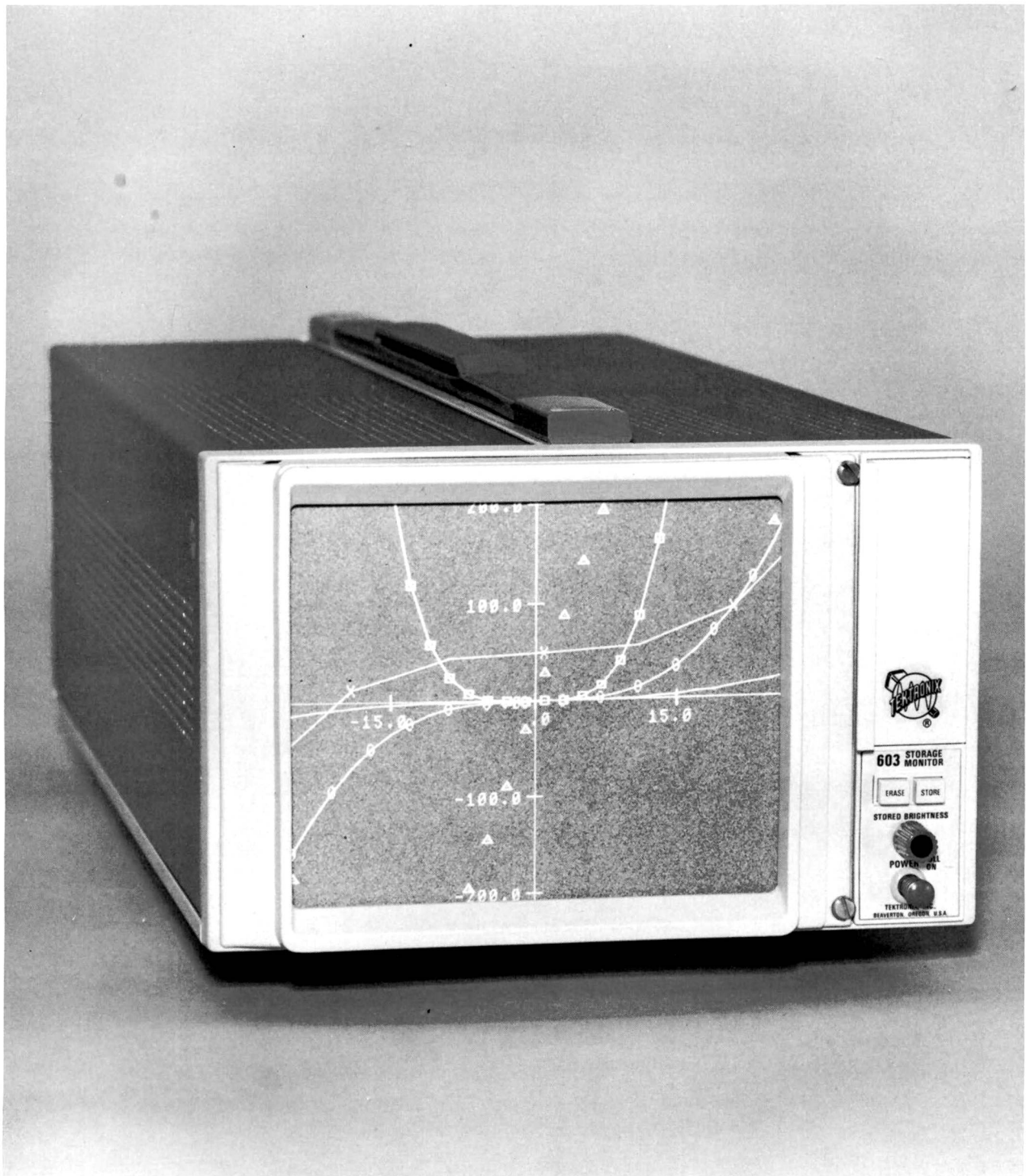


# INSTRUCTION MANUAL

Serial Number \_\_\_\_\_

## **603/604 MONITOR**



603 Storage Monitor with a graph display.

# SECTION 2

## THEORY OF OPERATION

### Introduction

This section of the manual contains an electrical description of the circuits in the 603 and 604 display monitors. An overall block diagram of these units and complete schematics are given on pullout pages at the rear of this manual.

### NOTE

*The following description applies to both the vertical and horizontal (Y and X) amplifiers; however, the circuit numbers used are those of the vertical (Y) circuit.*

### BLOCK DIAGRAM DESCRIPTION

The Deflection Amplifiers process input signals and provide push-pull outputs suitable to drive the vertical (Y) and horizontal (X) deflection plates. Input signals can be applied either single ended or differentially.

The Z-Axis Amplifier controls the beam intensity by providing a voltage to drive the CRT control grid. Input signals can be applied either single ended or differentially.

The CRT Circuit produces the high voltage (about -3450 volts) and contains the controls necessary for operation of the cathode-ray tube.

The Storage Circuit provides the voltage levels necessary to operate the storage elements associated with the CRT in the 603. The circuit includes the erase-pulse generator for erasing stored information and a multivibrator which permits the flood-gun duty cycle to be varied.

The Power Supply circuit provides the low-voltage operating power for the 603 and 604 monitors. Electronic regulation is used to provide stable, low-ripple output voltages.

### CIRCUIT DESCRIPTION

#### Deflection Amplifiers

**General.** The Deflection Amplifiers process input signals and provide push-pull outputs suitable to drive the deflection plates. Input signals can be applied either single ended or differentially. Negative feedback is employed to insure a highly-stabilized output.

**Inputs.** Signals can be applied to either J110 (+) or J130 (-) as single-ended inputs, or to both connectors as a differential input. Also, a signal may be applied via the Remote Program connector to the + input. An internal switch for each input (S110, S130) allows a choice of either 1:1 or 5:1 attenuation of the input signal before it is applied to the input FET gate. The input 5X attenuators are frequency-compensated voltage dividers.

**Preamplifier.** The preamplifier stage employs field-effect transistors to provide a high input impedance. This stage consists of two identical feedback amplifiers, Q120A-Q152 and Q120B-Q156, which can be operated as either a paraphase amplifier (with a single-ended input) or as a differential amplifier. A push-pull signal is produced at the collectors of Q152 and Q156. The FET gates are diode-clamped on negative-going overdrive signals, protecting the transistors in the amplifier. R125, Y Gain, provides an adjustable amplification factor to allow a CRT full-scale deflection range from 0.5 volt or less to 2.5 volts or more. This control is set by the factory to a nominal 1 volt for full-scale deflection on each axis.

**Output Amplifier.** The output amplifier stage consists of two identical non-inverting operational amplifiers connected in a differential configuration. Q172 and Q192 provide constant current for input emitter followers Q162 and Q182. Q162 and Q182 receive the push-pull signal from the preamplifier stage, and the input signal is developed across the resistance between their emitters. The signal current is forced through R165 and R185, producing the deflection-plate drive signal at the collectors of Q222 and Q226. Q202 and Q208, whose bases are diode-protected to ensure quick overdrive recovery, provide the drive for the output transistors. The Q222-Q226 collectors are diode-clamped on negative-going overdrive signals.

Display positioning is accomplished by adjustment of R175 (vertical) and R375 (horizontal). These resistors provide a shift in the constant-current source transistors, shifting the quiescent output voltage. Capacitors C168 and C368 are adjustable to provide frequency compensation.

### Z-Axis Amplifier

**General.** The Z-Axis Amplifier controls the CRT beam intensity by providing a voltage to drive the CRT control grid. Input signals can be applied either single ended or differentially.

**Inputs.** Signals can be applied to either J505 (+) or J515 (–) as single-ended inputs, or to both connectors as a differential input. Also, a signal may be applied via Remote Program connector J200 to the + input. A provision is made on each input line to permit installation of attenuating resistors.

**Preamplifier.** The Z-axis preamplifier stage employs field-effect transistors to provide a high input impedance. This stage consists of two identical feedback amplifiers, Q520A-Q526-Q534 and Q520B-Q528-Q536, which can be operated as either a paraphase amplifier (with a single-ended input) or as a differential amplifier. A single-ended output is produced at the collector of Q534, and is opposite in polarity to a signal applied to the + input and in phase with a signal applied to the – input. Constant current for the stage is supplied by Q532. The FET gates are diode-clamped on negative-going overdrive signals, protecting the transistors in the preamplifier. R512, Z Gain, provides an adjustable amplification factor to allow a full intensity control range of from +1 volt or less or +5 volts or more to be established when the INTENSITY control in the output stage is set to about midrange. Under this condition, a zero-volt input cuts off visual intensity.

**Output Amplifier.** The output amplifier is a non-inverting operational amplifier consisting of Q542, Q544, Q554, and Q556. The feedback resistor is R556. Q554 and Q556 are connected as a collector-coupled complementary amplifier to provide a fast, linear output signal while consuming minimum quiescent power. The quiescent output level can be set by adjustment of the INTENSITY control, R562. The output is applied to the CRT control grid circuit.

### CRT Circuit

**General.** The CRT circuit produces the high-voltage potential and provides the control circuits necessary for operation of the cathode-ray tube (CRT).

**High-Voltage Oscillator.** A class C oscillator consisting of Q580 and its associated circuitry provides the drive for the high-voltage transformer, T580. When the instrument is turned on, conduction of Q576 provides a base current path for Q580. The collector current of Q580 increases, producing an increased current in the Q580 base winding and causing increased conduction of Q580. Eventually the rate of collector current increase in Q580 becomes less than that required to maintain the voltage across the collector winding, and the voltage drops as the field collapses. This turns off Q580 by way of feedback voltage to the base. Q580 remains off until the feedback voltage on the base is near the peak positive value again. The cycle repeats at a frequency of 40 to 50 kilohertz. The amplitude of sustained oscillation depends upon the average current delivered to the base of Q580, and finally, the average Q580 collector current.

**High Voltage Regulation.** Regulation is accomplished as follows: Feedback from the –3450-volt cathode supply is summed with a low-voltage level through the voltage divider consisting of resistors R573A, R573B, and R575 to establish the DC level at the base of Darlington transistor Q570. This sample of the output voltage is compared to the regulated +15 volts in the base circuit of Q570. Any changes in the high-voltage output are sensed by Q570, which produces an error signal to control the conduction of Q576. Q576 correspondingly produces a change in the average Q580 base current, nullifying the change in the high-voltage output and thus holding it constant. The DC level at the base of Q570 is adjusted by R575, High Voltage, to set the high-voltage output to exactly –3450 volts.

**Electron Gun Cathode and Grid Supplies.** Half-wave rectifier CR580 produces –3450 volts DC, which is filtered and applied to the CRT cathode as the accelerating potential. The cathode heater is elevated to the cathode potential through R590.

Bias voltage for the grid is supplied by a DC restorer network consisting of CR566, CR567, and R565. The DC restorer has the –3450-volt cathode potential applied to it as a reference voltage, and it is driven by a varying voltage obtained from a tap on the secondary winding of T580. R588, Cutoff, provides a fine adjustment of the quiescent grid voltage to bias the electron gun just below cutoff when the Z-Axis Amplifier output is at its minimum quiescent level (INTENSITY control counterclockwise and no signals applied). A change in the Z-Axis Amplifier output produces an almost equal change of voltage on the control grid, allowing the Z-Axis Amplifier to control the CRT beam current.



**CRT Control Circuits.** In addition to the INTENSITY control discussed in the Z-Axis Amplifier circuit, front-panel FOCUS and internal astigmatism controls have been incorporated for arriving at an optimum CRT display. FOCUS control R595 provides the correct voltage for the second anode of the CRT. Proper voltage for the third anode is obtained by adjusting Astig control R594. In order to obtain optimum spot size and shape, both the FOCUS and Astig controls are adjusted to provide the proper electrostatic lens configuration in the CRT.

The Geom adjustment R596 varies the positive level on the horizontal deflection plate shields to control the overall geometry of the display. The TRACE ROTATION control, R598, permits adjustment of the DC current through beam-rotation coil L598 to align the display.

### Storage Circuit (603 Only)

**General.** The CRT used in the 603 is a direct-view bistable storage cathode-ray tube. Only those elements associated with the storage capability of the CRT are shown in the CRT symbol on the right side of the Storage Circuit diagram. The writing gun, its deflection systems and associated elements will be discussed under CRT Circuit.

**Storage Operation.** Four low-energy electron guns (flood guns) provide full coverage of the large screen area. The cathode heaters, which receive an unfiltered pulsating DC from full-wave rectifier CR775, are elevated to the cathode potential through R775. Quiescently Q615 is saturated, providing current to the flood-gun cathodes. The anode potential is established by VR734 and supplied via emitter follower Q735.

The collimation electrode is a metallic band around the inner wall of the CRT envelope. It produces an electrostatic field to distribute the flood-gun electrons uniformly over the storage target. R730, CE1, provides adjustment of the flood electron trajectories to cover the extreme rim of the targets and optimize uniformity of the target coverage. Emitter follower Q725 maintains a stable voltage on the collimation electrode, providing a low-impedance current path to absorb current variations.

The storage screen consists of a thin tin oxide layer called the target backplate, which is coated with an insulator material containing finely-ground phosphor particles called the target. A positive voltage potential is applied via Q680 to backplate to establish the operating level of the tube, which is the difference in potential between the backplate and the flood-gun cathodes.

The target operates in a bistable mode because of the secondary emission properties of the insulator material. The first stable state is the rest potential, at which the target has gathered low-energy flood-gun electrons, causing it to charge down to the flood-gun cathode potential. The second stable state is stored state, at which the target (or portions of it) is shifted to the backplate potential by increasing the secondary emission. While the flood guns do not have sufficient energy to shift the target to the stored state, they do supply sufficient energy to hold the target in the stored state after it has been shifted by the high-energy writing-gun beam (CRT beam). This is because the landing energy of the flood electrons has increased with the increased potential difference between the flood-gun cathode and the target. These higher energy electrons produce a visual display as long as the flood beam covers the target.

When the stored display is no longer needed, the information is erased by first shifting the entire target to the stored state, and then removing the charge. A positive-going short-duration pulse is first applied to the backplate, increasing the flood-gun electron landing energy and writing the entire target area. Next, the backplate voltage is pulled well below the rest potential of the target, which follows due to its inherent capacitive coupling. Then, as the backplate is gradually returned to its quiescent potential, the target charges to the rest potential and is ready to write again.

**Backplate Supply.** A regulated +360-volt DC power supply provides the storage level for the CRT and ensures a potential sufficient for the erasure process. Full-wave bridge rectifier CR820 through CR823 in the Power Supply circuit furnishes the required voltage. The regulator consists of series-pass transistor Q762, emitter follower Q760, and error amplifier Q764. The +360-volt output is compared to the -30-volt reference at the base of Q764, which supplies correction bias to Q762. Operation of this feedback amplifier system is similar to that described for the -30-volt supply (Power Supply circuit). VR763 is a protection device for the transistors, and is normally operated in a region of its characteristic curve below its Zener knee.

**Backplate Control Amplifier.** A high degree of control of the target backplate is maintained by a feedback amplifier system consisting of Q675, Q678, and Q680. The operational amplifier summing point is at the base of Q675, and the feedback resistor is R672. Variable resistor R670, Store Level, provides an adjustment of the current to the null point, and hence sets the backplate voltage through R672 to an optimum storage level.

## Theory of Operation—603/604

**Sensitivity Correction.** When the 603 is operated in the store mode, the divider network in the high-voltage regulator circuit is modified to shift the high voltage slightly, correcting for the deflection sensitivity changes that occur. The backplate voltage is applied through R716 to the base of Q715, removing the ground potential from the Q715 collector. R715 permits an adjustable sensitivity correction to be applied to the high-voltage regulator.

**Erase Generator.** The previously discussed backplate control operational amplifier is driven by a monostable multivibrator when it is desired to erase a stored display. The multivibrator consists of Q640, which is normally on, and Q644, which is normally off. Q648 is part of the erase interval circuit and will be discussed later. All inputs of U630B are held high (+5 volts), keeping output pin 8 low. The multivibrator is switched either by pushing the front-panel ERASE button or by remote application of a TTL-compatible low level (see Fig. 1-2). When any of the U630B input lines are pulled low, pin 8 snaps positive. The positive transition is coupled through C636 and CR636 to the base of Q644, causing the multivibrator to switch states. The negative-going step produced at the Q644 collector causes a corresponding positive-going step at the output of the operational amplifier. This positive-going step is applied to the target backplate, increasing the storage level and "writing" the entire target.

After an RC-controlled time of 10 milliseconds, the multivibrator reverts to its quiescent state, producing a positive-going step at the collector of Q644 as the transistor turns off. This positive-going step is coupled through C644, and the backplate is pulled negative through the action of the operational amplifier. The target is pulled well below its rest potential. As C644 charges, the voltage at the cathode of CR664 decays from about +15 volts toward the -30 volt supply at an RC-controlled rate until it is clamped at ground by conduction of CR664. This action allows the target backplate to be raised slowly to its operating level, while the target remains at the flood-gun cathode potential. The total time from initiation of erasure to the ready-to-write condition is about 250 milliseconds.

**Flood-Gun Cathode Control.** As previously mentioned, Q615 provides the current for the flood-gun cathodes. It operates at saturation, establishing a cathode potential of nearly -30 volts. Q615 is controlled by two circuits: collector-coupled multivibrator Q620-Q628 and transistor switch Q610. When either Q628 or Q610 is on, Q615 is conducting flood-gun current.

Symmetry of the multivibrator is controlled by R622 and R625. R625, STORED BRIGHTNESS, is adjustable to allow Q615 to conduct anywhere from 10% to 100% (Q610 must be off to enable multivibrator control), which has the effect of varying the stored brightness.

When Q610 is turned on, it provides a control to override the multivibrator output and hold Q615 in its conduction state. A positive level either from the output of the Z-axis circuit or from the Remote Program connector turns Q606 on, providing base current for Q610. Also, during the erase interval, CR608 provides base current for Q610. Q610 can be held off by application of a TTL-compatible low level to R602, enabling the stored brightness control.

**Erase Interval.** During erasure, a 250-millisecond negative pulse is made available to associated equipment via pin 7 of Remote Program Connector J200. Normally the output of U630A (pin 6) is held high by the low applied via CR652 to input pin 5. When the erase pulse is initiated, the 10-millisecond negative-going pulse at Q644 collector results in a corresponding positive-going pulse at Q648 collector. This pulls pin 5 of U630A high, producing a low level at pin 6. C652 holds pin 5 for the total erase cycle.

**Non-Store Mode.** In the non-store mode, the target is held below the rest potential, allowing the CRT to operate in the manner of a conventional CRT. This feature prolongs the life of the storage tube. During storage operation, Q700 is held above cutoff and Q690 conducts. If S695 is set to the non-store mode (front-panel button out), or if a TTL-compatible low level is applied via pin 6 of J200, Q700 is biased into saturation. Its collector rises to essentially ground potential, cutting off Q690 and forcing current into the operational amplifier null point (Q675 base) to pull the backplate negative. The backplate non-store level can be set by adjustment of R700.

## Power Supply

**General.** The Power Supply circuit provides the low-voltage operating power for the 630/604 Monitor. Electronic regulation is used to provide stable, low-ripple output voltages.

**Power Input.** Power is applied to the primary of transformer T800 through fuse F800, thermal cutout TK800, power switch S800, and line-selector block P810. The line-selector block allows changing the primary-winding taps of T800 to fit different line requirements.

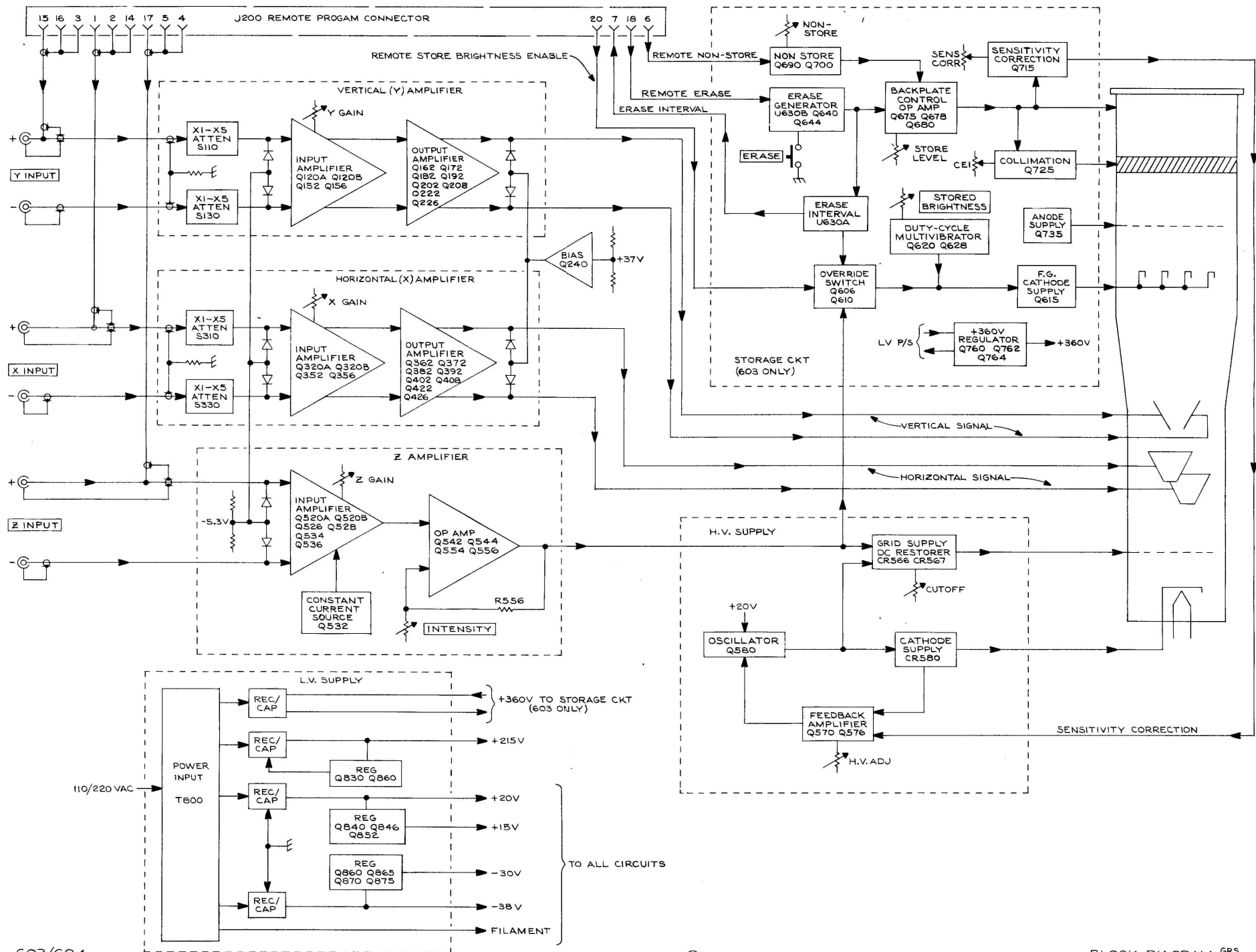
**Low-Voltage Rectifiers and Unregulated Outputs.** The full-wave bridge rectifiers and associated filter components in the secondaries of T800 provide filtered DC voltages for operation of the 603/604 or for regulation by the Low-Voltage Regulators. The unregulated +20-volt output to the high-voltage transformer and the regulated +215-volt output are fuse protected. In the 603, a bridge rectifier is provided to supply power to the +360-volt regulator located in the Storage circuit.

**Low-Voltage Regulators.** The -30-volt supply, besides providing power to circuitry throughout the instrument, provides a reference-voltage source to establish operating levels for the feedback regulators in the +15-volt, +215-volt, and the 603 +360-volt supplies. The regulator for the -30-volt supply is a feedback amplifier system which operates between ground and the unregulated -38 volts. Current to the load is delivered by the series-pass transistor, Q860, and the supply voltage is established by the drop across R877, R878, and R879. The feedback path is through R875, Q875, and Q865 to the base of Q860. Any variation in output voltage due to ripple, change of current through the load, etc., is immediately transmitted to the base of Q860 and nullified by a change in Q860 conduction, thus maintaining a steady output. The output of the supply is set to exactly -30 volts by adjustment of R878, -30 V Adjust. This control sets the conduction of Q870, which controls the bias levels of Q865 and Q860. CR865 and Q865 provide short-circuit protection by limiting the current through Q860.

The regulator for the +15-volt supply consists of series-pass transistor Q840 and error amplifier Q852. This is a feedback amplifier system similar to that just described for the -30-volt supply. Q846 protects the supply in the event the output is shorted by limiting the current demanded from the series-pass transistor under excessive load. During normal operation, Q846 is biased off.

The regulator for the +215-volt supply consists of series-pass transistor Q836 and error amplifier Q830. Operation of this feedback amplifier system is similar to that described for the -30-volt supply.

**CRT Heater Windings.** Two separate secondary windings are provided for the CRT writing-gun heaters and the 603 flood-gun heaters. The writing-gun heaters are elevated to -3450 volts in the CRT circuit to maintain a potential near that of the CRT cathode.



## 603/604 ASSEMBLY A-1

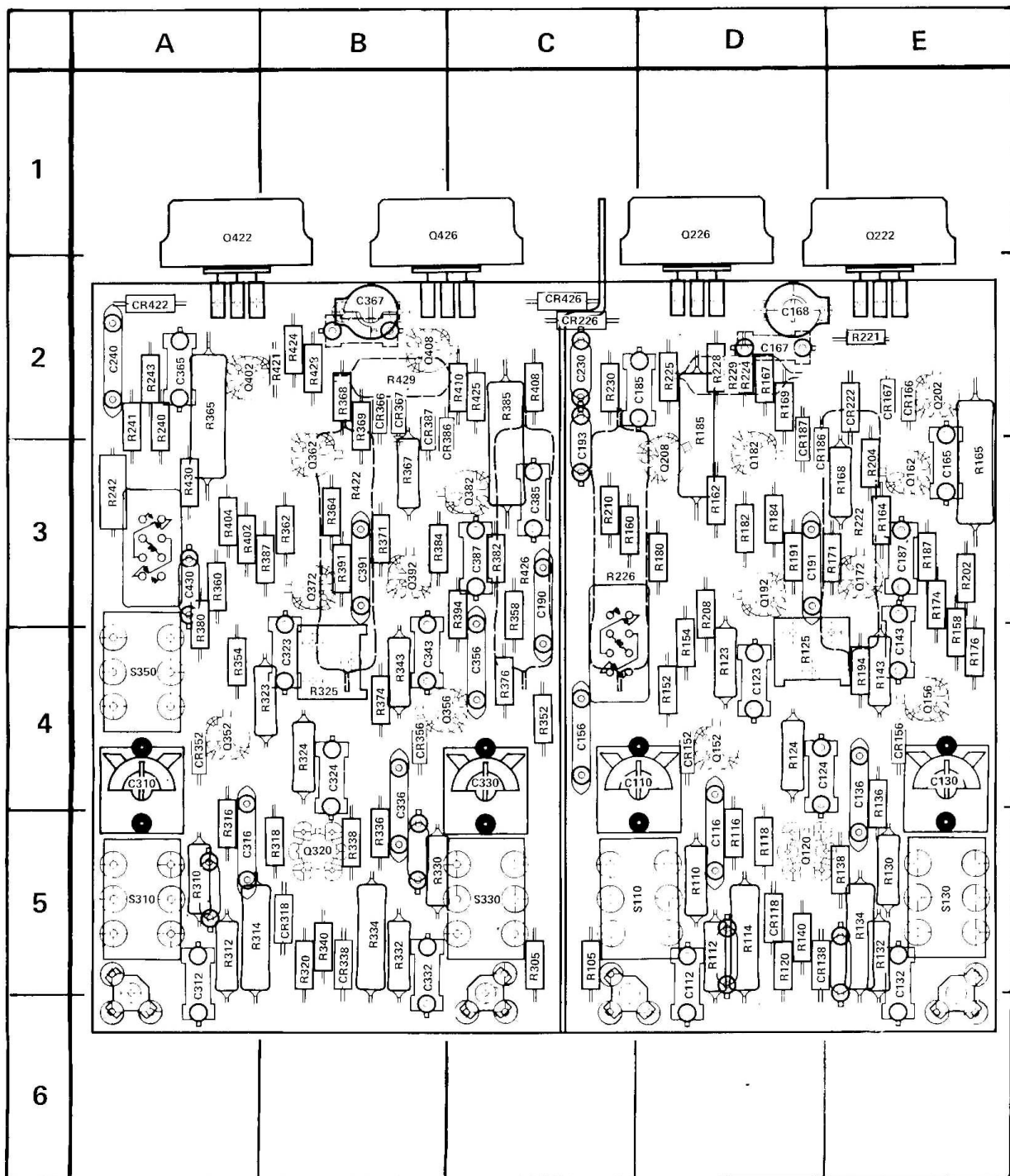


Fig. 4-1. 603/604 Deflection Amplifier component location grid.

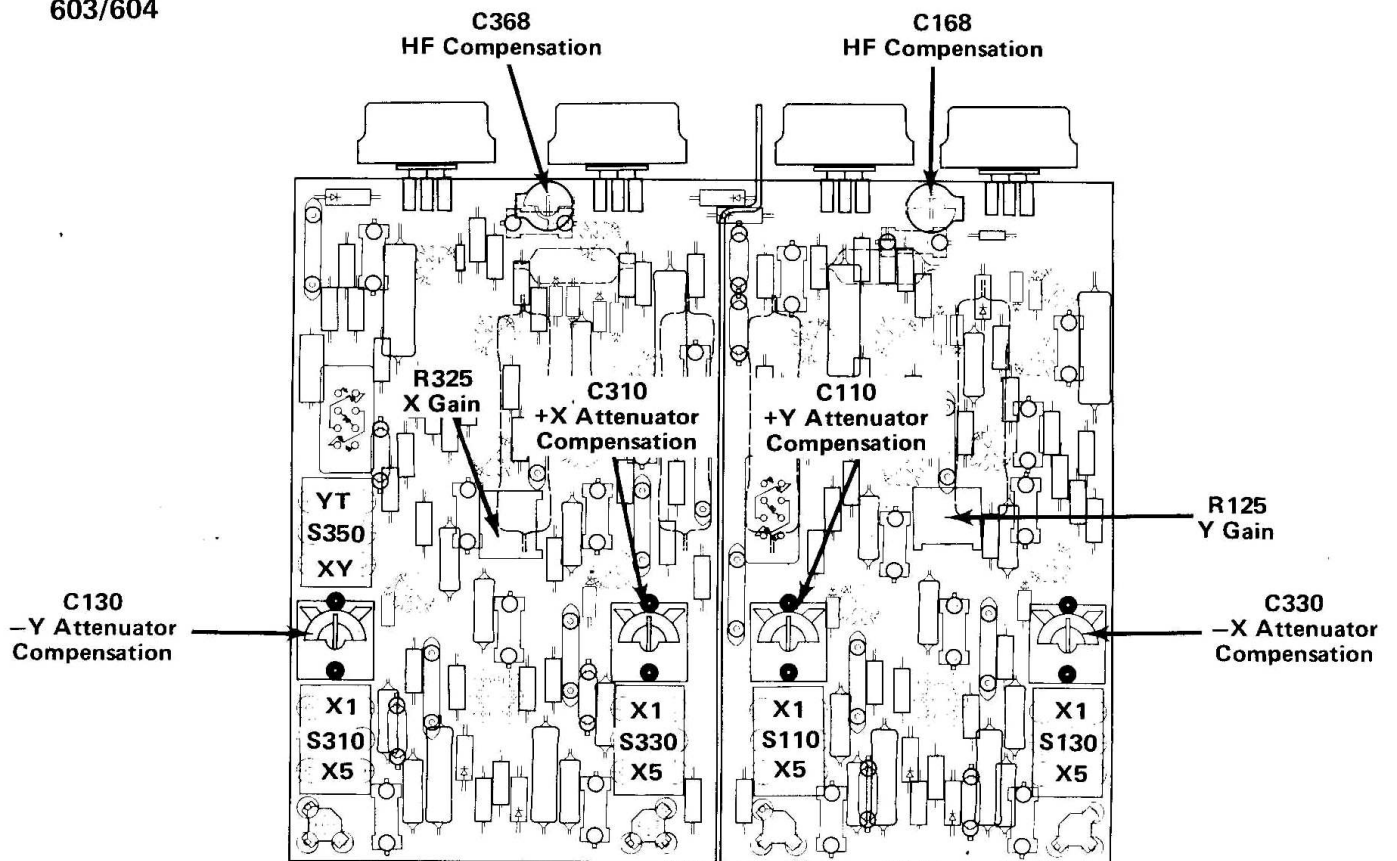
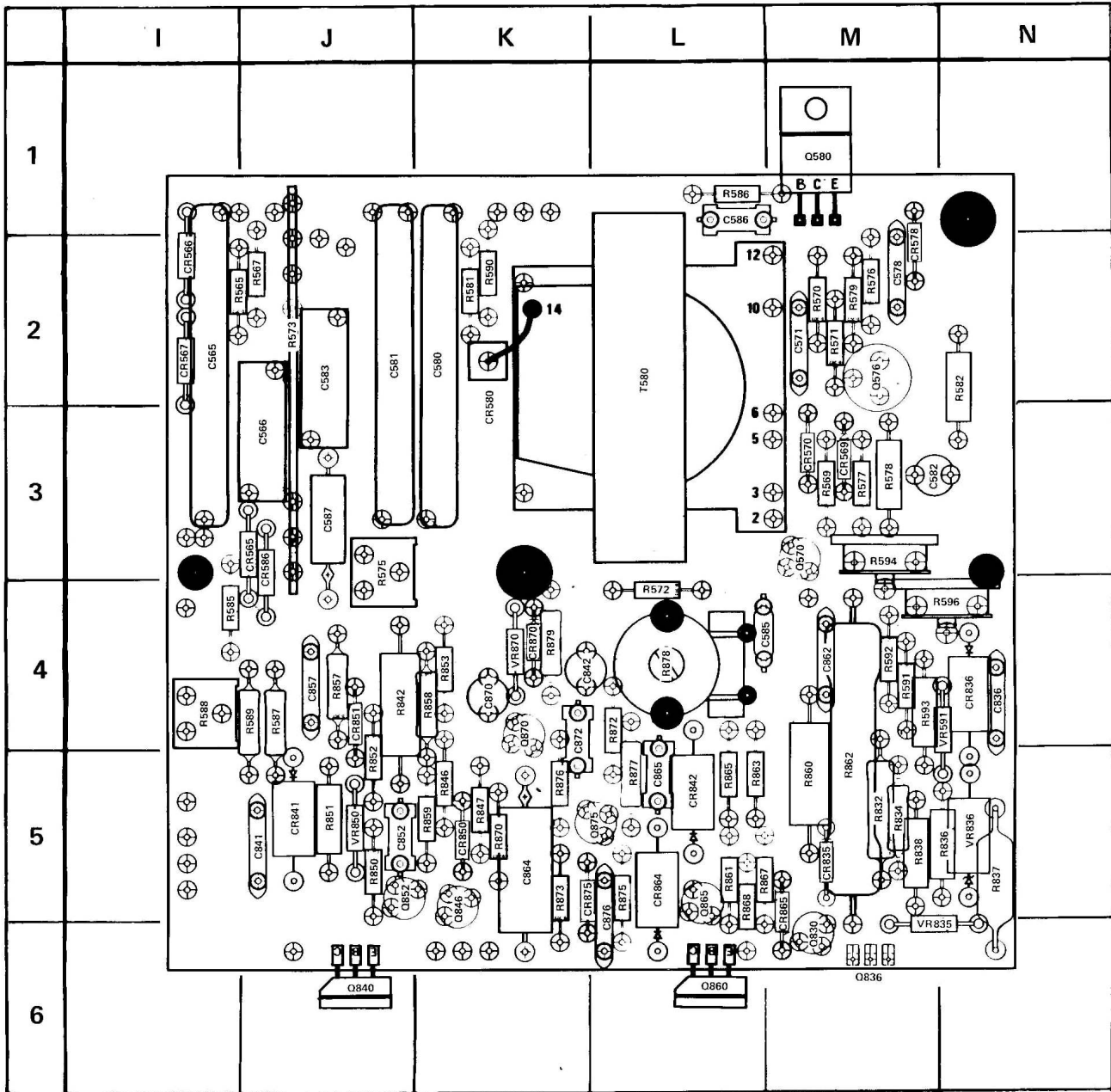


Fig. 4-2. Deflection Amplifier adjustments and test point locations.





## 603/604 ASSEMBLY A-3



**Fig. 4-4. 603/604 High Voltage & Regulators Board component location grid.**



603/604

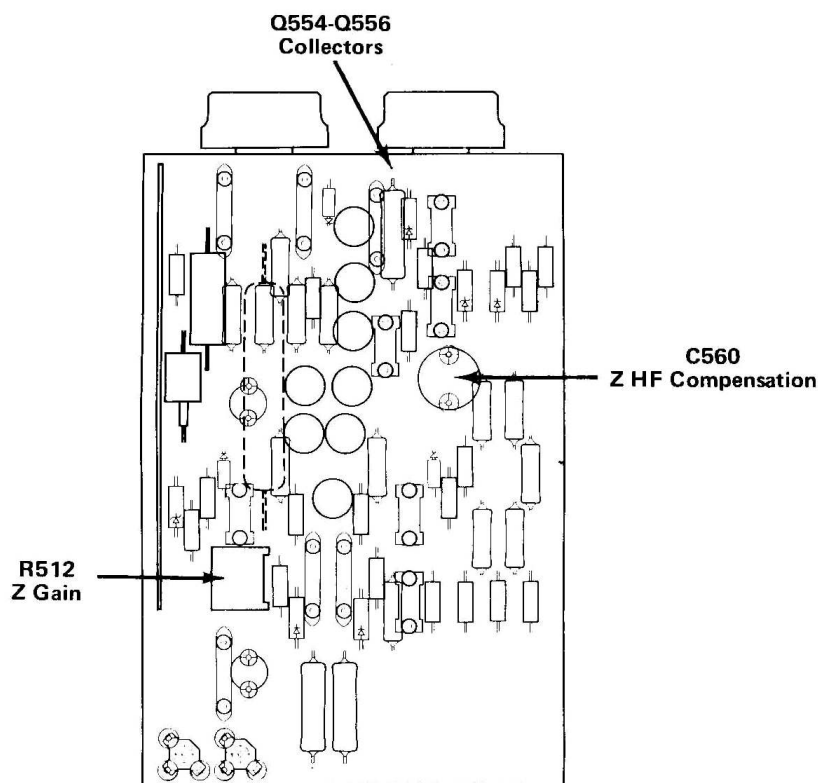


Fig. 4-5. Z-Axis Amplifier adjustments and test point locations.

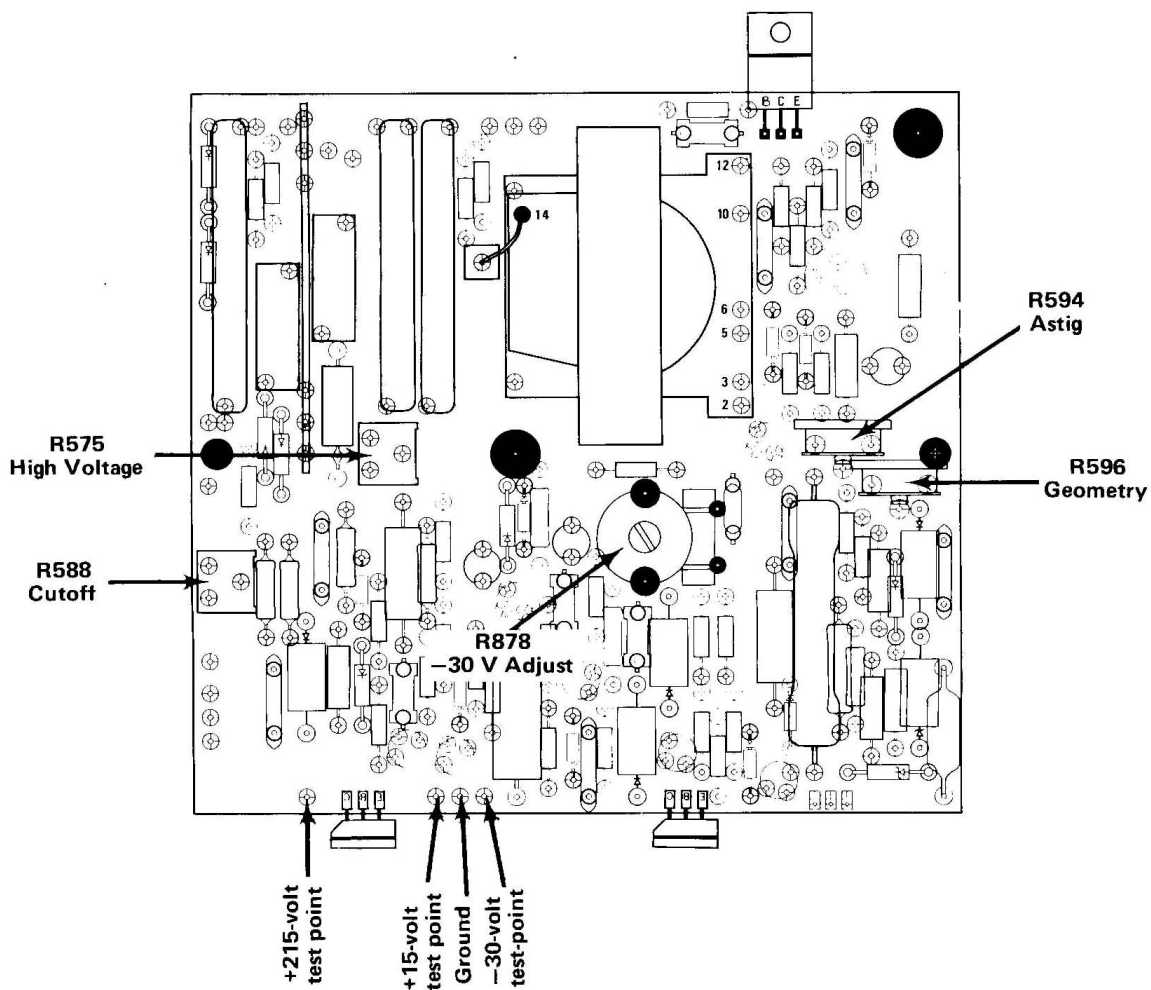


Fig. 4-6. CRT Circuit and Power Supply adjustments and test point locations.



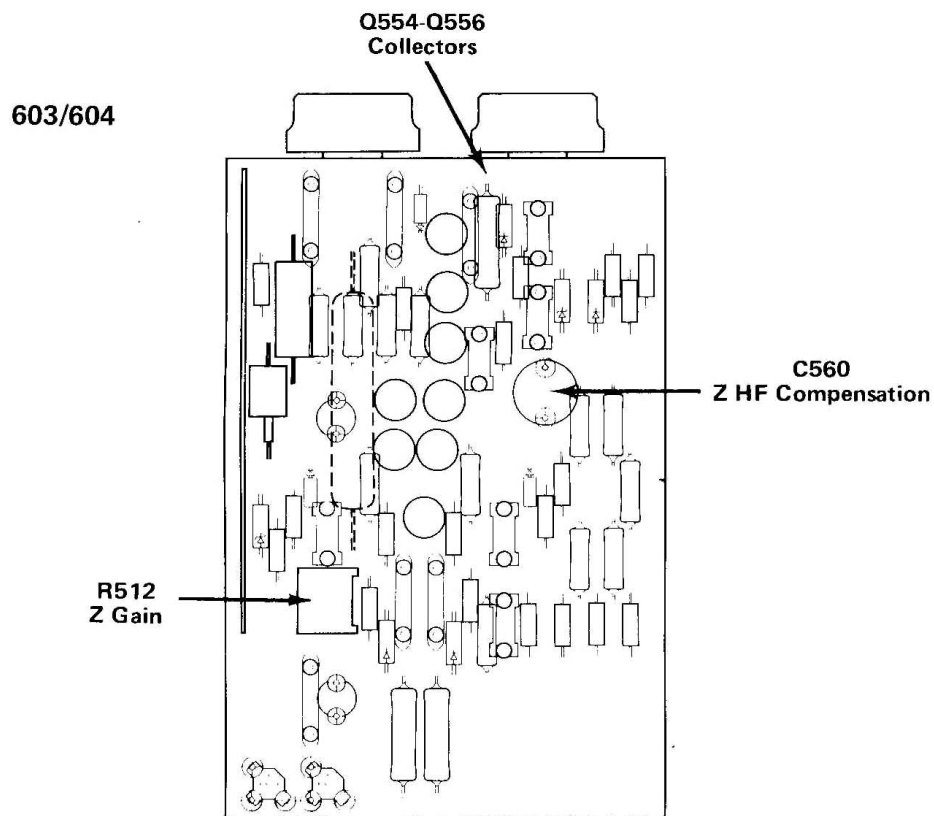


Fig. 4-5. Z-Axis Amplifier adjustments and test point locations.

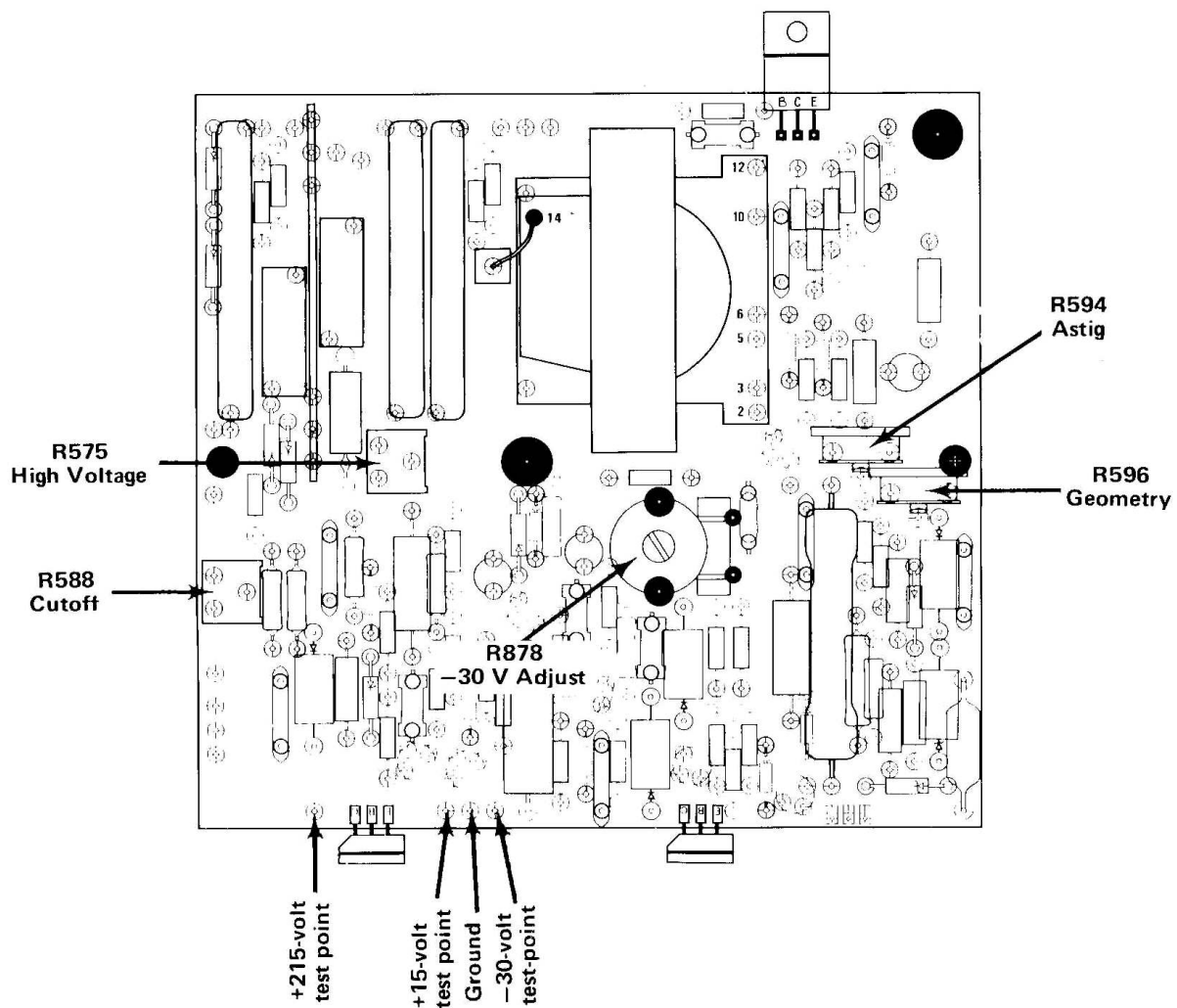
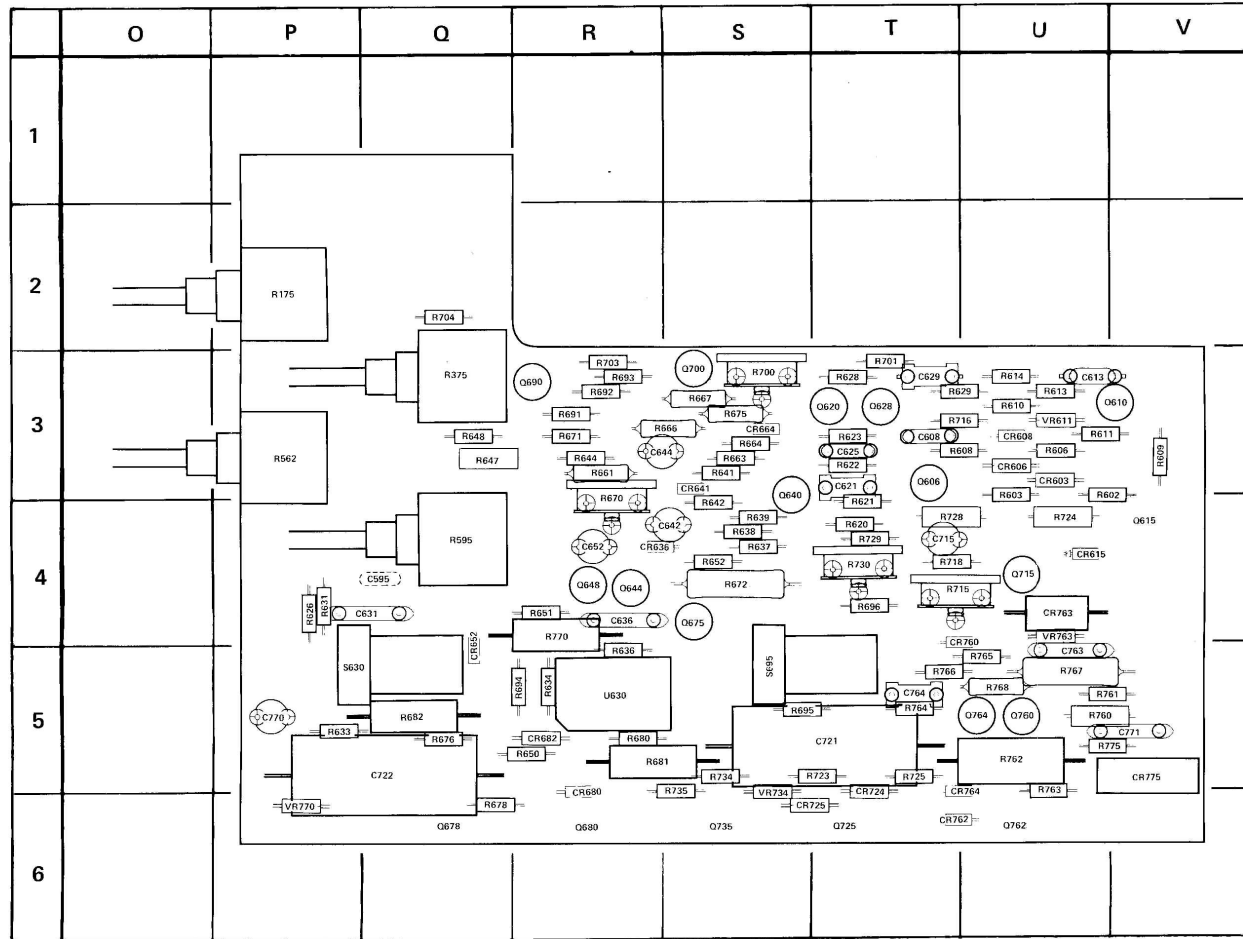


Fig. 4-6. CRT Circuit and Power Supply adjustments and test point locations.



603 ASSEMBLY A-4



604 ASSEMBLY A-4

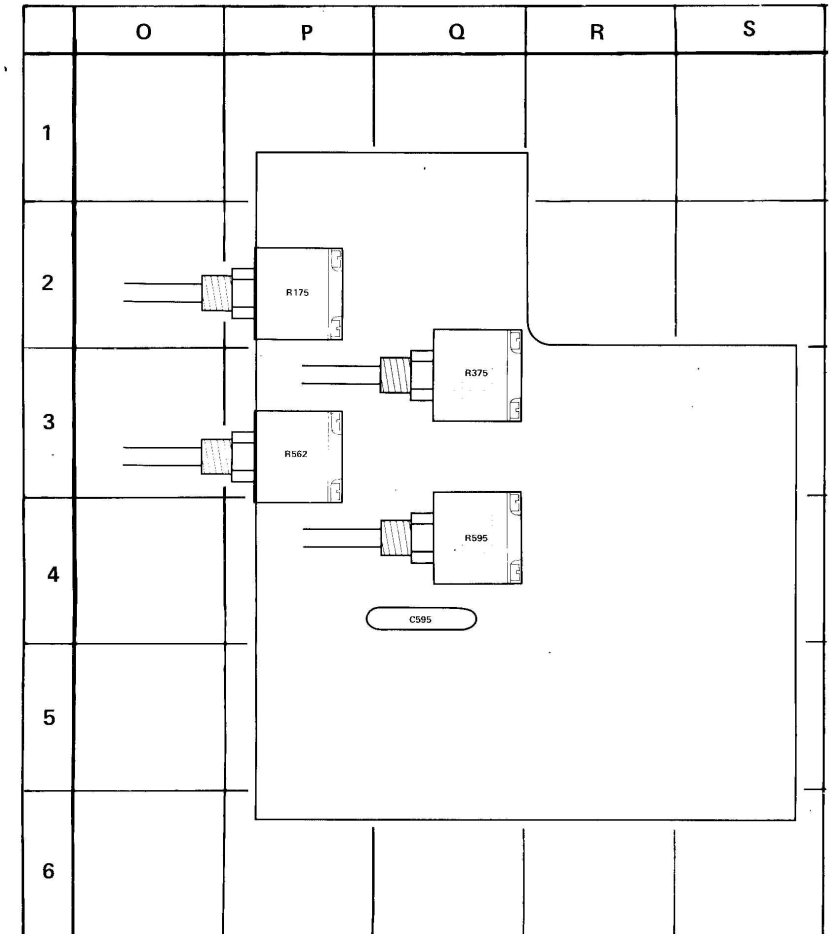


Fig. 4-7. Storage Board (603) and Control & Interface Board (604) component location grid.

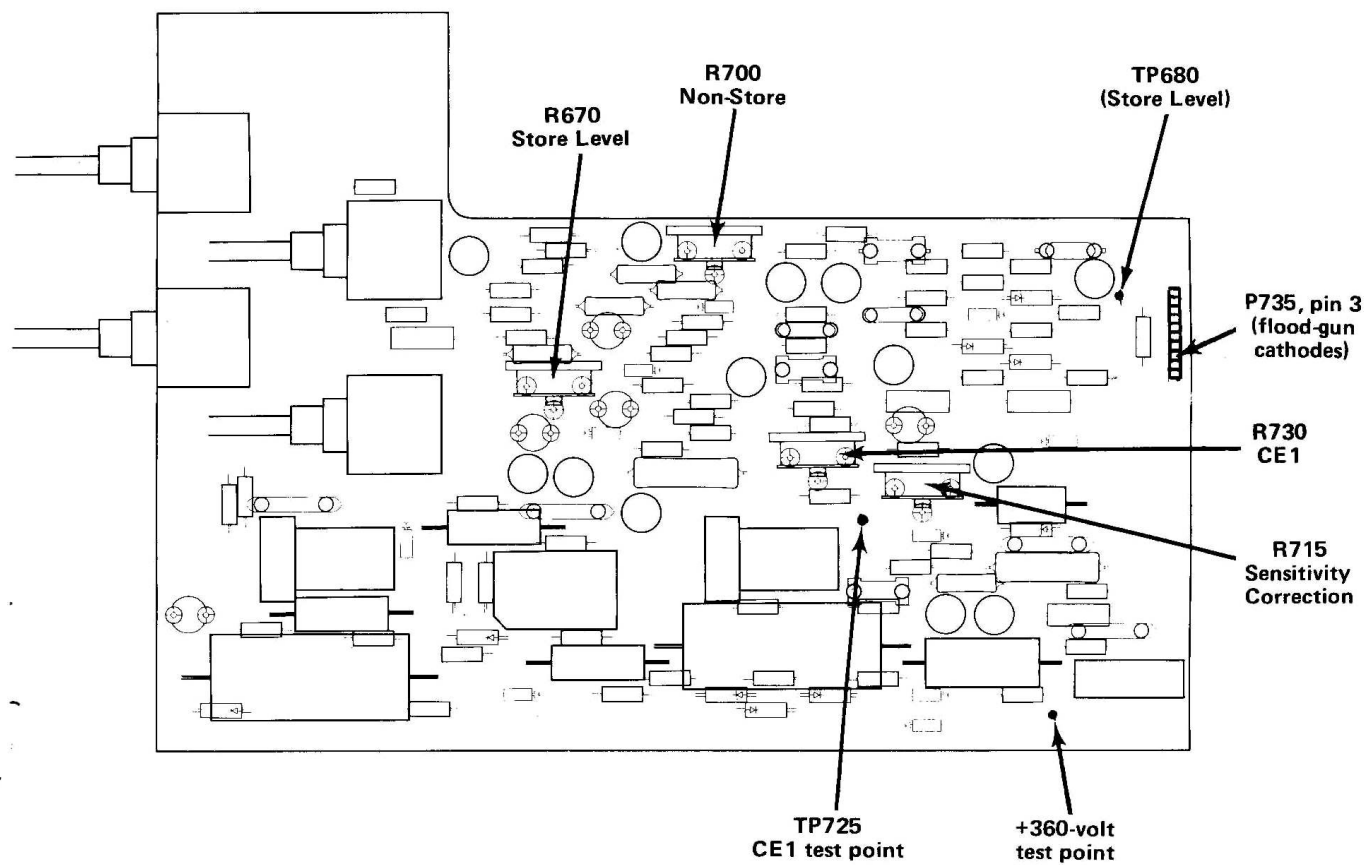
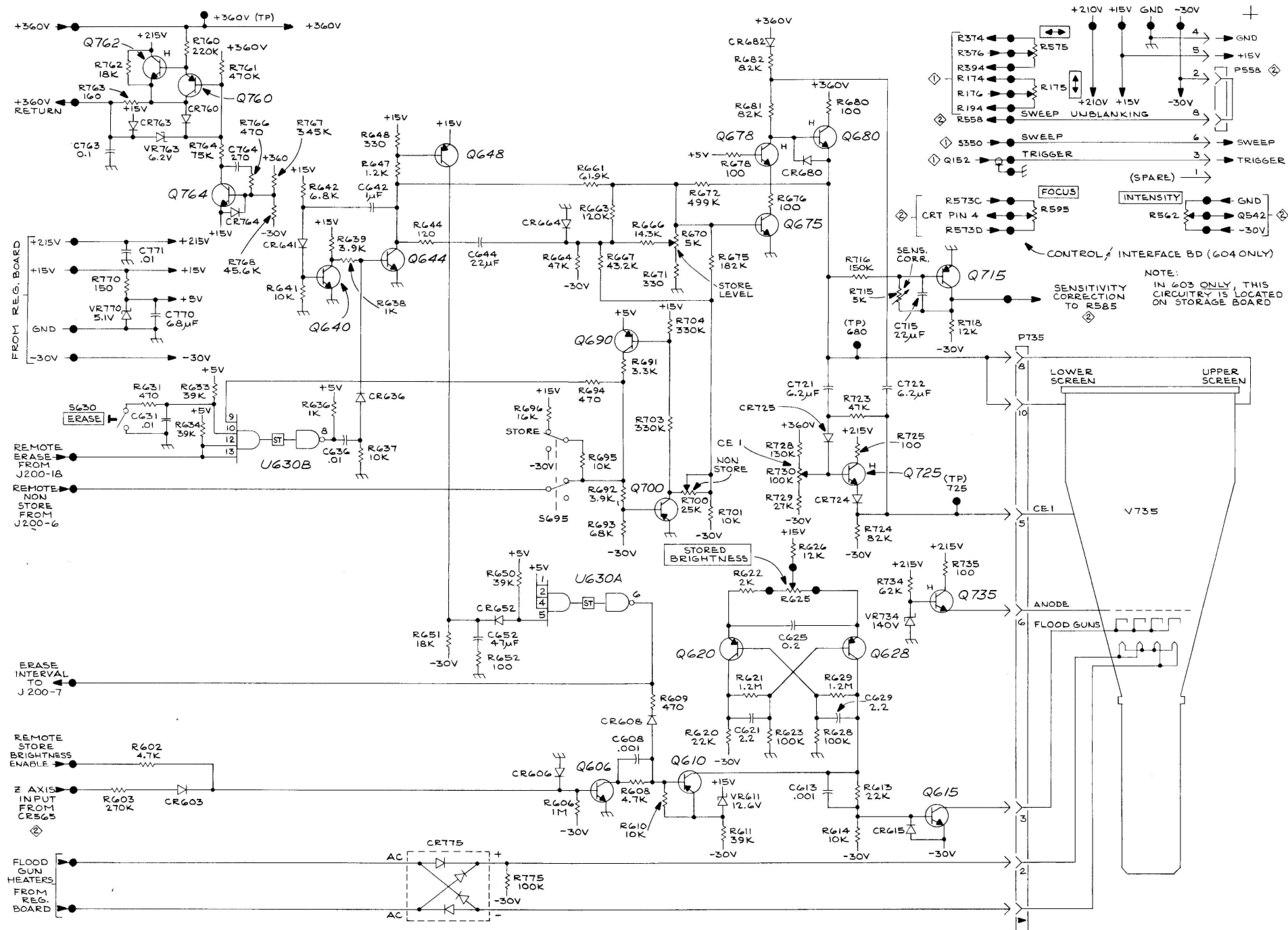
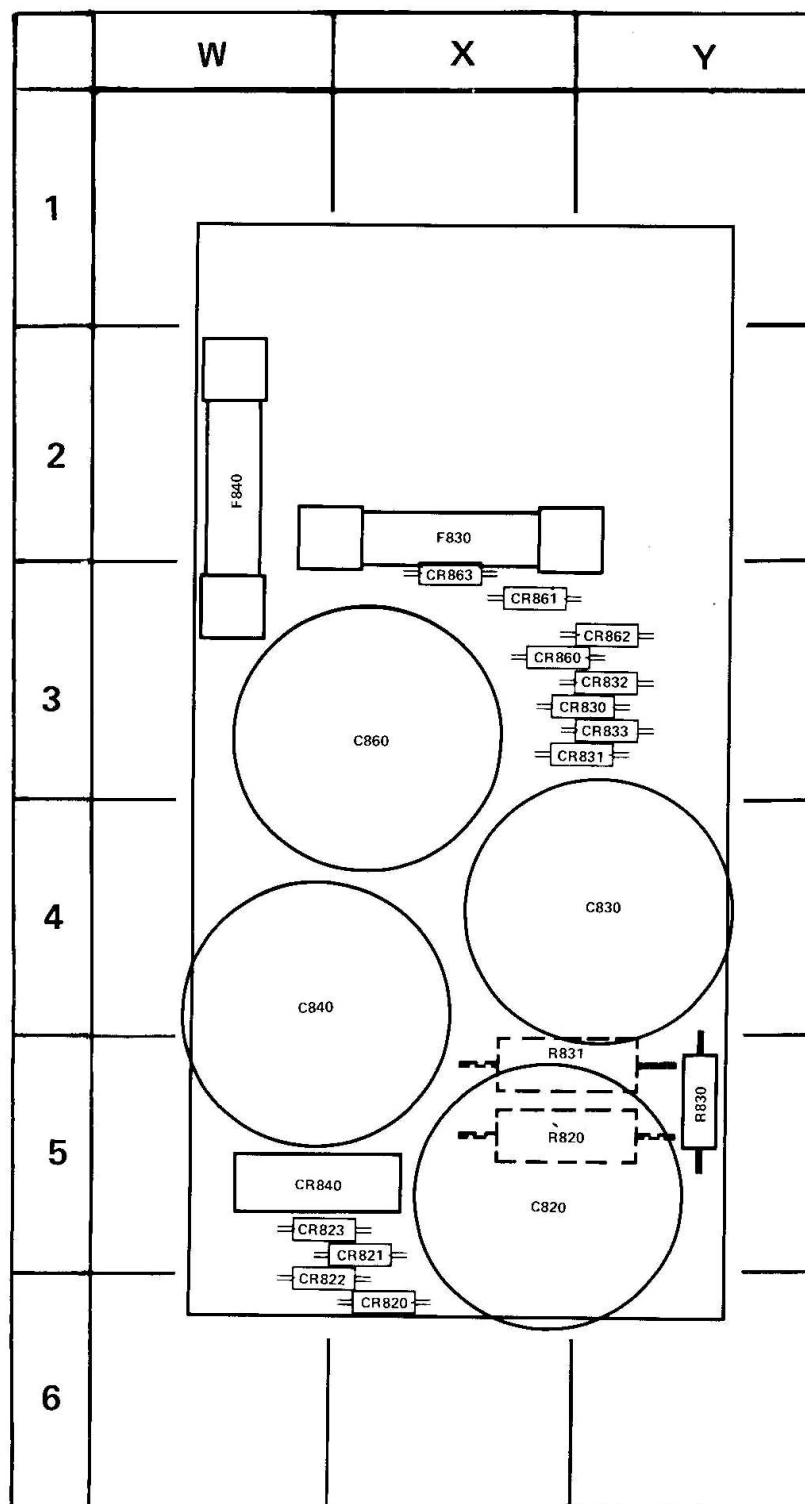


Fig. 4-8. Storage Circuit adjustments and test point locations.



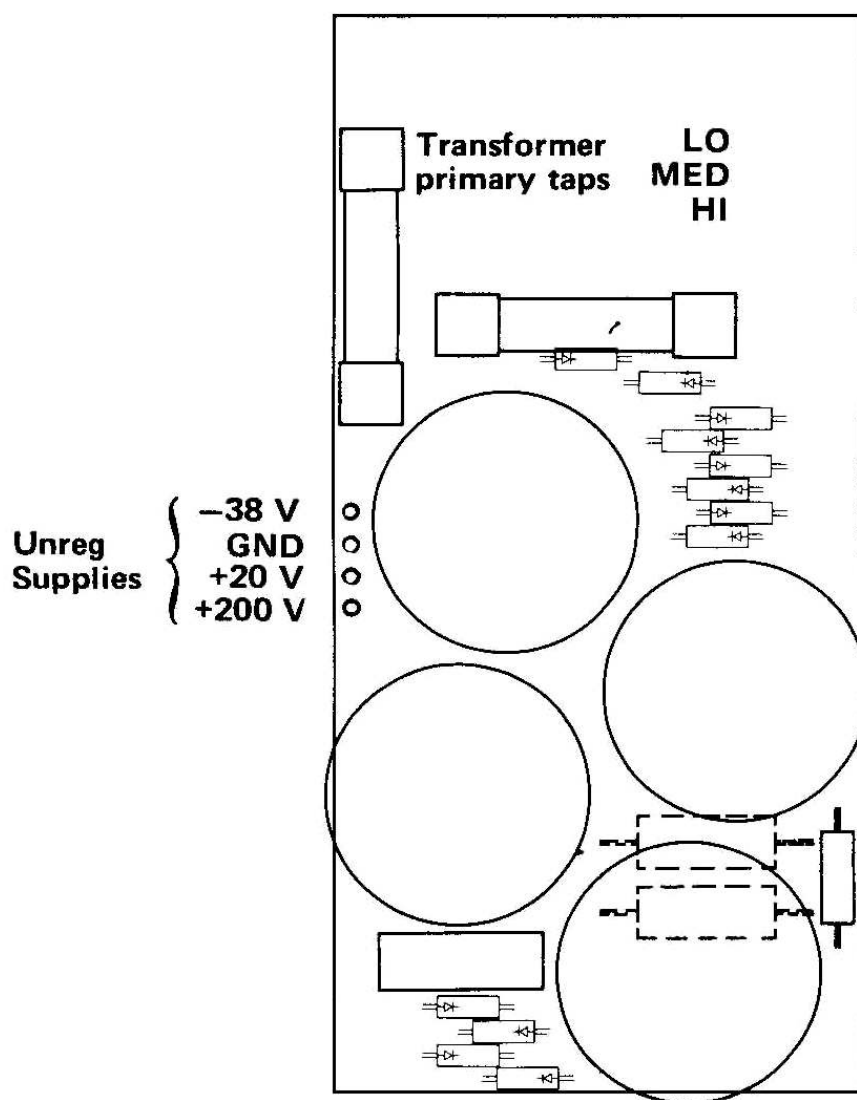
# 603/604 ASSEMBLY A-5



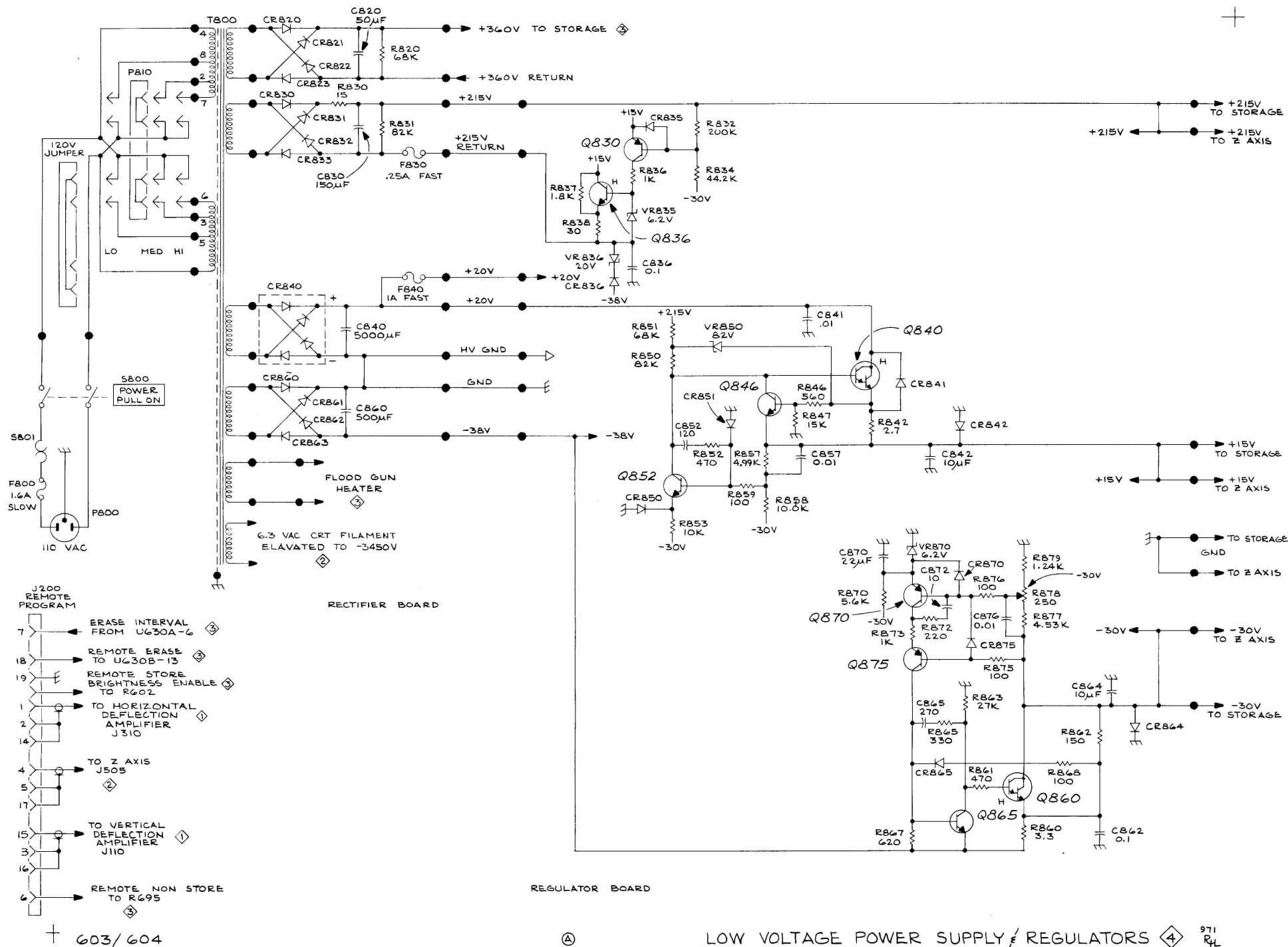
## NOTE

See Fig. 4-4 (Assembly A-3) for location of components on L.V. Regulator board.

Fig. 4-9. Power Input and Rectifiers Board component location grid.



**Fig. 4-10. Transformer primary taps and power supply test points.**



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LOW VOLTAGE POWER SUPPLY & REGULATORS ④ 971 R<sub>L</sub>