CBC
RADIO CANADA

VIDEO RECORDER MANUAL

Preliminary Operating Instruction Manual

for

VIDEO RECORDER

Model No. PA-3000

(Including Videogam Model PA-310)

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Part 1 - Video Recorder Instruction Book Notes

ROUGH DRAFT OF VIDEO RECORDER INSTRUCTION BOOK NOTES

The first part of this memo will be discussions of the individual chassis and other units of the video recorder. Under each unit a brief discussion of the operation will be given and then relevant points regarding operation and maintenance will be covered. The last part of the memo will give overall operation instructions and a summary of operating troubles that we have had and suggestions to minimize these troubles.

I - The Synch Separator and Setup Remover Chassis

The purpose of the synch separator and setup remover chassis is to provide a 75 Ω video output at standard level from which the synchronizing signal has been separated and to provide independent synchronizing signal output of approximately 30 uufd capacity. A secondary function of the unit is to remove any hum and low frequency noise which may be present on the incoming signal and provide a solidly clamped back porch level for the video and synchronizing signals.

The input signal to the unit is a standard composite television signal of from .7 to approximately 3 volts peak to peak. The video output signal is the standard 1 to $1\frac{1}{2}$ volt signal across 75 ohms with the white being positive polarity, the same as the input signal polarity. The synchronizing signal output is white positive and approximately $2\frac{1}{2}$ to 3 volts peak to peak in height. The first two stages, tubes V1 and V2, are ordinary video amplifier stages which drive a cathode follower V4 in whose grid circuit is a double diode clamp used to restore the dc level during the back porch interval to a prescribed potential. The cathode follower whose back porch signal level has been clamped is then used to drive a double diode separator with all portions of the signal which are positive from a reference point going through a video channel cathode follower, V6, and all signals which are negative from essentially the same point going through the synchronizing output jack. The key clamp is driven by the same synchronizing signal through an amplifier stage (one half of V7) which drives a blocking oscillator pulse forming tube V8. This pulse, which occurs during the back porch interval and is approximately two usec. wide, is then applied to the grid of the pulse amplifier stage, (the other half of V7) which is coupled through condensers C7 and C8 to the input electrodes of the double diode clamp V3. The only adjustment in this entire clamp loop is the separation level control R19 which is used to adjust the dc level to which the grid of the cathode follower V4 is clamped during the back porch intervals.

The only other control in this chassis is the setup control R47 whose function is to change the bias on the video output diode so that the separation level for the video signal can be raised slightly above that of the synchronizing signal. The synch and video diodes should cause separation at exactly the same voltage (back porch potential) when R47 is maximum resistance, i.e. counter-clockwise. Hence, reducing the value of the setup control resistance raises the separation level for the video signal alone and removes part of the pedestal in the video signal, that is, it enables the operator to remove some of the setup in the signal. The range of this adjustment is such as to allow about 15% of the video signal to be removed by this method.

The frequency response of the video channel is good enough to be used on a studio line where a bandwidth of 8 megacycles is required. This amplifier is down 3 db at ten megacycles and is plus or minus 1 db up to 8 megacycles per second. Ordinary series compensation is used in the first two video amplifier stages while a compensating capacitor C9 is required on the voltage divider at the output of the video separation diode in order to equalize the frequency response out to 8 or 9 megacycles. This trimmer capacitor C9 must be adjusted for each chassis using a video signal generator for the input signal and a vacuum tube voltmeter to read the output 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 resistence termination is approximately 5% greater at 4 megacycles than it is at $1\frac{1}{2}$ megacycles.

In order to obtain proper operation of the unit, the input gain control must be set so that when the separation level control is set for separation exactly at the back porch level with the set up control at maximum resistence (that is, for minimum setup removal, the signal output at J2 should be 1 to $1\frac{1}{2}$ volts.) If this level, that is, if the level of the signal through the entire video channel is too high, it may be so large as to over-ride the clamping pulses being fed into the double diode clamp so that the clamp will actually not function properly during high video signals and give streaks in the picture. Likewise, if the signal is too small through the system not only will the output signals be too small but the synchronizing signal which drives the blocking oscillator, which in turn operates the clamp, may become so small that the clamp will lose synchronization and then the signal becomes unusable. The range of signals over which the equipment will actually operate in a satisfactory manner is very large. The two units which we have checked experimentally have operated over a range of signals corresponding to those which produce a video output signal of approximately 2/10 of a volt on up to about 2 volts peak to peak.

The only troubles that have been experienced with this unit, once the video amplifier channel has been set at the proper response, have been associated with peculiar spikes that have come in on the input signal which cause the blocking oscillator to fire at some time other than the back porch. In order to cut down the possibility of this happening, even with very non-standard input signals with terrific overshoot, we have reduced the high-frequency response of the trigger amplifier tube V7 by putting C15 from its plate to ground in order to reduce the gain at high frequencies. It may also be found that certain combinations of V4, the cathode follower, and V8, the 6J6 blocking oscillator tube, may not give the proper range of control of separation level when turning R19. This may be remedied by reducing the value of R36 in the cathode of the pulse driving stage from 2.7K to 2.4K ohms. I will recommend that any future units which are manufactured be built to this specification, that is, with the smaller resistor in the cathode of the pulse driving stage.

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 $1\frac{1}{2}$ 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.

It should also be mentioned that in case of emergency it is possible to operate the equipment in a reasonably satisfactory manner by this method, that is, by removing V7 or V8 and letting the separator run unclamped. This will result in losing vertical synchronism at times but it may be better on occasion to run with poor vertical synchronism than to run with no picture at all. The appropriate waveforms at various strategic points in this chassis are shown on the schematic diagram, GPL sketch number SK6058.

II - The Synch Pulse Generator Chassis

The function of the synch pulse generator chassis is to receive the synchronizing signal from the synch separator chassis and from it generate horizontal and vertical synchronizing pulses of the proper amplitude and shape and in the proper phase relation to the original synchronizing signal to drive the rest of the equipment, including the horizontal and vertical deflection chassis and the electronic shutter and counter. V1 and V2 are simply pulse amplifiers in which the bandwidth has been maintained at around $1\frac{1}{2}$ mc in order to provide good stability in the horizontal circuits. The complete synchronizing signal is fed from plate No 1, that is, pin 1 of V2 through a coupling condenser C2 over through the vertical synch pulse generation channel which includes V4, 5, and 6. The same complete signal is fed through one half, pins 5 & 2, of the 6AL5 diode V3 to the other half, that is, pins 6, 7, and 8, of V2 and is coupled through C11 down to the horizontal pulse forming circuits consisting of V7, 8, 9, 10, and 11.

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 grid 3 and grid 1, of the mixer tube, respectively. 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, that is 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. The output pulse here is approximately 8 to 10 usec. wide in the order of 25 to 30 volts high. It occurs essentially at the trailing edge of either the second or third vertical block, depending on the adjustment of the vertical hold control, which is located on the control panel of the equipment and which changes the bias on the cathode of the 6BE6 mixer tube.

The horizontal pulse forming circuits utilize a standard RCA type automatic frequency control system for locking to the horizontal synch pulses which are coupled through C11. The 15,750 cycle oscillator V8 is controlled by the reactance tube, V9, which is biased by the phase comparison rectifier, V7. The output of this oscillator is then fed to the blocking oscillator driving tube, V10, which provides the proper phasing between the time that the blocking oscillator fires and the original sine wave at the plate of the oscillator tube, V8 so that the output pulse which is taken from the cathode V11 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. The horizontal output pulses are approximately a half usec. wide and 20 volts in amplitude.

Very little adjustment is required during normal operation in this chassis. The amplitude of the input synchronizing signals must be sufficient to drive the input amplifier so that it limits at both ends of its grid swing. It takes about $2\frac{1}{2}$ volts peak to peak signal in order to drive this unit properly. The <u>vertical hold control</u> should be adjusted by looking at the picture in the cathode ray tube and noting where a jump of one line, that is, by noting where a vertical jump occurs in the synchronizing of the vertical sweep. This jump corresponds to the shifting of the firing of the blocking oscillator from the tail end of the second vertical block to the third vertical block. The control should then be adjusted at a safe distance from this marginal operating point, either direction being quite satisfactory.

In the horizontal automatic frequency control circuit, a bit more care may be required for proper adjustment. The cores of the RCA 208T8 oscillator transformer are both adjustable. The core in the primary of the transformer, that is, associated with terminals A, B, and C 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 horizontal hold control elsewhere in the equipment have virtually the same effect, that is, changing the center frequency of the oscillator. The core associated with the other half of the transformer, terminals d, e, and f, effects the frequency of the oscillator very little but materially changes the relative phase of the sine-wave on the primary of the circuit as compared to the input synch pulses. In use, proper adjustment of the circuit is obtained by setting the horizontal hold control in approximately the center of its range and then adjusting the primary slug in the transformer until the system operates satisfactorily - the picture locks in horizontally. The phase controlling slug may then be adjusted until the picture is centered horizontally with respect to the rafter. The horizontal hold control and the slugs 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. It should be noted that both output blocking oscillators are free running at frequencies approximately half that at which they are driven so that any circuits further on in the equipment which required driving pulses will not go out of operation if the composite signal is lost.

A word of explanation is necessary on several of the components in the horizontal AFC circuit. C26, a 100 uufd capacity from terminal F on T2 to ground helps keep the phase modulation of the system to a minimum during the vertical block - it keeps vertical lines in the picture straight near the top of the picture where sometimes they tend to be bent to the right or left due to the vertical block's changing the equillibrium level in the AFC loop temporarily. The LC circuit L1 and C21 in the plate of the oscillator tube V8 are required in order to get the phase of the distorted sine-wave voltage at TP5 to the correct relationship in respect to the original horizontal synch pulses in order to give the previously described phase relation between the horizontal synch pulses and the horizontal output pulses of this unit. It was found that without this phase shifting circuit the automatic frequency control circuit does not run with proper phasing adjustment in T2, resulting in sideways drift at the picture on the CR Tube. 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 the limiting amplifier which is pins 6, 7, and 8 of triode V2.

This chassis should operate with essentially no adjustment after it has once been set except that drifts in the horizontal circuit which result in the picture moving slightly horizontally with respect to the raster will be noticed during warm up. Hence, the operator of the equipment must be careful during the first two or three hours of operation to check the horizontal positioning of the picture and the holding range of the horizontal hold control. After this time, we have observed that the picture is absolutely steady.

III - Electronic Shutter and Superblanking Chassis

The functions of this chassis are numerous, but the most important is that of providing an essentially rectangular waveform which is applied to the cathode of the picture tube in order to turn it off and on at the proper time as dictated by the motion of the film in the camera. Hence, the title "Electronic Shutter" since the recording camera actually has no mechanical shutter. This chassis also serves as a pulse forming amplifier which is used to turn on the electronic shutter from a pulse which is derived from the photocell in the recording camera after the film has been pulled into position so that a picture exposure may be made. A further function of the unit is to provide blanking pulses during the horizontal and vertical retrace times which are also applied to the cathode of the cathode ray tube along with the so called electronic shutter voltage. These large blanking signals have been termed "superblank" signals since they are used to override any other type of signal that may be influencing the beam current of the cathode ray tube. Since these signals are the order of 100 volts peak to peak as is the shutter signal, and the normal video swing is no more than 30 or 40 volts peak to peak, it can be seen that the superblank and shutter voltages are always in control and that the only time that the video signal controls the beam current of the cathode ray tube is during the time that the shutter is "ON" and that the superblank pulses are not blanking the cathode ray tubes. The final function of this chassis is to provide a compensating voltage for the shutter waveform whose function is to slightly increase the cathode ray tube current toward the end of the picture exposure so that those lines which occur toward the end of the exposure will receive a slightly larger current. This increase of light is necessary because the film will be pulled out of the aperture and a new section of the film brought into the aperture very soon after the last line has been exposed whereas the first lines have been allowed to receive the light from the cathode ray tube for almost a whole 30th of a second, during which time the phosphor has released essentially all its energy, whereas for the last few lines in the exposure, the phosphor energy has not been completely dissipated. The persistence of the phosphor is such that it is still putting out appreciable light for a good many horizontal lines after scanning of a particular spot has occured.

Referring now to the schematic diagram of the electronic shutter: at the upper left hand corner are V1 and V2, which are the amplifier and the pulse forming tubes respectively, which are used to trigger the electronic shutter when operating from the camera. The input signal at J1 is a 24 cycle pulse approximately .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 uufd capacity 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 only adjustment in either of these circuits is the hold adjustment R17 in the multivibrator which it is necessary to adjust using the cathode ray oscilloscope, to give 24 cycle synchronized operation. This adjustment is not critical. 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 comes from pin 7 of V11, the coupling diode and is a non-symmetrical "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, which amplifies and limits the pulse which is then applied to the 6,7,8 section of V13, a cathode follower whose cathode is coupled directly to the cathode of the picture tube. The load resistor for this CF is in the display unit. 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 not by the main gate, whose signal has enough amplitude to drive the output section of V13 completely below cutoff, but by the circuit associated with the two tubes in the lower region of the schematic diagram, that is, 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 from the plate potential of the left hand half of V22. Since this plate is directly coupled through the two tubes back to the original input grid in a reenforcing manner, we find that by adjusting the shape and amplitude controls, we can get a waveform at TP6, whose amplitude is the order of 1 volt peak to peak and whose shape is that of a parabola. That is, the slope of waveform actually increases as 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 and the ac signal at that point should be the parabolic waveform previously described approximately 1 volt peak to peak in amplitude. Hence, the circuits associated with V14 and V22 have determined the bottom potential of the cathode ray tube gate signal during the ON period.

We will now review the method by which the main gate is operated. The main gate tube, V12, is triggered on and off to provide beginning and end of the so-called shutter waveform, which is coupled to the cathode of the picture tube. The input trigger pulse, which comes in through S1A (above V10), 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 synch pulses, that is, it may occur anywhere during the picture and anytime during a horizontal line. This negative pulse knocks the No.1 plate of V8 down by conduction of the pin 5 and pin 2 section of V7 and in so doing, it sets up the No. 2 plate, pin 6, so that a negative pulse coming in through the other half of the diode V7 can drive plate No. 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 usec. After this time a pulse will finally come through which will trigger the tube and knock down plate No.2. This triggering action will occur almost in exact synchronism with the leading edge of the horizontal synch pulses but there may be a little bit of jitter in this firing. The V12 circuit is called the start coincidence circuit No. 1.

To remove this jitter, another start coincidence circuit is utilized. This flip-flop circuit is set up by this V8 pulse through the upper half of V9 and is then triggered back by the next horizontal pulse which comes from the plate of V16 through the lower half of V9. Thus, on the next horizontal pulse following the pulse which managed to trigger V8, V10 is triggered and the output pulse is coupled out through the upper half of V11 into the main gate. Note that 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 up to the same B+ as is used to operate the plates of all the gate tubes. So far, we have started the main gate in coincidence with one of the horizontal synch pulses at a time approximately 3 or 4 line periods after the synchronizing pulse has occurred in the camera.

The main gate pulse at pin 1 of V13 is fed not only to the cathode ray tube cathode but also out 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 usec. or so long which occurs essentially at the same time as the horizontal synch pulses. This pulse is coupled into the so-called stop coincidence circuit, V18, through the lower half of the diode V17 thus, knocking down the left hand plate of V18 at the end of the 524 line interval since the beginning of the counter operation. Note that the counter actually did not count the very first pulse which actually turned on the gate. This means that the so called counter pulse that comes back to the stop coincidence circuit has occurred after 524 lines have been scanned on the cathode ray tube. Setting up V8 by knocking the left plate down has driven up the right hand plate so that it now is driven down by the next horizontal synch pulse which couples through the upper half of V17, thus knocking down the right hand plate of V18 and providing a negative pulse which turns off the main gate. Knocking 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 19, 20 and 21 are the superblanking tubes. V19 is the pulse amplifier which drives V20 and V21. A vertical blanking pulse is generated by a multivibrater V20, which is triggered from the vertical synch pulse through one-half of V19, the pulse width being adjustable by changing the setting of the potentiometer R55. The pulse length is adjustable from approximately 10 to 20 horizontal line periode 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 usec.

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 have been provided at junctions in the system where any ordinary scope may be applied without causing any trouble. A test pulse input jack J2 has been provided so that any type of negative pulse of approximately 100 volts amplitude and 1 usec. dropping time could be used to trigger the shutter by throwing the switch S1 to the external position. The output jack J12 has been provided in order to allow the equipment operator to monitor on the waveform monitor in the control panel the waveform at TP6 which is so-called shutter correction waveform, namely, the waveform which 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 derived 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 scource 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 whereas when B+ is on terminal 3 of V3 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 available to it. This was done so that it was impossible for the camera to be operated unless switch S1 is in the position that will allow the camera to actually control the electronic shutter.

Adjustments required in this chassis in normal operation are the occasional checking of the amplitude and shape control settings in the shutter correction generator, that is, V14 and V22. It should be noted that adjusting either the amplitude or shape control will change the amplitude of the signal whereas the shape control will primarily effect the change in slope of the waveform; that is, when the shape control is set at the maximum gain, the waveform will be most parabolic. Once these controls are set they should require no further attention over quite long periods of time, although it is suggested that the signal be monitored daily in order to be sure that nothing has happened in the circuit and that the waveform is of the proper shape and magnitude. Failure of the compensating tube, V22, will show up as an unusually visible splice on the picture tube and a raster with the top lines much dimmer than the rest of the picture. The vertical and horizontal superblank width controls are adjusted so that the picture just has a white border around it of 1/16 to 1/8 of an inch width when operating with a negative polarity video signal. It should be noted here that the electronic shutter and the pulse counter actually operate together as a complete electronic shutter generating unit and that neither the electronic shutter nor the pulse counter can operate independently without special changes in the provisions for proper gating and control pulses. Thus, functionally, the shutter and pulse counter should have been described together.

The only troubles that have been encountered in the electronic shutter have been caused by tube burn-outs. We have also had trouble with pushing tubes into the sockets for V13 and V15 while the chassis is hot in that the wrong position of the pins puts B+ through the heaters of the tubes, thus instantaneously burning out the heaters. There is plenty of reserve gain in the pulse amplifier which operates from the camera photocell and all the rest of the circuits are very conservative in design and have always proven quite dependable in operation. It should be pointed out that when changing the tube, V22, the operating bias of the output cathode follower may change so that there may be a change in the operating bias adjustment for the recording equipment.

IV - The Pulse Counter

The function of the pulse counter is to count a certain integral number of horizontal synch pulses after the beginning of a gating signal and to provide a negative output pulse in coincidence with the counted horizontal synch pulse. There are two inputs to this pulse counter, the continuously occurring horizontal synchronizing pulses from the synch pulse generator and the so called 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, that is, the cathode ray tube is turned on, the gate coming into the counter is down and tube V17, which is the counter gate amplifier, is cut off. During this time the counter is allowed to operate; however, when the counter gate voltage rises and turns on V17 the upper row of diode tubes, that is V12, V13, V14, V15, and V16 actually 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 generated by a differentiating circuit C3 and R7 in the grid of the left hand 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 have been exposed to the film on the cathode ray tube. All the flip-flop stages of this counter as well as several of the flip-flop stages in the electronic shutter are built in so-called turret cans which can be 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. As in the electronic shutter, the interstage coupling for the counter is provided by dual diodes which are biased at B+ so that only negative going pulses from stage to stage cause any action. These coupling diodes are V1 through V10 respectively. Tube V11 is a pulse amplifier which amplifies and inverts the synchronizing pulses which come in on J1 from the synch pulse generator. Tubes V12 through V17 have already been discussed while 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 the cathodes of all the reseting diodes V12 through V16 down, thus pulling down the plates of the various stages of the c ounter 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. Notice that the input pulse, which causes the last counter to drop on the right hand plate or rise on the left hand plate actually suffers 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 usec. later. Since this output pulse feeds into the coincidence circuit in the electronic shutter chassis, this very slight delay is inconsequential.

This chassis has no adjustments of any kind and should operate with no attention providing the horizontal synch pulses used to drive it are of the proper magnitude. It has been found that any pulse from about 10 volts amplitude on up is satisfactory to drive the unit providing its rise time is a small fraction of a usec. The only critical stage in the counter is the first one, where it may be found that the clipping of a cathode ray oscilloscope test lead on to one or the other of the plates will cause the first flip-flop circuit to miss fire. The operation of the first flip-flop circuit is studied by the following procedure: first, remove any connection from J2, the c ounter gate input, so that pin 7 of V17 is simply returned to -150 volts and the reset diodes are permanently up at B+ since V17 is cut off. This, then, allows the counter to run continuously, that is, the counter is no longer gated and it 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 down the counter line which should be operating at ¼ of the input frequency, that is, one cycle should show up on either of the plates of the second stage on the horizontal sweep of the cathode ray oscilloscope where four pulse intervals had originally been seen. The same method may be used for checking the rest of the stages down the line of the counter, that is, the cathode ray oscilloscope may be synchronized on one stage, say the thrid, and then the fourth and fifth may be observed to see if they count down too, respectively. No trouble should ever be had in placing the cathode ray oscilloscope test lead on any of the plates on the counters except number one.

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

V - The Horizontal Deflection Chassis

The purpose of the horizontal deflection chassis is to provide a sawtooth current in the deflection yoke of the picture tube in the display unit. The current provided must, of course, be synchronized with the input horizontal synch pulse which comes from the synch pulse generator and must be a true linear function of time within plus or minus 2%. This high degree of linearity is obtained with comparatively few adjustments in this circuit by use of current feedback from the output circuit back into the input stage of the sawtooth amplifier. The feedback in this circuit is in the order of 20 db.

V1 is a pulse amplifier tube which triggers the blocking oscillator tube V2 whose second half is a switch tube used to discharge capacitor C3 which is the capacitor element 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 of the three tube amplifier consists of two 6BG6G tubes in parallel with the necessary stopper resistors in the screens and plates. A standard RCA type horizontal deflection output transformer is used with terminal No.3 which was designed for driving the plate of a fly-back type of rectifier being unused. The circuit uses two 6AS7G's in parallel for the triode type damping tubes whose grid signals are obtained by an RC network in order to give proper damping of the circuit. Controls are provided for horizontal centering and for bias on the 6BG6 output stage. There is also a connection brought from the cathodes of the damping tubes to terminal 8 of the terminal strip E1 for the purpose of operating a sweep loss protection circuit which is located in the vertical deflection chassis. Note that in the absence of any sweep, the cathodes of the 6AS7G's are at ground since there is nothing but the ac voltage from the secondary of the output transformer to provide any dc potential at this point.

The adjustments required in this unit are quite stable once they are set. The horizontal hold control is simply adjusted to provide synchronism of the blocking oscillator with the incoming horizontal synch pulse. The horizontal centering control is then adjusted to place the raster in the proper position on the cathode ray tube and then the drive and bias controls are adjusted successively until the proper linearity of the picture is obtained as determined by either a bar pattern or a test pattern. If may be found that better linearity can be obtained by disconnecting the plate of one half of one of the 6AS7G's in the damping circuit. If this modification must be made it will generally apply indefinitely for the particular installation in question except perhaps if the deflection yoke is replaced. Note that provision is made for locating the horizontal centering control at a remote position by simply opening the wire connecting the horizontal centering control to the high side of C13, the 1000 microfarad 15 volt electrolytic condenser located under the 6AS7G's on the schematic.

VI - The Vertical Deflection and Sweep Loss Protection Chassis

The purpose of this chassis is to provide vertical sawtooth current for the vertical deflection coils of the deflection yoke and also to provide a method of turning off 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. 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 and whose frequency is controlled by the hold control which varies its grid time constant. V3 is the switch tube which is used to discharge the capacitor C4 in the saw-tooth 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 and the coupling capacitor C5 back to the high end of the resistance, which provides the constant current for charging the capacitor in the RC sawtooth generator. The positive voltage necessary for returning this 6.8 megohm resistor is obtained through the diode 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 going over to the grid of the input amplifier, which is the left hand triode of V4. The other tubes in this amplifier are conventional except that the right hand half of the 12AX7 V4 is used only 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 may be necessary in some cases to make an adjustment of the 1000 ohm linearity control in order to get optimum linearity of sweep. It may seem off hand that this particular circuit has many extra tubes, which it does have when compared to an ordinary home television receiver. It was found, however, that proper vertical steadiness could not be obtained except by generating the sawtooth voltage at a very high level so that the very small uncertainties 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 is V7 and V8 and the relays K1 and K2. K2 will not pull in unless the minus 150 volt which is used as the bias in the cathode ray tube is available. K1 will not pull in unless both the screen and the control grid potential of tube V8 are at the proper value as determined by the presence of 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 outpout 6L6 of the vertical deflection amplifier. The other half of V7 is a cathode follower to drive 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 drop out. Note that this does not give complete protection against breakage of the circuit to the deflection yoke, however, it is considerably better than no protection at all. 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 pulled in, providing the vertical deflection circuit is operating properly. The contacts of K1 and K2 are in series with the 115 volt ac line, which operates the relay, which controls the 30KV supply voltage for the cathode ray tube.

VII - Power Supplies

Standard model of video recorder utilizes four power supplies while a recorder equipped with the videogam amplifier requires one more regulated power supply. A DuMont type 5019A low voltage power supply is used to provide regulated +330 and +250 volts at a total current of 430 milliamperes. Consult the instruction book furnished with this equipment for further details.

The next power supply is the +550, +450 volt power supply which is used for the plate voltage on the horizontal deflection output amplifier for the focus coil and for the plate voltage in the 30KV RF 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 extra dropping resistor to lower the voltage compared to the other +550 supply. A relay is provided in the output of the +450 volt supply to transfer said output from a dummy load to the load which actually consists of the plate current of the 30KV RF supply. The coil of this relay is actuated by the high voltage switch on the control panel through the various interlocks that are used to prevent operation of the cathode ray tube if no sweep or bias voltage is available.

The plus and minus 150 volt power supply provides electronically regulated +150 volts at 125 milliamperes for operation of the synch 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 the 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 a 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 adjustment whose range is actually about 125 to 175 volts. This must be set very close to 150 volts in order for the synch separator unit to operate properly. Note that all electrolytic condensers except the low voltage ones throughout the equipment are of the plug-in type for easy replacement.

The 30KV RF supply - This supply is a slightly modified Spellman television company 30 to 40 KV unit. The modifications were necessary because we needed a built-in meter to indicate the anode voltage in the equipment and also because we wanted to provide a separate voltage control and a separate meter which would read total anode current of the cathode ray tube.

The basic Spellman supply consists of an RF oscillator operating at approximately 100KC. It consists of three 6L6's in parallel driving a voltage tripler circuit which provides the 30KV output using 1B3's as the rectifier tubes. From the 10KV point in this tripler a voltage is obtained with a voltage divider to drive the grid of a regulator tube whose plate is coupled to a cathode follower which varies the screen voltage of the oscillator tube in order to maintain the 10KV voltage at the proper level. The circuit is so proportioned that the regulation is within about 1% over a change in load current of from 100 to 500 microamperes at 25KV.

The modifications previously mentioned have made it necessary to install a so-called floating ground in the equipment so that the ground return for the high voltage current may be isolated in order to place the milliammeter in the proper place to read said current. It was also necessary to correct the regulator voltage divider circuit to this floating ground in order to keep this divider current out of the milliammeter.

There is a screwdriver adjustment 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 26KV so that unwanted jostling of the control panel knob will not cause breakdown of the high voltage condenser which is across the output of this supply.

It is possible that in operation, especially after any major replacements have had to be 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 which is heated from a 60 cycle ac source of 1.25 volts potential. This adjustment is made by turning the trimmers associated with each filament using a long screwdriver made entirely of a tough insulting material.

IX - The Display Unit

The display unit consists of all the equipment mounted on the large base which mounts on top of the main recorder cabinet. The recording monitor unit contains the 10NP11 cathode ray tube and the associated deflection and focus coils together with protective resistors for the high voltage supply. These protective resistors are included in the circuit so that they will blow up in case of an arcover within the tube and thus preventing undue harm to the tube itself. Replacement of these resistors is done by loosening the high voltage connector at the rear end of the metal box in which these resistors are mounted.

The deflection yoke and focus coil are both specially made units. The deflection yoke is an iron core type in which the windings have been designed for the same impedance as that of the RCA standard type home receiver deflection unit, 201D1. The iron core gives a much more uniform magnetic field with considerably less stray field than is obtainable by ordinary means, thus giving better focus over the entire face of the picture tube. 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 of the cathode ray tube. The focus coil is a shunt type coil which requires approximately 25 milliamperes to give proper focus with 25KV 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 proper vertical positioning of the raster.

The cathode ray tube is supported by a removable face casting and by 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 take care of tubes of different lengths. A new tube may be quickly installed by loosening the yoke & focus coil plate and removing the tube socket and anode connection. The face casting is then loosened, carefully lifted over its locating pins and then 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.

The other part of the display unit is the recording camera. This camera contains the pull-down mechanism for pulling the film into position at 24 cycles per second and the associated pipper light mechanism which provides a 24-cycle pulse to trigger the electronic shutter as soon as the film has been pulled into position. The motor used in the camera is a 60-cycle cynchronous type which is geared to give pulldown operation at 24 cycles. The power wiring for the camera is brought in on a Jones plug which connects to a socket on the camera interlock unit. For proper operation of the recorder when used by itself, that is, not in conjunction with a rapid processor, terminals 4 and 6 on this six terminal Jones plug in the camera interlock unit must be jumpered. When used with a rapid processor this jumper must be removed and a processor adapter unit must be wired into the circuit as shown on the simplified power and control diagram, SK6667.

The gate structure of this camera is unique. Friction for holding the film after pull-down is obtained by a vacuum pressure shoe which utilizes a vacuum to press the back of the film against the friction producing surface. In this manner, the entire film path is designed without even touching the emulsion side of the film in the sound recording flutter filter.

Mechanical maintenance of the camera is a very important item if performance of the equipment is to remain at a maximum level for any length of time. It is imperative that the intermittent cams be kept oiled properly. Oiling is provided by a wick which touches all the cams in the intermittent mechanism. This wick must be kept saturated with oil at all times which probably means applying a drop of oil after every hour's running. Only through long use will the proper lubrication schedule be established. It can be stated, however, that failure to keep the cams lubricated will most certainly result in a worn out claw which means that the shuttle or claw itself must be replaced. Such replacement is fairly easy involving only the removal of the cover plate and cover casting from the intermittent movement and loosening the nuts which hold the cams on the shafts. After the cams have been removed the claw itself may be removed and a new one installed and all parts replaced exactly as they were removed. After installation of a new claw, said claw should be thoroughly oiled with excess oil and run for a minute or so and then oiled again and run for two minutes, oiled again and run for five minutes, slowly increasing the running time until the claw is free and yet there is no play in the gibs. Items that may need to be replaced in the camera are the photoelectric cell and the pipper light which are both readily accessible by removing the assembly to which they are attached in the top of the camera.

The magazine furnished with the recording camera is a wall type magazine which has a built-in light trap which must be released by hand when loading film. It may be released by depressing the little plunger located in the center of the bottom plate of the magazine with any small object or by using a special light trap opener which is furnished with the magazine. When the magazine is installed in the camera, the light trap is automatically opened by a built-in mechanism.

On the display unit and camera schematic diagram, the connections for the high voltage system are also noted. It is important to realize that the high voltage connector on the 30KV supply is never to be loosened and also there is to be no ground connection at the RG8U cable which carries the 30KV voltage over to the high voltage condenser unit. The only high voltage connector which is to be loosened in ordinary use is up at the protective resistor box on the picture monitor.

X - The Video Amplifier

The purpose of the video amplifier is to amplify the video voltage coming from the video gain control on the control panel and deliver it (with the back porch or the black level clamped) to the grid of the cathode ray tube and also to provide a monitoring signal which is bridged from the grid of the cathode ray tube. This monitoring signal is provided by a cathode follower whose input is operated from a voltage divider connected to the output amplifier. V1 is a stage that has a gain of one and is used as a phase inverter so that an output signal of either a positive or negative polarity may be obtained with any polarity of input signal. The amplifier itself is V2 and V3. These two tubes provide a gain of about 40. The frequency response of the unit has been extended so that it is about 3 db down at 9 megacycles and is plus or minus half a db through 7 megacycles. 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 is simple shunt peaking, and the third stage to the output has a series shunt peaking circuit and also has some high frequency by-pass on the cathode resistance. An ordinary dc restorer type circuit utilizing the diode V4 is used for bouncing on the blanking level of the signal which must have the synch pulses removed for proper operation of the circuit.

The switch S1 provides for either a white positive or a 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 hence to extend the bandwidth.

No maintenance should be required on this unit, but there is one adjustment which may be necessary if it has for some reason become maladjusted. This is the compensating capacitor C10 in the voltage divider which drives the monitor output circuit. The proper adjustment of this capacitor is easily arrived at by observing the waveform of the output signal at J2 when this jack is properly terminated in 75 or 100 ohms. Improper adjustment of C10 will show up either as an overshoot in the steep portion of the signal or as a rounding off of the steep portions of the signal. An entirely satisfactory operatiom of the monitor circuit may be obtained by this type of visual alignment; that is, no frequency run must be made in order to get proper monitoring signals.

This video amplifier is mounted in the display unit as close as possible to the grid connection of the cathode ray tube so that a very short lead may be run for this purpose. The amplifier contributes a negligible amount of noise and hum to the signal even for very low values of input voltage. The range of output voltage over which this circuit is essentially linear is about plus or minus 20 volts with a total possible swing being about plus or minus 30 volts.

XI - The Power Distribution and Control Circuits

The camera interlock unit will be discussed at this point as an introduction to the explanation of the power and control circuits. This camera interlock unit is a small chassis mounted at the top of the bay underneath the recording camera. Its purpose is to provide an interlock between the various switches in the recorder and the camera so that the camera cannot be operated unless the electronic shutter control switch is set in the proper position. The relay in the camera interlock chassis (refer to SK6667) is energized by rectified ac signals coming from the terminal 7 of the plus or minus 150 volt power supply which must go through the Camera-Standby switch on the control panel and also through S1C in the electronic shutter chassis. Therefore, if either one of these switches is open the camera and vacuum pump cannot be operated.

The power distribution system in the recorder is shown in SK6667. All power for the recorder comes in through the main power switch on the control panel and is then distributed by way of No. 12 wire throughout the equipment. Unregulated 115 volts ac is used for the various electronically 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 since it must be run from a regulated source in order to prevent line voltage jumps 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 (also shown on SK6667) goes through the CRT anode Switch connected between terminals 3 and 5 in the control panel and monitor and goes down 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 30KV RF supply. Note that terminal 11 of the +550, +450 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 30KV supply and does not necessarily mean that the 25KV is actually on the cathode ray tube. The previous discussion takes care of all the wiring for a normal recorder not used with a rapid processor.

When used with the rapid processing equipment, a few alterations and additions must be made to the power wiring of the unit in order to provide the proper interlocking between the control circuits of the processor and of the video recorder. When intending to use the equipment with the rapid processor, the optional adapter box must be added and the dotted wiring shown on SK6667 must be installed after first removing the jumper from terminal 4 to terminal 6 of the six prong Jones connector in the camera interlock chassis. After these corrections in the circuit, its operation is as follows: The vacuum pump and camera power still come on as they did before if the shutter and Camera-stand-by switches are in the proper position. After these two switches are in the proper position, the right hand relay in the optional adapter box will be energized providing the camera switch is turned on and the film break switch is in the normal position, that is the film is not broken. The camera motor still does not run. The camera motor under this operation is turned on by 115 volt ac power which comes in on the two conductor twist lock in the optional adapter box and operates the left hand relay in the adapter box, providing the right hand relay has been pulled in by proper setting of the switches mentioned previously. This 115 volt power comes from the high speed processor unit and is on only when the high speed processor motor is running, that is when the processor is in operation. Thus, we have provided for operation of the camera motor in step with the operation of the motor in the processor. The other contact of the right hand relay in the optional adapter box provides interlock protection in the processor control circuit so that unless the shutter and control panel switches are in the proper position to get energy to the camera, the processor cannot be operated since its control circuit is open.

This means that for normal operation without a processor the operator merely checks to be sure that the shutter switch is on camera or line and then throws the camera standby switch on the control panel to the camera position to get underway. Note that if the film is broken, meaning that the film break switch will be in the broken position, the film break neon lamp will light and the camera motor will not run although the vacuum pump will run as soon as the camera standby switch is thrown to camera.

For operation with the processor, the same procedure holds and in addition, the processor control button must be pushed. Under this operation, pushing the processor control button will do nothing unless the recorder has previously been set so that it would operated of its own accord if it were not connected to the processor. Since the processor is fully protected by film break switches of its own accord, the entire system is very well protected against misbehavior. It should be mentioned here that the camera standy switch in the control panel-monitor automatically turns on the 24 cycle multivibrator in order to artifically trigger the electronic shutter when the switch is thrown from camera to standby.

XII - Waveform Monitor and Control Panel

The waveform monitor and control panel has two separate and distinct functions. The first is to provide a good cathode ray tube waveform monitor capable of accurate calibration which can be used for checking waveforms throughout the system in normal operation and as a test scope. The other function of this unit is to act as a control panel or a control center for the video recording operations. The panel of this unit contains not only a 5" cathode ray tube but also a vacuum meter for measuring the vacuum which holds the film against the back plate in the camera and a meter which may be switched to various points in the circuit in order to measure strategic electrical parameters. The waveform monitor employs a 5" cathode ray tube and utilizes a three-stage video amplifier which has sufficient gain to provide usable deflections on approximately 1/20th of a volt peak to peak input signal. The input to this amplifier is controlled by a switch S5, the monitor selector switch, so that it may be used to look at various points along the signal path within the recorder and 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 usefulness 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 transformers 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 a 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 synch pulses. This relay also moves the centering from below center to above center simultaneously with changing the polarity of the clamping diode. The horizontal sweep circuits are more or less conventional in nature employing a three-tube synch 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. Adjustments are provided on the chassis for properly setting the synch signal amplitude and synchronizing of the blocking oscillator on line frame frequency in order to get proper horizontal deflection. The horizontal gain control is also located behind the panel and need only be set once. Intensity, focus, and the horizontal and vertical centering controls are located on a deck at the rear side of the control panel which is accessible by merely pulling the unit several inches out of the cabinet. The only controls on the front panel of the unit associated with the waveform monitor section of the equipment are the video gain control which is used to set the peak to proper gain and the calibration signal control R108 which is used to set the peak to peak regulated 60 cycle signal that is available for calibration of the cathode ray oscilloscope to the proper value as read on the test meter when the meter selector switch is on the calibrate position. Note that when on this calibrate position the meter reads peak to peak value of the ac wave.

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. The requirements on this signal are that it be negative in polarity and at least $\frac{1}{4}$ volt peak to peak in amplitude. For most normal synchronizing signals the synch amplitude control R94 on the chassis 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 $4\frac{1}{2}$ megacycles. The low frequency response is such that a 60 cycle square wave will suffer no more than a 2% tilt. The 5UP4 cathode ray tube is operated at approximately 1700 volts acceleration potential as furnished by a 60 cycle supply utilizing a 2X2 rectifier.

The power supply for this unit is conventional except that it was necessary to put in an RC filter section consisting of R57 and C35B in order to drop the high voltage to the proper level and to provide proper hum reduction.

All normally used operating controls are located on the control panel. The anode volts potentiometer R85 controls the voltage divider ratio in the 30KV supply and hence enables the operator to set the anode voltage at the proper 25KV. This voltage may be read on the meter by simply switching to the Anode volts position. It should again be pointed out that this system is not grounded but operates on a floating grounded but operates on a floating ground which must always be kept isolated from true ground. This floating ground is terminal 15 on E2 on the control panel. Cathode ray tube bias control merely adjusts the bias which is used as the restoring potential for the dc restorers of the video amplifier. Terminal strip E3 is used for the connection to the camera standby switch whose operation has been previously explained. When used with this control panel, the horizontal deflection circuit must be altered as previously mentioned so that the external horizontal centering control, R110, may be used. The Focus control is to be set for best focus of the picture tube. It controls the bias of a pentode focus current regulator tube.

The only normal operating adjustment in the waveform monitor section of the equipment is to set the input gain for a known peak to peak input signal so that signal levels may be accurately measured. It is suggested that the horizontal deflection circuits be set up to give deflection frequencies of 30 cycles per second and 15750/2 cycles per second or 15750/3 cycles per second, respectively.

It is conceivable that there may have to be a little bit of redesign in this horizontal deflection circuit in order to make the blocking oscillator lock better in the frame position. This is because the blocking oscillator transformer in one which is normally used for high frequency sweeps and has a very short pulse length and is consequently relatively hard to synchronize when being used at very, very long periods.

XIII - Sound Recording System

The sound recording system furnished with the video recorder is a very versatile film recording system which consists of three major units. The recording amplifier, its power supply, and the recording galvanometer. The amplifier and power supply are standard rack mounted units with 8-3/4 by 19 inche panels and can be mounted in any convenient location somewhere near the video recorder. The amplifier provides all the necessary controls for operating the recording equipment and of course incorporates the necessary amplification and equalization circuits. The modulator uses a galvanometer as the modulating element and incorporates a universal type optical system which is easily changed from variable density to variable area recording and is readily modified to give a non-linear modulation characteristic which is required when single film techniques are used such as in theatre television where the film upon which the sound is originally recorded must be played back with a minimum of distortion. Since neither of these units are as yet manufactured, the discussion here must be limited to rather general characteristics. The amplifier will provide the necessary equallization so that with a given reproducing slit in the projector the overall frequency response in the system will be flat up to 9 kilocycles. Under this condition the non-linear distortion in the system should be of the order of 5% intermod or 80% modulation. This performance is obtainable only with carefully controlled recording and processing conditions. The amplifier will also have the proper gain controls and the necessary meters to enable the operator to set the audio level and the recording lamp current respectively. The amount of light obtainable in the modulator unit is sufficient so that the equipment may be used with the slowest type of film and it may be stopped down for use with high speed film. All the sound recording equipment is being manufactured by J. A. Maurer, Incorporated of Long Island City, New York.

Proper operation of the sound system can be obtained only by making operating tests using various lamp currents in the recording process. For single film process, the film on which the recording is made is processed and the played back using some sort of distortion-measuring equipment to determine what the optimum lamp current should be under the existing processing conditions. In the case of two film operation, it is necessary not only to use various lamp currents in the recording process but also to use various amounts of light in the printing of the sound track so that there are a great number of variables in determining the optimum operating conditions for this method of recording. Further information on the sound system and its operation will be written up as a separate instruction book for the sound equipment when it is available.

XIV - The Videogam Amplifier

The Videogam Amplifier is a unit which must be used in the video recorder when single film technique is used and may be a desirable accessory in the case of two film work. The function of this Videogam Amplifier is to provide a non-linear amplitude characteristic in the video amplification channel in order to correct for various non-linear characteristics of other elements in the system. The present Videogam Amplifier as shown in SK 6218 is a video amplifier having a bandwidth of approximately 5 megacycles with a variable amplitude characteristic which approximates a power law in which the exponent is adjustable from approximately $\frac{1}{2}$ to $2\frac{1}{2}$. Thus, the output voltage of the unit is a video voltage in which the instantaneous voltage value above the black level is a constant times the input voltage raised to some power between $\frac{1}{2}$ and 2. Provision is made in the amplifier to normalize the gain of this system so that a $1\frac{1}{2}$ volt input signal will come out as a $1\frac{1}{2}$ volt peak to peak signal, even though the shape of the waveform between the two end points is markedly altered.

By way of illustration, let us see what the usefulness of this amplifier may be. First let us consider a system in which a negative is being made in the video recorder and then normal prints are made by a photographic laboratory from this negative, thus reproducing the television image in a form suitable for rebroadcast or projection. We assume that the television pick-up equipment, that is, the camera, is a device which produces an electrical signal which is linear in respect to the brightness of the subject. We find that in the process of getting over to the final image on the film, there are many non-linear elements through which the picture information has had to go. First, there is the cathode r ay tube on the video recorder, which in this particular case, since it is a triode, has an exponential or a power law function with an exponent in the order of 1.7. This tube alone would presumably give a pretty pleasing picture to the eye since the normal observer likes to see a picture which has a power law in the order of 1.5. The next non-linear element is the negative film which may be processed to a photographic gamma (which is the exponent of the power law relating film transmission to exposure) of .7 to 1.2. Let us assume .8 as an illustration. This negative is then printed photographically and the print developed to a photographic gamma of something like $2\frac{1}{2}$, which is typical of the printing process. If we confine ourselves to the center regions of all these curves and disregard the saturations or clippings at the end, we find that in the middle range where most of our important picture information should be, we have an exponential law which has a power of about 3.4. This response has considerably too high an exponent for good reproduction and will result in a film which has very high contrast; that is, it will jump from black to white very quickly and give very poor gray scale rendition. In order to correct this high exponential law, it would be highly desirable to use something like the videogam amplifier at a power of approximately $\frac{1}{2}$ to bring the overall power down to, let us say, 1.7 giving a much more pleasing picture and a much better rendition of gray scale.

The same sort of principle applies to single film video recording but the process is entirely different since the cathode ray tube in the video recorder is now being run with an inverted video signal which starts at some predetermined brightness level and cuts off the picture tube when the actual original picture is brightest. In this process then, we may no longer add the exponents (corresponding to multiplication of the various function) but we must rely on graphical analysis or experimental results to determine what the overall transfer characteristic of the system will be. It is found in this particular case that the overall exponent of the process will again be very, very high, approaching the sum of the exponents of the cathode ray tube and the single film near the light gray end of the gray scale as recorded on the film. In this application it is again found very useful to use a fractional exponent in the videogam amplifier in order to give a more pleasing rendition of the gray scale in the finished motion picture film.

The input signal to the videogam amplifier is either a composite signal or a video signal (which is composite with the synchronizing pulses removed). It must be approximately ½ to 2 volts peak to peak in value. The output of the unit will be 1 to 1½ volts peak to peak signal with a variable transfer characteristic as provided by the setting of the gamma adjustment potentiometer. The unit requires +285 volts at about 135 milliamperes and minus 150 volts at approximately 8 milliamperes and 6.3 volts at 3 amperes for the heaters of the tube.

The circuit utilizes crystal diodes as the non-linear elements. Tubes V1 and V2 are input amplifiers to raise the signal level to the proper value to drive V3, the cathode follower which provides the signal for operation of the non-linear crystal elements. V5 and V6 are output amplifiers which drive V7 the line driving cathode follower. A series resistance in the output line, the output adjust control, R38, is provided in order to equalize the gain in the output line to any desired level over a range of about 2 to 1. The tube V3 drives two non-linear networks. One of these networks provides the low power function, that is, an output which is approximately the square root of the input voltage while the other network provides a high power function where the output is approximately the square of the input voltage. These two non-linear outputs are then applied to the separate grids of the double triode cathode follower, V4. Between the cathodes of V4 is the power control potentiometer which allows the output signal to be taken as either one of the variable power signals or any combination thereof. The low power network is essentially a constant current source driving a crystal element while the high power network is essentially a constant voltage source with a crystal in series with the output load resistor. In the low power circuit is taken across a crystal element while in the high power circuit the output is taken across the resistor in series with the crystal element. Each of these circuits has a slight change from the basic simple circuit previously mentioned. The low power circuit which consists of R20 and the crystal Y2 is supplemented with another crystal connected to the high end of Y2 and returned to a point which is slightly positive with respect to ground in normal operation. The effect of this second crystal is to reduce the gain of this low power circuit for very small signals, instead of letting it approach infinity, as it would if the actual dc potential at the top of Y2 were to become zero or a negative. This circuit then, fairly high levels of signal, (two volts peak to peak swing at J1, starting at essentially zero voltage) provides a square root function which is slightly modified at the very low end by the shunting action of the lower crystal diode. The high power circuit is actually a two-stage circuit in that the voltage developed across a load resistor by a top crystal is then applied to a second crystal and resistor network across which the output is taken to drive the left hand grid of V4. This circuit arrangement gives a slightly higher exponential power function than could be obtained with a single crystal and seems to give a more constant exponent over the range the signal voltages use.

The videogam amplifier must be properly adjusted in order to give the required non-linear operation. When adjusted properly for a given input signal the output signal, which, let us say, is set to be 1 volt peak to peak, should remain essentially constant in peak to peak amplitude even though the power control potentiometer between the cathodes of the mixer tube V4 is turned from one end to the other. This result is accomplished in the following adjustment steps: First, the input adjust R1 is set so that at the cathode of V3 a two volt peak to peak signal is provided. This adjustment gives the voltage swing which is required for proper operation of the non-linear elements. Second, the zero adjust potentiometer is set so that with no signal input (V1 removed) the potential at J2 which is the top of the low power crystal is .05 volts. This voltage can be conveniently measured with a standard test meter. This adjustment may be combined with the previous adjustment by using a calibrated direct current cathode ray oscilloscope. The bottom voltage (the voltage at the bottom of the synch pulse or a blanking pedestal) may be set to .05 volts and the peak to peak swing is ten adjusted to two volts at J2. Third, the mixer adjust R19 is then set so that swinging the power control knob back and forth from low to high power gives essentially constant peak to peak amplitude at the output of the unit. Fourth, the output of the unit may now be adjusted by the output adjust potentiometer to whatever value is required in the outgoing 75 ohm line. This latter adjustment should be made with the line properly terminated.

This unit has proven to be reasonably reliable in operation but we have had some trouble with the bias level, that is the bottom level as adjusted at J2 with no signal, drifting with time. Tests have revealed that if the equipment is set after several hours warm-up it will hold ajustment indefinitely, providing the power supplies are regulating properly. Consequently, the equipment should be allowed the maximum possible warm-up before being put into use, in order to get the most consistent and reliable operation from the videogam amplifier. The crystals are easily checked by measuring the front and back resistance which should have a ratio of at least 100 to 1 if the crystal is in proper condition. Any marginal units should be replaced. It has been found that the tolerances between various crystal units are essentially negligible as far as the performance of this equipment is concerned providing the crystals are in proper condition, that is, have not been blown up or subject to tremendous overloads.

In normal operation a casual check of the performance of this unit may be made by observing a test pattern signal or some other steady type of video signal and checking to see whether the change in the waveform is what would be expected considering the transfer characteristics which the unit is supposed to be providing. For example, if the unit is set for a power of one half, a given level half way up the original input voltage should be 7/10 of the way up from black to white in the output voltage.

The power supply which is furnished with this unit provides the +285 volt plate voltage. This is a standard type of regulated supply utilizing a 6AS7 as the series control tube. The minus 150 volt bias supply is obtained from the ±150 volt power supply which furnishes the same bias potentials for the rest of the recording equipment.

INSTALLATION OF VIDEO RECORDER

The recorder, whose overall dimensions are given in SK6666, must be installed in a room which is large enough to give about 2 feet of clearance all around the unit for proper access for maintenance, and operation. Ventilation should be sufficient to keep the temperature down to a comfortable value for the personnel doing the operating. The power input for the unit is approximately 20 amperes at 115 volts ac and should preferably be provided on a separate branch circuit which is used only for this unit. Needless to say the voltage regulation should be as good as possible although the equipment is designed to take care of plus or minus 10 to 15% variations in line voltage with no appreciable change in performance. The other inputs for the unit are the composite signal input which is to be 1 to 2 volts peak to peak standard 75 ohm signal with the white positive 600 ohm, 0 ohm sound input, and a rubber hose or other tubing suitable for connecting the vacuum system to the vacuum pump. This vacuum pump may be located in any convenient point but must be connected electrically to the recorder since it gets its power from the camera interlock unit within the cabinet.

The sound amplifier and power supply are rack mounted units which must be mounted separately from the recorder at some convenient point at not too great a distance from the recorder. The five conductor, shielded cable which connects the modulator regulated supply utilizing a 6AS7 as the series control tube. The minus 150 volt bias supply is obtained from the ±150 volt power supply which furnishes the same bias potentials for the rest of the recording equipment.

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The sound amplifier and power supply are rack mounted units which must be mounted separately from the recorder at some convenient point at not too great a distance from the recorder. The five conductor, shielded cable which connects the modulator unit to the amplifier must also be brought in through one of the holes in the bottom of the cabinet.

The equipment must be mounted on a solid floor in a location which is not subject to the jarring caused by railroad trains or subways or to other forms of vibration. The top plate must be checked to be sure that it is floating properly on its chock mount. At no time should anything be jammed underneath this top plate to handicap the vibration absorbing action of the shock mounts. The vertical deflection chassis is also shock mounted on small rubber grommets, and these should be checked to see that they are not too tight.

It is suggested that during the initial turn on of the equipment after an installation that the monitor scope be checked for operation first and then used to determine that the sweep circuits are working properly before any attempt is made to turn on the high voltage of the display tube. It is also recommended that a delay of at least one half hour should be observed between the time that the heater of the cathode ray tube in the display unit is turned on and the time that the anode voltage is applied. This last precaution is necessary to be absolutely sure that there will be no internal arcing from the anode to other elements in the cathode ray tube.

When the recorder is to be used with the rapid processing unit further provision must be made for the cables which are used to interconnect between the two units. Refer to SK6667.

OPERATION OF THE VIDEO RECORDER

Normal operation of the video recorder is a relatively simple procedure, but one which must be carefully adhered to if satisfactory results are to be obtained. This operational procedure consists essentially of maintaining proper operating parameters throughout the entire recorder and in checking to be sure that circuits are operating properly. In this last category are such things as proper centering of the picture on the electronic shutter, all of which may be observed by looking at the picture on the cathode ray tube.

The determination of proper operating levels is one which involves considerable experimentation. As a general rule, the photographic processing which will be used will be standarized so that the operating levels of the video recorder may be tied down without a tremendous amount of experimenting involving parameters other than those immediately controllable at the recorder. If we assume then, that the photographic processing has been standardized, perhaps with a series of tests similar to those to be described, we then must determine the optimum operating levels. These statements apply both to the sound and to the picture. This discussion will be limited to that of determining the picture parameters. The operating levels to be determined are the black levels and the white levels in the film being recorded. These levels are affected by the amount of light getting to the film, which is determined by the bias level and by the video signal swing on the grid of the cathode ray tube and are also affected by the iris setting of the camera lens. It has been found in general, that we are working under conditions which require nearly all the available light in order to obtain proper maximum density on the film. This means that the lens must be operated at about its widest opening. It has been found that the depth of field of the lens when operated at f1.6 is so shallow that we cannot obtain good focus over essentially the entire raster area so that it is recommended that the lenses be operated between f2 and f28 for optimum results.

This now leaves us with the determination of optimum cathode ray tube parameters; that is, bias and video swing. A series of test films must be made using various cathode ray tube grid swings in order to arrive at the best set of values. It is recommended that these operating levels be determined so as to give a density range on the film of approximately 0.2 to 2.2 for single film recording and a density something of the order of 0.1 to 1.4 for recording in which a negative is being made. Note that this comparatively small range of densities in the negative will become a very large range of densities when printed on the high gamma print stock which is normally used. It should be mentioned here that if standard television signals are used for these tests, the operator must be very careful to be sure that there is a black signal in the picture which is being used for the test, since many television signals have considerable setup which will remove any true black from the signal being recorded. This condition must be corrected by adjusting the setup control in the synch separator chassis so that the blackest blacks in the signal just reach the blanking level as far as the signal on the grid of the cathode ray tube is concerned. Note that the cathode ray tube bias is read on a panel meter on the control panel and that the video swing is monitored by the waveform monitor in terms of voltage coming from the special monitor output of the video amplifier which drives the grid of the cathode ray tube. This means that whenever tubes are changed in this monitoring circuit, namely the cathode follower output tube in the video amplifier, the system will probably have to be recalibrated.

The only other parameter which is variable is the adjustment of the videogam amplifier. This adjustment is determined experimentally after the end points have been determined by simply making another set of test runs and trying different settings of the videogam amplifier. The settings will always be at some power less than 1 for any type of recording - either single or two film recording. It will also be found that the signal coming in will vary considerably from different cameras and from different studio locations with respect to the apparent curve of voltage output versus original scene brightness. An operator who has had some experience operating the video recorder can soon recognize the type of signal which will give a good looking picture when it is processed and then can adjust the videogam (by looking at the waveform monitor) to give a signal which most nearly approaches that which is known to give good results. This latter statement applies primarily to single film recording since this is the process in which the electrical circuit power law is much more critical than in the double film process. The waveform which seems to give the best overall picture when using single film technique is one in which the average value of the signal is about 70%. However, in this waveform there must be some black and some white which stick up farther. Compared to a standard television waveform, this recording waveform has its whites compressed and its blacks stretched.

When first setting up the video recorder many adjustments must be made which are normally not touched after original installation. The following list of items is intended to give an outline of the procedure to be followed after installation. Most of them should be checked during normal operation, that is, at the beginning of the operating day and probably several times during the day at convenient moments when not recording. It is important that no adjustments be made until the equipment has warmed up for at least half an hour.

1. Turn on power switch, being sure that the CRT anode switch is off. This turns on all the power in the equipment, except the 25KV anode voltage.

2. After several minutes warmup, adjust the calibration voltage to 2 volts peak to peak and then set the gain of the waveform monitor vertical amplifier so that this gives a 2" deflection on the waveform monitor.

3. Check the input waveform to be sure that the signal is 1 to 2 volts peak to peak amplitude and that there are no peculiar overshoots in the waveform and that there is no lack of high frequency response as indicated by slow roll off on the edges of the synch pulses and the blanking pulses. Also check synch to video amplitude. This is done with the monitor selector switch on the composite input position.

4. With the monitor selector switch in the video position, adjust the input gain control and the synch separation level and setup controls on the synch separator chassis to give a $1\frac{1}{2}$ output signal with the separation exactly

at the blanking level and with the setup removed if necessary. After this adjustment is made, the synch pulse generator should be receiving proper input voltage and may now be adjusted.

5. Adjust the vertical and horizontal hold circuits and, if necessary, the slugs in the horizontal AFC transformer, in order to get the sweep circuits properly locked as indicated by the raster on the cathode ray tube. Note that the proper adjustment of the synch generator chassis and the hold controls may not show up as proper synchronism of the sweeps on the picture tube since it is also conceivable that the hold controls on the sweep chassis are not properly adjusted. It will be found that the vertical deflection circuit will lock in no matter where the hold control is set, whereas the horizontal hold control on the horizontal deflection chassis is likely to be quite critical so that it must be adjusted along with the horizontal AFC controls and hold controls associated with the synch pulse generator chassis. It may be found necessary to use the test position of the waveform monitor oscilloscope in order to determine when the synch pulses coming out of the synch pulse generator have been properly locked so that faulty synchronism of the sweeps may be properly blamed upon either the synch pulse generator or the deflection circuit itself.

6. The high voltage may now be turned on, providing the cathode ray tube bias has been set to approximately 100 volts which should produce a fairly low beam current.

Watch the Anode voltage with the meter. Don't let it get above 26KV.

7. After several minutes of warming up, the cathode ray tube anode voltage control should be set for 25 kilovolts and the bias control then readjusted to give a raster of medium brilliance which is convenient for optical observation.

8. The focus control may then be adjusted for optimum focus. After several minutes the cathode ray tube anode setting should be rechecked because, for the first 15 or 20 minutes the output of the high voltage supply is likely to rise about 5%. Under no condition should the anode voltage ever be allowed to go above 26KV. After the anode voltage has been on for a half hour, both it and the focus current should stay constant.

9. The video gain control can now be turned up in order to get a picture or test pattern on the cathode ray tube and all the previous adjustments which affect centering, focus, brightness of the picture may be reset in order to get what looks like the best picture in the proper position.

10. The picture which is now on the cathode ray tube should exhibit two picture splices, that is two bars half a picture height apart. These bars are the beginning and the end of the ON time of the cathode ray tube and are caused by the electronic shutter operation. It may be necessary to adjust the 24 cycle multivibrator frequency control in the electronic shutter chassis in order to get the proper frequency control in the electronic shutter chassis in order to get the proper two picture splices on the cathode ray tube.

11. The shutter compensation waveform should now be checked to see that it is the proper shape and of approximately 8/10 of a volt peak to peak amplitude. The operation of this compensating circuit may be checked by turning off the video signal and turning the cathode r ay tube bias up so that the raster is very low in intensity. The increase in intensity toward the end of exposure, that is, just above the two splice bars should now be apparent.

12. After the horizontal and vertical sweeps have been properly synchronized and the horizontal centering control and the slug control in the synch pulse generator start to give a properly positioned picture, horizontally speaking, it may be necessary to reposition the focus coil by means of the mechanical adjusting screws associated with it in order to give proper vertical centering as determined by pictures taken with the camera. A test pattern of some type is the best kind of picture to use for these tests since the boundaries of the picture may be easily determined. These boundaries should be set so that the filmreceives all the information in the original picture, that is, so that the top and bottom of the picture are not cut off. This will leave a little bit of bare film on the sides of the picture because the 4 by 3 aspect ratio of the television picture is slightly different from the aspect ratio of the recording of the camera aperture which is something like 4.2 to 3. Before these picture positioning tests can be made, the linearity controls on the deflection chassis should be adjusted to the optimum position.

13. The camera must be checked for proper threading of the film and for proper lubrication of the intermittent mechanism. The wicks should be oiled and in the case of a camera which has not been used for some time it is probably a good idea to actually put a drop or two of oil on the vertical cam in the intermittent mechanism. The gate in the camera should also be removed and cleaned, being very careful to pull the gate out only when the claw is in the upward and retracted position. The pressure plate in the gate should be cleaned only with some soft material such as a handkerchief or a kleenex; it should never be cleaned with sandpaper or even crocus cloth. The pressure in the vacuum line should be checked. It should run at around 22 to 26 inches vacuum. This is another parameter which may be subject to some change for different installations. Too much vacuum may result in pairing of the scanning lines as recorded on the film immediately below the picture splice; whereas two little vaccuum will result in very unsteady pictures. The best way to check for picture steadiness is to project the film on a projector which is known to be fairly steady, although very bad unsteadiness may be detected by simply holding the processed film up to the light and looking at the white line between the frames to see whether this line is of constant width or whether it changes from frame to frame.

14. Test films may now be run in order to recheck the centering of the picture and to determine the bias and video swing adjustments which are required to get the proper range of density on the negative and also to check the power setting on the

videogam amplifier which will give the best gray scale rendition. Before making the test to determine operating levels it is necessary to make tests at various focus settings of the camera lens using say, F2.4 aperture in order to determine optical focus. This should be done with the camera running as it will be in use and with the raster on the cathode ray tube set to give a light gray image on the film. This will correspond to a fairly low intensity image on the cathode ray tube which means that very good focus can be obtained for the cathode ray tube beam. It is suggested that the electronic focus adjustment, that is the focus control which affects the current in the focus coil of the cathode ray tube, be set so that optimum focus is obtained in a circle about 4" in diameter centered in the center cathode ray tube face. This corresponds to slightly more current than is necessary to focus in the corners of the raster and slightly less current than is necessary to focus in the center of the raster. Use a microscope to look at the film.

15. The sound system should now be checked to be sure that the input sound is clean and is at the proper level. When the operating switch is turned to the program position, the motion of the light and dark region on the little monitoring glass in the galvanometer unit should be quite apparent. On original installation and whenever the recording lamp is changed it will be necessary to make test runs to determine the optimum value of recording lamp current which must be used.

The recorder should now be in proper operating condition and the necessary settings of the controls should have been determined.

It should be remembered that aging of components, especially the cathode ray tube itself, will cause the optimum settings of the controls to change slowly with time and that every once in a while the operating parameters should be rechecked and the films carefully scrutinized to determine what, if any, readjustments should be made.

The following is a brief outline of the things which the operator must watch during normal operation of the equipment. There are not the things which must be determined during original setup or during the determination of operating parameters.

1. Cathode ray tube anode voltage and bias voltage must be carefully maintained at the proper values. The cathode ray oscilloscope must be carefully calibrated and the video peak to peak signal swing maintained accurately at the proper level. This may be a difficult task under some conditions since changing between cameras and between studios sometimes results in very bad changes of level and terrific changes in setup which must be constantly corrected if the best possible pictures are to be recorded. The electronic focus of the cathode ray tube must be periodically checked by swinging the control slightly one way, then the other, and setting for optimum focus about 2" away from the center of the picture. The waveform of the signal in the cathode ray tube must be watched periodically, say, at 15 minute intervals in order to see that the basic characteristic of the signal has not changed, that is to be sure that the lighting has not gone haywire in the studio or that something has become non-linear in the transmission system bringing the signal to the recorder. This becomes a rather easy task after some experience has been obtained

in operating the recorder.

2. The mechanical operation of the camera may be casually noted by the amount of noise which is apparent during operation and the camera must be lubricated after every half hour run. Failure to provide proper lubrication will result in burning out the claw.

3. The sound level and the exciter lamp current must be carefully checked every few minutes to assure proper operating levels. Distortion tests on the sound system should be made frequently, at least once a week, to maintain proper sound quality.

4. All operating voltages should be checked every half hour or at the beginning of every recording period to be sure that they are at the proper value. Note that the 150 volt bias supply cannot be checked by meter readings but may be checked by simply opening the door of the left hand bay of the recorder and making sure that the three voltage regulator tubes in the 150 volt power supply are properly ionized.

5. If the equipment is being used in conjunction with the rapid processor it is very convenient and in fact necessary to continuously observe the projected picture as it comes out of the processor in order to maintain the white level of the picture properly since this level is very sensitive to very small changes in the amount of video swing at the cathode ray tube. If the video signal becomes slightly too small, the picture will take on a dark appearance, whereas, if it becomes just slightly too large, the whites will be badly washed out. These comments apply to single film operation only.

6. The operator should look at the picture on the

cathode ray tube every ten or fifteen minutes in order to be sure that it is not jumping or jittering in any way, to be sure that the lines are properly interlaced, and to be sure that the positioning has not drifted. This is one of the most important points in operation since almost anything that can go wrong with the equipment, except adjustments in the camera and loss of vacuum, can be seen on the picture itself, that is, on the picture as soon on the cathode ray tube.

APPENDIX ONE

Test strip Method of Setting Up the Video Recorder:

In order to check focus and picture position when setting up a recorder and for routine daily checks which do not require accurate photographic processing, the test strip scheme is recommended.

The equipment is run in a normal manner for ten or fifteen seconds and then shut off. With the room lights off, using only red safelight, the take-up magazine is opened and 2 or 3 feet of exposed film is removed by breaking the film.

This test strip may be developed, fixed, and washed in small open tanks or bakers and then dried in front of an electric fan. For quick processing, the following chemicals are suggested:

Developer:	Eastman Kodak D-8 stock solution. Takes 1-3 minutes at 68°F.
Fixer:	Eastman Kodak F-7. Takes about 30 seconds at room temperature. Lights may be turned on after film clears.

SECTION I - Video Recorder

Part 2 - Pertinent Video Recorder Drawings

LIST OF DRAWINGS

VIDEO RECORDER

Title:

Camera and Photographic Monitor Schematic

+550, +450 Power Supply Schematic

+150, -150 Regulated Power Supply Schematic

Simplified Power and Control Schematic

Interunit and External Wiring Schematic

30 KV RF Supply Schematic

Horizontal Deflection Unit Schematic

Waveform Monitor and Control Panel Schematic

Sync Pulse Generator Schematic

Electronic Shutter Unit Schematic

Vertical Deflection Unit Chassis

Pulse Counter Schematic

Sync Separator Schematic

Video Recorder Block Diagram

Video Amplifier Schematic

SECTION I - Video Recorder

Part 3 - Maurer Sound Equipment Drawings

LIST OF DRAWINGS

Maurer Sound Equipment

SECTION I - Video Recorder

Part 4 - Videogam Adjustment Procedure

VIDEOGAM ADJUSTMENT PROCEDURE

Power requirements:

285 volts regulated at 135 ma
-150 volts V. R. regulated at 7.5 ma
6.3 volts at 3.0 amps.

1. With power ON; No input signal; output terminated in 75 Ω load; 20,000 Ω/volt D. C. meter from J2 to grnd, adjust "ZERO ADJ" to obtain 0.05 volts at J2.

2. With input signal of approximately 1.5 volts P. to P. is obtained. (Input should be monitored and maintained after this adjustment in order to obtain constant output for any setting.)

3. Measure output voltage with γ control potentiometer set at minimum γ. Adjust γ control pot. to "MAX." γ and adjust "MIX ADJ" to obtain same peak voltage at MAX γ as was obtained at MIN γ.

4. "OUTPUT ADJ" may now be used to give output level desired within limits of 1.0 to 1.6 volts.
NOTE: Input signal should be stripped of sync. and contain approximately 5% set up.

WIDEBAND VIDEOGAM AMPLIFIER

DESCRIPTION

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.

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 constand 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 required 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 dirmly 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 R-15. Without R-15 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 R-15 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 R-15 and consequently, through the cathode follower, is 7.5 milliamps, 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 set up" 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 R-13. 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 u amps 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 R-13 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 R-33. Mixer control R-26 consists of two ganged, 100-ohm, carbon potentiometers connected to feed through a one-half power signal for full counter-clockwise rotation; a two-power signal for full clockwise rotatinn; 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 R-33 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 R-49 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.

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 Micro amps by means of R13, the zero adjust control. This insures proper setting to the transfer characteristics of the germanium crystals.

A test signal preferably a 15KC linear sawtooth of approximately 1V P/P amplitude is fed into the amplifier and the input gain control R2 adjusted for a 2V P/P 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 provided a constant P/P output signal for all gamma positions of the mixer control.

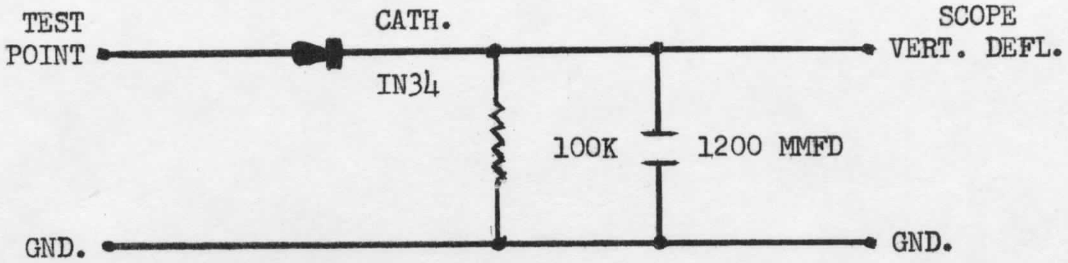
Once the above procedure has been performed by the factory or skilled maintenance personnel and the Videogam has been installed in a video recorder or similar equipment, the operator may find it more convenient to follow the following alighment procedure:

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 P/P 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 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.

<u>Low-frequency Response Adjustments.</u> 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 J4. 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 R-46 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:



This circuit can only be used when the test point has no or very little 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 be down about 5% at 10 MC. 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 2-5 MC region.

OPERATION

The only regularly used operating control is the characteristic selection control R-26. The user should realize, however, that it is necessary for both 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 noisly, 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. But, again it should be emphasized that this is due to the mathematics of the problem and not the amplifier.

SECTION I - Video Recorder

Part 5 - Videogam Schematics

LIST OF DRAWINGS

VIDEOGAM

Title:

SECTION II - Video Recorder Camera

Part I - Camera Maintenance Instructions

Camera Maintenance Instructions

Mechanical maintenance of the camera is a very important item if performance of the equipment is to remain at a maximum level for any length of time. It is imperative that the intermittent cams be kept oiled properly. Oiling is provided by a wick which touches all the cams in the intermittent mechanism. This wick must be kept saturated with oil at all times which probably means applying a drop of oil after every hour's running. Only through long use will the proper lubrication schedule be established. It can be stated, however, that failure to keep the cams lubricated will most certainly result in a worn out claw which means that the shuttle or claw itself must be replaced. Such replacement is fairly easy involving only the removal of the cover plate and cover casting from the intermittent movement and loosening the nuts which hold the cams on the shafts. After the cams have been removed the claw itself may be removed and a new one installed and all parts replaced exactly as they were removed. After installation of a new claw, said claw should be thoroughly oiled with excess oil and run for a minute or so and then oiled again and run for two minutes, oiled again and run for five minutes, slowly increasing the running time until the claw is free and yet there is no play in the gibs. Items that may need to be replaced in the camera are the photo-electric cell and the pipper light which are both readily accessible by removing the assembly to which they are attached in the top of the camera.

Gate should be removed after every 2 hours of operation and thoroughly cleaned by blowing and gently rubbing with soft cleansing tissue. Particles not removed by gentle rubbing may be loosened by moistening with the breath. The camera must be kept clean of foreign particles, such as, film emulsion, lint, dust, etc. Failure to keep gate and camera clean may result in scratched film.

SECTION II - Video Recorder Camera

Part 2 - Camera Drawings

LIST OF DRAWINGS

CAMERA

Title:

Camera Interlock Unit Schematic

SECTION II - Video Recorder Camera

Part 3 - Camera Threading Diagram