

WIDE - BAND DIFFERENTIAL PREAMP TYPE 53G

INSTRUCTION MANUAL



TEKTRONIX, INC.

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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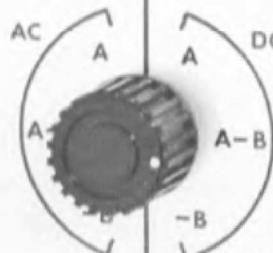
INPUT A



VERTICAL POSITION



TYPE 53G
PLUG-IN UNIT
SERIAL



VARIABLE
VOLTS/CM

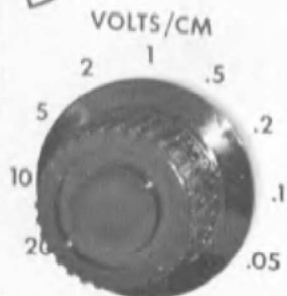


CALIBRATED



DC BAL.

INPUT B



WIDE-BAND
DIFFERENTIAL
CALIBRATED PREAMP
.05-20 V/CM DC COUPLED
PREAMP RISE TIME $\approx .015 \mu\text{SEC}$



DIFF. BAL.

TEKTRONIX, INC.,
PORTLAND, OREGON, U.S.A.



GENERAL DESCRIPTION

General

The Type 53G adapts Type 530-Series oscilloscopes for work requiring a differential input with a high rejection ratio for in-phase signals, combined with wide bandwidth and excellent transient response.

Characteristics

SENSITIVITY

Calibrated, .05 to 20 v/cm; continuously variable, .05 to 50 v/cm, ac or dc.

FREQUENCY RESPONSE

DC to 10 mc at any sensitivity. With ac coupling, the low-frequency 3-db point is 2 cps. (The low-frequency response is extended somewhat when the probe is used.)

TRANSIENT RESPONSE

Risetime .035 μ sec, 10% to 90%.

DIFFERENTIAL INPUT

100-to-1 rejection ratio at full gain for any in-phase signal within the pass band of the instrument; maximum amplitude handling capability, 2 volts, peak to peak, between the input grids. Independent step attenuators in each input.

PHYSICAL CHARACTERISTICS

Construction, aluminum alloy chassis; Finish, photo-etched, anodized panel; Weight, 4½ lbs.

Front-Panel Controls and Connectors

INPUT A INPUT B	Separate signal inputs to the preamplifier by way of the INPUT-SELECTOR switch.
INPUT- SELECTOR SWITCH	Six-position switch, to select either input separately or the two inputs differentially, with either ac or dc coupling.
VOLTS/CM	Two 9-position switches, one in each input circuit, to select the desired deflection sensitivity.
VARIABLE	Potentiometer to provide continuously variable attenuation between the calibrated sensitivities and to decrease the sensitivity to 50 v/cm.
VERTICAL POSITION	Dual potentiometer to move the trace up or down.
DC BAL	Screwdriver adjustment to set the dc voltage across the VARIABLE VOLTS/CM control to zero so the trace does not shift when the gain is varied.
DIFF. BAL.	Screwdriver adjustment to vary, differentially, the bias on the input-amplifier suppressor grids, to provide a fine differential adjustment of the input-amplifier gain so maximum rejection of the common-mode signal can be obtained.



OPERATING INSTRUCTIONS

General

The Type 53G Preamplifier is designed to operate as the preamplifier for a Tektronix 530-Series oscilloscope. We assume that it will be operated in this manner in the following instructions.

Signal Inputs

Either of the two signal inputs can be used independently by turning the input-selector switch to **A** or **—B** and connecting the signal to the corresponding input connector. The signal will be inverted when connected to **INPUT B**. Each input presents a load of 1 megohm shunted by 45 μf to the signal source.

CAUTION: IN NO CASE SHOULD THE COMBINED AC AND DC INPUT VOLTAGES EXCEED 600 VOLTS PEAK.

The **DC** and **AC** positions of this switch differ only in that, in the **AC** positions, a capacitor is inserted in series with the input to remove the dc component of the signal. When the switch is in either position marked **A — B**, both inputs are connected to the amplifier through individual, compensated attenuators. The signal presented to the oscilloscope amplifier will be the difference between these two signals after attenuation. This makes it possible to buck out a large signal with a relatively small one, or vice versa, by appropriate selection of attenuators.

Deflection Sensitivity

The two **VOLTS/CM** controls are nine-position switches which insert frequency-compensated attenuators between the input connectors and the amplifiers. The control labeled **VARIABLE VOLTS/CM** has a range of about $2\frac{1}{2}$ to 1 providing continuous attenuation between the step positions of the **VOLTS/CM** control and to 50 v/cm. This control varies the gain of the preamplifier and thus varies the sensitivity of both inputs at the same time.

NOTE: The control labeled **VARIABLE VOLTS/CM** must be clockwise against the stop for the sensitivity to be as indicated by the **VOLTS/CM** controls.

The ten-times-attenuation probe furnished with the 530-Series oscilloscopes will extend the attenuation to a maximum of 500 v/cm, and reduce the loading on the circuit under test to 10 megohms shunted by 12 μf . The peak potential applied to the probe should not exceed 600 volts. Larger signals must be externally attenuated.

AC Coupling

It is sometimes unnecessary or undesirable to display the dc level of a waveform. The **AC** positions of the input selector switch insert a capacitor in series with the input so that the dc component of the waveform is blocked and only the ac component is displayed. The low-frequency response is about 2 cps when ac coupling is used. The low-frequency response is extended to about .2 cps when the probe is used. The rejection ratio for the common-mode signal falls off at the very low frequencies when ac coupling is used, but it is still better than 100:1 at 60 cps.

Differential Input

The differential input makes possible the application of balanced signals to the 53G preamp. The best rejection ratio for common-mode signals is obtained in the unattenuated (maximum gain) position. When a balanced input is required, be sure both **VOLTS/CM** switches are on the same sensitivity position.

Sometimes it is desirable to use different sensitivities on the two inputs. You can buck out 60-cycle hum in a signal being viewed by applying a properly phased 60-cycle signal to the unused input. If variable attenuation is necessary this must be done externally. You can buck out up to 600 volts dc by connecting a battery to the unused input. Do not exceed 4 volts in the maximum gain position, or at the input grid after attenuation. Thus you can look at very-low-frequency changes of voltage in a 400-volt power supply at a sensitivity of 5 v/cm. Correspondingly higher sensitivities can be used on lower-voltage supplies.



CIRCUIT DESCRIPTION

General

The Type 53G Plug-in unit has a passband to 10 mc and a maximum sensitivity of .05 volts per centimeter. The amplifier consists of two stages of push-pull amplification, each stage followed by cathode followers.

Input Connectors

The input-selector switch, SW3027, connects the two input connectors to the grids of the input amplifiers. In either the **A** or **—B** positions of the switch, one of the grids is grounded and the other is connected to its associated input connector. In the **A—B** positions, both grids are connected to the signal inputs.

Input Attenuators

The **VOLTS/CM** switches SW3057 and SW3067 insert frequency-compensated attenuators into the input circuits. Four attenuators in each switch are used singly or in tandem pairs to produce nine sensitivities. The attenuators have voltage attenuation ratios of 2X, 4X, 10X and 100X, to produce sensitivities, in volts per centimeter of deflection, of 20, 10, 5, 2, 1, .5, .2, .1 and .05. When properly adjusted, the input resistance and capacitance of the unit remains unchanged as the attenuators are inserted.

Input Amplifier

The input amplifier, V3477 and V3487, is a common-cathode phase-splitter amplifier. R3397 and R3407 are current-limiting resistors to limit grid current in the event an excess voltage is applied to the input. The **DIFFERENTIAL BALANCE** control varies the voltage on the suppressor grids, raising one as it lowers the other. This increases the gain of one tube while decreasing the gain of the other. In this way the amplifier is adjusted for maximum rejection of the common-mode signal.

Cathode Follower

A cathode-follower stage, V3617B and V3627A, follows the input amplifier and provides a low-impedance drive for the output amplifiers. The input capacitance of the output amplifier varies as the gain controls are varied. The cathode-follower stage prevents this change of capacitance from affecting the high-frequency response.

C3557 and C3567 feed back the high-frequency components of the signal from each cathode to the grid of the opposite input amplifier. These capacitors are set to neutralize the grid-to-cathode capacitance of the input amplifiers. This prevents a high-frequency loss when the grid which is not being driven is at a high-impedance level.

Output Amplifier

The output-amplifier stage, V3617A and V3627B, amplifies the signal a second time and provides variable gain and positioning facilities. L3677 and L3687 are high-frequency peaking coils and are adjustable for best transient response.

The **VARIABLE VOLTS/CM** control, R3717, varies the gain over a 2½-to-1 ratio by varying the degeneration in the cathode circuit. Similarly, the **GAIN ADJ.** potentiometer sets the gain so that the sensitivity agrees with the front-panel calibration. The **DC BAL.** potentiometer balances the voltage on the cathodes so there is no vertical shift of the trace as the **VARIABLE VOLTS/CM** control is turned.

A dual potentiometer, R3827, positions the trace vertically. It is connected so that current is increased in one plate load as it is decreased in the other.

Output Cathode Followers

Frequency-compensated dividers reduce the dc potential applied to the cathode-follower grids to the correct value for the input of the Type 530-Series oscilloscopes. The **VERT. POS. RANGE** potentiometer allows the trace to be centered when the **VERTICAL POSITION** control is centered. The cathode followers, V3967, provide the low impedance necessary to drive the oscilloscope amplifier through the interconnecting plug. L3957 and L3967 are series peaking coils.

DC Heaters

The heaters for all the tubes in the preamp are connected in series to the regulated +100-volt supply through series dropping resistors in the plug-in unit and in the oscilloscope. This provides maximum stability in the presence of line voltage changes.



MAINTENANCE

Replacement of Components

Tektronix will supply replacement components at current net prices. However, since most of the components are standard electronic and radio parts we suggest you get them from your local dealer if you can. Be sure to consult your instruction manual first to see what tolerances are required.

We specially select some of the components, whose values must fall within prescribed limits, by sorting through our regular stocks. The components so selected will have standard RETMA color-code marks showing the values and tolerances of the stock they were selected from, but they will not in general be replaceable from dealers stocks.

Such selected parts, as well as the parts we manufacture at Tektronix, are identified in the parts lists either by notes or by our own stock numbers. Order these parts from the Tektronix factory in Portland, Oregon.

Parts-Ordering Information

You will find a serial number on the frontispiece of this manual. This is the serial number of the instrument the manual was prepared for. Be sure the manual number matches the number of the instrument when you order parts.

A Tektronix instruction manual usually contains hand-made changes to diagrams and parts lists, and sometimes text. These changes are in general only appropriate to the instrument the manual was prepared for, the instrument whose serial number appears on the manual frontispiece. The hand-made changes show changes to the instrument that have been made after the printing of the manual.

We make some of the instrument changes during the factory test procedure. Our technicians hand-tailor the circuits, if it seems appropriate, to provide the widest possible latitude of operation. Other changes are made to include the latest circuit improvements as they are developed in our engineering department, or when improved components become available. In any event, the changes are to your benefit. We have tried to give you the best instrument we can.

Soldering Precaution

The solder used on the ceramic terminals in this instrument must contain a small percentage of silver. If for any reason you resolder, be sure the solder you use contains silver. Silver-bearing

solder is used in printed-circuit techniques, and is therefore now available from all solder manufacturers. Repeated use of ordinary tin-lead solder will dissolve the fused bond of silver that makes the solder adhere to the porcelain, especially if the soldering iron is quite hot.

Adjustment

GENERAL

The following outline is based on the procedure used in our test department at the factory. Ordinarily, adjustment in the field will consist of merely touching up some of the dc level and balance controls, but if a complete readjustment is ever necessary, there is a sequence of adjustments that should be followed.

Most of the adjustments are accessible when the unit is plugged into a 530-Series oscilloscope whose cabinet is removed. However, some of the attenuators are more easily adjusted with the unit outside the oscilloscope. For this reason, we make the Type EP53 Plug-in Extension which permits the unit to operate outside the oscilloscope. The Type EP53 is available from Tektronix for \$5.00, postage paid.

Plug the unit into an oscilloscope and turn the power on. Wait about 5 minutes for the initial warm-up drift to cease. Free run the oscilloscope sweep at some convenient rate so a trace is visible on the crt face.

POSITIONING ADJUSTMENT

Center the **VERTICAL POSITION** control and adjust the **VERT. POS. RANGE** control until the trace is centered vertically.

DC BALANCE

Rotate the **VARIABLE VOLTS/CM** control back and forth while watching the trace for a vertical shift. Slowly turn the **DC BAL.** adjustment until the trace remains steady as the variable attenuator is rotated.

DIFFERENTIAL BALANCE ADJUSTMENT

Connect a 2-volt square-wave from the oscilloscope calibrator to both **INPUT A** and **INPUT B**. Set the input-selector switch to **A-B**. Set both **VOLTS/CM** switches to .05 and adjust the **DIFF. BAL.** adjustment for minimum deflection of the trace. Reset the **VERT. POS. RANGE** control. Failure to achieve a minimum deflection within range of the **DIFF. BAL.** control will normally indicate excessive difference between the characteristics of V3477 and V3487.



GAIN ADJUSTMENT

Connect a .2-volt signal from the oscilloscope calibrator to **INPUT A**, and set the input selector switch to **A**. Set the **VOLTS/CM** switch to .05 and turn the **VARIABLE VOLTS/CM** control clockwise against the stop to the **CALIBRATED** position. Adjust the **GAIN ADJ.** potentiometer to obtain four centimeters of deflection. Both attenuators use 1%-tolerance resistors, so this one adjustment should calibrate all ranges of both inputs.

DIVIDER COMPENSATION

If the Plug-in Extension is being used to make this adjustment, a shield should be placed over the unit to simulate chassis capacitance.

Connect a Tektronix Type 105 Square-Wave Generator to **INPUT A** using a 5-to-1 or 10-to-1 pad. Set the **VOLTS/CM** switch to the .05 position. Set the square-wave generator to 100 kc and adjust the amplitude for three or four centimeters of deflection. Adjust C3857 and C3867, mounted on ceramic strips near the rear of the plug-in unit, for a square corner and a flat top on the square wave. These adjustments interact, but one usually affects the corner more than the other.

NEUTRALIZATION ADJUSTMENT

Turn the input selector switch to **A—B**. Set both **VOLTS/CM** switches to .05. Apply a .2-volt square wave from the oscilloscope calibrator, to **INPUT A**. Set the sweep speed to see four or five cycles. Adjust C3567 for a square corner on the waveform, or so there is no change as the input selector switch is switched to **A**.

Next apply the square wave to **INPUT B** and adjust C3557 for a square corner on the square wave, or so there is no change as the input selector switch is switched to **—B**.

PEAKING-COIL ADJUSTMENT

Connect a Tektronix Type 105 Square-Wave Generator to **INPUT A** using a 5-to-1 or 10-to-1 pad. Set the **VOLTS/CM** switch to .05. Set the square-wave generator to 500 kc and adjust the amplitude for three or four centimeters of deflection. Adjust L3677 and L3687 for a square corner on the waveform, without over-shoot. Both slugs should be set to about the same position.

HIGH-FREQUENCY DIFFERENTIAL BALANCE

Connect a Tektronix Type 105 Square-Wave Generator to both inputs of the plug-in unit.

The length of the signal path to each input should be the same to avoid a phase difference between the two signals. At the factory we connect a tee coax connector to a properly terminated cable from the square-wave generator. To this tee we connect two six-inch coax cables, each of which is connected to one input. These two short cables should be of equal length, because a difference in length of one-half inch introduces a noticeable phase difference.

Set the input-selector switch to **A—B** and both **VOLTS/CM** switches to .05. Set the square-wave generator to 1 kc and the amplitude to about 2 volts. (The amplitude can be determined by switching the input-selector switch to **A** and the **"A"** **VOLTS/CM** switch to .5.) Recheck the adjustment of the front-panel differential-balance control.

Switch the square-wave generator to 500 kc. Set the oscilloscope sweep speed to 1 μ sec/cm and synchronize it with the waveform, using external trigger and the **SYNC OUTPUT** terminal on the square-wave generator. Adjust C3417 and C3427 for minimum deflection of the trace.

ATTENUATOR ADJUSTMENTS

For best results, the attenuator adjustments should be made with a square-wave generator having a short rise time, such as the Tektronix Type 105. An approximate adjustment can be made by using the calibrator waveform, but it is easy to over-compensate the attenuator when using this wave-form because of its long risetime.

There is an input capacitance adjustment in each position of both **VOLTS/CM** switches. All Tektronix Type 53-Series plug-in units are adjusted to have a standard input capacitance of 47 μ f. This makes the probes interchangeable between units without readjustment. To preserve this interchangeability, a standardized probe should be used in the following adjustments.

To standardize a probe, plug it into a unit you know to be properly adjusted and observe the calibrator waveform. Adjust the trimmer in the probe for a flat top on the waveform.

Attach the standard probe to **INPUT A** and connect it to the output of the square-wave generator. Set the square-wave generator to 1 kc and set the oscilloscope sweep speed to obtain five or six cycles on the screen. Set the input selector switch to **A**.



Adjust the capacitors listed in the following table with the **VOLTS/CM** switch in the position indicated. Adjust each capacitor for the flattest top possible on the square wave.

VOLTS/CM	CAPACITOR
.05	C3037
.1	C3257
	C3297
.2	C3197
	C3217
.5	C3137
	C3157
5	C3077
	C3097

Attach the standard probe to **INPUT B** and set the input-selector switch to **—B**. Adjust the capacitors shown in the table below.

VOLTS/CM	CAPACITOR
.05	C3047
.1	C3267
	C3307
.2	C3207
	C3227
.5	C3147
	C3167
5	C3087
	C3107

Turn the input-selector switch to **A—B** and recheck the neutralization adjustment.

Set both **VOLTS/CM** switches to .05 and the input selector switch to **A—B**. Connect both inputs to the oscilloscope calibrator and set the calibrator to 2 volts. Check the differential-balance adjustment. Move both **VOLTS/CM** switches to the positions shown below and switch the calibrator to the voltage listed. If there is a spike on the resulting waveform which exceeds one-half centimeter, adjust the capacitors listed very slightly to reduce this spike. The square wave which remains in some positions is caused by a slight unbalance in the 1% tolerance attenuator resistors.

VOLTS/CM	CAL.	CAPACITOR
.1	5	C3297
		C3307
.2	10	C3217
		C3227
.5	20	C3157
		C3167
5	100	C3097
		C3107



ABBREVIATIONS

Cer.	ceramic	m	milli or 10 ⁻³
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	PT	paper tubular
h	henry	Tub.	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

Capacitors

Order Parts by Number

C3017	.1 μf	PT	Fixed	600 v	Selected*	295048
C3027	.1 μf	PT	Fixed	600 v		
C3037	1.5-7 μμf	Cer.	Var.	500 v		281005
C3047	1.5-7 μμf	Cer.	Var.	500 v		281005
C3087	1.5-7 μμf	Cer.	Var.	500 v		281005
C3077	1.5-7 μμf	Cer.	Var.	500 v		281005
C3097	5-20 μμf	Cer.	Var.	500 v		281010
C3107	5-20 μμf	Cer.	Var.	500 v		281010
C3117	.002 μf	Mica	Fixed	500 v	5%	283529
C3127	.002 μf	Mica	Fixed	500 v	5%	283529
C3137	3-12 μμf	Cer.	Var.	500 v		281007
C3147	3-12 μμf	Cer.	Var.	500 v		281007
C3157	5-20 μμf	Cer.	Var.	500 v		281010
C3167	5-20 μμf	Cer.	Var.	500 v		281010
C3177	150 μμf	Mica	Fixed	500 v	10%	283508
C3187	150 μμf	Mica	Fixed	500 v	10%	283508
C3197	1.5-7 μμf	Cer.	Var.	500 v		281005
C3207	1.5-7 μμf	Cer.	Var.	500 v		281005
C3217	5-20 μμf	Cer.	Var.	500 v		281010
C3227	5-20 μμf	Cer.	Var.	500 v		281010
C3237	27 μμf	Cer.	Fixed	500 v	10%	281512
C3247	27 μμf	Cer.	Fixed	500 v	10%	281512
C3257	1.5-7 μμf	Cer.	Var.	500 v		281005
C3267	1.5-7 μμf	Cer.	Var.	500 v		281005
C3277	10 μμf	Cer.	Fixed	500 v	10%	281504
C3287	10 μμf	Cer.	Fixed	500 v	10%	281504
C3297	5-20 μμf	Cer.	Var.	500 v		281010
C3307	5-20 μμf	Cer.	Var.	500 v		281010
C3397	.01 μf	Cer.	Fixed	500 v	GMV	283002
C3407	.01 μf	Cer.	Fixed	500 v	GMV	283002
C3417	1.5-7 μμf	Cer.	Var.	500 v		281005
C3427	1.5-7 μμf	Cer.	Var.	500 v		281005
C3507	6.25 μf	EMC	Fixed	300 v	-20%+50%	295020
C3517	.01 μf	Cer.	Fixed	500 v	GMV	283002
C3527	.01 μf	Cer.	Fixed	500 v	GMV	283002
C3557	1.5-7 μμf	Cer.	Var.	500 v		281005
C3567	1.5-7 μμf	Cer.	Var.	500 v		281005
C3867	1.5-7 μμf	Cer.	Var.	500 v		281006
C3857	1.5-7 μμf	Cer.	Var.	500 v		281006
C3947	.01 μf	Cer.	Fixed	500 v	GMV	283002
C3987	.01 μf	Cer.	Fixed	500 v	GMV	283002

* Within 1% of each other.



Inductors

Order Parts
by Number
108072
108072
114007
114007
108062
108062

L3477	.75 μ h	Fixed
L3487	.75 μ h	Fixed
L3677	2.2-4.4 μ h	Var.
L3687	2.2-4.4 μ h	Var.
L3957	.45 μ h	Fixed
L3967	.45 μ h	Fixed

Resistors

R3037	27 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302270
R3047	27 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302270
R3057	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3067	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3097	990 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309013
R3107	990 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309013
R3117	10.1 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309034
R3127	10.1 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309034
R3157	900 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309111
R3167	900 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309111
R3177	111 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309046
R3187	111 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309046
R3217	750 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309010
R3227	750 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309010
R3237	333 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309053
R3247	333 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309053
R3277	500 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309003
R3287	500 k	$\frac{1}{2}$ w	Fixed	Prec.	1%	309003
R3297	1 meg	$\frac{1}{2}$ w	Fixed	Prec.	1%	309014
R3307	1 meg	$\frac{1}{2}$ w	Fixed	Prec.	1%	309014
R3377	1 meg	$\frac{1}{2}$ w	Fixed	Prec.	1%	309014
R3387	1 meg	$\frac{1}{2}$ w	Fixed	Prec.	1%	309014
R3397	390 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302394
R3407	390 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302394
R3417	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3427	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3447	10 k	5 w	Fixed	WW	5%	308054
R3477	470 Ω	$\frac{1}{2}$ w	Fixed	Comp.	5%	301471
R3487	470 Ω	$\frac{1}{2}$ w	Fixed	Comp.	5%	301471
R3507	18 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302183
R3517	3.3 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302332
R3527	3.3 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302332
R3537	15 k	2 w	Var.	Comp.	20%	311045
R3547	100 k	$\frac{1}{2}$ w	Fixed	Comp.	10%	302104
R3577	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3587	47 Ω	$\frac{1}{2}$ w	Fixed	Comp.	10%	302470
R3597	15 k	2 w	Fixed	Comp.	10%	306153
R3607	15 k	2 w	Fixed	Comp.	10%	306153
R3677	680 Ω	$\frac{1}{2}$ w	Fixed	Comp.	5%	301681
R3687	680 Ω	$\frac{1}{2}$ w	Fixed	Comp.	5%	301681

DIFF. BAL.



Resistors (continued)							Order Parts by Number
R3717	1 k	2 w	Var.	Comp.	20%	VARIABLE VOLTS/CM	311006
R3727	500 Ω	1/10 w	Var.	Comp.	20%	Gain Adj.	311056
R3737	22 k	2 w	Fixed	Comp.	10%		306223
R3747	22 k	2 w	Fixed	Comp.	10%		306223
R3767	100 k	2 w	Var.	Comp.	20%	DC Bal.	311026
R3777	47 k	1/2 w	Fixed	Comp.	10%		302473
R3797	100 k	1/2 w	Fixed	Comp.	10%		302104
R3807	100 k	1/2 w	Fixed	Comp.	10%		302104
R3827	2x100 k	2 w	Var.	Comp.	20%	VERTICAL POSITION	311028
R3857	143 k	1 w	Fixed	Prec.	1%		310088
R3867	143 k	1 w	Fixed	Prec.	1%		310088
R3877	200 k	1 w	Fixed	Prec.	1%		310051
R3887	200 k	1 w	Fixed	Prec.	1%		310051
R3907	5 k	2 w	Var.	Comp.	20%	Vert. Pos. Range	311049
R3917	47 Ω	1/2 w	Fixed	Comp.	10%		302470
R3927	47 Ω	1/2 w	Fixed	Comp.	10%		302470
R3947	3.3 k	2 w	Fixed	Comp.	10%		306332
R3957	6.8 k	2 w	Fixed	Comp.	10%		306682
R3967	6.8 k	2 w	Fixed	Comp.	10%		306682
R3987	84 Ω	5 w	Fixed	WW	5%		308056

Switches					not wired	wired
SW3027	2 wafer	6 position	rotary	Input Selector	260092	—
SW3057	4 wafer	9 position	rotary	VOLTS/CM	260091	262077
SW3067	4 wafer	9 position	rotary	VOLTS/CM	260091	262078

Vacuum Tubes					
V3477	12AU6	Input Amplifier		Selected	157012
V3487	12AU6	Input Amplifier		Selected	157012
V3617A	1/2 12AT7	Output Amplifier	}	Checked	157030
V3617B	1/2 12AT7	Cathode Follower			
V3627A	1/2 12AT7	Cathode Follower	}	Checked	157030
V3627B	1/2 12AT7	Output Amplifier			
V3967	12AT7	Output Cathode Follower		Checked	157030



