CHAPTER 11

OPERATING PRINCIPLES OF A REPRESENTATIVE SURFACE SEARCH RADAR, AN/SPS-10D (PART II)

INTRODUCTION

A general description of the AN/SPS-10D radar (fig. 10-1) is given in chapter 10 of this text with a detailed discussion of the transmitter and modulator. Chapter 11 concludes the description of this surface search radar with emphasis on the theory of operation of the radar receiver portion of the equipment.

The radar transmitter, radar receiver, antenna and antenna reflector, and indicator adapter (fig. 11-1) are the four major sections of the AN/SPS-10D radar. The receiver-transmitter chassis of the equipment is shown in figure 11-2.

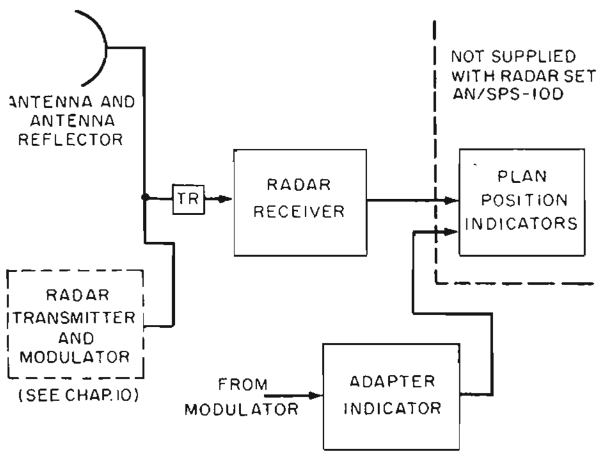

Figure 11-1.—Major sections of Radar Set AN/SPS-10D.

RADAR RECEIVER

A simplified block diagram of the radar receiver in the AN/SPS-10D is shown in figure 11-3. The microwave portion of the receiver consists of t-r tube V3002, mixer assembly W3011, and beacon reference cavity W3012.

The low-amplitude received echo pulses are fed through the t-r tube to the mixer assembly, where it is heterodyned with the receiver local oscillator, V3005, output during radar operation, or with the beacon local oscillator, V3006, output during beacon operation. The mixer output frequency is 30 mc for both radar and beacon operation.

The radar local oscillator operates at a frequency 30 mc higher than the returned signal frequency. The beacon local oscillator operates 30 mc below the received beacon signal.

The radar and beacon local oscillators are controlled by separate automatic-frequency-control (a-f-c) circuits to ensure that the difference frequency at the mixer assembly output will always be 30 mc regardless of magnetron (transmitter) frequency drift. The radar a-f-c circuit receives a small portion of the transmitter (magnetron) output from the radar a-f-c coupler on the transmitter waveguide (fig. 10-10, ch. 10). The energy fed to the coupler is attenuated to eliminate spurious output signals or jamming input signals.

Beacon reception of the AN/SPS-10D occurs on a single frequency (5450 mc). The beacon a-f-c circuit incorporates a beacon reference cavity, W3012, and an input from the pulse transformer, T3002 (fig. 10-11) to produce a fixed mixer assembly output at 30 mc below the received beacon signal.

The mixer assembly output is amplified in eight stages of i-f amplification. These stages are conventional i-f amplifiers with (sensitivity-time control) stc and instantaneous automatic gain control (iagc).

The iagc circuit applies an additional bias voltage on the 5th and 7th i-f amplifier stages to reduce the gain of the receiver during the time strong signals are being received. Strong signals may be received as a result of jamming, signal blanking or abnormal atmospheric conditions, such as when heavy clouds are within the range of the system. Without the iagc circuit

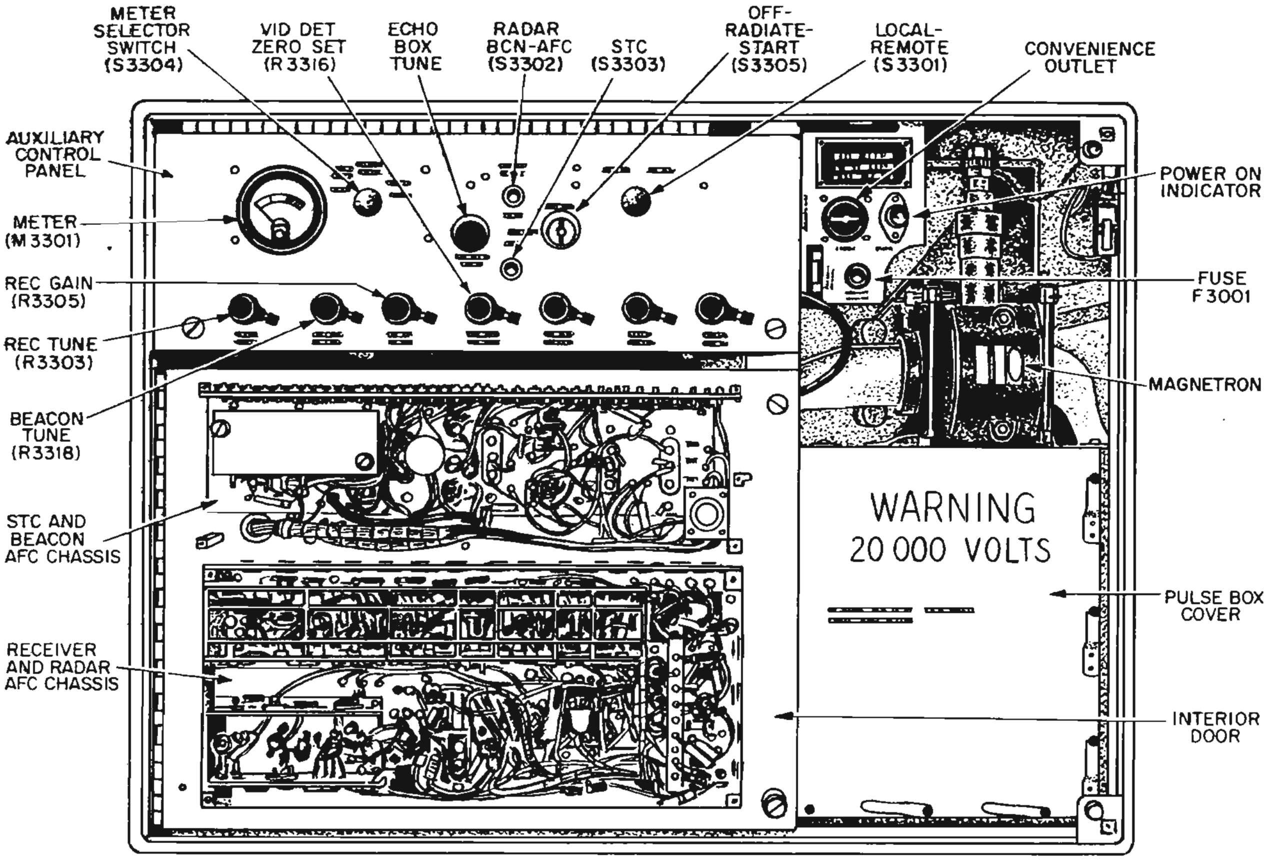

Figure 11-2.—Receiver-transmitter chassis showing front panel controls. 32.189

these signals may be sufficiently strong to saturate the final i-f amplifiers and the video stage which follow. This would result in the loss of additional targets in the strong signal area.

When the antenna reflector passes the area of the strong input signals the iagc circuit immediately allows the gain of the receiver to return to its normal value. This permits low-intensity targets that closely follow the strong signals to be recognized on the plan position indicator.

The sensitivity time control (stc) circuit provides a means of reducing the receiver sensitivity for close-in targets, thus minimizing sea return echo on the plan position indicator so that nearby targets can be distinguished. The circuit is actuated by a positive trigger pulse from pulse transformer, T3002 (fig. 10-11). The stc output (fig. 11-3) is a negative-going voltage which is applied to the grids of the 3rd and 4th i-f amplifiers. The on-off condition of the stc circuit is controlled by an stc switch, S3303 on the receiver-transmitter front panel (fig. 11-2). Other controls which affect the operation of the stc circuit are treated later in this chapter.

The amplified i-f output of the 8th i-f amplifier is rectified and filtered in a video detector and applied to a fast-time constant (ftc) circuit. The ftc circuit aids in presenting relatively short-duration target signals occurring in the midst of long-duration signals, such as signals from clouds, sea, jamming equipment, and land masses.

The output from the ftc circuit is impedance matched to the input of additional video amplifier stages. The final receiver video output is fed to the indicator adapter. The input video signal to the indicator adapter is amplified and made available at the output of five cathode followers. This output is the video signal which is displayed on the plan position indicators. The five output cathode followers makes it possible to operate five plan position indicators from the same indicator adapter.

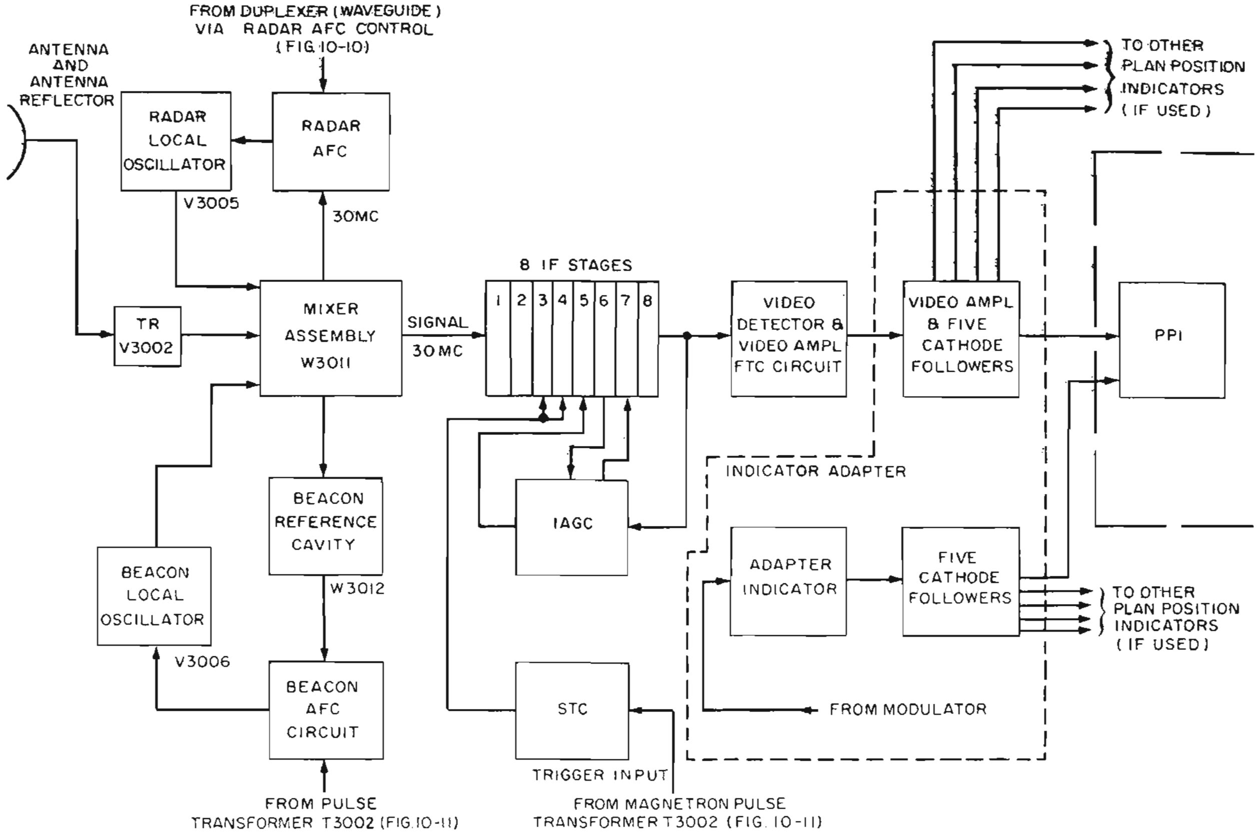

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Figure 11-3.—Radar receiver and adapter indicator, simplified block diagram.

RADAR RECEIVER DETAILED BLOCK DIAGRAM

A detailed block diagram of the receiver-transmitter and indicator adapter of the AN/SPS-10D is shown in figure 11-4. This diagram is essentially the same as the simplified block diagram of figure 11-3, except that a block for each stage (and associated tube or component number) is shown. Frequent reference will be made to the detailed block diagram (fig. 11-4) throughout the circuit operation discussion which follows.

CIRCUIT OPERATION

Many of the circuits contained in Radar Set AN/SPS-10D are conventional, i.e., they conform to similar stages encountered many times in previous discussions or experiences. Thus, old familiar circuits will not be considered; rather, the discussion will be limited to new circuits and concepts or to circuits peculiar to radar equipments.

Input Circuit

The input echo signal to the radar receiver is fed from the antenna and antenna assembly (fig. 11-4) through a slotted line, a t-r tube, V3002, and a shutter to the mixer assembly, W3011. The mixer assembly includes receiver crystal, CR3003, and radar a-f-c crystal, CR3002. The beacon reference cavity, Z3012, is connected to the mixer assembly, and operates in conjunction with crystal socket adapter, W3014, and beacon a-f-c crystal, CR3004, for beacon automatic frequency control.

A shutter in the receiver input path between the t-r tube and mixer assembly is operated by a shutter motor, B3002. When the radar set is shut down, the keep-alive circuit in the t-r tube (discussed in ch. 10) is not energized, and the shutter motor closes the shutter. This action prevents large amounts of r-f energy from nearby radar sets from being dissipated in the receiver crystal, CR3003, thereby causing damage to the crystal.

When the radar set is in standby, the keep-alive voltage is applied to the t-r tube. Thus, the t-r tube will readily fire and present a short circuit across the receiver input terminals when strong r-f signals are received. The shutter opens slowly when the radar set is energized, and is not fully open until the t-r tube is partially ionized by the keep-alive voltage. When power is removed from the shutter motor, a motor clutch (not shown) closes the shutter.

MIXER ASSEMBLY

As in conventional mixers, two signals are fed to the mixer assembly, W3011 (fig. 11-5). One of these signals is the heterodyne signal applied to W3011 from either the radar local oscillator, V3005, or the beacon local oscillator, V3006, depending on the mode of operation of the radar set. The second signal is the received echo from the antenna.

The operating mode is selected at the front panel of the radar set control (fig. 11-6) by the bcn-radar switch, S505. The radar set control contains all of the necessary controls for operating the radar system.

The mixing in W3011 (fig. 11-5) by CR3003 is similar to the more familiar action in a pentagrid converter tube. In the latter case separate signals on the control and injector grids simultaneously control the plate current. The result yields plate output signal components which are the sum, difference, and two original frequency signals.

In a like manner, the CR3003 output is controlled by the heterodyne and echo input signals. The difference frequency output of W3011 is 30 mc for radar or beacon operation. This signal is selected in the tuned circuit comprising C301 and the T301 primary. The T301 secondary signal is applied to the 1st i-f amplifier, V301 (fig. 11-4). See foldin.

Radar and Beacon Local Oscillators

The radar local oscillator, V3005 (fig. 11-5), and beacon local oscillator, V3006, are type 6115 reflex klystrons. These oscillators

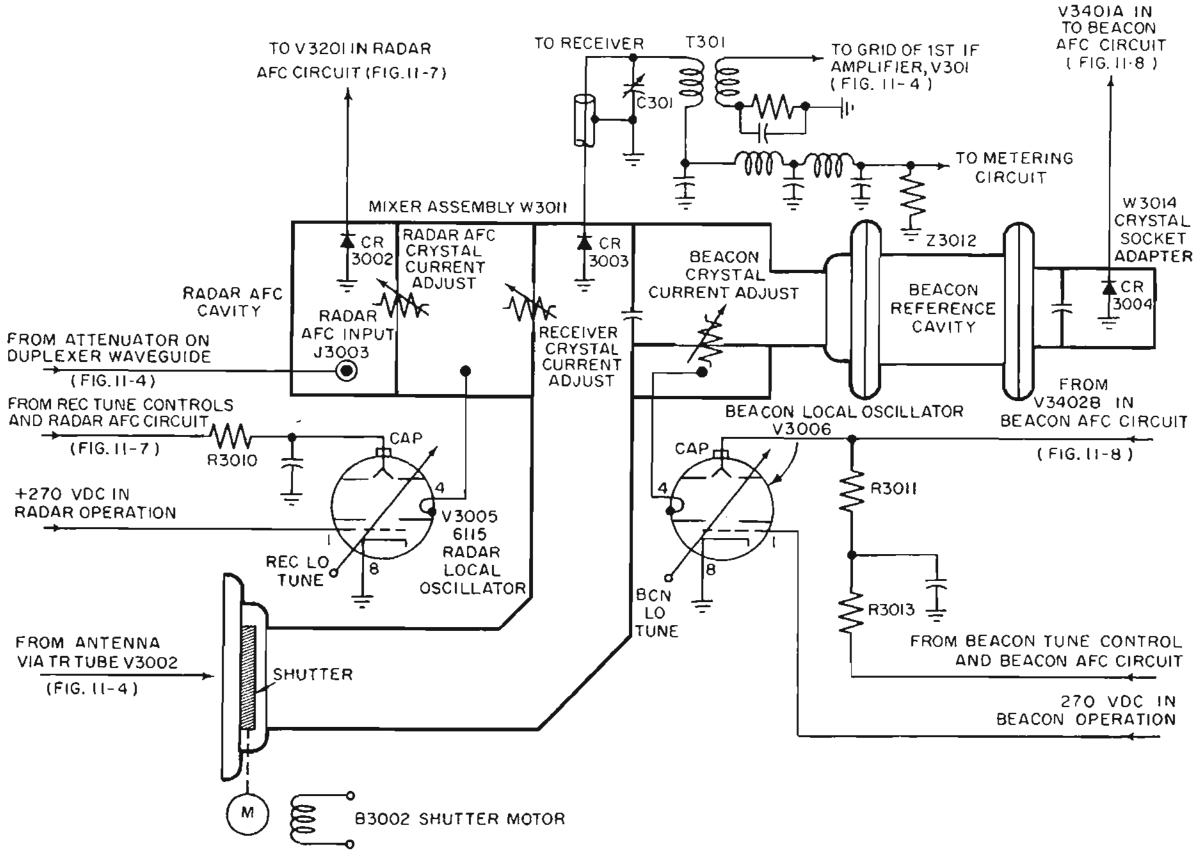

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Figure 11-5.—Mixer assembly of receiver-transmitter.

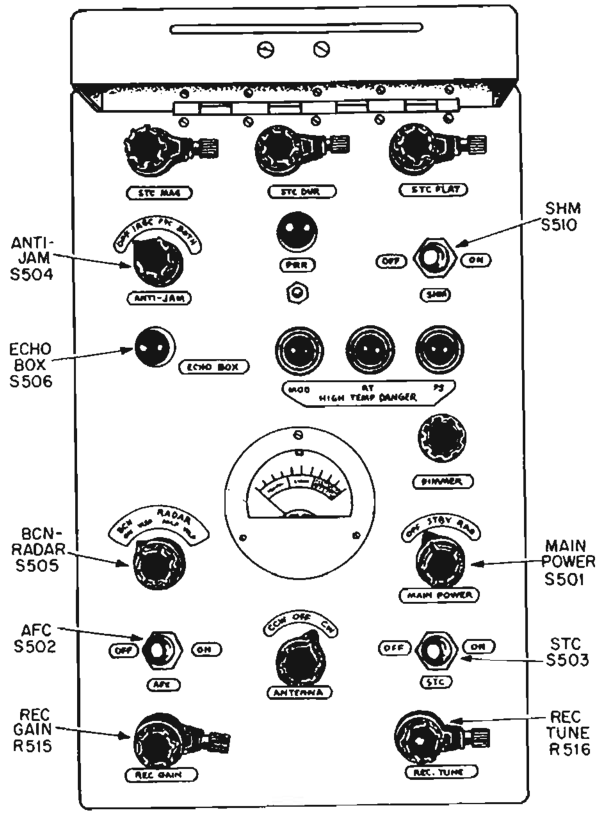

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Figure 11-6.—Front panel of radar set control.

employ resonant cavities as the frequency controlling device which supplies microwave energy to the crystal mixer assembly, W3011.

The klystrons (V3005 and V3006) are velocity modulated, i.e., the r-f potential on the klystron cavity alternately causes acceleration and deceleration of the electron stream. This action produces a grouping or bunching of the electrons in the klystron. The frequency at which the potential changes in the klystron is determined by the resonant frequency of the klystron cavity.

V3005 and V3006 each contain a built-in cavity which is tunable by changing the cavity dimensions. A screw attached to the strut on the V3005 klystron (fig. 10-9) is operated by the receive local oscillator (REC L.O.) tune control. As the control is turned, a stress is exerted on the strut causing it to increase or decrease the cavity dimensions. This permits the radar local oscillator to be tuned 30 mc higher than the incoming frequency, or over a range from approximately 5480 to 5855 mc.

Because beacon reception takes place on 5450 mc only, the beacon oscillator must operate at a single frequency. Klystron V3006 is tuned 30 mc below the incoming frequency by beacon local oscillator (BCN L.O.) tune control to 5420 mc. The beacon signal is fed through the same i-f stages as in radar operation.

RADAR A-F-C CIRCUIT

The radar a-f-c circuit (fig. 11-4) maintains a constant i-f signal in the receiver, regardless of minor drifts in the transmitter (magnetron) frequency. The method used to obtain automatic frequency control is to vary the repeller voltage of the radar local oscillator klystron, V3005, by means of a sawtooth voltage. The a-f-c circuit locks-in at a frequency which is 30 mc above the magnetron output.

The radar a-f-c circuit consists of two i-f amplifiers (V3201 and V3202), a-f-c discriminator, V3203, pulse amplifer, V3204, peak detector, V3205A, bias rectifier, V3205B, phantastron, V3206, and the receive tune resistance network.

The radar a-f-c coupler, connected to the waveguide, couples a small portion of the transmitted energy to CR3002 in the radar a-f-c mixer. A radar a-f-c control permits adjustment of the amount of the transmitted signal fed to the mixer.

An input from the radar local oscillator, V3005, is also applied to CR3002 via a radar a-f-c crystal current adjust. The two mixer input signals differ in frequency by 30 mc ± the transmitter magnetron error frequency.

The output of the a-f-c mixer crystal, CR3002, consists of pulses of r-f energy which recur at the same rate as the transmitted output. This signal is amplified in a two-stage i-f amplifier strip comprising V3201 and V3202. The bandwidth characteristics of the i-f amplifiers allow passage of the 30 mc ± magnetron error signal but rejects all other frequency components. The output of i-f amplifier V3202 is fed to a-f-c discriminator, V3203.

Radar A-f-c Discriminator Circuit

A schematic diagram of the radar a-f-c circuit is shown in figure 11-7, A. The discriminator (V3203A and B) comprises L3201 and L3202 which are tuned to resonate with distributed capacitance at 32.5 and 27.5 mc, respectively (2.5 mc above and 2.5 mc below the 30 mc desired intermediate frequency).

The radar a-f-c circuit is actually a closed loop, with the radar local oscillator, V3005, acting as the signal source in the loop. The V3005 output (5480 to 5855 mc) is heterodyned in the radar a-f-c mixer cavity with the a-f-c signal from the waveguide (5450 to 5825 mc) as discussed. If the transmitter remains on-frequency, the difference frequency will be constant at 30 mc. However, if the magnetron frequency drifts, it is necessary to produce a comparable drift in the radar local oscillator frequency to maintain the required difference frequency of 30 mc.

The radar a-f-c circuit performs this function by amplifying (in V3201 and V3202) the difference frequency obtained in the radar a-f-c cavity and analyzing the i-f output in the tuned circuits of discriminator, V3203, to determine the direction and the amount the i-f signal differs from 30 mc.

The i-f input signal from V3202 is applied to the junction of the two discriminator tuned circuits. The voltage developed by L3202 is applied in series with V3203A, C3211, and R3210. Likewise, the L3201 voltage is applied in series with V3203B, C3210, and R3210. Twin diodes, V3203A and V3203B, are connected in such a way that the a-f-c i-f signal applied to the discriminator circuit produces rectified pulses of opposite polarity with respect to ground across C3211 and C3210. The algebraic sum of the average voltages across these capacitors is the discriminator output which appears at the junction of R3211 and R3212. This output is applied between control grid and cathode of the pulse amplifier, V3204.

If the i-f signal is exactly 30 mc, equal voltage will be developed across L3202 and L3201. Tube V3203A conducts on alternate half cycles of the i-f signal to produce a negative voltage to ground on the upper side of C3211, while V3203B produces an equal voltage across C3210 with the lower plate positive to ground. The bridge, figure 11-7, B, (2) comprising C3211, C3210, R3211, and R3212 is balanced and the output voltage (point 0) to V3204 is zero.

When an input i-f signal higher than 30 mc is applied to the discriminator, the L3201 tuned circuit will produce a larger resonant step-up voltage than will L3202. Likewise, a larger voltage positive to ground will be developed at the lower side of C3210 than will negative voltage at the upper side of C3211. The resulting positive voltage at point 0, figure 11-7, B (1), is the discriminator output to V3204.

Conversely, when an input signal below 30 mc is received at the L3201-L3202 junction, L3202 will produce the larger voltage and the voltage across C3211 will be greater than the voltage across C3210. The voltage applied to the V3204 control grid, figure 11-7, B (3) point 0, will be negative to ground.

The response curve for the discriminator circuit is shown in the upper left corner of the schematic (fig. 11-7, A). The negative and positive peaks at 27.5 mc and 32.5 mc, respectively, result from the stagger-tuning of L3201 and L3202.

Adjustment of L3201 and L3202 may be required after changing a major component in the discriminator circuit. Subsequent adjustments should not be necessary.

Pulse Amplifier

Pulse amplifier, V3204, is a conventional pentode amplifier which inverts and amplifies the signal from the discriminator. The grid of V3204 returns to ground through R3211 or R3212, the conducting diodes of V3203, the discriminator tuned circuits L3201 or L3202, and R3210.

The pulse appearing at the plate of V3204 varies in amplitude, depending on the frequency of the i-f input to the discriminator. As the frequency rises higher than 30 mc, the plate output of V3204 decreases in amplitude. Conversely, as the frequency decreases below 30 mc, the V3204 output increases in amplitude. The waveform at TP3202 indicates the V3204 output which occurs as the i-f input sweeps through a range of frequencies above and below the 30 mc i-f during a 10 μs period.

Peak Detector

Peak detector, V3205A operates like a diode clamping circuit. Minus 250 volts are applied to the V3205A plate through R3217 and R3218 from a nonregulated supply (not shown). The same potential is applied to the V3205A cathode through R3215 and R3218.

Negative pulses appearing at the V3205A cathode from V3204 permit V3205A to conduct. Capacitor C3216 charges through R3215 to approximately the full value of the V3205A input pulse. Between pulses, C3216 starts to discharge through R3217. Because of the high resistance of R3217, the discharge time constant for C3216 is considerably longer than the charge time, and the C3216 voltage remains essentially constant at the peak value of the pulses from V3204. This action converts pulses from V3204 into a d-c control voltage across C3216 which is applied through R3219 to the control grid of phantastron, V3206.

Bias Rectifier

Phantastron, V3206, is controlled by the negative voltage at the upper side of C3216 as discussed. To make the a-f-c circuit more sensitive, an initial bias of about 2.5 volt is applied between the control grid and cathode of V3206 by the action of bias rectifier, V3205B, and its cathode connection to the 6.3 volt filament supply. This action produces a V3206 grid-cathode bias voltage so that a lower amplitude negative signal voltage from V3205A will immediately cause the phantastron circuit to operate.

Phantastron Search Circuit

Phantastron, V3206, generates a sawtooth voltage at its plate which is applied via A and A' and R3010 to the repeller of radar local oscillator, V3005. The klystron (V3005) output frequency changes as the repeller voltage changes, increasing in frequency as the repeller voltage is made more negative, and decreasing in frequency as the repeller is made less negative. Receive-tune control, R3303 sets the range over which the repeller voltage can be changed.

When the intermediate frequency to the discriminator, V3203, is incorrect, the phantastron sawtooth output provides a corrective voltage for the radar local oscillator until the proper i-f is reached. When the i-f is correct, peak detector, V3205A, produces an output across C3216 which is sufficiently negative to maintain the phantastron, V3206, beyond cutoff, thereby locking the oscillator to the correct frequency.

The V3005 output to the radar a-f-c mixer cavity should be at a frequency 30 mc above that of the magnetron input from the waveguide. If the magnetron frequency decreases, the difference frequency output from the a-f-c cavity will increase. If the magnetron frequency increases, the difference will decrease.

Local oscillator changes in the opposite direction produce the same effects. The sweeping action (searching) occurs only for large intermediate frequency errors, i.e., when the i-f error is outside the 6 mc bandpass of the i-f stages. For small errors, V3206 acts as a d-c amplifier to produce a corrective voltage for the repeller of the local oscillator, V3005.

Assume an output intermediate frequency from V3202 which is slightly higher than 30 mc. The discriminator, V3203, output to the V3204 control grid will be positive-going. The negative-going plate output of V3204 is fed through V3205A (without inversion), and applied as a negative input between grid and cathode of phantastron, V3206. The V3206 plate voltage increases toward ground potential, resulting in amplification of the d-c grid input voltage.

Because the intermediate frequency is too high (above 30 mc) the V3206 positive-going plate output to V3005 reduces the negative voltage at the klystron repeller, and thus produces a decrease in the local oscillator frequency. This action produces a local oscillator injection frequency to the radar a-f-c mixer cavity which nulls the intermediate frequency error.

If the intermediate frequency from V3202 is slightly lower than 30 mc, no input negative voltage will be applied to the grid of V3206, and the V3206 grid will automatically become less negative as C3216 discharges. The normal discharge action produces a negative-going plate output voltage from V3206. This negative voltage is the corrective voltage which is of the proper polarity to counteract the low-frequency local oscillator error.

Tube V3206 acts like a d-c amplifier (as described above) only when there is sufficient bias applied to the control grid (approximately -6 volts). If the control grid bias should drop below this value, the tube would no longer act as a d-c amplifier, but would, in effect, become a sweep generator, performing in much the same manner as a free-running multivibrator.

When the AN/SPS-10D is first turned on, the magnetron and local oscillator frequencies will drift beyond the 6 mc bandpass of the i-f stages. When this happens, the i-f output from V3202 is zero, and C3216 fully discharges to reduce the V3206 grid-cathode voltage to about -2.5 volts. In this condition, the phantastron will produce a sawtooth sweep voltage at a free-running frequency of about 7 cps. The sawtooth voltage sweeps the local oscillator frequency over a range of about 40 mc.

The action of the phantastron (V3206) to produce the sweep voltage is as follows: When the a-f-c circuit is initially energized, the grid-bias (egl) of V3206 is about -2.5 volts (see curve at A).

Plate current flow in V3206 causes the plate to cathode potential to decrease and C3217 to discharge. The negative-going potential is coupled to the control grid by C3217, thus causing a slight step in grid bias at A. As C3217 continues to discharge, the drop across R3219 decreases, and the grid bias decreases. This action is amplified in the tube, causing a further increase in the plate current and decrease in plate voltage resulting in a slow linear discharge of C3217. The tube reflects an amplified input capacitance (Miller effect). The input capacitance is essentially multiplied by the mμ of the tube, thus producing a large effective capacitance and a linear voltage decrease during the discharge period.

The low plate potential (at B) permits the screen current to slightly increase, and at the same time, the screen potential, eg2, drops (becomes more negative). The increased screen current produces a larger negative voltage to ground at the R3222-R3223 junction, and C3218 discharges through R3221. This action produces a negative voltage at the suppressor grid, eg3, causing the suppressor to divert electrons (which would normally flow to the plate) back to the screen grid, and the screen current increases further while screen voltage continues to decrease. Thus, in the area of operation of the tube, and by virtue of the regenerative feedback voltage at the suppressor, a decrease in screen potential produces an increase in screen current. Because of the regenerative action the screen and suppressor potentials go negative rapidly and plate current is cut off.

At plate cutoff (point B) the V3206 plate potential starts to rise (goes less negative), charging C3217 through the conducting grid to cathode resistance, R3220, and the -255 volt supply. The control grid, eg1, goes positive (with respect to the cathode) and grid current flows. The heavy tube current flows only to the screen as a result of the large negative voltage on the suppressor.

In region B to C, capacitor C3217 recharges, and C3218 discharges through R3221 toward the cathode potential. The combined actions permit plate current to again flow in V3206 and the cycle is repeated. The output frequency is about 7 cps as determined by circuit constants. The sweep voltage produced at the V3206 plate is applied to the local oscillator klystron repeller to produce the sweep searching action.

When the intermediate frequency passes through the vicinity of 30 mc higher than the magnetron frequency, (which is within the 6 mc i-f bandpass), an input signal passes through the i-f stages, the discriminator, the pulse amplifier, and the peak detector. The resulting voltage across C3216 stops the sawtooth sweeping action and the a-f-c circuit assumes a locked up condition.

For proper operation of the a-f-c circuit, the a-f-c discriminator must be precisely aligned with the signal i-f mid-frequency. If the alignment is inaccurate, the a-f-c circuit will lock on at a local-oscillator frequency which is higher or lower than the signal i-f channel mid-frequency, and received signals will be poorly represented on the PPI or completely absent from the presentation at the indicator.

The a-f-c circuit is particularly sensitive to the magnetron frequency spectrum, and will give erratic results if the magnetron doubles its frequency (double-modes) or jumps in frequency beyond the range of the a-f-c operation.

The local-remote switch, S3301, permits operation of the radar set from either the auxiliary control panel (fig. 11-2) or from the radar set control (fig. 11-6). When S3301 is in the local position adjustments must be made at the auxiliary control panel.

Radar beacon a-f-c (rdr bcn a-f-c) switch, S3302, (fig. 11-7, A) controls the operation of the a-f-c circuit. When S3302 is in the OFF position (opposite to the position shown), a-f-c relay, K3302, is deenergized, (contacts opposite to position shown). This places -105 volts d-c on the plates of phantastron V3206 (in the radar a-f-c circuit) and V3404 in the beacon a-f-c circuit (shown later). The -105 volts prevent the plate voltage of the phantastron from sweeping in the normal frequency-control action, and supplies an operating voltage to each local oscillator repeller.

When S3302 is in the ON position as shown, K3302 is energized from the +24 volt supply through contacts 8 and 9 of S3301 (section 1 rear) to ground. This action moves the K3302 contacts to the position shown, and thereby removes the -105 volts from the plates of the phantastron. The phantastron plate voltage is again applied from the -255 volt supply (via (R3303) and normal frequency control action is restored. Resistor R3303 is used to adjust the phantastron repeller voltage and therefore controls the voltage range of the phantastron sweep output.

BEACON A-F-C CIRCUIT

The general theory of operation of the beacon a-f-c circuit (fig. 11-4) is essentially the same as given for radar operation. Hence, the beacon a-f-c circuit will be discussed only as it differs from radar a-f-c.

During beacon operation the AN/SPS-10D works in conjunction with other beacons (generally shore-based) or landmarks to obtain navigational information. In beacon operation the AN/SPS-10D magnetron sends out a signal on any frequency within its range and triggers other land-based or shipboard beacon transponders which reply on 5450 mc. The reply is mixed with the output of local oscillator V3006 which always operates at 5420 mc (30 mc below the transponder reply frequency).

The function of the beacon a-f-c circuit is to maintain the frequency of the beacon local oscillator, V3006, at 30 mc below the received beacon signal. The transmitter of the AN/SPS-10D, during beacon operation, may operate on any frequency in its range, while beacon reception is limited to a single frequency (5450 mc). Thus, the beacon local oscillator frequency must be held at 5420 mc (30 mc below the received signal) regardless of the frequency output of the transmitter. This action is accomplished through the use of the beacon reference cavity.

The beacon a-f-c circuit consists of a beacon a-f-c crystal, CR3004 (fig. 11-8), three pulse amplifiers, V3401A, V3401B, and V3402A, which amplify the pulse from the beacon crystal, a peak detector, V3403A, a phantastron, V3404, a beacon tune resistance network, and a pulse amplifier, V3402B, which amplifies a positive pulse from pulse transformer T3002.

A portion of the energy from the beacon local oscillator, V3006, is fed through the beacon crystal current adjust in the beacon reference cavity to beacon a-f-c crystal, CR3004. The beacon reference cavity appears as a high-Q series tuned circuit, and the crystal current through CR3004 is maximum when the frequency of the beacon local oscillator is the same as the resonant frequency of the beacon reference cavity. Thus, the rectified CR3004 current, plotted versus frequency, has a conventional tuned circuit response characteristic, i.e., maximum at resonance and diminishing on either side of resonance.

The high-Q characteristics of the beacon reference cavity makes the circuit rigidly tuned to 5420 mc. This rigidity at resonance makes possible the use of the reference cavity as a reference frequency source for the beacon local oscillator. Thus, the primary purpose of the beacon a-f-c circuit is to maintain the beacon local oscillator at the frequency of the beacon reference cavity, or 5420 mc.

To perform this function, some type of discriminator action must be provided which will provide zero control on V3006 when the oscillator frequency is correct, and a corrective voltage to V3006 when the oscillator frequency is incorrect. The method by which this action is accomplished follows:

A positive trigger pulse from T3002 is applied to the grid of pulse amplifier, V3402B. During beacon operation, the recurrence frequency of the pulse is 325 cps. The repetition rate is determined by blocking oscillator, V106B (fig. 10-6) as discussed in chapter 10.

Voltage divider, R3428 and R3429 (fig. 11-8) maintains the cathode potential of V3402B approximately 60 volts above ground. The V3402B grid is at ground potential, and V3402B is cut off. The arrival of the positive pulse from the 7-8 winding of T3002 on the grid of V3402B causes a saturation plate current through R3430. The negative-going plate output of V3402B is applied through C3410 and R3425 to the junction of limiting diodes CR3401 and CR3402. Because V3402B is driven immediately from cutoff to saturation and back to cutoff, the pulse output of V3402B is clipped and will have a much steeper rise and decay time than that of the waveform at its grid.

Diode CR3402 short-circuits positive overshoot in the V3402B negative output pulse. A negative potential is applied to the anode (arrowhead) of CR3401 to prevent this diode from conducting until the cathode (bar) of CR3401 assumes a more negative potential than the plate. When this occurs, CR3401 conducts and the voltage from the CR3401-CR3402 junction to ground is limited to the voltage developed across R3424. The arm of R3424 can be adjusted to permit a variable negative pulse of approximately zero to 2 volts to be obtained.

The negative output pulse at the CR3401-CR3402 junction is approximately 2 μs long, and is applied through CR3409 to the repeller of the beacon local oscillator. This negative voltage causes the frequency of V3006 to increase for the duration of the pulse.

You will recall that the CR3004 crystal current output is maximum when the beacon reference cavity input from V3006 is exactly at the resonant frequency of the cavity. The increase in the V3006 frequency during the 2 μs period of the repeller pulse will cause the output of CR3004 to drop from its maximum value to a lower value (provided the local oscillator was operating at the same frequency as the beacon reference cavity at the beginning of the pulse). This action produces a negative-going output from CR3004.

This pulse is amplified and inverted and applied to the V3006 repeller as a positive-going

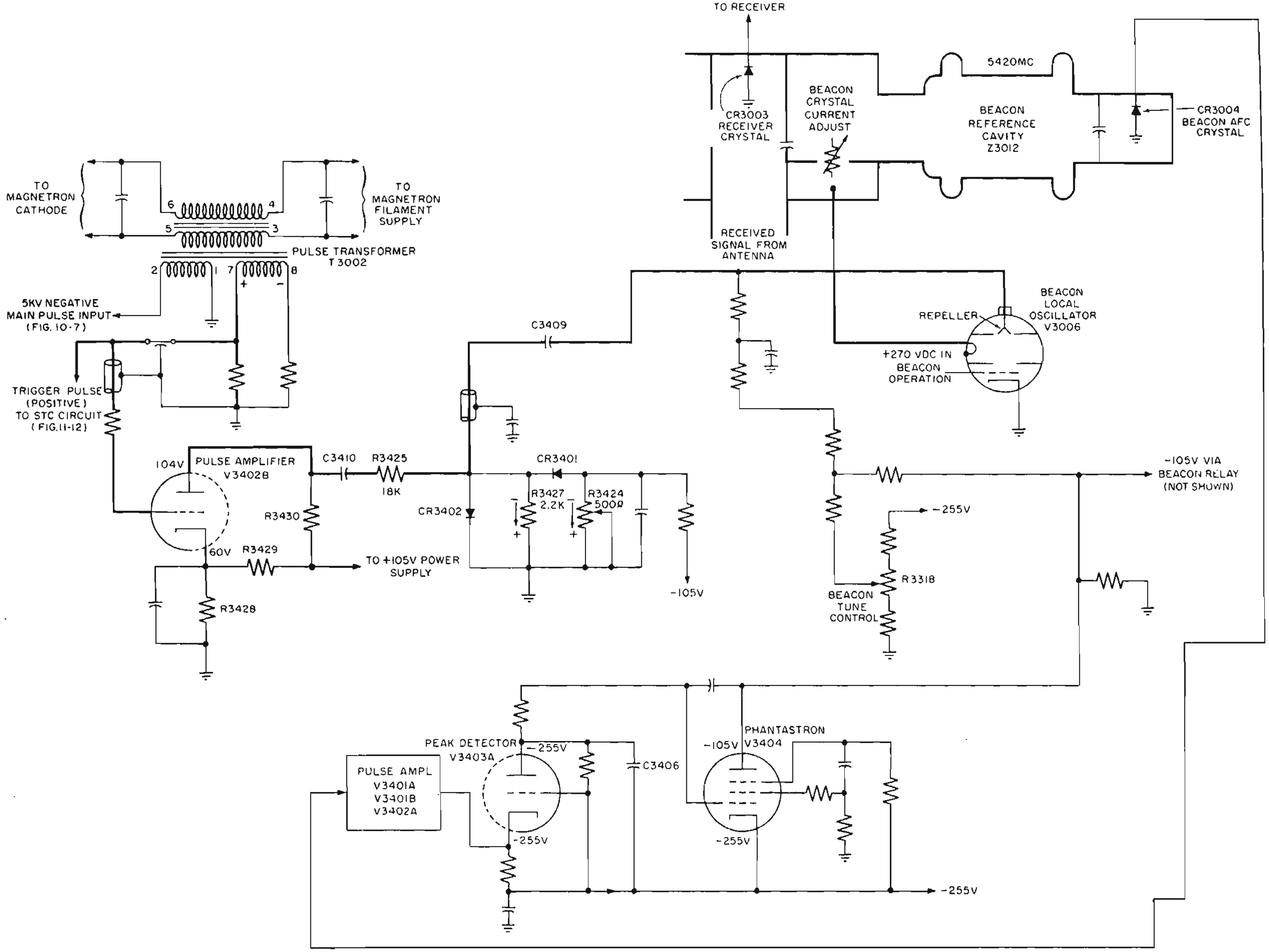

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Figure 11-8.—Beacon afc circuit.

pulse which opposes the initial negative-going pulse from V3402B so as to restore V3006 to its correct frequency.

If V3006 is operating at some frequency above the frequency of the beacon reference cavity, and the negative pulse is applied to the repeller, the oscillator frequency will increase further, and the CR3004 output will decrease even more. This negative CR3004 output is fed through three pulse amplifiers, a peak detector, and phantastron to produce a corrective voltage at the V3006 repeller. The phantastron, (V3404) output to the repeller of V3006 will be positive-going and the oscillator frequency will decrease to null the oscillator error.

If the local oscillator is operating at a frequency below the resonant frequency of the beacon reference cavity, the upward shift in frequency produced by the negative repeller pulse at V3006 will cause an increase in crystal current from CR3004. Thus, the pulse from CR3004 will be positive. Likewise, the phantastron output to V3006 will be negative-going and the oscillator frequency will increase to null the oscillator error.

The action of the local oscillator and reference cavity to produce a negative pulse for frequencies above the desired oscillator frequency and a positive pulse for frequencies below the desired oscillator frequency is very similar to the action of a standard frequency discriminator circuit. This discriminator action corrects the frequency of the local oscillator for a difference frequency of 30 mc below the received beacon signal.

The action of the peak detector, V3403A and the phantastron, V3404, in the beacon a-f-c circuit is the same as described in the discussion of the radar a-f-c.

RECEIVER I-F AMPLIFIERS

The 30-mc output of the mixer assembly, W3011, (fig. 11-4), obtained by heterodyning the received echo with either the radar or beacon local oscillator frequency is amplified in eight stages of i-f amplication consisting of V301 through V308. An instantaneous automatic gain control (iagc) circuit, comprising V311A and V311B, is provided at the fifth and sixth i-f stages, and a similar iagc circuit (V312A and V312B) is provided at the seventh and eighth stages.

As stated earlier, the iagc circuit prevents intense signals from saturating the i-f amplifiers by reducing the gain of the controlled stages for the duration of the strong received signal. The i-f gain is restored to normal immediately following the intense signal.

The operation of the iagc circuit (fig. 11-9) is controlled by anti-jam switch, S504, and by iagc relay, K303. When S504 is in either the IAGC or BOTH positions, K303 is energized from the 24 volt supply and the two iagc circuits operate. In the OFF position of S504, K303 deenergizes, and the iagc outputs from the cathodes of V311A and V312A is shorted to ground.

A portion of the i-f signal from the output of the sixth i-f stage, V306 (fig. 11-4) is coupled to the plate detector, V311B. A similar output of the eighth stage (V308) is applied to plate detector, V312B. The plate detectors provide negative-going controlling signals to their associated cathode follower stages (V311A and V312A) to produce the iagc output.

The two iagc circuits are identical, and the operation of only one of the circuits (V311) will be considered.

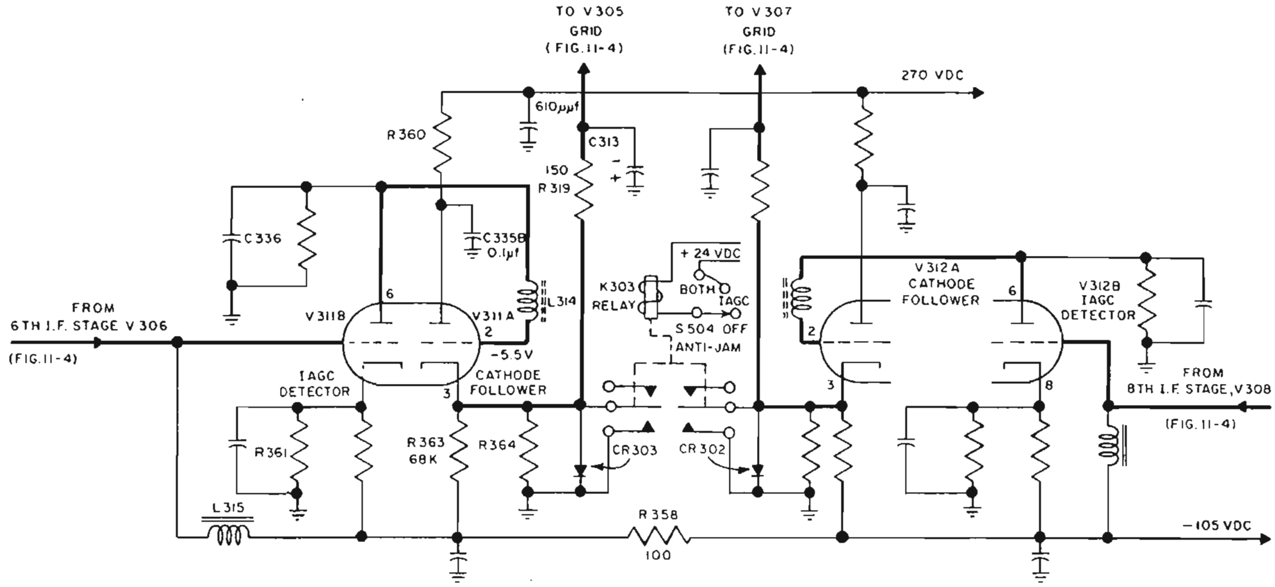
Bias voltage on V311B (fig. 11-9) places the tube just above cutoff. Positive half cycles of the 30-mc i-f input at the V311B grid cause increased conduction through the tube, and negative half cycles drive V311B below cutoff.

The rectified negative-going plate output video pulses from V311B are coupled to the grid of cathode follower, V311A. The pulses are integrated by C336 to remove the 30-mc i-f component and produce a more constant voltage on the V311A grid.

The V311A cathode is returned to a -105 volt supply, while its plate is connected to the +270 volt supply. The normal operating potential of the V311A cathode (during quiescence) is 0 volts to ground. As the conduction of V311A increases, its cathode attempts to become positive to ground, while a decrease in conduction produces a V311A cathode potential negative to ground.

Negative-going input signals from V311B during strong i-f signals cause the V311A conduction to decrease. This action produces a negative voltage to ground at the V311A cathode, and C313 charges to this voltage through the -105 volt supply, R358, R363, and R319. The negative voltage at the top of C313 is applied to the fifth i-f amplifier (V305) grid (fig. 11-4). This action reduces the gain of V305 and therefore reduces the input signal amplitude to all of the subsequent i-f amplifiers.

The reduction in gain in the i-f amplifiers is not instantaneous because the voltage on the grid of V305 can become more negative only as fast as C313 can charge through the path described above. This provides a slight delay in



32.196

Figure 11-9.—Instantaneous automatic gain control (iagc) circuit.

iagc action. At the end of the video pulse to V311A, C313 can discharge very rapidly through R319, V311A, and C335B, thus permitting an almost immediate return of the control grid bias of V305 to its normal operating level. Rectifier, CR303, prevents the cathode of V311A (and the V305 grid) from going more than a fraction of a volt positive to ground.

I-F AMPLIFIER BANDWIDTH SELECTION CIRCUIT

The receiver bandwidth is determined by bandwidth relay, K302 (fig. 11-4) located between the fifth and sixth i-f stages (V305 and V306). A bcn-radar switch, S505, located on the radar set control panel (fig. 11-6) simultaneously selects the pulse length of the radar transmitted pulse and the bandwidth of the receiver i-f stages.

Switch S505 has four positions, corresponding to ON, WSP (wide bandwidth short pulse), NLP and WLP. The ON position is used during beacon operation.

The bandwidth selection circuit diagram is shown in figure 11-10. Relay, K302, is energized only when S505 is in the NLP (narrow bandwidth, long pulse) position as shown. In this position the coupling circuit to V305 consists of C316, the primary and secondary of T305, and L310. The primary and secondary of T305 are loosely coupled, resulting in narrow-bandwidth response (approximately 1 mc) in the i-f amplifiers (see graph at lower left of fig. 11-10).

In both of the wide bandwidth positions of S505, K302 is deenergized, and the coupling circuit between the fifth and sixth i-f stage consists of C316, a tapped section of the T305 primary, and L310. Overcoupling results because the turns of the primary are closer to those of the secondary than before. This action produces the wide bandwidth characteristics of the i-f stages.

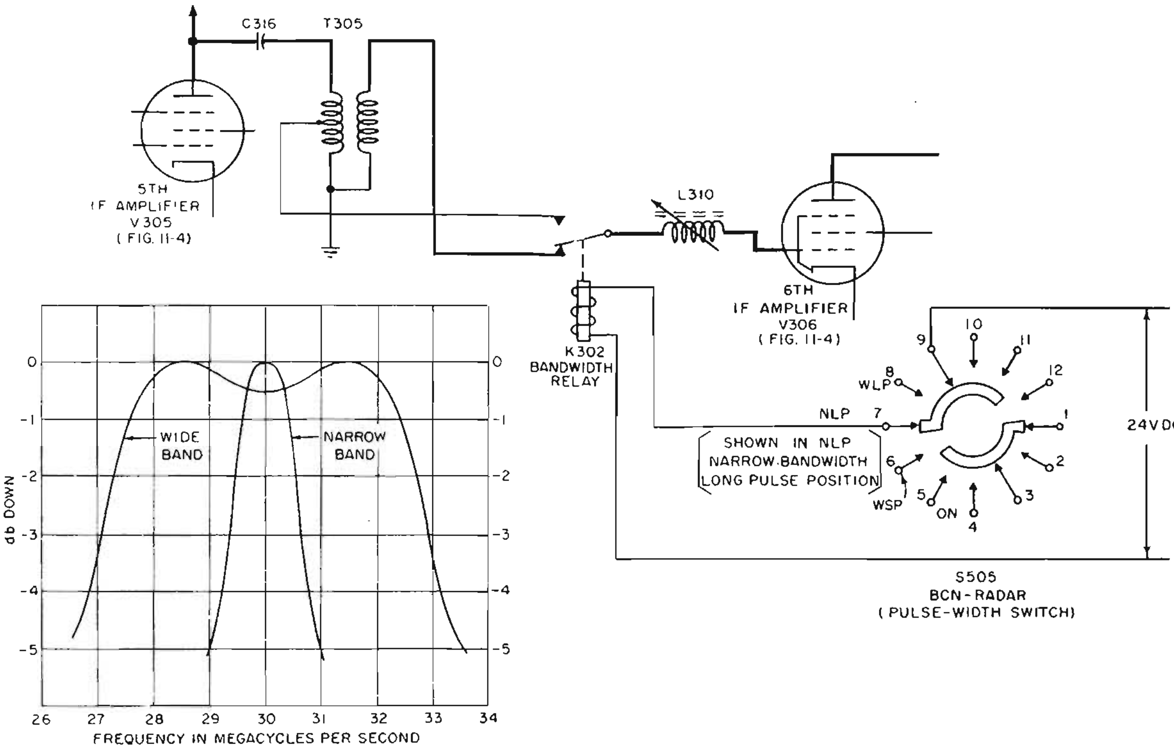
The inductance of the primary winding between the tap on T304 and ground is the same as the inductance of the T305 secondary so that the tuning at the input to V306 is not upset for wide bandwidth or narrow bandwidth operation.

VIDEO CIRCUIT

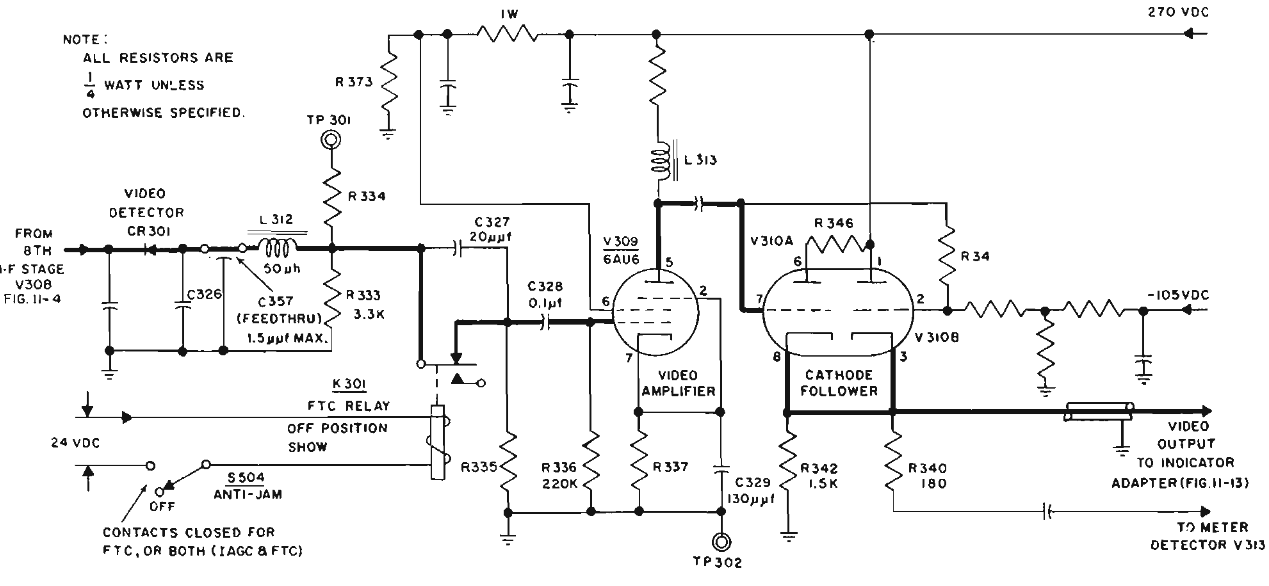
The receiver video circuit (fig. 11-11) consists of an ftc circuit, a video detector CR301, a video amplifier V309, and a cathode follower V310. The video circuit detects and amplifies the video signal and feeds its output through the indicator adapter to the plan position indicators.

Video Detector

The output of the eighth i-f amplifier stage, V308 (fig. 11-4), is coupled to germanium crystal diode, CR301 (fig. 11-11), which is used as the video detector. The negative video output pulses of CR301 are filtered by C326 and L312



32.197
Figure 11-10.—I-f amplifier bandwidth selection circuit.



32.198
Figure 11-11.—Video circuit.

to remove the 30-mc i-f signal. The filtered output is fed through the ftc circuit to video amplifier, V309.

Fast-Time Constant Circuit

The ftc (fast-time constant) circuit aids in presenting relatively short-duration target signals which occur in the midst of long-duration signals. The ftc circuit is controlled by the anti-jam switch, S504, on the panel of the radar set control (fig. 11-6).

The ftc circuit changes the time constant of the coupling circuit between video detector, CR301 (fig. 11-11), and video amplifier, V309. When S504 is in the OFF position (as shown) ftc relay, K301, is in the deenergized position, and its contacts short C327. The coupling circuit consists of C328 and R336, and the input signal is therefore differentiated at the V309 grid across R336. This arrangement represents a relatively long time constant coupling circuit, and, for long-duration signals, the video pulse to V309 may be long enough to blot out neighboring short-duration signals at the video detector output.

When K301 is energized, by placing S504 in either the FTC or BOTH position, its contacts move down (opposite to the position shown). The detected output video signal is now coupled through C327, which, in conjunction with R335 forms a fast-time constant coupling circuit. Differentiation across R335 produces a shorter duration video pulse than would be obtained from C328 and R336 for the same video pulse input, and the duration of the V309 input for all signals is considerably reduced.

The differentiation of the video signal reduces clusters of target signals on the plan position indicator to make individual targets easily distinguishable. Ftc is useful in preventing target area blotting of the plan position indicator to achieve a clearer presentation.

The ftc action differs from iagc in that ftc affects the time duration of the video pulses, whereas iagc action affects the amplitude of high-intensity video pulses.

Video Amplifier

Video amplifier, V309, inverts and amplifies the video signal from CR301. Inductor L313 is connected in the plate circuit of V309 to produce the proper high-frequency response in the leading and trailing edges of the V309 video output pulse. The V309 output is fed to parallel-connected cathode followers V310A and V310B. Parasitic oscillations are suppressed by R345 and R346.

The V310 cathode output is fed to the indicator adapter (fig. 11-13), and to the detector meter circuit (fig. 11-15). The value of R342 is selected so that the total output impedance is 75 ohms.

SENSITIVITY-TIME CONTROL CIRCUIT

The sensitivity-time control (stc) circuit (fig. 11-4) provides a means of reducing the receiver sensitivity for close-in targets, thus minimizing the sea return echo on the plan position indicators so that nearby targets can be distinguished. The circuit is actuated by a positive trigger pulse from pulse transformer T3002 (fig. 10-11).

The schematic diagram of the stc circuit is shown in figure 11-12. The circuit is controlled by stc switch S3303, (upper right corner) stc magnitude R3310, stc duration R3308, and stc flat R3313. The output of the stc circuit (from the V3102B cathode) is coupled to the 3rd and 4th i-f amplifiers (fig. 11-4).

All of the stc controls mentioned above are located on the auxiliary control panel (fig. 11-2). Many of the controls on this panel are duplicated on the radar set control (fig. 11-6). The local-remote switch, S3301 (shown in block form in fig. 11-12) is located on the auxiliary control panel and determines which set of controls is active. With S3301 in the LOCAL position, adjustments must be made at the auxiliary control panel. When S3301 is in the REMOTE position, adjustment must be made at the radar set control. Because each set of controls are alike and perform the same function, only those controls located on the auxiliary control panel are shown on the schematic diagram.

The stc circuit consists of multivibrator, V3101, a limiter and clamper network, a grounded grid amplifier, V3102A, and a cathode follower, V3102B.

Stage V3101 is a monostable multivibrator. In the absence of an input trigger pulse from T3002, V3101A conducts, causing the cathode to have a high positive voltage to ground (36.2 volts) because of the drop across R3103 and R3104. Although the grid of V3101B is held 13 volts positive to ground by voltage divider action, the grid-cathode bias is about -23 volts, and V3101B does not conduct until a trigger pulse arrives.

When a positive pulse enters the stc circuit from T3002, via C3102 and CR3107, the grid of V3101B is driven positive with respect to the cathode and V3101B conducts. The decreasing plate voltage of V3101B causes the discharge of C3105, and a cutoff bias voltage is developed at the V3101A grid across R3102. Section V3101A will remain cut off until C3105 can discharge through R3102 to the potential across C3101B. As the potential on the grid of V3101A approaches that of the cathode, V3101A again conducts, returning the multivibrator to its original state by cutting off V3101B.

The time elapsed before V3101A again conducts depends on the voltage across C3101B, or the potential toward which C3105 discharges. This voltage may be adjusted by stc flat control R3313.

During the period before V3101A again conducts, a negative-going pulse appears at the plate of V3101B. This pulse is the stc multivibrator output pulse which has a width determined by the position of the stc flat control. Thus, an stc negative-going square waveform with an adjustable flat section has been formed.

The negative pulse from the V3101B plate is fed through C3106, CR3103, and CR3104 to the cathode of V3102A. The crystal diodes (CR3103 and CR3104) are limiters which block positive overshoot portions of the pulse.

Capacitor C3108 at the V3102A cathode is charged positive to ground to approximately the potential at the arm of R3308. The input negative stc pulse from V3101B causes C3108 to discharge, and the conduction of V3102A increases for the duration of the pulse input. Likewise, the plate voltage of V3102A decreases during the pulse input.

Upon completion of the pulse, C3108 charges exponentially through R3111, R3115, R3308, and R3307. Stc duration control R3308 is variable so that the voltage to which C3108 must charge and the time required for the charge can be adjusted (see waveforms at TP3104 in fig. 11-4). By the combined actions of the stc flat and stc duration controls (fig. 11-12) the stc pulse now has a variable flat section and variable decay (duration).

During the time of the negative pulse to V3102A, CR3105 essentially shorts the V3102A cathode to ground. This provides an easy discharge path for C3108. Diode CR3102 is a part of a voltage divider which produces a low d-c voltage (positive to ground) across R3104. This voltage serves as a bias on V3101B and limits the amplitude of the V3101B plate output.

The grounded-grid amplifier (V3102A) output pulse has the same shape as the cathode input. The gain in V3102A depends on the plate voltage, which can be adjusted by stc magnitude control R3310. The resulting output waveform from V3102A, adjusted for proper flat, duration, and magnitude, is applied through C3109 to the V3102B grid.

Cathode follower V3102B couples the negative-going stc output pulse to the 3rd and 4th i-f amplifier (V303 and V304) control grids (fig. 11-4). As the stc input trigger pulse from T3002 occurs at the instant the transmitter magnetron output is keyed-on, the stc circuit output will provide its negative-going input to the 3rd and 4th i-f amplifiers during the time strong sea return echoes are received.

Cathode follower V3102B (fig. 11-12) is connected between the -105 and +105 volt supplies. The d-c potential at the cathode of V3102B (normally about -14 volts) can be varied by adjusting the positive potential applied to the V3102B grid from receive gain control, R3305. The cathode d-c potential can be adjusted from 0 to -15 volts. Because the V3102B cathode potential is applied along a d-c path to the 3rd and 4th i-f amplifier grids, as discussed, it follows that the gain of the i-f stages (and of the receiver) can be varied by positioning the arm of R3305. The stc voltage is superimposed on the V3102B cathode potential, and is independent of the receive gain setting.

To disable the stc circuit and still not affect the operation of the receive gain control, the plate voltage of V3102A is made negative by placing S3303 in the OFF position. The action is as follows: voltage divider R3311, R3310, and R3309 is connected between the -105 and +270 volt supplies. In the ON position of S3303 (as shown) the drop across R3311 is greater than 105 volts and the potential at the R3310-R3311 junction is positive to ground. The potential at the arm of R3310 is also positive to ground and is applied to the V3102A plate. With a positive plate voltage applied, V3102A performs its normal function.

When S3302 is in the OFF position, R3311 is shorted, and the potential at the R3310 arm (and consequently on the V3102A plate) is negative to ground. The negative plate voltage prevents V3102A from conducting, and the stc waveform output does not appear at the V3102B cathode.

Diodes CR3101 and CR3106 prevents the V3102B cathode voltage (and the voltage applied to the control grids of the 3rd and 4th i-f amplifiers) from becoming more than a fraction of a volt positive to ground.

The action of the stc circuit varies from that of iagc. The stc circuit attenuates close-range video echo pulses by reducing the i-f gain during the first portion of the receive period. This reduces blurred bright spots on the PPI caused by close-in targets. The iagc circuit is active on strong echo signals regardless of target range.

INDICATOR ADAPTER

The primary function of the indicator adapter (fig. 11-4) is to supply trigger pulses and video signals at the proper output levels and at the proper time to the plan position indicators. Provisions are made in this unit for the introduction of range markers and ship's heading marker (shm) signals. The origin and purpose of the shm signals are treated in chapter 10 of this training course.

BLOCK DIAGRAM

The indicator adapter (fig. 11-4) consists of a power supply, a trigger pulse delay circuit, a trigger pulse generator, a video amplifier, a ship's heading marker circuit and a range mark input circuit. The trigger pulse delay circuit receives the trigger pulse from the modulator output via the T110 secondary (fig. 10-7). This pulse is positive-going at the T110 secondary and occurs each time the magnetron is keyed to transmit an output pulse. After a selected time delay, in the trigger pulse delay circuit, the trigger pulse is applied through an amplifier (V907B) to a blocking oscillator, V907A. The blocking oscillator converts the broad, rounded, trigger pulse from the delay line into a sharp output pulse.

The V907A output is applied to as many as five plan position indicators. These pulses are used to trigger the sweep circuits of the indicators.

The video amplifier circuit receives the video signal from the receiver and feeds the amplified signal through five cathode followers to as many as five plan position indicators. The shm and range mark signals are mixed with the signal in the video amplifier circuit.

CIRCUIT OPERATION

The positive trigger pulse from the modulator (via T110 of fig. 10-7) is coupled to the delay line, Z901, through Z905 (fig. 11-13), through R943. The delay line consists of seven L-C sections, each of which can be added by means of separate switches, S901 through S907. By the proper combination of the switches, a delay from 0.05 to 2.5 μs can be selected in increments of 0.05 μs. The total amount of delay used must be determined to compensate for delays in the transmitter and the receiver. Each 0.05 μs increment is equal to a distance delay of 8 yards. Therefore, a delay range from 8 to 400 yards at 8-yard intervals may be selected.

Once the proper delay is selected at installation, the switch arrangement must not be disturbed unless certain cables and waveguides have been rearranged. The proper time delay, in microseconds, can be determined by using the formula:

$$TD = 2.43(A + B) + 1.54(C-D)\ 10^3$$

where A represents length (feet) of RG-27/U pulse cable from the modulator to the receiver-transmitter, B represents length (feet) of waveguide from the receiver-transmitter to the antenna assembly, C represents length (feet) of RG-12/U video cable from the receiver-transmitter to the indicator adapter, and D represents length (feet) of RG-12/U synchronizing (trigger) cable from the modulator to the indicator adapter.

Blocking Oscillator

The output pulse from the delay line is amplified and inverted in V907B and coupled from the 5-6 winding of T902 (terminal 6) to the single-swing blocking oscillator (V907A) control grid. The magnetomotive forces in the 3-4 and 1-2 primary windings of T902 are added to produce a greater induced voltage in the 5-6 secondary. The input pulse causes V907A to conduct.

During the period of the V907A input pulse, the grid is driven positive (with respect to the cathode), V907A conducts saturation current, and C916 assumes a negative charge toward the grid. At saturation, the induced voltage in the 5-6 winding of T902 drops to zero, and the accumulated negative charge on C916 immediately cuts off V907A. During cutoff, C916 discharges through R953. The tube (V907A) remains cut off until the charge on C916 is sufficiently reduced to permit the triggering pulses from T902 to again cause conduction.

The blocking oscillator output is a sharp positive pulse which is applied through parasitic suppressors R938 through R942 to five conventional cathode followers. The cathode followers provide a low-impedance output to the plan position indicators.

Video Amplifier Circuit

The video amplifier circuit (fig. 11-13) consists of two video amplifiers, V903 and V904A, and five cathode followers, V904B, V905A, V905B, V906A, and V906B.

The video amplifier V903A receives a positive 2 volt signal from the receiver via cathode follower, V310 (fig. 11-11). When the shm circuit is operating, V903A (fig. 11-13) will also receive the 5 volt positive shm input. The operation of the shm circuit is treated in chapter 10 of this training course.

Range marker input signals are applied to the V903B grid. The combined outputs of V903A and V903B are coupled through C907 and R912 to video amplifier, V904A. The V904A output is limited to a 2 volt positive going pulse which is fed through cathode followers to the plan position indicators.

The video amplifier response curve is shown in figure 11-14. From this curve it can be seen that the video amplifier has a bandwidth from 60 cps to 6 mc, with an amplitude variation not in excess of 3 db from the mid amplitude. The low-frequency response is determined by the interstage coupling capacitors, C907 and C908, (fig. 11-13) and resistors R912 and R920. As the frequency decreases, the reactance of the C907 becomes appreciable as compared with the resistance of R912 and R920. Hence, part of the signal is lost across C907, producing a decrease in low frequency response.

The high frequency response is determined by the value of the plate load resistance, and the input and output capacitance of each stage. At high frequencies, L902, C908, and the input capacitance to the five cathode followers form a broadly tuned series resonant circuit. The voltage developed across the input capacitance to the cathode followers rises as the input signal approaches the resonant frequency of the tuned circuit and thus increases the high frequency response of the video stages. The video output signals are applied to the cathode-ray tube in the plan position indicators.

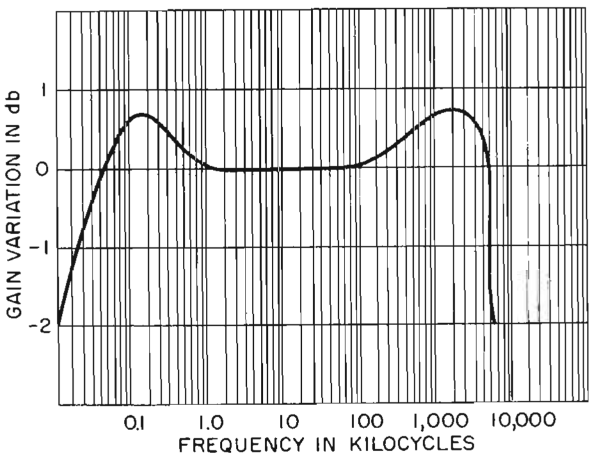


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Figure 11-14.—Frequency response curve of video amplifiers.

METER CIRCUITS

The meter circuit of the AN/SPS-10D (fig. 11-15) consists of three 0 to 200 microampere meters M103, M3301, and M501. Each of these meters has an internal resistance of 75 ohms. Meter M103 is always connected in the circuit to indicate magnetron current during radiation. This meter indicates magnetron current exclusively.

Separate selector switches, S3304 and S509, permit the selection of M3301 and M501 in the various radar circuits. These meters indicate magnetron, crystal, or video detector currents. The positions of the switches to indicate a desired circuit current is shown at the bottom of the illustration.

The local remote switch, S3301, permits the separate crystal currents to be read on M3301 or M501 in the local or remote positions.

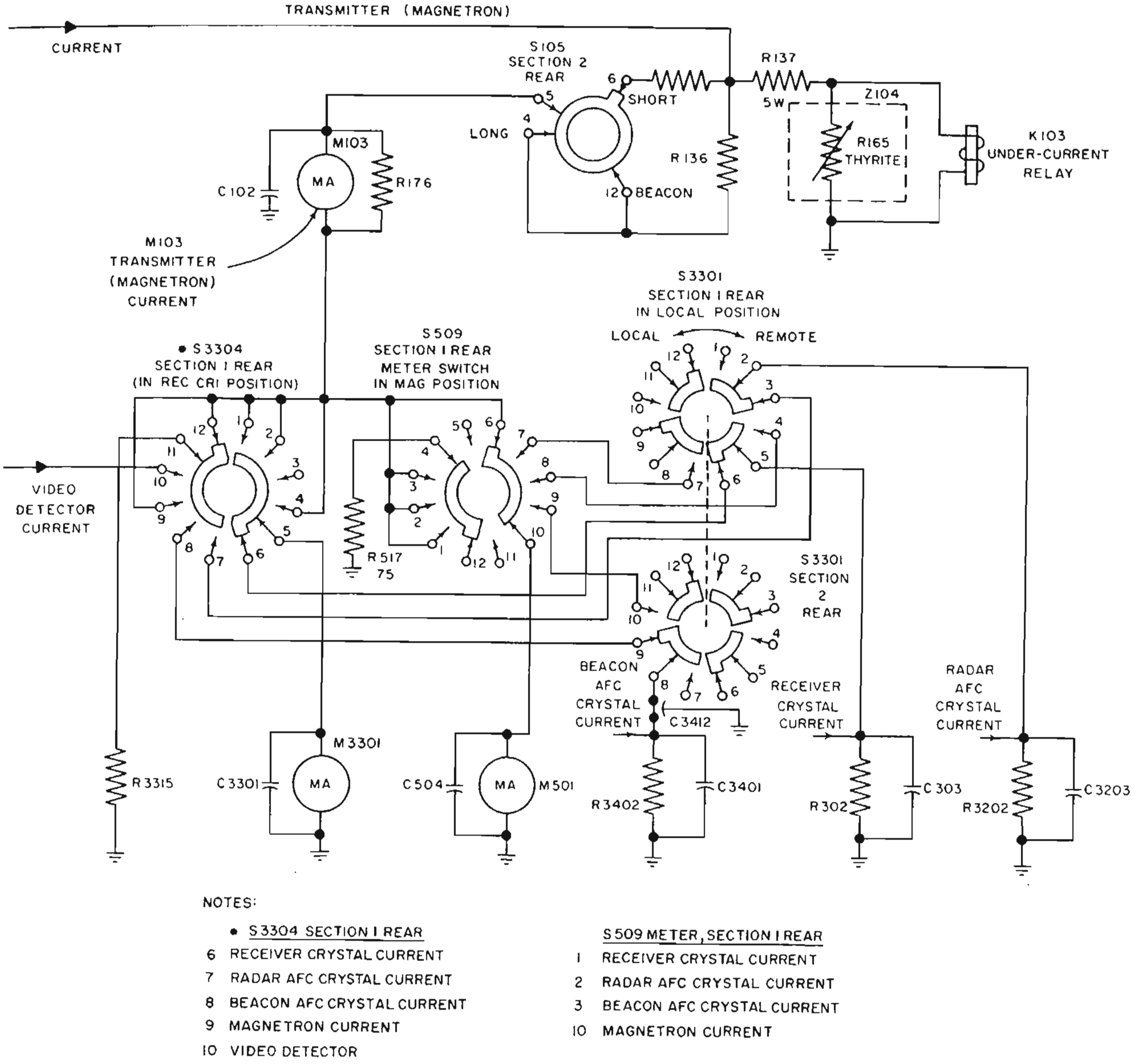
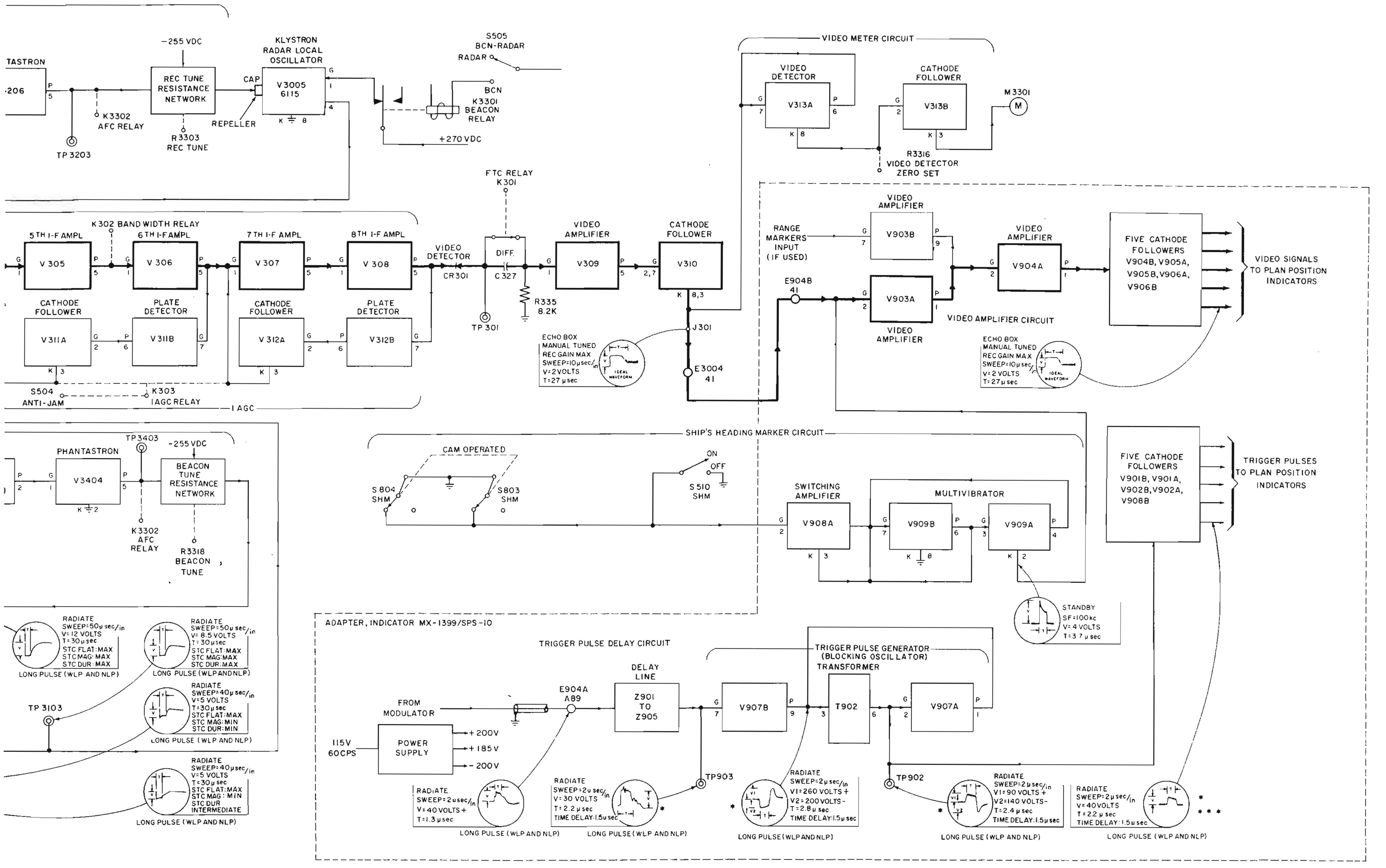


Figure 11-15.—Meter circuits. 32.202



LEGEND

1. HEAVY LINES INDICATE MAIN CIRCUITS.
2. LIGHT LINES INDICATE AUXILIARY CIRCUITS OR CONTROLS.
3. VARIABLE CONTROLS ARE INDICATED BY A CIRCLE AND DOTTED LINE, SHOWING POINT IN CIRCUIT WHERE THEY ARE CONNECTED.
4. LETTERS AND NUMBERS OUTSIDE TUBE BLOCKS INDICATE TUBE ELEMENT AND SOCKET PIN.
5. WAVEFORMS WERE MEASURED WITH AN OSCILLOSCOPE HAVING THE FOLLOWING CHARACTERISTICS:

   FREQUENCY RESPONSE--DOWN NOT MORE THAN 30 PERCENT FROM 10 CPS TO 10 MC.

   INPUT IMPEDANCE-- 2 MEGOHMS 40 μμf

   SWEEP RATE--10 INCHES PER MICROSECOND OR BETTER (START-STOP OPERATION)

   USE NAVY TYPE OS-4/U OSCILLOSCOPE OR EQUIVALENT TO MEASURE THESE WAVEFORMS.
6. ARROWS FROM WAVEFORMS INDICATE CIRCUIT POINT WHERE OSCILLOSCOPE IS CONNECTED.
7. EXPLANATION OF SYMBOLS PLACED BY WAVEFORMS:

   STANDBY--MAIN POWER SWITCH S501 AT STBY.

   RADIATE--MAIN POWER SWITCH S501 AT RAD.

   SF--SWEEP FREQUENCY OF TEST OSCILLOSCOPE.

   SWEEP-HORIZONTAL SENSITIVITY OF TEST OSCILLOSCOPE

   V--PEAK VOLTAGE OF WAVEFORM.

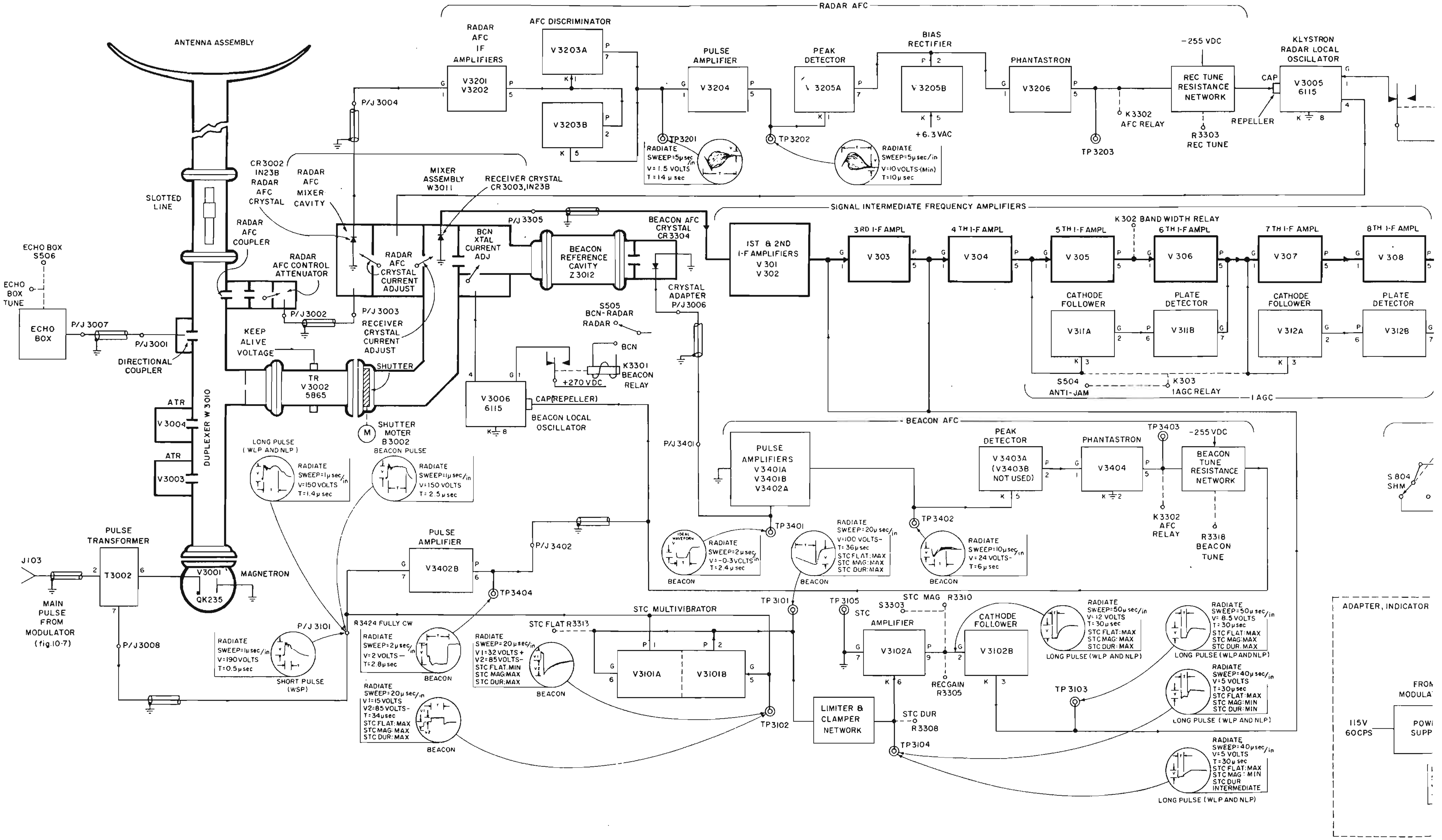
   T--DURATION IN MICROSECONDS OF PORTION OF WAVE INDICATED.
8. ALL WAVEFORMS SYNCHRONIZED TO PULSE AT TP103 EXCEPT WHERE NOTED.

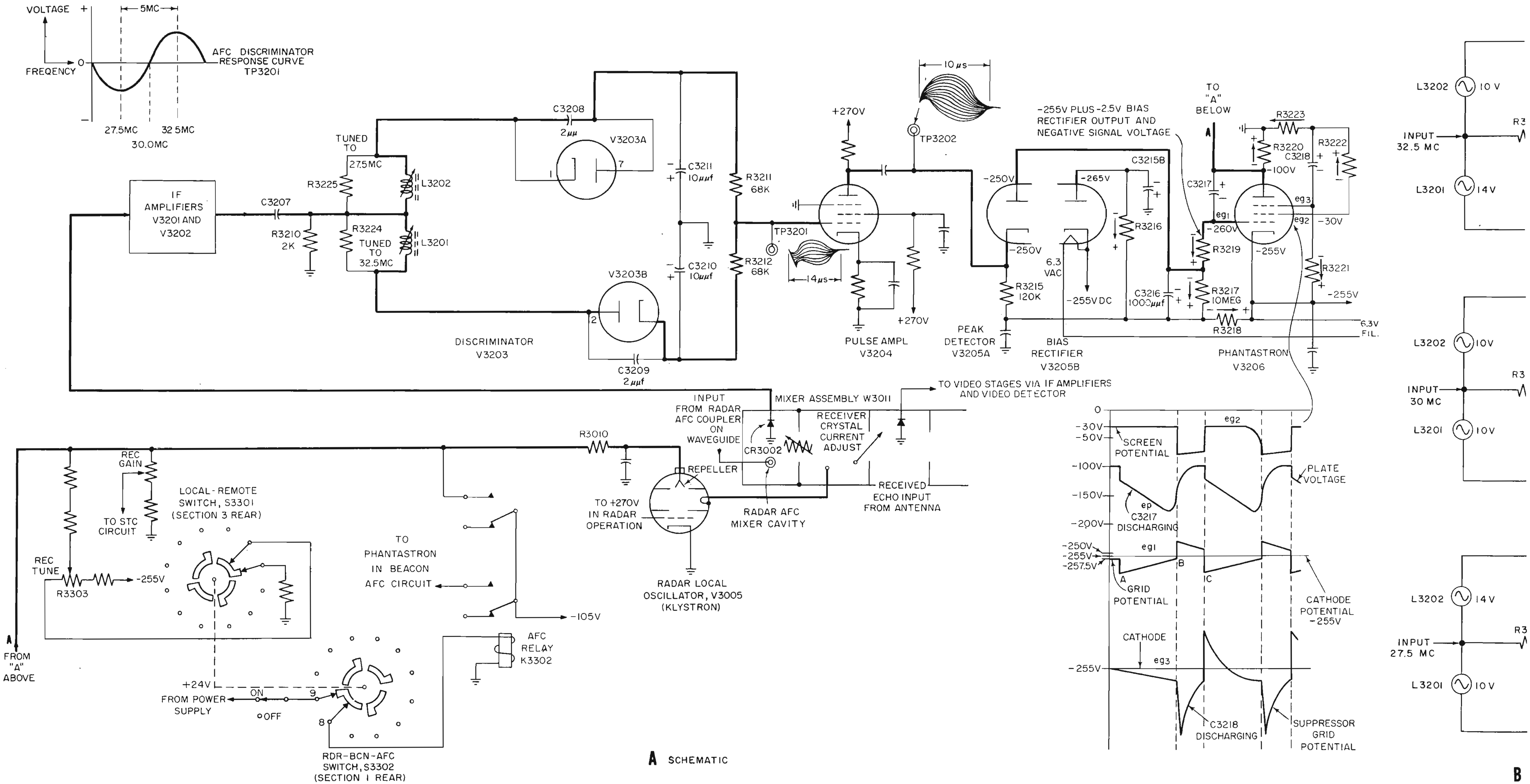
* OSCILLOSCOPE SYNCHRONIZED TO PULSE AT TP101

* * SHORT THE JUNCTION OF R934 AND R935 TO GROUND.

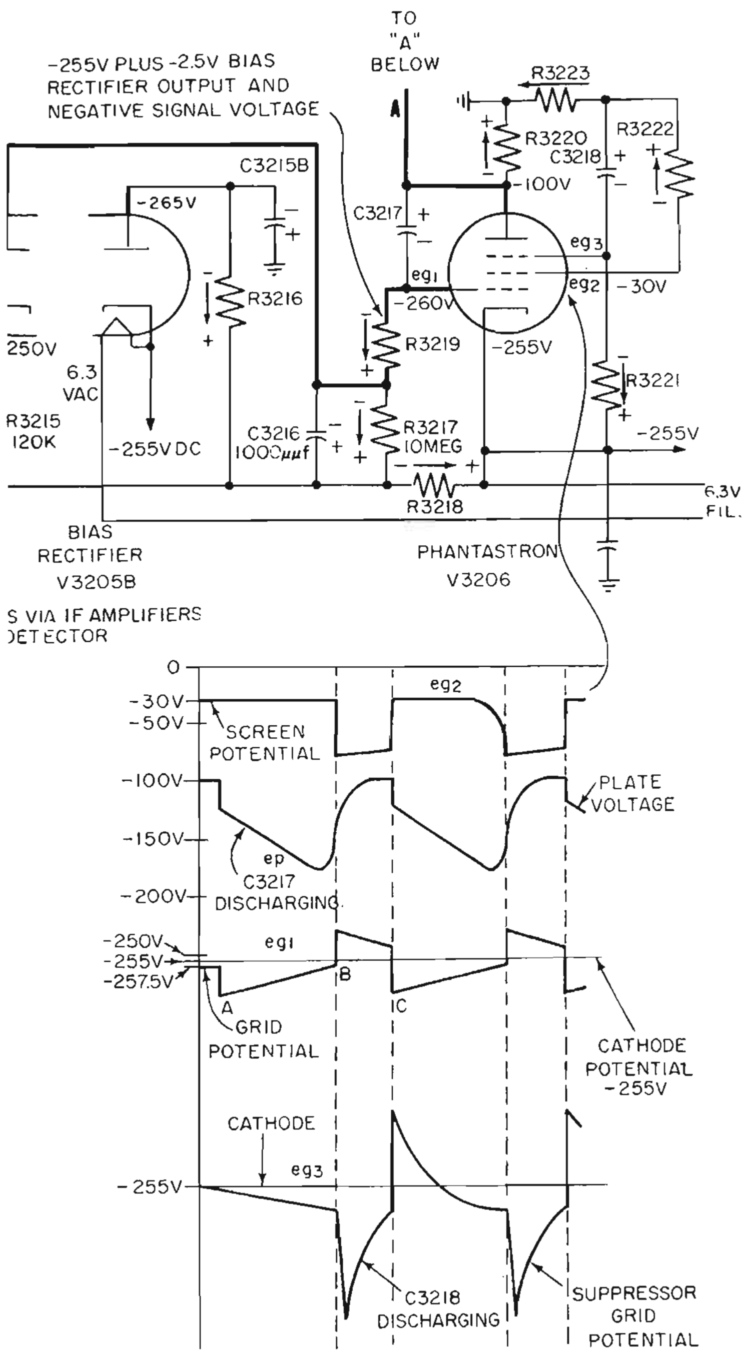
* * * TERMINATE IN 75 OHMS AT THE OSCILLOSCOPE.

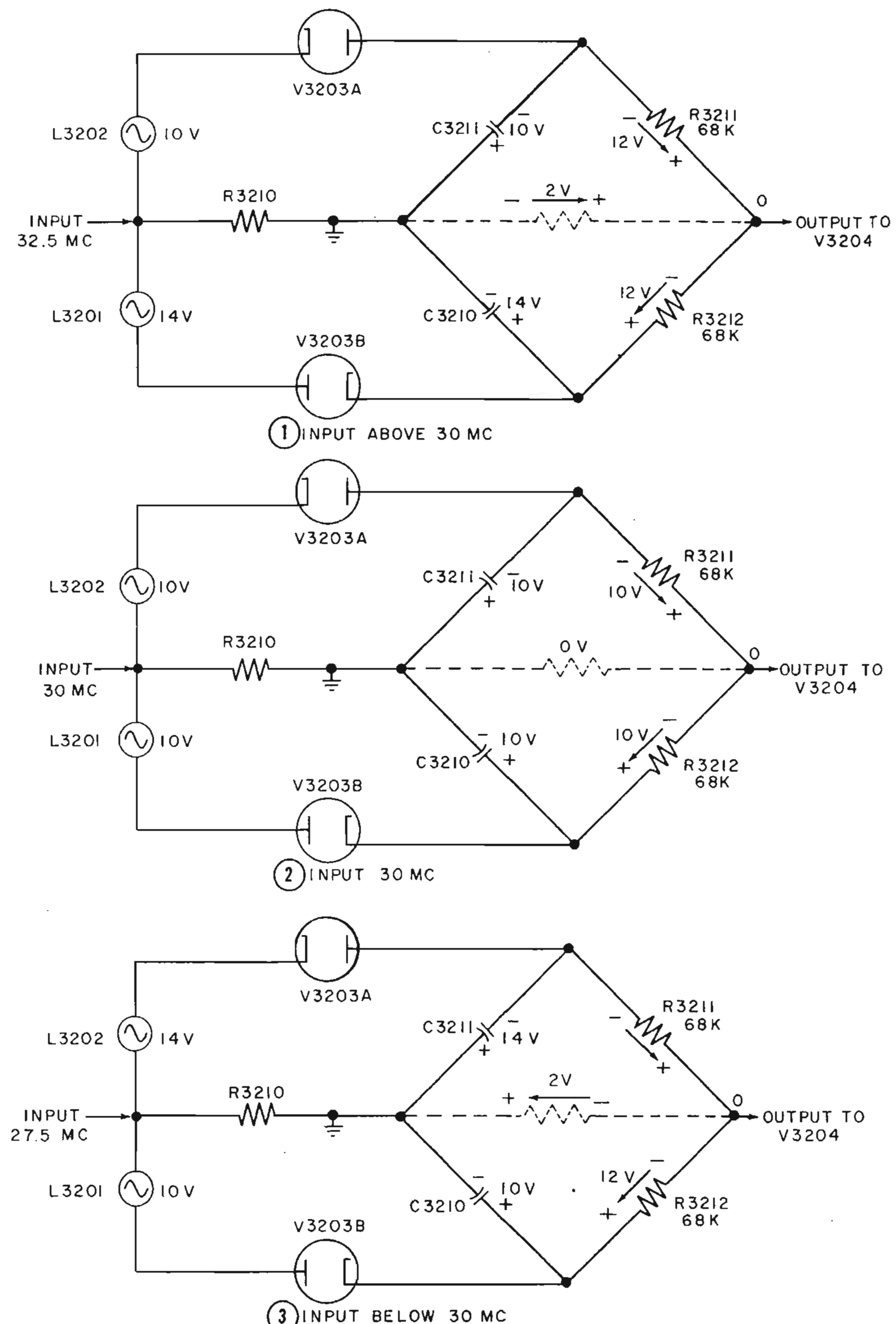
Figure 11-4.—Receiver-transmitter and indicator adapter detailed block diagram. 32.191


RADAR AFC
ANTENNA ASSEMBLY
RADAR AFC IF AMPLIFIERS
V3201
V3202
AFC DISCRIMINATOR
V3203A
V3203B
PULSE AMPLIFIER
V3204
PEAK DETECTOR
V3205A
BIAS RECTIFIER
V3205B
+6.3 VAC
PHANTASTRON
V3206
-255 VDC
REC TUNE RESISTANCE NETWORK
K3302 AFC RELAY
R3303 REC TUNE
REPELLER
KLYSTRON RADAR LOCAL OSCILLATOR
V3005
6115
TP3201
TP3202
TP3203
P/J 3004
SLOTTED LINE
CR3002 IN23B RADAR AFC CRYSTAL
RADAR AFC MIXER CAVITY
MIXER ASSEMBLY W3011
RECEIVER CRYSTAL CR3003, IN23B
P/J 3305
BEACON AFC CRYSTAL CR3304
RADAR AFC COUPLER
RADAR AFC CONTROL ATTENUATOR
RADAR AFC CRYSTAL CURRENT ADJUST
BCN XTAL CURRENT ADJ
BEACON REFERENCE CAVITY Z3012
CRYSTAL ADAPTER P/J3006
ECHO BOX S506
ECHO BOX TUNE
ECHO BOX
P/J 3007
P/J 3001
DIRECTIONAL COUPLER
P/J 3002
P/J 3003
RECEIVER CRYSTAL CURRENT ADJUST
KEEP ALIVE VOLTAGE
TR V3002 5865
SHUTTER
SHUTTER MOTER B3002
ATR
V3004
V3003
DUPLEXER W3010
S505 BCN-RADAR
RADAR
BCN
+270 VDC
K3301 BEACON RELAY
V3006 6115
CAP(REPELLER)
BEACON LOCAL OSCILLATOR
SIGNAL INTERMEDIATE FREQUENCY AMPLIFIERS
1ST & 2ND I-F AMPLIFIERS
V301
V302
3RD I-F AMPL
V303
4TH I-F AMPL
V304
5TH I-F AMPL
V305
K302 BAND WIDTH RELAY
6TH I-F AMPL
V306
7TH I-F AMPL
V307
8TH I-F AMPL
V308
CATHODE FOLLOWER
V311A
PLATE DETECTOR
V311B
V312A
V312B
S504 ANTI-JAM
K303 1AGC RELAY
1AGC
BEACON AFC
P/J 3401
PULSE AMPLIFIERS
V3401A
V3401B
V3402A
PEAK DETECTOR
V3403A (V3403B NOT USED)
PHANTASTRON
V3404
TP3403
-255 VDC
BEACON TUNE RESISTANCE NETWORK
K3302 AFC RELAY
R3318 BEACON TUNE
TP3401
TP3402
LONG PULSE (WLP AND NLP)
BEACON PULSE
PULSE AMPLIFIER
V3402B
P/J 3402
TP3404
PULSE TRANSFORMER
T3002
J103
MAIN PULSE FROM MODULATOR (fig.10-7)
P/J3008
V3001
QK235
MAGNETRON
P/J 3101
R3424 FULLY CW
SHORT PULSE (WSP)
STC FLAT R3313
STC MULTIVIBRATOR
V3101A
V3101B
TP3101
TP3102
TP3105
STC
S3303
STC MAG R3310
AMPLIFIER
V3102A
CATHODE FOLLOWER
V3102B
REC GAIN R3305
LIMITER & CLAMPER NETWORK
STC DUR R3308
TP3103
TP3104
LONG PULSE (WLP AND NLP)
S804 SHM
ADAPTER, INDICATOR
FROM MODULAT
115V 60CPS
POW SUPP



32.194 **Figure 11-7.—Radar afc circuit.**





B DISCRIMINATOR BRIDGE ANALYSIS

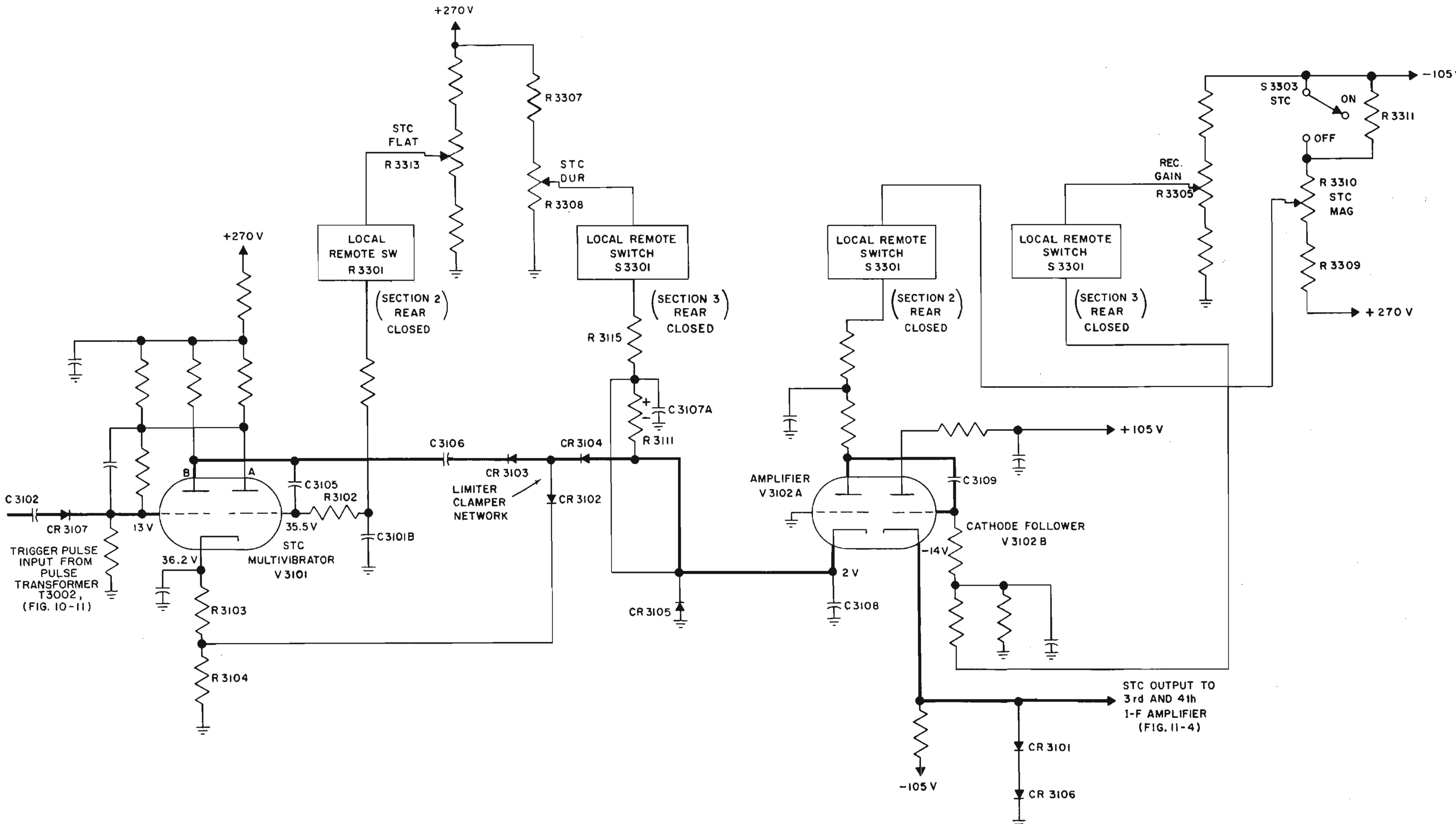
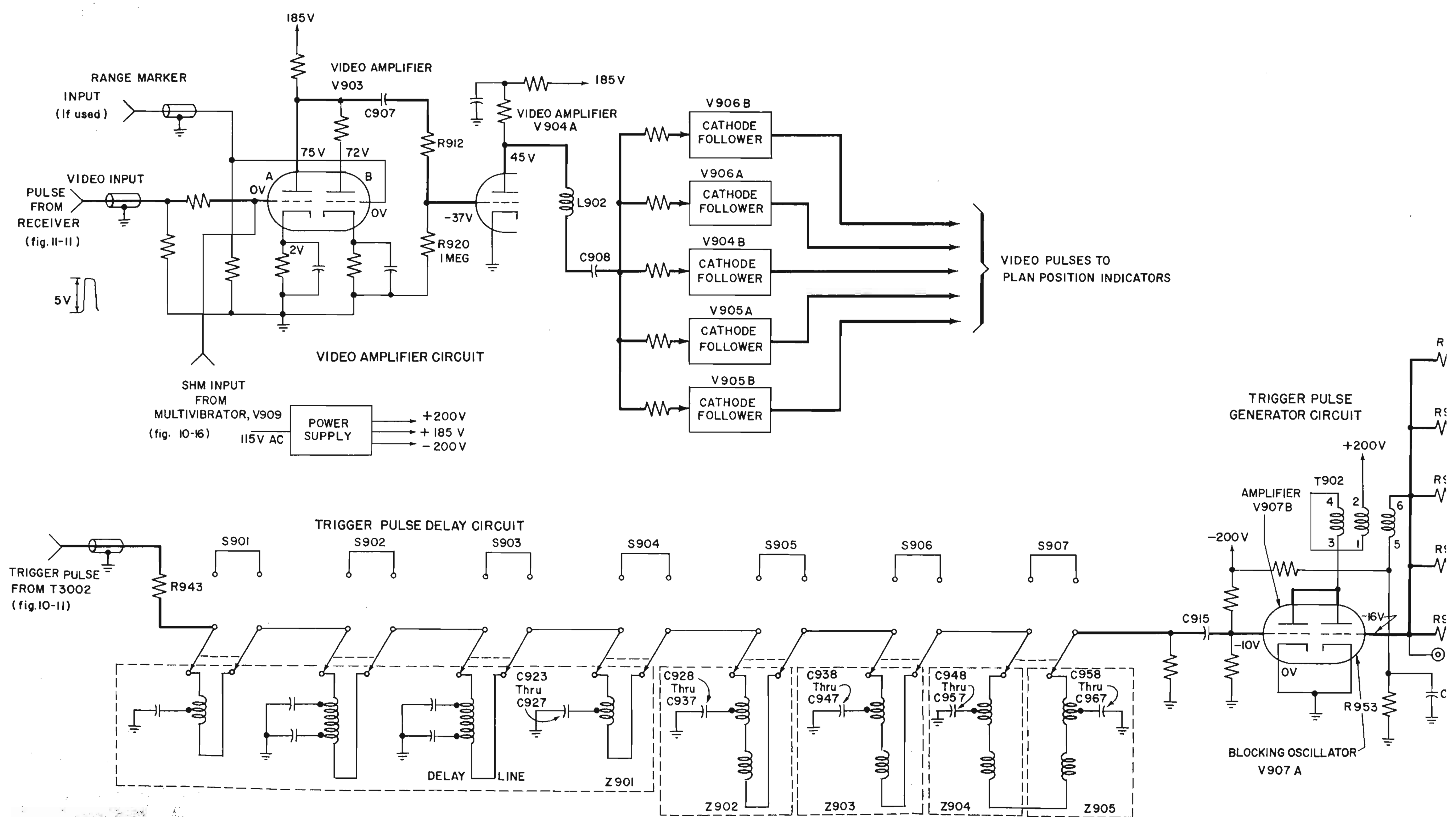
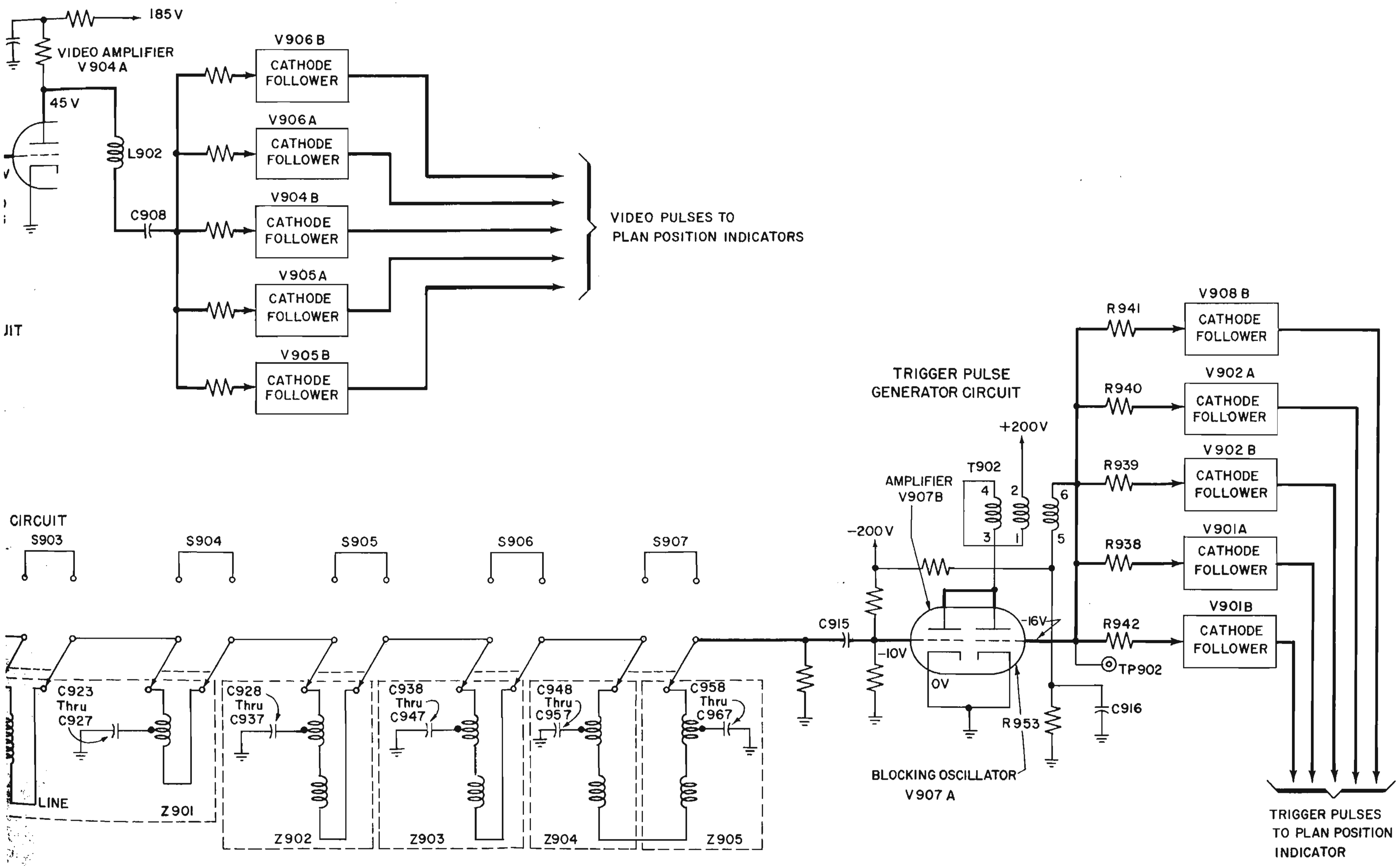


Figure 11-12.—Sensitivity-time-control circuit. 32.199



32.200 **Figure 11-13.—Indicator adapter.**



185 V
VIDEO AMPLIFIER
V904 A
45 V
L902
C908
V906 B
CATHODE FOLLOWER
V906 A
CATHODE FOLLOWER
V904 B
CATHODE FOLLOWER
V905 A
CATHODE FOLLOWER
V905 B
CATHODE FOLLOWER
VIDEO PULSES TO
PLAN POSITION INDICATORS
UIT
CIRCUIT
S903
S904
S905
S906
S907
C923 Thru C927
LINE
Z901
C928 Thru C937
Z902
C938 Thru C947
Z903
C948 Thru C957
Z904
C958 Thru C967
Z905
C915
TRIGGER PULSE
GENERATOR CIRCUIT
+200V
T902
AMPLIFIER
V907B
-200 V
-10V
-16V
0V
R953
C916
TP902
BLOCKING OSCILLATOR
V907 A
R941
V908 B
CATHODE FOLLOWER
R940
V902 A
CATHODE FOLLOWER
R939
V902 B
CATHODE FOLLOWER
R938
V901A
CATHODE FOLLOWER
R942
V901B
CATHODE FOLLOWER
TRIGGER PULSES
TO PLAN POSITION
INDICATOR