FINAL ENGINEERING REPORT

HIGH SPEED OSCILLOSCOPE

by

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Contract Number W19-122-ac-40

Period of Report - June 16, 1949 to May 31, 1950

Report Submitted - June 28, 1950

LIST OF ILLUSTRATIONS

Photographs

Block Diagrams & Schematic Diagrams

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PERFORMANCE DATA

FINAL ENGINEERING REPORT

TEKTRONIX, INC., PORTLAND, OREGON on contract W19-122-ac-40

SUBJECT: High Speed Oscilloscope.

INTRODUCTION:

This report covers the work done on the above contract for the period June 16, 1949 to date and deals with the final development, construction and performance test of a high-speed wideband cathode ray oscilloscope.

STATEMENT OF PROBLEM:

Interim Engineering Report No. 3 outlined the tentative characteristics of a high speed oscilloscope based on circuit development work done under the above contract.

Briefly the main requirements of the instrument were as follows:

VERTICAL AMPLIFIER:	Transient Response	.005 usec. rise time
	Sensitivity	.1 volts/cm (peak to peak)
	Deflection	1 inch peak to peak linear and push-pull deflection
	Overshoot	less than 5%
	Gain Control	continuous
SWEEP CIRCUIT:	Sweep Speeds	maximum of 40 inches/microsecond with slower speeds available
	Triggering	provision for triggering from signal being observed, as well as from external source of either polarity
AUXILIARY CIRCUITS:		provision for Z axis modulation, internal trigger generator, delayed sweep.

SOLUTION OF PROBLEM:

This report will cover in detail the description, circuitry, performance and operating instructions of a high speed wideband cathode ray oscilloscope developed for the Air Materiel Command in compliance with the requirements outlined above.

The instrument consists of three units - oscilloscope, an external power supply, and mobile mount. Figure 1 shows the instrument on the mobile mount with the power supply on the lower deck. Both units may be removed from the mobile mount and placed on a bench if desired. The oscilloscope is 18" high, 15" wide and 21-1/2" deep and weighs 75 pounds. The power supply is 10" high, 17-1/2" wide, 13" deep and weighs 57 pounds. An oil filled high voltage supply is located in the oscilloscope unit, thus making it unnecessary to bring any high voltage up from the external power supply.

A simplified block diagram of the oscilloscope is shown in figure 11. Here the main units are shown in single blocks to give a clearer overall picture of the complete instrument as more detailed block diagrams of the main units are shown later in connection with the description of those units. Figure 2 is a front panel view of the oscilloscope,and the following is a brief explanation of the function of each control and connector.

<u>SWEEP TIME/CM</u>: Gang switch controlling sweep duration and rate, selects appropriate charging capacitors, charging resistors, changes multivibrator length and selects appropriate high speed (millimicrosecond range) or low speed sweep (microsecond range) output circuit.

<u>SWEEP TIME MULTIPLIER</u>: Twin variable resistors (right hand control) and twin tapped resistors controlling time constant of low speed sweep generator (microsecond range) and period of multivibrator, thereby determines sweep rate within range set by SWEEP TIME/CM control when it is in the MICRO-SEC X MULT position.

<u>SWEEP MAGNIFIER</u>: Potentiometer and switch controlling voltage applied to grid of sweep magnifier (V29), thereby determining portion of sweep to be magnified. Functions on low speed (nicrosecond range) sweep only.

TRIGGER SELECTOR: Switch determines source and polarity of trigger voltage.

SWEEP STABILITY: Potentiometer varying grid bias of multivibrator tube, V12, determines whether multivibrator will run free or triggered.

TRIGGER AMPL: Potentiometer varying grid bias on 2nd distributed trigger amplifier stage, V6-8, thereby determining amplitude of trigger signals applied to following stage.

EXTER. SWEEP ATTEN: Potentiometer controlling the voltage applied to EXT. SWEEP INPUT binding post which will reach the grid of V32 when the SWEEP TIME/CM switch is in the EXT. position.

VERT. AMP. ATTEN: A 100 ohm potentiometer in grid circuit of V101 giving a 2 to 1 gain control of output amplifier.

VERT. POSITION: Twin potentiometers controlling average potentials of vertical CRT deflection plates and therefore image position.

HOR. POSITION: Potentiometer controlling cathode bias of V25 and V26, causing a differential plate current change which results in an average potential shift on CRT horizontal deflection plates and therefore positions sweep.

ASTIGMATISM: Potentiometer in grid circuit of V307A, a cathode follower, which in turn is connected to CRT anode #2. Varies potential A2 with respect to deflection plates, enables sharp focus of image in both directions simultaneously.

INTENSITY: Potentiometer controlling average grid voltage of the CRT and thereby the brightness of the image.

FOCUS: Potentiometer controlling the voltage applied to the focus anode of the CRT and thereby the sharpness of the image.

CAL. RANGE: Attenuator for reducing amplitude of 1 kc square wave calibrating signal. Steps correspond to ranges on CAL. VOLTAGE dial.

CAL. VOLTAGE: Potentiometer with calibrated dial for adjustment of 1 kc calibrator square wave to desired amplitude.

INTERNAL TRIGGER GENERATOR: (MULT. dial) - Switch for changing timing capacitors of phantastron trigger frequency generator.

(CYCLES/SEC. dial) - Variable timing resistor for above phantastron generator.

TRIGGER INPUT: UHF connector for connecting external trigger sources to +EXT and -EXT position of TRIGGER SELECTOR switch.

+SWEEP OUTPUT: Binding post connected to sweep generator via cathode follower.

+GATE: Binding post connected to positive multivibrator tube via cathode follower to furnish a positive pulse of the same duration as the sweep.

EXT. SWEEP INPUT: Binding post connecting to low speed sweep amplifier via EXT. SWEEP ATTEN. when SWEEP TIME/CM switch is in EXT. position.

P.P. AMP. INPUT: UHF connector connected to delay cable, the far end which is the grid of the input tube on the push-pull amplifier deck.

PRE-AMP. OUTPUT: UHF connector which is output of pre-amplifier cathode follower.

SIGNAL INPUT: UHF connector to grid of input tube V201 in pre-amplifier.

PROBE POWER: Connector where heater and plate voltages are available for probe power.

CAL. OUTPUT: Binding post connected to arm of CAL. VOLTAGE potentiometer.

CRT CATHODE: Binding post permitting connection of external modulation signals to the cathode of the CRT.

INTERNAL TRIG. OUTPUT (2): UHF connectors to cathode followers which are driven by a single blocking oscillator triggered by a phantastron.

INT. TRIG. SYNC. INPUT: UHF connectors permitting external synchronization of above blocking oscillator when INTERNAL TRIGGER GENERATOR MULT. switch is in EXT. SYNC. position.

<u>SCALE ILLUM</u>: Variable resistor controlling brightness of lamp which illuminates the plastic graticule over the face of the CRT.

<u>POWER</u>: On-off switch in the AC line voltage supply.

VERTICAL AMPLIFIER SYSTEM

Figure 12 is a complete block diagram of the vertical amplifier system. The amplifiers are of the distributed type and their theory was discussed in Interim Engineering Reports 1 and 2. The system consists of two main units, a pre-amplifier and a push-pull output amplifier.

Figure 13 is the schematic diagram of the pre-amplifier circuit and Figure 5 is a photograph of the right side of the oscilloscope showing the location of the unit. The pre-amplifier consists of a 6AK5 input tube, V201, coupled to the first distributed stage consisting of 5 - 6AK5's, V202-206. This is followed by a second distributed stage in cascade using 6 - 6AK5's, V207-212. The output of the second stage is coupled to 2 - 6J6 cathode followers, one, V213, providing signals to the sweep trigger amplifier, and the other, V214, providing the signal to the push-pull output amplifier unit via a signal delay cable (RG-62U). Figure 8 is a photograph of this cable mounted underneath the front lower deck. An adjustable biasing network in the grid circuit of the cathode follower V214 permits adjusting the average cathode potential to zero with respect to ground in order to remove DC potential from the gain control which is connected to the far end of the delay cable.

The overall voltage gain of the 2 stage pre-amplifier is approximately 5 from the input tube grid to delay line output.

The output of the pre-amplifier is brought out to the front panel of the instrument and is connected externally by a short length of RG-62U cable to the push-pull amplifier input connector. This connector, however, is the input to the signal delay cable which is terminated on the far end by the 2 to 1 gain control potentiometer discussed previously. This limited gain control is necessary due to the limited output from the pre-amplifier. By bringing the pre-amplifier output and push-pull amplifier input connector to the front panel additional delay cable may be inserted if greater signal delays are required than that provided by the internal cable. The internal cable has sufficient delay, however, to enable the complete observation of a pulse on the fastest sweep when triggering from the pulse being observed (see Figure 24). These front panel connectors also enable the signal to be connected directly into the push-pull amplifier provided the correct signal and impedance levels are maintained. When this is done, however, external triggering must be provided.

Figure 14 is the schematic of the push-pull output amplifier along with the associated driver, phase inverter, and input tube circuits. This unit consists of a 6AK5 input tube, V101, a phase inverter employing 2 - 6AK5's, V102 and 103, and a push-pull driver stage with 3 - 6AK5's per side, V104-109. The output amplifier consists of a total of 14- 6AK5's, 7 per side, V110-123. Figures 4 and 5 are side views of the oscilloscope and the amplifier may be observed mounted crosswise directly under the cathode ray tube.

As noted in the schematic (Figure 14) the push-pull output line has only a reverse termination. This results in twice the output voltage available for a given current shift over that of a line with a termination at both ends. This also results in reflections, however, but these are absorbed in the reverse termination which must be accurately matched to the line impedance in order to prevent a reflection back towards the output end of the line.

The performance characteristics of the vertical amplifier system are discussed under the heading "Performance Characteristics".

SWEEP GENERATOR CIRCUIT

Figure 15 is a complete block diagram of the sweep generator and associated circuits. The sweep generator includes two types of output circuits which are switched by a relay. One circuit is used for the "slow speed sweep" and the other is used for the "high speed sweep". Both sweep circuits, however, use the same trigger amplifier, multivibrator, unblanking, and clamp tube circuits. It was found more practical to generate the fast sweeps at the voltages required for direct application to the cathode ray tube, rather than to use conventional sweep amplifiers, and for this reason a form of the "bootstrap" circuit was used. This circuit was discussed briefly in Interim Engineering Report #3 and will be elaborated upon in this report.

As the connection diagram of the sweep selector switch (SWEEP TIME/CM) would complicate the sweep schematic diagram, the complete switch schematic is shown separately in Figure 17. The following is a description of the sweep circuit with reference to Figures 15 and 16:

TRIGGER PHASE CHANGER: A trigger selector switch in conjunction with V1 selects the source of trigger signal and reverses the phase if necessary as the input to the trigger amplifier stage, V2, requires a positive signal on its grid to provide correct trigger polarity to the multivibrator.

DISTRIBUTED TRIGGER AMPLIFIER: In order to provide a minimum of delay between the start of the trigger pulse and the start of the sweep, a broad band trigger amplifier is used. This amplifier has a rise time of approximately 7 to 8 millimicroseconds and consists of two distributed stages in cascade. The first stage consists of 1-6CB6, V2, and 3-6AK5's, V3 to 5. As the trigger amplifier must have low frequency response also, the 6CB6 provides a convenient method of coupling the output of V1 to the distributed trigger amplifier without the use of a bulky coupling capacitor. The second distributed stage consists of 3-6AK5's, V6-8. The grids of this stage are driven positive and the grid bias on this stage is controlled by the TRIGGER AMP. control, thus changing the gain of the trigger amplifier.

TRIGGER AMP. & LIMITER: The negative output pulse of V6-8 is applied to the grid of a 6AG7, V9, cutting off the plate current of this stage. By proper choice of load resistance, plate current, and shunt compensation in the plate of V9, the positive output pulse applied to the grid of V10 is limited in amplitude with very fast rise time. By limiting the positive signal on V10, the grid of V10 will not draw grid current.

TRIGGER SWITCH TUBE: V10 acts as a switch tube whose plate pulls down the plate of the multivibrator tube, V12, via a coupling diode, V11, thus triggering the multivibrator.

TRIGGER COUPLING DIODE: The diode, V11, disconnects the plate of V12 from the plate of V11 when the plate potential of V12 falls lower than that of V11.

MULTIVIBRATOR: V12 and V13 comprise the multivibrator circuit which converts the trigger pulses into square waves of controllable duration suitable for operating the sweep generator and unblanking circuits. The proper period of the multivibrator is determined by the position of the sweep switch (SWEEP TIME/CM) and the SWEEP TIME MULT. controls. The latter functions on the microsecond or slow speed range only. The SWEEP STABILITY control varies the grid bias on V12 and determines whether or not the multivibrator will oscillate and also controls the point at which triggering via V11 occurs.

SWEEP GENERATOR CLAMP CIRCUIT: The negative pulse from the plate of V12 is applied to the grids of the parallel clamp tubes, V17 and V18, allowing their plate voltage to rise across the charging capacitor as selected by the sweep switch. The proper charging resistor is also selected by the same switch. Parallel 6AG7's are used as clamp tubes as the charging current required for the fastest sweep is approximately 120 milliamperes and the ability of these tubes to be easily "cut off" makes them desirable. For the 10 & 20 millimicrosecond/cm sweep time positions, the plate of the clamp tubes in the quiescent state are resting at approximately 55 volts. For the slower speed or longer time ranges, the plate voltage is somewhat less than 55 volts.

As noted in the sweep switch diagram, Figure 17, switch section #9, the charging capacitors in the high speed sweep position, have series resistors. Their purpose is to aid in linearizing the very first part of the sweep by permitting the sweep voltage to rise faster by the charging current drop across the series resistor.

BOOTSTRAP CIRCUIT: When the SWEEP TIME/CM switch is in the MILLI-U-SEC range, the sweep circuit is connected for high speed operation and the grid of V20 (6AG7, bootstrap tube) is connected across a charging capacitor which is also selected by the switch. The voltage rise across the charging capacitor would be exponential if no provision were made to keep the charging current a constant value and the purpose of V20 is to maintain this current as constant as possible for the duration of the sweep voltage. The cathode of V20 is coupled to the top of the charging resistor by means of a coupling capacitor which supplies the current into the charging resistor as the charging capacitor voltage rises.

DECOUPLING DIODE: A decoupling diode, V19, a 6X4, is used to supply the quiescent current to the clamp tubes so that the supply end of the charging resistor will be disconnected from the 425 volt power supply when bootstrap action starts.

CATHODE FOLLOWER TO V20 SCREEN: In order for the bootstrap circuit to function properly, it must have a gain approaching unity and this is accomplished by "bootstrapping" the screen of V20 to the sweep voltage. A 6J6, V21, performs this function. In order for V21 to have sufficient plate voltage for the entire sweep voltage range, it is connected to a 750 volt supply.

+SWEEP TO CRT: A 6J6 cathode follower, V22, provides the positive sweep voltage to the cathode ray tube. The use of a cathode follower here isolates the sweep circuit capacitance from the cathode ray tube deflection plates and also provides a "stiff" source of positive sweep voltage for the sweep inverter, V24.

SWEEP INVERTER: To provide the negative portion of the sweep voltage a "plate unbalance" phase inverter is used. This consists of the 6AG7, V24, whose gain is maintained at unity by the voltage divider made up of the two (5-20) micromicrofarad feed-back capacitors between the plate and grid circuit. The 680 ohm resistor in series with the (5-20) micromicrofarad trimmer on the plate side aids in obtaining good linearity at the start of the sweep by compensating for the shunt capacitor across the plate load resistor. This type of circuit has the advantage of having a very "stiff" output circuit and can tolerate a capacitance load of several micromicrofarads.

EXTERNAL H.S. SWEEP: A 6C4 cathode follower, V23, provides a high speed sweep voltage to the front panel. This voltage has a peak value of approximately 100 volts.

UNBLANKING AMPLIFIER & CATHODE FOLLOWER: During the waiting periods, the bias on the CRT is such that it is completely cut off. As soon as a trigger appears and the sweep starts, it is necessary to provide a positive pulse on the CRT grid of approximately 30 volts. This pulse should have a very fast rise time and a flat top to insure fast unblanking and a uniform image brightness. This is accomplished by the unblanking amplifier, V15, and associated cathode follower output tube, V16. Shunt compensation of V15 provides the fast rise time requirements and being completely cut off by the large negative signal from the plate of the negative multivibrator, V12, the resultant pulse has a reasonably flat top. In order to provide an unblanking pulse of short enough duration for the fastest sweep (10 millimicroseconds per cm.), it was necessary to employ a "ringing" circuit in the grid of V15 in the form of a 300 microhenry inductance. This inductance is grounded via a 100 ohm resistor in the fastest speed only. The negative grid signal rings the circuit for a negative half cycle which is of the proper length for unblanking the fastest speed. When the ringing circuit starts to go positive, the oscillations are damped out by the diode action of the grid circuit as V15 is operating at zero bias. For unblanking at the very slowest speeds, (10,000 microseconds per cm.), low frequency compensation is used in the plate circuit of V15. This compensation in conjunction with the proper time constants in the grid circuits of V16 and the cathode ray tube, provides a satisfactory low speed unblanking signal.

GATE CATHODE FOLLOWER: V14 is a 6J6 cathode follower whose grid is coupled to the plate of the positive multivibrator tube, V13. The output of the cathode follower is brought out to a front panel binding post and provides positive gating pulses of the same duration as the sweep.

LOW SPEED ADJ.: When the SWEEP TIME/CM switch is in the MICROSECOND range, the sweep circuit is connected for low speed operation. The charging capacitor current is then supplied by a cathode follower, V27. The charging resistors are in the cathode circuit of V27 and are adjusted by the SWEEP TIME MULTIPLIER dials while the charging capacitors are changed by the SWEEP TIME/CM switch.

SWEEP PHASE SPLITTER & SWEEP AMPLIFIER: The basic low speed sweep voltage that is generated, is about 5% of the supply voltage, therefore the rate of rise is nearly linear. However, approximately 500 volts peak to peak is required to sweep the cathode ray tube and this is accomplished by a phase splitter, V32a,b, and a push-pull output amplifier, V33 and 34, operating from a plate supply voltage of 750 volts. The variable 5000 ohm resistor (ADJ. E) in the cathode return circuit of V32 adjusts the plate current in this stage and in the output stage also as the two stages are DC coupled. The 100,000 ohm potentiometer (ADJ. D) in the grid of V32b adjusts the optimum operating point of the output tubes for positive and negative sweep voltages. That is, for the quiescent state the plate voltage of V33 will be setting at approximately 200 volts while the plate of V34 will be setting at about 550 volts.

SWEEP DC RESTORER: A DC restorer, V31, removes any charge from the grid coupling capacitor of V32a which this capacitor may have gained during the sweep.

SWEEP MAGNIFIER CIRCUIT: The function of this circuit is to delay the start of the sweep for a variable time and then cause it to operate at five times its normal speed. This is accomplished by a biased cathode coupled amplifier, V29a,b. The sweep starting time is controlled by the SWEEP MAGNIFIER potentiometer in the grid of V29b which raises the grid potential of V29b and also the common cathode potential. No sweep appears on the plate of V29b until the sweep voltage on the grid of V29a overcomes the cathode bias. V30 is used as a DC restorer to insure that the magnifier sweep will start at the same potential each time, thus preventing jitter or instability of the trace. A switch on the SWEEP MAGNIFIER control switches the sweep magnifier circuit out when this circuit is not being used.

DC OUTPUT LEVEL: To obtain good focus on the cathode ray tube, it is necessary that both pairs of deflection plates and the second anode have approximately the same average potential. To permit convenient direct connection to the vertical plates, it is desirable that their average DC potential be zero. The horizontal deflection plates must therefore operate at the same average level. The circuit associated with V25 and V26 provides the shift of DC potential of the horizontal deflection plates to the required zero level. This circuit causes the effective plate impedance of these tubes to be extremely high. The result is a constant plate current for wide swings in plate voltage caused by the sweep potentials. By the proper choice of dropping resistors between the sweep output tubes and the plates of the pentodes, V25 & V26, the required average DC output level is obtained. A 10,000 ohm potentiometer in the cathode circuit of V25 & V26 permits a differential shift in the plate currents and provides a means of horizontal positioning of the sweep voltages. A potentiometer

(ADJ. C) in the grid circuit of these tubes changes the plate current in the same direction, thus providing an adjustment of the average DC operating level.

MISCELLANEOUS CIRCUITS

HIGH VOLTAGE SUPPLY: Figure 19 is a schematic diagram of the high voltage supply and associated oscillator and regulator circuits. The supply is of the audio oscillator type operating at a frequency of approximately 2000 cycles. The unit furnished -2000 volts and +3.3, +6.6 and +10 KV as accelerating potentials for the 5XP cathode ray tube. To insure constant CRT deflection sensitivity for changes in beam currents, the -2000 volt supply is regulated against load changes by the amplifier and regulator tubes V401 & 402. The components of the high voltage supply shown within the dotted line, Figure 19, are sealed in oil. Expansion of the oil is taken care of by forcing the air out of an immersed neoprene bladder. Figure 4 shows this unit mounted in the rear of the oscilloscope.

CATHODE RAY TUBE: The schematic diagram of the cathode ray tube connections is shown in Fugure 20. The neon glow lamps across the intensity control maintain the voltage drop across this control at a constant value independent of CRT cathode current. The second anode voltage is controlled by a cathode follower, V307A, as shown in Figure 18. This is the astigmatism control. A cathode follower is used in order to provide a low impedance path for the CRT second anode current; which, in conjunction with the constant voltage drop across the intensity control, enables the full advantages of the regulated -2000 volt supply to be utilized.

Provision is also made for Z axis modulation by means of the .03 microfarad coupling capacitor to the cathode. This connection is brought out to the front panel, however a lower capacitance connection is possible by means of the access hole in the left side of the oscilloscope cabinet.

CALIBRATOR CIRCUIT: To aid in signal amplitude measurement, a 1 KC square wave calibrator is employed. The schematic diagram for this circuit is shown in Figure 18, V308 & V309. This circuit provides a calibrated square wave at a front panel connector, which may be set to any desired value from 30 millivolts to 50 volts peak with an accuracy of $\pm 5\%$. Six ranges are provided. Calibration adjustment is accomplished with the 5K potentiometer in the cathode circuit of V309A.

TRIGGER GENERATOR CIRCUIT: An internal trigger generator provides positive trigger pulses to two front panel connectors which are the outputs of two cathode followers, V305 & V306, Figure 18. The grids of these tubes are driven positive by a blocking oscillator, V304, which in turn is triggered by a free running screen coupled phantastron, V302. V301B isolates the phantastron output from the blocking oscillator. V303 determines the level to which the plate of V302 may rise and V301A provides a low impedance path for recharging the timing capacitors. Two trigger outputs were provided in order to permit delaying one by means of external delay cable or networks which would give the effect of a delayed trigger when the non-delayed trigger output is used to trigger the oscilloscope. The output voltage for each trigger when working into a 50 ohm load is approximately 30 volts with a rise time of .15 microseconds and a duration of .4 microseconds.

TERMINAL CONNECTIONS: The input power or terminal connections are shown in Figure 21 and are located on the rear deck. The Jones connector from the external power supply and the terminal strip may be observed in the photograph of the oscilloscope's "Bottom View", Figure 7. The high voltage power supply equipment and filament transformer are also located on this deck.

EXTERNAL POWER SUPPLY: Figure 22 is a schematic diagram of the external power supply and Figures 9 and 10 are photographs of the unit. This supply furnishes the following regulated voltages:

+750 volts at 30 milliamperes

+425 volts at 150 milliamperes

+225 volts at 400 milliamperes

+120 volts at 325 milliamperes

-150 volts at 50 milliamperes

In addition, an unregulated voltage of +300 volts supplies 65 milliamperes to the series regulator tube of the high voltage oscillator, and an unregulated -250 volt supply furnished 5 milliamperes for operating the sweep DC level output circuit.

PERFORMANCE CHARACTERISTICS

VERTICAL AMPLIFIER: To determine the pulse characteristics of the vertical amplifier system, a test pulse with a rise time of 1 millimicrosecond and a duration of 45 millimicroseconds was used. This test pulse was generated by a line type pulser using a mercury wetted contact switch. Figure 23 is a photograph of this test pulse applied directly to the CRT vertical deflection plates. Two sweep rates are shown, 10 millimicroseconds/cm and 20 millimicroseconds/cm. The ringing observed on this pulse was found to be due to the deflection plate capacitance and lead inductance. The ringing frequency is approximately 550 megacycles, as about 5-1/2 cycles are observed for a period of 10 millimicroseconds. The amplitude of the test pulse as shown in Figure 23 is 15 volts. The graticule marks are 1 centimeter apart, hence the CRT vertical deflection sensitivity is about 16 volts/cm. The amplitude of the test pulse was reduced by a wide band attenuator for testing the amplifiers and Figure 23C & D is a photograph of the test pulse applied to the push-pull amplifier circuit only -- that is, the pulse was applied to the front panel P.P. AMP. INPUT connector. Both pulse polarities are shown at a sweep rate of 10 millimicroseconds/cm. Figure 24 shows the test pulse after passing through the complete vertical amplifier system. Both test pulse polarities are shown at sweep rates of 10 and 20 millimicroseconds/cm. A low frequency square wave was used as a test signal to determine the low frequency response of the vertical amplifier system. Figure 25 shows this response to a 100 cycle and 1000 cycle square wave.

The vertical amplifier sensitivity is approximately .06 volts per centimeter at a line voltage of 117 volts. At a line voltage of 105 volts, the sensitivity drops to .095 volts per centimeter. This decrease in gain has been determined to be a heater voltage effect which is particularly noticeable with type 6AK5 tubes.

The output amplifier is capable of a deflection of plus and minus 2 centimeters, and input signals which result in greater deflections should be attenuated externally. The limited gain control of 2 to 1 at the input to the push-pull amplifier is necessary due to the limited output from the pre-amplifier.

SWEEP CIRCUIT: The sweep circuit provides the following fixed sweep rates: 10, 20, 50, 100, 200 and 500 millimicroseconds/centimeter. In addition, the range from 1 microsecond to 10,000 microseconds/centimeter is covered continuously. To calibrate the faster sweep rates, a pulsed 50 megacycle timing wave was used. Figure 26 shows this 50 megacycle wave on the 10, 20 & 50 millimicrosecond/cm sweeps. The fixed sweep rates are adjusted by the trimming capacitors on switch section 9, Figure 17. The amplified test pulses shown in Figure 24 were obtained by triggering the sweep from the signal being observed. Any signal which results in a 1/4 to a 1/2 centimeter deflection will provide sufficient trigger voltage to trigger the sweep circuit. For external triggering, a .1 volt peak signal of either polarity is required.

FIGURE 1
HIGH SPEED
OSCILLOSCOPE

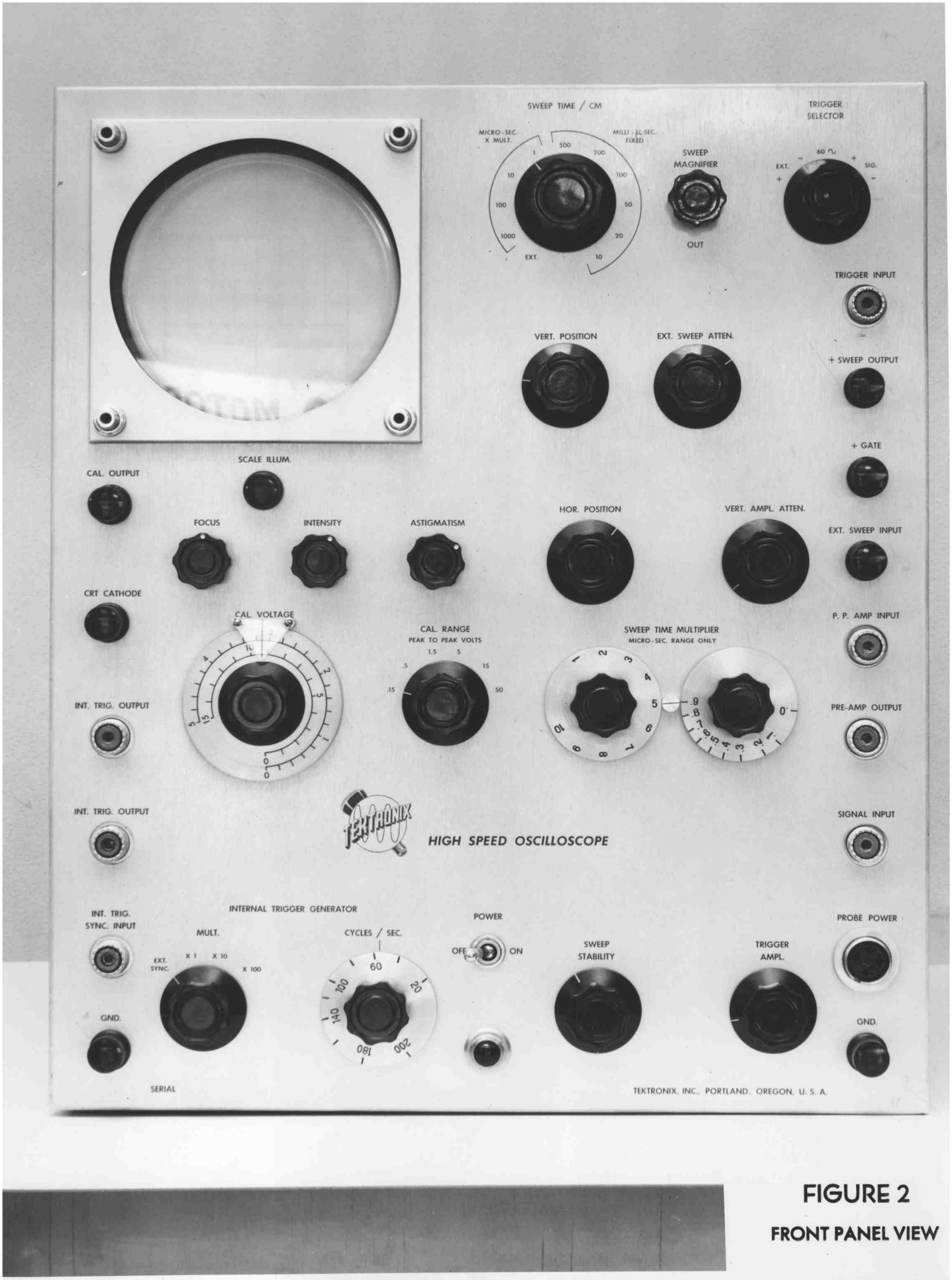


FIGURE 2

FRONT PANEL VIEW

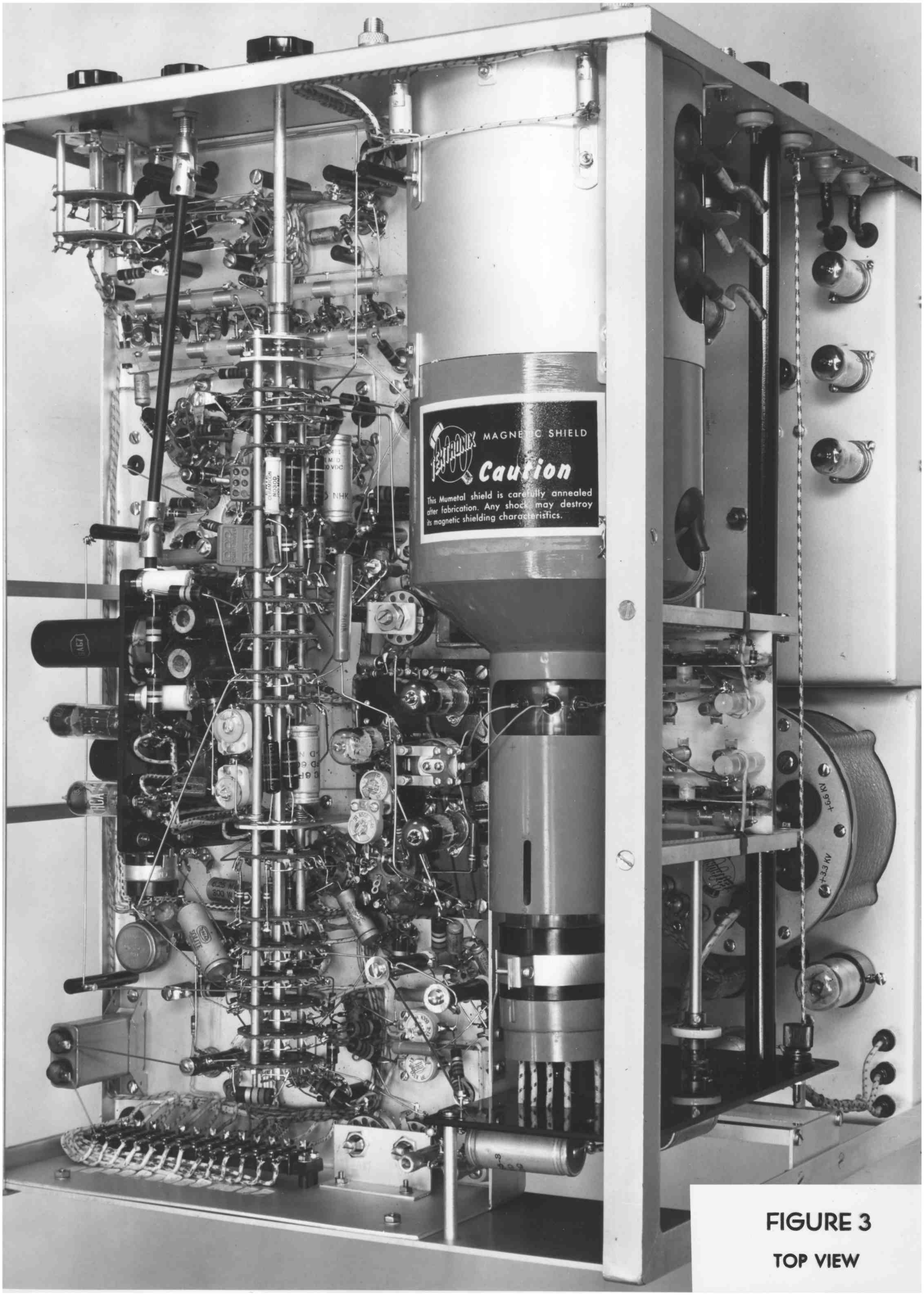


FIGURE 3

TOP VIEW

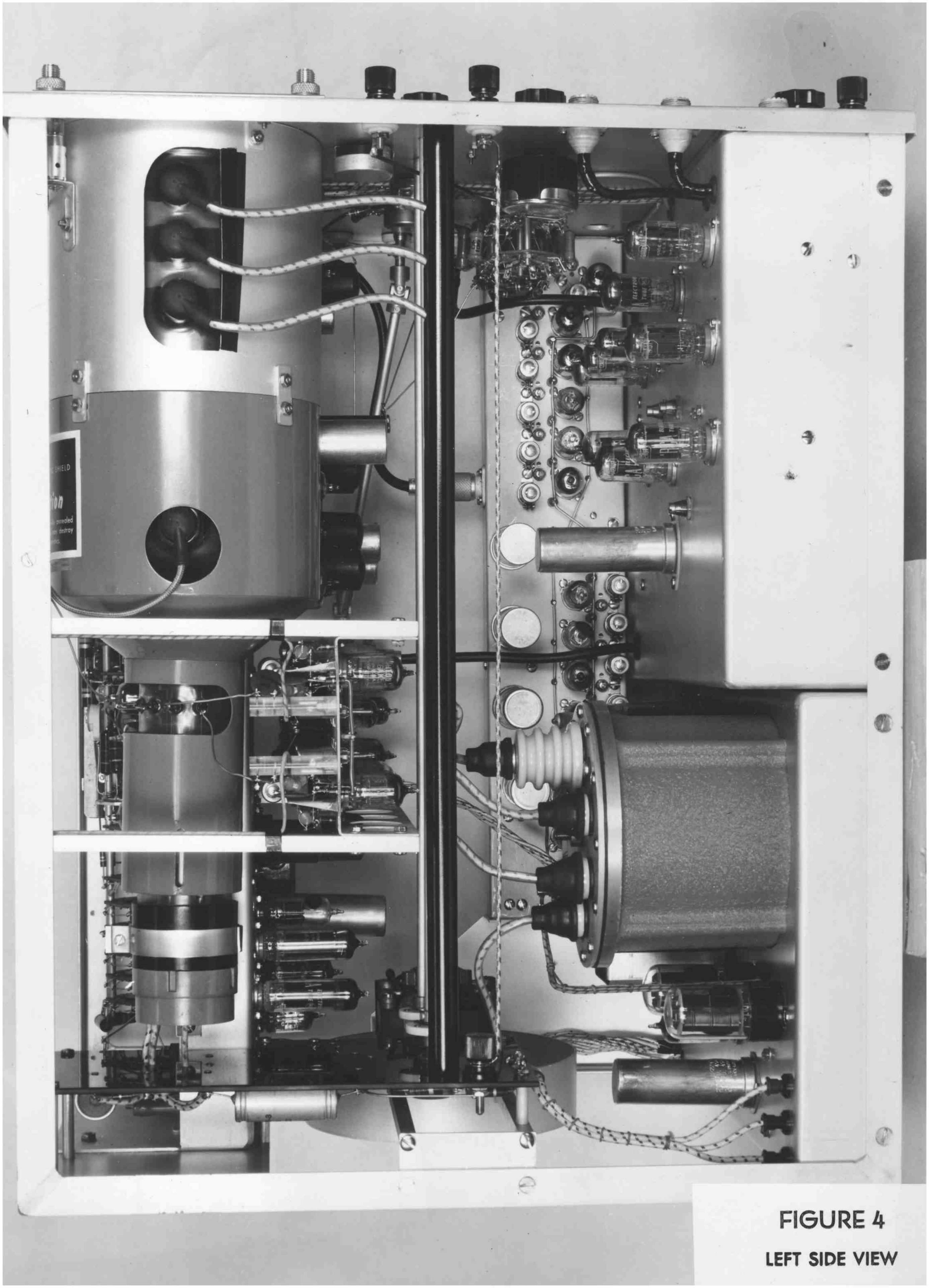


FIGURE 4

LEFT SIDE VIEW

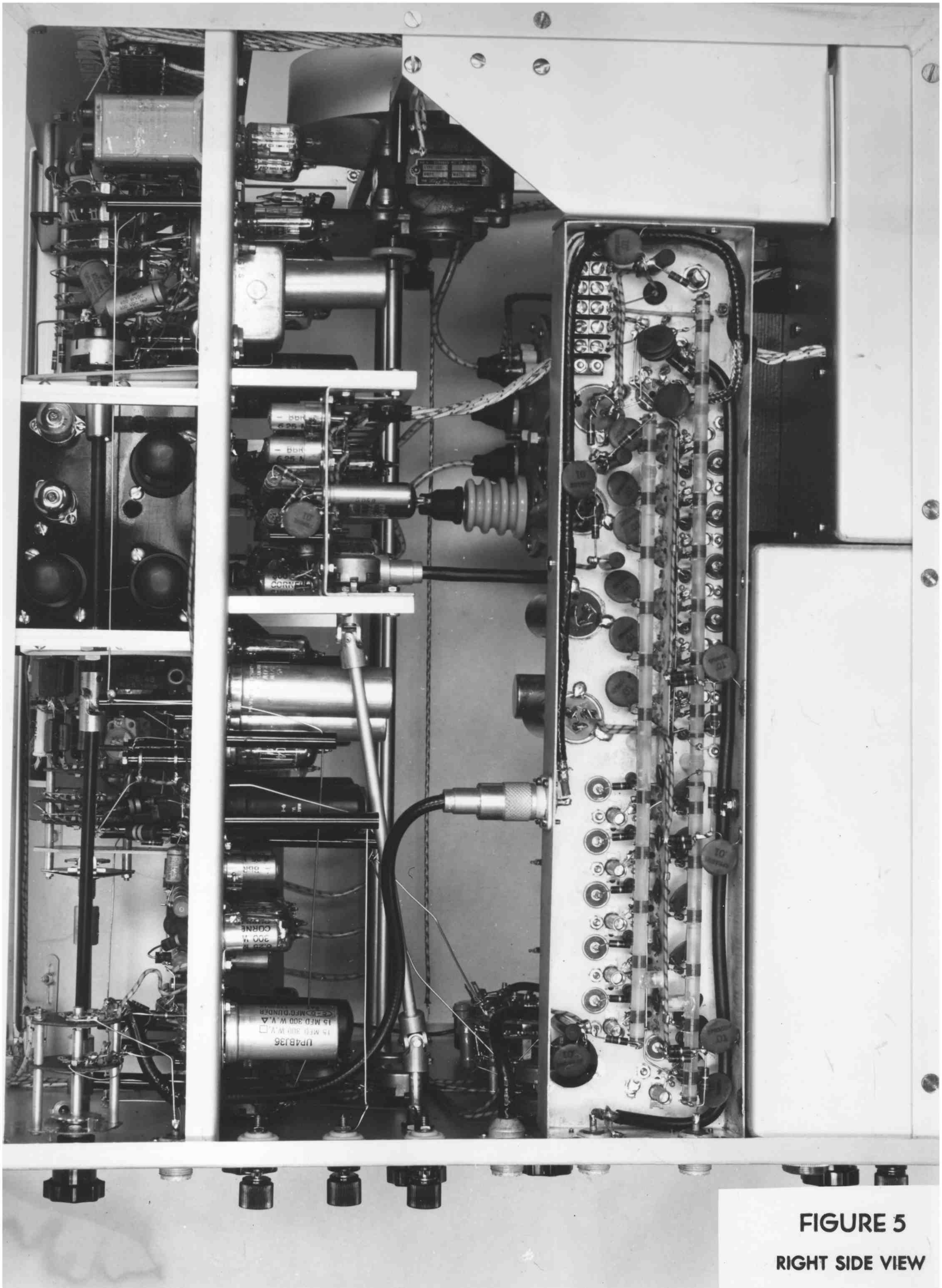


FIGURE 5

RIGHT SIDE VIEW

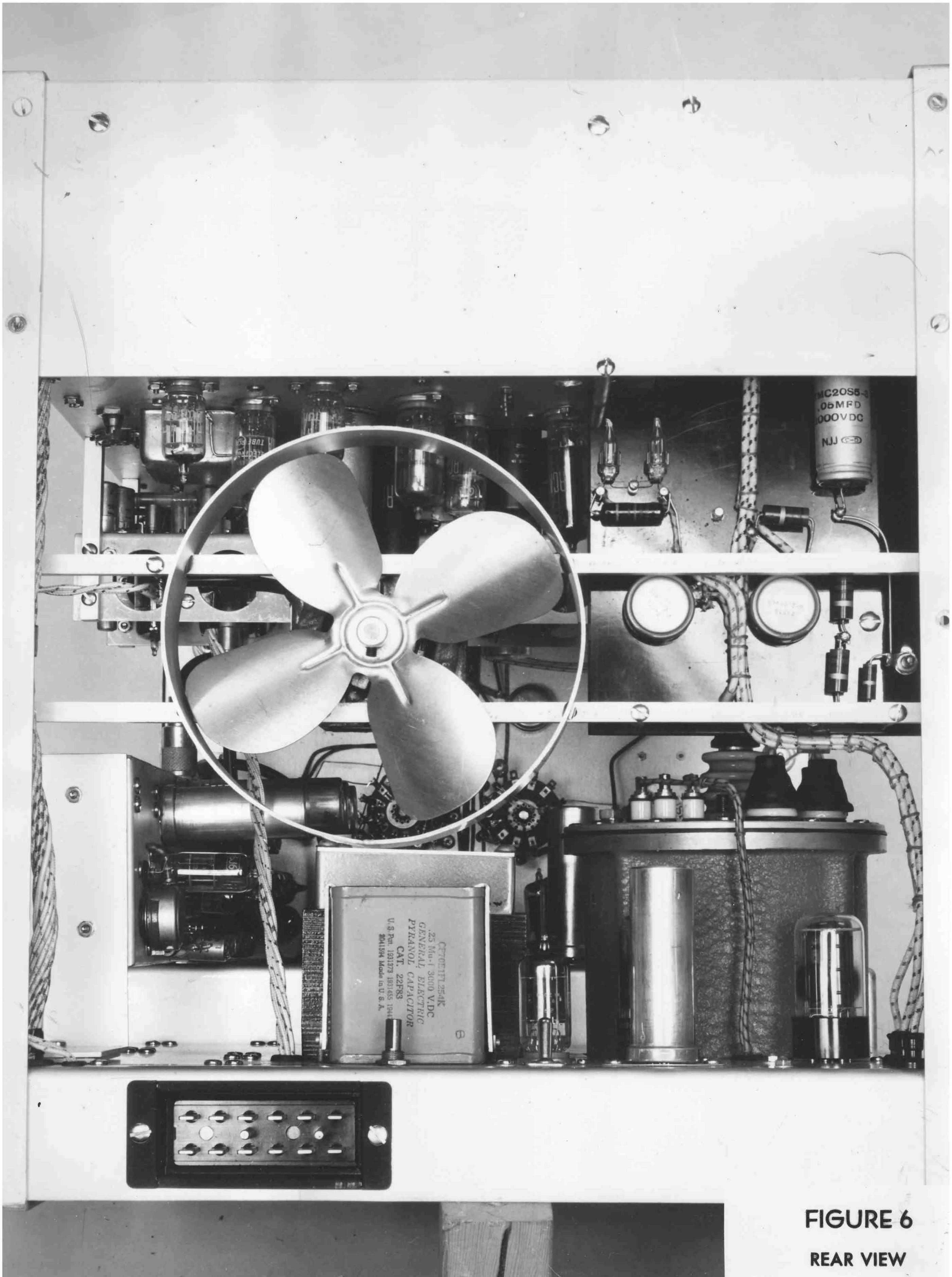


FIGURE 6

REAR VIEW

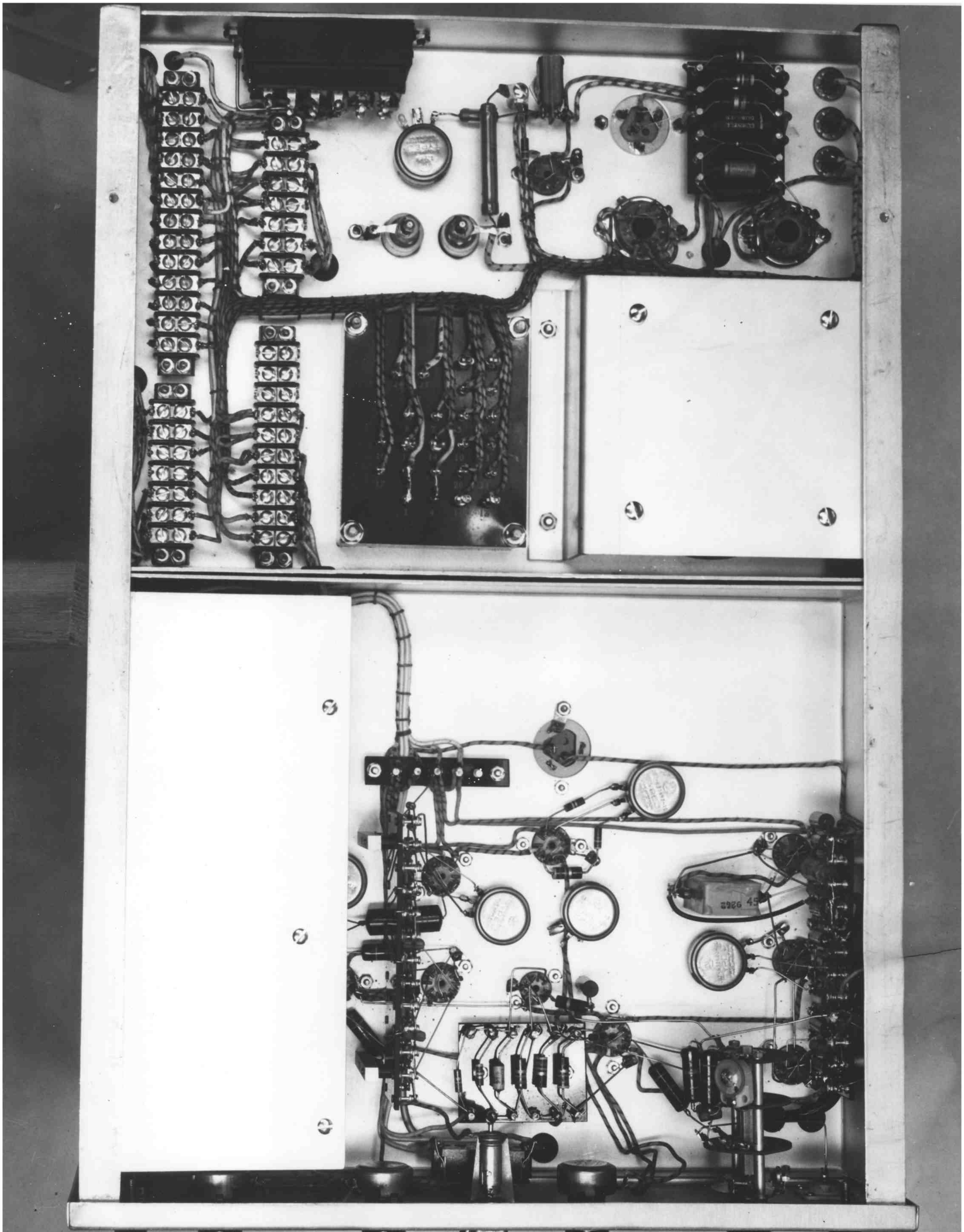


FIGURE 7

BOTTOM VIEW

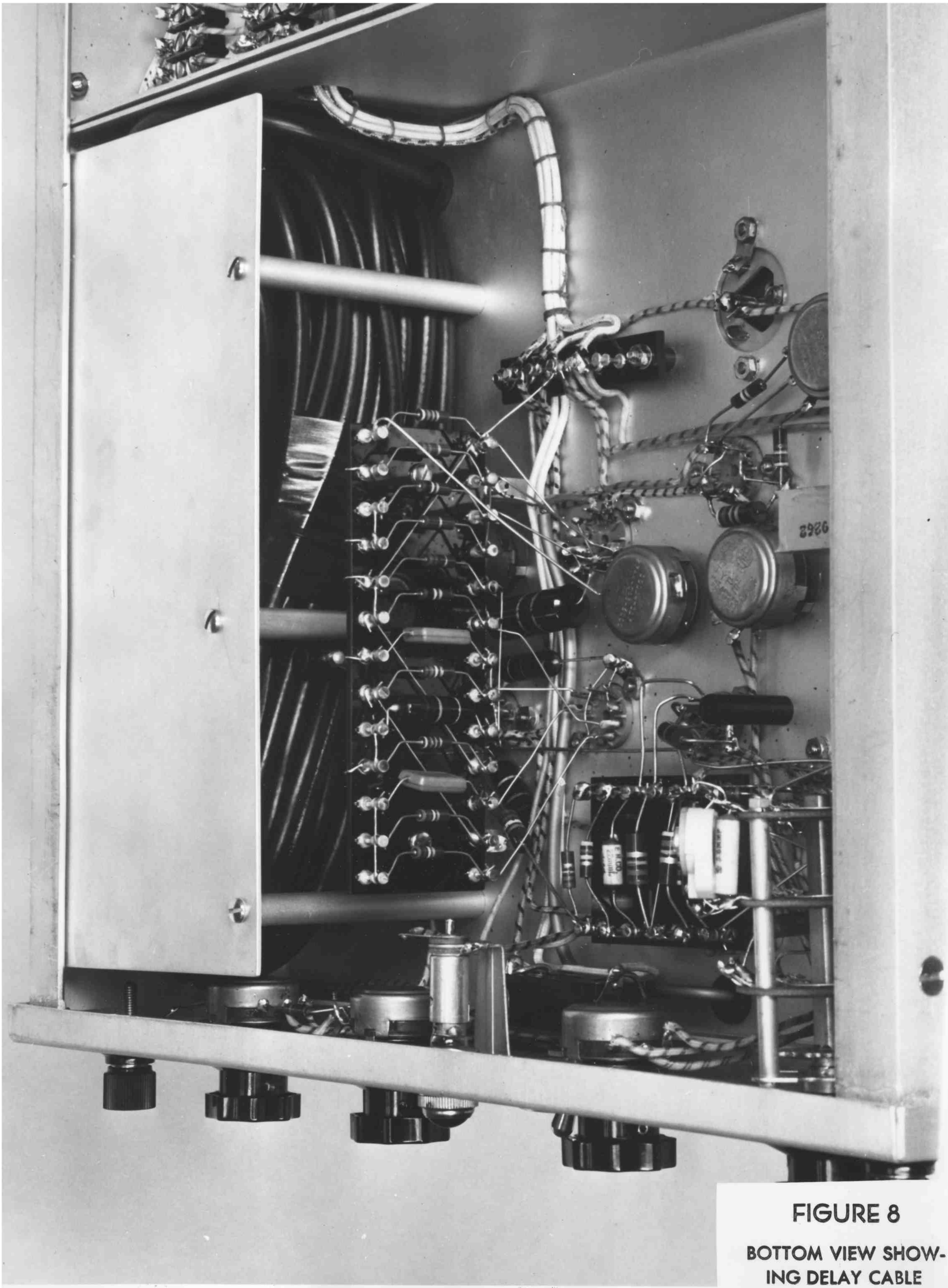


FIGURE 8

BOTTOM VIEW SHOWING DELAY CABLE

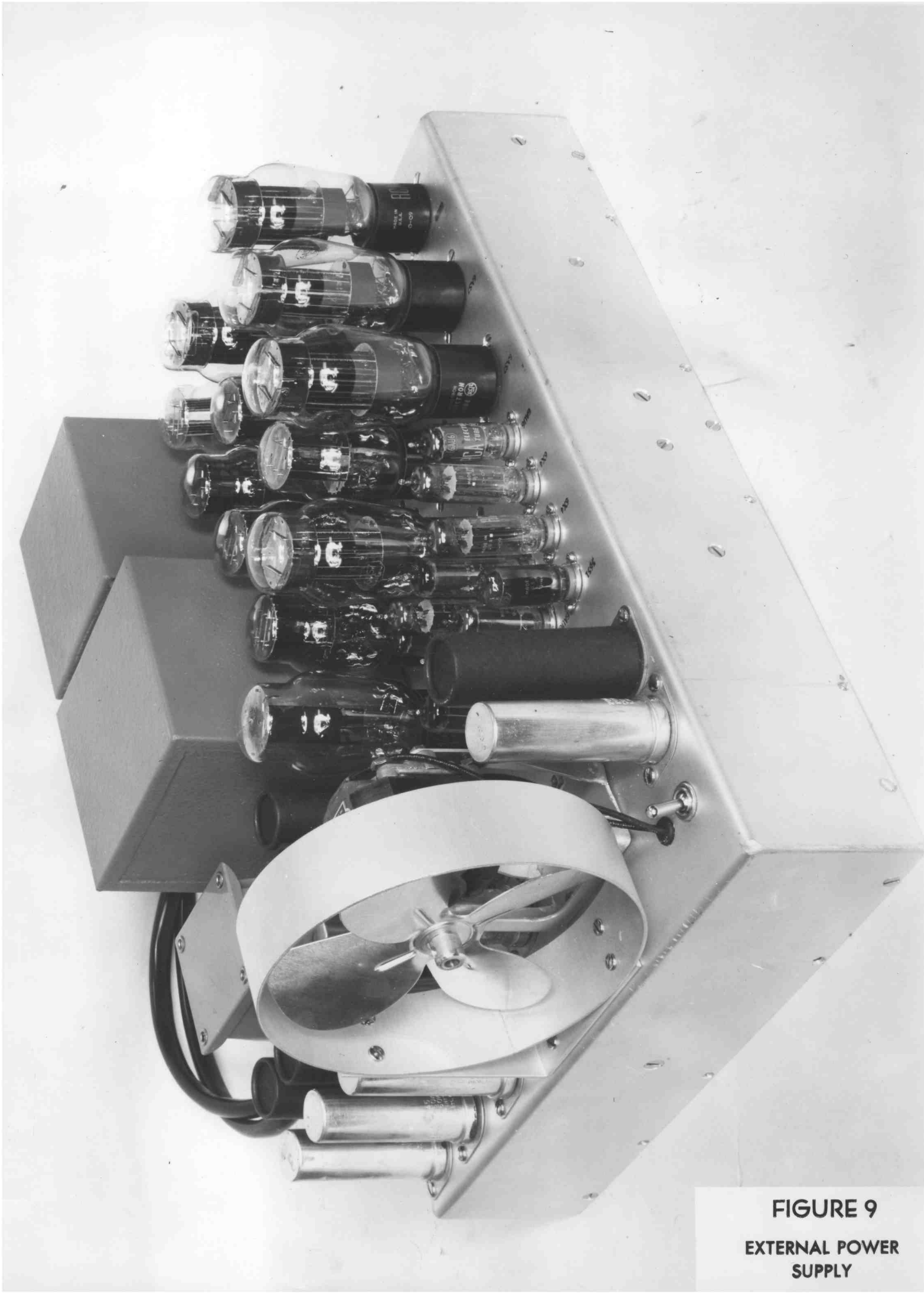


FIGURE 9

EXTERNAL POWER SUPPLY

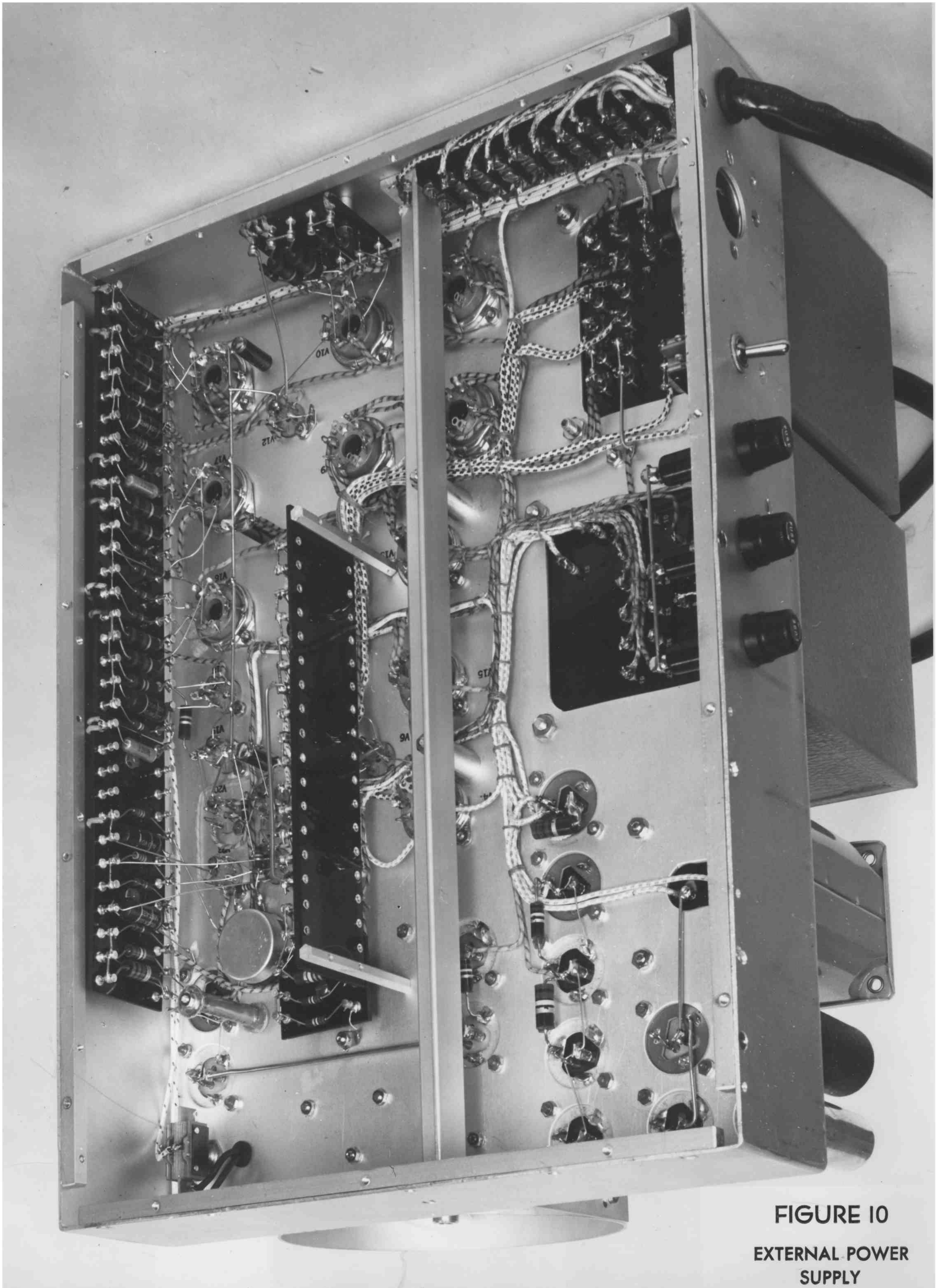


FIGURE 10

EXTERNAL POWER SUPPLY

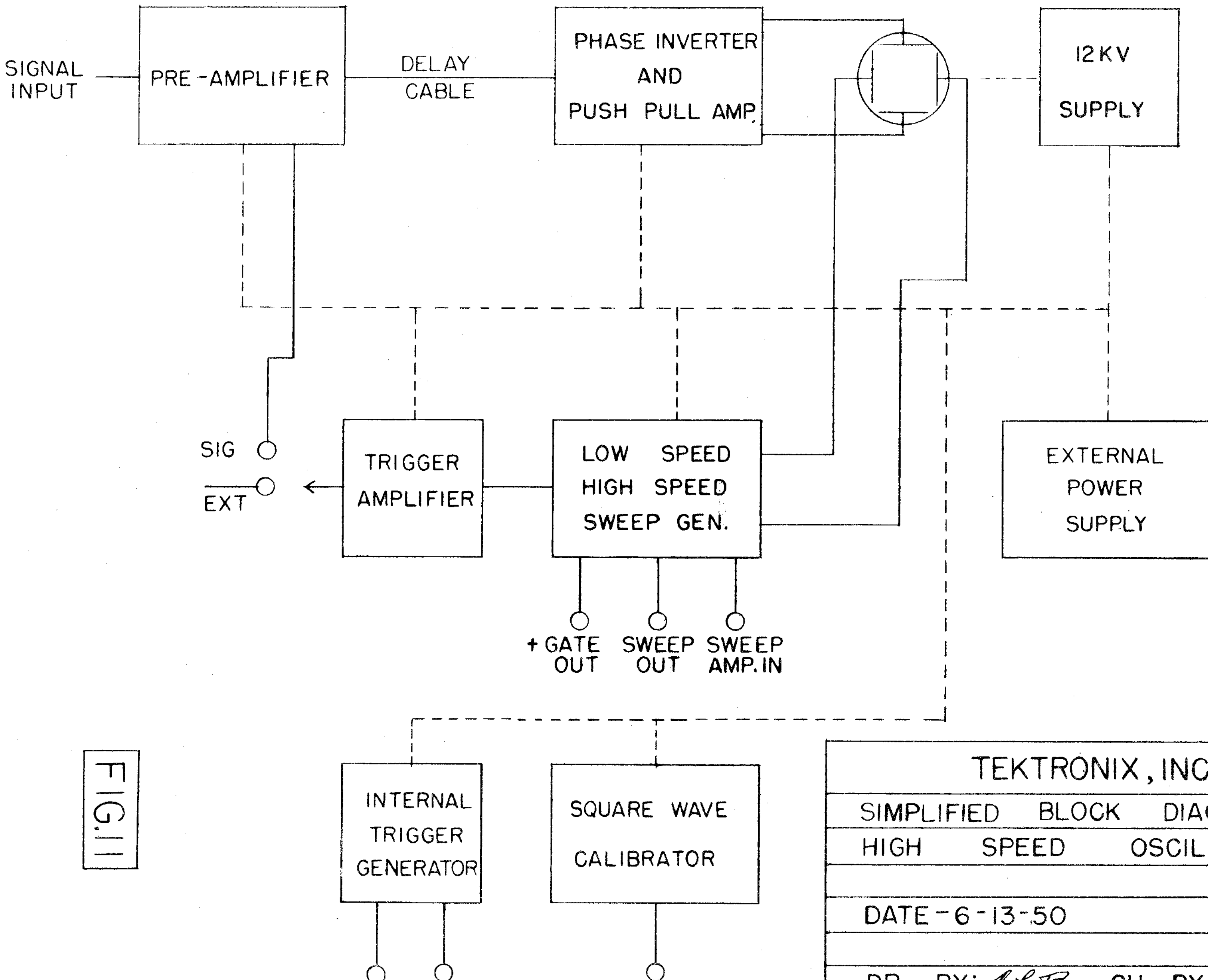
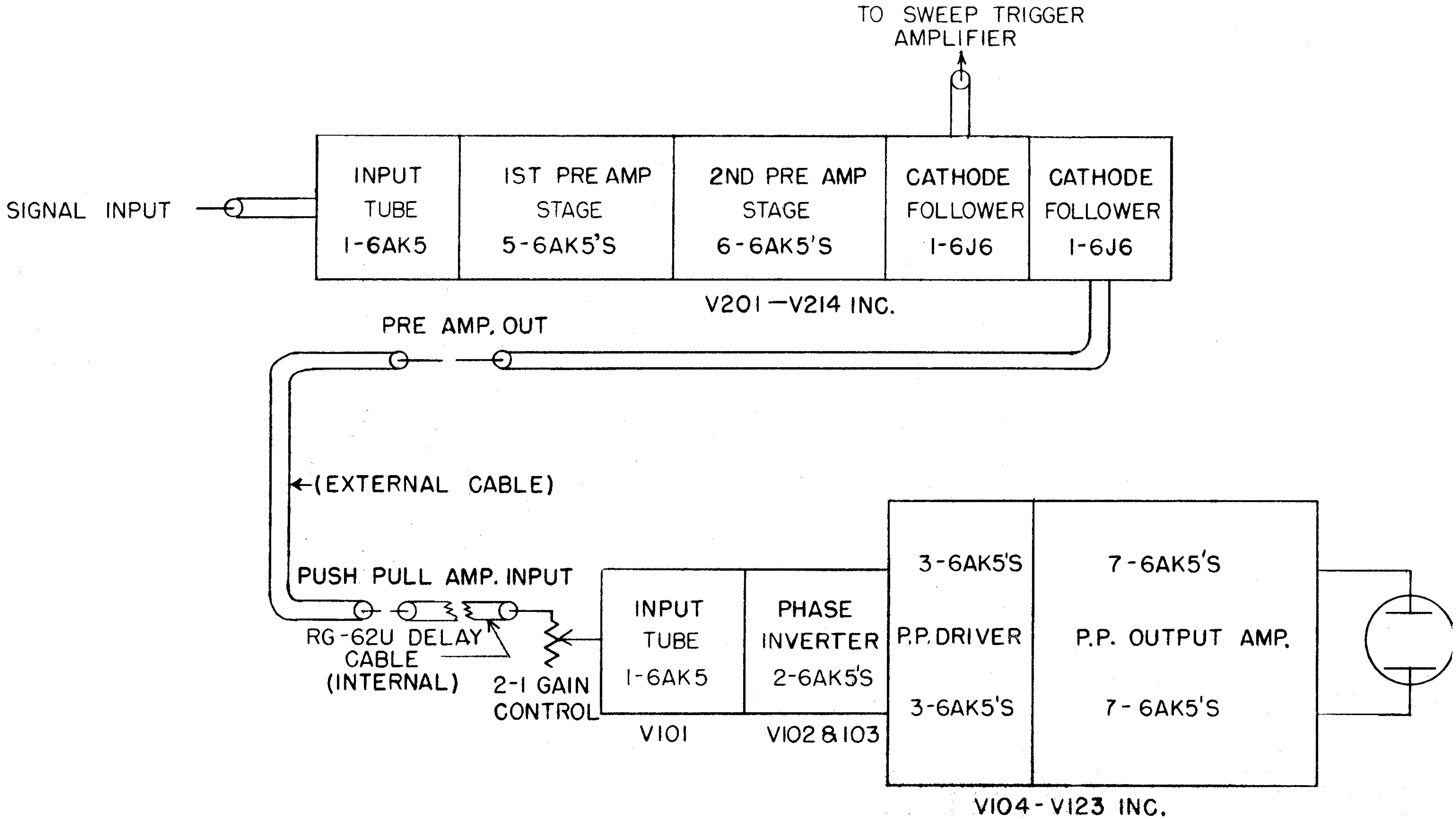


FIG. 11

TEKTRONIX, INC.
SIMPLIFIED BLOCK DIAGRAM
HIGH SPEED OSCILLOSCOPE
DATE - 6 - 13 - 50
DR. BY: C.L.B. CH. BY:



TEKTRONIX, INC.

BLOCK DIAGRAM

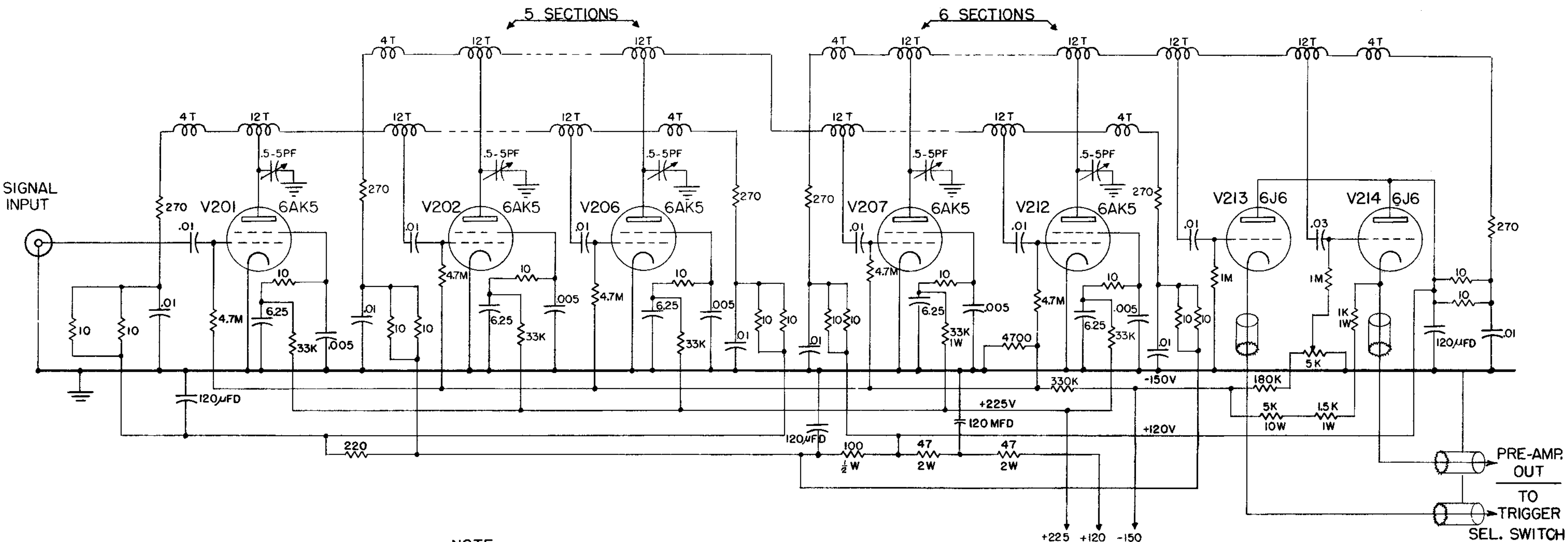
VERTICAL AMPLIFIER SYSTEM

HIGH SPEED OSCILLOSCOPE

DATE - 6-12-50

DR. BY: C.L.B. CH. BY:

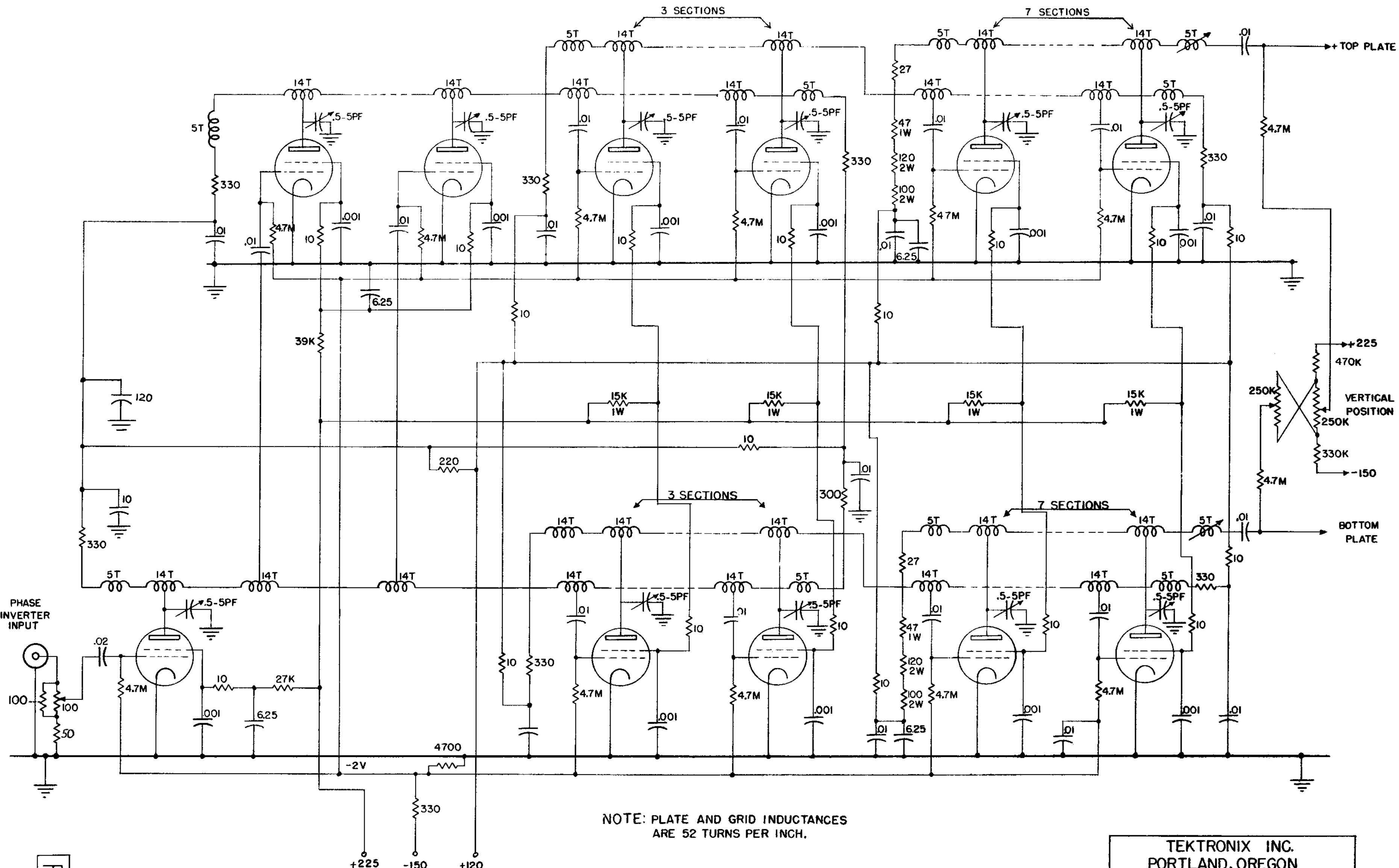
FIG. 12



NOTE- PLATE AND GRID INDUCTANCES 48 TURNS PER INCH

TEKTRONIX INC. PORTLAND, OREGON
PREAMPLIFIER FOR HIGH SPEED OSCILLOSCOPE
DATE: 4-6-50
A.M.C. CONTRACT # W-19-122-AC-40

FIG. 13



NOTE: PLATE AND GRID INDUCTANCES ARE 52 TURNS PER INCH.

TEKTRONIX INC.
PORTLAND, OREGON

OUTPUT AMPLIFIER FOR HIGH SPEED OSCILLOSCOPE

DATE: 4-10-50

A.M.C. CONTRACT # W19-122-AC-40

FIG. 14

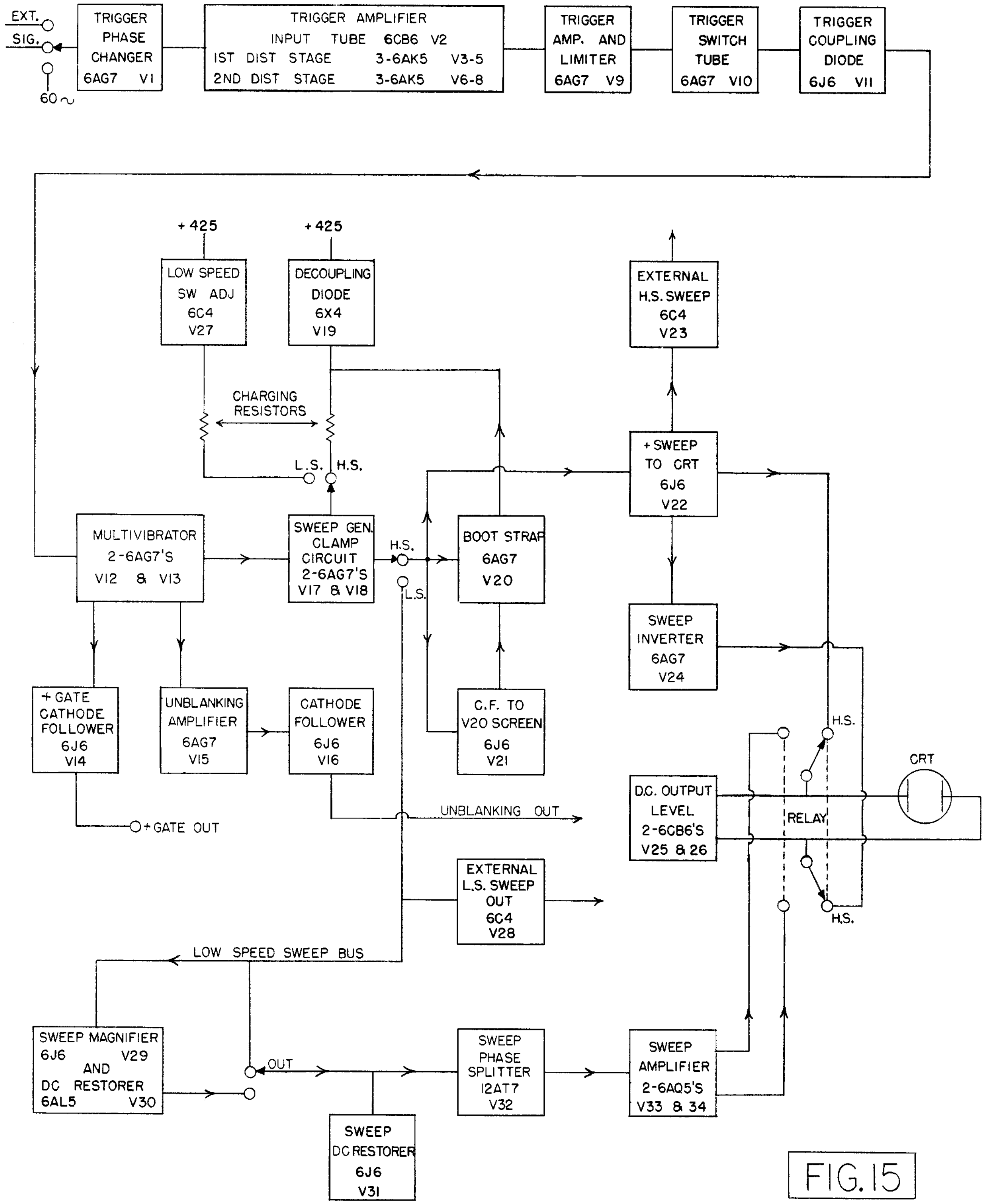
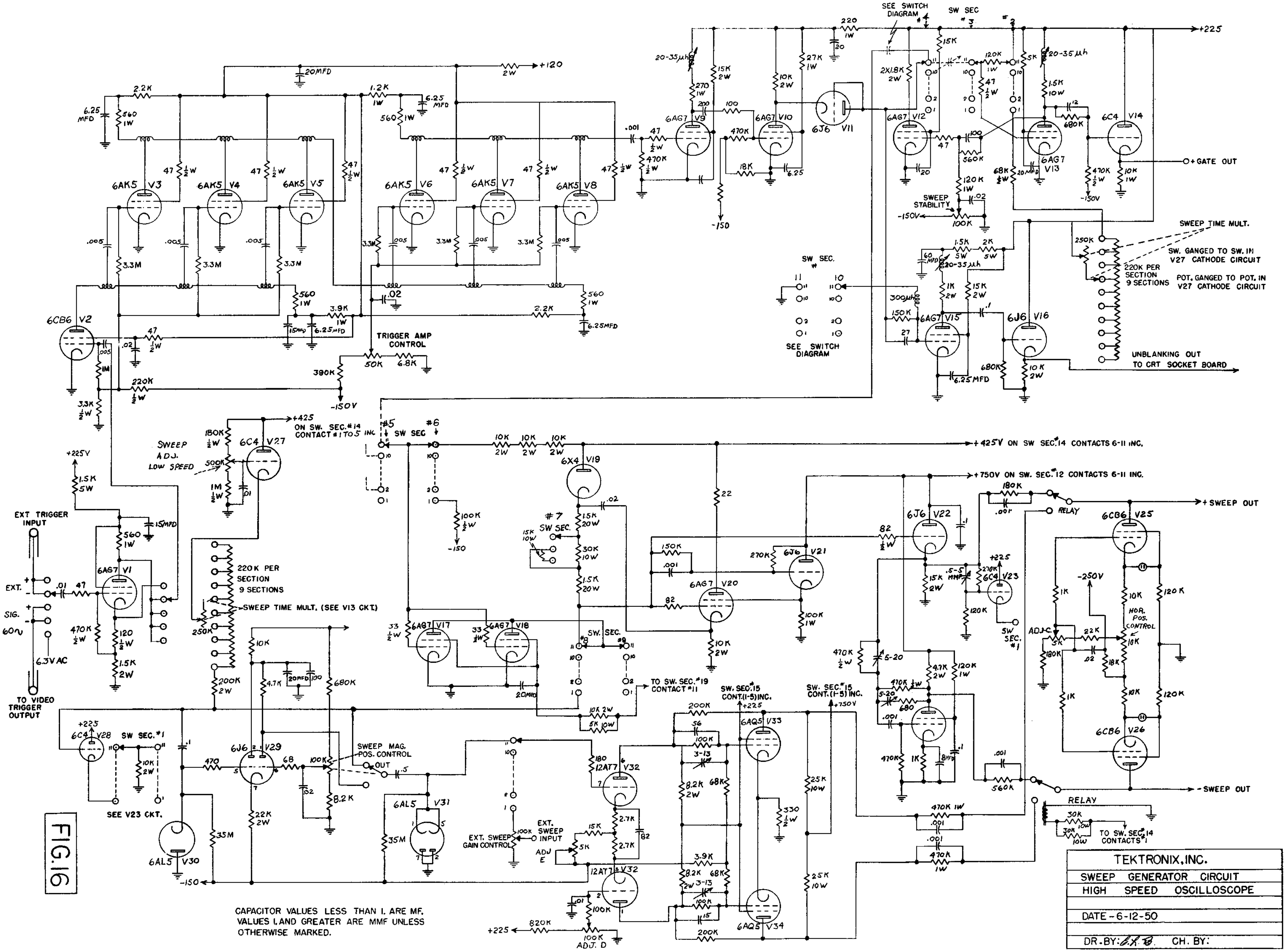


FIG.15

TEKTRONIX, INC.
BLOCK DIAGRAM
SWEEP CIRCUIT
HIGH SPEED OSCILLOSCOPE
DATE-6-14-50
DR. BY: [illegible] CH. BY:



TEKTRONIX, INC.

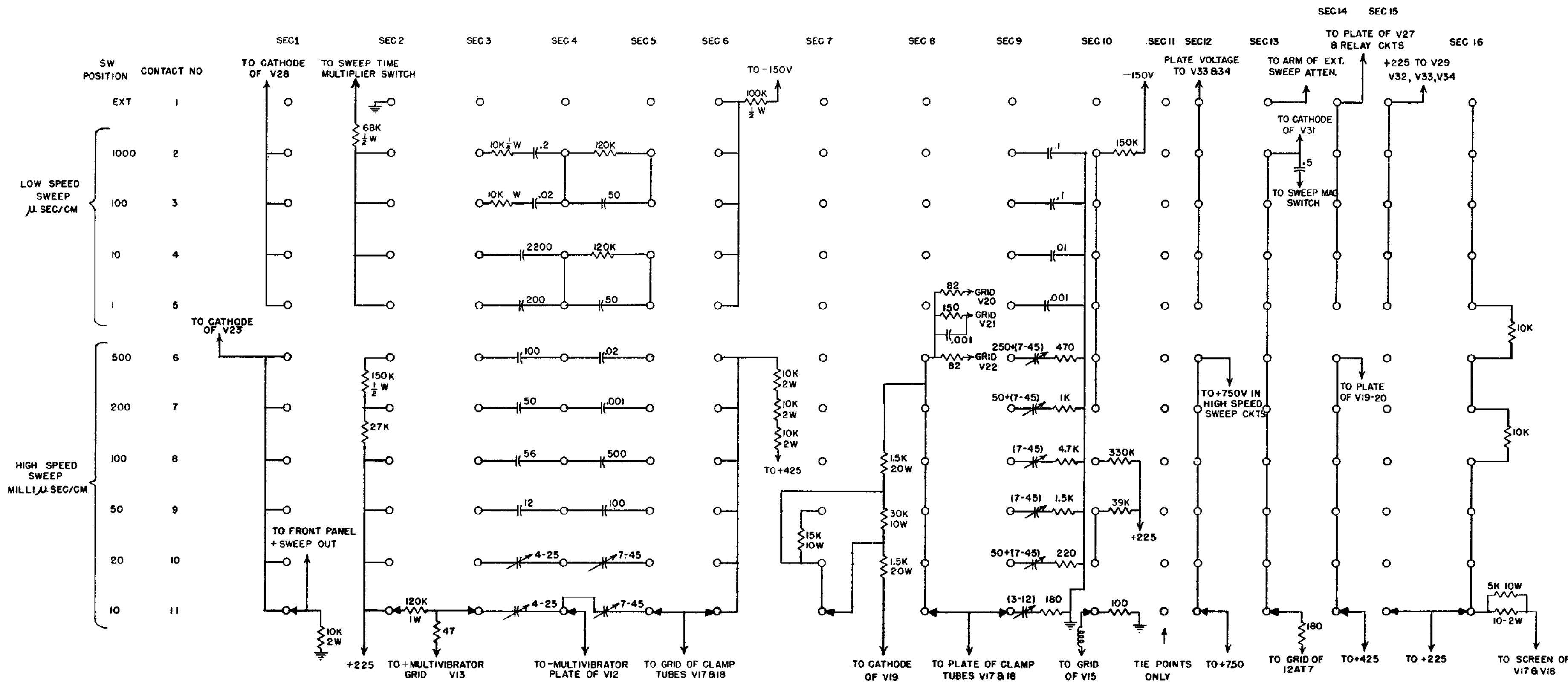
SWEEP GENERATOR CIRCUIT
HIGH SPEED OSCILLOSCOPE

DATE - 6-12-50

DR. BY: C.X.B. CH. BY:

CAPACITOR VALUES LESS THAN 1. ARE MF. VALUES 1. AND GREATER ARE MMF UNLESS OTHERWISE MARKED.

FIG. 16



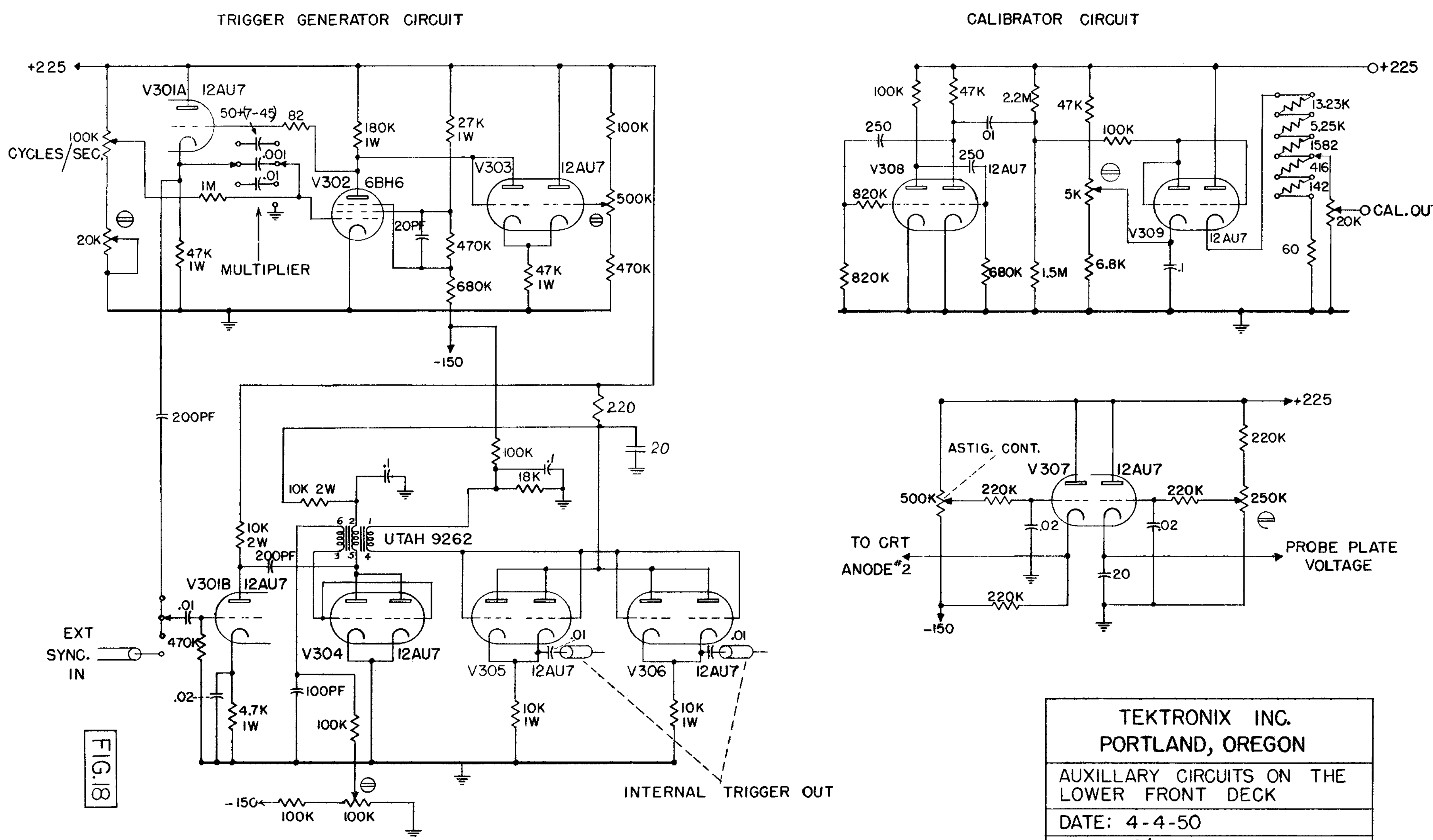
TEKTRONIX, INC.

HIGH SPEED OSCILLOSCOPE
SWEEP SWITCH

DATE-6-6-50

DR. BY: [illegible] CH. BY:

FIG.17



TEKTRONIX INC.
PORTLAND, OREGON

AUXILLARY CIRCUITS ON THE LOWER FRONT DECK

DATE: 4-4-50

DR. BY: C.L.B.

FIG. 18

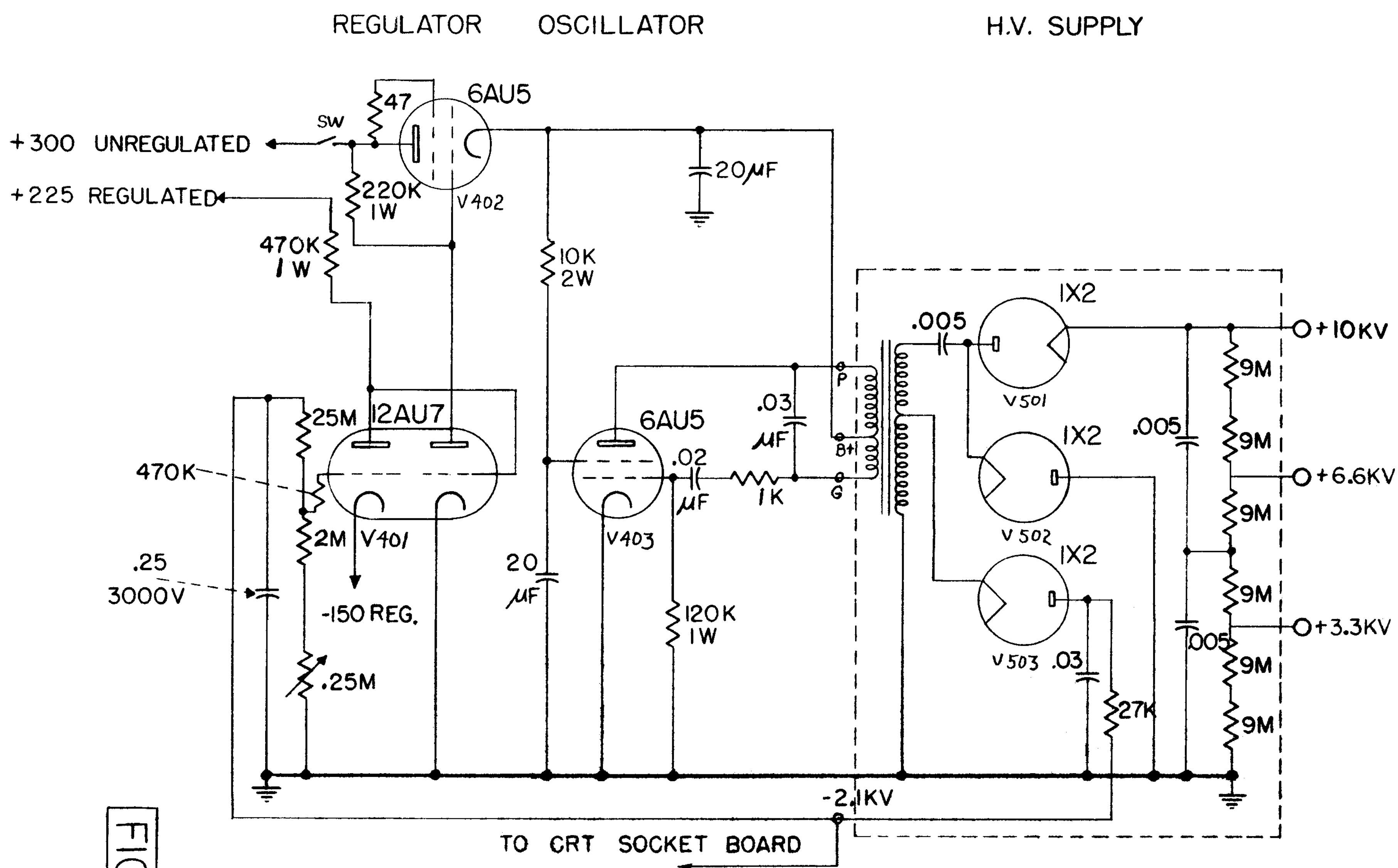


FIG.19

HIGH VOLTAGE SUPPLY INCLUDING REGULATOR AND OSCILLATOR CIRCUITS

TEKTRONIX INC. PORTLAND, OREGON

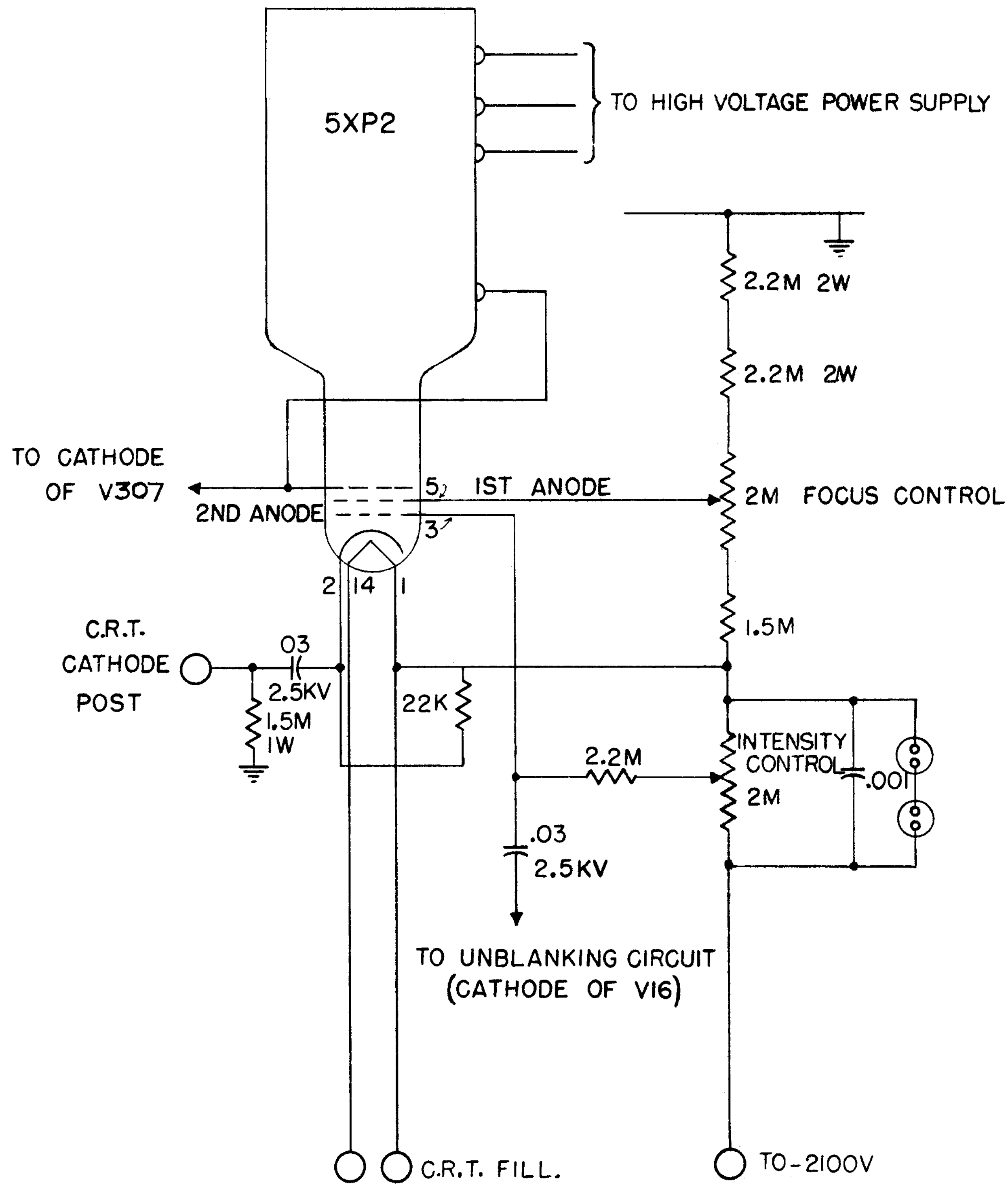


FIG. 20

CRT CONNECTION AND SOCKET BOARD

TEKTRONIX INC. PORTLAND, OREGON

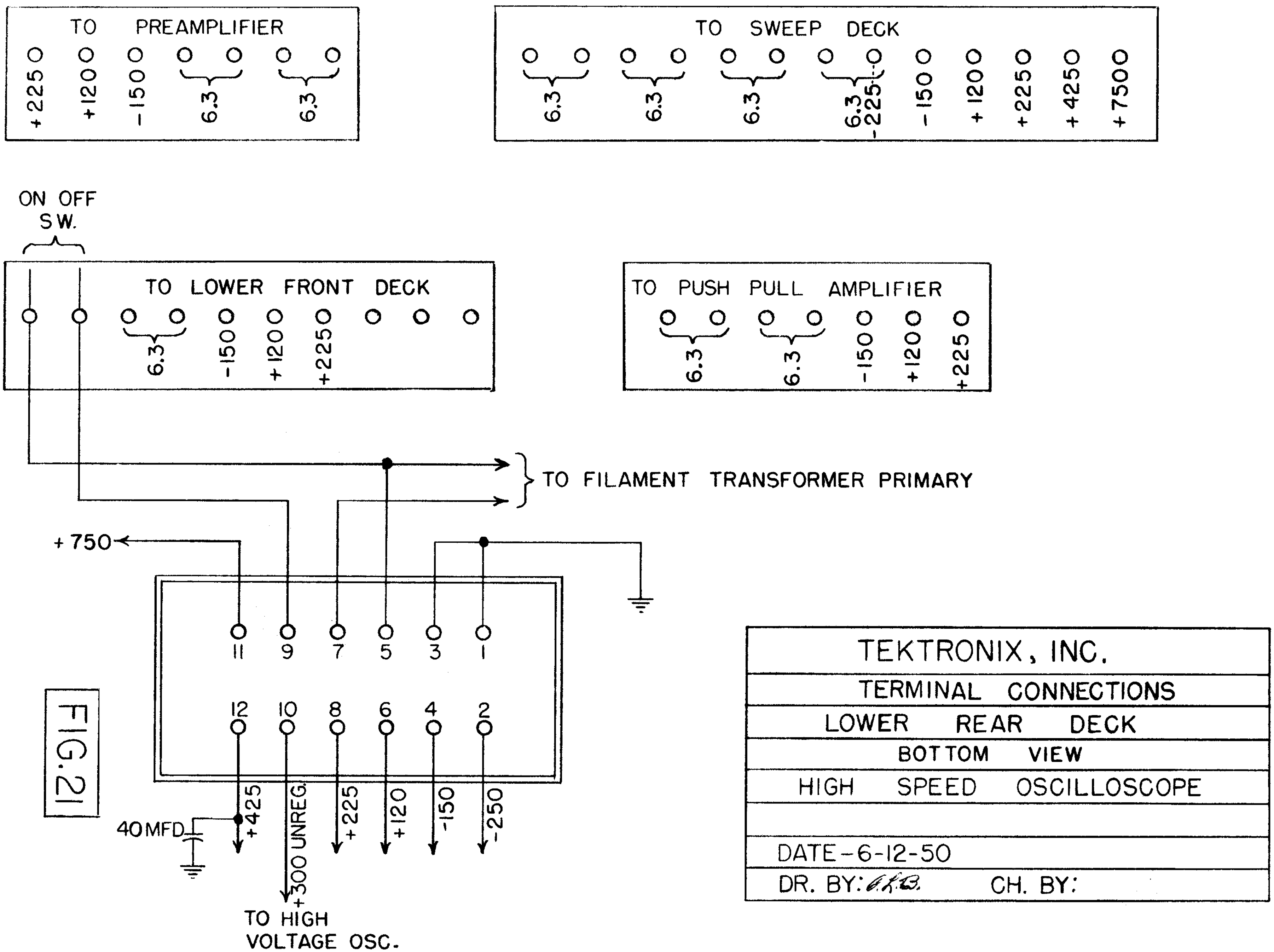

TO PREAMPLIFIER
+225
+120
-150
6.3
6.3
TO SWEEP DECK
6.3
6.3
6.3
6.3
-225
-150
+120
+225
+425
+750
ON OFF SW.
TO LOWER FRONT DECK
6.3
-150
+120
+225
TO PUSH PULL AMPLIFIER
6.3
6.3
-150
+120
+225
TO FILAMENT TRANSFORMER PRIMARY
+750
11 9 7 5 3 1
12 10 8 6 4 2
+425
+300 UNREG.
+225
+120
-150
-250
40 MFD
TO HIGH VOLTAGE OSC.
TEKTRONIX, INC.
TERMINAL CONNECTIONS
LOWER REAR DECK
BOTTOM VIEW
HIGH SPEED OSCILLOSCOPE
DATE-6-12-50
DR. BY:
CH. BY:

FIG. 21

TEKTRONIX INC
PORTLAND, OREGON

EXTERNAL POWER SUPPLY
FOR
HIGH SPEED OSCILLOSCOPE

A.M.C. CONTRACT # W-19-122-AC-40

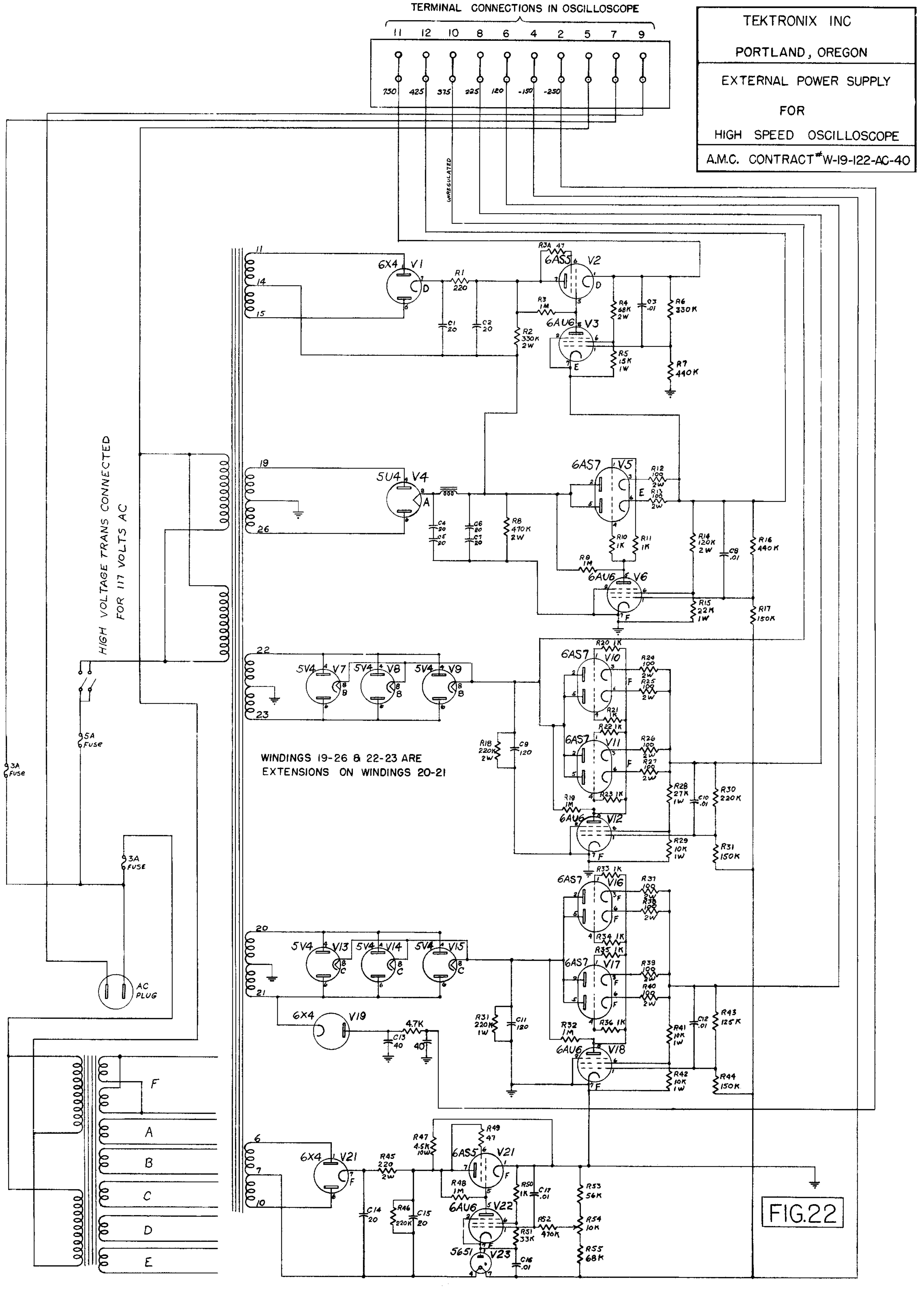


FIG.22

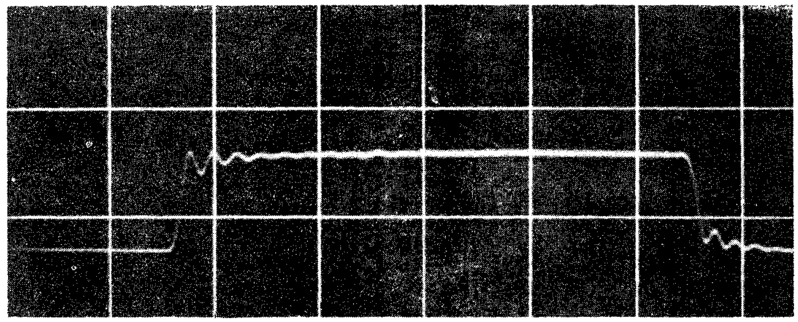


Fig. 23A -- Test pulse of 1 milliusec. rise time and 45 milliusec. duration applied directly to CRT deflection plates - sweep rate 10 milliusec/cm.

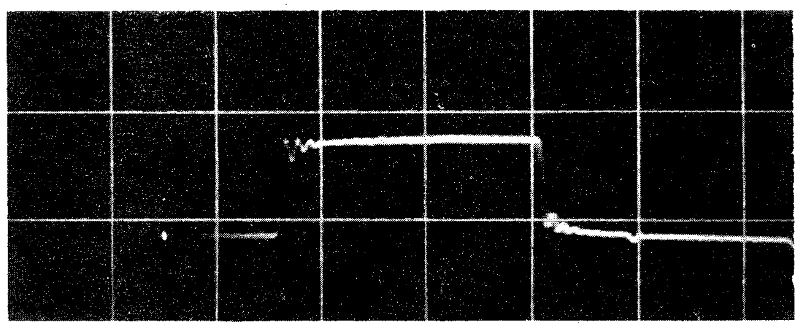


Fig. 23B -- Same as above except at a sweep rate of 20 milliusec/cm.

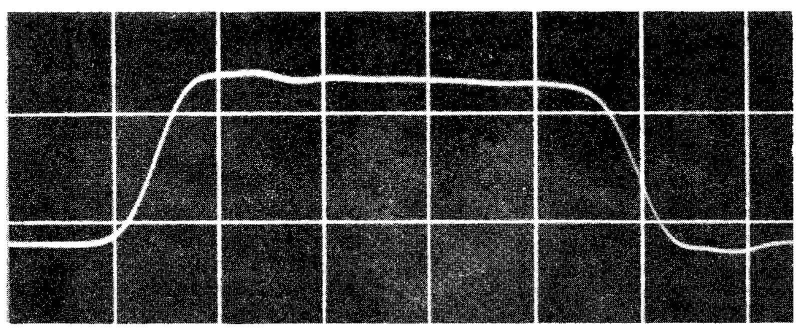


Fig. 23C -- Response of push-pull amplifier only to a positive test pulse - sweep rate 10 milliusec/cm.

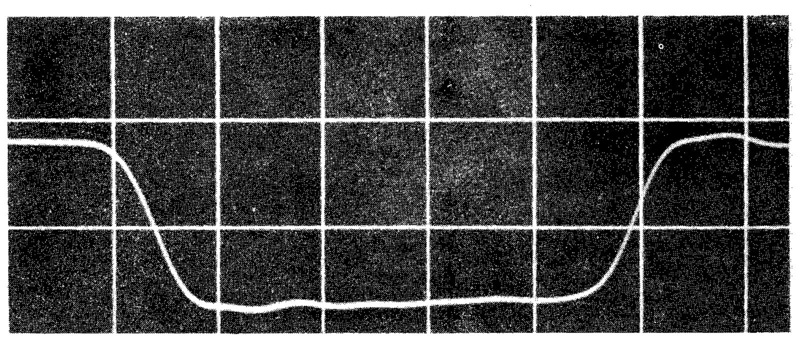


Fig. 23D -- Same as C except for a negative test pulse.

Figure 23

Fig. 24A -- Overall response of vertical amplifier system to positive test pulse - sweep rate of 10 millimicrosec/cm.- internal triggering.

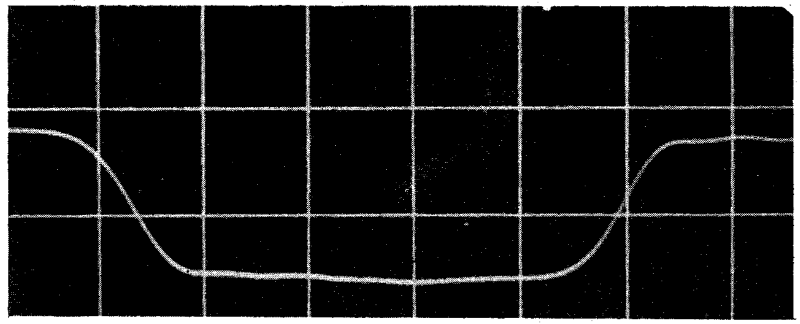


Fig. 24B -- Same as A except a negative test pulse was used.

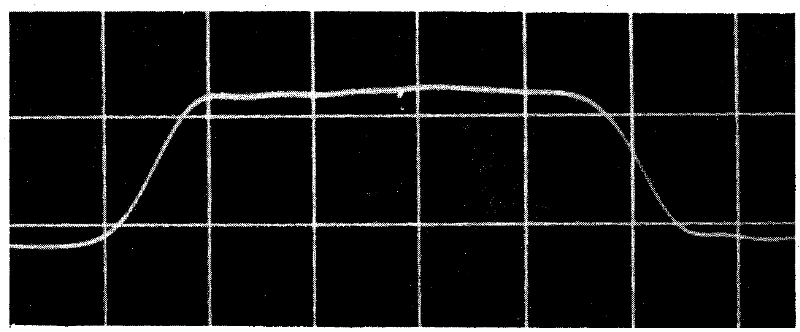


Fig. 24C -- Same as A except at a sweep rate of 20 millimicrosec/cm.

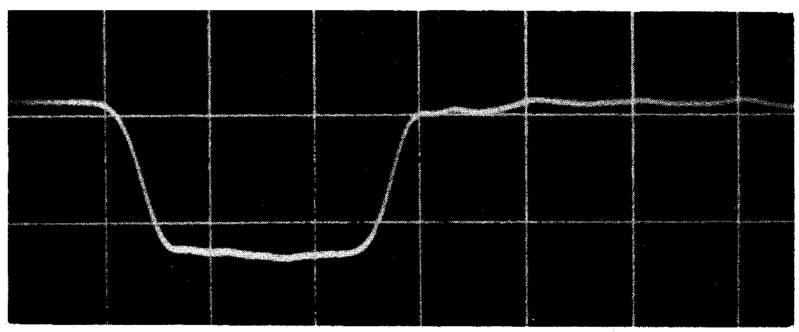


Fig. 24D -- Same as A except for a negative test pulse and a sweep rate of 20 millimicrosec/cm.

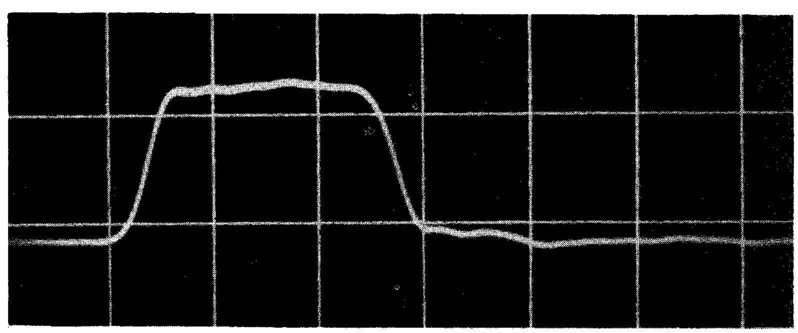
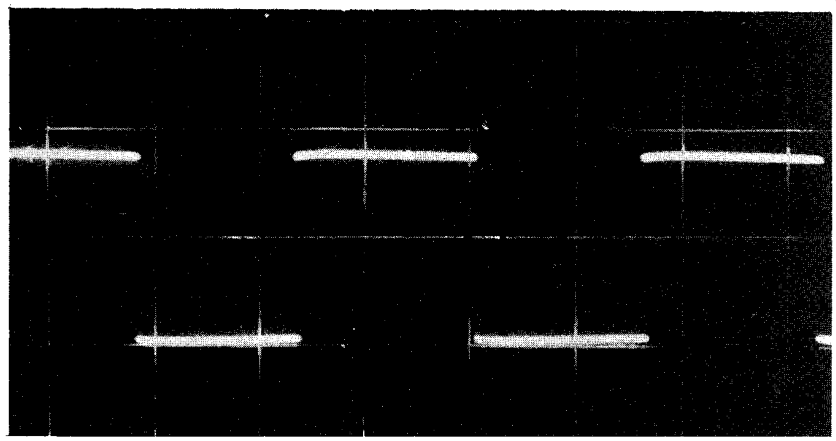
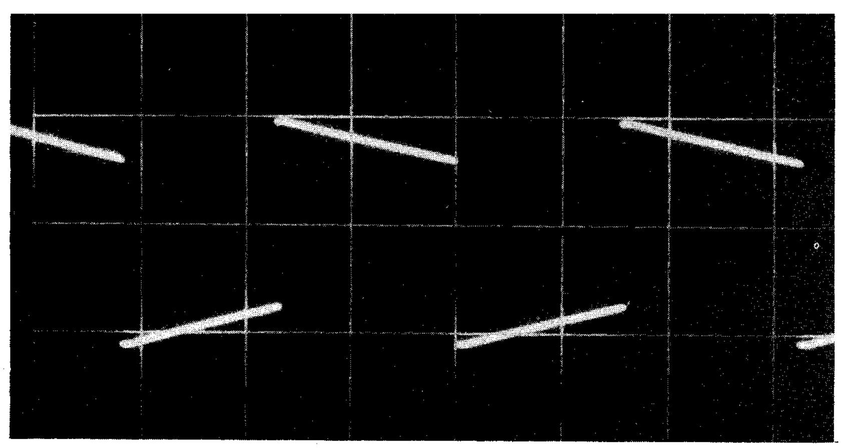


Figure 24



<u>Fig. 25A</u> -- Oveall response of vertical amplifier to 1000 cycle square wave - sweep rate of 300 microseconds/cm.



<u>Fig. 25B</u> -- Overall response of vertical amplifier to 100 cycle square wave - sweep rate of 3000 microseconds/cm.

Figure 25

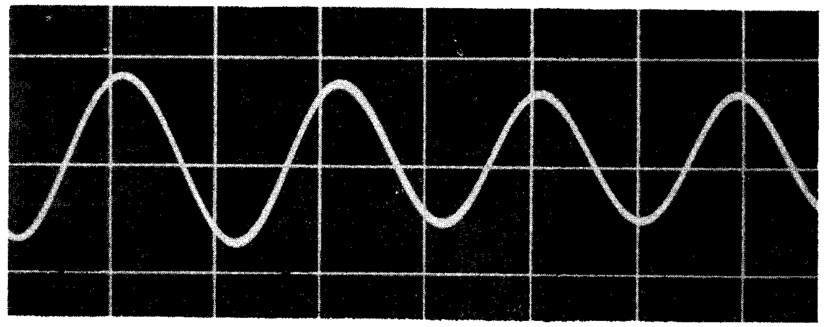


Fig. 26A -- 50 megacycle timing wave at sweep rate of 10 milliusec/cm.

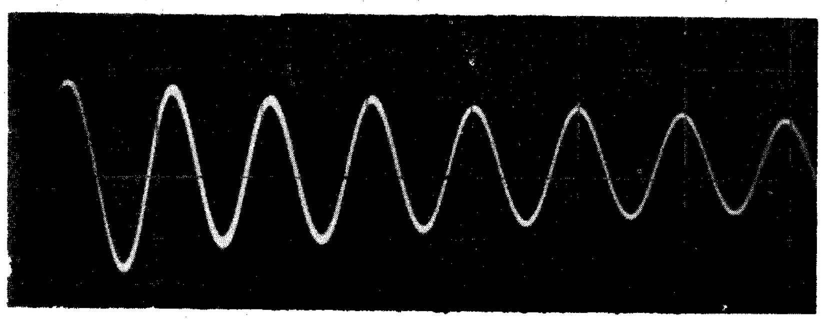


Fig. 26B -- 50 megacycle timing wave at sweep rate of 20 milliusec/cm.

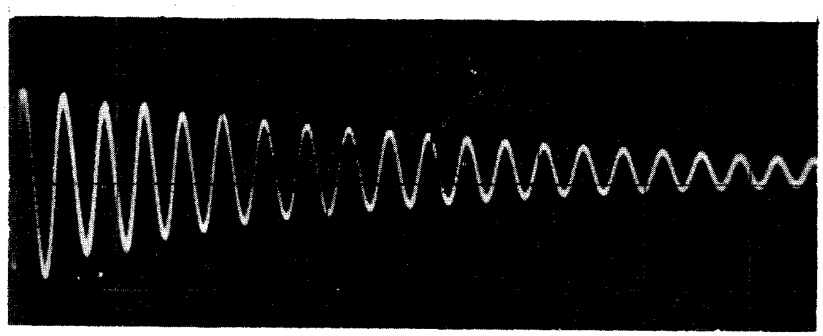


Fig. 26C -- 50 megacycle timing wave at sweep rate of 50 milliusec/cm.

Figure 26