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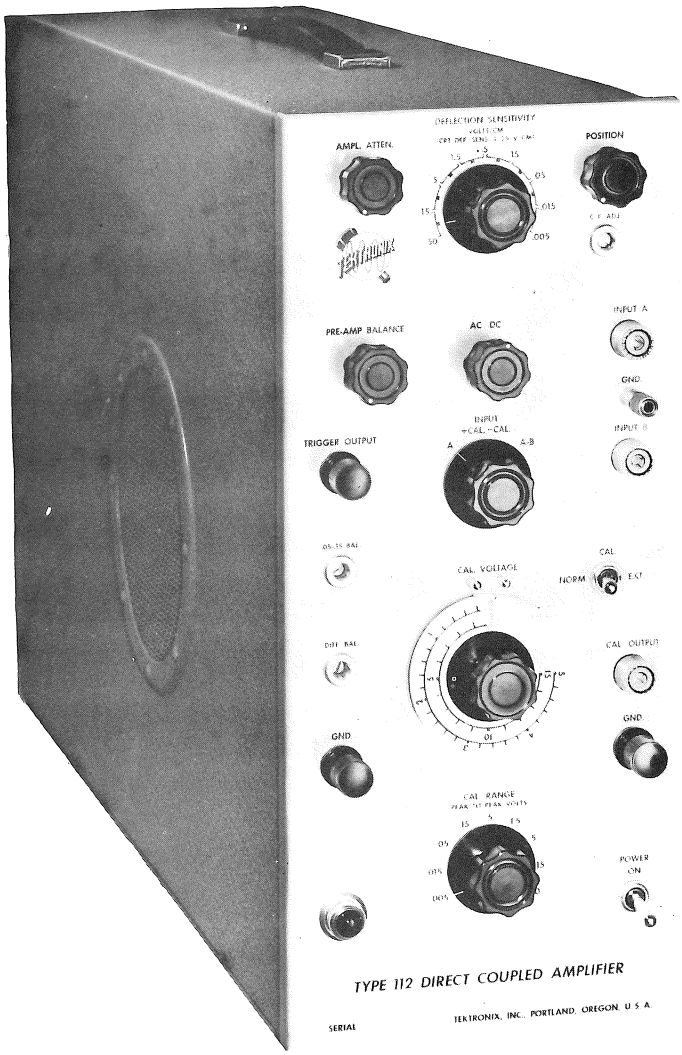
J. M. RODRIGUEZ EXT 9928
A852 PROD. TEST EQ.

TEKTRONIX

TYPE 112

DIRECT COUPLED AMPLIFIER

INSTRUCTION MANUAL



TEKTRONIX Inc.

Manufacturers of Cathode-Ray and Video Test Instruments

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General Description

The Tektronix Type 112 Direct Coupled Amplifier is a portable precision laboratory instrument, designed primarily for the amplification of signals to a magnitude suitable for observation on a cathode ray tube.

A four-stage balanced push-pull amplifier and associated circuits are mounted on the upper chassis. The lower chassis contains the square wave calibrator and power supply circuits. The dimensions and physical features are arranged, and leads are supplied, for convenient connection to a Tektronix Type 511-A, 511-AD or 512, or other oscilloscope having access to the cathode ray tube deflection plates.

A maximum deflection sensitivity of 5 millovolts peak to peak per centimeter (when used with a CRT having a basic deflection factor of 25 volts per centimeter), and a bandpass of DC to 1 megacycle (DC to 2 megacycles for deflection sensitivities of .15 volt per centimeter or less) permit observation of a wide range of electrical phenomena. Choice of single or balanced push-pull (differential) input provides additional flexibility of connection to the circuits under observation, and often permits rejection of undesired signal pickup. Signal amplitude may be accurately measured by means of the square wave calibrator. The heaters of the first three stages and all plate circuits are operated on electronically regulated DC supplies to provide stability against line voltage fluctuations.

The continuously variable voltage gain of .5 to 5000, optional DC or AC coupling and many other desirable features make the Type 112 an excellent general purpose amplifier.

The Type 112 is especially well adapted for use in conjunction with a Tektronix Type 511-A, 511-AD or other high speed wide band oscilloscope, thus providing a very flexible combination capable of displaying a wide variety of waveforms. By simple connections at the cathode ray tube access panel and trigger input, the sensitivity of the oscilloscope is increased to 5 millivolts/cm. with direct coupling, thus greatly extending the usefulness of the instrument.

The Type 112 Amplifier may be combined with a Tektronix Type 512 oscilloscope to provide amplifiers having identical characteristics in both horizontal and vertical axes.

Characteristics

Input Impedance

1 meg. shunted by 45 $\mu\mu$f. With probe 10 meg. and 14 $\mu\mu$f.

Voltage Gain

.5 to 5000 continuously variable.

Deflection sensitivity (peak to peak) when used with a CRT having a basic deflection factor of 25 v/cm. 5 mv/cm. to 50 v/cm. continuously variable.

Bandpass

DC to 2 mc for gain of 166 or less.
DC to 1 mc for gain of 166 to 5000.

Rise time (10% to 90%)

.2 μsec for gain of 166 or less.
.4 μsec for gain of 166 to 5000.

Calibrating Voltage

Square wave. Nine ranges 5 mv to 50 v full scale. Internal connection to amplifier. Available externally at CAL. OUTPUT connector. Accuracy $\pm$5%.

Time Marker Input

Via isolating amplifier. Recommended marker amplitude 5 to 15 v.

Output Voltage

150 v at high impedance.
75 v at 8000 ohms plate to plate.

Trigger Output

10% of the B signal output voltage.

Power Requirement

105-125/210-250 v, 50-60 cycles, 200 watts.

Dimensions

15½" high, 6½" wide, 21½" deep.

Weight (including accessories)

32 lbs.

Finish

Panel, photo etched aluminum with black letters. Cabinet, gray wrinkle.

Functions of Controls and Connections

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

Panel Markings	*Explanation*
AMPL. ATTEN.	Twin potentiometers R53 and R54 in cathodes of cathode followers V5 and V6 permit adjustment of gain of amplifier over a 3 to 1 range.
DEFLECTION SENSITIVITY	Gang switch SW 3 controlling gain of amplifier in steps of approximately 3 to 1. Connects two stage preamplifier in circuit for three most sensitive positions.
POSITION	Potentiometer R56 connected between cathode of V7 and V8, determining operating points of these tubes. Because of the DC coupling, this balances the output voltage, or shifts the image vertically when the Type 112 is used with a CRT.
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.
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 pre-amp output.
AC-DC	Gang switch SW2 which inserts coupling capacitors in the input circuit of the instrument and between the pre-amp and main amplifier, when DC coupling is not desired.
INPUT A	Input connector to amplifier. Polarity such that a positive signal produces positive output voltage on Output A jack and deflects beam upwards when normal connection to vertical deflection plates of CRT is employed.
GROUND	Binding post connection to frame of instrument.
INPUT B	Input connector to amplifier. Connects to opposite grid from INPUT A. A negative signal provides positive output voltage on OUTPUT A and deflects beam upwards when normal connection to CRT vertical plates is employed. When INPUT switch is in position A, the lead to V2 grid is grounded. See Section II for differential input connection.
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 CAL. VOLTAGE makes tops of square waves move upward when SW2 is set at DC. —CAL.—Same as +CAL. except calibration signal is applied to opposite grid so bottoms of CAL. square waves move downward. A—B.—INPUT A connected to V1 grid. INPUT B connected to V2 grid. OUTPUT (Waveshape on CRT) is the difference between A and B signals.
TRIGGER OUTPUT	Binding post to permit connecting a portion of the signal output voltage to the sweep trigger circuits of an oscilloscope or other equipment used in conjunction with the Type 112.
.015-.15 BAL.	Potentiometer R13 located in cathode circuit of V3 and V4. Used to secure balance of this stage in .015-.15 position of DEFLECTION SENSITIVITY switch.
DIFF. BAL.	Potentiometer R4 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.
CAL. RANGE	Atttenuator for reducing amplitude of square wave calibrating signal. Steps correspond to ranges on CAL. VOLTAGE dial.
CAL. NORM.	The calibrator output is connected to the amplifier and the +250 circuit closed, when the INPUT switch is in the +CAL. or —CAL. positions. Moving the INPUT switch to A or A—B opens the calibrator circuits.
CAL. EXT.	+250 volt circuit closed directly, and output lead to amplifier input opened and grounded. Calibrating signal available at CAL. OUTPUT connector only, but is not affected by setting of INPUT switch.
CAL. OUTPUT	Connector wired to arm of CAL. VOLTAGE potentiometer making the calibrating square wave available for external use.
GROUND	Connection to frame of instrument.
CAL. VOLTAGE	Potentiometer with calibrated dial used in conjunction with CAL. RANGE for adjustment of calibrator square wave to desired amplitude.
GROUND	Connection to frame of instrument.
POWER ON-OFF	On-off switch in the AC line voltage supply to the amplifier.
OUTPUT A B	Banana jacks on the right side to permit connection of the amplifier output to the deflection plates of a cathode ray tube or other equipment.
0 OR +150	Switch allowing the average potential of A and B outputs to be set at either 0 or +150 volts.
TIME MARK IN	Connector on back of amplifier to permit introduction of time markers via an isolating amplifier, V13.

SECTION II

Operating Instructions

The TEKTRONIX Type 112 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 amplifier. Several inches clearance should be provided on the left side, top and back of the case.

If the Type 112 is used continuously for the same application, and only one setting of the controls is required, it is advisable to periodically check the instrument at all control settings to be sure it is in normal operating condition. 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 112 should not be subjected to excessive vibration or rough handling.

To place the Type 112 in operation for the first time, the following procedure is suggested:

1. Connect to a source of 50-60 cycle, 105-125 v. power (or 210-250 v. if transformer connections are changed as directed in Sec. IV).

2. Connect the A, B, and GND. jacks of the OUTPUT panel of the Type 112 to the appropriate deflection plates of the cathode-ray Oscilloscope. Three banana plug leads are furnished for this purpose. If you are using a Tektronix Oscilloscope remove the jumper plugs from the CRT deflection plate access panel and make the connections as follows:

SW4 at 0 (Located at back of Type 112)	
511, 511A, 511AD	A to Y1, B to Y2
SW4 at +150V	
512	A to Y1, B to Y2
513	A to orange, B to yellow
514	A to Y2, B to Y1

In all cases GND. should be connected to the oscilloscope GND. jack.

With oscilloscopes of other manufacture modify the above procedure as necessary.

3. Connect the TRIGGER OUTPUT binding post of the Type 112 to the oscilloscope's trigger input.

4. Turn the oscilloscope power on and adjust the controls for a sweep time of about 1 millisecond per centimeter.

5. Set the Type 112 controls as indicated below:

AMPL. ATTEN.	Clockwise
DEFLECTION SENSITIVITY.	.5—1.5
POSITION	Index vertical
AC-DC	DC
INPUT	+CAL.
CAL. RANGE	5
CAL. VOLTAGE	5
CAL. NORM.-EXT.	NORM.

6. Turn the POWER switch to ON and wait about 60 seconds. Two horizontal lines about 3 cm apart should appear on the oscilloscope.

7. Adjust the sweep stability and trigger amplitude (or other synchronizing controls) of the oscilloscope until a stable pattern of the square wave calibrator signal is obtained.

CAUTION—ANY TIME THE TYPE 112 IS SWITCHED OFF, IT IS ADVISABLE TO WAIT 30 SECONDS BEFORE SWITCHING THE POWER ON. THIS PRECAUTION WILL AVOID "HOT SURGE" CURRENTS WHICH MIGHT BLOW THE FUSE.

Signal Input Connection

To observe other waveforms, connection to the Signal Input may be accomplished by attaching one of the Binding Post Adapters, which are supplied, and a single lead to INPUT A. The 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 OR INPUT CONNECTORS SHOULD NOT EXCEED 600 VOLTS.

It is also advisable to use an Input Probe when observing signals of low amplitude, as the shielding reduces pickup of stray fields. 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 INPUT switch should be set at A—B and connections made to both INPUT A and INPUT B. A ground lead to the equipment under observation should be provided, and often an earth ground is desirable.

NOTE: If the Type 112 is to be employed in an application requiring both high gain and direct coupling, a twenty to thirty minute warm-up period to stabilize tube characteristics should be provided.

Differential Input

In many applications, the desired signal is superimposed on an undesired signal such as line frequency hum, etc. The balanced "push-pull" or "differential" amplifier in the Type 112 makes it possible in many cases to increase the ratio of desired to undesired signals greatly. To accomplish this, the 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. When maximum differential action is required, it may be necessary to make a slight adjustment of the DIFF. BAL. control, R4, to compensate for variations in tubes, etc. When the equipment has been connected and is ready for use, this control may be trimmed for maximum rejection of the undesired signal. Only a very small adjustment should be required, except when V1 and V2 are replaced. See Section IV.

Standardized Input Impedance

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

Time Mark Input

Time markers, etc., may be introduced to the amplifier via the over-biased isolating amplifier V13 without interaction with the wave form under observation. This connection is at the rear of the Type 112. A positive time mark of 5 to 15 volts amplitude is recommended.

Output Connection

Banana jack output connections are provided on the right side of the amplifier. A toggle switch, SW4, at the rear of the instrument permits the average potential of the A and B connections to be set at either the output tube plate voltage (approximately +150 v.) or at ground. When the Type 112 is used with an oscilloscope, SW4 should be set so that the average potential of the cathode ray tube deflection plates connected to A and B is approximately equal to the average potential of the other pair of deflection plates.

The proper settings for use with Tektronix oscilloscopes are:

Type 511, 511-A, 511-AD.....0
Type 512, 513, 514 .....+150

If desired, the average potential of A and B may be varied considerably when the 0 setting is used, by means of the screwdriver controls A ADJ. and B ADJ., located at the rear of the amplifier. For best focusing, these controls, R67.2 and R68.2, should be adjusted until the average voltage of the deflection plates connected to the Type 112 output is equal to the average voltage of the other pair of plates.

The output jacks are isolated from the plates of the output tubes to prevent accidental short circuit hazard, by means of 100 K series resistors. Therefore, when the Type 112 is to be operated into a low impedance load, it is necessary to first remove the case and short circuit these resistors, R69 and R70.

Calibration

To aid in signal amplitude measurement, the Type 112 incorporates 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 being amplified may thus be measured to an accuracy of ±5%. This is accomplished by adjusting the calibrator output to coincide in amplitude with the signal under observation when the Type 112 is used in conjunction with a cathode ray tube.

If direct coupling is being used (SW2 in DC position) the calibrating voltage will produce a positive output with the INPUT switch set at +CAL. and a negative output 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 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 INDICATED 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 position to the signal being measured.

CAUTION—TO PROVIDE MAXIMUM ACCURACY, A REASONABLE LARGE DEFLECTION SHOULD BE USED, BUT TO PREVENT POSSIBLE ERROR DUE TO OVERLOADING OF THE AMPLIFIER, THE PEAK OUTPUT VOLTAGE SHOULD NOT EXCEED ±75 V. DURING CALIBRATION, WHEN A CATHODE RAY TUBE OR OTHER HIGH IMPEDANCE LOAD IS USED.

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 INPUT switch is set at +CAL. or —CAL. To obtain CAL. OUTPUT voltage with the 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 112 (See Section IV) and also provides a square wave of known amplitude suitable for testing other equipment.

SECTION III

Circuit Description

Amplifier

The balanced push-pull amplifier circuits of the Type 112 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 inherent conflicting problems of maximum bandwidth and high DC gain with good stability, a switching system is incorporated which automatically remove the two stage preamplifier whenever sufficient sensitivity can be attained without it. This same switch (DEFLECTION 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. (when the Type 112 is used with a cathode ray tube having a basic deflection factor of 25 volts per cm.). Constant input impedance is maintained for all DEFLECTION SENSITIVITY settings. When the preamplifier is not used, i.e., for sensitivity below .15 v/cm, the bandwith 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 bandwidth is reduced to 1 mc.

Input Circuit

Flexible design of the Type 112 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 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 No. 1 of V2 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 switch in the A—B position, INPUT A is connected to grid No. 1 of VI 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 capacity 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. R15, marked GAIN ADJ. A, permits the degeneration in the cathode circuit of V2 and V3 to be varied, thus controlling the overall gain of the preamplifier. In the 6th position (.05-.15 v/cm) of SW3 (DEFLECTION 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. R18, 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 capacity for all attenuator settings.

The DEFLECTION 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 DEFLECTION SENSITIVITY switch consists of 8 steps of approximately 10 db each. To provide continuously variable control, a dual potentiometer, R53 and R54 designated 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 AMPL. ATTEN. This is necessary because R53 and R54 must be of relatively low resistance to prevent stray capacities 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 (position) will occur when the gain is varied. A potentiometer, R51, labeled C. F. ADJ., is provided in the Type 112 to permit balancing of the cathode voltages of V5 and V6, thus making position independent of the 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 position control. R57 limits the range of positioning, making the adjustment of R56 less critical.

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. A value of 55 volts satisfies this requirement.

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.

Output Coupling Circuit

Since the average plate potential of the output stage is about +150 volts, it was decided to provide current limiting resistors, R69 and R70, between the plates and the output jacks of the Type 112 to prevent short circuit hazard. Capacitors C39 and C40 prevent loss of high frequencies which would otherwise occur due to shunt capacities in the load, such as cathode ray tube deflection plate capacity.

NOTE—See operating instructions for connection to a low impedance load.

The cathode ray tube deflection plates of many oscilloscopes operate at ground average potential. To achieve good focus when the Type 112 is used in con-

junction with this type of oscilloscope, it is necessary to reduce the average output voltage from about +150, the value at the plates of V9 and V10, to zero. This is accomplished by means of a coupling system which takes advantage of the constant plate current characteristic of pentode tubes operated in a degenerative circuit. The divider, R67.5 and R68.5, sets grid No. 1 of the coupling pentodes, V14 and V15, at about —115 volts. With SW4 closed (0 position), the cathode circuits are completed via R67.1, R67.2, R68.1 and R68.2, causing a flow of plate current in R69 and R70. Component values are chosen so that the resultant drop across R69 and R70 is approximately 150 volts.

Since the plate current of V14 and V15 is substantially independent of plate voltage over a wide range, a constant current is maintained in R69 and R70, and therefore the output signal at A and B is the same as at the plates of the output tubes, V9 and V10, except that the average value is moved down to ground potential. The screens are supplied via R67.4 and R68.4, and are maintained at constant voltage with respect to the cathodes by means of the NE-2 neon lamps. Variable resistors, R67.2 and R68.2, labeled A ADJ. and B ADJ., and located at the rear of the instrument, permit independent adjustment of the voltage at each output jack.

With SW4 open (+150 position), the cathode circuit of V14 and V15 is broken, and no voltage drop occurs in R69 and R70. Therefore, the average potential of the output stage plates appears at the A and B output jacks.

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 No. 1 of V13 at about —6 volts, which is well beyond plate current cut-off. 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 112.

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 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 prevents ripple due to electrostatic pick-up of stray fields.

The other section of V11 provides plate and screen voltage for V3 and V4 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 112 is made possible by means of the built-in square wave calibrator, consisting of V101, V102 and associated circuits, located on the front end of the power supply chassis. The square wave of approximately 1 kc used for the calibrating voltage is generated by a free running triode multivibrator, V101. A series limiting grid resistor, R102, is used to reduce the loading effect of the coupling capacitor, C101, 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 R101 and R105 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 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 V102.

The output of the multivibrator is fed to the grid of the output cathode follower via C103 and a series limiting resistor, R111. A divider, R106 and 107, maintains the signal at proper operating level for the diode connected limiter section of V102. 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, R108, R109 and R110. R109, a potentiometer, 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, R112, and the CAL. VOLTAGE potentiometer, R113. Excellent accuracy is provided by the use of 1% tolerance deposited carbon resistors in R112, and by a sufficient number of steps so that the minimum setting of the CAL. VOLTAGE control never need be under 30% of full scale.

A front panel toggle switch, SW102, labeled CAL., operates in conjunction with the 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 112 independent of 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.

Two separate power supply circuits are used, one providing —150 volts at 200 ma for the tube heaters and bias circuits, the other +250 volts at 100 ma for the plate and screen circuits.

In the —150 volt supply, two 5V4 rectifier tubes are used because of their low voltage drop. C108 reduces the 120 cycle ripple to about 9 volts peak to peak. The electronic regulator further reduces the ripple to less than .1 volt. In this circuit, the cathode of V108 is maintained at a fixed potential by the voltage reference tube, V109. Any fluctuations in the —150 volt supply are impressed on the grid of V108 via the divider, R127, R128 and R129, and the series resistor, R126, then are amplified and applied, opposite in phase, to the grid of the series regulator, V104B. Thus the drop across V104 B is increased when the —150 volt output is high and decreased when it is low, resulting in a stabilized output voltage. The shunt resistor, R123, is employed to reduce the current required of V104B. Potentiometer R128, labeled ADJ. TO —150 V., permits accurate adjustment of the output voltage, and has sufficient range to compensate for variation in tube characteristics.

DC for the +250 volt supply is obtained from V103. The output of the —150 volt supply serves as a reference voltage for the regulator V104A and V105. Any fluctuation on the +250 volt output is applied to V105 grid via the divider R119 and R120, and acts to stabilize the output voltage in the same manner as the —150 volt regular previously discussed.

SECTION IV

Adjustment and Maintenance

Removal of the Case

Set the amplifier face downward on a padded flat surface, remove the two screws in the rear, then lift off the case.

CAUTION—AFTER REMOVING THE CASE, THE FAN MOTOR TOGGLE SWITCH (LOCATED NEAR THE FAN MOUNTING BRACKET) SHOULD BE SET IN THE OFF POSITION BEFORE SERVICING OF THE INSTRUMENT IS UNDERTAKEN. BE SURE TO SWITCH THE FAN MOTOR ON BEFORE REPLACING THE CASE, OTHERWISE EXCESSIVE TEMPERATURE RISE MAY DAMAGE THE INSTRUMENT.

Power Supply

Output Voltage

An adjustment of the output voltage of the regulated supplies is provided by R128 (labeled ADJ. TO —150 V). The output of the +250 volt supply is dependent on the adjustment of the —150 volt supply.

Operation on 210-250 Volt 50-60 Cycle Line

The Type 112 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 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, by connecting the output of the Type 112 to a cathode ray tube and setting the AC-DC switch at DC. 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 amplifier gain such that the deflection will be large enough for an accurate comparison on the CRT. The comparison may readily be made by switching the 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 power supply chassis.

Amplifier

It is recommended that the following adjustments be made with the aid of an oscilloscope, with the amplifier output connected directly to the vertical deflection plates of the cathode ray tube. The deflections are specified for a CRT or 25 v/cm basic deflection sensitivity. In case an oscilloscope is not available, a 100-0-100 scale zero center voltmeter may be used to indicate DC balance, and differential balance may be determined aurally by means of head phones.

1. Differential and DC Balance Adjustments

The several stages of the Type 112 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 POSITION control which follows the amplifier gain adjustments and therefore 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 A and B outputs together 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 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. Cathode Follower Balance Adjustment

With the DEFLECTION SENSITIVITY switch in the .15-.5 position, adjust R51 (marked C. F. ADJ. on the front panel) so that varying the setting of the AMPL. ATTEN. or shorting its top terminals does not shift the 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 DEFLECTION 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 ±75 v.

e. First Stage and Differential Balance Adjustment

Set the DEFLECTION SENSITIVITY switch in the .005-.015 position, the 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 front panel and marked DIFF. 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 DIFF. BAL. control may be necessary to secure the best differential balance, as the DIFF. 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 DIFF. 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 DEFLECTION 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 potentiometer, R13, is provided to permit a separate adjustment of the balance for this position of the DEFLECTION SENSITIVITY switch. The following procedure is recommended: Set the DEFLECTION SENSITIVITY in the .15-.5 position and center the trace (or output meter). Change the DEFLECTION SENSITIVITY to the .005-.015 position and center the trace with the AUX. PRE-AMP. BAL. control. Set the DEFLECTION 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. Differential Balance Adjustment

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 DIFF. BAL. control, R4, as explain in Section e.

NOTE—One pair each 5879 and 12AU6 matched spare tubes are included with the Type 112. These tubes, located inside the instrument on the calibrator shield bracket, are selected to have similar characteristics to the matched tubes installed in the 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 112 amplifier. And adjustment of the overall gain of the instrument is provided by a variable resistor R15, marked GAIN ADJ. A. The gain of the Type 112 may be checked against the self contained calibrator. The maximum sensitivity should be adjusted to 5 mv/cm. (Overall voltage gain of 5000).

The second adjustment, R17, marked GAIN ADJ. B, provides an adjustment of the gain when DEFLECTION SENSITIVITY is in the .05-.15 position only. With the VERT. AMPL. ATTEN. fully clockwise, adjust R17 for a deflection sensitivity of .05 v per cm. (voltage gain of 500).

3. Compensation of the RC Attenuator and Voltage Divider Circuits

The various attenuators in the Type 112 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 112. Adjustment of these attenuators is readily made by observation of their square wave response on an oscilloscope with the vertical deflection plates of the CRT connected to the amplifier output. The self contained calibrator in the Type 112 is a suitable square wave source, and thus a check of the amplifier and attenuator is available by the turn of a switch. 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 PREAMPLIFIER SHIELD MUST BE IN PLACE DURING ADJUSTMENT.

a. The A and B input capacities of the third stage are equalized and the probes adjusted with the DEFLECTION 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 of the oscilloscope set at about 1 millisecond/cm. (10 cycles of the square wave for 10 cm. deflection) and C37 set 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 INPUT set at either + or — CAL. and the DEFLECTION SENSITIVITY switch in the .005-.015 position, adjust C5 and C6 using a sweep time of .1 to .2 millisecond/cm. Use an insulated screwdriver. These capacitors are complementary in action and should be at about equal settings.

c. Using a sweep time of .1 to .2 millisecond/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 DEFLECTION 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 DEFLECTION 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 DEFLECTION 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 deflection. A convenient method is to substitute a 1 megohm variable resistor shunted by a 50 $\mu\mu$F. capacitor for the probe. With DEFLECTION 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.

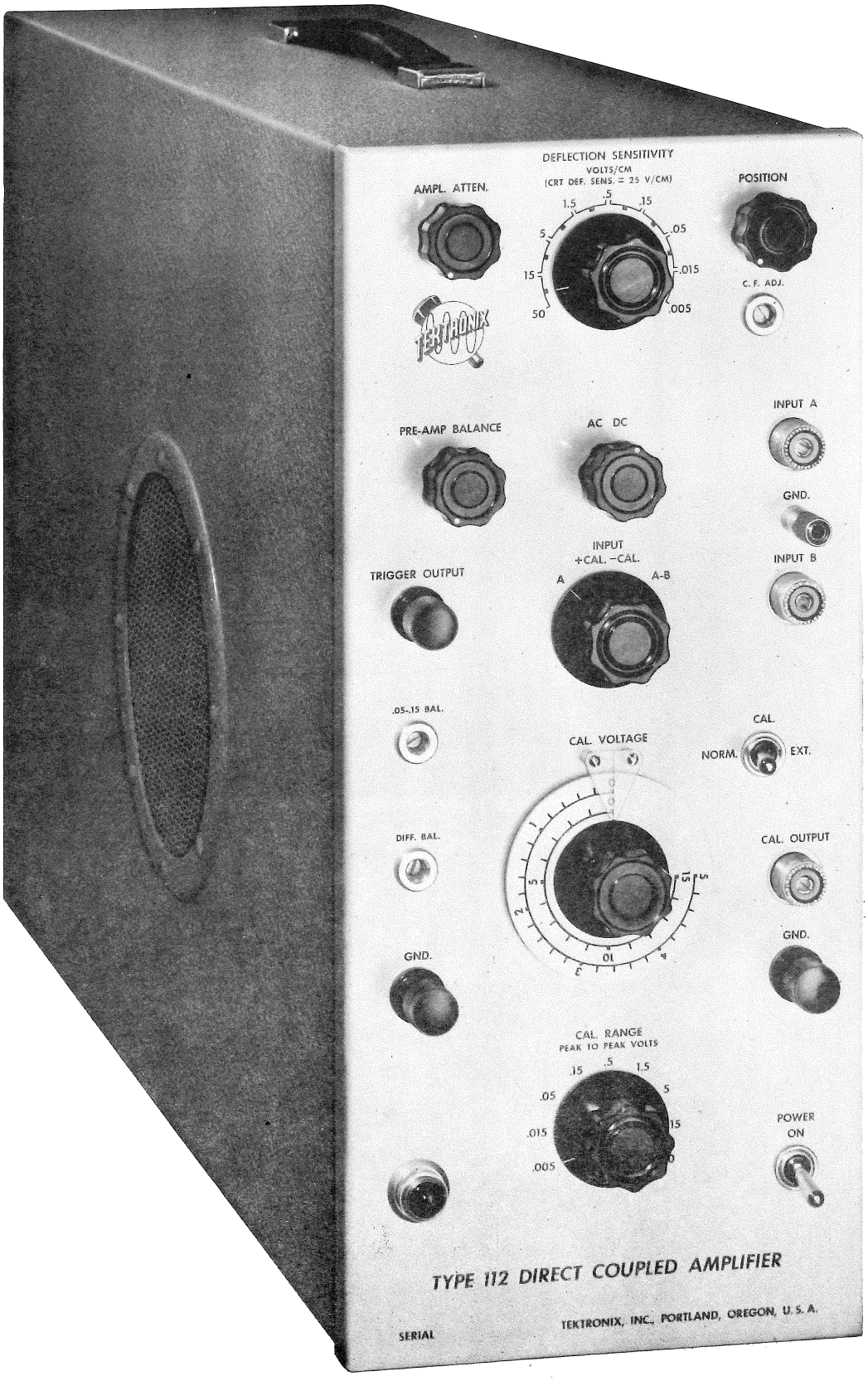
4. High Frequency Response

The Type 112 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 .1 microsecond or less. The Tektronix Type 104 or Type 105 Square Wave Generators provide a suitable signal.

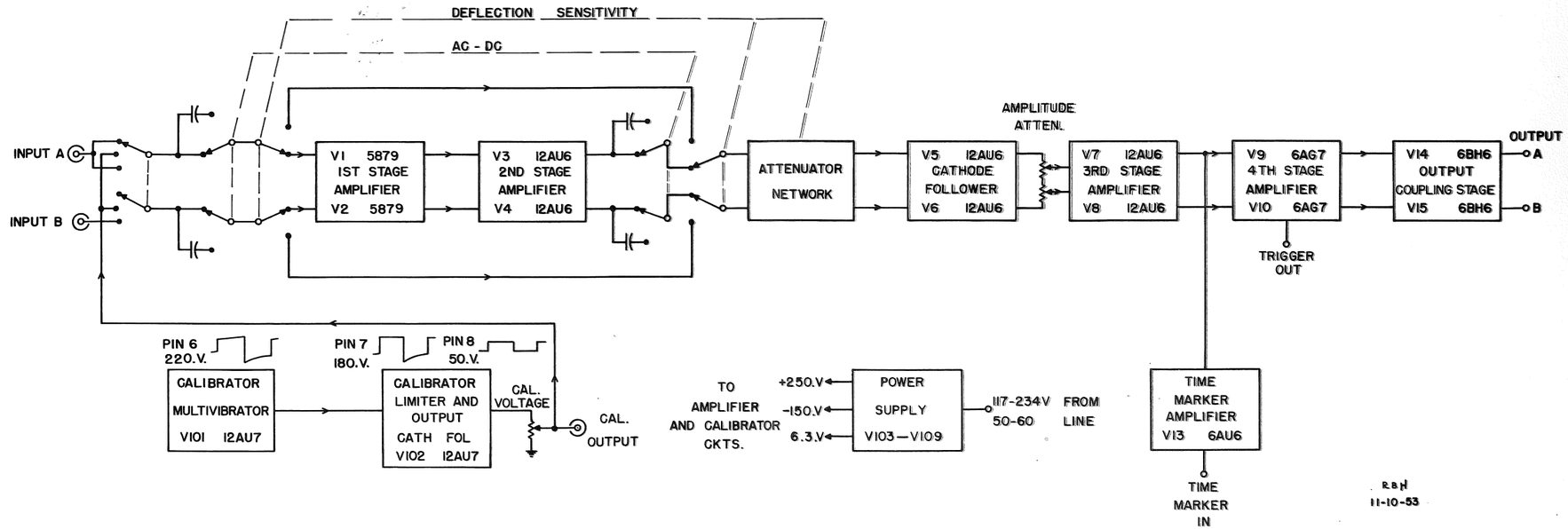
a. Set the sweep time at 3 microsecond/cm, the DEFLECTION SENSITIVITY at .15-.5 and adjust L5 and L6 until the corner of the leading edge is square. These inductors are complementary and interdependent in action and should be at about equal settings.

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

c. Set DEFLECTION SENSITIVITY at .05-.15 and adjust L1.



A TYPE 112 DIRECT-COUPLED AMPLIFIER



TYPE 112 DIRECT-COUPLED AMPLIFIER

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
$\mu\mu$	micromicro or 10^{-12}	WW	wire wound

VERTICAL AMPLIFIER

Capacitors

C1	.1 μf	PT	Fixed	600 v	20%
C1.1	.01 μf	Cer.	Fixed	500 v	GMV
C2	.1 μf	PT	Fixed	600 v	20%
C2.1	.01 μf	Cer.	Fixed	500 v	GMV
C3	5-20 $\mu\mu$f	Cer.	Var.	500 v	
C3.1	8 $\mu\mu$f	Cer.	Fixed	500 v	20%
C4	5-20 $\mu\mu$f	Cer.	Var.	500 v	
C4.1	8 $\mu\mu$f	Cer.	Fixed	500 v	20%
C5	7-45 $\mu\mu$f	Cer.	Var.	500 v	
C6	7-45 $\mu\mu$f	Cer.	Var.	500 v	
C7	.1 μf	PT	Fixed	600 v	20%
C8	.1 μf	PT	Fixed	600 v	20%
C11	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C12	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C13	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C14	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C15	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C16	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C17	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C18	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C21	27 $\mu\mu$f	Mica or Cer.	Fixed	400 v	20%
C22	27 $\mu\mu$f	Mica or Cer.	Fixed	400 v	20%
C23	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C24	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C25	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C26	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C27	100 $\mu\mu$f	Mica	Fixed	400 v	10%
C28	100 $\mu\mu$f	Mica	Fixed	400 v	10%
C31	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C32	3-12 $\mu\mu$f	Cer.	Var.	500 v	
C33	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C34	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C35	330 $\mu\mu$f	Mica	Fixed	400 v	10%
C36	330 $\mu\mu$f	Mica	Fixed	400 v	10%
C37	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C38	1.5-7 $\mu\mu$f	Cer.	Var.	500 v	
C39	.01 μf	Cer.	Fixed	500 v	GMV
C39.1	.01 μf	PT	Fixed	400 v	20%

Capacitors—Continued

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%

Inductors

L1	99-185 microhenries	Var.	CV993
L3	320-500 microhenries	Var.	CV324
L4	320-500 microhenries	Var.	CV324
L5	180-300 microhenries	Var.	CV194
L6	180-300 microhenries	Var.	CV194

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 Ω	2 w	Var.	Comp.	20%
R5	330 Ω	½ w	Fixed	Comp.	10%
R7	5.6 k	½ w	Fixed	Comp.	2%
R8	5.6 k	½ w	Fixed	Comp.	2%
R9	100 Ω	½ w	Fixed	Comp.	10%
R10	100 Ω	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%
R14	10 k	10 w	Fixed	WW	5%
R15	500 Ω	2 w	Var.	Comp.	20%
R16	220 Ω	½ w	Fixed	Comp.	10%
R17	500 Ω	2 w	Var.	Comp.	20%
R18	820 Ω	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%
R20.1	100 k	2 w	Var.	Comp.	20%
R21	100 k	½ w	Fixed	Comp.	10%
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%

Resistors—Continued

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%
R52	820 Ω	½ w	Fixed	Comp.	10%
R53 & R54	1 k	2 w	Var. Dual	Comp.	20%
R55	10 k	10 w	Fixed	WW	5%
R56	500 Ω	2 w	Var.	Comp.	20%
R57	100 Ω	½ w	Fixed	Comp.	10%
R59	1.8 k	½ w	Fixed	Comp.	5%*
R59.1	390 Ω	½ w	Fixed	Comp.	10%
R60	2.2 k	½ w	Fixed	Comp.	5%*
R61	100 Ω	½ w	Fixed	Comp.	10%
R61.1	68 k	½ w	Fixed	Comp.	10%
R61.2	100 k	2 w	Var.	Comp.	20%
R61.3	68 k	½ w	Fixed	Comp.	10%
R62	100 Ω	½ w	Fixed	Comp.	10%
R63	825 Ω (3.3k/4)	4x1 w	Fixed	Comp.	10%
R64	6.6 k (2x3.3k)	2x1 w	Fixed	Comp.	10%
R65	47 Ω	½ w	Fixed	Comp.	10%
R66	47 Ω	½ w	Fixed	Comp.	10%
R67	4 k	5 w	Fixed	WW	2%
R67.1	8.2 k	½ w	Fixed	Comp.	10%
R67.2	5 k	2 w	Var.	Comp.	20%
R67.3	1 k	½ w	Fixed	Comp.	10%
R67.4	68 k	½ w	Fixed	Comp.	10%
R67.5	330 k	½ w	Fixed	Comp.	10%
R68	4 k	5 w	Fixed	WW	2%
R68.1	8.2 k	½ w	Fixed	Comp.	10%
R68.2	5 k	2 w	Var.	Comp.	20%
R68.3	1 k	½ w	Fixed	Comp.	10%
R68.4	68 k	½ w	Fixed	Comp.	10%
R68.5	2.7 meg	½ w	Fixed	Comp.	10%
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%

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

Resistors—Continued

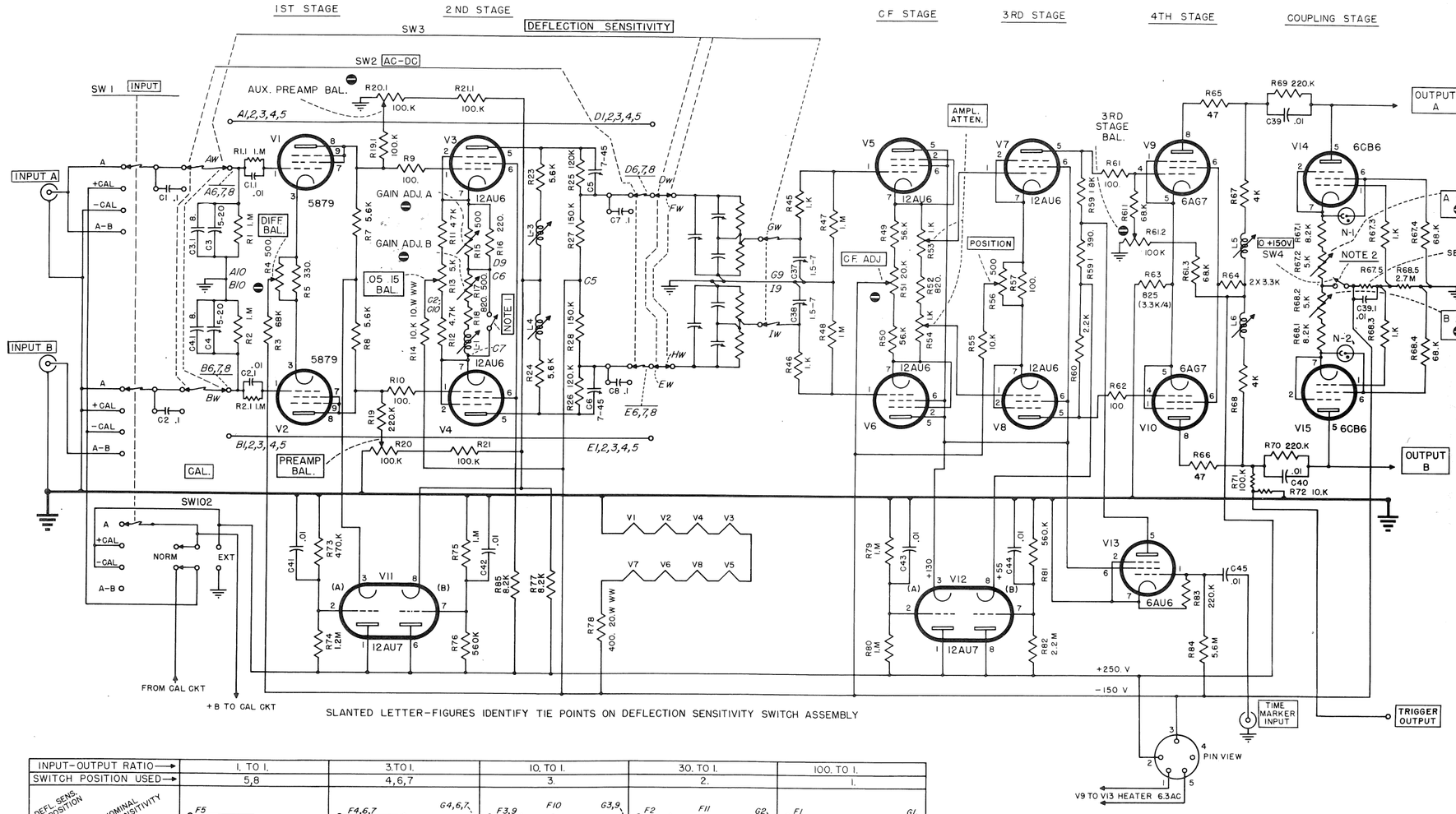
R74	1.2 meg	½ w	Fixed	Comp.	2%
R75	1 meg	½ w	Fixed	Comp.	2%
R76	560 k	½ w	Fixed	Comp.	2%
R77	8.2 k	2 w	Fixed	Comp.	10%
R78	400 Ω	20 w	Fixed	WW	5%
R79	1 meg	½ w	Fixed	Comp.	2%
R80	1 meg	½ w	Fixed	Comp.	2%
R81	560 k	½ w	Fixed	Comp.	2%
R82	2.2 meg	½ w	Fixed	Comp.	2%
R83	220 k	½ w	Fixed	Comp.	10%
R84	5.6 meg	½ w	Fixed	Comp.	10%
R85	8.2 k	1 w	Fixed	Comp.	10%

Switches

SW1	2 wafer	4 position	rotary	INPUT
SW2	4 wafer	2 position	rotary	AC-DC
SW3	9 wafer	9 position	rotary	DEFLECTION SENSITIVITY
SW4	Single pole	Single throw	toggle	0, 150V

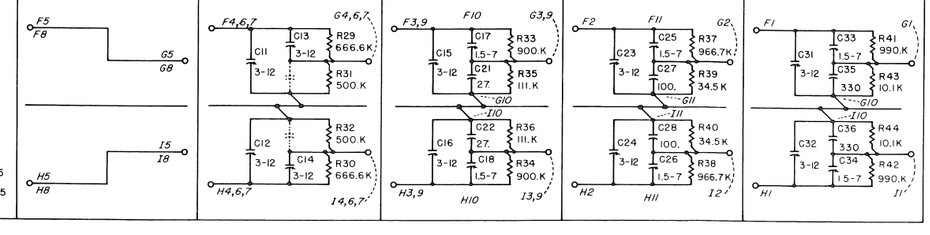
Vacuum Tubes

V1, V2	2-5879	Pre-amplifier Inputs
V3, V4	2-12AU6	Pre-amplifier Outputs
V5, V6	2-12AU6	Gain Control Cathode Followers
V7, V8	2-12AU6	Main Amplifier Inputs
V9, V10	2-6AG7	Main Amplifier Outputs
V11, V12	2-12AU7	Amplifier Voltage Regulators
V13	6AU6	Marker Input Amplifier
V14, V15	2-6CB6	Output Coupling



SLANTED LETTER-FIGURES IDENTIFY TIE POINTS ON DEFLECTION SENSITIVITY SWITCH ASSEMBLY

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.
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					



A

NOTE: 1
THIS SWITCH IS CLOSED EXCEPT IN POSITION 6 OF SW3.

NOTE 2
ON REAR OF CABINET

5-28-54

TYPE 112 DIRECT-COUPLED AMPLIFIER

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} ohms	w	watt
μμ	micromicro or 10^{-12} ohms	WW	wire wound

POWER SUPPLY

Capacitors

C104B	½ 2x20 μf	EMC	Fixed	450 v	—20%	+50%
C105	2 (2x20) μf	EMC	Fixed	450 v	—20%	+50%
C106	.01 μf	PT	Fixed	400 v	20%	
C108	2 (2x20) μf	EMC	Fixed	450 v	—20%	+50%
C109	.01 μf	PT	Fixed	400 v	20%	
C110	.01 μf	PT	Fixed	400 v	20%	

Resistors

R115	220 k	1 w	Fixed	Comp.	10%	
R116	1 meg	½ w	Fixed	Comp.	10%	
R117	270 k	½ w	Fixed	Comp.	10%	
R118	33 k	½ w	Fixed	Comp.	10%	
R119	1 meg	½ w	Fixed	Prec.	1%	
R120	600 k	½ w	Fixed	Prec.	1%	
R121	39 k	½ w	Fixed	Comp.	10%	
R122	1 meg	½ w	Fixed	Comp.	10%	
R123	1 k	25 w	Fixed	WW	5%	
R124	12 k	½ w	Fixed	Comp.	10%	
R125	27 k	½ w	Fixed	Comp.	10%	
R126	1 meg	½ w	Fixed	Comp.	10%	
R127	47 k	½ w	Fixed	Comp.	10%	Selected ±5%
R128	10 k	2 w	Var.	WW	20%	ADJ TO —150 v
R129	56 k	½ w	Fixed	Comp.	10%	SELECTED ±5%
R130	27 k	½ w	Fixed	Comp.	10%	

Switches

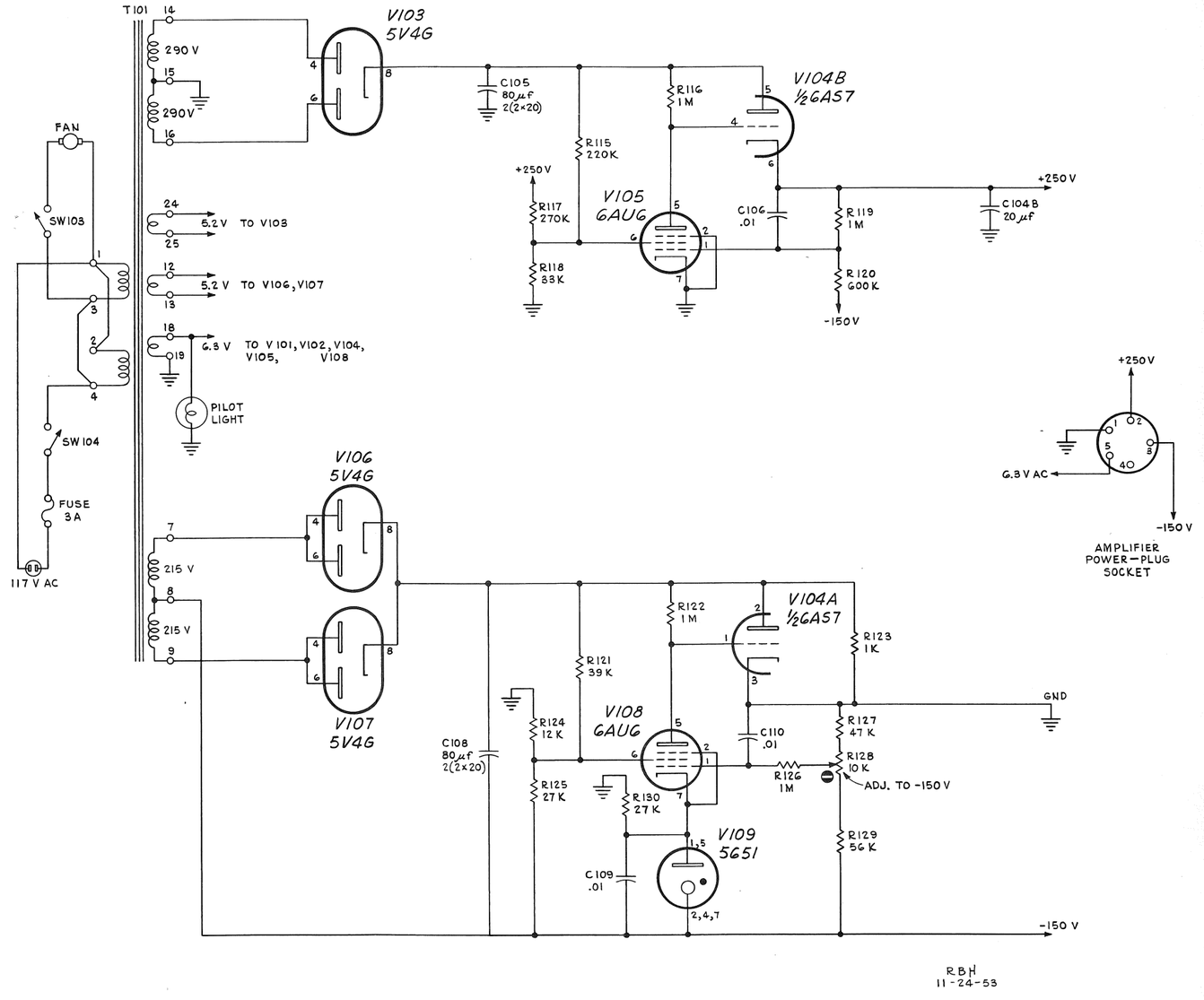
SW103	single pole	single throw	toggle	POWER

Transformers

T101	Plate and heater	117/234 vac. 50/60 cycle		T112PA1
	Primary:	215-0-215 vac	195 ma	
	Secondaries:	290-0-290 vac	95 ma	
		6.5 vac	6.2 amp	
		5.2 vac	4 amp	
		5.2 vac	2 amp	

Vacuum Tubes

V103	5V4G	+250-v Rectifier
V104A	½ 6AS7	+250-v Series Tube
V104B	½ 6AS7	—150-v Series Tube
V105	6AU6	+250-v Voltage-Regulator Amplifier
V106	5V4G	—150-v Rectifier
V107	5V4G	—150-v Rectifier
V108	6AU6	—150-v Voltage-Regulator Amplifier
V109	5651	Voltage Reference



RBH
11-24-53

TYPE 112 DIRECT—COUPLED AMPLIFIER A

POWER SUPPLY

POWER SUPPLY

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

CALIBRATOR

Capacitors

C101	330 μμf	Mica	Fixed	500 v	10%	
C102	330 μμf	Mica	Fixed	500 v	10%	
C103	.01 μf	PT	Fixed	400 v	20%	
C104A	½ 2x20 μf	EMC	Fixed	450 v	—20%	+50%

Resistors

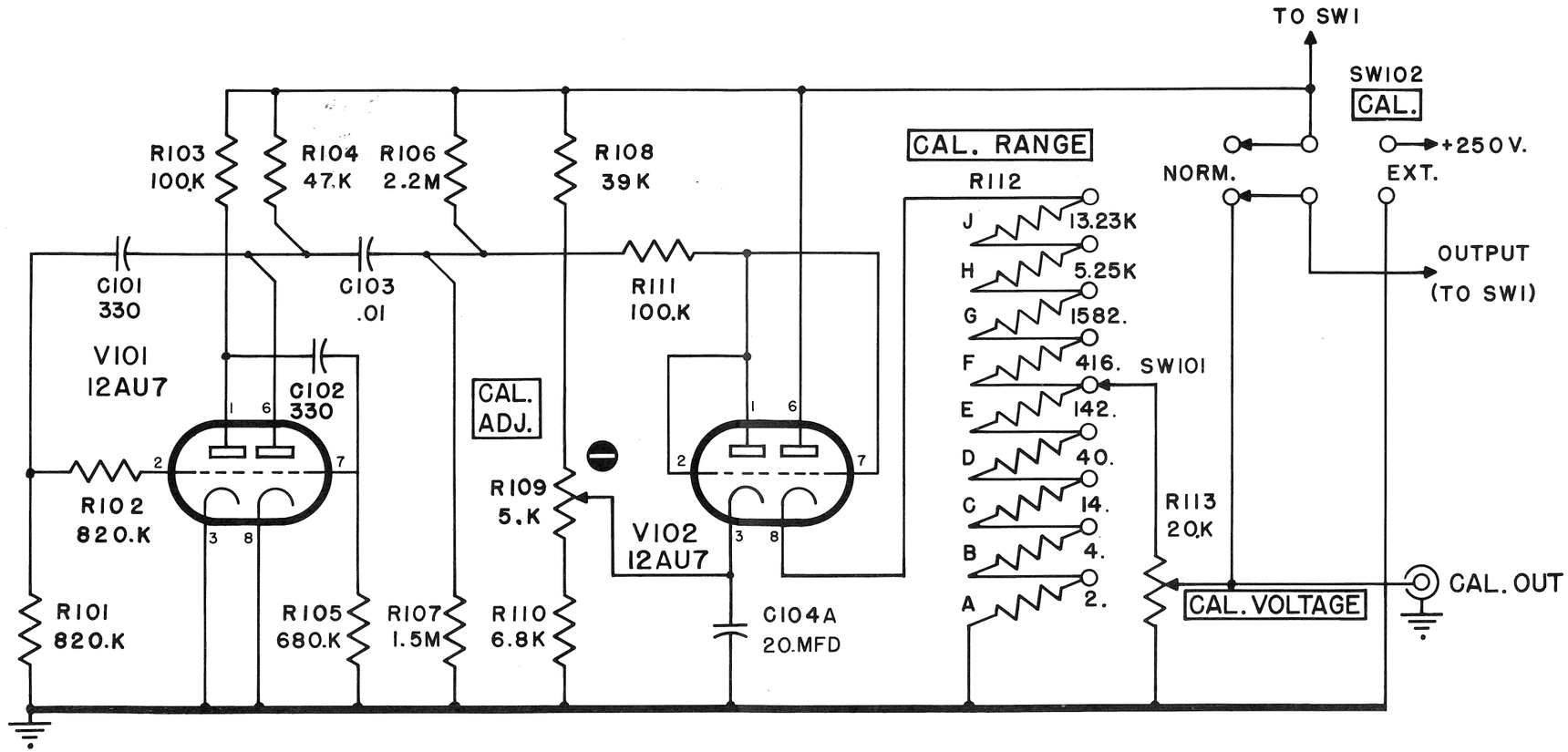
R101	820 k	½ w	Fixed	Comp.	10%	
R102	820 k	½ w	Fixed	Comp.	10%	
R103	100 k	1 w	Fixed	Comp.	10%	
R104	47 k	1 w	Fixed	Comp.	10%	
R105	680 k	½ w	Fixed	Comp.	10%	
R106	2.2 meg	½ w	Fixed	Comp.	10%	
R107	1.5 meg	½ w	Fixed	Comp.	10%	
R108	39 k	2 w	Fixed	Comp.	10%	
R109	5 k	2 w	Var.	WW	20%	CAL ADJ
R110	6.8 k	1 w	Fixed	Comp.	10%	
R111	100 k	½ w	Fixed	Comp.	10%	
R112A	13.23 k	½ w	Fixed	Prec.	1%	
R112B	5.25 k	½ w	Fixed	Prec.	1%	
R112C	1582 Ω	½ w	Fixed	Prec.	1%	
R112D	416 Ω	½ w	Fixed	Prec.	1%	
R112E	142 Ω	½ w	Fixed	Prec.	1%	
R112F	40 Ω	½ w	Fixed	Prec.	1%	
R112G	14 Ω	½ w	Fixed	Prec.	1%	
R112H	4 Ω	½ w	Fixed	Prec.	1%	
R112J	2 Ω	½ w	Fixed	Prec.	1%	
R113	20 k	2 w	Var.	WW	2%	CAL VOLTAGE

Switches

SW101	2 wafer	9 position	rotary	CAL. RANGE
SW102	double pole	double throw	toggle	CAL. NORM. EXT.

Vacuum Tubes

V101	12AU7	Calibrator Multivibrator
V102	12AU7	Calibrator Limiter and Output Cathode Follower



TYPE 112

A

11-3-53

CALIBRATOR

SERIAL NO. _____

IMPORTANT

Include the INSTRUMENT TYPE and the above SERIAL NUMBER in any correspondence regarding this instrument. The above serial number must match the instrument serial number if parts are to be ordered from the manual. Your help in this will enable us to answer your questions or fill your order with the least delay possible.

WARRANTY

This instrument is guaranteed to the original user to be free from defects in material and workmanship for a period of one year from date of purchase. Our responsibility under this warranty is limited to the repair or replacement of the instrument, or any part thereof, failure of which is not due to abuse.

For service under this warranty, promptly advise the factory of all details pertinent to the failure. Replacement parts will be shipped, via air transportation upon request, prepaid to any point within the continental United States or Canada. Should it be more convenient to ship the entire instrument, transportation prepaid, to the factory, it will be serviced as required, at no charge and returned via surface transportation.

Replacement parts ordered after termination of warranty will be billed at current net prices and shipped via air prepaid to any point within the continental United States or Canada.

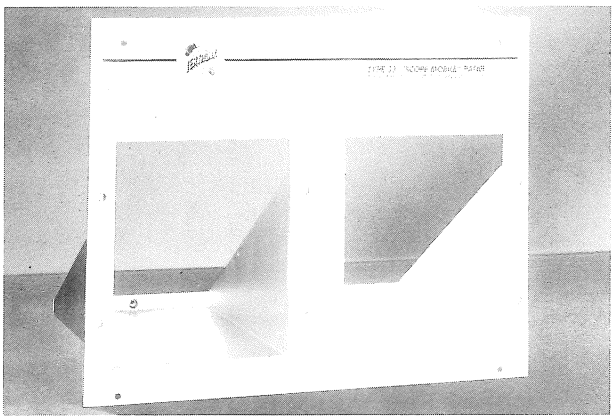
ACCESSORIES

The Tektronix Type 500 Scope-Mobile has been especially designed to accommodate Tektronix 5" Cathode Ray Oscilloscopes. It provides a sturdy yet mobile and therefore highly useful support for the Oscilloscope. Convenient and easy observation of the CRT face is achieved by a 20° tilt back.

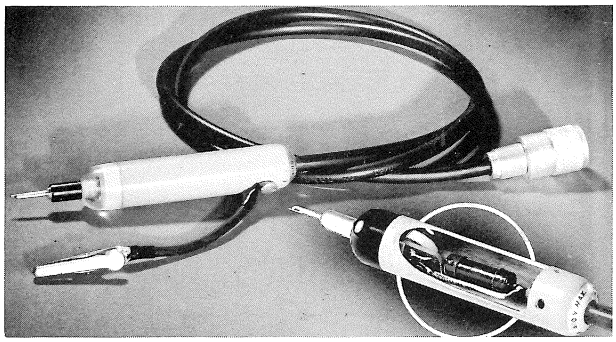
A blank panel, 11"x15", fronting a mounting space of approximately 1½ cubic feet allows for auxiliary built-in equipment as an aid in meeting specialized requirements. This space is fully ventilated by means of louvres. A power input connector and three convenience outlets appear at the back.

A drawer is provided for the handy storage of cords, probes, instruction books, small tools, etc. For quietness and ease of operation the drawer, 15"x15"x3" in size, is felt lined and operates in roller bearing support runners. An open shelf, 17"x24" in size and topped with battleship linoleum, is located at the bottom of the unit.

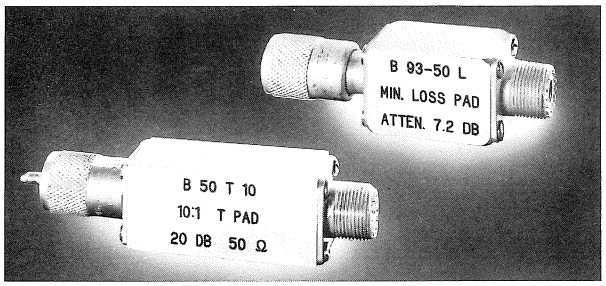
Total weight of the Scope-Mobile is approximately 42 pounds and clearance dimensions are 18½" wide, 39" high and 30" deep. Price—$97.50.



Type 53 Scope-Mobile Panel—replaces standard blank panel in the Scope-Mobile. It has two supporting cradles designed to accommodate the Type-53 Plug-In Preamplifiers used with Type-530 Series Oscilloscopes 10.50



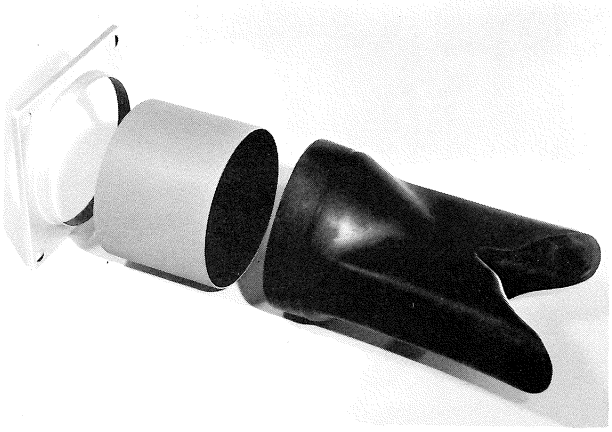
P510A Attenuator Probe provides an attenuation of ten times when used with Tektronix oscilloscopes and amplifiers. The P510A is small and streamlined, and presents an input impedance of 10 megohms paralleled by 14 $\mu\mu$f. The probe is completely insulated—made of high-impact-strength fiberglass-reinforced alkyd—and has an internal brass shield. Two interchangeable tips are furnished—a Klipzon tip and an alligator clip assembly. A ground clip is attached to the probe body. Probe has a 42" coaxial cable with uhf connector, and is rated at 600v peak-to-peak $8.50
Replacement Klipzon tips 65
Replacement alligator tips 40



B52-R	52-ohm terminating resistor, 1.5w . .	$ 8.50
B52-L5	52-ohm 'L' pad, 5 to 1 voltage ratio, 1.5w	8.50
B52-L10	52-ohm 'L' pad, 10 to 1 voltage ratio, 1.5w	8.50
B52-75L	Minimum-loss pad, 52 ohms to 75 ohms	11.50
B52-170L	Minimum-loss pad, 52 ohms to 170 ohms	11.50
B52-T10	52-ohm 'T' pad, 10 to 1 voltage ratio, 1.5w	11.50
B75-R	75-ohm terminating resistor, 1.5w . .	8.50
B75-L5	75-ohm 'L' pad, 5 to 1 voltage ratio, 1.5w	8.50
B75-L10	75-ohm 'L' pad, 10 to 1 voltage ratio, 1.5w	8.50
B75-T10	75-ohm 'T' pad, 10 to 1 voltage ratio, 1.5w	11.50
B93-R	93-ohm terminating resistor, 1.5w . .	8.50
B93-L5	93-ohm 'L' pad, 5 to 1 voltage ratio, 1.5w	8.50
B93-L10	93-ohm 'L' pad, 10 to 1 voltage ratio, 1.5w	8.50
B93-52L	Minimum-loss pad, 93 ohms to 52 ohms, 1.5w	11.50
B93-T10	93-ohm 'T' pad, 10 to 1 voltage ratio, 1.5w	11.50
B170-R	170-ohm terminating resistor, 1.5w .	8.50
B170-V	170-ohm attenuator, 1 to 64 db in 1 db steps, 0.25w	45.00

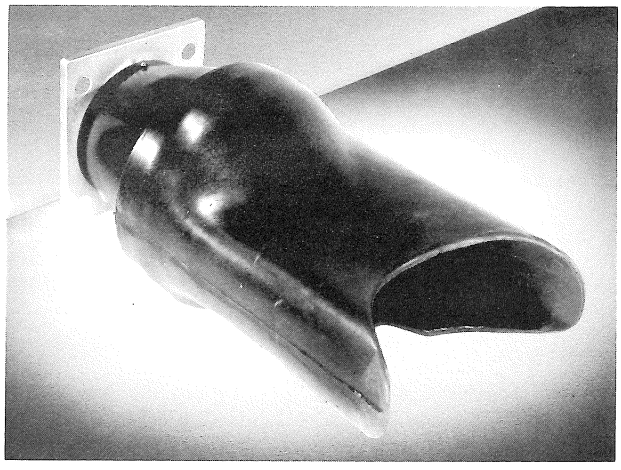
Prices f.o.b. Portland (Beaverton), Oregon

ACCESSORIES



H510 Viewing Hood, for Tektronix 5″ Oscilloscopes. Includes rubber eye-piece and aluminum light shield $4.50

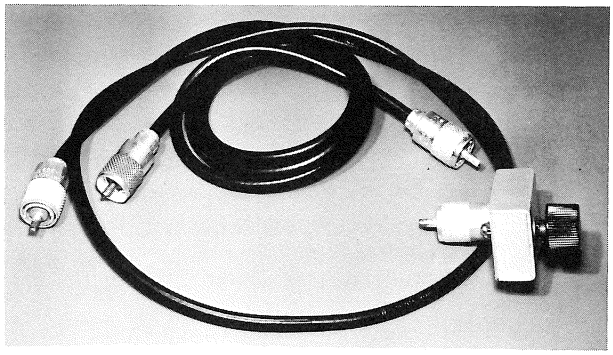
BE510 Bezel, for mounting camera on Tektronix 5″ Oscilloscopes. Dimensions—5⅞″ square; ring ⅞″ deep, diameter 5⅝″ outside, 5⅛″ inside. Die-cast construction, gray wrinkle finish, felt lined $4.50



H310 Viewing Hood, for Tektronix 3″ Oscilloscopes. Includes rubber eye-piece and spun-aluminum light shield $4.50

CATHODE-RAY TUBE LIGHT FILTERS

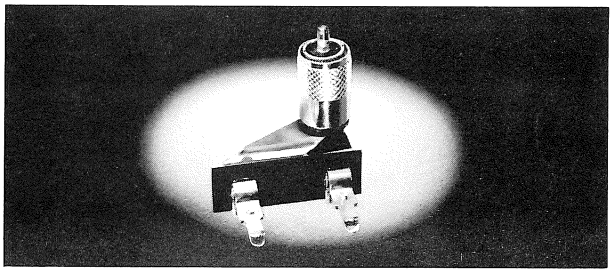
F310-3 (3″ amber)	$ .50
F310-5 (3″ green)	.50
F310-6 (3″ blue)	.50
F510-3 (5″ amber)	.90
F510-5 (5″ green)	.90
F510-6 (5″ blue)	.90



COAXIAL CABLES

P52	Coaxial Cable, 52 ohms nominal impedance, 42″ long	$ 4.00
P75	Coaxial Cable, 75 ohms nominal impedance, 42″ long	4.00
P93	Coaxial Cable, 93 ohms nominal impedance, 42″ long	4.00
P93A	Coaxial output cable, 93 ohms, terminated at end with variable attenuator, 42″ long	13.50
P93B	Coaxial output cable, 93 ohms, terminated at end with ½-watt 93-ohm resistor, 42″ long	5.00
P170	Coaxial cable, 170 ohms nominal impedance, 42″ long	9.50

S30 Delta Standards, for calibration of the Type 130 L,C Meter. The unit provides accurately adjusted steps of capacitance and inductance, selected by a rotary selector switch. Values of the capacitance steps correspond to the full-scale adjustments required on the five scales of the Type 130. Two resistors of identical manufacture and similar capacitance, values of 1 megohm and 0.1 megohm, are provided for the resistance compensation adjustment. A 300-μh standard permits proper adjustments of the inductance ranges $22.00



F30 Production Test Fixture, for use with the Type 130 L,C Meter. Speeds sorting and testing of capacitors and inductors $3.00

MISCELLANEOUS

A100	Adapter, clip lead	$2.50
A510	Adapter, binding post	1.88
FA160	Frame, mounting, for Type 122 and Type 160 series units	5.00

Prices f.o.b. Portland (Beaverton), Oregon

Tektronix, Inc.

AN OREGON CORPORATION

Main Office and Factory—Sunset Highway and Barnes Road
Mailing Address—P. O. Box 831, Portland 7, Oregon
Phone—CYpress 2-2611 Cable—TEKTRONIX

TEKTRONIX FIELD ENGINEERING OFFICES

BALTIMORE	Tektronix, Inc., 8118 Harford Road, Baltimore 14, Maryland	NOrthfield 5-2600
	Washington Area Phone	ENterprise 1-6023
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CHICAGO	Tektronix, Inc., 7514 W. North Ave., Elmwood Park 35, Illinois	GLadstone 6-7930
CLEVELAND	Tektronix, Inc., 3353 Edgecliff Terrace, Cleveland 11, Ohio	CLearwater 2-2121
	Detroit Area: ENterprise 7121	Pittsburgh Area: ZEnith 0212
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ATLANTA	Bivins & Caldwell, 267 East Paces Ferry Road, N. E., Atlanta, Georgia	CHerokee 7522
DALLAS	M. F. Klicpera Company, P. O. Box 4117, Sta. A, Dallas 8, Texas	FEderal 0992
DENVER	Hytronic Measurement Associates, 446 Broadway, Denver 3, Colorado	SHerman 4-2241
FORT MYERS	Arthur Lynch & Associates, P. O. Box 466, Fort Myers, Florida	Fort Myers 5-6762
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STOCKHOLM	Erik Ferner AB, Bjornsonsgatan 197, Bromma, Stockholm, Sweden	377700
TOKYO	Midoriya Electric Co., Ltd., 3,4-Chome, Ginzanishi, Chuo-Ku, Tokyo, Japan	Kyobashi (56) 0486
VOORBURG	I. R. C. A., Paradysstraat 92, Voorburg, Holland	0 1700—722449
ZURICH	Omni Ray AG., Dufourstrasse 56, Zurich 8, Switzerland	(051) 34-44-30

Other OVERSEAS areas please write or cable directly to the Export Department, Portland, Oregon, U.S.A.

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GENERAL INFORMATION

Terms and Shipment

Our terms are 1% ten days, net thirty days on domestic orders; net thirty days on export orders. Shipping delay may be prevented by establishing credit at time of placing order. When desirable, C.O.D. shipments can be arranged. All prices are f.o.b. Portland (Beaverton), Oregon.

For information relative to discounts on quantity purchases, please contact your nearest Tektronix field office, representative, or distributor.

Although all quotations are for shipment f.o.b. Portland (Beaverton), Oregon, upon request transportation costs can be prepaid and the amount added to the invoice.

Normally, shipments are made by Railway Express or Motor Freight. If shipment by air is desired, please specify Air EXPRESS or Air FREIGHT. Experience has eliminated rail freight as a satisfactory method of surface transportation for electronic instruments.

Export Orders

All orders and inquiries from countries other than the United States should be addressed directly to: Tektronix, Inc., Export Department, P. O. Box 831, Portland 7, Oregon. Cable address: TEKTRONIX.

Delivery

Acceptance of purchase orders is indicated by our acknowledgment, and estimated shipment time is given from date of acknowledged acceptance. Every effort is made to meet the estimated shipment date, but there is the possibility that circumstances beyond our control might make it impossible to meet the quoted schedules.

Field Maintenance

Tektronix Field Maintenance is provided on a non-profit basis, as a service to our customers. Work is expedited whether or not the instrument is in warranty.

Requests for repairs or replacement parts should include type number and serial number and should be directed to our representative or branch office in your area. In an emergency, please wire or phone Field Engineering, Tektronix, Inc., Portland, Oregon, in addition to notifying the local representative. This procedure will assure you the fastest possible service.

If an instrument must be returned to the factory for repairs, notify Field Engineering directly or through the local representative, ***indicating type number and serial number,*** and you will be notified at once as to procedure to be followed. PLEASE DO NOT RETURN AN INSTRUMENT BEFORE RECEIVING DIRECTIONS. Instruments and parts returned from countries other than the United States *must be accompanied by an invoice* to clear through customs.

It is standard practice for Tektronix to incorporate improvements into production instruments as they are developed in our laboratories. Owners of existing instruments are notified of modifications, and modification kits are made available, when practicable, to those who wish to modernize their own instruments.

For customers who have large quantities of Tektronix instruments and wish to equip their maintenance departments with factory-tested components, integrated kits of parts are available. Kits are designed to cover expected needs of a group of ten instruments of the same type.

Warranty

All Tektronix instruments are fully guaranteed against defective materials and workmanship for one year. Should replacement parts be required, whether at no charge under warranty or at established net prices, they will be shipped from the factory, via air transportation on request, prepaid to any point within continental North America.

Tektronix transformers manufactured in our own plant carry an indefinite warranty. In the event of failure please be sure to contact the nearest Tektronix Field Engineer, Representative or Headquarters.