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dated Mav 1968)

QUARTZ CRYSTAL TEST SET CT.554

GENERAL AND TECHNICAL INFORMATION (-1)

SCALE OF SERVICING SPARES(-3D)

BY COMMAND OF THE DEFENCE COUNCIL

MINISTRY OF DEFENCE

Sponsored for use in the
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CONTENTS

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The inclusion of references to items of equipment does not constitute authority for demanding the items.

Each leaf bears the date of issue or the date and number of the Amendment List with which it was issued. New or amended technical matter will be indicated by black triangles positioned to show the extent of the amended text, thus ▶.....◀. When a chapter is issued in a completely revised form the triangles will not appear.

LIST OF ASSOCIATED PUBLICATIONS

Crystal Units, Quartz, for oscillators, fundamental and overtone	DEF STAN 59-1/3 (superseding DEF 5271-A)

LEADING PARTICULARS

▶ Test Set, Crystal Unit, Quartz, CT554	.....	10S/6625-99-955-2760 ◀
Crystal Unit styles tested	.....	A, B, D, E, H, J and K
Frequency Range	.....	2 MHz to 20 MHz
Equivalent parallel resistance:		
range of measurement	.....	5 kΩ to 75 kΩ in one range
accuracy of measurement	.....	±10%
Load Capacitance	.....	20 pf ±0.5 pf, or 30 pf ±0.5 pf selected at the front panel for styles A, B, E, H, J and K. (An adapter provides 50 pf ±1 pf load capacitance for style D units)
Crystal Unit Dissipation	.....	Normally limited to 5 mW approx but facilities provided for increasing the dissipation to 15 mW (approx) if required.
Power Supplies	.....	110V to 130V, or 200V to 250V 45 Hz to 60 Hz; or 200V,400Hz.
Dimensions and Weight	.....	Height Width Depth Weight 178mm 445mm 279mm 9.98 kg

MODIFICATION RECORD

▶ This publication is technically up-to-date with respect to the modifications listed below:

Mod. No.	Brief Description
A3551	Change of pre-set capacitors C6, C7 plus addition of C22 and C23 in order to facilitate setting-up. Modification only carried out by Manufacturer when equipment returned for repair or recalibration. (Modification incorporated in all new equipments). ◀

QUARTZ CRYSTAL TEST SET
CT.554

GENERAL AND TECHNICAL INFORMATION (-1)

Chapter 1

GENERAL DESCRIPTION

CONTENTS

INTRODUCTION

1. The Test Set, Crystal Unit Quartz, CT554 (fig 1) is a portable item of equipment providing for the testing of a wide range of quartz crystal units ▶ in accordance with Defence Standard 59-1 (Issue 3). ◀

PRINCIPLES OF OPERATION

Crystal activity and equivalent parallel resistance (epr)

2. The activity of a quartz crystal unit may be defined as that characteristic of the unit which, assuming no other circuit losses exist, determines the amplitude of the alternating voltage developed across the unit. For crystal units operating in the parallel resonant mode, the activity is most conveniently expressed in terms of the epr of the unit. The equivalent circuit of such a unit is shown in fig. 2. If the unit is operated with a load capacitance Co, then it can be shown that:-

$$epr = \frac{1}{\omega^2 (Co+C_1)^2 R_1} \text{ ohms}$$

where $\omega = \frac{1}{L_1 C_1}$

Co = load capacitance
C_1 = self-capacitance of crystal unit
L_1 = self-inductance of crystal unit
R_1 = resistance of crystal unit

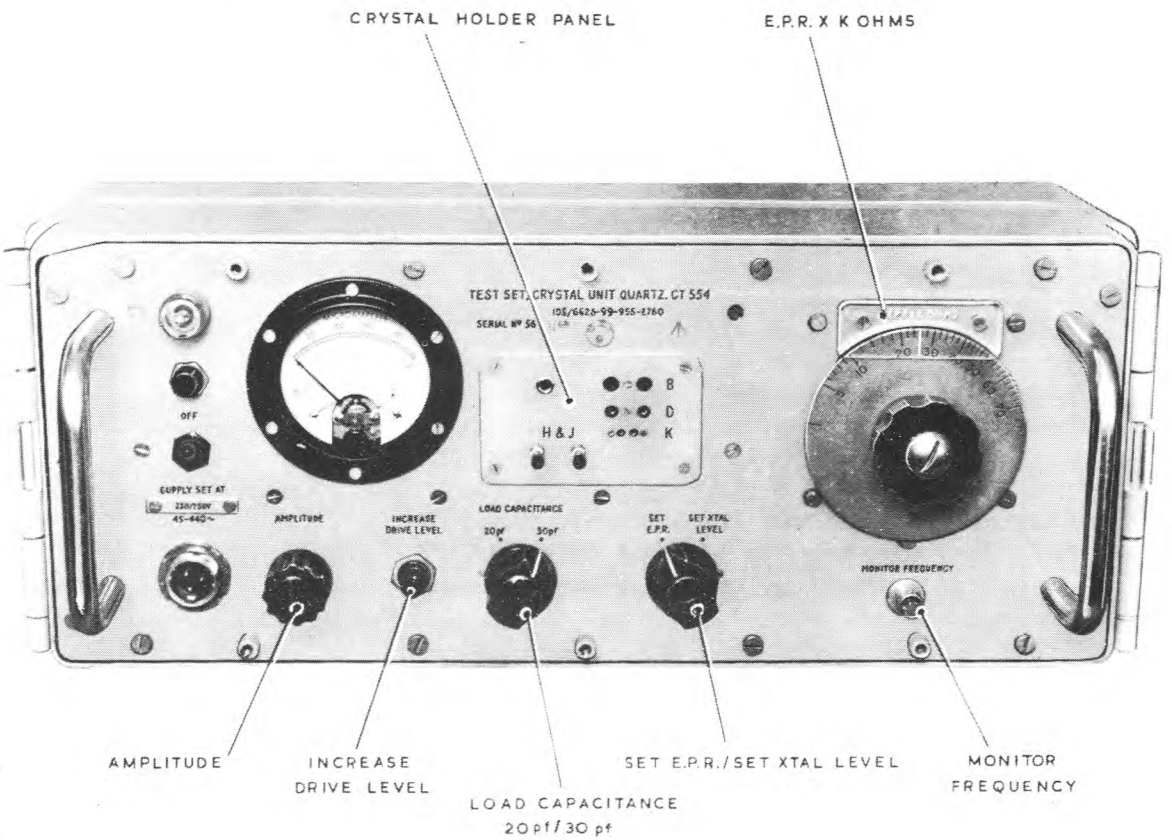


Fig 1 Test Set, Crystal Unit Quartz, CT554

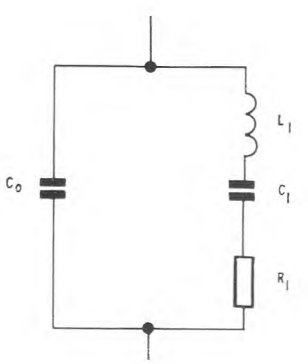


Fig 2 Quartz Crystal Unit: equivalent circuit

Load capacitance

3. From para. 2, it can be seen that the load capacitance used with a quartz crystal unit influences not only the unit's operating frequency but also its activity. Thus when defining either of these characteristics, it is also necessary to define the value of load capacitance for which the figures quoted apply.

Drive level

4. The magnitude of drive applied from the oscillator to the crystal unit determines not only the voltage developed across the unit but also the power dissipated in it, the two quantities being related by the formula:

$$\text{power dissipated} = \frac{(\text{voltage across unit})^2}{\text{epr}} \text{ watts}$$

Excessively high drive levels can, therefore, result in permanent damage to the crystal under test.

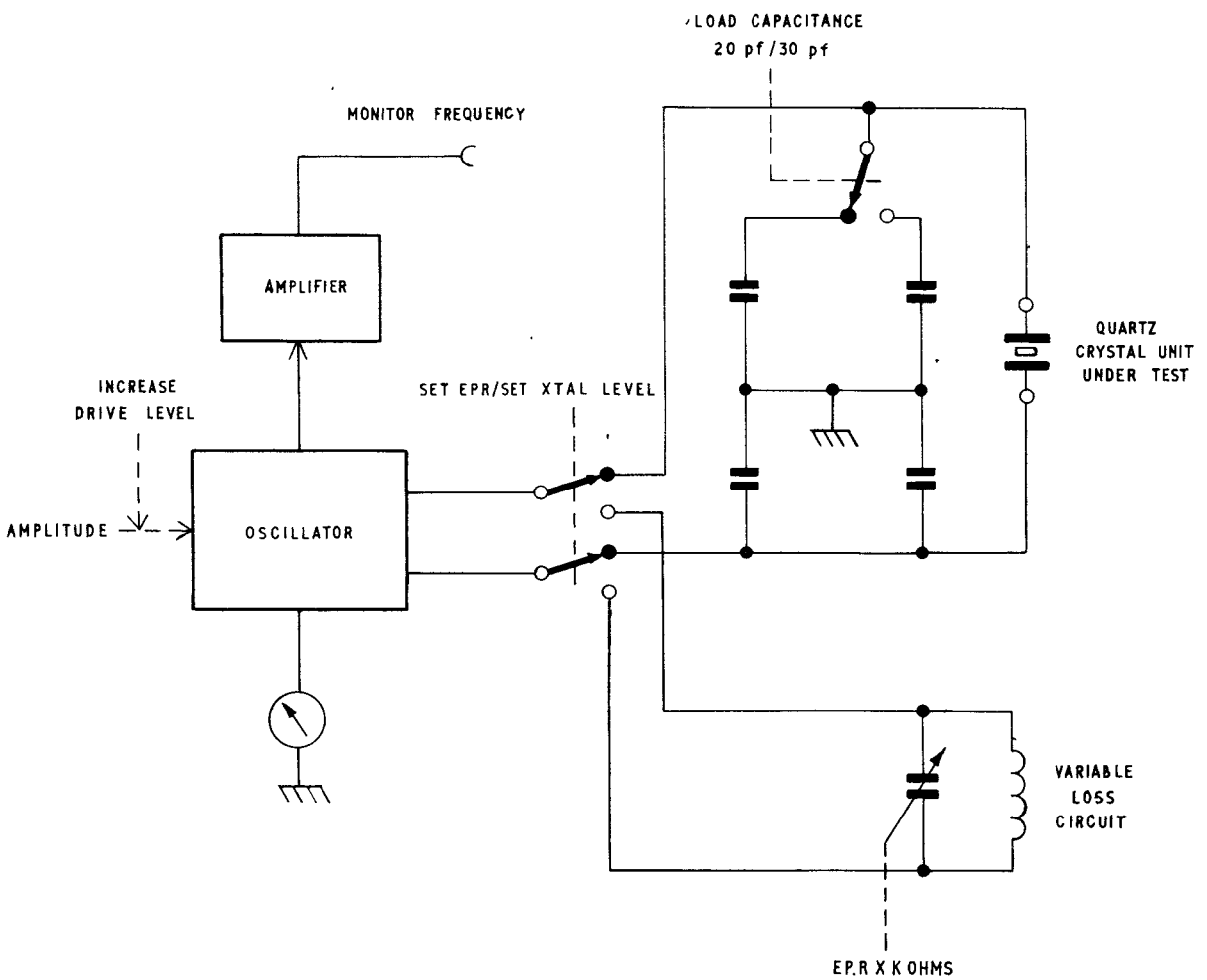


Fig 3 Test Set, Crystal Unit Quartz, CT554: simplified block diagram

Test data

5. All the information required to perform tests using this test set, and to enable the results of such tests to be interpreted, is contained in ▶ Defence Standard 59-1 (Issue 3). ◀ It is presented in the form of activity curves which show the lowest permissible limit of activity at a particular load capacitance for a group of crystal units.

Test set operation

6. A simplified block diagram of the Test Set is shown in fig 3. The basic arrangement of the instrument is that of an oscillator which can be operated with either of two resonant elements in circuit, a crystal or a calibrated variable loss circuit. A meter in the oscillator valve grid connection provides an indication of the signal amplitude present at that point. By switching the oscillator from one configuration to the other, therefore, a direct comparison may be made between the signal amplitude with the crystal in use and that with the variable loss circuit in use. In practice, the oscillator circuit is first adjusted, by means of the AMPLITUDE control, RV1, to obtain a convenient meter indication when the crystal is in circuit (switch S2 at SET XTAL LEVEL). The variable loss circuit is then substituted for the crystal (switch S2 at SET EPR) and adjusted, by means of the E.P.R.X K OHMS control, C10, to obtain an identical meter indication. The epr can then be read directly off the calibrated scale attached to the control.

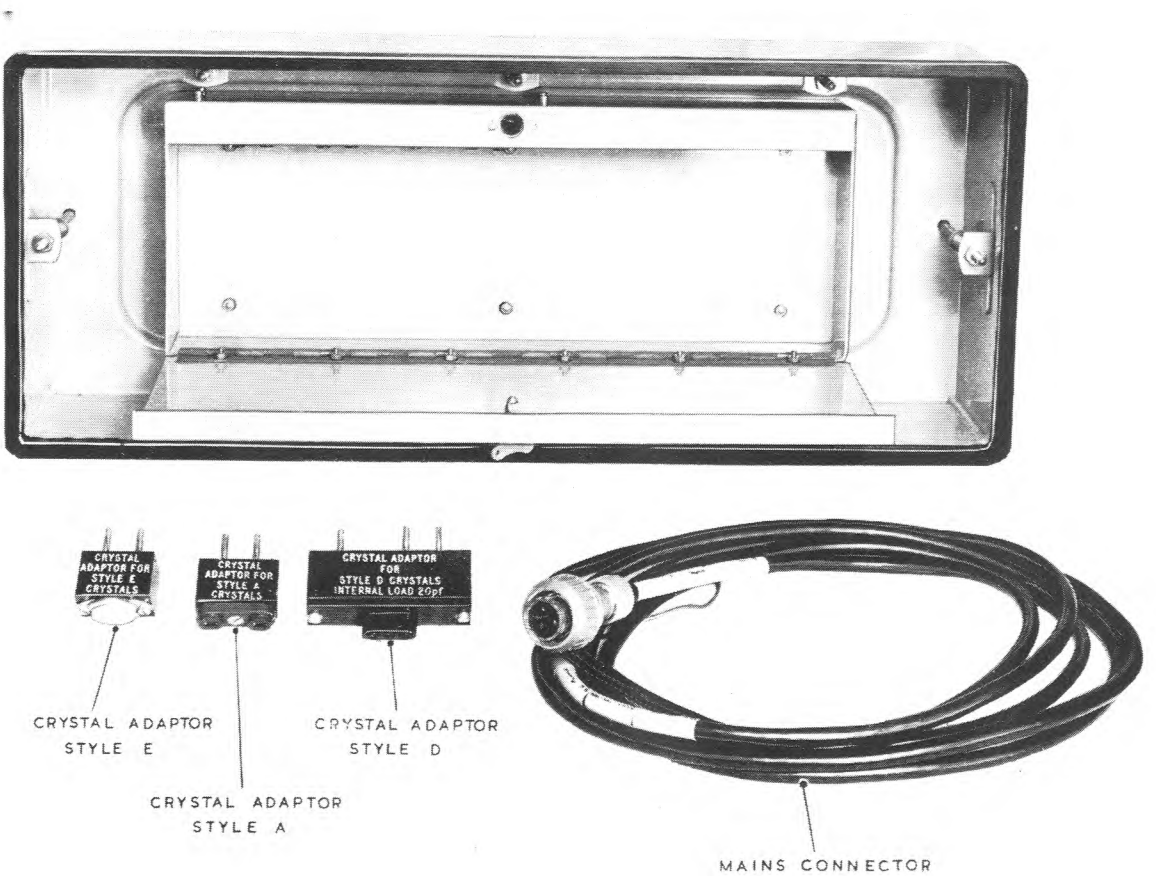


Fig 4 Test Set: case cover and contents

▶ 7. DEF STAN 59-1/3 standardizes on load capacitance values of 20, 30 and ◀ exceptionally, 50 pF, and these are catered for in the test set circuit. Values of 20 or 30 pF may be selected at the front panel switch S1, (LOAD CAPACITANCE), and 50 pf obtained by the use of a particular crystal adaptor in conjunction with the 30 pf position of this switch.

8. Normally, the oscillator circuit constants limit dissipation in the crystal unit under test to 5 mW, but provision is made, in the form of the INCREASE DRIVE LEVEL push-button switch S4, for increasing the maximum dissipation to 15mW if so required.

9. An output from the oscillator circuit, connected via a two-stage transistor amplifier, is made available at SKT 1 (MONITOR FREQUENCY) for connection to a suitable frequency counter. With S2 switch at SET XTAL LEVEL, the counter thus connected gives a direct indication of the frequency at which the crystal unit under test is oscillating. It should be noted that the frequency of oscillation of the variable loss circuit (as indicated by the counter in the SET E.P.R. position of the switch) bears no relationship whatsoever to that of the crystal unit.

Crystal styles and adapters

10. Under the Joint Service system of crystal unit designations, each standard crystal unit is recognised by four letters followed by up to six digits. The code is broken down as follows:

▶ 10.1 The first letter is always Z, which indicates Joint Services approval.

10.2 The second letter D to Z (with I and O omitted) indicates a unit in a holder, of a particular shape and size (style).

10.3 The third letter, A to Z (with I omitted), indicates the temperature range and frequency tolerance of the unit together with the load capacitance when used at a parallel resonance.

10.4 The fourth letter, A to Z (with I, O and S omitted), indicates the mode of operation of the unit, ie whether it operates on a fundamental or overtone mode of a particular order, and whether at series or parallel resonance.

10.5 Following these letters are not more than six digits with a decimal point, indicating the nominal frequency of the unit in KHz.

11. For example, a crystal unit ZLHA 2,345.67 would have physical dimensions as shown in the table related to style L as given in the DEF STAN 59-1/3, a temperature range of -20°C to + 70°C, a frequency tolerance of ± 0.005% over the temperature range, and a nominal frequecny of 2,345.67 kHz when measured at parallel resonance on the fundamental mode, with a load capacitance of 30 pf.

12. The Test Set is provided with sockets and adapters to enable it to be used to test crystals of the appropriate frequency range in styles A, B, D, E, H, J and K. If the style is either A, D or E, the appropriate adapter must be used. ◀

Construction

13. The Test Set is housed in a standard instrument case to Specification RAE/RSP 1966. The cover of this case is retained in position by eight captive screws loosening of which enables the cover to be removed, revealing the front panel of the instrument. The underside of the cover contains a compartment housing the three crystal adaptors and the mains connector supplied with the instrument (fig. 4), access to these items being gained by releasing the Dzus fastener securing the compartment door.

14. All controls and indicators necessary for operation of the test set are mounted on the front panel of the instrument (fig. 1), together with an insulated panel carrying the assorted sockets required to enable the range of crystals tested to be connected into the test set circuit. The instrument is retained in its case by twelve 2 BA screws fixing through the front panel, removal of which permits the instrument to be withdrawn from the case.

15. The circuits of the test set are divided between three main sub-assemblies. The front panel, as already indicated, the main chassis, and the variable dynamic impedance assembly, the latter two being mounted on the rear face of the front panel as shown in fig. 5 and 6.

16. The variable dynamic impedance assembly (the variable loss circuit) is completely contained within a screened compartment, connection between it and the main chassis being via feedthrough terminal posts. The main chassis carries the remaining circuits, including the printed-circuit sub-assembly containing the monitor amplifier.

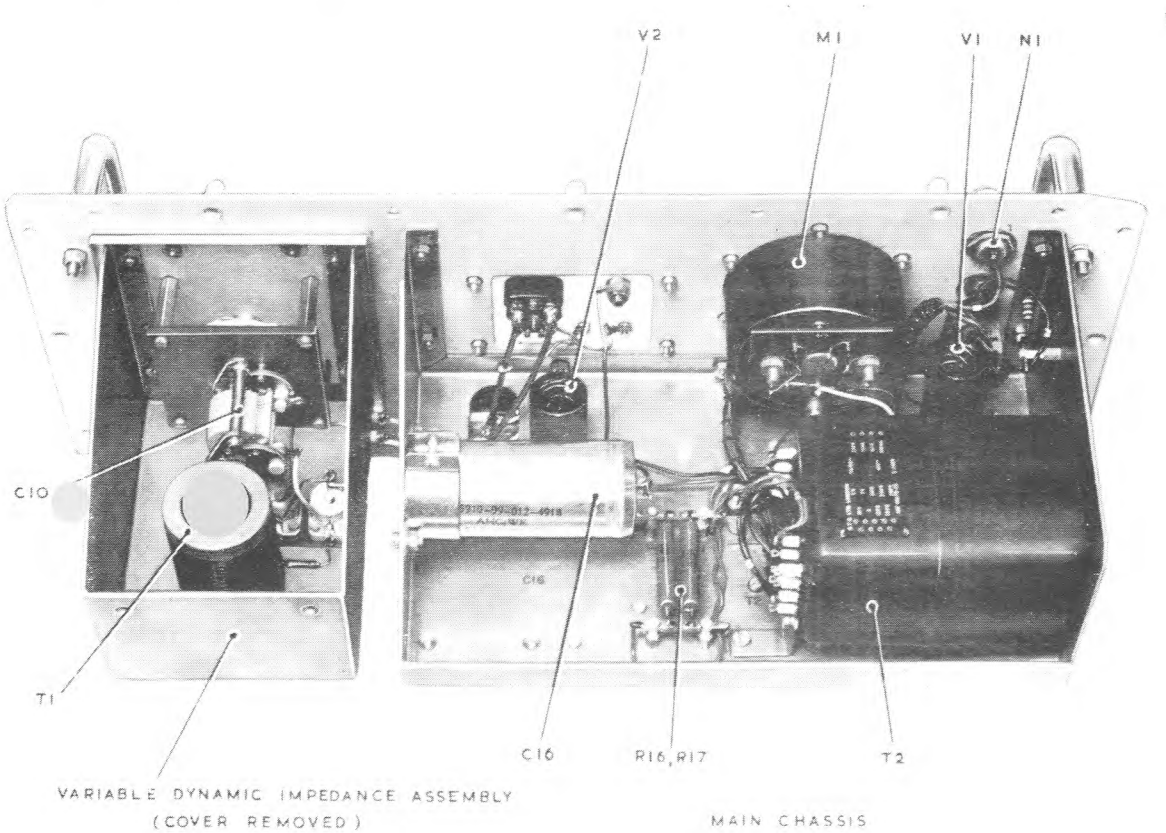


Fig. 5 Test Set: general top view of interior

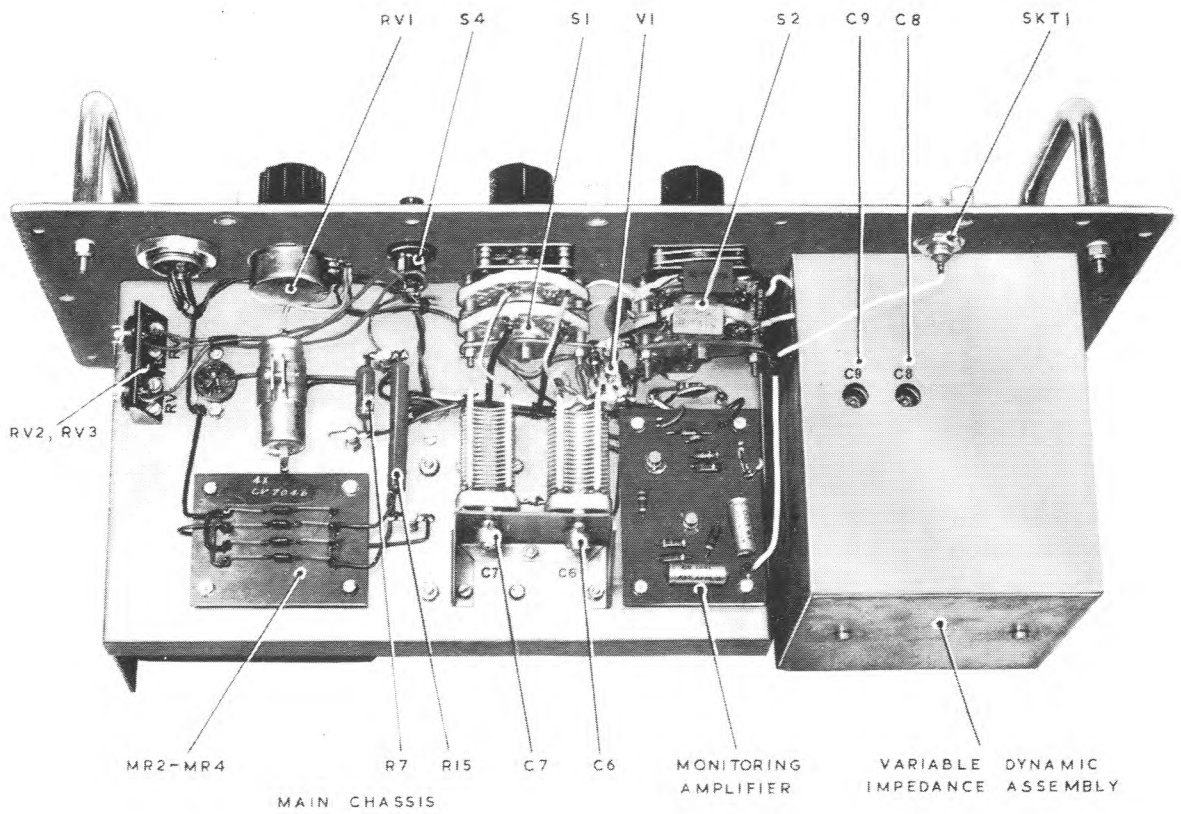
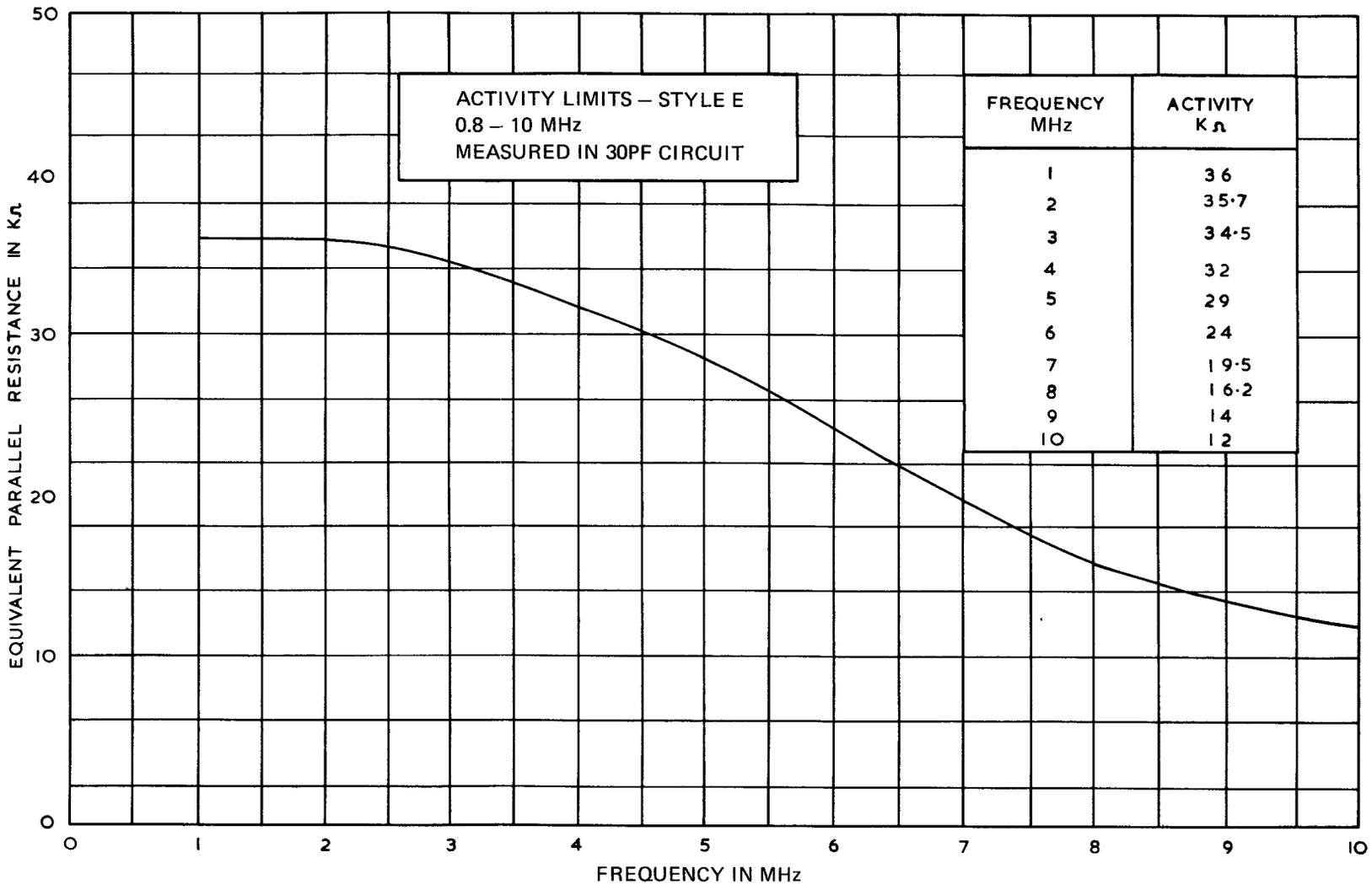


Fig. 6 Test Set: general underside view of interior



FREQUENCY MHz	ACTIVITY KΩ
1	36
2	35·7
3	34·5
4	32
5	29
6	24
7	19·5
8	16·2
9	14
10	12

Fig. 7 Typical crystal activity curve

Chapter 2

OPERATING INSTRUCTIONS

CONTENTS

PREPARATION

1. To bring the Test Set into service, proceed as follows:

(1) Ascertain whether the voltage of the ac mains supply from which the instrument is to be operated is within the range given on the plate above the power input plug on the instrument's front panel. If it is not, the power transformer connections must be reset as follows:

(a) Remove the twelve 2 BA screws around the periphery of the front panel and withdraw the instrument from its case.

(b) Adjust the connections to the primary of the power supply transformer as necessary to select the primary winding taps appropriate to the ac supply voltage.

(c) Return the instrument to its case and refit and tighten the securing screws removed in operation (a).

(d) Remove the two 6 BA screws securing the supply-voltage indicating plate and rearrange the plate so that it indicates the voltage range to which the transformer primary is set.

(e) Refit the plate and the securing screws.

(2) Connect the ac mains supply to the instrument using the 3-way connector supplied with the instrument.

(3) Set the SET E.P.R./SET XTAL LEVEL switch to SET XTAL LEVEL and the AMPLITUDE control fully counter-clockwise.

(4) Set the supply switch to the 'on' position. The indicator lamp above the switch should now be lit.

(5) Allow a warming-up period of approximately five minutes before making any measurements.

OPERATION

Measurement of equivalent parallel resistance

2. With the instrument prepared for use as detailed in para 1, proceed as follows:

2.1 Set the LOAD CAPACITANCE switch to the value indicated by the test specification for the crystal unit under test.

(2) For crystals type A, D or E, refer to para. 2(a) and for crystals type B, H, J or K refer to 2(b).

(a) Crystals type A, D or E. First plug the appropriate Crystal Adapter (to be found in the front cover stowage compartment) into the style B crystal socket in the Test Set, and then insert the crystal into that adapter.

(b) Crystals type B, H,J or K. Insert crystal into appropriate crystal socket on Test Set.

(3) Adjust the AMPLITUDE control until a meter indication of 50μA is obtained. At the lower levels of activity (ie lower values of epr) it may not be possible to attain this level. In such cases, the AMPLITUDE control may be set for a meter indication of 40μA or such other indication as is convenient.

(4) Set the E.P.R/SET XTAL LEVEL switch to SET E.P.R.

(5) Adjust the E.P.R. X K OHMS dial until the meter indication is the same as that obtained in para 2(3). The epr of the crystal unit under test can now be read directly off the scale against the graticule.

Drive level

3. Under normal test conditions, the crystal unit dissipation is limited to approximately 5mW. If the INCREASE DRIVE LEVEL pushbutton switch is operated, this dissipation is increased to approximately 15mW, remaining at this value until the switch is released.

Frequency monitoring

4. If it is required to measure the frequency at which the crystal unit under test is oscillating, connect the MONITOR FREQUENCY socket on the instrument to the signal input of a frequency counter having a minimum input sensitivity of 100mV r.m.s. With the SET E.P.R./SET XTAL LEVEL switch at SET XTAL LEVEL, a direct indication of the crystal oscillator frequency for the chosen load capacitance is given by the counter.

Alternative method of test

5. Where it is only desired to ascertain whether a number of identical crystal units are serviceable or not (i.e. that their activity is above a permissible minimum level) the following method of test can be used:

(1) With the instrument prepared for use as detailed in para. 1, set the LOAD CAPACITANCE switch to the value indicated in the test specification for the crystal unit under test.

(2) Set the E.P.R. X K OHMS dial to indicate the minimum permissible e.p.r.

(3) Set the SET E.P.R./SET XTAL LEVEL switch to SET E.P.R. and adjust the AMPLITUDE control to obtain a convenient meter indication (e.g. 50μA). Return the switch to SET XTAL LEVEL.

(4) The crystal units may now be tested by inserting them in turn into the appropriate holder (para. 2(2)). Those giving a meter indication in excess of that set in operation (2) having an activity level above the minimum permissible limit, those giving a meter indication less than that set in operation (2) having an activity level below the minimum permissible limit

Chapter 3

CIRCUIT DESCRIPTION

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The circuits of the Test Set CT554 may conveniently be divided into three main sections:

(1) The test circuit.

(2) The monitor amplifier.

(3) The power supplies.

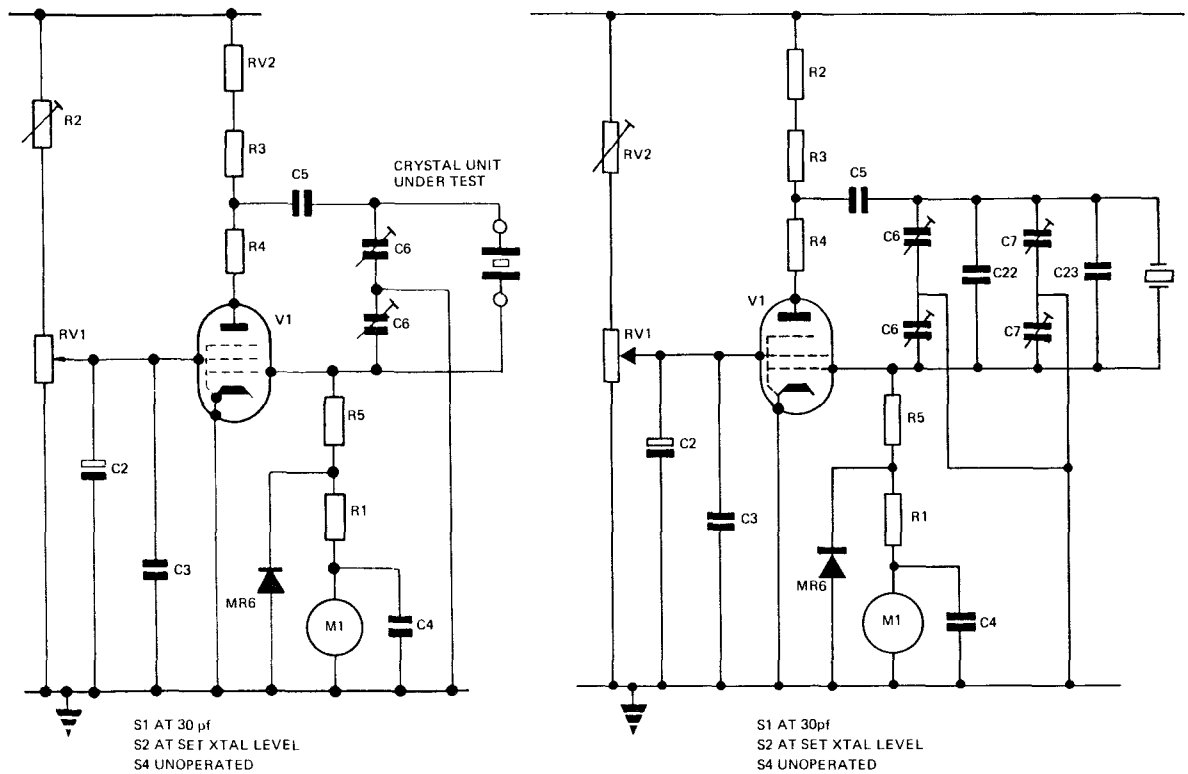
The paragraphs which follow contain a detailed description of the circuit's operation in terms of the operation of each of these main sections. A ▶ complete circuit diagram is given in fig 4 or 5 (depending on whether the equipment is pre or post mod A3551). ◀

TEST CIRCUIT

2. Oscillator valve V1 is operated in a normal pentode connection with the valve gain variable, over the preset range selected by push-button switch S4 (INCREASE DRIVE LEVEL), by means of variable resistor RV1 (AMPLITUDE). Preset variable resistors RV2 and RV3 enable the upper limits of these ranges of gain to be adjusted during calibration. Screen decoupling is provided by capacitors C2 and C3. A split anode load (R2, R3, R4) provides two levels of output signal from the valve, one being passed via C5 to the resonant element in use and the other to the monitor amplifier. A micro-ammeter (M1) is connected in series with the grid return of the valve. Thus the meter indication is at all times proportional to the signal amplitude applied to that electrode, and hence to the alternating voltage developed across the resonant element. The meter is decoupled by C4 and protected against overloads by diode MR6.

3. As described in chap 1, the oscillator circuit can be operated in either of two configurations, depending on the position of switch S2 (SET E.P.R. or SET XTAL LEVEL). Assume that this switch is set to (SET XTAL LEVEL).

The signal at the junction of R3 and R4 is routed via blocking capacitor C5 and the switch S2A to one pole of each of the crystal sockets mounted on the front panel of the instrument. The other poles of the crystal sockets are connected via switch S2B to the grid of V1.



(a) Pre-mod A3551 (b) Post-mod A3551

Fig.1 Test circuit: simplified diagrams

4. Pre-mod A3551. Depending on the setting of S1 (LOAD CAPACITANCE), either C6 or C7 is connected in parallel with the socket, the centre tap of both capacitors being taken directly to earth. With a crystal unit connected across any pair of socket poles, the circuit thus adopts the form of a crystal-controlled Pierce oscillator, as demonstrated in the simplified diagram of fig.1(a).

5. Post-mod A3551. In the 20 PF setting of switch S1 (LOAD CAPACITANCE), capacitors C7 and C23 only are connected across the crystal, and the circuit takes the form of a Pierce crystal-controlled oscillator. When S1 is set to 30 PF, additional capacitors C22 and C6 are introduced in parallel with C7 and C23 (see fig.1b), thus raising the total load capacitance to 30 pf.

6. All versions. In such a circuit, the amplitude of signal at the oscillator grid is determined by the activity of the crystal used by the circuit and the degree of anode-grid coupling provided by the load capacitors. In the present instance, the latter is preset by adjustment of the capacitors during manufacture. Thus it follows that under normal conditions any variations in the meter M1 indication observed between similar crystal units are due solely to differences in the level of activity of these units.

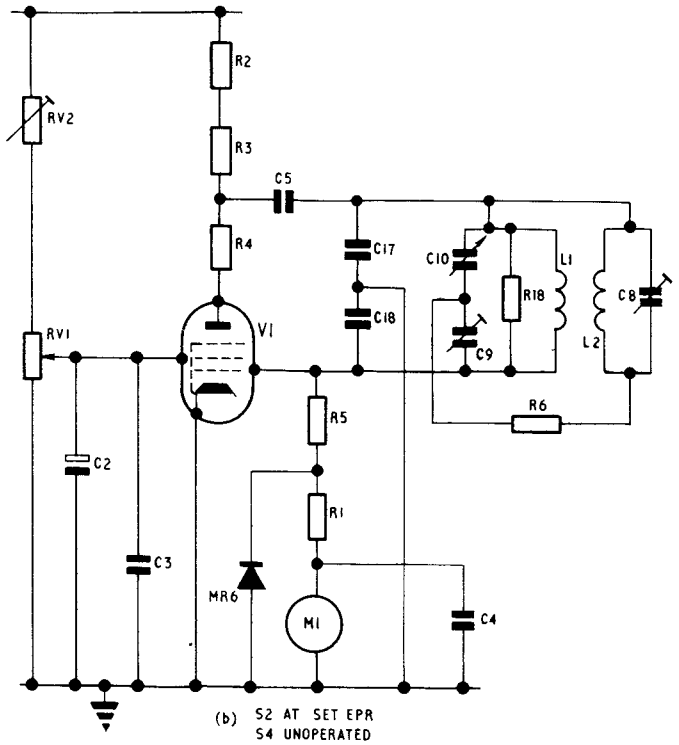


Fig 2 Test circuit: simplified diagrams (all versions)

7. When switch S2 is set to position 1 (SET E.P.R.), the valve output signal is coupled, again via C5 and S2A, to the input of the variable dynamic impedance assembly and the grid of the valve, coupled via S2B to the output of this assembly. A closer examination of the circuit so formed, fig 2, shows that it is again basically that of a Pierce oscillator, the circuit differences being introduced by the requirement for a variable loss. Thus the meter M1 indication is now dependent upon the setting of the variable element.

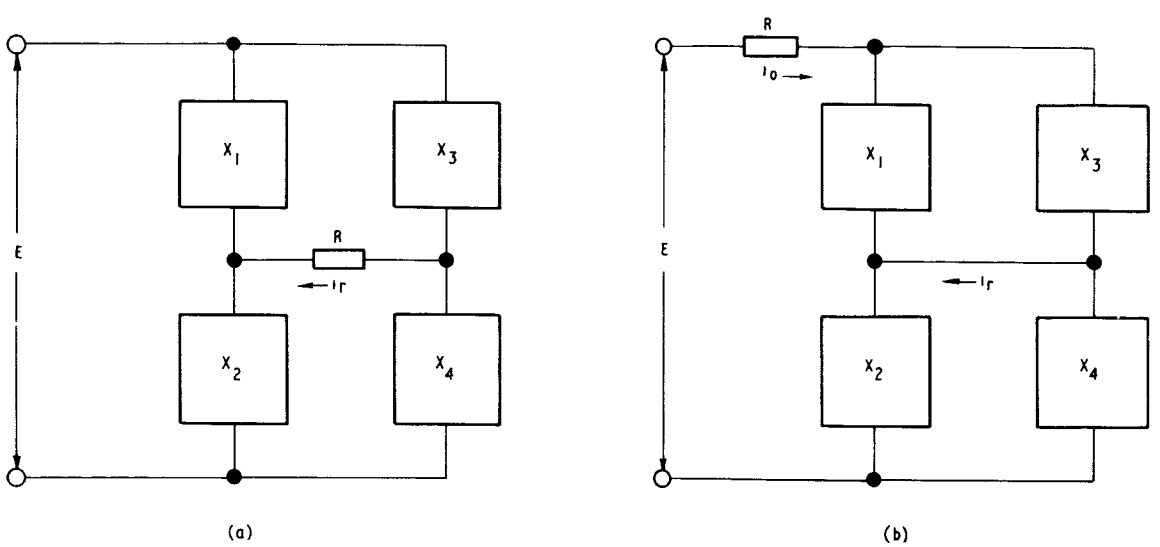


Fig 3 Variable dynamic impedance assembly: equivalent circuits.

8. The equivalent circuit of the variable dynamic impedance assembly is shown in fig 3(a). If E is the voltage applied across the terminals of the circuit, and i_r the current flowing through resistance R(R6), the circuit may be transformed into that of fig 3(b). From the latter circuit, it can be shown that:

$$\frac{i_r}{i_o} = \frac{\frac{X_1}{X_2} - \frac{X_3}{X_4}}{\left(\frac{1+X_1}{X_2}\right)\left(\frac{1+X_3}{X_1}\right)} = K$$

where K is independent of frequency. If Xo is the equivalent reactance of the series-parallel combination X_1, X_2, X_3, X_4 then:

$$i_o = \frac{E}{\sqrt{R^2+X_o^2}}$$

and

$$i_r = \frac{KE}{\sqrt{R^2+X_o^2}}$$

If the equivalent parallel resistance due to R is R_o, it follows that:

$$\frac{E^2}{R_o} = i_r^2 R = \frac{R(K^2E^2)}{(R^2+X_o^2)}$$

or

$$R_o = \frac{R\left(1+\frac{X_o^2}{R^2}\right)}{K^2}$$

The last equation enables the equivalent parallel resistance due to R to be calculated from the circuit constants for any required frequency. If this frequency happens to be resonance for a particular setting of the variable element of the circuit (ie C10), the formula gives the dynamic impedance of the circuit. Thus the circuit has the property of presenting a range of dynamic impedances corresponding to the range of resonant frequency adjustment afforded by the variable element. In the present case, this range of dynamic impedance is 5 kilohms to 75 kilohms, as indicated by the calibrated dial attached to C10 shaft. Trimmer C9 enables the upper limit of this range to be set by affording a measure of adjustment of the dynamic impedance/C10 setting characteristic of the circuit.

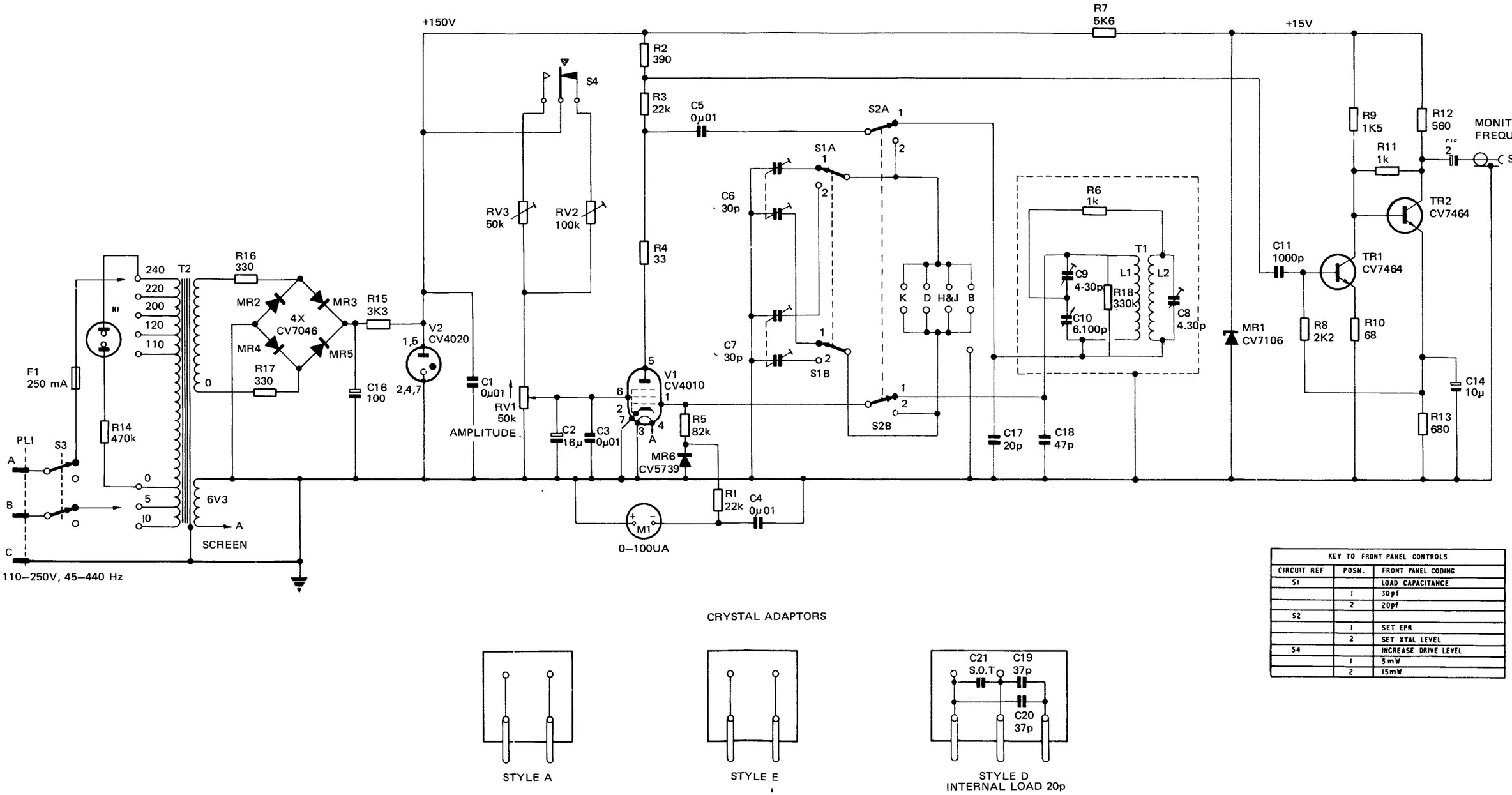
MONITOR AMPLIFIER

9. The test circuit output at the junction of resistors R2 and R3 is coupled by C11 to the input of the two-stage amplifier containing transistors TR1 and TR2. This is a conventional dc coupled amplifier in which both transistors are operated in a common emitter configuration and the overall gain is stabilized by dc feedback between TR1 emitter and TR2 base via R8. The amplifier output is coupled by C15 to SKT1 (MONITOR FREQUENCY) for

connection to a suitable frequency counting device.

POWER SUPPLIES (FIG 4 or 5)

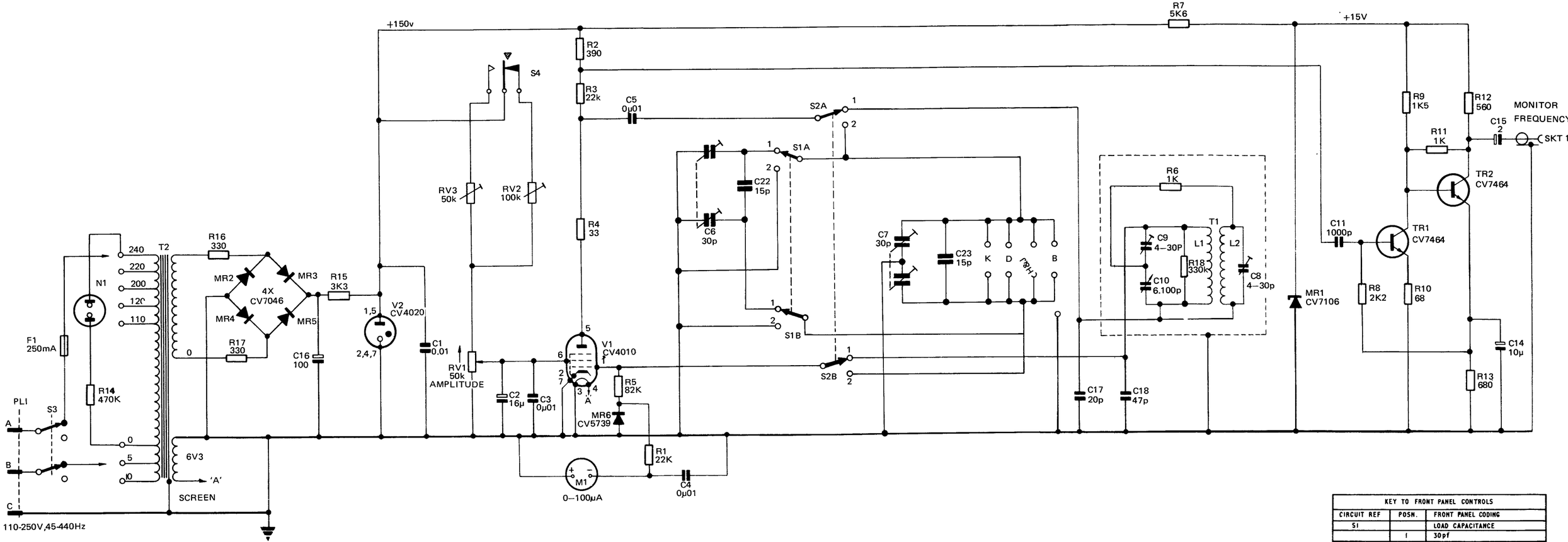
▶ 10. Mains input is to the 3 pin Plessey plug PL1 situated on the front panel of the instrument. The secondaries of transformer T2 provide a 6.3V heater supply to V1, and 250V to bridge rectifier MR2 to MR5 through limiters R16 and R17. The output is smoothed and stabilized at 150V dc. This feeds V1, and supplies, via R7, + 15V dc, stabilised by MR1, to TR1 and TR2 of the monitor amplifier. ◀



KEY TO FRONT PANEL CONTROLS		
CIRCUIT REF	POSN.	FRONT PANEL CODING
S1		LOAD CAPACITANCE
	1	30pf
	2	20pf
S2		
	1	SET EPR
	2	SET XTAL LEVEL
S4		INCREASE DRIVE LEVEL
	1	5mW
	2	15mW

CRYSTAL ADAPTORS

Fig.4 Test set,crystal unit quartz, CT554:circuit (pre–mod A3551)



KEY TO FRONT PANEL CONTROLS		
CIRCUIT REF	POSN.	FRONT PANEL CODING
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	1	30pf
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S2		
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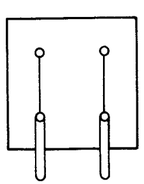
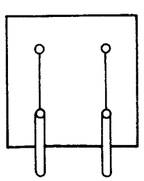
	2	SET XTAL LEVEL
S4		INCREASE DRIVE LEVEL
	1	5mW
	2	15mW

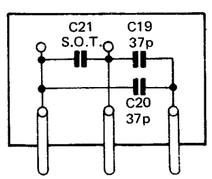
CRYSTAL ADAPTORS



STYLE A



STYLE E



STYLE D
INTERNAL LOAD 20p

Fig. 5 Test Set, Crystal Unit Quartz, CT554: circuit (post-mod A3551)

QUARTZ CRYSTAL TEST SET
CT.554

SCALE OF SERVICING SPARES (-3D)

TOPIC 3D

TEST SET, CRYSTAL UNIT, QUARTZ, CT554 (10S/6625-99-955-2760)

SCALE OF SERVICING SPARES

Introduction

This Scale of Servicing Spares is based on the most up-to-date information available at the time of printing. Any aspect of the scale thought to be unsatisfactory is to be reported in accordance with AP 100B-01, Order 0504 to the Ministry of Defence (ADSM 25) RAF via Command Headquarters.

COLUMN HEADINGS AND SPECIAL NOTES

Col 1 - Section and Reference number.

Col 2 - Nomenclature

Col 3 - Qty off per equipment

Col 4 - 4 months station holding to support one equipment.

Col 5 - 4 months station holding to support two equipments.

Col 6 - 4 months station holding to support three equipments.

Note 1...
Quantities scaled in Cols 4, 5 and 6 are maximum station holdings.

Note 2...
Items marked with an asterisk (*) in Col 4 may be demanded on a one-for-one basis by user units.

Col 7 - 6 months 3rd line test equipment repair unit holding. Items marked with an asterisk are to be demanded on a one-for-one basis as required.

Col 8 - Items marked ϕ affect calibration of the equipment.

Col 9 - Circuit reference, part number or other reference.

1		2	3	4	5	6	7	8	9
5L	9969215	LAMP, GLOW; clear	1	1	1	1	1		N1
5Q	1070213	MICROAMMETER, 0-100μA DC	1	*			*		M1
5UC	9403406	SWITCH, PUSH	1	*			*		S4
10AD	1070211	ADAPTOR, CRYSTAL SOCKET; adapts style A crystal to style B	1	*			*		
	1070212	ADAPTOR, CRYSTAL SOCKET	1	*			*		
10AE	0120913	LIGHT, INDICATOR	1	*			*		
	1070218	PANEL, ELECTRONIC CIRCUIT with components R1, C4, MR6	1				*	ø	
10AK	0970175	KNOB	1	*					
	9428675	KNOB	1	*			*		
	9428697	INSERT, CONTROL DIAL KNOB	1	*			*		
10AR	1070222	INSULATOR, ANGLE BRACKET; nylon; ¾ in. lg 1st leg, 13/32 in. 2nd leg	1				*		
10AS	1070216	PLATE, MOUNTING, ELECTRICAL PLUG-SOCKET; 2-½ in. lg	1	*			*		
▶ 10AS	7106230	ADAPTOR, TRANSISTOR; nylon	2				*		TR1, TR2 ◀
10AT	5800609	LENS, INDICATOR LIGHT; colourless	1	*			*		
10B	0560881	INSULATOR, STAND OFF	10				*		
10C	0123907	CAPACITOR, FIXED, 27pF ± 10%, 750V	1				*		
	0145505	CAPACITOR, FIXED, 16μF -20% +100%, 150V	1				*		C2
	0124918	CAPACITOR, FIXED, 100μF-20% +50%, 350V	1				*		C16
	9540128	CAPACITOR, FIXED, 0.01μF ± 25%, 300V	4				*		C1,C3,C4,C5
	1070225	CAPACITOR, FIXED 1000pF +40% -20%, 500V	1				*		C11
▶ †	6225640	CAPACITOR, FIXED 15pF ± 10%, 160V	2	Post Mod A3551					C22, C23 ◀
	9114604	CAPACITOR, FIXED, 30pF +5%, 750V	1				*	ø	C18
	9114638	CAPACITOR, FIXED, 20pF ±5%, 750V	1				*	ø	C17
▶ †	6249126	CAPACITOR, VARIABLE, 31pF max	2	Pre Mod A3551					C6, C7
†	6249126	CAPACITOR, VARIABLE, 31pF max	2	Post Mod A3551					C6, C7 ◀
	5193793	CAPACITOR, FIXED, 10μF +50% -10%, 16V	1				*		C14
	1123555	CAPACITOR, FIXED, 2μF +50% -10%, 40V	2				*		C13, C15
10CV	0004010	VALVE ELECTRONIC, CV4010	1				1	ø	V1
	0004020	VALVE ELECTRONIC, CV4020	1	*			1		V2

1		2	3	4	5	6	7	8	9
10CV	0372037	VALVE ELECTRONIC, CV7046	4				4		MR2,MR3,MR4 MR5
	0372206	" " CV7106	1				1		MR1
	0372580	" " CV5739	1				1		MR6
	0373671	" " CV7464	2				2	ϕ	TR1, TR2
10F	0510504	SWITCH, TOGGLE	1	*			*		S3
	1070220	SWITCH, ROTARY, WAFER	1				*		S2
	1070221	SWITCH, ROTARY, WAFER	1				*		S1
10H	9114721	TERMINAL, SPRING LOADED, black	2	*			*		
	0120235	SOCKET, ELECTRICAL; 1 pole	1	*			*		SKT1
	0560565	PLUG ELECTRICAL; Fixed; 3 pole	1	*			*		PL1
	0590136	FUSE LINK, ELECTRICAL, 250 mA	1	1	2	3	1		F1
	0590170	FUSE HOLDER, single way	1	*			*		
	0590171	CARRIER, FUSE LINK	1	*			*		
	1070223	TERMINAL, BOARD; srbp, 2½ in. lg, 2 in. w	1				*		
	9324549	SOCKET, ELECTRICAL	2	*			*		
10K	1073401	TRANSFORMER, POWER STEP DOWN & STEP-UP	1				*		T1
10W	0113338	RESISTOR, FIXED 5.6k ohms ± 5%, 6W	1				*		R7
	0113409	RESISTOR, FIXED 3.3k ohms ± 5%, 3W	1				*		R15
	0113475	RESISTOR, FIXED 330 ohms ± 5%, 4½W	2				*		R16, R17
	0118264	RESISTOR, VARIABLE 50k ohms ± 20%, ¼W	1	*			*		RV3
	0118265	RESISTOR, VARIABLE 100k ohms ± 20%, ¼W	1				*		RV2
	0216430	RESISTOR, FIXED 82k ohms ± 5%, ¼W	1				*	ϕ	R5
	0221046	RESISTOR, FIXED 33 ohms ± 10%, ¼W	1				*		R4
	0221088	RESISTOR, FIXED 68 ohms ± 10%, ¼W	1				*		R10
	0221184	RESISTOR, FIXED 390 ohms ± 10%, ¼W	1				*		R2
	0221214	RESISTOR, FIXED 680k ohms ± 10%, ¼W	1				*		R13
	0221205	RESISTOR, FIXED 560k ohms, ± 10%, ¼W	1				*		R12
	0222046	RESISTOR, FIXED 2.2k ohms, ± 10%, ¼W	1				*	ϕ	R1
	0222025	RESISTOR, FIXED 1.5k ohms, ± 10%, ¼W	1				*		R9
	0222004	RESISTOR, FIXED 1k ohms ± 10%, ¼W	1				*		R6, R11
	0222172	RESISTOR, FIXED 22k ohms ± 10%, ¼W	1				*		R3, R8

1		2	3	4	5	6	7	8	9
10W	0223121	RESISTOR, FIXED 470k ohms ± 10%, ¼W	1				*		R14
	0260006	RESISTOR, VARIABLE 50k ohms ± 20%, 1⅜W	1				*		RV1
	1070219	RESISTOR, FIXED 330k ohms ± 5%, ¼W	1				*		R18
10XAE	1042033	HOLDER, CRYSTAL UNIT	1	*			*		
	1070217	SOCKET, CRYSTAL; 41/64in. lg, 2 contacts	1	*			*		
	1950233	ADAPTOR, CRYSTAL SOCKET; adapts style D crystal to style B	1	*			*		
	9490137	SOCKET, CRYSTAL; 0.836 in, lg, 2 contact positions	4	*			*		
▶ 28FP	9993392	CLIP, SPRING TENSION	1	*			*		
5355	0970183	INSERT, CONTROL DIAL KNOB	3	*					
5355	0970184	CAP, ELECTRICAL	3	*					
5355	0970186	KNOB	2	*					
5355	1070214	CURSOR, INDICATOR, plastic, 2½in. lg	1				*		
6625	1070215	DIAL, SCALE Engraved; 5-10-20-30-40-50-60-70-80	1				*		

† The four Post Mod A3551 components are used instead of the two Pre-Mod A3551 components but only in future production or when the equipment has to be returned to the Manufacturer for repair and/or recalibration. ◀