APPENDIX J

TYPE J VERTICAL AMPLIFIER - HIGH-GAIN WIDEBAND

GENERAL

The Type J plug-in is a four-range amplifier offering a continuous coverage of sensitivities from 100µV to 125V/cm on a.c. and 10mV to 125V/cm on d.c. at bandwidths up to 25MHz.

The amplifier may be used in either the 43 or 53 series of oscilloscope.

TECHNICAL DATA

Sensitivity, approximate 3dB bandwidth and risetime.

Input coupling	Y gain	Calibrated sensitivity per cm +5%	Bandwidth	Risetime
DC	x1	100mV-50V	d.c.-25MHz	14ns
	x10	10mV-5V	d.c.-5MHz	70ns
AC	x1	100mV-50V	3Hz-25MHz	14ns
	x10	10mV-5V	3Hz-5MHz	70ns
ACx100	x1	1mV-500mV	3Hz-100kHz	3.5µs
	x10	100µV-50mV	3Hz-100kHz	3.5µs

Maximum input (via 400V capacitor a.c. coupled)	
DC & AC	400Vp
ACx100	100mVp-p before limiting
Input impedance approx.	
DC & AC	1 megohm & 60pF
ACx100	1 megohm & 20pF
Hum and noise	
Short-circuited input	20µVp-p or better
Open-circuited but shielded input	100µVp-p or better

Calibrator output		1Vp-p ± 2%
Overall dimensions approx.		
Height	6cm	2½ in
Width	20cm	7¾ in
Depth	35cm	13¾ in
Net weight approx.	1.4 kg	3 lb

OPERATION

Input

The outer of the UHF socket and the LOW terminal are not connected directly to chassis but through a 100ohm resistor. In most applications this resistor may be shorted-out by the plated earthing link, but where multiple-earth paths introduce problems, reference should be made to the General Description section of the main part of the manual.

Input selector switch

AC x100 In this setting a two-stage low-noise preamplifier, with a gain of 100 and a bandwidth of 100kHz is switched into circuit before the input attenuator; either the x1 or x10 Y GAIN switch settings may be used in conjunction. Since the maximum input signal handling capacity of the preamplifier, before limiting occurs, is 100mVp-p, it is recommended that, for signals in excess of 60mVp-p, the AC or DC input switch settings should be used. A 6cm display is obtainable from a 60mV signal on AC or DC with VOLTS/CM at 0.1 and Y GAIN at x10.

AC Except for inputs below 60mVp-p, when the ACx100 facility may be used as noted above, the AC position will be found usually more convenient than DC. This avoids frequent resetting of the shift control due to changes in d.c. level of input signals.

DC This position should be used for d.c. voltage measurement and for displaying low-frequency signals when the input time-constant on AC is inadequate to prevent waveform distortion. If d.c. blocking at very low frequencies is desired, the signal should be fed through an external capacitor, greater than 0.1μF with the switch set at DC.

Y shift

This control positions the display in the vertical axis of the CRT.

Volts/cm

A setting should be chosen to produce a convenient amplitude of display. With the variable control fully clockwise at CAL the calibrations, which relate to the x1 Y gain setting on AC or DC, are accurate to within ± 5%.

Variable

Amplifier gain may be reduced by a factor of up to 2.5:1 or greater, from the calibrated setting, by anti-clockwise rotation of this control. Volts/cm calibrations are only valid when VARIABLE is fully clockwise.

Y gain

The x1 or x10 setting should be selected as appropriate for the amplitude of the signal to be observed. The volts/cm indications should be divided by 10 in the x10 gain condition and further divided by 100 in the ACx100 condition.

Amplifier d.c. balance and x1 gain may be readily checked as follows:-

Check d.c. balance: In x1 gain condition and with no input signal, centre trace with Y SHIFT. Switch to x10 and recentre trace with DC BAL. Repeat until no trace shift occurs when switching between x1 and x10.

Check x1 gain: Select x1 gain, DC input and 0.2V/cm. Link CAL 1Vp-p and INPUT and adjust SET GAIN for a 5cm display. If there is insufficient range of adjustment, refer to Recalibration section.

Adjustment of probe trimmer

This adjustment is best carried out with a squarewave of about 1kHz. Connect the probe lead to the INPUT socket and apply the probe tip to the output of the squarewave generator. Adjust controls to display a few cycles of squarewave of about 5cm in amplitude and adjust the probe trimmer to give square corners and a flat top to the displayed waveform.

In the Type HZ1 probe, the trimmer has a screwdriver adjustment through a hole in the probe body.

To compensate the Type GE81000, slacken the narrower of the two knurled rings at the oscilloscope end of the probe lead, then rotate the adjacent broader ring until correct compensation is obtained. Retighten the narrower locking ring, taking care that the setting of the other ring is not disturbed.

NOTE The probe will require recompensation on switching between AC or DC and ACx100 and vice versa.

CIRCUIT DESCRIPTION

Preamplifier and attenuator - Figure J1

In the ACx100 position of S1, the input signal is passed via blocking capacitor C1 to the gate of TR1, an n-channel field-effect transistor. MR1 & 2 protect TR1 against over-voltage, R4 limiting the current through the diodes. Adjustment of overall preamplifier gain is effected by RV6 which controls the degree of feedback in the source of TR1.

The signal at the drain of TR1 is RC-coupled to the base of TR2, a grounded-emitter stage. The output at the collector is taken via C5 to the attenuator.

A stabilised supply at 13v for TR1 & 2 is provided by reference diode MR3 in association with C6 & R10.

The preamplifier is by-passed in the AC and DC positions of S1. The input signal is applied either via C1 or directly to the attenuator. S2 selects four frequency-compensated resistive dividers which are used singly or in tandem to give nine division ratios. The first section provides ratios of 1, 10 or 100:1 and the second section ratios of 1, 2 or 5:1. C10, 11, 14, 15, 18 & 19 serve to equalise time-constant for all ranges. C8 & 9 affect compensation only when a high-impedance probe is used.

The single-ended output from the attenuator is applied to the grid of V21 in the main amplifier.

Amplifier - Figure J2

V21 & 22 form a cathode-coupled phase-splitting stage which provides a push-pull output at the anodes. Gain control is provided by VARIABLE RV29. C23 compensates for variation of input capacitance of V21 with change of gain. SET GAIN RV37 and PRESET GAIN RV38 enable the amplifier gain to be accurately set in the x1 gain condition. VAR BAL RV41 is set for no trace shift on variation of RV29. Shift voltage is applied to the grid of V22 from Y SHIFT RV56. In the x10 gain condition R54 is brought into circuit to restrict the voltage swing provided by RV56. DC BAL RV58 is adjusted for no trace shift on switching between x1 and x10 gain. The voltage across RV58 is clamped at about 1 volt by MR22 & 23.

MR21 provides a d.c. supply for the heaters of V21 & 22; after further filtering, this supply is used to provide a negative voltage for the shift circuit and for the input stage tail via MR24.

Zener diode MR24 enables amplifier gain to vary inversely with changes in CRT deflection sensitivity caused by small changes in supply voltage.

The output at the anodes of V21 & 22 is coupled to the complementary long-tailed pair TR21, 23 & 22, 24. TR23 & 24 are effectively shorted-out in the x1 gain position, reducing the gain of the pair by a factor of 10. RV34 adjusts the feedback between TR23 & 24 and hence the gain of the stage in the x10 condition. R35, C32 and C33, R36 are frequency compensating components.

HT current for the shift circuit and the input stages V21, 22 and TR21 to 24 is provided mainly by the emitter currents of TR27 & 28 via R67 & 71. This arrangement has the merit of reducing total current consumption and of forming a feedback loop to stabilise gain and shift. The balance of the input stages' current is derived via R66.

The signal at the collectors of TR23 & 24 is directly-coupled to the bases of TR25 & 26, which form an emitter-coupled pair. Feedback via RV65 & C25 is adjusted for best transient response.

The bases of output emitter-followers TR27 & 28 are driven from the collectors of TR25 & 26. The output at the emitters of TR27 & 28 is coupled directly to the Y plates of the CRT via spring contacts at the left-hand side of the amplifier. A further spring contact at the right-hand side connects the output at the emitter of TR27 via R68 & C34 to the timebase trigger circuit for internal triggering of the sweep.

RECALIBRATION

The following procedure should be adopted if a more thorough recalibration is required than the balance and gain checks outlined in the operation section.

NOTE Insulated tools should be used for all internal adjustments to avoid the risk of damage to semi-conductors. All internal presets are accessible from the left-hand side excepting attenuator trimmers which are situated on the right.

A squarewave amplitude calibrator is required with an output in the region of 1kHz, variable between 50mV and 100Vp-p. For step 10 a squarewave generator of 5ns or better risetime is necessary with a termination to match its output impedance. The generator should have an output of up to about 500mV at a frequency from 100kHz to 1MHz.

1 Preliminary

Plug the amplifier into an oscilloscope, switch on and leave for at least 20 minutes for temperature to become stable.

2 d.c. balance

Set INPUT to DC, VOLTS/CM to 0.1, VARIABLE fully clockwise to CAL and Y GAIN at x1. Centre trace with Y SHIFT. Switch Y GAIN to x10 and recentre trace with DC BAL. Repeat, adjusting Y SHIFT on x1 and DC BAL on x10, until there is no trace shift on switching between x1 and x10.

3 Variable balance

Set Y GAIN at x10 and VARIABLE fully anti-clockwise. Centre trace with RV41 VAR BAL. Turn VARIABLE fully clockwise and recentre trace with DC BAL. Repeat, adjusting RV41 with VARIABLE anti-clockwise and DC BAL with VARIABLE clockwise, until there is no trace shift on rotation of VARIABLE.

Check that there is no trace movement when operating Y GAIN buttons. If trace moves, repeat steps 2 and 3.

4 Gain x1

With VOLTS/CM at 0.1, set VARIABLE fully clockwise, Y GAIN at x1 and SET GAIN slightly anti-clockwise of mid-range. Feed in a 500mVp-p 1kHz squarewave and adjust RV38 PRESET GAIN x1 for about 5cm deflection; RV38 is suspended between L21 & 22, adjacent to the two valves. Adjust SET GAIN for precisely 5cm deflection.

5 Gain x10

Reduce input to 50mVp-p and set Y GAIN at x10. Adjust RV34 SET GAIN x10 for 5cm deflection.

6 Gain ACx100

Reduce input to 5mVp-p, set Y GAIN at x1 and INPUT at ACx100. Adjust RV6, through the circular hole left-front, for 5cm deflection. Return INPUT to DC.

7 Amplifier input capacitance

With Y GAIN at x1, set VARIABLE fully anti-clockwise and VOLTS/CM at 0.2. Feed in about 1Vp-p at 1kHz from the calibrator and adjust C18 on attenuator for best squarewave. Turn VARIABLE fully clockwise and adjust C23, beside V21 & 22, for best corner with no overshoot. Repeat, adjusting C18 with VARIABLE anti-clockwise and C23 with VARIABLE clockwise, until there is no change at the corners of the squarewave with rotation of VARIABLE.

8 Attenuator compensation

With VARIABLE clockwise and Y GAIN at x1, set VOLTS/CM and 1kHz calibrator output as over. Adjust the appropriate trimmer for best squarewave with no undershoot or overshoot at the corners.

Volts/cm	Calibrator Vp-p	Adjust
0.2	1	C18
0.5	2.5	C19
1	5	C10
2	10	C14
5	25	C15
10	50	C11

9 Probe adjustment and attenuator compensation for probe

Remove squarewave input and connect probe between INPUT and calibrator. Set VOLTS/CM and 1kHz calibrator output as below and adjust appropriate trimmer for best squarewave. The calibrator output is stated for a x10 probe.

Volts/cm	Calibrator Vp-p	Adjust
0.1	5	Probe
1	50	C8
10	100	C9

10 High-frequency compensation

Remove probe and, with Y GAIN at x1 and VOLTS/CM at 0.1, connect the fast-rise squarewave generator via appropriate termination. Adjust output for 300 to 500mVp-p at a frequency from 100kHz to 1MHz. Unscrew cores of L21 & 22 until they are nearly out of the formers and set RV65 fully clockwise. Since the following adjustments affect only about the first 100ns of each half-cycle of squarewave, a fast sweep speed is required; however a slower speed should be selected from time to time during the procedure to check the squarewave for flat tops.

Adjust C25 for best corner. Turn RV65 slightly anti-clockwise, this will round-off the corner so readjust C25 to restore the corner. Repeat this procedure of reducing

RV65 and adjusting C25 until the sharpest corner without ringing is obtained. Over-reduction of RV65 will result in the shape of the corner deteriorating.

L21 & 22 should now be adjusted. Screw-in the core of either inductor to a position just before over-shoot begins to appear. Screw-in the core of the other inductor similarly. Adjust both cores in step for the fastest leading-edge and square corner.

The 3dB bandwidth should not be less than 25MHz on x1 gain, 5MHz on x10 gain and 3Hz to 100kHz on ACx100. Repeat step 10 if the specified bandwidth has not been attained.

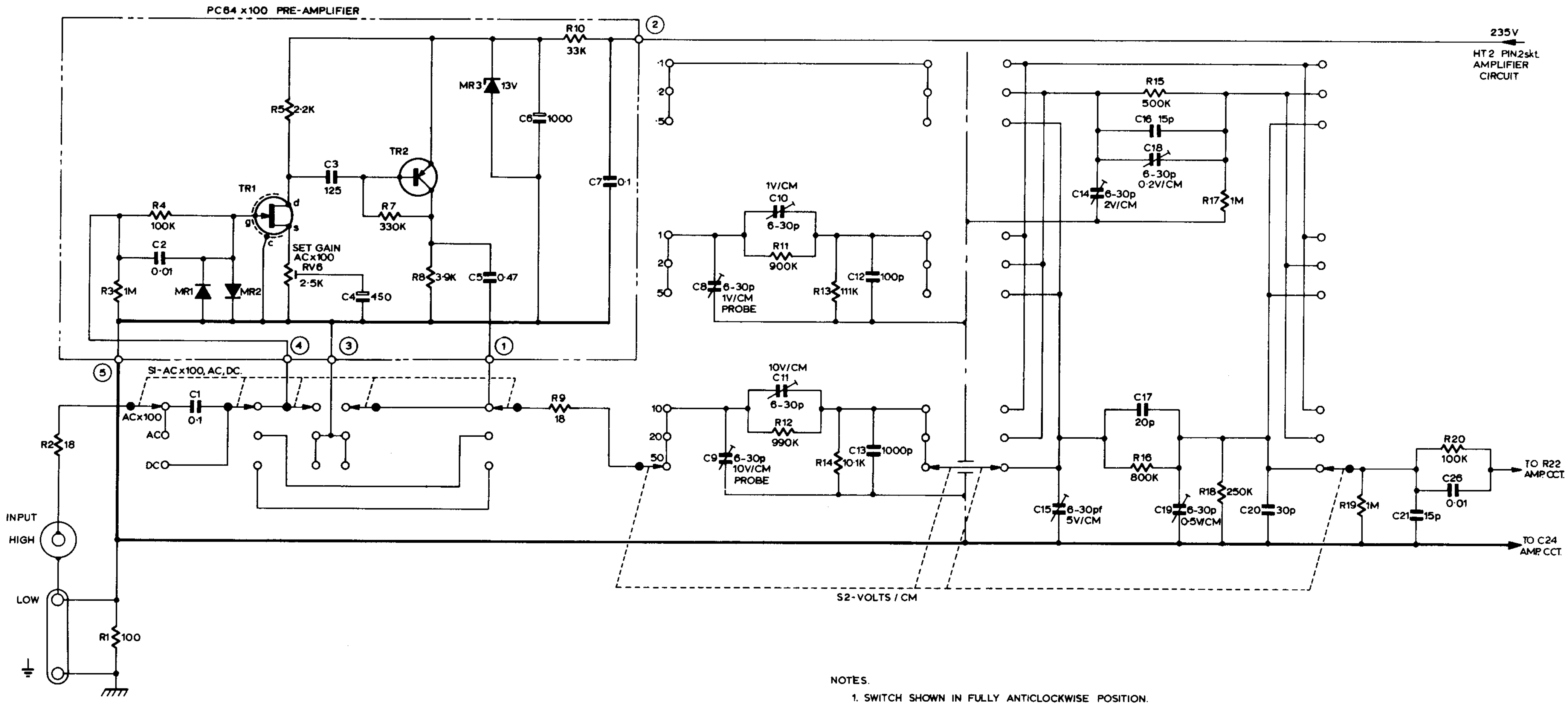
Cct. ref.	Part number	Value	Description	Tol. %	Rating
R1	316-0101-01	100	C		
R2	316-0180-01	18	C		
R3	319-0031-01	1M	HS	1	$\frac{1}{4}$
R4	316-0104-01	100k	C		
R5	315-0222-01	2.2k	C	5	$\frac{1}{4}$
RV6	311-0877-00	2.5k	CP	30	0.1
R7	319-0108-00	330k	HS	1	$\frac{1}{4}$
R8	316-0392-01	3.9k	C		
R9	316-0180-01	18	C		
R10	307-0137-00	33k	MO	5	$1\frac{1}{2}$
R11	319-0005-01	900k	HS	1	$\frac{1}{4}$
R12	319-0119-00	990k	HS	1	$\frac{1}{4}$
R13	319-0096-00	111k	HS	1	$\frac{1}{4}$
R14	319-0120-00	10.1k	HS	1	$\frac{1}{4}$
R15	319-0112-00	500k	HS	1	$\frac{1}{4}$
R16	319-0118-00	800k	HS	1	$\frac{1}{4}$
R17	319-0031-01	1M	HS	1	$\frac{1}{4}$
R18	319-0103-00	250k	HS	1	$\frac{1}{4}$
R19	319-0031-01	1M	HS	1	$\frac{1}{4}$
R20	316-0104-01	100k	C		
R21	316-0470-01	47	C		
R22	316-0101-01	100	C		
R23	307-0137-00	33k	MO	5	$1\frac{1}{2}$
R24	316-0562-01	5.6k	C		
R25	316-0561-01	560	C		
R26	315-0681-01	680	C	5	$\frac{1}{4}$
R27	316-0221-01	220	C		
R28	316-0100-01	10	C		
RV29	311-0726-00	500	CV	20	$\frac{1}{4}$
R31	316-0562-01	5.6k	C		
R32	316-0102-01	1k	C		
R33	316-0182-01	1.8k	C		
RV34	311-0798-00	2.2k	CP	20	$\frac{1}{4}$
R35	316-0154-01	150k	C		
R36	316-0331-01	330	C		
RV37	311-0723-00	500	CP	20	$\frac{1}{4}$

Carbon resistors are 10% $\frac{1}{4}$W unless otherwise shown

Cct. ref.	Part number	Value	Description	Tol. %	Rating
RV38	311-0909-00	20k	CP	20	0.05
R39	316-0122-01	1.2k	C		
RV41	311-0719-00	470	CP	20	$\frac{1}{4}$
R42	316-0562-01	5.6k	C		
R43	316-0100-01	10	C		
R44	316-0562-01	5.6k	C		
R45	316-0561-01	560	C		
R46	315-0681-01	680	C	5	$\frac{1}{4}$
R47	316-0221-01	220	C		
R48	307-0137-00	33k	MO	5	$1\frac{1}{2}$
R49	316-0101-01	100	C		
R51	316-0470-01	47	C		
R52	316-0684-01	680k	C		
R53	316-0683-01	68k	C		
R54	316-0106-01	10M	C		
R55	316-0474-01	470k	C		
RV56	311-0778-00	100k	CV	20	$\frac{1}{4}$
R57	316-0473-01	47k	C		
RV58	311-0783-00	100k	CP	20	$\frac{1}{4}$
R59	316-0473-01	47k	C		
R61	316-0180-01	18	C		
R62	316-0121-01	120	C		
R63	307-0164-00	1.5k	MO	5	$3\frac{1}{4}$
R64	307-0163-00	22k	MO	5	$3\frac{1}{4}$
RV65	311-0712-00	100	CP	20	$\frac{1}{4}$
R66	307-0146-00	7.5k	MO	5	$1\frac{1}{2}$
R67	307-0140-00	1.8k	MO	5	$1\frac{1}{2}$
R68	316-0152-01	1.5k	C		
R69	307-0176-00	3.9k	MO	5	7
R71	307-0140-00	1.8k	MO	5	$1\frac{1}{2}$
R72	316-0121-01	120	C		
R73	307-0164-00	1.5k	MO	5	$3\frac{1}{4}$
R74	307-0163-00	22k	MO	5	$3\frac{1}{4}$
R75	316-0271-01	270	C		
R76	316-0180-01	18	C		
R77	307-0185-00	1.5k	MO	5	$1\frac{1}{2}$
R78	308-0484-00	7.5	WW	5	2

Cct. ref.	Part number	Value	Description	Tol. %	Rating
C1	285-0772-00	0.1	PE	10	400
C2	285-0769-00	0.01	PE	20	400
C3	290-0406-00	125	E		4
C4	290-0341-00	450	E		3
C5	285-0779-00	0.47	PE	20	100
C6	290-0377-00	1,000	E		16
C7	285-0796-00	0.1	PE	20	250
C8	281-0137-00	6-30p	CT		350
C9	281-0137-00	6-30p	CT		350
C10	281-0137-00	6-30p	CT		350
C11	281-0137-00	6-30p	CT		350
C12	285-0854-00	100p	PS	2p	350
C13	285-0850-00	1,000p	PS	5	125
C14	281-0137-00	6-30p	CT		350
C15	281-0137-00	6-30p	CT		350
C16	285-0842-00	15p	PS	1p	500
C17	285-0867-00	20p	PS	1p	500
C18	281-0137-00	6-30p	CT		350
C19	281-0137-00	6-30p	CT		350
C20	285-0843-00	30p	PS	2p	500
C21	285-0842-00	15p	PS	1p	500
C23	281-0136-00	3-10p	CT		250
C24	285-0779-00	0.47	PE	20	100
C25	281-0132-00	10-40p	CT		250
C26	285-0769-00	0.01	PE	20	400
C27	290-0350-00	40	E		100
C28	290-0347-00	8	E		300
C29	290-0407-00	640	E		16
C30	290-0407-00	640	E		16
C31	290-0385-00	2,000	E (1,000 + 1,000)		18
C32	285-0850-00	1,000p	PS	5	125
C33	285-0786-00	33p	PS	2p	500
C34	285-0772-00	0.1	PE	10	400
C35	290-0347-00	8	E		300
L21	114-0263-00	2.2-5.1μH	Variable inductor		
L22	114-0263-00	2.2-5.1μH	Variable inductor		

Cct. ref.	Part number	Value	Description	Tol. %	Rating
MR1	152-0062-01		1N914 Si		
MR2	152-0062-01		1N914 Si		
MR3	152-0372-00	13V	Si zener	5	0.33W
MR21	152-0339-00	50V	Si rectifier		0.5A
MR22	152-0062-01		1N914 Si		
MR23	152-0062-01		1N914 Si		
MR24	152-0348-00	6.2V	Si zener	5	0.33W
S1	260-1027-00		Rotary (3-position)		
S2	260-0953-00		Rotary (9-position)		
S21	260-0997-00		Push (2-button)		
TR1	151-0265-00		KEM103 Union Carbide Si		
TR2	151-0244-00		U15712/2 Fairchild Si		
TR21	151-0242-00		SPS2506 Motorola Si		
TR22	151-0242-00		SPS2506 Motorola Si		
TR23	151-0244-00		U15712/2 Fairchild Si		
TR24	151-0244-00		U15712/2 Fairchild Si		
TR25	151-0245-00		2N1564T C.S.F. Si		
TR26	151-0245-00		2N1564T C.S.F. Si		
TR27	151-0245-00		2N1564T C.S.F. Si		
TR28	151-0245-00		2N1564T C.S.F. Si		
V21	154-0535-00		EF184/6EJ7		
V22	154-0535-00		EF184/6EJ7		

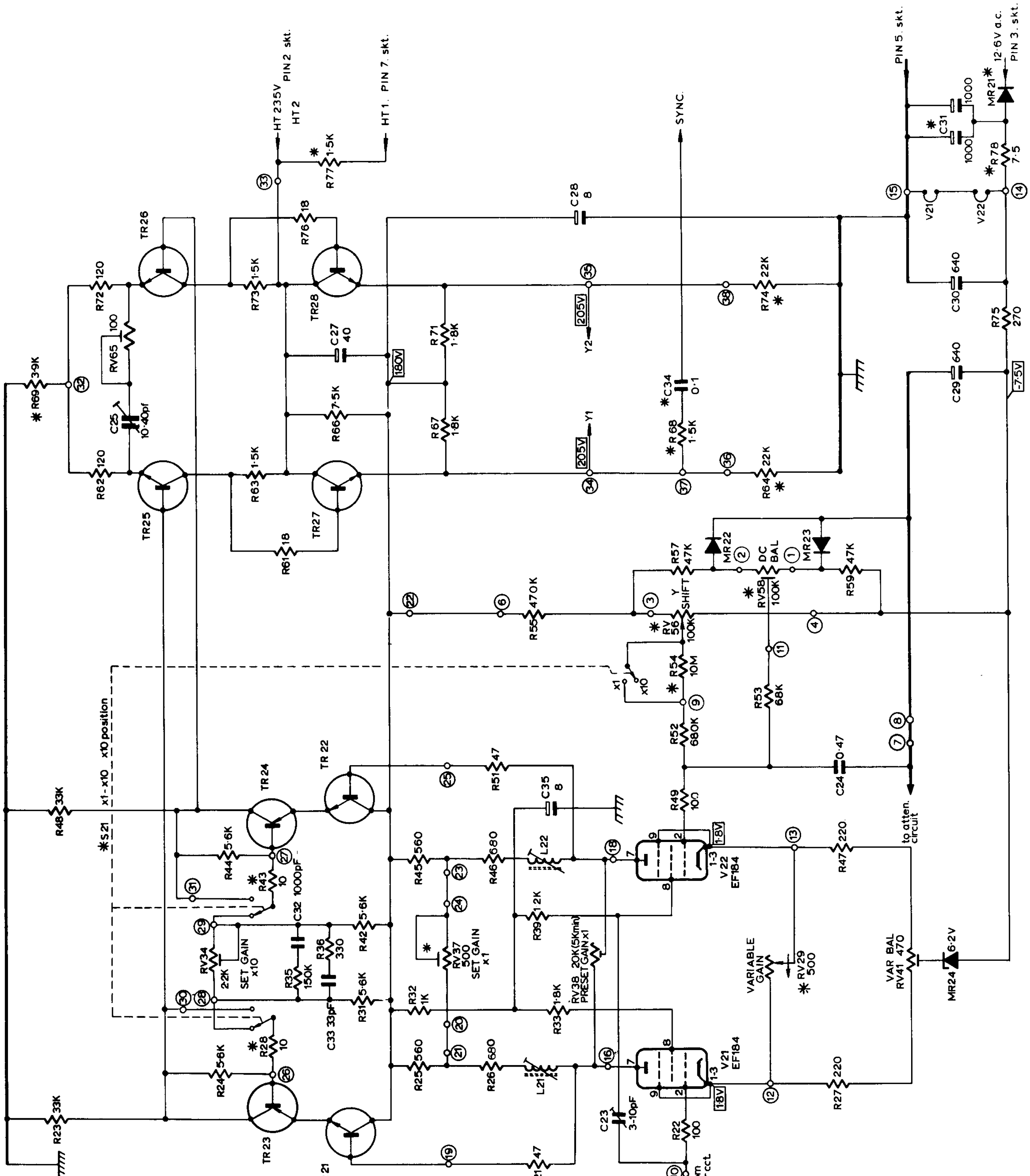


NOTES.

1. SWITCH SHOWN IN FULLY ANTICLOCKWISE POSITION.
2. (N°) DENOTES TAG NUMBERS ON PRINTED CIRCUIT BOARD PC64.

PRE-AMPLIFIER & ATTENUATOR TYPE J

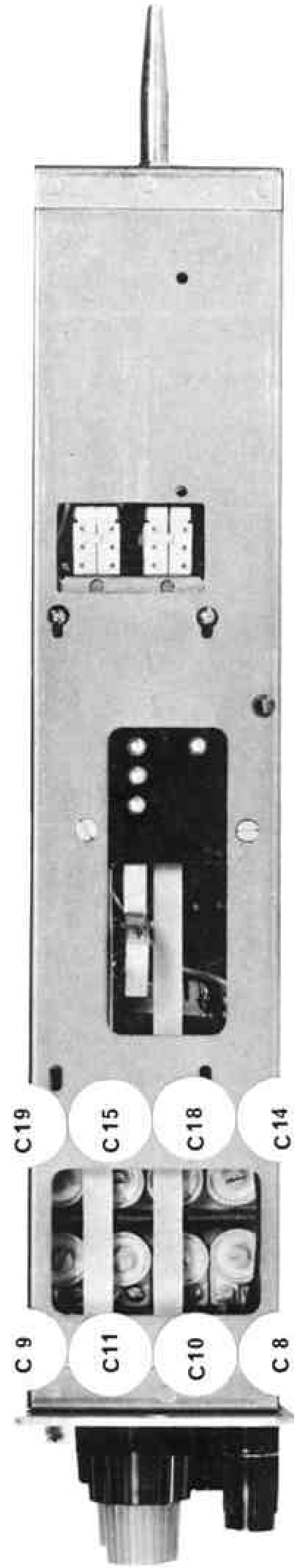
FIG.J·1



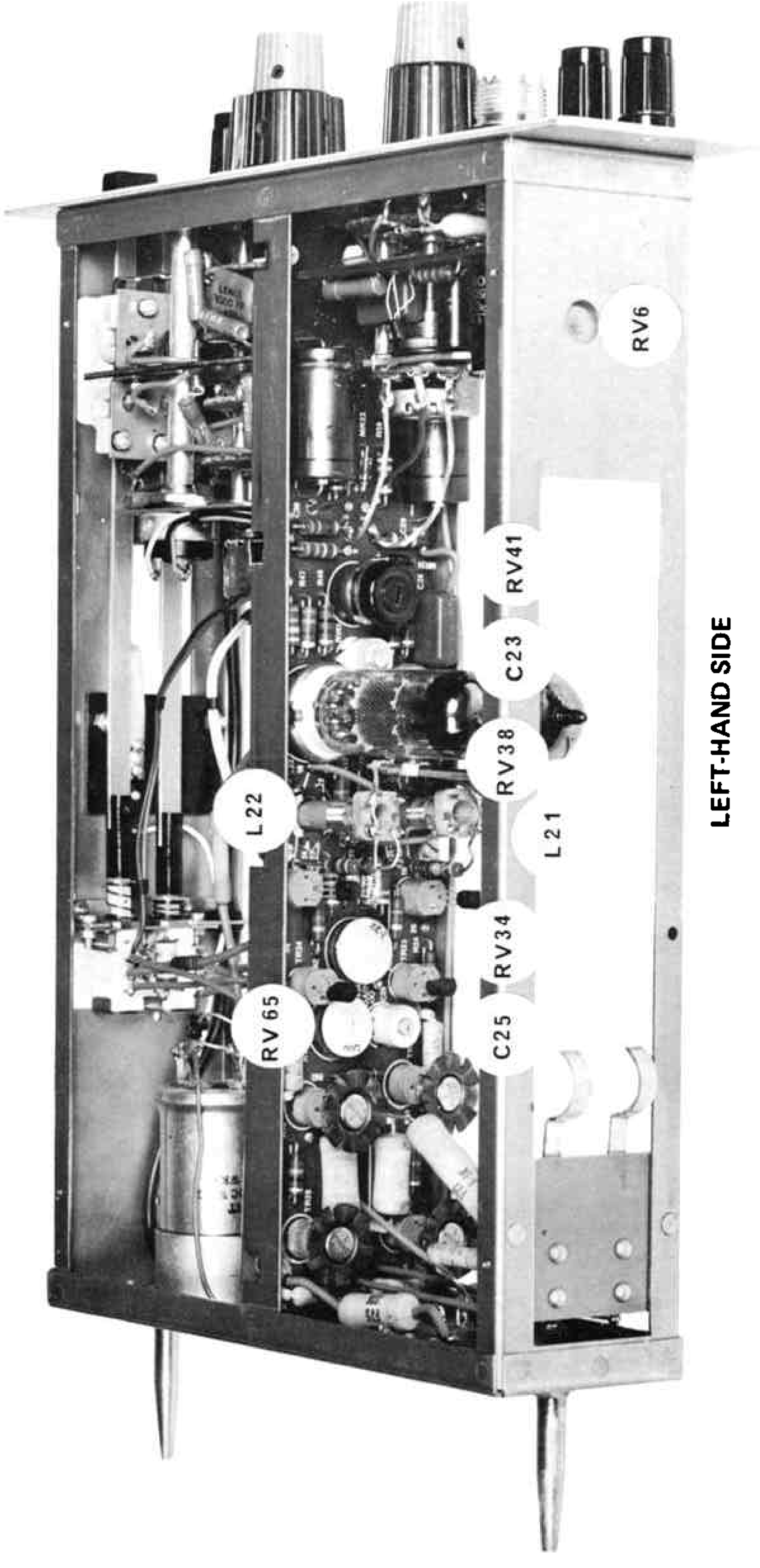
AMPLIFIER TYPE J FIG. J·2

NOTES
1. ✱ DENOTES COMPONENTS NOT MOUNTED ON PC66
2. (N°) DENOTES TAGS ON PRINTED CIRCUIT

CONNECTIONS TO POWER SOCKET(skt)
1. 110V AC
2. HT 2
3. 12·6V AC
4. 1vpp. CAL
5. EARTH
6. 110V AC
7. HT 1
8. 6·3V AC



RIGHT-HAND SIDE



LEFT-HAND SIDE

J AMPLIFIER PRESET CONTROLS