INSTRUCTION MANUAL

FOR

E.M.I. OSCILLOSCOPE

TYPE W.M.S

E.M.I. (AUSTRALIA) LIMITED

HOMEBUSH - N.S.W.

Part No. 682-5051

OSCILLOSCOPE — TYPE W.M.S

CONTENTS

OSCILLOSCOPE — TYPE W.M.S

GENERAL DESCRIPTION AND SPECIFICATION

The WMS Oscilloscope is a versatile instrument incorporating a direct-reading voltage measurement system, suitable for D.C. voltages, A.C. peak-to-peak voltages, or the measurement of vertical portions of any waveform.

The basic oscilloscope provides a wide-range linear time base, enabling waveforms of frequencies up to 1 Mc/s to be satisfactorily displayed.

An internal variable gain amplifier provides a maximum sensitivity of 0.115 v/cm, and an input attenuator is provided to prevent saturation by high input voltages.

The voltage measurement system is effective over a range of 0.2 to 500 volts, readable on a built-in centre-zero voltmeter.

CONTROLS

Front Panel:

Frequency Range Switch (12 position).
Fine Frequency.
Synchronising.
Focus.
Brilliance.
Horizontal Shift.
Voltage Measuring (Vertical Shift).
Voltage Range Switch (5 volts and 50 volts).
Amplifier Gain.
Input Attenuator Switch (1:1, 2:1 and 10:1).
D.C. and A.C. Input Terminals.
Earth Terminal.
External Time Base Input Jack.
Reference Potential Input Jack (provided to lift the "earthy" side of the input from the metal frame and allow points at high voltage to be examined and measured).

Rear Panel:

Amplifier Anode Balance.
Amplifier Cathode Balance.
External Sync. Terminal.
Internal Time Base Output.
H.T. Fuse.

VALVES

V1, V2 } N78 Balanced Amplifier
V3 6C4 Phase Splitter
V4 Z77 Time Base Oscillator
V5, V6 } 6X4 Voltage Doubler Rectifiers.

TUBE

3AFPI Screen diameter 2½ inches. Colour of trace, Green.

METER

Flush Pattern, 2-inch Scale, centre zero. Sensitivity of movement, ± 0.5 mA F.S.D.

AMPLIFIER SENSITIVITY

0.15 v. per cm. at max. gain.
Max.-Min. gain ratio 29 dB.

TIME BASE FREQUENCY RANGE

7.5 c/s to 90 Kc/s in 12 ranges.

COVERAGE OF TIME BASE FREQUENCY RANGE SWITCH

The following figures give the approximate coverages of each of the twelve positions of the Frequency Range Switch. They represent the average of several models and will be of value as a guide to the time base frequencies at any particular setting of the switch in conjunction with the Fine Frequency Control.

Frequency Range Switch Setting	*Coverage Provided by Fine Frequency Control*
1	7.5 ..... 21 c/s
2	23.5 ..... 66 c/s
3	42 ..... 120 c/s
4	75 ..... 230 c/s
5	155 ..... 490 c/s
6	360 ..... 720 c/s
7	720 ..... 2,300 c/s
8	1.55 ..... 5 Kc/s
9	2.9 ..... 9.2 Kc/s
10	7.8 ..... 24 Kc/s
11	17.5 ..... 49 Kc/s
12	39.5 ..... 90 Kc/s

AMPLIFIER INPUT CONDITIONS

Attenuator Setting	*Input Resistance*	*Input Capacity*	*Voltage Measuring Accuracy*
1 : 1	1 megohm	65 pF approx.	± 5% F.S.D.
2 : 1	2 megohms	65 pF approx.	± 7% F.S.D.
10 : 1	10 megohms	35 pF approx.	± 10% F.S.D.

VOLTAGE MEASUREMENT RANGE

0 — 5 volts and 0 — 50 volts direct.

0 — 10 volts, 0 — 50 volts, 0 — 100 volts and 0 — 500 volts with attenuator.

MAINS SUPPLY

110, 120 and 200 to 250 volts A.C., 50/60 c/s (200-250 volts in 10-volt steps).

CONSUMPTION

90 watts.

PROTECTION

A 250 mA fuse is fitted in the mains transformer H.T. lead to the junction of the voltage doubler reservoir condensers.

PHYSICAL CHARACTERISTICS

Dimensions ..... Height, $9\frac{7}{8}$ inches; Width, $8\frac{1}{4}$ inches; Depth, 13 inches.

Weight ..... $25\frac{1}{2}$ lb.

Finish ..... Two-tone Green Baked Enamel.

WARNING: It is essential that a good earth connection be made to the earth terminal of this oscilloscope at all times.

SETTING UP

1. Remove from carton and check for any external evidence of transit damage.

2. Remove the four rubber feet. The screws for these fit into the chassis.

3. Withdraw the chassis, wth its front panel, from case.

4. Check carefully for any apparent damage due to transit. See that the C.R. Tube and all valves are fully inserted in their holders. Check that the fuse (FS1) is firmly in position (screwed to maximum clockwise position).

5. Adjust the mains connections on the mains transformer to suit the voltage of the mains supply to which the oscilloscope is to be connected. For example, if the mains voltage is 230 volts, connect one lead to the terminal marked 10 and the other lead to the terminal marked 220. Thus, by using the 0 or 10 terminal, voltages of 200, 210, 220, 230, 240 and 250 may be covered. An extra tapping for 110-volt operation is also provided.

6. Replace cover and re-insert the fixing screws and rubber feet.

NOTE: There is no mains ON/OFF switch incorporated in this instrument, and the mains supply must be controlled at the supply point.

8. If no trace is observed on the screen of the oscilloscope a short interval after switching on, this may be due to the adjustment of the BRILLIANCE control, which may be at its minimum position. Completely rotating the control will immediately establish this point. Should only a spot be obtained in the centre of the screen and the spot cannot be deflected vertically by the volts control or horizontally by the SHIFT control, this will indicate that the fuse has been blown or is not making proper contact.

EARTH CONNECTION: The terminal marked E must be connected to a suitable earth point. The "earthy" side of the oscilloscope circuit and all metalwork will then be earthed and full protection provided against accidental shock. The earth terminal may also be used as an input connection for the "earthy" side of any circuit output being examined, but only if it is known that the "earthy" side is at true earth potential, or is completely isolated from earth. If there is any doubt on this point, connect the "earthy" side of the circuit being examined to the REF. POTL. jack. As explained in the section dealing with the REF. POTL. jack, this isolates the circuits from the case which, however, still remains earthed, giving full protection. This is an exclusive feature of this oscilloscope. As an example: to examine a valve anode signal between the load resistor and chassis of a D.C./A.C. receiver, the anode connection would be taken to the A.C. terminal and the chassis connection to the REF. POTL. jack. A D.C./A.C. chassis is nearly always at mains potential and to connect the chassis to the oscilloscope E terminal with an earth lead already on it, would probably blow the mains fuse.

OPERATION

VOLTAGE MEASUREMENTS

The special feature of voltage measurements which dispenses with graduated transparent cursors over the tube screen, is easily applied to any waveform or image being observed.

Before switching on the oscilloscope, check that the meter needle is at zero calibration. If it is not, adjust the small zero adjusting screw on the meter. This mechanical zero adjustment must always be carried out before any electrical adjustments are made.

Allow ten minutes for warming up before commencing voltage measurements; a horizontal line trace should be obtained and made to coincide with the metal cursor across the tube screen. This is accomplished by adjusting the VOLTS control and when alignment is achieved, the voltmeter should register zero. If it does not, due, for example, to valve ageing, etc., the pre-set BALANCE controls on the rear sub-panel should be adjusted. Normally, these require very infrequent adjustment, but when necessary, it is carried out as follows:

With the GAIN control (front panel) at maximum, adjust the MAX. balance control until the trace coincides with the cursor.

The MIN. balance control is adjusted, if necessary, at low setting of the GAIN control to prevent any vertical movement of the trace when the GAIN control is operated. If movement is evident when the GAIN control is rotated, adjust the MIN. balance control. Check and adjust both balance controls if necessary at various settings of the GAIN control, until no vertical movement is apparent.

The input whose waveform is to be examined may then be injected into the oscilloscope and voltage measurements obtained by rotating the VOLTS control, which will shift the trace vertically. The voltmeter will register the voltage difference between the two portions of the trace which coincide with the cursor before and after adjusting the VOLTS control. The voltage reading must be considered in relation to the settings of the ATTENUATOR and VOLTAGE RANGE controls. The effect of these controls is shown in the table below.

Attenuator	*Volts Switch*	*Meter Scale*
1 : 1	5.0 volts	5 — 0 — 5 volts
2 : 1	5.0 volts	10 — 0 — 10 volts
10 : 1	5.0 volts	50 — 0 — 50 volts
1 : 1	50.0 volts	50 — 0 — 50 volts
2 : 1	50.0 volts	100 — 0 — 100 volts
10 : 1	50.0 volts	500 — 0 — 500 volts

Overloads on particular ranges will not damage the instrument, but may falsify voltage readings due to valve overload.

It should be appreciated that the voltage reading obtained between the extremes of a sine wave trace will be double the peak voltage. The relationship between Peak, Effective (R.M.S.) and Average values for a sine wave are:

Peak	100%
Effective (R.M.S.)	70.7%
Average	63.6%

For example: an A.C. voltage of 212.1 R.M.S. will give a peak reading of 300 volts (or 600 volts between maximum positive and maximum negative).

USE OF "REF. POTL." JACK

As will be seen from the circuit diagram of the oscilloscope, the REF. POTL. jack isolates the chassis and earth terminal of the oscilloscope from the negative or "earthy" side of the circuit when the plug is inserted in the jack. The tip of the plug performs the switching action and therefore EXTERNAL CONNECTION MUST BE MADE TO THE SLEEVE TERMINAL OF THE PLUG AND NOT TO THE TIP.

THE JACK PLUG MUST BE INSERTED BEFORE THE EXTERNAL CIRCUIT IS SWITCHED ON, AND MUST NOT BE WITHDRAWN BEFORE THE EXTERNAL CIRCUIT IS SWITCHED OFF.

A.C. INPUT

As an example of the type of measurement or waveform observation this arrangement allows, we may consider the signal potential and waveform existing across an anode resistor in an amplifier. The valve anode is, say, at 250 volts positive, and the other, or H.T. end of the load resistor is expected to be around 300 volts positive. To the anode is connected the A.C. input terminal of the oscilloscope. The H.T. connection obviously cannot be taken to the earth terminal of the oscilloscope because this would cause the chassis and case of the instrument to be "live" and would short the H.T. supply if an earth lead is already connected to the earth terminal. Instead, the H.T. connection is taken to the sleeve terminal of the jack plug. When the plug is inserted in the jack, the H.T. end of the load resistor is connected to the "earthy" side of the input end and, after suitably adjusting the controls, a trace of the signal waveform across the load resistor will be seen on the C.R.T. screen. The A.C. potential difference between maximum and minimum limits of the trace, or any portion of the trace, may be measured by the use of the VOLTS control, as has already been explained.

D.C. INPUT

To measure the D.C. potential across such a component as a load resistance mentioned in the previous section, the same general explanation as given under "A.C. Input" holds good, except that the input connection must be taken to the D.C. terminal on the oscilloscope. Only a horizontal straight line trace should be obtained (assuming no hum is apparent). Insert the jack plug (which is connected to H.T. positive), register the trace with the cursor and see that the voltmeter reads zero. If necessary, adjust BALANCE controls.

Connect the anode test lead to the D.C. terminal; this will shift the horizontal trace, which should then be moved by means of the VOLTS control until it again registers with the cursor. The voltmeter reading will then give the D.C. potential across the load resistor. In the present example, the reading would be 50 volts.

COMBINED A.C. AND D.C. INPUT

When an input consists of an A.C. signal superimposed on a D.C. potential, the value of each component may be found as follows, provided that the A.C. signal is symmetrical. The voltmeter readings corresponding to the positive and negative peaks are taken in the usual way. The D.C. potential is equal to half the sum of these readings; the A.C. peak potential to half their difference. The polarity of the readings must be taken into account in calculating these potentials.

MEASURING SMALL VARIATIONS OF A LARGE VOLTAGE

Another application of the REF. POTL. jack is when it is desired to measure a small variation of only a volt or so in a supply having a high total value. The latter may be, say, 400 volts and the variations in the neighbourhood of 2 volts. Such a variation on a trace would be very difficult to measure accurately on the 500 volt range of the voltmeter, but by applying a known potential of, say, 395 volts via the REF. POTL. jack, only the voltage difference between 395 volts is measured on the 10 volts range, thus ensuring an accurate and easily observed reading of the voltmeter. This type of measurement is useful when investigating the output from a stabilised supply circuit. By means of the VOLTS control, the horizontal trace is maintained in register with the cursor and the voltmeter will show the voltage variation.

NOTE ON A.C. RIPPLE MEASUREMENTS

The use of the REF. POTL. jack is not necessary when investigating or measuring A.C. ripple of a few volts on an H.T. or D.C. supply. By using the A.C. input terminal the standing D.C. voltage will be blocked (see C3 in circuit diagram), leaving only the ripple, which will provide a trace on the oscilloscope screen. This trace can be used for voltage measurements, using a low range of readings.

CIRCUIT DESCRIPTION

INPUT ATTENUATOR

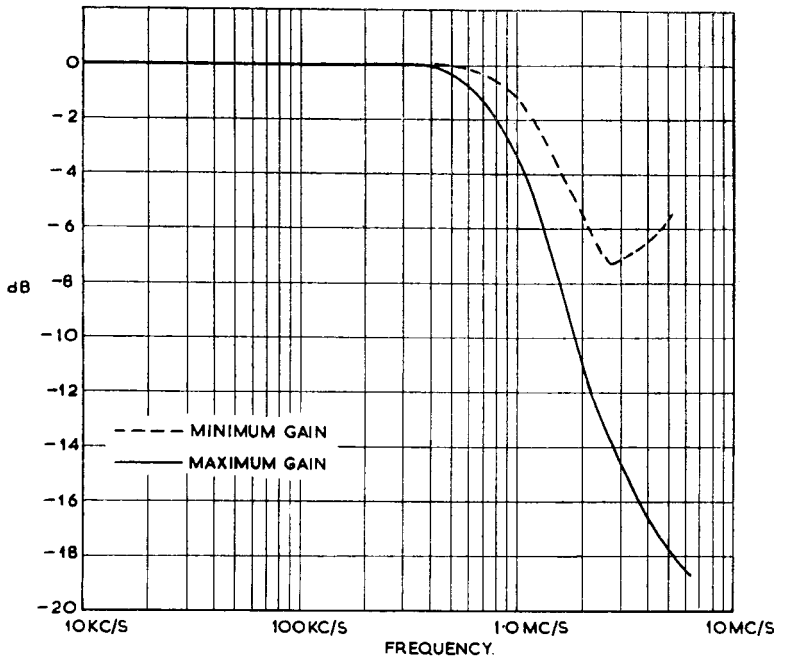
The input terminals connect via C3 for A.C. or directly for D.C. into a switched attenuator, with capacitive correction for high frequencies, giving the ratios 1 : 1, 2 : 1, 10 : 1.

Variations in the input capacity of V1 causes small errors in the attenuator high frequency response at some gain control settings. The trimmer condensers TC1 and TC2 are normally adjusted for correct compensation at average gain, but may be re-set for any desired gain control position by applying a known square wave and adjusting for the correct wave shape.

Y AMPLIFIER MEASUREMENT SYSTEM

V1 and V2 serve three purposes:

(a) To act as a push-pull amplifier feeding the Y plates.
(b) To provide vertical shift.
(c) To measure vertical shift directly in volts, in conjunction with the meter circuit.



FREQUENCY RESPONSE OF 'Y' AMPLIFIER.

SK(P)CO516

The two valves constitute a direct-coupled balanced amplifier, with equal electrode voltages and load resistances on both valves. The grid of V1 is the signal input grid. V2 grid is tied to earth and H.T. by C6 and C7 for A.C. and its D.C. potential is fixed equal to that normal for V1 grid by the potentiometer R22 and R23 across the H.T. supply.

A positive change of potential at V1 grid will be followed by its cathode, and since both V1 and V2 cathodes are joined in the common load R13, R53 (ignoring for the moment the other cathode resistors) it will appear to V2 as a negative change in its grid-to-cathode potential. A change of potential at V1 grid will, therefore, produce amplified opposite changes at the two anodes and at the Y plates to which they are connected.

The waveform of an A.C. signal applied to V1 grid will be displayed on the tube screen, and the application of a D.C. potential will cause a vertical shift of the trace.

Vertical shift produced by either a D.C. potential or any point on an A.C. waveform may be cancelled by the application of a further potential in series with the input circuit, and its amplitude will then equal that of the original shift volttage. This further potential is supplied by the potentiometer network R24, VR4 and R25, across the H.T. supply, and its magnitude relative to V2 grid potential (which equals the normal grid potential of V1) determined by the meter M1. Two ranges of checking voltage are provided, 0—50 volts with the ranges switch SW2 in the 50 volts position, and 0—5 volts with SW2 in the 5 volt position, when the series resistance R21 and the internal resistance of M1 act as a 10 : 1 potential divider.

The magnitude of any input voltage may, therefore, be determined by cancelling the deflection produced by means of the volts control, and reading the voltage on M1 which is of standard construcion. In conjunction with the input attenuator, the voltage measurement facilities provide five ranges of measurement up to 500 volts. For measurements up to approximately 100 Kc/s the instrument is direct reading. At higher frequencies the amplifier frequency characteristic should be taken into account, since the lower gain will cause the meter to indicate a voltage below the true value.

GAIN CONTROL

When the value of the GAIN control VR2 is zero, the two cathodes are connected together and the amplifier provides maximum gain. At other settings, the resistors R10 and R16 are effectively introduced in the individual cathode circuits and reduce gain by negative feedback. This method closely retains the valve balance and provides a maximum - minimum gain ratio of approximately 29 dB.

It should be noted that the GAIN control does not affect the validity of voltage readings, since gain adjustment automatically modify the amount of shift given by the VOLTS control, while the measurement of grid voltage on the amplifier is unaffected. Further, an input waveform may be amplified until only a portion of it fills the screen, and the VOLTS control used to examine sections of its vertical amplitude. This is equivalent to a greatly increased screen size.

BALANCE CONTROLS

These are the pre-set potentiometers VR1 and VR3 which serve to take up variations in valves and components, and ensure correct balance of the amplifier section. The BALANCE MAX. control VR1 is used to align the trace and cursor line, when the GAIN control VR2 is set for full gain. At reduced gain V1 and V2 cathodes are no longer joined directly by the GAIN control and their potentials may differ. The BALANCE MIN. control is adjusted to maintain them at the same potential and so prevent rotation of the GAIN control causing a vertical movement of the tube trace.

EXTERNAL TIME BASE JACK

A.C. deflecting voltages connected to the EXT. TB jack are applied to the X plates through the phase splitter valve, V3. Connections should be made to the sleeve of the jack plug and earth. The tip of the plug must be left disconnected, as this operates the time base internal on/off switch and prevents the application of unwanted blackout pulses to the tube grid.

HORIZONTAL SHIFT

The SHIFT control VR7 with its associated network, R28, R33, R34, R35, R36, R54, provide horizontal shift approximately equal to the full screen diameter.

TIME BASE

A single valve provides a linear time base waveform over a wide range of frequencies, selected by the twelve-way range switch SW3 and the fine frequency control, VR8.

To describe the circuit action, let us take a selected capacity C from the range switching, and the sum of VR8, R41, R42, R43 and R59 as R.

At the start of the sweep, the condenser C is fully charged, and the valve is momentarily acting as a normal class A amplifier with a negative grid potential. As C discharges, the negative potential on the grid is gradually reduced. This change of grid voltage produces a negative change at the anode, which constitutes the sweep voltage.

Self-oscillation and flyback are provided by using the screen and suppressor grids in a transitron circuit. As the grid voltage approaches zero, the fall in the screen voltage produces a negative potential on the suppressor grid through C25. This negative potential checks the anode current, but increases the screen current, causing the suppressor to be driven still further negative and so on cumulatively until the anode current is cut off. This process is very rapid and provides the flyback condition.

The anode is now cut off and at full H.T. potential, and C is partially discharged through R. The grid is positive to its cathode and C may recharge through the grid-cathode path. As C charges, the grid returns to cathode potential. This fall in grid voltage is accompanied by a fall in screen current and a rise in screen voltage, which is passed to the suppressor, allowing anode current to re-commence. The screen current is, therefore, further reduced and screen suppressor voltages rise rapidly. The flow of anode current causes a decrease in anode voltage which, in series with the potential across C, drives the grid negative. The circuit has now re-set itself to the initial condition and the whole cycle re-commences.

The negative pulse on the screen is used to black out the trace during the flyback period. It is applied to the tube grid at suitable amplitude through R48 and C9.

Synchronising is effected by injecting either the voltage applied to the SYNC. terminal, or a portion of the voltage to be examined, into the screen circuit through C121 and VR9, the sync. control. The internal sync. circuit is arranged to operate on signals from the amplifier connections. The time base frequency is available as a negative going sawtooth voltage at the INT. TIME BASE OUT socket.

BRILLIANCE AND FOCUS CONTROLS

The brilliance and focus control circuits follow usual practice. VR5, the brilliance control, allows the potential between the tube cathode and modulator to be varied between that which provides full brilliance (maximum beam current) and that which cuts off the beam.

POWER SUPPLY

H.T. at 700 volts is supplied by a voltage doubler circuit. Smoothing is provided by L3 tuned by C29, and by C27 and C28 in series. The series connection enables normal voltage working condensers to be employed.

An auxiliary supply of 200 volts, to supply extra voltage for the tube, is provided by transformer winding h, and the metal rectifiers MR1 and MR2.

VOLTAGE TABLE

These measurements were taken with a 20,000 ohms-per-volt meter (AVO Model 8), using the 1000 volt range for all readings except V4, which were taken on the 250V. range.

Mains: 240V., 50 c/s.

NOTE: Voltage should not be measured with respect to the chassis as the meter M1 would be included in the circuit.

Total A.C. primary current of transformer TR1, 240 volt tapping: 320 mA.
Total DC voltage from negative end of C28 to positive end of C27: 700 volts.
Total DC voltage from negative rail (C30, R50), to positive rail (C27, C29): 950 volts.
Total HT current (through L3): 35 mA.

Negative terminal of the meter connected to negative end of C26, C28, for measurements given in the table below:

VALVE	FUNCTION	TYPE	ANODE VOLTS	SCREEN VOLTS	CATHODE VOLTS	COMMENTS
V1	Balanced Amplifier	N78	Pin 5 530	Pin 7 710	Pin 2 365	
V2	Balanced Amplifier	N78	Pin 5 530	Pin 7 710	Pin 2 365	
V3	Phase Splitter	6C4	Pin 1 410	—	Pin 7 210	
V4	Time Base Oscillator	Z77	Pin 5 40 - 70 (1)	Pin 7 40 - 65 (1)	—	(1) Variations with time base frequency
V5	Voltage Double Rectifier	6X4	Pin 1-6 370		Pin 7 730	
V6	Voltage Double Rectifier	6X4	Pin 1-6 —	—	Pin 7 370	

Negative terminal of the meter connected to negative end of C30 for measurements given below:

VALVE	TYPE	ANODE VOLTS	FOCUSSING ANODE	GRID VOLTS	CATHODE VOLTS
		Pin 4	Pin 7	Pin 8	Pin 1
C.R.T.	3AFP1	770	90 - 275 (2)	0 - 65 (3)	50

COMMENT: (2) Variation with setting of focus control.
(3) Taken from tap of Brilliance control and varies with setting.

The C.R.T. grid voltage (Pin 8) can be read correctly only by using a valve voltmeter and should be in the region of 0—20 volts.

PARTS LIST

CAPACITORS

REF.	PART No.	DESCRIPTION
C1	273-0821	33 pF ± 5%, Type M.S.
C2	273-0811	22 pF ± 5%, Type M.S.
C3	279-5241	.1 mfd. ± 10% 600V. wkg.
C4	279-5741	.1 mfd. ± 10% 1000V. wkg.
C5	277-0001	1 mfd. ± 20% 750V. wkg.
C6	277-0011	.25 mfd. ± 20% 1000V. wkg.
C7	277-0011	.25 mfd. ± 20% 1000V. wkg.
C8	277-0011	.25 mfd. ± 20% 1000V. wkg.
C9	279-5741	.1 mfd. ± 10% 1000V. wkg.
C10	277-0011	.25 mfd. ± 20% 1000V. wkg.
C11	279-4741	.1 mfd. ± 10% 400V. wkg.
C12	279-5241	.1 mfd. ± 10% 600V. wkg.
C13	273-0821	33 pF. ± 5%, Type M.S.
C14	273-0901	47 pF. ± 5%, Type M.S.
C15	273-0731	150 pF. ± 5%, Type M.S.
C16	273-0841	470 pF. ± 5%, Type S.S.
C17	273-0721	.001 mfd. ± 5%, Type S.S.
C18	273-0861	.0022 mfd. ± 5%, Type S.M.
C19	273-0871	.0047 mfd. ± 5%, Type S.M.
C20	279-4621	.01 mfd. ± 10% 400V. wkg.
C21	279-4661	.022 mfd. ± 10% 400V. wkg.
C22	279-4701	.047 mfd. ± 10% 400V. wkg.
C23	279-4741	.1 mfd. ± 10% 400V. wkg.
C24	279-4821	.47 mfd. ± 10% 400V. wkg.
C25	279-4821	.47 mfd. ± 10% 400V. wkg.
C26	269-0031	8 mfd. 525V. wkg. Electrolytic.
C27	269-0081	16 mfd. 525V. wkg. Electrolytic.
C28	269-0081	16 mfd. 525V. wkg. Electrolytic.
C29	279-5751	.15 mfd. ± 10% 1000V. wkg.
C30	269-0421	1 mfd. 525V. wkg. Electrolytic.
C31	269-0031	8mfd. 525V. wkg. Electrolytic.
C32	269-0031	8 mfd. 525V. wkg. Electrolytic.
C33	269-0421	1 mfd. 525V. wkg. Electrolytic.
TC1	281-0031	3-30 pF. Trimmer.
TC2	281-0031	3-30 pF. Trimmer.

RESISTORS

REF.	PART No.	DESCRIPTION
R1	741-0121	8.2 Megohms ± 2% H.S. I.R.C. 1 Watt
R2	741-0101	910,000 ohms ± 2% H.S. Erie ½ Watt
R3	741-0091	1 Megohm ± 2% H.S. Erie ½ Watt
R4	741-0091	1 Megohm ± 2% H.S. Erie ½ Watt
R5	742-0632	1 Megohm ± 5% B.T.A.
R6	740-0693	150 ohms ± 20% Morg. ¼ Watt
R7	750-0101	10,000 ohms ± 5% Reco. 10 Watt
R8	740-0693	150 ohms ± 20% Morg. ¼ Watt
R10	750-0131	5000 ohms ± 10% Reco. 10 Watt
R11	740-0693	150 ohms ± 20% Morg. ¼ Watt

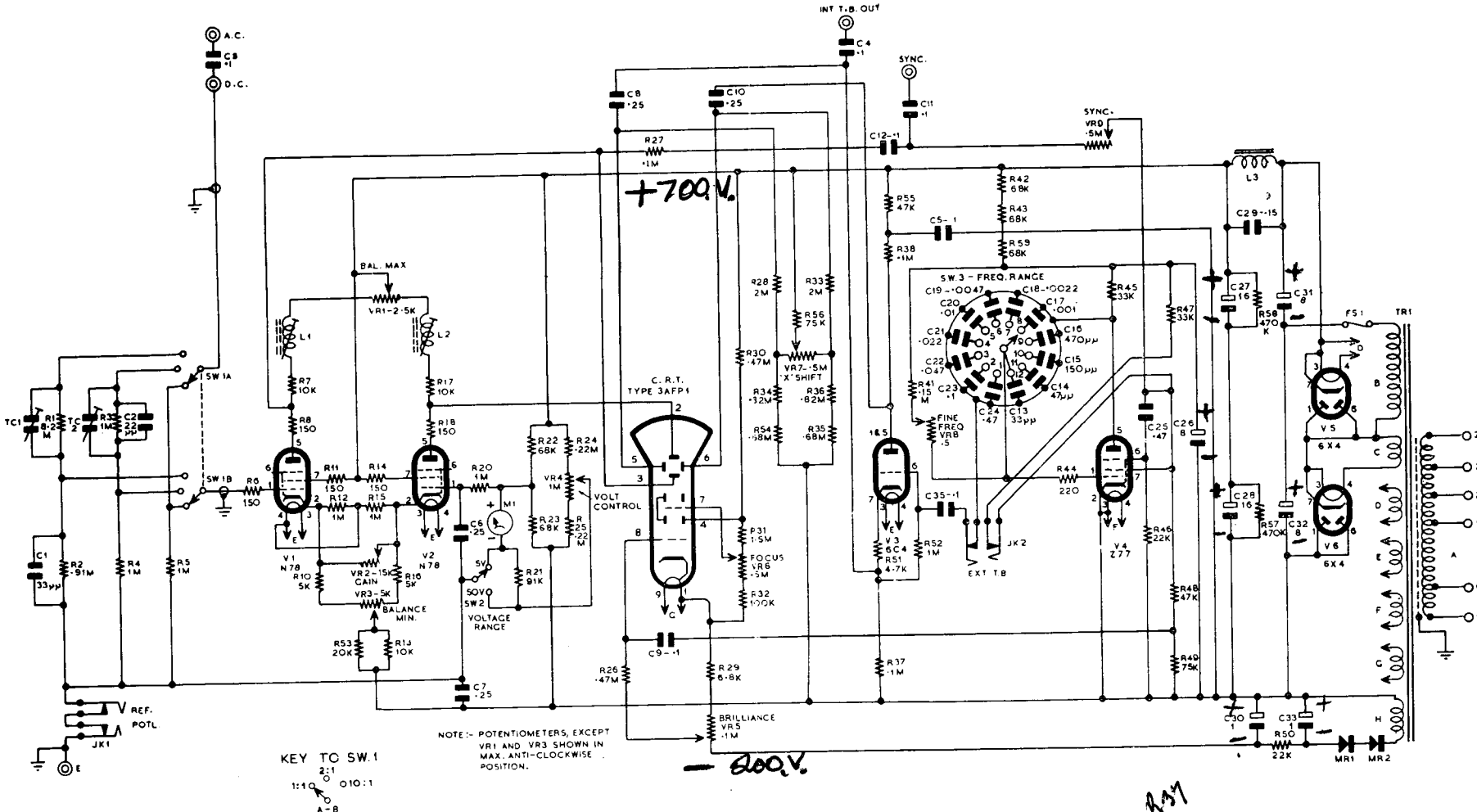
RESISTORS

REF.	PART No.	DESCRIPTION
R12	740-0532	1 Megohm ± 20% B.T.S.
R13	750-0101	10,000 ohms ± 5% Reco. 10 Watt
R14	740-0693	150 ohms ± 20% Morg. ¼ Watt
R15	740-0532	1 Megohm ± 20% B.T.S.
R16	750-0131	5000 ohms ± 10% Reco. 10 Watt
R17	750-0101	10,000 ohms ± 5% Reco. 10 Watt
R18	740-0693	150 ohms ± 20% Morg. ¼ Watt
R20	740-0532	1 Megohm ± 20% B.T.S.
R21	741-0111	91,000 ohms ± 2% H.S. Erie. ½ Watt
R22	749-0112	68,000 ohms ± 5% B.T.2.
R23	749-0112	68,000 ohms ± 5% B.T.2.
R24	742-0452	220,000 ohms ± 20% B.T.A.
R25	742-0452	220,000 ohms ± 20% B.T.A.
R26	742-0172	470,000 ohms ± 10% B.T.A.
R27	740-0512	100,000 ohms ± 20% B.T.S.
R28	742-0612	2 Megohms ± 5% B.T.A.
R29	742-0532	6,800 ohms ± 10% B.T.A.
R30	742-0172	470,000 ohms ± 10% B.T.A.
R31	742-0202	1.5 Megohm ± 10% B.T.A.
R32	742-0412	100,000 ohms ± 20% B.T.H.
R33	742-0612	2 Megohms ± 5% B.T.A.
R34	742-0652	820,000 ohms ± 5% B.T.A.
R35	742-0692	680,000 ohms ± 5% B.T.A.
R36	742-0652	820,000 ohms ± 5% B.T.A.
R37	742-0412	100,000 ohms ± 20% B.T.A.
R38	742-0412	100,000 ohms ± 20% B.T.A.
R41	742-0402	150,000 ohms ± 20% B.T.A.
R42	749-0112	68,000 ohms ± 5% B.T.2.
R43	749-0112	68,000 ohms ± 5% B.T.2.
R44	740-0282	220 ohms ± 10% B.T.S.
R45	749-0122	33,000 ohms ± 20% B.T.2.
R46	742-0052	22,000 ohms ± 10% B.T.A.
R47	749-0122	33,000 ohms ± 20% B.T.2.
R48	742-0282	47,000 ohms ± 5% B.T.A.
R49	742-0662	75,000 ohms ± 5% B.T.A.
R50	742-0672	22,000 ohms ± 5% B.T.A.
R51	742-0022	4,700 ohms ± 10% B.T.A.
R52	740-0532	1 Megohm ± 20% B.T.S.
R53	750-0111	20,000 ohms ± 5% Reco. 10 Watt
R54	742-0692	680,000 ohms ± 5% B.T.A.
R55	742-0092	47,000 ohms ± 10% B.T.A.
R56	742-0662	75,000 ohms ± 5% B.T.A.
R57	742-0172	470,000 ohms ± 10% B.T.A.
R58	742-0172	470,000 ohms ± 10% B.T.A.
VR1	678-0001	Potentiometer 2500 ohms W.W. Linear
VR2	677-0291	Potentiometer 15,000 ohms Linear
VR3	678-0011	Potentiometer 5000 ohms W.W. Linear
VR4	677-0321	Potentiometer 1 Megohm Linear.
VR5	677-0301	Potentiometer 100,000 ohms Linear
VR6	677-0311	Potentiometer 500,000 ohms Linear
VR7	677-0311	Potentiometer 500,000 ohms Linear
VR8	677-0311	Potentiometer 500,000 ohms Linear
VR9	677-0311	Potentiometer 500,000 ohms Linear

MISCELLANEOUS

REF.	PART No.	DESCRIPTION
FS1	431-0031	Fuse, 0.25 Amp.
JK1	824-0321	Socket — Jack.
JK2	824-0321	Socket — Jack.
L1	232-0171	Coil — Peaking.
L2	232-0171	Coil — Peaking.
L3	232-0161	Choke — Filter.
M1	982-0021	Meter.
MR1	982-0701	Rectifier — Sentercel Type Q8/5.
MR2	982-0701	Rectifier — Sentercel Type Q8/5.
SW1	855-0291	Switch — Attenuator.
SW2	855-0301	Switch — Voltage Range.
SW3	855-0311	Switch — Frequency Range.
TR1	904-0141	Transformer — Power.
V1	932-0721	Valve Type N78
V2	932-0721	Valve Type N78 Matched Pair.
V3	932-0731	Valve Type 6C4.
V4	932-0741	Valve Type Z77.
V5	932-0301	Valve Type 6X4.
V6	932-0301	Valve Type 6X4.
CRT	932-0711	Cathode Ray Tube Type 3AFP1.

South Tweed Heads



CIRCUIT DIAGRAM E.M.I. OSCILLOSCOPE TYPE WM.S.

682-5041

Check A38/A37