Telequipment
SERVISCOPE
MINOR

All Telequipment instruments are the subject of continuous development and improvement and, in consequence, may incorporate minor detail changes from the information contained herein.

TELEQUIPMENT LIMITED
313 Chase Road,
London, N.14.

INTRODUCTION

OSCILLOSCOPES AND THE TEACHING OF MODERN PHYSICS

By: David Chaundy, M.A., B.Sc. *

The designers of the Serviscope Minor have considered what features are most desirable in an introductory oscilloscope for students themselves to use. They have decided that a direct-coupled Y amplifier, very slow time-base speeds, infallible synchronisation, and simplicity of operation are the most important. By concentrating on these features, instead of producing a simplified version of a versatile laboratory oscilloscope, it has been possible to reduce the price so that it is comparable with the cost of a moving-coil meter with adaptors to cover several ranges of D.C. and A.C. voltage. The comparison does not end here for, with the time base switched off, the oscilloscope is scarcely more complicated than a multirange voltmeter. With this oscilloscope an introductory course of electricity could well be based on an ammeter and an oscilloscope, in place of the customary moving-coil ammeter and voltmeter. There are several advantages to this approach.

Firstly, the movement of an electron beam depends on electrostatic attraction and a cathode-ray tube is thus a voltage-operated device, whereas a moving-coil meter is fundamentally a current-operated device. Secondly, an oscilloscope is quite unlike a moving-coil meter, and this should help students to distinguish between volts and amps at a much earlier stage than when they use two instruments which

* Malvern College

look almost identical. Thirdly, students will gain familiarity at an early stage with an instrument which is becoming increasingly used in sixth-form physics courses and in many branches of science and technology.

The precise manner of using Serviscope Minors will clearly depend on how electricity is taught, but a possible approach to electric currents is outlined below. If the initial stages are covered in this way, students will find that the use of an oscilloscope in later stages will seem both obvious and natural rather than mysterious and difficult as has so often been the case in the past.

The ideas of an electric current are introduced and currents are measured with a moving-coil ammeter. Then the oscilloscope, switched to D.C. and with the time-base off, is used to measure the e.m.f. of cells singly and in series. The Y-gain control can be adjusted to give, say, one division per cell and the Y-shift control can be used to "zero" the spot in the centre or at the bottom of the screen as preferred. The calibration of the instrument is not precise and does not need to be while it is being used as a "cell-counter". In laterwork it can be calibrated against a more sophisticated oscilloscope or a moving-coil voltmeter. In this way the need for an accurate standard of voltage becomes clear. Indeed, as the input resistance of the instrument is one megohm, it may be connected directly to a Weston standard cell. When the instrument has been calibrated it may be used as a voltmeter in all the usual experiments. The scale length is similar to that of a small moving-coil voltmeter though there are fewer calibrations.

In later work the time base will be used and it is likely that it will have been switched on in the earlier work on D.C. However, this is not recommended for normal D.C. use as the sweep repetition rate is very low when there is no A.C. input to trigger the time base. By first using the time base at the very low speed of about 3 cm/sec one can see how the spot moves. If now a cell is alternately connected to the input and disconnected from it one can see just how an oscilloscope plots a graph. Following this the waveforms of various A.C. generators and of the output of a step-down transformer connected to the mains can be investigated. With a carbon microphone, 6-volt battery, and step-up transformer speech waveforms are easily shown. The comparison of peak and r.m.s. voltages, the effects of rectification and smoothing, and the behaviour of square waves could be studied next. The oscilloscope will also be found to work well in situationswhere oscilloscopes are not normally used. For instance, as a null detector in a Wheatstone bridge it can give the balance point to the nearest millimetre on a metre wire, and unlike a galvanometer it will not suffer if it is put straight across the battery.

One of the first things the student will notice is the large Y deflections when the "high" terminal is touched, especially when the Y-gain control is at maximum. A full explanation of this effect involves a knowledge of resistance and capacitance in A.C. circuits, but an explanation on the following lines might be accepted.

Calling the potential of the "low" terminal nought, the spot will be deflected whenever the potential of the "high" terminal is not nought. Normally the mains wiring with its A.C. potential of 240V is far away from the "high" terminal. But if a mains lead is bought physically near the "high" terminal, its potential becomes electrically nearer to 240V and a deflection is noticed. When the "high" terminal is connected to a stray piece of wire it is effectively nearer the mains potential and with the whole of one's body connected to the terminal, its potential is much higher still. Touching the "low" terminal with another finger at the same time will lower this potential and jumping off the floor while touching the "high" terminal produces interesting effects.

After using the oscilloscope in some way, such as those suggested above, it should be such a familiar tool that it will be used whenever it is suitable and will no doubt be tried even when it is not suitable.

CHAPTER 1

GENERAL DESCRIPTION

CATHODE RAY TUBE

The $2\frac{3}{4}$" diameter cathode ray tube operates at 600 volts overall, giving a bright trace over the whole of the working area (5 x 5 cms).

A green filter improves the contrast under conditions of high ambient light.

VERTICAL DEFLECTION AMPLIFIER (Y AXIS)

The amplifier is DC coupled to the Y deflection plates. It has a sensitivity greater than 100 Mv/division and a frequency response from DC - 30 Kc/s (-3db).

The input gain control varies the signal level from 100 Mv/div. to 50 volts/div.

The input impedance is 1 megohm shunted by approximately 30 pf.

SWEEP CIRCUIT (X AXIS)

The sweep generator is a triggered Miller run down circuit providing good linearity. Three preset sweep speeds are provided, ranges 1, 2 and 3. These are approximately 100 Msecs/div., 10 Msecs/div. and 1 Msec/div. A variable control provides continuous overlap between the ranges, giving a total range of sweep speeds from 100 Msecs/div. to 100 usecs/div.

TRACE BLANKING

The blanking waveform from the sweep generator is AC coupled and DC restored, so giving uniform brightness at all sweep speeds.

TRIGGERING

The oscilloscope triggers internally, automatically. No adjustment is provided. In the absence of a signal the sweep free runs at about 10 c/s.

REMOVAL OF COVERS

Access to valves and preset adjustments can be gained by removing the two side covers. Remove the two screws at the top and bottom of each side cover, remove the sides together with the top and rear, so exposing the complete instrument.

COOLING

The Serviscope Minor is cooled by convection. Air enters at the rear of the bottom of the instrument, flows past the valves and other hot components and out at the slot at the top front of the instrument. Do not obstruct the air flow in any way.

CHAPTER 2

FIRST TIME OPERATION

CHECK SUPPLY VOLTAGE

To check that the oscilloscope is adjusted to the correct supply voltage, first disconnect instrument from supply mains, then remove the right hand side cover by undoing four screws, two at the top and two at the bottom of the instrument. The correct setting is obtained by soldering the supply leat to the appropriately marked tag on the power transformer.

USE OF CONTROLS

Unless you are familiar with this type of oscilloscope, follow these simple instructions carefully and then run through the procedure a few times to feel thoroughly at home with the instrument before putting it to use.

Set the front panel controls as follows:

INPUT SWITCH	to	D.C.
Y GAIN CONTROL	to	1
Y SHIFT	to	Mid-position
T.B. SWITCH	to	2
" VARIABLE	to	Mid-position
FOCUS	to	Mid-position

Switch on and allow the instrument a few minutes to warm up.

Advance the brilliance control until a trace appears and centre it using the Y shift control.

Connect a 50 c/s signal to the input sockets, adjust the Time Base variable control until there are two at three cycles of signal displayed. Adjust the focus and brightness controls for a clear, sharp picture.

This is a convenient display for demonstrating the functions of the controls.

Y GAIN

This adjusts the amplitude of the display by inserting a continuously variable resistance attenuator between the signal and the Y amplifier.

Y SHIFT

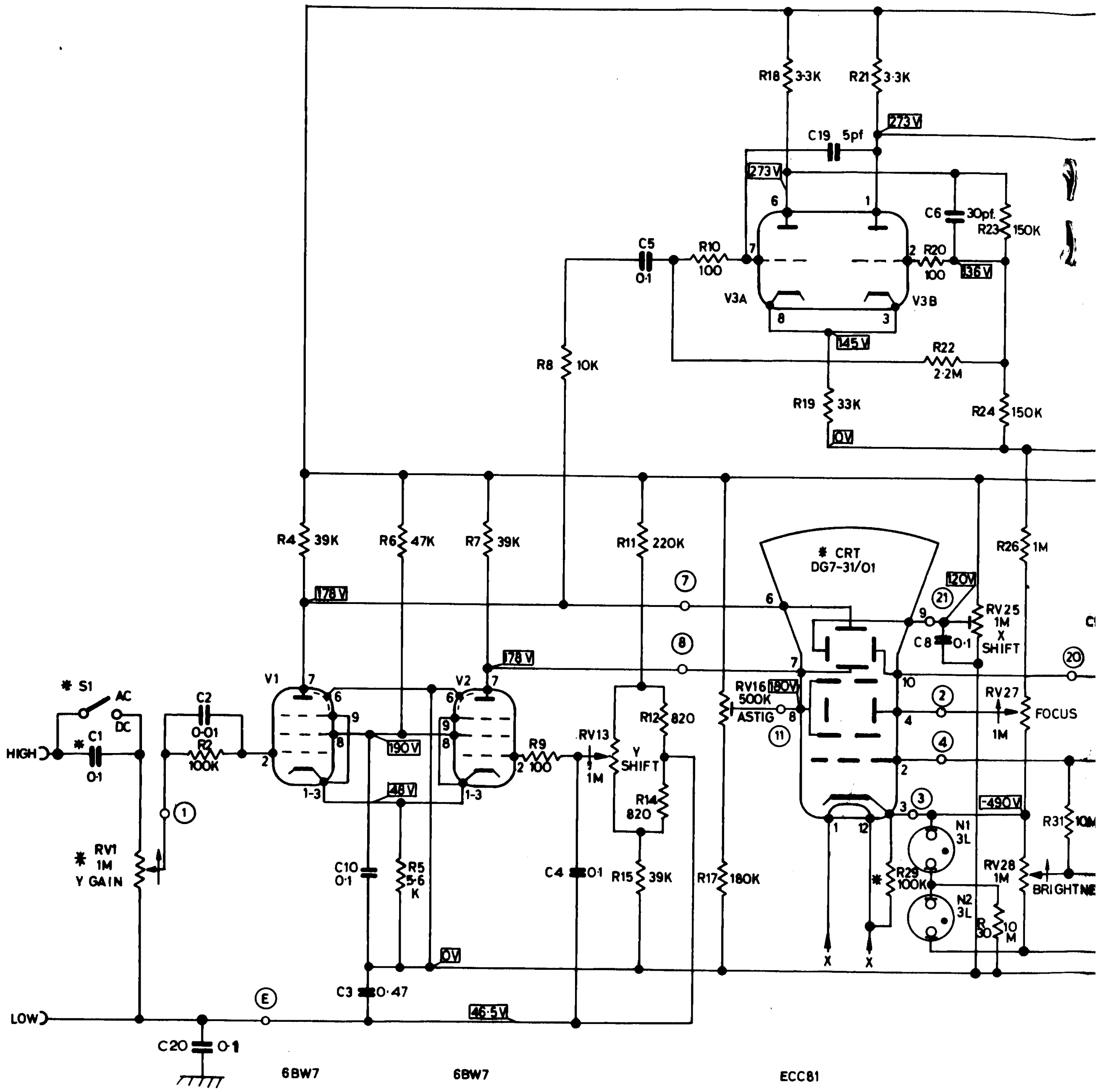
Provides approximately one screen diameter of shift and allows the trace to be positioned anywhere on the face of the CRT.

DC/AC SWITCH

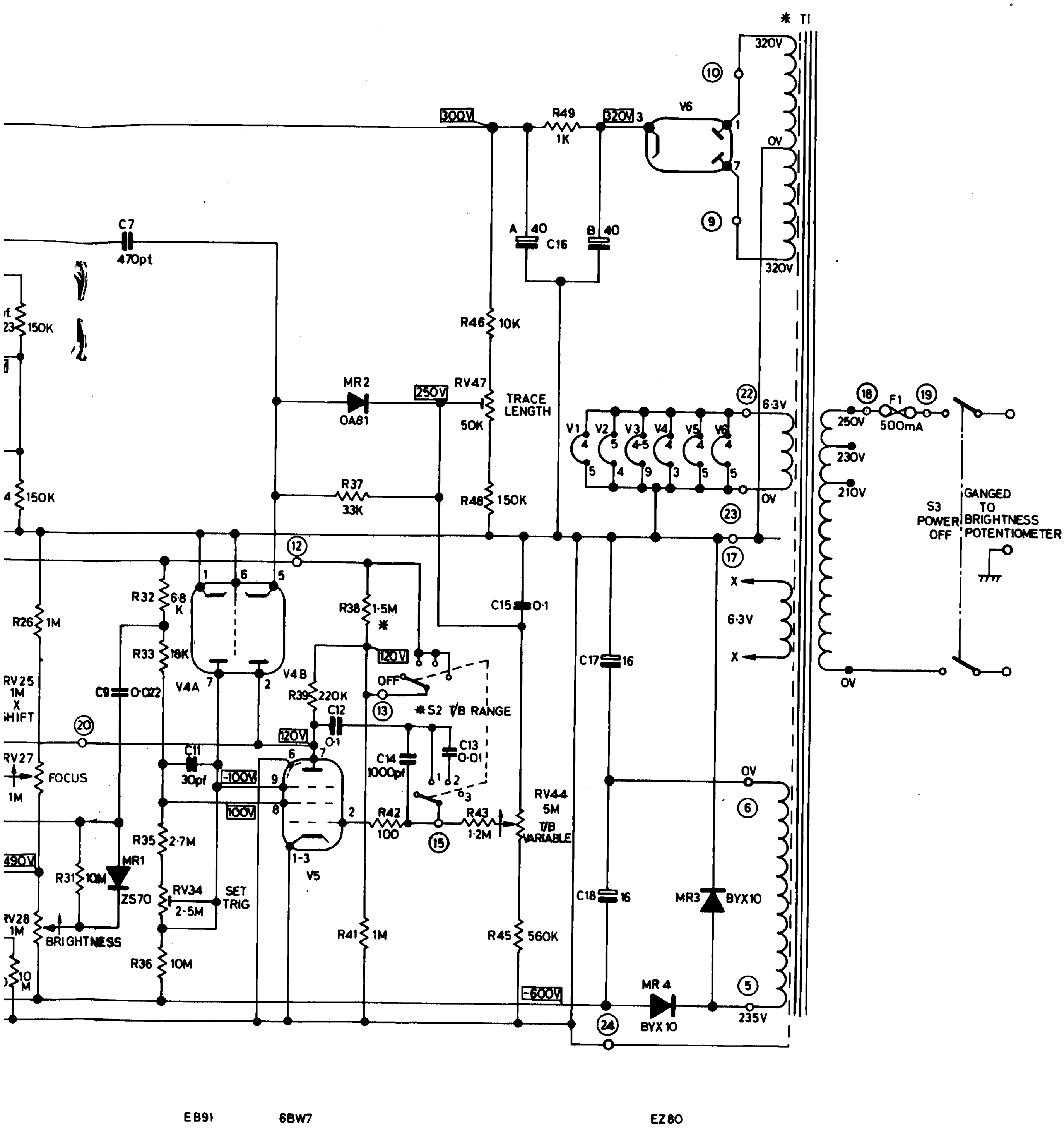
This switch will normally be used in the 'AC' position, in which a blocking capacitor removes the DC component of the input signal to the Vertical Deflection Amplifier. The time constant of the input circuit in this position is such that the response is 3 dB down at 2 c/s, which, whilst adequate for most normal purposes, may prove critical in some applications. If a longer time constant is required, an external blocking capacitor must be used, with a value suitably greater than 0.1 mfd and the input switch set to 'DC'.

TIME BASE

A four position switch, provides an 'OFF' position and approximate sweep speeds of 0.1 sec/div., 0.01 sec/div. and 0.001 sec/div., while the variable control provides continuous adjustment between the ranges, of approximately 10:1. Hence the sweep speeds will vary from 0.1 secs/div. to 0.0001 sec/div. In the 'OFF' position of the switch a stationary spot will be produced in the horizontal centre of the CRT.



NOTES
1. (Nº) DENOTES PRINTED CIRCUIT TAG NUMBERS.
2. COMPONENTS NOT MOUNTED ON PRINTED CIRCUIT MARKED THUS *.
3. ALL VOLTAGES MEASURED WITH A VALVE VOLTMETER. 'Y SHIFT' POSITIONED CENTRALLY AND TIME BASE IN 'OFF' POSITION.



SERVISCOPE MINOR

CHAPTER 3

CIRCUIT DESCRIPTION

The signal is connected to one end of RV1, the Y Gain control, either through C1, in the AC position, or directly, in the DC position of S1, the AC/DC switch. A portion of the signal is then taken from the slider of RV1 to the input grid of V1. C1 and R2 are provided to limit the grid current of V1 in case a very large signal is applied. Valves V1 and V2 act as a long tailed pair. Their cathodes are connected together and returned to HT negative through R5. Y Shift is applied to the grid of V2, via RV13, and push pull signal from the anodes of V1 and V2 are connected directly to the Y plates of the CRT. The synchronising signals are taken from the anode of V2.

V3 acts as a Schmitt trigger circuit. In the absence of an input signal, it will oscillate at a frequency determined approximately by R22, C5. The vertical signal, coupled from V2 anode, via R8 will trigger V3, and an output square wave will be produced at the anode of V3B. This signal is differentiated by C7, R37 and the positive going spike is removed by MR2, so that a train of negative going spikes, triggered by the vertical signal are passed to the diode of V4B.

The time base consists of V5, a screen coupled, triggered Miller run down circuit. Consider the operation at a time when the suppressor grid is highly negative, it is connected via R36 to EHT negative, cutting off V4A. Then V5 anode current is cut off and the anode is held at a potential determined by RV47, the trace length control. All the valve current therefore passes to the screen, so that the screen potential is low.

A negative going pulse, from C7 is passed through the diode V4B to the anode of V5 and hence via the timing condenser C12 (in position 1) to the grid of V5. This causes the valve current to decrease, the screen voltage to rise and this rise is transmitted through C11, R35 and RV34 to the suppressor grid causing it to go positive and so permitting anode current to flow. The anode potential then starts to fall, causing the anode of V4B to fall so shutting off any further trigger signals. Diode V4B will conduct to clamp the suppressor grid at cathode potential. The anode potential falls linearly until the bottoming potential is reached, at which time, the current will flow to the screen, the screen potential will fall, taking the suppressor negative and so cutting off anode current. The anode potential will rise until diode V4B conducts and clamps it at RV47 potential and the circuit is ready to recycle once again.

The sawtooth time constant is determined by C12 (range 1), R43 and the relevant portion of RV44. To alter the range a condenser C13 or C14 is added in series with C12.

The sawtooth signal is taken from the anode of V5 to one X plate of the CRT, while the other X plate is taken to RV25, the X shift control.

The bright up waveform is taken from a top on the screen potential divider, across R32 and is AC coupled via C9 to the grid of the CRT. The waveform is DC restored by MR1 to provide a flat toppedwaveform, and hence uniform brightness along the trace.

When the time base is switched off, the anode potential is switched to half the H.T. supply. This open circuits diode V4B so preventing any trigger pulses coming through, and the stationary spot is placed at the horizontal centre of the CRT.

HT supplies are provided by a fullwave rectifier V6 and reservoir condenser C16B. Smoothing is effected by R49 and C16A.

EHT supplies are provided by a voltage doubler circuit consisting of MR3, MR4, C17 and C18. The EHT negative is connected to the CRT cathode through a low impedance voltage dropper provided by N1 and N2. The brightness control RV28 is connected across the two neons. Neon N2 acts as the front panel pilot light and R30 is provided to bleed extra current into it, and ensure that it strikes on switching on.

Two heater supplies are provided, one for the CRT and one for all the other valves.

CHAPTER 4

MAINTENANCE, SERVICING AND SETTING UP PROCEDURE

The simplicity of the circuitry makes the "Minor" an extremely reliable instrument and for the most part servicing will be limited to the replacement of defective valves. Should a less common fault occur, no difficulty should be experienced in detecting the source if the circuit diagram is used in conjunction with the following test procedure.

To remove the side covers, ensure that the instrument is disconnected from the mains supply then, remove the four screws at the top and bottom of the instrument, and detach the covers together with the top and rear cover. The whole instrument is then exposed.

SETTING UP PROCEDURE

Set 'Y' Gain' fully clockwise.
Set 'Y Shift', Focus, RV47 (Trace length),
RV16 (Astig) and
RV25 (X Shift) to their mid-positions.
Set 'T.B. Variable'
and RV34 (Set Trig) fully anticlockwise.
Set T.B. Range to 3.

Feed in a 0.1V RMS sinewave signal, at 1 Kc/s from Levell oscillator or similar generator. Switch on and allow to warm up then turn 'Brightness' control clockwise until a trace is obtained. Centre the trace with the 'Y Shift' Turn RV34 (Set Trig) clockwise until a locked picture is obtained. Adjust the presets Focus (RV27), Astig (RV16), X Shift (RV25) and Trace Length (RV47) to obtain a finely focussed trace approximately 11 divisions long in the centre of the tube. Turn 'T.B.

Variable' fully clockwise, then turn RV34 (Set Trig) clockwise until the right hand and of the trace begins to shorten Set RV34 (Set Trig) to a position midway between this and its previous position. Adjust the input frequency until one cycle occupies 10 divisions. The frequency should be greater than 700 cycles.

Turn 'T.B. Variable' fully anticlockwise and reduce input frequency until one cycle occupies 10 divisions. The frequency should be less than 0.1 of the previous frequency.

Set 'T.B. Range' to 2 and check that the 'T.B. Variable' can be set so that one cycle occupies 10 divisions.

Turn the 'T.B. Variable' fully anticlockwise and reduce the input frequency until one cycle occupies 10 divisions.

Set the 'T.B. Range' to 1 and check that the 'T.B. Variable' can be set so that one cycle occupies 10 divisions.

Set the input frequency to 12 cycles and turn the 'T.B. Variable' fully anticlockwise.

Check that one cycle occupies less than one division.

Set the input frequency to 1 Kc/s and 'T.B. Range' to 3. Set the input voltage to 0.25V RMS. Then the deflection should be greater than 7 divisions.

Set the input voltage to give a deflection of 6 divisions and turn 'Y Gain' anticlockwise until the deflection is 3 divisions. Increase the input frequency until the deflection is 2 divisions. The frequency should be greater than 30 Kc/s.

Set the input frequency to 1 Kc/s and increase the input voltage 10 times (20dBs).

Set the knob on 'Y Gain' control to read 1 when deflection is 6 divisions.

CHAPTER 5

COMPONENTS LIST

ABBREVIATIONS

Capacitors

CER	Ceramic Tubular
ELEC	Electrolytic
P.E.	Polyester

Resistors

C	Carbon Composition
MO	Metal Oxide

In the following components list, no manufacturers' names have been included. When replacing components, locally available alternatives may be used if exact replacements are not to hand, provided the physical size is the same.

It is, however, preferable to use exact replacements whenever possible, and these should be ordered direct from:

TELEQUIPMENT LIMITED
313 Chase Road,
Southgate,
LONDON, N.14.

Telephone: FOX Lane 1166
Telegraph: Telequipt. London. N.14.

or from our agents.

COMPONENTS LIST

Part No.	C.C.T. Ref.	Value	Description	Tol.	Rating
C45	RV1	1M	C Potentiometer 'Y Gain' P125	20%	
8P10410	R2	100K	C Resistor	10%	$\frac{1}{4}$w
4P39310	R4	39K	C "	10%	$\frac{1}{2}$w
4P56210	R5	5.6K	C "	10%	$\frac{1}{2}$w
8P47310	R6	47K	C "	10%	$\frac{1}{4}$w
4P39310	R7	39K	C "	10%	$\frac{1}{2}$w
8P10310	R8	10K	C "	10%	$\frac{1}{4}$w
8P10110	R9	100	C "	10%	$\frac{1}{4}$w
8P10110	R10	100	C "	10%	$\frac{1}{4}$w
8P22410	R11	220K	C "	10%	$\frac{1}{4}$w
8P82110	R12	820	C "	10%	$\frac{1}{4}$w
C40	RV13	1M	Potentiometer 'Y Shift'		
8P82110	R14	820	C Resistor	10%	$\frac{1}{4}$w
8P39310	R15	39K	C "	10%	$\frac{1}{4}$w
C13	RV16	500K	C Potentiometer 'Astig'	20%	$\frac{1}{8}$w
8P18410	R17	180K	C Resistor	10%	$\frac{1}{4}$w
8P33210	R18	3.3K	C "	10%	$\frac{1}{4}$w
L122	R19	33K	MO "	5%	1.5w
8P10110	R20	100	C Resistor	10%	$\frac{1}{4}$w
8P33210	R21	3.3K	C "	10%	$\frac{1}{4}$w
8P22510	R22	2.2M	C "	10%	$\frac{1}{4}$w
8P15410	R23	150K	C "	10%	$\frac{1}{4}$w
8P15410	R24	150K	C "	10%	$\frac{1}{4}$w
C21	RV25	1M	C Potentiometer 'X Shift'	20%	$\frac{1}{8}$w
8P10510	R26	1M	C Resistor	10%	$\frac{1}{4}$w
C40	RV27	1M	C Potentiometer 'Focus'	20%	

COMPONENTS LIST (continued)

Part No.	C.C.T. Ref.	Value	Description	Tol.	Rating
C41	S3) RV28)	1M	Power 'On/off' C Potentiometer 'Brightness'	20%	
S10410	R29	100K	C Resistor	10%	$\frac{1}{4}$w
8P10610	R30	10M	C "	10%	$\frac{1}{4}$w
8P10610	R31	10M	C "	10%	$\frac{1}{4}$w
8P68210	R32	6.8K	C "	10%	$\frac{1}{4}$w
L123	R33	18K	MO Resistor	5%	1.5w
C29	RV34	2.5M	C Potentiometer	20%	$\frac{1}{8}$w
8P27510	R35	2.7M	C Resistor	10%	$\frac{1}{4}$w
8P10610	R36	10M	C "	10%	$\frac{1}{4}$w
8P33310	R37	33K	C "	10%	$\frac{1}{4}$w
915510	R38	1.5M	C "	10%	$\frac{1}{4}$w
8P22410	R39	220K	C "	10%	$\frac{1}{4}$w
8P10510	R41	1M	C "	10%	$\frac{1}{4}$w
8P10110	R42	100	C "	10%	$\frac{1}{4}$w
8P12510	R43	100	C "	10%	$\frac{1}{4}$w
C36	RV44	5M	C Potentiometer	20%	
8P56410	R45	560K	C Resistor	10%	$\frac{1}{4}$w
8P10310	R46	10K	C "	10%	$\frac{1}{4}$w
C28	RV47	50K	C Potentiometer 'Trace' Length	20%	$\frac{1}{8}$w
8P15410	R48	150K	C Resistor	10%	$\frac{1}{4}$w
4P10210	R49	1K	C "	10%	$\frac{1}{2}$w
K16	C1	0.1	P.E. Capacitor	10%	400V
J67	C2	0.01	P.E. Capacitor	20%	400V
J89	C3	0.47	P.E. Capacitor	20%	100V
J66	C4	0.1	P.E. Capacitor	20%	250V
J66	C5	0.1	P.E. Capacitor	20%	250V
J5	C6	30P	CER Capacitor	10%	350V

COMPONENTS LIST (continued)

Part No.	C.C.T. Ref.	Value	Description	Tol.	Rating
J3	C7	470P	CER Capacitor	10%	500V
J65	C8	0.1	P.E. Capacitor	20%	400V
J88	C9	0.022	P.E. Capacitor	20%	1000V
J65	C10	0.1	P.E. Capacitor	20%	400V
J5	C11	30p	CER Capacitor	10%	350V
J65	C12	0.1	P.E. Capacitor	20%	400V
J67	C13	0.01	P.E. Capacitor	20%	400V
K18	C14	1000P	P.E. Capacitor	20%	400V
J65	C15	0.1	P.E. Capacitor	20%	400V
J95	C16	40			
		+40	ELEC Capacitor		350V
J92	C17	16	ELEC Capacitor		450V
J92	C18	16	ELEC Capacitor		450V
K44	C19	5pf	CER Capacitor	5%	750V
K16	C20	0.1uf			400V
T16	V1		Valve 6BW7 BRIMAR		
T16	V2		Valve " "		
T13	V3		Valve ECC81 MULLARD		
T11	V4		Valve EB91 MULLARD		
T	V5		Valve 6BW7 BRIMAR		
T31	V6		Valve EZ80 MULLARD		
E10	MR1		Diode ZS70		
E34	MR2		Diode OA81		
010	MR3		Rectifier MULLARD BYX10		
010	MR4		Rectifier " "		
C78	S1		Switch AC/DC		
D40	S2		Switch "		

COMPONENTS LIST (continued)

Part No.	C.C.T. Ref.	Value	Description	Tol.	Rating
	S3		Switch 'Power On/Off' Mounted on RV28		
S47	T1		Transformer		
Y100	F1		Fuse $\frac{1}{2}$ amp. @ 240V		
Y36	N1		Neon 3L		
Y36	N2		Neon 3L		
	CRT		DG7-31/02 MULLARD		

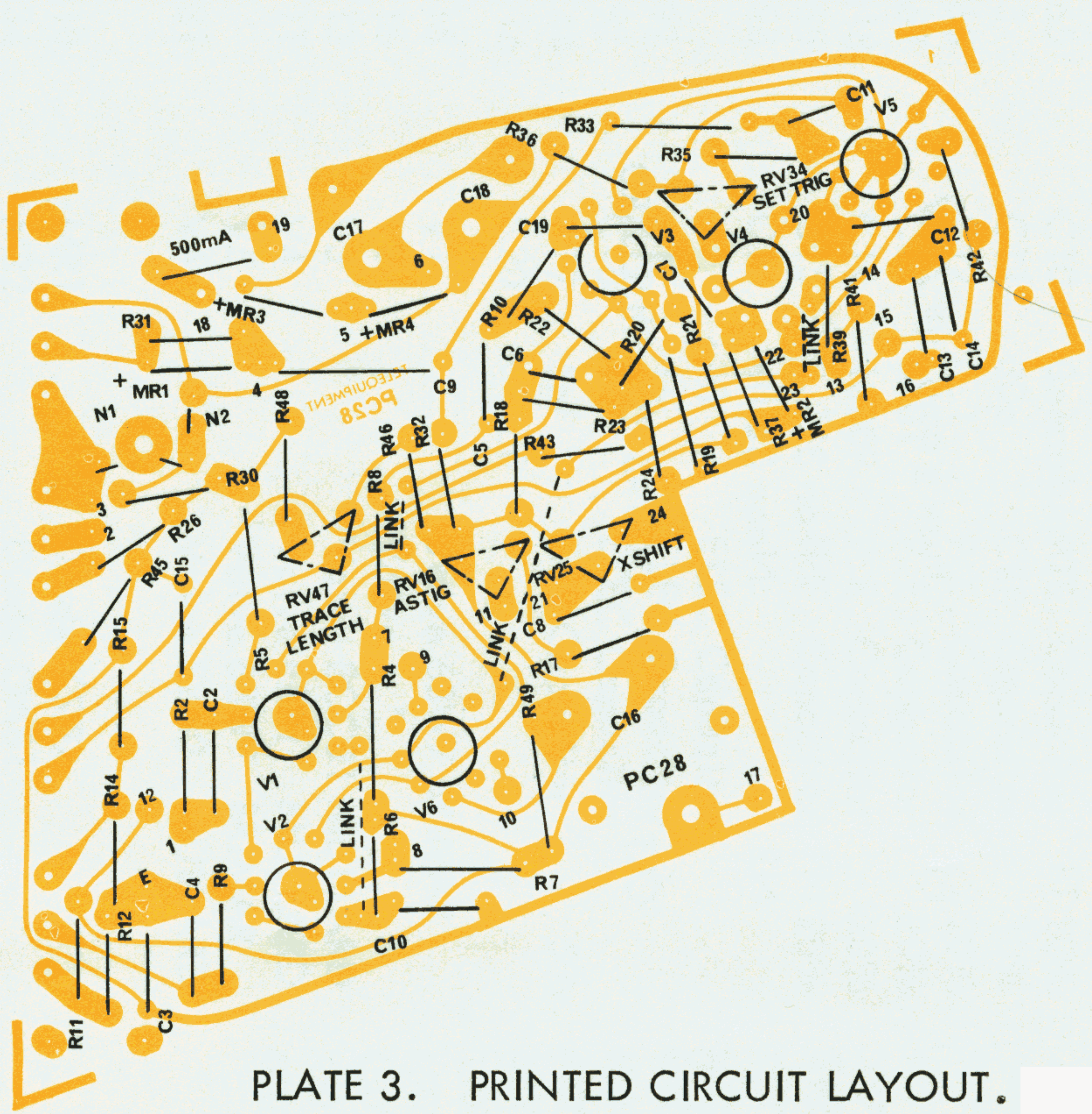


PLATE 3. PRINTED CIRCUIT LAYOUT.