The frequency response of the video channel is good enough to be used on a studio line. Ordinary series compensation is used in the first two video amplifier stages while a compensating capacitor C9 is required across voltage divider at the output of the video separation diode in order to equalize the frequency response. This trimmer capacitor C9 must be adjusted for using a video signal generator for the input signal. The method of adjustment is to set the response of the unit using C9 so that the output at J2 with a 75 ohm resistance termination is approximately 5% greater at 4 megacycles than it is at 1½ megacycles.

It should be pointed out that when tests are made in the video channel of this chassis the clamping circuits must be disabled. This is done by removing V7 and V8 from their sockets and then adjusting the separation level control so that the output signal in the video channel, as observed at J2 (when properly terminated in a 75 ohm resistance) is a signal which is not clipped at either end and is of approximately 1 or 1-1/2 volts peak-to-peak value. This method of test keeps the shunt capacity in the video system the same as normal and properly disables the clamp so that the system then operates as a non-clamp system.

6. SYNCHRONIZING PULSE GENERATOR CHASSIS (see Sync Pulse Generator schematic)

a. Function.—To receive the composite synchronizing signal and from it generate horizontal and vertical driving pulses of the proper amplitude and shape, and in the proper phase relation to drive the video recorder circuits.

b. Theory and Adjustment.—V1 and V2 are simple pulse amplifiers. The complete synchronizing signal is fed from pin 1 of V2 through coupling capacitor C3 to the vertical sync pulse generation channel which includes V4, 5, and 6. The same complete signal is fed to pin 5 of the 6AL5 diode V3; pin 2 of V3 drives the other half of V2, which is then coupled through C11 to the horizontal circuits consisting of V7 and V8.

The vertical pulse forming circuit uses a mixer tube V5 to coordinate an integrated vertical block signal that is generated at the plate of the first half of V4 and the differentiated trailing edges of the vertical block pulses. These are applied to pins 1 and 7 of the mixer tube. By this method, absolute time interlace is secured and fairly good freedom from interference is provided because of the integrating system. The output pulse at the plate of V5 is amplified by the second half (pins 6, 7, and 8 of V4) and applied to the trigger tube and blocking oscillator (V6) where the output pulse is taken from the cathode of the blocking oscillator. It occurs essentially at the trailing edge of either the second or third vertical block, depending on the adjustment of the vertical hold control.

The horizontal pulse forming circuits utilize a standard automatic frequency control system for locking to the horizontal sync pulses which are coupled through C11. The 15,750 cycle oscillator $\frac{1}{2}$V8 is controlled by the second half of V8 which is biased by the phase-comparison rectifier, V7. The output of this chassis provides the proper phasing between the time that the blocking oscillator fire and the original sine wave appears at the plate of the oscillator tube, V8. The output pulse occurs essentially at the beginning of the front porch of the original television signal. This timing is necessary so that the horizontal output signal can be used to trigger blanking circuits which are required elsewhere in the equipment at the time that the front porch normally occurs.

In the horizontal automatic frequency control circuit, care is required for proper adjustment. The cores of the oscillator transformer are both adjustable. The core in the primary of the transformer has its main effect on the inductance of this coil and, hence, controls the free running frequency of the oscillator. Adjustment of this core and adjustment of the coarse horizontal hold control will produce both the correct waveform at TP5 and the correct center frequency of the oscillator. The horizontal hold control slug and the coarse hold control should then be readjusted so that the system operates in the center of its range. When set properly the horizontal hold control should stay approximately in the middle of its range, but the circuit should hold synchronism almost to both extremes of the horizontal hold control rotation.

In order to cut down the effects of noise on the horizontal AFC circuit and also to provide absolutely constant amplitude pulses to this circuit, the signals are slightly clipped by the first half of diode V3 before being fed to pin 7 of the limiting amplifier V2.

7. ELECTRONIC SHUTTER CHASSIS (see Electronic Shutter schematic)

a. Function

(1) To provide a gated rectangular waveform at the cathode of the display tube in order to turn it on and off as dictated by the camera.

(2) To provide a 24-cycle pulse for artificial timing when the camera is inoperative.

(3) To provide a pulse forming amplifier for the camera photocell output.

(4) To provide blanking pulse during the horizontal and vertical retrace times for the display tube.

(5) To provide a correction waveform to the display tube which takes into account the decay time of the picture tube so that insofar as the film is concerned E =   .

b. Adjustments

(1) Hold pulse: Set R17 to give 24-cycle operation.

(2) Shape and Amplitude: Set R79 and R80 to obtain a perfectly corrected picture splice.

(3) Horizontal and Vertical Width: Set R64 and R55 for blanking pulse widths such that a 1/16" to 1/8" white border around the picture is visible with a negative video signal.

c. Theory.—The mechanical shutter of a conventional motion-picture camera performs the cyclic tasks of starting, stopping, and timing each film exposure. The electronic shutter is an assemblage of electronic circuit blocks which performs these same tasks. It differs from a mechanical shutter in the following respects:

(1) The exposure is started and stopped by successively applying and blanking the picture on the face of the cathode-ray tube, rather than by intervention of a mechanical shutter blade.

(2) The exposure is times by counting the scanning lines which composed the television picture. Exposure of each film frame is terminated on completion of the 525th scanning line, regardless of whether or not the camera and

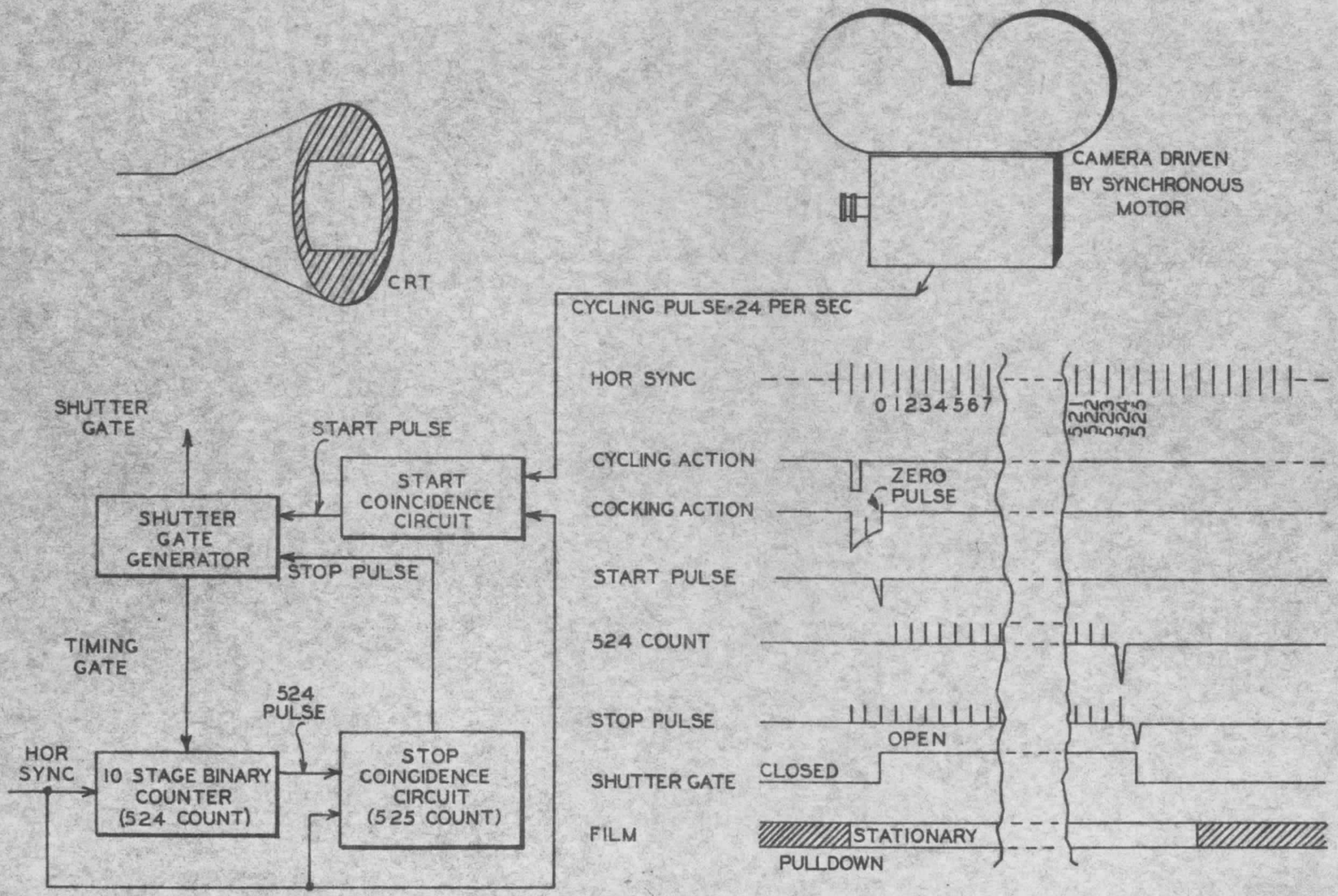

Figure 3-7. Stages of the Electronic Shutter

the television synchronizing generator are in synchronism with each other. To achieve the same desirable objective with a mechanical shutter, two major variables must be controlled. These variables are the operating speed of the shutter and the angular blade width. The angular blade width is fixed in the camera design so that the time of shutter opening is 525 lines when the shutter is running at nominal operating speed. Departure from nominal speed during nonsynchronous operation cuases line-count errors. During synchronous operation, momentary changes in power line frequency may cause line-count errors because of the inertia associated with the camera mechanism.

(3) With either mechanical or electronic timing, the start of exposure should not start until film pulldown has been completed and the film has become stationary. With a mechanical shutter, this function is performed by the trailing edge of the shutter blade (or the leading edge of the shutter opening). With an electronic shutter, it is performed by a mechanical cycling disc which generates an electrical cycling pulse suitable for actuating the counting circuits.

The circuit blocks which compose the electronic shutter are shown in figure 3-1 with a timing diagram.

Referring to figure 3-1, the cycling pulse, after amplification, actuates the start coincidence circuit. The pulse does not initiate the actual exposure, but merely cocks the circuit. A single horizontal synchronizing pulse then trips the circuit. This same synchronizing pulse, which may lie anywhere in the scanning cycle, becomes the start pulse which opens the shutter gate. Photography of the first scanning line commences with this pulse and continues as long as the shutter gate is open, the duration of the shutter gate opening

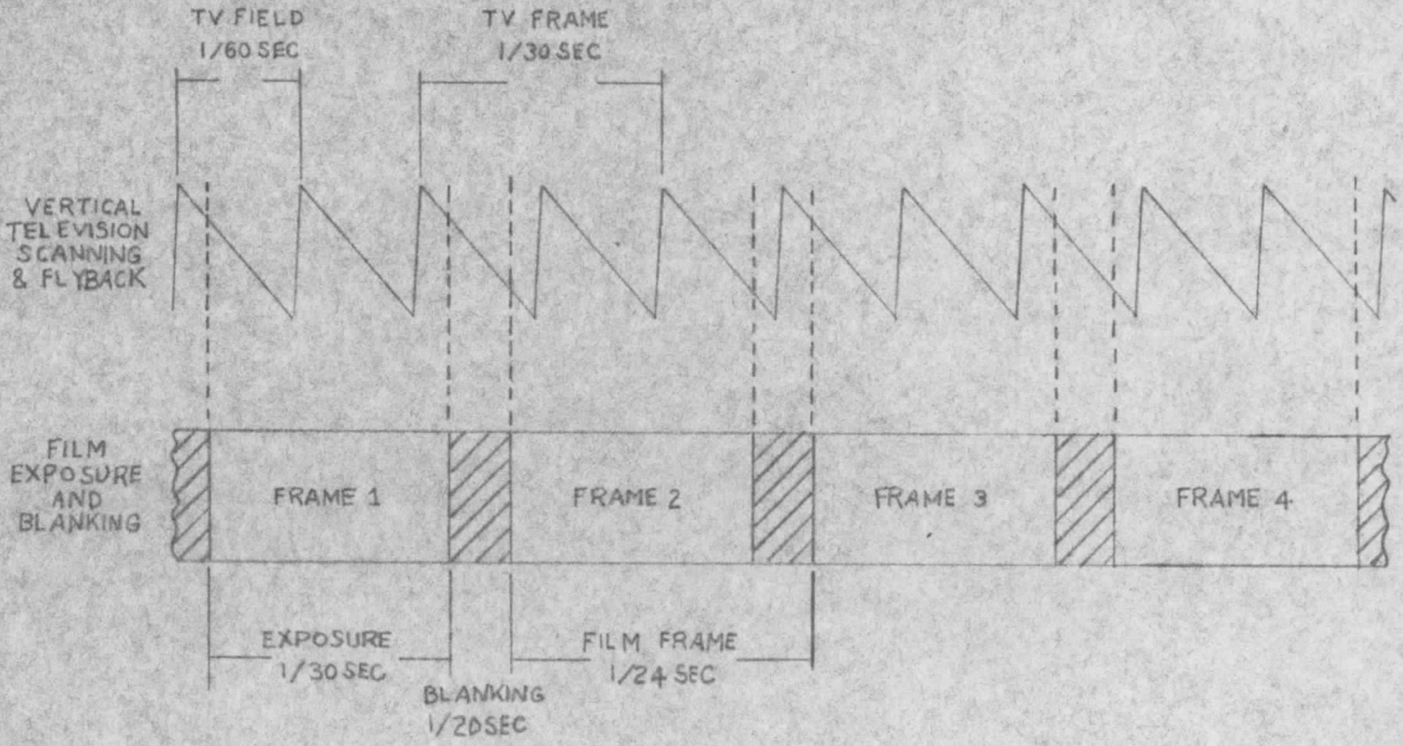

Figure 3-8. Time Relationships Between Scan and Film Exposure

being determined entirely by the timing gate.

The timing gate resembles the shutter gate, but the starting edge is intentionally delayed so that the gate opens during the first scanning line, after passage of the zero pulse. With the timing gate open, each pulse following the start pulse trips an appropriate stage in the binary counter circuit until the 524th pulse trips the 10th stage. This, in turn, actuates the stop coincidence circuit, effectively cocking the circuit. The 525th horizontal synchronizing pulse then trips the circuit, closing both the shutter gate and the timing gate. The gates remain closed during the blanking interval. At the conclusion of this interval, the camera generates a new cycling pulse, exposure starts and the operation repeats itself.

The scanning method commonly used with either a mechanical or electronic shutter is shown in figure 3-2. Since four film frames are to be exposed during the period of five television frames, one television frame must be dropped out of every five. By utilizing the interlace feature of the television scan, the same result is obtained by dropping one-quarter frame out of every one and one-quarter. One complete field and two complementary portions of adjoining interlaced fields are photographed during a single shutter opening, the separate portions adding up to a single television frame.

Accurate shutter timing is essential for correct operation. The shutter not only blanks the picture during the film motion interval, but also times the exposure to allow exact completion of a single television picture on each film frame. It is this additional timing function that imposes the severe accuracy requirement. With correct shutter timing, the starting line of the first field and the ending line of the third field occupy adjoining positions in the raster. If the shutter remains open a trifle too long the film records several extra scanning lines, which appear on top of a completed frame as a bright horizontal strip.

Similarly, early shutter closure causes a dark horizontal strip. This strip, either light or dark, becomes an obvious exposure defect which is sometimes called a shutter bar. The region of the picture where shutter closure occurs is known as the join-up or splice.

These conventions apply to a positive print produced from a negative film. The light values reverse for a direct positive print.

It is characteristic of the scanning method that the join-ups of alternate frames have different positions. The two join-up locations are separated from each other by one-half the picture height. In figure 3-2 the intersections of the dotted lines with the vertical sawtooths indicate the join-ups. The phasing chosen places one join-up near the top of the first and third frames, and the other join-up near the bottom of the second and fourth frames. One join-up can be removed from the picture area by phasing the camera to place the join-up at the raster edge, but the other join-up lies within the picture area. The join-up locations remain stationary when the television can camera rates are synchronized to each other. Otherwise, they travel up or down, depending on the difference between rates. An invisible join-up is a necessity in either case, and shutter timing must be correspondingly accurate. As an illustration of the degree of accuracy required, it may be noted that the edge of a mechanical shutter blade is hand-finished to almost micron dimensions in order to produce a satisfactory join-up. Even with this degree of accuracy, changes in the cyclic time base during nonsynchronous operation cause a shutter bar effect.

A shutter gate generator, rather than a timing circuit alone, blanks the cathode ray tube during a portion of the film cycle. The phasing and duration of the shutter gate are established by several associated electronic circuits. One of these circuits opens the gate and starts the timing action as soon as pull-down of the preceding exposed frame has been completed. Another circuit times the exposure. A third circuit closes the gate. This combination of circuits forms an electronic shutter which replaces the conventional mechanical shutter and affords greater inherent accuracy. The electronic shutter in the camera described has an inherent timing accuracy of better than one percent of a single horizontal line, or 0.5 microsecond, in either synchronous or non-synchronous operation. The join-up reduces to a small line break in the unused margin of the raster, outside the picture area.

Since each television frame contains exactly 525 horizontal scanning lines, counting circuits may be used to time the film exposure. The counting circuits blank the recording cathode ray tube when the correct number of horizontal lines has been scanned. Film exposure may start at any horizontal scanning line. Once started, the exposure continues to completion of the television frame, and then stops until triggered by a cycling pulse. In the camera, film pull-down starts after the exposure stops. On completion of pull-down, when the film has become stationary, the camera generates the cycling pulse and starts a new cycle.

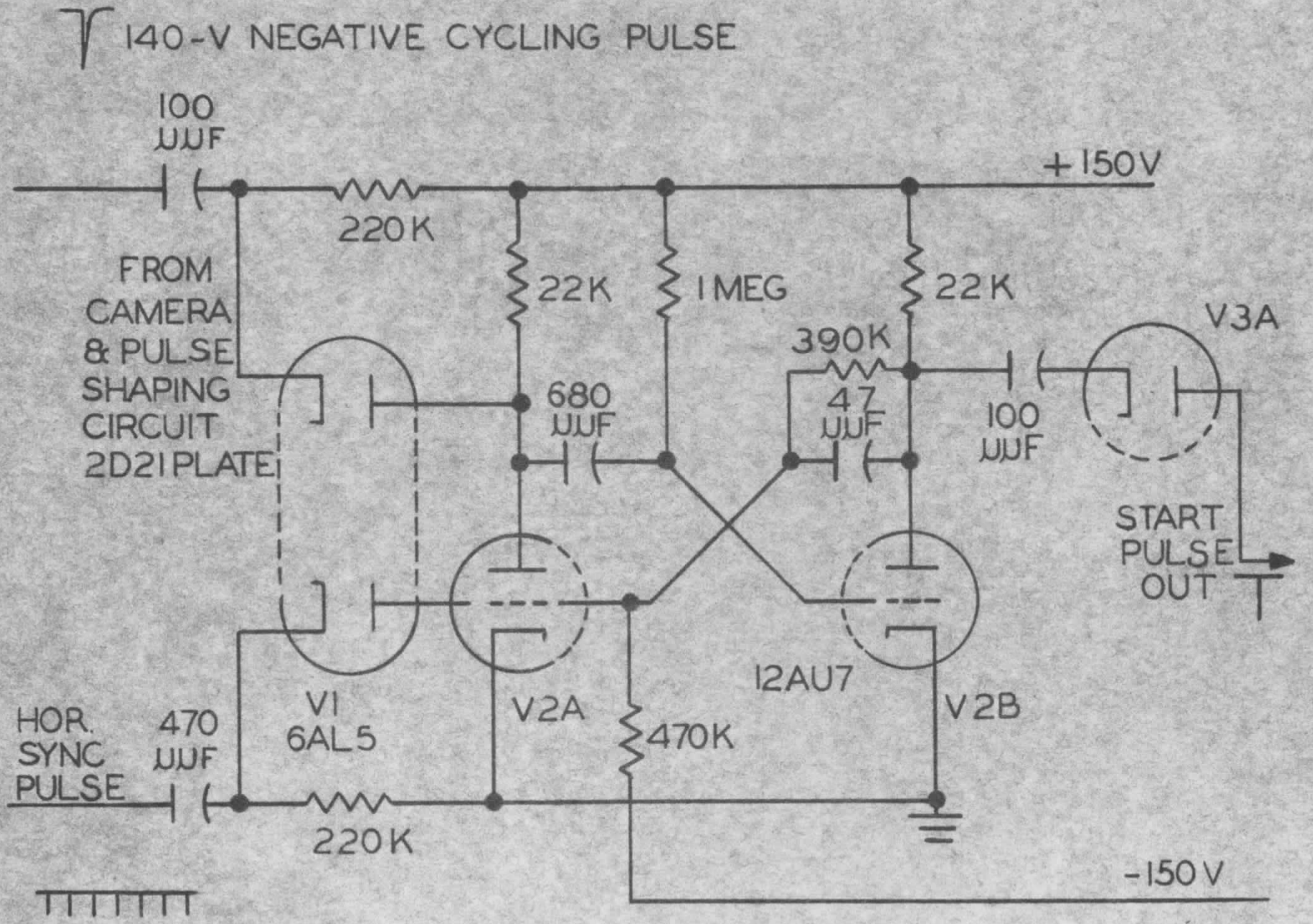

Figure 3-9. Start Coincidence Circuit

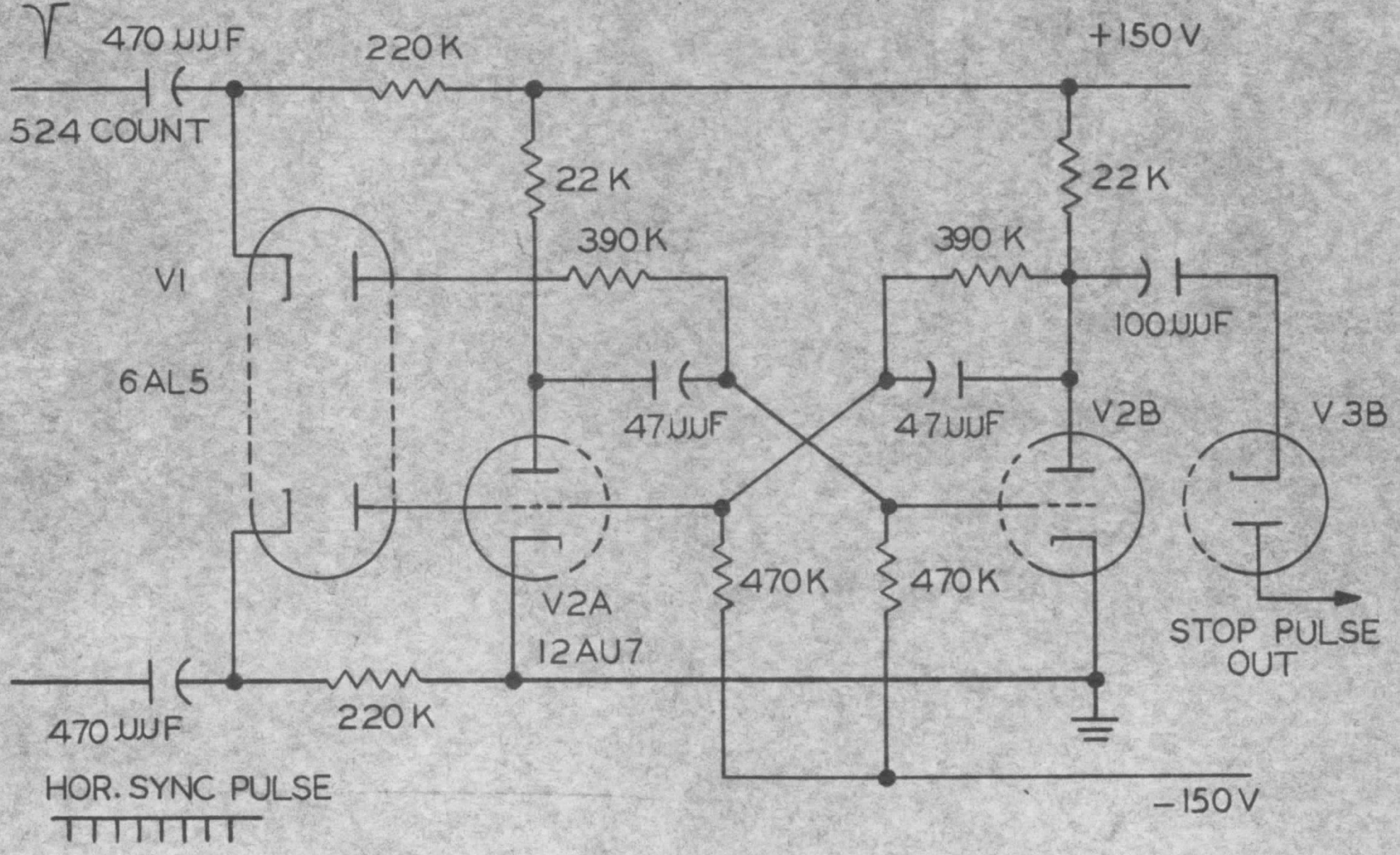

Figure 3-10. Stop Coincidence Circuit

8. START COINCIDENCE CIRCUIT

Figure 3-3 shows the start coincidence circuit. Under static conditions, triode V_{2B} is strongly conducting and V_{2A} is biased to cutoff.

The negative cycling pulse from the camera passes through diode V_{1A} and arrives at the grid of V_{2B} as a strong negative pulse, sufficiently large to stop conduction in this triode section. The voltage at the plate of V_{2B} goes positive, carrying the grid of V_{2A} with it. Conduction thus transfers to V_{2A}. Meanwhile, the negative charge on V_{2B} grid starts leaking off through the 1 megohm resistor.

The time constant in the grid circuit is such that V_{2B} grid can remain negative during the period of several horizontal lines. (This is the cocking action illustrated in Fig. 3-1.) While V_{2A} is conducting, the horizontal sync pulses are amplified in V_{2A} and appear as positive pulses on V_{2B} grid. Within the time of a few scanning lines, the negative potential on V_{2B} grid becomes so small that a particular pulse in the string of horizontal sync pulses overrides the negative potential on the grid of V_{2B}. This is the zero pulse, illustrated in Fig. 3-1, which causes transfer of conduction to V_{2B}. The voltage at the plate of V_{2B} falls abruptly from + 150 volts almost to ground potential, giving rise to a large negative pulse which becomes the start pulse.

9. STOP COINCIDENCE CIRCUIT

The stop coincidence circuit is shown in Fig. 3-4. It is similar to the start coincidence circuit, except for the use of direct coupling to V_{2B} grid. The 524 count (Fig. 3-1) from the 10-stage binary counter replaces

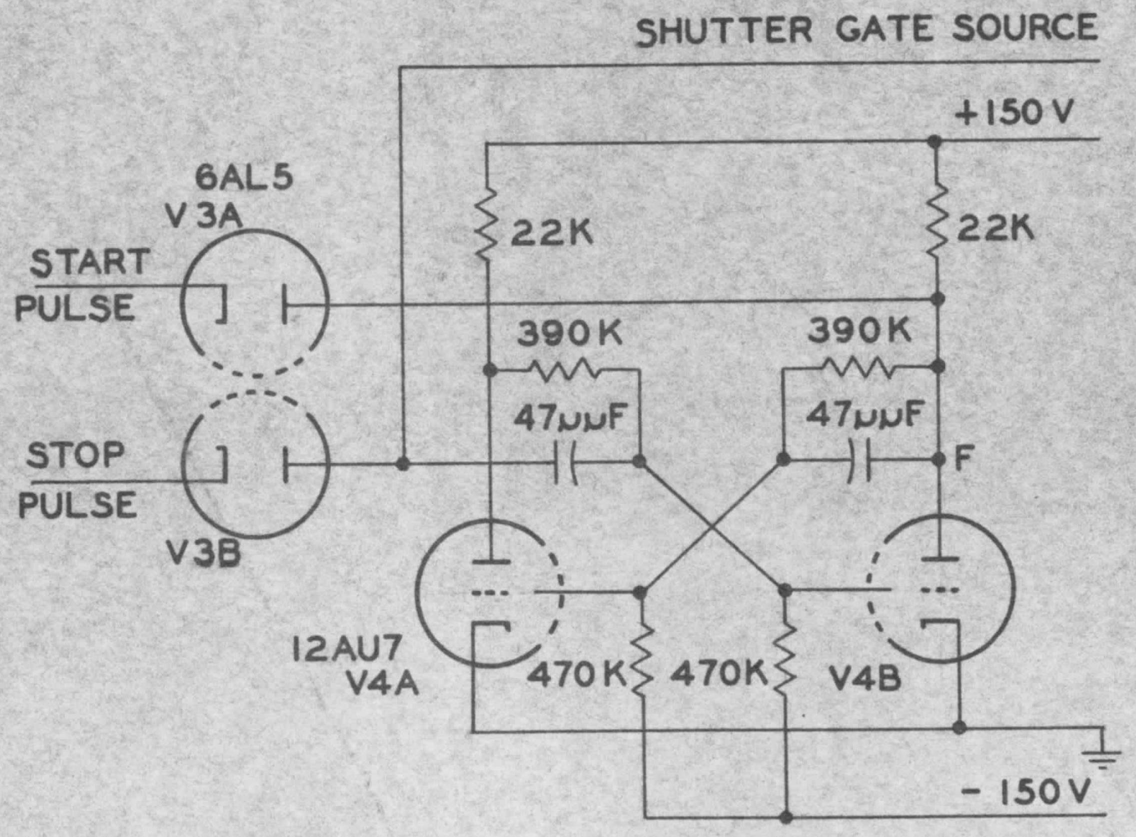

Figure 3-11. Shutter Gate Generator

the cycling pulse as one of the inputs. The other input, the string of horizontal sync pulses, remains the same. The output is the stop pulse. The stop coincidence circuit contributes the 525 count.

10. SHUTTER GATE CIRCUIT

The heart of the shutter gate generator is shown in Fig. 3-5. The circuit is a symmetrical version of the start coincidence circuit, and may be recognized as a form of the scale-of-two counter. It has two stable positions, characterized by conduction of one or the other of the two triodes. If triode V_{4B} is conducting, a negative pulse applied through diode V_{3B} transfers conduction to triode V_{4A}; when triode V_{4A} is conducting a negative pulse applied through diode V_{3A} transfers conduction to triode V_{4B}.

A full frame of 525 lines is scanned during the exposure interval. One quarter frame is then dropped during the blanking interval to effect the 5:4 frame rate conversion. Under synchronous conditions, the average blanking interval covers 131.25 lines. However, since the counting circuits do not recognize fractional lines, the actual number of lines dropped during successive blanking intervals is 131, 131, 131, 132, 131, 131, 131, 132, and so on. The difference on the fourth count is caused by an accumulation of fractional line increments to the point where they start the blanking interval a whole line earlier. Each picture, meanwhile, scans to completion.

On the fourth count, the scan merely starts and ends one line higher. Since the beginning of the blanking interval is tied to the end of the picture, while the end of the blanking interval is tied to the cyclic

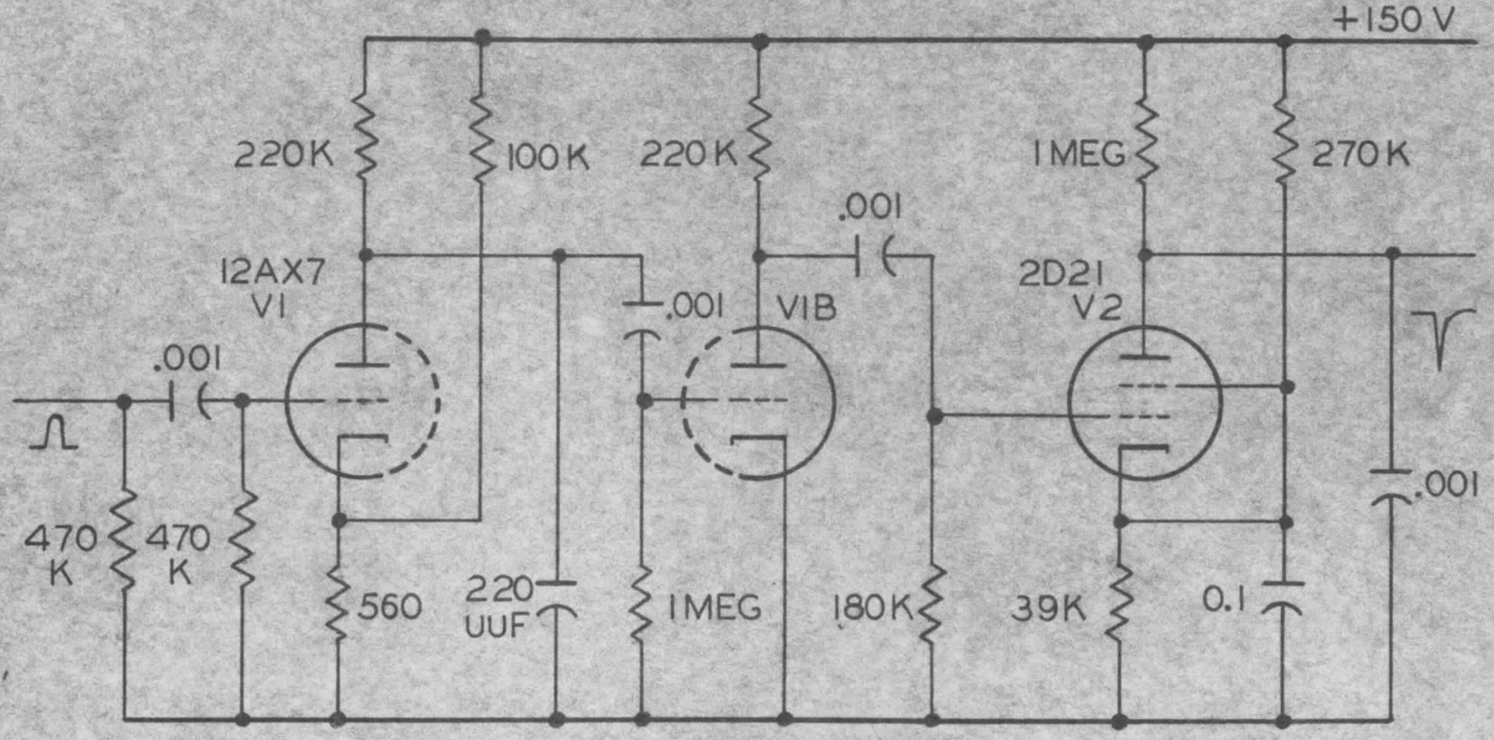

Figure 3-12. Pulse Amplifier

rate of the camera, the blanking interval is not subject to rigid cyclic control. It can shrink several lines, or increase by any necessary amount. Because of this flexibility, the camera need not be locked to the frequency of the television signal. A full frame of 525 lines is photographed during each synchronous exposure cycle, and any short or over lines are dropped out during the blanking interval.

In the camera, a disc rotates at a constant speed of 24 turns per second (1,440 rpm) and passes a single light pulse during each revolution. It is phased so that the light pulse follows immediately after completion of film pulldown. A phototube with associated amplifying and pulse shaping circuits translates the light pulse into the electrical cycling pulse.

Fig. 3-6 shows the amplifying and pulse-shaping circuits. Triode V1A and V1B are a two-stage amplifier and V2 is a gas tetrod used as a pulse regenerator. It is biased to cutoff in the absence of an input pulse. A positive pulse applied to the grid fires the tubes and produces a single negative-going pulse at the plate. This pulse is fed to the start coincidence circuit.

Film pulldown must be accomplished in a relatively short time. The blanking interval of 1/120 second establishes the maximum time allowance for film pulldown, but only a portion of this interval may be utilized. The film must remain stationary during the initial portion of the blanking interval to allow for phosphor persistence effects in the recording cathode-ray tube.

A P11 phosphor is used in the recording cathode-ray tube. The major component of this phosphor's light output is in the blue region of the spectrum, where video recording films are most sensitive. This phosphor has a desirably high decay rate, the persistence illumination dropping to a very small percentage of initial illumination within the scanning time of a few lines.

Persistence illumination preserves each line for photographic exposure during an interval after scanning, and supplies an appreciable additional light contribution in relation to initial illumination. If the last line scanned in each frame is to contribute its full share of persistence illumination before film pulldown starts, the phosphor decay rate must be very high.

The P11 phosphor is almost entirely satisfactory in this respect, but has one shortcoming which seems to be common to all presently available phosphors. Complete extinction of low-level illumination requires several seconds. Residual illumination from this source causes a brightness difference between the first and last lines. Although the magnitude of the effect is small, the brightness difference can be quite apparent because these lines are adjacent in the recorded picture, and because the high contrast of the photographic film emphasizes any brightness difference. Exposure on the film will equal .

Compensation is effected quite simply by using a waveform which decreases the bias on the cathode ray tube (increases brightness) as the exposure proceeds. The peak amplitude of the compensating sawtooth waveform is adjustable to meet different tube characteristics. The adjustment need be made only when a new tube is installed, and need not be repeated during the life of the tube.

V1 and V2, which are the amplifier and the pulse forming tubes respectively, are used to trigger the electronic shutter when operating from the camera. The input signal at J1 is a 24-cycle pulse approximately 0.01 volt in amplitude. This signal is amplified by V1 and is applied to the grid of V2, a gas tetrode, which is fired and produces a sharp negative pulse at its plate. This is coupled through the 47 mmfd. capacitor, C33, into the electronic shutter starting circuits. Tubes V3, V4, and V5 are a multivibrator, diode trigger coupling tube, and rectifier, respectively. The 120-cycle full wave rectifier, V5, provides pulses at the plate of V4 so that the multivibrator may be run at 24 cycles per second in synchronism with the 120-cycle per second signal coming from the original 60-cycle heater voltage. This circuit then provides output pulses from the left hand plate of V3 which occur at a 24-cycle rate and are synchronized with the 60-cycle power line. The V3 output pulse is used to trigger the electronic shutter circuit during standby periods when the camera is not in use so that the picture may be seen on the picture tube just as it would be if the camera were being run.

The electronic shutter portion of this chassis uses conventional flip-flop circuits which are coupled with diodes in order to give more dependable operation than can be obtained by most other methods of coupling. V12, whose associated components are constructed within an octal turret, as is V10, is the main gate tube. The useful output of this tube is taken from pin 7 of V11, the coupling diode and is a nonsymmetrical "square" wave rising at the beginning of the "ON" period of the cathode ray tube. This square wave is coupled to the grid of the 1, 2, 3 section of V13, a cathode follower whose cathode is coupled directly to the cathode of the picture tube. Thus, a shutter waveform, which is down during the "ON" period of the cathode-ray tube, is generated at the cathode of the cathode follower section of V13. The bottom potential of this waveform is determined by the circuit associated with the two tubes, V14 and V22. This is the shutter compensation circuit. The output of V22, which is a cathode follower, is attached directly to the cathode of the output section of V13 and determines the bottom potential of the cathode ray tube cathode during the "ON" period. Operation is as follows: V14 is normally cut off, but during the "OFF" period of the cathode ray tube it is turned on, thus discharging C31. Then, during the "ON" period of the cathode ray tube the charge on C31 is built up toward a positive potential through the resistance R74 plus R80 by the plate potential (pin 1) of V22. Since this plate is directly coupled back to the original input grid in a reinforcing manner, subsequent adjustment of the "SHAPE" and "AMPLITUDE" controls will result in a waveform at TP6 whose shape is that of a parabola. The waveform slope actually increases as the time goes by and it is steepest at the end of the "ON" period of the cathode ray tube. The DC potential of TP6 (the grid of the output cathode follower V22) should be near 4 or 5 volts positive DC; the AC signal at this point should be the parabolic waveform previously described and measuring approximately 1 volt peak-to-peak. In this manner the circuits associated with V14 and V22 determine the bottom potential of the cathode ray tube gate signal during the "ON" period.

The main gate tube, V12, is triggered on and off to provide the beginning and end of the shutter waveform, which is coupled to the cathode of the picture tube. The input trigger pulse, introduced through S1A, is derived from the camera in normal operation and is timed so that it occurs just after the film has been pulled down in the recording camera. This pulse may occur at any time with respect to the horizontal or vertical sync pulses, that is, it may occur any time during the picture or during a horizontal line. This negative pulse drives one plate of V8 down by conduction of the pin 5 and pin 2 section of V7 and in so doing, it sets up the #2 plate, pin 6, so that a negative pulse coming through the other half of the diode V7 can drive plate #2 down again. This single-shot multivibrator has been designed so that the grid bias as maintained by the charge on C13 is so great for a period of two or three horizontal lines that the horizontal pulses coming in through the lower half of V7 do not trigger the circuit for a period of 100 to 150 microseconds. After this interval a pulse will finally come through which will trigger the tube and drive down plate #2. This triggering action will occur almost in exact synchronism with the leading edge of the horizontal sync pulses but there may be a little bit of jitter in this firing.

To remove this jitter, another start coincidence circuit (V12) is utilized. This flip-flop circuit is set up by the V12 pulse through the upper half of V9 and is then triggered back by the next norizontal pulse which comes from the plate of V16 through the lower half of V9. Thus, on the next horizontal pulse following the pulse which triggered V8, V10 is triggered and the output pulse is coupled through the upper half of V11 into the main gate. All these output pulses which couple through the diodes to the next stage are negative in polarity. Pulses which are positive in polarity do not get through these diodes because all the coupling condensers are returned through their coupling resistors to the same B + point as is used to operate the plates of all the gate tubes. In this manner the main gate is started in coincidence with one of the horizontal sync pulses at a time approximately 3 or 4 line periods after the synchronizing pulse occurs in the camera.

The main gate pulse at pin 1 of V13 is fed not only to the cathode ray tube cathode but also through J4 to the binary counter so that when the cathode ray tube is turned on, the binary counter starts to count horizontal pulses. After 524 pulses have occurred, the counter is set so that it sends back on J3 a negative pulse approximately 80 volts high and 10 u/sec long, occuring essentially at the same time as the horizontal sync pulses. This pulse is coupled into the stop coincidence circuit, V18, through the lower half of the diode V17, thus driving down the left hand plate of V18 at the end of the 524 line interval (measuring from the beginning of the counter operation). Note that the counter actually does not count the very first pulse which turns on the gate. This means that the counter pulse that comes back to the stop coincidence circuit occurs after 524 lines have been scanned on the cathode ray tube. Setting up V8 by driving the left plate down, drives up the right hand plate so that it now is driven down by the next horizontal sync pulse. This pulse couples through the upper half of V17, thus driving down the right hand plate of V18 and providing a negative pulse which turns off the main gate. Driving down the left hand plate of the main gate, drives up the cathode of the output cathode follower section of V13, thus turning off the cathode ray tube.

Tubes V19, V20, and V21 are the superblanking tubes. V19 is the pulse amplifier which drives V20 and V21. A vertical blanking pulse is generated by multivibrator V20, which is triggered from the vertical sync pulse through one-half of V19, the pulse width being adjusted by changing the setting of the potentiometer R55. The pulse length is adjustable from approximately 10 to 20 horizontal line periods which easily takes care of any possible vertical blanking periods that should be found in television signals. The same sort of circuit is used to provide the horizontal superblanking pulses except that in this case the pulses are much more narrow and the range of adjustment is from approximately 4 to 12 microseconds.

All the circuits in this unit should still operate when a normal cathode ray oscilloscope test lead is attached to any plate in the system, although attaching to some of the grids may knock some of the flip-flops out of operation. Test points are provided at junctions in the system where an ordinary scope may be applied without causing any trouble. A test pulse input jack J2 is provided so that any type of negative pulse of approximately 100 volts amplitude and 1 microsecond dropping time may be used to trigger the shutter by throwing the switch S1 to the external position. Output jack J12 is provided to permit control panel monitoring of the waveform at TP6. This is the shutter correction waveform and determines the potential of the bottom of the shutter waveform during the "ON" time of the cathode ray tube.

It should be noted that the B + voltage for V1, V2, V3, and V4 is supplied through S1B and an external interlocking switch which is connected to terminal board E3. The purpose of this connection is to allow the operator to control the source of triggering signal by a single switch on the control panel. Thus, when S1 is either in the "CAMERA" or "LINE" positions (which are identical) B+ is provided on terminal 2 of E3 and the camera pulse will do the triggering of the shutter. When B+ is on terminal 3 of E3, the artificial 24-cycle pulse from V3 will do the triggering. S1C is provided so that unless S1 is on either the "CAMERA" or "LINE" position, the camera itself cannot be operated because no 115-volt power is applied to it. This is done so that it is impossible for the camera to be operated unless switch S1 is in the position that will actually allow the camera to control the electronic shutter.

11. PULSE COUNTER CHASSIS (See Pulse Counter schematic)

a. Function.-This circuit provides a pulse occurring 524 horizontal line periods after the main gate in the electronic shutter chassis has turned on the display tube.

b. Adjustments.-None

c. Theory.-There are two inputs to this pulse counter; the continuously occurring horizontal synchronizing pulses from the sync pulse generator and the counter gate which comes from the main gate cathode follower driving tube in the electronic shutter. As long as the main gate in the electronic shutter is down (cathode ray tube turned on) the gate coming into the counter is down and tube V17 (the counter gate amplifier) is cut off. During this time the counter is allowed to operate. When the counter gate voltage rises sufficiently, it turns on V17, causing the upper row of diode tubes (V12, V13, V14, V15, and V16) to pull down the plates of the counter stages to which they are connected, thus disabling all the counter stages and setting them in the proper phase for the next count of 524 pulses. The output pulse from the counter is shaped by a differentiating circuit, C3, and R7, in the grid circuit of one half of V17, which is normally cut off. This sharp positive pulse produces a sharp negative pulse at the plate of this tube which is coupled out through J3 to the counter pulse input of the electronic shutter where it is used to turn off the main gate through the stop coincidence circuit after the proper number of lines on the cathode ray tube have been exposed to the film. All the flip-flop stages of this counter as well as several of the flip-flop stages in the electronic shutter are built in turret cans which are plugged into octal sockets on the chassis of the unit. This type of construction makes for easy replacement of the entire flip-flop unit so that if trouble occurs, an entirely new scale-of-two turret designated as ST1 may be inserted. The interstage coupling for the counter is provided by dual diodes (V1 through V10) which are biased at B+ so that only negative going pulses from stage to stage cause any action. Tube V11 is a pulse amplifier which amplifies and inverts the synchronizing pulses which come in on J1 from the sync pulse generator. V18 is the voltage regulator tube which provides the necessary +150 volts for the plates of the entire circuit.

The action of this counter circuit is as follows: during the off time of the main gate, the right hand side of V17 is conducting and pulls down the cathodes of all the resetting diodes V12 through V16, thus pulling down the plates of the various stages of the counter to which these diodes are connected. These diodes have been connected so that it will take exactly 524 pulses before the left hand plate of the last turret will rise, thus providing the necessary polarity to drive the grid of the output stage, the left hand half of V17. By reconnecting the reset diodes to different plates along the counter stages it is possible to make this binary counter count from 1 through 1,024 pulses. The input pulse, which causes the last counter to drop on the right hand plate or rise on the left hand plate undergoes a small delay when it goes down through the nine previous stages of the counter so that the output pulse actually occurs approximately 1/10 of a microsecond later. Since this output pulse feeds into the coincidence circuit in the electronic shutter chassis, this very slight delay is inconsequential.

It has been found that any pulse from about 10 volts amplitude or greater is satisfactory to drive the unit providing its rise time is a small fraction of a microsecond. The only critical stage in the counter is the first one, where it has been found that the connection of a cathode ray oscilloscope test lead may cause the first flip-flop circuit to misfire. The operation of the first flip-flop circuit is clarified by the following procedure; First, remove any connection from J2, the counter gate input, so that pin 7 of V17 is simply returned to -150 volts. The reset diodes are at B+ potential since V17 is cut off. This allows the counter to run continuously. That is, the counter is no longer gated and will simply act as a circuit in which each stage runs at half the frequency of the preceding stage. A cathode ray oscilloscope may then be synchronized on the input pulses and four pulse intervals made visible on the screen of the oscilloscope. The operation of the first two stages is then checked by looking at either plate of the second stage which should be operating at 1/4 of the input frequency. One cycle should show up on either of the plates of the second stage with the horizontal sweep frequency of the cathode ray oscilloscope at the setting previously used. The same method may be used for checking the rest of the stages of the counter. The cathode ray oscilloscope may be synchronized on one stage, for instance the third, and then the fourth and fifth may be observed to see if they count down properly. No trouble should ever be had in connecting the cathode ray oscilloscope test lead to any of the plates on the counters except No. 1.

If it is necessary to disable the electronic shutter with the picture tube "ON", merely pull out any one of the counter turrets.

12. HORIZONTAL DEFLECTION CHASSIS (See Horizontal Deflection Schematic)

a. Function.—To provide a linear sawtooth current in the deflection yoke of the display unit picture tube, synchronized with the input horizontal synchronizing pulse.

b. Adjustments

(1) Horizontal Drive Control (R7) adjusts the magnitude of the output of the sawtooth generator V2.

(2) Bias Control (R17) adjusts the bias of the output stage V4 and V5.

(3) Horizontal Hold Control (R5) is adjusted to provide synchronism of the blocking oscillator with the incoming horizontal trigger.

(4) Linearity Control (R36) is used to set the sawtooth so that it represents a true linear function of time within ± 2%.

c. Theory.—The high degree of linearity in the output is obtained with comparatively few adjustments in this circuit by use of current feedback from the output circuit back to the input of the sawtooth amplifier stage.

The feedback in this circuit is on the order of 20db.

V1 is a pulse amplifier tube which triggers the blocking oscillator tube V2, the second half of which is a switch tube of an RC type sawtooth generator. This generator provides a synchronized sawtooth voltage of approximately 6 volts peak-to-peak value, the magnitude being determined by the adjustment of R7, the horizontal drive control. The left hand half of tube V3 is an amplifier which has two inputs, one of which is the sawtooth input voltage on its grid while the other is the feedback voltage from the feedback resistor R38 which is coupled into the cathode. The output stage consists of two 6BG6G tubes in parallel with the necessary suppressor resistors in the screens and plates. The circuit uses two 6AS7G's in parallel for the triode type damping tubes whose grid signals are passed through an RC network in order to give proper damping of the circuit. A connection between the cathodes of the damping tubes and terminal 8 of the terminal strip E1 provides the circuit path for operating a sweep loss protection circuit located in the vertical deflection chassis. In the absence of any sweep, the cathodes of the 6AS7G's are at ground potential.

13. VERTICAL DEFLECTION CHASSIS (See Vertical Deflection Schematic)

a. Function

(1) To provide a linear sawtooth current in the deflection yoke of the display unit picture tube synchronized with the input vertical synchronizing pulse.

(2) To provide a method of removing the cathode ray tube anode voltage if either the horizontal or vertical deflection circuits fail or if the biasing circuit of the cathode ray tube should fail.

b. Adjustments

(1) Hold Control (R5) is adjusted to provide synchronism of the blocking oscillator with the incoming vertical trigger.

(2) Amplitude Control (R9) adjusts the magnitude of the output of the sawtooth generator V2.

(3) Linearity Control (R27) is used to set the sawtooth so that it represents a true linear function of time within ±2%.

c. Theory.—The first half of tube V1 is a pulse amplifier which is used to trigger the synchronized blocking oscillator which is the left-hand half of tube V2. V3 is the switch tube which is used to discharge the capacitor C4 in the sawtooth generator circuit which is bootstrapped in order to provide a more linear sawtooth voltage than can be obtained otherwise. This bootstrapping is provided by coupling the sawtooth voltage through a cathode follower (1/2 of V1) and coupling capacitor C5 back to the high end of R35 which provides the constant current for charging the capacitor in the RC sawtooth generator. The positive voltage necessary for the 6.8 megohm resistor R7 is obtained through the diode V3 in order to use the full B+ voltage for effective sawtooth generation. A linear sawtooth of approximately 70 volts peak-to-peak amplitude is generated at test point 1 and this voltage is attenuated approximately 20-to-1 in being fed to the grid of the input amplifier (one-half of V4). The 6, 7, and 8 section of V5 is utilized to increase vertical deflection and provide faster recovery time when noise or loss of sync disturbs the circuit. The other stages in this amplifier are conventional except that one-half of the 12AX7 (V4) is used as a feedback injection amplifier. This circuit uses current feedback similar to that utilized in the horizontal sweep circuit in order to obtain proper linearity and independence of changes in tube characteristics. It was found that proper vertical steadiness could not be obtained except by generating the sawtooth voltage at a very high level so that very small variations and irregularities in the sawtooth generating circuit were of no consequence compared to the very large useful signal. It was also found necessary for optimum steadiness to operate this chassis from the +250 volt supply which is double regulated; that is, it is the output of a regulated supply whose input is likewise from a regulated supply.

The sweep loss and bias protection circuit consists of V7 and V8 and the relays K1 and K2. K2 will not be energized unless the minus 150 volt supply used as the bias for the cathode ray tube is available. K1 will not close unless both the screen and the control grid potential of tube V8 are at the proper value, established by the deflection voltage as follows: the left-hand half of V7 is a diode which acts as a peak detector to generate a DC voltage from the AC voltage on the plate of the output 6L6 of the vertical deflection amplifier. The other half of V7 is a cathode follower driving the screen of V8. Hence, if the vertical sweep voltage at the plate of the 6L6 fails the tube V8 will be cut off and K1 will open. Note that this does not give complete protection against breakage of the circuit to the deflection yoke. The control grid of V8 is operated from the cathodes of the damping triodes in the horizontal deflection circuit in such a manner that as long as an appreciable amount of horizontal deflection voltage exists on the secondary of the horizontal deflection output transformer, the control grid of

V8 will be at ground potential and K1 will be closed, provided the vertical deflection circuit is operating properly. The contacts of K1 and K2 are in series with the 115-volt a-c line which operates the relay controlling the 30 KV supply voltage for the cathode ray tube.

14. VIDEO AMPLIFIER CHASSIS (See Video Amplifier Schematic)

a. Function

(1) To amplify the video signal fed from the video gain control.

(2) To deliver the amplifier video signal to the grid with the back porch level clamped to black.

(3) To provide phase inversion so that either negative or positive output polarity may be obtained with either polarity input signal.

(4) To provide a monitoring signal of the CRT grid voltage.

b. Adjustments

(1) C10 is a compensating condenser in the voltage divider which drives the monitor output circuit. It should be set for essentially flat frequency response to 4 megacycles.

(2) R26 and R27 are low frequency compensation adjustments and should be set whenever the frequency response is checked.

c. Theory.—V1 is a stage that has a gain of one and is used as a phase inverter so that an output signal of either positive or negative polarity may be obtained with either polarity of input signal. The amplifier itself consists of V2 and V3. These two stages provide a gain of about 40. The first stage utilizes a small amount of shunt peaking and some high frequency by-pass in the cathode resistor, while the interstage coupling from the second to third stage uses simple shunt peaking. The third stage (V3) has a series-shunt peaking circuit and also provides some high frequency by-pass for the cathode resistance. A conventional DC-restorer type circuit utilizing the diode V4 is used for clamping on the blanking level of the signal which must have the sync pulses removed for proper operation of the circuit. Switch S1 provides for either a white positive or white negative signal at the output for a white positive signal at the input. Note that section S1B of this switch also changes the polarity of the DC restorer at the output. The entire amplifier is built on a bakelite chassis in order to reduce the stray capacity of the circuit and extend the usable bandwidth.

The video amplifier is mounted in the display unit as close as possible to the grid connection of the cathode ray tube so that only a very short interconnecting lead is necessary. The amplifier contributes a negligible amount of noise and hum to the signal even for very low values of input voltage.

15. THE DISPLAY UNIT (See Display Unit Schematic)

The display unit consists of the cathode ray tube, the associated deflection and focus coils, together with the protective resistors (R3 to R7 inclusive) for the high voltage supply. These protective resistors are included in the circuit so that they will open up in case of arcover within the tube and thus prevent undue harm to the tube itself. Replacement of these resistors necessitates loosening the high-voltage connector at the rear end of the metal box in which these resistors are mounted.

The video signal is applied to the grid of the cathode ray tube while the shutter waveform (which includes the superblanking) is supplied to the cathode.

The focus coil is a shunt type coil which requires approximately 25 milliamperes to give proper focus with 25 KV on the anode of the cathode ray tube. The focus coil should be positioned as close as possible to the deflection yoke and should then be mechanically adjusted for the proper vertical position of the raster.

The cathode ray tube is supported by a removable face casting and the deflection yoke. The yoke and focus coil are mounted on a plate which is adjustable in the direction of the picture tube axis to accommodate tubes of different lengths. A new tube may be quickly installed by loosening the yoke and focus coil plate and removing the tube socket and anode connection. The face casting is then loosened, carefully lifted over its locating pins and slid toward the camera, thus pulling the tube out of the yoke. The sponge rubber clamps that hold the tube in the face casting are then loosened, freeing the tube.

On the display unit, the connections for the high voltage system will also be noted. It is important that the high voltage connector for the 30 KV supply should never be loosened and there should be no ground connection at the RG 8/U cable which carries the 30 KV voltage to the high voltage condenser unit. The only high voltage connector normally loosened in ordinary use connects to the protective resistor-box on the picture monitor.

16. WAVEFORM MONITOR AND CONTROL PANEL (See Waveform Monitor Schematic)

a. Function

(1) To provide a cathode ray tube waveform monitor which will serve for normal monitoring plus unit testing.

(2) To provide the controls necessary for video recording.

b. Adjustments

(1) Front Panel

(a) A vacuum gauge for monitoring the vacuum supply used with the General Precision Laboratory 16mm Video Recording Camera.

(b) A 5" cathode ray tube for visual monitoring of video signals.

(c) A microammeter for voltage and current monitoring at selected points in the system.

(d) The MONITOR SELECTOR switch (S5) is provided for switching selected signals to the input of the amplifier feeding the waveform monitor. In position #5, it also reverses clamp polarity.

(e) The "METER SELECTOR" switch (S3) is provided for switching selected signals to the meter and switching in the proper range calibrating resistors simultaneously. In position #6, a push button switch increases the meter sensitivity.

(f) The "CAL. ADJ." potentiometer supplies a voltage for calibrating the waveform monitor in volts/inch vertical deflection.

(g) The "VERT GAIN" control varies the gain of the amplifier feeding the waveform monitor.

(h) The "VIDEO GAIN" control varies the gain of the amplifier which feeds the display CRT.

(i) The "ANODE VOLTS" control varies the 25 KV supply on the anode of the display tube.

(j) The "V." and "H HOLD" controls vary the frequency of the output of the horizontal and vertical deflection chassis.

(k) The "H. CENT." control is used to center the raster horizontally on the display tube.

(2) Chassis

(a) LINE/FRAME lock is used to set the time base of the deflection voltage.

(b) The SYNCH control is used to lock the frequency of the internal oscillator to the frequency of the incoming signal.

(c) The ASTIGMATIC control is used to set best overall focus on the waveform monitor in conjunction with the FOCUS control located on the shelf in back of the panel.

(d) The FOCUS control (R44) is the coarse focus adjustment for the display tube.

(e) The INTENSITY control on the shelf controls the WFM brightness.

(f) Horizontal and Vertical Centering controls for the WFM are located on the shelf. A second Vertical centering control is provided on the chassis for centering the waveform observed when the Monitor Selector Switch is in position #6.

(g) A Horizontal Gain control is provided for controlling the amplitude of the horizontal deflection voltage.

c. Theory.-The waveform monitor employs a 5" cathode ray tube and utilizes a three-stage video amplifier which has sufficient gain to provide usable deflection with approximately 1/20th of a volt peak-to-peak input signal. The input to this amplifier is controlled by switch S5 (the Monitor Selector Switch) to permit observation of waveforms at various points along the signal path within the recorder. The amplifier may also be used with a separate input jack as a test oscilloscope. The horizontal sweeps of the unit are independent of the sweeps in the rest of the video recorder and they will run free if necessary so that the usefullness of the scope is not impaired by failure of anything else in the system. Although the power for this unit is normally obtained from the regulated transformer within the equipment, it is possible, in cases of emergency when complete breakdown of the equipment has occurred, to use an external power source for test scope operation. The DC restorer circuits in the output of the video amplifier for the vertical deflection are double-ended and controlled by relay K1 which is energized in one position of the monitor selector switch so that when looking at waveforms which should be clamped at the top end they may be properly clamped; whereas for all the rest of the positions, the signal is clamped at the bottom which corresponds to the standard white positive video signal which should be clamped at the bottom of the sync pulses. This relay also moves the centering from below center to above center while simultaneously changing the polarity of the clamping diode. The horizontal sweep circuits are more or less conventional in nature employing a three-tube sync signal amplifier consisting of V11 and V12 to drive a blocking oscillator which in turn drives a switch tube, the left hand half of V14, which is the sawtooth generator.

The signal which is used to synchronize the horizontal sweep of the waveform monitor is either the composite signal which comes in on J5 and J6 of the unit or any suitable external synchronizing signal which may be selected and which is brought into the unit on J8. This signal must be negative in polarity and at least 1/4 volt peak-to-peak in amplitude. For most normal synchronizing signals the sync amplitude control (R94) should be left at the full maximum position.

The performance of the waveform monitor is entirely adequate for most television purposes, being approximately 3 db down at 4.5 megacycles. The low frequency response is such that a 60-cycle square wave will exhibit no more than a 2.0% tilt. The 4UP4 cathode ray tube is operated at approximately 1700 volts acceleration potential as furnished by a 60-cycle supply utilizing a 2X2 rectifier.

17. POWER SUPPLIES

The standard Model PA-303 GPL Video Recording Monitor utilizes four power supplies; a recorder equipped with the videogam amplifier requires one additional regulated power supply. The low voltage power supply is used to provide regulated +330 and +250 volts at a total current of 430 milliamperes.

The +550/+450 volt power supply provides plate voltage for the horizontal deflection output amplifier, for the focus coil and for the plate voltage in the 30 KV r-f power supply. The +550/+450 volt power supply is conventional in every detail and its two halves differ only in that the +450 supply has an additional dropping resistor to lower the output voltage as compared to the +550 supply. A relay (K1) is provided in the +450 volt supply to switch its output from a dummy load (R3) to the load which actually consists of the plate current of the 30 KV r-f supply. The coil of this relay is actuated by the high-voltage switch on the control panel through interlocks used to prevent operation of the cathode ray tube if sweep or bias voltages are not applied.

The plus and minus 150 volt power supply provides electronically regulated +150 volts at 125 milliamperes for operation of the sync separator chassis and provides two separate -150 volt outputs regulated by voltage regulating tubes for various biasing purposes throughout the equipment. The same power transformer is used to provide plate voltage for both rectifiers in this supply. The negative supply not only provides bias output voltage but also furnishes the negative voltage for reference in the electronic regulator circuit. Winding 6, 7, and 8 of the power transformer is a 160 volt center tapped winding, half of which is used to supply power to rectifier in the camera interlock unit. This output is at terminal 7 on the terminal strip E1. The only adjustment on this chassis is the +150 Volt Adjust which can vary the output voltage from 125 to 175 volts.

The 30 KV r-f supply is a slightly modified commercial unit (Spellman Television Company) providing 30 to 40 KV. The modifications were necessary to permit including a built-in meter to indicate the anode voltage in the equipment and to include a separate voltage control and a separate meter which would read total anode current of the cathode ray tube.

The basic high voltage supply consists of an r-f oscillator operating at approximately 100 KC. It consists of three 6L6's in parallel driving a voltage tripler circuit which provides the 30 KV output, using 1B3's as the rectifier tubes. From the 10 KV point in this tripler, a voltage is obtained from a voltage divider to drive the grid of regulator tube V2. The V2 plate is coupled to cathode follower V1 which varies the screen voltage of the oscillator tubes V4, V5 and V6 in order to maintain the 10 KV point at a constant value. The circuit is so designed that the regulation is within ±1% over a current range of 100 to 500 microamperes at 25 KV.

The modifications previously mentioned have made it necessary to utilize a floating ground in the equipment so that the ground return for the high voltage supply could be isolated in order to place the milliammeter in a better circuit location to read the high voltage supply current. It was also necessary to connect the regulator voltage divider to this floating ground in order to keep the divider current out of the milliammeter.

A screwdriver adjustment (R17) is provided in the top deck of the unit between tubes V3 and V7 in order to adjust the control range of the anode voltage adjustment potentiometer located on the control panel of the video recorder. It is suggested that this voltage range adjustment be so set that when the control panel adjustment is turned up, the maximum voltage output will be 26 KV. This will prevent breakdown of the high voltage capacitor due to an incorrect setting of the anode voltage control.

It is possible, especially after any major replacements have been made in this unit, that it may be necessary to readjust the heater potentials of the 1B3's while the unit is actually in operation under load. This should be done by comparing the color of the 1B3 filament in question with that of a 1B3 heated from a 60-cycle a-c source of 1.25 volts. This adjustment is made on the trimmers associated with each filament using a long, insulated screwdriver.

18. POWER DISTRIBUTION AND CONTROL

Power for the GPL Video Recorder is interlocked thru a relay-operated power interlock chassis mounted in the left rear side of the monitor console looking at the unit from the rear. The relay is energized by the main power switch on the control panel. The interlock switches on the rear doors and display unit are in series with the coil of this relay so that AC is removed when these interlocks are open. Unregulated 115-volts AC is used for the regulated power supplies and for all but one of the heater transformers and to operate the camera. Regulated 115-volts AC is furnished to the filament transformer TR1 and to the +550/+450 volt power supply. This same regulated 115-volt AC is also used to operate the control panel and monitor and functions to prevent line voltage surges from affecting the waveform on the cathode ray tube and from changing the calibration signal used to set the gain of the vertical amplifier. The high voltage control circuit feeds through the CRT anode switch connected between terminals 3 and 5 in the control panel and monitor and passes through the two contacts on the relays in the vertical deflection chassis then through the door interlock in the high voltage condenser unit and then out to the transfer relay in the +550/+450-

volt power supply which transfers the 450-volt supply to the 30 KV r-f supply. Note that terminal 11 of the ≠550, ≠450-volt power supply is also connected back to terminal 6 on E1 of the control panel and monitor to light the red pilot light on the control panel indicating that the high voltage is ON. It should be pointed out that this red pilot light is merely an indication that the B≠ voltage is on the 30 KV supply and does not necessarily mean that the 25 KV is actually on the cathode ray tube.

The recorder has an additional interlocked circuit which provides for proper operation of the camera. A relay is energized by a rectified AC signal coming from the 150-volt power supply which must go thru the CAMERA-STANDBY switch on the control panel and S1 on the electronic shutter chassis. Furthermore, if the GPL Rapid Film Processor is operated in conjunction with the GPL Video Recorder, the proper interlocking circuits are provided so that the actual camera power is fed from the processor for operation of the camera motor in step with the processor drive motor.

SECTION IV

WIDEBAND VIDEOGAM AMPLIFIER

1. GENERAL

Many of the currently available light-to-signal and signal-to-light transducers used in TV systems do not accurately reproduce the gray scale or tonal quality of the original scene. The effect, generally described as either compression of the whites or compression of the blacks, is due to an inherent non-linearity in the input vs. output response. The Videogam Amplifier provides linearity control of the overall system response, restoring the original gray scale or otherwise modifying tonal quality. The factor controlled in this device is similar to the quantity which photographers define as "gamma".

The Videogam is a non-linear amplifier which receives a video signal and produces an output signal which has a power law relationship with respect to the input such that

$$E_{out} = C\ (E_{in})^K$$

where E_{in} is the input voltage, E_{out} is the output, K is an exponent and C is a proportionality constant.

The value of K may be varied in the amplifier from 0.5 to 2.0 without change in maximum white level. Normally the videogam is adjusted for unity gain at the maximum white level, with a proportionality constant C of unity. Differences in the ratio of maximum white output to input level (gain at maximum white level) equivalent to values of C ranging from 3 down to very low values (less than 0.1) may be utilized to adjust lower or higher than normal line levels to a standard output level. The exponent K corresponds to the "gamma" of a photographic transfer characteristic, which is the relationship between the log of the exposure and the density of the resulting film.

2. THEORY OF OPERATION AND CIRCUIT DESCRIPTION

The Videogam normally operates from a 1 to 1.4 volts peak video signal with white positive and no synchronizing pulses. A 75-ohm termination to the incoming line is always provided by a resistor, which also serves as a gain control, thus permitting adjustment of the amplifier gain to exceptionally large input signals without danger of overloading any portion of the amplifier.

Stages V1 and V2 form a regular video amplifier with response flat to almost 10 megacycles. V2, a 6AC7, drives the grid of the 6AG7 cathode follower, V3, to approximately 5 volts. This cathode follower is the heart of the Videogam, driving two sets of germanium diodes--one set (Y2 and Y3) to obtain a 0.5-power-law signal and the other (Y4 and Y5) to obtain a 2 power-law signal. In the low-power-law side, the constant voltage source of the 6AG7 cathode follower and the 1.5K resistor R22 effectively comprises a constant current generator for Y2. Thus, the current supplied to the diode Y2 is proportional to the input voltage to the amplifier. Since it is characteristic of a germanium diode to have a voltage drop which is proportional to the square root of the current passing through it, the input voltage at grid 2 of V4 is proportional to the square root of the input voltage to the Videogam.

The two-power-law signal is obtained by driving two diodes Y4 and Y5 from the constant voltage generator V3. The voltage across R52 connected in series with the diodes is proportional to the current through the diodes and due to the characteristics of germanium diodes is proportional to the second power of the applied voltage (at cathode of V3). Because the voltage and resistance values actually used make it difficult to obtain a full two-power curve from one diode, the 330-ohm resistor R20, is used to terminate the first diode Y4 and the voltage across this resistor drives Y5. Thus, the characteristics of the two diodes are multiplied, resulting in a power-law curve of 2.

These two methods of obtaining the exponential characteristics require that the cathode follower, V3, be a direct-coupled video amplifier capable of producing an output voltage varying from zero to two with the zero level firmly clamped to ground. This is accomplished by a d-c restorer, V10, a 6AL5 tube in the grid circuit of the cathode follower connected to a negative voltage source, so that the cathode-to-ground voltage can be adjusted to zero with no signal input.

Linear operation of the cathode follower is maintained by the use of resistor R15. Without R15 the cathode follower would be required to operate from zero current to full current and consequently, would be extremely non-linear over the low level portion of the signal range. Since the cathode follower output is a direct-coupled circuit, ordinary biasing methods for obtaining a zero signal current cannot be used. Instead, the cathode is connected to the negative supply through the 20K resistor R15 and the grid bias adjusted until the cathode is close to zero voltage with respect to ground.

With a negative supply of 150 volts, the current through R15 and consequently, through the cathode follower, is 7.5 milliamperes, which is a satisfactory quiescent current to provide linear operation of the cathode follower.

This method of driving the diodes from zero volts is essential to obtain the proper form of non-linear characteristics from the germanium diodes. As stated above, the transfer characteristics of the diodes have a desirable exponential relationship, but this holds true only if they are operated from zero current or voltage input. If too large a quiescent current flows through the diode, the effect of adding a constant to a power-law curve is produced, causing the curve to deviate considerably from the desired power-law curve. The same effect is also caused by having "black-level setup" in the incoming video signal. The best input signal for the Videogam is one containing no black level setup. If some is unavoidably present, it can be compensated for by adjusting the "Zero Adj" control R13. Tests have determined that the best non-linear characteristic from the square root diode is obtained when the zero-signal d-c voltage across the diode Y2 is between 0.05 and 0.1 volts. Meter M1 is included in the design to facilitate obtaining this condition. The meter should be set for 25 microamperes with no signal present. Normally it will not have to be checked more than once a day. The diode Y3, which is connected backward across the square root diode Y2 has no effect upon the normal operation of the circuit, but should an unusual signal or misadjustment of R13 allow a signal pulse to drive the cathode of V3 below ground, diode Y3 becomes a low resistance and limits the excursion of the negative pulses. No such problem is encountered in the "high-power" diode circuit (Y4 and Y5), since the gain is very low at low levels in this circuit.

The two signals are each fed through pentode amplifier tubes V5 and V6 and combined in the common plate resistor R33. Mixer control R26 consists of two ganged, 100-ohm, carbon potentiometers connected to feed through a one-half power signal for full counterclockwise rotation; a two-power signal for full clockwise rotation; and nearly a linear signal for the mid-position. To obtain proper operation, it is necessary to have circuit gains adjusted so that there is no change in maximum white level as the control is rotated.

Tubes V7, V8 and V9 comprise a video amplifier which amplifies the mixed signal obtained from R33 and L3. The output 6AG7 is a-c coupled through the 80 mfd capacitor, C24, into a load of 75 ohms, which is normally located at the receiving end of the output cable. The 1000-ohm resistor R49 serves to keep the case of C24 from charging up to a high voltage when no load is connected to J2. An output voltage up to 2 volts peak-to-peak is obtainable from the amplifier.

3. VIDEOGAM ALIGNMENT

With no signal input to the videogam amplifier and an adequate warm-up period being provided, meter M1 should be adjusted to read 25 microamperes by means of R13, the zero adjust control. This insures proper setting of the transfer characteristics of the germanium crystals.

A test signal preferably a 15 KC linear sawtooth of approximately 1V peak-to-peak amplitude is fed into the amplifier and the input gain control R2 adjusted for a 2V peak-to-peak signal at the cathode of V3 (J4-yellow), using an oscilloscope.

The oscilloscope is then shifted to the output terminals of the amplifier (J2) where a proper termination of 75 ohms should be provided.

Mixer control R26 is then rotated for full low power operation (counter clockwise) and the output noted on the oscilloscope. The mixer control should then be shifted completely clockwise to the high power side and R52 the balance control adjusted for the same amplitude as previously. This adjustment provides a constant peak-to-peak output signal for all gamma positions of the mixer control.

Once the above procedure has been performed by the factory or skilled maintenance personnel and the Videogam has been installed in a video recorder or similar equipment, the operator may find it more convenient to follow the following alignment procedure:

The input signal should preferably come from a test pattern so that reference black and peak white levels are contained in the signal. The video recorder synch-separator gain control will have been set to feed a signal of about one volt peak-to-peak to the Videogam input. The waveform monitor switch on the video recorder can be operated to show the composite input signal as it comes off the line; this just serves as a check that the signal is there at proper amplitude. Then the video recorder waveform monitor switch should be operated to show the output signal of the videogam and the input gain control R2 adjusted to give equal peak-to-peak amplitudes as the Videogam characteristic control R26 is rotated from low to high power conditions. This entire alignment procedure is contained in the preceding sentence and it has been found that the operator will use this procedure for routine

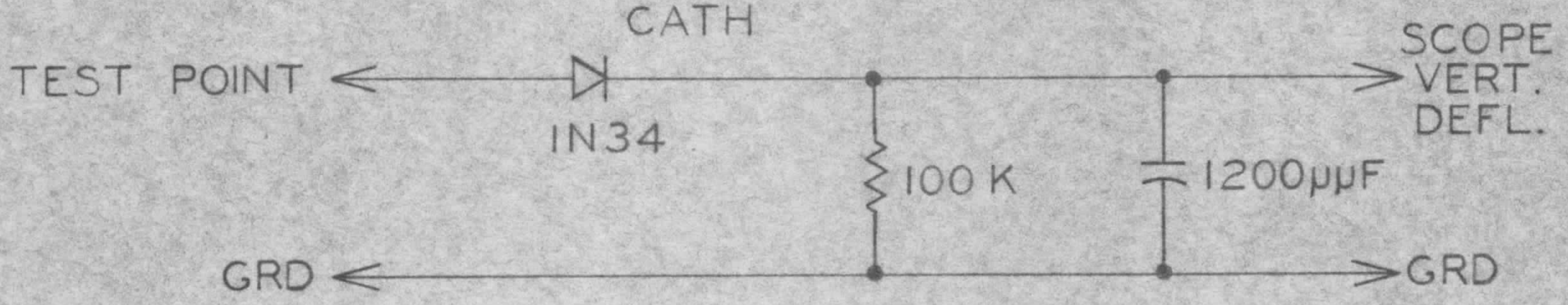

FIG 4-1 OSCILLOSCOPE DETECTOR

adjustments and checks. As an aid to making this adjustment the operator will find that if the high power output is lower than the low power output, more gain will be required; while if the high power output is higher than the low power output, less gain is required.

a. Low-frequency Response Adjustments.-Low-frequency response adjustments should be made before the high-frequency adjustments. A low-frequency square wave of about 60 to 100 cps should be fed into the input jack J1 and the signal observed at jack 4. The potentiometer R9 should be adjusted until a flat-topped waveform is obtained. The test oscilloscope should then be moved to the output test jack J5 and Potentiometer R46 adjusted for a flat-topped waveform. (J2 should be terminated with 75 ohms resistance.

The following circuit was used for the oscilloscope detector for the Markasweep signal (see figure 4-1):

This circuit can only be used when the test point has little or no d-c voltage on it.

To align and test the high-frequency response of the unit a sweep-frequency test signal should be fed into the input circuit and the output measured with detector and scope at the yellow J4 test point. The high-frequency trimmers C2 and C7 should be set to their mid positions. The output as observed on the scope should not rise above the input signal and should be down about 5% at 10 megacycles. Turning the trimmers down will increase the high-frequency response.

CAUTION

Be sure "Zero Adj" control R13 is set for proper meter reading of 25 micro-amps with zero signal.

The detector and scope should then be moved to the output terminal (Red J5 or Co-ax J2). The output circuit should be terminated with a 75 ohm resistor. The trimmers (C11, C17, C23) should be set to their mid positions. Crystals Y2 and Y3 should be replaced with a 180 ohm resistor. A general rise starting at zero frequency, reaching a maximum at 5 megacycles, and dropping to about 5% down at 10 megacycles may then be seen. There should be no pips or kinks in the response curve. The most important factor is to prevent excessive peaking in the 2 to 5 megacycle region.

a. Adjustment.-The only regularly used operating control is the characteristic selection control R26. The operator should realize, however, that it is necessary for <u>both</u> the black and maximum white levels of the incoming signal to be held as closely as possible to fixed values, especially when using a 0.5 power characteristic. Furthermore, if the incoming signal is noisy, use of the 0.5 power curve will increase the amplitude of the noise pulses with respect to the maximum white level. Therefore, in some cases, the user will have to decide whether the beneficial effects obtained by the 0.5 power characteristic are worth the additional noise. However, it should be emphasized that this is due to the mathematics of the problem and not the amplifier.

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