Serviscope Minor

by

TELEQUIPMENT

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, in most oscilloscopes, the movement of an electron beam depends on electrostatic attraction and their 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

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which 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 later work 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 5 cm/s 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 situations where 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 brought 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 ways, 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.

C O N T E N T S

LIST OF PLATES

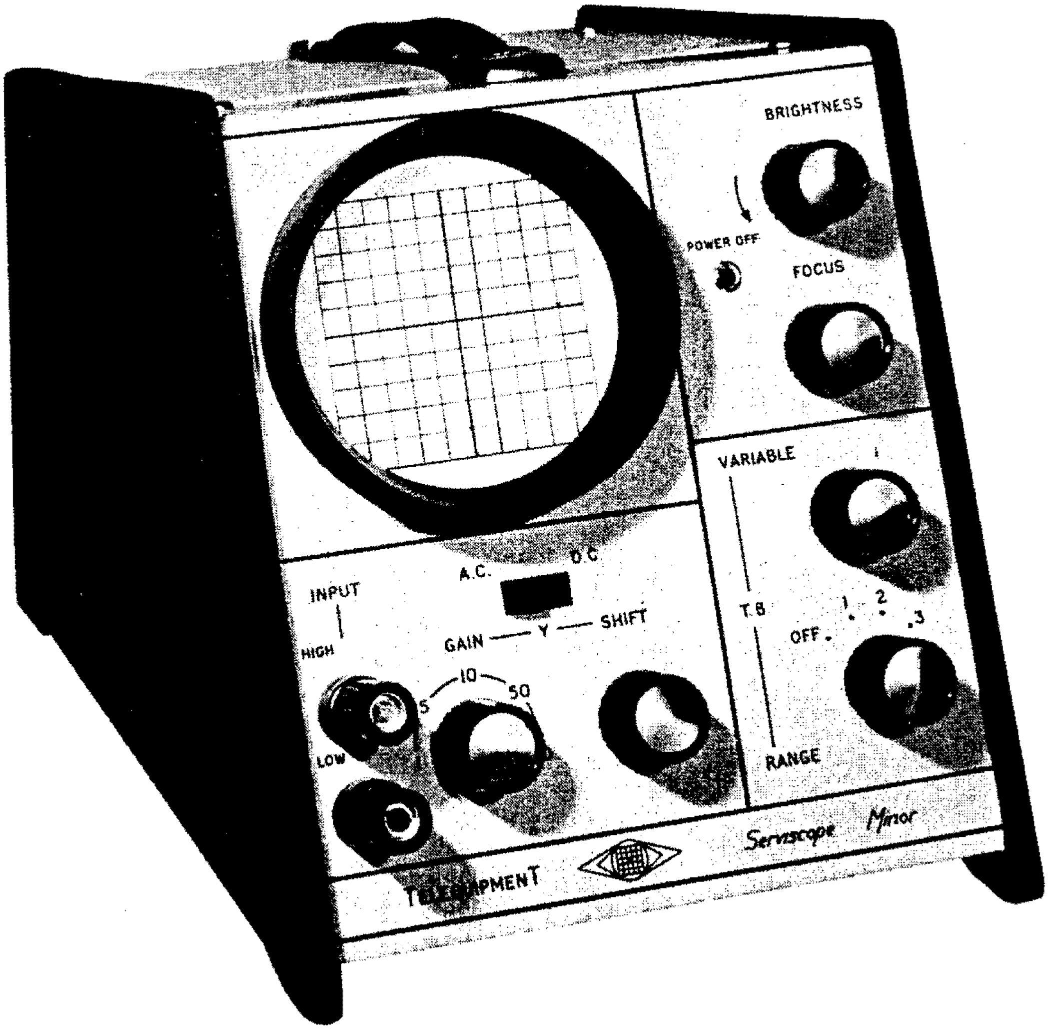


PLATE 1. SERVISCOPE MINOR.

GENERAL DESCRIPTION

CATHODE RAY TUBE

The $2\frac{3}{4}$in diameter cathode ray tube operates at 600 volts overall, giving a bright trace over the whole of the working area of 5 x 5 cm. Each division is 0.5 cm.

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

VERTICAL DEFLECTION AMPLIFIER (Y AXIS)

The amplifier is d.c.-coupled to the Y deflection plates. It has a sensitivity greater than 100 mV/division and a band-width from d.c. - 30 kHz (-3dB).

The input gain control varies the signal level from 100 mV/div. to 50 V/div.

The input impedance is 1 MΩ 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 10 ms/div., 1 ms/div. and 100 µs/div. A variable control provides continuous overlap between the ranges, giving a total range of sweep speeds from 100 ms to 100 µs/div.

In the OFF position a stationary spot is produced. The Variable control then acts as a shift control and so allows the spot to be centred. X input sockets at the rear of the instrument allow external signals to be displayed. The sensitivity is approximately 1.1 V/div. and the frequency response 2 Hz - 50 kHz (-3dB). The input impedance is 1 MΩ shunted by approximately 100 pF.

TRACE BLANKING

The blanking waveform from the sweep generator is a.c.-coupled and d.c.-restored, so giving uniform brightness at all sweep speeds.

TRIGGERING

The oscilloscope triggers automatically from an applied signal. No external adjustment is provided. In the absence of a signal the sweep free runs at about 10 Hz.

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.

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 red supply lead 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:

Brightness	Fully anti-clockwise, power off
Focus	Mid-range
T.B. Variable	Mid-range
T.B. Range	2
A.C. - D.C.	A.C.
Y Gain	10
Y Shift	Mid-range

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

Advance Brightness until a trace appears and centre it with Y Shift.

Connect a 50 Hz signal to the input sockets, adjust T.B. Variable until there are two or three cycles of signal displayed. Adjust Focus and Brightness 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 resistive attenuator between the signal input terminals and the Y amplifier. The calibrations provide an approximate indication of the percentage of the input signal applied to the amplifier.

Y SHIFT

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

A.C. - D.C. SWITCH

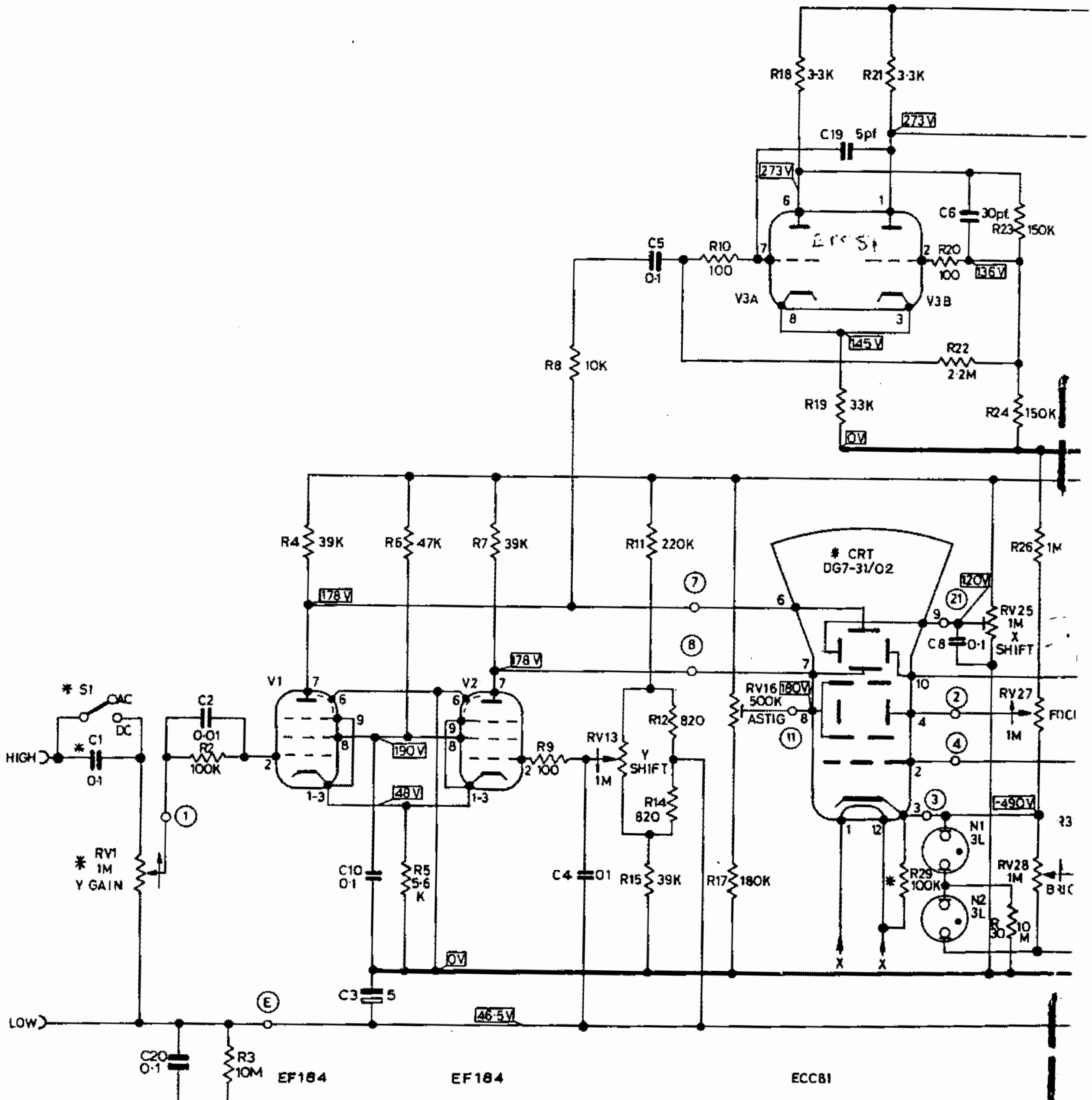
This switch will normally be used in the A.C. position, in which a blocking capacitor removes the d.c. component of the input signal to the vertical deflection amplifier. The time constant of the input circuit in this position is such that the response is 3dB down at 2 Hz, which, whilst adequate for 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 μF and the input switch set to D.C.

TIME BASE

The four-position T.B. Range switch provides an OFF position and three preset ranges of sweep speed in conjunction with the T.B. Variable control. The approximate ranges of sweep speed are as follows:

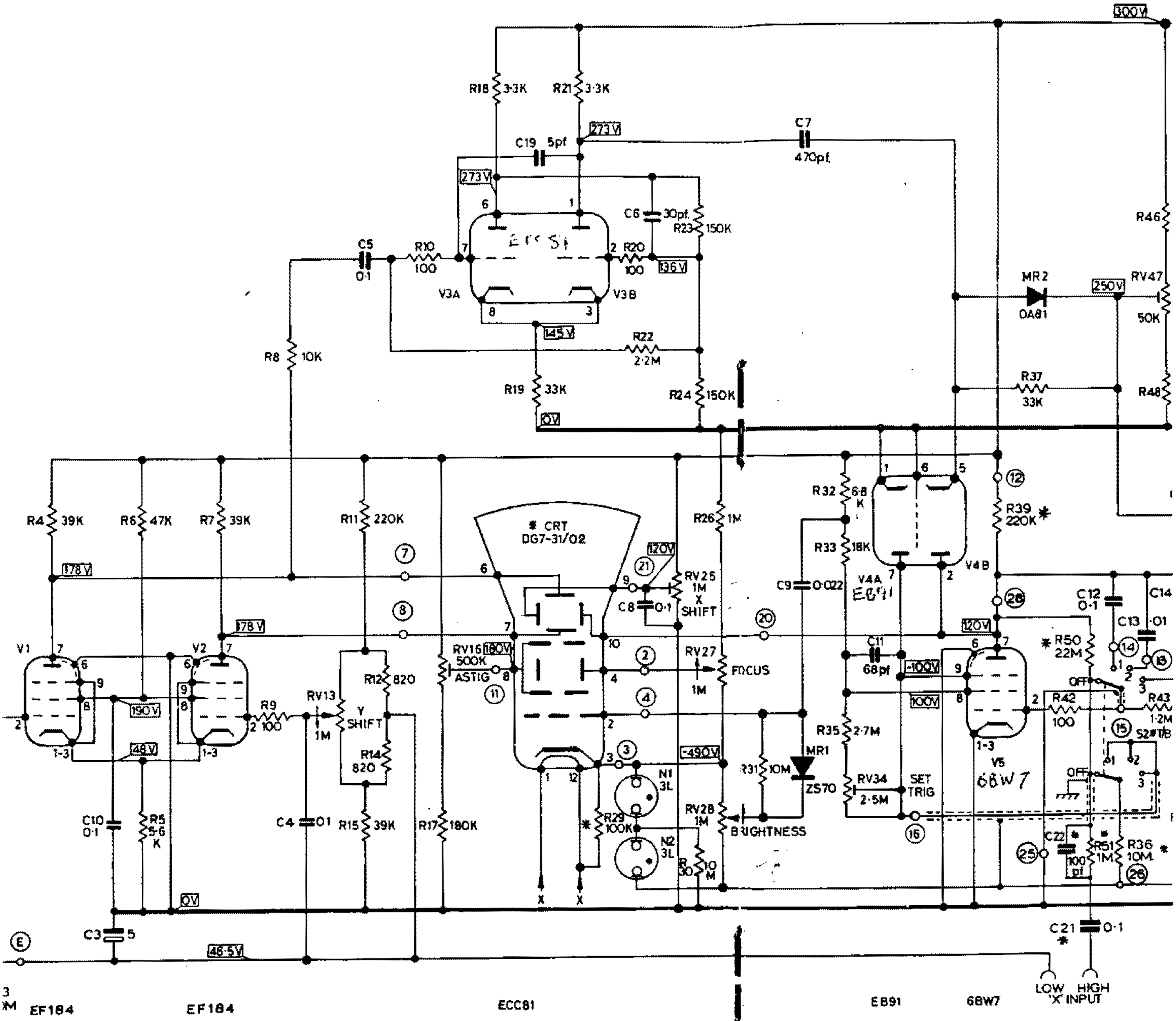
Range	1	100-10ms/div.
	2	10-1 ms/div.
	3	1ms-100μs/div.

In the OFF position, the sweep generator becomes a horizontal amplifier with fixed gain. If an a.c. signal of approximately 10V peak to peak, 7V r.m.s., is applied to the rear X input sockets, a horizontal trace approximately 10 divisions long will result. T.B. Variable now acts as an X shift control to effect lateral displacement of the trace.



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.

PLATE 2. CIR



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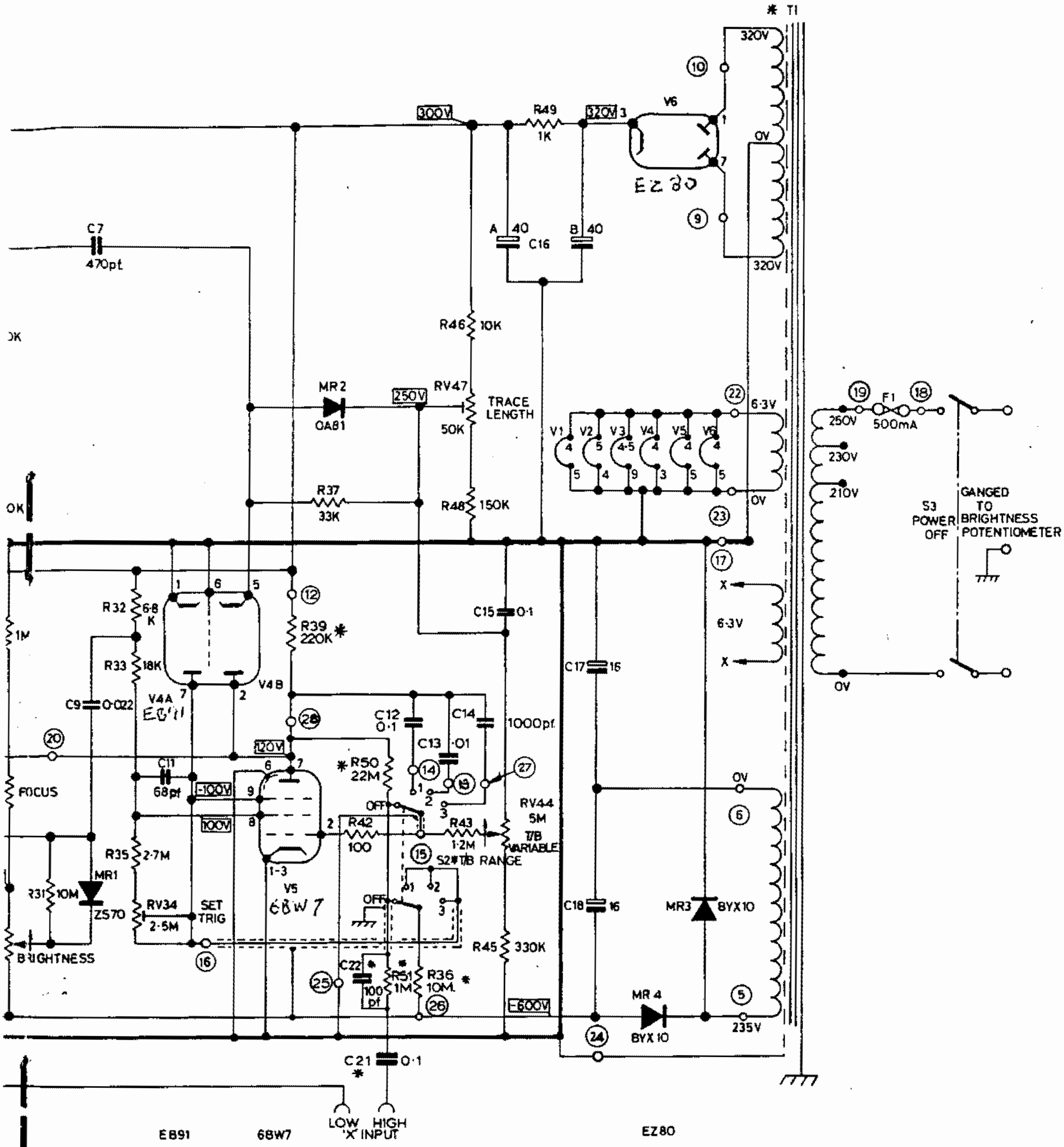
SERVISCOPE MINC

PLATE 2. CIRCUIT DIAGRAM.



SERVISCOPE MINOR

CIRCUIT DIAGRAM.

CIRCUIT DESCRIPTION

The signal is connected to one end of RV1, the Y Gain control, either through C1, in the A.C. position, or directly, in the D.C. position of S1, the A.C.-D.C. switch. A portion of the signal is then taken from the slider of RV1 to the control grid of V1. C2 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 signals 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 V1.

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 V1 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 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 RV46, the trace length preset. 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 capacitor 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 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 V4A will conduct to clamp the suppressor 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 (on range 1), R43 and the relevant portion of RV44. To alter the range, capacitor C13 or C14 replaces 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 blanking waveform is taken from a tap on the screen potential divider, across R32 and is a.c.-coupled via C9 to the grid of the CRT. The waveform is d.c.-restored by MR1 to provide a flat topped waveform, and hence uniform brightness along the trace.

When the time base is switched off, R36 is connected to the control grid of V5 instead of the suppressor. Resistor R50 is switched between anode and grid and the X Input socket is connected via R51, C22 and C21 to the grid of V5. This converts V5 into a virtual earth amplifier with a gain determined by R50 and R51. RV44 now acts as an X shift control.

HT supplies are provided by a full-wave rectifier V6 and reservoir capacitor 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 provider by N1 and N2. 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.

MAINTENANCE, SETTING-UP AND TEST

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 eight 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 - Set controls as follows:

Brightness, T.B. Variable and Set Trig fully anti-clockwise.
Y Gain and T.B. Range fully clockwise.
Y Shift, Focus, Trace Length, Astig and X Shift to mid-range.
A.C. - D.C. to A.C.

Apply a 100mV 1kHz sinewave to input terminals.

Switch on, allow to warm up and advance Brightness until a trace is obtained, centre it with Y Shift.

Turn Set Trig clockwise until display locks.

Adjust Focus, Astig, X Shift and Trace Length to obtain a finely focussed trace about 12 divisions long starting a half division before the first graticule line.

Turn T.B. Variable fully clockwise.

Note position of Set Trig and turn clockwise until trace begins to shorten at right hand end. Set it mid-way between the two positions.

TEST

TIME BASE - Sweep speed

Apply a 250mV r.m.s. sinewave to input terminals.

a) Set T.B. Variable fully clockwise and T.B. Range to 3. Adjust and note input frequency to give 1 cycle in 10 divisions. The frequency should exceed 700Hz.

b) Turn Variable fully anti-clockwise and reduce and note frequency to give 1 cycle/10 div. The frequency should be less than a tenth of that in a).

c) With frequency as in b), set Range to 2 and check that Variable can be set for 1 cycle/10 div.

d) Turn Variable fully anti-clockwise and reduce and note frequency for 1 cycle/10 div. The frequency should be less than a tenth of that in b) & c).

e) With frequency as in d) set Range to 1 and check that Variable can be set for 1 cycle/10 div.

f) With frequency as in d) & e) tu n Variable fully anti-clockwise and check that 1 cycle occupies less than 1 division.

Y AMPLIFIER - Gain and bandwidth

Apply a 250mV r.m.s. 1kHz sinewave to input terminals. Set Y Gain fully clockwise. Check that deflection exceeds 7 divisions.

Reduce input for 6 div. deflection. Set Y Gain for 3 div. deflection. Increase frequency until deflection reduces to 2 div. Check that frequency exceeds 30kHz.

X AMPLIFIER - Gain and bandwidth

With T.B. Range at OFF, feed in a 2.5V r.m.s. 1kHz sinewave to rear X input sockets. Centre trace with T.B. Variable. Check that horizontal deflection is from 4 to 9 div.

Reduce input to give 4 div. deflection. Increase frequency until deflection reduces to 2.8 div. Check that frequency exceeds 50kHz.

COMPONENT LIST

All resistor and capacitor values are stated in ohms and microfarads. Ratings at 70°C are stated in watts and volts respectively unless otherwise shown.

Whenever possible, exact replacements for components should be used. These may be ordered from the company or its agents specifying the instrument type and serial number, shown on underside of instrument, and the component circuit reference, part number and value.

Abbreviations

C	Carbon composition	ELEC	Electrolytic
CER	Ceramic	MO	Metal oxide
CP	Carbon preset	PE	Polyester
CV	Carbon variable		

Cct. ref.	Part no.	Value	Description	Tol. %	Rating
RV1	311-0819-00	1M	CV	20	0.125
R2	316-0104-02	100k	C		
R3	316-0106-01	10M	C		
R4	302-0393-01	39k	C	10	½
R5	302-0562-02	5.6k	C	10	½
R6	316-0473-02	47k	C		
R7	302-0393-01	39k	C	10	½
R8	316-0103-02	10k	C		
R9	316-0101-02	100	C		
R10	316-0101-02	100	C		
R11	316-0224-02	220k	C		
R12	316-0821-02	820	C		
RV13	311-0820-00	1M	CV	20	¼
R14	316-0821-02	820	C		
R15	316-0393-02	39k	C		
RV16	311-0804-00	500k	CP	20	0.125
R17	316-0184-02	180k	C	20	¼
R18	316-0332-02	3.3k	C		
R19	307-0137-00	33k	MO	5	1½
R20	316-0101-02	100	C		
R21	316-0332-02	3.3k	C		
R22	316-0225-02	2.2M	C		
R23	316-0154-02	150k	C		
R24	316-0154-02	150k	C		
RV25	311-0818-00	1M	CV	30	0.1
R26	316-0105-02	1M	C		
RV27	311-0820-00	1M	CV	20	¼
RV28	311-0823-00	1M	CV (with S3)	20	¼
R29	316-0104-01	100k	C		
R30	316-0106-02	10M	C		
R31	316-0106-02	10M	C		

Resistors are 10% ¼W unless otherwise shown

Cct. ref.	Part no.	Value	Description	Tol. %	Rating
R32	316-0682-02	6.8k	C		
R33	307-0136-00	18k	MO	5	$1\frac{1}{2}$
RV34	311-0830-00	2.5M	C	20	0.125
R35	316-0275-02	2.7M	C		
R36	316-0106-01	10M	C		
R37	316-0333-02	33k	C		
R39	316-0224-01	220k	C		
R42	316-0101-02	100	C		
R43	316-0125-02	1.2M	C		
RV44	311-0829-00	5M	CV	20	$\frac{1}{4}$
R45	316-0334-02	330k	C		
R46	316-0103-02	10k	C		
RV47	311-0761-00	50k	C	20	0.125
R48	316-0154-02	150k	C		
R49	302-0102-02	1k	C	10	$\frac{1}{2}$
R50	307-0186-00	22M	C	20	$\frac{1}{4}$
R51	316-0105-01	1M	C		
C1	285-0772-00	0.1	PE	10	400
C2	285-0769-00	0.01	PE	20	400
C3	290-0355-00	5	ELEC		64
C4	285-0796-00	0.1	PE	20	250
C5	285-0796-00	0.1	PE	20	250
C6	285-0843-00	30p	PS	2p	500
C7	281-0688-00	470p	CER	10	500
C8	285-0773-00	0.1	PE	20	400
C9	285-0785-00	0.022	PE	20	1k
C10	285-0773-00	0.1	PE	20	400
C11	281-0719-00	68p	CER	10	750
C12	285-0773-00	0.1	PE	20	400
C13	285-0769-00	0.01	PE	20	400
C14	285-0858-00	1000p	PS	1	350
C15	285-0773-00	0.1	PE	20	400

Cct. ref.	Part no.	Value	Description	Tol. %	Rating
C16A C16B	290-0373-00	40+40	ELEC		350
C17	290-0365-00	16	ELEC		450
C18	290-0365-00	16	ELEC		450
C19	281-0712-00	5p	CER	5	750
C20	285-0772-00	0.1	PE	20	400
C21	285-0772-00	0.1	PE	20	400
C22	285-0854-00	100p	PS	2p	350
F1	159-0067-00	½A	Fuse		
MR1	152-0339-00		ZS70 Ferranti Si		
MR2	152-0062-01		1N914 C.S.F. Si		
MR3	152-0352-00		BYX10 Mullard Si		
MR4	152-0352-00		BYX10 Mullard Si		
N1	150-0069-00		Neon 3L		
N2	150-0069-00		Neon 3L		
S1	260-0926-00		Slide (2-position)		
S2	260-0965-00		Rotary (4-position)		
S3	311-0823-00		Rotary (with RV28)		
T1	120-0534-00		Transformer		
V1	154-0535-00		EF184 Mullard		
V2	154-0535-00		EF184 Mullard		
V3	154-0039-04		ECC81 Mullard		
V4	154-0534-00		EB91 Mullard		
V5	154-0538-00		6BW7 Brimar		
V6	154-0541-00		EZ80 Mullard		
CRT	154-0524-00		DG7-31/02 Mullard		

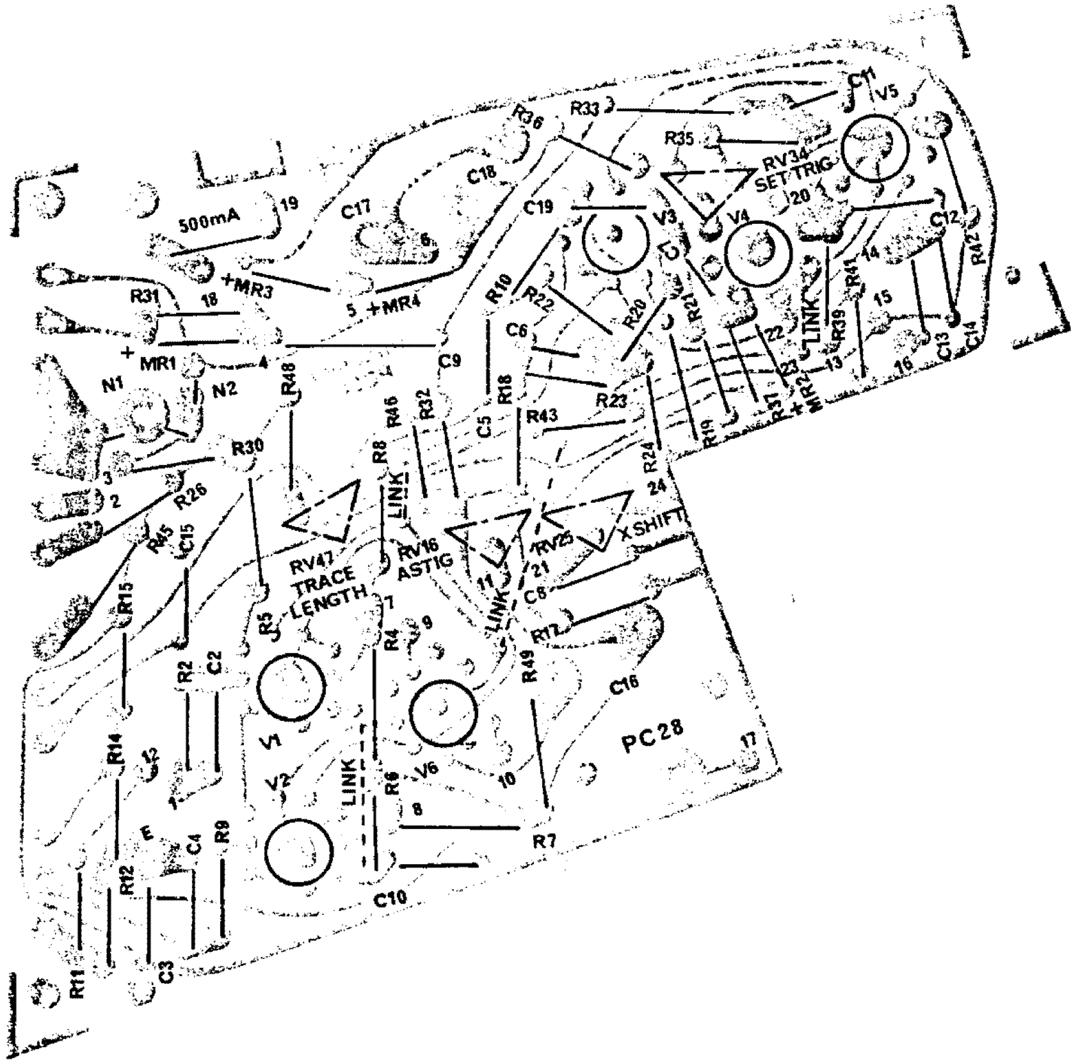


PLATE 3.   PRINTED CIRCUIT LAYOUT.

INDEX