1956 NATIONAL CONVENTION

IRE Convention Record

Part 7
Audio and Broadcasting

SESSIONS ON

- Trends in TV Equipment
- Audio Techniques
- TV Transmitting Equipment and Techniques
- High Quality Sound Reproduction
- Color Television Tape Recording
- Broadcast Transmission Systems—New Horizons

SPONSORED BY
IRE PROFESSIONAL GROUPS ON

- Audio
- Broadcast Transmission Systems

Presented at the IRE National Convention, New York, N. Y., March 19-22, 1956

The Institute of Radio Engineers

Additional Copies

Additional copies of 1956 Convention Record Parts may be purchased from The Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y., at the prices listed below.

PART	TITLE	Prices for Members (M) College and Pub. Libraries (L) Non-Members (NM)		
		M	L	NM
1	Telemetry, Antennas and Propagation Sessions: 5, 14, 22, 24, 28, 33, 38, 40	$3.00	$7.20	$9.00
2	Circuit Theory Sessions: 30, 41, 49	1.25	3.00	3.75
3	Electron Devices and Receivers Sessions: 16, 23, 29, 37 43, 50	2.50	6.00	7.50
4	Computers, Information Theory, Automatic Control Sessions: 7, 10, 32, 39, 42, 46, 53	3.50	8.40	10.50
5	Microwave and Instrumentation Sessions: 1, 26, 34, 47, 48, 54	2.75	6.60	8.25
6	Manufacturing Electronics Sessions: 6, 8, 17, 27, 35, 44, 45, 52	3.25	7.80	9.75
7	Audio and Broadcast Sessions: 12, 13, 20, 21, 25, 55	2.25	5.40	6.75
8	Aeronautical, Communication and Military Electronics Sessions: 3, 4, 11, 15, 19, 31, 36	2.75	6.60	8.25
9	Ultrasonics, Medical and Nuclear Electronics Sessions: 2, 9, 18, 51	1.50	3.60	4.50
	Complete Convention Record (All Nine Parts)	$22.75	$54.60	$68.25

IRE CONVENTION RECORD

1956 NATIONAL CONVENTION

PART 7 - AUDIO AND BROADCAST

TABLE OF CONTENTS

HIGH STABILITY TELEVISION SYNCHRONIZATION GENERATOR

Francis T. Thompson

Westinghouse Research Laboratories
Pittsburgh 35, Pennsylvania

Abstract

A method for obtaining a new order of phase stability in frequency dividers is described. The output of a high frequency crystal oscillator is sampled in order to obtain an output corresponding to a half cycle of a high frequency reference. The application of this method to television results in accurately phased horizontal and vertical synchronization pulses. This method is particularly applicable to television systems which utilize dot interlace.

Problem

The function of a television synchronization generator is to provide timing pulses which assure that the picture information will be displayed in the correct location. The timing accuracy that is required depends upon the particular television system that is being used. The greater the number of picture subdivisions employed, the higher the required timing accuracy.

In conventional monochrome television, two timing signals are required: the horizontal synchronizing pulse which controls the starting of each line and the vertical synchronizing pulse which controls the starting of each field. The NTSC monochrome television standards specify that the time interval between the leading edges of successive horizontal pulses shall vary less than 0.5 percent of the average interval.[1] The tolerance of the vertical synchronization repetition frequency, nominally 60 cycles, is wide enough to allow the 60 cycle power frequency to be used as a reference for the system. In order to achieve good interlace it is desirable that the time between successive vertical pulses vary less than 10 microseconds or 0.06 percent of the average vertical interval which is 262.5 times the average horizontal interval. This relationship may be alternately expressed as a phase relationship between the vertical and horizontal synchronizing signals.

The introduction of the color subcarrier in compatible color television necessitated more accurate control of the timing signals. The frequency specification of the color subcarrier 3.579545Mc $\pm$ 0.0003%, is necessary to assure proper operation of color reference oscillators in color receivers.[2] This frequency forms the reference for the timing pulses in compatible color, thereby precluding the possibility of synchronization with the 60 cycle power frequency. In order to obtain interlacing of luminance and chrominance information, the color subcarrier frequency was chosen to be an odd multiple of one-half the horizontal line frequency (455/2). This relationship reduces the degradation of the luminance signal caused by the chrominance signal because a 180 degree phase shift of the chrominance signal occurs between successive scans of identical areas. The cancellation of the dot pattern caused by the chrominance signal occurs at a 30 cycle rate if the phase relationship between the color subcarrier and the horizontal synchronizing pulse is accurately maintained. A phase shift of 0.8 degrees at 15734 cps in the horizontal synchronizing pulse during this 1/30 sec. will cause the dot pattern to be reinforced, rather than cancelled.

The requirement for proper phasing between the horizontal and vertical synchronizing pulse to achieve good vertical interlacing remains the same as in monochrome television.

Television systems which use a higher order of interlace to achieve high definition require an even greater timing accuracy. A high definition system which provides 1016 horizontal picture elements and 1050 vertical picture elements[3] samples the video presented on a single line during a single field into 254 dots. The other 762 dots are placed in between these 254 dots during subsequent fields. In order to achieve good interlace of these dots, it is desirable that the phase of the horizontal synchronizing pulse vary less than 0.12 degrees at 15.7 kc with respect to the phase of every 254th dot. This requires that the interval between horizontal pulses be maintained to within .02 microseconds. The timing of the vertical synchronizing pulse must be twice as accurate as in conventional television, since a vertical interlace ratio of four is used.

The synchronization generator, which is described in this paper, was developed in conjunction with the dot interlaced television system described above. The principles are applicable to synchronization generators in general.

Timing inaccuracies in a television system are caused by inaccuracies in the transmitter and the receiver. It is economically desirable to provide more accuracy in the transmitter so that most of the allowable tolerance may be employed at the receiver.

Stability

The timing accuracy required in dot interlacing television systems dictates the use of a highly stable frequency reference. A temperature-controlled crystal oscillator provides a very satisfactory reference. It will be assumed in the discussion that follows that this reference frequency remains perfectly constant during the period of time required to complete an interlaced picture.

Stability of the timing signals produced by the synchronizing generator will be divided into the following two classes: frequency stability and phase stability. Although they are related by a time derivative, they will be defined for the purpose of this paper as follows:

> Frequency Stability - The ability to maintain the period between consecutive timing pulses accurately enough so that the desired number of crystal oscillator reference pulses occurs during each of these periods.
>
> Phase Stability - The ability to maintain the phase of the timing pulses with respect to the crystal oscillator reference pulses within the desired limits.

A loss of frequency stability results in counting down by the wrong number of pulses. This type of instability is associated with tearing or rolling of the picture. Frequency stability is necessary before phase stability can be considered. Phase instability is associated with pairing of interlaced lines or dots in the picture.

Present-day commercial synchronization generators provide excellent frequency stability. It is the purpose of this paper to investigate methods of improving the phase stability of existing synchronization generators.

Sinusoidal Divider Chain

The sinusoidal divider chain illustrated in Figure 1 divides from a crystal reference frequency f by integral factors n and m to a frequency f/mn. Let us assume that each dividing stage counts down by the proper integer and that the phase of the output of each stage is related to the input of that stage as follows:

Divider m input phase θ_m output phase $\theta_m \pm \phi_m$

Divider n input phase θ_n output phase $\theta_n \pm \phi_n$

Input and output phase angles of each stage are referred to the input frequency of that stage.

The $\pm \phi$ terms represent the limits of the phase jitter in each divider. The phase jitter in a cascaded divider of this type is cumulative. The phase jitter of the output of the divider chain referred to the input frequency f is $\phi_m + m\,\phi_n$.

It can be seen that small amounts of phase jitter in the low frequency divider, n, cause a large jitter of the output phase with respect to the phase measured at the reference frequency f.

Sinusoidal Divider Chain With Sampling

The sinusoidal divider chain illustrated in Figure 2 is identical with that of Figure 1. Equal amplitudes of the reference frequency f and the outputs of dividers m and n are added in a divider network. The addition of three sinusoids of frequencies f, f/4, and f/16 is illustrated in Figure 3. These three sinusoids add together periodically to produce a small peak which has a higher amplitude than the other peaks.[4] The repetition rate of this small peak corresponds to the repetition rate of the lowest frequency sinusoid. The phase of this peak is identical with one of the peaks of the reference sinusoid to a first approximation.

This peak may be selected by a clipper to obtain a synchronizing pulse at a frequency of f/mn cps. The phase jitter of this pulse is much lower than that of the f/mn cps sinusoid because of the sampling process of adding the various sinusoids and selecting the desired pulse.

Amount of Reduction of Phase Jitter

The sampled pulse does not remain exactly in phase with the reference sinusoid frequency f. Phase shifts in the various divider output sinusoids, which are added to the reference sinusoid, cause a slight shift in the location of the peak of the sampled output pulse. The amount of the shift of the sampled output pulse is equal to the sum of the shifts caused by each of the divider sinusoids.

The shift of the peak of the sampled pulse is plotted in Figure 4 as a function of the shift of a divider output sinusoid for several values of r, the ratio of the reference frequency to the divider output frequency. All angles are referred to the reference frequency f. It is assumed that the amplitude of the sinusoids f and f/r are equal and that their peaks are initially in phase.

It can be seen that the phase shift caused by the divider output decreases as the ratio r is increased. The importance of this fact can be understood by considering the previously described sinusoidal divider chain. The phase jitter of the lowest frequency output sinusoid with respect to the reference sinusoid is ϕ_m +

$m\phi_n$. This jitter is large because it represents the cumulative jitter of both dividers. The ratio, r, of the reference frequency f to the frequency of the divider sinusoid f/mn is equal to mn. This large ratio results in a small jitter in the sampled output pulse even though the jitter of the f/mn sinusoid is large.

The phase shift of the leading edge of the sampled pulse has been found to be even smaller than the phase shift of the peak. This is to be expected because of the steep slope of the front edge of the sampled pulse.

Low Frequency Pulse Sampling

A highly stable pulse can be obtained from a pulse dividing chain by adding the outputs of the various divider stages and using them to sample the input pulse as illustrated in Figure 5. Astable multivibrator dividers were used in this particular chain, although the principle is applicable to bistable multivibrators and phantastron dividers. Figure 6 illustrates how the positive pulse duration of each divider was selected so as to select one of the p pulses that it divides by. The relative phase of these square pulses was chosen to insure that the output pulse is sampled by the flat portion of the square wave top. The peak square pulse allows one of the input pulses to pass through the gate insuring that the output is in phase with the input. Jitter in the firing time of the chain multivibrators has no effect on the phase of the output pulse as long as the counting ratio remains constant and the pulse is sampled by the flat portion of the square pulse peaks.

Experimental Equipment

High Frequency Divider

This divider was built as a part of a dot interlacing bandwidth reduction television system. Block and circuit diagrams are shown in Figures 7 and 8. Regenerative dividers were used in the sinusoidal dividing chain which divided from 2.47 Mc to 58.8 kc in steps of 6 and 7. Figure 9 is a photograph of the waveform obtained at the cathode of V10. The peak of this waveform causes pulses of cathode current to flow in V11. The outputs from the 14.7 kc and 7.35 kc multivibrators are added and applied to the suppressor of V11. Every eighth pulse of cathode current is drawn from the plate, while the other seven draw screen current. The narrow plate pulse, which has a 7350 cps rate, is amplified and inverted in V12 and applied to cathode follower V13. The 100 µµf condenser is rapidly charged by this pulse through the 1N48 diode. The condenser discharges exponentially through the 270 K resistor. This pulse widening circuit provides the output pulse shown in Figure 10.

Low Frequency Divider

This divider shown in Figure 11 divides from 14700 cps to 60 cps using multivibrator dividers. Block and circuit diagrams are shown in Figures 12 and 13. The synchronizing pulse to the first multivibrator is delayed by 14 microseconds to assure that a portion of the pulse triggering the multivibrator is not sampled by it. The phase relationships of synchronizing and sampling are illustrated in Figure 6. The sampling waveform which is applied to the suppressor of V12 is shown in Figure 14. The sampled output pulse is widened as explained previously.

Experimental Results

A simple experiment was performed to illustrate the improvement in phase stability obtained by sampling. The B^+ voltage of the low frequency divider was slowly varied from 200 to 300 volts. Time exposures of the 14.7 kc input pulse, Figures 15 and 16, were taken while this voltage was varied. In Figure 15, the time sweep was synchronized by the 60 cps sampled output pulse. In Figure 16, the time sweep was synchronized by a pulse obtained from the 60 cps multivibrator. The pulse from the 60 cps multivibrator represents the output of a conventional divider chain. The relative phase stability of the input and output pulses using sampling and conventional techniques is clearly illustrated.

Conclusion

The methods of sampling described in this paper provide a significant improvement in the phase stability of synchronization generators. These methods are applicable to most divider chains and should prove particularly valuable in color television. A color television synchronization generator which uses these sampling methods is being built in our laboratories.

References

1. National Television System Committee, Television Standards and Practice, p. 367, New York, McGraw Hill Book Company, First Edition, (1943.)

2. Fink, D. G., "NTSC Color Television Standards." Electronics, December 1953.

3. F. T. Thompson, P. M. G. Toulon, "A High Definition Monochrome Television System," 1955 IRE Convention Record, Part 7, PP. 153-164.

4. P. M. G. Toulon, U.S. Patent 2,565,102, August 1951.

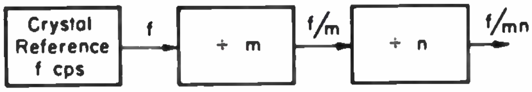

Fig. 1
Sinusoidal dividing chain

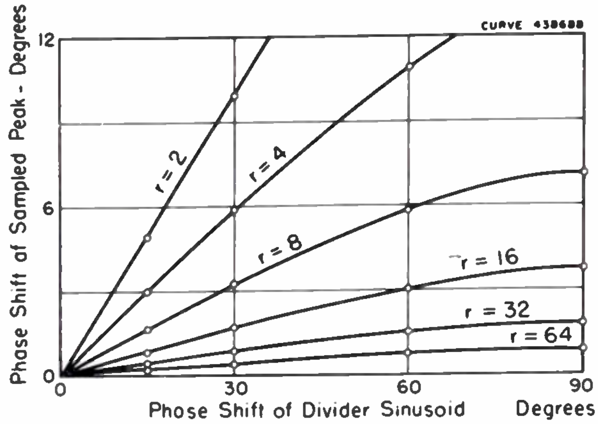

Fig. 4
Reduction of phase jitter

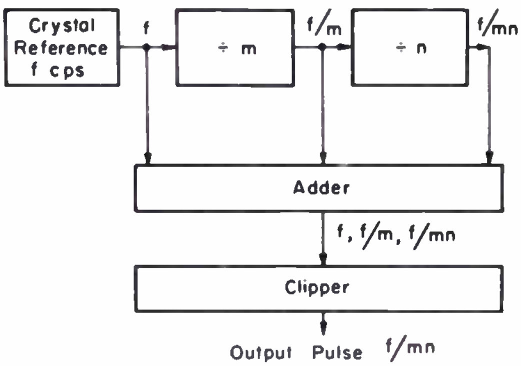

Fig. 2
Sinusoidal dividing chain with sampling

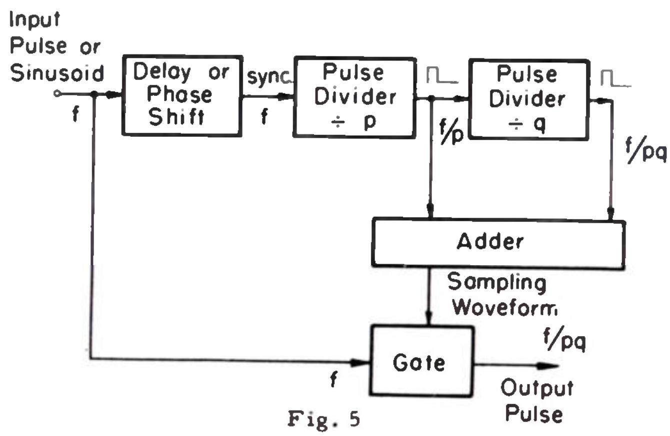

Fig. 5
Pulse dividing chain with sampling

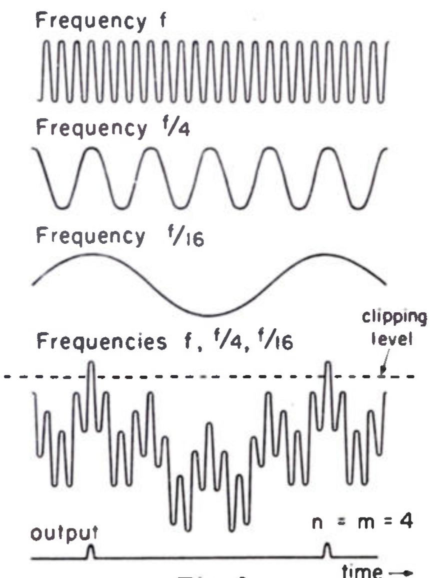

Fig. 3
Sampling dividing waveforms

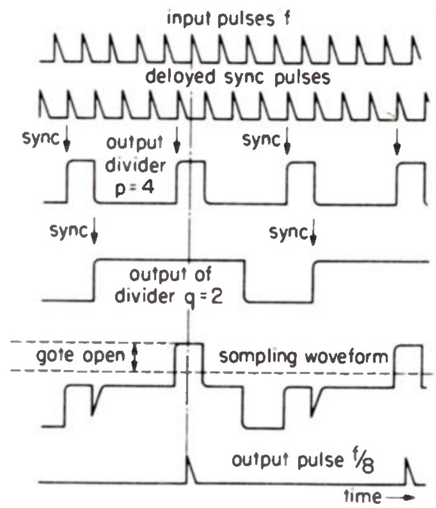

Fig. 6
Sampling dividing chain with pulse input

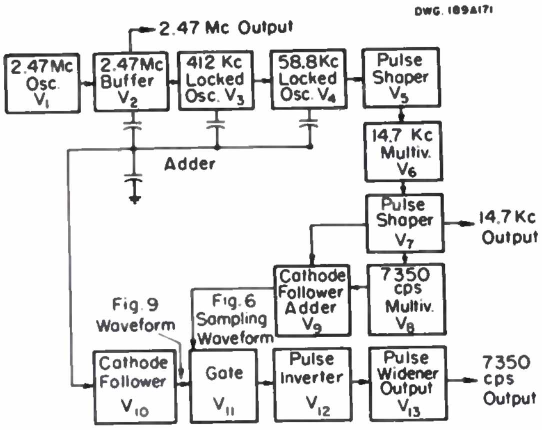

Fig. 7
High frequency divider

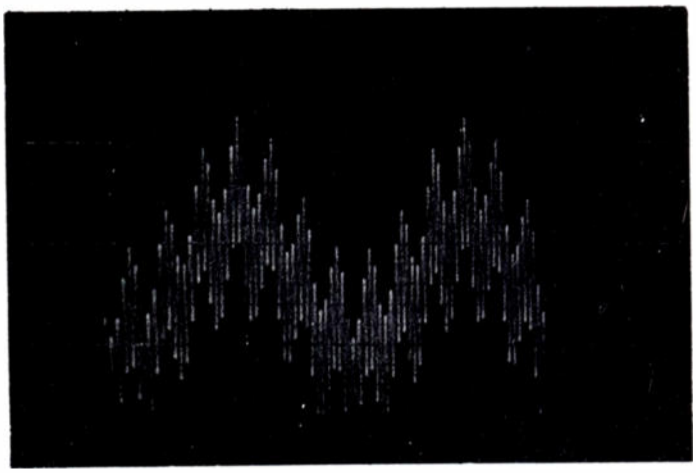

Fig. 9
Addition of sinusoids

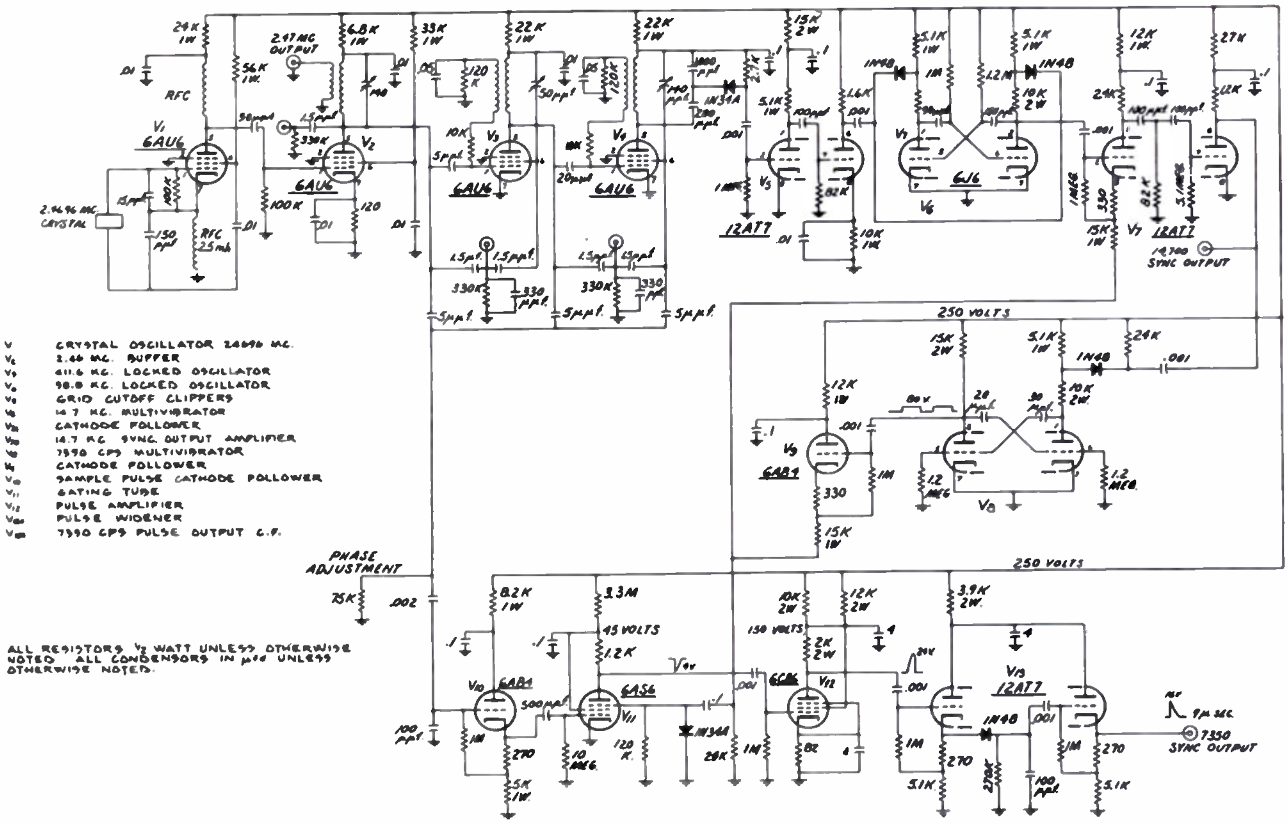

Fig. 8
High frequency divider

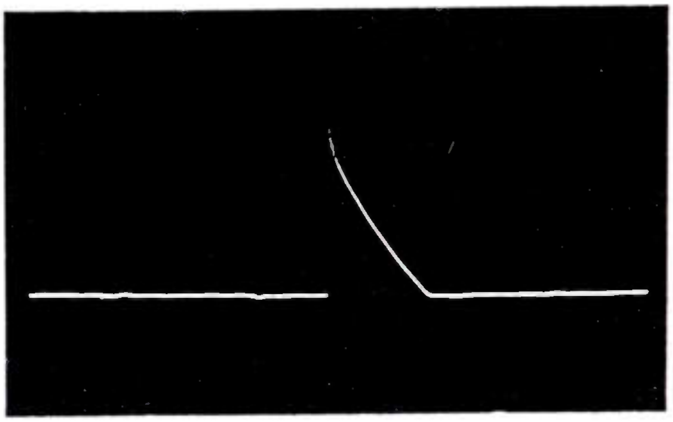

Fig. 10
7350 cycle sampled output

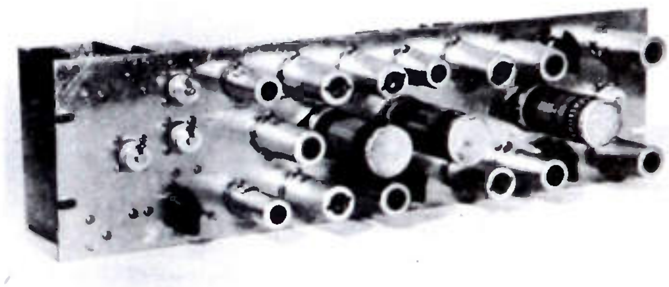

Fig. 11
Low frequency divider

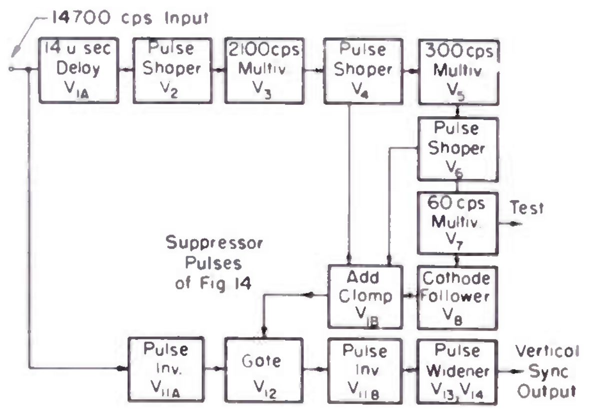

Fig. 12
Low frequency divider

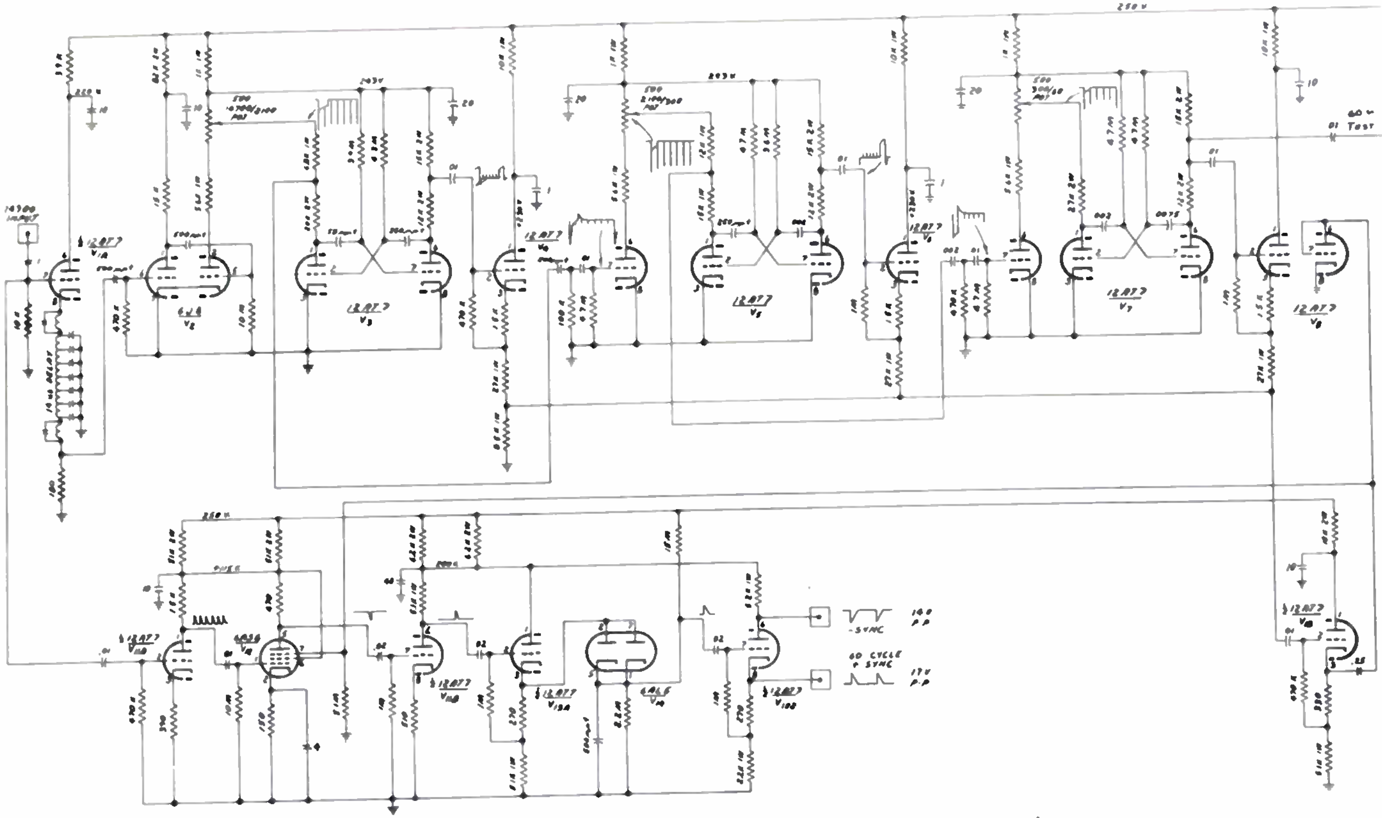

Fig. 13
Low frequency divider

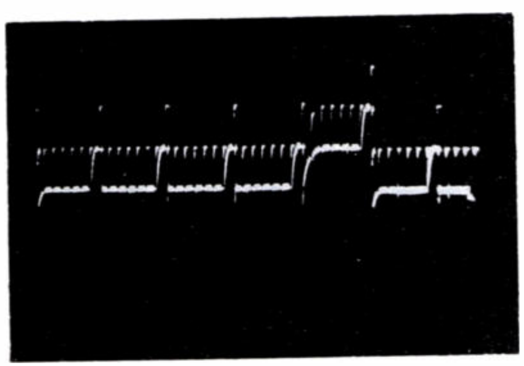

Fig. 14
Low frequency divider gating waveform

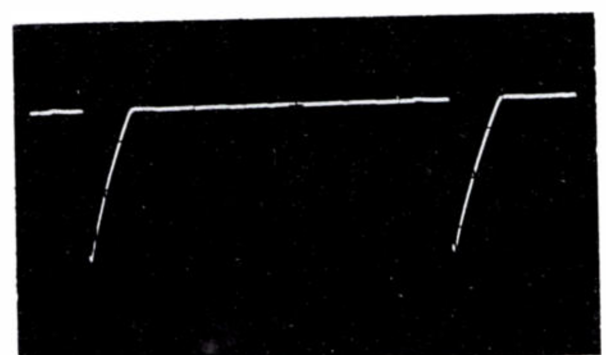

Fig. 15
Jitter between input and sampled output

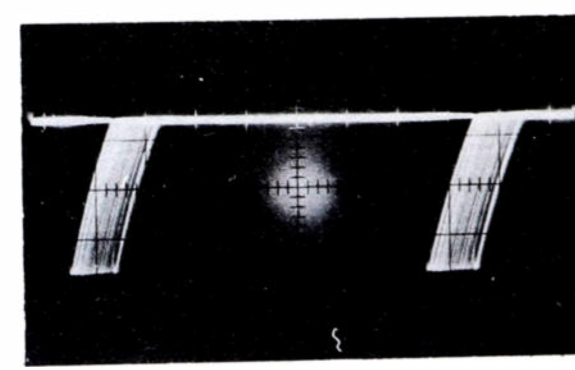

Fig. 16
Jitter between input and conventional output

PEDESTAL PROCESSING AMPLIFIER
FOR TELEVISION

Ralph C Kennedy
National Broadcasting Company
New York, N.Y.

Summary

The Pedestal Processing Amplifier is intended to provide the essential signals for a color genlock system. Since a unique method of sync cancellation is used, it is felt that the term stabilizing amplifier, as commonly known for monochrome, should not be used to describe this equipment. Additionally, an improved sync separator is described which provides constant output sync amplitude for input signal level variations of ± 14 db.

Introduction

Television has presented many interesting challenges to the engineer. This is true not only in the area of transmission where many new problems have arisen but also in the areas of various special effects where continuing attempts have been made to try to accomplish the same results as the motion picture producer realizes on film.

With the advent of color television, a whole new transmission system has had to be designed. Manifestly the range of color special effects has been considerably greater than for monochrome and it has generally been more difficult to find satisfactory solutions.

Special Effects Require Genlock Operation

One of the procedures used in monochrome television to facilitate various special effects is to lock the sync generators together which provide the pulses for the various signals. This is known as genlocking and is used to create various video effects which require the simultaneous appearance on the screen of signals from two different locations. Such signals are used to produce split screen, video inset, lap dissolve and other types of effects. The introduction of commercials, which generally are on film and originate in the film studio, into the live program sequence originating in another location requires genlocking. In fact, without genlocking television would be at a very distinct disadvantage.

Stabilizing Amplifiers

Genlock operation has been successful due primarily to the availability of stabilizing amplifiers. These are capable of recovering the sync signal from the composite monochrome video signal and of clipping the sync signal from the incoming composite so as to reduce it to a simple video signal. The sync recovered from the signal has been used to lock the sync generators together while the video signal free of sync has permitted it to be introduced into the studio switching system in the same manner as a normal camera signal.

Such stabilizing amplifiers, however, are not usable on a color signal. The recovery of the sync signal permits the burst and chroma components, which extend below the blanking level, also to be present. Further, the clipping of sync from the signal to produce a simple video waveform simultaneously results in burst and many chroma components being clipped.

Two Line Genlock Operation

To circumvent the lack of a suitable stabilizing amplifier, color genlocking has heretofore been accomplished by using two wideband circuits. One has carried the sync and burst to lock the generators. The simple video signal free of sync to be introduced into the switching system has been carried on the other circuit. Clamper amplifiers in the Telco circuits, since they clamp on the tip of sync, have clamped on the blanking signal and operated satisfactorily. Further genlock operation has been attempted only on film camera signals. Pedestal has been easily controlled and no chroma components nor burst have been allowed to extend far enough below blanking to cause confusion in the clamper amplifiers.

However, when live pickups have been attempted the pedestal has not been so easily controllable and burst and chroma components have extended so far below the blanking level that the clampers have stopped functioning properly.

The Pedestal Processing Amplifier

This equipment has been designed and built with the main objectives being to recover the sync signal from an incoming composite video signal, either monochrome or color, and to produce a simple video signal as well. This eliminates the need for two circuits when genlocking and restores genlock operation to the same procedures as are used on monochrome television. Needless to say, the saving in line costs is substantial.

The operation of the unit may be described briefly in the following manner. A composite monochrome or color signal is introduced at the input terminals where it branches in two paths. In one the sync is recovered. Further a circuit permits adjusting the location of the back edge of sync so as to produce sync having adjustable width. Clamp pulses are also developed from this sync.

The second path has an adjustable video delay line for delaying the composite video signal. This delayed signal is fed to a clamped adder tube which is also fed the sync signal. The sync is added in the same polarity as that in the composite video. Enough is added to cause the sync in the resultant output to extend well below the negative peaks of burst. The sync is clipped so as to produce a clean tip but it is not clipped enough to distort the burst. This signal is fed to another clamped adder tube which is likewise fed the sync signal. The polarity of the sync in the composite signal is opposite to that of the sync being added. This causes the sync in the output signal to be reduced to zero, i.e., blanking level by proper adjustment of the amount of the sync introduced.

The proper timing of the front edges of the sync in the composite signal and the added sync is realized by adjusting the video delay line. The timing of the back edges of the two syncs is adjusted with the pulse width control.

Three outputs are available from the unit. One is processed sync whose output remains constant for input level variations of ± 14 db from a standard one volt peak-to-peak signal. A second output is a composite signal having processed sync. The third output is a simple video signal having a processed pedestal.

The evolution of these three signals from the original composite signal may be understood by referring to Figure 1. The 417-A-1 is a high gain amplifier. It is coupled through an L-C circuit anti-resonant at a frequency 3.579 mc/s to the grid of 6BN6-2. The tuned circuit removes the chroma components and burst from the signal. About 10 volts of sync is present in the signal at the grid of 6BN6-2. This is sufficient to produce very positive gating action for input signal level variations of ± 14 db. This circuit is essentially the key to the success of the whole unit since variations in input are removed. As a result constant amplitude sync and clamp pulses are assured which eliminates many of the usual stabilizing amplifier problems.

The output of 6BN6-2 is amplified in 12AT7-3 and is again gated in 6BN6-4. The accelerator output of this tube is amplified in 5687-5 to produce a sync output of between 4 and 5 volts into 75 ohms.

The plate output of 6BN6-4 is fed to 12AU7-6. The first half has a number of open circuited delay lines of varying lengths in its plate circuit which is used to control the location of the back edge of sync. A base clipper is used to couple the pulse to the second half of 12AU7-6. A tip clipper couples the plate to 12AT7-7.

This tube acts as a cathode follower having one fixed output and two adjustable outputs. The two adjustable outputs are the sync addition and subtraction controls. Since processed sync is first introduced into the signal to drive the original impure sync below clipping level and thereby removing it, it is necessary to have the identical sync for cancellation. This is realized by feeding the syncs to the two adder tubes from the same source.

The fixed sync output from the cathode follower is amplified and differentiated in 12AX7-8 to form clamp pulses. The base is clipped and the pulse is coupled to 5687-9. This tube amplifies the pulse and splits its phase to drive the clamp tubes 6AL5-13 and 6AL5-17.

As mentioned earlier, the input signal to the unit split in two paths. The second is to a 12AU7-10. This tube is a cathode follower gain control which allows adjustment of the overall video gain of the unit.

The second tube in the video circuit is 417A-11 which has a 75 ohm adjustable delay line in its plate circuit. The delay of this line is 0.3 usec. The last 0.1 usec is tapped at each 0.01 usec. This line has response variations of about 5% at most to 5 mc/s.

The line output feeds 12AT7-12 which is a straight amplifier feeding clamped amplifier 6U8-14. The triode section of this tube is a sync amplifier which injects the sync on the cathode of the pentode section. The polarity of the sync adds to that of the composite signal in the adder tube. The 6U8-14 has a clipper 6AL5-15 in its plate to clip sync.

Precise clipping is realized by regulating both the screen and plate voltages of the pentode section of 6U8-14. The 6BQ7-19 acts as the regulator for these two voltages.

At the output of 6AL5-15 the signal is composite video having processed sync. The timing of the front edge of the inserted sync is made to coincide with that of the original signal by adjustment of the delay line in the video path. The back edge of these same pulses coincides by adjusting the pulse width in the pulse path.

The signal out of 6AL5-15 divides into two paths. One is through 12AU7-16 which is a straight video amplifier into a 2:1 gain line amplifier. This signal is composite video with processed sync.

The second output is fed to the clamped grid of adder tube 12AU7-18. Processed sync is fed to the second grid of this tube. The inserted sync is out of phase with the composite signal sync so that, by adjusting the amplitude of the inserted sync, cancellation of sync results. The signal out of 12AU7-18 is a simple video signal including burst and chroma. This is fed through a second line amplifier having a gain of 2 to 1. This signal having a processed pedestal is now in condition to enter a conventional switching system.

Adjustment of the Apparatus

As previously mentioned, the primary purpose for the Pedestal Processing Amplifier is to provide a video signal from a composite color signal. This objective is kept in mind when adjusting the apparatus. The power requirement is 115 volts ac for heater power and 585 ma at +285 volts dc for plate and screen power.

The apparatus should have a few minutes to stabilize after applying power. Referring to Figure 1 it is seen that test point A may be used to monitor the input signal. This signal should be 1 volt peak-to-peak composite. A color bar signal appears at this point as shown in Figure 2.

Test point B shows the signal after amplification and chroma filtering. The trap circuit ordinarily requires no adjustment except during the initial installation. Figure 3 shows the signal when the trap is properly adjusted. If chroma is present, readjust the chroma trap condenser to eliminate the chroma.

Test point C shows in Figure 4 a correctly recovered sync signal at the single terminated sync output.

Test point D and Figure 5 shows the signal at the cathode follower video gain control output. This signal should be the same as that at test point A except at a lower level.

Test points E and F permit monitoring several adjustments. They allow the two pulse shaping clippers associated with 12AU7-6 to be properly adjusted and also they indicate the level of addition and cancellation syncs. The controls #6 and #7 should be rotated clockwise as should also the pulse width control. Control #1 should be adjusted so that the base of the pulse is just clipped clean as viewed at points E or F. Control #2 is adjusted so that the tip of the pulse is also clipped clean. When the clippers are properly adjusted the sync signal at points E or F appears as shown in Figure 6.

Test point G permits monitoring the clamp pulse and is shown in Figure 7. The clamp pulse should begin just after the back edge of sync and last throughout the duration of burst. The variable coupling condenser between the two halves of 12AX7-8 controls the location of the back edge of the clamp pulse.

At this point controls #6 and #7 should be returned to zero so that no signal is present at points E and F. Rotate controls #5, #8, and #9 clockwise to attain maximum output.

Controls #8 and #9 are intended to adjust the level of the composite and video signals into the two line amplifiers. The usual procedure is to set each for maximum output observing the level of the video at the input to each line amplifier. Next reduce the amplitude of whichever signal is greater so that the video level in each signal is the same. Now adjust control #5 for the desired output level from the line amplifiers.

By adhering to this procedure the level through the whole equipment is operated at the lowest value possible, thereby causing the differential phase distortion to be kept to a minimum.

Adjust control #3 so that the tip of sync is barely clipped as it appears at the test point of the input to the video signal line amplifier. Adjust control #6 so that sync is driven back up to the pedestal. Adjust the video delay line so as to minimize the transient at the previous location of the front edge of sync. Adjust the pulse width control to minimize the transient where the back edge of sync previously occurred. Further reduction of the magnitudes of the transients may be affected by adjusting control #7.

The realization of the optimum cancellation condition is more of an art than a science. Sequential adjustments of controls #3, #6, and #7 will produce a pedestal having less than $\pm$ 3.5% of peak transient ripple in the processed pedestal region. Figures 8 and 9 show the signal at the inputs to the two line amplifiers. It should be emphasized that no attempt is made to cause the composite output signal to have the correct sync to video ratio. Only the optimum video pedestal adjustment is important. The sync in the composite output is always great enough to extend beyond the blacker than black tips of burst so that it can be used wherever a composite signal is acceptable. Control #4 is the clamp balance of the sync cancellation circuit. This should be set so that 12AU7-18 grid #7 is about -0.1 volts with respect to the chassis as ground.

Test Results

Three of these equipments have been built and used commercially. The first time this method of genlocking was attempted commercially was during the 1955 World's Series where in 6 days a total of 21 hours time genlocking was maintained. The "Great Waltz" and "Producer's Showcase" have also used this method of genlocking. In the latter case, Brooklyn was locked to Radio City, which in turn was locked to Burbank. Split screen and numerous fast switches between the East and West Coast were made with no loss of genlock.

Another test included genlocking a film studio whose output was a continuous loop of film leader which causes extreme signal variations. This signal was fed for half an hour with no interruptions in genlocking.

Performance Data

As has been mentioned earlier the dc power requirements are 285 volts at 585 ma. Additionally, the response is dependent upon the video delay line which has been covered previously. The differential gain is less than 2% while the differential phase is $\pm \frac{1}{4}^{\circ}$.

Conclusion

The Pedestal Processing Amplifier is a device which makes color genlock operation a practical procedure. The unit may be used either on color or monochrome signals. With such a device it is now possible to begin work on a "fail safe" type of genlock system, having automatic relocking facilities upon restoration of the signal. Large yearly savings in line costs are possible since only one line is required instead of two. Further, coast to coast genlock heretofore was impossible, since there are only two color circuits. On the old two line system no spares were available.

APPENDIX

It is well to consider the transient conditions during the sync cancellation period. The situation may be better understood by referring to Figure A. The sync pulse is shown having two different rise times, τ_1 and τ_2 . τ_1 is the rise time of the leading edge of sync and is shorter than τ_2. This is the sync in the incoming composite signal after it has been clipped to smooth the tip but prior to the insertion of the inphase processed sync. The values for τ_1 and τ_2 will vary depending upon the sync generator output, transmission path, etc; however, for an average $\tau_1 = 0.2$ usec and $\tau_2 = 0.3$ usec.

Figure B shows the inphase sync to be added to Figure A sync. The rise time is about 0.1 usec for both τ_3 and τ_4

The result of the inphase addition is shown in Figure C where the front edge has a rise time of 0.2236 usec while that of the back edge is 0.3162 usec.

In Figure D is shown the result when sync cancellation occurs. Theoretically the condition of minimum ripple occurs when two pulses having identical rise times are added exactly 180° out of phase. Since the recovery of sync without changing the pulse rise times and width is next to impossible it then becomes a matter of compromise. Further, alteration of the pulse is minimized by making the rise time of the recovered sync as short as possible. However, here again a practical limit on circuit complexity dictates something of the order of 0.1 usec.

Finally, since we know that the minimum amount of overshoot and optimum phase linearity occurs for a transition approaching a unit doublet response, the video delay line is adjusted to realize that objective where the leading edge of sync occured. The pulse width control is adjusted to try to improve matters in the region of the back edge of sync.

The resultant signal after it has passed through switching and has had new sync added, has resulted in a signal having no observable ripple on the edges of sync. This fact serves to justify the rather loose approach used to solve the transient problem.

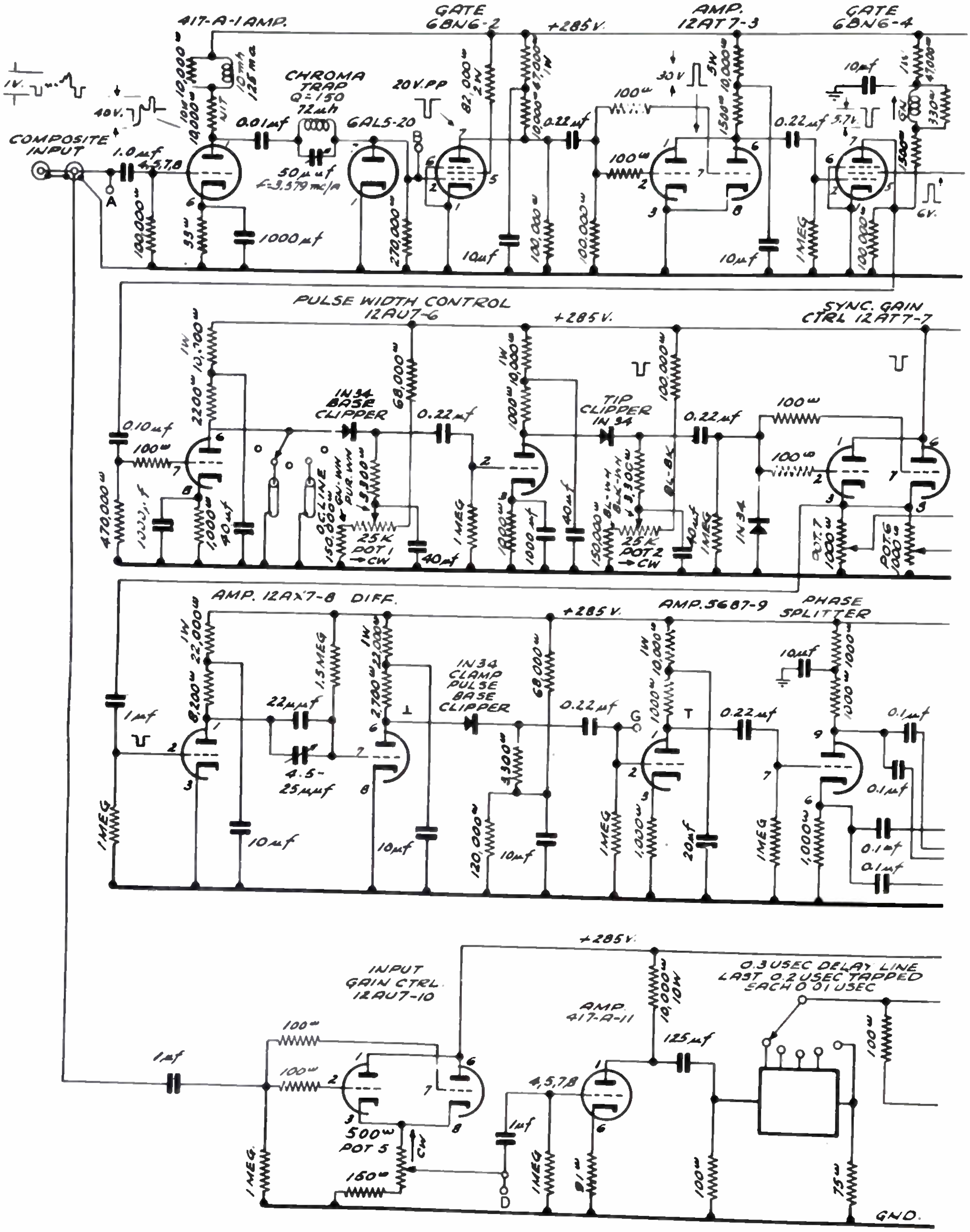

Fig. 1a
Circuit diagram of pedestal processing amplifier

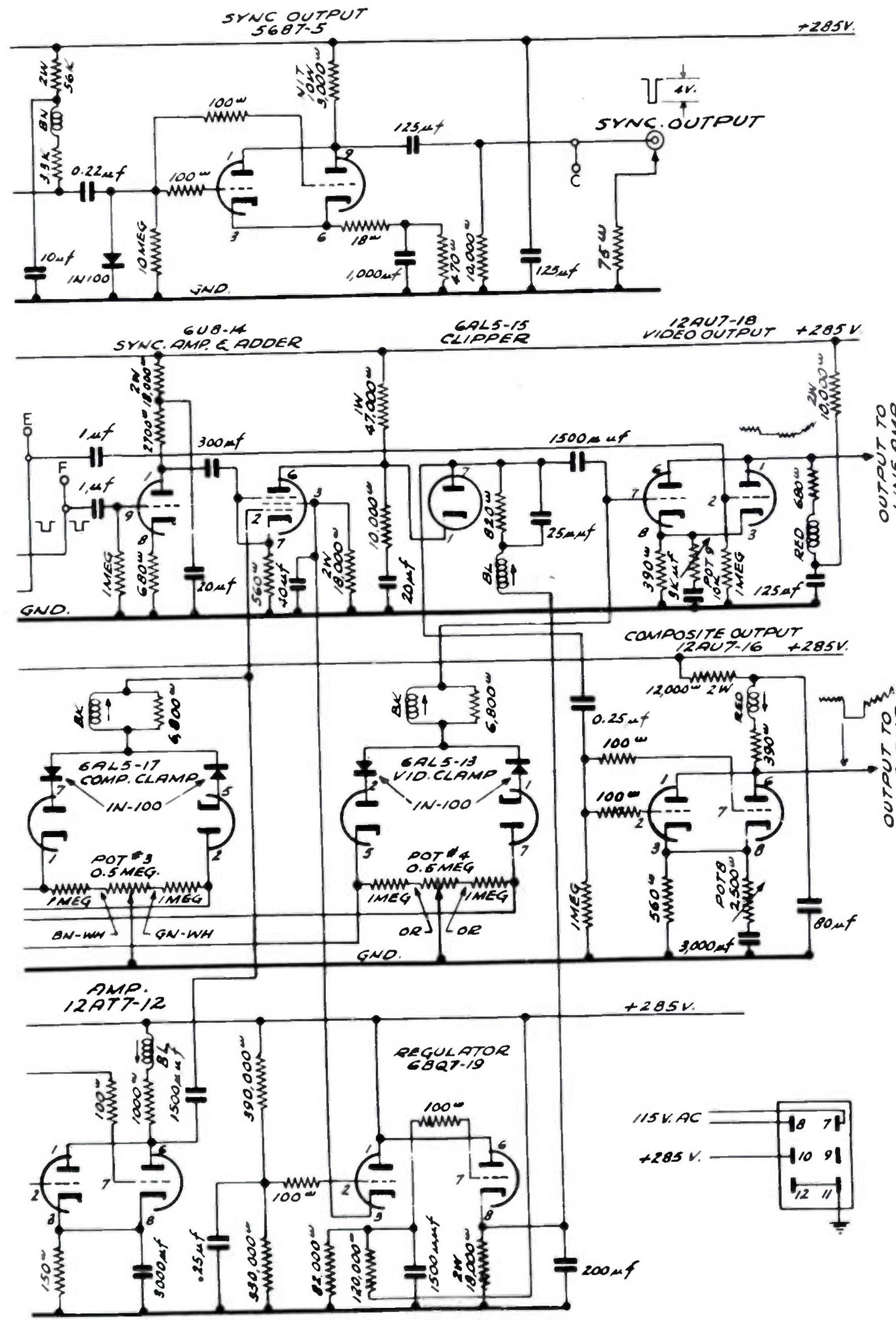

Fig. 1b
Circuit diagram of pedestal processing amplifier

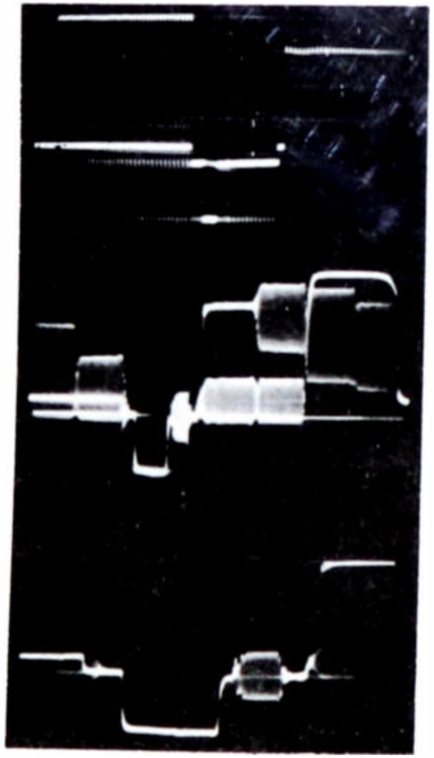

Fig. 2
Color bar signal waveforms at test point A

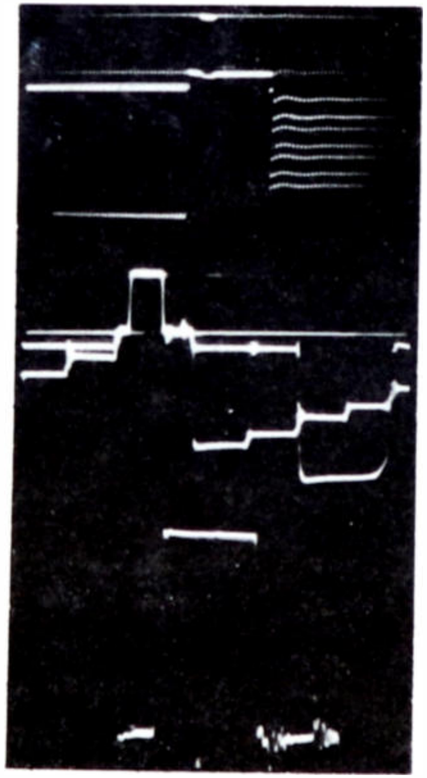

Fig. 3
Color bar signal waveforms at test point B

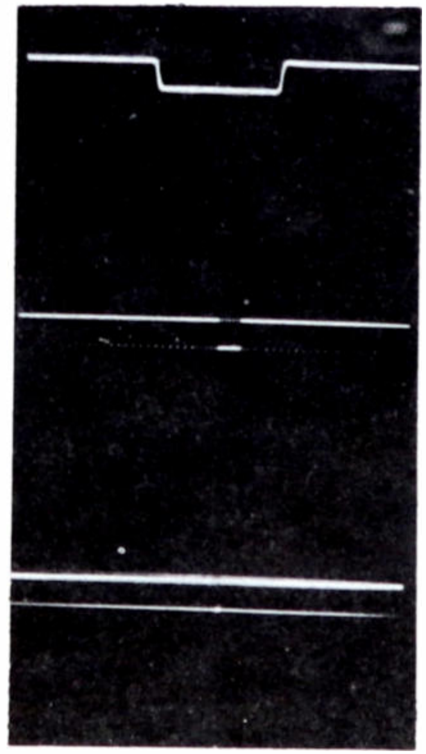

Fig. 4
Sync waveforms at test point C

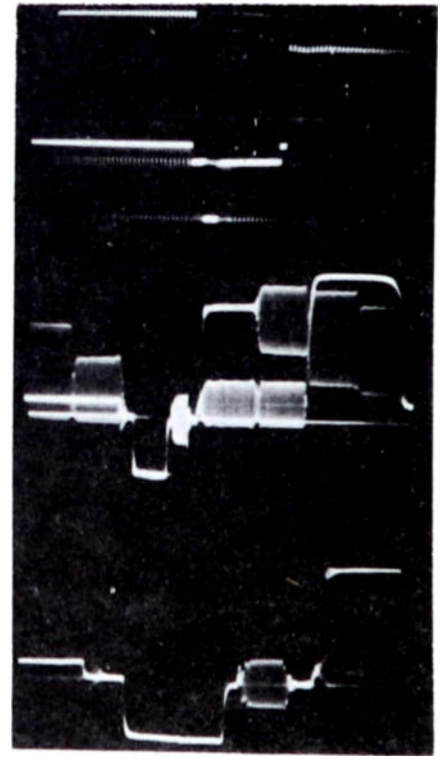

Fig. 5
Color bar signal waveforms at test point D

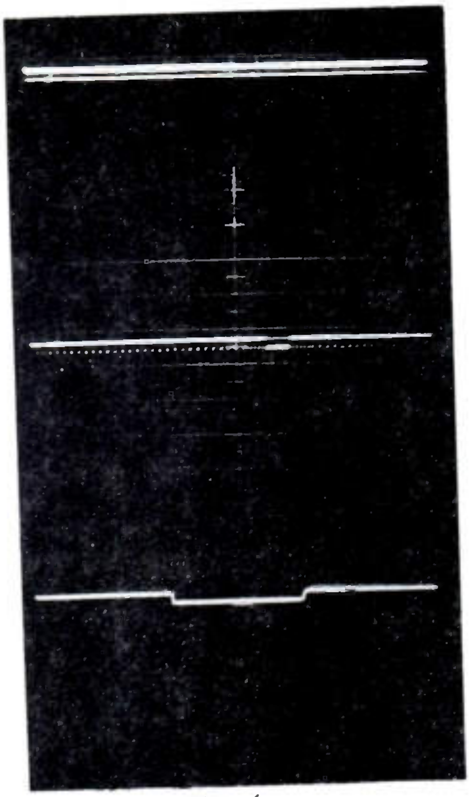

Fig. 6
Sync waveforms at
test points E or F

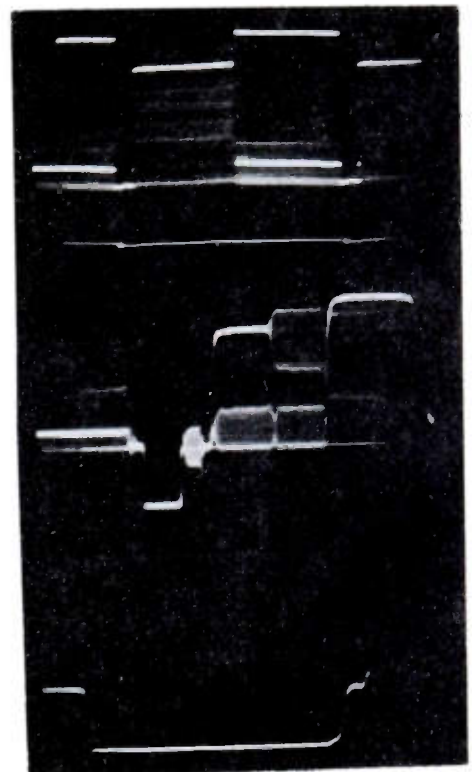

Fig. 8
Color bar signal
waveforms of com-
posite output signal

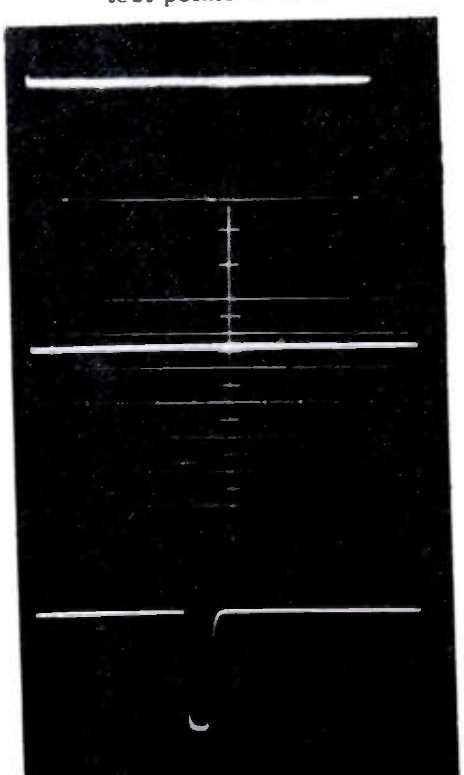

Fig. 7
Clamp pulse wave-
forms at test point G

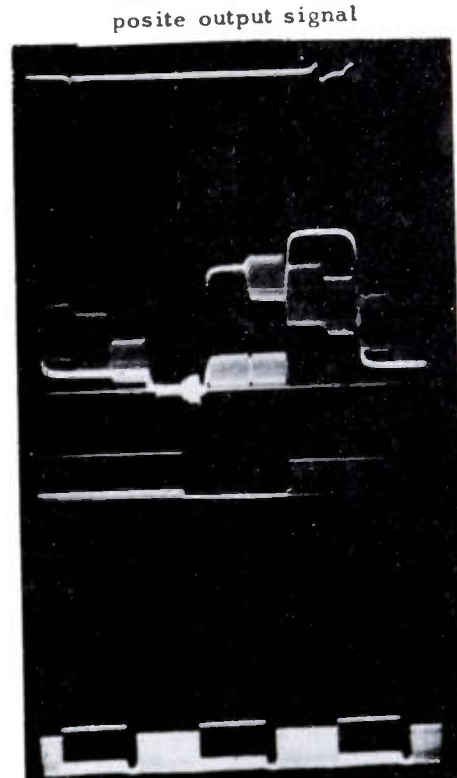

Fig. 9
Color bar signal
waveforms of video
output signal

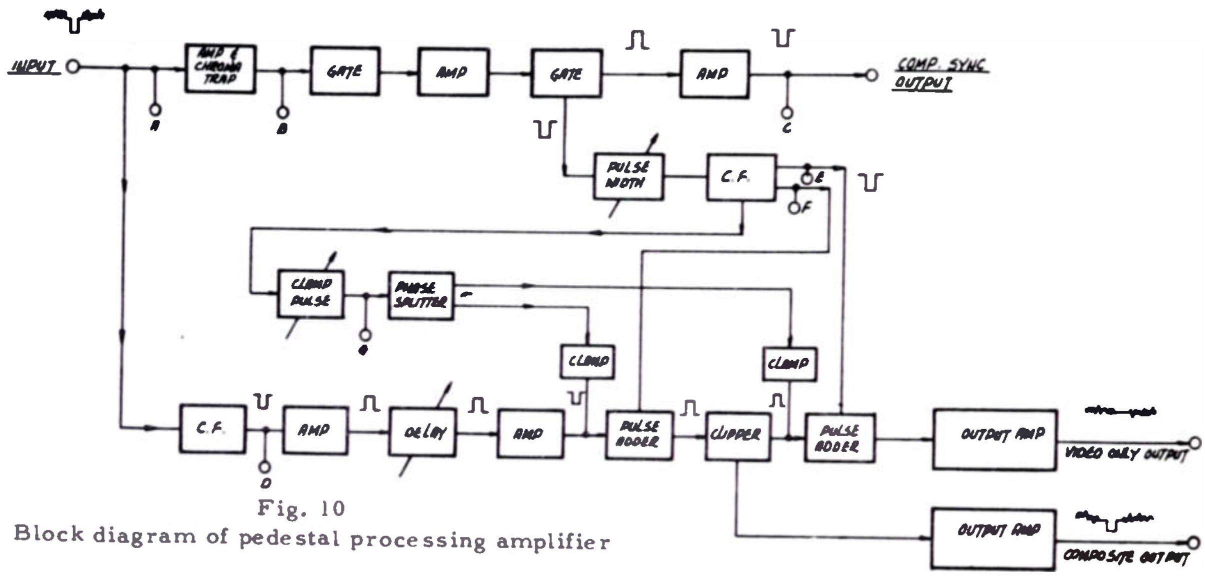

Fig. 10
Block diagram of pedestal processing amplifier

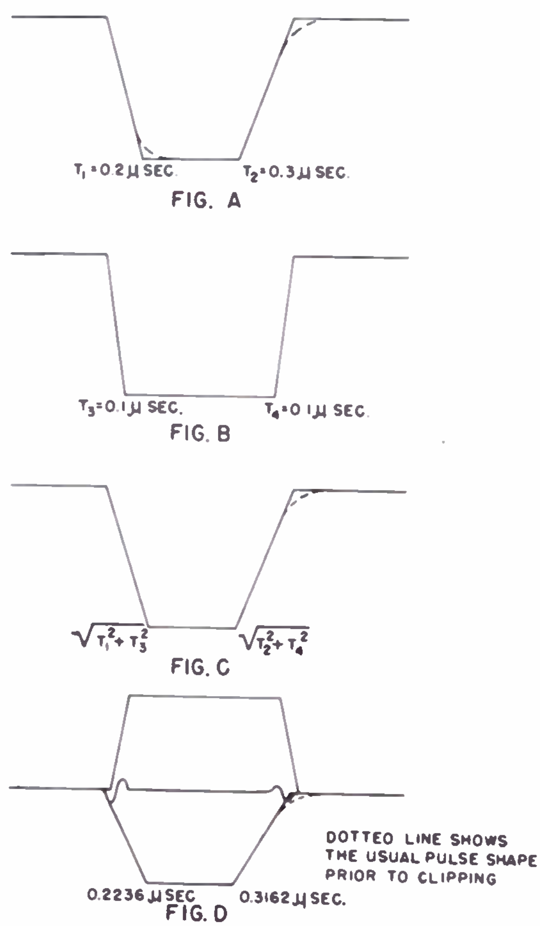

Fig. 11
Sync waveforms described in the appendix

A NEW ELECTRONIC MASKER FOR COLOR TELEVISION

Jesse H. Haines
Allen B. Du Mont Laboratories, Inc.
Circuit Research Laboratories
Passaic, New Jersey

Summary

A new color masker is described having improved performance, operational convenience, and efficiency. The color-difference mask signal is formed by a specially designed video mixing transformer, thus permitting major circuit simplification and greatly improved neutral balance stability. Use of the narrow-band mask principle substantially reduces luminance noise crosstalk into the encoded chroma signal. The philosophy of masking controls is discussed. Trilinear colorimetric plots illustrate the color shifts produced by incremental changes in the masking controls of various proposals.

Introduction

Early in 1954, electronic color masking was just emerging from the laboratory into practical broadcasting use. The first pioneering papers on the subject, from Burr of Hazeltine, and Brewer, Ladd, and Pinney of Kodak, had just appeared in the literature.[1,2]

Two years ago at this convention, we presented a paper concerning the use of electronic masking in color broadcasting.[3] Mentioned in the paper was a masker we had developed and which soon went into production under the name of the Du Mont Electronic Masker, Type 9005B. This is pictured in Figure 1.

Since the introduction of the 9005B masker, our efforts have been directed at developing an improved masker. In general, the aim was to achieve major circuit simplifications, improved reliability and stability, and certain performance improvements. One specific improvement was to incorporate narrow-band masking, which was first proposed in the previous paper. Another aim was to investigate the proper function of the various masking controls to be made available to the operator.

At last year's IRE Convention, Brewer, Ladd, and Pinney presented the paper[4], "Proposed Controls for Electronic Masking in Color Television." These proposed controls were fundamentally different from the controls used by Burr and also used in our masker. A masker employing these different controls was subsequently built and tested.

This paper is thus divided into two major parts. First, the results of the new masker circuit development are described. Secondly, a detailed comparison is made of the various control philosophies leading to the final choice.

Before proceeding, however, it may be in order to give a very brief definition of color masking. A mask operates on a color picture to change the relative luminance and saturation of some colors, or to shift the hue of some colors. This is often necessary, when televising color film, to compensate for improper taking emulsion sensitivities and improper dyes having overlapping and unwanted absorptions. The table below points out the more familiar shortcomings of a typical color film.[5]

Original	Reproduction
Gray scale	Higher contrast
All colors	Desaturated
Red	Only slightly desaturated
Green	Much darker, hue shifted slightly toward blue
Blue	Darker, hue shifted slightly toward green
Yellow	Hue shifted toward red
Magenta	Greatly desaturated, hue shifted toward red
Cyan	Much darker

Depending on the exact color process involved, certain variations in the above table will occur. Indeed, colorimetric differences between reversal and negative-positive processes, such as Anscochrome and Eastmancolor. occur specifically because it is feasible photographically to incorporate color masking in the negative-positive processes, but not in the reversal processes. Nevertheless, with all color films, due chiefly to the dye deficiencies, it is characteristic that luminance and saturation of all saturated primaries are reduced. There are also minor shifts in the hue of some colors.

It should also be clearly understood that the statements above apply strictly to the objectively measured aspects of color film reproduction. On the other hand, it is not at all uncommon for the photographer to purposely predistort the colors and luminances in the original scene so as to produce the desired result on the film. In such a case, it is quite possible that no masking would be required. Thus, in the final analysis, the specific masking selected is a subjective matter and hence the importance of the proper controls becomes obvious.

As now used in color TV, maskers perform a linear transformation on R, G, B input voltages prior to encoding to produce the corrected R', G', B' outputs. In a mathematical sense, a color masker is simply a linear 3 x 3 matrix, represented by the equation:

$$R' = a_{11}R + a_{12}G + a_{13}B$$

$$G' = a_{21}R + a_{22}G + a_{23}B$$

$$B' = a_{31}R + a_{32}G + a_{33}B$$

However, practical broadcast operational techniques dictate that control of the coefficients be suitably linked together, rather than having a gain control for each of the nine coefficients. The first and most important operational requirement is that an input neutral scale of equal R, G, B signals remain perfectly neutral in the output. This is satisfied when the sum of the coefficients in each equation always equal unity. This condition reduces the number of independent variables from nine to six, as seen below.

$$R' = (1-a_{12}-a_{13})R + a_{12}G + a_{13}B$$

$$G' = a_{21}R + (1-a_{21}-a_{23})G + a_{23}B$$

$$B' = a_{31}R + a_{32}G + (1-a_{32}-a_{33})B$$

Because of the necessity for increased saturation, it is also characteristic of color TV maskers that all of the off-diagonal coefficients are negative. Typical coefficients found in mask equations are shown below.

$$R' \quad 1.10R \quad -.05G \quad -.05B$$

$$G' \quad -.30R + 1.60G \quad -.30B$$

$$B' \quad -.20R - .20G + 1.40B$$

Note that the off-diagonal terms are small and negative while the diagonal terms are large and positive. With no masking, the off-diagonal terms would be zero, the diagonal terms unity. In the example shown, the Green channel could thus be said to have a .6 mask amplitude.

Basic Circuit Design

Figure 2 shows the block diagram of the Mask Amplitude-Mask Makeup control scheme used in the 9005B masker. As can be seen, the Mask Makeup selects the amount of the off-diagonal terms relative to each other. The Neutral Balance adjustment insures that when the input is neutral, complete signal cancellation occurs so that no mask signal is produced. The Mask Amplitude determines the total amount of masking. With these two operating controls in each channel, any desired mask equation can be produced. Thus two controls in each channel, six in all, provide complete control of the six indepandent coefficients in the masking equation.

In translating the block diagram above into actual circuitry, the adding and subtracting circuits cause the most difficulty. The problem is completely analogous to that found in many other kinds of color TV broadcast equipment. That is, there should be no color-difference output for equal R, G, B inputs.

In the very simplified single-channel schematic of the 9005B masker, Figure 3, it is apparent that three tube sections are required to form the mask. One tube simply inverts the signal polarity and the other two, with plates tied together, add the negative and positive signals to form the mask. This color-difference signal, which may be either positive or negative depending on picture content, is then added to the direct signal in the plates of the output tubes. Obviously, if the gain of any one tube drifts in the mask mixer, an unwanted color-difference signal will appear on white. Actually, the above circuit is not at all unstable. Nevertheless, tubes inevitably age and this drift must be checked occasionally. Fortunately, this is quickly and easily done. But it is much better to eliminate the probelm completely.

As also seen in Figure 3, the approach taken with the new masker to eliminate the Neutral Balance drift problem was to employ completely passive circuit elements to form the mask signal. This was accomplished by employing a specially designed video mixing transformer. As before, the resistive signal addition of the Mask Makeup selects the ratio of subtracting coefficients, although the signals are still actually positive at this point. By feeding voltages of the same polarity at either end of the center-tapped transformer primary, a difference signal is automatically formed, without the need for an inverter stage. Thus, the color-difference mask signal is produced with passive circuitry and the tube drift problem is completely avoided. The Neutral Balance control is set once and locked at time of manufacture of the unit. Over a test period of several months, no readjustment of the prototype unit was necessary, indicating that the resistances in the divider did not change. A possible disadvantage of the transformer type of mixing circuit is that to avoid crosstalk, resistive isolation must be provided, thus giving a certain loss in gain. In the circuit above, there was no problem in restoring the gain.

The specially designed video transformer is toroidal wound on an extremely high permeability core of Arnold Supermalloy. Fortunately, experience with a wide variety of pictures has shown that the mask signal contains no significant low-frequency components, the black level base line being absent, and thus a primary inductance of several henrys, giving a few percent tilt at 1000 cycles, is quite adequate. Due to the stray capacity and leakage inductance of the transformer, the high-frequency response falls off at about 2 mc and this, in combination with the peaking in the next stage, provides the desired low-pass response for the mask channel. The frequency response specifications of the narrow-band mask are $\pm \frac{1}{2}$ db to 1 mc, less than 3 db down at 1.3 mc, and greater than 20 db down at 3.6 mc. Rise time is .3 μs with less than 2% overshoot. Because of the delay caused by the narrow-band mask, a .25 μs delay line is employed in the direct channel.

The narrow-band mask is used to insure that the masking process does not add noise to the luminance signal which would be demodulated into the chroma channel of the receiver. It is inherent with masking that any noise existing in the input signals is increased. This is because even though the mask signal is cancelled out on a gray scale, the added noise coming from the cancelling signals will remain. If this noise occurs near 3.6 mc, it will be demodulated at the receivers to low frequencies and will form coarse bluish noise, since the B-Y gain is the highest. By rejecting the mask signal above 3 mc, where it is not needed anyway, this added noise is eliminated.

The direct and mask channel are added in the plates of two pentodes and a high-efficiency double-cathode follower provides the output. By incorporating video mixing transformers, not only does the new C masker exhibit improved performance over the B masker, but 6 less tubes are employed. Although not shown in the schematic, the C unit has dual output stages, compared to the single outputs of the B masker. While the new unit provides twice the number of outputs, it draws only one-half the power and occupies only one-half the space. Quite obviously in this particular application, the use of video transformers permits an impressive improvement in the overall circuit design. It is to be hoped that a fresh evaluation of this long-neglected circuit component for video design will be made by other workers in this field. There appear to be many possible applications for the impedance matching and mixing properties of video transformers.

In passing, the basic circuit required by the Hue Shift, discussed later, is considerably more complex than the Mask Makeup control since it involves cross linkages between all three channels. Fortunately, by using video mixing transformers, no tubes were required and such a circuit was rather easily constructed. Without the transformers, perhaps 12 tube sections would have been required. Actually, it was substituted directly into the C masker, the chief cost being 3 more transformers, 3 dual pots and a few resistors.

Manual Controls

In actual TV operation over the past few years, good results have been obtained with the Mask Amplitude-Mask Makeup controls provided in the 9005B masker. However, before completing the 9005C design, it was decided to conduct a rigorous investigation of the philosophy of manual controls for maskers, particularly in reference to the proposals for Saturation-Hue Shift controls.

In evaluating the various control schemes, two considerations were uppermost:

1. The masker control knobs should directly correct for the known deficiencies of color film reproduction.

2. The masker control knobs should be related as directly as possible to resultant visual effects.

The investigation of masker control philosophy was divided into two parts. First, a theoretical analysis, involving colorimetric calculations, was made up of the various candidates for masker controls. Secondly, on the basis of the theoretical analysis, two different maskers were built and tested, incorporating the most promising control schemes. Side-by-side operational comparisons were made with a wide variety of color slides over a complete color TV system. For the theoretical analysis, a number of relatively desaturated colors were selected for masking. Then, an arbitrary mask equation was applied. From this reference point, differential changes were made with the four proposed controls. In the calculations, a square-law reproducer was assumed. White luminance, which does not change with masking, was set at 100, the luminance of other colors was specified relative to white.

The unmasked starting colors, and the changes when the reference mask is applied, are shown in Figure 4. Although the CIE plot is perhaps more familiar, a simple trilinear plot eliminates considerable computational labor and will be used in all subsequent plots. Figure 5 shows exactly the same data on a trilinear plot.

Since the colors to be masked were chosen quite arbitrarily, the computing time was further reduced by choosing the rather regular set of starting voltages shown, actually desaturated color bars. The reference mask was likewise chosen for the same reasons of symmetry.

With the reference mask initially set, differential changes were then made in the mask equations by turning the various knobs that are candidates for the attention of the operator. Following the terminology of the previous proposals, the following controls were considered: Mask Amplitude, Mask Makeup, Hue Shift, and Saturation. In all cases, the coefficient differentials are of the same size.

Figures 6, 7, 8 show the changes produced by each of the four proposals by the knobs labelled, respectively, Red, Green and Blue.

The changes produced in the Green controls will be considered in detail. The actual equation coefficient changes for the Green controls are summarized below.

<u>Green Control Knob Changes</u>

Mask Amplitude	- Δa_{21} and Δa_{23} are equal
Saturation	- Δa_{12} and Δa_{32} are equal
Mask Makeup	- Δa_{21} and Δa_{23} are equal and opposite
Hue Shift	- Δa_{12} and Δa_{32} are equal and opposite

The really basic differences between the Mask Amplitude and the Mask Makeup controls on the one hand, and the Hue Shift and Saturation controls on the other, are very simple. In the Mask Amplitude and Mask Makeup, the changes affect only the one channel labelled by the knob, but with the Hue Shift and Saturation, the other two channels are the ones affected. Thus, in the former cases, only the Green signal is affected. In the latter cases, the Red and Blue signals are affected, but not the Green.

Referring to Figure 7, the Green Mask Amplitude control is considered first. Increased masking, indicated by the solid arrows, is applied. Note here the increase in Green saturation, but especially the major increase in Green luminance due to the increase in the Green signal. Yellow and Cyan, the other colors containing considerable Green, have a smaller increase in the green signal, thus give a smaller hue shift towards Green. The other colors show practically no change because of the very small changes in luminance. In simple terms, it suffices to say that increasing the Green Mask Amplitude will increase Green color differences.

The Green Saturation control is next considered. The amount of saturation increase is slightly more than with the Mask Amplitude. However, the luminance remains relatively constant, in fact, decreases slightly. Magenta saturation is not affected. The other colors apparently suffer small changes.

The Green Mask Makeup control is seen next. Interestingly enough, Green Mask Makeup has no effect on colors lying along the Green-Magenta axis. In general, hues are shifted but in small, nearly equal amounts in all the colors except Green and Magenta.

Next is seen the Green Hue Shift control. Here, as desired, the hue shift rotates the Green-Magenta axis. The off-axis colors are affected very little. It is immediately obvious that considerably more shift is given to Magenta than to Green. Virtually no changes occur in Yellow and Cyan, but luminance changes occur in Red and Blue. As proposed, the Hue Shift appears theoretically to perform its purpose.

As described previously, the next step in evaluation was to compare the operation of masking units incorporating different control philosophies. At this point, it was decided to limit the possible control schemes to only two. Further consideration of the "Saturation" control was discontinued. The reasons for eliminating the Saturation control from consideration is simply that in all color films, the nature of the dyes are such that a decrease in saturation of either Red, Green or Blue is always accompanied by a decrease in luminance relative to white. It should be kept in mind that the dye errors are substantially greater than errors contributed by the color reproduction capabilities of the TV system. Thus, it is most logical to provide a single control in each channel which simultaneously increases both saturation and luminance. Hence, the Mask Amplitude control is to be clearly preferred over the Saturation control. The remaining question is thus whether the remaining controls should be Hue Shift or Mask Makeup.

A new masker was then built of the "Mask Amplitude-Hue Shift" variety and compared critically with the "Mask Amplitude-Mask Makeup."

The evaluation of the two control schemes employed 2" x 2" slides displayed on high-quality color monitors and receivers. The signal originated from a flying-spot scanner and obeyed a half-power transfer characteristic. Twenty slides were utilized, 5 original Kodachromes, 5 Kodachrome duplicates selected from the old NTSC set, 5 Eastmancolor and 5 Anscochrome from the new SMPTE set.

Before comparing the maskers, a determination was made of the required Mask Amplitude settings. In evaluating the results obtained, the amount of gamma correction employed is important. The half-power gamma correction used corrected only for the TV system but not for the high gamma reproduction of the color film. If additional gamma correction had been used, even more mask amplitude would have been required. For this test, Hue Shift and Mask Makeup were put in the center of the range and thus both maskers yielded exactly the same equations initially.

Although the amount of masking varied somewhat, depending on the type of color film, several observations stood out clearly.

First - all slides required considerable Green Mask Amplitude. Amounts ranged from .5 to 1.0.

Second - all slides required very little Red Mask Amplitude. A figure of .1 gave good results with all slides.

Third - all slides gave acceptable pictures, improved by masking, in regard to hue.

Fourth - all slides gave excellent hue reproduction with the Hue Shift or Mask Makeup in the normal position in the middle of the range.

It thus became apparent that the need for a Hue Shift control was not urgent compared to the need for the Mask Amplitude control. The Mask Amplitude controls alone were extremely effective and positive in action. In looking at the pictures, "Brilliance" suggested itself as a more descriptive name for the Mask Amplitude control.

Actually, even without changing Hue Shift or Mask Makeup, one specific hue shift did occur due to the fact that the Mask Amplitudes were not equal. Since the Green mask amplitude was always considerably greater than the Red, a very definite shift toward Green occurred in Yellows. However, this appeared to compensate very well for the opposite hue shift deficiency found in all color films. Figure 9 shows the color changes caused by the typical mask equation, previously given, which gave good results in the preceding tests.

The Hue Shift control was next tested. To simulate the calculations, desaturated color bars were used. As predicted by the trilinear plots, the complementary color shifts were quite marked. However, with relatively saturated primaries, no hue shift was visually detectable, although the proper shift voltages were seen on the waveform monitors. This result was apparently caused by the display devices having greater than a square-law transfer characteristic. Unfortunately, a very serious defect of the Hue Shift control was noted in that the luminance changes of color colors off the hue shift axis were visually quite annoying. Apparently, the luminance changes were greater than predicted by the calculations.

On the slide material, the same conclusions were reached. Since saturations were somewhat less, hue shift in primary colors was seen. It was most apparent in Reds, considerably less in Blues and practically indistinguishable in Greens. In all slides, the unwanted luminance changes in other colors were noted. Another annoying feature was that with the Red and Blue Hue Shift knobs at certain ends of their range, it was impossible to obtain Green mask amplitude. This could happen with other combinations, for example, but not simultaneously. In general, however, out-of-channel Hue Shift settings determine the amount of Mask Amplitude obtainable. In short, the operation of the Hue Shift controls left a great deal to be desired.

Attention next turned to the Mask Makeup control. Here the pictorial changes were actually more predictable than with the Hue Shift. Furthermore, the bad side effects were not present. As compared to the Hue Shift control, no matter where the Mask Makeup is set, full Mask Amplitude is always obtainable.

Changes in Mask Makeup in any channel will shift the hue in saturated colors containing that primary color. Thus, the Green Mask Makeup will effect the hue of saturated Yellows and Cyans, although only saturated Yellows will actually be found in nature. While theoretically the Red Makeup will also affect the hue of saturated Yellows, it will have little effect because of the normally low mask amplitude of Red. Magentas, found much less frequently in nature, will have their hues affected chiefly by the Blue rather than Red Mask Makeup. Thus, as a practical matter, Green Mask Makeup will control Yellow hue and Blue Mask Makeup will control Magenta hue.

Before making a final evaluation of the two proposed control schemes, it is in order to take a quick look at some of the other problems confronting the color film video operator. Aside from other auxiliary controls required in certain types of television reproducing equipment afflicted with spurious shading signals, the operator will have up to eight video controls. These might be master gain and black level control plus individual R, G, B gain and black level controls. Very often, it is possible to preset the R, G, B black levels and operate satisfactorily with only the master black level control. However, it is still true that the video modulation in most color films varies enough so that the operator is often quite busy adjusting the master gain control so as to maintain a reasonably constant level of modulation at the TV transmitter. He probably will also be adjusting individual R, G or B gain controls in order to compensate for shifts in white balance in the film. These variations are not only quite frequent in the film but they become much more bothersome in the home than in the theatre because of the closer tolerances, both electrical and visual, under which the system operates. It should be clearly understood that the above adjustments must be proper at all times for the mask to be most effective. The masker controls simply cannot be used to correct for errors in the gain and black levels of the R, G, B channels.

It is clear then why there is a certain resistance to using any masking at all, purely from the standpoint of video operator fatigue. Certainly we wish to keep the mask controls as simple as possible, preferably using 3, not 6. Fortunately, Mask Amplitude meets these requirements admirably for two reasons. First, it directly compensates for the chief colorimetric failing in the film - simultaneous loss of saturation and luminance of saturated colors, relative to neutrals. Secondly, the results produced are straightforward - an increase in any Mask Amplitude knob will always increase the brilliance of that color.

Experience has shown that the need for the shifting of hues is relatively unimportant. Neither Hue Shift nor Mask Makeup need be an operational control. On the basis of simplicity, Mask Makeup is favored. Thus, the new 9005C masker employs Mask Amplitude-Mask Makeup controls.

References

1. W. L. Brewer, J. H. Ladd, J. E. Pinney, "Brightness Modification Proposals for Televising Color Film", PROC IRE, Vol. 42, PP 174-191, January, 1954.

2. R. P. Burr, "The Use of Electronic Masking in Color Television," PROC IRE, Vol. 42, PP 192-200, January, 1954,

3. J. H. Haines, "Color Characteristics of a Television Film Scanner," IRE 1954 National Convention Record, Part 7, Broadcasting and Telecasting, PP 100-104, 1954.

4. W. L. Brewer, J. H. Ladd, J. E. Pinney, "Proposed Controls for Electronic Masking in Color Television," IRE 1955 National Convention Record, Part 7, Transmitters, Receivers, and Audio, PP 63-68, 1955.

5. R. M. Evans, W. T. Hanson, W. L. Brewer, "Principles of Color Photography," John Wiley and Sons, Inc., New York, 1953.

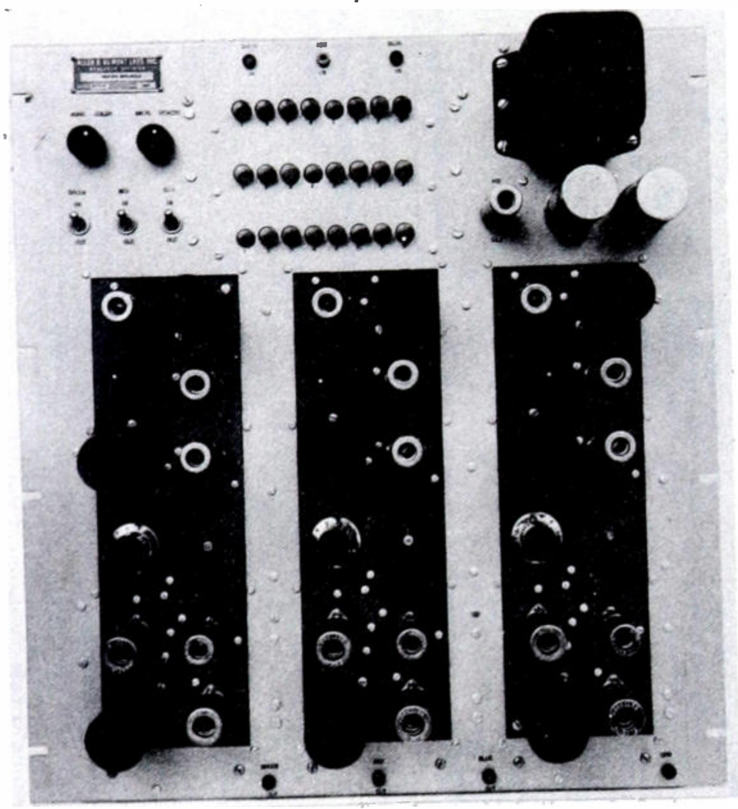

Fig. 1
Type 9005B electronic color masker

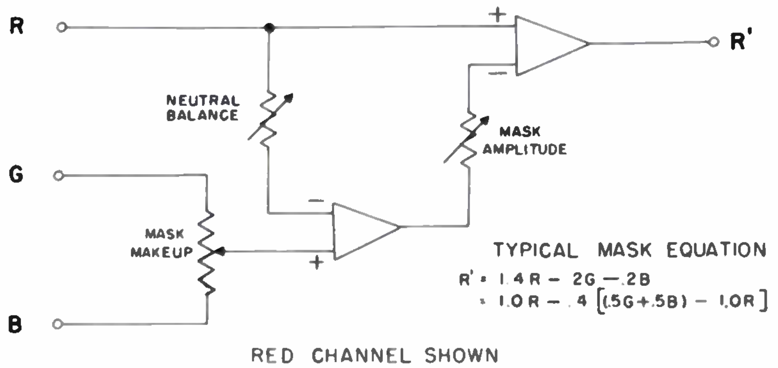

Fig. 2
Mask amplitude-mask makeup block diagram

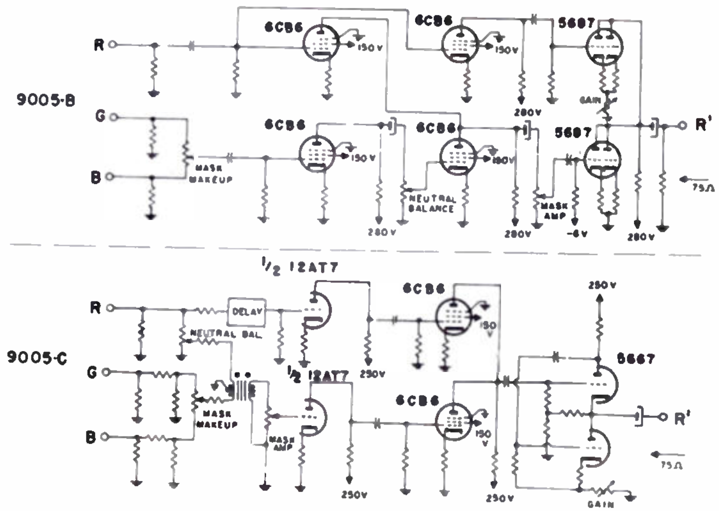

Fig. 3
Simplified schematics, 9005B and 9005C maskers (red channel)

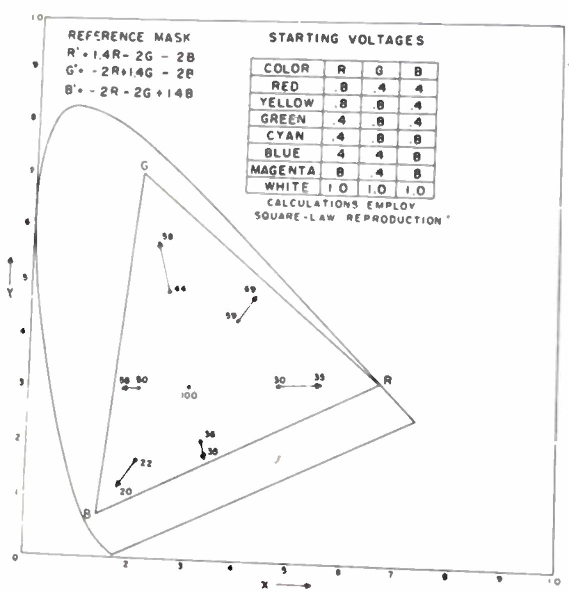

Fig. 4
Starting colors and reference mask (CIE diagram)

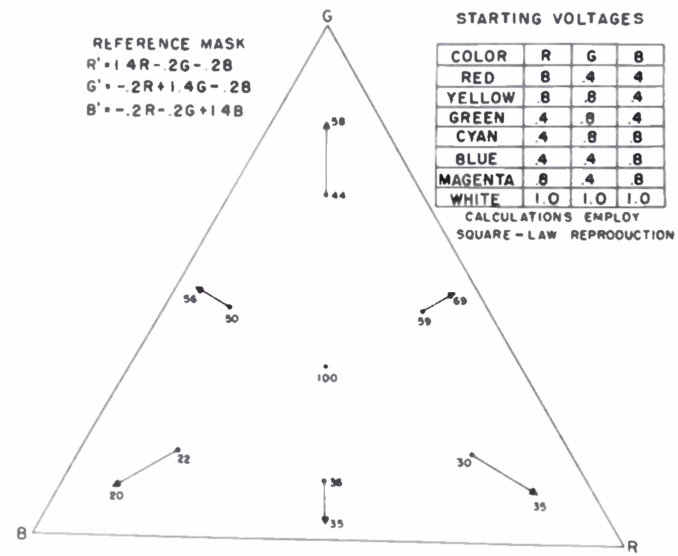

Fig. 5
Starting colors and reference mask (trilinear plot)

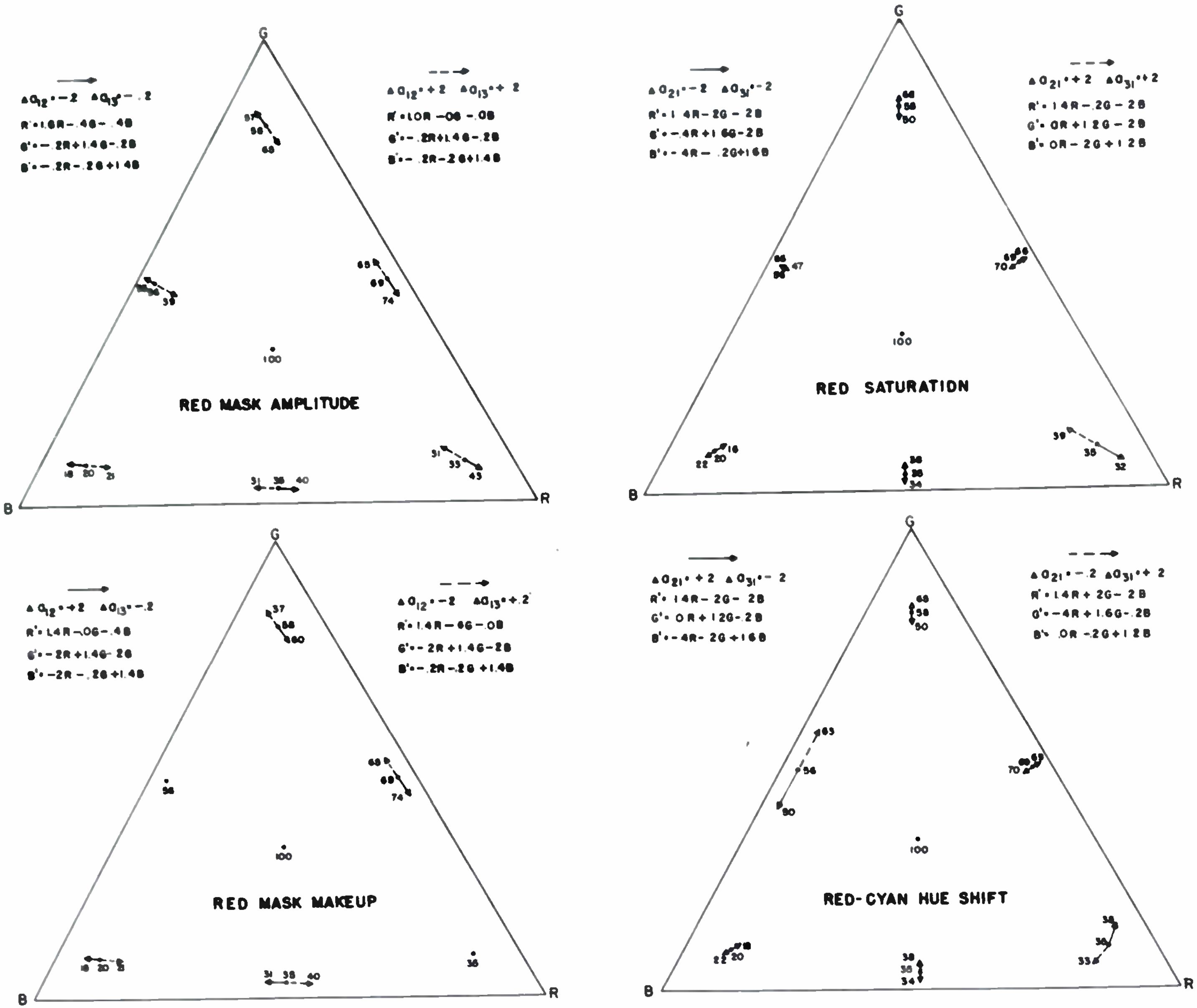

Fig. 6
Red knob control differential changes

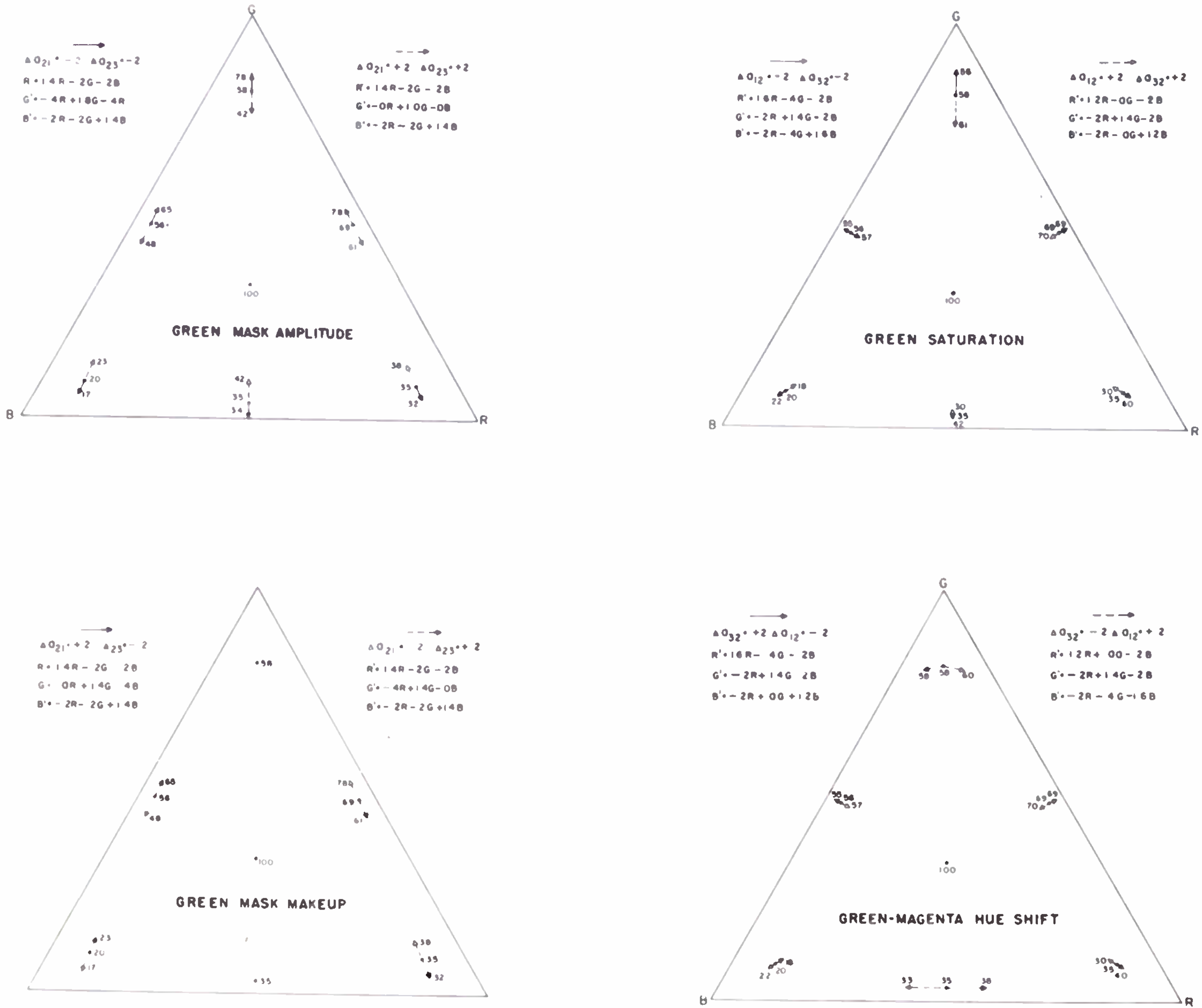

Fig. 7
Green knob control differential changes

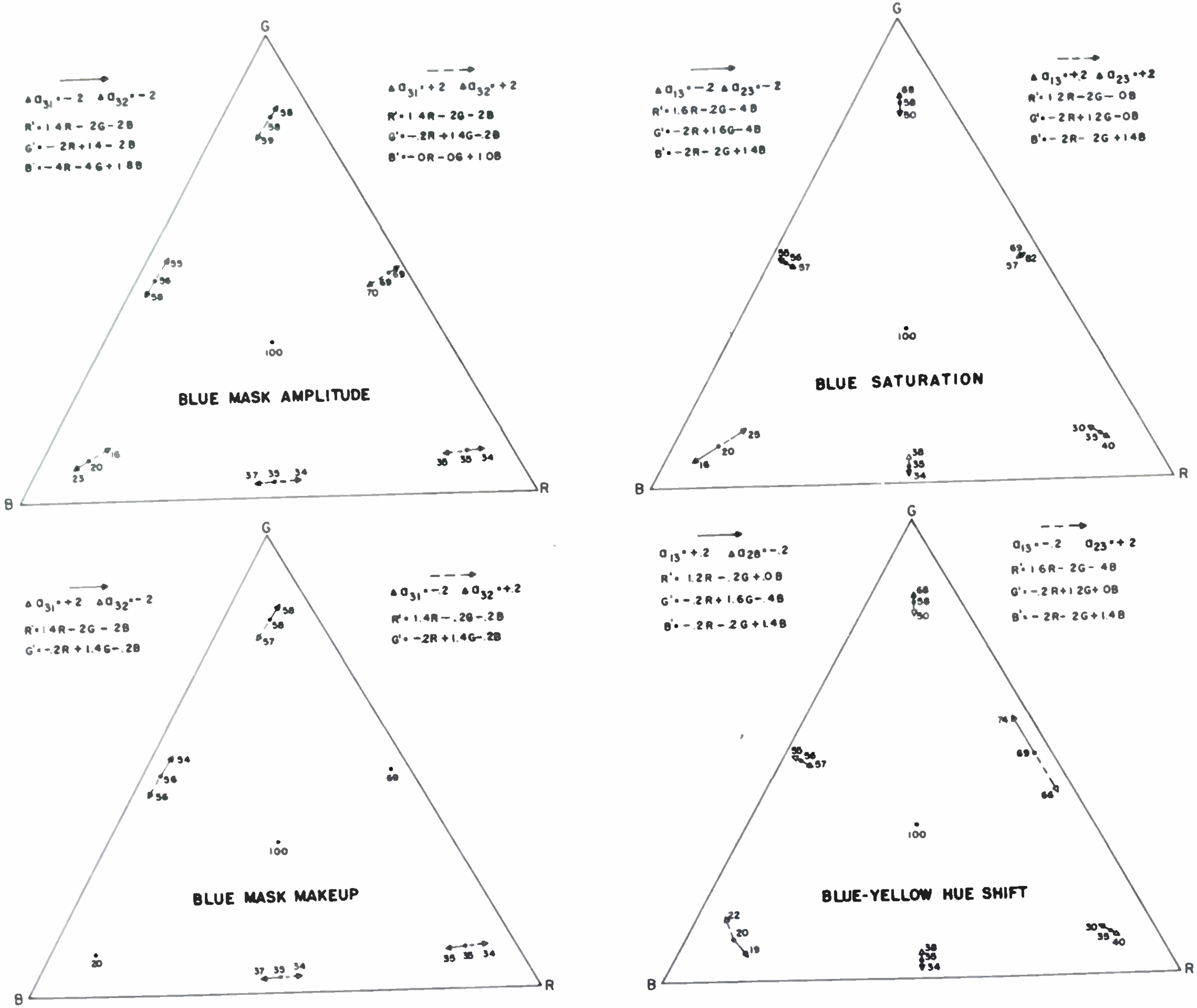

Fig. 8
Blue knob control differential changes

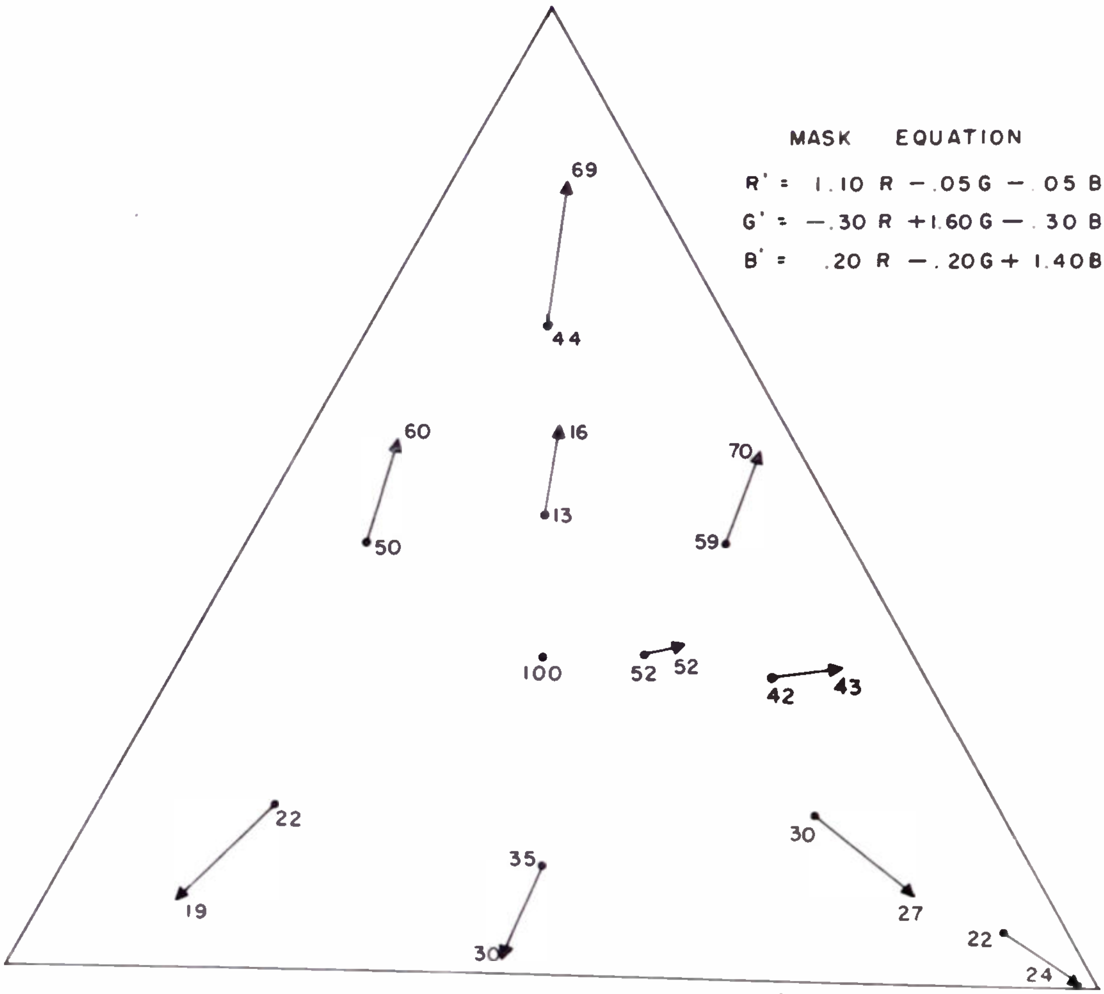

Fig. 9
Color changes with typical mask

REWORKING THE NETWORK OR REMOTE VIDEO SIGNAL

Ray R. Embree
Engineering Department, KING-TV
320 Aurora Avenue, Seattle, Washington

Summary

The network or remote picture signal can be improved locally to a varying extent, depending on the nature of its discrepancies. These improvements will be in the regions of synchronization and gamma. The defective signal is also shown to further deteriorate in passing through amplifiers employing keyed clamps. Pictures included show clearly the results for some deficiencies. Reasons for the inadequacy of presently available gear are discussed. The methods of circumventing many of the overlooked problems are incorporated in the circuitry and external hookup of the sync generator locking device called "Betterlok." This device, that will work under more adverse video signal conditions, is fully described.

The Problem of Airing a Defective Video Signal

Various attempts have been made to improve the video signal at points too far along the path of transmission to permit corrections of the original fault. It would be preferable to correct the trouble at the point of origin, but since this so often is not known, it is expedient to do what can be done locally.

Attempts to locate the origin of such troubles are not only time consuming, but often futile. In the interim, one is faced with having to broadcast the signal the best way one can. While it is impossible to restore lost resolution, or to entirely remove noise or snow from the picture, it is possible to restore good synchronizing information and to improve gamma on many signals. The most difficult problem with which we must deal in broadcasting a defective video signal is one on which the sync is erratic, or far enough removed from standards in one or more respects that the keyed clamps (driven) fail to function properly. Such a signal will often show up better if displayed on a picture monitor before going through a stabilizing amplifier.

The above observation led the author to develop a circuit called "Betterlok." The explanation of the necessity to design a new piece of gear and the method of its incorporation with associated equipment will be attempted in the following paragraphs.

The main variances from the standards that we encounter and correct by the use of the described circuits are listed below:

1. Insufficient back porch width
2. Too narrow sync pulse width (horizontal)
3. Extreme tilt of porches
4. Too narrow equalizing pulse width on one or both fields
5. Video spikes in the sync pulse region
6. Erratic replacement of some of the first in the group of leading equalizing pulses with the equivalent of vertical block pulses
7. Amplitude offset in front and back porches

Obviously, if a stabilizing amplifier, due to its poor clamping action, renders a less presentable picture than a plain video amplifier, the signal should not be run through it unless it is absolutely necessary. However, in some cases it will be necessary, or highly desirable, to have separate control of video and sync which a stabilizing amplifier provides. In cases where a separate amplitude linearity corrective amplifier is used in a compatible color system keyed clamps are also employed. Here too poor clamping action leads to the desire to get around this piece of gear as well. The one unit which usually employs keyed clamps and around which the video signal may not be shunted is the video modulator. Without going further, even the least experienced can see the desirability of having good sync on the video signal. A snowy or low resolution picture can be broadcast, but a picture that is streaking, tearing, jumping and rolling might better remain unaired.

If the defective sync could be replaced with clean, locally generated sync before having to pass through any amplifiers having keyed clamps, the signal could then pass through all normal channels in good order. Of course, in order to replace the defective sync with good sync, it is necessary to lock a local sync generator to the remote signal.

Why Available Equipment Has Fallen Short

Sync generator locking devices comercially available require that standard, reasonably clean sync, stripped from the network or remote composite video, be fed to them. The usual method is to obtain this network sync from a stabilizing amplifier that employs keyed clamps. This number one step in locking a local sync generator to the network signal has already run into a snag if the network signal will not properly operate the keyed clamps in the stabilizing amplifier performing the stripping action.

Therefore, stripped sync is not obtained from a stabilizing amplifier to feed the "Betterlok." No criticism is intended to the engineers or manufacturers who recommend such hook-ups. They expected a normal signal from the network (or remote), and desired only to allow the local studio to treat the network signal as a local picture signal. Provided with such a normal signal this hook-up permitted superimposition and cross fades, etc., with other studio originated signals, with certain limitations. We are primarily concerned with reworking the network signal so that it will make a better picture.

The manner in which the aforementioned signal discrepancies cause further picture degradation in passing through amplifiers employing keyed clamp circuits must be explained on an individual fault basis. In the case where the back porch is too short in duration, the back porch clamping pulse that is applied to the clamping diodes occurs on or later than the trailing edge of blanking. When this happens, the clamping action is erratic, and changes as the picture content changes. This shows up as streaking, tearing, or black bars at various points along the raster, and changing in character as the picture content changes. Too narrow horizontal sync pulses can cause trouble in various manners, depending on the extent of its narrowness and the exact type of keyed clamp being used. An extreme case of sync narrowness will develop insufficient amplitude and jagged shapes in the clamp keying pulses. If peak of sync clamping is used, and the clamp keying pulse is formed from the leading edge of sync, the clamping pulse may occur wholly or partly on the trailing edge of sync. Anytime a clamp keying pulse is applied during an interval of fast signal voltage change, such as on the edge of a pulse or a video voltage excursion, erratic clamping takes place. The clamping action is intended to, among other things, remove low frequency discrepancies from the video signal. High frequency discrepancies are not only not removed, but if their amplitude is very high and they occur during the clamping pulse, the signal is imparied by passing through the clamping amplifier.

The first attempts at adding on locally generated sync to the stripped network signal were done with commercially available sync generator locking devices. The problem already described plus others were evident. The other most disconcerting problem was the loss of vertical in phase condition at random times. Then, too, was the time involved in regaining the vertical in phase condition each time it was lost. The reason the vertical in phase condition was so often lost is quite easily shown to be due to random long period noise bursts on the network signal. These noise bursts would get through the integrator in the locking device, and thus to the sync generator counters.

Betterlok Circuitry and Features

Reference to the block diagram and schematic should be made as often as necessary to aid in understanding the following explanations.

The network (or remote) video signal is looped by the video input, and thence to the GE TV16B stabilizing amplifier. The interstage coupling between V1 and V3 has a fast time constant with a section of V2-a 6AL5 diode connected as d.c. restorer to remove any hum or low frequency discrepancies at the grid of the sync separator V3. An a.f.c. voltage for the sync generator master oscillator is developed by the bridge circuit of V6 by comparing the output of the horizontal blocking oscillator synchronized by the network signal to a pulse developed at V8 locked to the local sync generator horizontal drive. To control the GE PG2 sync generator, a positive voltage is applied in series with this bridge. The stripped network and local vertical sync are treated almost identically to develop 30V positive pulses representing the trailing edges of the last vertical block pulse at V10B and V20A. The trailing edge of vertical sync was chosen to avoid the aforementioned occasional problem with leading group of equalizing pulses changing erratically to vertical block pulses.

In order to speed up the vertical lock-in time, the pulse width of the vertical phase correction pulse fed to the sync generator is increased to a maximum value of about 6000 microseconds. This is accomplished by phanastron pulse generators for the network and local vertical sync separately. The phanastrons put out a pulse for each trigger pulse they receive from their respective vertical sync sources. The duration of a phanastron pulse is linear with the controlling d.c. voltage. Since this controlling voltage is common to both network and local phanastrons, their pulse durations have a fixed relation one to another. A vertical lock-in time of about one-quarter second is easily obtained from a maximum out-of-phase condition. This figure is about one eighth of the time necessary for other locking devices, and is barely discernible to the average eye. The squared-up phanastron pulses are oppositely polarized in the mixer V28. When the local sync generator is in vertical phase with the network, no correction pulse is present at V27 output. Since the positive vertical phase correction pulse is coincident with, and resting in the notch of the wider and higher amplitude negative notch pulse, no pulse at all gets by the dual clippers of 1N48's and V27. When the above condition exists, the input to the vertical error output V26B is automatically disconnected by the open relay contacts of K2. If a vertical phase error does exist or occurs for any reason, it is basic that it will persist until K2 relay contacts close and pass the correction pulse to the local sync generator. On this premise the "door knocking" circuit of V17B, V29 and K2 was incorporated. This repetitious error pulse being rectified by V17B biases V29 and gains entrance to the sync generator. In a matter of a few correction pulses, the vertical in-phase condition will again exist, and K2 disconnects. This "door knocking" action to gain connection to the sync generator prevents long duration noise or other extraneous pulses from disrupting the vertical in-phase condition once gained.

An automatic drop-back for the local sync generator to power line control of the master oscillator and vertical phasing is provided by V24, V15B, V30, K1 and K4. This gives a positive control of the local sync generator at all times, and automatically provides for normal studio operation, even though the network signal drops out. The GE TV16B stabilizing amplifier was chosen to operate with this unit because it permitted, without modification, the passage of a composite video signal, or the addition of local sync and blanking within the one unit by merely operating the existing relay. This realy is automatically controlled by the network signal if switch S4 is in the automatic position.

Remote control is also provided for operational adjustments to the "Betterlok." These include a switch for selecting either local powerline or automatic network (or remote) control of the local sync generator.

Should the circuit be duplicated, there is the matter of reversal of the action of GE TV16B relay. This was done to make this unit interchangeable in this respect with RCA TA5C and D, that were being used elsewhere in the station. The addition of local blanking besides sync in the GE TV16B provides a means of regaining lost setup, as well as straightening out a signal with porches at different amplitude levels. Grass or noise at black level will also be removed completely by the addition of blanking and properly setting the black clip-balance control. (Note that in a locked condition, local sync is used to key the clamps in the stabilizing amplifier!)

Hook-Up Requirements

Power

1. 115V a.c., 60 cycles -- 2 amps.
2. 300V d.c., regulated -- 325 mils.

Signal Inputs

1. Network or remote composite video -- 1.4V, P.P. sync negative
2. Local horizontal drive - Negative 3.5V P.P.
3. Local R.T.M.A. sync -- Negative 3.5V P.P.
4. D.C. locking voltage from the local sync generator power line lock discriminator.

Signal Outputs

1. AFC voltage for sync generator master oscillator external control.
2. Vertical phase correction pulses.

Remote Control and Connections

1. Switch permits the selection of local 60 cycle power line, or automatic locking of sync generator master oscillator to network signal.
2. Horizontal fine phase control.
3. Black clip balance control.
4. Connection from stabilizing amplifier relay to "Betterlok" relay, to provide automatic operation of stabilizing amplifier relay.

Initial Adjustments

1. Connect all voltages, signal inputs and outputs in accordance with the diagrams and tabulated information.

2. Set R2 in mid range.

3. Set S4 to "local 60 cycles."

4. Remove V1 and V5.

5. Adjust R4 to operate the horizontal blocking oscillator at its highest frequency as viewed at J2.

6. Set S1 to ± 0 Ref.

7. Connect a zero center V.T.V.M. from J4 to chassis, using a 3 volt scale. The Voltohmist is very satisfactory.

8. Adjust R5 to obtain zero reading on the V. T. V. M. This balances the bridge of V6.

9. (If a positive reference voltage is required, carry out this step, if not, pass on to #10.) Set S1 to Pos. Ref. Adjust R7 to obtain the required positive reference for the sync generator, as indicated by a V. T. V. M. at J5 to chassis.

10. Replace V1 and V5 and set S4 to "auto lock."

11. Adjust R11 to a point slightly beyond the complete removal of all video from the sync as viewed with a scope at J1. R3 is then adjusted to clean up the sync peaks.

12. Lock the blocking oscillator of V4B to the remote sync by adjusting R4. This may be done by feeding a signal from J2 to the positive external sync input on an oscilloscope, while displaying a few horizontal pulses of the network stripped sync from J1. R4 is adjusted to the center of its locking range which causes the scope pattern to remain stationery. A double check is to be made on the setting of R4 by resetting the scope to positive internal sync, but not changing the sweep timing. Then display the pulse at J2. The time interval or spacing between pulses should be the same as that between horizontal sync pulse in the initial adjustment.

13. The master oscillator in the sync generator should be locked now to the network signal. This may be checked by viewing the mixture of the network and local sync at J3. The signal at J3 will be much distorted, but all components should be locked together.

14. Remove V18 and observe the signal at J7 with the oscilloscope set to view vertical information. Adjust R8 to a point where the observed negative pulse is reduced to a minimum. Replace V18.

15. With the scope still set to display vertical information, observe the pulses at J6. If the positive lower amplitude pulse is not resting in the notch of the wider negative pulse, R9 should be adjusted slowly to increase the width of the negative notch pulse until the positive pulse comes to rest in negative notch pulse. When this condition exists the local sync generator is in vertical phase with the network signal. If it is desired to view the vertical correction pulse at J8, it will be necessary to disconnect the vertical output cable and interrupt the network signal.

16. Now the horizontal phase may need some fine adjustment. This may best be done at the remote control, which for convenience, is located close to the network stabilizing amplifier remote controls. Therefore, switch S4 is set to remote position and the remote control switch to auto-lock position. Adjust the horizontal phase control to line up the leading edges of local blanking with that of the network signal.

17. Adjust the stabilizing amplifier remote black clip for desired setup. The remote black-clip balance should then be adjusted to give the best black level appearance when the remote switch is in the "local 60 cycle" position. The one meg. black-clip balance control is paralleled with the regular remote black clip control.

18. If the blanking is too short or long in duration, correction may be made at the sync generator to match the network signal.

19. Switching the remote control to "local 60 cycle" position will allow composite operation of the network stabilizing amplifier and "power line" control of the local sync generator. This enables the operator to see just how much improvement is being made in the signal by this reworking and permits an easy method of getting in and out of locked operation.

Using the Unit in Normal Station Operation

It is the primary function of this locking device to permit the reworking of a defective video signal. However, it will permit cross fades and superimposition of network, or remote, and any locally originated picture signal, except from film or video tape. The latter two video sources may also be included, providing the film driving motors are powered by an A. C. that is locked to the remotely controlled sync generator and pulsed light is used with film. It is understood that the vidicon is not subject to this exclusion when used in a film chain, as it has a very long image retentivity.

There is an advantage in being able to devote one staibilizing amplifier and one sync generator to normally operate with the "Betterlok." The advantages are that the operation of the unit can be checked at any time without any regard to interference with locally scanned film, etc. Then, too, maintenance and adjustments may be made to any of the units just before airing the reworked signal. After any pre-adjustments have been made, the sync generator changeover switch may be operated, placing the network controlled sync generator in general studio use, if such a hook-up is desirable. The operator must keep in mind the above mentioned limitations in connection with film chains. In case it is impossible to