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

IRE CONVENTION RECORD

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PART 7 - AUDIO AND BROADCAST

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HIGH STABILITY TELEVISION SYNCHRONIZATION GENERATOR

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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

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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.

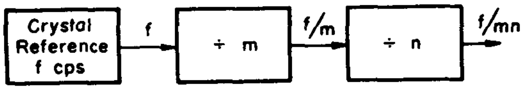

Fig. 1
Sinusoidal dividing chain

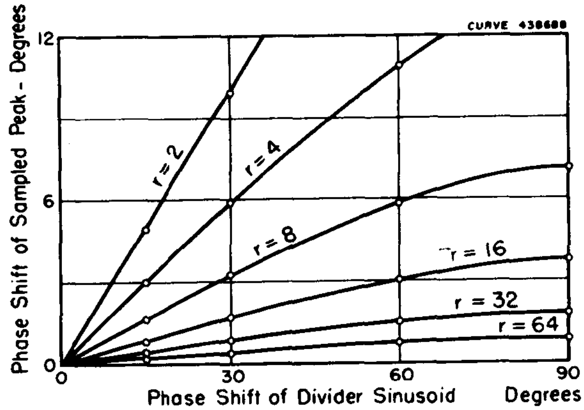

Fig. 4
Reduction of phase jitter

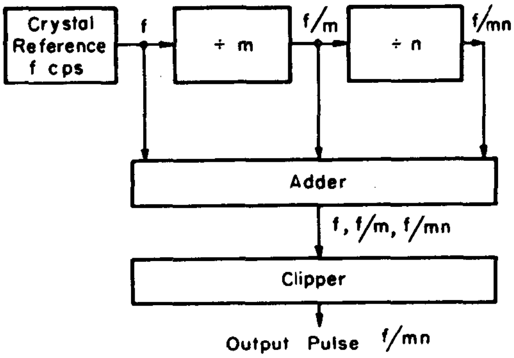

Fig. 2
Sinusoidal dividing chain with sampling

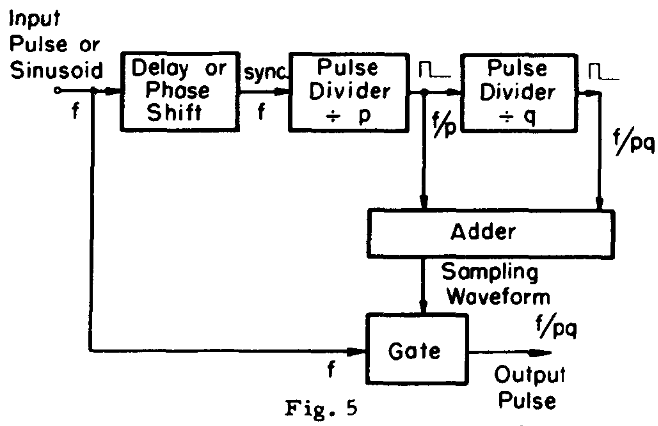

Fig. 5
Pulse dividing chain with sampling

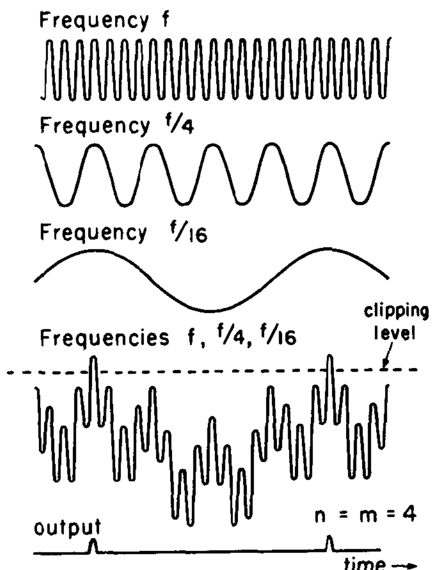

Fig. 3
Sampling dividing waveforms

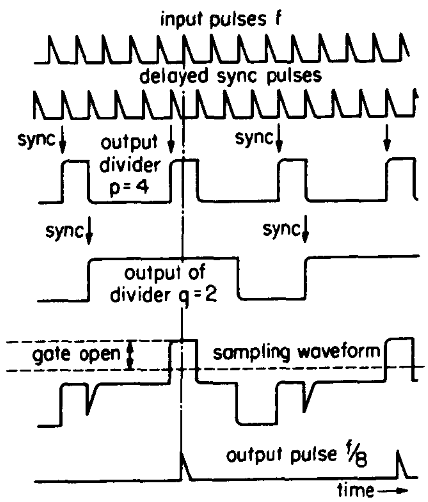

Fig. 6
Sampling dividing chain with pulse input

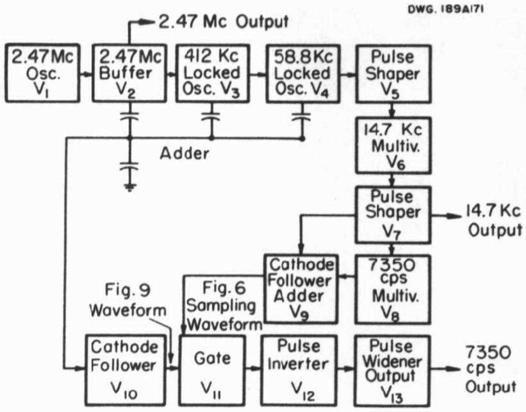

Fig. 7
High frequency divider

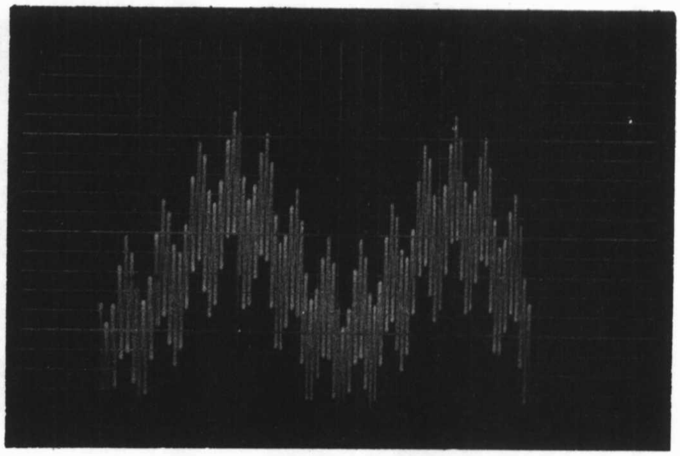

Fig. 9
Addition of sinusoids

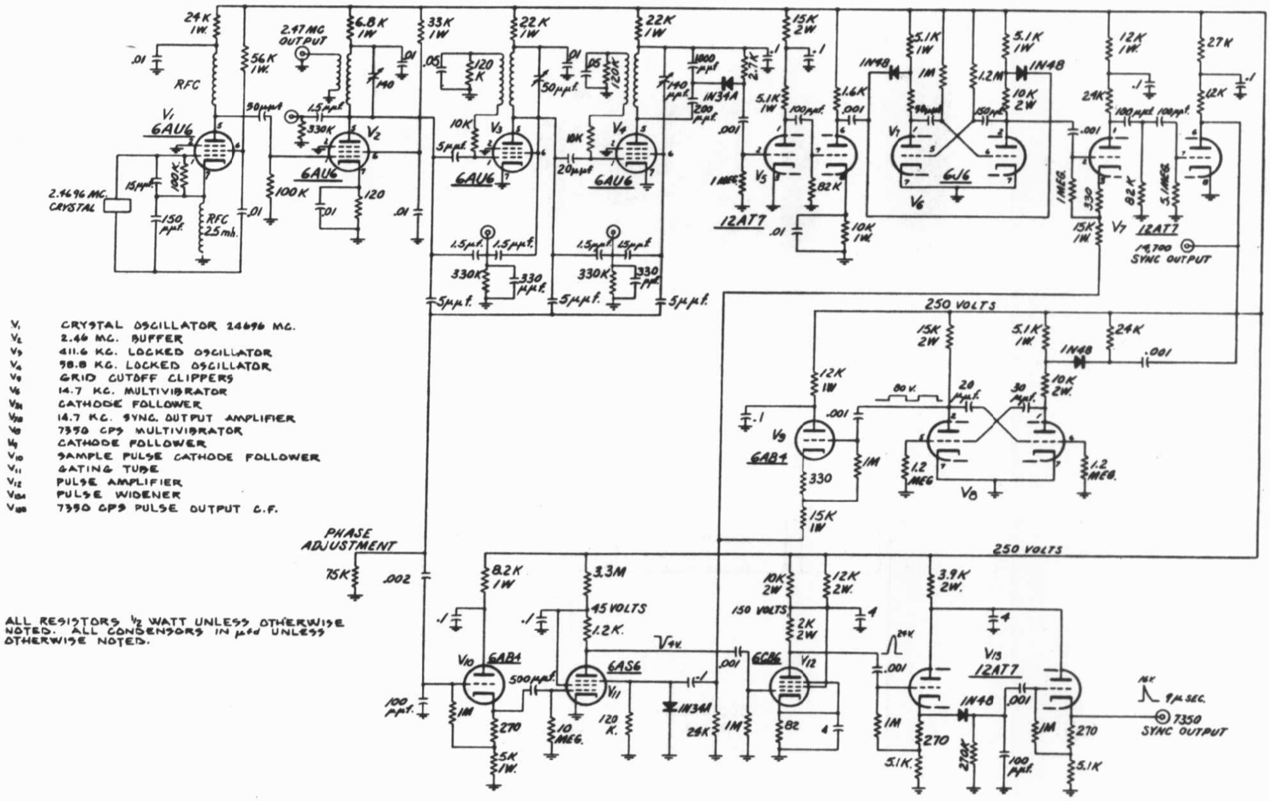

Fig. 8
High frequency divider

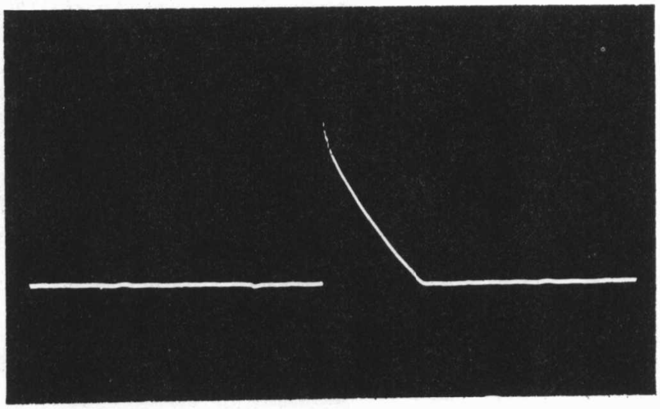

Fig. 10
7350 cycle sampled output

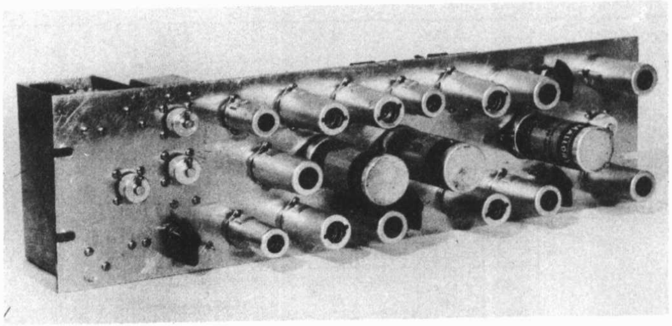

Fig. 11
Low frequency divider

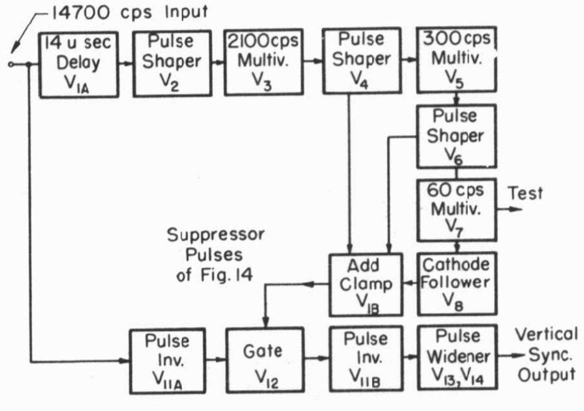

Fig. 12
Low frequency divider

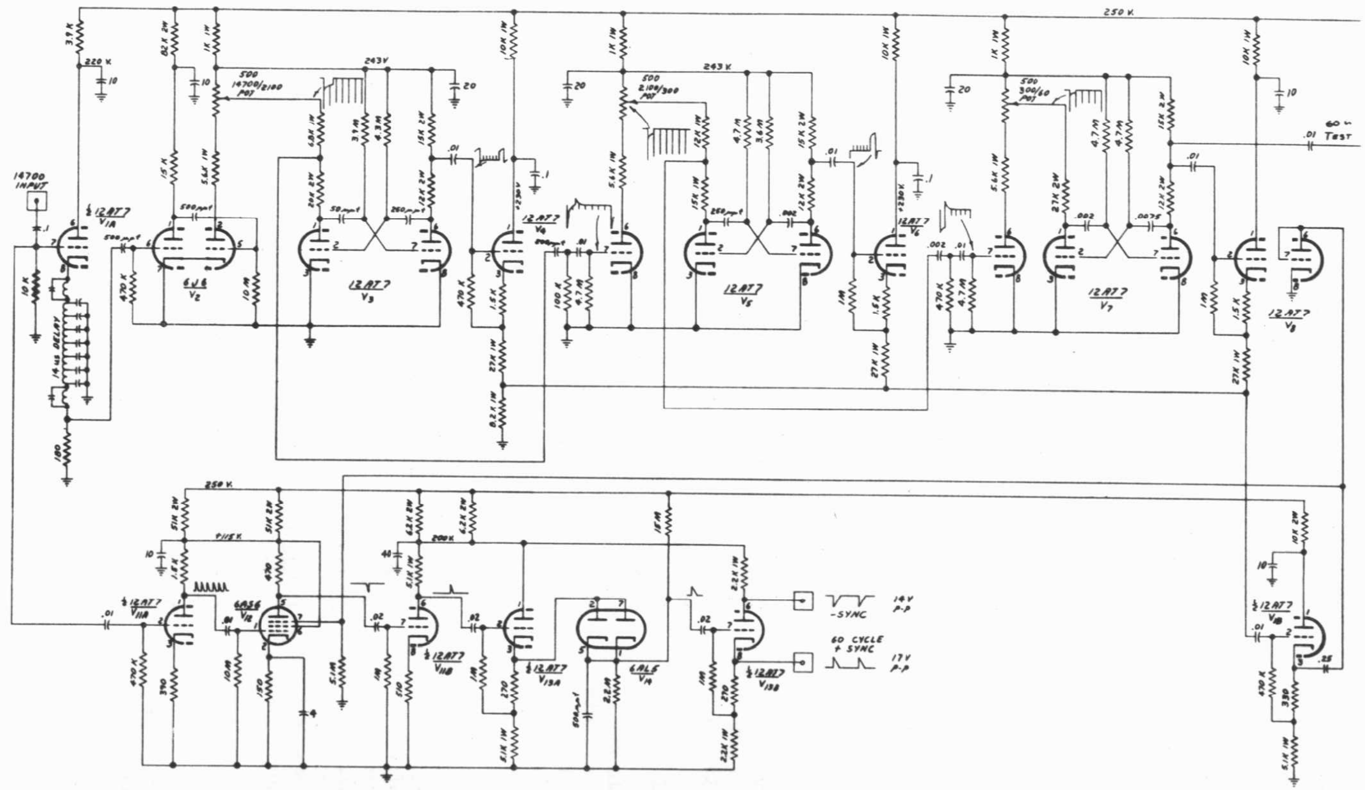

Fig. 13
Low frequency divider

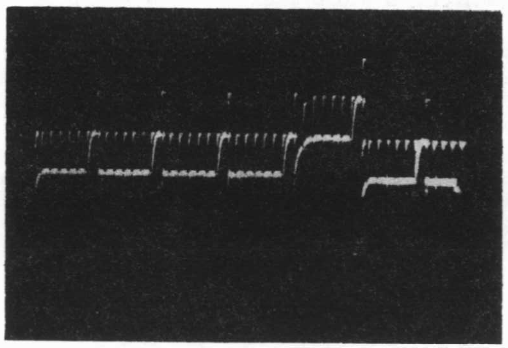

Fig. 14
Low frequency divider gating waveform

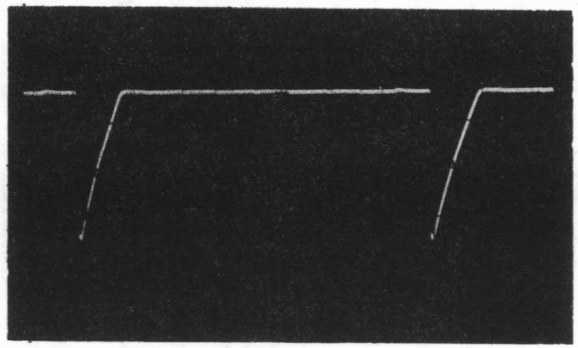

Fig. 15
Jitter between input and sampled output

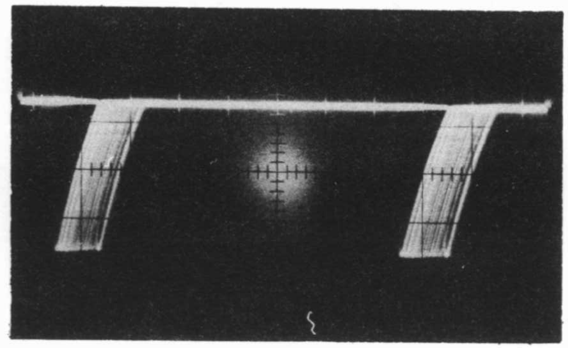

Fig. 16
Jitter between input and conventional output

PEDESTAL PROCESSING AMPLIFIER FOR TELEVISION

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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 $\pm$ 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 $\pm$ 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.

<u>Adjustment of the Apparatus</u>

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 ± 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 τ_1 = 0.2 usec and τ_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.

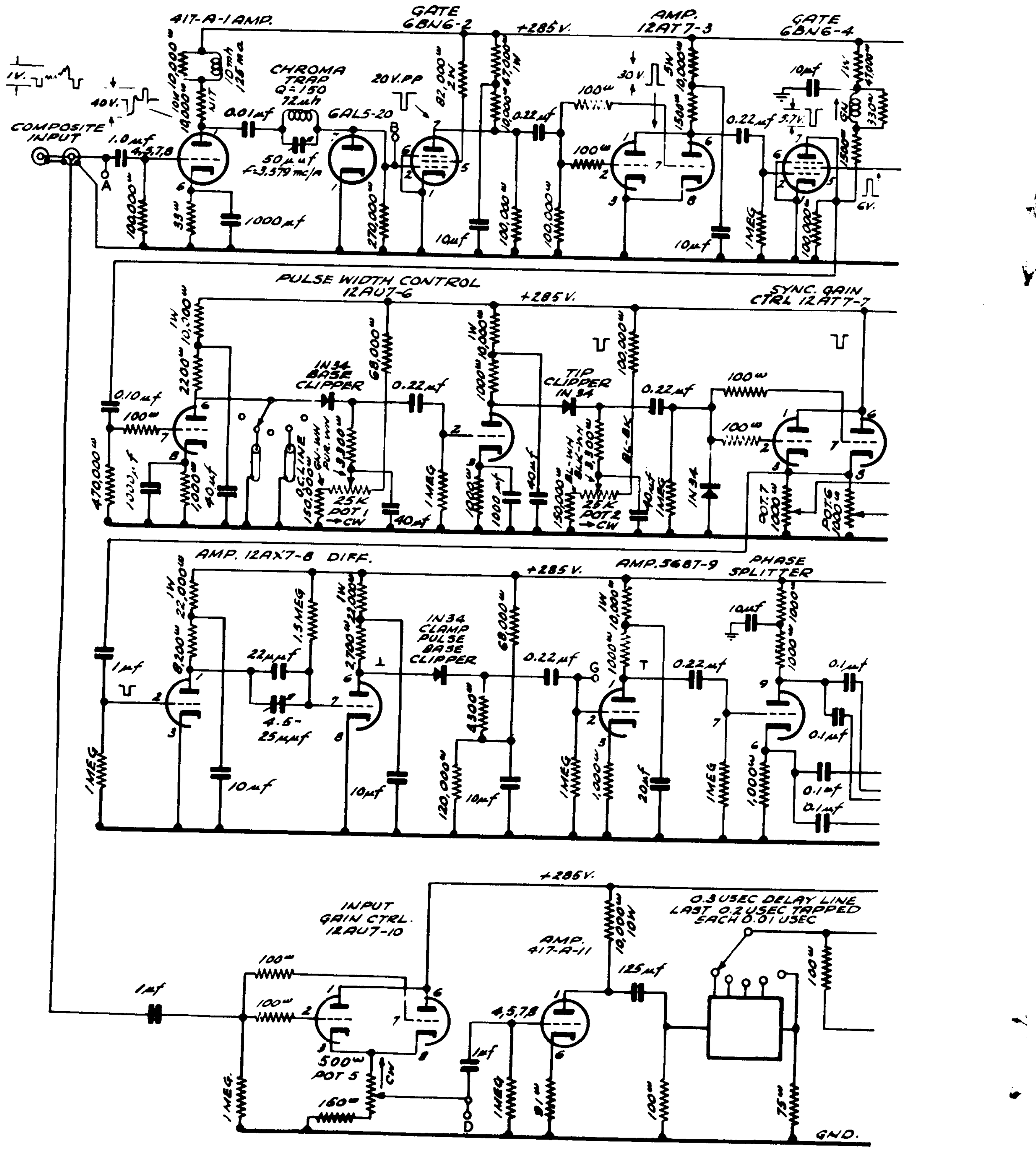

Fig. 1a
Circuit diagram of pedestal processing amplifier

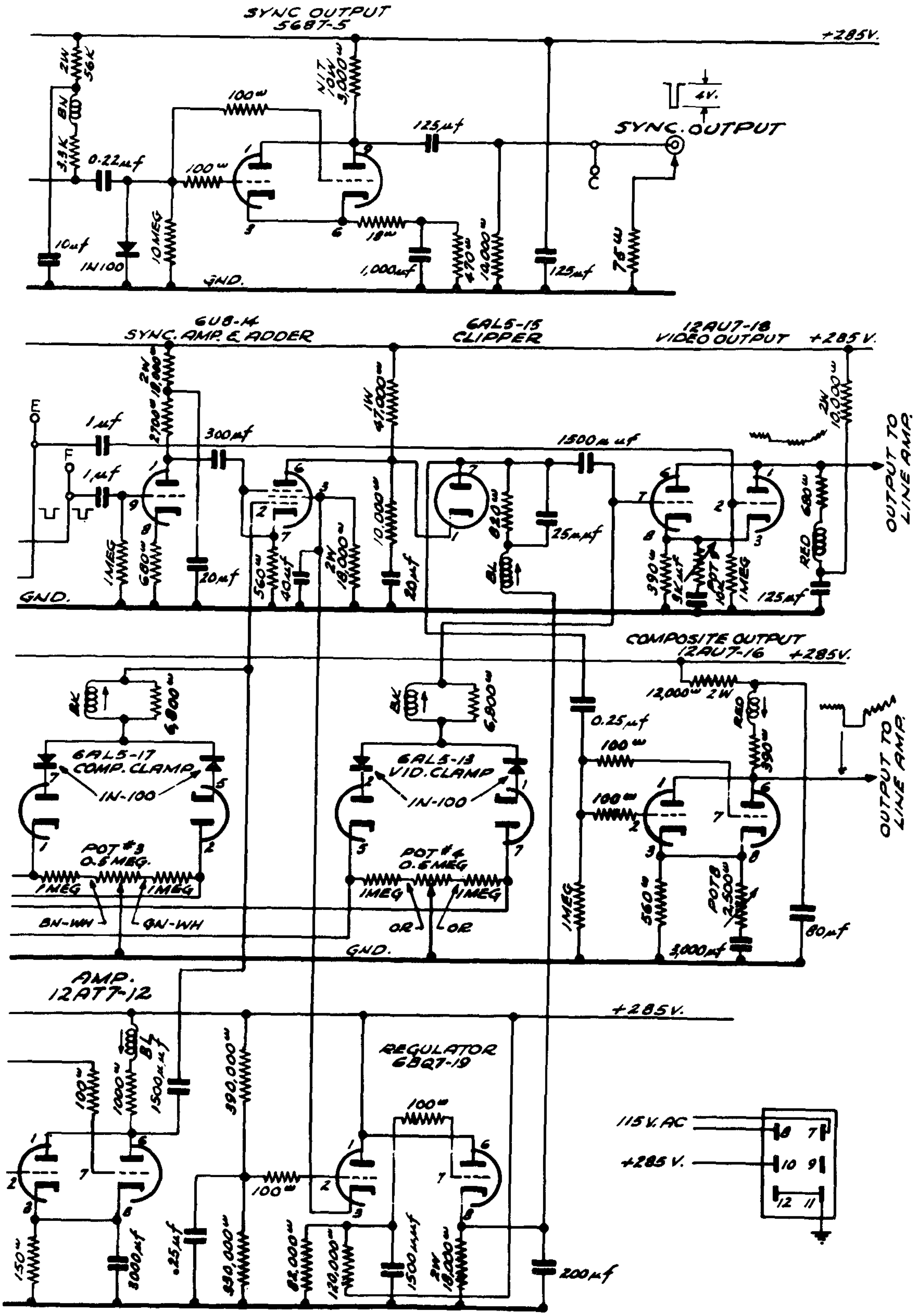

Fig. 1b
Circuit diagram of pedestal processing amplifier

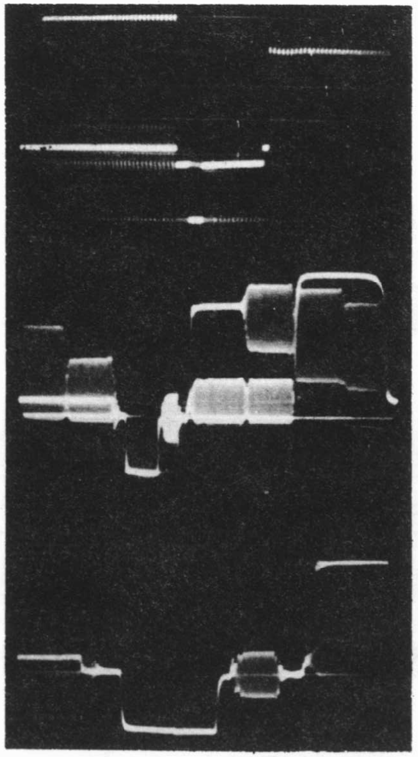

Fig. 2
Color bar signal
waveforms at
test point A

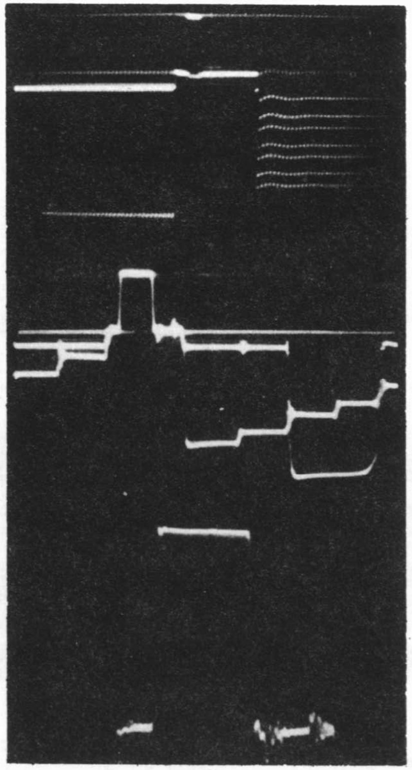

Fig. 3
Color bar signal
waveforms at
test point B

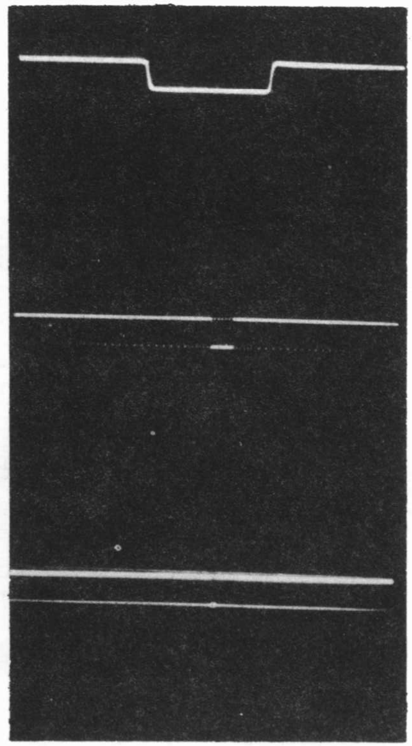

Fig. 4
Sync waveforms at
test point C

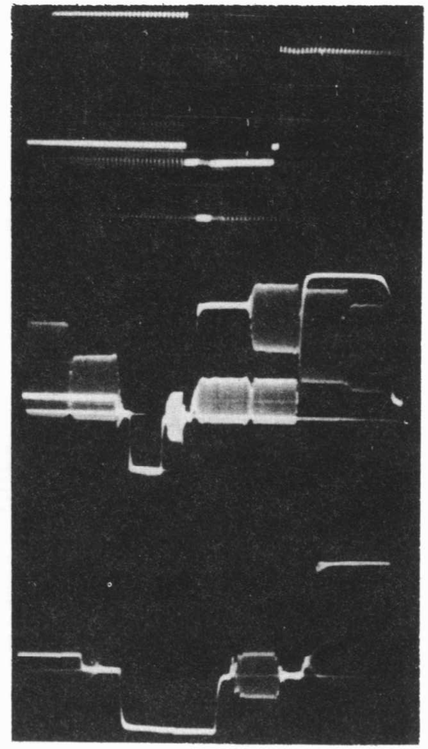

Fig. 5
Color bar signal
waveforms at
test point D