
INSTRUMENT REFERENCE BOOK

for the Tektronix type

10A2

dual-trace environmentalized
plug-in unit

For all serial numbers

NEW INSTRUMENT TRAINING PACKAGE



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GENERAL DESCRIPTION

General Information

The Type 10A2 Dual-Trace Amplifier plug-in unit is part of a wide-band oscilloscope system designed for severe environmental operation and storage. It contains two identical vertical preamplifiers that can be used singly or combined for a variety of measurements. The Type 10A2 operates in the Type 647 Oscilloscope.

ELECTRICAL

The following electrical characteristics are divided into general operating characteristics and environmental specifications. All data applies to the Type 10A2 as operated in a Type 647 Oscilloscope.

Deflection Factors

Each channel has eleven calibrated steps from 10 mv/cm to 20 volts/cm in a 1, 2, 5 sequence. A variable control with at least a 2.5:1 uncalibrated range extends the maximum deflection factor to 50 volts/cm.

Calibration Accuracy

Adjustable to 0% at 10 mv/cm at the front panel.

Attenuator Accuracy

$\pm 2\%$ from -30° C through $+65^{\circ}$ C.

Risetime

Typically 6.4 nsec, never longer than 7 nsec, 10% to 90% for all positions of VOLTS/CM switch. 50 Ω signal source impedance with 50 Ω termination at the Type 10A2 input.

Frequency Response

Dc to 50 mc. Ac Coupled: 2 cps to 50 mc.

Input Impedance

1 megohm paralleled by 20 pf.

Maximum Input Voltage

Type 10A2

Operating Modes

Channel 1 only, normal or inverted.

Channel 2 only, normal or inverted.

Alternate between channels.

Chopped between channels at 1-mc rate.

Added algebraically.

Channel Isolation

At least 20 db, up to 20 mc.

Maximum Dc-Coupled Common-Mode Signal

50 X the VOLTS/CM switch setting (limited to 600 volts at 20 volts/cm) for linear display operation.

Algebraic Subtraction Common-Mode Rejection Ratio

At least 20:1 throughout instrument bandpass for common-mode signals up to 10 cm.

Display Linearity

A 1-cm centered signal will not change amplitude over $\pm 1\%$ when offset to top or bottom of graticule. (Offset voltage externally applied and POSITION control centered.)

Trace Drift

At 25° C ambient temperature: typically 2mm/hr, not more than 5mm/hr.

Internal triggering information to the Timing Unit can be selected from the common output amplifier or from the channel 2 input signal only. Signal to the Timing Unit allows reliable internal triggering to a frequency beyond the bandwidth of the Type 647 system.

Dc Trace Displacement

Less than +1 cm/20° C from -30° C to +65° C.

Channel 2 Output Signal

Front-panel BNC connector labeled CH 2 OUT is a dc coupled signal from channel 2. Output level centered at ground. Output signal, 100 mv/cm related to crt display.

Output impedance, 50 Ω .

ENVIRONMENTAL

	<u>0° C to +40° C</u>	<u>-30° C to +65° C</u>
Ac Gain Stability		
Display Signal	±1.5%	±3%
CH 2 OUT Signal	±1%	±2%
3 Db Bandwidth		
Display Signal		
	_____ mc min.	_____ mc min.
CH 2 OUT	20 mc min.	20 mc min.
Chopped Mode Frequency, 1 Mc	±10%	±15%

Storage

The Type 10A2 Dual-Trace Amplifier can be stored alone, or in the Type 647 Oscilloscope at any temperature between -65° C and +85° C. After storage at either extreme, the instrument must be allowed sufficient time for all components to return to the operating ambient temperature range of -30° C to +65° C.

MECHANICAL

Construction

Aluminum-alloy chassis with chrome-plated brass side rails.

Finish

Photo-etched, anodized aluminum panel.

Dimensions

6 1/4 inches high, 4 1/4 inches wide, 1 1/4 inches deep.

Weight

5 pounds net.

Accessories

2-Instruction Manuals Tektronix Part No. 070-376.

HISTORY PARTS LIST

CONTENTS:

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TENTATIVE

10A2

Publication:
NOT STOCKED
July 1963



For all serial numbers.



ABBREVIATIONS:

cer	ceramic
comp	composition
emc	electrolytic, metal cased
emt	electrolytic, metal tubular
gmv	guaranteed minimum value
h	henry
k	kilo (10^3)
k	kilohm
m	milli (10^{-3})
ma	milliamp
meg	megohm
mh	millihenry
mpt	metalized, paper tubular
mt	mylar, tubular
mv	millivolt
μ	micro (10^{-6})
μ f	microfarad
μ h	microhenry
μ sec	microsecond
n	nano (10^{-9})
nsec	nano second
Ω	ohm
p	pico (10^{-12})
pbt	paper, "bathtub"
pcc	paper covered can
pf	picofarad ($\mu\mu$ f)
piv	peak inverse voltage
pmc	paper, metal cased
poly	polystyrene
prec	precision
pt	paper, tubular
ptm	paper, tubular molded
sn or S/N	serial number
tub	tubular
v	working volt, dc
var	variable
w	watt
WW	wire wound

SPECIAL NOTES AND SYMBOLS:

\pm	approximate serial number
X000	part first added at this serial number
000X	part removed after this serial number
*000-000	asterisk preceding Tektronix part number indicates manufactured by or for Tektronix, also Tektronix reworked or checked components
mod w/	modify with _____. Simple replacement is not recommended. Replace with parts listed for later instruments and also modify the circuit symbol numbers listed after mod w/

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ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulbs			
B119	150-030	Neon NE 2V	
B144	150-027	Neon NE 23	UNCAL
B219	150-030	Neon NE 2V	
B244	150-027	Neon NE 23	UNCAL

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3V - 50V = -10% , $+250\%$
 51V - 350V = -10% , $+100\%$
 351V - 450V = -10% , $+50\%$

C101	*285-634	.1 μ f	MI	600 v	
C102	281-558	18 pf	Cer	500 v	
C103	281-064	.2-1.5 pf	Tub.	Var	
C104A	281-534	3.3 pf	Cer		$\pm .25$ pf
C104B	281-064	.2-1.5 pf	Tub.	Var	
C104C	281-081	1.8-13 pf	Air	Var	800 v
C104D	281-592	4.7 pf	Cer		$\pm .5$ pf
C105A	281-572	6.8 pf	Cer	500 v	10%
C105B	281-027	.7-3 pf	Tub.	Var	
C105C	281-027	.7-3 pf	Tub.	Var	
C106A	281-572	6.8 pf	Cer	500 v	10%
C106B	281-027	.7-3 pf	Tub.	Var	
C106C	281-027	.7-3 pf	Tub.	Var	
C107A	281-572	6.8 pf	Cer	500 v	10%

Capacitors (Cont'd)

C107B	281-027	.7-3 pf	Tub.	Var		
C107C	281-027	.7-3 pf	Tub.	Var		
C107E	281-512	27 pf	Cer		500 v	10%
C108A	281-503	8 pf	Cer		500 v	±.5 pf
C108B	281-027	.7-3 pf	Tub.	Var		
C108C	281-027	.7-3 pf	Tub.	Var		
C108E	281-519	47 pf	Cer		500 v	10%
C109A	281-503	8 pf	Cer		500 v	±.5 pf
C109B	281-027	.7-3 pf	Tub.	Var		
C109C)	281-071	.2-1.5pf/100 pf	Mica	Var		10%
C109E)						
C110A	281-503	8 pf	Cer		500 v	±.5 pf
C110B	281-027	.7-3 pf	Tub.	Var		
C110C)	281-069	.2-1.5pf/200 pf	Mica	Var		10%
C110E)						
C111A	281-503	8 pf	Cer		500 v	±.5 pf
C111B	281-027	.7-3 pf	Tub.	Var		
C111C)	281-072	.2-1.5pf/500 pf	Mica	Var		10%
C111E)						
C112A	281-503	8 pf	Cer		500 v	±.5 pf
C112B	281-027	.7-3 pf	Tub.	Var		
C112C)	281-073	.2-1.5pf/1000 pf	Mica	Var		10%
C112E)						
C113A	281-503	8 pf	Cer		500 v	±.5 pf
C113B	281-027	.7-3 pf	Tub.	Var.		
C113C)	281-074	.2-1.5pf/2000 pf	Mica	Var		10%
C113E)						

Capacitors (Cont'd)

C118	281-614	.0068 pf	Cer		500 v	
C123	283-079	.01 μ f	Cer		250 v	
C130	285-622	.1 μ f	PTM		100 v	
C131	283-079	.01 μ f	Cer		250 v	
C132	281-519	47 pf	Cer		500 v	10%
C134	283-081	.1 μ f	Cer		25 v	
C159	281-577	14 pf	Cer		500 v	5%
C169	281-081	1.8-13 pf	Air	Var	800 v	
C176	281-081	1.8-13 pf	Air	Var	800 v	
C192	281-504	10 pf	Cer		500 v	10%
C193	281-504	10 pf	Cer		500 v	10%
C199	290-183	1 μ f	EMF		20 v	10%
C201	*285-634	.1 μ f	MF		600 v	
C202	281-558	18 pf	Cer		500 v	
C203	281-064	.2-1.5 pf	Tub.	Var		
C204A	281-534	3.3 pf	Cer			\pm .25 pf
C204B	281-064	.2-1.5 pf	Tub.	Var		
C204C	281-081	1.8-13 pf	Air	Var	800 v	
C204D	281-592	4.7 pf	Cer			\pm .5 pf
C205A	281-572	6.8 pf	Cer		500 v	10%
C205B	281-027	.7-3 pf	Tub.	Var		
C205C	281-027	.7-3 pf	Tub.	Var		
C206A	281-572	6.8 pf	Cer		500 v	10%
C206B	281-027	.7-3 pf	Tub.	Var		
C206C	281-027	.7-3 pf	Tub.	Var		

Capacitors (Cont'd)

C207A	281-572	6.8 pf	Cer		500 v	10%
C207B	281-027	.7-3 pf	Tub.	Var		
C207C	281-027	.7-3 pf	Tub.	Var		
C207E	281-512	27 pf	Cer		500 v	10%
C208A	281-503	8 pf	Cer		500 v	±.5 pf
C208B	281-027	.7-3 pf	Tub.	Var		
C208C	281-027	.7-3 pf	Tub.	Var		
C208E	281-519	47 pf	Cer		500 v	10%
C209A	281-503	8 pf	Cer		500 v	±.5 pf
C209B	281-027	.7-3 pf	Tub.	Var		
C209C)	281-071	.2-1.5pf/100 pf	Mica	Var		10%
C209E)						
C210A	281-503	8 pf	Cer		500 v	±.5 pf
C210B	281-027	.7-3 pf	Tub.	Var		
C210C)	281-069	.2-1.5pf/200 pf	Mica	Var		10%
C210E)						
C211A	281-503	8 pf	Cer		500 v	±.5 pf
C211B	281-027	.7-3 pf	Tub.	Var		
C211C)	281-072	.2-1.5pf/500 pf	Mica	Var		10%
C211E)						
C212A	281-503	8 pf	Cer		500 v	±.5 pf
C212B	281-027	.7-3 pf	Tub.	Var		
C212C)	281-073	.2-1.5pf/1000 pf	Mica	Var		10%
C212E)						
C213A	281-503	8 pf	Cer		500 v	±.5 pf
C213B	281-027	.7-3 pf	Tub.	Var		

Capacitors (Cont'd)

C213C)	281-074	.2-1.5pf/2000 pf	Mica	Var		10%
C213E)						
C218	281-614	.0068 μ f	Cer		500 v	
C223	283-079	.01 μ f	Cer		250 v	
C230	285-622	.1 μ f	PTM		100 v	
C231	283-079	.01 μ f	Cer		250 v	
C232	281-519	47 pf	Cer		500 v	10%
C234	283-081	.1 μ f	Cer		25 v	
C259	281-577	14 pf	Cer		500 v	5%
C269	281-081	1.8-13 pf	Air	Var	800 v	
C271	281-519	47 pf	Cer		500 v	10%
C276	281-081	1.8-13 pf	Air	Var	800 v	
C281	281-519	47 pf	Cer		500 v	10%
C292	281-504	10 pf	Cer		500 v	10%
C293	281-504	10 pf	Cer		500 v	10%
C299	290-183	1 μ f	EMT		20 v	10%
C343	283-084	270 μ f	Cer		1000 v	5%
C344	283-080	.022 μ f	Cer		25 v	
C348	283-088	.0011 μ f	Cer		500 v	5%
C353	283-084	270 pf	Cer		1000 v	5%
C354	283-080	.022 μ f	Cer		25 v	
C366	283-084	270 pf	Cer		1000 v	5%
C371	283-080	.022 μ f	Cer		25 v	
C382	283-080	.022 μ f	Cer		25 v	
C387	283-084	270 pf	Cer		1000 v	5%

Capacitors (Cont'd)

C390	283-080	.022 μ f	Cer	25 v	
C452	283-081	.1 μ f	Cer	25 v	
C462	281-578	18 pf	Cer	500 v	5%
C497	283-080	.022 μ f	Cer	25 v	
C498	283-080	.022 μ f	Cer	25 v	
C550	281-519	47 pf	Cer	500 v	10%
C560	281-519	47 pf	Cer	500 v	10%

Diodes

D125	152-061	Silicon	6061		
D133	*152-075	Tek Spec			
D157	152-141	Silicon	1N3605		
D192	*152-075	Tek Spec			
D193	*152-075	Tek Spec			
D225	152-061	Silicon	6061		
D233	*152-075	Tek Spec			
D257	152-141	Silicon	1N3605		
D292	*152-075	Tek Spec			
D293	*152-075	Tek Spec			
D302	152-065	Silicon	HD500		
D305	152-065	Silicon	HD500		
D309	152-065	Silicon	HD500		
D312	152-065	Silicon	HD500		
D322	152-065	Silicon	HD500		
D325	152-065	Silicon	HD500		
D329	152-065	Silicon	HD500		
D332	152-065	Silicon	HD500		
D348	*152-075	Tek Spec			
D358	*152-075	Tek Spec			
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Diodes (Cont'd)

D369	* 152-075	Tek Spec
D387	152-141	Silicon 1N3605
D391	* 152-075	Tek Spec
D392	152-065	° Silicon HD500

Inductors

L343	276-507	Core, Ferramic Suppressor
L353	276-507	Core, Ferramic Suppressor
L390	108-226	100 μ h
L392	*108-146	5 μ h
L434	*108-260	.1 μ h
L444	*108-260	.1 μ h
L465	*114-160	.1-.12 μ h Var
L504	*108-211	.5 μ h
L514	*108-211	.5 μ h
L527	*108-260	.1 μ h
L554	*108-112	.3 μ h
L564	*108-112	.3 μ h
L577	*108-220	.15 μ h

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R102	315-470	47 Ω	1/4 w		5%
R104C	322-610	500 k	1/4 w	Prec	1%
R104E	322-481	1 meg	1/4 w	Prec	1%
R105C	323-620	800 k	1/2 w	Prec	1%
R105E	321-618	250 k	1/8 w	Prec	1%

Resistors (Cont'd)

R106C	323-611	900 k	1/2 w	Prec	1%
R106E	321-617	111 k	1/8 w	Prec	1%
R107C	323-612	950 k	1/2 w	Prec	1%
R107E	321-616	52.6 k	1/8 w	Prec	1%
R108C	323-621	980 k	1/2 w	Prec	1%
R108E	321-615	20.4 k	1/8 w	Prec	1%
R109C	323-614	990 k	1/2 w	Prec	1%
R109D	315-470	47 Ω	1/4 w		5%
R109E	321-614	10.1 k	1/8 w	Prec	1%
R110C	322-625	995 k	1/4 w	Prec	1%
R110D	315-620	62 Ω	1/4 w		5%
R110E	321-613	5.03 k	1/8 w	Prec	1%
R111C	322-628	998 k	1/4 w	Prec	1%
R111D	315-220	22 Ω	1/4 w		5%
R111E	321-222	2 k	1/8 w	Prec	1%
R112C	322-629	999 k	1/4 w	Prec	1%
R112D	315-331	33 Ω	1/4 w		5%
R112E	321-193	1 k	1/8 w	Prec	1%
R113C	323-481	1 meg	1/2 w	Prec	1%
R113D	315-300	30 Ω	1/4 w		5%
R113E	321-612	500 Ω	1/8 w	Prec	1%
R114	323-481	1 meg	1/2 w	Prec	1%
R115	316-101	100 Ω	1/4 w		
R116	316-104	100 k	1/4 w		
R117	311-390	25 k		Var	CH1 GRID CURRENT ZERO

Resistors (Cont'd)

R118	301-105	1 meg	1/2 w		5%
R119	316-100	10 Ω	1/4 w		
R120	311-328	1 k		Var	VAR ATTEN BAL
R121	321-209	1.47 k	1/8 w		Prec 1%
R122	311-387	5 k		Var	CH1 ATTEN BAL RANGE
R123	323-305	14.7 k	1/2 w		Prec 1%
R125	303-153	15 k	1 w		5%
R129	315-153	15 k	1/4 w		5%
R130	308-077	1 k	3 w		WW
R132	315-151	150 Ω	1/4 w		5%
R133	322-225	2.15 k	1/4 w		Prec 1%
R134	315-510	51 Ω	1/4 w		5%
R135	321-251	4.02 k	1/8 w		Prec 1%
R136	321-153	383 Ω	1/8 w		Prec 1%
R138	311-169	100 Ω		Var	GAIN ADJ
R140	311-390	25 k		Var	Q154 BASE CURRENT
R142	321-325	23.7 k	1/8 w		Prec 1%
R143	315-823	82 k	1/4 w		5%
R144	311-385	250 Ω	1/2 w	Var	VARIABLE
R148	322-215	1.69 k	1/4 w		Prec 1%
R149	321-117	162 Ω	1/8 w		Prec 1%
R150	311-258	100 Ω		Var	CH1 COM MODE CURRENT
R151	322-097	100 Ω	1/4 w		Prec 1%
R154	322-161	464 Ω	1/4 w		Prec 1%
R157	321-129	215 Ω	1/8 w		Prec 1%

†Furnished as a unit with SW144.

Resistors (Cont'd)

R158	322-211	1.54 k	1/4 w		Prec	1%
R159	321-097	100 Ω	1/8 w		Prec	1%
R160	311-390	25 k		Var		CH1 GRID CURRENT ZERO
R161	321-297	12.1 k	1/8 w		Prec	1%
R163	321-103	115 Ω	1/8 w		Prec	1%
R164	322-161	464 Ω	1/4 w		Prec	1%
R165	322-202	1.24 k	1/4 w		Prec	1%
R167	321-129	215 Ω	1/8 w		Prec	1%
R168	322-211	1.54 k	1/4 w		Prec	1%
R169	321-080	66.5 Ω	1/8 w		Prec	1%
R170	321-257	4.64 k	1/8 w		Prec	1%
R171	321-121	178 Ω	1/8 w		Prec	1%
R174	321-081	68.1 Ω	1/8 w		Prec	1%
R176	311-258	100 Ω		Var		CH1 GAIN RANGE
R178	321-223	2.05 k	1/8 w		Prec	1%
R180	321-257	4.64 k	1/8 w		Prec	1%
R181	321-121	178 Ω	1/8 w		Prec	1%
R184	321-081	68.1 Ω	1/8 w		Prec	1%
R188	321-223	2.05 k	1/8 w		Prec	1%
R190	321-073	56.2 Ω	1/8 w		Prec	1%
R191	321-073	56.2 Ω	1/8 w		Prec	1%
R192	321-069	51.1 Ω	1/8 w		Prec	1%
R193	321-069	51.1 Ω	1/8 w		Prec	1%
R195	315-103	10 k	1/4 w			5%
R196	311-389	2 x 10 k		Var		POSITION

Resistors (Cont'd)

R197	315-103	10 k	1/4 w		5%
R199	315-510	51 Ω	1/4 w		5%
R202	315-470	47 Ω	1/4 w		5%
R204C	322-610	500 k	1/4 w	Prec	1%
R204E	322-481	1 meg	1/4 w	Prec	1%
R205C	323-620	800 k	1/2 w	Prec	1%
R205E	321-618	250 k	1/8 w	Prec	1%
R206C	323-611	900 k	1/2 w	Prec	1%
R206E	321-617	111 k	1/8 w	Prec	1%
R207C	323-612	950 k	1/2 w	Prec	1%
R207E	321-616	52.6 k	1/8 w	Prec	1%
R208C	323-621	980 k	1/2 w	Prec	1%
R208E	321-615	20.4 k	1/8 w	Prec	1%
R209C	323-614	990 k	1/2 w	Prec	1%
R209D	315-470	47 Ω	1/4 w		5%
R209E	321-614	10.1 k	1/8 w	Prec	1%
R210C	322-625	995 k	1/4 w	Prec	1%
R210D	315-620	62 Ω	1/4 w		5%
R210E	321-613	5.03 k	1/8 w	Prec	1%
R211C	322-628	998 k	1/4 w	Prec	1%
R211D	315-220	22 Ω	1/4 w		5%
R211E	321-222	2 k	1/8 w	Prec	1%
R212C	322-629	999 k	1/4 w	Prec	1%
R212D	315-331	33 Ω	1/4 w		5%
R212E	321-193	1 k	1/8 w	Prec	1%

Resistors (Cont'd)

R213C	323-481	1 meg	1/2 w	Prec	1%
R213D	315-300	30 Ω	1/4 w		5%
R213E	321-612	500 Ω	1/8 w	Prec	1%
R214	323-481	1 meg	1/2 w	Prec	1%
R215	316-101	100 Ω	1/4 w		
R216	316-104	100 k	1/4 w		
R217	311-390	25 k		Var	CH2 GRID CURRENT ZERO
R218	301-105	1 meg	1/2 w		5%
R219	316-100	10 Ω	1/4 w		
R220	311-328	1 k		Var	VAR ATTEN BAL
R221	321-209	1.47 k	1/8 w	Prec	1%
R222	311-387	5 k		Var	CH2 ATTEN BAL RANGE
R223	323-305	14.7 k	1/2 w	Prec	1%
R225	303-153	15 k	1 w		5%
R229	315-153	15 k	1/4 w		5%
R230	308-077	1 k	3 w	WW	
R232	315-151	150 Ω	1/4 w		5%
R233	322-225	2.15 k	1/4 w	Prec	1%
R234	315-510	51 Ω	1/4 w		5%
R235	321-251	4.02 k	1/8 w	Prec	1%
R236	321-153	383 Ω	1/8 w	Prec	1%
R238	311-169	100 Ω		Var	GAIN ADJ
R240	311-390	25 k		Var	Q254 BASE CURRENT
R242	321-325	23.7 k	1/8 w	Prec	1%
R243	315-823	82 k	1/4 w		5%

Resistors (Cont'd)

R244†	311-385	250 k	1/2 w	Var	VARIABLE
R248	322-215	1.69 k	1/4 w		Prec 1%
R249	321-117	162 Ω	1/8 w		Prec 1%
R250	311-258	100 Ω		Var	CH2 COM MODE CURRENT
R251	322-097	100 Ω	1/4 w		Prec 1%
R254	322-161	464 Ω	1/4 w		Prec 1%
R257	321-129	215 Ω	1/8 w		Prec 1%
R258	322-211	1.54 k	1/4 w		Prec 1%
R259	321-097	100 Ω	1/8 w		Prec 1%
R260	311-390	25 k		Var	CH2 INV BAL
R261	321-297	12.1 k	1/8 w		Prec 1%
R263	321-103	115 Ω	1/8 w		Prec 1%
R264	322-161	464 Ω	1/4 w		Prec 1%
R265	322-202	1.24 k	1/4 w		Prec 1%
R267	321-129	215 Ω	1/8 w		Prec 1%
R268	322-211	1.54 k	1/4 w		Prec 1%
R269	321-080	66.5 Ω	1/8 w		Prec 1%
R270	322-197	1.1 k	1/4 w		Prec 1%
R271	321-085	75 Ω	1/8 w		Prec 1%
R272	321-097	100 Ω	1/8 w		Prec 1%
R273	323-163	487 Ω	1/2 w		Prec 1%
R274	321-081	68.1 Ω	1/8 w		Prec 1%
R276	311-258	100 Ω		Var	CH2 GAIN RANGE
R278	321-223	2.05 k	1/8 w		Prec 1%
R280	322-197	1.1 k	1/4 w		Prec 1%

†Furnished as a unit with SW244.

Resistors (Cont'd.)

R281	321-085	75 Ω	1/8 w	Prec	1%
R282	321-097	100 Ω	1/8 w	Prec	1%
R283	323-163	487 Ω	1/2 w	Prec	1%
R284	321-081	68.1 Ω	1/8 w	Prec	1%
R286	315-120	12 Ω	1/4 w		5%
R288	321-223	2.05 k	1/8 w	Prec	1%
R290	321-073	56.2 Ω	1/8 w	Prec	1%
R291	321-073	56.2 Ω	1/8 w	Prec	1%
R292	321-069	51.1 Ω	1/8 w	Prec	1%
R293	321-069	51.1 Ω	1/8 w	Prec	1%
R295	315-103	10 k	1/4 w		5%
R296	311-389	2 x 10 k		Var	POSITION
R297	315-103	10 k	1/4 w		5%
R299	315-510	51 Ω	1/4 w		5%
R314	315-270	27 Ω	1/4 w		5%
R317	321-193	1 k	1/8 w	Prec	1%
R318	321-201	1.21 k	1/8 w	Prec	1%
R334	315-270	27 Ω	1/4 w		5%
R335	311-328	1 k		Var	MAIN AMP DIFF BAL
R336	311-328	1 k		Var	MAIN AMP CURRENT
R337	321-193	1 k	1/8 w	Prec	1%
R338	321-201	1.21 k	1/8 w	Prec	1%
R341	315-101	100 Ω	1/4 w		5%
R342	315-332	3.3 k	1/4 w		5%
R343	323-125	196 Ω	1/2 w	Prec	1%

Resistors (Cont'd)

R344	321-213	1.62 k	1/8 w	Prec	1%
R345	322-181	750 Ω	1/4 w	Prec	1%
R347	321-249	3.83 k	1/8 w	Prec	1%
R351	315-101	100 Ω	1/4 w		5%
R352	315-332	3.3 k	1/4 w		5%
R353	323-125	196 Ω	1/2 w	Prec	1%
R354	321-213	1.62 k	1/8 w	Prec	1%
R355	322-181	750 Ω	1/4 w	Prec	1%
R357	321-249	3.83 k	1/8 w	Prec	1%
R364	323-153	383 Ω	1/2 w	Prec	1%
R365	315-223	22 k	1/4 w		5%
R369	315-682	6.8 k	1/4 w		5%
R371	315-224	220 k	1/4 w		5%
R373	321-289	10 k	1/8 w	Prec	1%
R374	315-332	3.3 k	1/4 w		5%
R375	321-161	464 Ω	1/8 w	Prec	1%
R382	315-152	1.5 k	1/4 w		5%
R384	322-221	1.96 k	1/4 w	Prec	1%
R387	315-330	30 Ω	1/4 w		5%
R389	321-069	51.1 Ω	1/8 w	Prec	1%
R390	315-221	220 Ω	1/4 w		5%
R391	315-221	220 Ω	1/4 w		5%
R392	315-222	2.2 k	1/4 w		5%
R411	321-161	464 Ω	1/8 w	Prec	1%
R412	321-080	66.5 Ω	1/8 w	Prec	1%

Resistors (Cont'd)

R413	321-145	316 Ω	1/8 w	Prec	1%
R415	321-157	422 Ω	1/8 w	Prec	1%
R421	321-161	464 Ω	1/8 w	Prec	1%
R423	321-145	316 Ω	1/8 w	Prec	1%
R425	321-157	422 Ω	1/8 w	Prec	1%
R432	322-133	237 Ω	1/4 w	Prec	1%
R434	321-115	154 Ω	1/8 w	Prec	1%
R444	321-115	154 Ω	1/8 w	Prec	1%
R450	321-109	133 Ω	1/8 w	Prec	1%
R452	322-085	75 Ω	1/4 w	Prec	1%
R453	321-629	5.11 k	1/8 w	Prec	1/2%
R454	322-094	93.1 Ω	1/4 w	Prec	1%
R455	321-630	6.81 k	1/8 w	Prec	1/2%
R456	322-173	619 Ω	1/4 w	Prec	1%
R457	323-137	261 Ω	1/2 w	Prec	1%
R458	323-137	261 Ω	1/2 w	Prec	1%
R459	322-043	27.4 Ω	1/4 w	Prec	1%
R460	321-109	133 Ω	1/4 w	Prec	1%
R462	315-242	2.4 k	1/4 w		5%
R464	322-094	93.1 Ω	1/4 w	Prec	1%
R465	321-080	66.5 Ω	1/8 w	Prec	1%
R466	322-173	619 Ω	1/4 w	Prec	1%
R467	323-137	261 Ω	1/2 w	Prec	1%
R468	323-137	261 Ω	1/2 w	Prec	1%
R481	322-193	1 k	1/4 w	Prec	1%

Resistors (Cont'd)

R482	321-173	619 Ω	1/8 w		Prec	1%
R483	301-151	150 Ω	1/2 w			5%
R485	315-100	10 Ω	1/4 w			5%
R487	315-151	150 Ω	1/4 w			5%
R494	*310-606	67 Ω	4 w	Mica		1%
R496	*310-606	67 Ω	4 w	Mica		1%
R497	322-073	56.2 Ω	1/4 w		Prec	1%
R498	322-085	75 Ω	1/4 w		Prec	1%
R504	321-125	196 Ω	1/8 w		Prec	1%
R514	321-125	196 Ω	1/8 w		Prec	1%
R525	321-161	464 Ω	1/8 w		Prec	1%
R526	321-058	39.2 Ω	1/8 w		Prec	1%
R527	321-053	34.8 Ω	1/8 w		Prec	1%
R529	323-170	576 Ω	1/2 w		Prec	1%
R530	311-390	25 k		Var		CH2 OUT DC LEVEL
R531	315-392	3.9 k	1/4 w			5%
R532	323-181	750 Ω	1/2 w		Prec	1%
R533	321-103	115 Ω	1/8 w		Prec	1%
R535	321-161	464 Ω	1/8 w		Prec	1%
R536	321-058	39.2 Ω	1/8 w		Prec	1%
R539	323-170	576 Ω	1/2 w		Prec	1%
R541	315-820	82 Ω	1/4 w			5%
R543	315-820	82 Ω	1/4 w			5%
R545	321-289	10 k	1/8 w		Prec	1%
R546	311-390	25 k		Var		NORM TRIG DC BAL

Resistors (Cont'd)

R548	321-105	121 Ω	1/8 w	Prec	1%
R550	321-065	46.4 Ω	1/8 w	Prec	1%
R551	321-297	12.1 k	1/8 w	Prec	1%
R554	321-127	205 Ω	1/8 w	Prec	1%
R560	321-065	46.4 Ω	1/8 w	Prec	1%
R561	321-297	12.1 k	1/8 w	Prec	1%
R564	321-127	205 Ω	1/8 w	Prec	1%
R574	323-181	780 Ω	1/2 w	Prec	1%
R576	323-173	619 Ω	1/2 w	Prec	1%
R577	321-073	56.2 Ω	1/8 w	Prec	1%
R579	321-145	316 Ω	1/8 w	Prec	1%
R584	323-181	750 Ω	1/2 w	Prec	1%
R586	323-173	619 Ω	1/2 w	Prec	1%
R589	321-145	316 Ω	1/8 w	Prec	1%
R591	321-169	562 Ω	1/8 w	Prec	1%
R592	321-230	2.43 k	1/8 w	Prec	1%
R595	315-270	27 Ω	1/4 w		5%
R597	303-221	220 Ω	1 w		5%

Switches

	Unwired	Wired		
SW1	260-522	*262-566	Rotary	VOLTS/CM
SW51	260-522	*262-566	Rotary	VOLTS/CM
SW1444	311-385			
SW190	260-447		Slide	PULL TO INVERT
SW24444	311-385			

†Furnished as a unit with R144.

††Furnished as a unit with R244.

Switches (Cont'd)

SW290	260-447	Slide	PULL TO INVERT
SW350	260-524	Rotary	MODE
SW540	260-523	Rotary	TRIGGER SELECTOR

Transformers

T371	*120-273	Toroid, Bifilar	5T-10T
T390	*120-273	Toroid, Bifilar	5T-10T

Transistors

Q123	*151-103	Tek Spec
Q133	*151-103	Tek Spec
Q154	*151-109	Tek Spec
Q164	*151-109	Tek Spec
Q174	*151-109	Tek Spec
Q184	*151-109	Tek Spec
Q223	*151-103	Tek Spec
Q233	*151-103	Tek Spec
Q254	*151-109	Tek Spec
Q264	*151-109	Tek Spec
Q274	*151-109	Tek Spec
Q284	*151-109	Tek Spec
Q304	*151-109	Tek Spec
Q314	*151-109	Tek Spec
Q324	*151-109	Tek Spec
Q334	*151-109	Tek Spec
Q345	*151-103	Tek Spec
Q355	*151-103	Tek Spec
Q364	*151-103	Tek Spec
Q374	*151-103	Tek Spec

Transistors (Cont'd)

Q383	*151-103	Tek Spec
Q390	*151-108	Tek Spec
Q413	*151-120	Tek Spec
Q423	*151-120	Tek Spec
Q434	*151-109	Tek Spec
Q444	*151-109	Tek Spec
Q454	*151-120	Tek Spec
Q464	*151-120	Tek Spec
Q483	*151-103	Tek Spec
Q504	*151-120	Tek Spec
Q514	*151-120	Tek Spec
Q523	*151-120	Tek Spec
Q533	*151-120	Tek Spec
Q554	*151-120	Tek Spec
Q564	*151-120	Tek Spec
Q574	*151-120	Tek Spec
Q584	*151-120	Tek Spec
Q593	*151-103	Tek Spec

Electron Tubes

V133	154-306	7586
V233	154-306	7586

FACTORY CALIBRATION PROCEDURE

CONTENTS:

General	C-805
Circuit specifications	C-807
Calibration procedure	

INTRODUCTION:

This isn't a field recalibration procedure as is the procedure in your instruction manual. This is a guide in calibrating brand-new instruments, just assembled instruments that have never been turned on before. Therefore it calls out many procedures and adjustments that are rarely required for subsequent recalibration.

Even though we wrote this procedure primarily for our own factory test department, it's valuable to others also if used with some caution:

1. Special test equipment, if mentioned, is not available from Tektronix unless it's listed also in our current catalog. This special equipment is used in our test department to speed calibration. Usually you can either duplicate its function with standard equipment in your facility, devise alternate approaches, or build the special test equipment yourself.
2. Factory circuit specifications are not guaranteed unless they also appear as catalog or instruction manual specifications. Factory circuit specs usually are tighter than advertised specs. This helps insure the instrument will meet or exceed advertised specs after shipment and during subsequent field recalibrations over several years of use. Your instrument may not meet factory circuit specs but should meet catalog or instruction manual specs.
3. Presetting internal adjustments, if mentioned, usually is unnecessary. This is helpful for "first-time" calibration only. If internal adjustments are preset, you'll have to perform a 100% recalibration. So don't preset them unless you're certain a "start-from-scratch" policy is the best.

In this procedure, all front panel controls for the instrument under test are in capital letters (SENSITIVITY) and internal adjustments are capitalized only (Gain Adj).

10A2



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For all serial numbers



ABBREVIATIONS:

a	amp	mid r	midrange or centered
ac	alternating current	min	minimum
approx	approximately	mm	millimeter
b	base	mpt	metalized, paper tubular (capacitor)
bulb	light, lamp, etc.	msec	millisecond
c	collector	mt	mylar, tubular (capacitor)
ccw	counterclockwise or full counterclockwise	mv	millivolt
cer	ceramic	μ	micro (10^{-6})
cm	centimeter	μ f	microfarad
comp	composition (resistor)	μ h	microhenry
cps	cycles per second	μ sec	microsecond
crt	cathode ray tube	n	nano (10^{-9})
cw	clockwise or full clockwise	nsec	nanosecond
db	decibel	Ω	ohm
dc	direct current	p	pico (10^{-12})
div	division	pbt	paper, "bathtub" (capacitor)
e	emitter	pcc	paper covered can (capacitor)
emc	electrolytic, metal cased (capacitor)	pf	picofarad ($\mu\mu$ f)
emt	electrolytic, metal tubular	piv	peak inverse voltage
fil	filament	pmc	paper, metal cased (capacitor)
freq	frequency	poly	polystyrene
gmV	guaranteed minimum value (capacitor)	pot	potentiometer
gnd	chassis ground	prec	precision (resistor)
h	henry	pt	paper, tubular (capacitor)
hv	high voltage	ptm	paper, tubular molded (capacitor)
inf	infinity	ptp	peak-to-peak
int	internal	sec	second
k	kilo (10^3)	sn	serial number
k	kilohm	term	terminal
m	milli (10^{-3})	tub	tubular (capacitor)
ma	milliamp	unreg	unregulated
max	maximum	v	volt
mc	megacycle	var	variable
meg	megohm	w	watt
mh	millihenry	WW	wire wound
		x-former	transformer

TYPE 10A2 PLUG-IN
TEST SPECIFICATIONS
(TENTATIVE)

ITEM	CHARACTERISTICS	SPEC LIMITS
Variable Balance	<ol style="list-style-type: none"> 1. Range of Adjustment ATTEN. BAL RANGE VAR. ATTEN. BAL. BASE CURRENT 2. Setting Accuracy 3. Trace drift or shift 	<p>Must adjust Nuvistor Cathode voltage from +1.15 to +1.25V.</p> <p>Set for 180° back from full cw.</p> <p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Less than 1 mm trace shift as VARIABLE rotates through its range.</p> <p>Less than .5 cm/hour after Nuvistors were aged over 12 hrs.</p>
Invert Balance	<ol style="list-style-type: none"> 1. Range of Adjustment INV. BAL. 2. Setting accuracy 	<p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Less than .5 cm shift between normal and invert.</p>
Trace Drift		<p>After 10-minute warm-up, trace drift or shift must be less than 2 mm with power off momentarily and then back on.</p>
Microphonics	Ringing Type	<p>Less than 1/2 cm when strike lightly on front panel or operate the front-panel controls.</p>
Input Nuvistor Grid Current	<ol style="list-style-type: none"> 1. Range of Adjustment GRID CURRENT ZERO 2. Setting Accuracy 	<p>Adjust with $\pm 90^\circ$ of center of rotation.</p> <p>No observable shift when input is switched from GND to DC.</p>

ITEM	CHARACTERISTICS	SPEC LIMITS
Common-Mode DC Output	<ol style="list-style-type: none"> 1. Range of Adjustment CH 1 COMMON-MODE CURRENT CH 2 COMMON-MODE CURRENT MAIN AMP CURRENT 2. Setting Accuracy 	<p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>0 \pm 0.05 volt at TP453 for CH 1, CH 2 and ADDED MODES.</p>
Main Amp Diff. Bal.	<ol style="list-style-type: none"> 1. Range of Adjustment MAIN AMP. DIFF. BAL. 2. Setting Accuracy 	<p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Less than 2 mm for all modes with POSITION control electrically centered.</p>
CH 2 OUT (DC)	<ol style="list-style-type: none"> 1. Range of Adjustment CH 2 DC LEVEL 2. Setting Accuracy 3. CH 2 OUT NOISE 	<p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>± 10 mv into 1 m load.</p> <p>± 40 mv shift when switched to CH 2 ONLY trigger.</p> <p>Less than 5 mv into 1 m load.</p>
Trigger Amp DC Bal.	<ol style="list-style-type: none"> 1. Range of Adjustment NORM TRIG DC BAL 2. Setting Accuracy 	<p>Adjust within $\pm 90^\circ$ of center of rotation.</p> <p>Trigger out DC balance less than 0.1 volt in NORM with POSITION control electrically centered.</p> <p>Trigger out DC balance less than 0.3 volt in CH 2 ONLY.</p>

ITEM	CHARACTERISTICS	SPEC LIMITS
Operating Bias Voltages	CHANNEL AMP: CH 1 Q174 - Emitter CH 2 Q274 - Emitter MAIN AMP: Q413 - Base Q454 - Emitter TP485 SWITCHING CIRCUIT: TP 345 TP 345 TP 355 TP 355 TRIG AMP: TP 593 TP 595	+1.45 to +1.55V +1.45 to +1.55V With MODE in CH 1 and position electrically centered: +6.5 to +6.8V +6.0 to +6.3V +4.75 to +4.85V +2 to +4V with MODE in CH 1 +8 to +10V with MODE in CH 2 +8 to +10V with MODE in CH 1 +2 to +4V with MODE in CH 2 -3.4 to -3.5V -4.1 to -4.3V
Gain	1. Range of Adjustment GAIN GAIN RANGE 2. Setting Accuracy	Set for 180° back from full cw. Adjust within $\pm 90^\circ$ of center of rotation. No observable error at 10 mv/cm.
Variable Atten. Range	VARIABLE	At least 2.5 to 1 attenuation ratio.
Input Attenuator	VOLTS/CM 1. Accuracy 2. Compensation	within $\pm 2\%$ within $\pm 1\%$
Trigger Amp Output	1. CH 2 output 2. TRIGGER NORM + - 3. TRIGGER CH 2 ONLY + -	105 to 150 mv/cm 90 to 120 mv/cm 90 to 120 mv/cm 90 to 140 mv/cm 90 to 140 mv/cm

ITEM	CHARACTERISTICS	SPEC LIMITS
Alternate Mode	<ol style="list-style-type: none"> 1. Trace shift from CH 1 and CH 2 modes 2. Triggering 	<p>Less than 1/2 mm.</p> <p>Must follow fastest 11B2 sweep rate.</p>
Chopped Mode	<ol style="list-style-type: none"> 1. Trace shift from CH 1 and CH 2 modes 2. Time duration of chopped element 3. Blanking 	<p>Less than 1/2 mm</p> <p>.45 to .55 μsec</p> <p>Operative and sufficient to blank out switching transient at normal intensity.</p>
Added Mode	<ol style="list-style-type: none"> 1. Addition Accuracy 	<p>Within <u>\pm2.5%</u></p>
Linearity	<p>Vertical Compression or Exapansion</p>	<p>Less than 1/2 mm over center screen diameter with 2 cm signal display.</p>
Transient Response	<ol style="list-style-type: none"> 1. CH 1 and CH 2 <ul style="list-style-type: none"> Risetime Fast overshoot Subsequent undershoot overshoot and ringing above 100 mc. Overshoot and ringing below 100 mc. 2. ADDED MODE <ul style="list-style-type: none"> Risetime Overshoot 3. TRIGGER NORM <ul style="list-style-type: none"> Risetime Overshoot 	<p>Less than 3.5 nsec</p> <p>Less than 4%</p> <p>Less than 3%</p> <p>Less than 1%</p> <p>Less than 4 nsec</p> <p>Less than 6%</p> <p>Less than 6 nsec</p> <p>Less than 100%</p>

ITEM	CHARACTERISTICS	SPEC LIMITS	
4. TRIGGER CH 2 ONLY	Risetime	Less than 10 nsec	
	Overshoot	Less than 10%	
5. CH 2 OUT	Risetime	Less than 10 nsec into 50Ω	
	Overshoot	Less than 4%	
Transient Response in 647	1. CH 1 and CH 2		
	Risetime	Less than 7 nsec	
	Overshoot, undershoot and/or ringing	Less than 2%	
	2. ADDED MODE		
	Risetime	Less than 7.5 nsec	
	Overshoot, undershoot and/or ringing	Less than 3%	
Overall Freq. response in 647	CH 1 and CH 2 Bandwidth	More than 50 mc at 3 db down.	
Channel Isolation		10,000 to 1 minimum	

TEKTRONIX TYPE 10A2 PLUG-IN
FACTORY CALIBRATION PROCEDURE
(T E N T A T I V E)

The following instruments and equipment are needed for a complete calibration of the Tektronix Type 10A2 Plug-in:

- 1 Test Scope (Type 543 or equivalent)
- 1 Type 647 Oscilloscope (accurately calibrated)
- 1 Type 11B2 Time Base
- 1 Type 661 Oscilloscope with Type 4S1 and Type 5T1A
- 1 Type 109 Pulse Generator
- 1 Type Constant Amplitude Signal Generator
- 1 Type 113 Delay Cable
- 1 Input Capacitance Standardizer (C520)
- 1 10X T 50Ω Pad (O17-044)
- 1 50Ω Termination (O11-049)
- 1 Plug-in Extension
- 2 50Ω Cables (RG-8A/U Amphenol 21-290, 5nsec)
- 2 50Ω Cables (with BNC Connectors)
- 1 10:1 T Pad (B52T10)
- 1 GR Type 874-QBPA Adapter

The Type 11B2 Time Base should be set as follows unless otherwise stated:

HORIZ DISPLAY	A
MAG	OFF
TIME/CM	1 mSEC
VARIABLE	CALIB
TRIG MODE	FREE RUN
SOURCE	INT
COUPLING	AC
SCOPE	+

PRELIMINARY INSPECTION:

a. Make a careful inspection for wiring errors, rosin joints, unsoldered joints, long wire ends and wire dress. Check all controls for smooth mechanical operation.

b. Make the following resistance-to-ground checks at the 32-pin Amphenol connector:

<u>Between Conn.</u> <u>Pin No. & Gnd.</u>	<u>Approx.</u> <u>R in Ohms</u>	<u>Between Conn.</u> <u>Pin No. & Gnd.</u>	<u>Approx.</u> <u>R in Ohms</u>
1	Infinite	17	Infinite
2	3.5K	18	160Ω
3	28Ω	19	Infinite
4	Infinite	20	11.5K
5	200Ω	21	Infinite
6	Infinite	22	Infinite
7	200Ω	23	Infinite

PRELIMINARY INSPECTION (Continued)

<u>Between Conn. Pin No. & Gnd.</u>	<u>Approx. R in Ohms</u>	<u>Between Conn. Pin No. & Gnd.</u>	<u>Approx. R in Ohms</u>
8	Infinite	24	Infinite
9	Infinite	25	Infinite
10	Infinite	26	Infinite
11	Infinite	27	Infinite
12	Infinite	28	Infinite
13	460Ω	29	Infinite
14	Infinite	30	Infinite
15	460Ω	31	Infinite
16	Infinite	32	0

c. Make DC resistance checks on all diodes.

Pre-set all controls of 10A2 as follows:

POSITION	Center
VAR ATTEN BAL	180° back from full CW
INPUT Switch	GND
GAIN	180° back from full CW
VOLTS/CM	.01
VARIABLE	Full CCW
INVERT Switch	In
MODE	CH 1
TRIGGER	NORM

Pre-set all internal controls and adjustments to midrange.

Insert 10A2 into VERTICAL Compartment of 647.

Turn power on and permit sufficient time for Nuvistors to warm up and stabilize.

1. CHECK INPUT CAPACITOR FOR LEAKAGE: (CH 1 and 2)

Using POSITION, INV BAL and ATTEN BAL RANGE controls, set trace to midscreen. Set AC-DC-GND input switch to AC. Apply 500 volts to the appropriate input and observe the trace shift after it returns to the screen. There must be less than one major division of displacement from the original position.

2. CHECK MICROPHONICS: (CH 1 and 2)

Set AC-DC-GND input switch to DC. Strike lightly on the front panel of the plug-in and watch for excessive ringing type of microphonics (no more than 1/2 major division).

3. DC ADJUSTMENTS: (CH 1 and 2)

a. ATTEN. BAL. RANGE initial adjustment: Connect a DC Voltmeter between the cathode of V133 (V233 for CH 2) and ground. Adjust ATTEN BAL RANGE to bring Nuvistor cathode voltage to about +1.2 volts. It must be able to adjust +1.15V to +1.25V. Adjust INVERT BAL to bring the trace to midscreen.

b. CH 1 (CH 2) COMMON MODE CURRENT initial adjustment: Adjust for +9V at TP 345 (TP 355) with the MODE switch in CH 2 (CH 1) position. Return MODE switch to CH 1 (CH 2).

c. MAIN AMP CURRENT initial adjustment: Adjust for Zero volt at TP 453.

3. DC ADJUSTMENTS (Continued)

- d. ATTEN. BAL. RANGE final adjustment: Rotate VARIABLE to full CW position and observe resultant trace shift. Adjust ATTEN. BAL. RANGE to bring the trace back to the original position and overcorrect by $2/3$ the amount of the initial trace shift. Use INV BAL control to keep trace on screen as necessary. Repeat if necessary to bring trace positions at both extremes of VARIABLE control to within .5 cm of each other.
- e. BASE CURRENT initial adjustment: Rotate VARIABLE to a position showing maximum trace departure from the reference positions at the end of this control. Adjust BASE CURRENT to bring trace back to this reference position and overcorrect by 4 times the initial trace departure. Use INV BAL to keep trace on screen as necessary.
- f. INV. BAL. initial adjustment: Set INV. BAL. for midscreen trace. (POSITION control should still be in midrange.) Pull INVERT switch out and observe trace shift. Adjust INV. BAL. to bring trace halfway back to original position. Push INVERT switch to "in" position.
- g. VAR. ATTEN. BAL. and BASE CURRENT final adjustment: Rotate the VARIABLE control through its range and observe any trace shift or departure from a steady position. Adjust VAR. ATTEN. BAL. and BASE CURRENT controls using steps (e) (except use VAR. ATTEN. BAL. rather than ATTEN BAL RANGE) and (f) so that trace shift is less than 1 mm as the VARIABLE is rotated through its range.
- h. INV. BAL. final adjustment: Observe trace shift as INVERT switch is pulled "out". Adjust INV. BAL. control to bring trace halfway back to the original position. Repeat this until the trace shift is less than .5 cm.
- i. GRID CURRENT ZERO final adjustment: Use POSITION control to set trace on midscreen. Set INPUT switch from GND to DC and observe trace shift. Adjust GRID CURRENT ZERO to bring trace back to initial midscreen position. Repeat until there is no trace shift as input is grounded.

Repeat the above steps to make CH 2 adjustments.

4. MAIN AMPLIFIER DC ADJUSTMENTS:

- a. Observe the DC voltage at TP 453. With MODE in CH 2, adjust CH 2 COMMON MODE CURRENT to obtain 0 volts at TP 453.
- b. CH 1 COMMON MODE CURRENT final adjustment: Switch MODE to ADDED and adjust CH 1 COMMON MODE CURRENT for 0 volts at TP 453.
- c. MAIN AMP CURRENT final adjustment: Switch MODE to CH 1 and adjust MAIN AMP CURRENT to bring voltage back to 0 volts at TP 453.
- d. CH 2 COMMON MODE CURRENT final adjustment: Switch MODE to CH 2 and re-adjust CH 2 COMMON MODE CURRENT for 0 volts at TP 453. Now voltage at TP 453 must remain $0 \pm .05$ volt in CH 1, CH 2 or ADDED modes.
- e. MAIN AMP DIFF. BAL. final adjustment: With MODE in CH 2, set CH 2 POSITION control for midscreen trace. Switch MODE to ADDED MODE and set CH 1 position control for midscreen trace. Switch MODE to CH 1 and adjust MAIN AMP DIFF. BAL. for midscreen trace. Set MODE to CH 2 and re-adjust CH 2 POSITION for midscreen trace. The trace should not move from midscreen by more than 2 mm as MODE is switched through all modes of operation.

5. CH 2 OUT DC ADJUSTMENT:

Set MODE switch to CH 1; CH 1 POSITION for midscreen trace, VOLTS/CM to .01 and input switch to DC. Connect front panel CH 2 OUT into CH 1 input and set CH 2 input to GND. Adjust CH 2 DC LEVEL to obtain midscreen trace. Observe trace shift as TRIGGER Selector is switched from NORM to CH 2 ONLY. The trace shift must not be greater than 40 mv.

5. CH 2 OUT DC ADJUSTMENT (Continued)

The CH 2 OUT noise as observed on screen in both TRIGGER modes must be less than 1/2 major divisions. Remove CH 2 OUT connection from CH 1 input.

6. ADJUST NORM TRIG DC BAL.:

Set TRIGGER selector switch to NORM and CH 1 POSITION control for midscreen trace. Connect a DC Voltmeter across \pm trigger output (Pin 13 and 15). Remove Type 11B2 and set Voltmeter to 1.5V (or less) scale. Adjust NORM TRIG DC BAL for zero volt. Re-install Type 11B2 into scope. Set TRIGGER selector to CH 2 ONLY and check for less than .3 volt change. Return TRIGGER selector to NORM and remove Voltmeter connections.

7. CHECK TRACE DRIFT: (CH 1 and 2)

Set both channel POSITION controls for midscreen trace with MODE switch in appropriate position. Switch power off momentarily and then turn it back on. Check for excessive trace shift or drift from the original position (less than 2 mm).

8. CHECK BIASING VOLTAGES:

Measure DC voltages for a check of proper biasing as indicated below. Set CH 1 and 2 inputs to GND and POSITION control for midscreen with MODE switch in appropriate position.

	<u>Measure Voltage</u>	<u>At</u>	<u>With MODE</u>	<u>Acceptable Voltage Range</u>
CH 1	(Q174 Emitter	C176 Junction	CH 1	+1.45 to +1.55 V
MAIN AMP	(Q413 Base	R318 Junction	CH 1	+6.5 to +6.8 V
	(Q454 Emitter	R465 Junction	CH 1	+6.0 to +6.3 V
	(Test Point	TP 485	CH 1	+4.75 to +4.85 V
CH 2	(Q274 Emitter	C276 Junction	CH 2	+1.45 to +1.55
SWITCH CKT.	(Test Point	TP 345	CH 1	+2 to +4 V
	(Test Point	TP 345	CH 2	+8 to +10 V
	(Test Point	TP 355	CH 1	+8 to +10 V
	(Test Point	TP 355	CH 2	+2 to +4 V
TRIG	(Test Point	TP 593		-3.4 to -3.5 V
AMP	(Test Point	TP 595		-4.1 to -4.3 V

9. ADJUST GAIN: (CH 1 and 2)

Set CH 1 and CH 2 inputs to DC, VOLTS/CM to .01 and VARIABLE to CALIB. From the CALIBRATOR, apply a 50 mv signal to CH 1 input. With MODE switch set at CH 1, adjust CH 1 GAIN RANGE for 5 major divisions of vertical deflection. Set MODE switch to ADDED and pull CH 2 INVERT switch "out". Apply 50 mv CALIBRATOR signal to CH 1 and CH 2 inputs. Adjust CH 2 GAIN RANGE for cancellation of the signal.

10. CHECK ADDED OPERATION:

Push CH 2 INVERT switch "in". Apply a 20 mv CALIBRATOR signal to CH 1 and CH 2 inputs. Addition of two input signals should provide four major divisions of vertical deflection (± 1 mm).

11. CHECK VARIABLE VOLTS/CM CONTROL: (CH 1 and 2)

Set MODE switch to appropriate position. Apply a 50 mv CALIBRATOR signal (5 major divisions) to the input. Set VARIABLE to minimum gain position and check for two major divisions (or less) of vertical deflection. Check for smooth electrical operation over the entire range. Re-set VARIABLE to CALIB and check that the UNCAL NEON is properly turned off.

12. CHECK INPUT SWITCH: (CH 1 and 2)

With a 50 mv CALIBRATOR signal applied to the input, position the base line of the calibrator waveform to the midscreen. Set the input switch to AC. The waveform should shift downward so that the midscreen graticule line is approximately through the center of the waveform. Pull INVERT switch "out" and repeat the same procedure for INV operation. When switching from DC to AC, the waveform should shift upward.

13. CHECK VOLTS/CM SWITCH: (Ch 1 and 2)

Set MODE switch to appropriate position, INVERT switch "in" and input switch to DC. Apply CALIBRATOR signal to the input and check for proper deflection as follows:

<u>VOLTS/CM</u>	<u>CALIBRATOR SIGNAL</u>	<u>DEFLECTION</u>
.02	.1 volt	5 major div
.05	.2 volt	4 major div
.1	.5 volt	5 major div
.2	1 volt	5 major div
.5	2 volts	4 major div
1	5 volts	5 major div
2	10 volts	5 major div
5	20 volts	4 major div
10	50 volts	5 major div
20	100 volts	5 major div

14. ADJUST ATTENUATOR COMPENSATIONS: (CH 1 and 2)

Set MODE switch to appropriate position and VOLTS/CM to .01. From Type 105 apply a 1kc signal to the input through a B52T5, a 52Ω cable and a 20 pf standardizer (CS-20). Set Type 105 OUTPUT AMPLITUDE control to produce approximately four major divisions of vertical deflection for the following VOLTS/CM settings. Set Type 11B2 TRIGGERING LEVEL for a stable display. Adjust the appropriate variable capacitors for optimum waveform.

<u>VOLTS/CM</u>	<u>ADJ FOR OPTIMUM SQUARE CORNER</u>		<u>ADJ FOR OPTIMUM FLAT TOP</u>	
	<u>CH 1</u>	<u>CH 2</u>	<u>CH 1</u>	<u>CH 2</u>
	.01			C103
.02	C104C	C204C	C104B	C204B
.05	C105C	C205C	C105B	C205B
.1	C106C	C206C	C106B	C206B
.2	C107C	C207C	C107B	C207B
.5	C108C	C208C	C108B	C208B
1	C109C	C209C	C109B	C209B
2	C110C	C210C	C110B	C210B
5	C111C	C211C	C111B	C211B
10	C112C	C212C	C112B	C212B
20	C113C	C213C	C113B	C213B

15. CHECK TRIGGER AMP OUTPUT:

Set MODE switch to CH 2 and CH 2 VOLTS/CM to .01. From Type 105 apply a 1 kc signal to CH 2 input. Adjust Type 105 OUTPUT AMPLITUDE for 5 major divisions of vertical deflection. Using a X10 probe, check the trigger amp output for proper gains as follows:

<u>MEASURE</u>	<u>AT</u>	<u>ACCEPTABLE RANGE</u>
CH 2 OUT	Front Panel	525 mv to 750 mv
NORM +	Pin 13	450 mv to 600 mv
NORM -	Pin 15	450 mv to 600 mv
CH 2 ONLY +	Pin 13	450 mv to 700 mv
CH 2 ONLY -	Pin 15	450 mv to 700 mv

Return TRIGGER to NORM.

16. CHECK LOW FREQUENCY RESPONSE: (CH 1 and 2)

Set VOLTS/CM switch to .01 and AC-DC-GND to DC. From Type 105 apply a 100 cps signal to the input. Adjust Type 105 OUTPUT AMPLITUDE control for four major divisions of vertical deflection and check for a flat-topped waveform.

17. CHECK VERTICAL COMPRESSION OR EXPANSION: (CH 1 and 2)

From Type 105 apply a 1 kc signal to appropriate input to produce exactly 2 major divisions of vertical deflection when the display is centered vertically. This deflection must not be increased or decreased by more than 1/2 mm (overall) when the display is positioned to the top or bottom of the graticule. Remove the signal from the input and set 11B2 to FREE-RUN.

18. CHECK ALTERNATE MODE OPERATION:

With MODE switch in appropriate setting, position CH 1 trace 2 cm above midscreen and CH 2 trace 2 cm below midscreen. Set MODE switch to ALTER and observe that trace shifts are less than 1/2 mm. Check for stable alternate trace between channels at various settings of the Type 11B2 TIME/CM switch.

19. CHECK CHOPPED OPERATION:

Set Type 11B2 TIME/CM switch to 1 mSEC. Switch MODE to CHOP and observe that trace shifts are less than 1/2 mm. Set Type 11B2 TIME/CM to .5 μSEC. Check that time duration of each chopped element is between .45 μSec and .55 μSec. Check for proper chopped blanking.

20. ADJUST HF TRANSIENT RESPONSE:

a. Remove 10A2 from the plug-in compartment and re-install the plug-in unit into scope through special plug-in extension for high frequency adjustments. (Note: This special plug-in extension disconnects the outputs of 10A2 from 647 vertical inputs and provides a 90 to 50Ω matching work.) Set MODE switch to CH 1 and VOLTS/CM to .01.

b. Elevate or "float" Type 661 Sampling Scope above ground and set up each unit as follows:

20. ADJUST HF TRANSIENT RESPONSE (Continued)

	<u>5T1A</u>		<u>4S1</u>
TRIGGERING SOURCE	FREE RUN	MILLIVOLTS/CM	50
TRIGGERING POLARITY	+	VARIABLE	CALIBRATED
RECOVERY TIME	MIN	DISPLAY (CHANNEL A)	NORMAL
SWEEP MODE	NORMAL	DISPLAY (CHANNEL B)	INVERTED
SAMPLES/CM	50	VERT POSITION	Midscreen trace
TIME EXPANDER	X1	SMOOTHING	NORMAL
TIME POSITION	CW	MODE	ADDED ALGEB.
SWEEP TIME/CM	20 nsec	TRIGGERING	A AC
VARIABLE	CALIBRATED		

661 HORIZONTAL DISPLAY

SWEEP MAGNIFIER	X1
POSITION and VERNIER	Center

c. Connect Pin 5 output of 10A2 into CHANNEL A of 4S1 and Pin 7 output into CHANNEL B. Set CH 1 POSITION for midscreen trace on Sampling Scope and then use 4S1 VERT POSITION for trace positioning.

d. Connect a Type 113 Delay Cable to CHG LINE 1 or 2 of Type 109 Pulse Generator. Set the 109 VOLTAGE RANGE to 5.0, AMPLITUDE to 2.5 and PULSE POLARITY to +. Turn Power on and apply the 109 OUTPUT to 10A2 CH 1 input through two 10X T (O17-044), a 50Ω cable and 50Ω termination (O11-049).

e. Set the 5T1A TRIGGERING to INT and adjust THRESHOLD for proper triggering. Set the 109 AMPLITUDE control for 5 cm display on the Sampling Scope. Adjust C176 and L465 for CH 1 transient response with less than 4% fast overshoot. Subsequent undershoots, overshoots or ringing above 100 mc are to be less than ±3%, and overshoots and ringing below 100 mc less than ±1%. Set 5T1A TIME/CM to 1 nSEC. Use TIME POSITION control to bring the display back to the screen and measure the 10-90% risetime (less than 3.5 nsec). Return 5T1A TIME/CM to 20 nSEC and TIME POSITION to CW.

f. Set MODE switch to CH 2 and apply Type 109 OUTPUT to CH 2 input. Adjust C276 for best CH 2 transient response. Measure 10-90% risetime as in Step (e). Set MODE switch to ADDED and measure the risetime and overshoot (less than 4 nsec with 6% overshoot maximum). Return MODE switch to CH 2.

g. Remove the 10A2 output connections from 4S1 inputs. Connect PIN 13 + trigger output of 10A2 into CHANNEL A INPUT of 4S1 and PIN 15 - trigger output into CHANNEL B INPUT. Set CHANNEL A and B MILLIVOLTS/CM to 50. Set 5T1A SWEEP TIME/CM to 2 nsec. Use TIME POSITION control to bring the display back to midscreen. Measure 10-90% risetime and overshoot of NORM TRIG output (less than 6 nsec with 10% overshoot maximum). Set TRIGGER select switch to CH 2 ONLY. Measure 10-90% risetime and overshoot of CH 2 TRIG output (less than 10 nsec with 10% overshoot maximum).

h. Remove the 10A2 trigger output connections from 4S1 inputs. Connect front panel CH 2 OUT into 4S1 CHANNEL A. Measure 10-90% risetime of CH 2 OUT (less than 10 nsec with 4% overshoot maximum). Remove 10A2 CH 2 OUT connection from 4S1 input. Re-install 10A2 into 647 VERTICAL compartment.

21. CHECK OVERALL TRANSIENT RESPONSE IN 647: (CH 1 and 2)

a. Set MODE switch to CH 1 and TRIGGER select switch to NORM. Set Type 11B2 TIME/CM to .1 μSEC and X10 MAG ON. Apply Type 109 signal to CH 1 input. Adjust 109 AMPLITUDE control for 4 major divisions of vertical deflection. Set 11B2 TRIGGERING LEVEL for a stable display. Measure 10-90% risetime (less than 7 nsec). Check the displayed waveform with less than 2% overshoot, undershoot and/or ringing. Pull

21. CHECK OVERALL TRANSIENT RESPONSE IN 647 (Continued)

INVERT switch "out" and repeat the same procedure for channel-invert operation. Push INVERT switch "in".

b. Set MODE switch to CH 2. Repeat Step (a) to check CH 2 response with TRIGGER select switch set at NORM and CH 2 ONLY.

c. Set MODE switch to ADDED and TRIGGER select switch to NORM. Apply Type 109 signal to CH 1 input. Measure 10-90% risetime (less than 7.5 nsec). Check the waveform with less than 3% overshoot, undershoot and ringing.

22. CHECK CROSSTALK & CHANNEL ISOLATION:

a. Set MODE switch to CH 1 and CH 1 VOLTS/CM to .05. Apply Type 109 signal to CH 1 input to produce 6 major divisions of vertical deflection. Set CH 1 VOLTS/CM to .01 and MODE switch to CH 2. Check the amplitude of crosstalk in CH 2 (less than 2 mm). Reverse channel operation and check crosstalk in CH 1.

b. Set CH 2 VOLTS/CM to 20. Apply Type 109 signal to CH 2 input to produce 2.5 major divisions (50V) of vertical deflection. Set MODE switch to CH 1 and CH 1 VOLTS/CM to .01. Check crosstalk in CH 1 (less than .5 cm). Reverse channel operation and check crosstalk in CH 2. Remove Type 109 signal from channel input.

23. CHECK OVERALL HF RESPONSE IN 647: (CH 1 and 2)

Set CH 1 VOLTS/CM to .01 and MODE switch to CH 1. From Type Constant Amplitude Signal Generator, apply a 50 kc signal to CH 1 input to obtain 4 major divisions of vertical deflection. Set Type signal to 50 mc. Do not change Type output amplitude and check for at least 2:8 major divisions of vertical deflection (upper 3 db point). Set CH 2 VOLTS/CM to .01 and MODE switch to CH 2. Repeat the same procedure to check CH 2 bandwidth.

OPERATION INSTRUCTIONS

FUNCTIONS OF FRONT-PANEL CONTROLS

AC-DC-GND

In the DC position, both the ac and dc components of input signals are displayed. In the AC position, a capacitor blocks dc components of the signal. The low-frequency limit (3-db point) of the AC position is about 2 cps (0.2 cps when a 10 meg Ω 10X probe is used). In the GND position, the Type 10A2 input circuit is grounded (it does not ground the signal).

VOLTS/CM

An eleven-position switch that sets the vertical deflection factor of the Type 10A2. All positions are calibrated when the red VARIABLE knob is in the switch detent at the CALIB position. Range is from 0.01 to 20 volts/cm.

VARIABLE VOLTS/CM

Red knob concentric with the VOLTS/CM switch provides continuously variable reduction in amplifier gain (uncalibrated) to at least 2.5 to 1. For example, if the VOLTS/CM switch is in the 1 position, the VARIABLE control will vary the sensitivity between the deflection factors of 1 volt/cm and

about 2.5 volts/cm. When used in conjunction with the oscilloscope calibrator voltage, this control permits setting any specific deflection factor within the range of the instrument.

UNCAL

A neon lamp that lights when the VARIABLE control is turned away from its CALIB position.

POSITION

Varies the vertical position of the trace.

PULL TO INVERT

A two-position switch that presents the signal in normal or inverted polarity.

MODE

A five-position switch that sets the mode of operation. The positions are as follows: CH 1: Connects the internal circuits to operate channel 1 only. The signal in channel 2 is still applied to the CH 2 OUT connector.

CH 2: Connects the internal circuits to operate channel 2 only.

ALTER: Sets the amplifier channels to display on alternate sweeps. For example, the first sweep would be the channel 1.

signal; the second sweep the channel 2 signal. The flicker between channels will depend on the sweep rate.

CHOP: Electronic switching changes the display between channels at a 1-Mc rate. Each display segment lasts for about 0.5 microsecond.

ADDED: The algebraic sum of the channel 1 and channel 2 signals will be displayed with the MODE switch in this position. To measure the algebraic difference between signals, use one PULL TO INVERT knob.

TRIGGER

A two-position switch that selects the trigger signal to the time-base unit trigger circuits. Either channel 2, or the signal driving the crt vertical deflection plates can be selected.

GAIN

A screwdriver adjustment that permits the gain of the channel to be correctly set.

VAR ATTEN BAL

A screwdriver adjustment that balances the amplifier so that with no signal applied there is no vertical shift of the trace as the VARIABLE VOLTS/CM control is turned.

FIRST-TIME OPERATION

The Type 10A2 should be inserted into the left-hand (Y-axis) opening of the Type 647 Oscilloscope. A time-base unit such as the Type 11B2 should be inserted in the right-hand (X-axis) opening.

The following procedure will help you become familiar with the Type 10A2 operation:

1. Set the front-panel controls as follows:

AC-DC-GND----- DC (both channels)
VOLTS/CM ----- .01 (both channels)
VARIABLE ----- CALIB (both channels)
POSITION ----- Midrange (both channels)
MODE ----- CH 1
PULL TO INVERT ----- Pushed in (both channels)
TRIGGER ----- NORM

2. Apply a 20 mvolt signal from the oscilloscope calibrator to both Type 10A2 input connectors. Adjust the time-base controls for a stable display. Use ac low-frequency reject internal-trigger coupling. The display will be a rectangular waveform 2 divisions in amplitude. With the channel 1 POSITION control, move the display above the graticule centerline.
3. Turn the MODE switch to CH 2. A similar 2-division waveform will be displayed. With the channel 2 POSITION control, move the display below the graticule centerline.
4. Set the MODE switch to ALTER. If necessary, adjust the time-base triggering for a stable display. Both signals should be displayed. The switching rate

will depend on the sweep rate.

5. Set the MODE switch to CHOP, and the TRIGGER switch to CH 2 ONLY. If necessary, adjust the time-base triggering for a stable display. Two separate traces should appear.
6. Set the MODE switch to ADDED. There should be one display 4 divisions in amplitude. This is the addition of the channel 1 and 2 waveforms (2 divisions each). Notice that either POSITION control can move the trace vertically.
7. Pull the Channel 1 PULL TO INVERT switch. Free run the time-base unit. The display should be a straight line, indicating the algebraic difference between the two signals. Since the signal amplitudes are equal, the difference is zero.

Variable Attenuator Balance and Gain Adjustment

Before the Type 10A2 is used for accurate measurements, the VAR ATTEN BAL and GAIN controls (front-panel screwdriver adjustments) for each channel should be checked and adjusted as necessary. The GAIN should also be checked each time the Type 10A2 is moved from one Type 647 Oscilloscope to another.

If the variable dc balance of a channel is not properly set, the position of a no-signal trace will shift vertically as the VARIABLE VOLTS/CM control of that channel is turned.

Adjust the VAR ATTEN BAL control as follows:

1. Set both AC-DC-GND switches to GND.
2. Set the MODE switch to CH 1 and position a free-running trace to the center of the crt.

3. Adjust the channel 1 VAR ATTEN BAL control to a point where there is no trace shift as the VARIABLE VOLTS/CM control is turned clockwise to its normal.
4. Repeat the preceding steps for channel 2.

Set the GAIN control as follows:

1. Set the TRIGGER switch to NORM.
2. Set the channel 1 AC-DC-GND switch to DC and the MODE switch to CH 1.
3. Set the channel 1 VOLTS/CM switch to .01 (or other required position) and the VARIABLE control to CALIB.
4. Set the time-base plug-in unit for a free-running 0.1 millisecc/cm sweep.
5. Apply 50 millivolts (or other required value) from the oscilloscope calibrator to the channel 1 input connector.
6. There should be 5 cm of display, if not, adjust the GAIN control.
7. Repeat the preceding steps for channel 2 GAIN adjustment.

General Operation

Either of the two preamplifier channels can be used independently by setting the MODE switch to CH 1 or CH 2 and connecting the signal to be observed to the appropriate input. ^{Table} Chart 2-1 lists several input systems suitable to the Type 10A2 input. Fig. 2-1 shows a block diagram of the input when using the system of Method 7 of ^{Table} Chart 2-1.

Talk
 CHART-2-1

Methods of Coupling a Signal To The Type 10A2.

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-2-3, Input R ₀ & C _p curves.	Precautions
1. Open test leads.	Simplicity.	Limited frequency response. Subject to stray pickup.	BNC to Banana Jack adapter (103-033). Two test leads.	1 Meg Ω & 20 pf at input, plus test leads.	Stray pickup
2. Underterminated coax. cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coax. cable with BNC connector(s).	1 Meg Ω & 20 pf plus cable capacitance.	High capacitive loading.
3. Terminated coax. cable. Termination at 10A2 input.	Full sensitivity. Total 10A2/647 bandwidth. Relatively flat resistive loading. Long cable with uniform response.	Presents R ₀ (typically 50 Ω) load- ing at end of coax. May need blocking capacitor to prevent dc loading or damage to termination.	Coax. cable with BNC connector(s). R ₀ termination at 10A2 input. (F6005, 50 Ω Termination, O11-049).	R ₀ plus 20 pf at 10A2 end of coax can cause reflections.	Reflection from 20 pf at input. Dc and ac loading on test point. Power limit of termination.
4. Same as 3, with coaxial attenuator at termination.	Less reflection from 20 pf at termination.	Sensitivity is reduced (increased Deflection Factor).	BNC Coaxial attenuators.	R ₀ only.	
5. Tap into terminated coax. system. (BNC Tee: UG-274/U at 10A2 input.)	Permits signal to go to normal load. Dc or ac coupling without coaxial attenuators.	20-pf load at tap point.	BNC Tee and BNC connectors on signal cables.	1 Meg Ω & 20 pf at tap point.	Reflections from 20 pf input.
6. 10X, 10 Meg Ω Probe. (Coax, 10 Meg Ω Probe. Coax, 100 Meg Ω Probe, 10 A2/647)	Reduced resistive and capacitive loading; at nearly full bandwidth of 10 A2/647	X0.1 sensitivity. X0.01 sensitivity. X0.001 sensitivity.	P6006, P6008, P6003, 4 (P6005 is 100X, P6015 is 1000X.)	P6006: 27 pf, 9 M Ω . Check probe P6008: 7 pf, 10 Meg Ω frequency P6003: 12 pf, 10 Meg Ω compensation. P6005: 26 pf, 9.1 Meg Ω P6015: 3 pf, 100 Meg Ω	

<p>7. 500 Ω and 5 kΩ probes. (Must be terminated in 50 Ω at LOA2 input.)</p>	<p>Reduced capacitive loading to about 0.7 pf. Bandwidth that of LOA2/647.</p>	<p>Resistive loading. XO.1 or XO.01 sensitivity. May need blocking capacitor to prevent dc loading or damage to termination. Limited low-frequency response when ac coupled. See Fig. 2-4.</p>	<p>P6034 - 10X. P6035 -10X. Items in Fig. 2-1.</p>	<p>P6034: 500 Ω, 0.7 pf. P6035: 5 kΩ, 0.5 pf. See Rp & Cp curves in Fig. 2-2.</p>	<p>Dc and ac loading. Voltage rating of probe.</p>
<p>8. Current transformer. Terminated in 50 Ω at LOA2. Bandwidth that of LOA2/647.</p>	<p>Current transformer can be permanent part of test circuit. Less than 2.2 pf to test circuit chassis. Measure signal currents in transistor circuits: CT-1: 20 amps pk. CT-2: 100 amps pk.</p>	<p><i>RMS</i> Be current level: CT-1: 0.5 amp. CT-2: 2.5 amps. Sensitivity: CT-1: 5mv/ma. CT-2: 1mv/ma.</p>	<p>CT-1: Coax.adapter and ENC termination paralleled by about 5μh. Up to 1.5 pf. CT-2: nothing extra (Perhaps additional coax.cable for either transformer)</p>	<p>CT-1: Insertion; 1 Ω paralleled by about 5μh. Up to 1.5 pf. CT-2: Insertion; 0.04μh paralleled by about 5μh. Up to 2.2 pf.</p>	<p>Not a quick-connect device. CT-1: low-frequency limit about 100 kc. CT-2: low-frequency limit about 1.2 kc, & is 1/5th as sensitive as the CT-1.</p>

Input Coupling

To display both the ac and dc components of an applied signal, set the appropriate AC-DC-GND switch to DC; to display only the ac component of a signal, set the switch to AC. In the AC position of the switch, the dc component of the signal is blocked by a capacitor in the input circuit. The low-frequency ac -3 db point is about 2 cps when the source impedance is low. Therefore, some low-frequency distortion of signals with components below this frequency can be expected when using the AC position. When using a 10X 10 meg Ω probe, the low-frequency response is about 0.2 cps in the AC position.

Deflection Factor

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of a probe, the setting of the VOLTS/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the VOLTS/CM switch apply only when the VARIABLE control is set fully clockwise to the CALIB position.

The range of the VARIABLE VOLTS/CM control is at least 2.5 to 1 to provide variable (uncalibrated) vertical-deflection factors between calibrated settings of the VOLTS/CM switch.

The VARIABLE VOLTS/CM control extends the vertical deflection factor of the Type 10A2 to above 50 volts/cm.

Dual Trace Operation

The choice of alternate or chopped mode of operation can be made from the following discussions, and Table 2-2.

Displaying Two Non-Repetitive Signals. The chop mode of operation allows good resolution of non-repetitive signals to be ob-

tained using sweep rates as fast as 10 $\mu\text{sec}/\text{cm}$. The 10- $\mu\text{sec}/\text{cm}$ sweep rate is probably the fastest sweep rate you will want to use and still get good resolution. Thus, non-repetitive signals up to 0.1 millisecc duration will produce a useful display with about 100 segments making up each trace.

To obtain useful displays when observing fast non-repetitive signals with the faster sweep rates, use one-channel operation.

Displaying Two Repetitive Signals. When displaying two repetitive signals using the alternate mode of operation, use sweep rates 0.5 millisecc/cm or faster. When viewing a repetitive display from signals 250 cps or higher, alternate mode of operation produces an uninterrupted display (the alternate-mode switching cycle is sufficiently fast to produce an apparently steady display). If slower sweep rates are used for viewing signals 250 cps or lower, the alternate-mode switching cycle becomes more apparent and you may prefer to use chopped mode of operation.

Internal Triggering Recommendations for
Dual-Trace Operation

Signals	10A2 MODE Switch	10A2 TRIGGER Switch	Time-Base Triggering
1. Two of same ^{/or} harmonically related frequency, 250 cps and above. (Lower frequency into Channel 2).	ALTER	CH 2 ONLY	AC
2. Two of same ^{/or} harmonically related frequency, anywhere within full bandwidth.*	CHOP	NORM CH 2 ONLY	AC KR or DC or AC LF REJ
3. Two of dissimilar (not harmonically related) frequency, 1 kc and above.	ALTER	NORM	AC LF REJ only
4. Two one-shot signals, time related . First signal to Channel & 2. Sweep rate limited to 10 μ sec/cm max.	CHOP	CH 2 ONLY	AC or DC or AC LF REJ

* Occasionally the signals will be harmonically related to then the chopping rate, and at sweep rates above 10 μ sec/cm the chop segments may be to obvious.

Voltage Measurements

To measure the voltage between two points on a signal (such as peak-to-peak ac volts), measure the vertical distance in graticule divisions between the two points and multiply by the setting of the VOLTS/CM switch and the attenuation factor, if any, of a probe. Be certain that the VARIABLE VOLTS/CM control is in the CALIB position.

For example, assume you use a 10X probe with the VOLTS/CM switch set to .02, and your display has a vertical deflection of 4 centimeters. In this case, 4 divisions X 0.02 volt/div. = 0.08 volt. This voltage times the probe attenuation factor of 10 shows a true peak-to-peak voltage of 0.8 volt.

To measure the dc level at a given point on a waveform, proceed as follows:

1. Set the VOLTS/CM switch so that the expected voltage (at the input connector) is not more than six times the setting. Be sure the VARIABLE VOLTS/CM control is in the CALIB position.
2. Set the time-base controls so that the sweep free runs.
3. Set the AC-DC-GND switch to GND, and use the POSITION control to align the trace with one of the graticule lines. This line is a ground (or zero) reference. The position selected for this reference line depends on the polarity and amplitude of the signal to be measured. Do not move the POSITION control once the reference line has been established.

4. Set the AC-DC-GND switch to DC.
5. Apply the signal to the input connector and set the time-base triggering controls for a stable display.
6. Measure the vertical distance, in major graticule divisions, from the ground (zero) reference line to the point on the waveform that you wish to measure.
7. Multiply this distance by the setting of the VOLTS/CM switch and any probe attenuation factor. This is the instantaneous dc level of the point measured.

Check the zero reference line at any time by setting the AC-DC-GND switch to GND. It is not necessary to disconnect the signal probe from the Type 10A2. To use a reference other than zero, set the AC-DC-GND switch to DC and touch the signal probe to the reference voltage; then use the POSITION control to align the trace with a reference graticule line.

Voltage Comparison Measurements

In some applications a set of vertical deflection factors other than those set by the VOLTS/CM switch need to be used. This is convenient for measuring signals that are multiples of fractional voltages between VOLTS/CM switch positions. To establish a set of deflection factors based on some specific voltage, use the following procedure:

1. Apply the new voltage reference signal to either Type 10A2 input connector. Set the VOLTS/CM switch and the VARIABLE control so that the display covers an exact number of graticule divisions. Do not move the VARIABLE control.

2. Divide the amplitude of the reference signal (in volts) by the product of the deflection established in step 1 (in centimeters) and the setting of the VOLTS/CM switch. The result is the deflection conversion factor.

$$\text{Conversion Factor} = \frac{\text{Amplitude of reference signal (in volts)}}{\text{Amount of deflection X VOLTS/CM switch setting}}$$

3. To calculate the true deflection factor at any position of the VOLTS/CM switch, multiply the switch setting by the deflection conversion factor.

$$\text{True Deflection Factor} = \text{VOLTS/CM switch setting X Conversion Factor.}$$

This new set of deflection factor values applies to this channel only, and only as long as the VARIABLE control is not moved.

Accurate Dc Millivolt Measurements

Operation of the Type 10A2 at 0.01 mv/cm may be quite common when working with 50-ohm coaxial systems near the upper frequency limit of the system. Measurement accuracy requires careful atten-

tion to both the VAR ATTEN BAL adjustment, and the input-stage grid current. The VAR ATTEN BAL adjustment must be made first, as described under "First-Time Operation" earlier in this section.

To check the input stage grid current, warm up the Type 10A2 at least 10 minutes. Check grid current as follows:

1. Set the MODE switch to channel in use.
2. Adjust the VAR ATTEN BAL control.
3. Set the VOLTS/CM switch to .01 VARIABLE to CALIB, and input selector to GND.
4. Center a free-running trace. Switch input selector to DC and watch for a trace shift. If the trace shifts, you may wish to touch-up the internal GRID CURRENT ZERO adjustment in the affected channel. See Section 4, step 1-J.

CIRCUIT DESCRIPTION

General Information

The Type 10A2 Dual-Trace Amplifier is a wide-band vertical plug-in unit for the Type 647 Oscilloscope. It contains two vacuum tubes and 38 silicon transistors.

Fig. 3-1 is the simplified block diagram. The VOLTS/CM attenuators permit large signal amplitudes to be reduced before being amplified. The amplifier gain is not changed when switching between various deflection factors, keeping the drift and noise characteristics the same for all positions of the VOLTS/CM switch.

The Input Amplifiers raise the signal level before positioning is added. The Input Amplifier essentially changes the input voltage signal to an internal current signal. Thus, the positioning is by current offset of the Input Amplifier output. The PULL TO INVERT switch is between the Input Amplifier and the POSITION control to permit inverting the display without inverting the action of the POSITION control.

The Channel 2 Input Amplifier sends an isolated signal to the Channel 2 Trigger Amplifier. The Channel 2 Trigger Amplifier sends the Channel 2 signal to both the Trigger Amplifier (for internal triggering) and to the front panel CH 2 OUT connector.

The Switching Circuit accepts one channel at a time or both channels together for use by the Output Amplifier. The MODE switch sets the conditions of operation of the Switching Circuit.

The Output Amplifier sends an isolated output signal to the Trigger Amplifier for internal triggering.

The Trigger Amplifier receives information from either the CH 1 or CH 2 input through the TRIGGER switch. Thus, the Time-Base unit can be triggered either from the (composite) vertical information, or from Channel 2 information only.

Input Circuit

The Type 10A2 input connectors are the BNC type. The input signals pass through frequency compensated voltage dividers, except at 0.01 volts/cm. All deflection factors present 1 meg Ω paralleled by 20 pf to the input circuit (see Fig. 2-2 and Fig. 2-3). Each position of the VOLTS/CM switch (see Attenuators schematic diagram) is individually adjustable for input capacitance and frequency compensation. This system permits the full bandpass of the instrument to be used at all deflection factors.

Each attenuator is made up of two or three resistors in series and two capacitors in series, forming a frequency compensated attenuator. An additional small shunt input capacitor permits adjusting each attenuator to exhibit a 20 pf input.

Channel 1 Input Amplifier

Input tube V133 is a cathode follower that drives the Input Amplifier. The plate voltage for V133 comes from cascaded emitter followers Q123 and Q133. By adjusting the plate voltage of V133, its cathode voltage is set to the correct value of about +1.2 volts. Any grid current of V133 is offset by a small negative voltage set by R117, the CH 1 GRID CURRENT ZERO internal control.

The cathode voltage of V133 is adjusted to be equal to the voltage at the junction of R135-R136. The GAIN ADJ (R138) and VARIABLE (R144) resistors have no dc current through them. Thus, either control can be turned without shifting the crt display vertically. The base current of Q154 (that would otherwise apply current to the VARIABLE control) is canceled by R140, the Q154 BASE CURRENT internal control.

By proper adjustment of the plate voltage and grid current of V133, and the base current of Q154, the GAIN ADJ and VARIABLE controls pass no dc current. *when the input signal is zero.*

Q154 is one-half of a *push-pull* *stage* paraphase amplifier (with fixed emitter degeneration) that drives a second *push-pull* *stage* paraphase amplifier Q174-Q184. The CH 1 GAIN RANGE control in the emitter circuit of Q174-Q184 permits adjusting the total Input Amplifier gain so the front panel GAIN control has its proper range of adjustment.

The dc balance of the two *stages* paraphase amplifiers is set at the base of Q164 by the CH 1 INV *BAL* control, R160. R160 ~~is~~ *given the name "CH 1 INV" because it is adjusted during calibration,* by using the PULL TO INVERT switch to check the amplifier balance.

The dc level of the push-pull output leads of the Input Amplifier is set by varying the supply voltage to Q154-Q164 with the CH 1 *COM MODE* CURRENT control R150.

First-order temperature compensation of Q174-Q184 is by D157 in the base ground-return lead. The change in voltage across D157 with temperature change is almost equal to and is opposite the change across the base-emitter diodes of Q174-Q184.

that measuring V_{dc} level or signal voltage at the collector of Q174_e does not indicate that Channel 1 is being displayed.

Common-Base Stage of Switching Circuit

The "pentode-like" characteristics of the collectors of Q304-Q314, and their common-base circuit, permit their collector voltages to be changed without affecting the Input Amplifier. The switching multivibrator, Q345-Q355 divert[✓] the collector current of the common-base stage of the channel not being displayed. Fig. 3-3 shows that the common base stage

current is independent of gain

ADDED mode of operation combines the output of both input amplifiers. (See Fig. 3-3) This ^{requires} resistor 12 ~~is~~ in each base lead from Q413-Q423. R318 and R338 are placed in parallel with the current supply to the common base stages, R411-R417 on one side and R421-R427 on the other side. The dc current ~~flow~~ through the resistors normally used for single channel operation remains the same. The switching multivibrator is set so it does not supply current to either channel common-base stage.

Output Amplifier

The voltage level at the base of Q413-Q423 (+6.6 volts) is set by the emitter return voltage of Q434-Q444. The base-emitter diode drop of each transistor is about 0.7 volts, elevating the 5.1 volts at the emitters of Q434-Q444 to 6.6 volts at the bases of Q413-Q423.

^Q Q413-Q423 are each an emitter follower. Their emitters are isolated so they are not in ~~paraphase~~ ^{push-pull}. Q434-Q444 emitters are also isolated, but feedback to their bases make them part of the ~~paraphase~~ ^{push-pull} output pair Q454-Q464. The static current of the Output Amplifier three transistor pairs is

common mode of output voltage

set at the bases of Q413-Q423 by the MAIN AMP CURRENT control R336. R336 sets both the amplifier β and output dc level.

The feedback resistors R459 and R469 ^{set} reduce the current gain of the four output transistors Q434-Q444 and Q454-Q464 to a ~~very~~ ^{multi-} low value so the stage current gain will be ^{multi-} virtually independent of transistor β throughout the required ~~remain constant with β changes due to temperature change.~~ ^{temperature and frequency changes.}

Chart 3-2 shows the voltage gain and current gain data for the Output Amplifier.

TABLE
CHART 3-2

Approximate Voltage and Current Gains of One-Half the Output Amplifier

Test Point	Approximate Impedance	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q413 Base		23	0.132	
Q413 Emitter	1.6 k	2.6	0.31	
Q434 Base	5 Ω	21.6	0.317	Q4133 to Q434B: A=0.53, G=2.4
Q434 Collector	154 Ω	248	3.52	
Q454 Base	1.7 k	248	0.028	(Z and Ma/Cm only theoretical.)
Q454 Coll.	46 Ω	2275	1.68	Q434E to Q454C: A=48, G=5.3
647 Input	93 Ω	2275	0.84	to 647 input

*Note difference between Q413 base current and Q304 emitter current is due to Q304 base current.

Channel 2 Input Amplifier

The Channel 2 Input Amplifier is identical with that of Channel 1, except for the trigger take-off point in the emitter circuit of Q274-Q284. The emitter-circuit resistors have been changed from Channel 1 to keep the emitter degeneration the same while providing the trigger takeoff as if from an emitter follower. The Channel 2 trigger signal goes first

to the base terminals of Q504-Q514, then to the TRIGGER switch.

Trigger Amplifiers

The Channel 2 Trigger Amplifier and the Trigger Amplifier are similar amplifiers with low input impedance and high current output. Each has a stabilizing feedback loop that keeps the stage current gain constant regardless of changes of β with temperature change.

Signal voltage and current data for both amplifiers is in ^{Table} Chart 3-3. The information is based upon the TRIGGER switch being at CH 2 ONLY.

~~Table~~
Chart 3-3

Approximate Voltage and Current Gain of One-Half the Triggers Amplifiers, TRIGGER switch at CH 2 ONLY.

Test Point	V _{in} /Cm	I _{in} /Cm	Gain: A = Voltage; G = Current
Q504 Base	0.8	0.005	
Q523 Base	17		→ stage input
Q523 Emtr	17	1.0	Q504B to Q523B: A = 20; G = 24
Q554 Base	1.5	0.15	
Q574 Base	50		→ stage input
Q574 Coll	100	1.0	Q554B to Q574C: A = 70; G = 22

Dual-Trace Switching Multivibrator

The dual-trace multivibrator transistors Q345-Q355 conduct current only when the MODE switch is at either CHOP or ALTER. In the Chopped mode, the emitter leads are connected to the -15-volt supply through R345-R355 and the primary of T371. To prevent the Blanking Amplifier from sending an alternate-trace blanking pulse to the Type 647, R369 and D369 lower the voltage level of Q374 emitter far enough to

effectively disconnect it from R345-R355. R369 limits the current in the primary of T571 to prevent any significant signal from being applied to the base of Q374.

The voltages at the multivibrator test points are listed for all modes of operation in ~~Chart~~ ^{Table} 3-4. The emitter voltages listed in ~~Chart~~ ^{Table} 3-4 do not indicate transistor conduction for Ch 1, Ch 2 or ADDED, but rather are a measure of the base voltage set by the base divider resistors.

~~Table~~ ^{Table} 3-4
Switching Multivibrator Conditions

Test Point	MODE				
	CH 1	CH 2	ALTER	CROP	ADDED
TP 345	+2.8	+3.8	+6.5	+6.5	+2.8
TP 355	+3.8	+2.8	+6.5	+6.5	+2.8
Q345 Emtr	+2.0	+2.0	+0.9	+1.8	+2.0
Q355 Emtr	+2.0	+2.0	+0.9	+1.8	+2.0

* Meter: 20,000 Ω /volt.

Chopped Mode Operation

The multivibrator is ⁷ ~~not~~ non-saturating ^{type} ~~with~~ with the ~~network connected~~ ^{capacitors in the} switching time-constant ^{network} between emitters. The ~~short-time-constant network in each base lead is only for fast signal coupling to the base.~~ ^{for coupling only.}

Chopped mode multivibrator waveforms are shown in Fig. 3-4. They show that the emitter of conducting Q345 (Q345E) rests at +2.5 volts until the emitter voltage of Q355 (Q355E) falls to -1.6 volts at the flip point. As the flip action begins, Q345 cuts off; its collector goes positive (TP 345) taking the base and emitter of Q355 positive. As the emitter of Q355 rises, it takes the emitter of Q345 to

+4.3 volts via C348, assuring that Q345 goes deep into cut-off. Then the r-c fall of C348-R345 takes Q345 emitter negative (the slope from +4.3 to -1.6 volts). As soon as Q345 emitter ^{drops below} reaches its base voltage, the multivibrator flips back to the first condition.

NOTE

Fig. 3-4 through Fig. 3-9 were taken with a Tektronix C-12 Camera, a Type 535A Oscilloscope with Type CA Dual-Trace Plug-In Unit, and two 10X, 10 Meg Ω probes. The oscilloscope was externally triggered from TP 345 and the plug-in unit operated in the Alternate Mode.

Crt Blanking

The Type 647 crt is blanked to cutoff during the ^{point} Chopped Mode switching time of the Type 10A2. The blanking pulse is generated by Q374, Q383 and Q390.

Q374 is energized by the MODE switch and ^{turns on briefly} is lightly ~~each time the Q345-Q355 multivibrator switches,~~ turned-on-with-its collector at about ground and its base at about -11.2 volts. (The decoupled -15-volt supply is about -11.6 volts.) As the multivibrator flips, the positive pulse from the multivibrator emitters is coupled through T371, in phase, to the base of Q374. Q374 turns on to saturation and its collector falls to about -12 volts. See Fig. 3-4. The signal to the base of Q383 is greatly attenuated by R374 and R375 in series to ground. ^{As the voltage across T371}

The base voltage of Q383 rests at about ^{0.7} ~~1~~ volt when Q374 is ^{off} not-saturated. The emitter of Q383 is at about zero

collapses, Q374 is turned off and hold on to the stored charge on C371 until the next multivibrator pulse turns on.

volts. See Fig. 3-6. C387 is at zero volts keeping Q390 at cut^{off}. As Q374 saturates, Q383 is cut off and its emitter starts to fall at a rate set by C387, ~~D387, R384, C394, R387 and R385.~~ ^{and the current through} ~~and R385.~~ As soon as C387 reaches about ^{-0.7} ~~-0.9~~ volt, Q390 conducts and regenerates in blocking oscillator action. The ^{base} ~~two-turn~~ winding of T390 takes the base of Q390 from ground to about ⁺⁴ ~~+~~ volts (Fig. 3-7) and sends about 100 mv of signal through D392 to the Type 647. The pulse lasts about 0.08 μ second.

Alternate Mode Operation

When the MODE switch is at ALTER. Q364 is energized and Q345-Q355 emitters are connected to the -15-volt supply through D348-D358, and ^{R364.} ~~R365.~~ The multivibrator emitter impedance is such that a trigger is required before it will switch. The trigger arrives from terminal 17 of P11 and the Type 647. The signal at terminal 17 rests at about +5 volts, and goes rapidly to ground at the end of each sweep. See Fig. 3-8.

The alternate trigger amplifier base voltage is about -10.9 volts, (the decoupled -15-volt supply is about -11.6 volts) and the collector voltage is about -11.5 volts; Q364 is saturated. The junction of D348-D358 and R365 rests at ^e ~~+1~~ $\frac{1}{2}$ volt.

As the negative trigger ^{arriving} arrives at the base of Q364, ^{momentarily} ~~it~~ turns it ^{off} (Fig. 3-9). ^{at Q364 turns base off.} a positive pulse is sent to the emitter circuit of Q345-Q355 (Fig. 3-8). ^{multivibrator} The conducting transistor is ^{momentarily} ~~momentarily~~ cut off and a regenerative switch to the other transistor causes the ^{opposite multivibrator transistor to turn on.} ~~opposite~~ takes place. The bistable multivibrator will remain at the

new state until another trigger pulse arrives and the conducting transistor has its emitter raised positive. Thus, the successive Time Base negative trigger at the end of each sweep switches the display first from channel 1 to channel 2 and back.

The relationship between the alternate mode triggers to the bistable multivibrator and the voltages that control the channel diode switches is shown in Fig. 3-9.

Voltage Source Transistors

Two voltage-setting emitter followers provide special supply voltages within the Type 10A2. They are: Q483, diagrammed with the Switching Circuit and Output Amplifier, *schematic* and Q593, diagrammed with the Trigger Amplifier, *schematic*. Each transistor provides two low-current level voltages, *sources* for special use. The voltage value is set by two precision resistors in the base lead. Q483 supplies +5.9 and +4.8 volts, and Q593 supplies -3.45 and -4.2 volts.

SCHEMATICS

10A2

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For all serial numbers.

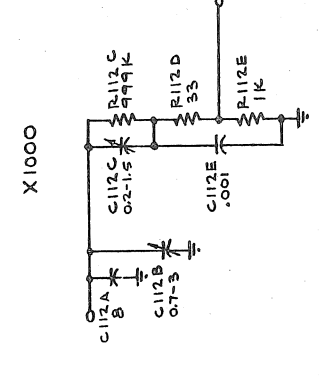
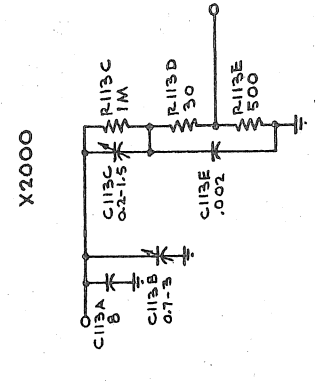
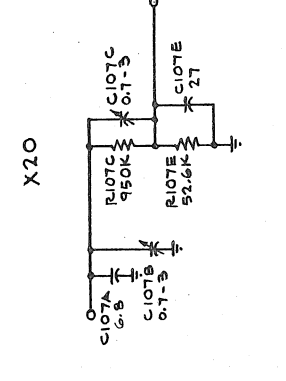
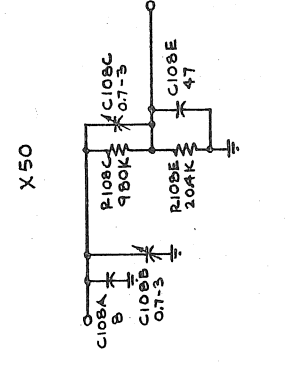
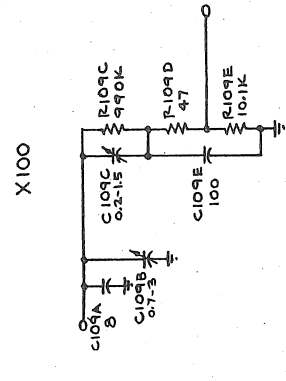
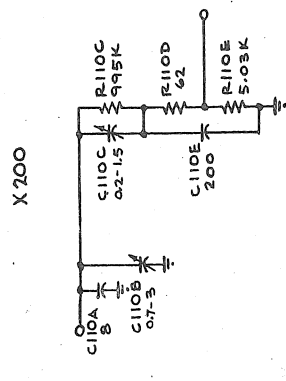
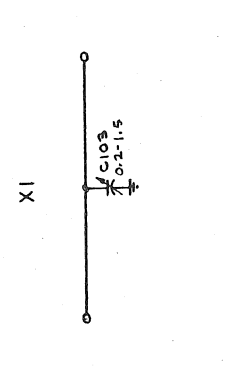
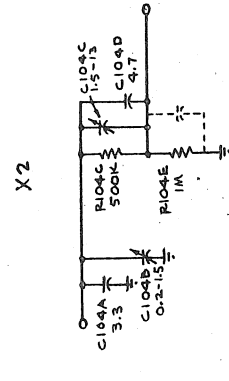
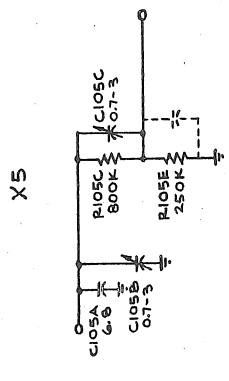
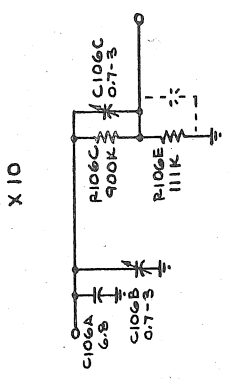
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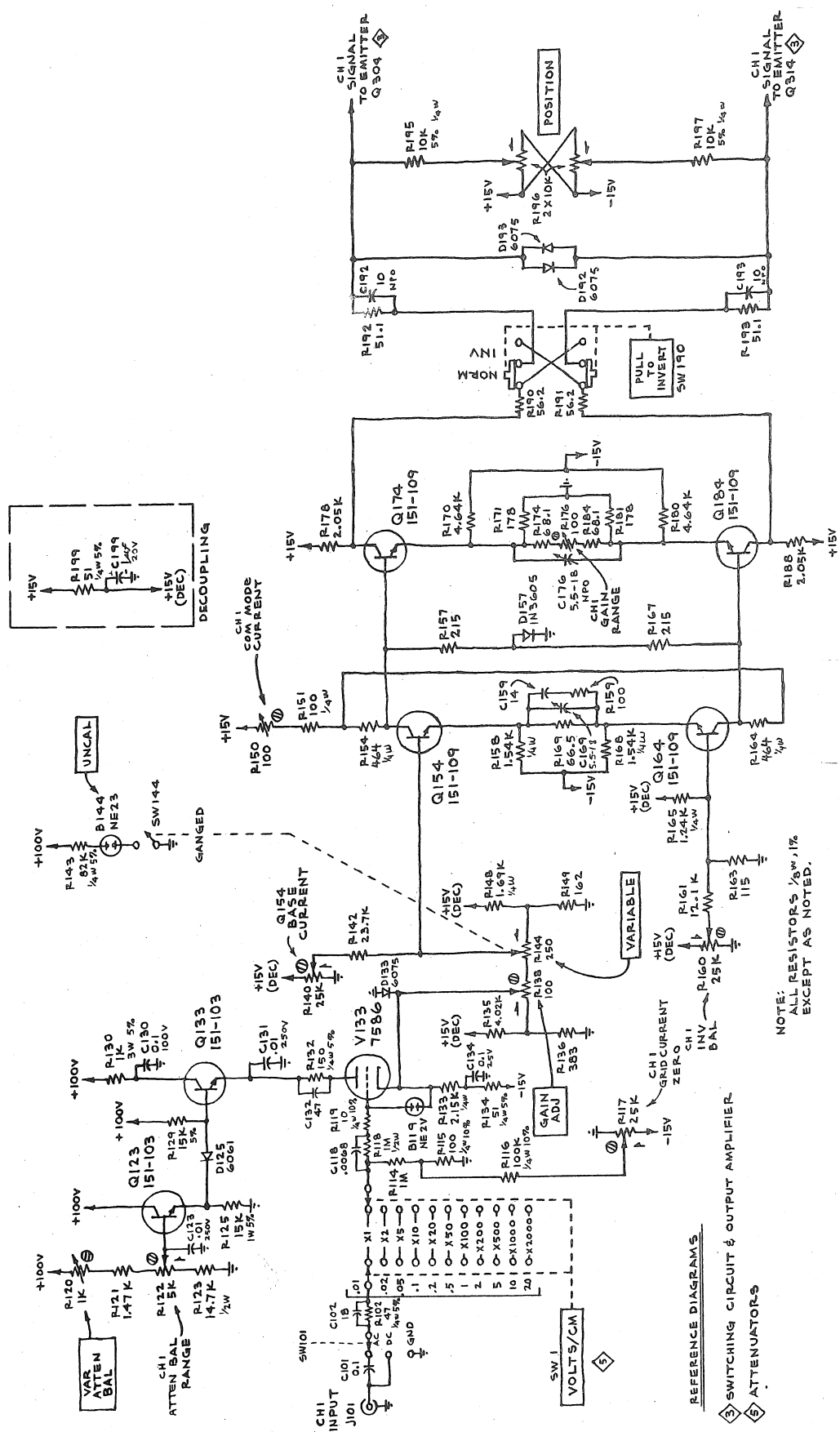
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CHANNEL 2 ATTENUATORS	--	7-22-63
CHANNEL 2 INPUT AMPLIFIER	--	7-22-63
TRIGGER AMPLIFIER	--	6-20-63
SWITCHING CIRCUIT and OUTPUT AMPLIFIER	--	7-22-63



ABBREVIATIONS:

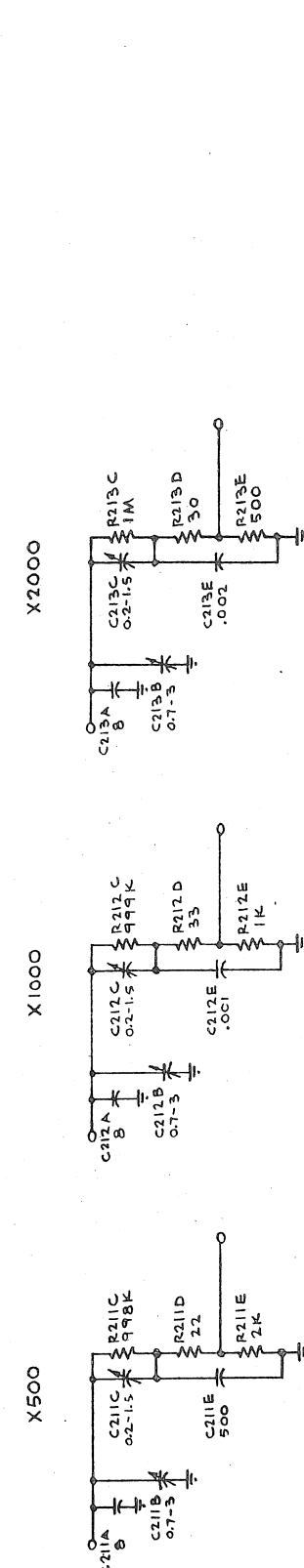
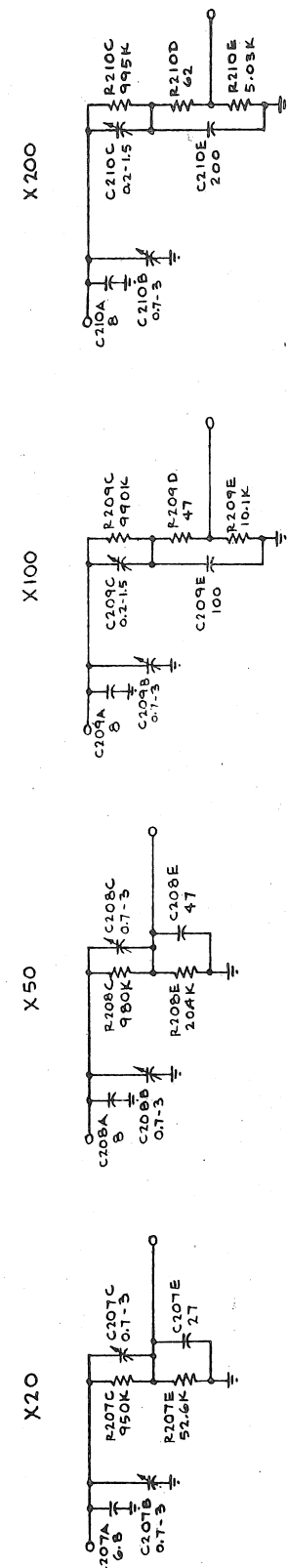
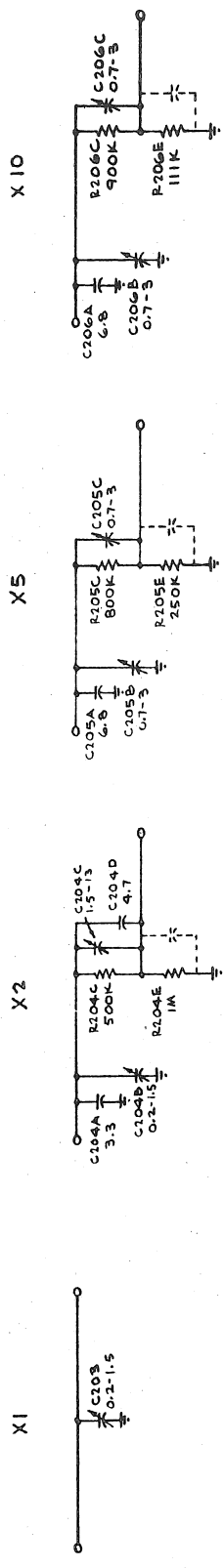
cer	ceramic
comp	composition
emc	electrolytic, metal cased
emt	electrolytic, metal tubular
gmv	guaranteed minimum value
h	henry
k	kilo (10^3)
k	kilohm
m	milli (10^{-3})
ma	milliamp
meg	megohm
mh	millihenry
mpt	metalized, paper tubular
mt	mylar, tubular
mv	millivolt
μ	micro (10^{-6})
μ f	microfarad
μ h	microhenry
μ sec	microsecond
n	nano (10^{-9})
nsec	nano second
Ω	ohm
p	pico (10^{-12})
pbt	paper, "bathtub"
pcc	paper covered can
pf	picofarad ($\mu\mu$ f)
piv	peak inverse voltage
pmc	paper, metal cased
poly	polystyrene
prec	precision
pt	paper, tubular
ptm	paper, tubular molded
sn or S/N	serial number
tub	tubular
v	working volt, dc
var	variable
w	watt
WW	wire wound





NOTE: ALL RESISTORS 1/2W, 1% EXCEPT AS NOTED.

- Ⓢ REFERENCE DIAGRAMS
- Ⓢ SWITCHING CIRCUIT & OUTPUT AMPLIFIER
- Ⓢ ATTENUATORS



X 10

X 5

X 2

X 1

X 200

X 100

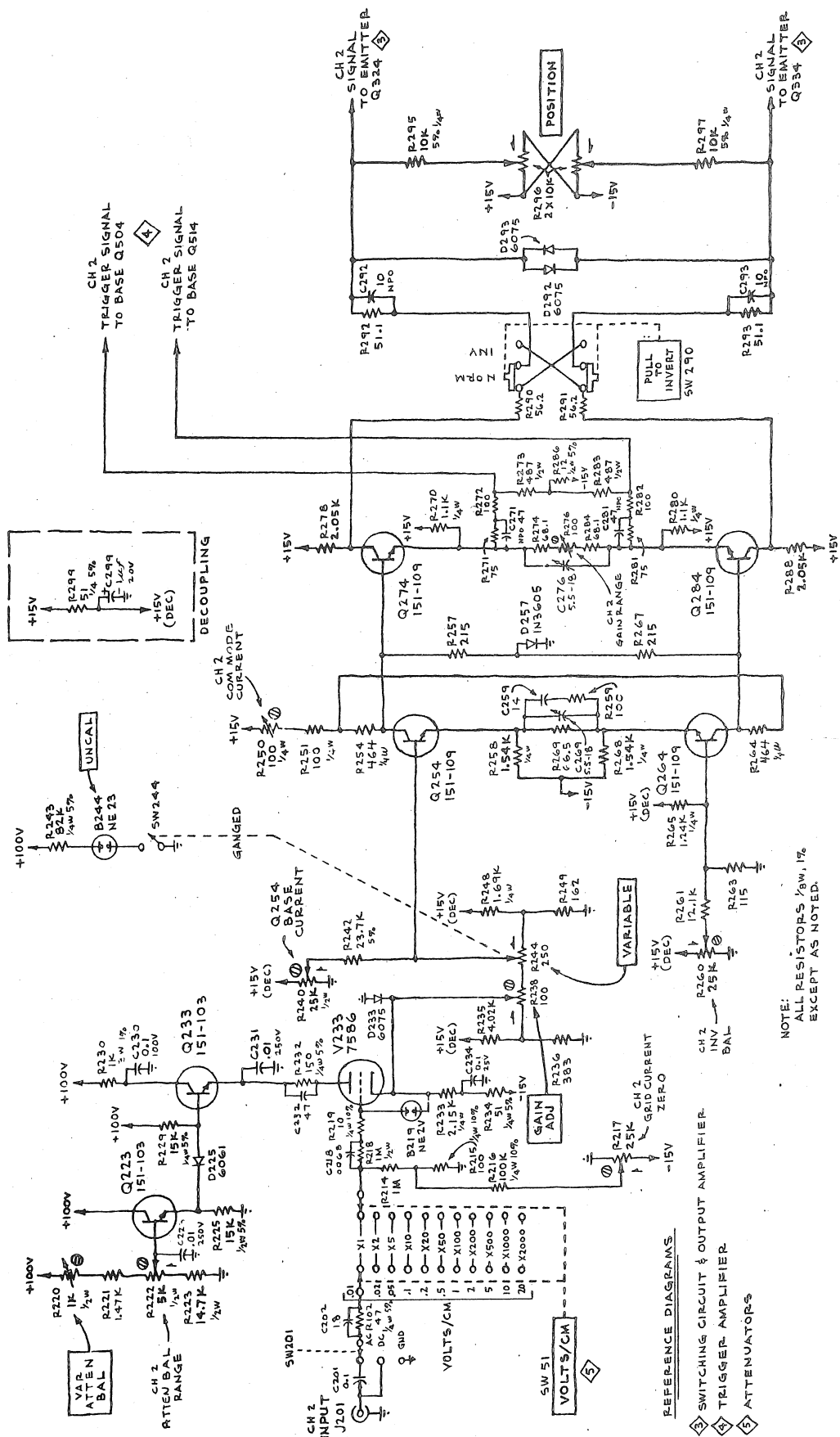
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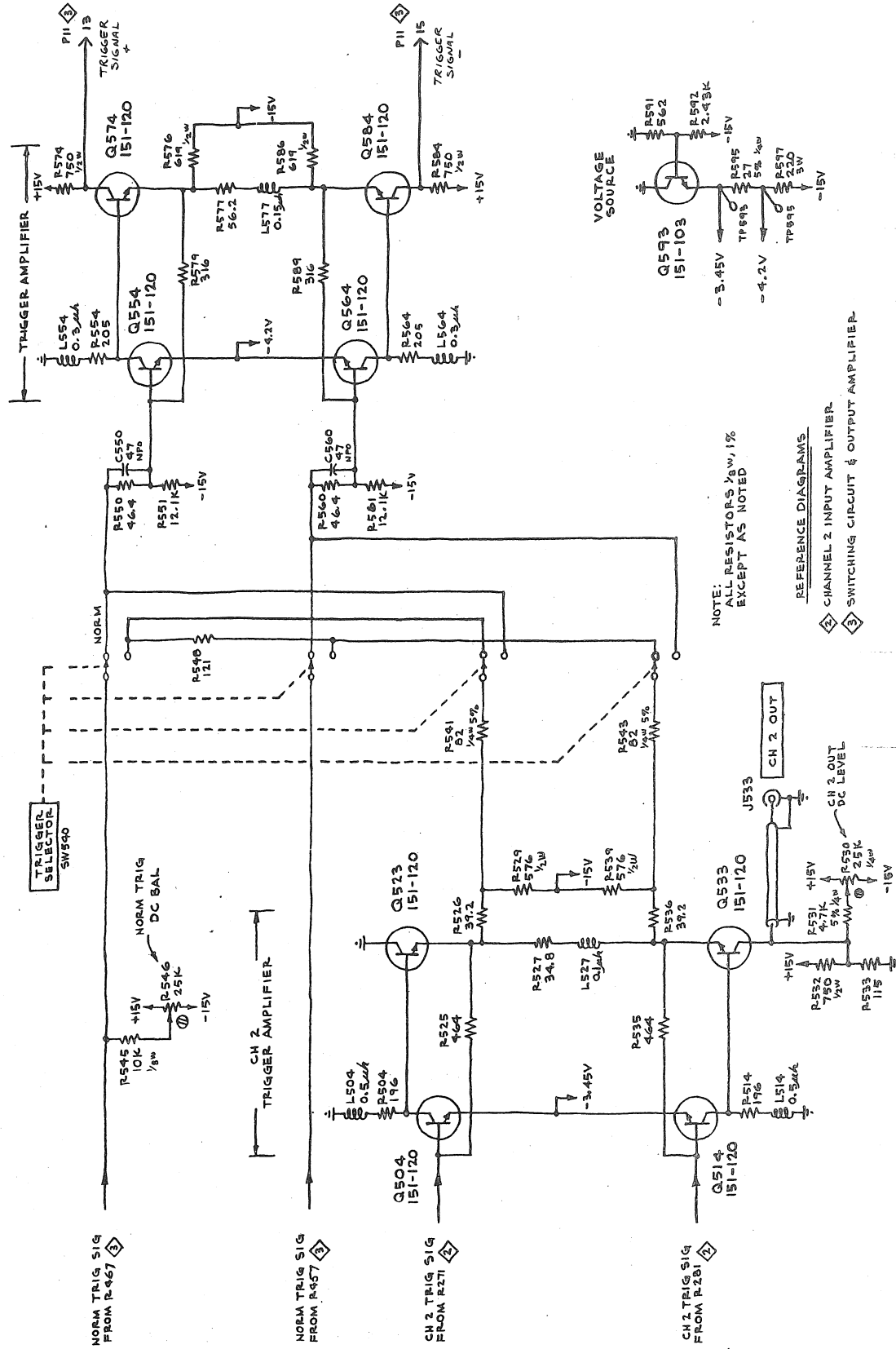
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NOTE: ALL RESISTORS 1/8W, 1% EXCEPT AS NOTED.

REFERENCE DIAGRAMS

- 1 SWITCHING CIRCUIT & OUTPUT AMPLIFIER
- 2 TRIGGER AMPLIFIER
- 3 ATTENUATORS



NOTE:
ALL RESISTORS 1/2W, 1%
EXCEPT AS NOTED

REFERENCE DIAGRAMS

◇ CHANNEL 2 INPUT AMPLIFIER

◇ SWITCHING CIRCUIT & OUTPUT AMPLIFIER

