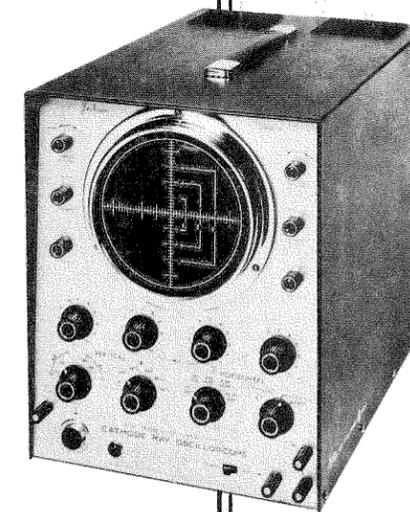


OPERATING INSTRUCTIONS
OSCILLOSCOPE



MODEL
CRO-3

*manufacturers of
"Service Engineered"
Electronic Test Equipment*



Electrical Instrument Company

35 WINDSOR AVE.

MINEOLA, N. Y.

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SPECIFICATIONS

Power Supply Source

Rating—110-120 volts, 50-60 cycle
 Power consumption—(60) watts
 Fuse Protection—1½ amperes

Physical Dimensions

Height (Including handle)—13¼ inches
 Width—10⅛ inches
 Depth—16½ inches
 Weight—18 lb

Tube Complement

1—Type 6C4—Vertical input cathode follower
 2—Type 6J6—Vertical push-pull amplifiers
 1—Type 6C4—Horizontal input cathode follower
 1—Type 6J6—Horizontal push-pull amplifier
 1—Type 6J6—Saw-tooth sweep oscillator
 1—Type 6C4—Retrace blanking amplifier
 1—Type 5UP1—Cathode ray tube
 1—Type 5Y3GT—Low voltage rectifier
 1—Type 5Y3GT—High voltage rectifier

Amplifier Frequency Response

Vertical—Amplifier set for Wide Band operation.
 Sine wave response uniform within 10% from 20 cycles to 4.5 megacycles.
 Vertical—Amplifier set for High Sensitivity. Sine wave response uniform within 10% to 100 kc., down not more than 25% at 200 kc., down not more than 50% at 300 kc.
 Horizontal amplifier—Sine wave response uniform within 25% from 20 cycles to 100 kc., down not more than 50% at 200 kc.

Input Impedance

Vertical amplifier—1.5 megohms, shunted by 25 mmf.
 Horizontal amplifier—1.1 megohms.

Deflection Factor

Vertical amplifier, High Sensitivity—.018 volt R.M.S. sine for 1 inch peak-to-peak deflection.
 Vertical amplifier, Wide Band—0.25 volt R.M.S. sine for 1 inch peak to peak. Attenuation factors of 10 and 100 available for both High Sensitivity and Wide Band.
 Horizontal amplifier—0.40 volt R.M.S. for 1 inch peak-to-peak deflection. Attenuation factor of 10 available.

Horizontal Sweep

Frequency range 20 cycles to 50 kilocycles.
 Synchronizing signal sources
 Internal (vertical signal) (+)
 Internal (vertical signal) (-)
 External
 60 cycle
 120 cycle

Maximum Signal Inputs

AMPLIFIER
 Peak AC plus DC 600 volts
 Max. AC 600 volts R.M.S.
 DEFLECTION PLATES DIRECT
 Peak AC plus DC 400 volts
 Max. AC 200 volts R.M.S.
 EXTERNAL SYNC.
 Peak AC plus DC 400 volts
 Intensity modulation

FUNCTIONS OF OPERATING CONTROLS

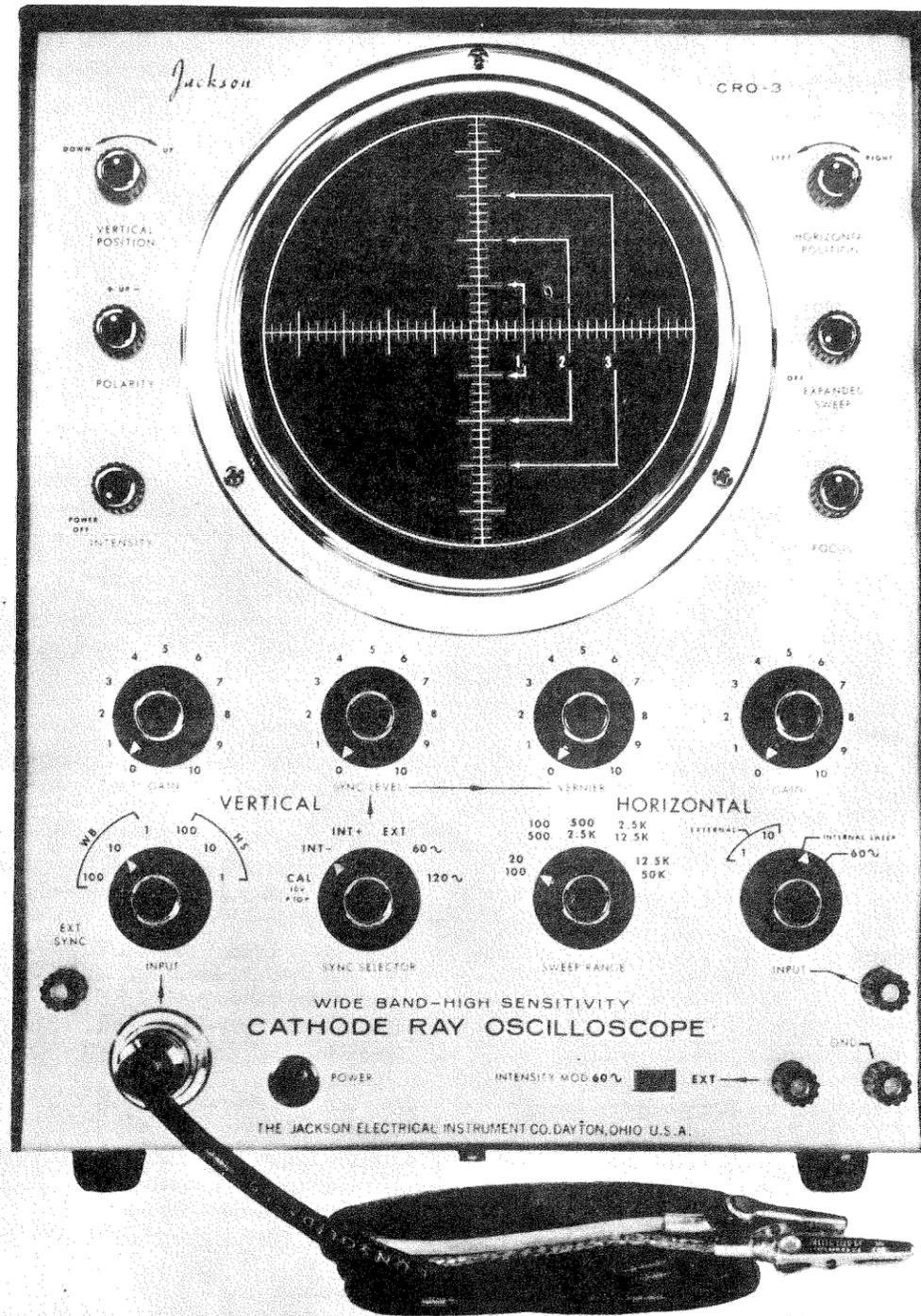


Fig. 1. Operating control of Model CRO-3 oscilloscope.

Beam Controls

- 1. Intensity Control**
The Power Off-On switch is off when the control is in the extreme counterclockwise position. The switch is turned on and the brilliance of the trace is increased as the control is rotated in the clockwise direction.
- 2. Focus Control**
Adjusts the sharpness of the trace.
- 3. Vertical Position Control**
Moves the position of the trace up or down on the screen.
- 4. Horizontal Position Control**
Moves the position of the trace to the right or left on the screen.
- 5. Polarity Control**
When in + position a positive signal moves the trace up. When in - position a negative signal moves the trace up.

Vertical Input and Controls

- 1. Vertical Input**
Vertical input connections are made to alligator clips on Vertical Input cable. Input clip is on the insulated lead in the cable. The ground clip is on the shield.
- 2. Vertical Input Switch**
Provides two modes of operation—WB (Wide Band) for reproducing waveforms of signals containing a wide band of frequencies, and HS (High Sensitivity) for increased sensitivity to the signal with some decrease in frequency response. Each mode is provided with three steps (100-10-1) of attenuation.

Horizontal Input and Controls

- 1. Horizontal Input**
Input is made to INPUT (top) terminal. Ground is made to GND (bottom) terminal.
- 2. Horizontal Input Switch**
Switches input for:
EXTERNAL—Input with two steps of attenuation.
INTERNAL SWEEP—Saw-tooth sweep.
60~—Internal 60 cycle line frequency sweep.
- 3. Horizontal Input Gain Control**
Gives continuous control of input for each position of Horizontal Input Switch.

Sweep Circuits

- 1. Horizontal Sweep Range Switch**
Selects horizontal sweep frequencies in five steps over a range of 20 cycles to 50 KC.

Obtaining the Trace

- 1. The CRO-3 should be placed in a convenient position where the screen is in full view of the operator. The trace will be much easier to observe**

- 2. Horizontal Sweep Vernier**
Provides fine adjustment for each position of the Horizontal Sweep Range Control.
- 3. Sync Selector**
This six-position switch selects sync signals or calibrating voltage.
Position 1. 10 volt peak-to-peak calibrating voltage.
2. Negative internal sync signal.
3. Positive internal sync signal.
4. External sync signal.
5. 60 cycle line frequency sync signal.
6. 120 cycle sync signal.
- 4. Sync Level Control**
Adjusts level of sync signal to "lock-in" the sweep frequency.
- 5. External Sync Input**
EXT SYNC terminal on the front panel for connecting the source of external sync signal.
- 6. Expanded Sweep Control with OFF-ON Switch**
Expands the trace in horizontal direction when internal sweep is used. The switch is off when the control is in the extreme counterclockwise position.

Intensity Modulation

- 1. Intensity Modulation Switch**
Applies 60 cycle line frequency voltage to the cathode ray tube when in the 60~ position. Applies external modulating signal to CRT when in the EXT position.
- 2. EXT Terminal**
For connection of external intensity modulation signal.

Direct Deflection

Direct connection (through blocking capacitors) to the cathode ray tube deflection plates are made to terminal boards on the rear of the CRO-3 (Fig. 2). To make direct connection to deflection plates remove jumpers and connect signal source to inside pair of terminals.

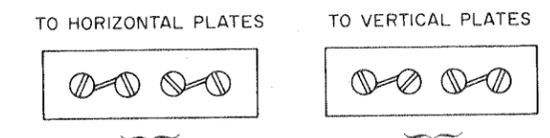


Fig. 2. Rear terminal boards.

OPERATING INSTRUCTIONS

- 1. if a minimum of external light is allowed to shine on the face of the cathode-ray tube.**
- 2. The controls are set as follows:
INTENSITY control set to POWER OFF.
FOCUS control to center of range.**

HORIZONTAL POSITION control to center of range.

VERTICAL POSITION control to center of range.

POLARITY control to + UP.

VERTICAL INPUT switch to WB 10.

VERTICAL GAIN control on 0.

SYNC SELECTOR to INT +.

SYNC LEVEL control to 0.

SWEEP RANGE switch to 20-100.

VERNIER control to 5.

HORIZONTAL INPUT switch to INTERNAL SWEEP.

HORIZONTAL GAIN control to 5.

INTENSITY MOD to EXT.

EXPANDED SWEEP to OFF.

3. Plug the line cord into a 110-120 volt, 60 cycle AC outlet.

4. Turn the Intensity control clockwise until the Power switch turns on. Allow the CRO-3 to warm up for at least 30 seconds. Then turn the Intensity control further clockwise until a horizontal trace appears on the screen. If the trace does not appear or is not centered, adjust the Vertical Position control until the trace is centered on the screen.

CAUTION: A small high intensity spot should never be allowed to remain motionless on the screen. The screen of the cathode ray tube may be discolored or burned if this precaution is not observed. To extend the useful life of the cathode ray tube, the Intensity control should always be adjusted for the lowest brightness level of the trace that will provide satisfactory visibility.

5. Adjust the Focus control to make the trace as sharp as possible. If it is now necessary to re-adjust the Intensity control to restore the brightness of the trace, re-adjustment of the Focus control may also be necessary. Note that the Intensity and focus controls interact and when one is adjusted the other will usually also have to be adjusted.

6. Turn the Vertical Position control clockwise to move the trace up, counterclockwise to move the trace down.

7. Turn the Horizontal Position control clockwise to move the trace to the right, counterclockwise to move the trace to the left.

8. Connect the clips of the Vertical Input cable to a source of 6.3 volts, 60 cycle AC for a test signal. Turn the Vertical Gain control clockwise to produce vertical deflection and increase the height of the trace on the screen. Turn the Vernier control to produce the desired number of sinewaves. Turning counterclockwise to increase the number.

9. Turn the Sync Level control clockwise to make the trace stand still on the screen. Do not advance the Sync Level control beyond the position where the trace stands still or "locks in". Applying too much synchronizing voltage has a tendency to disturb stability.

Horizontal Frequency Control

The number of cycles or waveforms displayed on the screen is controlled by the settings of the Hori-

zontal Sweep Range switch and the Vernier control. These two controls determine the frequency (25 cycles to 50 kc) at which the horizontal sweep generator operates.

Expanded Sweep

The expanded sweep feature permits the linear center portion of the trace to be made wider (expanded horizontally) by approximately four times for more detailed observation of the waveform, when internal sweep is used.

Turn the Expanded Sweep control in a clockwise direction to turn on the switch which expands the trace. Rotate the control to center the linear portion of the waveform on the screen.

CAUTION: The Sweep Expander control must always be in the OFF position at all times except when the sweep expander is in use.

Intensity Modulation

Intensity Modulation brightens certain portions of the trace while reducing the brightness of other portions. This feature is valuable in applications such as blanking out the return trace and in adding markers of brighter intensity.

A 60 cycle sinewave is applied to the grid of the cathode ray tube when the Intensity Modulation switch is in the 60 \sim position. When the switch is in EXT position, any modulating voltage connected to the Intensity Modulation binding post will be applied to the grid of the CRT.

CAUTION: A signal large enough to swing the grid of the CRT positive with respect to the cathode should never be applied. Such a condition may shorten the life of the CRT. This condition can be recognized by the marked defocusing of the trace during the bright phase of the modulating signal.

Calibration

Peak-to-peak voltage measurements are made by comparing the height of the trace made on the screen by the AC voltage being measured, with the height of the calibrated trace displayed on the screen when the Sync Selector switch is in the CAL 10V P to P position.

To calibrate the CRO-3, with controls set as in Step 2 under "Obtaining the Trace" turn the Sync Selector switch to CAL 10V P to P, the Vertical Input switch to HS 10, and adjust the Vertical Gain control to produce a 1 inch (10 lines) high trace on the screen. This sets up the calibration gain so the sensitivity is 10 volts peak-to-peak per inch or 1 volt for each line or division on the screen.

Do not disturb the Vertical Gain control after this calibration has been made. If adjustments are necessary to obtain a satisfactory trace size while making voltage measurements, change the setting of the Vertical Input switch instead. This changes the vertical input but does not disturb the calibration.

With the CRO-3 calibrated as above, changing the Vertical Input switch changes the ratio as follows:

Vertical Input Ratio	Deflection per Inch	Deflection per Division
1	1 volt	0.1 volt
10	10 volts	1 volt
100	100 volts	10 volts

The calibration of the WB (Wide Band) section of the Vertical Input switch is accomplished in the same manner as the calibration of the HS (High Sensitivity) section. Then the number of vertical divisions would be multiplied by 0.1. For example: 15 divisions would be $15 \times 0.1 = 1.5$ or 1.5 volts peak-to-peak.

APPLICATIONS OF THE CRO-3

Testing Audio Amplifiers

An oscilloscope's ability, to make many characteristics of a complex audio signal visible on its screen, makes it a valuable test instrument for anyone working with audio equipment. Tests can be made for distortion, frequency response, stability, phase shift, and overloading.

Testing an Amplifier for Distortion

A high percentage of distortion in an amplifier will be seen on the screen of the oscilloscope as a

visible difference in the waveform of the output signal when compared with the input signal. An audio signal generator, which will generate an undistorted sine wave over the range of frequencies covered by the amplifier, must be used to supply the test signal.

Connect the generator, amplifier and CRO-3 as shown in Fig. 3.

If the amplifier distorts the signal, the trace on the screen may look like one of those shown in Fig. 4A, B, or C. A indicates considerable second harmonic distortion, B odd harmonic distortion, and C clipping

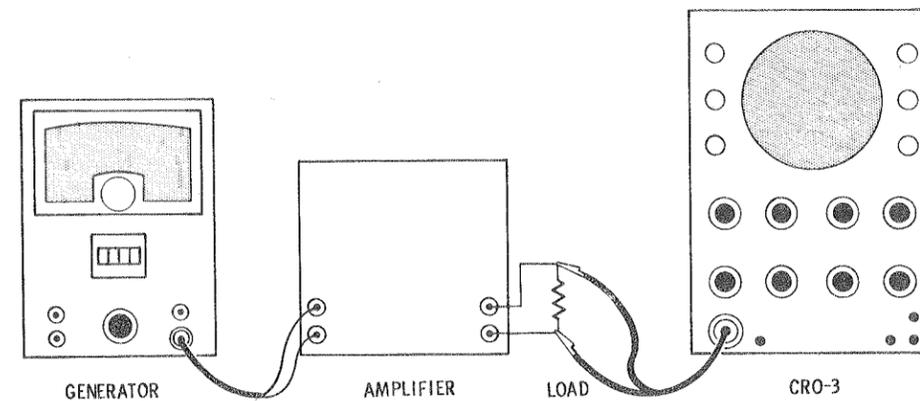


Fig. 3. Connections for checking audio amplifier.

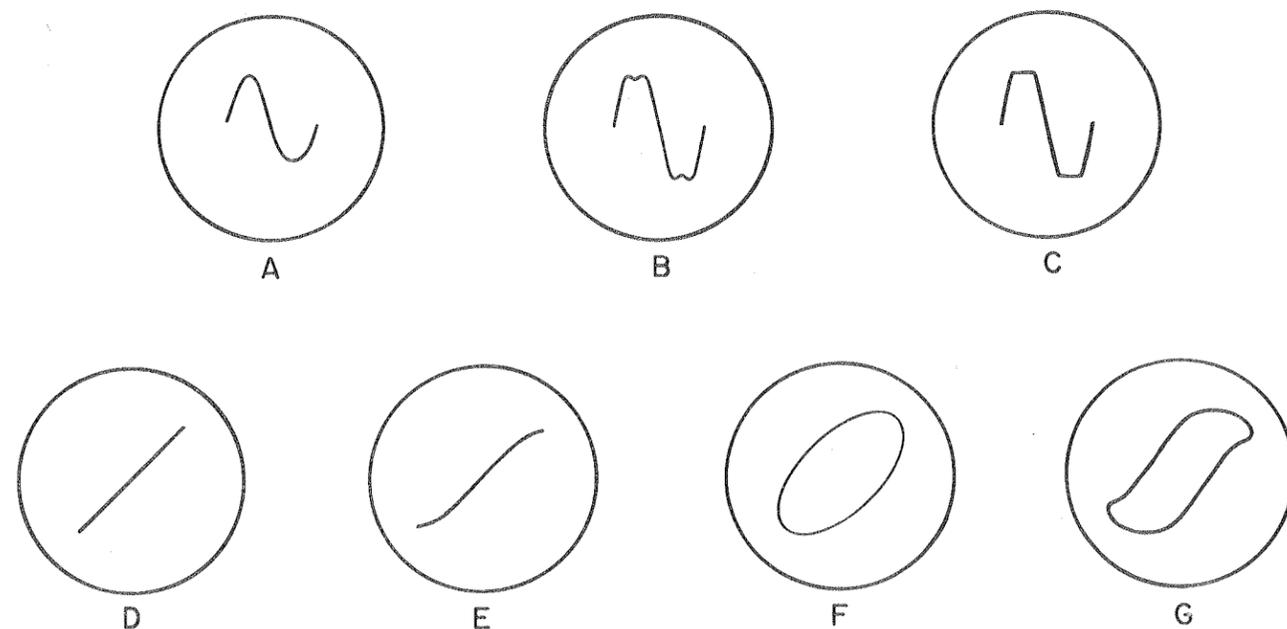


Fig. 4. Distortion and phase shift patterns.

of the signal due to overloading in some amplifier stage.

With the signal generator connected as in the preceding distortion test an additional connection can be made from the output of the signal generator to the horizontal input terminals of the CRO-3 to make more distortion and phase tests. Connecting the signal generator output to the horizontal input terminals on the CRO-3 and setting the Horizontal Input control to Internal Sweep should produce a normal sine wave on the screen. Adjust the signal generator and CRO-3 controls if necessary.

Turn the Horizontal Input control to External using the attenuator setting 1 or 10 and Horizontal Gain setting for a trace similar to those in Fig. 4D thru G.

- D—No distortion and no phase shift.
- E—Distortion with no phase shift.
- F—No distortion with phase shift.
- G—Distortion with phase shift.

Peak-to-Peak Voltage Measurements

To make a peak-to-peak voltage measurement after the calibration has been made as previously described, turn the Sync Selector switch from the CAL 10V P to P and connect the voltage to be measured to the Vertical Input cable. If the trace is of a convenient vertical size, count the number of divisions covered and, in this case since the Vertical Input switch is on HS 10, the number will be the peak-to-peak volts.

If the trace had been too high and the Vertical Input switch had to be turned to HS 100, then the number of vertical divisions covered, 15 for example, would be multiplied by 10 and the peak-to-peak voltage would be 150.

If the trace was too small to count divisions and the Vertical Input switch was turned to HS 1, then

the number of vertical divisions would be multiplied by 0.1. For example: 15 divisions would be $15 \times 0.1 = 1.5$ or 1.5 volts peak-to-peak.

AC Current Measurement

Alternating current measurements can be made on an oscilloscope if the current to be measured is changed to voltage. This can be done by inserting a low-resistance, non-inductive resistor in series with the current. The value of the resistor must be kept low or the current flow in the circuit will be disturbed and the indication on the CRO-3 will not be the true value.

The peak-to-peak voltage developed across the resistor is measured as described under "Peak to Peak Voltage Measurements", and the current calculated, using ohm's law $I = \frac{E}{R}$. The current value obtained is peak-to-peak and can be converted to rms. The relationship between rms, peak and peak-to-peak values of sine waves is as follows:

$$\begin{aligned} \text{rms} &= .707 \times \text{peak value} \\ \text{peak} &= 1.414 \times \text{rms value} \\ \text{rms} &= .3535 \times \text{peak-to-peak value} \\ \text{peak-to-peak} &= 2.828 \times \text{rms value} \\ \text{peak-to-peak} &= 2 \times \text{peak value} \end{aligned}$$

Phase Measurement

The phase difference between two signals of the same frequency can be determined from Lissajous figures, obtained by feeding one signal into the vertical input of the CRO-3 and feeding the second signal into the horizontal input. The figure on the screen will be a straight line (Fig. 5A) slanting up from left to right, if the signals have exactly the same phase. The trace will change from a straight line to a narrow ellipse if the phase between the signals

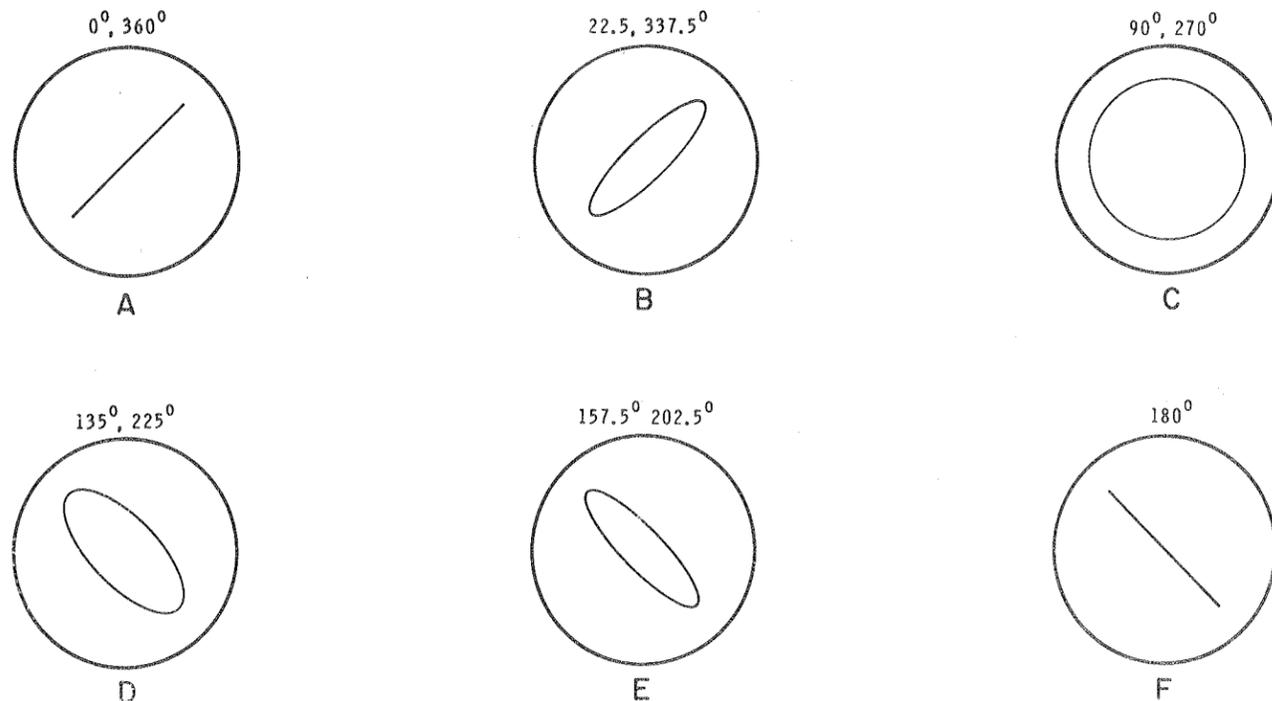


Fig. 5. Phase difference between two signals.

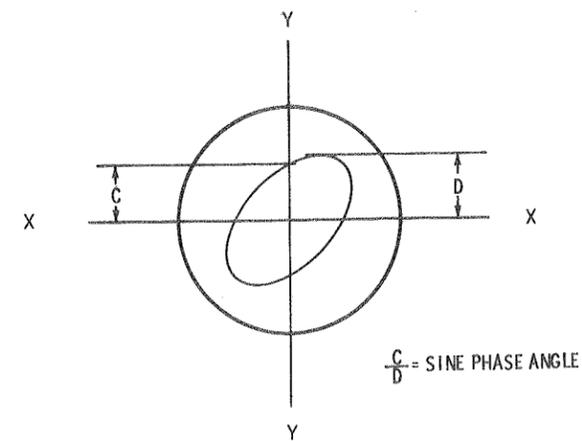


Fig. 6. Method for calculating phase angle.

change. With an increase of phase difference, the ellipse will broaden until at a difference of 90° it becomes a circle (Fig. 5C). With a further increase in phase shift the circle will change to an ellipse, at a phase difference of 180° , and becomes a line tilted in the opposite direction as shown in Fig. 5F. As can be seen in Fig. 5, if the phase difference is changed through 360° , the same figure is seen two times. For example: the pattern at 22.5° is the same as the 337.5° , and 135° is the same as at 225° .

The approximate phase difference for each pattern is shown in Fig. 5. A method for calculating phase difference is shown in Fig. 6. The ellipse should be centered on the grid lines of the CRO-3 calibration screen and the distances C and D measured as shown in Fig. 6. The values of C and D are substituted for C and D in the formula to obtain the sine of the phase angle. The phase angle can then be found by locating this value in a table of sines.

Measurement of Frequency

The frequency of a signal can be determined in several ways with an oscilloscope. They are:

1. Direct comparison of the unknown frequency with a known frequency. Most easily done by means of an electronic switch.
2. With Lissajous figures.
3. Beating the unknown signal with a known frequency and viewing the beat frequency.

The amplifiers in the oscilloscope must have a response effective at the frequencies involved. So methods 1 and 2 are most satisfactory for measuring audio frequencies on up to the lower radio fre-

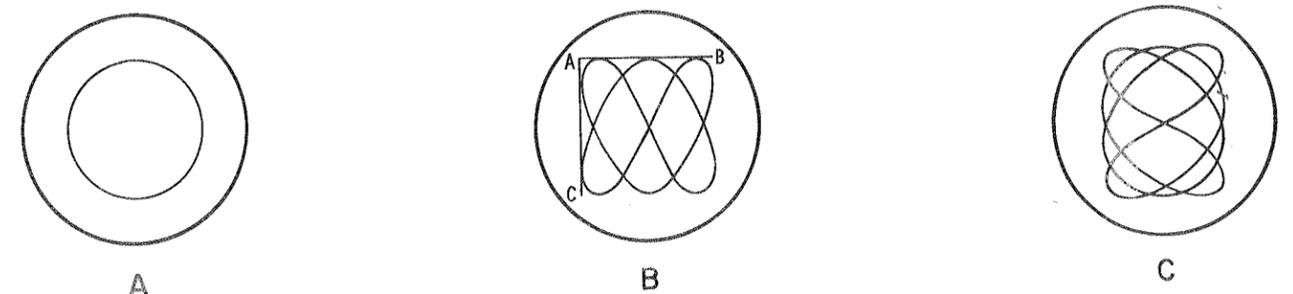


Fig. 8. Frequency ratios shown by Lissajous figures.

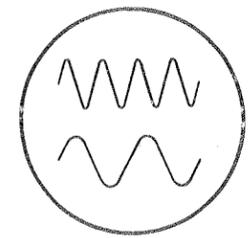


Fig. 7. Frequency comparison of two signals.

quencies. The beat method (3) is suitable for the higher frequencies.

Direct Comparison Method

When using the direct comparison method using an electronic switch, the known frequency is fed into one input of the electronic switch and the unknown frequency to the other. The output from the electronic switch is fed to the vertical input of the CRO-3, and two traces will be seen, with one signal displayed on one trace and the other signal displayed on the other trace as in Fig. 7. Here, if the upper trace represents the unknown signal, it is evident that its frequency is twice that of the known signal. Therefore, it is only necessary to read the frequency of the known signal direct from the generator and multiply by two to obtain the frequency of the unknown signal.

Lissajous Figures Method

When checking frequency with Lissajous figures, the unknown frequency is fed to the vertical input of the CRO-3 and a known frequency is fed to the horizontal input. Lissajous figures are obtained by feeding two sine-wave signals into an oscilloscope—one into the vertical input and the other into the horizontal input. The resulting figure is a direct indication of the ratio between the two frequencies. If one of the frequencies is known, the other can be determined by means of this ratio. The circular trace in Fig. 8A represents a 1:1 ratio. Other ratios are found as shown in Fig. 8B, where a horizontal line AB is drawn across the top of the waveform and a vertical line AC is drawn down the left side. Each loop of the trace touching line AB represents a vertical excursion of the oscilloscope trace, and each loop touching line AC represents a horizontal excursion. So in Fig. 8B, three cycles of vertical and two cycles of horizontal make a ratio of 3:2. With one frequency known the other can be calculated easily from this ratio. Fig. 8C has a 3:4 ratio, three vertical and four horizontal.

The Beat Method

The beat method is used for high frequencies. Both the known and unknown frequencies are fed into a detector and the output fed into the vertical input of the oscilloscope. The generator supplying the known frequency is tuned until the frequencies are equal as indicated by zero beat on the screen. The unknown frequency can then be read from the dial of the known frequency generator.

Checking Frequency Response

Frequency response of an amplifier can be measured using the equipment employed in making the distortion tests. Keep the output of the signal generator at a constant amplitude while operating it at selected frequencies covering the range of the ampli-

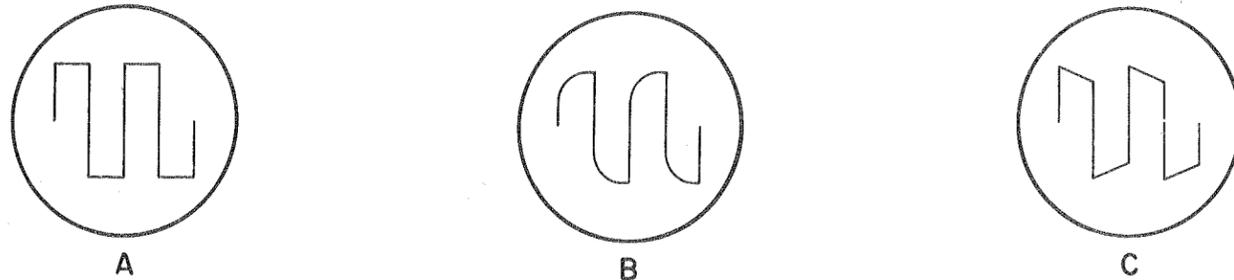


Fig. 9. Effects of frequency response when testing with square waves.

fier. Using the calibration feature of the CRO-3, measure the output of the amplifier at the different frequencies. A frequency response curve will result when these measured values are plotted on a graph.

Checking Amplifier Frequency Response with Square Waves

A square wave generator can be connected in the test hookup, in place of the sine wave generator, to check the frequency response of the amplifier. Square waves, of a frequency ranging from about 60 to 2000 or 3000 cycles, are fed into the amplifier. The lower frequency square waves give a severe test of the low frequency responses while the higher frequencies check the extreme high frequency response.

Fig. 9A shows the square wave fed into the input of the amplifier. The CRO-3 input cable connected to the output terminals of the square wave generator.

Fig. 9B is the waveform seen on the screen with not audible since they are too high in frequency, but

the CRO-3 connected to the output of an amplifier deficient in high frequency response. This is indicated by the rounding off of the leading corners of the square wave.

The tilt toward the following edge of the square waves (Fig. 9C) indicates a deficiency in low frequency amplifier response.

These are relative tests and are very useful in giving quick response and comparison checks. Results are not directly measurable in db or other units.

Testing with Square Waves, Instability

The following waveforms may be encountered when making square wave tests. Fig. 10A shows instability in the waveforms caused by the amplifier being shocked into momentary oscillation by the steep front of the square wave. Such oscillations are

they do indicate border line instability. They may not appear when sine waves or normal audio signals are amplified.

Fig. 10B shows constant oscillation in the amplifier at frequencies above audibility. These oscillations may not appear with normal audio signals but can effect the operation of the amplifiers, especially while amplifying complex signals.

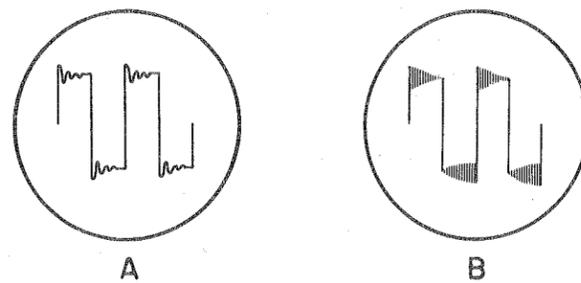


Fig. 10. Effects of amplifier instability.

ALIGNMENT OF TV RECEIVER

The advantage of being able to see on the screen what is happening while aligning a TV receiver makes the process faster and more accurate. The complete response curve is seen on the screen and the effect of any adjustments upon the entire response is noticed immediately. Conditions such as undesirable oscillations and effects of overloading,

indicated only as readings on a meter, can be seen and recognized on the oscilloscope.

A sweep generator is required to supply the signal for alignment. Marker signals, needed to mark important frequencies on the response curve, are usually supplied by the sweep generator. If not, a separate marker generator is required. In some

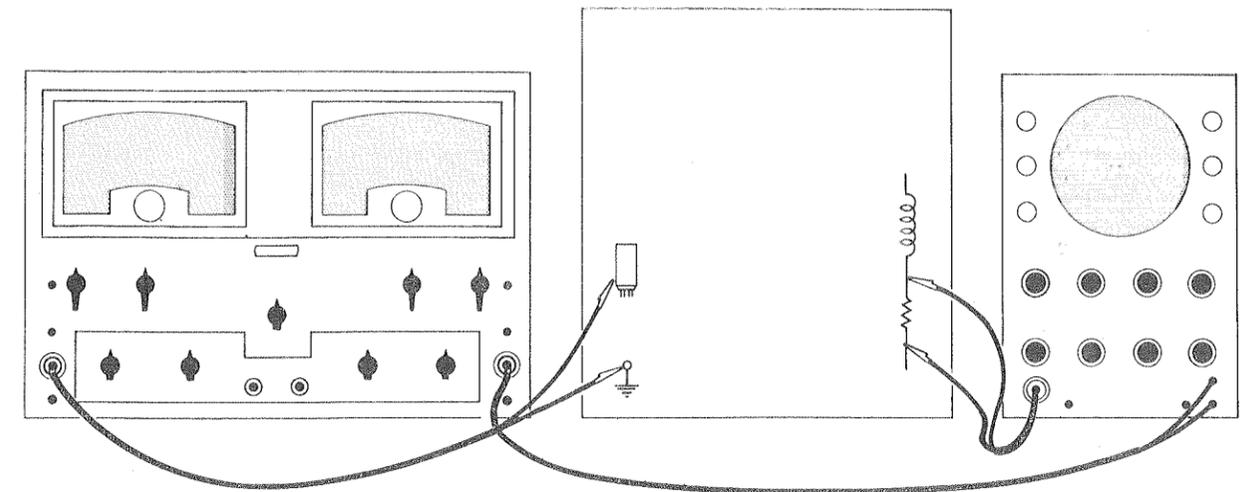


Fig. 11. Connections for alignment of TV receiver.

cases, if the signal is not detected in the TV receiver, a detector probe must be used on the vertical input cable of the oscilloscope. Most routine alignments will be made without a detector probe since the signal will be detected in the mixer and video detector stages.

The manufacturer usually supplies information as to where to connect the sweep generator and oscilloscope. Also where and how much negative voltage is to be applied to clamp the AGC circuit so adjustments will not be nullified by the AGC action. A typical alignment setup is shown in Fig. 11.

1. The output (hot lead) of the sweep generator is connected to an ungrounded shield on the mixer tube in the TV tuner. The ground lead (shield) of the output cable is connected to the chassis near the mixer tube.

The tube in the mixer stage is one from which the oscillator grid pin has been removed to disable the tuner oscillator. This is done to eliminate interference from outside TV signals. If the oscillator is not disabled, the TV receiver should be tuned to an unoccupied channel to eliminate outside interference as much as possible.

2. The synchronized sweep output of the sweep generator is connected to the horizontal input terminals on the CRO-3.

3. The insulated lead of the vertical input cable is connected to the high side of the video load resistor. The shield lead of the cable is connected to the ground side. The exact place to make the connection is usually indicated in the service information supplied for the TV receiver.

4. A marker generator is connected if marker signals are not supplied by the sweep generator.

5. A battery or bias supply is connected to the AGC line to clamp the AGC action. Required voltage and information as to where to connect it in the circuit is usually supplied in the service information. The equipment and TV receiver should be turned on and allowed to warm up for at least 20 minutes before making the alignment.

6. The sweep generator is set to the frequency and sweep indicated in the alignment instructions and only enough output used to provide a usable indication on the screen.

7. Marker frequencies are set as indicated in the alignment instructions and only enough output used to make the marker points usable. Too much marker output distorts the response curve.

8. Following the alignment instructions, the adjustments are made in correct order for maximum gain and symmetry of response similar to the typical response curve shown for the TV receiver. A typical response curve with frequencies indicated, is shown in Fig. 12.

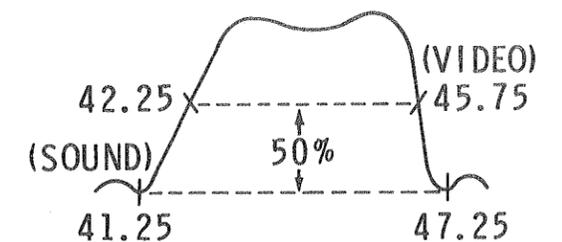


Fig. 12. Video IF response curve.

ALIGNMENT OF FM RADIO RECEIVER

An FM radio receiver must be aligned properly to produce the wide range undistorted reception of which it is capable. Proper alignment can be made accurately and quickly with an oscilloscope and sweep generator. The procedure to be followed in making the alignment is usually supplied in the service information supplied for an FM receiver.

The following are some typical steps to be made in aligning the IF and detector stages of an FM receiver with the CRO-3:

1. Connect the hot lead of the sweep generator to an ungrounded shield on the converter tube in the receiver. Connect the ground lead to the chassis.
2. The insulated lead of the vertical input cable of

the CRO-3 is connected to point C as shown in Fig. 13A. The ground lead is connected to the chassis

The receiver, sweep generator, and CRO-3 should be turned on and allowed to warm up for at least 20 minutes.

- The sweep generator is set for the frequency, sweep, and modulation indicated in the alignment instructions for the receiver. Usually these will be 10.7 mc with a 450 kc sweep and modulated at 60 cycles. If the sweep generator supplies marker frequencies, the marker will be set at 10.7 mc.
- The CRO-3 is put into operation as described in the Operating Instructions. The Horizontal Input switch is set on External 1 or 10. The Horizontal Input is connected to synchronized sweep from sweep generator.
- The 10 mfd stabilizing capacitor in receiver is disconnected to make the adjustments more evident on the screen.
- Adjust the primary of the ratio detector transformer and the primaries and secondaries of the IF transformers for maximum gain and symmetry of a response curve similar to that in Fig. 13B.
- Reconnect the stabilizing capacitor.
- Connect the insulated lead of the vertical input cable of the CRO-3 to point D as shown in Fig. 13.
- Adjust the secondary of the ratio detector transformer for the straightest and best centered response as shown in Fig. 12C. If a 10.7 mc marker is used it should be located in the exact center of the straight portion of the curve. The primary adjustment should be retouched

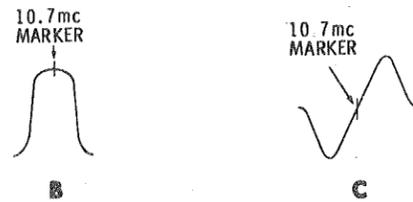
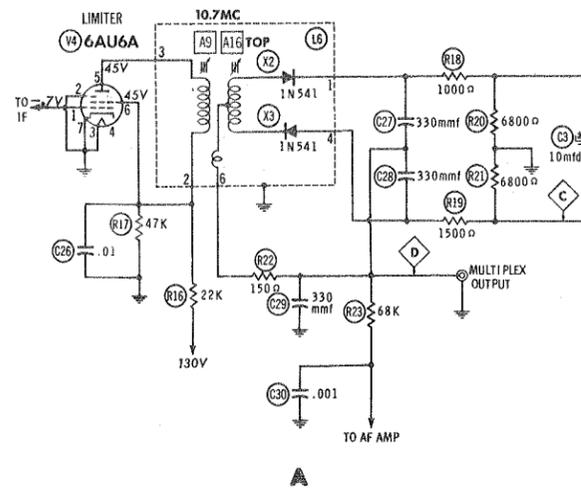


Fig. 13. Ratio detector circuit of FM receiver and typical alignment curves.

slightly for maximum amplitude and straightness of the curve. Since the secondary and primary adjustments are interactive, they should be repeated several times with the secondary being adjusted last.

SIGNAL TRACING TV RECEIVERS

Signal tracing a TV receiver by using an oscilloscope to look at the waveforms obtained at different points in the circuit, is one of the most effective and fast methods of isolating trouble. Most service information supplied for TV receivers shows waveforms, with peak-to-peak voltage and frequency, to be found at definite points in the receiver when operating normally. The following paragraphs and illustrations give examples of typical waveforms to be found in specific circuits.

Video IF Stages

A Jackson CRO demodulator probe is used with the CRO-3 when signal tracing the IF section of a TV receiver. The vertical input switch is set on HS1 and the sweep range switch set on 20-100.

A typical video IF stage, with normal waveforms, is shown in Fig. 14. The demodulator probe is connected to each point indicated in Fig. 14. The ground clip is connected to the chassis near the point being checked. The signal can be traced through the IF section by connecting the probe to each succeeding video IF stage. The demodulator probe may load the circuit to some extent so that the gain of each IF stage may not be apparent, but the presence of the signal can be traced quickly from stage to stage.

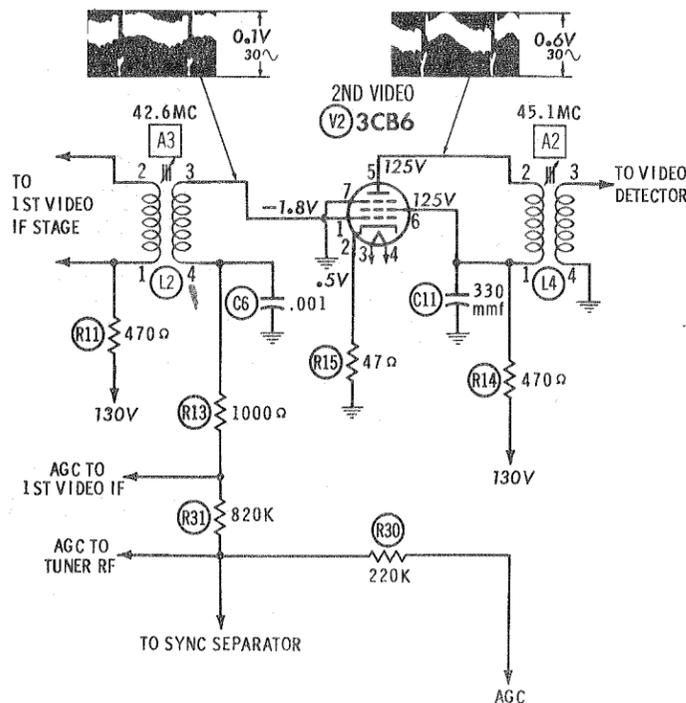


Fig. 14. Video IF stage.

Video Amplifier

The LC10-1P low capacity probe is used with the CRO-3 when signal-tracing a video amplifier stage. The vertical input switch is turned HS 1, 10 or 100 as required to obtain a waveform of suitable size on the CRO-3 screen. The sweep range switch is set on 20-100.

A typical video amplifier stage is shown in Fig. 15. The waveforms shown are typical of those found at the points indicated. The signal can be traced from the input of the video amplifier stage to the output at the picture tube cathode by connecting the probe at the points shown. The waveforms will be similar and the gain in signal strength should be apparent when the probe is moved from the input to the output of the amplifier stage.

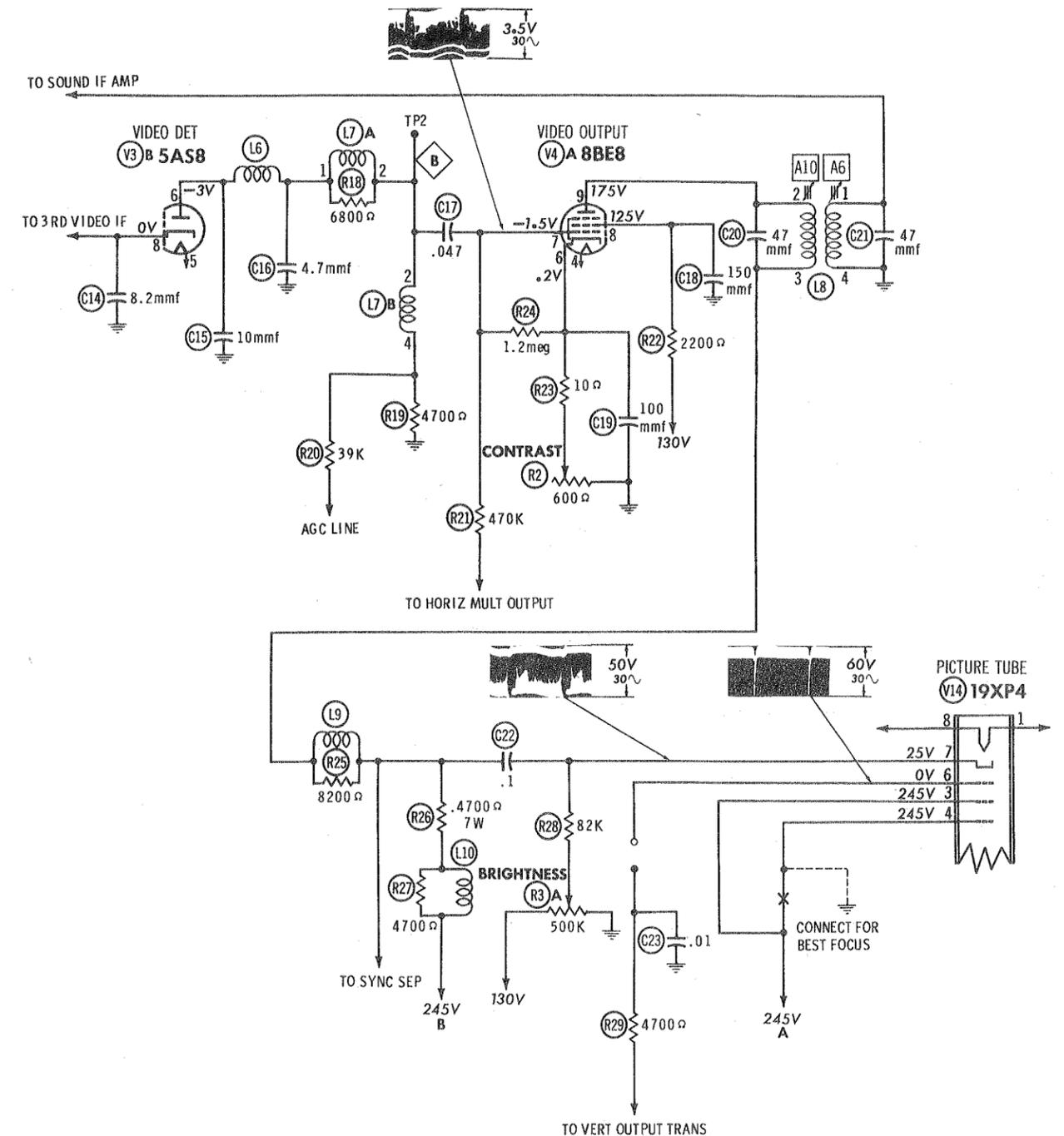


Fig. 15. Video amplifier stage.

Sync Separator, Noise Limiter and AGC Keyer

A typical sync separator circuit using a 3BU8 tube is shown in Fig. 16. One section of the tube provides sync separation and noise limiting. The other section is an AGC keyer. Typical waveforms to be found at certain points in the circuit are shown in Fig. 16. The LC10-1P low capacity probe is used with

CRO-3 when signal tracing the sync separator circuit. The sweep range switch is set on 20-100 when the probe is connected to pin 6 of the 3BU8 to obtain the waveform of the signal from the sync amplifier. The sweep range switch remains on 20-100 when the probe is connected to pin 9 of the 3BU8. The sweep range switch is set on 2.5K-12.5K when checking the waveforms at pins 3 and 7 of the 3BU8.

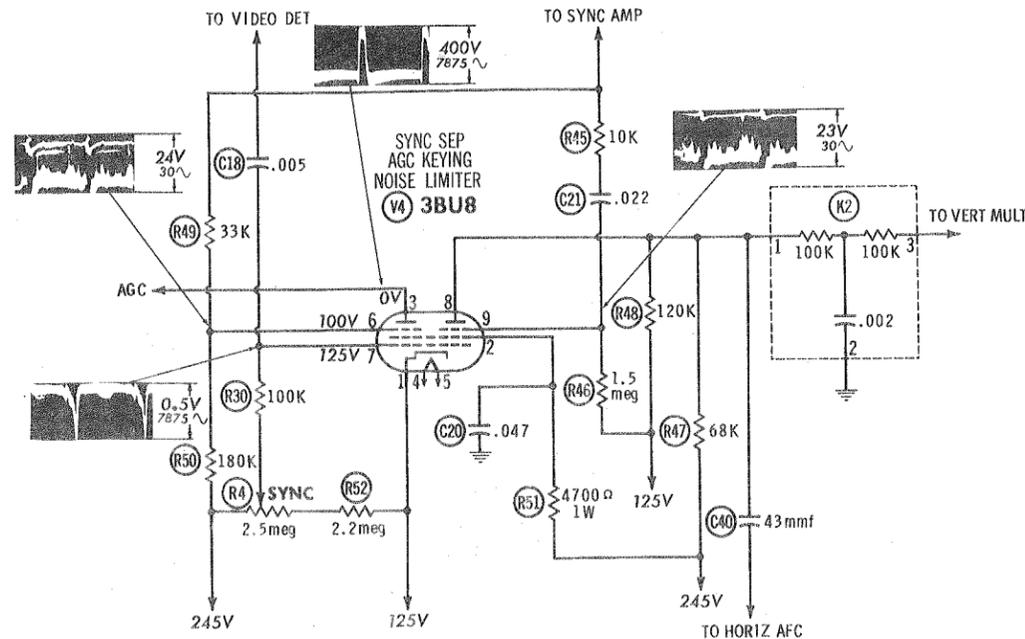


Fig. 16. Sync separator, noise limiter and AGC keyer stage.

Sync Separator

A typical sync separator circuit using a 3CS6 tube is shown in Fig. 17. The LC10-1P low capacity probe is used to obtain waveforms as shown.

The sweep range switch is set on 20-100 for viewing the waveforms at pins 1 and 7 of the 3CS6 tube. The sweep range switch is changed to 2.5K-12.5K for the horizontal sync waveform at the output to the horizontal multivibrator.

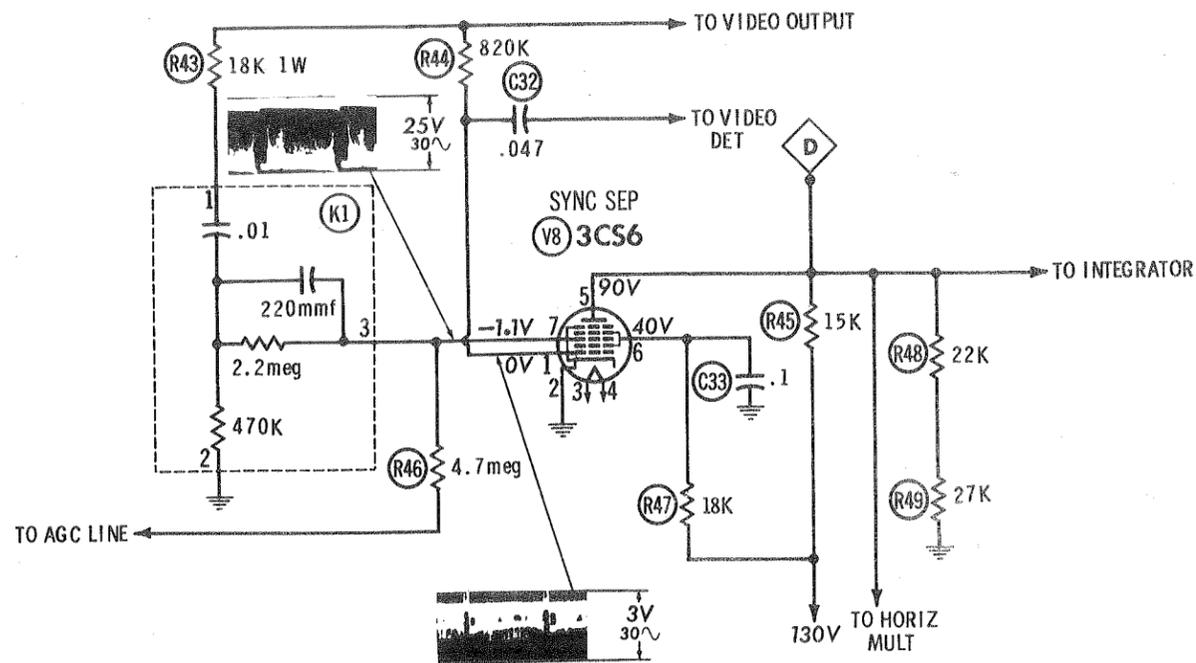


Fig. 17. Sync separator stage.

Horizontal AFC and Oscillator

A horizontal AFC and horizontal multivibrator circuit is shown with waveforms in Fig. 18. The two

diodes provide AFC rectification and the 6CG7 tube operates as the horizontal multivibrator.

The LC10-1P low capacity probe is used and the sweep range switch is set on 2.5K-12.5K.

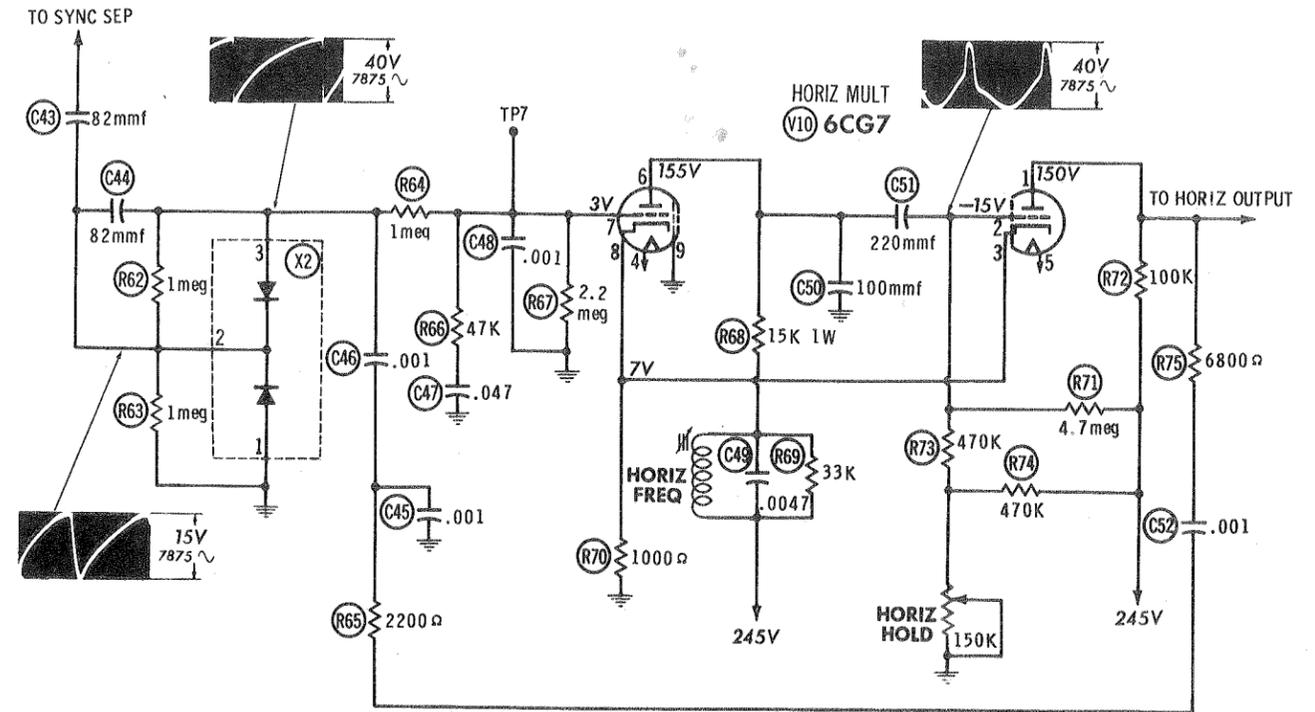


Fig. 18. Horizontal AFC and oscillator stage.

Horizontal Output Stage

A horizontal output stage, with associated high voltage rectifier and damper tubes, is shown in Fig.

19. The waveform of the drive signal on the grid of the 12DQ6B horizontal output tube is shown.

The LC10-1P low capacity probe is used and the sweep range switch is set on 2.5K-12.5K.

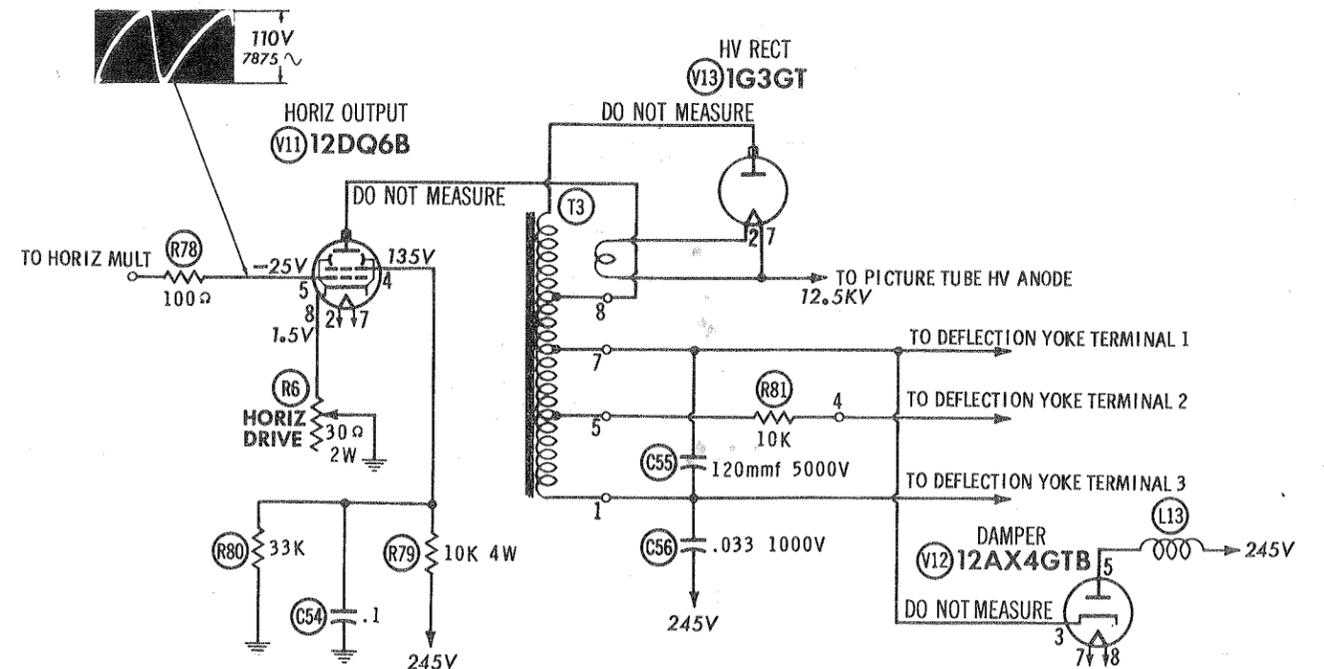


Fig. 19. Horizontal output stage.

Vertical Sweep

A typical vertical sweep section using a 6EM7 tube as the vertical multivibrator and output tube is shown in Fig. 20. Waveforms found at the output of the integrator and other points in the circuit, are shown.

The sweep range switch is set on 20-100.

shown in Fig. 20. Waveforms found at the output of the integrator and other points in the circuit, are shown.

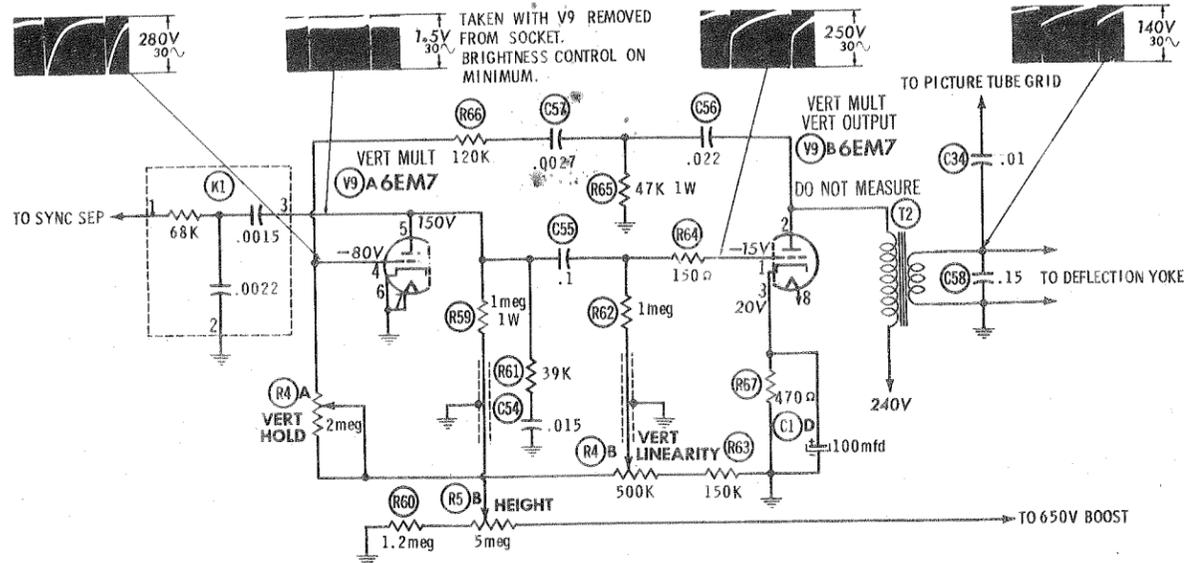


Fig. 20. Vertical sweep section.

Keyed AGC

A 6AU6A tube is used as the keyer in the keyed AGC stage shown in Fig. 21. Typical waveforms are shown.

The LC10-1P low capacity probe is used with CRO-3 to view these waveforms. The sweep range switch is set on 2.5K-12.5K.

Low Voltage Power Supply

Two TV receiver low voltage power supply schematics are shown in Fig. 22. Typical waveforms are shown.

Set the sweep range switch on 20-100.

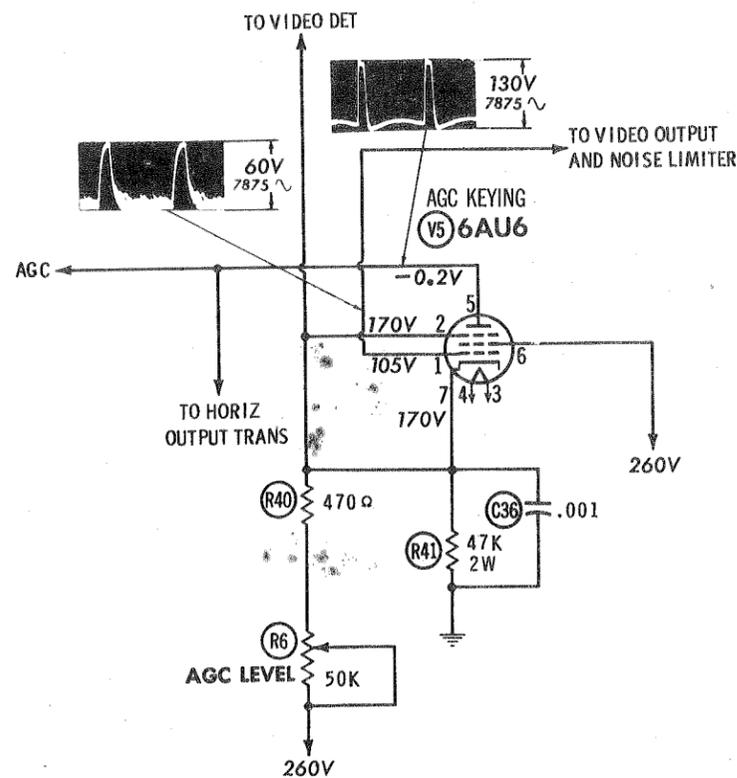


Fig. 21. AGC keying stage.

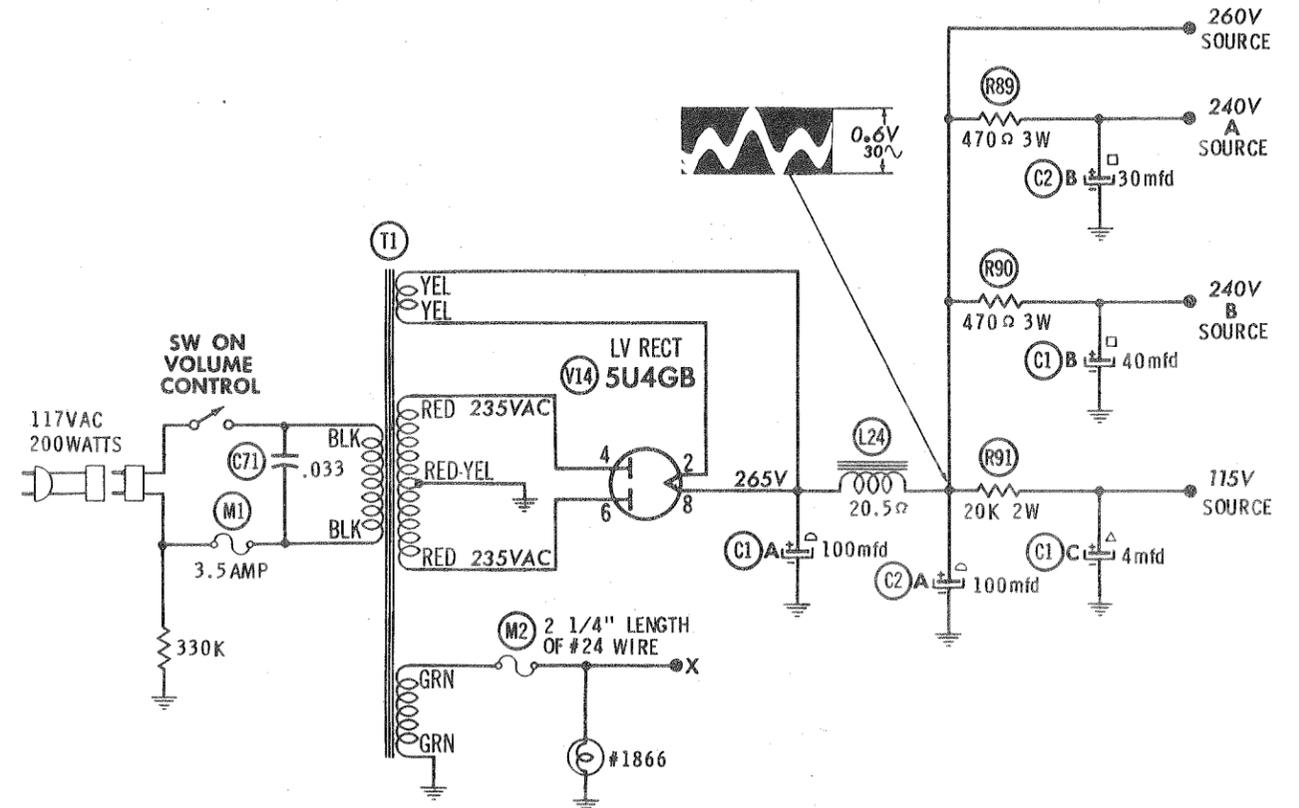
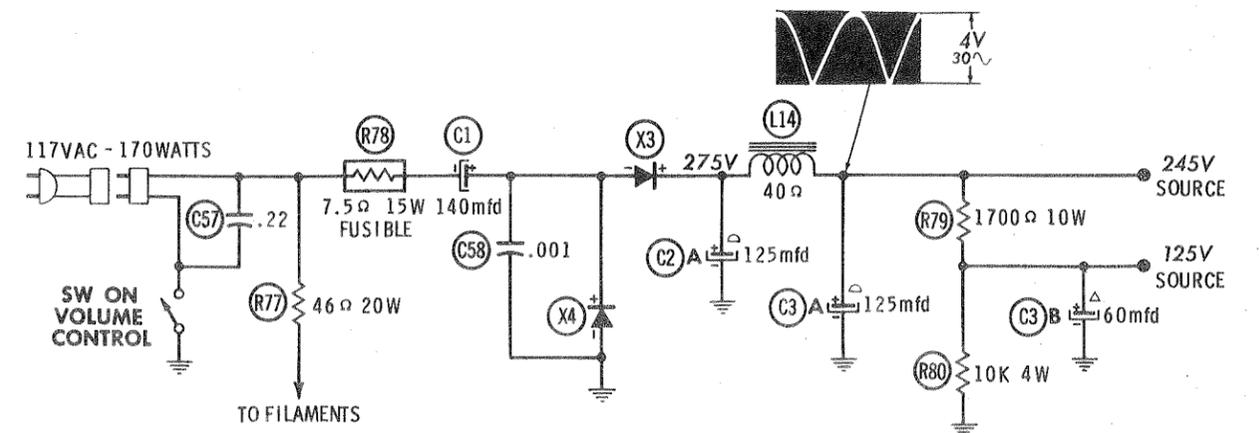


Fig. 22. Typical low voltage power supply circuits.



SIGNAL TRACING A COLOR TV RECEIVER

The CRO-3 and a sweep generator are used (in the same way they are used with a black and white TV receiver) when signal-tracing the tuner, IF, video, sound, sync, vertical and horizontal sections of a color TV receiver. A color generator must be used instead of the sweep generator when signal-tracing the "color" circuits of a color TV receiver.

The schematic in Fig. 23 shows the circuit of the color section of a typical color TV receiver. The waveforms were made with the CRO-3 and a Jackson Color Bar-Dot Generator 800 with a B-Y signal used for all waveforms shown.

The RF output cable of the Color Bar-Dot Generator 800 is connected to the antenna terminals of the receiver. The generator is turned on and the desired pattern selector button is depressed. (The B-Y button was depressed for the waveforms in Fig. 23.)

The LC10-1P low capacity probe is used with CRO-3. The sweep range switch is set on 2.5K-12.5K. The input selector switch is turned to WB1-10 or 100 as required to obtain a waveform of convenient size.

PARTS LIST

Ref. No.	Part No.	Description	Ref. No.	Part No.	Description
TUBES			CAPACITORS (Cont'd)		
V1	22-35	6C4, Vert Input Cathode Follower	C33	26-93	.5 mfd @ 400V, Mylar
V2	22-42	6J6, 1st Vert Amp	C34	26-64	.005 mfd, Mica
V3	22-42	6J6, 2nd Vert Amp	C35	26-236	.5 mfd @ 1500V, Oil
V4	22-35	6C4, Horiz Input Cathode Follower	C36		5 mmf, Ceramic
V5	22-42	6J6, Horiz Amp	C37	26-177	.25 mfd @ 400V, Mylar
V6	22-42	6J6, Sweep Osc	C38	26-177	.25 mfd @ 400V, Mylar
V7	22-34	5Y3GT, HV Rect	C39		.01 mfd @ 1000V, Ceramic Disc
V8	22-34	5Y3GT, LV Rect	C40		.01 mfd @ 1000V, Ceramic Disc
V9	22-44	5U1, Cathode Ray Tube	C41	29-94	.25 mfd @ 600V, Mylar
V10	22-35	6C4, Retrace Blanking Amp	C42	26-120	.05 mfd @ 1600V, Tubular, Oil
			C43	26-97	.05 mfd @ 400V, Mylar
CAPACITORS			CONTROLS AND RESISTORS		
C1	26-70	8 mfd @ 450V, Electrolytic	R1	4-40	1000Ω, Calibrate Voltage Adjustment
C2	26-120	.05 mfd @ 1600V, Tubular, Oil	R2	4-65A	10K, Vert Gain Control
C3	26-70	8 mfd @ 450V, Electrolytic	R3A	4-64A	1 meg, Sweep Vernier Control
C4	26-70	8 mfd @ 450V, Electrolytic	B		1 meg, Sweep Osc Grid Control
C5	26-96	.1 mfd @ 400V, Mylar	R4	4-62A	250K, Sync Level Control
C6A	26-90	10 mfd @ 450V, Electrolytic	R5	4-92	500K, Expanded Sweep Position Control with Expanded Sweep Switch
B		10 mfd @ 450V, Electrolytic	R6	4-65A	10K, Horiz Input Gain Control
C		10 mfd @ 450V, Electrolytic	R7	4-62A	250K, Horiz Position Control
C7	26-176	25 mfd @ 50V, Electrolytic	R8	4-62A	250K, Vert Position Control
C8	26-28	25 mfd @ 25V, Electrolytic	R9	4-63A	2 meg, Focus Control
C9	26-94	.25 mfd @ 600V, Mylar	R10	4-61A	500K, Intensity Control with Power Off Switch
C10	3-25	1-3.5 mmf, Trimmer	R11	52-2135	1.3 meg, Precision
C11	3-26	5-20 mmf, Trimmer	R12	52-2134	130K, 5%, 1/2 Watt, Carbon
C12	26-100	250 mmf, Mica	R13	52-2153	15K, 5%, 1/2 Watt, Carbon
C13	26-96	.1 mfd @ 400V, Tubular	R14	52-3101	100Ω, 10%, 1/2 Watt, Carbon
C14	26-98	.01 mfd @ 400V, Mylar	R15	52-3475	4.7 meg, 10%, 1/2 Watt, Carbon
C15	26-79	510 mmf @ 500V, Ceramic	R16	52-6681	680Ω, 10%, 1 Watt, Carbon
C16	26-177	.25 mfd @ 400V, Mylar	R17	52-3103	10K, 10%, 1/2 Watt, Carbon
C17	26-177	.25 mfd @ 400V, Mylar	R18	52-3272	2700Ω, 10%, 1/2 Watt, Carbon
C18	26-177	.25 mfd @ 400V, Mylar	R19	52-6471	470Ω, 10%, 1/2 Watt, Wirewound
C19A		10 mfd @ 450V, Electrolytic	R20	52-3105	1 meg, 10%, 1/2 Watt, Carbon
B		10 mfd @ 450V, Electrolytic	R21	53-2512	5100Ω, 5%, 1 Watt, Carbon
C20	26-96	.1 mfd @ 400V, Mylar	R22	53-3472	4700Ω, 10%, 1 Watt, Carbon (Part of Coil L1)
C21	26-96	.1 mfd @ 400V, Mylar	R23	53-3273	27K, 10%, 1 Watt, Carbon
C22	26-96	.1 mfd @ 400V, Mylar	R24	53-3273	27K, 10%, 1 Watt, Carbon
C23	26-95	.25 mfd @ 400V, Tubular	R25	53-3472	4700Ω, 10%, 1 Watt, Carbon (Part of Coil L4)
C24	26-97	.05 mfd @ 400V, Tubular	R26	52-3104	100K, 10%, 1/2 Watt, Carbon
C25	26-98	.1 mfd @ 400V, Tubular	R27	52-2242	2400Ω, 5%, 1/2 Watt, Carbon
C26	26-104	.002 mfd @ 400V, Mica	R28	52-2242	2400Ω, 5%, 1/2 Watt, Carbon
C27	26-99	400 mmf, Mica	R29	52-3105	1 meg, 10%, 1/2 Watt, Carbon
C28	26-101	80 mmf, Mica	R30	52-3105	1 meg, 10%, 1/2 Watt, Carbon
C29	26-93	.5 mfd @ 400V, Mylar			
C30	3-26	5-20 mmf, Trimmer			
C31	26-97	.05 mfd @ 400V, Mylar			
C32A	26-90	10 mfd @ 450V, Electrolytic			
B		10 mfd @ 450V, Electrolytic			
C		10 mfd @ 450V, Electrolytic			

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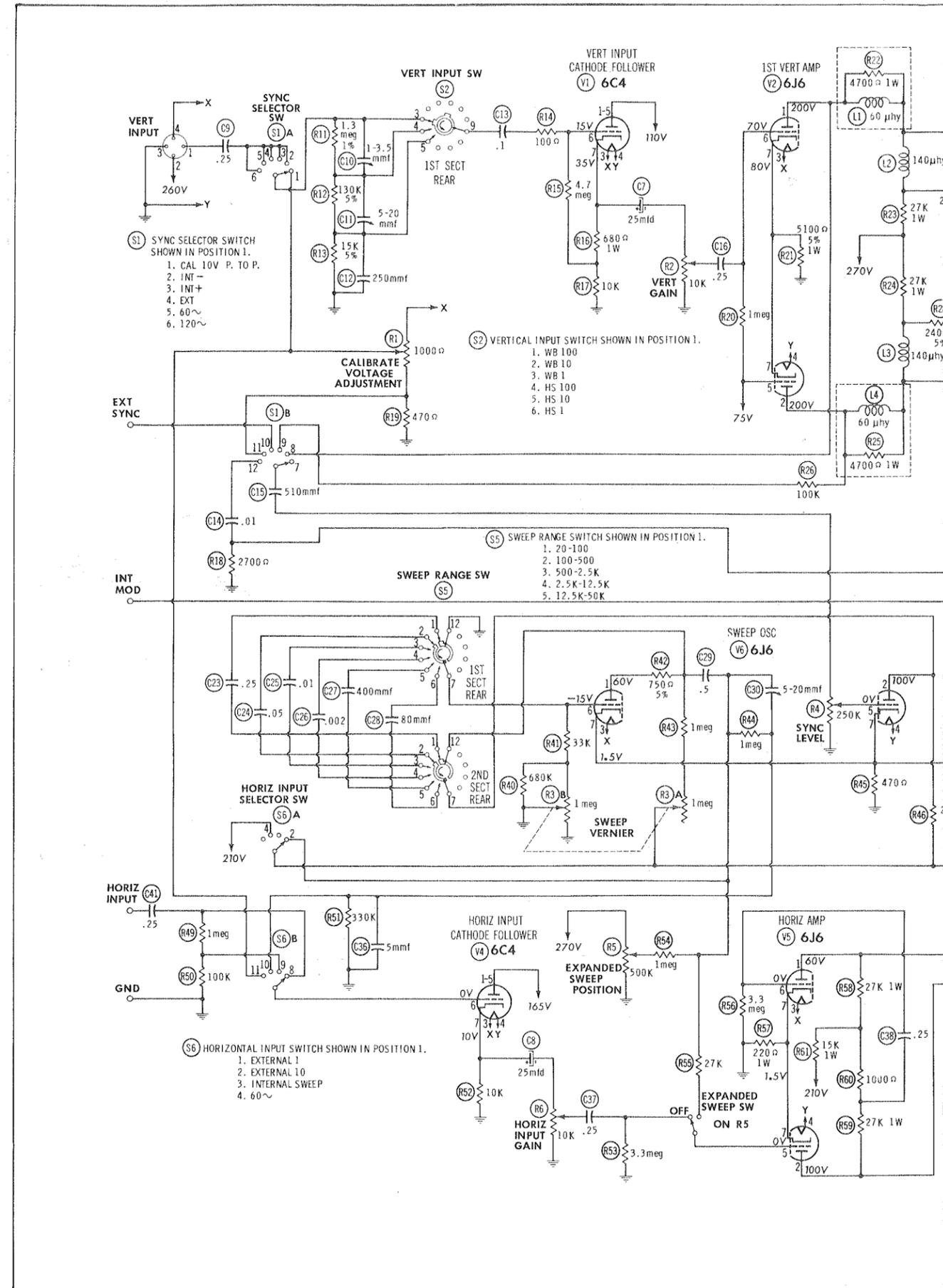


Fig. 24. Model C

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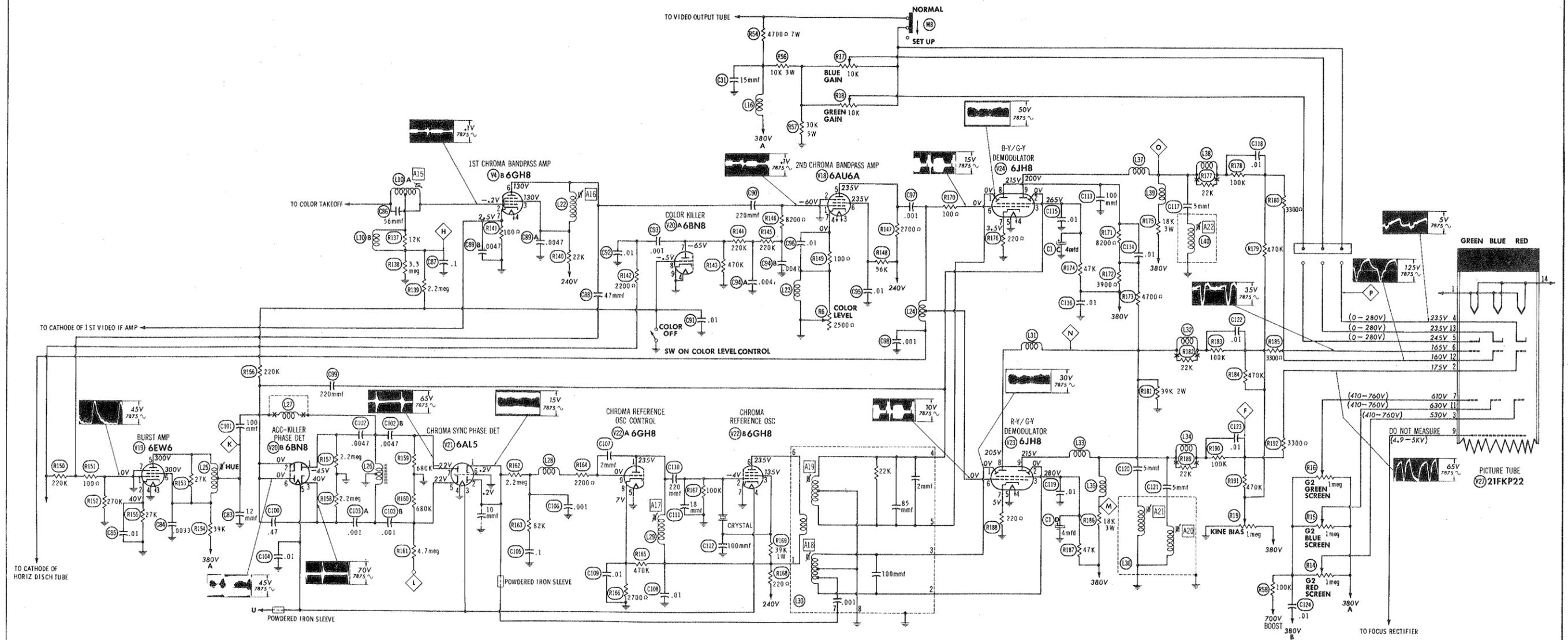


Fig. 23. Color section of color TV receiver.

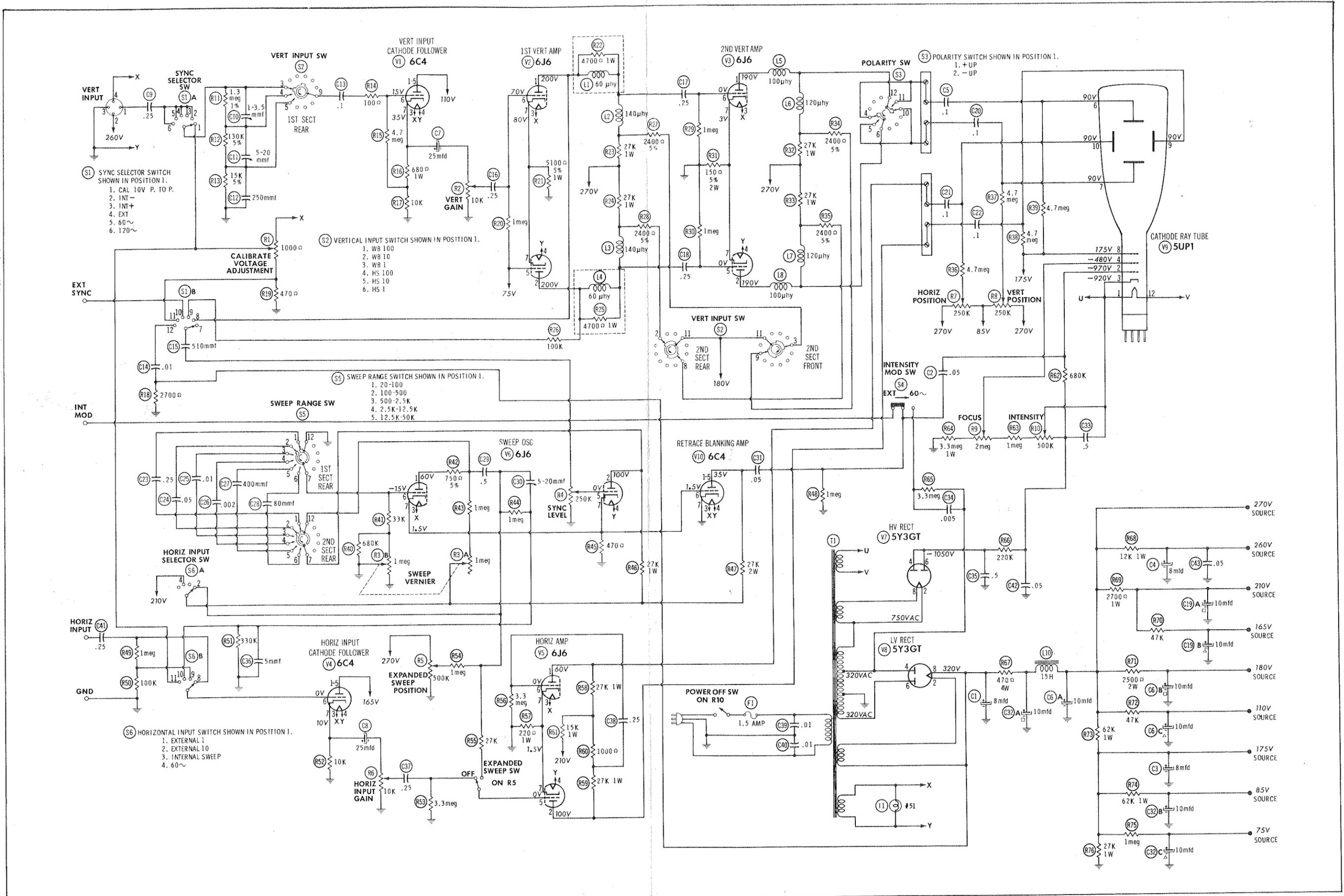
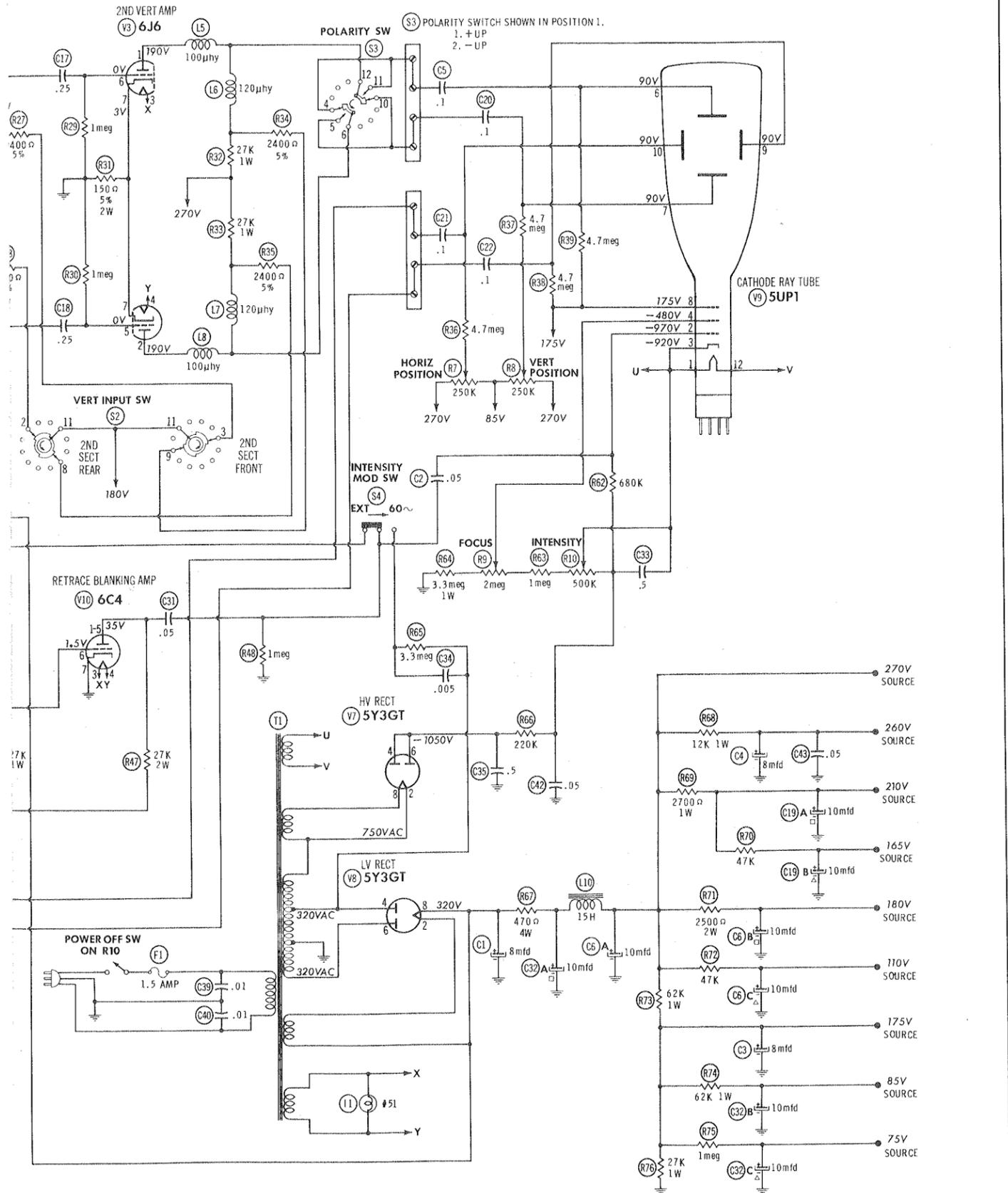


Fig. 24. Model CRO-3 schematic.

PARTS LIST—Cont'd

Ref. No.	Part No.	Description
CONTROLS AND RESISTORS (Cont'd)		
R31	53-2151	150Ω, 5%, 1 Watt, Wirewound
R32	53-3273	27K, 10%, 1 Watt, Carbon
R33	53-3273	27K, 10%, 1 Watt, Carbon
R34	52-2242	2400Ω, 5%, ½ Watt, Carbon
R35	52-2242	2400Ω, 5%, ½ Watt, Carbon
R36	52-3475	4.7 meg, 10%, ½ Watt, Carbon
R37	52-3475	4.7 meg, 10%, ½ Watt, Carbon
R38	52-3475	4.7 meg, 10%, ½ Watt, Carbon
R39	52-3475	4.7 meg, 10%, ½ Watt, Carbon
R40	52-3684	680K, 10%, ½ Watt, Carbon
R41	52-3333	33K, 10%, ½ Watt, Carbon
R42	52-2751	750Ω, 5%, ½ Watt, Carbon
R43	52-3104	100K, 10%, ½ Watt, Carbon
R44	52-3105	1 meg, 10%, ½ Watt, Carbon
R45	52-3471	470Ω, 10%, ½ Watt, Carbon
R46	53-3273	27K, 10%, 1 Watt, Carbon
R47	54-3273	27K, 10%, 2 Watt, Carbon
R48	52-3105	1 meg, 10%, ½ Watt, Carbon
R49	52-3105	1 meg, 10%, ½ Watt, Carbon
R50	52-3104	100K, 10%, ½ Watt, Carbon
R51	52-3334	330K, 10%, ½ Watt, Carbon
R52	52-3103	10K, 10%, ½ Watt, Carbon
R53	52-3335	3.3 meg, 10%, ½ Watt, Carbon
R54	52-3105	1 meg, 10%, ½ Watt, Carbon
R55	52-3273	27K, 10%, ½ Watt, Carbon
R56	52-3335	3.3 meg, 10%, ½ Watt, Carbon
R57	52-6221	220Ω, 10%, ½ Watt, Wirewound
R58	53-3273	27K, 10%, 1 Watt, Carbon
R59	53-3273	27K, 10%, 1 Watt, Carbon
R60	52-3102	1000Ω, 10%, ½ Watt, Carbon
R61	53-3153	15K, 10%, 1 Watt, Carbon
R62	52-3684	680K, 10%, ½ Watt, Carbon
R63	52-3105	1 meg, 10%, ½ Watt, Carbon
R64	53-3335	3.3 meg, 10%, 1 Watt, Carbon

Ref. No.	Part No.	Description
CONTROLS AND RESISTORS (Cont'd)		
R65	52-3335	3.3 meg, 10%, ½ Watt, Carbon
R66	52-3224	220K, 10%, ½ Watt, Carbon
R67	53-6471	470Ω, 10%, 1 Watt, Wirewound
R68	53-3123	12K, 10%, 1 Watt, Carbon
R69	53-3272	2700Ω, 10%, 1 Watt, Carbon
R70	52-3473	47K, 10%, ½ Watt, Carbon
R71	56-3252	2500Ω, 10%, 4 Watt, Wirewound
R72	52-3473	47K, 10%, ½ Watt, Carbon
R73	53-2623	62K, 5%, 1 Watt, Carbon
R74	53-2623	62K, 5%, 1 Watt, Carbon
R75	52-3105	1 meg, 10%, ½ Watt, Carbon
R76	53-3273	27K, 10%, 1 Watt, Carbon
COILS AND TRANSFORMER		
L1	15-70	Peaking Coil, Red, 60μhy (On R22)
L2	15-69	Peaking Coil, Blue, 140μhy
L3	15-69	Peaking Coil, Blue, 140μhy
L4	15-70	Peaking Coil, Red, 60μhy (On R25)
L5	15-72	Peaking Coil, Green, 100μhy
L6	15-71	Peaking Coil, Black, 120μhy
L7	15-71	Peaking Coil, Black, 120μhy
L8	15-72	Peaking Coil, Green, 100μhy
L10	14-46	Choke, Filter, 15hy
T1	14-59B	Transformer, Power
FUSE AND SWITCHES		
F1	5-28	Fuse, 1½ Amp, 3AG
S1	8-125	Switch, Sync Input, Rotary Type
S2	8-96	Switch, Vert Input, Rotary Type
S3	8-103	Switch, Polarity, Rotary Type
S4		Switch, Intensity Mod, Slide Type
S5	8-97	Switch, Sweep Range, Rotary Type
S6	8-98	Switch, Horiz Input, Rotary Type
I1		Lamp, #51, Pilot



GUARANTEE

(MATERIALS AND WORKMANSHIP)

We guarantee this instrument to be free from defects in materials or workmanship under normal use. Our obligation under this warranty is limited to repairing or replacing the instrument, provided it is returned, Transportation Prepaid, to our Factory within three months after date of sale.

This guarantee expressly does not cover vacuum tubes of any description which are shipped within or as accessories to any instrument. (Tubes are guaranteed by the tube manufacturer.)

Guarantee will not apply to any instrument which has been tampered with or which has the serial number altered or removed, the seals broken, or which has been subjected to negligence, misuse or accident.

GENERAL INFORMATION

Mail the registration card for your instrument promptly, giving correct name and address, so that additional technical bulletins from our factory will be properly delivered. Notify us of a change of address, listing model and serial number of your instrument in the notice.

Repairs and adjustments will be made under the terms and conditions stated in the guarantee furnished with this instrument. The instrument should not be returned to our factory except where we authorize such return to be advisable. When corresponding concerning this instrument always mention model and serial number. Be certain to describe fully and accurately the information desired.