

substituting eq. (10) and (12) in eq. (8)

$$A_T = 1/2\,(7^2)(0.82 - 0.73) + 1/2(8^2)(0.75 - 0.68) = 4.5\,\text{mil}^2 \;(13)$$

There are two such areas envolved therefore the percentage of the spot causing contamination due to illumination of the blue phosphor is:

$$\frac{A_T}{A_{beam}} = \frac{9.0}{\pi(49)} = 5.8\,\% \text{ ------------------------ } (14)$$

The area of the spot size striking the red and green phosphors is approximately 80% since about 14% strikes phosphor void areas and 6% the blue phosphor. Than if we considered the energy distribution constant across the spot size instead of normal current density distribution; the ratio of energy in blue to yellow is $\frac{5}{80}$" or 7.5%. With equalized phosphors this means that 7.5% of the total luminance causes desaturation; however, since the energy is greater in the center of the spot compared to the edges, this figure is somewhat pessimistic.

This type of tube does have advantages over many single gun tubes. Primarily because conduction angles are not restricted, consequently a 100% duty cycle is realized. Also saturated colors can be obtained without contamination due to the other two primaries.

On the other hand, the gun must be capable of producing three times the peak current of one gun of a three gun tube on high light white. A further limitation may be purity sensitivity to deflection potentials.

SINGLE GUN P.A. TUBE

A single gun P.A. tube could be constructed with just two pair of deflection plates since the vertical stripes require color bases on a line. However, the beam would have to be switched at sub-carrier rate and gated in a similar fashion as the Lawrence tube (Miscellaneous Investigation Report #84). Consequently, the tube would suffer from low duty cycle and loss in brightness. The sub-carrier deflection potentials can be calculated from Figure 1 and Equation 1, so if equal potentials are desired

$$V_{D_1} = 2\ (0.36\ /1.5\ )\ \ (0.5/2)\ 6KV = 720 \text{ Volts P-P} \qquad (15)$$

$$V_{D_2} = 2\ (0.15\ /\ 1.5)\ \ (0.9/1.5)\ 6KV = 720 \text{ volts P-P} \qquad (16)$$

The electrostatic deflection voltages requirment is less than in the A.M. tube primarily due to the lower gun potential in the P.A. tube. Magnetic deflection may also be used in this tube, however the electrostatic is more attractive, particularly when the deflection sensitivity may be increased by tapered plates. Kunt Schlesingers" report on "Post-Acceleration and Electrostatic Deflection" in May 1956 IRE Proceedings shows the sensitivity gain by taper is given by:

$$g_t = \frac{l_n\ m}{1 - 1/m} \qquad (17)$$

Therefore with a taper ratio of m = 4/1 the sensitivity gain is 1.83/1.

Michael J. Palladino
Development Engineering
TELEVISION RECEIVER DEPARTMENT

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SUBJECT: The use of Beaded Glass for
picture tube contrast improvement.

ELECTRONICS PARK - SYRACUSE

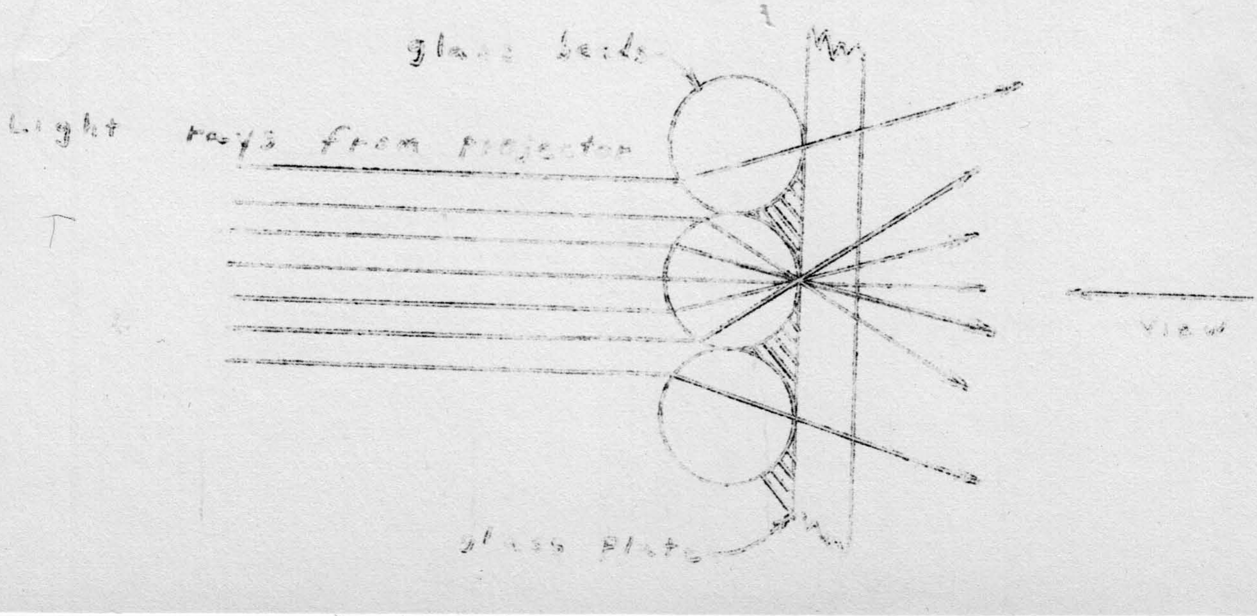
April 8, 1957

Mr. D. N. Timbie
Room 222 - Bldg.
Patent Section
ELECTRONICS PARK

This disclosure letter describes a method of improving contrast ratio in a picture tube. The method utilizes a structure on the inside surface of the tube. Operation is such that light emitted from the phosphor covering the back surface of the structure is concentrated to small points or lines of light at the structure to faceplate contact points. The area around the contact points is filled with a light absorbing material to reduce the reflection of room light back to the observer.

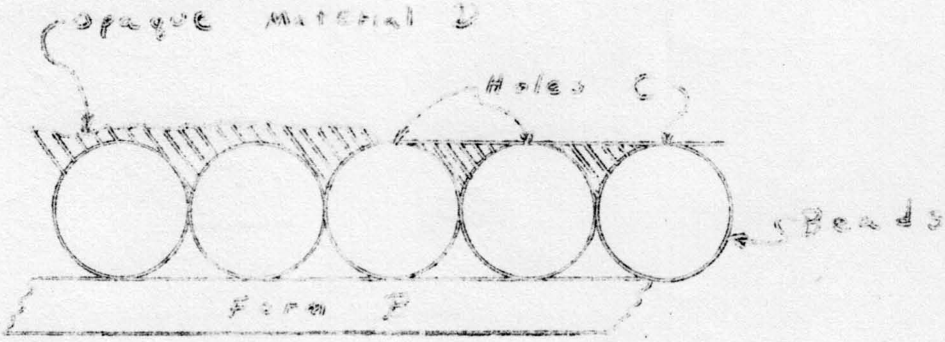
The advantage of this system over one which uses a neutral density filter glass is "ultravision" effect with less light loss. In present monochrome sets approximately 50% of the tube's light is absorbed by the filter glass. A second advantage of this system will be a contrast ratio, under high ambient light condition, which approaches that obtainable in a dark room. This idea may also be used in color television where such improvements would be even more significant.

The ideas proposed here were derived in conjunction with Dr. W. E. Good in a conversation relating to work being done by Eastman Kodak Co., on a beaded screen for back projection. With the Eastman screen, parallel light rays enter the beads and are focused to a point on the opposite side of the bead. By placing the beads in a dark bonding substance, as shown by the following diagram, considerable contrast ratio improvement is realized. The beads are laid down close together (to prevent a mottled screen structure) and in contact with the glass plate.



In a TV picture tube, several structures are possible in addition to glass spheres. Among these are ellipsoid, paraboloid cylinder, elliptical cylinder, and parabolic cylinder. Presently it is not known which of these might prove the most efficient (most light directive). For purposes of explanation only, the spherical structure will be described in the following discussion.

One possible technique for making the tube might be as follows: The glass beads are laid down adjacent to each other on form B (shown in the following figure). Form B should have a shape and curvature similar to the inside of the tube face plate. The beads are now temporarily bonded in place. Side A of the beads is now aluminized and the depressions filled in with low light reflecting material as shown on the left hand side of the diagram. Excess material is then removed to give the small openings at C (as shown on the right hand side of the figure) by which light will exit. The aluminum coating must also be removed at points C. The structure B is now moved and the exit holes C placed in contact with the inside surface of the picture tube. These two surfaces must be bonded



together possibly by the opaque material D. The bond between the beads and structure B is now disolved and structure B removed. The B side of the beads is now covered with phosphor and the phosphor then aluminized. This procedure is not necessarily the only or even the best for making such a screen but demonstrates one possibility and also the desired product of the effort.

Operation is as follows: Electrons from the beam strikes the phosphor producing light over the B side of the spheres. Some of this light passes directly through holes C. The remainder strikes the glass-aluminum boundry and is reflected. After one or more such reflections this light will be attenuated but will pass through exit C. The purpose of the aluminum coating is to reduce light loss upon reflection. Since the light as it exits from C is coming from all angles, the observer viewing angle will not be restricted (unless a more light directive structure is used).

For color tube operation it remains only to arrange the beads in rows or triads (depending upon the type of tube) and covering the beads with color phpsphors (white phosphors with colored beads could be used). As an example, in an A.M. tube, the beads (of diameter approximately equal to the present phosphor dots) would be arranged in triangular form. Each bead of the triad would then be covered by a primary color. The shadow mask operation would be identical to that in present tubes. In this type of color tube the improvement of contrast ratio is much more important than in monochrome tubes since the already limited light output precludes the use of a dark safety glass.

A discussion of the ideas presented here are given on pages 57 through 59 of my patent notebook #1018. Would you please docket this disclosure.

SIGNED________________

DATE ________________

SIGNED________________

DATE________________

WITNESS________________

DATE________________

I.E.LYNCH
4-8-57

March 1, 1957

TRIP REPORT

PARK PRODUCTS COMPANY, CLEVELAND, OHIO

WEDNESDAY, FEBRUARY 26, 1957

COPIES TO: JF McAllister, RB Dome, JA Griffin, JD Walter, DE Harnett, WE Good (3), DW Pugsley, DE Garrett, TV Zaloudek, BA Field, FG Cole, DN Timbie, LC Maier - Bldg. #6, JC Nonnekens " ", EF Schilling " "

RE: Coplanar Gun Aperture Mask Color Picture Tube

On Wednesday, February 26, 1957, a trip was taken by Messers. Dome, Griffin and Schupp to the Park Products Company, Cleveland, Ohio to witness a demonstration of a coplanar gun version of the aperture mask tube.

PARK PRODUCTS COMPANY - The system to be described was developed by Mr. Saul Reiches, president of the Park Products Company. Mr. Reiches is interested, he claims, only in the manufacturing and licensing for manufacture, the magnetic devices that he has patented. His company is engaged in the manufacture of magnetic devices, such as centering rings, iron traps, etc. The business is a $800,000 business consisting of a second floor office and model shop, with production facilities at another location. The production facility was inspected by Mr. Griffin. Mr. Reiches claims that he has no basic color system interest but he is only interested in magnetic components. He seems to be much of the promoter type and is, of course, anxious for color TV to take off since this will enhance his business. He believes that a good market can be established at $600.00 for color TV receivers.

COPLANAR GUN APERTURE MASK TUBE - Mr. Reiches allegedly conceived the idea of using coplanar guns with the Aperture Mask Tube and was instrumental in getting Zenith, Rauland and Westinghouse interested in his project. Rauland developed the mask and printing while Westinghouse designed the gun structure. The entire tube was assembled by Rauland; incidentally, Reiches claims that he saw our PA tube setup at Rauland. The tube we saw was of the 22" rectangular glass variety with a dot face, and with a neck very similar to our 22" PA tube. He had the equipment set up in a corner of his model shop. The equipment consisted of the above tube hooked up to a Warwich chassis. He claimed that this system accomplished better convergence, reduced cost and good purity. He also felt that 10% more brightness could be obtained by opening up the holes in the aperture mask because of reduced tolerances required by the in-line guns. A diagram of the tube structure is shown at the end of this report.

The units on the tube neck are described as follows:

a. Vertical Aiming Unit - The vertical aiming unit is necessary to provide beam alignment in the vertical plane on the red and blue guns. Throughout the convergence procedure, red and blue are matched to green which itself is untouched. The unit contains two small magnets since the amount of alignment required is very small because of the good gun alignment that has been achieved in tube production.

b. Convergence Unit - The convergence unit consists essentially of two segments of the type used today on the delta gun AM tube (which uses three segments). The sketch shows the location of the convergence plates within the tube neck. These plates are similar to those in use on the delta gun. Note that there are two vertical plates surrounding the green gun for shielding purposes.

c. Yoke - The yoke used is a Sickles variety SK-100. This yoke, Reiches claims, has a vertical winding best suited for in-line gun operation. He claims that the yokes in use today have had distortion introduced because of the delta gun requirements. These distortions produce much more vertical bending of the beams at the extremities than would be predicted by the unconverged geometric beam path.

d. Trapezoidal Correctors - Reiches claims that the color yokes have inherent trapezoidal distortion problems. He intends to aid the trapezoidal problem by introducing four magnets, one at each corner of the yoke corresponding to the corners of the raster. These correctors are magnets which can be moved forward and backward as a field strength control, rotated and swiveled to provide proper field direction.

e. Post Deflection Purity Device (PDP) - The DPD device had been suggested by Mr. Reiches to us many months ago when we were first starting the pilot run of our color sets. This device is essentially a unit for producing proper beam bending for purity forward of the yoke. This allows the beam to proceed down the center of the tube neck, through the center of the yoke and then be bent for purity. This, of course, allows the beam to utilize the best protion of the yoke field.

Mr. Reiches went through the operational setup of his equipment and then allowed Mr. Dome and myself to play with it as we wished. We spent quite a bit of time setting up the equipment. The operation is described as follows: With no convergence voltage applied, the vertical aiming unit is adjusted on a cross-hatch pattern to provide coincidental landing of the red, green and blue horizontal lines. The dynamic convergence procedure was then followed similar to our PA tube. All adjustments were made relative to green. The vertical dynamic amplitude and tilt were adjusted for parallel, vertical lines and horizontal amplitude and phase controls were adjusted for equally spaced vertical lines. At this point, it was quite noticeable that the convergence was better than anything we normally see on the delta gun, since the horizontal lines were nearly coincident over the entire tube face. There were no droops and wiggles of blue as we see today at the edge of our rasters.

At this point a dot pattern was used to adjust the trapezoidal correctors. These adjustments were quite difficult. It is necessary to work in each of the four corners of the raster. The trap correctors caused the dots in any one cluster to rotate with respect to each other. A point was found which optimized their coincidence. This is not a mass production operation and similar to the yoke tabs of the old days. However, with these adjustments made, an apparently excellent convergence pattern was produced. It was the best convergence that I have seen around the entire periphery of the tube other than the CCIR PA set. The tube, itself, was somewhat of a dog for purity and could not be purified with the PDP device. We have seen the PDP device on our AM tubes and feel that good purity can be obtained with this device. The purity adjustments, incidentally, were made prior to convergence as we do conventionally today. We were impressed by the ease of convergence which is very similar to the PA tube that we have worked with. There was little or no inter-action between the beams while convergence was being done except, of course, when using the trap correctors. Sine waves were used as convergence wave forms. There was a noticeable vertical raster size error on the order of magnitude of 1/32 of an inch. Again, the finished convergence appeared much better than anything seen here on AM, however, the brightness level was somewhat low and, of course, we know that the convergence problemdoes not appear as bad at lower brightness. The convergence procedure required no going back to touch up controls after the controls were once set. The procedure we know from PA experience is fast and logical.

Reiches originally claimed to our people that there would be a $35.00 cost saving over the current RCA set. However, in discussing cost in detail, it proved to be highly optimistic. The yoke, he claims, would cost $10.00 as compared with the $16.00 we pay today. This saving he claims is due to reduced shrinkage because of relaxed tolerances allowed because of trapezoidal correction external to yoke. He feels that the vertical aiming device should cost 25¢. The four trap correctors should cost 15¢ each. The convergence assembly, he estimated at $1.00. However, we feel that this price should be only 2/3 of the current estimate of $2.50 for the delta gun. The post deflection purity device, he estimates, at $1.50 in large quantities. This would replace our current purity magnet at 20¢ and our current purity belt at $3.10. A fast calculation in materials shows that the overall cost reduced might be on the order of $6.75 plus a reduction in factory labor in the convergence area.

COMPETITIVE PRODUCTION PLANS - Mr. Reiches seemed to be very free in discussing the plans of others interested in this project. Caution should be exercised in talking with him since he doesn't seem to keep things too confidnetial. Some of the plans he claims are as follows:

a. Westinghouse - This company is committed to build sets with coplanar rectangular 22" glass tubes with a target production date in April 1958 and a release on December 1, 1957 with sample tubes and components ready within a few weeks from today. He feels that Westinghouse is enthusiastic about this system and also claims that they will attempt to build the set without RCA patents.

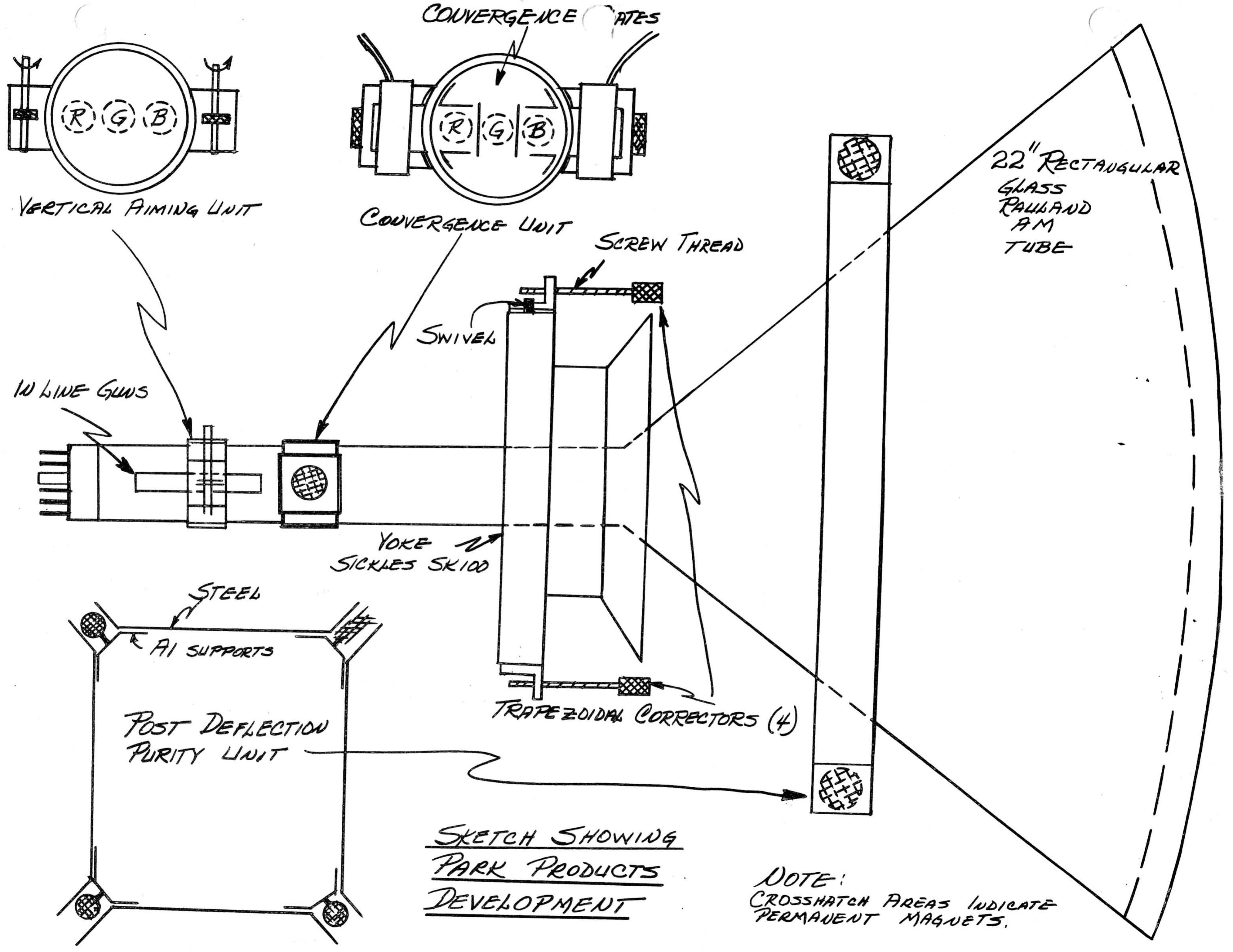
b. Zenith-Rauland - These companies are playing along with the system but no firm schedule has been established to his knowledge. He thinks that McDonald of Zenith is throwing up a smoke screen of negative comments and will launch a program taking the industry off guard.

c. Philco - This company has been approached and has been receptive to the idea, but no action is being taken to his knowledge.

d. RCA - has not been approached.

e. GE - This visit was the first knowledge we had of this system.

G. A. Schupp, Manager
Color TV Product Engineering
Television Receiver Dept.


CONVERGENCE PLATES
R G B
R G B
VERTICAL AIMING UNIT
CONVERGENCE UNIT
SCREW THREAD
SWIVEL
IN LINE GUNS
YOKE
SICKLES SK100
STEEL
AI SUPPORTS
POST DEFLECTION
PURITY UNIT
TRAPEZOIDAL CORRECTORS (4)
22" RECTANGULAR
GLASS
RAULAND
AM
TUBE
SKETCH SHOWING
PARK PRODUCTS
DEVELOPMENT
NOTE:
CROSSHATCH AREAS INDICATE
PERMANENT MAGNETS.

DOUBLE GRILL PA COLOR TUBE

by: T. T. TRUE

ABSTRACT

Major advantages and limitations of the double-grill color tube are discussed. The conventional single-grill PA tube is used as a basis for comparison.

CONCLUSIONS

The addition of a second grill to the conventional PA tube appears to be a logical step to improve performance. However, the gain in performance must be weighed against the added tube complexity, somewhat higher cost, and higher sweep power requirements of the double-grill tube.

Major advantages and disadvantages of the double-grill PA tube are tabulated as follows:

ADVANTAGES

1. No secondary emission haze:
   - (a) Good contrast ratio
   - (b) Good color saturation
2. High anode voltage gun:
   - (a) High brightness because of increased beam current capability
   - (b) Good resolution on high-lights (good beam focus)
   - (c) Good purity stability under conditions of varying magnetic fields. (High velocity beam.)

DISADVANTAGES

1. Complex grill structure will make tube difficult to build. (And consequently, more costly.)
2. High sweep power required (comparable to AM because of high-velocity beam).
3. Possible field emission and arcing troubles (because of high field-intensity between grills).
4. Possible moire (crossed grills may result in a beat between horizontal grill wires and horizontal raster lines). This trouble cannot occur with in-line grills.

There are two physical orientations which the grills may have with respect to each other:

(1) Crossed grills (grill wires mutually perpendicular)
This results in the lowest field strengths between grills, but restricts mechanical configuration to a "flat sandwich".

(2) In-line grills
This allows use of cylindrical grills and P.O.F., but requires higher field strengths between grills.

Consider the following example:

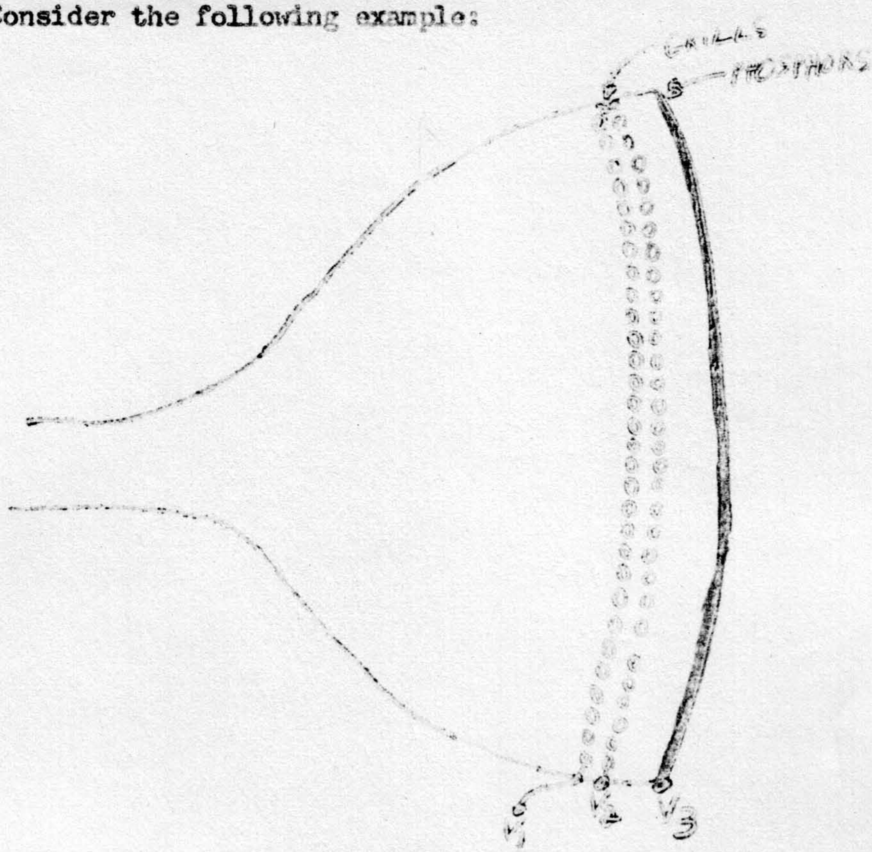


Figure 1

The two grills and phosphors are assumed to have voltages V_1, V_2, and V_3 respectively. There are numerous combinations of grill-spacing and voltage ratios which will focus the beam into lines at the phosphor plate. However, for purposes of illustration, assume that the grill-to-grill spacing is 1/8 the grill-to-phosphor spacing. The following tabulation can be made*: (See next page)

The major differences between the Type A and Type B configurations are as follows: Type A gives complete suppression of secondary electron effects because a retarding field is present in the vicinity of the phosphors. However, it does not give as much brightness advantage as the Type B, because the phosphors are not operated at the highest potential in the tube.

Type B gives good, but not perfect suppression of secondary electron effects, since the region of the phosphors is essentially field-free.

A compromise between the Type A and Type B systems can be made providing three separate voltages are supplied to the tube. However, this would complicate the ratio-regulation problem for the receiver driving the tube, and would require an extra hi-voltage button to be brought out from the tube.

* See RCA LB-1026

	TYPE A: $V_1 = V_3$, $V_2 > V_1$		TYPE B: $V_2 = V_3$, $V_2 > V_1$	
	CROSSED GRILLS	IN-LINE GRILLS	CROSSED GRILLS	IN-LINE GRILLS
Voltage ratio necessary for line focus at screen	$\frac{V_2}{V_1} = 1.23$	1.60	1.25	1.57
Brightness improvement over single-grill PA tube at equivalent resolution (same high voltage)	= 2.26	= 1.48	2.74	2.42
Voltage gradient between grills, as compared to that between grill and phosphor in conventional PA tube (at same highest voltage)	$\frac{E}{E_{PA}} = 2.02$	4.05	2.16	3.93

T. T. True

T. T. True
Development Engineering
TELEVISION RECEIVER DEPARTMENT

TTT:rer
5-15-57
cc: RB DOME
DE GARRETT
DE HARNETT
JF McALLISTER
DW PUGSLEY
WE GOOD
M GRASER
N JOHANNESSEN
IE LYNCH
MJ PALLADINO
TT TRUE
HJ VANDERLAAN
FG COLE
BA FIELD
GA SCHUPP
TV ZALOUDEK
LC MAIER #6
JC NONNEKENS #6
WD RUBLACK #6
[illegible]F SCHILLING #6

C O P Y

COLOR TELEVISION SYSTEMS

4

Alternative Systems Which May Be Feasible In The Light Of Present Technology

Part c

Beam Control At The Phosphor Screen And Velocity Sensitive Types.

(Lafferty Tube and Variations, Controlled Grills, Penetron, Field And Line Sequential Switching And Two Color.)

Color television display devices may be divided into two broad classifications, namely, simultaneous and sequential types. In general the simultaneous display devices have one gun for each color to be displayed and color selection may be said to be built into the tube by suitable mechanical arrangements of parts so that all that is necessary to produce a given color is to supply the associated gun control grid with a video frequency picture signal. The RCA aperture mask tube and the GE post-acceleration tube are good examples of simultaneous display devices, each tube having three guns. On the other hand, sequential display devices invariably utilize only one gun. In order to produce a given color at a given time two events must occur in synchronism. The beam must be made to land on the desired color phosphor and the beam current must be modulated to a maximum at that same time in accordance with the presence of the desired color in the received signal. The Philco apple tube and the Lawrence Chromatron are good examples of sequential display devices, each having one gun.

One tube illustrating the sequential principle is the Lafferty tube[1]. In one version of this tube, a single gun is employed. This gun directs a beam of electrons to a metallic mask at an average angle of 45° with respect to the mask. The mask is slitted horizontally. When the beam passes through a slit it is bent back by means of a retarding field set up by a transparent conductive plate set parallel to the mask. The trajectory of the beam is such that it eventually strikes the mask on the opposite side from the gun. The back side of the mask is coated with triades of horizontal lines of three different color producing phosphors. The number of triades equals the number of slits. By controlling the voltage on the reflector it is possible to make the beam land on a desired color stripe. In a practical tube built according to this principle, a change of 300 volts caused the beam to go through a complete cycle of hues. The reflector is thus excited by a dot-rate frequency. If there is no color signal present in the beam, the rapid switching of color stripes gives the illusion of white. If a red field is desired, a synchronous pulse present in the beam current will be transmitted at the time the beam is over a red phosphor stripe so that color is produced.

Another version of the Lafferty tube is one built very much along the lines of the reflector type but in which the reflector is replaced by a plate with phosphor lines on it. This plate is operated at a high voltage and the voltage is modulated so

(1) "A Reflection-Type Color Television Picture Tube", J. M. Lafferty, Research Laboratory Report RL-542, September, 1951.

that the beam is made to strike the plate on different lines as required. In one design of this tube, a peak-to-peak voltage change of 600 volts produced a complete gamut of hue change. As before, the modulation of the beam coacting synchronousing with the modulated phosphor plate voltage produces the hues desired. This form of tube loses some of the advantages of the reflector type because a registration problem has been introduced as the result of the mask and phosphor stripes being physically separated.

Other variations of the Lafferty tube might include three-gun versions. For example in the reflector type tube, three guns operated at cathode voltages differing by some 150 volts in three steps would cause the three beams to land on different color stripes. The reflector voltage in this case would be constant and the three guns would be closely spaced so that the beams would all be in line. Another variation would be to space the guns vertically so as to produce three different arrival angles. After reflection, the beams would land on different stripes to produce the color desired by each beam.

In summing up the merits of the Lafferty type tubes, it can be said that a receiver utilizing the reflector type would appear to be about as expensive as receivers employing aperture mask type tubes wherein the mask and phosphor screen are separated. But the public's non-acceptance of any tube wherein the picture is not on the picture tube bulb face plate creates a difficult commercial problem in the face of competition. On the other hand, the other forms of the Lafferty tube in which the mask and phosphor screen are separated do not seem to offer any advantage cost-wise over other designs such as the RCA aperture mask.

Another series of color picture tubes makes use of the principle already described in connection with the Lawrence tube. In essence, a single beam is diverted from its normal trajectory as it approaches the phosphor screen so as to cause it to land on a particular color stripe. Ideally this would be done by switching the potential of the phosphor stripes lying flat on the face plate. A calculation of the switching voltage required for such a tube, however, shows that the voltage is at least half the Ultor voltage so that arc-over difficulties as well as prohibitive switching energies render such a tube design impractical. The natural resort, then, is to build a structure out from the face plate so as to gain control of the beam over a longer part of its path. One proposal involves hundreds of interleaved deflection plates a half an inch to one inch high with the sides of the plates coated with different phosphors. Other forms proposed include multiple sandwiches of phosphor backed aperture masks interleaved with grilles to divert the beam to the desired phosphors. All of these types, however, represent manufacturing complexities even greater than designs discussed earlier by Mr. Schupp and so are not attractive as a solution to our problem.

Another series of color picture tubes makes use of velocity sensitive phosphors. This type of tube has been called the Penetron. The phosphor screen is made up of two or more layers of different color phosphors(2). Color is determined by the ultor voltage, the higher the voltage the deeper the penetration. At the latest reporting, a change of 5 kv is required to effect a color change when operating in the range of 10 to 15 kv. A screen of this type could be made into a color picture tube in different

(2) "Multilayer Cathode Ray Tube Screens", L. R. Koller, Research Laboratory Report RL-317, January, 1950.

ways. One way would be to use one gun and one deflection yoke and switch the ultor voltage at dot, line, or field rate. In order to compensate for size change with voltage change, a post-acceleration design could be used so that deflection could take place with a constant velocity beam. Such an arrangement would probably call for a grille to be placed in the tube to be held at some intermediate voltage. It has been estimated that the power required to switch the screen at a dot rate would be in the order of 100 watts. It would be difficult to prevent excessive radio frequency radiation with this much power. At line rate the switching power would drop to about 14 watts, while at field rate the power would be less. Field rate switching would result in intolerable flicker. Line rate switching would result in a coarse structure for any color corresponding to one of the primaries.

These conclusions were reached as the results of observing a test set up about two months ago in Syracuse. In this test, a two-color receiver employing two monochrome picture tubes whose pictures were superimposed by means of a 45° semi-transparent mirror was arranged to have the beam currents of the tubes keyed on and off alternately at line or at field rates. The 30 cycle flicker was extremely objectionable in field rate alternation, and the line coarseness in line rate alternation. It was therefore concluded that we could not take advantage of the reduced switching powers of field and/or line rate switching but that we would definitely have to consider dot rate switching exclusively.

A non-switching penetron could be built by using two or more guns each in separate necks, each gun operated at a different d.c. voltage with respect to the phosphor screen. Each neck would have its own deflection yoke with the currents adjusted so as to produce the same size picture for each color. Some keystone correction would be necessary because of off-center operation. This scheme would seem to be unattractive for a three-color tube but might be considered for a two-color tube, although there seems to be some misgivings in the design area concerning the difficulty of matching of yokes, the differential effects of the earth's magnetic field and the problem of adequate high voltage regulation. At best a two-color system would not meet our needs for a top-of-the-line receiver because such a receiver should be a three-color set. Therefore the two-color penetron would still leave us with the problem of what to do for a full-color set.

Summing up, then, while there are several feasible color tube systems employing color selection by control at the phosphor screen, none of them shows sufficient advantages as to make it more attractive than the current systems described by Mr. Schupp, and, therefore, we must either explore new and at present unknown forms of the system or turn to some other system for our answer for a low-cost color receiver.

R. B. Dome

R. B. Dome
Consulting Engineer
TELEVISION RECEIVER DEPARTMENT

ELECTRONICS PARK
SYRACUSE, NEW YORK

RBD:rer
4-25-57

Miscellaneous Investigation Report #83
April 25, 1957

Development Engineering
Television Receiver Dept.

A GRID-CONTROLLED COLOR KINESCOPE

By: I. E. Lynch

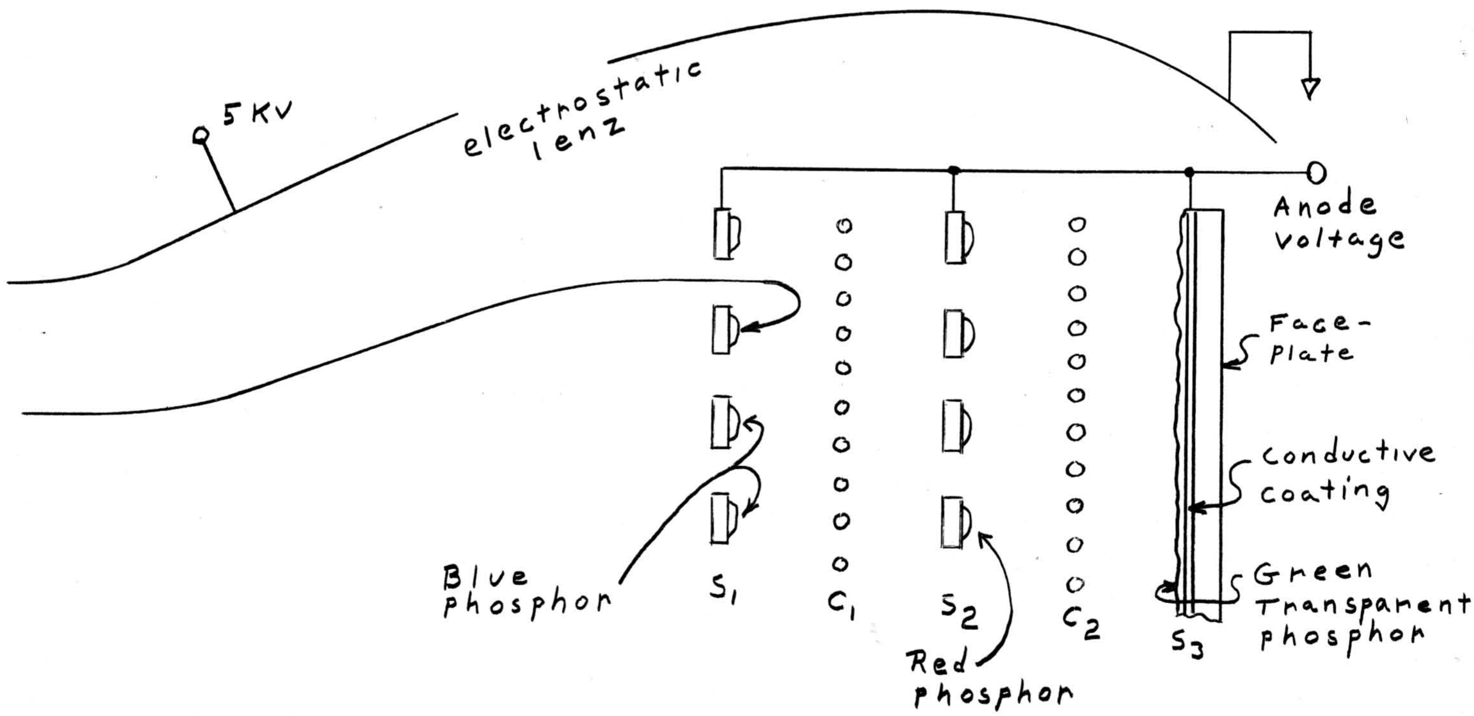
COPY

ABSTRACT

This report relates to information presented to the Color Study Group on March 29, 1957, concerning an R.C.A. developed grid-controlled color tube. Operation depends on the switching of grid voltages in the screen assembly to control the point of beam termination, and thus the color. A list of advantages and disadvantages is given in the conclusions.

OPERATION

A diagram of the tube construction is shown below. The front end face-plate is covered on the inside by a conductive coating and the green transparent phosphor. This is then followed by a steel mesh C_2 used for switching colors.



Behind C_2 is a grill S_2 on which the red phosphor is placed. Behind S_2 is mesh C_1 again followed by a grill structure S_1. C_2 is a second switching mesh. S_1 has the blue phosphor deposited on it. S_1, S_2, and the screen S_3 are all tied to the anode supply voltage. C_1 and C_2 are close to gun cathode potential. The electron beam is accelerated to S_1 where a portion is wasted in grill current while the rest enters the retarding field between S_1 and C_1. If C_1 is low with respect to the gun voltage, the beam will reach zero velocity, stop, and then be accelerated back to the blue phosphor or pass back through one of the grill spaces. If C_2 is higher in voltage than the gun cathode, the beam will pass through C_1 and again be accelerated to S_2.

COPY

The same operation is performed by mesh C_2 to select between red and green. Operation can be either one or three guns. With one gun operation, C_1 and C_2 are sinusoidally switched at a dot rate. Approximately 120 V p-p would be required. With three gun operation, the three guns are biased as follows: Green cathode = -30 V, Red cathode = + 30 V, and Blue cathode = + 90 V. By now placing C_1 at + 60 V, and C_2 at ground, each gun beam will hit the correct phosphor without the requirement of switching voltages.

CONCLUSIONS

A - Advantages offered by such a tube -

1. No switching power required in three gun version.

2. Low switching power in the one gun version if the gun is switched.

3. A two-color tube can easily be produced by elimination of two grill structures.

4. Low sensitivity to magnetic fields.

5. Gun differences in potentials (to produce color selection) is so slight, picture size errors (red-to-green-to-blue fields) do not result.

6. Operation can be either dot or field sequential.

B - Disadvantages of the tube -

1. Usable viewing angle is limited by paralax errors produced by virtue of the fact that the three phosphor screens are at different distances from the viewer. On an experimental tube with a 300 line test pattern and a minimum grill spacing distance of 25 mils (for 9 KV anode voltage) the viewing angle was limited to 50 degrees.

2. The grill structures upon which the red and blue phosphors are placed, require alignment. No other alignment is critical.

3. Phosphor must be prevented from plugging up grill holes. If this is not done color errors will result.

4. A 10% blue haze results on red fields.

5. Beam blanking (for the one gun version) is required during the color switch - over period for best color purity.

6. A 15% reduction in resolution is experienced on the color fields produced on the grills over the one produced on the front glass surface. This is caused by grill interference with the light produced on these structures.

C - Light efficiency of the tube

	One Gun	Three Gun
Blue	5%	15%
Red	7%	21%
Green	18%	54%

These figures include screen and mesh electron losses, screen and mesh light attenuation losses, and electron losses which after direction reversal miss the desired phosphor and are lost through a mesh hole. If proper one gun operation is to be achieved, the one gun values must be equalized, to produce grey. Using the three gun values, it is found by calculation that the light output luminance efficiency for illuminant C is 3.62 F.L./m.w./c.m.^{2}. This compares to a figure of 2.3 for the three gun A.M. tube.

REFERENCES

Stanley V. Forgue, "A Grid-Controlled Color Kinescope," Proceedings I.R.E. Vol. 39, pages 1212-1218; October 1951.

I E Lynch

I. E. Lynch

IEL:REL

COPY

SUBJECT: Color Picture Tube and Receiver
File 9.101

ELECTRONICS PARK - SYRACUSE, NEW YORK

January 17, 1957

Mr. D. N. Timbie
Patent Section
Room 146 - Bldg. 5
ELECTRONICS PARK

This disclosure letter deals with a television receiver and picture tube for the reception of pictures in color.

A number of picture tubes for color picture reproduction have been described in the literature, such as the three-gun shadow mask tube, the three-gun post-acceleration tube, the Lawrence tube, and the Apple tube. All of them have one or more shortcomings which tend either toward making the overall receiver performance unacceptable or toward making the overall receiver cost excessive.

The tube I am about to describe is quite different from any of these and overcomes the shortcomings of them. The tube is a single gun tube with its usual control grid and cathode. The luminance or Y component of the N.T.S.C. signal is applied to the control element in the customary manner as in monochrome practice. The hue control is applied to the special face-plate that I provide so that if red is desired in the picture, a voltage is applied to the face plate connections to cause the beam always to land on dots of red-glowing phosphor. A different hue control voltage applied to the same face plate connections would be arranged to cause the beam to land on blue-glowing phosphor to portray the blue colored portions of the picture. This method, then, has an advantage that the hue control voltage frequency need not be any higher than the color resolution desired since hue in nowise contributes to brightness and image detail resolution. Hazeltine has shown color pictures with hue bandwidths as low as 100 kilocycles, although bandwidths up to 600 kc are recommended for better color resolution.

The problem then resolves itself into the relatively simple one of providing some means for switching hue at the picture tube screen at a rate of a few hundred kilocycles per second as a maximum. I propose to accomplish this by means of magnetic deflection. Figure 1 shows a portion of the screen of a cathode ray picture tube built in accordance with my principle.

The face of the tube is covered by a matrix of conducting strips A, B, C, D, E, F, etc. zig-zagging as indicated. The hue control voltage is arranged, for a particular color, to cause currents to flow in the strips in the directions shown by the arrows. These currents will produce small magnetic poles on the face of the tube as indicated by the letters N and S.

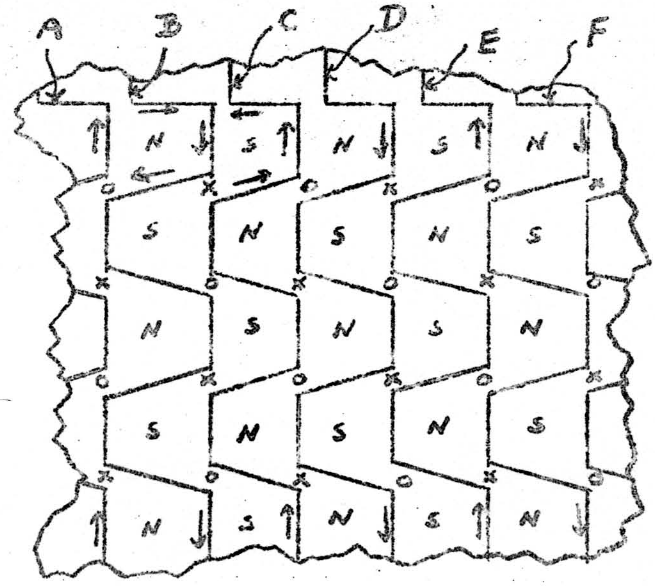


Figure 1

If now the beam of electrons is caused to scan this area with horizontal lines, it will be found that the lines will not be straight but will have wiggles in them so as to cause bunching at points marked x and vacancies centered at points marked o. Phosphor dots of one color may be deposited at the points marked x so that these dots receive current and glow. The dots marked o may be dots of another color glowing phosphor, and will not glow with the hue current in the direction shown. However, if the hue current is reversed in direction, the scanning line bunching will occur at the points marked o while vacancy will occur at the points marked x so that the other hue will be obtained. I have described a tube suitable for two-color reproduction. One skilled in the art can conceive of an extension of the principle whereby three positions for color dots are provided whereby three-color reproduction would be achieved.

If no current is sent through the conductors no bunching would occur and the two colors would be equally excited. If the two colors are complementary, the mixed colors would be white if the phosphor efficiencies were properly chosen. The tube could thus be employed for black-and-white monochrome reproduction.

I have demonstrated the principle of bunching and vacancies to [illegible] Mr. D. E. Harnett today in the laboratory by means of two permanent horseshoe magnets. Either a bunching or a spreading could be observed depending on the sequence arrangement of the north and south poles of the two magnets. The tube used in this test was a standard 5-inch oscilloscope tube and the magnets were held outside the face of the tube. The trace consisted of two closely spaced horizontal lines.

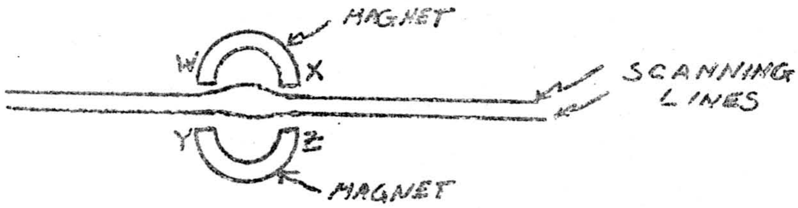


Figure 2

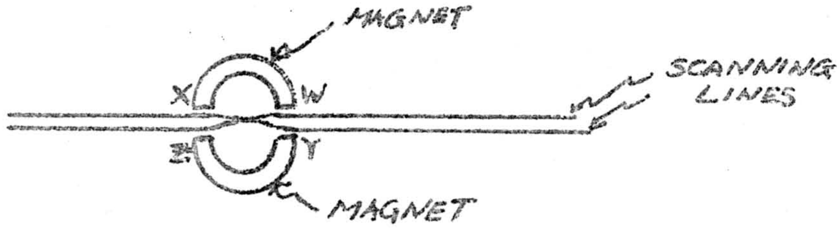


Figure 3

Spreading to form a vacancy is shown in Figure 2, while bunching is shown in Figure 3. Note in the two figures that the two magnets have been turned over (poles reversed) to produce this difference. W and Y are unlike poles.

The conducting strip may be evaporated or deposited on the face plate to form a continuous conductor with but two terminals external to the tube. The maze may look like that shown in Figure 4 except that in a full-sized tube there may be hundreds of bends per picture tube height.

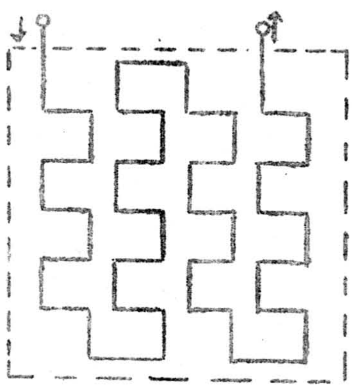


Figure 4

The hue control signal may be derived from a single balanced synchronous detector for the two color system whereby, for example, orange hue transmission produces a positive direction current while cyan hue transmission produces a negative direction current while no color transmission produces no current. This kind of detector is well known to those skilled in the art. A simple circuit of this type is shown in Figure 5. Chroma side bands are fed to the two rectifiers 1 and 2

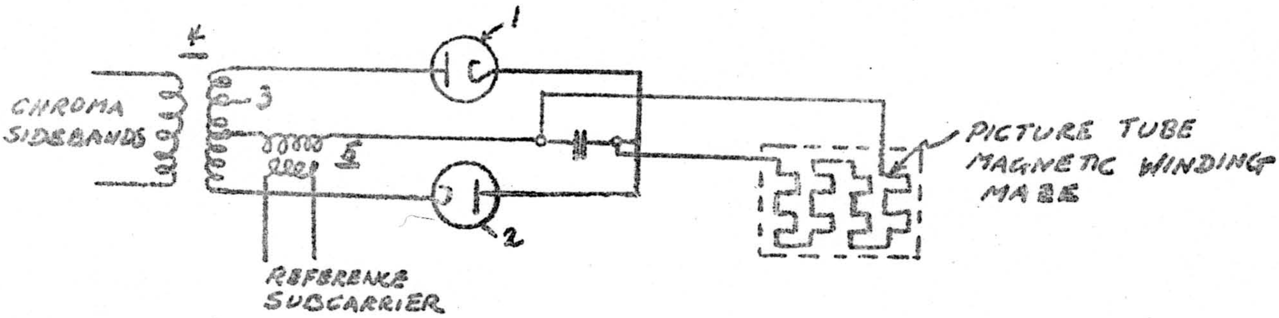


Figure 5

out of phase by secondary 3 while the reference subcarrier of 3.58 MC is fed in parallel to the two rectifiers through a center tap on the secondary 3. Impedance matching to the load may be accomplished by changing the ratios of transformers 4 and 5 feeding the chroma sidebands and the reference subcarrier respectively to the two detectors or rectifiers.

It is seen that the tube I have described is devoid of certain shortcomings that affect other color tubes. To name a few of them:

(1) The tube does not need a high voltage regulator.

(2) There is no bad effect from the earth's field.

(3) There is no convergence problem.

(4) A good monochrome picture is obtainable.

(5) External circuitry is minimized.

(6) No frequency greater than a few hundred kilocycles need be used in switching.

(7) No separately supported mesh of wires or aperture plate is used and hence no mechanical registration problem.

(8) The horizontal size may be varied at will without color contamination.

(9) Full fly-back time is available corresponding to horizontal blanking.

(10) No unduly sharp focussing is needed.

(11) The gun is a single gun of any good design.

(12) The dots and maze can be put on by photo techniques through the funnel without having to make a seal near the rim of the face-plate.

(13) Any angle deflection tube may be built as desired - 70°, 90°, 110°, etc., since the deflection problem and hue control are entirely divorced.

Will you kindly issue a patent docket covering this disclosure?

Signed ____________________

Date ____________________

Witness ____________________

Date ____________________

R.B.DOME:rer
1-21-57

cc: DE Harnett
JF McAllister

RB Dome
DE Harnett
JF McAllister

Color Picture Tube and Receiver

ELECTRONICS PARK - SYRACUSE, NEW YORK

January 29, 1957

Mr. D. N. Timbie
Patent Section
Room 222 - Bldg. 5
ELECTRONICS PARK

This letter concerns Mr. R. B. Dome's letter of January 17, 1957, to you.

Mr. D. E. Harnett asked me to make a calculation about the magnitude of the current through the conductors on the face-plate needed to deflect the electron beam an amount equal to half the height of one rectangle of the maze on the tube face.

For these calculations I assumed that the height of such a rectangle would be equal to one line-width. Supposing there are 35 lines/inch on a 21" tube, one line-width would be about 0.72 mm (0.028"). Computations showed that a current of 5 mA flowing through a length of wire of 0.72 mm, with an accelerating voltage of 16 kV, would produce a deflection of the electron beam of about 1.4×10^{-9} meters (55×10^{-9} inches) at the wire, i.e. at the face-plate. Further approximate calculations showed that a current of 500 amperes still would produce a deflection of only about 0.2 mm (0.008").

It is obvious that currents of this magnitude are not obtainable as switching current at the face-plate of a picture tube.

(Signed) Henry J. Vanderlaan
Development Engineering
TELEVISION RECEIVER DEPARTMENT

HJV:rer

COPY

MISCELLANEOUS INVESTIGATION REPORT #82
APRIL 25, 1957

DEVELOPMENT ENGINEERING
TELEVISION RECEIVER DEPARTMENT

A DISCUSSION OF THE LAFFERTY - SIXTY DEGREE TUBE

by: I. E. LYNCH

ABSTRACT

The present report deals with the 1957 status of the Lafferty tube. Important factors relating to theory of operation, construction, basic differences from other color tubes, advantages, disadvantages, and possible tube modifications, are included. The purpose of the discussion is to present in concise form, the discussion given to the Color Study Group on April 12, 1957.

CONCLUSIONS

A - Advantages of the One Gun Reflection Type Lafferty Tube

1. Low chroma switching power - 4.6 watts (215 volts r.m.s.) for a 24 inch tube.

2. Reduced projected tube length.

3. No dynamic convergence circuitry.

4. Color purity more easily obtained and maintained since the phosphors are layed down on the shadow mask and thus mask movement or distortion produces the same phosphor movement.

5. Mask heating is less critical for the same reason listed in 4.

6. Mask etching and phosphor printing can all be done outside the tube.

7. There is no mask to screen registration problem (only mask to reflector spacing is critical).

8. Color control is independent of focus.

B - Disadvantages

1. Reflector-to-mask spacing must be held parallel and spaced at 0.5 inches plus or minus one-half mill (0.2%).

2. The phosphor structure is visable and objectionable both in size and curved shape. The curved nature of the slits (and thus the phosphors) is necessary for most efficient operation. The curved structure could be broken up into short horizontal slit and phosphor segments but would require a more complex mask design.

3. Webbing lines are not visible but scanning lines and slit beating moire is visible at low brightness.

4. Keystone correction must be provided.

5. Unsymmetrical pinchusioning results because of the 60° neck offset.

6. Vertical dynamic focus may be required because of the difference in distance between the gun-to-raster-top and gun-to-raster-bottom.

7. Contrast ratio will be lowered because of four instead of one glass-to-air surfaces. Contrast will also be reduced because of haze light produced by secondary electrons around both the aperture hole through which the beam is passing, and the spot where the beam is returning to the mask. On the other hand, contrast will be improved because of the "ultravision" effect of the 66% light transmission of the reflector assembly, and because of the 25% non-light-reflecting area of the aperture slits.

C - Light Output Capability

The following is a tabulation of basic light efficiencies and light losses in the Lafferty tube. Both one and three gun figures are given. Figures for the RCA aperture mask tube are included for comparison.

		One Gun Lafferty	Three Gun Lafferty	Three Gun A.M.
A	Calculated luminance efficiency for an illuminant C field using G.E. phosphors in Foot Lamberts/milli watt/square centimater. The numbers are based on measurements taken through one clear glass structure.	8.5 equalized to produce white	15.3 non-equalized	15.3 non-equalized
B	Mask transmission factor	.25	.25	.15
C	= A X B	2.12	3.83	2.3
D	Estimated light improvement factor resulting from beam not having to pass through an aluminum backing before hitting the phosphor.	1.15	1.15	1.0
E	= C X D	2.43	4.4	2.3
F	Estimated light improvement factor produced by beam landing on the viewing side of the phosphor.	1.15	1.15	1.0
G	= E X F = luminance efficiency produced at the phosphor surface in F.L./m.w./c.m.^{2}.	2.79	5.06	2.3

The numbers given in row G for theoretical luminance efficiencies indicate that the one gun Lafferty tube is slightly more efficient than the A.M. tube. The three gun version is roughly twice as efficient in light output. To produce these light output values, three additional factors must be considered in the case of the Lafferty tube. They are: gun conduction angle (one gun tube), peak gun current capability (one gun tube), and reflector transmission factor (both one and three gun tube). A switching conduction factor of 40% was proposed by Lafferty. The peak gun current capability of the single gun tube must be better than the three gun A.M. tube (for equal brightness) by a factor equal to the product of the illuminance efficiency ratio, the conduction factor, and the factor three since the single gun is doing the work of three. This gives a value of $\frac{2.3}{2.79} \times \frac{1}{.4} \times 3 = 6.2$ for the increased current capability requirement of the single gun. The final factor to be considered is the 66% light transmission factor of the Lafferty tube reflector. Since this factor improves attainable contrast ratio (in lighted room viewing) in the process of attenuating phosphor light, its effect is not included in the above table.

TUBE CONSTRUCTION REQUIREMENTS

1. Oblique slits in the mask (etched from both sides) to allow maximum practical beam passage for a given slit width.

2. Slits held together by radial webbing lines to give regidity.

3. Mask vibration prevention by radial snare soldered to mask at mask center with a drop of indium. The soldering is done during bake out.

4. A 100 ohm per square tin oxide coating must be provided on the mask side of the reflector to which the switching voltage is applied.

5. A several thousand ohm per square tin oxide coating must be applied to the viewing side of the reflector to prevent erratic charging.

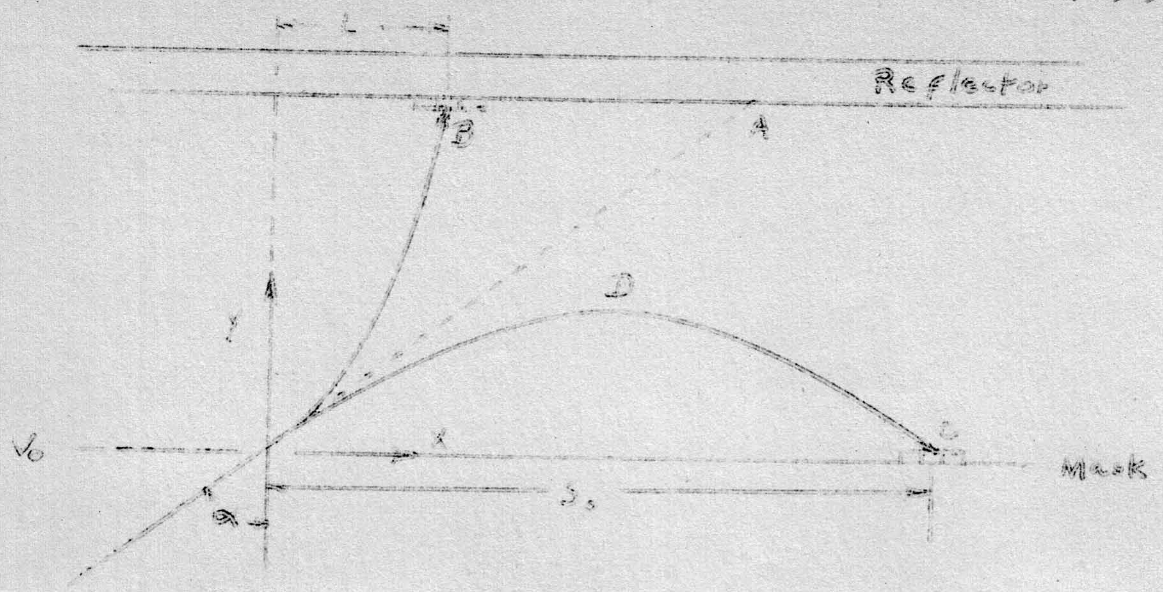
6. Reflector to mask spacing must be held to 0.5 inches ±0.5 mills or within 0.2% over the entire tube face.

7. Reflector to mask spacers must be provided which will withstand 20 KV. Eight lead silicate glass blocks are used which have a total of 53 ua. leakage or one watt of power supply loss.

8. An electron gun of high current capability must be provided for the one gun tube. The gun developed focused current from a large area cathode through a small low-voltage first anode. Current density was then modulated by a three aperture einzel lenz. Resulting zero bias current was from 1.5 to 3.0 m.a.

DISCUSSION OF TUBE OPERATION

The Lafferty tube may be either of two basic types. Both are shown in the following diagram. The first is called the transmission case and the second, the reflection case. In either case the throw distance L or So may be controlled by changing either α, V_c, or V_o. When the voltage of V_c and V_o are equal, the beam will follow the dotted line hitting the reflector (a misnomer here) at point A and providing aperture mask operation. When V_c is larger than V_o, the beam follows a curved path to point B. This is the transmission case. Operation is quite comparable to the post-acceleration tube. The reflection case is realized when V_c is lower in voltage than V_o. When the beam enters an aperture hole it enters a retarding field. This field affects both the beam trajectory and the beam focus. The Y component of velocity is reduced to zero at point D (the X component remaining constant) and then increases in the reverse direction with final termination at point C. During this process two types of focusing actions take place. The first is produced by the aperture slits in the mask, acting as lenzes by virtue of the difference in electric fields on the two sides of the mask. With the transmission type tube ($V_c > V_o$) the action of this lenz is converging in nature. With reflection operation ($V_c < V_o$) the



lenz action is divergent in nature. The second focusing action occurs while the beam is traveling through the region between the mask and the reflector and is produced by the bending nature of the trajectory. Since the degree of focusing action is dependent upon V_c, V_o, and α, as well as the previously mentioned aperture slit focusing effect, these values must be properly set to insure a smaller beam width at the final terminating point, than at the aperture slits. Calculations by Lafferty(1) show that best focus is most easily obtained by centering the vertical sweep around an angle of 60-degrees. This conclusion differs from that reached by Weimer(2) who chose 45-degrees for α. Such a tube will (because of less uniform focus) have less purity tolerance. On the other hand keystoning will be less and phosphor structure will be more uniform (S_o will have less variation from top to bottom of the tube). Keystone correction in the 60-degree tube must compensate for a horizontal sweep angle change of from 41-degrees at the tube top to 81-degrees at the bottom.

When the Lafferty tube is operating in the transmission case, several new factors must be considered. Among these are: six to eight times higher switch voltage (36 to 64 times as much power) is required. Radiation would become a problem. Mechanical registration between the screen and the grill would be necessary. The tube would be more sensitive to magnetic fields.

Other possible forms which the Lafferty tube might take, employ three guns. One possible arrangement would be in-line guns at equal cathode voltages. Operation would be similar to the RCA shadow mask tube. No color switching voltage would be required. A second three gun possibility would have closely spaced guns (or three coaxial guns) with the cathode voltages spread. The spread in voltages would produce color since the three different velocity beams would have different throw distances S_o or L.

(1) James M. Lafferty, "Beam Deflection Color Television Picture Tubes," Proc. I.R.E., Vol. 42, pages 1478 - 1495: October 1954.

(2) P. K. Weimer and N. Rynn, "A 45-degree Reflection-Type Color Kinescope," Proc. I.R.E., Vol. 39, pages 1201-1211: October, 1951.

I.E.Lynch:rer

MISCELLANEOUS INVESTIGATION REPORT #76
MARCH 13, 1957

DEVELOPMENT ENGINEERING
TELEVISION RECEIVER DEPARTMENT

PENETRON COLOR PICTURE TUBES

by: MICHAEL GRASER, JR.

ABSTRACT

The penetron is a cathode ray tube having two or more continuous phosphor layers on its face plate. The depth of penetration and therefore the choice of layer can be selected by controlling the energy of the scanning electron beam. If the layers emit different colored light, the possibility of producing a colored television picture exists.

CONCLUSIONS

1. The simple, non-precision construction of the one gun penetron promises a cost reduction as compared to the present RCA AM tube.

2. Dot-sequential (3.58 mc) switching of the single-gun grille type penetron using present-day high switching voltages (5-7 KV) does not seem practical.

3. Line-sequential and field-sequential switching is possible, but of course along with the usual defects of the systems.

4. Multiple-gun penetron tubes suffer from severe convergence problems.

CONSTRUCTION

In its simplest form, the penetron tube is merely a monochrome tube with a multiple layer phosphor screen. Figure 1 shows the latest two-color tube screen construction which has been developed at the General Electric Research Laboratory in Schenectady.

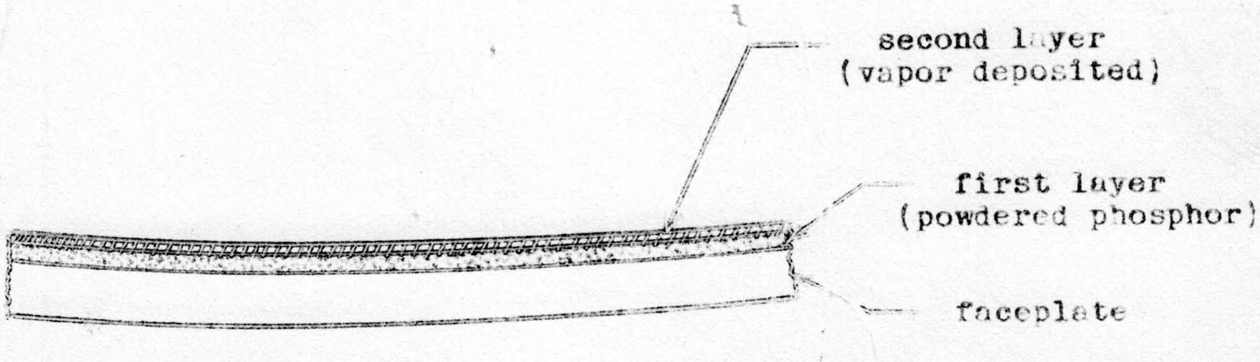


Figure 1

Two-Color Penetron

The first layer is a thin, very fine particle, settled phosphor. This has a light transmission of 80%. The second layer is vacuum evaporated over the first one. The thickness of this layer must be carefully controlled to obtain the best color separation with a minimum switching voltage. A third layer could be evaporated upon the second layer if three color operation were desired. The aluminizing is done over the final layer.

OPERATION

In operation, a low energy beam of electrons will dissipate most of its energy in the second layer (the one nearest the electron gun) and therefore give the characteristic color of this phosphor. Some excitation of the first phosphor by radiation from the second phosphor or by electrons that have penetrated the second phosphor may occur and will result in a reduction in color saturation.

A high energy beam will completely penetrate the second layer, dissipate most of its energy in the first layer, and therefore emit light characteristic of the first layer. Some emission from the second layer will always occur, thereby reducing the saturation. The maximum color saturation from either layer is less than 80% of the saturation of a single layer of that phosphor. An improvement in saturation appears to be possible only by the development of new phosphors.

Experimental tubes made at the General Research Laboratory in Schenectady have a blue powdered first phosphor and a yellow vapor deposited second phosphor. These tubes give yellow light at 15 K.V. and blue light at 22 K.V. Work is presently being done on the development of an orange-cyan phosphor combination for two color use.

The luminous efficiency of the composite screen is less than 1/3 of the efficiency of the same phosphor when used in a single layer. The evaporated phosphors have a lower efficiency than the corresponding powdered phosphors. Improvements in the phosphor deposition techniques may raise the composite screen efficiencies somewhat.

Lowering of the switching voltages depends largely upon phosphor developments. With optimum phosphor layer thickness 5 K.V. switching seems to be the minimum value at the present consistent with good purity.

SINGLE GUN TUBES

Assuming a one gun tube, color selection can be accomplished by switching the screen voltage. Using a simple monochrome tube type of construction, where the screen and cone are tied to the second anode, an appreciable raster size change with switching will occur. In fact, if magnetic deflection is used, the raster size is inversely proportional to the square root of the accelerating potential. For a case where the screen voltage is switched from 15 K.V. to 20 K.V. a change in size of 13% will occur. This will evidently necessitate a corresponding sweep size correction to obtain convergence.

The change of raster size problem can be minimized by using the post-acceleration principle. Here the gun (and cone) is operated at a constant lower potential and only the screen is switched. Unfortunately, if no grille is used, there will be considerable distortion of the picture when the screen voltage differs from the cone voltage.

By using a grille, however, it is possible to reduce the picture distortions to a small value. For example, using a 90°, 21 inch cylindrical face tube having an internal face radius of 27 inches, the maximum misconvergence at the edge when the screen is switched from 15 K.V. to 20 K.V. (cone and grille at 15 K.V.) is only 30 mils for a one inch grille-to-screen spacing. Since 30 mils is just within the maximum allowable misconvergence, a one inch grille-to-screen spacing is apparently the maximum permissible spacing.

Assuming a 21 inch tube and a one inch screen-to-grille spacing the screen-to-grille capacity comes to 70 uufd. This capacity produces difficulties when high switching rates are used. For 3.58 mc sine wave switching with 5 kilovolts peak-to-peak, the reactive power required is 5 KVA. If a Q of 50 is assumed the power dissipation comes to 100 watts. This is evidently too high to be practical. The radiation would also be quite severe.

Line-sequential switching looks more promising. This requires a 7.87 K.C. square wave of 5 K.V. peak-to-peak amplitude. Since a rise time of 11.5 usec. (horizontal blanking time) is required, a bandwidth of 30 K.C. is indicated. A 30 K.C. amplifier with 5 K.V. peak-to-peak output will dissipate 14 watts in the plate load resistor, assuming that peaking coils are used to extend the bandwidth three to one over the uncompensated case. A transformer may be used to step up the output of the amplifier tube to 5 K.V. This eases the voltage problem but will not reduce the power requirement. Line-sequential switching therefore appears practical although the system will suffer from all of the defects of the line-sequential color system (crawl, coarse structure, and color break-up).

Field-sequential switching appears to be easy with the low frequencies involved. Unfortunately, the flicker with an N.T.S.C. signal without storage is so severe that the system is not practical.

Color-difference switching presents an interesting 2-color possibility. Here the tube is operated with enough D.C. on the screen to cause the electron beam to give up most of its energy at the boundry between the phosphor layers. White light is thereby produced for monochrome reproduction. If a 5 K.V. peak-to-peak O-Y signal is then used to switch the screen, 2-color reproduction will occur. A 600 K.C. bandwidth amplifier with an output of 5 K.V. peak-to-peak is required to drive the 70 uufd screen. If peaking methods are used to increase the bandwidth three times over the uncompensated case, it turns out that 300 watts will still be dissipated in the plate load resistor. This is prohibitively high and rules out the color difference switching method.

MULTIPLE GUN TUBES

Switching problems can be eliminated by using several guns operating at different accelerating voltages (cathode voltages). Unfortunately, the use of a common magnetic deflection yoke is not possible because of the differing deflection sensitivities.

A two or three necked tube is required. This produces some severe convergence problems because separate yokes are required. Furthermore, keystone correction of the off-axis guns is also necessary.

For two-color use a two necked tube with both guns equally off-axis in a horizontal plane has some possibilities. Keystone correction of the vertical sweep, which can be accomplished by unbalancing the vertical yoke windings, would be required. Convergence, of course, would also be a problem but the tube may still be practical.

For three-color use a three necked tube would be required. The convergence in this case is so much more difficult that it is doubtful if this tube is practical.

A special coaxial gun has been proposed by Shepard Roberts of the Research Laboratory. In this arrangement the high voltage gun fires through the center of the cathode of the low voltage gun to form a composite beam. This composite beam is then deflected by a suitable combination of magnetic and electrostatic deflection so that both the high velocity and low velocity components are deflected equally.

Unfortunately, the gun construction is quite complex and the combined deflection rather tricky, making the system somewhat costly. Of course this gun is only good for two colors.

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Roberts, Shepard - Patent Letter, January 11, 1955. Describes coaxial gun for 2-color penetron. Copy in W. E. Good's File G-5, TVRD.

MG:rer

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cc: RB DOME
DE GARRETT
DE HARNETT
JF McALLISTER
DW PUGSLEY
WE GOOD
N JOHANNESSEN
IE LYNCH
MJ PALLADINO
TT TRUE
HJ VANDERLAAN
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LC MAIER #6
JC NONNEKENS #6
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MISCELLANEOUS INVESTIGATION REPORT #87
TELEVISION RECEIVER DEPARTMENT

DEVELOPMENT ENGINEERING
May 28, 1957

INVESTIGATION OF THE GABOR COLOR TELEVISION DISPLAY DEVICE

by: M.J. PALLADINO

ABSTRACT

This report deals with the principles of the Gabor flat color picture tube and its operational advantages and difficulties. Included is a discussion of the electron optical system, the technology of the scanning array and vertical sweep; the construction of the shadow mask, phosphor screen and envelope, and registration and purity errors.

CONCLUSIONS

The unique features of this display device are its shallow depth, vertical guns with reflecting lens system and the method of obtaining vertical sweep.

A 21 inch picture can be obtained from this tube constructed with approximately a 4½ inch depth. This shallowness is achieved by using a vertically mounted gun with three independently modulated cathodes and common grid. The three beams leave the gun with ∠ 14° divergence, travelling down behind the screen and separated from it by a mumetal plate. The beams then pass through a reflecting lens and "collimator" which provide approximately 4 times the divergence; hence they sweep the tube like vertical rods or columns. See Figure 1 in the body of this report. The final bending is accomplished by a scanning array which consists of independent conductors printed on a glass borosilicate cloth. The insulation properties of this array are such that it requires a "potential gradient of one million volts per cm. for breakdown". This novel electron optical system enables the handling of three collimated beams and treating them as a single entity, thus eliminating dynamic convergence corrections. In addition the final lens is capable of bringing to a spot, of the usual size, three beams which diverge by 30° to 40°.

The vertical sweep is a traveling wave of potential variation due to the differential potentials on the scanning array conductors. The charging and discharging of these conductors is effected by the electron beam itself. In order to realize the vertical sweep 3 to 3.5 watts of power is required with a gun capable of delivering 1 - 3 ma of current for 8% of each horizontal line scan, and 1 ms during the vertical interval. The discharge current must be regulated to assure constant vertical sweep and beam gating techniques employed for maintaining interlace.

The charging of the array depends on the secondary emission from magnesium oxide coating on the conductors. The second cross over point of the secondary emission curve limits the ultor potential to 12 to 16 KV. In addition the transmission efficiency of the aperture mask is in the order of 20%. Therefore, the high light white brightness is limited to a maximum of 26 to 27 foot lamberts.

In order to maintain purity the beam must be held to within ∠ 1 mm tolerance in a direction perpendicular to the phosphor screen. Consequently, horizontal components of the earth's magnetic field plus any other extraneous fields, transverse to the screen, must be attenuated to approximately 0.03 gauss.

The aperture mask is attached to the phosphor screen by folds or ribs in the aperture mask cemented to the screen. Since they are separated by only 0.025" they are handled as a unit and narrow phosphor stripes 0.005" wide printed by a screen settling process.

The envelope is made by pre-stresing and quenching, hence "will withstand pressures 3 to 4 times greater than normal glass". In addition the flat tube design has a built-in safety factor against implosions due to the scanning array 3/4 inch behind the screen and the mumetal plate another 1/8 inch behind the scanning array.

The flat tube design offers a radically different type of television receiver package. H owever, the cost of this tube would probably be in the order of twice the cost of a normal aperture mask tube and more difficult to manufacture. These factors, added to the additional receiver complexity, makes it apparent that the Gabor tube does not provide the immediate answer to the "color display device" problem.

DISCUSSION

The color picture tube discussed in this report was developed by Dr. D. Gabor, F.R.S., of the Imperial College of Science and Technology in London, England. His invention is a flat tube having a 3 1/2 inch depth for a 12 inch screen and 4 1/2 inch depth for a 21 inch screen.

The tube is divided into two halves by a metal tray which carries the electron optical system and simultaneously serves as a magnetic shield. The electron gun has three independently modulated cathodes and a common lens system. The guns are aimed vertically down and separated from the phosphor screen by a metallic plate. The beams pass through a reflecting lens and "collimator" which bends them back vertical so that they scan the screen like vertical rods. The final bending is achieved by a "scanning array" which is charged differentially over several horizontal conductors. The horizontal scanning is accomplished with "X deflection plates" while the vertical scan is obtained automatically as will be explained later. Color selection is obtained by passing the three beams through the aperture mask slits at different angles; therefore, the horizontal phosphor stripes are illuminated by independent beams.

ELECTRON OPTICS

Figure 1 shows the path of the electron beams from the gun to the screen.

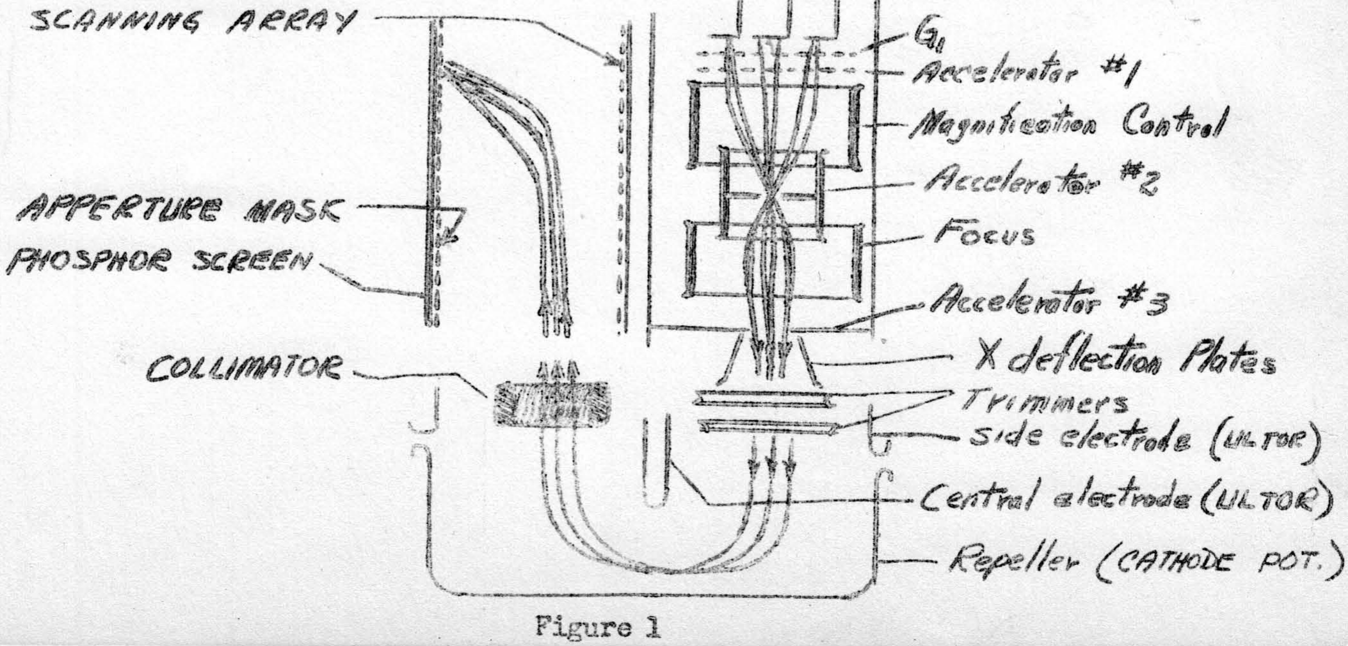

Figure 1

As shown in the diagram, the guns have a common grid and accelerator, they are rotationally symmetrical and essentially have three unipotential lens. The first lens provides a triple cross over in a small stop at the ultor potential, near the focus of the second lens, which makes the three beams collimated; the third is a field lens which provides an image of the triple cross over near the center of the last lens for reduction of spherical abberation. Figure 2 shows three types of focus controlling structures Dr. Gabor experimented with. The design of 2A provides

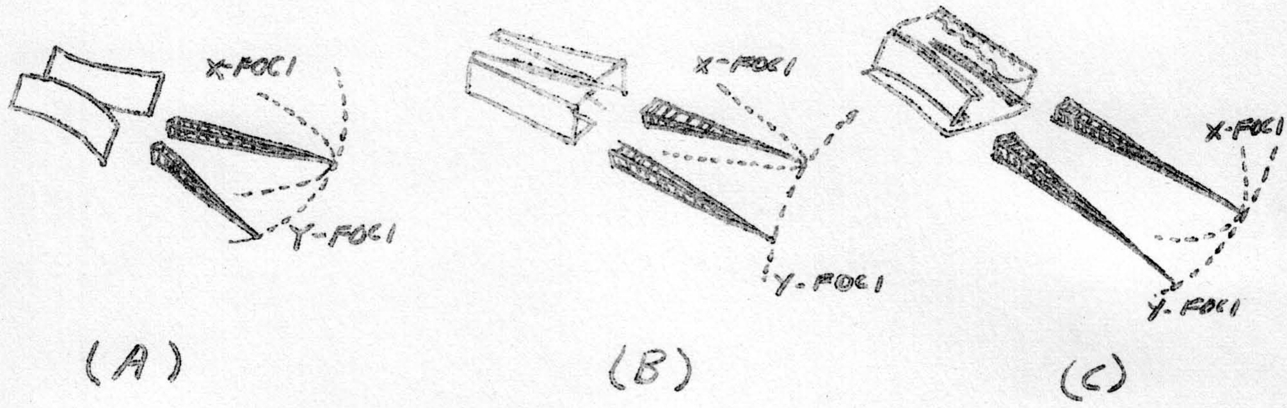

Figure 2

a parabolic locus of constant focus in the "X" direction and circular in the "Y" direction due to the parallel field. The channel design of Figure 2B provides over focus in the X direction and under focus in the Y direction, consequently, the locus of constant focus in the X direction becomes more parabolic while a straight line focus is nearly realized in the Y direction. The final design of Figure 2C provided a locus of focus in the X direction with one-half the curvature caused by the parallel plates of Figure 2A and further reduced the circular locus of constant focus in the Y direction.

The three beams leave the final gun electrode at ultor potential and pass between the X deflector plates, which deflects them horizontally into a plane fan of rays with $\angle$ 14° divergence. Following the X deflection plates are two pair of trimmer electrodes to compensate for mechanical misalignments. The collimated beams then enter the reversing lens which consists of a central, two side and a repeller electrode and has several electron-optical functions. The repeller electrode is at cathode potential, so the plane fan of rays from the X-deflector plates are converted into another plane fan approximately in the opposite direction; however, they leave the repeller or reversing lens with about four times greater divergence. Moreover, the reversing lens compensates the over-focusing effect of electrostatic deflection; this assures a near perfect focus during the scanning of a horizontal line.

The three beams then pass through the "collimator" which has a rectangular magnetic circuit with an evenly distributed winding, therefore, a sawtooth correction is required to obtain pure vertical beams. In optical parlance this electromagnetic lens has a power of f: 0.5.

TECHNOLOGY OF SCANNING ARRAY

The final bending of the beams is accomplished by a "scanning array". This is a system of parallel conductors printed on glass borosilicate cloth, varnished with silicone resin. "The array is outgassed at 350°C and baked one hour at 400-420°C to obtain the desired insulating qualities." The insulation properties of the array were determined by evaporating stripes of gold spaced 0.4 mm on its surface and applying a potential. The breakdown potential was measured as 10 KV; therefore, the maximum gradient before breakdown was approximately one million volts per cm.

The 120 horizontal conducting lines have no direct relation to the line number in the picture. They are not connected to anything and their charging and discharging is effected by the electron beam itself. The two sides of the array are bent around in loops so that the electron beam strikes the conductors in the left loop during horizontal fly back, and the conductors in the right loop during the vertical interval. In the looped regions the conductors are staggered upward. The array is physically placed about 1/8 inch in front of the magnetic metallic plate which separates the gun and screen.

VERTICAL SWEEP

The manner of achieving vertical sweep is the most unique feature of the Gabor tube. Associated with the scanning array is a conducting strip at the top tied to cathode potential and one at the bottom of the array at the ultor potential. At the beginning of a field scan all conductors are charged to the ultor potential, therefore, the beam travels up until it reaches the top of the array. Here the beam is bent towards the screen due to the gradient caused by cathode potential. Horizontal sweep is begun and, at the end of a line scan and faster than normal fly-back, the beam rests for approximately 8% of a line scan in the left hand loop. Secondary electron emission is suppressed in this loop so the conductors of the scanning array are discharged to approximately 1/4 the ultor potential. The beam is defocused in this area so it falls on several conductors associated with line scans that will follow. Once started, the transition zone automatically moves down as a wave of potential variation until it reaches the bottom of the picture. The line scan is now stopped and the beam rests in the right hand loop.

The scanning array conductors, in the right hand loop, are coated with magnesium oxide. A screen grid is also placed in the right hand loop and held at the maximum positive potential. Since the second cross over point of the secondary emission curve for magnesium oxide occurs at approximately 16 KV, then the screen must be held slightly below this potential to assure many secondaries per primary electrons. While the beam is in the right hand loop it strikes the coated conductors charging them up to the ultor potential; hence, the traveling wave moves up the scanning array during the vertical interval. Thus, during the interval between two fields, the entire array becomes charged; when the beam reaches the top of the array the cycle begins again.

In the English TV system the vertical field rate $f_v = 50$ ~/sec. and 405 lines per frame are used; therefore the horizontal frequency

$$f_h = 50\left(\frac{405}{2}\right) = 10{,}125 \text{ ~/sec.} \qquad (1)$$

The major capacity of the scanning array exists between the array and the metal plate 1/8 inch behind it. This amounts to approximately 250 uu/ft^2. A 21 inch black and white tube has about 2 ft^2 of area. Therefore, the capacity of each conductor in the array:

$$C_c = \frac{(250\ \mu\mu f/ft^2)(2\ ft^2)}{120\ \text{Conductors}} \cong 4\ \mu\mu f \qquad (2)$$

Assuming each conductor to be discharged from the ultor potential 12 KV to 3 KV in 2 or 3 lines scans, than the current required is:

$$i_{max} = C\frac{dv_p}{dt} = \frac{4\cdot10^{-12}(12-3)10^{3}}{2(.08)\frac{1}{19,125}} = 2.5\ \text{ma} \quad (3)$$

$$i_{min} = \frac{4\ \mu\mu f\ (12-3)\ kv}{3(.08)\ 100\ \mu sec} = 1.5\ \text{ma} \quad (4)$$

Taking an average current of 2 ma and 8 us per line scan for discharging and 1 ms per vertical interval for charging, than the average power required for generating vertical sweep is:

$$P_{AVE} = EI\left[\frac{1ms}{1/f_v} + \frac{8\ \mu s}{1/f_h}\right] \quad (5)$$

$$P_{AVE} = (9\ kv)(2\ ma)\left[\frac{1ms}{20ms} + \frac{8\mu s}{100\mu s}\right] \cong 3.3\ \text{watts} \quad (6)$$

The high voltage filter capacity required for the equivalent beam source impedance, on the basis of a black and white tube (2000 volts per 100 ua), is determined by:

$$R_{eq} = \frac{2000\ v}{100\ \mu a}\left(\frac{2\ ma}{12\ kv}\right) \cong 3.3\ \text{Megohms} \quad (7)$$

Assuming t_c = 10 times charging rate = 10 ms

$$C = \frac{10\cdot10^{-3}}{3.3\cdot10^{6}} \cong 3000\ \mu\mu f \quad (8)$$

In order to assure that the beam advances only one field scan line during vertical sweep the discharge current must be regulated. Regulation is achieved by taking an impulse off a one inch capacity strip running down the right side of the tube. The signal sampled from this strip is in the form of a sawtooth of current; if the peaks are too high the beam current is reduced, if the peaks are too low the discharge current is increased due to the action of a current regulated amplifier and integrating network. This same sawtooth of current is used for focus modulation to aid in maintaining focus over the entire screen.

One difficulty encountered with the traveling wave type of vertical sweep is the lack of interlace. There are several methods of achieving interlace which require additional circuitry; however, automatic interlace can conceivably be realized in the following manner. During the vertical interval the beam must remain in the right hand loop to charge up the scanning array conductors; therefore, horizontal sweep must be de-activated or a d.c. component added to the X deflector plates to hold the beam in the right hand loop. If this d.c. component is controlled by the vertical sync pulse, i.e., an amplifier is turned on by the leading edge of vertical sync and delivers the d.c. and turned off by the trailing edge; then a remote cut-off pentode or an amplifier with a precise time constant could be made to remove the d.c. during the first horizontal retrace of the first field. Interlace is then realized because, on the second field of the same frame, a one half line time delay exists and, consequently, the scanning array conductors are discharged to a different value causing dissimilar potential gradients on two fields. It is obvious that the precise cut-off time required by the preceeding, coupled with the close tolerance and high degree of stability, would amplify circuitry difficulties. As previously mentioned, interlace can be realized rather simply by adding another circuit not associated with d.c. control during the vertical interval. One method would be to use the trailing edge of the vertical sync pulse to trigger a multivibrator on and the first horizontal sync pulse of each field to trigger it off. The "trigger-on" signal can be obtained by integrating the output of the sync clipper and differentiate the signal derived from the integrator. The multivibrator would then be used as either a gate for turning the beam on, or off, during the time the beam rests in the upper left loop awaiting for the first line of sweep. Interlace is then realized in the same manner explained on the previous system, however, the precision timing is not required here.

THE SHADOW MASK

The shadow mask is made of metal copper foil of 0.0013" - 0.002" thick. On this is printed a pattern of parallel stripes with a lithographers resist. The clear spaces between the resist stripes, 50 lines per inch, are about 20-23% of the total area. This sheet is now crimped, so that it forms a great number of sharp folds, which stand out as closely spaced ribs at its uncoated back, about 0.025" high. The aperture mask ribs are then stuck to the glass envelope, which is coated with a suitable adhesive, such as silicon varnish. The bare areas are etched, either with a mordant or by electrolysis, and the resist washed off. A machine is under development which can produce the crimped sheet continuously with the folds spaced by .035".

The end result is an aperture mask with 20-23% transmission. This low transparancy, coupled with the restricted ultor potential, places severe limitations on the high light brightness capabilities. As pointed out earlier, the ultor potential is limited by the second cross over point of the secondary emission curve for the scanning array coating in the right hand loop. Assuming the gun is capable of delivering 2 ma at 15 KV and a 20% transmission aperture mask than the average power at the phosphor screen of a 21 inch picture tube is:

$$P_{SC} = \frac{0.20\,EI}{A_{SC}} = \frac{0.20(15\,KV)(2\,ma)}{1600\,cm^2} = 3.75\ mw/cm^2 \qquad (9)$$

Then on the basis of a "Luminous Efficiency" of 7ft L./mw/cm2 for an illuminant C field yields a maximum "high light white" brightness of:

$$H.L.W. = 7\,ft.L./mw/cm^2 (3.75\,mw/cm^2) = 26.25\ ft.Lamberts \qquad (10)$$

PHOSPHOR SCREEN

The Gabor tube was made with 0.005" wide phosphor stripes by a screen settling process. The aperture mask and screen are handled as a single unit since they are separated by only 0.025". The apparatus designed for the screen settling process consists essentially of a column of air, in a large pipe, into which the phosphor powder is blown in such a way that the air column is not moved as a whole and the powder evenly distributed in it. During the blowing the screen is covered by a shutter below the powder cloud. The shutter is withdrawn when phosphor particles below 10 microns had time to descend to its level, thus larger powder grains are removed by the shutter. This simple process, coupled with the extremely small aperture mask-to-screen spacing, makes narrow phosphor stripes realizeable.

THE ENVELOPE

The envelope of the Gabor tube was prestressed by quenching to overcome the need of extreme thickness necessary with conventional glass. The tube envelope consists of two glass shells, this design suggests the joint for bringing out all the leads; therefore, the normal neck, capping and socket are not required. The leads can be metal wires laid into notches in the rims of the shells, or they can be tapes, in which case notches are not necessary. Glass solder in the form of a paste is applied between the two halves and the envelope heated up. During this operation the envelope is flushed with an inert gas to protect the cathode from oxidation. Once the joint is made, the envelope can be evacuated and baked in the same heat, thus avoiding unnecessary cooling.

The end product is 12 inch tube with 7-8 mm wall thickness which withstands "3-4 At. outer pressure as compared to 1 At. for conventional glass." It was expected that a 12 mm wall thickness would be necessary for a 21 inch tube to withstand the same pressures.

The flat tube design has a built-in safety factor against implosions due to the scanning array 3/4 inch behind the screen and the mumetal plate another 1/8 inch behind the array.

REGISTRATION AND PURITY

The color control is achieved by the normal shadow mask prinicple, but with an important difference. In the conventional shadow mask tubes three beams are aimed from separate guns towards one point on the screen. The beams are therefore separate from the start at the cathodes, through the yoke, and up to the screen. Their exact convergence must be ensured by deflection systems capable of handling a beam much wider than any of the individual beams. In the Gabor tube, on the other hand, the three beams are collimated when they leave the gun and remain overlapped throughout most of their travel. They get separated only in what might be called the "screen region" near the end of the trajectories. Here the three beams are separately focused, near the entry into the final deflecting field, which throws them against the screen. If this final deflecting field is correctly shaped, the three beams, carrying the three fundamental colors again come to a triple cross-over at the phosphor screen. This has the advantage that the three beams separate slightly, so that each beam is collimated in itself, but falls on the screen at different angles. Thus avoiding the moire effect which might arise if only one or two of the finely pointed beams passed through the aperture slits. The strong final lens is of sufficiently good quality to bring together, in a spot of the usual size, three beams which diverge by 30° to 40°. It is due to this treatment of three beams as a single entity which permits the operation of this tube without conventional dynamic convergence circuitry.

In order to maintain color purity it is necessary to guide the foci of the three beams along planes parallel to the screen, with an error of $\pm$ 1 mm. in the direction at right angles to the picture. Consequently the magnetic shield must be capable of attenuating the earth's magnetic field, plus any other fields, to a value calculated in the following manner:

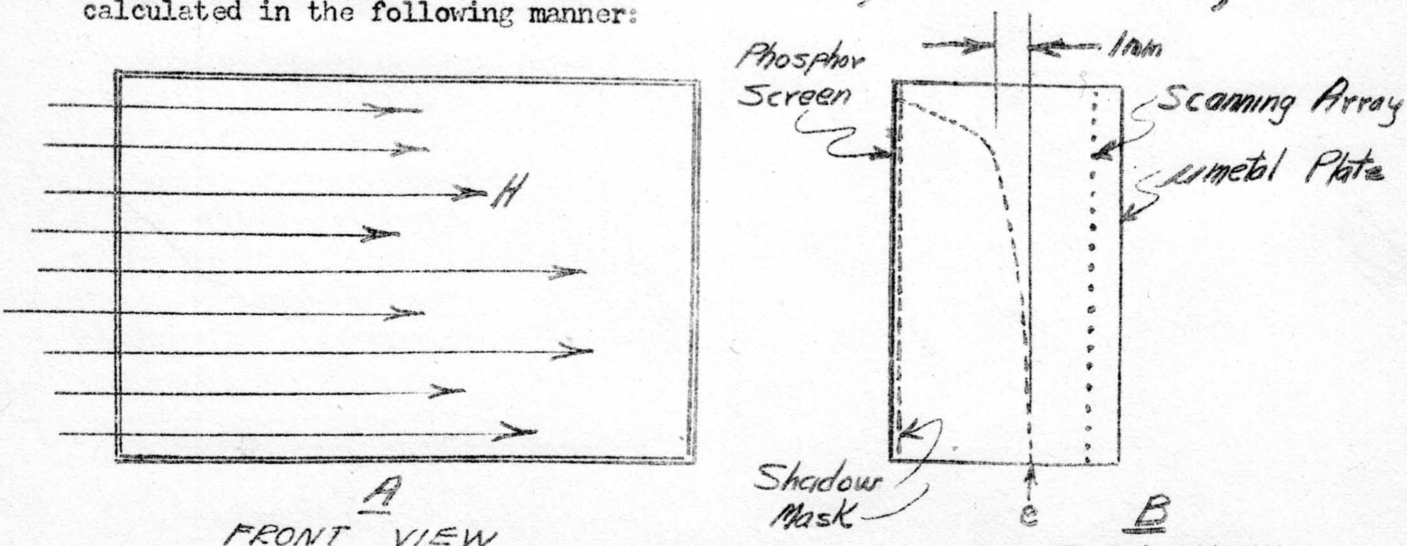

Figure 3

Figure 3A shows a transverse uniform magnetic field at the phosphor screen which will cause deflections prependicular to the screen. Figure 3B shows a beam, assumed vertically collimated, entering the bottom of the screen and traveling to the top. A 21 inch tube with a 15 inch heighth is assumed and a tolerance of $\pm$ 1 mm indicated at the top of the screen. Than the radius of curvature of the electron trajectory, for this tolerance, is given by:

$$R \cong \frac{360^\circ (2.54) h_v}{2\pi \theta} \text{ cm} \quad (11)$$

$$\theta = \tan^{-1} \frac{1 mm}{15 in} = \tan^{-1} \frac{0.0394}{15} = 0.15^\circ \quad (12)$$

$h_v =$ vertical heighth of the picture tube in inches

$$\therefore R = \frac{360 (2.54)(15'')}{2\pi (0.15)} = 14{,}550 \text{ cm} \quad (13)$$

Then the maximum tolerable horizontal transverse magnetic field component is determined from the relationship:

$$R = \frac{mv}{eH} = \frac{3.36 \sqrt{V}}{H} \quad (14)$$

$$\therefore H = \frac{3.36 \sqrt{15{,}000 \text{ volts}}}{14{,}550 \text{ cm}} = 0.0283 \text{ gauss} \quad (15)$$

The horizontal component of the earth's magnetic field is several orders of magnitude larger than this field intensity. Moreover, the magnetic shield in the tube is parallel with the field components which will cause purity errors. Therefore, at best, this shield will adequately attenuate transverse fields in certain areas of the screen. In addition 60 ∿ components, which exceed the amplitude dictated by Equation (15), will appear as floating purity errors similar to the effects seen on a post acceleration tube.

To summarize, the probable difficulties associated with the Gabor tube, in addition to the cost of manufacturing such a tube, discourages the consideration of this tube as the immediate answer to the color display device problem.

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MJP:rer
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DE HARNETT
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FG COLE
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GA SCHUPP
TV ZALOUDEK
LC MAIER
JC NONNEKENS
WD RUBLACK
EF SCHILLING

SUBJECT: A Gabor Type Self Sweeping
Tube Employing A Lafferty
Type Deflection Mask.

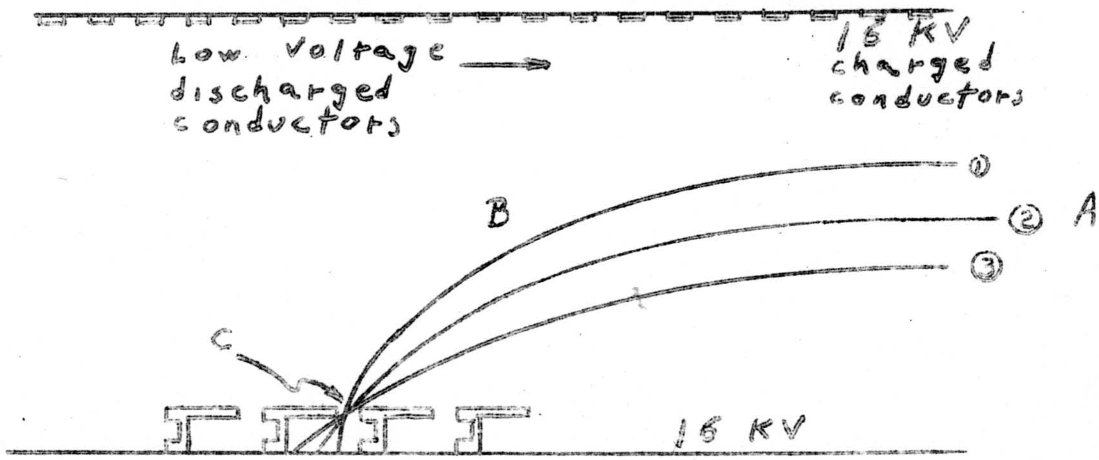
ELECTRONICS PARK - SYRACUSE

May 2, 1957

Mr. D. N. Timbie
Patent Section
Room 222 - Bldg. 5
ELECTRONICS PARK

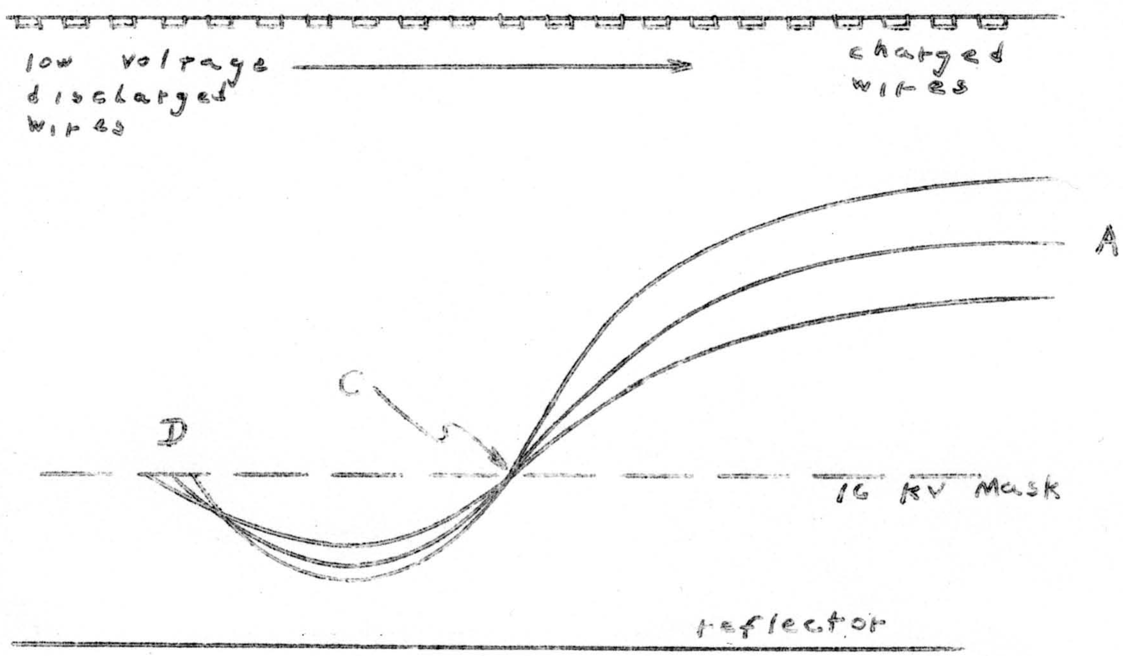
This disclosure letter describes the combination of two existing techniques into a new type of color picture tube. The combination has advantages over either of the two techniques as they now exist in separate color tubes.

The present day Gabor tube is a flat, three gun, folded tube, which by charging and discharging of insulated wires, provides its own vertical sweep. Power for the vertical sweep is obtained from the picture tube's beam current. Color is controlled by a "direction sensitive" screen and aperture mask assembly both of which are attached to the faceplate of the tube. The arrangement used is shown in the following diagram:



In region (A), the three beams are following parallel paths. In region (B), the traveling wave of conductor discharging (which produces the vertical sweep) causes a field which bends the beams to convergence at the aperture hole (C). "Direction sensitive" operation is realized since each of the three beams passes through hole (C) at a different angle. This tube can operate with a single gun provided the single beam is dot or field sequentially switched from position 1 to 2, and 3, depending on the color desired.

One of the principal disadvantages of this tube is the high cost and construction complexity of the mask and phosphor assembly. The present proposal will greatly reduce these factors by substituting a mask and reflector assembly for the face plate structure previously shown. The new arrangement is shown in the following figure. The arrangement is similar to that used in the Lafferty tube.



Operation is as follows: The three beams in region (A) are again bent into convergence at slit (C), by the same field effect as described above. The three beams after passing through the aperture mask enter a retarding field established by the reflector which is near ground potential. This field causes the three beams to turn around and strike the mask at some point in the region indicated by (D). The potential of the reflector is held constant after original adjustment for purity. Depending on tube geometery and the angle of beam entry through the slits, the throw distance C to D may be set as desired. In practice this distance would probably be in the order of one inch. Regardless of the distance chosen, color purity is limited only by manufacturing variations in the relatively small distance between (C) and (D). In the RCA type shadow mask tube, errors can accumulate in any direction from one edge of the mask to the other.

For one gun operation, the proposed tube offers two possible methods of selecting color. The first consists of dot-sequentially positioning the beam in the region (A), to change the entry angle at (C), and thus the color. A more practical approach would be to always have the beam in the center location (of area A) and dot sequentially switch the reflector to control the throw distance and thus the color.

In making the mask, the slits and phosphor stripes can all be equal area, parallel, and straight, only if the beams of electrons in the region (A) are parallel or collimated (not fan shaped with horizontal sweep). With a fan shaped sweep, the slits may still be straight (the vertical sweep traveling wave is straight) but the phosphor lines will have to be curved to keep the throw distance constant. Alternate approaches would be to modulate the reflector or use a curved shape reflector. Both of these complexities make the collimated sweep system appear the more attractive.

A discussion of this idea is given on pages 52 through 54 of my Patent Notebook #1018 (dated February 11, 1957). Would you please docket this disclosure?

SIGNED ______________________
I. E. LYNCH

DATE ______________________

WITNESS ______________________

DATE ______________________

IEL:rer
cc: RB Dome
WE Good
DE Harnett

Miscellaneous Investigation Report #79
April 19, 1957

Development Engineering
Television Receiver Dept.

Light Amplifiers for Color Television

By: Michael Graser, Jr.

Abstract

The present state of the art is discussed. Specifically, the construction and characteristics of both single element and two element light amplifier cells is presented. The principle emphasis is upon the use of the light amplifier as a means of producing color by electrical switching of the cells.

Conclusions

1. The two element type of cell with its independent choice of photoconductor and electroluminescent phosphor appears to be closer to practical realization.

2. The long decay times and the high electrical capacities of the present designs make switching rates higher than field sequential impractical.

3. Further development is required to obtain materials giving the correct NTSC primary colors

Single Element Type

The single element light amplifier uses the same material as both the photosensitive element and the electroluminescent phosphor. The basic construction of this type cell is shown in Fig. 1.

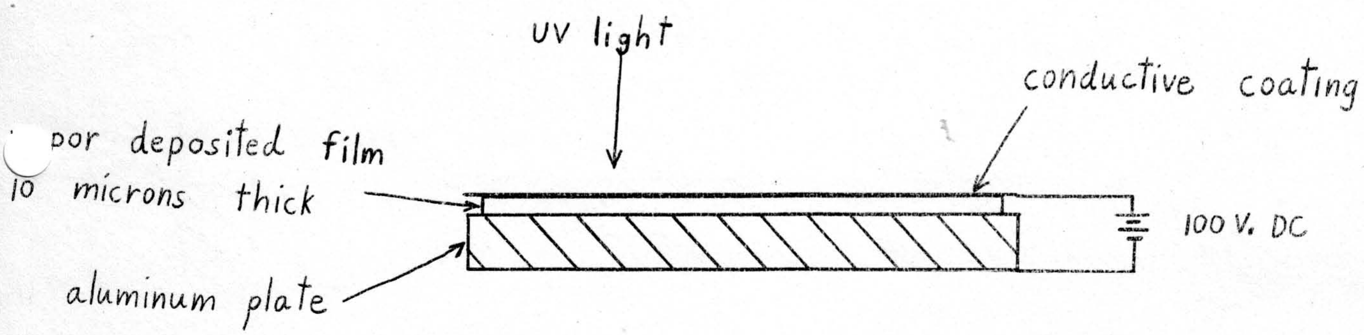


Fig. 1

One material, which has been investigated to some extent by D. Cusano of the General Electric Research Laboratory in Schenectady, is zinc sulphide activated with manganese and chlorine. This material when illuminated with ultraviolet light will glow with a yellow light. When the D.C. voltage is applied the brightness increases considerably. Increases as high as 50 times, which correspond to a gain of 10 photons for each incident photon, have been observed.

The decay times are rather long varying from 0.1 seconds to several seconds depending upon the magnitude of the excitation. Similar decay times are observed when the D.C. field is switched. These time constants are long even for field sequential display.

The electrical capacity of the cell is about 500 uufd/cm^2 which means a capacity of about 1 ufd for a 21" screen. This high capa city practically excludes any switching rates higher than field sequential.

Development of other materials giving colors closer to the N.T.S.C. primaries and having shorter decay times is required before this light amplifier appears to be suitable for color television.

Two Element Type

The two element light amplifier consists of a photoconductor electrically connected in series with an electroluminescent phosphor. A source of low frequency A.C. (audio range) is applied to this series combination as shown in Fig. 2.

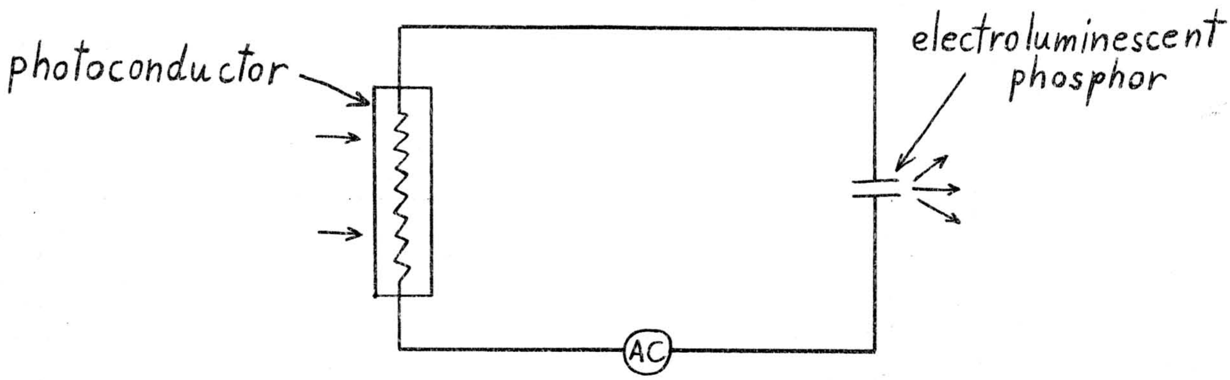


Fig. 2

Under dark conditions the photoconductor resistance is higher than the electroluminescent phosphor impedance thereby leaving only a small portion of the applied voltage across the phosphor. Under bright illumination the photoconductor resistance drops to a value less than the electroluminescent phosphor impedance causing the phosphor to be excited by the A.C. voltage. Amplification is achieved by a proper choice of materials and the proper impedance match between the photoconductor and the phosphor. Gains of up to 50 have been observed.

Fig. 3 shows the basic construction of a typical two element cell.

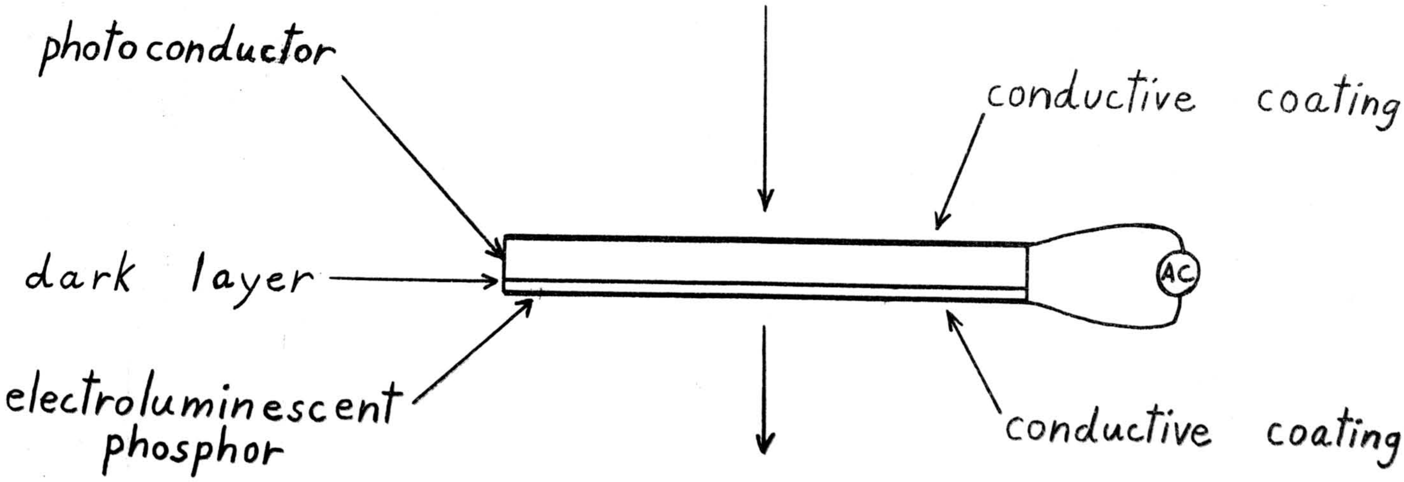


Fig. 3

Cadmium sulphide with the correct activator to secure the proper spectral response appears to be a favorite photoconductor material. Various electroluminescent phosphors are available to produce different color outputs. The dark layer between the two materials is used to reduce light feedback.

The decay times of the photoconductor may vary from 0.1 seconds to several seconds. The decay times of the phosphors is around one millisecond. It is evident that photoconductor decay is the limiting factor in using higher switching rates than field sequential.

The electrical capacity of the cell elements will depend upon the exact construction but same typical values can be given. The photoconductor capacity may be 8 uufd/cm^2 (assuming a 20 mil layer) giving 0.01 ufd for a 21" screen. The electroluminescent phosphor capacity may be 200 uufd/cm^2 (assuming a 1 mil layer) giving 0.3 ufd for a 21" screen. These high capacities limit the exciting voltage to the audio range and limit electrical switching to field sequential rates.

Light Amplifier Applications

For obtaining color pictures, a panel containing many small cells is required. In the usual application a monochrome picture is projected onto the photosensitive surface of a light amplifier panel consisting of red, green, and blue emitting cells. Color selection would be accomplished by suitable electrical switching of the cells. It is evident that color selection rather than amplification is the primary purpose of a light amplifier for color television. A more detailed study of the application of light amplifiers to color television is given in the next article "Use of the Light Amplifier for Color Display" by T. True.

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True, T.T.	"Use of the Light Amplifier for Color Display", follows this report.

USE OF THE

LIGHT AMPLIFIER

FOR COLOR DISPLAY

by: T.T. TRUE

ABSTRACT

The use of light amplifier panels for color picture display is discussed. Example systems for both Dot-Sequential, and Simultaneous display are presented. Requirements which must be placed upon materials and devices in order to make these systems work are discussed.

CONCLUSIONS

A tri-color light amplifier panel can be combined with a simple monochrome picture tube to produce a color picture display. This combination system may have cost and size advantages over present color display tubes. However, in order to make the system feasible, performance requirements are placed upon the light amplifier device and upon the picture tube phosphor, which are completely beyond those which are realized in present technology.

Specifically, the performance requirements which are necessary are as follows:

Picture tube -
This may be a conventional monochrome tube with one exception - the phosphor decay and rise time must be very rapid: ($t_d \ll .1$ usec.)

Light amplifier -
(a) The light input sensitivity must be capable of being gated on and off at 3.58 MC repetition rate (by electrical input).
(b) Electroluminescent materials capable of giving NTSC primary lights are necessary.
(c) The above function of gating and light production should be accomplished with moderate amounts of power driving the light amplifier.

LIGHT AMPLIFIER TECHNIQUES

A - Introduction

Since monochrome television preceded color television chronologically, the concept of using an "adapter" for color naturally evolved. In the old CBS proposal, a whole color system was built around the use of similar adapters (spinning "color wheels") for both the camera and the receiver.

With the present "compatible" color system, the idea of using an adapter to convert a monochrome display to color is still interesting, although rather difficult to achieve. Consider, for a moment, what restriction the NTSC system places upon the color display.

Field sequential display, which involves displaying successive fields of red, green, and blue, cannot be conveniently used because frame and field rate is too slow to prevent "flicker" and "color breakup."

Similarly, line sequential display cannot be conveniently used because "line crawl", and low vertical resolution become objectionable.

This leaves two major possibilities for the display device:

(1) Simultaneous display may be used in which the red, green, and blue video signals are first derived from the composite signal, and then applied simultaneously to the display device. Examples of display devices utilizing this approach are the aperture mask tubes, and the post-acceleration tube.

(2) Dot sequential display may be used, in which successive dots of red, green and blue elements are displayed. The Lawrence tube and the Apple tube are examples of display devices which utilize this method.

B - Light Amplifier Techniques

The light amplifier may offer one possibility for a color "adapter" which may be used with a monochrome picture tube. In Figure (1), a simplified illustration of a light amplifier is given. It consists of a layer of photo conductive material physically adjacent to, and electrically in series with, a layer of electroluminescent material.

As incident light on an elementary area of the photoconductor is increased, the impedance of the photoconductor decreases, and the proportion of applied voltage appearing across the electroluminescent material increases. Therefore, the light emitted by the electroluminescent material increases as incident light increases. Thus, the incident light is "amplified" by the device. If a large panel is made up of small elemental units, it can be seen that an incident picture may be amplified and reproduced.

(1) Dot sequential display - One way in which the light amplifier device might be utilized for color is illustrated in Figure (2).

In essence, the "adapter" consists of three light amplifiers which can be sequenced such that they are sensitive to incoming light only during desired periods of time. The electroluminescent materials of the three amplifiers give lights which correspond respectively to the R, G, and B primaries of the NTSC system. Three separate panels are shown, although a single panel matrix might also be used. EL-PC material is deposited in vertical lines (say), so that a maximum of 1/3 of each panel is "active," while the remainder is transparent. The active portions of each panel are staggered as shown in the figure.

The system illustrated in Figure (2) can be recognized as being sequential. In synchronism, R, G, and B signals are sequentially applied to the picture tube control grid, while the R, G, and B light amplifiers are sequentially energized. The frequency of synchronizing, with respect to sweep frequency, will determine whether the system is field sequential, line sequential, or dot sequential. However, as pointed out in previous sections, field and line sequential color displays are not very practical when used with the present NTSC system. This restricts the frequency of synchronization to one which is high enough to produce dot sequential display. This means that the minimum frequency of synchronization will be 3.58 MC. In its simplest form, the system would involve applying the composite video signal to the control grid of the picture tube, and applying three 3.58 MC gating signals (approx. 120° apart) to the three light amplifiers.

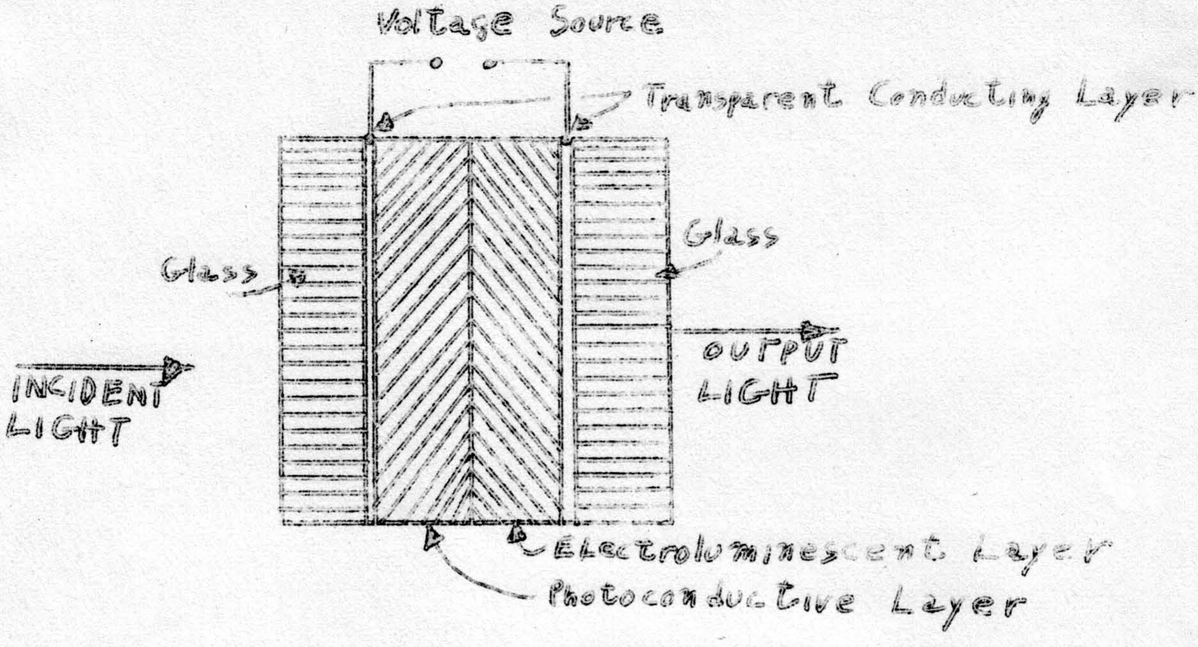


Figure (1) CROSS-SECTION OF LIGHT AMPLIFIER CELL

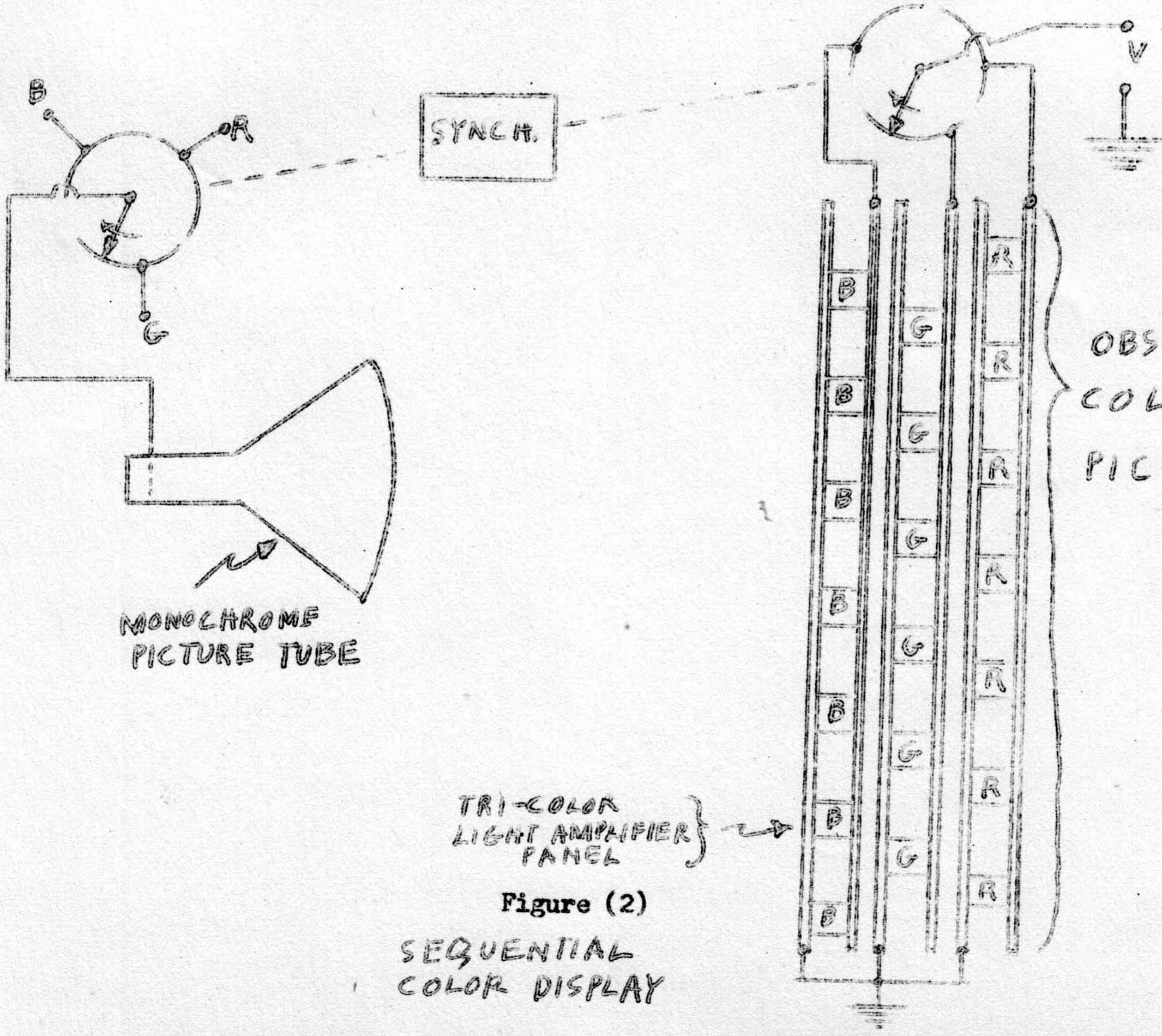


Figure (2)

SEQUENTIAL COLOR DISPLAY

The techniques for signal circuitry which would be associated with this display are well known in present art, but realization of the display device itself depends upon major development. The required performance characteristics which the component parts must have in order for the system to be feasible, are as follows:

Picture tube requirements

In most respects, the picture tube is the same as standard monochrome type. However, one major exception is that a phosphor must be used which has a rise and decay time of less than 1/10 u second. The tube light must accurately follow a sinusoidal 3.58 MC beam current variation. If this criterion is not met, color desaturation will result.

One minor stipulation is that the imaged horizontal spot size must be no smaller than a limit, determined by the stripe spacing of the light amplifier. If the beam size becomes too small, moire effects may occur.

Light amplifier requirements

The input light sensitivity of each light amplifier must be capable of being electrically gated at 3.58 MC repetition rate, with an "on" period which is less than 1/3 of the 3.58 MC period. However, the output light decay time does not have to be particularly rapid, needing only to decay during about the period of one or so frames (1/30 second or so).

The photoconductor must be responsive to the spectral output of the picture tube phosphor, and response time must be consistent with the gating requirements.

The electroluminescent materials must be capable of giving light outputs which approximate the NTSC primaries. Light output capability of 80 foot lamberts (peak white) without "ultravision", or 40 foot lamberts with "ultravision" would be desirable.

(2) Simultaneous color display - Another approach which might be used with light amplifiers is illustrated in Figure (3).

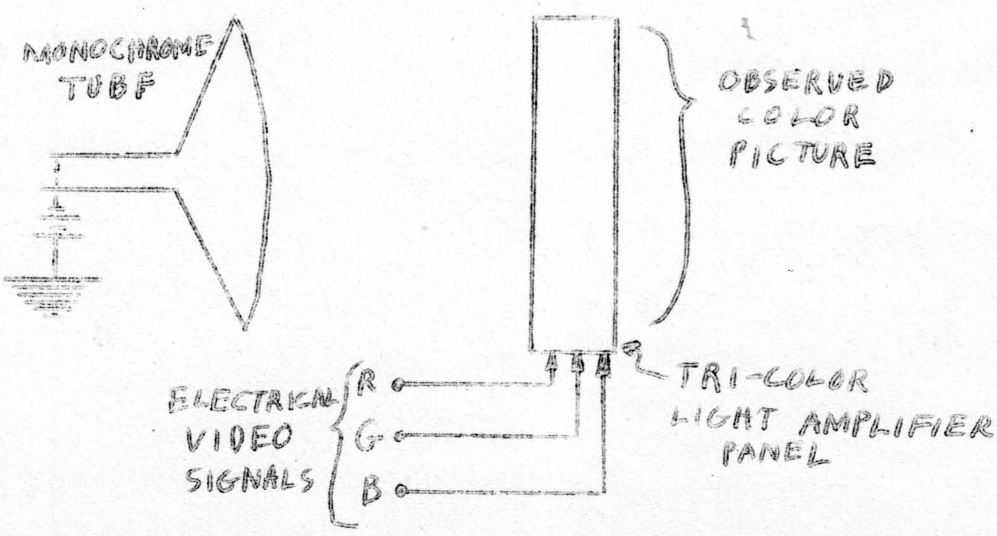


Figure (3): SIMULTANEOUS COLOR DISPLAY

The light amplifier "sandwich" is similar to that of Figure (2), except that the required characteristics are different. The picture tube beam is unmodulated, the light which it produces being used only to "scan" the light amplifier. R, G, and B video signals are applied to electrical inputs of the light amplifiers. Thus, the picture tube supplies the element position information, while the light amplifier electrical inputs supply the element intensity and color information.

The required performance characteristics for this system are as follows:

Picture tube -
Phosphor decay time of less than .2usec is needed. No control grid modulation is applied to the tube, and therefore a simplified gun structure may be possible.

Light amplifier -
The output light of each light amplifier must be proportional to its electrical input signal. The equivalent electrical bandwidth must be at least 3 MC.

The electrical sensitivity of the light amplifiers must be capable of being gated on and off depending upon presence of input light. The equivalent rise and decay time must be less than .2 usec.

C - POW (Picture-On-Wall) Display*

For some time now, the "ultimate" in television display configuration has been visualized as a thin, flat, rectangular device which could be hung on the wall like a picture, if desired. This type of device would be desirable for color display as well as monochrome, but the problem of execution would naturally be more difficult for color.

One way in which the POW objective can be realized is by projection, using light amplifying screens. Any of the light amplifier systems presented for color display might possibly be driven by incident light applied to the viewing side of the screen, rather than to the back side. However, this adds two serious problems. Since the input and output lights are not physically separated, regeneration in the light amplifier will occur unless the input and output spectra are sufficiently distinct to be separable. Ambient light falling on the screen will also be amplified. This will ruin contrast unless the input spectrum can be located in a region away from ambient light spectrum. With sunlight, incandescent, and fluorescent sources to be considered, the region of low ambient excitation may be difficult to find.

One of the light amplifier color systems which may be capable of being reduced to a rather thin dimension without using front projection is that shown in Figure (3). In this system, the picture tube provides only one function - that of scanning the light amplifier. No modulation of the electron beam is needed, and also, no special linearity of sweep, or sharpness of focus is required. Therefore, a very simple type of small depth, wide sweep angle, tube may be used, the only requirement being that the phosphor must have rapid decay time. In the end result, a flat scanning tube, different from conventional tubes, may be possible because of the simple tube requirements. If this type of scanning tube can be combined with a workable light amplifier

* TIS #R56ELS62: "Feasibility Study of 'Picture-On-Wall' Display"

"sandwich", a color display which is substantially thinner than even present monochrome tubes could result. However, both the scanning tube and the light amplifier need major invention to be feasible.

T.T.TRUE:rer
April 29, 1957
SYRACUSE, NEW YORK
ELECTRONICS PARK

T. T. True
Development Engineering
TELEVISION RECEIVER DEPARTMENT

ELECTRICALLY CONTROLLED COLOR FILTERS

by: W. [illegible] GOOD

The basic application of an electrically controlled color filter would be to place a transparent sandwich of appropriate materials in front of a monochrome picture tube and control its color filtering action by applying electrical color signals. This procedure would permit a direct view color display system in which a monochrome picture tube supplies the scanning and luminance portions of the signal and the electrically controlled color filter provides the color.

There appears to be at least one method by which such a filter could be made. That is a type of filter that depends on the action of an optical retardation plate placed between crossed polarizers. Such a filter is called a Lyot-Ohman filter, a birefringent filter, a polarizing monochromatic filter or a polarization interference filter. In principle the retardation plate causes the system to become frequency sensitive, thus transmitting some wave lengths and cancelling others, giving rise to a channel or comb type optical filter. If the double-refraction or bi-refringence effect of the retardation plate is varied by an applied field then the portion of the spectrum selected for transmission may be varied in a known manner. It is this fundamental principle I wish to describe and then discuss a possible method of applying such a filter to a color TV system.

Color filters have been built for specific purposes and they all perform essentially like this simple model. This one was made by placing stripes of scotch tape between crossed polaroids. Quite a variety of colors are apparent in this one stage filter. Let us briefly review the principles involved.

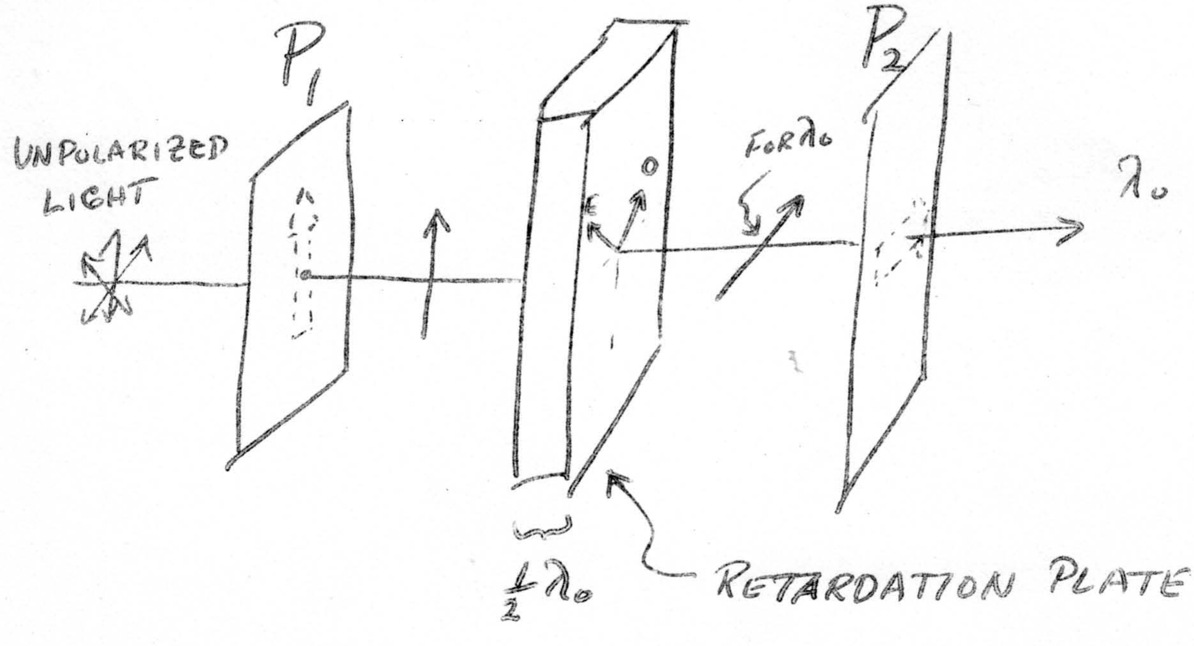
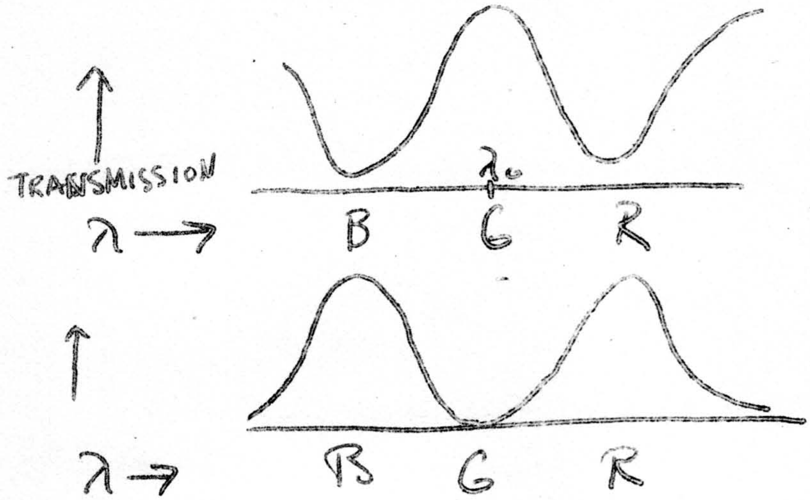


Figure 1

Figure 1 shows how the plane of the polarized light from P_1 is rotated during its travels thru the $\frac{1}{2}\lambda$ retardation plate and is consequently transmitted at P_2. Inasmuch as the 90° rotation holds true for only one wavelength - light will be passed at λ_0, but not at adjacent frequencies, thus giving rise to color. If the polaroids had been parallel then λ_o would not be passed. The pass band for a 2 λ plate is:



Parallel Polarizers

Crossed Polarizers

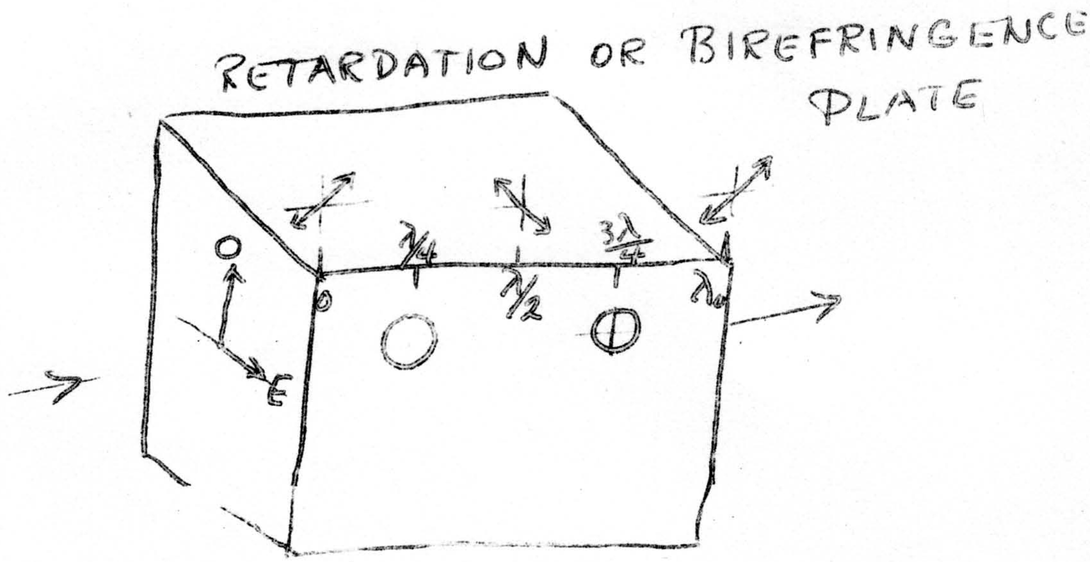


Figure 2

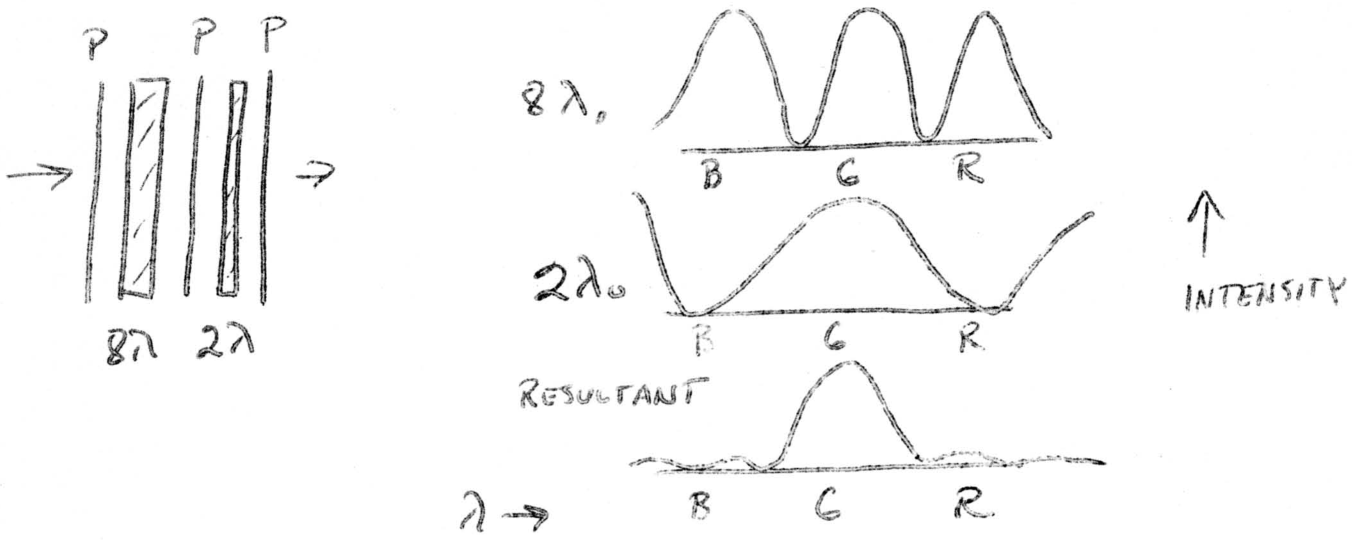
With a simple 2λ filter it is possible to make a green or magenta filter by crossed or parallel polarizers. The expression for transmission is:

$$I'' = \frac{I_o}{2} \cos^2 \frac{\pi d}{\lambda}$$

where d = the optical path difference for the E and O rays.

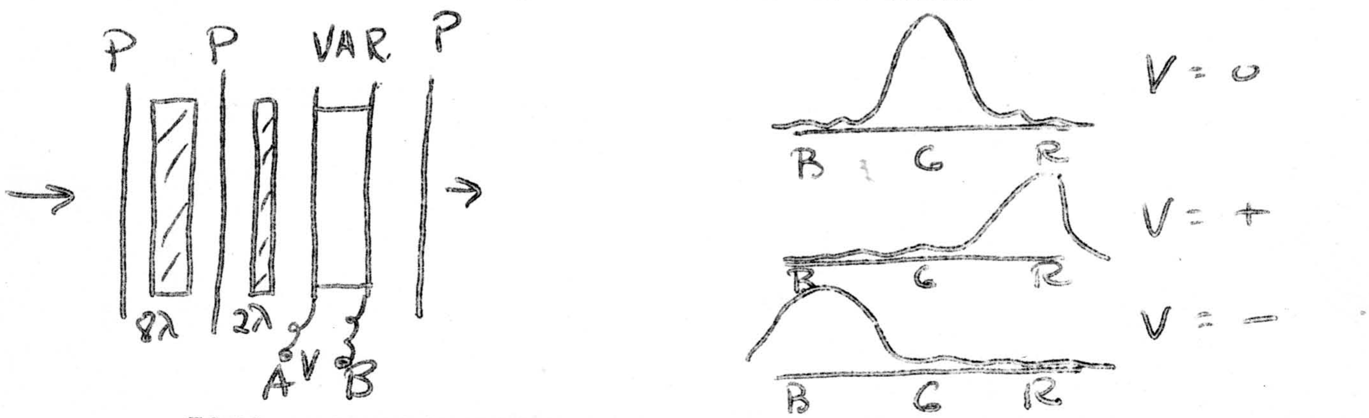
To obtain more precise selection of wavelength it is necessary to use two or more stages in cascade. For instance a six stage filter has been constructed for viewing the radiation of the H_α line from solar prominances. This filter was 4 Å wide and centered at 6563 Å .

Our need for "saturation" is not that great (say 500 to 1000Å wide). If an 8λ stage is combined with a 2λ stage the transmission is as follows -



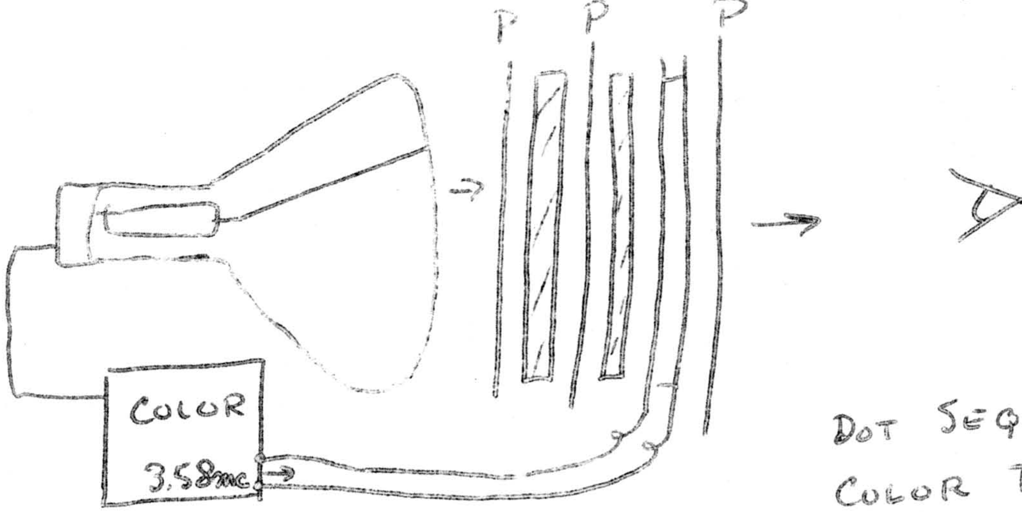
To make such a combination "tunable" or variable it is necessary to add a plate of material whose magnitude of double-refraction can be varied with an applied field. Various substances show such effects when magnetic or electric fields are applied such as the well known Kerr cell. The Kerr cell requires the electric field to be applied at right angles to the direction of transmission of light, which is somewhat awkward in a practical filter. ADP crystals, cut perpendicular to the optic axis and equiped with transparent electrodes responds to an in line field.

If such a variable element is added to the second stage of the proposed filter it is possible to vary the transmission thru the range of Blue to Red and thus perform the basic functions required for a color TV filter.



If the potential difference of A and B is zero, the color is green, if B is positive with respect to A, the transmission goes to Red and if B is minus, the pass band is blue. Thus with a sine wave applied to the variable element it should be possible to realize a dot-sequential color filter. If the composite color signal is now applied to the monochrome picture tube and the filter placed in front of the tube, it should result in a colored display.

A variable plate of APD crystal requires 4000 to 5000 volts peak voltage to make the simple filter described above. With a capacitance of 3000 uufds for a 21" screen, it would require several kilo-watts of 3.58 MC switching power.



It is apparent that the picture tube could be coated with a phosphor which has the same spectrum as the 8λ filter and then perhaps a 2 stage filter with both elements variable could be substituted to obtain easier switching and better color saturation. The decay time of the picture tube must be not greater than 1/3 of a 3.58 MC cycle or $\sim 0.1 \mu s$. As far as the filter is concerned - both large sheets of polaroid and retardation plate material are available. Practical materials for the variable retardation plates are not, to my knowledge, available. It has been suggested that some of the newer plastics which may be electrically polarized may be likely candidates. Dr. Wolf of the Electronics Lab has suggested the Isotactic Polymers. What is needed of course, is a material which can be made in large sheets and has a high electo-optic coefficient.

Certainly some loss of light will take place in the filter besides the basic 50% due to the initial polarization. In a two stage filter with 80% transmission per polaroid, the overall transmission thru three polaroids would be 0.8x0.8x0.8 or 50%. With the initial 50%, the resultant is 25%. If now 1/3 of the light is transmitted thru the filter from the source then the overall transmission might be 8%. This leads one to believe that a system which permits continuous transmission of white light such as the one which uses color video applied to the color filter is required. This would permit 25% off on white high lights and one third of this on saturated colors, which would be quite acceptable. Ultravision would come with such a filter. One severe problem in this filter is the change of color with the angle of view. Suggestions for using a double layer of retardation plate with optic axes adjusted to give a constant retardation over a wider viewing angle have been made.

With a variable material having a high electo-optic effect and with improved techniques for switching the filter it may be possible to reduce the switching power to the one watt range and make such a system practical. Switching voltages of the order of 100 volts or less would be required.

LIGHT VALVES: TRANSMISSION AND REFLECTION

1. Eidophor

The Eidophor with Dr. Glenn's modification for introducing simultaneous color would certainly show potential for future home application if the proper materials could be developed. It is our understanding that this is a long time off, and therefore does not present a very hopeful avenue of approach at the present time.

One interesting example of a monochrome light valve for transmission was suggested by Ralph Bondley several years ago. This "valve" made use of an ADP crystal plate that was scanned by an intensity modulated electron beam. Light, transmitted through crossed polaroids was caused to be passed or absorbed by the degree of rotation of the angle of polarization induced in the ADP plate by the scanned electron charge. This system is proposed primarily as a projection one. However, the same principles applied to a reflection type of light valve might make a direct view screen possible. Such a "reflection type" light valve would be illuminated by ambient light. This is a concept to which we have not given very much consideration, but it does seem logical to strive for a screen whose performance increases when taken outdoors or to the beach - rather than trying to generate larger and larger quantities of light and then placing an absorbing filter in front of the picture to keep it from being completely masked by ambient light. Dark trace tubes would also fall into this catagory. Color displays of this type would require frequency selective absorption or reflection type materials. It appears worthwhile to give more thought to a tube that uses only a small amount of energy to change the reflectivity of the screen surface and which can be made brighter by shining more light on it!

Finally, another possibility that is worthy of note is that of obtaining <u>color control by secondary excitation</u>. Here is a suggestion by which, perhaps, the scanning and the luminance are contributed by an electron beam while the color of the emitted light from the phosphor depends on the presence of another form of radiation or energy, say, another electron beam, a particular frequency of ultra violet or infra-red light. Each color might have a particular UV frequency of light associated with it. Thus three UV sources of different frequencies would be required for three-color television.

W. E. Good
Development Engineering
TELEVISION RECEIVER DEPARTMENT

WEG:rer
4-30-57

ELECTRONICS PARK
SYRACUSE, NEW YORK

Miscellaneous Investigation Report #93
June 13, 1957

Development Engineering
Television Receiver Dept.

Evaluation of the Electrically Controlled Color Filter

By: WE Good and TT True

The electrically controlled color filter is of importance to color TV because it may lead the way to selecting colors external to the picture tube. This permits the construction of a color TV system which consists basically of a monochrome type tube with an external transparent panel whose color can be controlled electrically. It is apparent that this is the exact analogy to the old color wheel system except that the electrically controlled filter can be switched at much higher rates than was possible for the mechanical wheel. Thus the electrical color filter is potentially capable of being adapted to a dot sequential system, and take obvious advantage of the simple monochrome tube as the source of light.

There are two types of color filters which can be controlled electrically. These are the birefringent polarized filter and the dichroic polarized filter (combination of dye and polarized light). Both of these make use of a variable electro-optic wave-plate which rotates the plane of polarization as a function of applied electric field. The color or hue of either filter is a function of the applied voltage.

Simple calculations and a brief survey of the technical patent literature indicate that any degree of color saturation may be obtained with these filters, provided a large number of stages (5 or 6) is permitted. For the saturations required for color TV, two stages appear to be sufficient. For example, Babits & Hicks, (Electronics, Nov. 1950) state that they were able to obtain saturations of 50% with one stage and 90 to 95% with two stages. The latter should be quite adequate for color TV.

It would be possible, today, to build such a color filter using the dot sequential switching technique, except for two serious drawbacks. The first is that it requires exorbitantly high voltages to switch the known electro-optic materials and the second is that a phosphor is required that has an extremely short decay time. If one assumes that research on these materials directed towards reducing the switching voltage and shortening the decay times was successful, then we can predict that the future color receiver will be of this type. While it is impossible to estimate just how much improvement might be achieved by significant research effort in this area, it is apparent that the specific dot sequential system that was assumed for this analysis puts the most severe requirements on these materials of any system that one might imagine. If one could devise alternative ways of color switching, particularly with the above limitations in mind, it is quite possible that the extreme requirements mentioned may be relieved sufficiently so that the materials could be realized at an earlier date.

A preliminary survey of the technical and patent literature, along with basic knowledge of the NTSC system leads one to believe that more practical switching methods may be devised. These fall into two basic categories: the first is to devise color filters or color filtering action that requires less than the full

90° rotation of the plane of polarization of the electro-optic material in order to achieve the required color changes and the second is to explore the possibility of switching at chroma rates (0 to 0.6 mc) rather than at the 3.58 mc dot sequential rates. It would appear that chroma switching requires a filter that is clear for white signals and only changes as color is required. This implies a subtractive type of color filtering action. It is not clear whether the readily available color difference signals can be used directly to switch this type of filter or not.

In view of the above, a more detailed study is needed to determine the future feasibility of the color filter approach. The study would be directed toward devising a system which puts the minimum requirements on the electro-optic material and phosphor decay times as well as the associated equipment. The specific requirements for the materials would be spelled out. An analysis of the subtractive color approach would be made to determine if any basic changes have to be made in the color signal processing. It is suggested that three man months be spent in clarifying the above points and that the project be reviewed at the end of that time to determine the appropriate direction to take from thereon. From a broad point of view this study should be applicable to any device or system that selects color external to the tube.

The specific suggestions for carrying out the above program are as follows:

1. Review the tehnical literature on electrical color filters.

2. Study in detail the 10 patents that appear pertinent to this field.

3. Obtain information directly from the Polaroid Corp. on these types of filters. (They appear to have the patents in this field.)

4. Analyze the problem of the subtractive color approach as to the signal processing required.

5. Devise simplified systems for using these filters for color TV and state the material requirements for each system.

6. Set up a small size color filter experimentally and become familiar with its mode of operation. Materials are available which would permit the design and construction of an inexpensive two-inch diameter electrical-color-filter which can be used for basic evaluation of performance and for checking the theoretical solutions to the above problems. It is very likely that this filter could not be switched at 3.58 mc, however, it could be switched at a field rate and the basic principles of color selection could be evaluated and developed at this lower rate. In fact it would be possible to view a large monochrome tube through this small filter and futher determine and evaluate the problems associated with this approach. While it is not likely that the experimental part of this project can progress too far in three months, it is fairly clear how one might proceeed after that time, provided the overall evaluation looks favorable at the review time. Briefly, it would be to continue with the simple filter as applied to a field sequential two-color display.

True, the saturated orange and cyan would flicker, but it would be possible to look at color transmissions and evaluate the potential performance of this approach and of the technique of using the filters. These techniques would be applicable later to three color displays but the two color approach would permit a quicker and less expensive way of obtaining a preliminary evaluation. If it still looks favorable at this point, it might be worthwhile to change to line-sequential two color to gain experience in faster switching and to have a picture that is less objectionable in view. It appears that improved materials would be required to make the next logical step to that of chroma-rate switching of a two-color receiver. This would be the basic break-through that is required for the eventual sucess of a three color electrical filter and the probability of reaching this point would be the thing that we would be attempting to tie down at all times. It is somewhat fortuitous that the basic materials and techniques appear to be available as well as a fairly clear path is indicated for both theory and experiment to take, in order to check the feasibility of a system that is highly speculative today.

It is concluded that the electrical-color-filter approach to color TV is technically feasible provided that major improvements are made in the characteristics of electro-optic and phosphor material. In order to determine the magnitude of the improvements required it is suggested that a three month program be undertaken to explore the most promising techniques for applying these filters, and to specify the required material characteristics. An experimental approach is indicated to supplement the study and to permit futher evaluation of the problems pertinent to this system.

W. E. Good - T. T. True
Development Engineering
Television Receiver Dept.

WEG:TTT:REL

COPY

RYD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
5-9-57		Variable Color Filter

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
			Future System	

DESCRIPTION:

Variable Color Filter (Poloroid Type)
21" 90° Aluminized
Table Model Metal

MATERIAL			
CABINET	9.00		
CABINET ACCESSORIES	4.78		
CATHODE RAY TUBES	24.00		
OTHER TUBES	17.42		
SPEAKER	.84		
CHASSIS ASSEMBLY	62.48		
PACKING	2.00		
Filter	10.00		
TOTAL	130.52		
FREIGHT	1.31		
SPOILAGE	2.62		
TOTAL MATERIAL	134.45		
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION			
SPEAKER			
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT			
TOOL MAINTENANCE			
TOTAL P.E.C.E.	14.00		
WARRANTY COSTS			
SET WARRANTY	1.53		
PICTURE TUBE WARRANTY	.90		
TOTAL WARRANTY	2.43		

LIST PRICE			
DISCOUNT			
DISTRIBUTOR COST			
EXCISE TAX			
NET G.E. SELLING PRICE			
GROSS MARGIN — DOLLARS			
GROSS MARGIN — PER CENT			
QUANTITY	1,000,000		
COST SUMMARY			
MATERIAL	134.45		
LABOR	8.00		
I.M.E.	11.00		
SHOP COST	153.45		
P.E.C.E.	5.00		
WARRANTY	2.43		
EXTRA COST	3.20		
MFG. COST LESS ROYALTY	164.08		
ROYALTY	2.25		
TOTAL MFG. COST	166.33		

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

Miscellaneous Investigation Report #89
May 31, 1957

Development Engineering
Television Receiver Dept.

Color Eidophor Theory

By: Michael Graser, Jr.

Eidophor is a light valve, projection television system employing a Schlieren optical system. Fig. 1 shows the basic Eidophor projection system.

Light from the projection lamp strikes the slit mirror, which is front-silvered in equally spaced stripes, so that half the light is reflected down toward the Eidophor tube and half passes through and is absorbed. The position of the front-silvered spherical mirror inside the Eidophor tube is adjusted to precisely reflect the light back to the silvered stripes so that no light can get through to the projection lens. This is the unmodulated condition which results in a dark screen.

The constant current electron beam scans a raster on the transparent gel leaving a negative charge on the surface corresponding to the scanning lines. If the beam is now velocity modulated by a carrier frequency (30 mc for example) applied to a pair of horizontal deflection plates, the density of the resulting charge distribution along the lines will correspond to this frequency. The attraction between these electrical charges and the silvered surface of the s pherical mirror causes deformation (ripples) of the surface of the gel corresponding to the charge distribution. These ripples make the gel behave like a diffraction grating as shown in Fig. 2 (section taken through a scanning line and perpendicular to the gel surface). The diffraction pattern being symmetrically off-axis passes through the slits on to the projection lens which focuses the raster on the screen. The amount of light that is diffracted depends upon the depth of the ripples. Therefore, if the carrier is amplitude modulated by the video signal (black equal to zero carrier) a monochrome picture will be produced on the screen.

Dr. W. E. Glenn of the Research Laboratory in Schenectady has suggested the method for getting color from the Eidophor system that is illustrated in Fig. 3. Here the slits have been narrowed to admit only that part of the diffraction spectrum corresponding to the red, green, or blue primaries. Changing the carrier frequency alters the spacing of the ripples, which causes a shift of the position of the diffraction spectrum thereby permitting a different part of the spectrum to pass through the slits. For example, if red is produced at 30 mc, then green requires 34 mc and blue requires 39 mc. If these three carriers are amplitude modulated by R, G, and B signals a colored picture results.

Dr. Glenn has proposed a two-carrier system to replace the three-carrier system. This might use 30 mc for red, and 36.5 mc frequency modulated by B-G and amplitude modulated by B+G. Fig. 4 shows how color is produced by this arrangement. The Color Eidophor receiver described in the next article uses this idea.

Although the Color Eidophor system appears to be fairly simple it is actually subject to considerable practical difficulties. For example, the gel which has not been developed to date, must possess certain special properties. It must have the proper conductivity and viscosity to permit the image to disappear after one frame while still retaining some storage properties. The gel must also resist the corrosive effect of the electron beam.

The electron gun must have a 30 mc resolution, which requires a rectangular spot of 20 by 30 microns. Finally, the Schlieren optical system must have sufficient accuracy and stability to block out all undiffracted light and to select the proper colors according to the modulation.

Michael Graser, Jr.

MG:REL

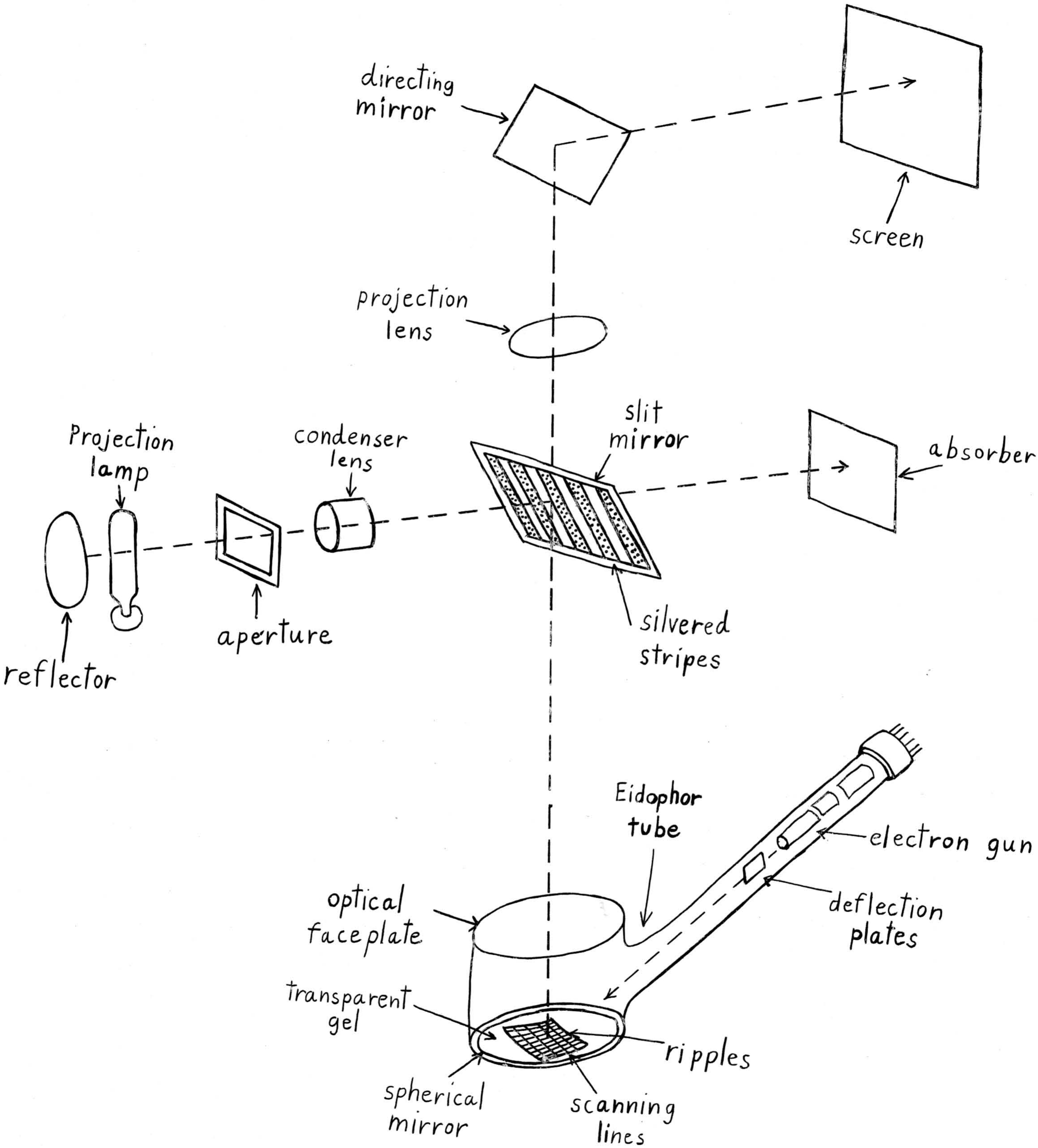


Fig. 1

Eidophor Projection System

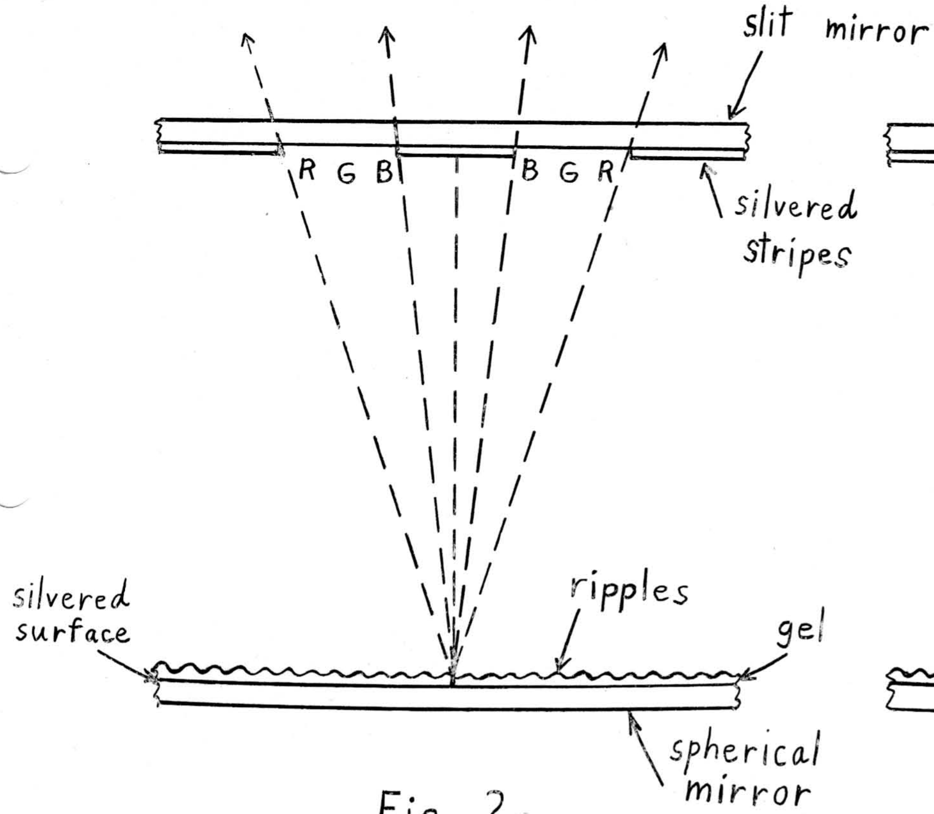


Fig. 2

Monochrome Eidophor

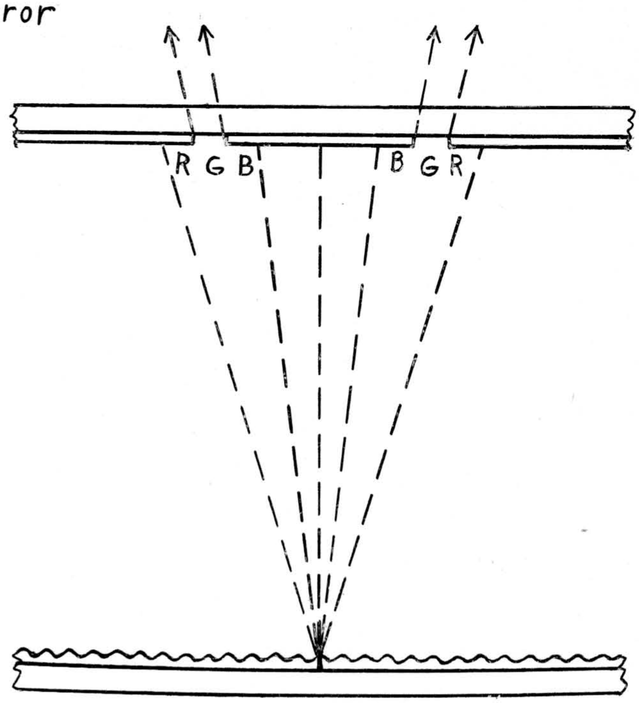


Fig. 3

Color Eidophor

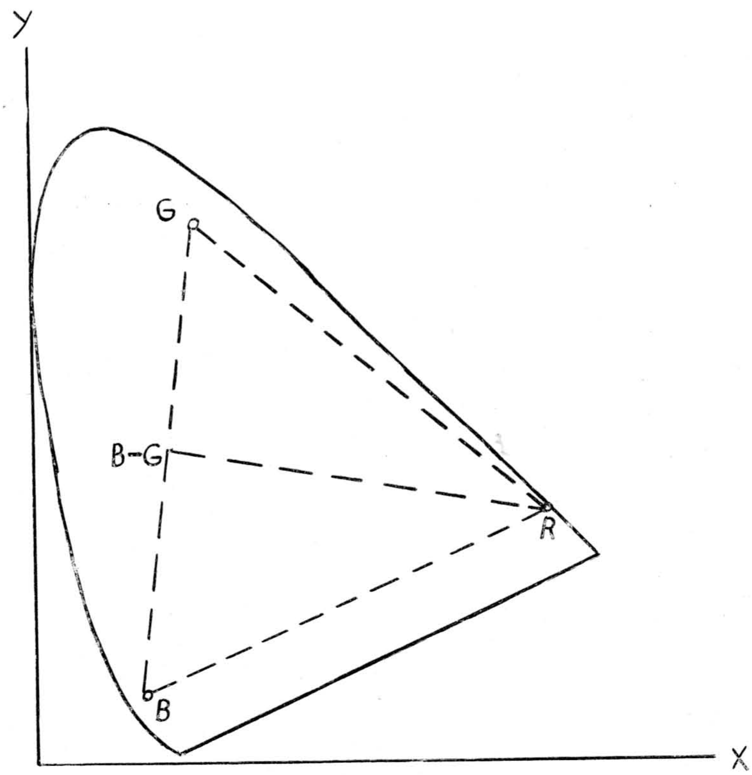


Fig. 4

2-Carrier Color Eidophor

Subject: Color Eidophor Receiver

Electronics Park, Syracuse, N. Y.
June 11, 1957

Dr. W. E. Glenn
Research Laboratory
The Knolls
SCHENECTADY

At the May 1, 1957 meeting, held at the Research Laboratory in Schenectady, you mentioned the possibility of using color Eidophor in a home TV receiver. As a follow-up to this suggestion we at TVRD have investigated the idea. B.A. Field and I have come up with a block diagram and cost analysis of a receiver using your principle of obtaining color directly from the Eidophor diffraction pattern.

Figure 1 shows the optical arrangements we would use. We assumed the existence of a gel that could be placed on a stationary mirror inside a sealed off tube. Furthermore, we assumed the characteristics of the gel were such that the extreme scanning accuracy requirements could be relaxed. With these assumptions we were able to draw the block diagram shown in Figure 2. We employed your scheme of using 1 AM carrier for red (30 MC) and 1 amplitude and frequency modulated carrier (center frequency of 36.5 MC) for the blue-green axis. To insure stability both the low and high voltages were regulated. We further assumed that sweep width and height servos would not be required.

The block diagram had a sufficiently close resemblance to the Crabapple schematic (Crabapple is an optimized Apple receiver chassis) to permit direct comparison. A slight modification of the Crabapple costs then was used to arrive at the Eidophor chassis costs given on the cost sheet. This cost is based on a 100,000 unit per year production rate.

The breakdown of the optical system is given at the bottom of the cost sheet. These prices are rather crude estimates and are probably on the optimistic side. The slit mirror and special long-life projection lamp prices are particularly doubtful.

The Eidophor vacuum tube price was estimated by J.C. Nonnekens and E.F. Schilling of the Cathode Ray Tube Dept. They envisioned a gel-coated, spherical surface mounted in a two-piece bulb having an optical faceplate and equipped with an extremely fine focus, rectangular spot, electron gun. As the construction details are largely unknown, the tube price is merely a crude estimate and according to J.C. Nonnekens, definitely on the optimistic side.

The total material cost comes to $466.09. This figure is at least $250 higher than the other existing color TV systems such as AM, PA and Apple. On the basis of cost, the color Eidophor system does not appear hopeful.

We would appreciate hearing any comments you might have regarding this analysis.

Michael Graser, Jr.

Michael Graser, Jr.
Development Engineering
Television Receiver Dept.

MG:REL
Enc. (3)

cc: RB Dome
DE Garrett
DE Harnett
JF McAllister
DW Pugsley
WE Good
N Johannessen
IE Lynch
MJ Palladino
TT True
HJ Vanderlaan
GA Schupp
BA Field
FG Cole
TV Zaloudek
LC Maier - #6
JC Nonnekens - #6
WD Rublack - #6
EF Schilling - #6
S Altes - #3- Court St. Plant
LM Leeds - #7
LR Fink - Research Lab. - The Knolls - Schenectady
CG Fick - Research Lab. - The Knolls - Schenectady

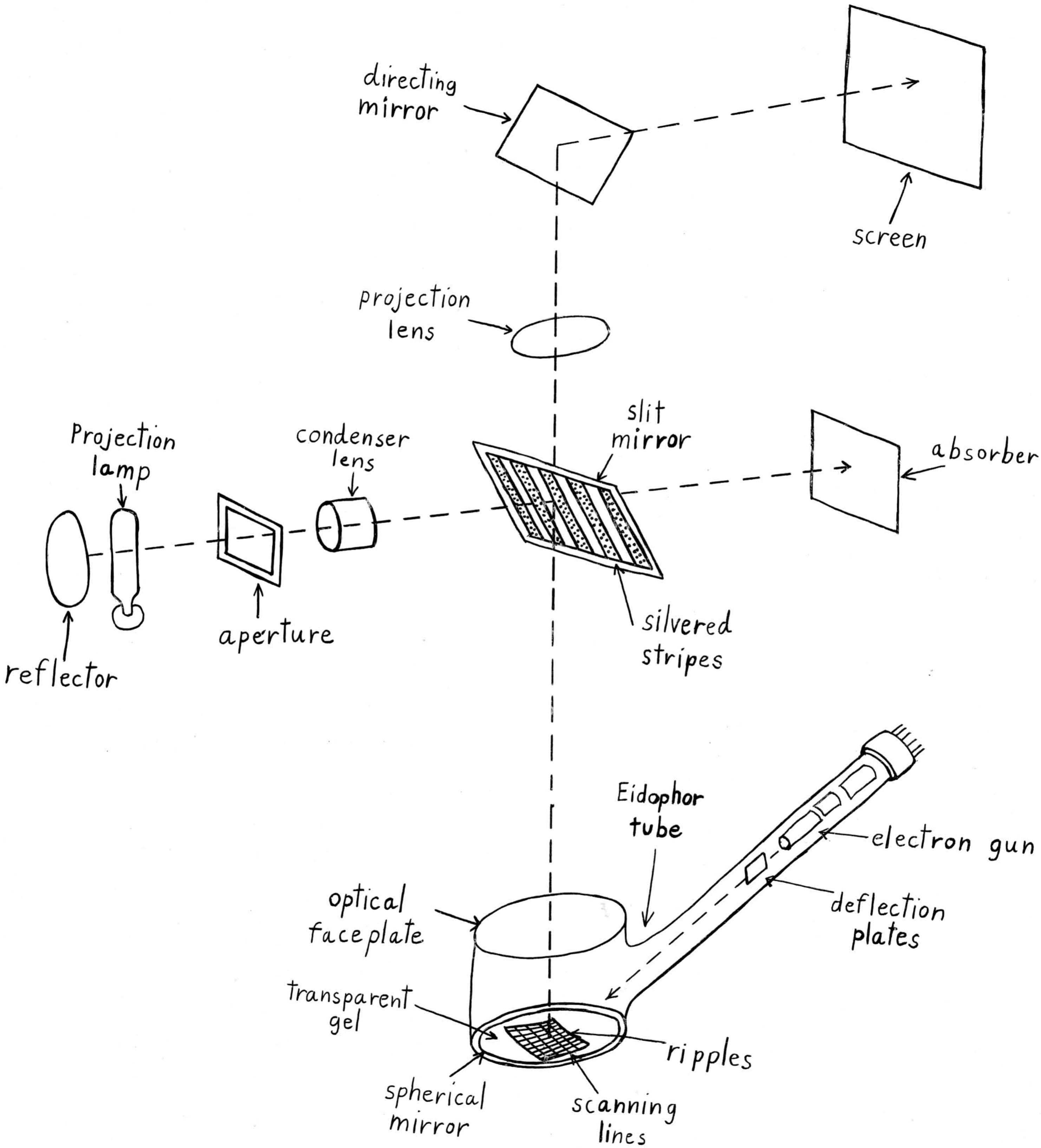


Fig. 1

Eidophor Projection System

RTD-459-12 (10-56)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
6/11/57		

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT

DESCRIPTION:

COLOR EIDOPHOR RECEIVER – Cost Sheet

Costs at 100,000 units per year production

MATERIAL			
CABINET	19.00		
CABINET ACCESSORIES	10.00		
CATHODE RAY TUBES	280.00		
OTHER TUBES	31.00		
SPEAKER	.84		
CHASSIS ASSEMBLY	85.25		
PACKING	3.00		
Optical system	37.00		
TOTAL	466.09		
FREIGHT			
SPOILAGE			
TOTAL MATERIAL			
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION			
SPEAKER			
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT			
TOOL MAINTENANCE			
TOTAL P.E.C.E.			
WARRANTY COSTS			
SET WARRANTY			
PICTURE TUBE WARRANTY			
TOTAL WARRANTY			

LIST PRICE			
DISCOUNT			
DISTRIBUTOR COST			
EXCISE TAX			
NET G.E. SELLING PRICE			
GROSS MARGIN — DOLLARS			
GROSS MARGIN — PER CENT			
QUANTITY			

COST SUMMARY			
MATERIAL			
LABOR			
I.M.E.			
SHOP COST			
P.E.C.E.			
WARRANTY			
EXTRA COST			
MFG. COST LESS ROYALTY			
ROYALTY			
TOTAL MFG. COST			

Other System Material Costs

AM	$205
PA	197
Apple	195
Chromatron	204
Monochrome	85

Optical System Cost

Screen	5
Slit Mirror	3
Projection Mirror	5
Condenser, projection lens, and aperture	5
Long life projection lamp	2
Blower	2
Alignment and mounting	15
Total	$37

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING
B. Field and M. Graser			

Miscellaneous Investigation Report #90
June 3, 1957

Development Engineering
Television Receiver Dept.

Color Scophony

By: Michael Graser, Jr.

The Scophony television system is a mechanical scanning, light valve projection system. A simplified optical arrangement showing the basic principles is illustrated in Fig. 1.

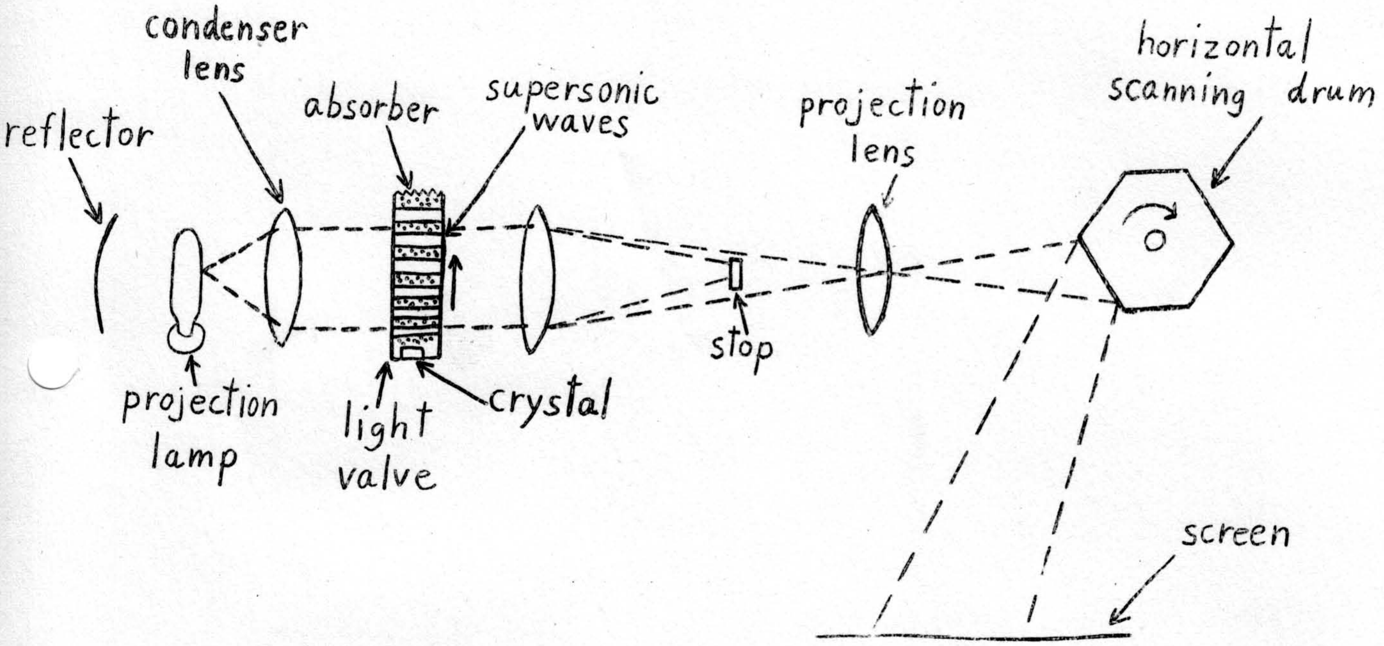


Fig. 1

Scophony Optical System

The heart of the system is the supersonic light valve. This valve consists of a fairly long liquid-filled chamber containing a quartz piezolectric crystal at one end. When the crystal is made to oscillate, compression waves travel down the chamber until they are absorbed at the other end by a layer of absorbing material. As the index of refraction of the compressed and rarefied regions is different, a pattern of variable index of refraction corresponding to the compression waves is formed. If the spacing of the compression waves is made small enough by using a high crystal frequency (around 10 mc), the liquid will act like a diffraction grating.

The intensity of the light in the diffraction pattern is a function of the amplitude of the supersonic waves. Therefore, if the crystal frequency is amplitude modulated by the video signal (black corresponds to zero amplitude) the diffracted light will also be modulated by the video. The stop shown in Fig. 1 permits only the diffracted light (modulated) to reach the screen.

The modulated wave pattern travels down the length of the chamber with a velocity equal to the speed of sound in the liqud. A rotating mirror is therefore required to compensate for the moving pattern, that is, image the moving distribution as a stationary pattern on the screen. By making the liquid chamber the right length a complete horizontal line can be stored in the moving pattern.

It is evident that the compensating mirror can be a horizontal line scanning drum which will rotate at high speed (for a 20 face drum about 47,000 revolutions per minute are required for a 525 line picture). A second rotating mirror drum is used for vertical scanning.

Color pictures can be obtained by using three Scophony units with red, green and blue filters respectively. The three pictures then must be added by some optical means to form a single, converged image.

Conclusions:

1. The Scophony system suffers from all of the disadvantages of a mechanical scanning system.

2. The Schlieren optical system requires rather high mechanical accuracy and stability.

3. Color Scophony will have convergence and grey scale problems.

4. Since the picture brightness is determined by the light source, there is no inherent brightness limitation.

References:

1. D.G. Fink, Television Engineering Handbook, McGraw-Hill, 1957, p.p. 3-49.

2. V.K. Zworykin and G.A. Morton, Television, 2nd Ed., John Wiley & Sons, 1954, pp. 274 - 278.

MG:REL

Michael Graser, Jr.

REPORT NO. 75
February 13, 1957

DEVELOPMENT ENGINEERING
TELEVISION RECEIVER DEPARTMENT

MISCELLANEOUS INVESTIGATION REPORT

FIELD AND LINE SEQUENTIAL TWO-COLOR

INTRODUCTION

A cheap system for a two-color receiver might be feasible if the information for the two colors, derived from a N.T.S.C. signal, field-sequentially were applied to a two-color tube, e.g. a penatron, where during the even and odd fields alternant orange and cyan pictures are produced.

In order to determine whether such a system would render an acceptable picture, it has been tried out on the two-color receiver, mentioned in TIS 55-ERT-5, (J.E. Allen, September 9, 1955). In this receiver two monochrome picture tubes, 17AVP4-A, have been installed; on the face of the tubes an orange and cyan gelatin filter was placed respectively. By means of a partly transparent mirror, the pictures of both tubes were combined to one picture in two colors. The gray-scales were adjusted for a good monochrome performance.

After evaluating field-sequential two-color, with the same set-up, line-sequential two-color was observed.

TEST SET-UP

To get field-sequential two-color, a 30 c/s square wave was applied to the G_2 of both picture tubes so that during one half cycle the orange picture tube was cut-off and the cyan tube normally conducting, and during the next half cycle the reverse. The 30 c/s square wave was obtained from a Tektronix square wave generator, and two amplified phase-inverted output voltages were produced by means of a cathode-coupled phase inverter. A double diode clamped the top of the obtained square wave voltages to the voltage levels of the original G_2 voltages, and then the output voltages were fed to the G_2's of both picture tubes.

For the phase inverter at first a 12AX7 was tried with an anode supply voltage of 450 volts. However, in order to cut-off the picture tubes completely during each other half cycle, the brightness level had to be brought down to an unacceptable low value. To be able to work with a reasonable brightness level, the amplitude of the output voltages of the phase inverter had to be increased. For this purpose a 6BK7A was used instead of the 12AX7, the anode voltage was increased to 600 volts (obtained by a series connection of the outputs of two separate power supplies), and the square wave generator was terminated by a resistor of 300 Ω instead of the specified 93 Ω, in order to increase the output from 15 to about 30 volts.

The following circuit has been used for the tests.

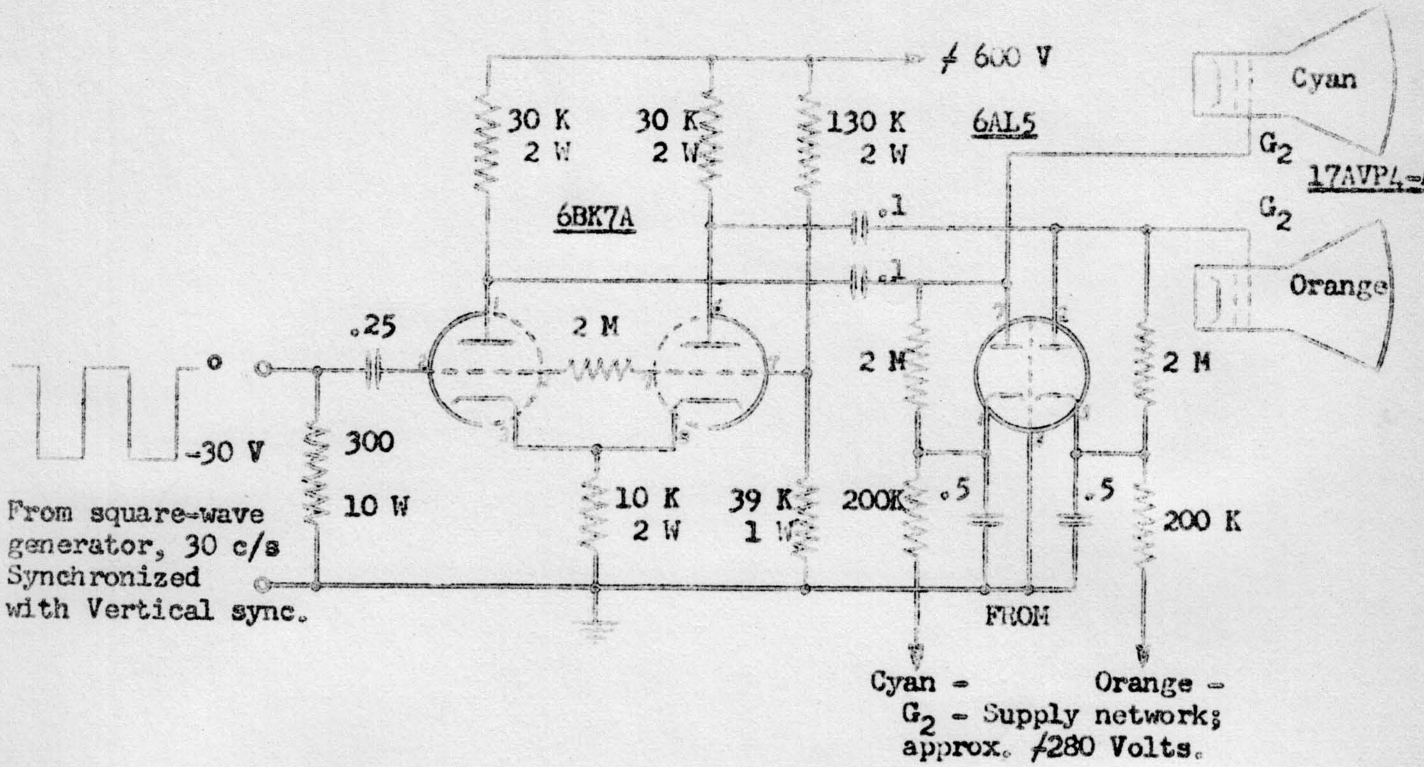


Figure 1

FLICKER-TEST FOR FIELD-SEQUENTIAL TWO-COLOR TV

Both color and monochrome pictures were unacceptable due to bad flicker, though the flicker was not as bad as three-color field-sequential with rotating disc, which has been watched in the Electronics Lab, Building 3. The brightness was about half of that before applying the square wave. Further, when moving head or eyes while the tube face was within the field of sight, even unintentionally, a very noticable color-breakup occurred; e.g. if the eyes were moving from right to left, a row of successive orange and cyan fields was seen, as shown in Figure 2.

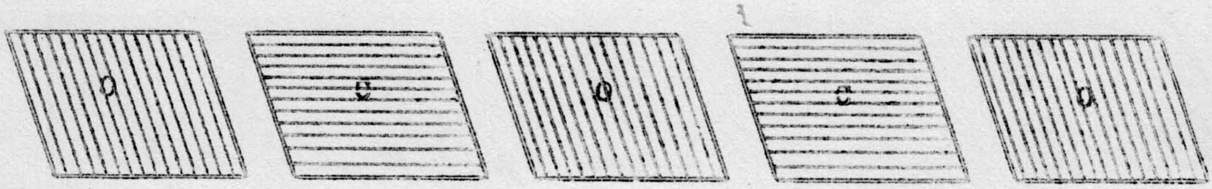


Figure 2

The whites flickered worse than the saturated colors, as the brightness was higher. On monochrome the flicker was as objectionable as on color.

Next an attempt was made to get the least possible flicker in the whites and in monochrome performances, by balancing the primaries for equal luminance. With the

G_2 controls the gains were adjusted for minimum flicker in the highlights, and with the G_1 controls a uniform gray-scale was obtained. This gray-scale proved to be reddish for minimum flicker. It was found however, that about 50% of the observers would adjust for the same gray-scale, but the others wanted a setting either on the cyan or on the orange side, for minimum flicker. For instance, a person with eyes less sensitive for cyan flicker would adjust for a gray-scale more on the cyan side than average, for minimum flicker.

The orange seemed to be more saturated than the cyan. To increase the cyan saturation, a second gelatin cyan filter was placed on the tube face, and the gray-scale was readjusted accordingly. It was still on the reddish side for minimum flicker in the whites and in monochrome, though less than before. The monochrome picture was not bad (barely perceptible flicker) although the brightness level was rather low compared with monochrome sets. In highlights of 20ft.l., even if there was no monochrome flicker, still an impression of the presence of successive orange and cyan fields was obtained. The sensitivity of a person for flicker changed with time however. Color-breakup was very noticable too. In a color picture, the more saturated colors flickered very objectionably.

SUMMARIZING

The unanimous opinion of all who watched two-color field-sequential (at a 30 c/s rate) was: No good; too objectionable flicker and color-breakup.

LINE-SEQUENTIAL TWO-COLOR TV

Now that field-sequential proved to be not practicable, line-sequential two-color was tried to see if it would render an acceptable picture. The frequency of the square wave generator was increased to 7875 cycles per second, and synchronized with horizontal instead of with vertical sync. The resultant picture for a white field is shown in Figure 3, for an interlaced and for a non-interlaced picture. (To obtain a steady 100% out-of-interlace picture, pulses at line frequency were fed to the vertical multivibrator-oscillator.)

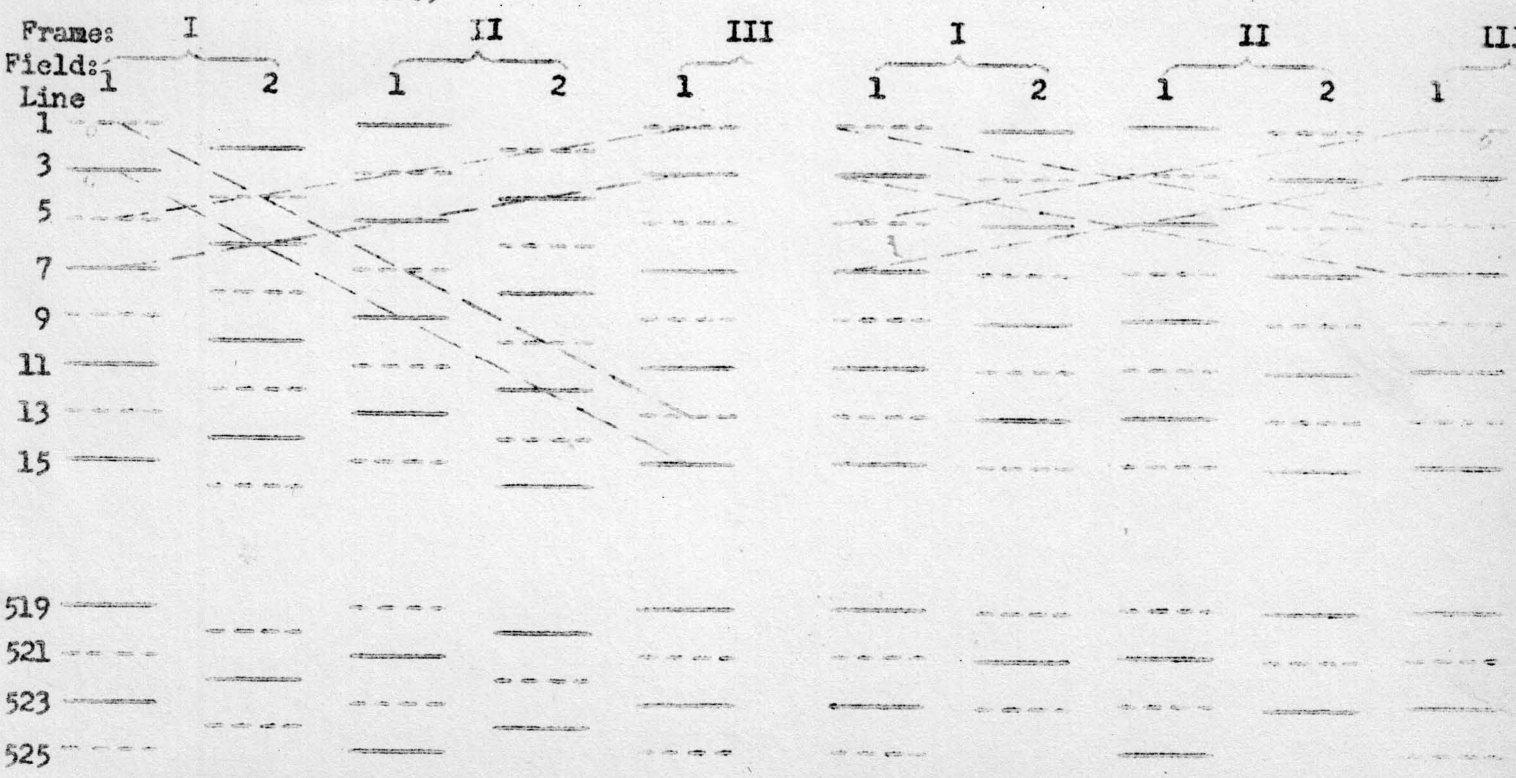


Figure 3a: Interlaced

Figure 3b: Non-interlaced

The slanting lines in Figure 3 show the crawl. For a non-interlaced picture, there is a not obvious up and downward crawl at equal speed; there is interline flicker. For an interlaced picture, there is a very obvious upward crawl at the same speed as the non-interlaced crawl, and a not obvious downward crawl at thrice this speed.

From a distance, for each field the eye combines one orange and one cyan line together to one white line, which is very obvious, crawling upwards. As a result, an interlaced picture looks to all extents as coarse as a non-interlaced picture. For a saturated orange or cyan field in the picture, only one of four lines was scanned: equally coarse as white or monochrome.

OBSERVATIONS

Line-sequential, like field-sequential, has been watched by the group of Dr. W. C. Good and by Messrs. D.E. Harnett, R.B. Dome, J.F. McAllister, G.A. Schupp, T.V. Zaloudek, G.F. Devine, D.N. Timbie, E.F. Schilling and other people.

Summarizing the opinions after observations:

Interlaced line-sequential: objectionable crawl.
Non-interlaced line-sequential: not obvious crawl.
Both equally coarse; whites, monochrome and saturated colors four times as coarse as a normal monochrome interlaced system. Both color breakup, crawl along edges in the picture: small bright objects and lines change continuously from orange to cyan and vice versa, which makes those look like sparkling jewels. Colored moire effects are present. There are intensified beats compared with the interferences which may be present in monochrome systems, because these interferences now are beating too with the 7.825 kc.
Line-sequential was observed with equal luminance primaries (reddish gray-scale) and with white gray-scale; no difference in performance was noticed.
In general, line-sequential two-color was considered as being too coarse, and having objectionable crawl, color breakup and beats.

Mr. D. N. Timbie mentioned that flicker in blue is less noticable than in other colors for the same brightness. This was checked for field-sequential 30 c/s flicker. The face of one tube was half covered with a blue filter, and the other half was left uncovered. The brightness of the white part was measured, and the flicker observed. Then the brightness level was increased till the brightness of the blue part was equal to that of the white part before. The flicker was indeed less, but still present at a brightness of 4 ft. l.

PROPOSAL OF TIMBIE-DEVINE

A consideration has been given to a proposal by Messrs. D.N. Timbie and G.F. Devine for a field-line-sequential three-color system: Scan odd fields green, and even fields line-sequential red and blue. The expected results are shown in Figure 4.

It is expected that there will be no obvious crawl effects, that there will be interline flicker. Obviously all saturated colors will flicker at a 30 c/s rate; green will be twice as coarse, and red and blue four times as coarse as an interlaced monochrome system. On a basis of the results of the two-color tests, this system seems also to be too objectionable.

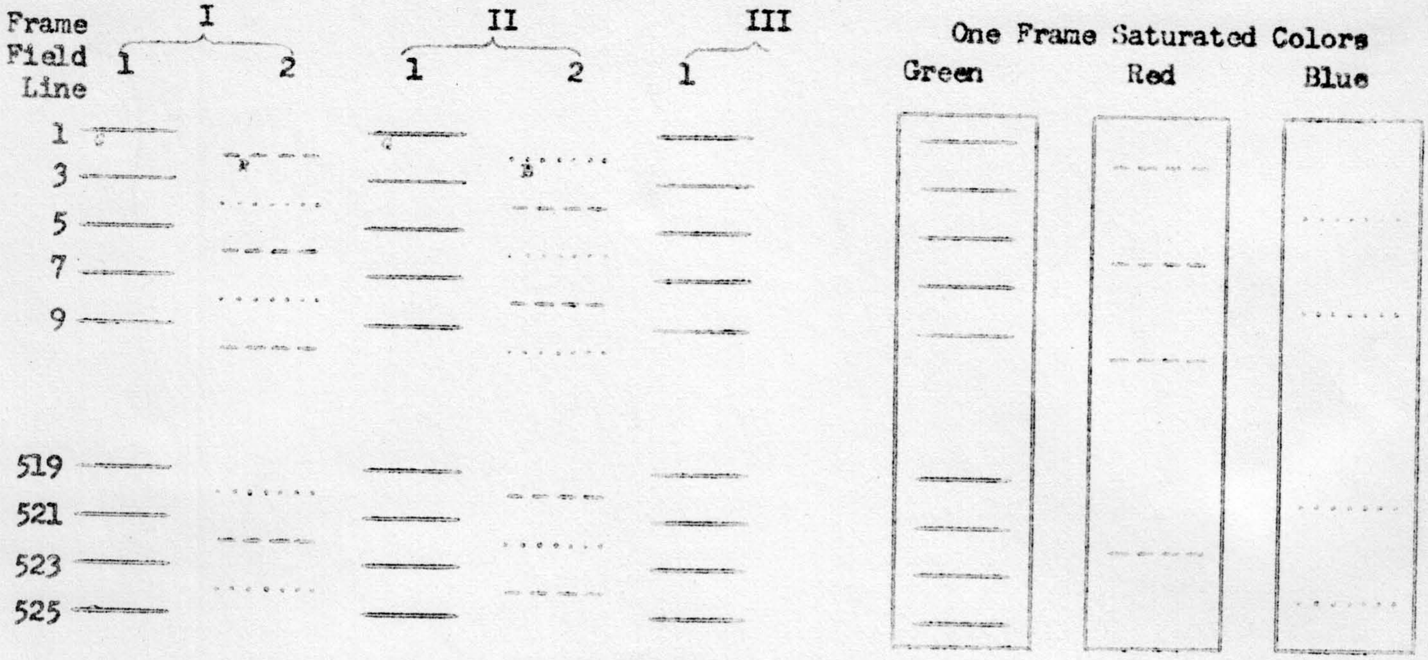


Figure 4

OTHER PROPOSAL - TWO BEAMS

Dr. W. E. Good mentioned a system, which may have been proposed before. There would be an always present green field (insofar as green is present in the picture), and superimposed (thus double beam necessary) line-sequential red and blue. The expected results are shown in Figure 5. In this figure it is assumed that the red and blue scanning is displaced vertically over one linewidth with respect to green.

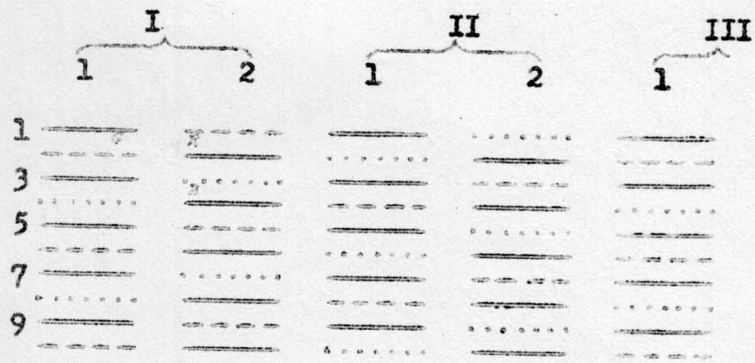


Figure 5

For red and blue this system will have the same effects as the line-sequential two-color; however, as these are the colors in which the flicker is less noticable than in green, and in which a lack of information is less obvious, the objectionable defects will be less noticable here, due to the always present green field.

On basis of the above experiments and considerations, it is felt that two- or three-color field- and/or line-sequential systems appear not to be feasible, as far as N.T.S.C. specifications are to be followed.

The work mentioned in this report has been carried out in cooperation by M. Graser and the undersigned.

Harry J. Vanderlaan.

H. J. Vanderlaan
Development Engineering

HJV:rer
2-13-57

cc: CG Fick
WE Glenn

June 21, 1957

Dr. L.R. Fink
Research Laboratory
The Knolls
Schenectady, New York

During the May 1, 1957 Research Laboratory meeting you raised several questions concerning field sequential color television receiver operation. These questions have served as the basis for two investigations by IE Lynch, TT True, and myself on field sequential receivers and field sequential standards conversion. Reports on these investigations are attached.

We would appreciate hearing any comments you might have regarding these reports.

Frank G. Cole

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Color TV Product Engineering
Television Receiver Department
Room 303, Building 5

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Report No. 96
6/20/57

MISCELLANEOUS INVESTIGATION REPORT

Picture Tubes and Systems Considerations Under Field-sequential Operation

By: FG Cole
and
IE Lynch

Abstract

The following investigation relates to considerations of receiver operation with field-sequential standards. All presently known tubes were given consideration. The purpose of the investigation was to determine if any reduction in receiver cost or improved performance resulted. With the presently available compatible signal, such cost savings would have to offset the cost of a signal or standards converter. Consideration is also given to future cost savings should field-sequential standards again be adopted.

Conclusions

Several picture tubes indicate improved operation under field-sequential system standards. Chromatron and penatron are the two tube types that show above average improvement. Both of these types have improved brightness and require less switching power.

The results of a system analysis using the chromatron and penatron tubes operating with field-sequential standards indicate that circuitry and cost reduction can result. However, the $150.00 manufacturing cost objective established by the TVRD Marketing group can not be met through this cost reduction. In view of the complexities of changing the standards, the design problems of field-sequential, and the relatively low cost reductions, a recommendation for field-sequential standards can not be made.

Tube Evaluations With Field-Sequential Operation

The following general comments can be made about present day color tubes when operated field-sequentially:

1. Three gun tubes offer no improvement. Convergence problems still exist, and tube brightness is reduced by approximately three times. Examples of this tube type are RCA - AM, GE-PA, three gun Lafferty and penetron, and the Gabor tube.

2. One gun tubes with "accurate beam location" either by indexing or accurate scan, are not improved. There is no easing of sweep tolerance or indexing requirements, and brightness is again reduced by a factor of three. Examples of this type of tube are "accurate beam scan tubes" and Apple.

3. One gun "direction sensitive" tubes are slightly improved by reduction of the switching power required to change the direction of beam approach. Brightness is increased by increasing conduction angle from approximately 40 degrees to approximately 120 degrees per color. Convergence circuitry is required and registration would probably be more difficult than with three guns. Examples of this type of tube are the one gun AM, one gun PA, and one gun Gabor

(with position switching in the neck). Exceptions to this statement are as follows: The one gun AM with chroma rate switching or movement of the beam in the tube neck, and the one gun Gabor modification with a reflector electrode similar to that in the Lafferty tube. With the AM tube field-sequential operation would produce the same white brightness but reduced color saturation. Convergence problems would remain. With the Gabor tube variation brightness would be improved.

4. One gun tubes with "color processing at the screen", offer improved operation because of increased conduction angle and brightness, and because switching power is generally reduced. Examples of this tube type are the Chromatron, single gun Lafferty, and Dome's magnetic tube.

From the above discussion, it is seen that only the following four presently available tubes show improved operation with field-sequential operation:

1. Lafferty
2. Gabor tube with Lafferty reflector.
3. Dome's magnetic tube.
4. Chromatron

These will now be discussed in more detail.

Lafferty Tube:

Field-sequential operation of the Lafferty tube will result in decreased switching power. Since switching power is small even at dot rate, this is a minor factor. Brightness will be improved since the conduction angle per color can be increased from approximately 45 degrees to approximately 110 degrees. Disadvantages to be considered are secondary electron haze, keystone correction requirement, power supply regulation requirements, and a mask transmission of only 25%.

Gabor Tube with Lafferty Reflector:

All comments made on the Lafferty tube apply here with the exception that "collimation" will eliminate the need for keystone correction.

Dome's Magnetic Tube:

Field-sequential operation of this tube will decrease switching power but switching current and power will remain high. Physical size of the conductors required to carry 500 amps switching current would be excessive. Only two-color operation can result.

Chromatron:

Field-sequential operation of this tube will reduce switching power. Brightness on saturated colors will be improved by a factor of three. White brightness will not be improved over current Chromatron circuitry where dot rate switching is stopped when white is being produced. Subcarrier radiation will be eliminated.

This tube seems to offer the best field-sequential possibilities of the four tubes discussed even though tube cost is high.

In addition to presently available tubes and systems, several proposed and experimental systems could be operated at a field-sequential rate. The most prominent of these are:

1. Electrically controlled filters.

2. Light Amplifiers.

3. Mechanically moved filters.

4. Secondary excitation.

5. Eidophor.

6. Scophony.

7. Single gun pentron.

Electrically Controlled Filters and Light Amplifiers:

Field-sequential operation of these systems will reduce the required switching power to the point of practicability. With dot rate switching, an extremely fast rise and decay time (less than 0.1 us) is required of the phosphor in the light source. Field-sequential operation greatly lessens this difficult to attain requirement. High-voltage regulation is required but may prove only slightly troublesome if overall efficiency can be made high. Picture brightness should be higher than with dot rate operation since switching would be square-wave instead of sine-wave.

Based on a filter capacity of 3,000 uuf, a switching voltage requirement of 4.5 kv, and a blanking time of 445 us the following numbers were calculated for switching power:

Power delivered to tube capacity = 3 watts.

Power required of broad-band amplifier to deliver this power in the available time = 400 watts.

The actual power required for such switching may be anywhere between 3 and 400 watts depending upon the efficiency of the system designed.

The following calculation is an estimate of the theoretical switching power reduction factor which should be saved by field-sequential operation. The factor is proportional to the frequency ratio and is modified by a factor of 50 since Q multiplication no longer exists, and a factor of 10 because square wave switching is required instead of sine-wave.

$$\text{power reduction factor} = \frac{f\ \text{subcarrier}}{f\ \text{field}} \times \left(\frac{1}{50 \times 10}\right)$$

$$= \frac{3.58 \times 10^6}{144/3} \left(\frac{1}{500}\right)$$

$$\approx 150$$

Mechanically Moved Filters:

Mechanically moved filters offer operation with a monochrome tube. Picture tube size is limited by filter rotation problems. Mechanical systems always produce noise. Color synchronism is difficult. The power supply must be regulated to maintain registration. Receiver cost would probably be as low or lower than any other known type.

Secondary Excitation:

Switching power of this sytem may be reduced slightly by field-sequential operation. High-voltage regulation is required. Picture brightness would be improved since conduction angle would be increased.

Eidophor:

Field-sequential operation is presently used in this system. Picture size is not limited by filter wheel size. An alternate system proposed by Dr. WE Glenn makes use of a more closely spaced defraction grating to produce color. Field-sequential operation of this system offers no advantages over simultaneous operation.

Scophony:

To produce simultaneous color, three units with color filters would probably be used. Field-sequential operation would use only one unit with a color wheel. With this arrangement, switching power would be low, picture size would not be limited, brightness would be reduced (less units and light sources), registration and regulation would be no problem. An alternate approach would be to produce the desired color in the cell. Field-sequential operation in this case would probably produce equivalent operation.

Single Gun Penetron:

With field-sequential operation, the penetron tube will require less switching power, but switching voltage would be high with present phosphors. Using a square wave type switching voltage, it is calculated that a driving power source of 17 watts (based on 100 uuf capacity, ± 5000V switching, and a blanking time interval of 445 us) will be sufficient. The power actually dissipated in the tube's capacity, is insignificant. Color reproduction with presently available phosphors would be poor. Phosphor efficiencies are between three and five times poorer than powdered phosphors. Should future phospher development eliminate this disadvantage, the penetron would become a good field-sequential candidate.

Cost and Circuit Consideration

The preceding section has shown that the Chromatron and Penetron picture tubes have the potential of providing above average improvement when operated under field-sequential standards. Circuit and cost analysis of these tubes in complete receivers are presented in this section in order to determine the improvement. For comparison purposes only a color wheel mechanical system is also presented.

The transmission standards used for this cost estimate are the 1951 CBS standards. These were chosen because they are known in the industry and require a minimum of circuit changes and no transmission bandwidth change.

Many observers judge the 1951 CBS standards as inadequate. In view of this, standards capable of production of a picture with NTSC quality were also considered. These standards require higher frequency sweeps and switching and about 12 mcs transmission bandwidth necessitating additional RF, IF and video bandwidth. Circuitry and cost analysis indicates that an increase in manufacturing cost of $27.00 would suffice to handle the improved performance regardless of the tube type.

The cost estimates are for the manufacturing cost of a complete color television receiver. The basis for the cost is a standard present production monochrome U2 table model receiver. Necessary circuitry is added to this receiver to operate the given tube and then a cost estimate is made of the resulting receiver. The receiver manufacturing costs are as follows:

Receiver Manufacturing Costs - Field-Sequential

	CBS-1951	NTSC Quality
Chromatron Tube	230.37	257.37
Penetron Tube	188.17	215.17
Color Wheel with Monochrome Tube	175.00	202.00

Typical NTSC receivers operating at dot sequential rate are shown below for comparison:

Receiver Manufacturing Costs - NTSC

Chromatron Tube	$266.00
"Apple" Tube	258.00
AM Tube	268.00

The Chromatron receiver, the one common to both field-sequential and NTSC cost estimates, shows a small cost reduction through use of transmitted field-sequential signals. Considering the problems and cost involved with a standards change, this reduction is not enough to warrant a change recommendation.

The Penetron receiver shows a greater reduction over the average NTSC receiver than the Chromatron. The projected tube cost accounts for this difference. The pentron is now only in a stage of early development - too early to draw any conclusions or recommendations from present projected costs.

The spinning color wheel represents a sizable cost reduction over the average NTSC receiver although past history dictates that the marketability and the viewing problems are too serious to give further consideration to this system.

In conclusion, the field-sequential standards do provide a reduction in receiver costs but not to the $150.00 objective of the TVRD Marketing group. In view of the problems of the standards change, circuit design, and resulting low cost reduction, a recommendation for field-sequential standards cannot be made.

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I Edward Lynch
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MISCELLANEOUS INVESTIGATION REPORT #86
DEVELOPMENT ENGINEERING

TELEVISION RECEIVER DEPARTMENT
MAY 21, 1957

CONVERSION OF THE NTSC SIGNAL TO FIELD-SEQUENTIAL OR LINE-SEQUENTIAL SIGNALS

by: T. T. TRUE

ABSTRACT

Systems are presented for conversion of the NTSC signal to one suitable for application to field-sequential or line-sequential color display devices.

CONCLUSIONS

It is technically possible to convert the NTSC color signal to either field-sequential or line-sequential type signals. However, the system required for this conversion is both complex and expensive. There are certain basic functions of scanning, storage, and rescanning which are fundamentally necessary in the "converter". It is therefore very doubtful whether the system could ever be economical or practical enough for use in a mass-production color receiver.

Figures (1) and (2) show systems for field and line-sequential conversion, respectively. Being extremely optimistic, it is estimated that the cost, over and above normal A.M. receiver circuit costs, will be $108 for the field-sequential converter and $66 for the line-sequential converter. It can be seen, from these costs, that any possible savings which might be realized by use of a field sequential or line-sequential color display device will be more than offset by the cost and complexity of the necessary converter.

If a choice is made between the "lesser of the two evils", line-sequential conversion appears to have the most future potentialities. Storage requirements are much less than in field-sequential systems, since only one or two lines of element information need to be stored.

INTRODUCTION

In seeking possibilities for a cheap color set, it has been proposed that field-sequential and line-sequential color display systems may be simpler and cheaper than the presently used dot-sequential and simultaneous systems. Unfortunately, however, the NTSC color signal does not lend itself to direct use with either field or line-sequential display devices. But, with the hypothesis that field-sequential or line-sequential display devices are cheap, a receiver system may be proposed in which the NTSC signal is first "converted", and then applied to a sequential color display. If the "conversion" could be accomplished cheaply enough (say, twenty dollars), then the overall receiver cost might, indeed, be low enough to be commercial.

TECHNICAL REQUIREMENTS FOR THE CONVERTER

The NTSC signal has the following scanning rate:

Field rate	60 cps
Frame rate	30 cps
Line rate	15.73 KC

The red, green, and blue color signals can be derived from the NTSC composite signal and applied either simultaneously or dot-sequentially to a color display device. However, if the NTSC color picture is to be presented by field or line-sequencing, without degradation, the sequence must be completed during the time of one NTSC field (1/60 sec.), or during the time of one NTSC line ($\frac{1}{15,734}$ sec.). This necessitates new scanning rates as follows:

Field sequential:		
Field rate	180 cps	R, G, and B fields presented sequentially, 1/60 sec. being required to complete a sequence.
Line rate	47.25 KC	
Frame rate	30 cps	
Line sequential:		
Field rate	60 cps	R, G, and B lines presented sequentially, $\frac{1}{15,734}$ sec. being required to complete a sequence.
Line rate	47.25 KC	
Frame rate	30 cps	

Now, the NTSC signal cannot be converted to the above scan rates by any simple process, such as electrical gating. The conversion fundamentally requires some form of storage and rescanning. This is necessary because the new scanning system calls for signal element information at a different rate and different time than it is presented by the NTSC signal.

The amount of required storage is different for a field-sequential converter than it is for line-sequential. For a field-sequential converter, it is necessary to store at least one complete field, and usually a complete frame of element information. However, for line-sequential conversion, it is only necessary to store one or two lines of element information. Therefore, it appears that the storage problem will be much simpler for a line-sequential converter.

PROPOSED CONVERTER FOR FIELD-SEQUENTIAL

In Figure (1), a block diagram of a proposed scan converter is given. The system operates as follows: Red, Green, and Blue video signals are derived from the NTSC composite signal by use of normal circuitry. These signals are applied to separate storage tubes using normal 60 cps and 15.73 KC sweeps. The signals are read out of the storage tubes at the new sweep rates, 180 cps and 47.25 KC. The signals from the three channels then need only to be sequentially gated into a common output in order to generate the desired field-sequential signal.

The known storage tubes which might be used in this application have very high signal transfer loss. For about 50 volts input video signal, only 10 millivolts or so output can be obtained. Thus, a high gain, wide band video amplifier must be used to amplify the output to reasonable levels. A voltage gain of 300 is needed to obtain second detector signal levels, and a gain of 12,000 is needed to obtain picture tube driving levels. The bandwidth must be 9 MC in order to correspond to an original video bandwidth of 3 MC in the conventional scan system. Needless to say, this will introduce noise and stability problems.

If the reading and writing scan lines are oriented parallel to each other, moire effects will cause light and dark "bands" in the rescanned picture. However, this can be prevented by such techniques as spot wobble, controlled beam size, or by "cross scanning". The first two methods do not preserve interlace resolution of the original picture, whereas the latter approach does. But, in order for the cross scanning system to preserve all of the original interlace resolution, a bandwidth of better than 11 MC is necessary in the video amplifiers following the storage tube. Bandwidths this wide would not be very practical, and therefore some compromising of vertical resolution will be necessary.

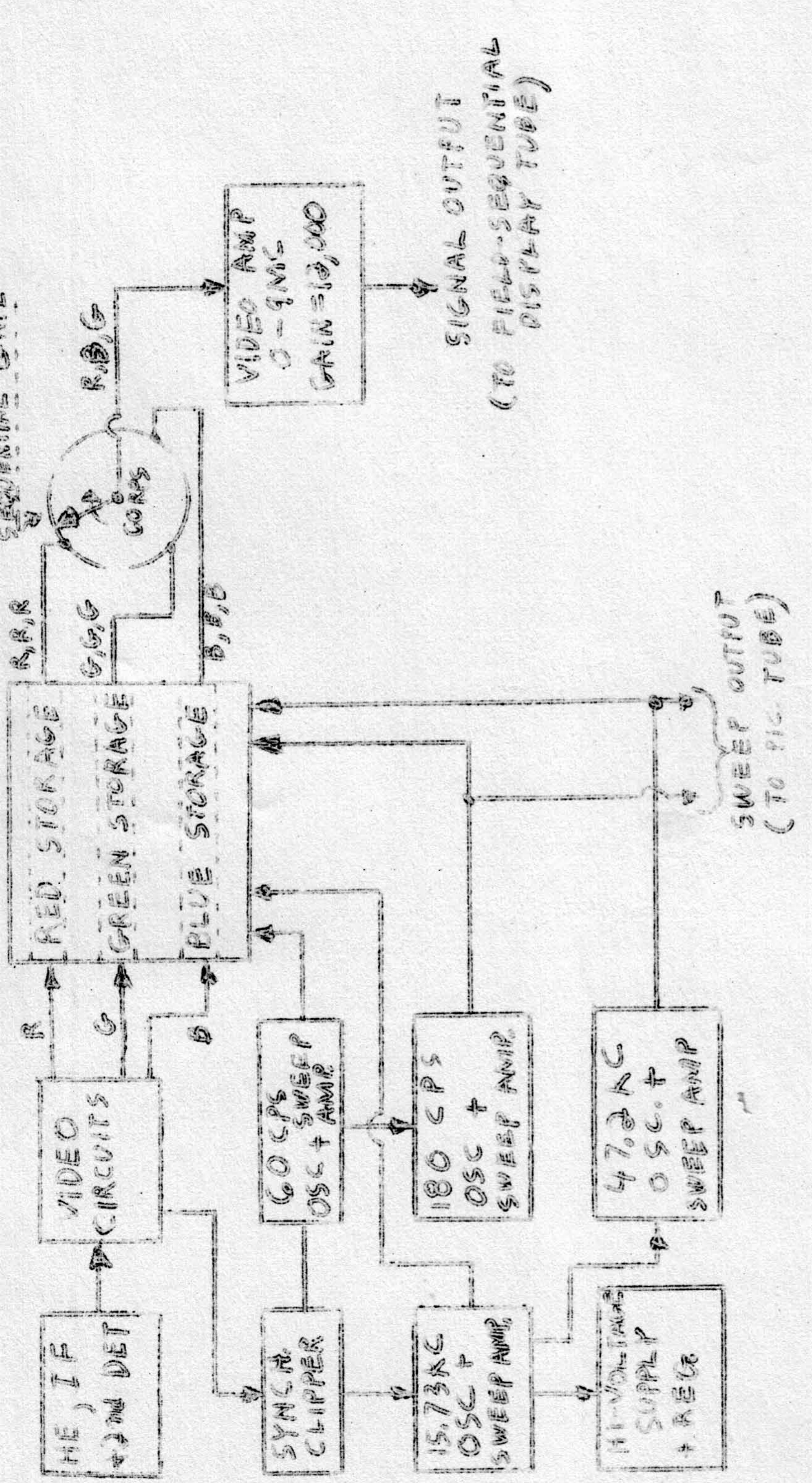


FIG. (1)
BLOCK DIAGRAM
NTSC to FIELD-SEQUENTIAL CONVERTER

Figure (1)

COST OF NTSC-TO-FIELD-SEQUENTIAL CONVERTER

It is not necessary to go into an exact cost analysis of the converter system (Figure (1)) to tell that it will cost considerably more than $20. The major cost is tied up in the storage tubes, but even the circuits which are associated with them, when considered separately, cost more than $20 to manufacture. Storage tubes of a type which might be used for this purpose in the immediate future cost around $600 apiece. Naturally, the cost of these tubes in mass-production would be considerably less, but it is not reasonable to expect the cost to ever be less than the cost of a picture tube (say, $20 apiece). The following is an approximate tabulation of the mass-production costs of the converter. These costs do not include the video processing circuits necessary to produce R, G, and B signals, nor any other circuits common to the AM receiver.

Function:		Estimated mass-production cost
Storage tubes (3)	Present cost $1800	$60
Receiving tubes (10) and circuits		$30
Misc.: Yokes (6 matched)		$18
	TOTAL COST	$108

The above costs are considered very optimistic, and actual cost of the converter would probably be higher.

PROPOSED CONVERTER FOR LINE-SEQUENTIAL

A proposed scan converter for line-sequential display is shown in Figure (2). The basic operation involved is very similar to that of the Figure (1) system. Major difference is that 60 cps and 180 cps sweeps are not necessary on the storage tubes. Lines of R, G, and B signals are stored at 15.7 KC, and are read out at 47.25 KC sweep rate. The sequential gate now operates at 15.7 KC rather than 60 cps.

COST OF NTSC-TO-LINE-SEQUENTIAL CONVERTER

The line-sequential converter should cost less than the field-sequential converter because of the decreased storage and sweep needs. However, it is difficult to estimate the exact cost for the storage tubes involved because their exact form is not known.

Function:		Estimated mass-production cost
Storage tubes (3)		$30
Receiving tubes (8) and circuits		$24
Misc.: 6 yokes (Horizontal coils only)		$12
	TOTAL COST	$66

ALTERNATIVE APPROACHES

Although the systems shown in Figures (1) and (2) appear to be the most straight forward approach to standards conversion, there are many variations and alternatives which might also be used. Unfortunately, none of these appear to be appreciably simpler or cheaper. Some of the alternatives which are considered are as follows:

Other storage means may be used, such as magnetic tape or drum storage. This approach usually requires mechanical movement of both the storage medium and the pick-up heads. A "color wheel" field-sequential display device might be used with this system, the same rotating means being used to drive both the color wheel and the storage device.

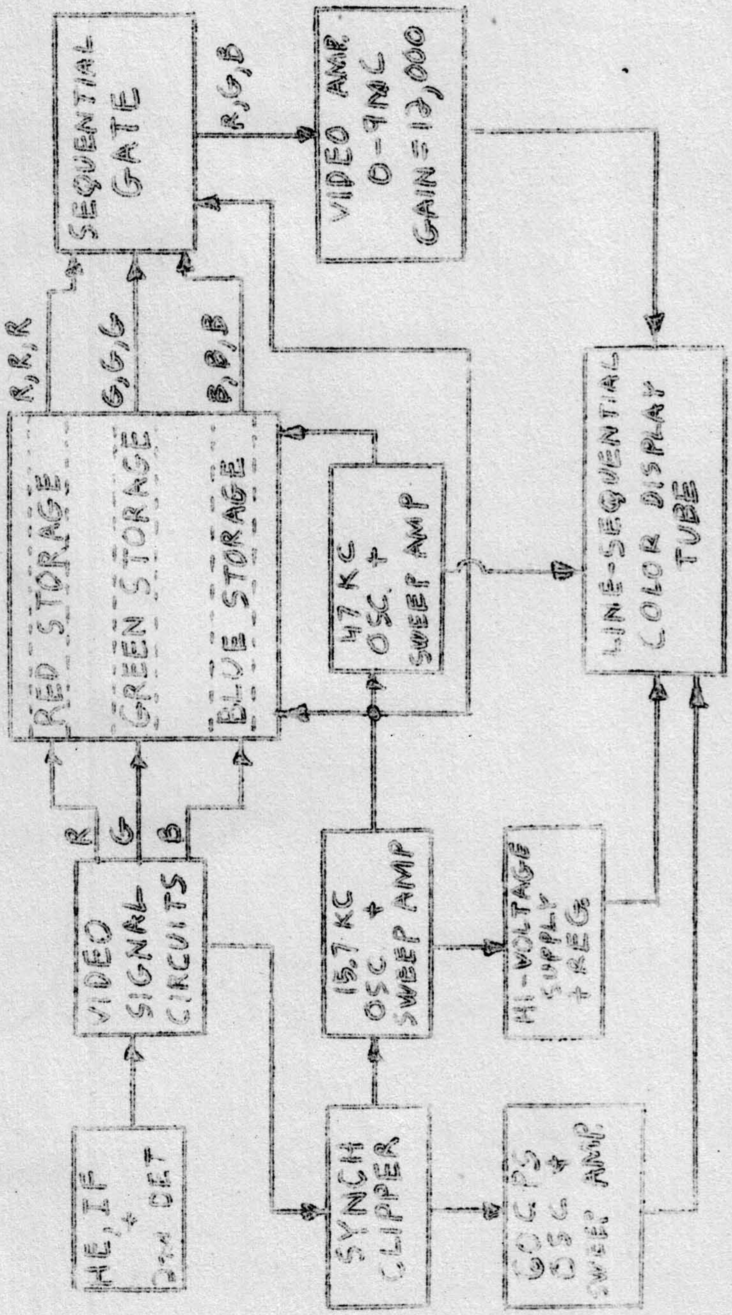


FIG. (2)
BLOCK DIAGRAM
NTSC to LINE-SEQUENTIAL CONVERTER

Figure (2)

Different signal processing may be used prior to storage. For example, the quantities Y, (R-Y), and (B-Y) might be derived and stored instead of R, G, and B. This would complicate the matrix circuitry since it would now follow the storage devices, but it would allow two of the storage devices to operate at reduced bandwidth (500 KC) for the (R-Y) and (B-Y) signals).

The NTSC composite video signal could be stored directly without going through the processes of sub-carrier regeneration and color-difference signal demodulation. This would require only one storage device, with the color processing circuits occuring after the rescanning operation. However, in order to derive a consistent sub-carrier reference signal (which would be 10.7 MC in the new scan system), extremely accurate time consistency would be required of the storage and rescanning sweeps. Also, the storage device would need to be very linear to avoid luminance errors caused by the presence of the sub-carrier signal.

T. T. True
Development Engineering
TELEVISION RECEIVER DEPARTMENT

TTT:rer
5-23-57
cc: RB DOME
DE GARRETT
DE HARNETT
JF McALLISTER
DW PUGSLEY
WE GOOD
M GRASER
N JOHANNESSEN
IE LYNCH
MJ PALLADINO
TT TRUE
HJ VANDERLAAN
FG COLE
BA FIELD
GA SCHUPP
TV ZALOUDEK
LC MAIER #6
JC NONNEKENS #6
WD RUBLACK #6
EF SCHILLING #6

COPY

RTD-458-12 (1-57)

TELEVISION RECEIVER DEPT.

DATE	D.A. NUMBER	MODEL NUMBER
5-10-57		Gross Two Color

CLASS	ISSUE	BANDS	CHANNELS	MANUFACTURING PLANT
Preliminary				

DESCRIPTION:
Color TV - Table Model
Gross Two Color Aperture Mask

MATERIAL			
CABINET	10.07		
CABINET ACCESSORIES	7.50		
CATHODE RAY TUBES	42.00		
OTHER TUBES	11.84		
SPEAKER	.80		
CHASSIS ASSEMBLY	58.29		
PACKING	1.50		
TOTAL	132.00		
FREIGHT	1.98		
SPOILAGE	1.98		
TOTAL MATERIAL	135.96		
LABOR			
ASSEMBLY LABOR			
UNAPPLIED LABOR			
VARIANCE			
TOTAL LABOR			
P.E.C.E.			
D.A. LIQUIDATION			
SPEAKER			
ELECTRONIC REPRODUCER			
GEN. DEVELOPMENT			
TOOL MAINTENANCE			
TOTAL P.E.C.E.	12.50		
WARRANTY COSTS			
SET WARRANTY	1.61		
PICTURE TUBE WARRANTY	1.75		
TOTAL WARRANTY	3.36		

LIST PRICE		365.00		
DISCOUNT				
DISTRIBUTOR COST		254.56		
EXCISE TAX		25.46		
NET G.E. SELLING PRICE		229.10		
GROSS MARGIN	DOLLARS	45.81		
	PER CENT	20%		
QUANTITY		100,000		

COST SUMMARY			
MATERIAL	135.96		
LABOR	10.00		
I.M.E.	15.00		
SHOP COST	160.96		
P.E.C.E.	12.50		
WARRANTY	3.36		
EXTRA COST	3.53		
MFG. COST LESS ROYALTY	180.35		
ROYALTY	2.94		
TOTAL MFG. COST	183.29		

PREPARED BY	APPROVAL—FINANCIAL	APPROVAL—ENGINEERING	APPROVAL—MANUFACTURING

COLOR TV SYSTEMS PATENT SEARCH

In order to complete the study of all the known color TV systems, a search of the U.S. Patent Office files was made. A total of 246 patents were found that pertained to color TV receiver systems and color display devices. Specific circuit patents which did not embrace the system concept were not included. The degree of completeness of this file is indicated by the fact that the issue dates range from 1912 to 1956. To facilitate the investigation, the patents were divided into ten categories as follows:

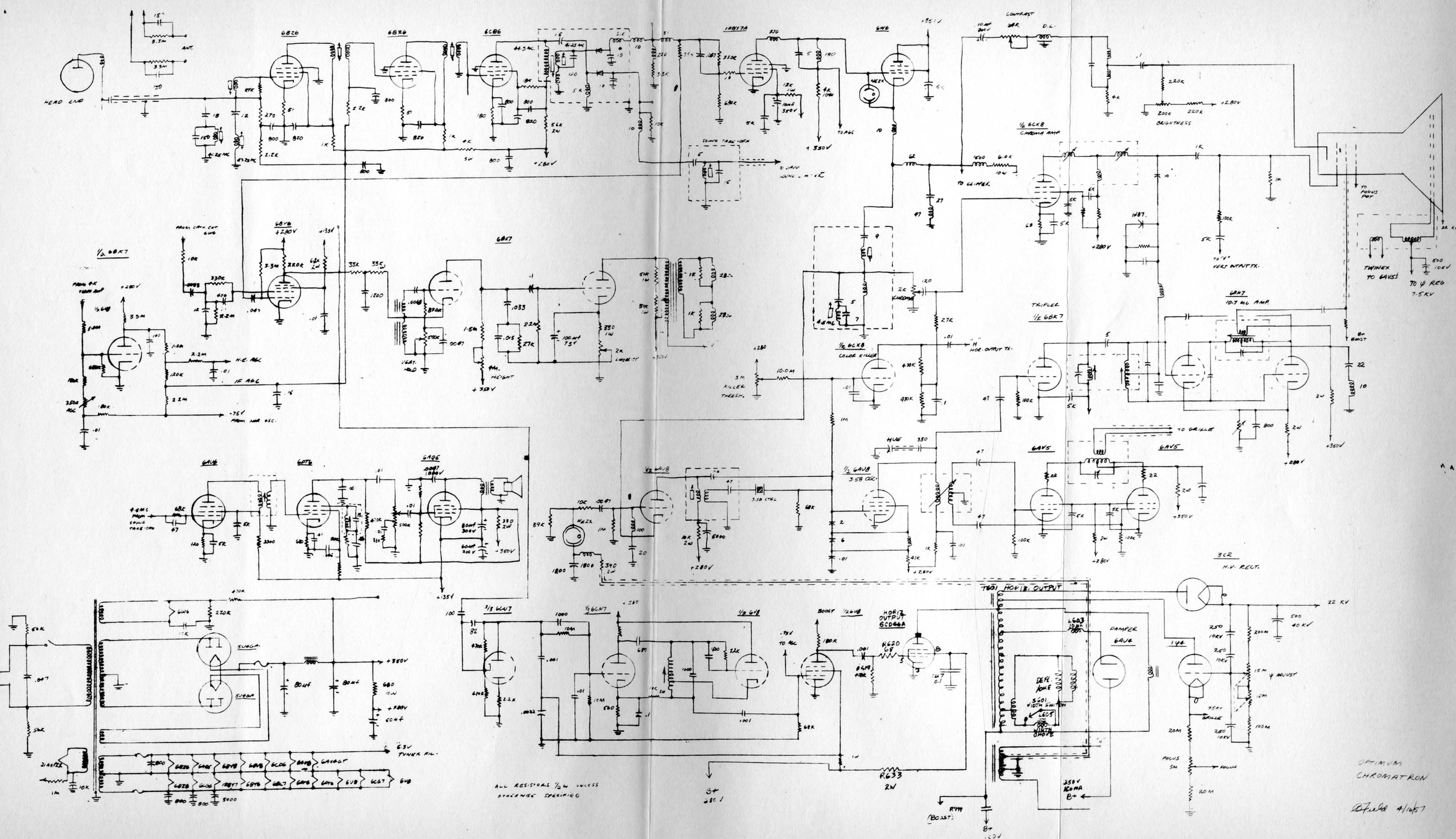
1. Direction sensitive color selection.
2. Color switching at the phosphor screen.
3. Velocity sensitive color selection.
4. Light amplifiers and electroluminescence.
5. Accurate beam scan.
6. Color filters and light valves.
7. Projection.
8. Beam indexing systems.
9. Mechanical systems.
10. Miscellaneous.

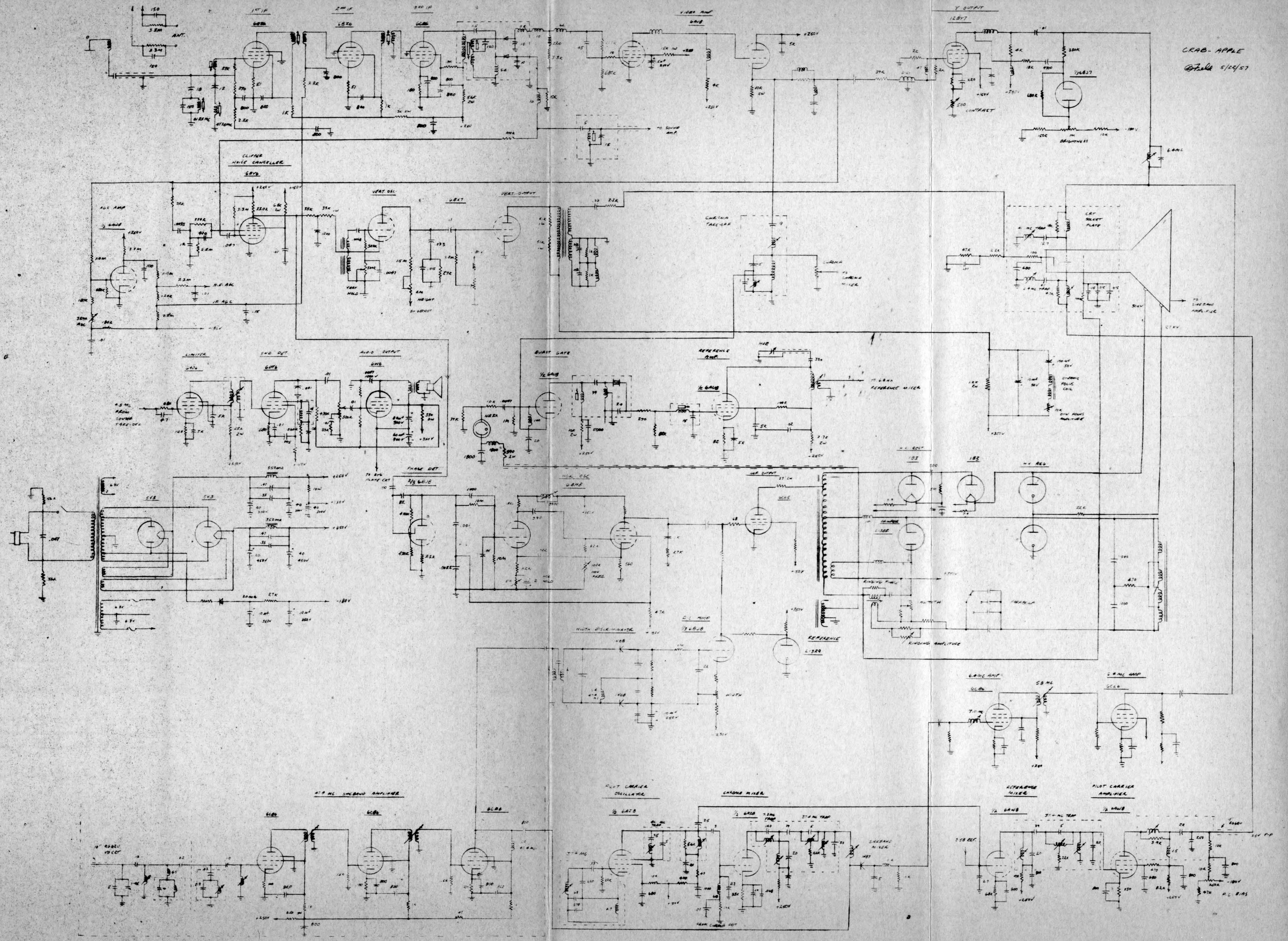
Each of the above groups were carefully examined to determine if they contained any significant contributions that would affect any of the system analyses. No patents were found in any group that in themselves offered the possibility of the major cost break through for which this color study group has been searching. None of the patents presented information that affected any of the conclusions presented elsewhere in this report. However, patents were found in both the Beam indexing and Color Filter categories that described techniques worthy of further investigation. For example, about ten patents were found on controllable color filters that present possible approaches to this method. While none of these patents show color systems that have been reduced to practice, they should be thoroughly analyzed on the basis of receiver requirements in the light of the development of new materials.

In summary, none of the patents reviewed disclosed information that altered the conclusions presented in this report. A few patents were found that should be studied further on the basis of future developments of materials and processes.

T. V. Zaloudek
TV Zaloudek
Color TV Product Engineering

TVZ:erh
6/19/57


HEAD END
ANT.
6BZ6
6BZ6
6CB6
12BY7A
6W6
CONTRAST
BRIGHTNESS
1/2 6CX8
CHROMA AMP
SOUND TAKE-OFF
1/2 6BK7
6BK7
TRIPLER
1/2 6BK7
6BK7
10.7 MC AMP.
1/2 6CX8
COLOR KILLER
6AU6
6DT6
6AQ5
1/2 6AU8
3.58 XTAL
6AV5
6AV5
TO GRILLE
H.V. RECT.
T601 HORIZ. OUTPUT
DAMPER
6AU4
HORIZ OUTPUT
6CD6GA
R633
2W
6.3V
TUNER FIL.
ALL RESISTORS 1/2 W UNLESS
OTHERWISE SPECIFIED
OPTIMUM
CHROMATRON



CRAB-APPLE
5/25/57
1st IF
2nd IF
3rd IF
ANT.
VIDEO AMP
Y OUTPUT
CONTRAST
BRIGHTNESS
TO SOUND AMP.
CLIPPER NOISE CANCELLER
AGC AMP
VERT OSC.
VERT OUTPUT
VERT HOLD
HEIGHT
CHROMA TAKE-OFF
CHROMA
CRT SOCKET PLATE
LIMITER
SND DET
AUDIO OUTPUT
BURST GATE
REFERENCE AMP
PHASE DET
HOR OSC
HOR OUTPUT
H.V. RECT
H.V. REG
RINGING AMPLITUDE
WIDTH DISCRIMINATOR
REFERENCE
PILOT CARRIER OSCILLATOR
CHROMA MIXER
REFERENCE MIXER
PILOT CARRIER AMPLIFIER

CONT ON SHEET SH NO.

DRAWING NO.

GENERAL ELECTRIC

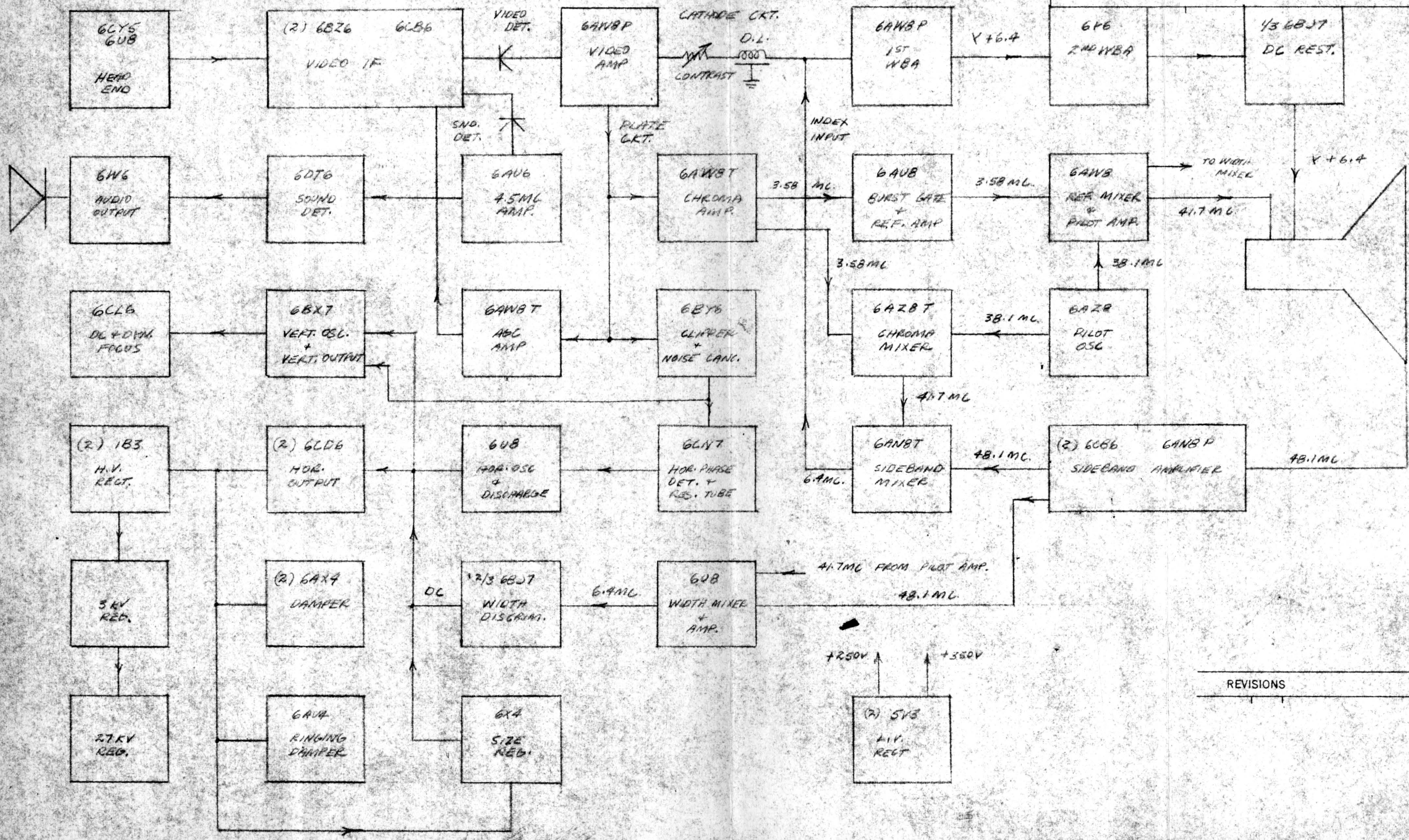
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:—

APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS			REV NO.
		FRACTIONS	DECIMALS	ANGLES	
	✓	±	±	±	CONT ON SHEET SH NO.

TITLE SIGNAL BLOCK DIAGRAM

FIRST MADE FOR CRABAPPLE

CONT ON SHEET SH NO.



REVISIONS	PRINTS TO

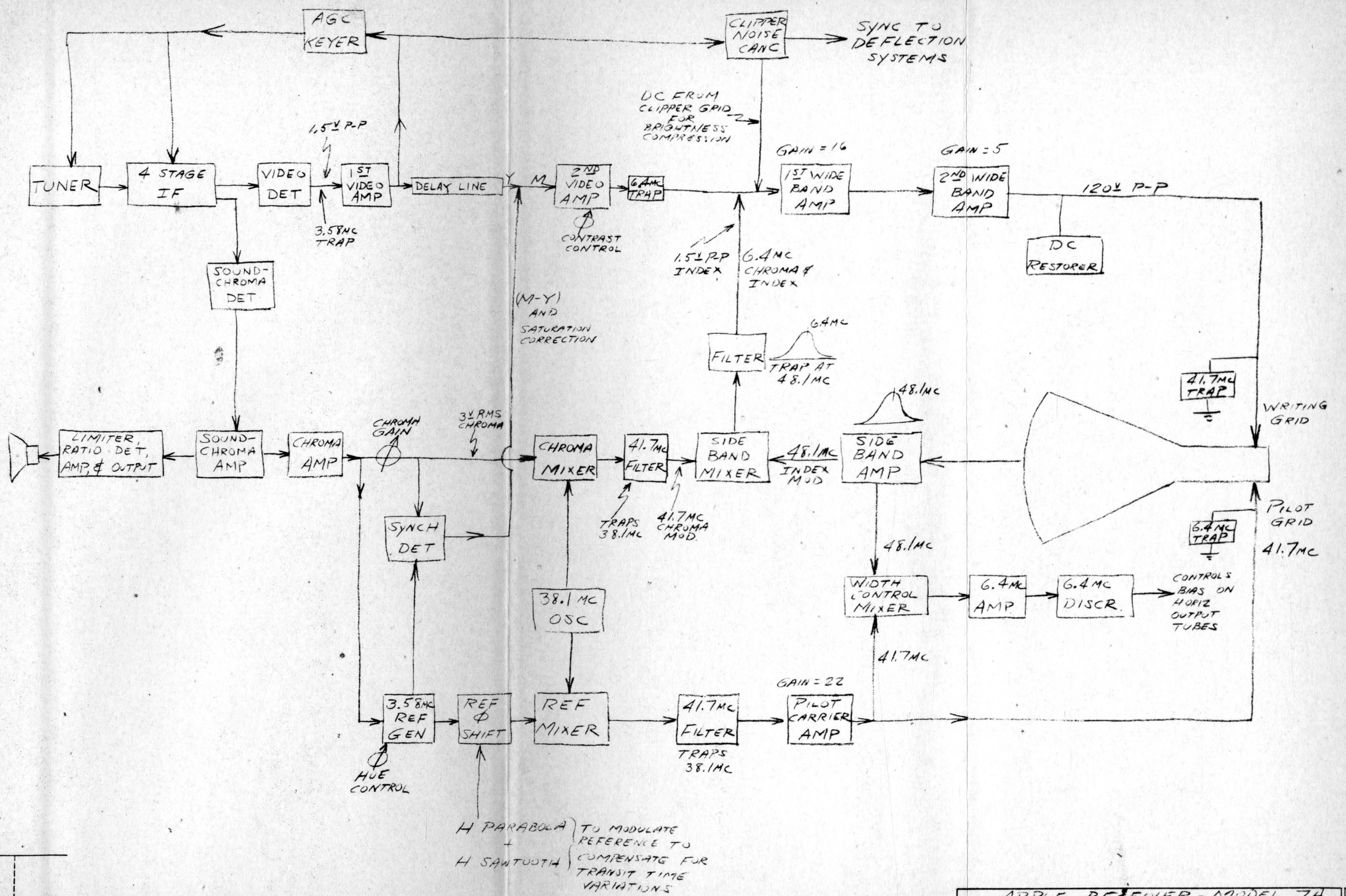
MADE BY	B. Field	APPROVALS	TELEVISION RCVR.	DIV OR DEPT
ISSUED	3/13/57		ELECTRONICS PARK	LOCATION

CONT ON SHEET SH NO.

FOLD

FF-806-P (4-54) PRINTED IN U.S.A.

1 | 2 | P- | 4 | THIRD ANGLE PROJECTION | 6 | 7



REVISIONS

APPLE RECEIVER - MODEL 7A

COMPLETE SIGNAL PROCESSING

TOLERANCES UNLESS SPECIFIED
FRACTIONS ¼ OR LESS ± .008
3 PLACE DECIMALLS ± .005
ALL OTHER DIM. ± .015
ANGLES ± ONE DEGREE

FIRST MADE FOR

DRAWN BY T.V. Zabudek

TRACED BY

INSPECTED

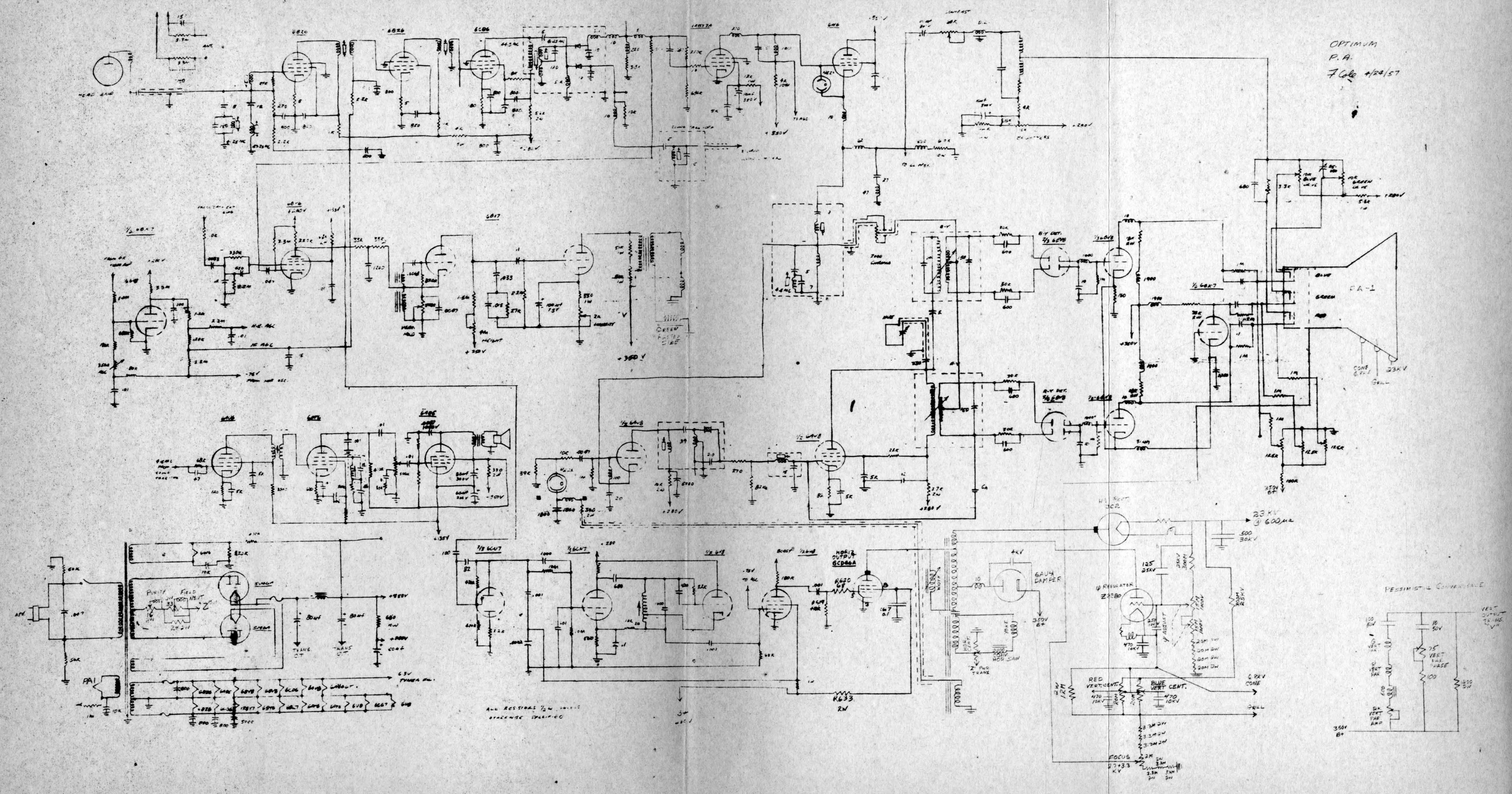
GENERAL ELECTRIC
ELECTRONICS PARK
1/30/57

P-

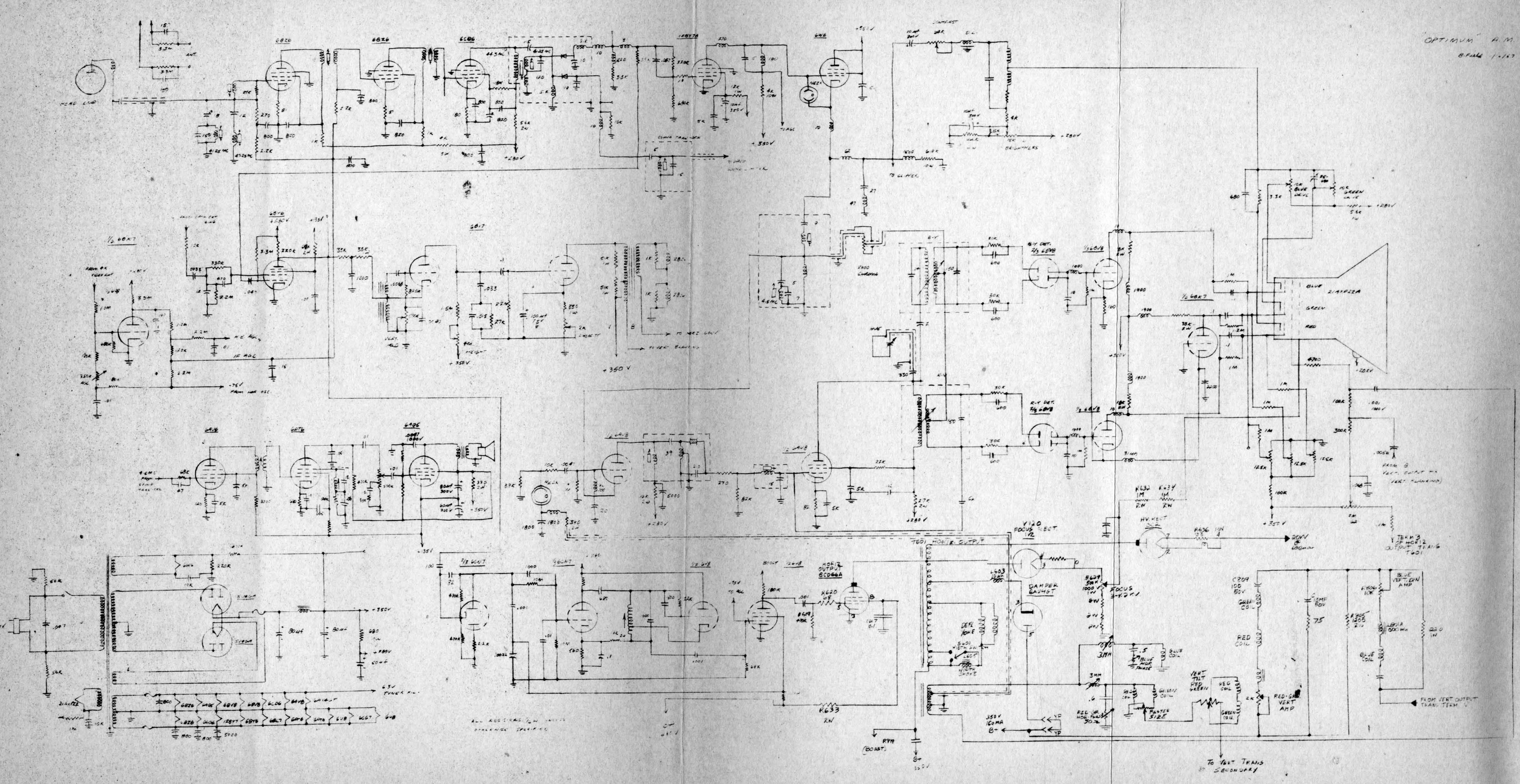
PRINTS TO

RADIO & TELEVISION DEPT.

1 PRINTED IN U.S.A. | 2 | 3 | 4 | 5 | 6



OPTIMUM
P. A.
PESSIMISTIC CONVERGENCE
23 KV
@ 600μa
500
30KV
6AU4
DAMPER
HORIZ
OUTPUT
6CD6GA
R620
R633
2W
FOCUS
RED
VERT CENT.
BLUE
VERT CENT.
CONE
GRILL
PA-1
BLUE
GREEN
RED
GREEN
RASTER
SIZE
HEIGHT
+350V
ALL RESISTORS 1/2 W UNLESS OTHERWISE SPECIFIED



OPTIMUM A.M.
CONTRAST
BRIGHTNESS
+280V
+350V
1/2 6BK7
IF AGC
CHROMA
B-Y DET.
R-Y DET.
1/2 6BK7
BLUE
GREEN
RED
21AXP22A
T601 HORIZ. OUTPUT
V120
FOCUS RECT.
1X2
DAMPER
6AU4GT
HORIZ OUTPUT
6CD6GA
FOCUS
GREEN COIL
RED COIL
BLUE COIL
BLUE VERT DYN AMP
RED-GRN VERT AMP
RASTER SIZE
R633
RW
R914
(BOOST)
B+
350V
160MA
B+
TO VERT TRANS SECONDARY
FROM VERT OUTPUT TRANS TERM V
ALL RESISTORS 1/2 W UNLESS OTHERWISE SPECIFIED

CONT ON SHEET SH NO
DRAWING NO

GENERAL ELECTRIC

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:

APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS	DECIMALS	ANGLES
	✓	±	±	±

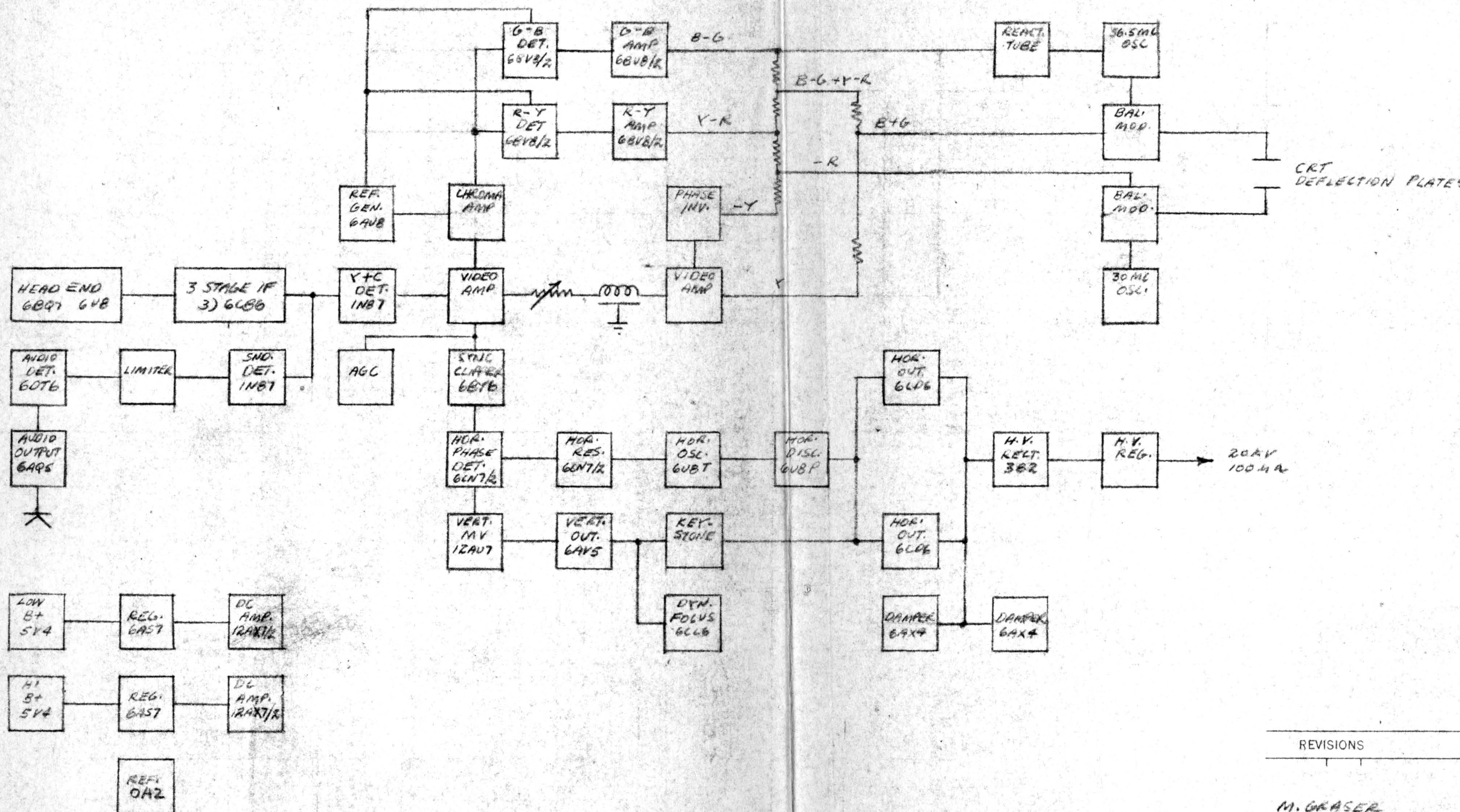
REV NO
CONT ON SHEET SH NO

TITLE BLOCK DIAGRAM RECEIVER CIRCUITS

FIRST MADE FOR COLOR EIDOPHOR

CONT ON SHEET SH NO

Fig. 2



REVISIONS

PRINTS

M. GRASER
B. FIELD

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ISSUED	5-9-57			LOCATION	CONT ON SHEET SH NO

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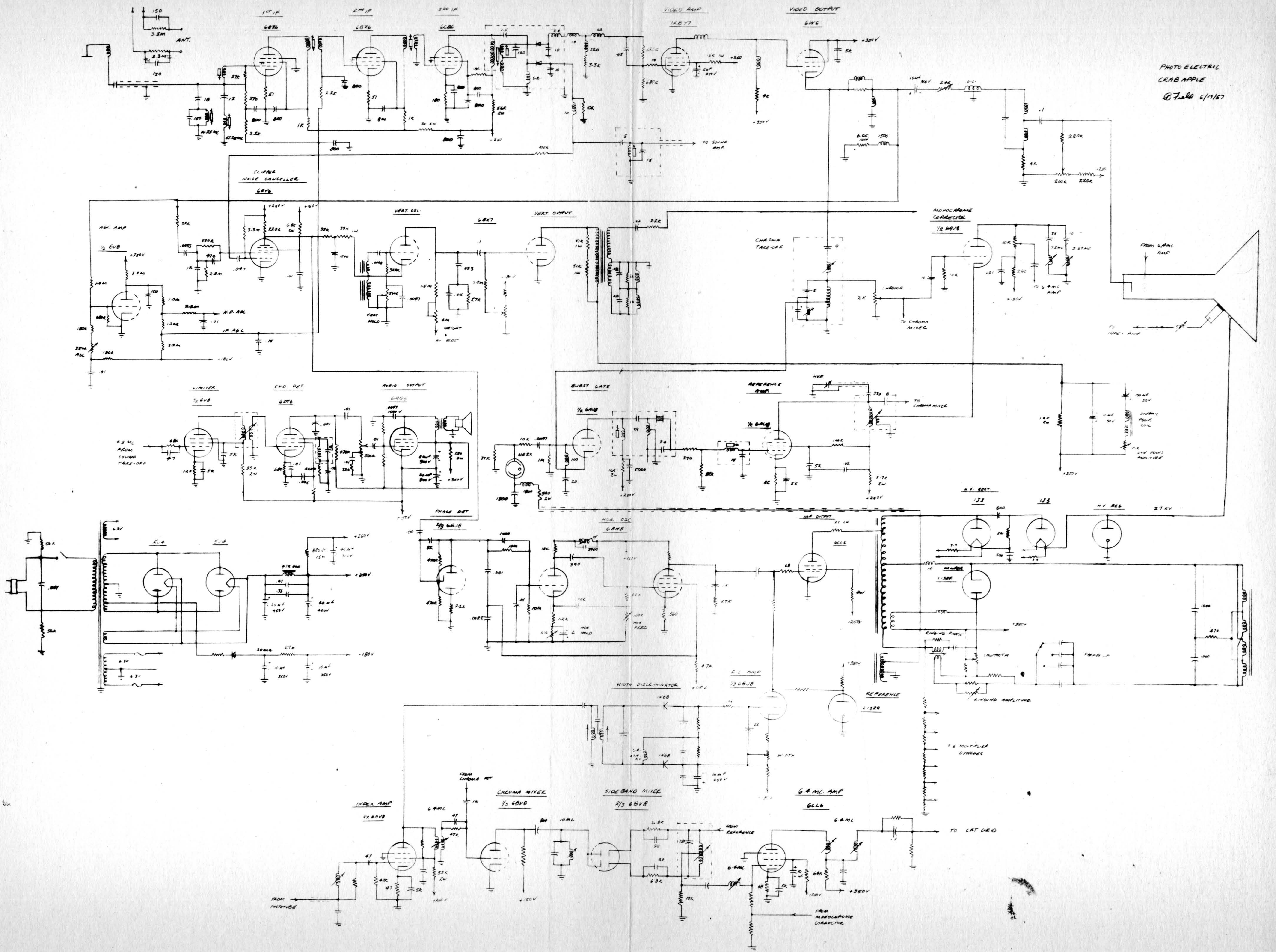
PHOTO ELECTRIC
CRAB APPLE
6/19/57
ANT.
1ST IF
2ND IF
3RD IF
VIDEO AMP
VIDEO OUTPUT
TO SOUND AMP
CLIPPER NOISE CANCELLER
AGC AMP
N.B. AGC
IF AGC
VERT OSC.
VERT OUTPUT
VERT HOLD
HEIGHT
CHROMA TAKE-OFF
MONOCHROME CORRECTOR
CHROMA
TO CHROMA MIXER
FROM 6.4MC AMP
TO INDEX AMP
LIMITER
SND DET.
AUDIO OUTPUT
4.5 MC FROM SOUND TAKE-OFF
BURST GATE
REFERENCE AMP
TO CHROMA MIXER
PHASE DET.
HOR. OSC
HOR HOLD
HOR FREQ
HOR OUTPUT
H.V. RECT
H.V. REG
27 KV
RINGING PHASE
RINGING AMPLITUDE
WIDTH DISCRIMINATOR
D.C. AMP
REFERENCE
WIDTH
H.V. MULTIPLIER DYNODES
INDEX AMP
FROM CHROMA POT
CHROMA MIXER
SIDEBAND MIXER
FROM REFERENCE
6.4 MC AMP
TO CRT GRID
FROM PHOTOTUBE
FROM MONOCHROME CORRECTOR