CATHODE-RAY OSCILLOSCOPE
TYPE 512

SERIAL NUMBER __________

INSTRUCTION MANUAL

TEKTRONIX

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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General Description

The Type 512 is a portable precision laboratory instrument incorporating dc coupled amplifiers throughout. Its sensitivity of 5 mv/cm dc and sweeps as slow as 0.3 sec/cm solve many problems confronting workers in the fields where comparatively slow phenomena must be observed. The vertical bandwidth of 1 mc at maximum sensitivity (2 mc at lesser sensitivity) and sweeps as fast as 3 μsec/cm make it an excellent general purpose oscilloscope as well.

Characteristics

Signals Observable

1. Sine waves from 1/3 cps to above 500 kc.
2. Pulses of 1 μsecond to 3 seconds.

Sweep Circuit

Phantastron followed by push-pull linear amplifier. Triggered, recurrent or single sweeps as desired.

Sweep Speeds

Continuously variable from 0.3 sec/cm to 3 μsec/cm in ten calibrated ranges. Calibration accuracy ±5%.

Magnification

Any desired 20% of the sweep can be spread over the entire trace.

External Sweep Input

Via 100 k potentiometer and dc coupled amplifier. 1.0 v/cm maximum sensitivity.

Trigger Requirements

Will trigger from signals being observed which produce deflection of 5 mm or greater.

External triggers of either polarity.

Square waves or sine waves 0.15 v to 50 v peak to peak, or pulses 0.15 v to 15 v peak.

Vertical Deflection Sensitivity (peak to peak)

Direct to plate 13 v/cm. Via amplifier 5 mv to 50 v/cm.

Sensitivity reduced by a factor of 10 when probe is used.

Input Impedance

1 megohm shunted by 45 μμf. With probe 10 megohms and 14 μμf.

CAUTION—IN NO CASE SHOULD THE COMBINED AC AND DC INPUT VOLTAGES EXCEED 600 VOLTS PEAK WITH EITHER DIRECT CONNECTION OR PROBE.

Vertical Amplifier Response

For sensitivities of 0.15 v/cm or lower: Bandwidth dc to 2 mc. Rise time 0.2 μsec.

For sensitivities between 5 mv and 0.15 v/cm: Bandwidth dc to 1 mc. Rise time 0.4 μsec.

Calibrating Voltage

Square wave of approximately 1 kc. Nine ranges 5 mv to 50 v full scale. Accuracy ±5%.

Waveforms Available Externally

Sweep sawtooth, 100 volts peak.
Delay trigger, 75 volts peak.
Positive gate, 150 volts peak.
Square wave calibrating signal, 0-50 volts peak.

Connection to Crt Cathode

Via 0.1 μfd capacitor. RC=0.01 sec.

Accelerating Voltage on Cathode-Ray Tube

3 kv.

Time-Marker Input

Via isolating stage to video amplifier. Minimum marker amplitude 8 v.

Power Requirements

105-125 volts, or 210-250 volts, 50-60 cycles, 280 watts . (See Section IV.)

Dimensions

15½″ high, 12½″ wide, 21½″ deep.

Finish

Panel, photo etched aluminum with black letters. Cabinet, gray wrinkle. Weight (including accessories) 54 lbs.

Functions of Controls and Binding Posts

A brief explanation of the function of each control and binding post is given below. For a more detailed explanation consult Section III, Circuit Description.

PANEL MARKINGS	EXPLANATION
VERT. AMPL. ATTEN.	Twin potentiometers R53 and R54 in cathodes of cathode followers V5 and V6 permit adjustment of gain of vertical amplifier over a 3 to 1 range.
VERT. DEF. SENSITIVITY	Gang switch SW3 controlling gain of vertical amplifier in steps of approximately 3 to 1. Connects two-stage preamplifier in circuit for three most sensitive positions.
VERT. POSITION	Potentiometer R56 connected between cathode of V7 and V8, determining operating points of these tubes. Because of the dc coupling, this shifts the image vertically.
PRE-AMP BALANCE	Potentiometer R20 provides a source of variable voltage which is applied to the plate of V2 via R19, permitting the plate potential of V2 to be varied positive or negative with respect to V1, as required to balance the preamplifier output.
AC-DC	Gang switch SW2 inserting coupling capacitors in the input circuit of the instrument and between the preamplifier and main amplifier, when dc coupling is not desired.
INPUT A	Input connector to vertical amplifier. Polarity is such that positive signal deflects beam upwards.
GROUND	Binding post connecting to chassis of instrument.
INPUT B	Input connector to vertical amplifier. Connects to grid opposite from Input-A grid. Negative signal deflects beam upwards. When VERTICAL INPUT switch is in position A, the B input is grounded.

PANEL MARKINGS	EXPLANATION
VERTICAL INPUT	Gang switch SW1, connecting grids of amplifiers to permit either single-ended or push-pull input + or — calibration as follows: A. INPUT A connected to amplifier grid (V1 or V5). Grid of V2 or V6 grounded. +CAL. Square wave amplitude calibration signal connected to grid (V1 or V5). Increasing calibration voltage makes tops of square waves move upward. —CAL. Same as +CAL except calibration signal is applied to opposite grid so bottom of calibration square waves move downward. A-B. INPUT A connected to one grid, INPUT B connected to opposite grid. Waveshape on crt shows difference between A and B signals.
CRT CATHODE	Binding post permitting connection of external modulating signals to the cathode of the cathode-ray tube via a 0.1 μfd capacitor. RC=0.01 sec.
FOCUS	Potentiometer controlling the voltage applied to the focus anode (A1) of the crt and thereby the sharpness of the image.
INTENSITY	Potentiometer controlling bias on crt grid when the tube is unblanked and therefore controlling brightness of image.
CAL. RANGE	Attenuator for reducing amplitude of square wave calibrating signal. Steps correspond to ranges on CAL. VOLTAGE dial.
CAL. VOLTAGE	Potentiometer with calibrated dial for adjustment of calibrator square wave to desired amplitude.
GROUND	Connection to frame of instrument.

PANEL MARKINGS	EXPLANATION
ASTIGMATISM	Potentiometer varying potential on Anode No. 2 with respect to the deflection plates. Correct adjustment of this control makes possible a sharp focus of the image in both horizontal and vertical planes simultaneously.
BLANKING	Potentiometer controlling the bias on the suppressor of V107 and therefore the amplitude of the blanking voltage applied to the crt grid.
SWEEP OUTPUT	Binding post connecting to cathode of V113 providing sweep generator waveform at an amplitude of 100 volts.
CAL NORM.-EXT.	Toggle switch making it possible to connect the calibrating square wave generator to either the vertical amplifier input or the calibration output binding post.
CAL OUTPUT	Binding post connected to arm of CAL VOLTAGE potentiometer making the calibrating square wave available for external use.
SCALE ILLUM.	Variable resistor controlling brightness of the lamp which illuminates the plastic graticule over the face of the cathode-ray tube.
+GATE	Binding post for connection to the plate of V106 providing a positive gate of 150 volts amplitude having the same duration as the sweep.
DELAYED TRIGGER AND SWEEP MAGNIFIER POSITION	Potentiometer controlling the bias on V101. When the sweep sawtooth reaches this amplitude, the magnified sweep starts. If the MAGNIFIER OUT-IN switch is set to IN, the magnified sweep replaces the regular sweep.
MAGNIFIER IN-OUT	Switch connecting sweep amplifier to either normal- or magnified-sweep generator.

PANEL MARKINGS	EXPLANATION
SWEEP TIME/CM	Potentiometer controlling charging voltage for sweep generators and therefore controlling sweep rate. Controls both normal and magnified sweeps.
EXT. SWEEP ATTEN.	Potentiometer controlling the fraction of the voltage applied to EXT. SWEEP INPUT binding post which will reach the grid of the sweep amplifiers when the SWEEP RANGE switch is set in the EXT. position.
HOR. POSITION	Potentiometer controlling the bias applied to the grid of one sweep amplifier tube and thereby the horizontal position of the image.
EXT. SWEEP IN.	Binding post connecting to sweep amplifier via EXT. SWEEP ATTEN. when SWEEP RANGE switch is in EXT. position (100-k input impedance).
DELAYED TRIGGER	Binding post providing 75 v positive step at any point on the normal sweep as selected by the DELAYED TRIGGER AND SWEEP MAGNIFIER POSITION control. 15 ma maximum output current.
SWEEP RANGE	Gang switch selecting appropriate capacitors and resistors in sweep generator for the various sweep ranges. In the EXT. position, the sweep generator is disconnected and provision is made to feed sweep signals from EXT. SWEEP IN. binding post.
SWEEP STABILITY	Variable resistor controlling bias on grid 3 of the sweep generator tube V112. This bias determines whether the sweep will operate recurrently or must be triggered.
POWER	On-off switch in the ac line voltage supply to the oscilloscope.

PANEL MARKINGS	EXPLANATION
TRIGGER AMPL.	Potentiometer controlling the bias on the trigger amplifier V110, thereby determining the size of the trigger pulse required to trigger the sweep generator.
TRIGGER SELECTOR	Switch determining source and polarity of trigger voltage.
TRIGGER INPUT	Binding post connecting external trigger sources to +EXT. and —EXT. position of TRIGGER SELECTOR switch.
TIME MARKER IN.	Connector on back of oscilloscope to permit introduction of time markers via an isolating amplifier, V13.
C.F. ADJ.	Potentiometer R51 located in cathode circuit of V5 and V6. Shifts relative operating points of these tubes so that a change in AMPL. ATTEN. setting will not affect the positioning.
.05-.15 BAL.	Potentiometer R13 connected between the cathodes of V3 and V4. This control will alter the operating points of these tubes as required to balance this stage in .05-.15 position of VERT. DEF. SENSITIVITY.
DIFF. BAL.	Potentiometer located in cathode circuit of V1 and V2. Shifts relative operating points of these tubes to provide a fine adjustment for equalizing A and B input gains for use when the INPUT switch is in the A —B position.

Operating Instructions

The Type 512 may be operated in any normal indoor location, or in the open if protected from moisture. If the instrument has been exposed to dampness, it should be left in a warm room until thoroughly dry before being placed in operation.

To prevent excessive interior temperatures, it is important to allow adequate ventilation for the oscilloscope. Several inches clearance should be provided at the side, back and top of the case.

If the Type 512 is used continuously for the same application, and only one setting of the controls is required, it is advisable to check the instrument periodically at all control settings to be sure it is in normal operating condition. For example, if only direct connection to the vertical deflection plates of the crt is used, a defect in the vertical amplifier might not become evident. Operation of the controls also helps to prevent accumulation of dirt and tarnish on their contacts.

Although the components are well supported and the adjustments are very stable in setting to allow for portable operation, the Type 512 should not be subjected to excessive vibration or rough handling.

To place the Type 512 in operation for the first time, the following procedure is suggested.

1. Connect to a source of 60 cycle, 117 v power (or 234 v if transformer connections are changed as directed in Sec. IV).
2. Set controls as indicated below
   VERT. AMPL. ATTEN. ...... Clockwise
   VERT. DEF. SENSITIVITY. 5-1.5
   VERT. POSITION .... Index vertical
   AC-DC .... DC
   VERTICAL INPUT .... +CAL
   FOCUS .... Index vertical
   INTENSITY .... Counterclockwise
   ASTIGMATISM .... Counterclockwise
   BLANKING .... Clockwise
   CAL. RANGE 15
   CAL. VOLTAGE 0
   MAGNIFIER OUT-IN .... Out
   SWEEP TIME/CM 2
   HOR. POSITION .... Clockwise
   SWEEP RANGE .... 1-3 Milliseconds
   SWEEP STABILITY .... Counterclockwise
   TRIGGER AMPL. .... Counterclockwise
   TRIGGER SEL. .... +Int
3. Turn POWER switch to ON and wait about 60 seconds.
4. Advance INTENSITY control until a spot is seen.
5. Adjust VERT. POSITION, HOR. POSITION, ASTIGMATISM, and FOCUS until a sharply focused spot is obtained at the left center of the screen.
   CAUTION—DO NOT ALLOW THIS SPOT TO BE EXCESSIVELY BRIGHT OR REMAIN FOR LONG IN ONE POSITION.
6. Advance the SWEEP STABILITY control until a sweep appears, then turn it back just under this point.
7. Set the CAL. VOLTAGE control to 5 and a vertical line about 3 cm high should appear.
8. Advance the TRIGGER AMPL. control until a stable image of the calibrating signal appears.
9. Retard BLANKING control until the return trace is removed.

The oscilloscope is now displaying the square wave calibrating signal. To observe other waveshapes, connect them to the INPUT A connector (or probe), turn VERTICAL INPUT switch to A, select the appropriate sweep time, vertical deflection sensitivity, etc.

Differential input, high frequency operation, etc., are explained under "Vertical Deflection System".

CAUTION—ANY TIME THE TYPE 512 IS SWITCHED OFF IT IS ADVISABLE TO WAIT ABOUT 30 SECONDS BEFORE SWITCHING THE POWER BACK ON. THIS PRECAUTION WILL AVOID "HOT SURGE" CURRENTS WHICH MIGHT BLOW THE FUSE.

Sweep Circuit Adjustments

The sweep circuit of the Type 512 employs a phantastron sweep generator which is much more flexible and accurate than the gas tube type usually employed in portable oscilloscopes. By one simple adjustment, the sweep can be made to run either triggered or recurrently as desired.

In a recurrent sawtooth sweep as generated by a gas tube or similar device, the synchronization takes place at the end of the sweep. The sync impulse causes the beam to return to the left side of the tube where it immediately starts another sweep. Thus, the sweep time must be a multiple of the signal period, or expressed another way, the sweep frequency an integral fraction of the signal frequency.

In a triggered sweep circuit, each sweep is started independently of the preceding sweep by a trigger or synchronizing impulse. When no trigger is being received, the beam remains at the left side of the screen. When the trigger arrives, the beam goes linearily to the right for a time in this case determined by the phantastron sweep generator. At the end of its sweep, it returns to the left side again to await another trigger. It is this variable waiting period which makes the synchronization so easy since the sweep time is now independent of the signal period.

Adjustment of Sweep Stability

The SWEEP STABILITY control varies the bias on the suppressor (grid 3) of V112 and therefore determines whether the sweep will oscillate recurrently or wait for a trigger impulse. The correct setting of the SWEEP STABILITY control depends somewhat on the particular sweep speed in use, but satisfactory operation can be obtained for all but the smallest triggers by a single setting a little below the critical point.

Function of Trigger Selector

This control selects the trigger impulse to be used from three sources, the line frequency (60 cycles), the vertical amplifier (+INT and —INT), or the TRIGGER INPUT binding post. Two positions are available for both the INT and EXT sources. When using those marked +, the sweep starts at the rising portion of the trigger impulse. The — positions start the sweep on the falling portion. For satisfactory operation in the EXT positions, a trigger of from 0.15 v to 50 v sine or square wave or pulses of 0.15 v to 15 v should be provided. Larger triggers should be reduced by an external attenuator.

Adjustment of Trigger Ampl.

The TRIGGER AMPL. control adjusts the bias in the trigger amplifier and therefore the amplitude of the impulse which reaches the sweep generator. After the SWEEP STABILITY is set as described previously, and the TRIGGER SEL. switch set to the correct position, advance the TRIGGER AMPL. control until a stable image is obtained. When the trigger source is a slowly changing wave such as a sine wave or sawtooth, adjustment of the TRIGGER AMPL. setting will change the phase of the signal relative to the start of the sweep.

In general, it is desirable to use the minimum TRIGGER AMPL. setting required to insure a stable image.

If poor synchronizing is experienced when the Type 512 is used to observe repetitive signals containing erratic peak voltages, such as produced by vibrating contacts, it may be possible to form a stabilized trigger signal by the use of auxiliary limiting and differentiating circuits. The TRIGGER SEL. switch should be set to the proper EXT. polarity, and connection made to the TRIGGER INPUT.

Adjustment of Sweep Rate

The combination of the SWEEP RANGE and SWEEP TIME/CM controls allows the operator to vary the sweep rate from 0.3 sec/cm to 3 microseconds/cm. The rate in time/cm may be read directly from the appropriate scale on the SWEEP TIME/CM dial. Provision has been made to correct this calibration should the cathode ray tube or sweep amplifier tube be replaced. Procedure for this adjustment will be found in Section IV.

Recurrent Sweep

In case it is desirable to have a sweep without using any sort of trigger, merely advance the SWEEP STABILITY control until a stable sweep is obtained. This sweep is the conventional sawtooth variety as used in most oscilloscopes.

Single Sweep

The triggered sweep circuit used in the Type 512 inherently provides for single sweep operation. The beam is blanked out until the trigger simultaneously turns it on and starts the sweep. This trigger may be a suitable pulse, or if a mechanical contactor is to be used it is merely necessary to set the TRIGGER SEL. switch to —EXT. and ground the TRIGGER INPUT binding post by means of the contactor. When a mechanical contactor is employed, it may prove desirable to shunt the contactor with a suitable capacitor so that a definite time must elapse before a second sweep may occur. This eliminates the possibility of unwanted sweeps caused by bouncing contacts.

Blanking

A control is provided on the Type 512 to vary the amplitude of the blanking voltage applied to the crt grid at times when the sweep is not running. In many single-sweep applications it is desirable to know the position of the spot before the sweep starts. This may be accomplished by adjusting the BLANKING control until a spot of the desired intensity is obtained.

Ext. Sweep Input

Provision has been made for the connection of external sweep generators to the Type 512. This might be a sine wave oscillator for frequency comparison, the sweep obtained from a "frequency sweep" signal generator, or a sweep generator designed for some particular purpose. The EXT. SWEEP INPUT binding post is connected to the horizontal deflection plates via the EXT. SWEEP ATTEN. and a one-stage push-pull amplifier. The entire system is dc coupled permitting the use of very slow sweeps. With the EXT. SWEEP ATTEN. fully clockwise, the deflection sensitivity is approximately 1.0 volt per cm dc or peak to peak ac.

Sweep Magnifier

Frequently it is desirable to examine in some detail a portion of the waveshape under observation, for instance the rate of fall of the end of a fairly long pulse. In the Type 512 the Sweep magnifier circuit makes it possible to expand any desired 20% of the sweep to cover the entire tube face. When the MAGNIFIER IN-OUT switch is moved to the IN position, the sweep is delayed for a variable time and then goes at 5 times its normal rate. The operating procedure is to turn the MAGNIFIER IN-OUT switch to OUT and adjust the sweep rate controls so that the portion of the wave to be magnified is at the right side of the tube. Change the MAGNIFIER IN-OUT switch to IN. Now turn the DELAYED TRIGGER AND SWEEP MAGNIFIER POSITION knob completely clockwise and then decrease it until the desired signal moves in from the left to the center of the tube face. When the SWEEP RANGE switch is in the fastest position, the magnified sweep is less accurate and linear than in the other positions because of the shunting effect of circuit capacities.

Delayed Trigger

The DELAYED TRIGGER output is a +gate of approximately 75 volts amplitude, starting at any desired time during the period of the sweep, as determined by the setting of the DELAYED TRIGGER and SWEEP MAGNIFIER POSITION control. The start is coincident with the start of the magnified sweep when the SWEEP MAGNIFIER is in use. Should a spike be desired rather than the positive step an external differentiating circuit of any desired time constant may be used.

Sweep Output

The SWEEP OUTPUT binding post makes available the waveshape appearing on the plate of the sweep generator tube. V113 is used as a cathode follower to isolate the sweep generator from whatever is connected to the SWEEP OUTPUT post. The amplitude is approximately 100 v peak to peak.

Gate Output

A positive square wave of the same duration as the sweep and 150 volts amplitude is available for external use. Isolation is provided by one section of V106.

Vertical Deflection System

The Type 512 is equipped with two input probes which fit the UHF Input Connectors directly and two Binding Post Adapters which convert the UHF connectors to binding posts. A ground lead to the equipment under observation must be provided and often an earth ground is desirable. Connect one of the probes or a Binding Post Adapter and a single lead to INPUT A. The VERTICAL INPUT switch should be in position A. When reduced loading on the circuit under test is desired, one of the Input Probes should be used.

CAUTION — THE PEAK POTENTIAL APPLIED TO THE PROBES SHOULD NOT EXCEED 600 VOLTS.

However, since the Probe introduces an attenuation of 10X, it will be advantageous to employ a common shielded lead (no attenuation) instead when dealing with very low level signals, provided the additional circuit loading is permissible. If balanced (push-pull) input is desired, the VERTICAL INPUT switch should be set at A —B and connections made to both INPUT A and INPUT B.

Vertical Amplifier

In order to reconcile the inherent conflicting problems of maximum bandwidth and high dc gain with good stability, a switching system is incorporated which automatically removes the two stage preamp whenever sufficient sensitivity can be attained without it. This same switch (VERT. DEF. SENSITIVITY) inserts appropriate rc compensated attenuators in the circuit so that eight steps (approximately 10db each) of sensitivity are available, ranging from 5 mv to 50 v per cm. Sensitivity is reduced by a factor of 10 when the standard probe is used. When the preamp is not used, i.e., for sensitivity below 0.15 v/cm the bandwidth is 2 mc. For higher sensitivities, it is necessary to pay more attention to grid current, stability, hum, microphonics, etc., and suitable high conductance tubes are not available for the first preamp stage. This reduces the possible bandwidth for reasonable gain so that only a 1-mc pass band is obtained. To provide continuously variable control of gain between the steps on the VERT. DEF. SENSITIVITY switch, twin potentiometers are provided in the cathode-follower stage.

If the Type 512 is to be employed in an application requiring both high gain and direct coupling of the vertical amplifier, a twenty- to thirty-minute warm-up period to stabilize tube characteristics should be provided.

Differential Amplifier

In many applications, the desired signal is superimposed on an undesirable signal such as line frequency hum, etc. The balanced "push-pull" or "differential" amplifier in the Type 512 makes it possible in many cases to greatly increase the ratio of desired to undesired signals. To accomplish this, the VERTICAL INPUT switch is placed in the A-B position and both inputs A and B are used. The image on the CRT will be the difference in potential between the A and B inputs. If a connection can be made with one input having both signals and the other having only the undesired signal, the difference between them, i.e., the desired signal will appear. To compensate for variation in tubes, etc., a screwdriver control, labeled DIFF. BAL., is provided (see Section IV.)

Standardized Input Impedance

By means of trimming capacitors and accurate (1%) resistors the input impedance of both sides of the amplifier, at any setting of the VERT. DEF. SENSITIVITY switch is standardized at 1 meg. shunted by 45 mmfd. This makes the probes interchangeable on the A and B inputs and between various instruments.

Direct Connection to Deflection Plates

Direct connection to the crt deflection plates is made by means of the banana jacks on the access panel. This panel is accessible through an opening in the left side of the case. By removing the jumpers the internal circuits may be disconnected. The terminal marked Y1 is the top plate and the one marked X2 is the right plate. Deflection sensitivity is approximately 13 v/cm on the vertical plates and 18 v/cm on the horizontal plates.

High Frequency Operation

The Type 512 may be used to observe the envelope shape of radio frequency voltages above the frequency capabilities of the vertical amplifier by means of a connection via the side access panel. Since the deflection plates are operated at the plate voltage of the vertical amplifier output stage (+150), a series coupling capacitor should be employed. The jumpers from Y1 and Y2 to the vertical amplifier output should be replaced with 1 megohm resistors, to provide vertical positioning voltage. Unless balanced input is desired, the unused deflection plate should be by-passed to ground. Input to Y1 will provide upward deflection for a positive voltage.

Time Marker Input

Time markers, etc., may be introduced to the vertical amplifier via the over biased isolating amplifier V13, without interaction with the waveform under observation. This connection is at the rear of the Type 512. A minimum time marker amplitude of about 8 volts is required.

Calibration

The cathode ray oscilloscope provides the only means for making many types of measurement on non-sinusoidal wave shapes, usually qualitative rather than quantitative in nature. To aid in amplitude measurement, the Type 512 incorporates a square-wave calibrator. By means of a step attenuator and calibrated potentiometer the amplitude of this square wave may be set to any desired value from 1 mv to 50 volts, peak to peak. Ten ranges are available by means of the step attenuator and the amplitude of any portion of the signal under observation may thus be measured to an accuracy of ±5%.

If direct coupling is being used (SW2 in DC position) the calibrating voltage will produced an upward deflection with the VERTICAL INPUT switch set at +CAL. and a downward deflection when —CAL. is used. Thus, the amplitude of any portion of the signal under observation may be measured with respect to the zero potential (ground) point by moving the VERTICAL INPUT switch to the desired CAL. polarity and adjusting the CAL. RANGE and CAL. VOLTAGE until the variable portion of the calibrating waveform coincides with the deflection produced by the signal. The peak amplitude is then read directly in volts from the CAL. RANGE and CAL. VOLTAGE controls.

CAUTION—IF THE INPUT PROBE (ATTEN. 10X) IS USED, THE SIGNAL AMPLITUDE IS EQUAL TO TEN TIMES THE CALIBRATING VOLTAGE.

It is not necessary to change the sweep time or to synchronize the calibrating signal, as two horizontal lines are produced when the sweep is not in sync with the calibrating voltage.

If the AC position of SW2 is used, the Calibrating Voltage produces equal deflection in both directions in either the +CAL. or —CAL. positions. In this case, the same procedure is followed, except that the calibrating voltage is adjusted to coincide in both amplitude and vertical position to the signal being measured.

CAUTION—TO PROVIDE MAXIMUM ACCURACY, A REASONABLY LARGE DEFLECTION SHOULD BE USED, BUT TO PREVENT POSSIBLE ERROR DUE TO OVERLOADING OF THE VERTICAL AMPLIFIER, THE DEFLECTION SHOULD NOT EXCEED THE RULED PORTION OF THE GRATICULE (±3 cm.) DURING CALIBRATION.

The calibrating voltage is available externally at the CAL. OUTPUT binding post when the CAL. toggle switch is in either the NORM. or EXT. position if the VERTICAL INPUT switch is set at +CAL. or —CAL. To obtain CAL. OUTPUT voltage with the VERTICAL INPUT in the A or A —B position, the CAL. switch must be set at EXT. It is convenient to use this connection in determining the signal amplitude when an attenuating probe is used, as it is then unnecessary to make allowance for the attenuation factor of the probe. The CAL. OUTPUT may be used during adjustment of the Type 512's vertical amplifier (see SECTION IV) and also provides a square wave of known amplitude suitable for testing other equipment.

Intensity Modulation

If desired, signals may be impressed on the cathode of the cathode-ray tube thus modulating its brightness. The CRT CATHODE binding post is connected to the cathode via a .1 mfd. capacitor. The cathode resistor is 100 k. Since the time constant is only .01 sec. long, square pulses cannot be transmitted without some loss of shape. Its primary purpose is to transmit short pulses such as timemarkers, etc.

Circuit Description

Cathode Ray Tube Circuits

The Type 512 employs a 5CPA cathode ray tube. This tube has a 5-inch fluorescent screen and utilizes electrostatic focus and deflection. A post accelerating electrode (intensifier) provides increased spot intensity. The total accelerating potential of about 3000 volts produces a sharp bright image easily visible in normal room light.

The various negative voltages necessary to operate the cathode ray tube are obtained from a voltage divider network across the —1500-volt supply. The components of this network and the blanking bias rectifier circuit are mounted on a small chassis at the base of the tube. Potentiometer R351, labeled INTENSITY, permits adjustment of the grid bias, which controls the beam current and thus the image brightness. Bypassing is provided by C304 and C257 (located in the power supply). R352, in series with the cathode, limits the maximum beam current to a desirable value and allows external brightening or blanking impulses to be introduced via the CRT CATHODE binding post and the .1 μf 2000 volt capacitor, C303. In order to bring the electron beam into sharp focus at the screen, the potential of the first anode is made adjustable by means of the FOCUS potentiometer, R305. Adjustment of the second anode potential is provided by the ASTIGMATISM potentiometer, R303, permitting good focus to be obtained on both horizontal and vertical lines simultaneously. R303 is connected between the +250-volt and —150-volt supplies, and has adequate range to provide proper focusing when the crt deflection plates are operated at either their normal average potential of +150 volts, or at ground average potential.

Each of the four deflection plates is connected via a short, low capacitance lead to a banana jack on the side access panel. This feature permits convenient direct connection for high-frequency observation, etc. See Operating Instructions.

The accelerating electrode is connected directly to the +1500-volt circuit of the power supply. Edge lighting of the plastic graticule is provided by two Mazda No. 47 lamps, and the intensity of the lines is varied by means of the SCALE ILLUM. control, R302.

The sweep chassis, located in the lower front portion of the Type 512, contains the circuits which deflect the electron beam horizontally across the crt screen at a uniform rate. The sweep may be operated either recurrently (sawtooth); or triggered (driven) by the signal under observation, an external impulse, or the 60-cycle line. Other circuits apply a blanking bias to the crt grid during the flyback and waiting periods. Gate, sweep sawtooth, and delayed trigger waveforms are made available at front panel binding posts. A square-wave calibrator, operating at approximately 1 kc, provides an accurate means of measuring signal amplitudes and a convenient signal source for many circuit adjustments of the Type 512. The calibrator circuits are described under "Vertical Deflection System".

Trigger Circuits

With the SWEEP STABILITY control adjusted for triggered sweep operation, each sweep is initiated independently of the preceding sweep by a trigger or synchronizing impulse. The function of the trigger circuits is to select the trigger signal from the desired source, amplify or attentuate it as required, and apply it with suitable polarity to the sweep generator.

Trigger Selector

The TRIGGER SEL. switch, SW101, operating in conjunction with the cathode coupled amplifier stage, V108 and V109, selects the source of trigger signal and reverses its polarity if necessary. The trigger impulse or signal under observation is applied to the grid of V108 and appears at the plate amplified and opposite in polarity. Due to the common cathode resistor, R139, and the grounded grid of V109, an amplified signal of the original polarity appears at the plate of V109. A positive impulse is required at the grid of V110 to produce the proper trigger polarity for the sweep generator. Therefore, the TRIGGER SEL. switch is connected so that on the +EXT. setting the amplified trigger signal is taken from the plate of V109, thus maintaining its original polarity. In the —EXT. position, polarity inversion is required and connection is made to the plate of V108.

The internal trigger signal is taken from a divider, R71 and R72, in the plate circuit of the vertical amplifier output stage. Since the polarity of this signal is opposite that of the signal applied to the vertical amplifier INPUT A, it is necessary to connect to the plate of V108 for +INT. and to the plate of V109 for —INT.

positions of the TRIGGER SEL. in order to obtain correct trigger polarity.

In the fifth position of SW101, the trigger amplifier input is connected to the 6.3-volt ac heater supply, to permit synchronization with the line frequency.

Trigger Amplitude Control

The extended bandwidth and versatility of the Type 512 require utmost flexibility in the trigger circuits to assure stable images of the wide variety of waveforms which may be encountered. The desired control is achieved by an amplifier stage with V110. The TRIGGER AMPL. potentiometer, R143, permits adjustment of the bias of V110 from the point at which plate-current cutoff occurs (about 7 volts) to about 80 volts. This range of control together with the high overall gain of the trigger circuits provides suitable trigger impulses from external inputs of 0.15 to 15 v, and from crt deflections of 5 mm or greater when the internal settings are used. The special taper of R143 makes adjustment very smooth in operation. Since the plate current of V110 remains cut off (until a positive signal is applied to the grid) the grid of the limiting cathode-follower section of the 6J6 tube, V111, is held at constant potential of approximately 150 volts by the divider R146 and R147. The cathode of V111 is maintained at a similar value. This potential is divided between R150 and R151, with 2.5 volts appearing across R151.

The amplified trigger impulse, of negative polarity, which appears at the plate of V110, is applied to the grid of the cathode follower. The cathode falls with the grid, but because of the long time constant of R150 and the charged capacitor, C113, the fall is limited to 2.5 volts. This value is sufficient to properly trigger the sweep, but small enough to prevent disturbing the sweep linearity. The peak of the trigger impulse is clipped by this limiting action of the cathode follower, and the base level is determined by the bias on V110, which the TRIGGER AMPL. control establishes. Therefore, when the trigger source is a sinewave, sawtooth or other slowly changing waveform, the phase of the observed image will vary relative to the start of the sweep with changes in trigger signal amplitude or setting of the TRIGGER AMPL. control.

Trigger Coupling Diode

During the period when no signal is being received from the trigger amplifier, the plate of the sweep generator, V112, is held at about +150 volts by the diode connected section of V111. When a trigger impulse causes the cathode of V111 to fall to the potential of C113, an equal fall occurs at the diode and sweep generator plates, thus initiating the sweep cycle. The diode is used in preference to a coupling capacitor because it disconnects the sweep generator from influence of the trigger amplifier as soon as the sweep is underway. This occurs because the plate of V112 falls linearly until the sweep cycle is completed, holding the diode plate negative with respect to its cathode, and thus prevents conduction of additional trigger impulses until the sweep generator is ready to begin another cycle.

Phantastron Sweep Generator

The sweep generator circuit, employing a screen coupled phantastron*, V112, and associated charging cathode follower, ½ of V113, provides a linear sawtooth voltage for deflection of the crt beam, and a gating voltage for control of the crt blanking bias oscillator. The excellent linearity and stability of this circuit, matched by accurately calibrated timing controls, virtually obviates the need for time markers.

This flexible circuit is inherently capable of producing a sawtooth voltage of large amplitude, with excellent linearity. A single SWEEP STABILITY control, R152, provides for either triggered or recurrent operation of the sweep by adjusting the suppressor bias of V112.

Triggered Sweep

With the SWEEP STABILITY control set for triggered operation, sufficient suppressor bias is applied to cause plate-current cutoff and the plate of V112 is held at about +150 volts, as described under "Trigger Circuits". Since the cathode is grounded, the grid is held slightly positive by the current flowing in the timing resistor R165 (or R164 and R165), and the screen is at a low potential as it is taking the current which would normally flow to the plate.

When the negative trigger impulse is received, causing the plate to fall, the grid and consequently the cathode of the charging cathode follower section of V113 fall correspondingly. Since the timing capacitor, C117 to C121, which is charged to 150 volts, cannot discharge immediately, this impulse is coupled to the grid as a negative bias, thus greatly reducing the screen current. This causes the screen voltage to rise. As the suppressor voltage is determined by the voltage

*For a discussion of phantastron circuits, see Radiation Laboratory Series, Vol. 19, pp. 195-204.

appearing across the divider R152, R153 and R154, it is simultaneously raised and plate current begins to flow. C114 compensates for shunt capacitance, maintaining the fast rise necessary at high sweep speeds. Since the cathode current in a pentode is fairly constant, any increase in plate current decreases the screen current. This action is regenerative and causes the plate current to increase rapidly. The resultant voltage drop is transferred to the grid via the cathode-follower section of V113 and timing capacitor. (C117-C121). With the circuit constants used in the Type 512, this initial fall is limited to about five volts by the feedback between plate and grid, before the phantastron action begins. When the grid is carried below cathode potential, two effects take place. First, the total plate and screen current is reduced to a very small value. Second, the grid no longer takes the current flowing in the timing resistor R165 (or R164 plus R165). This current now can flow only in the timing capacitor. As one end of the timing resistor is held constant by the SWEEP TIME/CM control, R161, the voltage drop across it and consequently the discharge current of the timing capacitor will depend on the grid voltage of V112. Any tendency for the grid to change causes a corresponding plate current change and is counteracted by an opposing voltage coupled back to the grid from the plate via the cathode follower and timing capacitor. Thus a state of equilibrium is maintained, holding the grid potential nearly constant. As the timing capacitor discharges, the grid rises slightly, permitting the increased plate current necessary to cause the phantastron plate and cathode follower cathode to fall correspondingly. Since the grid needs to change less than a volt to cause the entire plate swing, the voltage across the timing resistor and therefore the current through it remains almost constant during the sweep. This constant current, discharging the timing capacitor, causes a linear change in the voltage across it. Since the grid end of the timing capacitor changes very little, the other end falls in a linear sawtooth. To get a quantitative idea of the linearity, consider the following typical constants. Plate load 500K, charging voltage 100, G_m of tube 2 ma/v. For a 100-volt plate swing 0.2 ma discharging current would be needed. This requires 0.1 v grid change. The initial discharging current will therefore be only 0.1% greater than the terminal discharging current.

When the plate reaches such a low voltage that it can no longer hold the grid down, the total current begins to rise. Since the plate can take no more current, the increased current goes to the screen which begins to fall. The screen-suppressor coupling carries the suppressor down, thus decreasing the plate component of the total current. This regenerative action rapidly cuts the plate current off because of the suppressor bias, and leaves the circuit in its initial condition, i.e., grid taking the charging current (formerly flowing in the timing capacitor), screen at a low voltage and plate held by the trigger coupling diode.

Charging Cathode Follower

The purpose of the charging cathode follower is to reduce the time required to recharge the timing capacitor. If the timing capacitor were connected between the grid and plate of V112, the sweep portion of the cycle would remain unchanged, but the time necessary to recharge the timing capacitor would be much longer since it would charge through the 470-k plate resistor, R157. By connecting the cathode follower (one section of V113) between the plate and the timing capacitor, very rapid recharging is possible. The plate of V112 rises rapidly since it has only the tube capacities in shunt with it. When the plate rises, it carries the grid up with it and consequently the cathode of V113. The other side of the timing capacitor is held near ground by the diode action of the phantastron grid. Thus the timing capacitor charging current is supplied by V113, and may be large due to the low circuit resistance. This feature reduces the sweep flyback time to a minimum.

Recurrent Sweep

Recurrent (sawtooth) operation is obtained by advancing the SWEEP STABILITY control, R152, until the negative suppressor bias of V112 is reduced sufficiently to permit plate current to flow at the beginning of the cycle. With this setting, a new cycle is started immediately upon completion of the previous one, as a trigger impulse is not required to cause the initial plate fall.

Sweep Timing

Accurate adjustment of sweep time is made possible by two calibrated front-panel controls. The 11-position SWEEP RANGE switch, SW102, selects one of the timing capacitors. Each capacitor is used for two ranges. Another section of SW102 short circuits a portion (R164) of the precision timing resistor in alternate ranges. Thus, the complete sweep time range of 3 μsec/cm. to .3 sec/cm. is covered, in two steps per decade, with ten switch positions. The eleventh position provides for connecting an external signal to the sweep amplifier. Precise, continuously variable control for each step of the SWEEP RANGE switch is provided by the calibrated SWEEP TIME/CM.

potentiometer, R161. This control adjusts the voltage to which the timing resistor is returned, thereby controlling the discharge rate of the timing capacitor.

Good tracking of the SWEEP TIME/CM. dial is made possible by the screwdriver controls, SWEEP TIME A and SWEEP TIME B, which permit accurate adjustments of the voltage at both ends of R161. R156 and R158 compensate for the change in timing resistance as the SWEEP RANGE switch is rotated, and permit the same setting of the SWEEP STABILITY control at all ranges.

Sweep Output Cathode Follower

The other section of V113 is employed as a cathode follower to isolate the SWEEP OUTPUT binding post from the sweep generator, providing a sawtooth waveform of about 100 volts amplitude at the front panel.

Sweep Amplifier

The sweep amplifier provides the balanced (push-pull) waveform of about 350 volts amplitude required to deflect the beam horizontally across the crt screen. The balanced output maintains a constant average deflection plate potential over the entire sweep and thus prevents defocusing of the spot. This amplifier employs V114 in a cathode-coupled* circuit. With SW102 in any of the first ten positions, i.e., when using the internal sweep generator, the phantastron plate waveform is connected to the control grid of V114B via the divider, R166 and R167. This divider is necessary because the 150-volt sweep-generator waveform must be attenuated to prevent overdriving the sweep amplifier. Attenuation is employed, rather than a reduction of amplifier gain, so that maximum sensitivity is available when the SWEEP RANGE switch is in the eleventh or EXT. position.

In the EXT. position, the sweep amplifier grid connections are reversed, so that a positive-slope sawtooth applied to the EXT. SWEEP INPUT causes a left to right deflection. Amplitude is controlled by the EXT. SWEEP ATTEN. potentiometer, R171. In either case, horizontal positioning of the beam is accomplished by varying the bias of the opposite grid, thereby changing the plate current and consequently the plate voltage of one section of V114 with respect to the other. The range of the HOR. POSITION control, R169, is set by the dividers R169.1 and R170 on the positive end, and R169.2 and R169.3 on the negative end.

*See Puckle "Times Bases", pp. 119-125, for a discussion of cathode-coupled amplifiers.

To obtain good focus on the cathode-ray tube, it is necessary for the second anode and both pairs of deflection plates to operate at approximately the same average potential. Since the 150-volt average potential of the vertical deflection plates is determined by the vertical amplifier output stage, the 250-volt average at the sweep amplifier plates must be reduced to this value. This is accomplished by two Type NE-2 neon lamps in series with each plate of V114 and associated crt deflection plate. As the neon lamps maintain a constant potential of about 55 volts each, the sweep sawtooth (or other waveform) at the plates of V114 appears unchanged at the deflection plates except moved down 110 volts. A steady current of about 250 microamperes, supplied from the negative high-voltage power supply via R179 and R180, keeps the neon lamps ionized regardless of changes in the sweep amplifier plate potentials. The stabilizing resistors, R177.1 and R178.1, eliminate any tendency toward spurious oscillation. The impedance of the neon lamps is rather high at the frequencies involved in the faster sweeps, so a low-impedance path is provided by C123 and C124.

Any change in gain of the sweep amplifier, such as might be caused by aging or replacement of V114, will be evidenced by error in the indicated sweep time. Therefore, in order to realize the full benefits of the accurate timing controls and stable adjustments of the sweep generator, the sweep amplifier gain is made variable. This is accomplished by means of degeneration in the cathode circuit, which may be varied by adjusting R176. See the Adjustment Section for details.

Delayed Trigger and Sweep Magnifier

The delayed trigger and sweep-magnifier-gate waveforms are derived from the sawtooth output of the phantastron sweep generator. Since the magnified-sweep generator employs its own time constants, and the normal sweep generator functions only as a gate, the magnified sweep waveform is independent of the preceding circuits. This design results in a magnified sweep having excellent linearity and accurate timing.

Delay Selector

This circuit, utilizing a cathode-coupled dual triode, V101, determines the point on the normal sweep at which the delayed trigger and start of the magnified sweep occur. The 150-volt sweep-generator sawtooth is applied to the control grid of V101A and a similar waveform appears at the cathode across R101. The potential of the control grid of V101B is determined by the divider R103, R104 and R105, and may be varied by adjusting the DELAYED TRIGGER AND SWEEP MAGNIFIER POSITION control, R104. C101 holds the grid constant during the sweep cycle. Since the large amplitude of the cathode waveform causes either plate current saturation or cutoff (or both, depending on the setting of R104) only a small portion of the sawtooth waveform appears in amplified form at the plate of the output section. The range of R104 is sufficient to permit selection of any desired portion of the cathode waveform, thus providing a continuously variable delay.

Shaper

The waveform at the selector plate requires further limiting and amplifying to provide the steep wavefront required for gating the magnified-sweep generator and triggering associated equipment. This is accomplished by the shaper circuit with V102. The compensated divider, R106, C102 and R107, provides direct coupling to the grid, preserving the waveform at both the extreme high and low sweep speeds. The amplified and inverted signal which appears at the shaper plate has a rise time of approximately 1% of the 10-centimeter sweep duration. (The rise is somewhat slower at the highest sweep speeds.)

Delayed-Trigger Cathode Follower

One section of V104 is employed as a cathode follower to provide a relatively low impedance for the delayed-trigger output. This cathode follower also serves to isolate equipment connected to the DELAYED TRIGGER binding post from the magnified-sweep circuits.

Magnified-Sweep Generator

The magnified sweep is generated by an externally gated Miller run-down circuit which is similar in operation to the phantastron circuit employed in the normal-sweep generator. The same group of timing capacitors is used, except for the two highest ranges, and these capacitors are selected by the SWEEP RANGE switch. While SW102D and SW102G insert the desired timing capacitor into the phantastron circuit, SW102E and SW102F simultaneously select the next smaller capacitor for the magnified sweep. SW102B selects corresponding timing resistors, R115 and R116, of 1% tolerance, thus accurately maintaining the magnified sweep time at 20% of the normal sweep time.

At the beginning of the normal sweep, the plate voltage of the shaper, V102, is held at a low value because of the large plate current. This voltage, applied to the compensated divider, R110, C104 and R111, holds the suppressor of V103 at negative potential, since the divider is returned to the —150-volt supply. The negative suppressor bias prevents plate current flow and the plate voltage is determined by the cathode-follower voltage regulator, V105. The grid is near ground potential and a large screen current flow keeps the screen voltage at a low value. The timing capacitor is charged.

After a delay, determined by the setting of the DELAYED TRIGGER AND SWEEP MAGNIFIER POSITION control, the amplified portion of the normal-sweep sawtooth from the delay selector appears at the grid of V102, causing rapid plate-current cutoff. This causes the plate voltage to rise quickly toward the +250-volt supply, and results in a slightly positive suppressor bias on V103. The plate current flow which now occurs in V103 causes the plate voltage to fall rapidly, carrying with it the grid and consequently the cathode of V104A. As the timing capacitor cannot discharge immediately, the grid of V103 also falls rapidly. This action continues several volts until the grid approaches the point of cathode current cutoff, and an equilibrium is established, where further fall is counteracted by the reduced plate current it causes.

At this point, the linear run down (described under "Phantastron Sweep Generator") begins and continues until the plate is nearly at ground and the timing capacitor almost discharged. This condition is maintained until the end of the normal sweep, when the positive gate pulse is removed from the suppressor of V103, and the negative bias reapplied. As plate current is now cut off, the plate rapidly returns to its original potential, set by V105, carrying with it the grid and cathode of the charging cathode follower, thus recharging the timing capacitor. Simultaneously the grid and screen return to their original potentials and the circuit now ready to generate another sawtooth waveform when another gate is applied to the suppressor. The sawtooth waveform is taken from the tapped cathode resistor, R117 and R118, in the same manner as the normal sweep. With the MAGNIFIER switch, SW103, in the IN position, the sweep amplifier input is connected to the magnified sweep generator; in the OUT position connection is made to the normal-sweep generator.

Cathode Follower Voltage Regulator

This circuit, with V105, is similar in operation to the limiting cathode follower described under "Trigger Amplitude Control", but omits the limiting function. Its purpose is to prevent the magnified-sweep generator plate from rising above a desired potential. This is the value required to make the starting point of the magnified sweep coincident with that of the normal sweep. The voltage of the cathode follower section grid of V105 is set by the divider R123, R124 and R125 and maintains the cathode at a similar value. As the magnified-sweep generator plate is connected to the diode section plate of V105, it cannot rise appreciably above the cathode potential. When the plate of V103 falls during the period of the magnified sweep, the diode plate becomes negative with respect to the cathode, and the cathode follower exercises no further control until the end of the normal sweep cycle. The variable section of the divider, R123, labeled MAG. POS., permits accurate adjustment of the magnified sweep starting position to be made.

Blanking Oscillator

In addition to the manual INTENSITY control, R352, an automatic blanking circuit is employed to cut off the crt beam current during the sweep fly back and waiting periods. Since the waiting period (with spot at the left side of crt and sweep generator awaiting the initiating trigger) may be minutes long when the Type 512 is used for observing a periodic phenomena or for single sweep operation, it is essential that the blanking bias amplitude be independent of time. That is, the spot should remain completely extinguished regardless of the duration of the waiting period. Control of the blanking is also desirable to permit a dim spot for position reference.

These requirements are satisfied by a gated high-frequency oscillator and rectifier, or carrier circuit.

The gate voltage is derived from the positive square-wave screen waveform of the phantastron sweep generator. This signal is direct coupled to the blanking gate inverter amplifier (½ of V106) grid via the compensated divider R126, C106 and R127. The large grid swing causes both saturation and cut off of plate current, resulting in a very nearly square, inverted plate waveform, which is applied to the suppressor of the blanking oscillator, V107, by way of another divider, R131.1, R131.2 and R131.3.

V107 is employed in a conventional Colpitts oscillator circuit. Link coupling provides a low-impedance connection to the blanking-bias rectifier, V302, and also the necessary insulation from the —1500-volt crt circuit. Both the oscillator and rectifier tuned circuits are made adjustable by means of variable inductors, so that they may be resonated. The rectifier is polarized so that the rectified high-frequency carrier is applied as a negative bias to the crt grid. The BLANKING control, R131.1, permits variation of the oscillator suppressor bias existing during the flyback and waiting periods, thus controlling the amplitude of oscillation and consequently the blanking bias.

Positive-Gate Generator

The +gate, a 150-volt square wave of the same duration as the sweep, is also derived from the screen waveform of the phantastron sweep generator. A portion of the square negative waveform at the plate of the blanking-gate inverter section of V106 is applied to the grid of the other section and appears, inverted and amplified, at the plate. This circuit provides a relatively low impedance output and isolates any equipment connected to the +GATE binding post from the blanking circuit.

Vertical Deflection System

The vertical deflection system provides the means of attenuating or amplifying input signals so that they present an image of convenient amplitude on the cathode-ray-tube screen. Signals may be attenuated 2 times (20 times with probe) or amplified as much as 5,000 times without appreciable distortion. Signal amplitude is easily determined by means of accurate attenuator and calibrator circuits. Direct banana-jack connections to the cathode-ray-tube deflection plates at a side access panel provide a convenient low-capacitance, low-inductance input when it is undesirable to use the vertical amplifier.

Vertical Amplifier

The balanced push-pull vertical-amplifier circuits of the Type 512 are located on the upper chassis, and consist of a two-stage preamplifier, a step attenuator, a variable attenuator and associated cathode follower, a two-stage final amplifier, a time-mark amplifier and four cathode-follower voltage regulators.

In order to reconcile the inherently conflicting problems of maximum bandwidth and high dc gain with good stability, a switching system is incorporated which automatically removes the two-stage preamplifier whenever sufficient sensitivity can be attained without it. This same switch (VERT. DEFL. SENSITIVITY) inserts appropriate rc-compensated attenuators in the circuit so that eight steps (approximately 10 db each) of sensitivity are available, ranging from 5 mv to 50 v per cm. Constant input impedance is maintained for all VERT. DEFL. SENSITIVITY settings. When the preamplifier is not used, i.e., for sensitivity below 0.15 v/cm, the pass band is 2 mc. For higher sensitivities, it is necessary to pay more attention to grid current stability, hum, microphonics, etc., and suitable high-conductance tubes are not available for the first preamplifier stage. Therefore, in order to obtain the desired gain, the pass band is reduced to 1 mc.

Input Circuit

Flexible design of the Type 512 input circuit permits either single-ended or balanced (differential) signal input connection and positive or negative calibrator connection.

Frequency-compensated signal-input probes are supplied to provide reduced loading on the circuit under observation. They consist of 9-megohm series resistors paralleled with compensating capacitors, and provide an input impedance of 10 megohms shunted by 14 $\mu\mu$f. With the VERTICAL INPUT switch (SW1) in position A, INPUT A is connected to grid No. 1 of V1 via the AC-DC switch, and the connection to grid 1 of V2 is grounded. In the +CAL. position, the output of the calibrator is connected to V1 (when the CAL. switch is set at NORM.), and the input to V2 is grounded. When SW1 is in the —CAL. position, opposite connections are made. With the INPUT swith in the A—B position, INPUT A is connected to grid No. 1 of V1 and INPUT B to grid No. 1 of V2. When amplification of the ac component only is desired, SW2 (AC-DC) permits insertion of coupling capacitors C1, C2, C7 and C8. This prevents drift in the preamplifier from changing the output positioning and also permits the use of full gain to observe signals such as power-supply ripple, when otherwise the dc component would exceed the range of the POSITION control and deflect the trace off the crt screen.

Preamplifier

Drift due to grid current in V1 and V2 is minimized by the tube type selection, and by operating the plates and screens at low voltage. Grid-current limiting resistors R1.1 and R2.1 permit rapid recovery of positioning in case a large potential is inadvertently applied to the preamplifier. C3 and C4 are used to provide the same input capacitance when the preamplifier is in use, as when it is switched out in the first five positions of SW3. A balanced output at the plates of V1 and V2 is secured by cathode coupling due to the common resistor R3, when either single or balanced input is employed. The DIFF. BAL. control, R4, enables the gain of V1 and V2 to be adjusted to compensate for variation in tube characteristics, and thus allows the operator to realize maximum benefit from the differential-input connection.

V1 and V2 are coupled directly to the 2nd stage, V3 and V4, via the parasitic suppressors, R9 and R10. GAIN ADJ. A, R15, permits the degeneration in the cathode circuit V3 and V4 to be varied, thus controlling the overall gain of the preamplifier. In the 6th position (0.05-0.15 v/cm) of SW3 (VERT. DEFL. SENSITIVITY), additional degeneration is introduced in the second stage as a means of reducing the gain by a factor of three. This is used rather than the next attenuator position in order to reduce the maximum output voltage required of the preamplifier, thus eliminating any tendency toward overload distortion. This additional degeneration is provided by R17 and R18. R17, marked GAIN ADJ. B, is variable, allowing the sensitivity to be individually adjusted in this position of SW3. L1 provides further increase in degeneration at high frequencies, thus compensating for shunt capacitance in the circuit. Overall high-frequency compensation of the preamplifier is accomplished by the adjustable inductors L3 and L4.

A voltage divider, R25, R26, R27 and R28, frequency compensated by C5 and C6, is employed so that the average output voltage of the preamplifier will be at ground potential. This method permits operation of the cathode follower stage input at ground potential, allowing signal-input connection direct to the cathode follower grid when the gain of the first and second stages is not needed.

Adjustment of the preamplifier balance is provided by two potentiometers, the PRE-AMP. BALANCE, R20, and the AUX. PRE-AMP. BAL., R20.1. These controls are connected so that, depending on their adjustment, they either add to or subtract from the potential which would otherwise be present at the plates of V1 and V2. The use of two controls allows initial balance to be secured by adjusting the screwdriver control, R20.1, with the panel control, R20, centered. This makes available the full range of R20 to compensate for possible changes in tubes and other components.

Attenuator

All input signals and calibrating voltages pass through a five-section frequency-compensated attenuator. The attenuation ratios are 1:1, 3:1, 10:1, 30:1 and 100:1 respectively. Each section is designed to have an input resistance of 1 megohm shunted by a capacitance of 40 $\mu\mu$f when connected to the cathode-follower-stage input circuit. Variable trimmers permit the capacitive divider ratio to be adjusted to equal the resistive divider ratio, thus making the attenuation independent of frequency. Other variable capacitors shunted across the input side of each section are adjusted to maintain a constant input capacitance for all attenuator settings.

The VERT. DEFL. SENSITIVITY switch, SW3, combines the functions of shifting the input connections, changing the second-stage gain and selecting the appropriate attenuator section, thus providing a very wide adjustment of sensitivity with a single control.

Cathode Follower Stage

The sensitivity (gain) control provided by the VERT. DEFL. SENSITIVITY switch consists of 8 steps of approximately 10 db each. To provide continuously variable control, a dual potentiometer, R53 and R54 designated VERT. AMPL. ATTEN., is employed to fill in between the steps of SW3.

The cathode followers V5 and V6 provide a low-impedance circuit for the VERT. AMPL. ATTEN. This is necessary because R53 and R54 must be relatively low resistance to prevent stray capacitances from appreciably restricting the high-frequency response. R52 limits the maximum attenuation of this control, and thus limits the output voltage required of the previous circuits to a value well below the point of overload.

In a direct-coupled amplifier, any unbalance of the circuits will be acted upon in the same manner as a signal, and consequently a change in the output voltage (vertical position) will occur when the gain is varied. A potentiometer, R51, labeled C. F. ADJ., is provided in the Type 512 to permit the cathode voltages of V5 and V6 to be made equal, thus making position independent of the VERT. AMPL. ATTEN. setting.

Since these tubes may exhibit small variations which would cause unbalance of the circuit, screwdriver access to R51 is provided at the front of the instrument.

Final Amplifier

A balanced output at the plates of the third stage, V7 and V8, with either single or balanced input, is secured by the use of a cathode resistor, R55, which is common to both tubes.

Since the third stage is directly coupled to the fourth (output) stage, any change in balance of the third stage will be present in amplified form at the output. Therefore, it is possible to employ a potentiometer, R56, in the cathode circuit of V7 and V8 as a vertical-position control. R57 limits the range of positioning, making the adjustment of R56 less critical.

A potentiometer, R61.2, labeled 3RD STAGE BAL., employed in the same type of circuit as the PRE-AMP. BAL. permits correction of any unbalance in the third stage due to mismatch of V7 and V8.

The third-stage plate-supply voltage is made as low as is consistent with an adequate undistorted output, to make available increased plate voltage for the fourth stage, thus permitting maximum overall undistorted output.

The output-stage plate-load resistors, R67 and R68, are each composed of four composition resistors in series. This construction minimizes frequency effects in the load resistors.

Shunt compensation provided by the variable inductors, L5 and L6, permits a bandwidth of 2 megacycles and rise time of .2 microseconds to be achieved in the final amplifier.

Since the average plate potential of the output stage is about +150 volts, current limiting resistors, R69 and R70, are provided between the plates and the output jacks of the Type 512, to prevent short-circuit hazard. Capacitors C39 and C40 prevent loss of high frequencies which would otherwise occur due to shunt capacitances of the cathode-ray-tube deflection plates.

Time-Marker Input

A means of inserting time-marker pulses without affecting the balance of the amplifier circuits is provided by V13 which is connected to the tapped plate-load resistor of V7. The divider, R83 and R84, maintains grid 1 of V13 at about —6 volts, which is well beyond plate-current cutoff. When a marker pulse having sufficient amplitude to overcome this bias is applied to the grid via the TIME MARK INPUT connector, it appears in amplified form at the output of the Type 512.

Cathode-Follower Voltage Regulators

Reduced voltages at good regulation (low impedance) are required for the plate and screen supplies of the first, second, cathode-follower, and third stages. The plus 35-volt supply for the first stage, V1 and V2, is obtained from one section of the dual triode, V11, which is operated as a cathode follower. The output voltage at the cathode is determined by the grid voltage, which is set by the divider, R73 and R74. Bypass capacitor C41 reduces ripple due to electrostatic pickup of stray fields.

The other section of V11 provides plate and screen voltage for V2 and V3 in a similar manner, except that part of the current is supplied through a shunt resistor, R77.

The dual triode, V12, operates in the same fashion, supplying the cathode-follower stage and the third stage.

Calibrator

Accurate measurement of signal amplitude in the Type 512 is made possible by means of the built-in square-wave calibrator, consisting of V115, V116, and associated circuits, located on the rear of the sweep chassis. The square wave of approximately 1 kc used for the calibrating voltage is generated by a free-running triode multivibrator, V115. A series limiting grid resistor, R182, is used to reduce the loading effect of the coupling capacitor, C125, thus providing a waveform with a sharp leading edge. This resistor affects the symmetry of the output, so that it is necessary to make timing resistors R181 and R185 unequal in order to obtain a symmetrical output. Since precise symmetry is not required, no provision is made to adjust the duration of the positive and negative portions of the waveform.

Since the square-wave output is to be used for amplitude comparison and adjustment of frequency-compensated attenuators, it is essential for the output waveform to be accurate, and to have a means of setting and maintaining the maximum output level at the desired value of 50 volts. This is accomplished in the diode limiter and output cathode-follower stages using the dual triode V116.

The output of the multivibrator is fed to the grid of the output cathode follower via C127 and a series limiting resistor, R190. A divider, R185.1 and R186, maintains the signal at proper operating level for the diode-connected limiter section of V116. Since the voltage at the diode plate cannot rise appreciably above the cathode, maximum positive amplitude is determined by the cathode potential, which is set by the divider, R187, R188, and R189. A potentiometer, R188, allows the amplitude to be accurately adjusted. Since the limiting action of the diode occurs at a point well below the maximum amplitude of the multivibrator output, the positive portion of the waveform applied to the cathode-follower grid has a flat top and square corners. The maximum negative amplitude of this signal drives the cathode-follower grid to well below cathode current cut-off. This results in a clean square-wave output as the negative portion is held at ground potential, and the positive is a replica of the diode-limited waveform at the cathode-follower grid.

Output voltage of the calibrator is controlled by the CAL. RANGE step attenuator, R191, and the CAL. VOLTAGE potentiometer, R192. Excellent accuracy is provided by the use of 1% tolerance resistors in R191, and by a sufficient number of steps so that the minimum setting of the CAL. VOLTAGE control never need be under 30% of the full scale.

A front panel toggle switch, SW105, labeled CAL., operates in conjunction with the VERTICAL INPUT switch, SW1, to apply the calibrator output to either V1 or V2 with the CAL. switch at NORM. and the INPUT switch in + or — CAL. position. In the A or A-B INPUT positions, the +250-volt supply lead is opened by SW1, and the CAL. switch must be set to EXT. to permit the calibrator to function.

When the EXT. position is used, the lead to SW1 is disconnected from the calibrator and grounded to prevent coupling to the amplifier input. The calibrator voltage is available for external use at the CAL. OUTPUT connector on the front panel.

Power Supply

In order to make the operation of the Type 512 independent of the line-voltage fluctuations over the range of 105 to 125 volts, electronically-regulated direct current is supplied to all plate, screen, and bias circuits, as well as the heaters of the tubes in first, second, cathode-follower, and third stages of the vertical amplifier.

Four separate power circuits are used, providing:

1. —150 volts at 200 ma for the tube heaters and bias circuits.
2. +250 volts at 190 ma for the plate and screen circuits.
3. +450 volts at 8 ma for the sweep amplifier plate circuit.
4. —1500 volts at 1500 μa for the cathode-ray-tube and sweep-amplifier neon-lamp coupling circuits. +1500 volts for the crt accelerating anode.

—150-Volt Supply

In the —150-volt supply, two rectifier tubes are used in a full-wave circuit. C211 reduces the 120-cycle ripple to about 9 volts peak to peak. The electronic regulator further reduces the ripple to less than 0.1 volt. In this circuit, the cathode of V212 is maintained at a fixed potential by the voltage reference tube, V213. Any fluctuations in the —150-volt supply are impressed on the grid of V212 via the divider, R224, R225 and R226, and the series resistor, R223, then are amplified and applied, opposite in phase, to the grid of the series regulator, V206A. Thus, the drop across V206A is increased when the —150-volt output is high and decreased when it is low, resulting in a stabilized output voltage. The shunt resistor, R220, is employed to reduce the current required of V206A. Potentiometer R225, labeled ADJ. TO —150 V., permits accurate adjustment of the output voltage, and has sufficient range to compensate for variation in tube characteristics.

+250-Volt Supply

DC for the —250-volt supply is obtained from V207 and V208. The output of the —150-volt supply serves as a reference voltage for the regulator, V206B and V209. Any fluctuation on the +250-volt output is applied to V209 grid via the divider R216 and R217, and acts to stabilize the output voltage in the same manner as in the —150-volt regulator previously discussed.

+450-Volt Supply

The +450 volts required for the sweep amplifier is obtained by adding a 200-volt regulated supply to the +250-volt output. Rectified current is supplied by V204 in a half-wave circuit. The cathode of the regulator amplifier (one-half of V205) is held constant as it is connected to the output of the +250-volt supply. Any fluctuations appearing at the cathode of the series regulator (the other half of V205) are impressed on the amplifier grid via the divider R208 and R209. This fluctuation signal is amplified, inverted, and applied to the series-regulator grid, controlling the regulator output voltage in the same manner described under "—150-Volt Supply".

High-Voltage Supply

Plus and minus 1500-volt cathode-ray-tube accelerating potentials are supplied by an oscillator power supply. V201 is employed in a conventional Hartley circuit oscillating at approximately 70 kc. Since the plate and screen of the oscillator tube are supplied from the plus 250-volt regulated bus the high-voltage output is unaffected by line-voltage fluctuations. R253, R254, R255 and R256 form a voltage divider that sets the grid of V225A at approximatly —150 volts. Since the cathode of V225A is held at —150 volts by the regulated supply bus any fluctuations of voltage presented to the grid will appear amplified and inverted at the plate. This amplified and inverted signal is direct coupled to the grid of V225B. Any variation in the current drawn by V225B will appear as a voltage change at the screen of the oscillator tube and thus will increase or decrease the oscillator output. The phasing of the feedback loop is such that a drop in output voltage will increase the oscillator output or an increase in output voltage will decrease the oscillator output. Therefore, changes in output voltage due to load variations are reduced to a minimum. Potentiometer R254, labeled —1500 ADJ., permit accurate adjustment of the output voltage.

Adjustments and Maintenance

CAUTION—VOLTAGES HIGH ENOUGH TO BE DANGEROUS ARE PRESENT IN THIS INSTRUMENT. SINCE MUCH MAINTENANCE MUST OF NECESSITY BE DONE WITH THE CASE REMOVED, GREAT CARE SHOULD BE TAKEN. USE ONLY INSULATED TOOLS, STAND ON A DRY FLOOR, AND IF POSSIBLE KEEP ONE HAND IN YOUR POCKET.

Replacement of Components

Most of the components used in the construction of TEKTRONIX instruments are standard parts obtainable from any well-equipped parts distributor. Some of the components carrying 1% and 2% tolerances may not be so readily obtainable but may be purchased from the manufacturer at these tolerances. The remainder of the low-tolerance components are standard 10%- and 20%-tolerance parts that are checked at the factory for proper value or performance. Replacement parts are available on order from the factory at current net prices but in the case of standard parts it is probably more economical of time to purchase them locally. It is not feasible to attempt to check out low-tolerance parts or matched pairs without a reasonably large stock to choose from as the rejection percentage is quite high in most cases.

A TEKTRONIX instruction manual will usually contain hand-made changes of diagrams, parts lists, and text, appropriate only to the instrument it was prepared for. There are good reasons why this is true.

First, TEKTRONIX engineers are continually working to improve TEKTRONIX instruments. When the improved circuitry is developed or when better components become available, they are put into TEKTRONIX instruments as soon as possible. As a result of constant improvement TEKTRONIX instruments are always built as good as we can build them, but the changes caused by these improvements must frequently be entered by hand into the manual.

Second, when TEKTRONIX instruments go through our exhaustive test procedure, TEKTRONIX technicians adjust them individually to obtain optimum operation. This kind of hand tailoring occasionally requires substitution of components differing from the nominal values printed in the manual.

Third, because of procurement difficulties, equivalent but different parts are sometimes used. Usually such parts are directly interchangeable with those originally specified. No alternate parts have been used which have adversely affected the instrument, and you were able to receive your instrument much earlier that you might have otherwise.

To assure that you will receive the correct replacement parts with the minimum of delay it is therefore important that you include the instrument serial number with your order, along with the instrument type and part numbers, of course. And as a further precaution, get ordering information from the instruction manual whose serial number agrees with the instrument.

Equivalent parts, supplied by the factory when the exact replacement parts ordered are not available, will be accompanied by an explanation and will be directly interchangeable in most cases.

Removal of the Case

Set the oscilloscope face downward on a padded flat surface, remove the access panel jumper plugs and the two screws in the bottom, then lift off the case.

Power Supply

Adjustments of the output voltages of the regulated supplies are provided by potentiometers R225, labeled ADJ. TO —150 V, and R254, labeled —1500V ADJ. The plus 250- and 450-volt supplies are dependent on the adjustment of the minus 150-volt supply. A voltmeter with an internal impedance of at least 20,000 ohms/volt should be used when adjusting the minus 1500-volt supply.

Operation on 210-250-Volt 50-60-Cycle Line

The Type 512 power transformer is wound with two 117-volt primaries. These windings are ordinarily connected in parallel at the factory for 117-volt operation. If 234-volt operation is desired, remove the jumpers connecting terminals 1 to 2 and 3 to 4. Connect terminal 2 directly to terminal 3. With the line still connected to terminals 1 and 4, the instrument is now ready for 234-volt operation.

Calibrator

Before adjustments are made on the vertical amplifier, it is well to check the output adjustment of the calibrator. This may be conveniently done by a comparison between the output of the calibrator and a known dc voltage. A suggested dc source is a 45-volt B battery and an accurate dc voltmeter. As an example then, let us assume the dc voltmeter indicates 47 volts. Set the calibrator controls to an indicated 47 volts. Connect the battery (with voltmeter connected) negative terminal to GND. and positive terminal directly to INPUT A (no probe). Set the vertical amplifier gain such that the deflection will be large enough for an accurate comparison. The comparison may readily be made by switching the VERTICAL INPUT selector switch between A and +CAL. If satisfactory agreement is not indicated, an adjustment may be made by means of R188, labeled CAL. ADJ. and located on the sweep chassis.

Vertical Amplifier

1. Differential-and-DC-Balance Adjustments

The several stages of the Type 512 vertical amplifier are balanced and direct coupled. To avoid shifts of position with change of gain, each stage should be in balance. The PRE-AMP BALANCE should be used only as a balance control and any desired positioning should be done with the VERT. POSITION control which follows the amplifier gain adjustments and hence is not affected by them. Conversely, any unbalance preceding either the step attenuator or the variable attenuator will be acted upon exactly the same as a signal and a change of position will accompany any change of gain. A complete check of the balance of each stage may best be made by starting at the output of the amplifier and progressing toward the input. A suggested procedure follows:

a. Output-Stage Balance

Balance of the output stage, V9 and V10 may be checked as follows: Connect the grids of V9 and V10 together. Now short the Y1 and Y2 plates and observe the deflection of the trace. If more than 1 cm deflection occurs, replacement of one or both of the output tubes is indicated.

b. Third-Stage Balance

To check the balance of V7 and V8, short the top terminals of the dual gain-control potentiometers R53 and R54 marked VERT. AMPL. ATTEN. and observe whether or not the vertical-position control, R56, has adequate range in each direction. If not, the range of R56 should be equalized by adjusting R61.2, labeled 3rd STAGE BAL.

c. VERT. AMP. ATTEN. Cathode-Follower Balance Adjustment

With the VERT. DEFL. SENS. switch in the .15-.5 position, adjust R51 (marked C.F. ADJ.) so that varying the setting of the VERT. AMPL. ATTEN. or shorting its top terminals does not shift the vertical position of the trace. If proper adjustment cannot be obtained, V5 and V6 must be replaced with more nearly balanced tubes.

d. Second-Stage Balance

Balance of the second stage may be checked by connecting together the grids and also the cathodes of V3 and V4. The amount of unbalance is indicated by the change in vertical positioning when the VERT. DEFL. SENSITIVITY switch is moved from the .15-.5 to the .015-.05 position. Although the PRE-AMP BALANCE and the AUX. PRE-AMP BAL. controls will compensate for considerable unbalance in the second stage, it is desirable to install a more nearly matched pair of tubes if the unbalance exceeds ±2½ cm.

e. Differential-Balance Adjustment

Set the VERT. DEFL. SENSITIVITY switch in the .005-.015 position, the VERTICAL INPUT switch in the A-B position, the AC-DC switch in the AC position, and the toggle switch marked CAL. to the EXT. position. Center the PRE-AMP BALANCE control, R20. Connect the CAL. OUTPUT to both INPUT A and INPUT B. Set the calibrator for an output of 5 volts. Slowly adjust R4, located on the right side and marked DIF. BAL., for minimum deflection of the trace. When an approximate adjustment is obtained, switch the AC-DC switch to DC and adjust the AUX. PRE-AMP BAL. control (R20.1) for centering of the trace. Alternate or simultaneous adjustment of this control and the DIF. BAL. control may be necessary to secure the best differential balance, as the DIF. BAL. control has a large effect on the positioning and the AUX. PRE-AMP. BAL. has a small effect on the differential balance. If the proper adjustments of either the DIF. BAL. or the AUX. PRE-AMP BAL. are found to be beyond the range of the controls, it will be necessary to substitute a more nearly matched pair of tubes for V1 and V2. The use of the AUX. PRE-AMP BAL. to secure initial balance, with the PRE-AMP BALANCE (R20) centered, makes available the full range of R20 to compensate for possible changes in tube characteristics.

f. .05-.15 BAL. Adjustment

In the .05-.15 position of the VERT. DEFL. SENSITIVITY switch, additional degeneration is introduced in the second stage of the preamplifier as a means of reducing the gain by a factor of three. This is used rather than the next attenuator step in order to reduce the maximum output voltage required of the preamplifier. A balancing control, R13, is provided which permits maintaining the trace in the same vertical position in the .05-.15 as in the other positions of the VERT. DEFL. SENSITIVITY switch. The following procedure is recommended: Set the VERT. DEFL. SENSITIVITY in the .15-.5 position and center the trace. Change the VERT. DEFL. SENSITIVITY to the .005-.015 position and center the trace with the AUX. PRE-AMP BAL. control. Set the VERT. DEFL. SENSITIVITY in the .05-.15 position and center the trace with R13, marked .05-.15 BAL. Repeat until the trace remains centered in all three positions.

g. Readjust Differential Balance

Since a change in setting of the .05-.15 BAL. adjustment causes a slight change in the differential balance, it is desirable to readjust the DIF. BAL. control, R4, as explained in section e.

> **NOTE** — One pair 5879 and one pair 12AU6 matched spare tubes are included with the Type 512. These tubes, located inside the instrument on a bracket near the crt socket, are selected to have characteristics similar to the matched tubes installed in the vertical amplifier. If it becomes necessary to replace a defective tube in any of the balanced stages, it is usually desirable to install the spare pair and order a replacement matched pair from the factory. The remaining good tube, which has been removed from the amplifier, will be useful as an emergency spare.

2. Gain Adjustments

Two gain adjustments other than the panel controls are included in the Type 512 Oscilloscope. An adjustment of the overall gain of the instrument is provided by a variable resistor R15, marked GAIN ADJ. A. The gain of the Type 512 may be checked against the self contained calibrator. The maximum sensitivity should be adjusted to 5 mv/cm.

The second adjustment, R17, marked GAIN ADJ. B, provides an adjustment of the gain when VERT. DEFL. SENSITIVITY is in the .05-.15 position only. With the VERT. AMPL. ATTEN. fully clockwise, adjust R17 for a deflection sensitivity of 0.05 v per cm.

3. Compensation of the RC Attenuator and Voltage Divider Circuits

The various attenuators in the Type 512 are of the rc type in which the resistor divider ratio is equal to the capacitor divider ratio and hence the voltage division is constant for any frequency from zero to well above the requirements of the Type 512. Adjustment of these attenuators is readily made by observation of their square-wave response. The self-contained calibrator in the Type 512 is a suitable square-wave source. A vertical deflection of 3 to 5 cm is recommended. When the variable capacitors in the attenuators are properly adjusted, a square wave will be correctly reproduced by the oscilloscope. If the capacitive divider has a lower attenuation ratio than the resistive divider, a spike appears on the corner of the leading edge. If the capacitive divider has a higher attenuation, the corner of the leading edge is rounded.

To simulate the presence of the case, a metal sheet should be placed on top of the instrument during these adjustments. A hole in the sheet will be required for access to some of the variable capacitors.

> **CAUTION** — THE PREAMP SHIELD MUST BE IN PLACE DURING ADJUSTMENT.

a. The A- and B-input capacitances of the third stage are equalized and the probes adjusted with the VERT. DEFL. SENSITIVITY switch in the .15-.5 position (input direct to the third stage). Attach one of the probes to INPUT A and connect it to CAL. OUTPUT. With the sweep time set at about 1 millisecond/cm (10 cycles of the square wave for 10-cm deflection) and C37 at ⅓ capacitance, adjust the probe capacitor, C9. Move the probe to INPUT B, ground INPUT A, and adjust C38. If proper adjustment cannot be obtained, reset C37 and readjust the probe and C38. If the setting of one probe is changed, the other should be adjusted to correspond.

b. With VERTICAL INPUT set at either + or —CAL. and the VERT. DEFL. SENSITIVITY switch in the .005-.015 position, adjust C5 and C6 using a sweep time of 0.1 to 0.2 milliseconds/cm. Use an insulated screwdriver. These capacitors are complementary in action and should be at about equal settings.

Using a sweep time of 0.1 to 0.2 milliseconds/cm adjust the attenuator series capacitors. The +CAL. input may be used for C13, C17, C25 and C33, and the —CAL. for C14, C18, C26 and C34.

> **NOTE**—Attenuator adjustments are listed in order of increasing attenuation, corresponding respectively to the .5-1.5, 1.5-5, 5-15 and 15-50 positions of the VERT. DEFL. SENSITIVITY switch.

d. Attach one of the probes to INPUT A, connect it to CAL. OUTPUT, set the sweep time at about 1 millisecond/cm and adjust the parallel attenuator capacitors C11, C15, C23 and C31. Set VERT. DEFL. SENSITIVITY at .005-.015 and adjust input capacitor, C3. Move the probe to INPUT B, ground INPUT A and adjust C12, C16, C24 and C32. Move VERT. DEFL. SENSITIVITY to .005-.015 and adjust C4.

Greater accuracy in the adjustment of C31 and C32 may be obtained by providing increased signal input and therefore greater vertical deflection. A convenient method is to substitute a 1-megohm variable resistor shunted by a 50 $\mu\mu$f capacitor for the probe. With VERT. DEFL. SENSITIVITY in the .15-.5 position, adjust the variable resistor until the square wave is properly reproduced, then proceed with the adjustment of C31 and C32.

4. High Frequency Response

The Type 512 vertical amplifier employs shunt compensation to improve the high-frequency characteristics, and is adjusted for best transient response rather than greatest bandwidth. This is accomplished by observing the response to a square-wave signal of about 100 kc having a rise time of 0.1 microsecond or less. The TEKTRONIX Type 104 or Type 105 Square Wave Generators provide a suitable signal.

a. Set the sweep time at 3 microseconds/cm, the VERT. DEFL. SENSITIVITY at .15-.5 and adjust L5 and L6 until the corner of the leading edge is square. These inductors are complementary and interdependent in action and should be at about equal settings.

b. Set VERT. DEFL. SENSITIVITY at .015-.05 and adjust L3 and L4 in a similar manner.

c. Set VERT. DEFL. SENSITIVITY at .05-.15 and adjust L1.

Timing-Series Capacitors

We manufacture our own timing capacitors with the characteristics needed to maintain sweep-time accuracy and linearity. The capacitance ratio between capacitors used is accurate within half of one per cent so that the time-base calibrations will be right at all speeds. Most capacitors change value with voltage, temperature, and age. Variation of capacitance with voltage is particularly undersirable because it causes nonlinearity of the time-base sawtooth. Our timing capacitors are especially free from this voltage effect. They also have minimum temperature and aging variations.

Timing capacitors C119, C120, and C121 are enclosed as a unit in a single sealed can. If you need to replace any one of these you must replace all three. C118 may be composed of two capacitors, chosen to have the right characteristics and capacitance value when connected in parallel. We therefore recommend that you obtain replacements for this capacitor from TEKTRONIX. Be sure to include the instrument serial number with your order.

Sweep

1. Adjustment of the sweep amplifier to compensate for variation of its gain or the sensitivity of the crt is provided by R176, marked SWEEP AMPL. GAIN. The gain may be set to the specified 1.0 volts per cm deflection using the calibrator as a source of known voltage. Connect CAL. OUTPUT to EXT. SWEEP IN. With the sweep range switch set to EXT., the CAL. toggle switch to EXT., the calibrator output adjusted to 10 volts, and with the EXT. SWEEP ATTEN. set for maximum gain, adjust R176 (SWEEP AMPL. GAIN) so that a deflection of 10 cm is obtained. This adjustment should be checked whenever the sweep amplifier or cathode-ray tubes are changed.

> **CAUTION** — THE CRT DEFLECTION SENSITIVITY WILL BE CHANGED IF THE INTENSITY CONTROL IS ADVANCED EXCESSIVELY.

2. Two screwdriver adjustments, located on the sweep chassis and marked SWEEP TIME A (R163) and SWEEP TIME B (R159) permit adjustment of the sweep speed to correspond to the calibration of the

SWEEP TIME/CM dial. R163 has a large effect on the "fast" end of the SWEEP TIME/CM potentiometer, R161, and a small effect on the "slow" end. while R159 has the opposite action, therefore adjustment of either control requires a minor readjustment of the other. These adjustments may be made at any convenient setting of the SWEEP RANGE switch except 3-10 microseconds and 10-30 microseconds. If an accurate oscillator or time-mark generator is not available, the 60-cycle line may be used as a standard.

a. If it is desired to use the 60-cycle line, connect any convenient source of 60-cycle voltage, such as the heater bus of the instrument, to the vertical-amplifier input. Set the SWEEP RANGE switch to the 10-30 millisecond position, and the SWEEP TIME/CM dial at 1.0. Adjust SMEEP TIME A so that 6 cycles correspond to 10 cm of the sweep. Set the SWEEP TIME/CM dial to 3.0 and adjust SWEEP TIME B so that 18 cycles correspond to 10 cm of the sweep. Repeat the above procedure until accuracy is obtained at both ends of the scale.

b. The sweep time in the 3-10 and 10-30 microsecond positions, and the magnified sweep in the 30 microsecond to .1 millisecond and the .1-.3 millisecond positions is controlled by the variable ceramic capacitor, C117. The magnified sweep in the 3-10 and 10-30 microsecond positions is controlled by the variable ceramic capacitor C116. These adjustments may be made with the aid of a calibrated oscillator of suitable frequency. A commonly available instrument suitable for the purpose is the Army Frequency Meter BC221 or the Navy equivalent, Type LM. If one of the above instruments is available, set it to a frequency of 166.67kc. Set the Sweep range switch to 3-10 microseconds and the SWEEP TIME/CM dial to 1. Adjust C117 so that 5 cycles of the observed waveform will extend over 10 cm of the sweep.

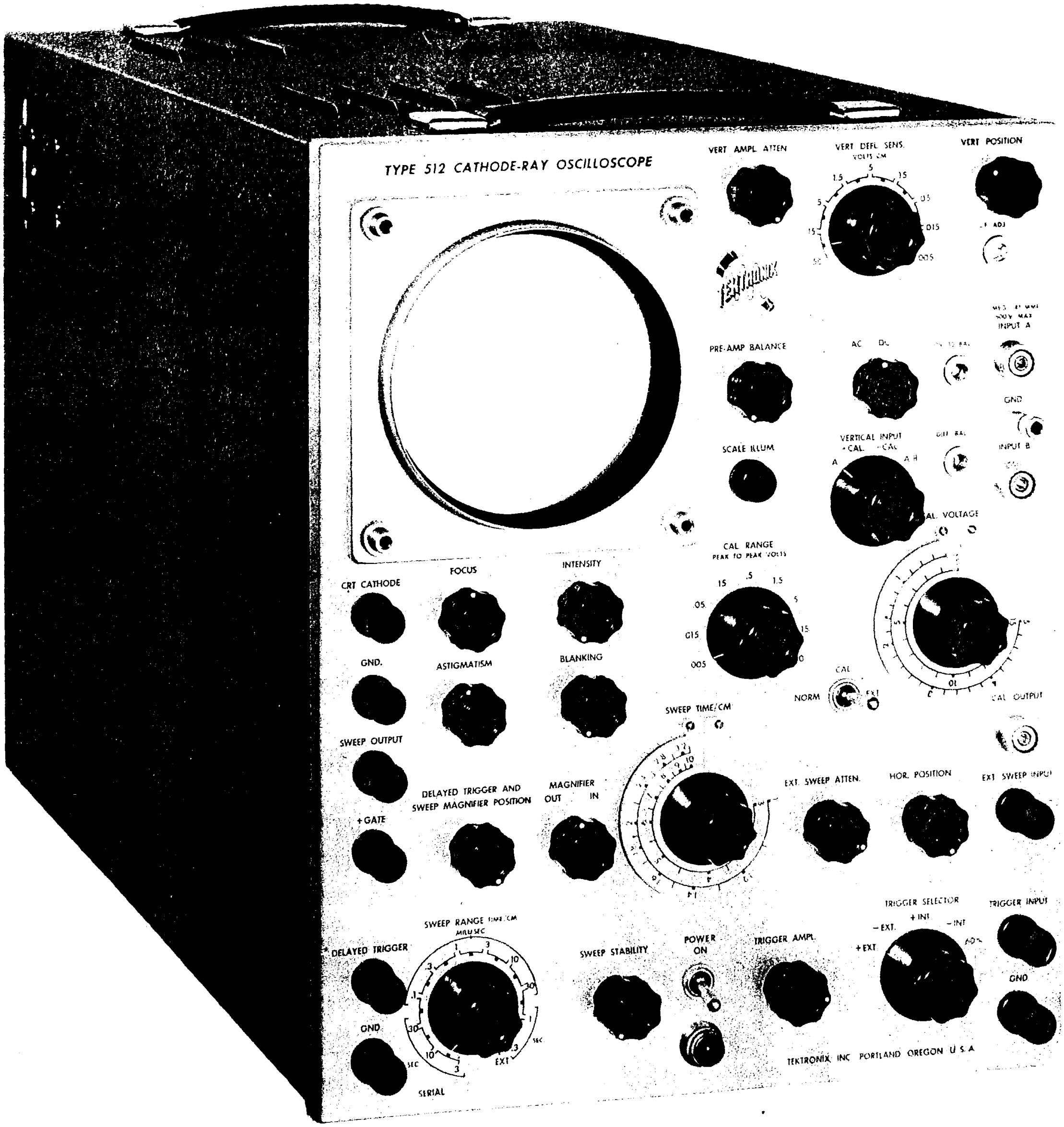
c. Change the SWEEP RANGE switch to the 10-30 microsecond position and the MAGNIFIER switch to IN. Set the SWEEP MAGNIFIER position to about the center of its range and adjust C116 so that 3 cycles of the observed waveform extend over 10 cm of the sweep.

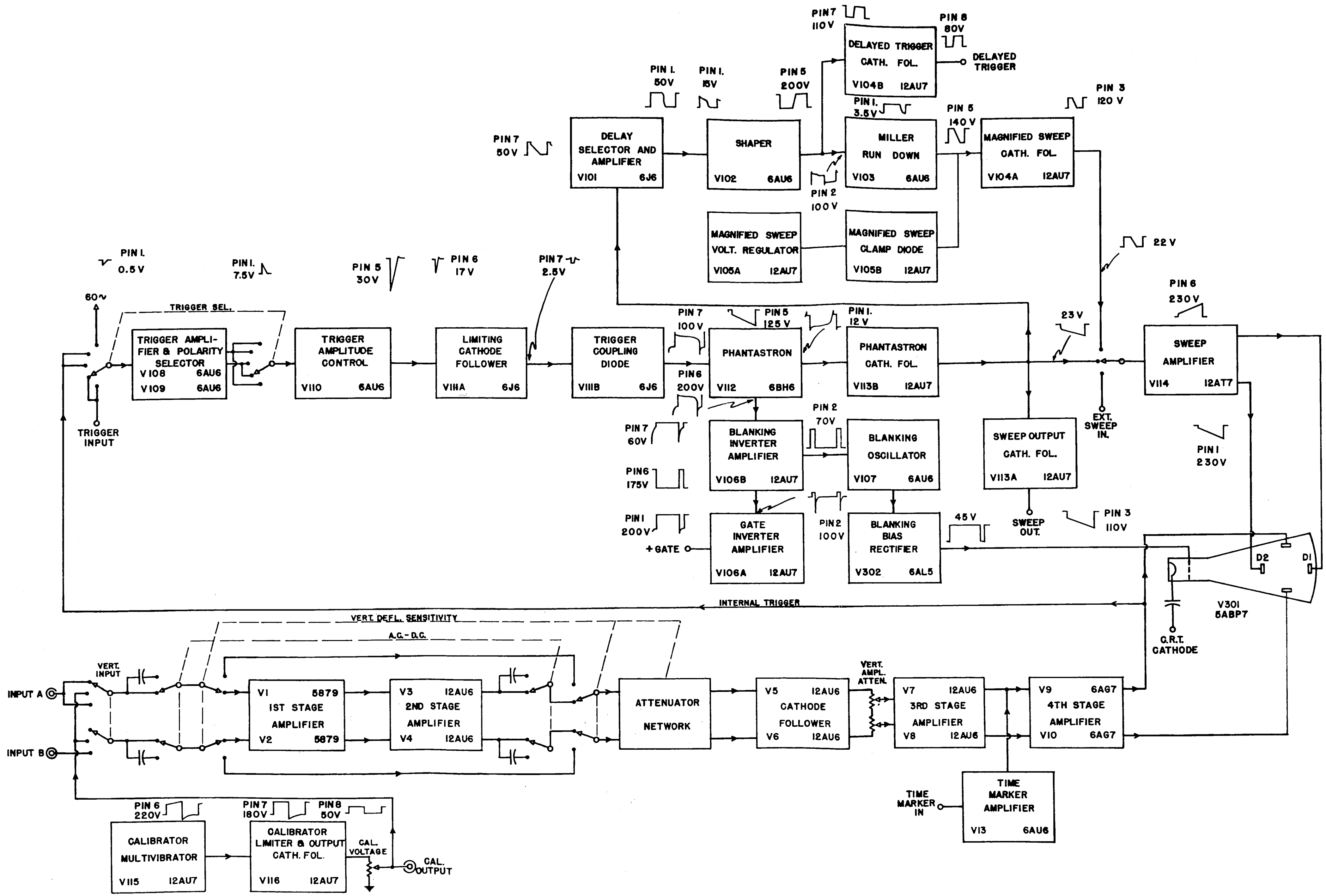
3. A screwdriver control, R123, located on the sweep chassis and marked MAG. POS. is provided to adjust the initial position of the magnified sweep to correspond with that of the normal sweep.

Blanking

Blanking in the Type 512 is accomplished by means of an rf oscillator, transmission line, and rectifier system which provide cut-off bias for the crt during standby and flyback periods. During the period of the sweep the oscillator, V107, is blocked by a negative voltage applied to the suppressor. The oscillator and rectifier circuits may be tuned to the same frequency by means of the variable slugs in coils L101 and L301.

Set the SWEEP STABILITY fully counterclockwise and the BLANKING control fully clockwise. Turn the HOR. POSITION control clockwise until the spot has moved onto the crt screen. Turning the BLANKING control counterclockwise should cause the spot to be blanked out. Turn the BLANKING control slightly past the point where the spot disappears and then advance the INTENSITY control until a spot is faintly visible. Adjust L101 and/or L301 for minimum intensity of the spot, advancing the INTENSITY control as necessary.


TYPE 512 CATHODE-RAY OSCILLOSCOPE
VERT. AMPL. ATTEN.
VERT. DEFL. SENS.
VERT. POSITION
PRE-AMP BALANCE
AC
SCALE ILLUM.
VERTICAL INPUT
INPUT A
GND
INPUT B
CAL. VOLTAGE
CAL. RANGE
PEAK TO PEAK VOLTS
CRT CATHODE
FOCUS
INTENSITY
GND.
ASTIGMATISM
BLANKING
NORM
CAL
EXT
CAL. OUTPUT
SWEEP OUTPUT
SWEEP TIME/CM
DELAYED TRIGGER AND
SWEEP MAGNIFIER POSITION
MAGNIFIER
OUT
IN
EXT. SWEEP ATTEN.
HOR. POSITION
+GATE
TRIGGER SELECTOR
TRIGGER INPUT
SWEEP RANGE
DELAYED TRIGGER
SWEEP STABILITY
POWER
ON
TRIGGER AMPL.
+EXT
−EXT.
+INT
−INT
GND
SERIAL
TEKTRONIX INC PORTLAND OREGON U.S.A.



7-29-53

A BLOCK DIAGRAM

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly.	polystyrene
GMV	guaranteed minimum value	Prec.	precision
h	henry	PT	paper tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

SWEEP

Capacitors

C101	.1 μf	PT	Fixed	400 v	20%	
C102	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C103	20 μf (½ 2x20)	EMC	Fixed	450 v	—20% +50%	(with C113)
C104	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C104.1	.1 μf	PT	Fixed	400 v	20%	
C105.1	.01 μf	PT	Fixed	400 v	20%	
C105.2	3-12 μf	Cer.	Var.	400 v	20%	
C106	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C107	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C107.1	47 μμf	Mica or Cer.	Fixed	400 v	20%	
C108	100 μμf	Mica	Fixed	400 v	10%	
C108.1	47 μμf	Mica or Cer.	Fixed	400 v	20%	
C109	47 μμf	Mica or Cer.	Fixed	400 v	20%	
C110	.1 μf	PT	Fixed	600 v	20%	
C111	.1 μf	PT	Fixed	600 v	20%	
C113	20 μf (½ 2x20)	EMC	Fixed	450 v	—20% +50%	(with C103)
C114	56 μμf	Mica or Cer.	Fixed	400 v	10%	
C116	7-45 μμf	Cer.	Var.	500 v		
C117	7-45 μμf	Cer.	Var.	500 v		
C117.1	56 μμf	Mica or Cer.	Fixed	400 v	20%	
C118	.001 μf	Mica	Fixed	600 v	3%	Timing Series See Text
C119	.01 μf	Special				
C120	.1 μf	Special				
C121	1 μf	Special				
C122	.1 μf	PT	Fixed	400 v	20%	
C123	.001 μf	PT	Fixed	600 v	20%	
C124	.001 μf	PT	Fixed	600 v	20%	
C125	330 μμf	Mica	Fixed	500 v	20%	
C126	330 μμf	Mica	Fixed	500 v	20%	
C127	.01 μf	PT	Fixed	400 v	20%	
C128.1	6.25 μf	EMC	Fixed	300 v	—20% +50%	
C129	40 μf (2x20)	EMC	Fixed	450 v	—20% +50%	
C301	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C302	27 μμf	Mica or Cer.	Fixed	400 v	20%	
C303	.1 μf	PT	Fixed	2000 v	20%	
C304	.1 μf	PT	Fixed	400 v	20%	

Inductors

L101	4.8-9 μh	Var.	CV482
L301	4.8-9 μh	Var.	CV482

Resistors

R101	100 k	1 w	Fixed	Comp.	10%	
R102	22 k	1 w	Fixed	Comp.	10%	
R103	270 k	½ w	Fixed	Comp.	10%	
R104	500 k	2 w	Var.	Comp.	20%	DELAYED TRIGGER
R105	33 k	½ w	Fixed	Comp.	10%	
R106	750 k	½ w	Fixed	Prec.	1%	
R107	490 k	½ w	Fixed	Prec.	1%	
R108	47 k	1 w	Fixed	Comp.	10%	
R109	27 k	2 w	Fixed	Comp.	10%	
R110	750 k	½ w	Fixed	Comp.	5%	
R111	1 meg	½ w	Fixed	Comp.	10%	
R113	27 k	2 w	Fixed	Comp.	10%	
R114	220 k	½ w	Fixed	Comp.	10%	
R115	1.5 meg	½ w	Fixed	Prec.	1%	
R116	3.5 meg	½ w	Fixed	Prec.	1%	
R117	6.25 k	½ w	Fixed	Prec.	1%	
R118	45 k	1 w	Fixed	Prec.	1%	
R119	47 k	1 w	Fixed	Comp.	10%	
R120	1.5 meg	½ w	Fixed	Comp.	10%	
R121	1 meg	½ w	Fixed	Comp.	10%	
R122	47 k	1 w	Fixed	Comp.	10%	
R123	.5 meg	2 w	Var.	Comp.	20%	MAGNIFIER POSITION
R124	1.2 meg	½ w	Fixed	Comp.	10%	
R125	1 meg	½ w	Fixed	Comp.	10%	
R126	1.5 meg	½ w	Fixed	Comp.	10%	
R127	1 meg	½ w	Fixed	Comp.	10%	
R128	47 k	1 w	Fixed	Comp.	10%	
R129	47 k	1 w	Fixed	Comp.	10%	
R130	1.5 meg	½ w	Fixed	Comp.	10%	
R131	1 meg	½ w	Fixed	Comp.	10%	
R131.1	500 k	2 w	Var.	Comp.	20%	BLANKING
R131.2	100 k	½ w	Fixed	Comp.	10%	
R131.3	680 k	½ w	Fixed	Comp.	10%	
R132	10 k	½ w	Fixed	Comp.	10%	
R133	27 k	2 w	Fixed	Comp.	10%	
R134	10 k	2 w	Fixed	Comp.	10%	
R135	1 meg	½ w	Fixed	Comp.	10%	
R136	10 meg	½ w	Fixed	Comp.	10%	
R137	1 meg	½ w	Fixed	Comp.	10%	
R138	27 k	1 w	Fixed	Comp.	10%	

R139	47 k	1 w	Fixed	Comp.	10%	
R140	68 k	½ w	Fixed	Comp.	10%	
R141	27 k	1 w	Fixed	Comp.	10%	
R142	47 k	½ w	Fixed	Comp.	10%	
R143	500 k	2 w	Var.	Comp.	20%	TRIGGER AMPLITUDE
R144	390 k	½ w	Fixed	Comp.	10%	
R145	1 meg	½ w	Fixed	Comp.	10%	
R146	47 k	2 w	Fixed	Comp.	10%*	
R147	68 k	1 w	Fixed	Comp.	10%*	
R149	47 k	1 w	Fixed	Comp.	10%	
R150	27 k	1 w	Fixed	Comp.	10%	
R151	470 ohm	½ w	Fixed	Comp.	10%	
R152	500 k	2 w	Var.	Comp.	20%	SWEEP STABILITY
R153	150 k	½ w	Fixed	Comp.	10%	
R154	470 k	½ w	Fixed	Comp.	10%	
R155	33 k	2 w	Fixed	Comp.	10%	
R156	3.3 k	½ w	Fixed	Comp.	10%	
R157	470 k	½ w	Fixed	Comp.	10%	
R158	3.3 meg	½ w	Fixed	Comp.	10%	
R159	10 k	2 w	Var.	WW	20%	SWEEP TIME B
R160	4.5 k	10 w	Fixed	WW	5%	
R161	20 k	2 w	Var.	WW	5%	SWEEP TIME/CM
R163	10 k	2 w	Var.	WW	20%	SWEEP TIME A
R164	1.75 meg	½ w	Fixed	Prec.	1%	
R165	750 k	½ w	Fixed	Prec.	1%	
R165.1	100 k	½ w	Fixed	Comp.	10%	
R166	6.25 k	½ w	Fixed	Prec.	1%	
R167	45 k	1 w	Fixed	Prec.	1%	
R168	47 k	1 w	Fixed	Comp.	10%	
R169	500 k	2 w	Var.	Comp.	20%	HOR. POSITION
R169.1	150 k	½ w	Fixed	Comp.	10%	
R169.2	68 k	½ w	Fixed	Comp.	10%	
R169.3	1 meg	½ w	Fixed	Comp.	10%	
R170	1 meg	½ w	Fixed	Comp.	10%	
R171	100 k	2 w	Var.	Comp.	20%	EXT. SWEEP ATTEN.
R172	150 ohm	½ w	Fixed	Comp.	10%	
R173	150 ohm	½ w	Fixed	Comp.	10%	
R174	110 k	1 w	Fixed	Comp.	5% **	
R175	110 k	1 w	Fixed	Comp.	5% **	
R176	5 k	2 w	Var.	Comp.	20%	SWEEP AMP. GAIN
R177	100 k	2 w	Fixed	Comp.	10% **	
R177.1	100 k	½ w	Fixed	Comp.	10%	
R178	100 k	2 w	Fixed	Comp.	10% **	
R178.1	100 k	½ w	Fixed	Comp.	10%	
R179	4.7 meg	2 w	Fixed	Comp.	10%	

* R146, R147 paired with ratio 47/68 ±2½%.

** R174, R177 and R175, R178 paired with ratio 110/100±2½%.

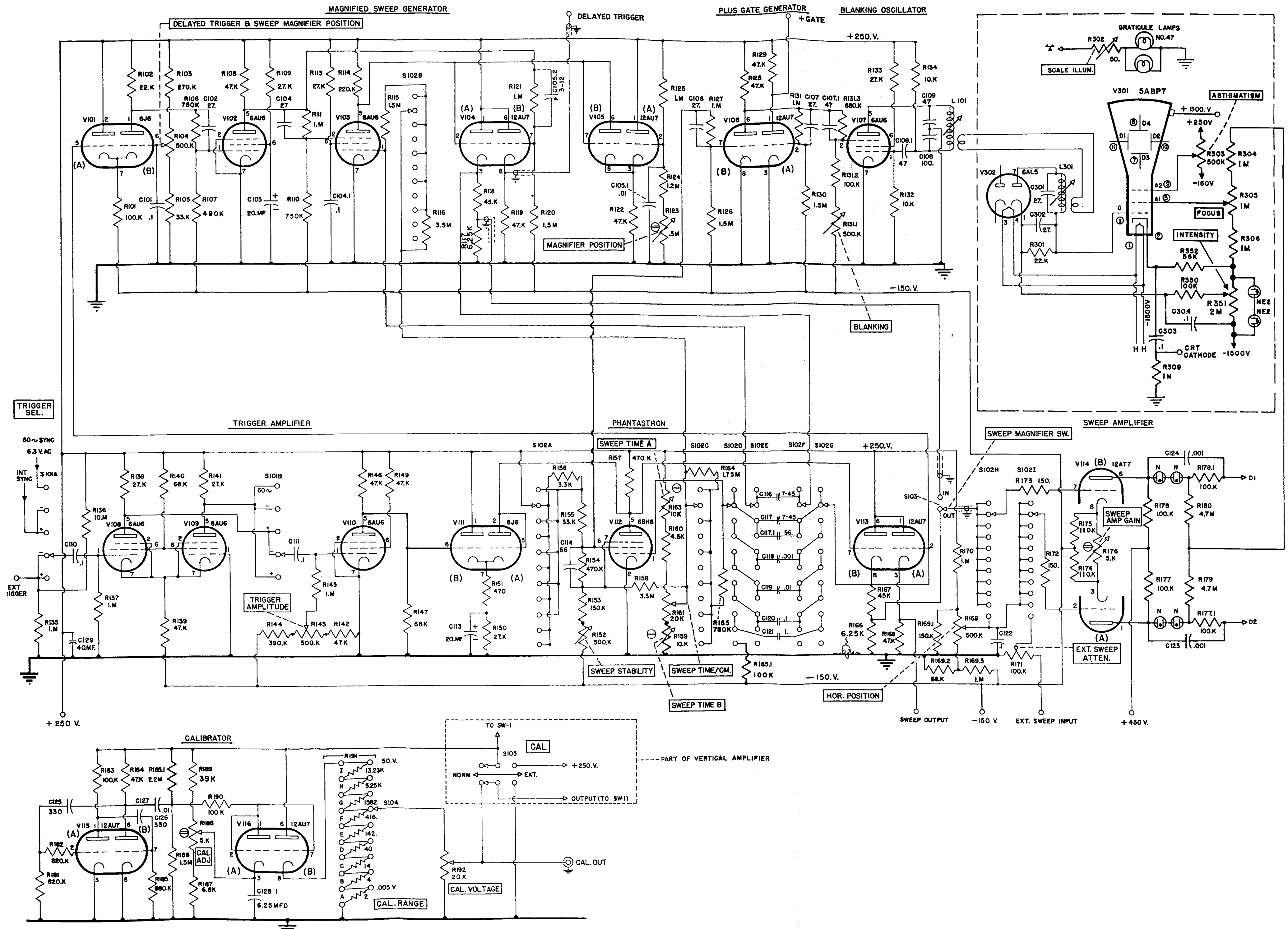
R180	4.7 meg	2 w	Fixed	Comp.	10%	
R181	820 k	½ w	Fixed	Comp.	10%	
R182	820 k	½ w	Fixed	Comp.	10%	
R183	100 k	1 w	Fixed	Comp.	10%	
R184	47 k	1 w	Fixed	Comp.	10%	
R185	680 k	½ w	Fixed	Comp.	10%	
R185.1	2.2 meg	½ w	Fixed	Comp.	10%	
R186	1.5 meg	½ w	Fixed	Comp.	10%	
R187	6.8 meg	1 w	Fixed	Comp.	10%	
R188	5 k	2 w	Var.	Comp.	20%	CAL. ADJ.
R189	39 k	2 w	Fixed	Comp.	10%	
R190	100 k	½ w	Fixed	Comp.	10%	
R191A	2 ohm	½ w	Fixed	Prec.	1%	
R191B	4 ohm	½ w	Fixed	Prec.	1%	
R191C	14 ohm	½ w	Fixed	Prec.	1%	
R191D	40 ohm	½ w	Fixed	Prec.	1%	
R191E	142 ohm	½ w	Fixed	Prec.	1%	
R191F	416 ohm	½ w	Fixed	Prec.	1%	
R191G	1582 ohm	½ w	Fixed	Prec.	1%	
R191H	5.25 k	½ w	Fixed	Prec.	1%	
R191J	13.23 k	½ w	Fixed	Prec.	1%	
R192	20 k	2 w	Var.	WW	2%	CAL. VOLTAGE
R301	22 k	½ w	Fixed	Comp.	10%	
R302	50 ohm	2 w	Var.	WW	20%	SCALE ILLUM.
R303	500 k	2 w	Var.	Comp.	20%	ASTIGMATISM
R304	1 meg	½ w	Fixed	Comp.	10%	
R305	1 meg	2 w	Var.	Comp.	20%	FOCUS
R306	1 meg	½ w	Fixed	Comp.	10%	
R309	1 meg	½ w	Fixed	Comp.	10%	
R350	100 k	½ w	Fixed	Comp.	10%	
R351	2 meg	2 w	Var.	Comp.	20%	INTENSITY
R352	56 k	½ w	Fixed	Comp.	10%	

Switches

SW101	2 Wafer	5 Position	Rotary	TRIGGER SELECTOR
SW102	9 Wafer	11 Position	Rotary	SWEEP RANGE
SW103	2 Wafer	2 Position	Rotary	SWEEP MAGNIFIER
SW104	1 Wafer	9 Position	Rotary	CAL. RANGE
SW105	Double Pole	Double Throw	Toggle	CAL.

Vacuum Tubes

V101	6J6	Delayed Trigger and Magnifier Selector
V102	6AU6	Delayed Trigger and Magnifier Shaper
V103	6AU6	Magnified Sweep Generator
V104	12AU7	Magnified Sweep and Delayed Trigger Cathode Followers
V105	12AU7	Magnified Sweep Voltage Regulator and Clamp Diode
V106	12AU7	+Gate Amplifier and Blanking Gate Inverter
V107	6AU6	Blanking Oscillator
V108	6AU6	Trigger Amplifier
V109	6AU6	Trigger Amplifier
V110	6AU6	Trigger Amplitude Control
V111	6J6	Trigger Limiter and Clamp Diode
V112	6BH6	Phantastron Sweep Generator
V113	12AU7	Phantastron and Sweep Output Cathode Follower
V114	12AT7	Sweep Amplifier
V115	12AU7	Calibrator Multivibrator
V116	12AU7	Calibrator Diode and Output Cathode Follower
V302	6AL5	Blanking Bias Rectifier



B

SWEEP, CALIBRATOR, AND CRT

TYPE 512

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly.	polystyrene
GMV	guaranteed minimum value	Prec.	precision
h	henry	PT	paper tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

VERTICAL AMPLIFIER

Capacitors

C1	.1 μf	PT	Fixed	600 v	20%*
C1.1	.01 μf	Mica	Fixed	500 v	20%
C2	.1 μf	PT	Fixed	600 v	20%*
C2.1	.01 μf	Mica	Fixed	500 v	20%
C3	5-20 μμf	Cer.	Var.	500 v	
C3.1	8 μμf	Cer.	Fixed	500 v	25%
C4	5-20 μμf	Cer.	Var.	500 v	
C4.1	8 μμf	Cer.	Fixed	500 v	25%
C5	7-45 μμf	Cer.	Var.	500 v	
C6	7-45 μμf	Cer.	Var.	500 v	
C7	.1 μf	PT	Fixed	600 v	20%
C8	.1 μf	PT	Fixed	600 v	20%
C9	3-12 μμf	Cer.	Var.	500 v	
C11	3-12 μμf	Cer.	Var.	500 v	
C12	3-12 μμf	Cer.	Var.	500 v	
C13	3-12 μμf	Cer.	Var.	500 v	
C14	3-12 μμf	Cer.	Var.	500 v	
C15	3-12 μμf	Cer.	Var.	500 v	
C16	3-12 μμf	Cer.	Var.	500 v	
C17	1.5-7 μμf	Cer.	Var.	500 v	
C18	1.5-7 μμf	Cer.	Var.	500 v	
C21	27 μμf	Cer. or Mica	Fixed	400 v	20%
C22	27 μμf	Cer. or Mica	Fixed	400 v	20%
C23	3-12 μμf	Cer.	Var.	500 v	
C24	3-12 μμf	Cer.	Var.	500 v	
C25	1.5-7 μμf	Cer.	Var.	500 v	
C26	1.5-7 μμf	Cer.	Var.	500 v	
C27	100 μμf	Mica	Fixed	400 v	10%
C28	100 μμf	Mica	Fixed	400 v	10%
C31	3-12 μμf	Cer.	Var.	500 v	
C32	3-12 μμf	Cer.	Var.	500 v	
C33	1.5-7 μμf	Cer.	Var.	500 v	
C34	1.5-7 μμf	Cer.	Var.	500 v	
C35	330 μμf	Mica	Fixed	400 v	20%
C36	330 μμf	Mica	Fixed	400 v	20%

* Paired within ±1%.

Capacitors (Cont.)

C37	1.5-7 μμf	Cer.	Var.	500 v	
C38	1.5-7 μμf	Cer.	Var.	500 v	
C39	.01 μf	Cer.	Fixed	500 v	GMV
C40	.01 μf	Cer.	Fixed	500 v	GMV
C41	.01 μf	PT	Fixed	400 v	20%
C42	.01 μf	PT	Fixed	400 v	20%
C43	.01 μf	PT	Fixed	400 v	20%
C44	.01 μf	PT	Fixed	400 v	20%
C45	.01 μf	PT	Fixed	600 v	20%
C93	.022 μf	PT	Fixed	400 v	20%

Inductors

L1	99-185 μh	Var.	CV993
L3	320-500 μh	Var.	CV324
L4	320-500 μh	Var.	CV324
L5	120-195 μh	Var.	CV124
L6	120-195 μh	Var.	CV124

Resistors

R1	1 meg	½ w	Fixed	Prec.	1%	
R1.1	1 meg	½ w	Fixed	Comp.	10%	
R2	1 meg	½ w	Fixed	Prec.	1%	
R2.1	1 meg	½ w	Fixed	Comp.	10%	
R3	68 k	1 w	Fixed	Comp.	10%	
R4	500 ohm	2 w	Var.	Comp.	20%	DIFF. BAL.
R5	330 ohm	½ w	Fixed	Comp.	10%	
R6	9 meg	1 w	Fixed	Prec.	1%	
R7	5.6 k	½ w	Fixed	Prec.	1%	
R8	5.6 k	½ w	Fixed	Prec.	1%	
R9	100 ohm	½ w	Fixed	Comp.	10%	
R10	100 ohm	½ w	Fixed	Comp.	10%	
R11	4.7 k	1 w	Fixed	Comp.	10%	
R12	4.7 k	1 w	Fixed	Comp.	10%	
R13	5 k	2 w	Var.	Comp.	20%	.05-15 BAL.
R14	10 k	10 w	Fixed	WW	5%	
R15	500 ohm	2 w	Var.	Comp.	20%	GAIN ADJ. A
R16	220 ohm	½ w	Fixed	Comp.	10%	
R17	500 ohm	2 w	Var.	Comp.	20%	GAIN ADJ. B
R18	820 ohm	½ w	Fixed	Comp.	10%	
R19	220 k	½ w	Fixed	Comp.	10%	
R19.1	100 k	½ w	Fixed	Comp.	10%	
R20	100 k	2 w	Var.	Comp.	20%	PREAMP. BAL.
R20.1	100 k	2 w	Var.	Comp.	20%	AUX. PREAMP. BAL.
R21	220 k	½ w	Fixed	Comp.	10%	

Resistors (Cont.)

R21.1	100 k	½ w	Fixed	Comp.	10%	
R23	5.6 k	1 w	Fixed	Comp.	2%	
R24	5.6 k	1 w	Fixed	Comp.	2%	
R25	120 k	½ w	Fixed	Prec.	1%	
R26	120 k	½ w	Fixed	Prec.	1%	
R27	150 k	½ w	Fixed	Prec.	1%	
R28	150 k	½ w	Fixed	Prec.	1%	
R29	666.6 k	½ w	Fixed	Prec.	1%	
R30	666.6 k	½ w	Fixed	Prec.	1%	
R31	500 k	½ w	Fixed	Prec.	1%	
R32	500 k	½ w	Fixed	Prec.	1%	
R33	900 k	1 w	Fixed	Prec.	1%	
R34	900 k	1 w	Fixed	Prec.	1%	
R35	111 k	½ w	Fixed	Prec.	1%	
R36	111 k	½ w	Fixed	Prec.	1%	
R37	966.7 k	1 w	Fixed	Prec.	1%	
R38	966.7 k	1 w	Fixed	Prec.	1%	
R39	34.5 k	½ w	Fixed	Prec.	1%	
R40	34.5 k	½ w	Fixed	Prec.	1%	
R41	990 k	1 w	Fixed	Prec.	1%	
R42	990 k	1 w	Fixed	Prec.	1%	
R43	10.1 k	½ w	Fixed	Prec.	1%	
R44	10.1 k	½ w	Fixed	Prec.	1%	
R45	1 k	½ w	Fixed	Comp.	10%	
R46	1 k	½ w	Fixed	Comp.	10%	
R47	1 meg	½ w	Fixed	Prec.	1%	
R48	1 meg	½ w	Fixed	Prec.	1%	
R49	56 k	1 w	Fixed	Comp.	10%	
R50	56 k	1 w	Fixed	Comp.	10%	
R51	20 k	2 w	Var.	Comp.	20%	C. F. ADJ.
R52	820 ohm	½ w	Fixed	Comp.	10%	
R53 & R54	1 k	2 w	Var. Dual	Comp.	20%	VERT. AMP. ATTEN.
R55	10 k	10 w	Fixed	WW	5%	
R56	500 ohm	2 w	Var.	Comp.	20%	VERT. POSITION
R57	100 ohm	½ w	Fixed	Comp.	10%	
R59	1.8 k	½ w	Fixed	Comp.	5%*	
R59.1	390 ohm	½ w	Fixed	Comp.	10%	
R60	2.2 k	½ w	Fixed	Comp.	5%*	
R61	100 ohm	½ w	Fixed	Comp.	10%	
R61.1	68 k	½ w	Fixed	Comp.	10%	
R61.2	100 k	2 w	Var.	Comp.	20%	3RD STAGE BAL.
R61.3	68 k	½ w	Fixed	Comp.	10%	
R62	100 ohm	½ w	Fixed	Comp.	10%	
R64	6.6 k (2x3.3 k)	2x1 w	Fixed	Comp.	10%	

* R59, R60 paired with ratio 1.8/2.2 ±1%.

Resistors (Cont.)

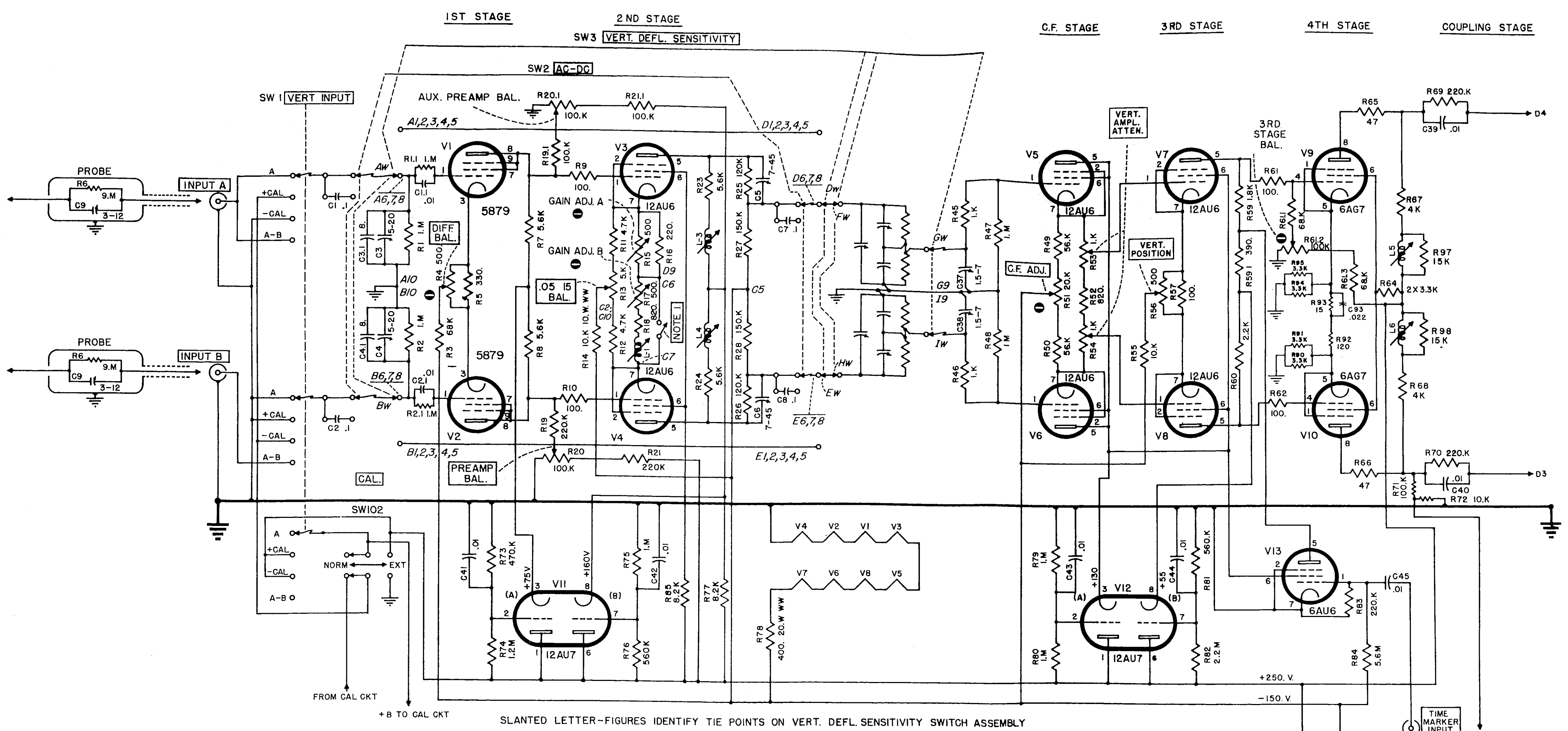
R65	47 ohm	½ w	Fixed	Comp.	10%
R66	47 ohm	½ w	Fixed	Comp.	10%
R67	4 k	5 w	Fixed	WW	1%
R68	4 k	5 w	Fixed	WW	1%
R69	220 k	½ w	Fixed	Comp.	10%
R70	220 k	½ w	Fixed	Comp.	10%
R71	100 k	1 w	Fixed	Comp.	10%
R72	10 k	½ w	Fixed	Comp.	10%
R73	470 k	½ w	Fixed	Comp.	2%
R74	1.2 meg	½ w	Fixed	Comp.	2%
R75	1 meg	½ w	Fixed	Comp.	2%
R76	560 k	½ w	Fixed	Comp.	2%
R77	8.2 k	2 w	Fixed	Comp.	10%
R78	400 ohm	20 w	Fixed	WW	5%
R79	1 meg	½ w	Fixed	Comp.	2%
R80	1 meg	½ w	Fixed	Comp.	2%
R81	560 k	½ w	Fixed	Comp.	2%
R82	2.2 meg	½ w	Fixed	Comp.	2%
R83	220 k	½ w	Fixed	Comp.	10%
R84	5.6 meg	½ w	Fixed	Comp.	10%
R85	8.2 k	1 w	Fixed	Comp.	10%
R90	3.3 k	1 w	Fixed	Comp.	10%
R91	3.3 k	1 w	Fixed	Comp.	10%
R92	120 Ω	½ w	Fixed	Comp.	10%
R93	15 Ω	½ w	Fixed	Comp.	10%
R94	3.3 k	1 w	Fixed	Comp.	10%
R95	3.3 k	1 w	Fixed	Comp.	10%
R97	15 k	½ w	Fixed	Comp.	10%
R98	15 k	½ w	Fixed	Comp.	10%

Switches

SW1	2 Wafer	4 Position	VERTICAL INPUT
SW2	2 Wafer	2 Position	AC - DC
SW3	9 Wafer	8 Position	VERT. DEFL. SENS

Vacuum Tubes

V1	5879	Vertical Pre-Amp. Input
V2	5879	Vertical Pre-Amp. Input
V3	12AU6	Vertical Pre-Amp. Output
V4	12AU6	Vertical Pre-Amp. Output
V5	12AU6	Vertical Gain Control Cathode Follower
V6	12AU6	Vertical Gain Control Cathode Follower
V7	12AU6	Vertical Main Amplifier Input
V8	12AU6	Vertical Main Amplifier Input
V9	6AG7	Vertical Main Amplifier Output
V10	6AG7	Vertical Main Amplifier Output
V11	12AU7	Vertical Amplifier Voltage Regulator
V12	12AU7	Vertical Amplifier Voltage Regulator
V13	6AU6	Marker Input Amplifier

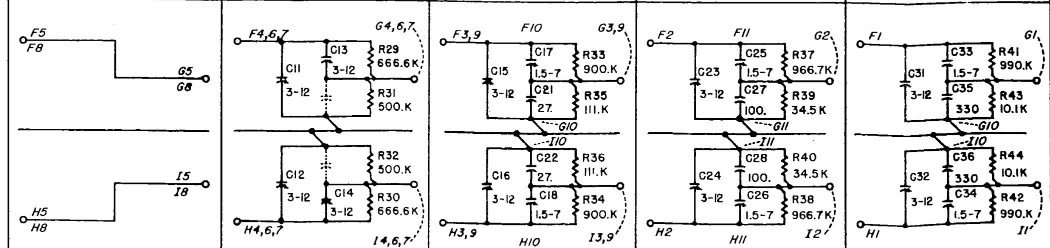


SLANTED LETTER-FIGURES IDENTIFY TIE POINTS ON VERT. DEFL. SENSITIVITY SWITCH ASSEMBLY

(SW3 SWITCH DETAIL)

INPUT-OUTPUT RATIO →	1. TO 1.	3. TO 1.	10. TO 1.	30. TO 1.	100. TO 1.
SWITCH POSITION USED →	5,8	4,6,7	3.	2.	1.

VERT. DEFL. SENS. SW POSITION		NOMINAL SENSITIVITY
1.	15. TO	50. V
2.	5.	15.
3.	1.5	5.
4.	.5	1.5
5.	.15	.5
6.	.05	.15
7.	.015	.05
8.	.005	.015



NOTE: I
THIS SWITCH IS CLOSED EXCEPT IN POSITION 6 OF SW3.

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly.	precision
GMV	guaranteed minimum value	Prec.	variable
h	henry	PT	wire wound
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

POWER SUPPLY

Capacitors

C207	40 μf (2x20)	EMC	Fixed	450 v	—20% +50%
C208	.01 μf	PT	Fixed	400 v	20%
C209	80 μf (2-2x20)	EMC	Fixed	450 v	—20% +50%
C210	.01 μf	PT	Fixed	400 v	20%
C211	80 μf (2-2x20)	EMC	Fixed	450 v	—20% +50%
C212	.01 μf	PT	Fixed	400 v	20%
C213	.01 μf	PT	Fixed	400 v	20%

Resistors

R206	270 k	½ w	Fixed	Comp.	10%	
R207	100 k	½ w	Fixed	Comp.	10%	
R208	2 meg	½ w	Fixed	Prec.	1%	
R209	1.11 meg	½ w	Fixed	Prec.	1%	
R211	220 k	1 w	Fixed	Comp.	10%	
R212	1 meg	½ w	Fixed	Comp.	10%	
R213	1 k	25 w	Fixed	WW	5%	
R214	33 k	½ w	Fixed	Comp.	10%	
R215	270 k	½ w	Fixed	Comp.	10%	
R216	600 k	½ w	Fixed	Prec.	1%	
R217	1 meg	½ w	Fixed	Prec.	1%	
R218	39 k	½ w	Fixed	Comp.	10%	
R219	1 meg	½ w	Fixed	Comp.	10%	
R220	1 k	25 w	Fixed	WW	5%	
R221	27 k	½ w	Fixed	Comp.	10%	
R222	18 k	½ w	Fixed	Comp.	10%	
R223	1 meg	½ w	Fixed	Comp.	10%	
R224	56 k	½ w	Fixed	Comp.	5%	
R225	10 k	2 w	Var.	WW	20%	ADJ. —150V
R226	47 k	½ w	Fixed	Comp.	5%	
R227	27 k	½ w	Fixed	Comp.	10%	

Switches

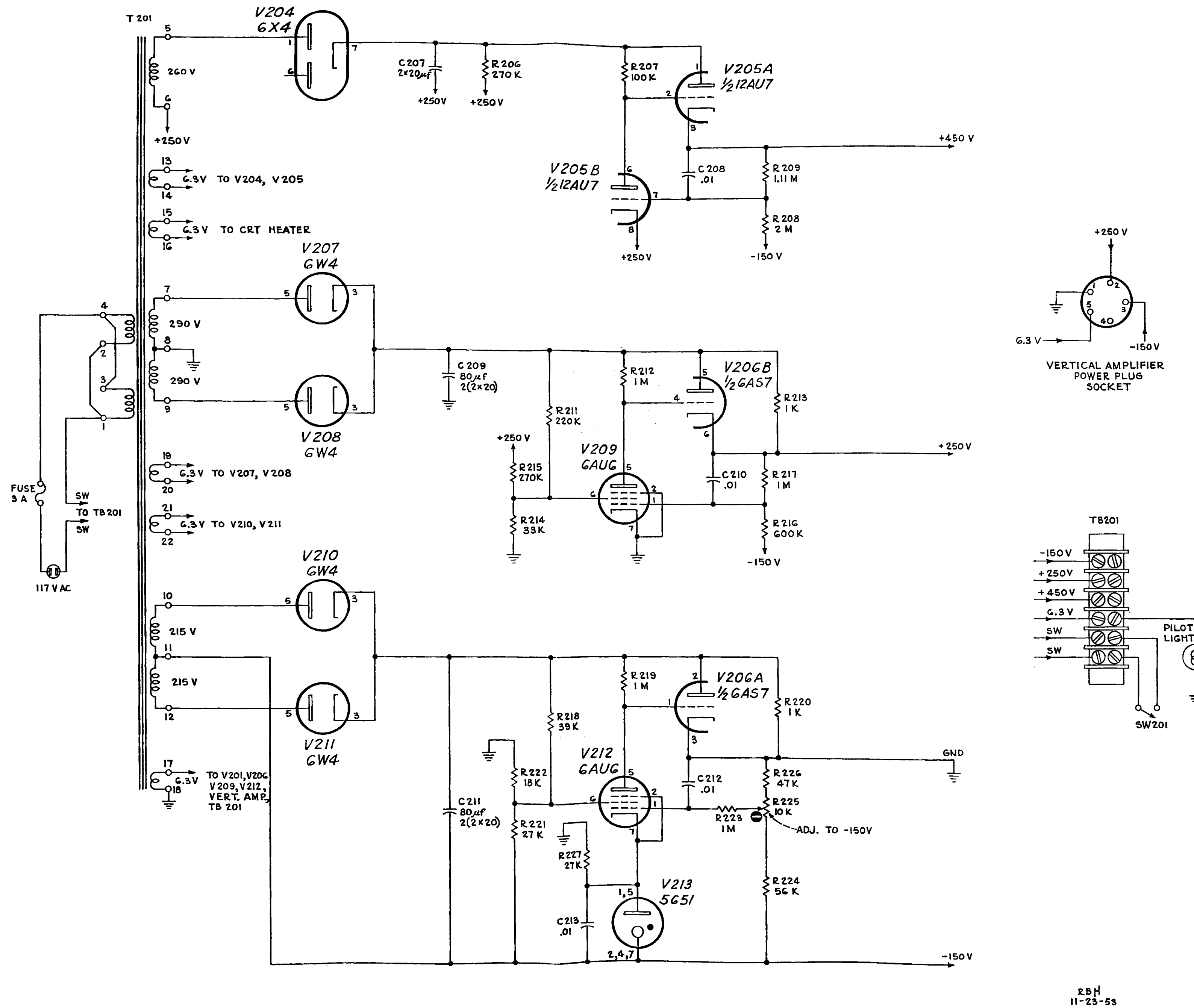
SW201	Single Pole	Single Throw	Toggle	POWER

Transformers

T201	Plate and Heater Supply			T512-PC1
	Primary:	117/234 volt	50/60 cycle	
	Secondaries:	215-0-215V,	210 ma.	
		290-0-290V,	165 ma.	
		260 V	10 ma.	
		6.5 V	11 A	
		6.5 V	2.4 A	
		6.5 V	2.4 A	
		6.5 V	.9	
		6.5 V	.9 insulated 1500 V DC	

Vacuum Tubes

V204	6X4	Sweep Power Supply Rectifier
V205A&B	12AU7	Sweep Power Supply Regulator
V206A&B	6AS7G	Voltage Regulator Series Tube
V207	6W4GT	Low Voltage Rectifier
V208	6W4GT	Low Voltage Rectifier
V209	6AU6	Voltage Regulator Amplifier
V210	6W4GT	Low Voltage Rectifier
V211	6W4GT	Low Voltage Rectifier
V212	6AU6	Voltage Regulator Amplifier
V213	5651	Voltage Reference


T 201
260 V
+250 V
6.3 V TO V204, V205
6.3 V TO CRT HEATER
290 V
290 V
6.3 V TO V207, V208
6.3 V TO V210, V211
215 V
215 V
TO V201, V206, V209, V212, VERT. AMP., TB 201
FUSE 3 A
SW
TO TB201
SW
117 V AC
V204 6X4
C207 2x20µf
R206 270 K
+250 V
+250 V
R207 100 K
V205A ½12AU7
V205B ½12AU7
C208 .01
R209 1.11 M
R208 2 M
+450 V
-150 V
V207 6W4
V208 6W4
C209 80µf 2(2x20)
R211 220K
R212 1M
V206B ½6AS7
R213 1K
+250 V
R215 270K
R214 33K
V209 6AU6
C210 .01
R217 1M
R216 600K
-150 V
+250 V
V210 6W4
V211 6W4
C211 80µf 2(2x20)
R218 39K
R219 1M
V206A ½6AS7
R220 1K
R222 18K
R221 27K
V212 6AU6
C212 .01
R226 47K
R225 10K
R223 1M
ADJ. TO -150V
GND
R227 27K
C213 .01
V213 5651
R224 56 K
-150 V
+250 V
6.3 V
-150 V
VERTICAL AMPLIFIER POWER PLUG SOCKET
TB201
-150 V
+250 V
+450 V
6.3 V
SW
SW
PILOT LIGHT
SW201
RBH 11-23-53

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly.	polystyrene
GMV	guaranteed minimum value	Prec.	precision
h	henry	PT	paper tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

H. V. SUPPLY

Capacitors

C201	40 μf (2x20)	EMC	Fixed	450 v	—20%	+50%
C251	.001 μf	PT	Fixed	600 v	20%	
C252	.001 μf	PT	Fixed	600 v	20%	
C253	.001 μf	PT	Fixed	600 v	20%	
C254	.0068 μf	PT	Fixed	3000 v	20%	
C255	.0068 μf	PT	Fixed	3000 v	20%	
C256	.0068 μf	PT	Fixed	3000 v	20%	
C257	.015 μf	PT	Fixed	3000 v	20%	

Resistors

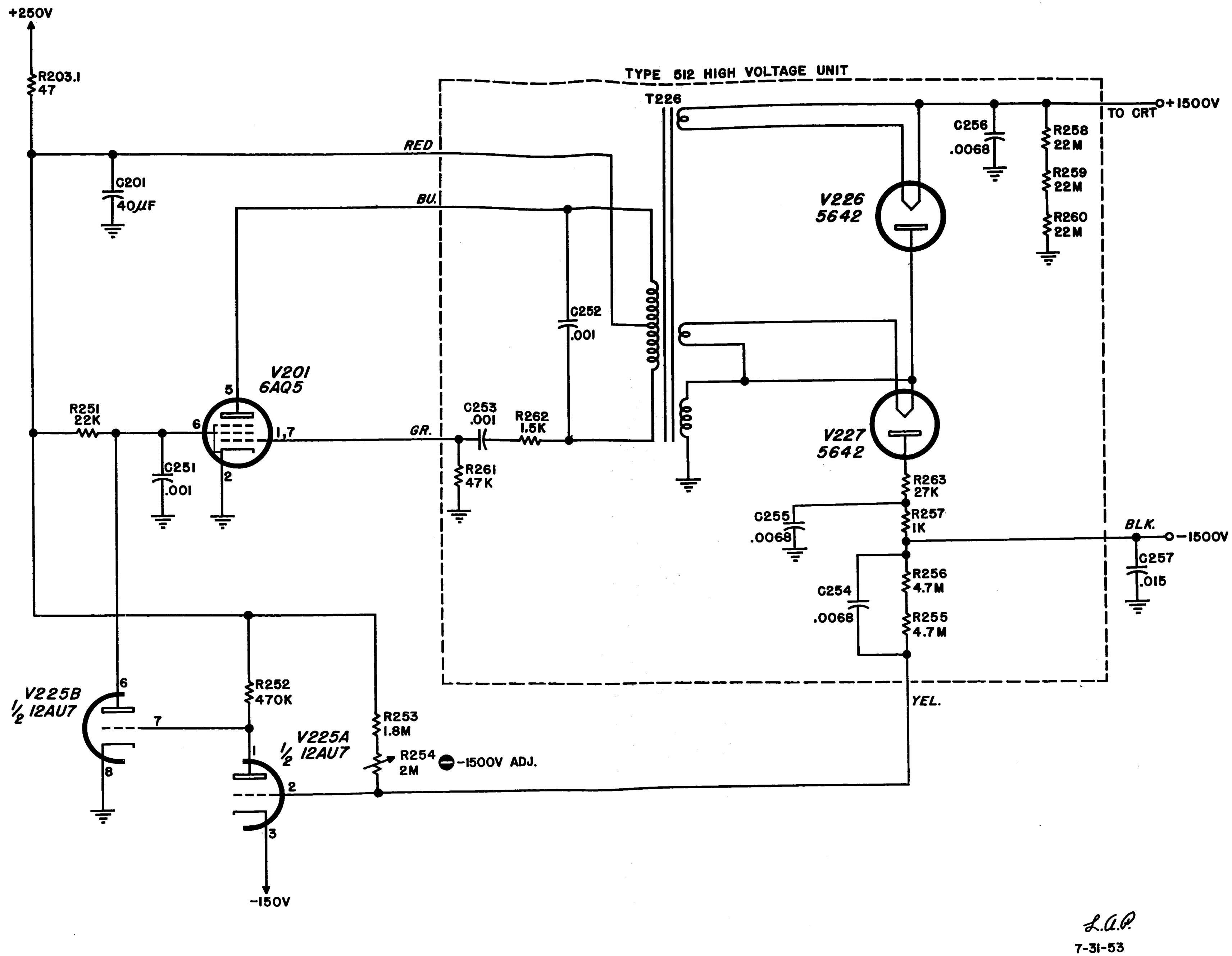
R203.1	47 ohm	½ w	Fixed	Comp.	10%	
R251	22 k	2 w	Fixed	Comp.	10%	
R252	470 k	½ w	Fixed	Comp.	10%	
R253	1.8 meg	½ w	Fixed	Comp.	10%	
R254	2 meg	2 w	Var.	Comp.	20%	—1500V ADJ.
R255	4.7 meg	2 w	Fixed	Comp.	10%	
R256	4.7 meg	2 w	Fixed	Comp.	10%	
R257	1 k	½ w	Fixed	Comp.	10%	
R258	22 meg	½ w	Fixed	Comp.	10%	
R259	22 meg	½ w	Fixed	Comp.	10%	
R260	22 meg	½ w	Fixed	Comp.	10%	
R261	47 k	½ w	Fixed	Comp.	10%	
R262	1.5 k	½ w	Fixed	Comp.	10%	
R263	27 k	½ w	Fixed	Comp.	10%	

Transformers

T226	CRT Supply			T512OC2
	Primary:	Approx 200 V, 70 KC		
	Secondaries:	1250 VAC	1 ma.	
		1.25 VAC	200 ma	
		1.25 VAC	200 ma	

Vacuum Tubes

V201	6AQ5	High Voltage Supply Oscillator
V225A	½12AU7	DC Amplifier
V225B	½12AU7	High Voltage Oscillator Screen Supply
V226	5642	+1500V Rectifier
V227	5642	—1500V Rectifier



H.V. SUPPLY

TYPE 512 OSCILLOSCOPE

A

70KC H.V. SUPPLY

TEKTRONIX
TYPE 512 CALIBRATION & TEST PROCEDURE

1. Power Supply

Supply	Approx. Res. To Ground	Tolerance	Max. Hum Peak-Peak New	Max. Hum Peak-Peak Old*
150v	500Ω	Adjustable	30mv	75 - 125mv
225v	11K	10v	30mv	80 - 150mv
450v	3M	10v	60mv	80 - 150mv
1500v	100M	Adjustable		
1650v		100v		

Check regulation - Supply voltages should remain constant as line voltage is varied between 105 - 125 volts. Note: All supplies are dependent on the -150 supply for proper operation.

2. Blanking Adjustment

Preset:
INTENSITY - - - CW
BLANKING - - - CCW

Procedure:
Defocus a spot and tune L301 (located near V302) for minimum intensity.

3. Calibrator Adjustment

Preset:
AC DC selector - - - DC
VERTICAL INPUT selector - - - A
CAL toggle - - - Normal

Equipment:
Accurate DC voltmeter
45-volt B battery

Procedure:
a. Measure battery voltage.
b. Set CALIBRATOR indicators to battery voltage.
c. Connect battery directly (no probe) to INPUT A and set scope gain for 4-5 cm of deflection.
d. Switch VERTICAL INPUT selector to + CAL and adjust Cal. Adj. pot. (located near V111) for same deflection as caused by battery.

4. Vertical Amplifier
4th Stage Balance Check

Procedure:

a. Position a sweep near center of graticule.

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*512's before Serial #2676, without power supply ripple reducing Mod. #672

b. Short together plates (pin 8) of V9 and V10 and note position of trace. Remove short.
c. Short together grids (pin 4) of V9 and V10. If deflection is more than 1 cm from position found in step b, replace V9 or V10 or both until a pair is found that will balance.
d. Remove short.

5. <u>3rd. Stage Balance Adjustment</u>

Procedure:
a. Center VERTICAL POSITION indicator.
b. Short together grids (pin 1) of V7 and V8.
c. Position trace to center of graticule with <u>3rd. Stage Bal.</u> pot. (located near V11).
d. If centering of trace is beyond control of <u>3rd. Stage Bal.</u> pot., (approx. 4 cm of control) try switching V7 and V8 or changing one or both.
e. Remove short.

6. <u>Cathode Follower Balance Adjustment</u>

Procedure:
a. Set VERT. DEFL. SENS. to .5- .15 position.
b. Adjust <u>C.F. Adj.</u> pot. (located near V5) so that trace does not shift as VERT. AMPL. ATTEN. is rotated.
c. If proper adjustment cannot be obtained, replace V5 or V6 or both.

7. <u>2nd. Stage Balance Check</u>

Preset:
VERT. DEFL. SENS. - - .5 - .15
AC DC selector - - DC

Procedure:
a. Short together grids (pin 1) and also the cathodes (pin 7) of V3 and V4.
b. When VERT. DEFL. SENS. is switched to .05 - .015 position, the deflection should be less than $2\frac{1}{2}$ cm or V3 and V4 are probably out of balance.
c. Remove short.

8. <u>Differential Balance Adjustment</u>

Preset:
VERT. DEFL. SENS. - - .015 - .005
VERTICAL INPUT selector - - A-B
AC DC selector -- AC
CAL toggle - - Ext.
PRE-AMP. BALANCE control - - Center the indicator

Procedure:

a. Connect 5 volts of calibrator signal to both INPUT A and INPUT B.
b. Slowly adjust Diff. Bal. pot. (located near V1) for minimum deflection of the signal.
c. Return AC DC switch to DC and adjust Aux. Pre-Amp Bal. pot. (located near V3) to center the trace.
d. Repeat steps b and c until all interaction is overcome.
e. If unable to accomplish steps b and c, it may be necessary to substitute a more nearly matched V1 and V2 pair.

9. .05 - .15 Balance Adjustment

Preset:

VERTICAL INPUT selector - - A
AC DC toggle - - - DC
VERT. DEFL. SENS. - - .5 - .15

Procedure:

a. Position and center the trace.
b. Switch sensitivity to .015 - .005 position and again center the trace with Aux. Pre-Amp. Bal. pot.
c. Switch sensitivity to .15 - .05 position and now center the trace with .05 - .15 Bal. pot (located near V1)
d. Repeat steps a, b and c until trace remains centered in all three positions.
e. Repeat steps 8 and 9, as a change in .05 - .15 Balance causes a slight change in the Differential Balance.

10. Pre-Amp. Microphonic and Gas Check

Preset:

VERTICAL INPUT selector - - - A
VERT. DEFL. SENS. - - - .015 - .005

Note: Pre-Amp. shield should be in place for the following check.

Procedure:

a. Jar instrument with fist - do not tap V1 and V2. Pre-Amp tubes should be suspected if excessive ringing is observed, or if trace shifts to a new position.

b. Alternately short grids (pin 1) of V1 and V2 to ground. If trace shifts more than 1 cm in either case, replace the gassy tube. Make ground connection first.

11. A and B Attenuator Ratios and Vertical Sensitivity Check

The indicated Vertical Sensitivity is approximate, but should be at least panel indication.

Preset:

VERT. AMPL. ATTEN. control - - - CW
VERTICAL INPUT selector - - +CAL
VERT. DEFL. SENS. - - 50 - 15
CAL. toggle - - - Normal

Procedure:

a. Obtain 3 cm of calibrator signal.
b. Switch VERT. DEFL. SENS. and CAL. RANGE simultaneously thru their ranges, step by step, and check for 3 cm of deflection at each step.
c. Adjust Gain Adj. A pot. in the .015 - .005 setting for 3 cm.
d. Adjust Gain Adj. B pot. in the .15 - .05 setting for 3 cm.
e. Readjustment of the 3rd. Stage Balance and .05 - .15 Balance will be necessary with changes in Gain Adj. A and Gain Adj.B.

Note: The relative sensitivity of the .05 - .015 setting will normally be greater than the other ranges.

f. To check channel B Attenuator Ratios, repeat step b with VERTICAL INPUT selector on -CAL.

12. Probe Capacitor Adjustment and 3rd . Stage Input Capacitance Equalization

Preset:

VERT. DEFL. SENS. - - - .5 - .15
VERTICAL INPUT selector - - A
CAL. toggle - - Ext.

Procedure:

a. Attach probe cable to INPUT A and connect probe body to CAL. OUTPUT.
b. Set the calibrator and sweep to observe 10 cycles at 3-5 cm.
c. Adjust capacitor in probe for flat response.
d. Move cable end of probe from INPUT A to INPUT B and switch VERTICAL INPUT selector to A-B - ground INPUT A. Adjust C38, if necessary, for flat response.
e. If C38 cannot be adjusted to a flat response, turn C37 to another position and repeat a thru d.

13. R. C. Attenuator Adjustment

Preset:

CAL. toggle - - - Normal

Procedure:

Observe several cycles of the calibrator at 4-5 cm and make adjustments according to the following chart.

VERT. DEFL. SENS. Position	VERTICAL INPUT Selector	ADJUST	TUNE
.015 - .005	CAL.	C6	Spike
.015 - .005	"	C5	"
1.5 - .5	"	C13	"
5 - 1.5	"	C17	"
15 - 5	"	C25	"
50 - 15	"	C33	"
1.5 - 5	CAL	C14	"
5 - 1.5	"	C18	"
15 - 5	"	C26	"
50 - 15	"	C34	"

Switch CAL. toggle to Ext. and connect calibrator thru probe for the remaining adjustments. - - - - Probe body on CAL. output.

VERT. DEFL. SENS. Position	VERTICAL INPUT Selector	ADJUST	TUNE
.015 - .005	A	C3	Level
.0.5 - .005	A-B	C4	"
1.5 - .5	A	C11	"
5 - 1.5	"	C15	"
15 - 5	"	C23	"
50 - 15	"	C31	"
1.5 - 5	A-B	C12	"
5 - 1.5	"	C16	"
15 - 5	"	C24	"
50 - 15	"	C32	"

14. High Frequency Response

Preset:
- VERT. DEFL. SENS. - - - .5 - .15
- Set sweep time at 3 microseconds/cm

Procedure:

a. Observe a square-wave signal of about 100 kc having a rise time of 0.1 microseconds or less. The TEKTRONIX Type 104 or Type 105 Square-Wave Generators provide a suitable source. Adjust L5 and L6 for square corner on leading edge.
b. Set VERT. DEFL. SENS. at .05 - .015 and adjust L3 and L4 in a similar manner.
c. Set VERT. DEFL. SENS. at .15 - .05 and adjust L1 as above.

15. Sweep Amplifier
<u>Gain Adjustment</u>

Preset:
- SWEEP RANGE selector - - - Ext.
- EXT. SWEEP ATTEN. - - - CW
- CAL. toggle - - - Ext.

Procedure:
Connect 10 volts of calibrator signal to EXT. SWEEP INPUT jack and adjust <u>Swp. Ampl. Gain</u> (located near V114) for 10 cm of horizontal deflection.

16. <u>External Trigger Sensitivity</u>

Preset:
- TRIGGER SELECTOR - - - + Ext.
- TRIGGER AMPL. control - - - CW
- CAL. toggle - - - Ext.
- VERTICAL INPUT selector - - - A

Procedure:
When SWEEP STABILITY control is slowly advanced a point should be found where sweep is triggered by 5 millivolts of calibrator signal into the TRIGGER INPUT jack.

17. <u>Sweep Calibration Adjustments</u>

<u>Sweep Time A</u> pot. adjusts fast end of TIME/CM dial.
<u>Sweep Time B</u> pot. adjusts slow end of TIME/CM dial.
Sweep Time A and Sweep Time B can be adjusted on any SWEEP RANGE except the 3-10 microsecond and 10-30 microsecond. Adjustments should be repeated until interaction is overcome.
<u>C117</u> adjusts the 3-10 microsecond and 10-30 microsecond SWEEP RANGEs.
<u>C116</u> adjusts the magnified 3-10 and 10-30 microsecond SWEEP RANGEs.

<u>Sweep Time A Adjustment</u>

Preset:
- SWEEP RANGE selector - - .3 - 1 millisecond
- SWEEP TIME/CM dial - - - 3

Observing 1 millisecond markers adjust <u>Sweep Time A</u> pot. for 3 markers in 10 cm. Note: The mark at the zero graticule line is not included in the count.

<u>Sweep Time B Adjustment</u>

Preset:
- SWEEP RANGE selector - - .3 - 1 milliseconds
- SWEEP TIME/CM dial - - 10 CCW

Observing 1 millisecond markers adjust Sweep Time B pot. for 10 markers in 10 cm. Note: The mark at the zero graticule line is not included in the count. Repeat Sweep Time A and Sweep Time B adjustments until interaction is overcome.

C117 Adjustment

Preset:
SWEEP RANGE selector - - 3 - 10 microseconds
SWEEP TIME/CM dial - - - 3 CW

Observing 10 microsecond markers adjust C117 for 3 markers in 10 cm. Note: The marker at the zero graticule line is not included in the count.

C116 Adjustment

Preset:
SWEEP RANGE selector - - - 10 - 30 microseconds
SWEEP TIME/CM dial - - - 1 CW
MAGNIFIER switch - - - IN

Observing 10 microsecond markers adjust C116 for 2 markers in 10 cm. Note: The marker at the zero graticule line is not included in the count.

18. Z Axis Modulation Check

Preset:
INTENSITY - - - Just visible
SWEEP RANGE selector - - 1 - 3 milliseconds
CAL. toggle - - - Ext.

Procedure:
Make connection from CAL. OUTPUT to CRT CATHODE binding post on front panel. Increase calibrator voltage from zero and observe that Z axis modulation occurs within 5 - 10 volts.

19. Magnifier Position Adjustment

Preset:
SWEEP STABILITY - - - CCW
TRIGGER AMPL. control - - CCW
HOR. POSITION - - - Center a spot

Procedure:
a. Switch MAGNIFIER control to IN and turn SWEEP MAGNIFIER POSITION control until spot is again centered.
b. Alternately switch MAGNIFIER IN and OUT and adjust Mag. Pos. pot. (located near V105) until spot remains stationary.

20. Delayed Trigger Wave Form Adjustment (C105.2)

Observe the waveform from the DELAYED TRIGGER jack on a test scope. Adjust C105.2 (located near V102) for best looking square wave. Note: C105.2 was make adjustable after Serial #1465 with a 3 - 12 trimmer capacitor.

21. Output Waveforms Check

SWEEP - - 100 volts peak-peak minimum
+GATE - - 150 volts peak-peak minimum
DELAYED TRIGGER - - 75 volts peak-peak