

*Berry & Town*  
Hertz  
7-10-38

# HAZELTINE SERVICE CORPORATION

(A SUBSIDIARY OF HAZELTINE CORPORATION)

NEW YORK LABORATORY:  
333 West 52nd Street  
Columbus 5-0793

CHICAGO LABORATORY:  
325 West Huron Street  
Superior 0790

BAYSIDE LABORATORY:  
Bayside, Long Island.  
Flushing 7-5300

This Report is the property of the Hazeltine Service Corporation and is prepared for the exclusive use of its authorized representatives.

*Report No. 1822*

TITLE      **FORMATION OF COMPLETE VIDEO WAVE**  
                  **( TELEVISION PRINCIPLES — CHAPTER 3 )**

DATE        *June 6, 1938.*

MFR.        *General.*

Approved *W. A. Mac Donald*

This report gives the result of investigations by our engineers. Use of the information herein contained is on the sole responsibility of the recipient of the report. No recommendations are made by the Company and no responsibility is assumed by the Company. The report is forwarded to you for your information only. It is not for general distribution and should be treated as confidential.

HAZELTINE SERVICE CORPORATION

FORMATION OF COMPLETE VIDEO WAVE  
(TELEVISION PRINCIPLES - CHAPTER 3)

By C. E. Dean

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION - - - - -	45
RELAXATION OSCILLATORS - - - - -	45
TIMING CIRCUITS - - - - -	47
LIMITERS - - - - -	48
WAVE-SHAPING CIRCUITS - - - - -	50
KEYING - - - - -	51
BACKGROUND INSERTION - - - - -	53
FORMATION OF SIGNAL - - - - -	55
ILLUSTRATIONS - - - - -	56
CARRIER-FREQUENCY TRANSMISSION - - - - -	62
REFERENCES - - - - -	62

SPECIFICATIONS SELECTED FROM  
THIS CHAPTER

Amplitude Used for Picture Signals	-	-	-	-	80%
Amplitude Used for Sync Signals	-	-	-	-	20%
Duration of Field Blanking	-	-	-	-	7% of Field Cycle
Duration of Line Blanking	-	-	-	-	15% of Line Cycle
Line Frequency	-	-	-	-	13,230 per Second
Type of Horizontal Sync Signal	-	-	-	-	Single Pulse
Type of Vertical Sync Signal	-	-	-	-	6 Broad Pulses
Total Duration of Line Doubling for Equalization	-	-	-	-	9 Lines
Highest Frequency of Timer Chain	-	-	-	-	26,460 Cycles
Lowest Frequency of Timer Chain	-	-	-	-	60 Cycles
Polarity of Cathode-Follower Limiting	-	-	-	-	Negative
Polarity of Sync Pulses for Two-Tube Relaxation Oscillator	-	-	-	-	Positive

\* \* \* \* \*

FORMATION OF COMPLETE VIDEO WAVE  
(TELEVISION PRINCIPLES - CHAPTER 3)

INTRODUCTION

In the first chapter, Report 1776, we have given a general introductory account of a modern television system and a discussion of persistence of vision and flicker. In the second chapter, Report 1789, we have given a detailed account of the operation of the usual mosaic type of camera tube and described the form of the signals supplied by the tube. The present chapter is devoted to the formation of the complete video wave. This wave is described, and the various operations required to form it from the output of the camera tube are discussed in general terms. The following chapter will discuss the use of this wave in the receiver.

The wave which will probably be used in the United States is shown in Figure 1. This diagram shows that 80 percent of the total signal amplitude is used for transmitting the video signals supplied by the camera tube; the remaining 20 percent is used to convey the synchronizing information. The diagram also shows that 79 percent ( $.93 \times .85$ ) of the time is used to transmit the picture information; the remainder of the time is used to transmit the synchronizing information and to return the scanning spot from the end of one trace to the start of the next. A comparison of Figure 1 with that of Figure 7 of Report 1789 (page 39) shows that the following operations must be performed to convert the camera-tube output to the desired video wave: (1) elimination of the shading component; (2) elimination of the surge; (3) addition of blanking pulse or pedestal; and (4) addition of the synchronizing component.

Amplification of the signal from the camera is accomplished by means of resistance-coupled amplifiers which are modified to pass the required wide frequency band without introducing objectionable phase distortion. The modifica-

tions of a resistance-coupled amplifier which enable it to pass the television band will be described in a later chapter. Until then we will consider that the amplifiers are simply resistance-coupled.

In order to explain the various operations in the formation of the complete video signal, we will first discuss the following subjects: (1) relaxation oscillators; (2) timing circuits; (3) limiters; (4) wave-shaping circuits (performing integration and differentiation); and (5) keying.

RELAXATION OSCILLATORS

A relaxation oscillation differs from the usual periodic oscillation in that the wave consists of aperiodic portions occurring in regular succession.

While there are many types of relaxation oscillators used in television systems, the present discussion is limited to one type - the modified form of multi-vibrator shown in Figure 2.

Considering the operation of this oscillator, we may assume that at the beginning the condenser  $C_1$  is charged, giving the cathode of  $T_1$  a high positive voltage with respect to ground. This is the condition at  $t_0$  in the voltage-time diagrams. The high cathode potential prevents the flow of current thru  $T_1$ , so that condenser  $C_1$  starts to discharge thru resistors  $R_1$  and  $R_2$  in series. Resistor  $R_1$  is of the order of 0.1 percent of  $R_2$ . The rate of discharge is determined by the RC time constant, which determines the shape of the output voltage during the trace part of the cycle. When the condenser is sufficiently discharged to reach the cutoff voltage of  $T_1$ , current starts to flow in  $T_1$ . This causes a drop in the anode voltage of  $T_1$  and the grid voltage of  $T_2$ . This in turn reduces

the current flowing thru  $T_2$ , raising its anode voltage and hence increasing the grid potential of  $T_1$ . The bias here was already falling as  $C_1$  was discharging. The system is thus violently regenerative. A large flow of plate current thru  $T_1$  is quickly established; this is the retrace portion of the cycle. The plate current charges up condenser  $C_1$ , completing the cycle. That is, when the current thru  $T_1$  starts to decrease, the reversing action of tube  $T_2$  lowers the grid potential of  $T_1$ , stopping the current flow.

From this it is evident that the characteristics during the trace portion of the cycle are determined by  $R_1$ ,  $R_2$ , and  $C_1$ . The characteristics during the retrace are determined by the cathode-anode resistance of tube  $T_1$  and the capacitance  $C_1$ . The duration of the trace portion of the cycle may be varied by changing the  $R_2 C_1$  time constant, or by varying the tube potentials to adjust the voltage limits between which the system oscillates. The duration of the retrace portion of the cycle may be varied by changing the capacity  $C_1$ . In order to accomplish this without changing the trace duration,  $R_2$  must also be changed to keep the same time constant.

Near the end of the trace portion of the cycle, the oscillator is sensitive to small fluctuations in the potentials applied to tube  $T_1$ . A small positive potential applied in series with a high resistance to the grid of  $T_1$  will terminate the trace portion of the cycle;

in this way the oscillator may be synchronized. For example assume that a series of pulses such as  $E_1$  in Figure 2 is applied to the grid of  $T_1$ . The oscillator will then be synchronized by these pulses, the retrace starting on every other pulse. In this way there is a two-to-one division of frequency, that is, the frequency of the oscillator is half that of the pulses. Frequency ratios of unity, two-to-one, three-to-one and seven-to-one are employed in various equipment used in forming the complete video signal. The pulses received between the ones which initiate retraces are ineffective because they occur at times in the cycle when  $T_1$  is insensitive to them. The "active" pulses reach the grid shortly before the retrace would start in the free-running condition. This means that the synchronizing action raises the oscillator frequency. If the free-running frequency of the oscillator is equal to or slightly higher than the frequency of the controlling pulse, synchronism is lost - that is, the oscillator "slips sync".

The trace portion of the saw-tooth voltage wave in Figure 2 has an exponential character in accordance with the well-known properties of a condenser-resistance discharge. In Figure 3 we show a modification of Figure 2 in which a pentode (substituted for  $R_2$ ) is provided to act as a constant-current tube. This gives a linear, rather than an exponential, change of voltage with time and we therefore obtain a linear trace portion of the saw-tooth wave.

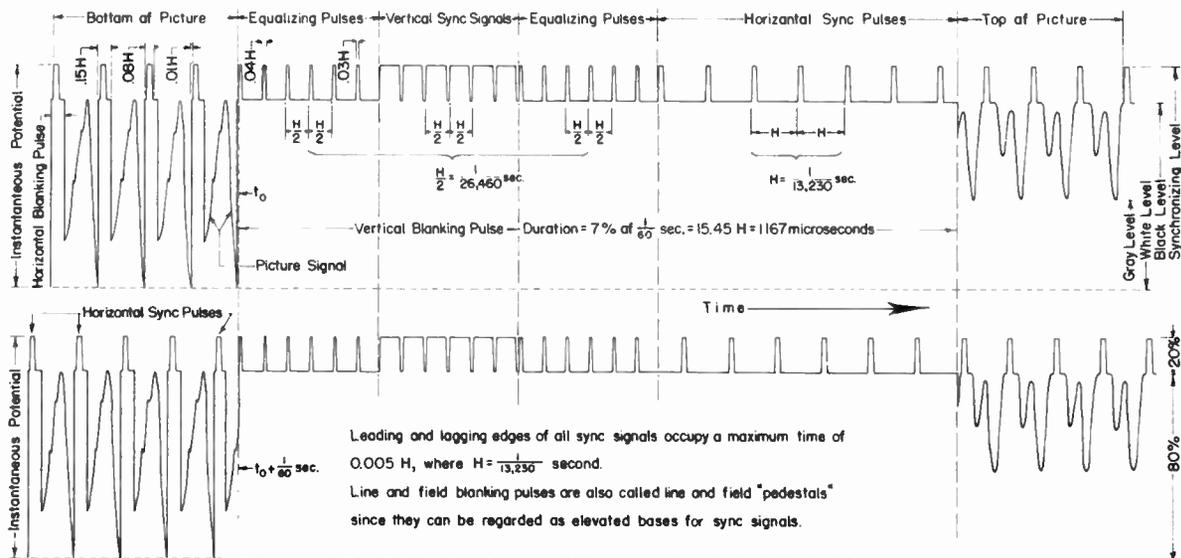


Fig. 1. Field-Retrace Portion of Complete Video Wave.

From the above treatment the reader should understand for himself the following functions of this type of oscillator:

- (1) The formation of saw-tooth voltages of two types: (a) exponential; and (b) linear;
- (2) The formation of rectangular pulse waves;
- (3) The control of the ratio of trace to retrace in both saw-tooth and pulse types of waves; and
- (4) The synchronizing action for: (a) one-to-one frequency relation; and (b) frequency division, in

which the oscillator operates at a sub-multiple of the synchronizing frequency.

TIMING CIRCUITS

One important timing operation in a television system is the generation of the line and field frequencies (13,230 cycles and 60 cycles) with exact phase relations. This may be accomplished by operating an oscillator at 26,460 cycles and using frequency dividers of the type just discussed above. The 13,230-cycle voltage is obtained by one oscillator which divides the 26,460 by 2; the 60 cycles is obtained by a separate chain of oscillators which divides the 26,460 cycles by 3, then 3 again, and then twice by 7, the total being a division by 441.

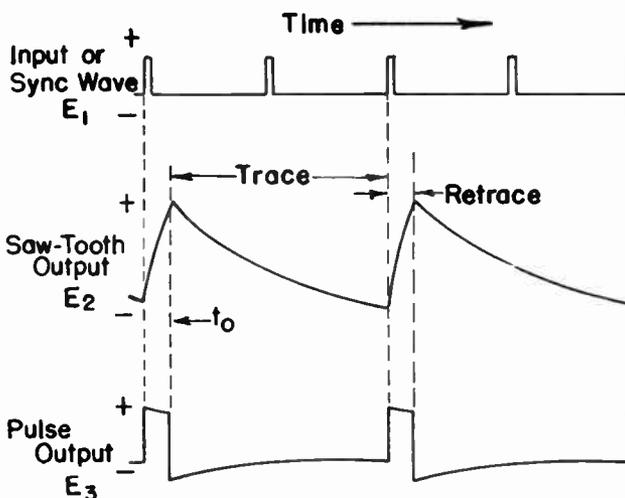
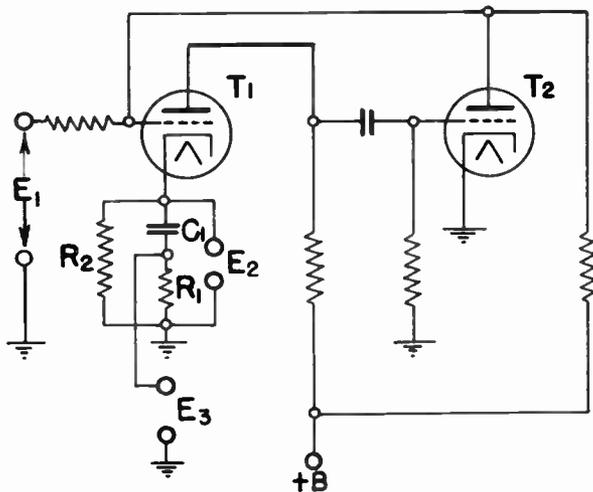


Fig. 2. Circuit of Two-Tube Relaxation Oscillator World Radio History

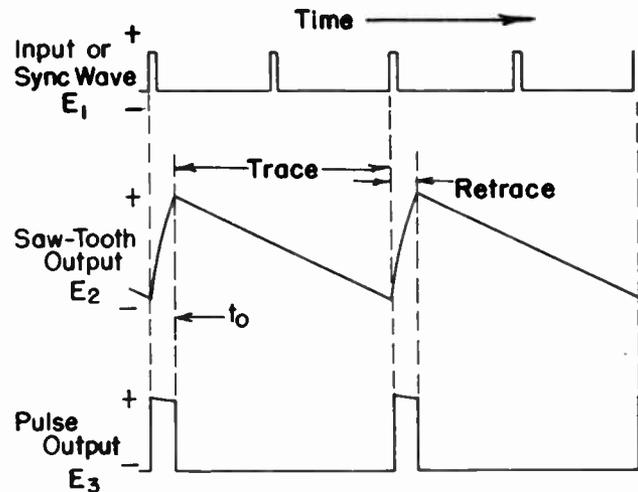
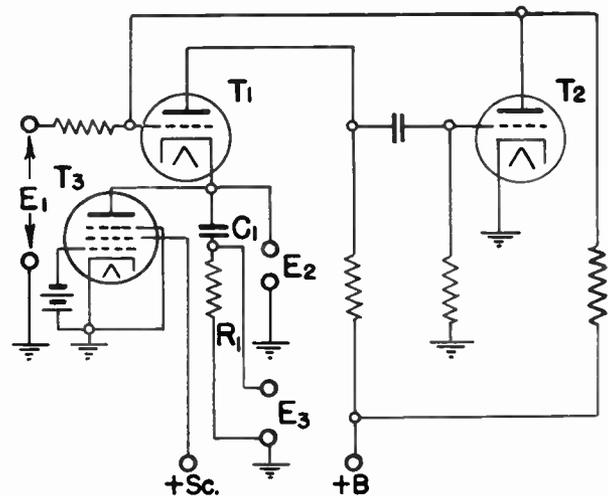


Fig. 3. Relaxation Oscillator Providing Linear Saw-

Since each of these divisions is an accurate operation, the required precise relation between the 60 cycles and the 13,230 cycles is obtained.

Another timing operation is synchronizing such a chain with the 60-cycle power-supply system. This may be done by detecting the phase difference between the 60-cycle power supply and the 60-cycle pulse from the chain. The detected difference is used to control the frequency of the 26,460 oscillator, as is shown in Figure 4.

The 60-cycle pulse from the bottom oscillator in the chain and the 60-cycle sine wave from the power line are added in the plate circuit of  $T_1$  and  $T_2$ . The resulting wave, applied to the peak detector diode, is shown in the voltage-time diagrams of this figure. The diode output regulates the grid bias of  $T_3$  which is a constant-current tube. This tube in Figure 4 has the function of tube  $T_3$  in Figure 3, as part of the 26,460-cycle oscillator at the top of the oscillator chain.

If the timer chain tends to run fast, there will be a greater rectified voltage, and the bias on  $T_3$  in Figure 4 is thereby increased. This reduces the discharge rate during the trace portion of the cycle, and thus stabilizes the frequency and locks it to the 60-cycle power line.

Other important timing operations can be better explained after the reader has followed the discussion of limiters and wave-shaping circuits. The discussion of these further timing actions is therefore deferred to the section on keying.

### LIMITERS

The limiting operation consists in flattening off a voltage wave at a desired level. Figure 5 illustrates several limiters, all consisting of tubes which are overloaded.

An important characteristic of a limiter is the sharpness of the overload or limiting action. It is usually desired that there be no distortion of the wave until the limiting voltage level is reached. The output should then be flat until the voltage returns to the overload limit. Both these characteristics are obtained if the limiter has sharp operation.

Figure 5A shows a diode used as a limiter to flatten off the peaks of the wave. The potentiometer sets the voltage at which limiting occurs. By reversing the plate-cathode terminals of the diode, the limiter may be used to flatten the negative peaks. Figure 5B shows positive-grid limiting. Figure 5C shows the action of a negative-grid limiter which depends on the cutoff characteristic of the

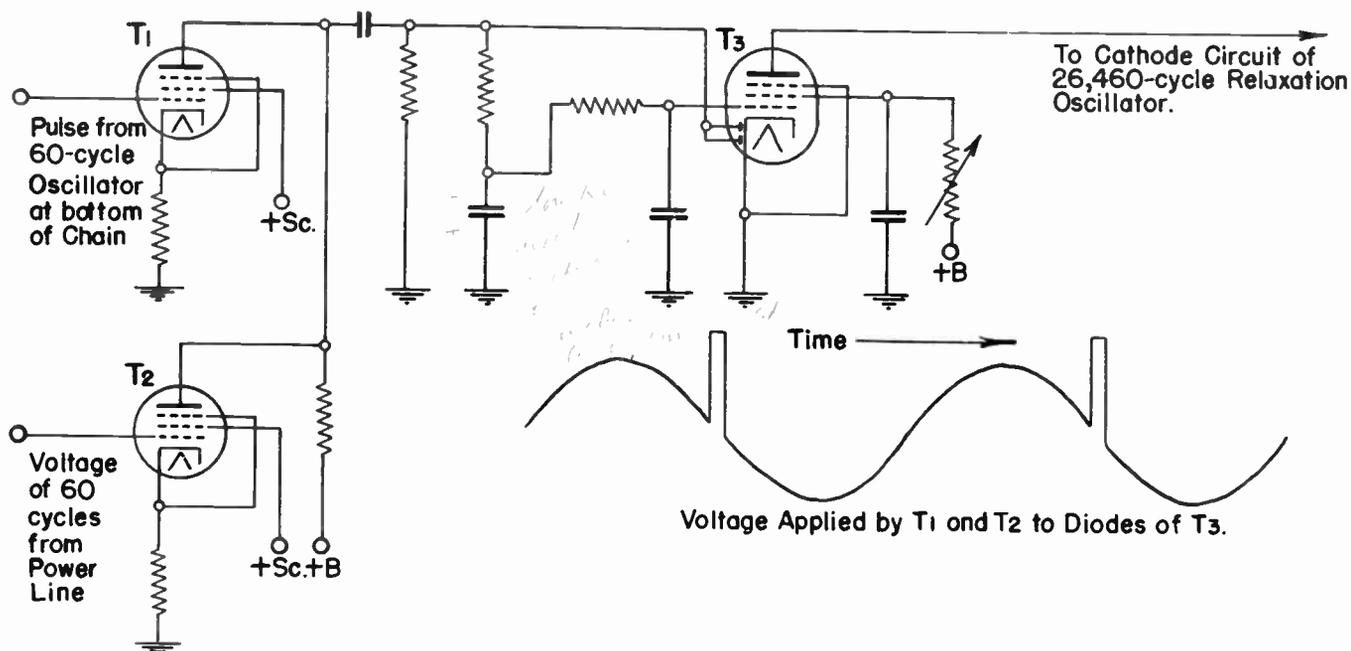
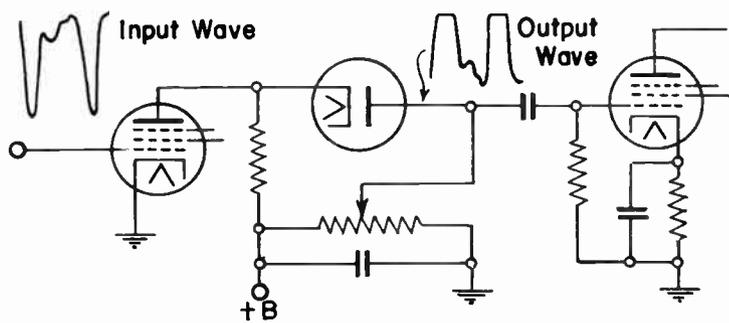


Fig. 4. Control of 26,460-Cycle Oscillator to Keep Phase of 60-Cycle

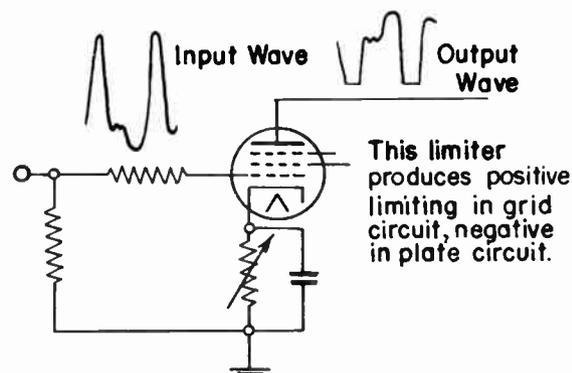
tube. These first three types cause some distortion of the wave near the cutoff, clipping, or limiting point. That is, the operation is not as sharp as often wanted. Figure 5D shows a cathode-follower type of limiter. In this circuit the negative feedback, provided by the cathode load, gives considerable improvement in the sharpness of cutoff.

characteristic, namely that it acts as an impedance transformer. The impedance on the grid side of the tube is usually high. The impedance between the cathode terminal and ground is the reciprocal of the sum of the conductance of the cathode load resistor and the transconductance of the tube. Consequently, the circuit is useful when operating into low-impedance circuits. This is the case, for example, with coaxial transmission lines, whose characteristic is frequently less than 100 ohms; these lines are used to transmit video signals around the studio, etc.

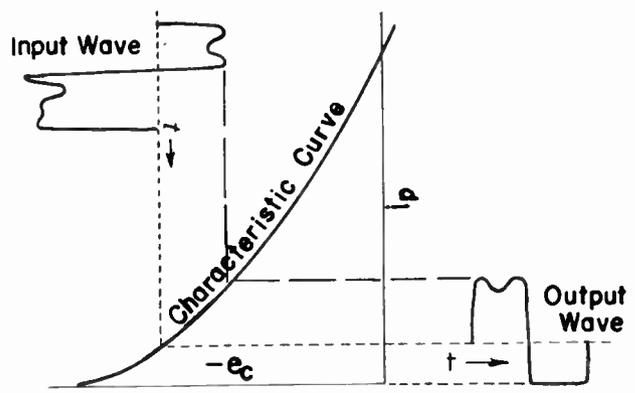
Digressing for a moment, we may note that the cathode-follower circuit of Figure 5D has another important



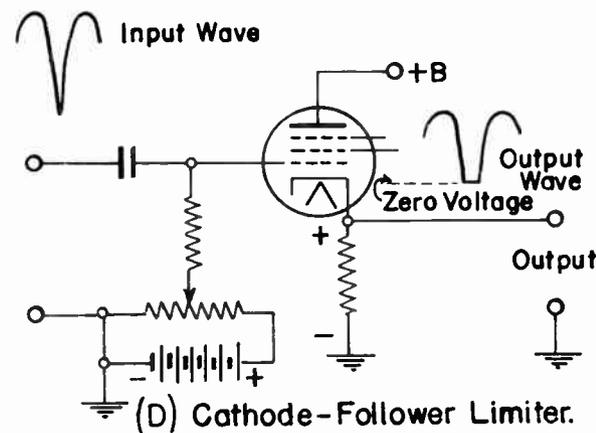
(A) Series-Diode Limiter Poled for Positive Limiting.



(B) Positive-Grid Limiter.



(C) Action of Negative-Grid Limiter.



(D) Cathode-Follower Limiter.

Fig. 5. Limiting Circuits.

The term cathode follower is used because the cathode potential follows the grid potential; for example, if the grid goes positive by 10 volts, in a typical circuit the cathode will go positive by 8 or 9 volts. The polarity is not reversed. On account of the voltage loss, the tube is not used for voltage amplification with this circuit.

### WAVE-SHAPING CIRCUITS

One important wave-shaping operation is accomplished by means of limiters such as just described. For example, assume that the wave of Figure 6A is to be changed to that of Figure 6B.

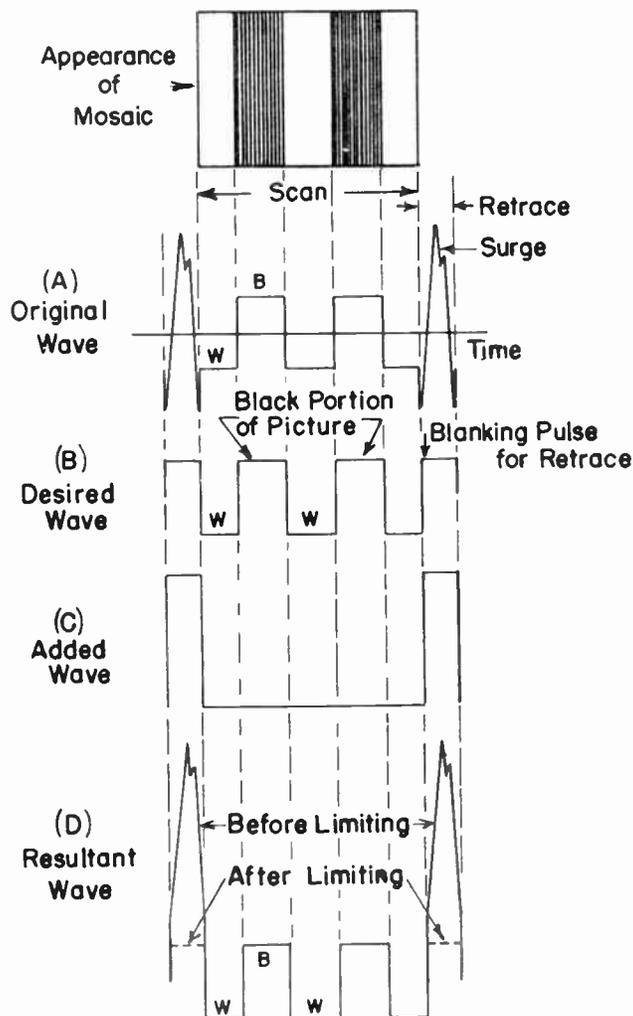


Fig. 6. Example of Wave Shaping.

The first operation is to add a rectangular pulse of the proper retrace interval such as shown in Figure 6C to the wave of Figure 6A. The exact timing requirements are easily met because of the common synchronizing source for the two components. The result of the addition is illustrated in Figure 6D, the wave shape after limiting being shown by dotted lines. A circuit for accomplishing this operation is illustrated in Figure 7. The voltage at which the limiting occurs can be controlled by the setting of the potentiometer.

Another important series of wave-shaping operations is illustrated by the derivative series of waveforms shown in Figure 8. This figure illustrates differentiation and integration accomplished severally by inductances and condensers. It is possible to choose reasonable values of inductance and capacitance which may be connected in the plate circuits of pentode tubes with negligible effect on the plate currents.

The plate current has a waveform which is the same as that of the applied signal voltage. The plate voltage, however, is either the derivative or integral of that voltage waveform. In other words any available waveform may be applied to the grid of the pentode and the plate voltage will be either the integral or the derivative of the applied wave according to the reactance in the plate circuit. For example, consider the rectangular pulses in the second line of Figure 8. If a current of this form flows thru an inductance, the voltage across the inductance will be the series of narrow double pulses shown by the top line, since

$$e_L = -L \frac{di}{dt}$$

As another example, if the double current pulses of the form shown at the top of Figure 8 flow thru a condenser, the voltage across the condenser will be the rectangular pulse shown in the second line, since

$$e_c = \frac{1}{C} \int i \, dt.$$

It is apparent that each wave shape shown in Figure 8 is the integral of the one above it and the derivative of the one below it.

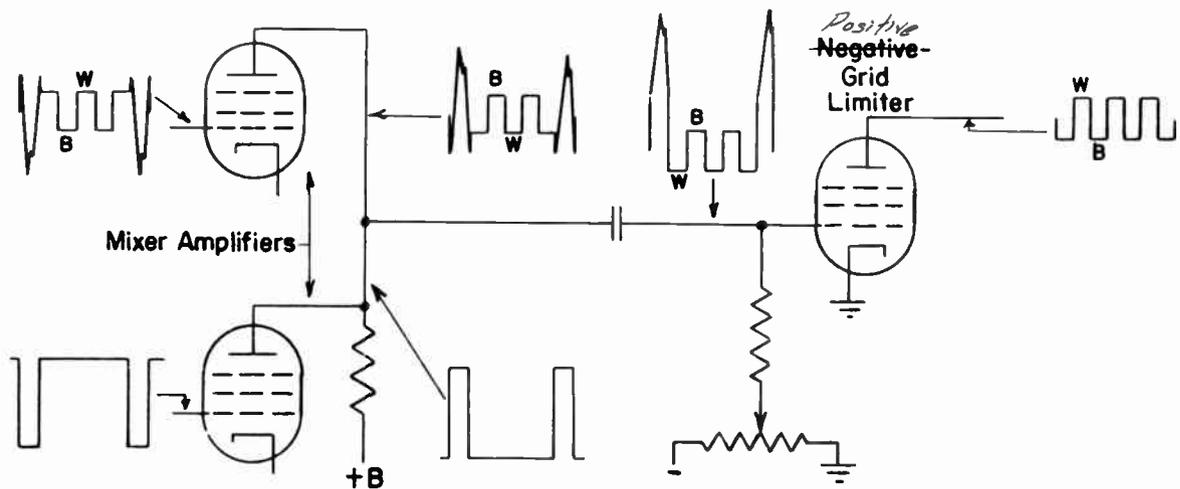


Fig. 7. Circuit for Performing Wave Shaping of Figure 6.

The parabolic waveform (second from the bottom) is of special interest. This wave consists of two parabolas; the one with the sharp curvature is the integral of the retrace portion of the saw tooth, and the one with the gradual curvature is the integral of the trace portion of the saw tooth. From this figure it is apparent that further integration would cause the wave to approach the sine wave more closely, that is continued integration reduces the relative amplitudes of harmonics; on the other hand differentiation increases their relative amplitudes.

Two examples of wave shaping may be seen in the oscillator circuit of Figure 3. Let us first consider that the output voltage supplied by the oscillator is the saw-tooth voltage  $E_2$ . The rectangular pulse voltage  $E_3$  is then obtained by measuring the current flow thru  $C_1$ , the resistance  $R_1$  being small enough so that it has no appreciable effect on the shape of the current wave flowing thru  $C_1$ . This is an example of the use of a condenser for differentiation.

If we consider this same circuit from another point of view, that is, consider the oscillator output to be the cathode current of  $T_1$ , which is of the rectangular-pulse type, we then use the condenser as an integrator to obtain the voltage  $E_2$ .

KEYING

The keying operation is used to connect an available waveform to a load circuit for a specified portion of the cycle. One of the usual methods of

accomplishing this operation is illustrated in Figure 9. The circuit arrangement of the figure shows a pentode tube with the signal to be keyed applied to its inner grid and the keying signal to its outer grid. Operating voltages are so adjusted that the more negative portion of the keying signal cuts off the tube's anode current, thus preventing the signal on the inner grid from operating in the anode circuit during this portion of the time cycle. Proper relations must be maintained between the operating

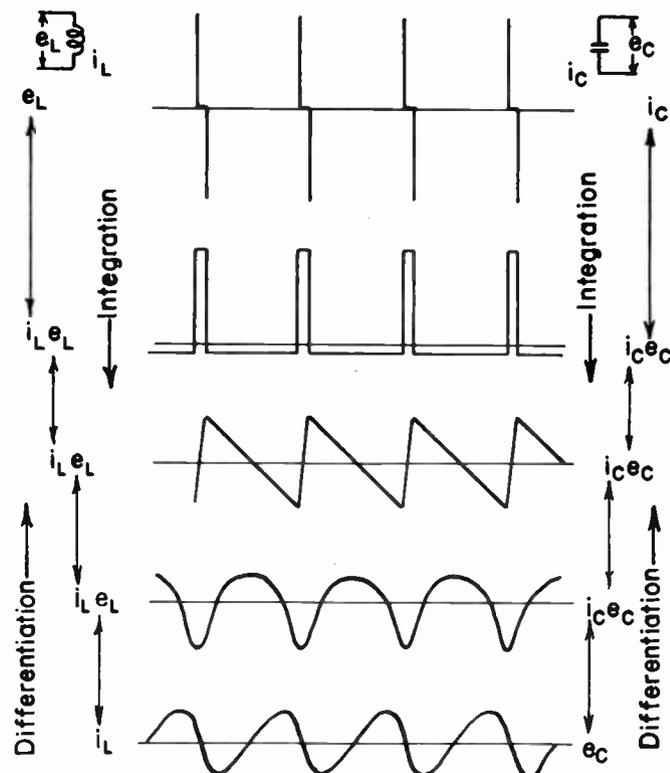


Fig. 8. A Series of Derivative and Integral Waveforms.

voltages and both signal amplitudes in order to produce a clean output signal such as that shown in the figure.

Consider now the problem of constructing the field pedestal portion of the complete video wave shown in Figure 1. For convenience this portion of the figure has been redrawn as Figure 10A. Figure 10B shows the output of the video system with picture and pedestal components; it is apparent that the addition of the synchronizing signal to this wave will give the desired waveform. The available waves from which the synchronizing signal is to be formed are shown in Figures 10C, 10D and 10E. It is obvious that the synchronizing signal can be formed by keying in these for different portions of the cycle. To do this we assume that a single 60-cycle pulse is available, as shown in Figure 10F. The first operation is to obtain keying pulses using this pulse as the control signal. This may be done by using F to synchronize two 60-cycle oscillators with carefully adjusted retrace intervals. This will give waves 10G and 10H, these waves being formed in similar fashion to  $E_3$  in Figure 3. The pulse 10H may be differentiated, giving the wave 10I. This may be applied to the grid of a positive limiting amplifier which will remove the first pulse of 10I; the plate voltage of this amplifier will be the wave 10J. This wave may be used to control a third oscillator which will supply the wave 10K. We now have the keying pulses 10G and 10K, and the four voltages 10B, 10C, 10D and 10E which are to be combined to give the desired signal 10A. The pulse 10G is timed for the interval during which the line synchronizing signals

are to be stopped and the line doubling pulses inserted. Wave 10K is timed to give the period during which the broad pulses are to be inserted. These broad pulses are the field synchronizing signal. The apparatus of Figure 11 may be used to combine all of these waves in such a fashion as to produce the desired output.

In Figure 11 two signal amplifier stages are shown connected in cascade. The first of these stages has four pentode amplifiers  $T_1$ ,  $T_2$ ,  $T_3$ , and  $T_4$ , with their anode circuits common. This stage will serve, therefore, to mix the four required signals without permitting intermodulation. This operation of mixing may be seen to be similar to the addition of waves shown in Figures 6 and 7. The signal of Figure 10B requires no keying and is hence the only signal applied to Tube  $T_1$ . The signals 10C, 10D, and 10E all require keying so that their respective amplifier tubes  $T_2$ ,  $T_3$ , and  $T_4$  are arranged to be keyed by the voltages applied to their suppressor grids. Thus the signal 10C which must appear in the output except during the pulse interval of 10G is keyed by passing the signal 10G thru the pulse amplifier  $T_6$  for polarity reversal. This reversed signal is then applied to the suppressor of  $T_2$  where it cuts off the tube during the pulse interval. The same signal 10G, without reversal, is applied directly to the suppressor of  $T_3$ , thus permitting the flow of anode current for this tube during exactly the interval when  $T_2$  is cut off. In consequence the waveform 10D will appear in the output during that portion of the cycle in which 10C is absent. The

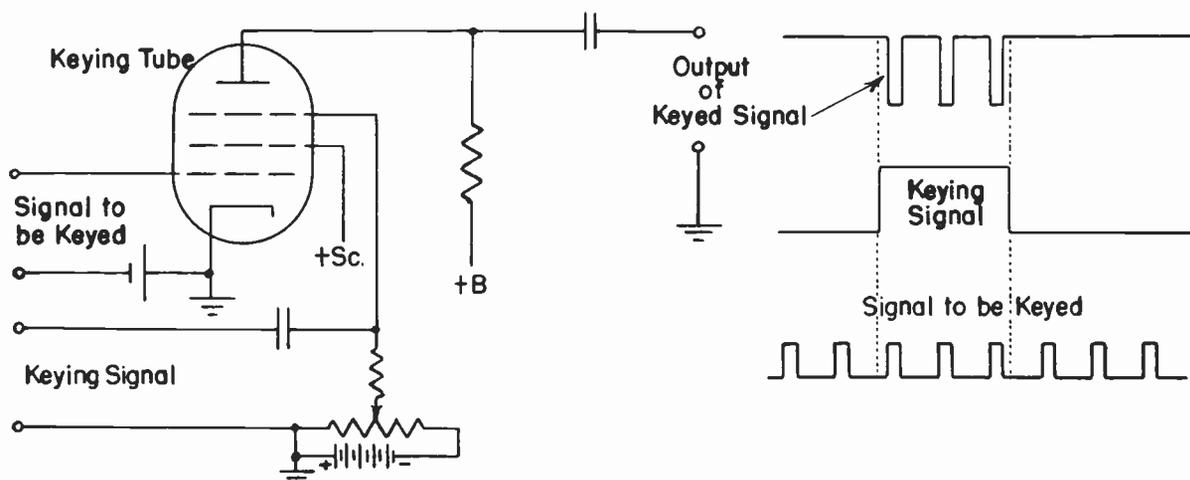


Fig. 9. Keying Circuit and Operating Waveforms.

synthesis is completed by keying in the wave 10E during the pulse interval of 10K as indicated by the connections to tube  $T_4$ . The resulting anode circuit waveform is that shown at 10L. This wave differs from that of 10A in that the signals of 10D ride on top of those of 10E; by properly biasing the grid of the following amplifier  $T_5$  the entire wave may be limited at the correct level and the excess height eliminated. The output voltage of the stage  $T_5$ , then, is the wave 10A. (In the figure a simple battery bias is shown for  $T_5$ . In practice it is necessary to

supply a bias which will vary in proper fashion. This problem is discussed in the next section, which is on background insertion.)

#### BACKGROUND INSERTION

As explained on page 27 (Report 1789), the signal from the camera tube does not contain information as to the average brightness of the scene. The signal shows only the changes in shading across the picture. Consider two pictures, each of only two shades. The first

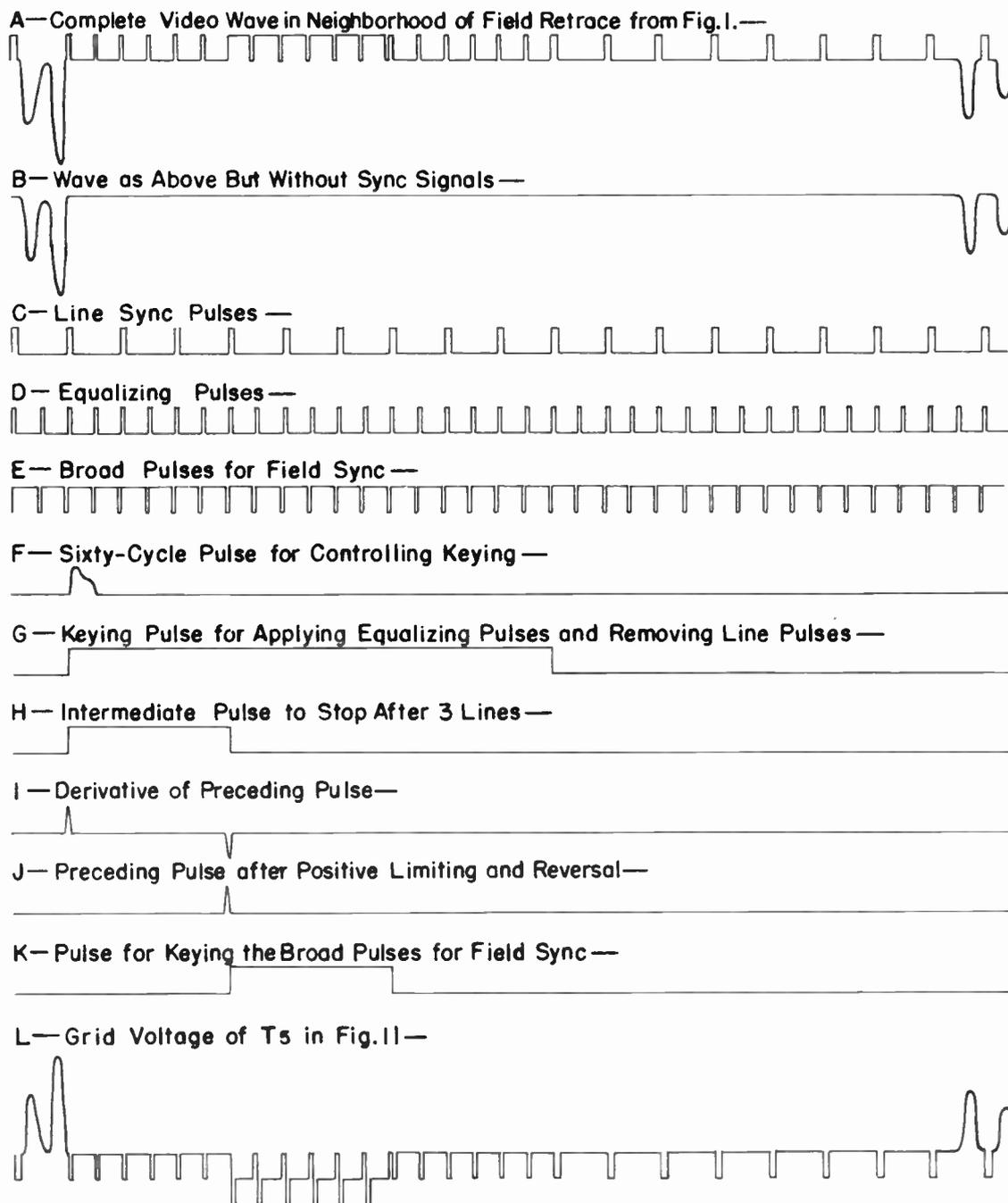


Fig. 10. Waveforms Entering Into Formation of Complete Video Signal

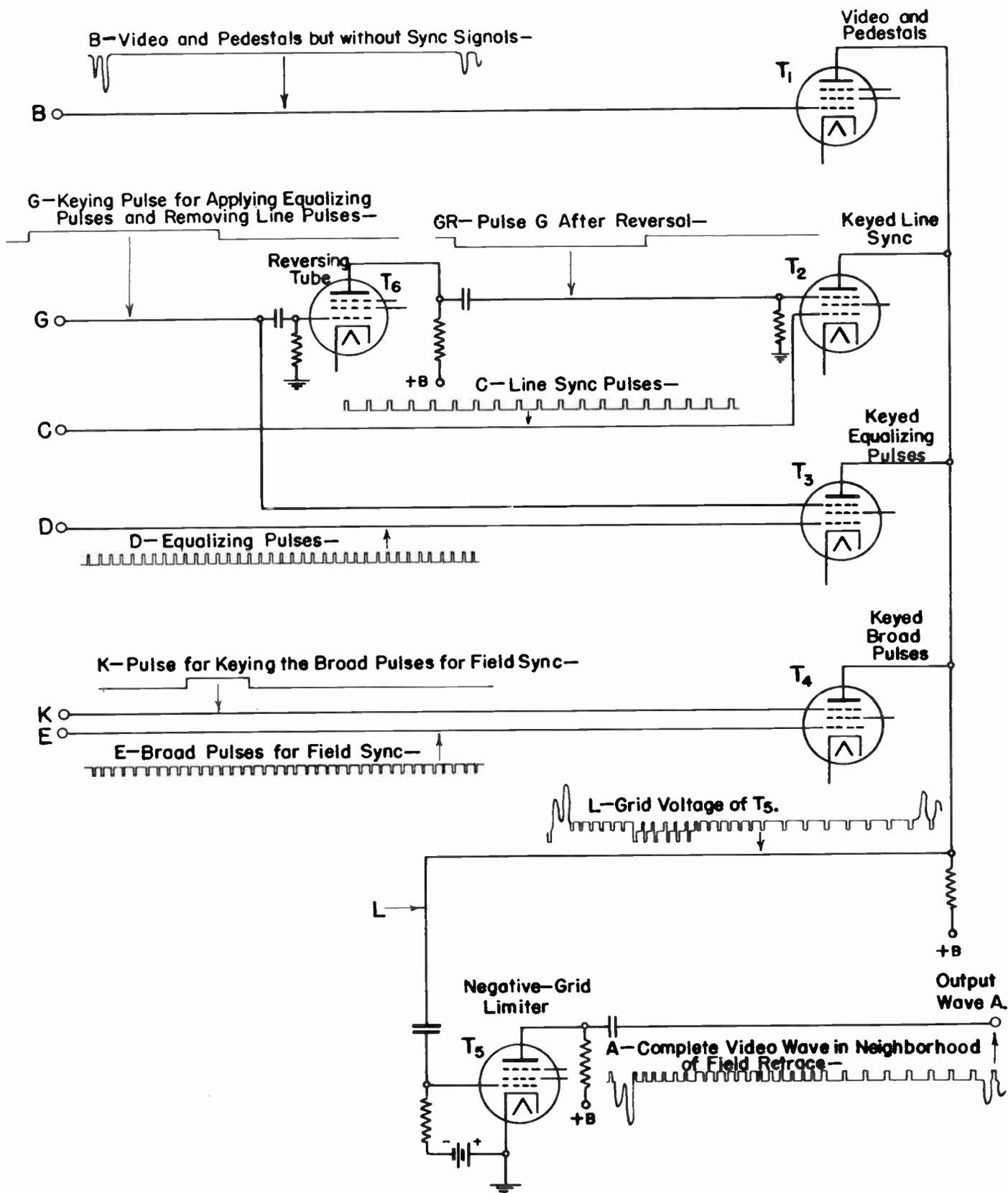


Fig. 11. Circuit for Formation of Complete Video Signal

consists of a gray object on a white background, and the second of a similar black object on a gray background. For these two pictures the output of the camera tube might well be identical. In other words, the camera shows the difference in shading but does not show the absolute level. The average brightness is usually referred to as the background brightness.

There are several methods which may be used for background insertion. The usual one is to adjust black to an arbitrary voltage level. Black is used instead of white because it is a critical tone. That is, signals which are blacker than black are simply black whereas signals which are whiter than white become more brilliant. Another point is that there is always some black in the complete video signal, but there may be no white; in case the picture being transmitted has no blacks, the blacks occur in the complete video signal during the retrace interval.

One method of background insertion is to use a cathode-follower limiter, such as shown in Figure 5D. The signal polarity at this point is chosen to make blacks negative and whites positive. The potentiometer shown in Figure 5D is then adjusted to cause the cutoff to occur at black level. The output then contains the direct-current light information because black always corresponds to zero voltage. The grid voltage which sets the black level may be adjusted manually or the average illumination of the scene may be picked up by a photocell and the output used with a suitable fixed bias to make this adjustment automatically.

Once the black level is set it must be maintained throughout the rest of the system. That is the remainder of the system must be, in effect, a direct-current amplifier; it need not however actually have all, or even any, direct couplings. Frequently one or two stages with such direct couplings are used to maintain the direct-current component. However, a more common method is to reinsert the direct-current component at each stage as is shown in Figure 12. Since the signal peaks are always black during the retrace, and possibly during other portions of the picture, this peak

level may be detected by a diode and used to bias the tube to maintain the black level. In other words the black pedestals act as a carrier, or reference value, to transmit the direct-current light information.

In its handling of a television signal, the alternating-current-coupled amplifier with direct-current reinsertion may be made to function exactly like the direct-current amplifier; it is free, however, from the serious practical disadvantages of the latter.

#### FORMATION OF SIGNAL

After the foregoing explanation of the several operations, the formation of the complete signal may be readily understood. The actual circuits employ a large number of tubes. The following explanation covers the general arrangement only.

Referring to Figure 13, the timer unit contains the chain of relaxation oscillators which provide the necessary frequencies of 26,460, 13,230, and 60 cycles in their proper phase relation. The pedestal generator forms the keying pulses and wave shapes which are to be used in forming the synchronizing signal and for timing the other relaxation oscillators. One pair of outputs from the pedestal generator is used to control the line and field oscillators in the camera scanning generator. This generator supplies scanning current to the camera-tube deflecting coils. Another keying pulse from the pedestal generator is used to drive the camera-tube grid negative beyond cutoff during the retrace interval. This prevents the removal of stored mosaic charges during the retrace.

The output of the camera is increased by a preamplifier mounted in the camera case. This output goes to a mixing amplifier. Another input to the mixing amplifier is received from the shading generator. This generator contains a line and a field oscillator timed from the pedestal generator. The unit generates various waveforms such as are shown in Figure 8 at both the line and field frequencies. These are added to the signal by means of parallel pentode

amplifiers. The shape and amplitude of the added signal is manually adjusted to cancel the shading component from the camera. The video signal then goes to the modulation amplifier. In this unit the camera-tube surge is suppressed by suitable keying pulses, or pedestals. These pedestals are added here, and also adjusted by means of the background control to represent black. The synchronizing signals are also added in the modulation amplifier, as explained above on page 52 in connection with keying. The output of the modulation amplifier is then a complete television signal which contains both the picture and the synchronizing information. The signal is now ready to be used to modulate the carrier frequency of a radio transmitter.

The signal is also used to form a picture on a monitor tube in the transmitter so that the appearance of the picture may be checked prior to the carrier-frequency modulation process. With this picture on the monitor tube, the apparatus becomes a complete wire television system. The parts of the monitor are indicated in Figure 13, but will not be discussed in this chapter. Their function is the same as that of the corresponding parts in the receiver which will be discussed in detail in following chapters. In addition to the monitor it is necessary to have various oscilloscopes to adjust the amplitudes of the video signal and the sync signal. Both oscilloscopes and the monitor picture are used in adjusting the shading-correction circuits.

## ILLUSTRATIONS

The discussion in the first two chapters and the present one is intended to give an understanding of the methods used in forming a complete video signal. As a review of this subject we now consider a group of photographs showing the appearance of the monitor picture tube and the monitor oscilloscope under various conditions.

The description of the photographs is being written from their appearance as they are being sent to the offset printer. The reproduction of the pictures in the final copies may, therefore, be somewhat different. For example, if a normal picture is reproduced too light in the offset printing, it may look quite similar to the example showing crushed whites, which is given in Figure 16. On the other hand, a dark printing may give nearly the same appearance as crushed blacks in the televised picture, which effect is shown in Figure 17. In regard to detail, there has already been some loss in the photographic printing of the positives, and there may be some further loss in the final offset printing. All the photographs are unretouched. In taking the series of photographs the relation of the television camera to the object was maintained constant throughout except of course for copying the scene itself, which is shown in Figure 14.

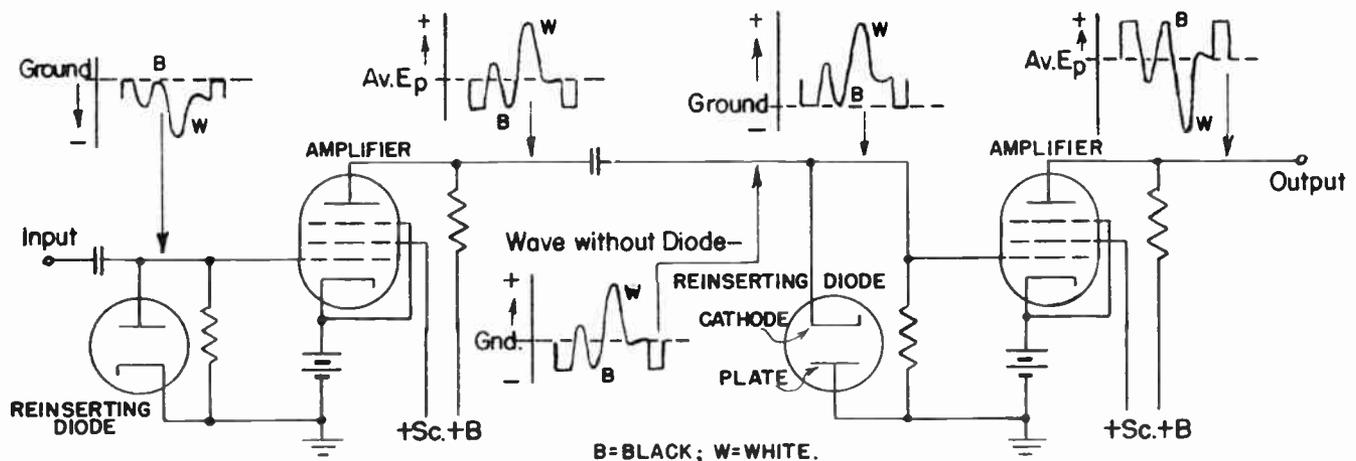


Fig. 12. Reinsertion of Direct-Current Component with Diode.

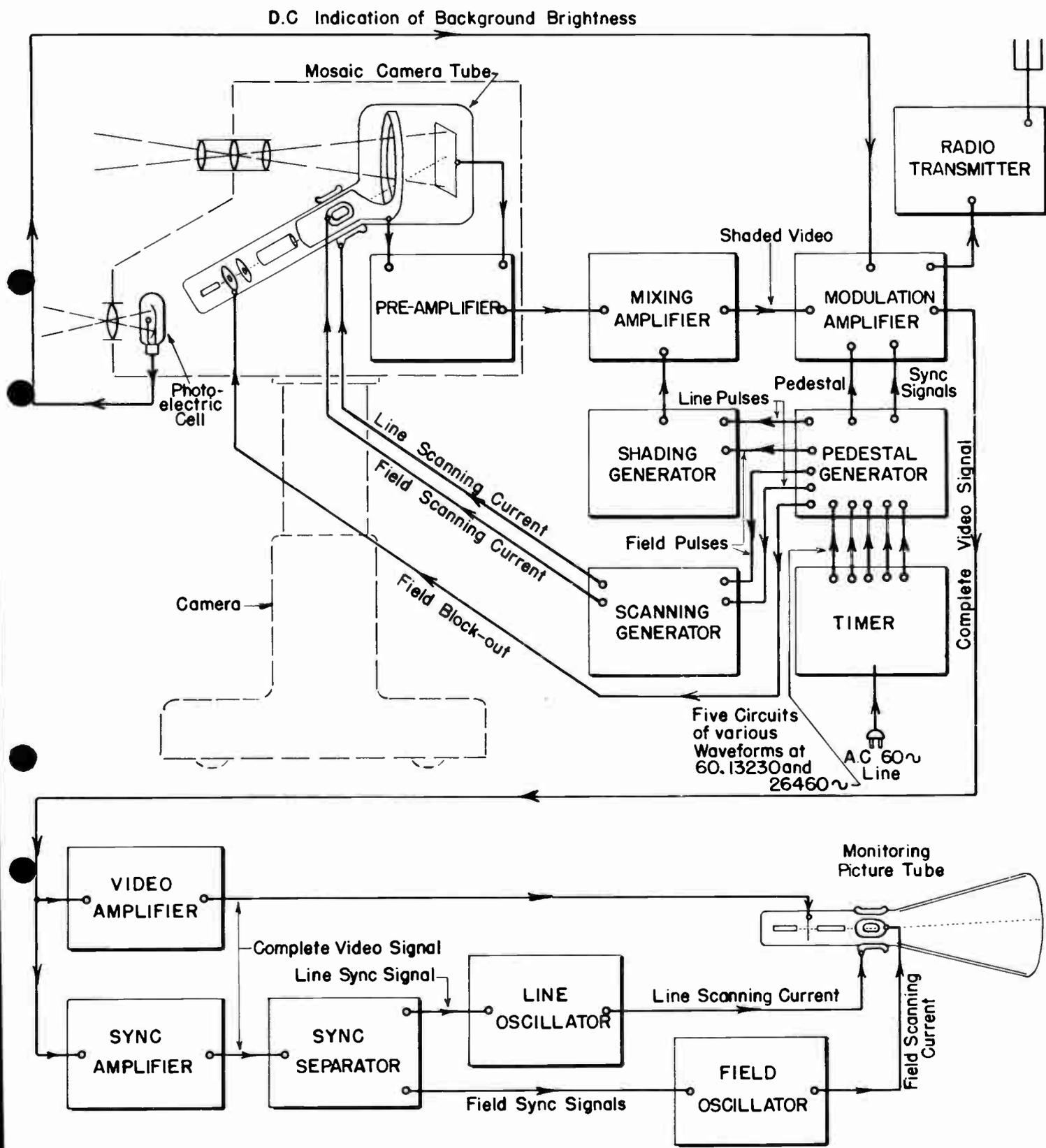


Fig. 13. Main Parts of Television Transmitting System.

Fig.  
14

Figure 14 is a picture of the photograph of Professor Hazeltine which was placed before the television camera and is therefore the scene in this series. This photograph used as the scene is a 7 x 9-inch print.

Fig.  
16

Figure 16 shows the appearance of the image when the system is overloaded in the white direction. The contrast in the whiter portions of the picture has vanished.

Fig.  
15

Figure 15 is a normal monitor picture. Note that the shading correction is not perfect. The background in the original photograph is nearly flat, but the monitor picture shows a lighter background at the top. The high light in the picture is the collar, and the darkest region is the subject's right shoulder; this may be seen to be a fairly wide range of contrast which is handled by the television apparatus.

Fig.  
17

Figure 17 shows the effect of overload in the black direction. The contrast in the black portions of the picture has disappeared. This is caused partly by "crushed blacks" (that is, the amplitude difference between black and dark gray has been reduced relative to that between light gray and white), and partly by black cutting or limiting such as would be caused by too great an average negative bias on the picture tube.

Fig.  
18

Figure 18 shows the picture with the correct amplifier adjustments but with a distorted horizontal scanning wave at the monitor. The line scanning current was exponential, the motion of the spot at the start of the line being too rapid and at the end of the line too slow. This scanning distortion expands the left-hand side of the picture and crowds the right-hand side, as a comparison with Figure 15 shows.

Fig.  
19

Figure 19 shows the effect of wrong aspect ratio. In this case the incorrect adjustment was at the camera, the line scanning amplitude being too small. For this reason only an intermediate portion of the width of the scene was scanned in the camera, so that, upon normal handling in the receiving monitor, the picture appears with exaggeration of horizontal distances. The effect may be introduced at either the camera or

the picture tube. Regardless of the aspect ratio at the camera, the picture tube can be adjusted to give the correct appearance. If the monitor scanning amplitude had also been reduced for this picture, it would have been narrow but the subject would not have been distorted. (The horizontal "trailers" seen at the right and left sides of the picture are caused by variation of the camera's shading signal associated with sharp dark regions. This illustrates the variation of shading with picture content mentioned on page 38 of Report 1789.)

Fig.  
20

Figure 20 shows the effect on the picture of omitting the keystone correction at the camera. Otherwise the picture is the same as Figure 15.

Fig.  
21

Figure 21 shows the effect of a ripple in the line scanning current at the camera. The camera scanning

retrace shock-excites the scanning coils. Unless the circuit is damped during the trace portion of the cycle these ripples occur. They are of course more intense at the start of the line. Normally these are damped. In this picture the ripples have an effect on the video output (causing black bars to appear in a white area. for example) which is even more pronounced than the direct effect of the irregular scanning.

Fig.  
23Fig.  
22

Figure 22 shows the image when the picture-tube bias is set at too small a negative value. This allows the line scanning to show during the field retrace. (It also appears during the line retrace but the high speed prevents its being observed.) The picture-tube bias is normally set at the black level during the retraces. When the average bias is too positive, as here, the retrace lines become visible. The close spacing of the retrace lines shows that the picture is properly interlaced. (In some cases, which will be discussed in later chapters, the picture may be interlaced during the field retrace but not during the trace portion of the cycle.) If a horizontal line is drawn across the picture, it will be seen to cross two of the retrace lines, showing the existence of the interlacing.

Figure 23 shows the appearance of the monitor when the picture is not interlaced. The conditions are otherwise the same as in Figure 22. In the positive photographic print the line structure in the trace portion of the picture is apparent, but it may not appear in the off-set reproduction.

Fig.  
24

Figure 24 shows the picture with the field shading component removed; otherwise the conditions are the same as in Figure 15.

Fig.  
25

Figure 25 is the same as Figure 24 except that both line and field shading-correction voltages are removed.

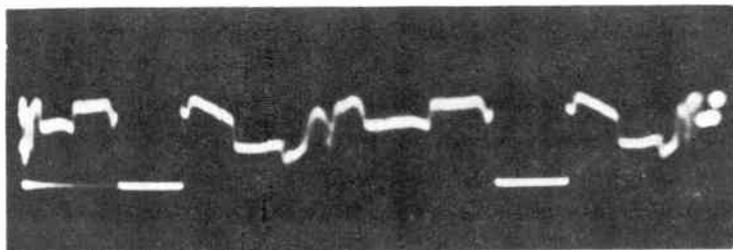
Fig.  
26

Figure 26 shows the waveform of two lines of the video signal thru the center of the picture. The two horizontal sections at the bottom of the figure are the successive line blanking pulses. Between them appears one line of video. The sloping portion at the left end of this line is the left-hand white margin of the picture. (The slope of this portion is due to incomplete shading correction.) The following darker portion represents the gray background to the left of the face, and the irregular portion in the center is the face itself.

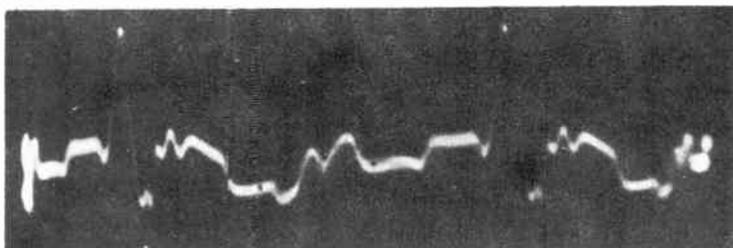
Fig.  
27

Figure 27 is the same as Figure 26 except that the camera surge is not suppressed and the pedestal is not inserted.

World Radio History

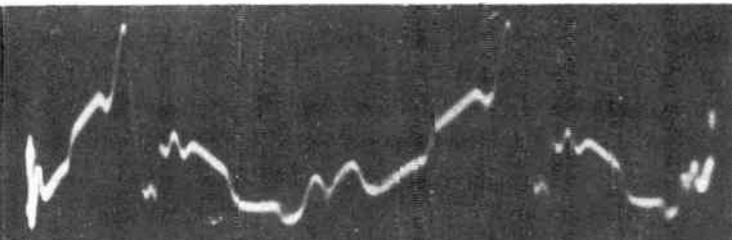
Fig.  
28

Figure 28 is the same as Figure 27 except that all shading correction is omitted.

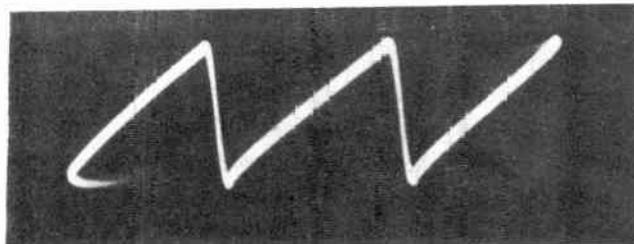
Fig.  
29

Figure 29 shows the scanning current in the horizontal deflection coil of a properly adjusted scanning circuit.

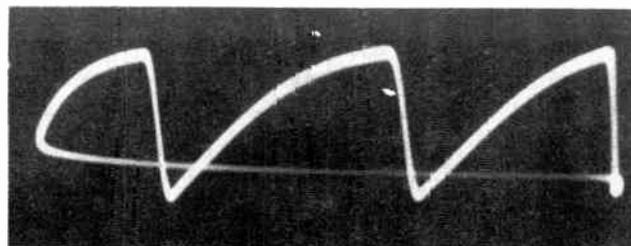
Fig.  
30

Figure 30 shows the form which the scanning current may take if the circuit is incorrectly adjusted. The non-linearity of the trace portion is approximately that which causes the pictorial distortion of Figure 18.

Fig. 31



Figure 31 shows a scanning-current waveform in which the ripples are not damped. This is the kind of ripple which causes the effect shown in Figure 21. The

difference is that the ripples in Figure 21 are of considerably higher frequency than those in Figure 31.

Fig.  
32

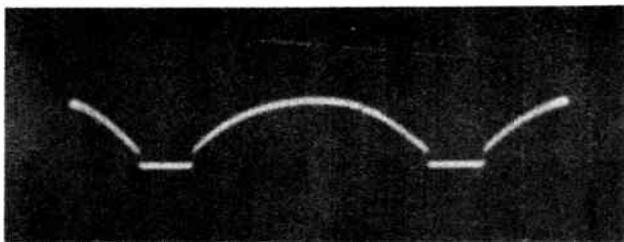


Figure 32 shows a parabolic waveform from the shading generator. The line pedestals are inserted as a time reference.

Fig.  
33

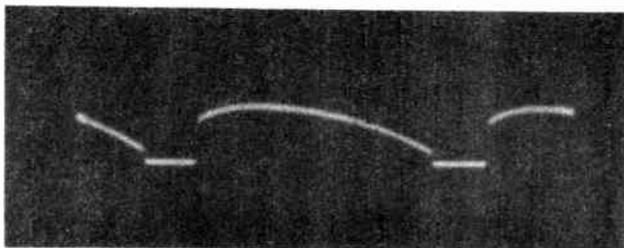


Figure 33 shows the output of the shading generator under similar conditions except that a saw-tooth waveform is added to the parabolic waveform.

Fig.  
34

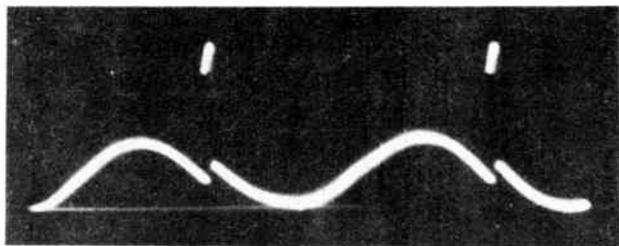


Figure 34 is an oscillogram of the waveform given in Figure 4, page 48. This shows the control of the frequencies of the timer chain by the power-line frequency.

#### CARRIER-FREQUENCY TRANSMISSION

The preceding discussion has described the formation of the complete video signal. If this signal is applied to the grid of a radio-frequency amplifier so as to modulate the latter, the output will be a modulated signal of the

correct form for application to a transmitting antenna. If the modulation is applied with the synchronizing pulses positive, the envelope of the radiated wave will be as shown in Figure 35. The figure illustrates a few lines from each of three pictures as follows: (1) a white background having a black vertical bar in the center, for which the waveform is shown at the left; (2) a gray background having a black bar followed by a white bar, for which the waveform is shown in the center; and (3) a black background having a white bar, for which the waveform is shown at the right. The figure shows that direct-current transmission is employed, because the synchronizing pulses occur at a fixed level in the transmitted wave and likewise the various shades, while the carrier or the average radiated power varies. This power is small in the first case and large in the third case.

The use of this video polarity in modulation, as shown in Figure 35, is called negative transmission for the reason that a transition from a dark point to a light point in scanning produces a decrease in the radiated power. That is, in negative transmission, the passage of the scanning spot to a point of more light causes less radiated power. It will be realized from the discussion already given in the present chapter that passage thru one more, or one less, plate-loaded stage of amplification will reverse the video polarity, so that from a circuit standpoint it is easy to obtain either desired polarity of transmission.

Positive transmission is of course the opposite of negative transmission; this type is illustrated in Figure 36. In positive transmission, scanning progress from a dark to a light point produces an increase of transmitted power. Positive transmission is widely used in Europe. Negative transmission is specified in the tentative standards of the (American) Radio Manufacturers Association.

#### REFERENCES

Two articles on nomenclature have appeared in *ELECTRONICS* as follows: (1) "Television Terminology", signed with the initials of D. G. Fink, Managing Ed-

B= BLACK; G= GRAY; S= SYNC; W= WHITE.

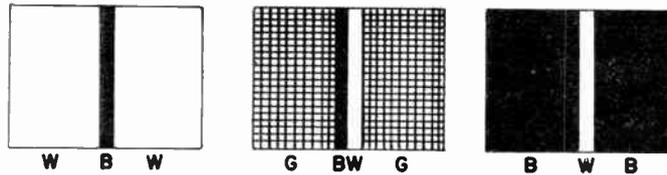
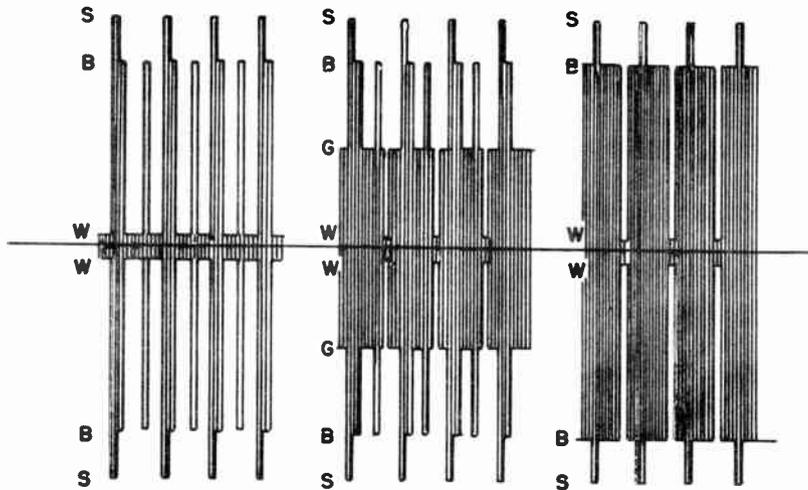


Fig. 35. Carrier Wave with Direct-Current Transmission and Negative Polarity.

B= BLACK; G= GRAY; S= SYNC; W= WHITE.

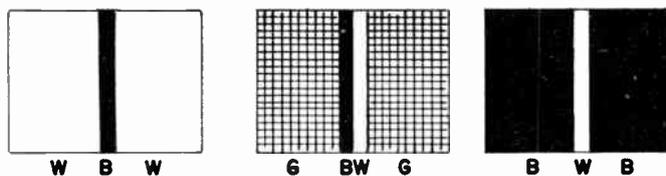
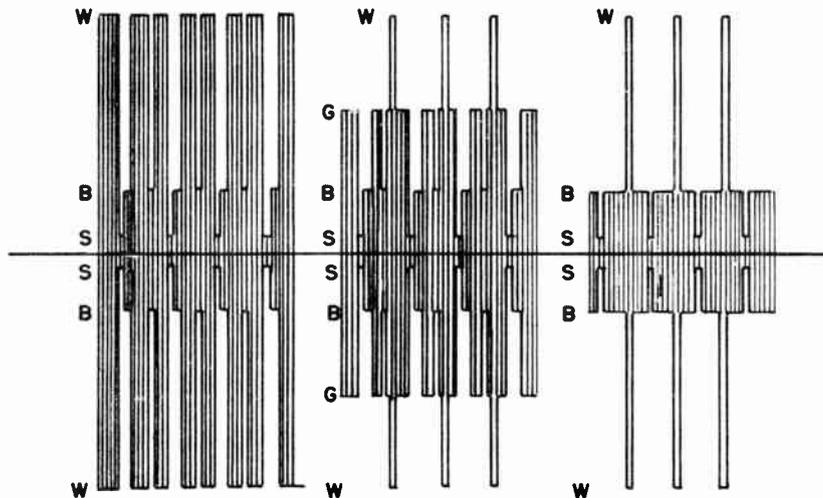


Fig. 36. Carrier Wave with Direct-Current Transmission and Positive Polarity.

itor of the magazine, appearing in the June 1937 issue, pages 14-17 and 68; and (2) "Television Terms", by Frank J. Somers of Farnsworth Television, Inc., in the August 1937 issue, page 34.

Papers by RCA personnel including material on topics of the present chapter have appeared as follows: (1) "An Experimental Television System-Part II, The Transmitter" by R. D. Kell, A. V. Bedford, and M. A. Trainer, published in the PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS for November, 1934, pages 1246-1265, and also in the bound RCA reprints, TELEVISION, Volume I, pages 259-278; (2) "Experimental Studio Facilities for Television" by O. B. Hanson, published in RCA REVIEW for April 1937, pages 3-17, and also in TELEVISION, Volume II, pages 163-177; and (3) "Television Studio Design" by R. M. Morris and R. E. Shelby, published in RCA REVIEW for July, 1937, pages 14-29, and also in TELEVISION, Volume II, pages 178-193.

The use of cathode loading to obtain a low output resistance is shown in the technical pamphlet on the RCA #1851 tube; the values of constants are given.

Two papers by Hazeltine engineers discussing standardization matters and the status of television in the United States and Great Britain appeared last summer in Electronics as follows: (1) "Standards in Television", by

H. M. Lewis, appearing in the July 1937 issue, pages 10-13 and 50-51; and (2) "Television in Great Britain", by H. M. Lewis and A. V. Loughren, appearing in the October 1937 issue, pages 32-35, 60 and 62. These papers consider television from the standpoint of the entire system, and may be found helpful for this reason.

The British signal-forming and transmitting equipment, supplied by Marconi-E.M.I. and now operating in London, was described in a paper, "The Marconi-E.M.I. Television System", presented before the (British) Institution of Electrical Engineers on April 21, 1938. This paper consists of three parts as follows: Part I - "The Transmitted Waveform", by A. D. Blumlein; Part II - "The Vision Input Equipment", by C. O. Browne; and Part III - "The Radio Transmitter", by N. E. Davis and E. Green. It is assumed that this paper will be published in a few months in the JOURNAL OF THE (BRITISH) INSTITUTION OF ELECTRICAL ENGINEERS. The transmission of the direct-current component, cathode loading, and numerous other matters are discussed.

The following portions of the text, "Television Engineering" by J. C. Wilson, to which book reference is made above on page 19 (Report 1776), are of interest in connection with the present chapter: background insertion, 185-198; sync insertion, 183-185; cathode loading, 165-166; forms of complete video signal, 333-336; and saw-tooth oscillators, 286-297.

*Hazeltine patents 2,118,977 & 2,052,183  
on relaxation oscillators and derivative-  
integral series of waveforms.*

