CRYSTAL TEST SET, TYPE AM 193

DATA SUMMARY

PURPOSE
To measure the activity of crystals operating on frequencies between 3Mc/s and 10Mc/s.

DESCRIPTION
An oscillator in which the oscillatory circuit can be either the crystal under test, or a variable Colpitts circuit. Similar operating conditions are set up for these in turn, and the tuning condenser of the Colpitts circuit is calibrated in equivalent parallel resistance.

PHYSICAL DATA
Weight : 24lb.
Height : 5¼in.
Length : 8¼in.
Width : 19in.

REMARKS
May be either rack or bench mounting.

FREQUENCY
Coverage : 3 to 10Mc/s.
The crystal activity can be measured with three alternative input capacities, 20, 30 or 50pF, selected by means of a switch.

POWER REQUIREMENTS AND CONSUMPTION
80, 110, 115, 180 or 230V A.C., 2,000 to 50c/s.
Approx. 65W.

VALVES
ARP 35 1
AW 4 1

SPECIAL FACILITIES
An output socket is provided on the front panel, coupled by stray capacity effects to the oscillatory circuit, and the output can be used to measure the crystal frequency by feeding into a wavemeter.

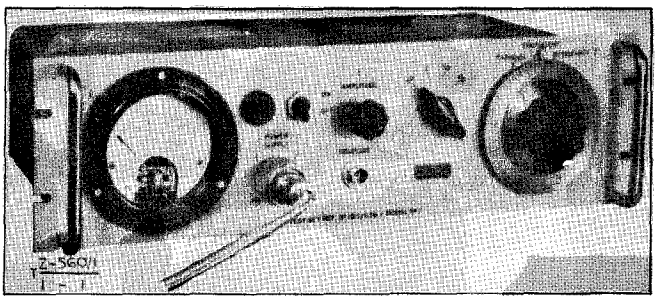

FIG. 1— General view of equipment

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RESTRICTED

CRYSTAL TEST SET, A.M. 193

OPERATORS' INSTRUCTIONS

Preliminary

1. Open the case and check that the valve and voltage stabilizer are held securely in their sockets, and that the mains transformer is adjusted to the correct tapping. Replace in the case and screw up.

Operation

2. Switch on and allow the test set to warm up for 5 minutes.

3. Place the crystal unit to be tested in the crystal socket, and turn the selector switch to the 30pF position, which is the normal testing position. Crystals which require testing with the selector switch in the 20pF or 50pF position will very rarely be met.

4. Adjust the AMPLITUDE control until the meter reads exactly 50μA (half-scale deflection).

5. Turn the selector switch to the Z position and adjust the EQUIVALENT PARALLEL RESISTANCE dial until the meter again reads 50μA.

6. Repeat operations 3 and 4, and if any change in adjustment is necessary, repeat operation 5 also. The dial now indicates directly the equivalent parallel resistance of the crystal unit, in thousands of ohms.

7. Compare the value obtained with the specification curve given in the accompanying graph, Fig. 1

Notes

8. If it is not possible to adjust the meter reading to 50μA by means of the AMPLITUDE control, it is permissible to use a lower reference level say, 30μA, provided the same procedure is used as in the operations 3, 4 and 5.

9. For convenience in measuring the frequency at which the crystal is oscillating a socket is provided labelled OUTPUT. This provides loose coupling to the crystal circuit and a direct lead can be taken from it to a suitable wavemeter.

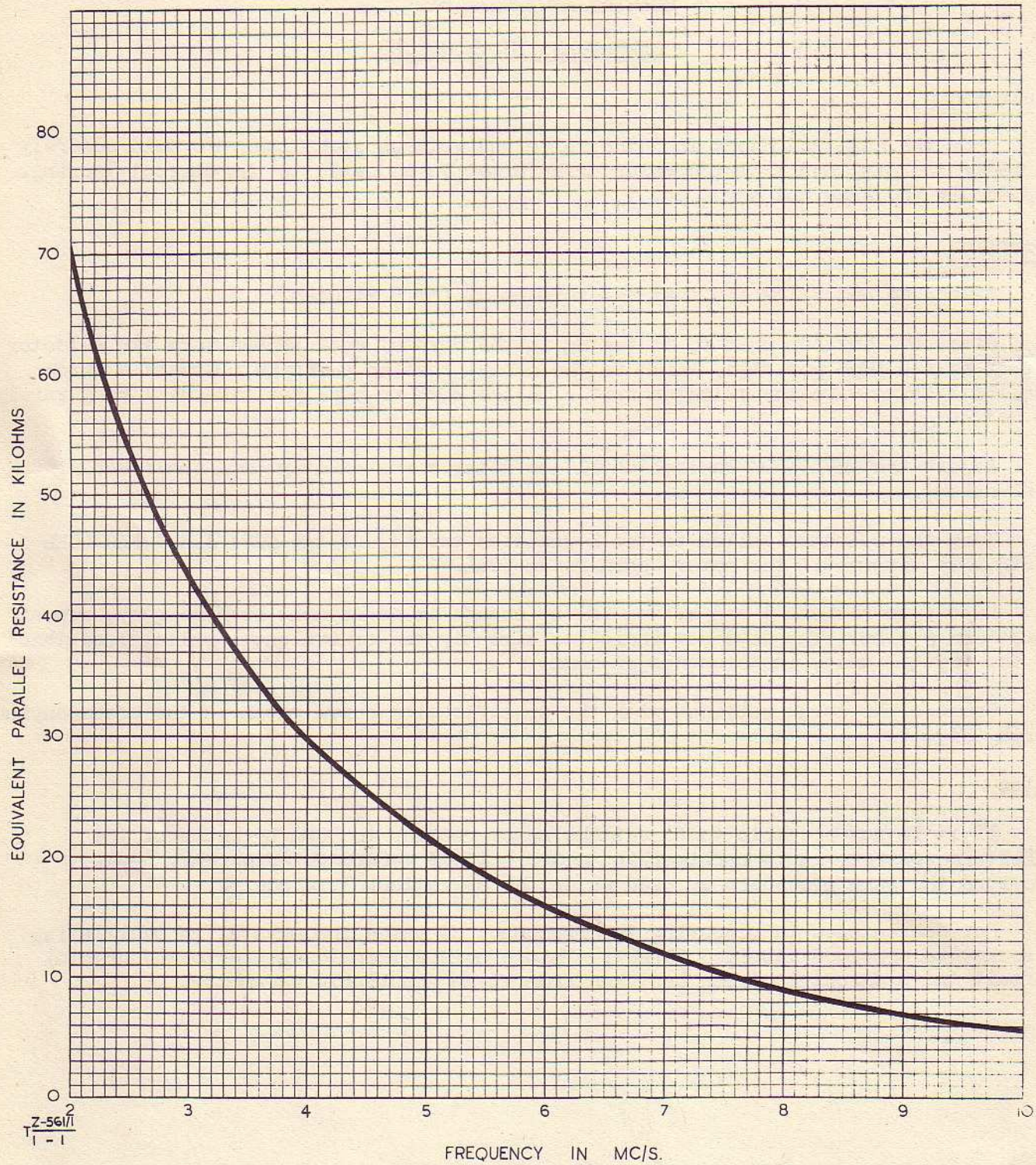

Fig. 1 - Low limit for crystal units in the range 2-10Mc/s

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CRYSTAL TEST SET, TYPE A.M.193

GENERAL DESCRIPTION

INTRODUCTION

1. The purpose of the Test set A.M.193 is to provide an indication of the activity of quartz oscillator crystals so that crystals which fail to reach satisfactory standards can be rejected and be replaced by more efficient specimens.

2. When placed in an oscillatory circuit, usually between grid and anode or grid and earth in a pentode stage, the crystal acts like an inductor with a very high Q and, in parallel with the capacitance presented by the valve, it forms a resonant circuit. To the crystal, the valve stage looks like a capacitance of from 15pF to 60pF, depending upon the type of circuit used. To the valve, the crystal looks like an inductance in parallel with a resistance, and the higher the resistance, the better the crystal, i.e., the higher the Q value of the resonant circuit. In practice, for the range of crystals oscillating between 3Mc/s and 10Mc/s, usual values of parallel resistance are from 5kΩ to 150kΩ, and these are the values for which the Test set A.M.193 has been designed.

3. The method of testing used is to place the crystal under test into a typical oscillatory stage and to measure the grid current flowing. Provision is made for three input capacities of 20, 30 or 50pF, selected by means of a switch. The current is controlled within limits by means of an amplitude control, which varies the screen voltage of the oscillator valve. In practice it is used to set up a suitable meter reading of about half-scale which is then noted. The crystal oscillates under low-drive conditions. The anode circuit of the stage is not tuned in any way.

4. Having noted the meter reading with the crystal in circuit, the selector switch is turned to the Z position in which the crystal is replaced in the oscillatory valve stage by a built in Colpitts type resonant circuit. This can be tuned by means of a variable condenser (C10) until the meter reading of the grid current is the same as it was when the crystal was being tested. The calibrated dial of the tuning condenser (C10) then indicates directly the equivalent parallel resistance of the crystal.

Note: In the Z position the frequency of oscillation is not that of the crystal.

5. The power supply is from A.C. mains; 80V to 240V tappings are provided on the transformer. The output from the transformer secondary is taken to a voltage-doubler stage, using two metal rectifiers, and then to an AW4 voltage stabilizer. A dial lamp LP1 is fitted and indicates when the power supply is switched on.

6. The 3-hole socket provided on the front panel takes the standard Air Ministry type of crystal holder. A further concentric socket marked COUPLING is connected by stray capacitance only to the oscillatory circuit and can be used as a R.F. output to a radio receiver or wavemeter if it is desired to check the frequency of oscillation of the crystal under test.

7. The instrument is designed to be rack-mounted on a standard 19 in. rack, but can also be used as a bench-mounted instrument.

TECHNICAL DESCRIPTION

8. There are four circuit conditions, selected by means of the selector switch, and they are best explained by reference to the simplified circuit diagrams in Figs. 1, 2, 3 and 4.

(a) 20pF position (Fig. 1)
The crystal is connected across a simple Colpitts type circuit consisting of C6 and C5, which are carefully balanced.

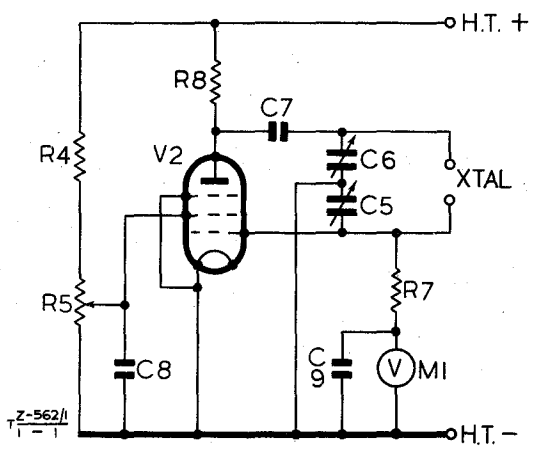

Fig. 1 - Selector switch in 20pF position

Note:- R5 is the amplitude control, V2 is an ARP35 and M1 is a 0-100 microammeter with a 3 in. scale.

(b) 30pF position (Fig. 2)
Additional capacitance is added by C15 and C16, which are carefully balanced.

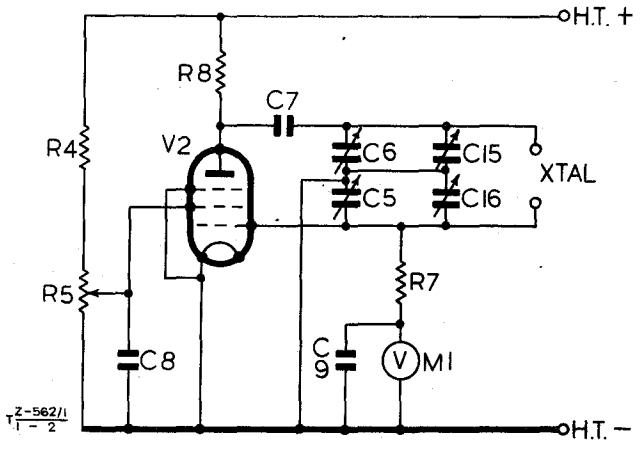

Fig. 2 - Selector switch in 30pF position

(c) 50pF position (Fig. 3)
Additional capacitance is added by C13, C14 and C17, which are carefully balanced.

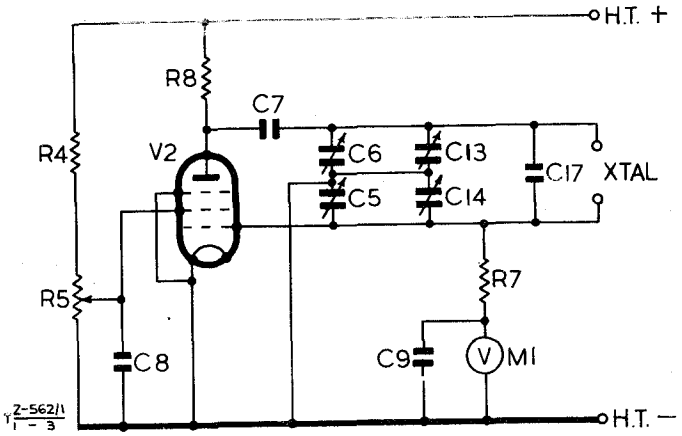

Fig. 3 - Selector switch in 50μF position

(d) Z Position (Fig. 4)
In this position the crystal is earthed on both sides and a variable Colpitts resonant circuit replaces it. C10 is the tuning condenser and has a dial calibrated in thousands of ohms. C11 and C12 are used to align the circuit at each end of the calibrated scale. C11 is used at the low-n resistance end of the scale and C12 at the high-resistance end.

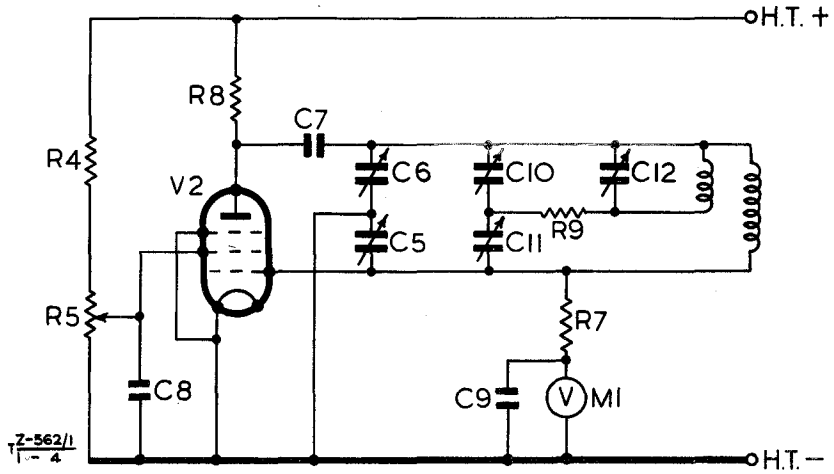

Fig. 4 - Selector switch in Z position

Note: The next page is page 1001

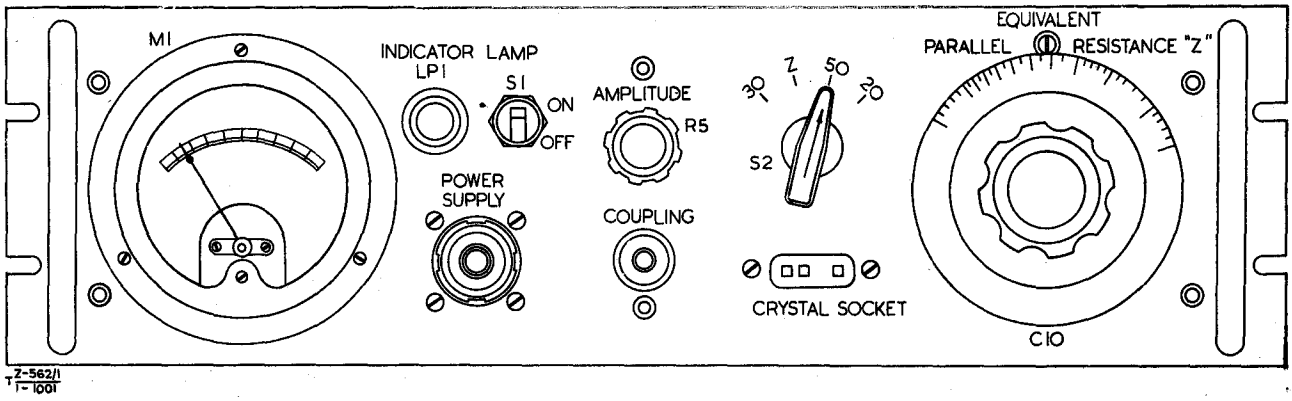

Fig. 1001 - Front panel layout

Circuit reference	Value	Rating	Tolerance	Remarks
RESISTORS				
R1	2k	10W	± 20%	
R2	2k	10W	± 20%	
R3	220k	1W	± 50%	
R4	51k	1W	± 50%	
R5	50k			Potentiometer
R7	100k	½W	± 1%	
R8	51k	1W	± 5%	
R9	1k	½W	± 5%	
R10	51k	½W	± 5%	
R11	100k	½W	± 1%	
CONDENSERS				
C1	2 F	350V		
C2	2 F	350V		
C3	4 F	350V		
C5	50pF			Variable
C6	50pF			"
C7	0.001 F	250V	± 20%	
C8	0.01 F	500V	± 20%	
C9	0.1 F	500V	± 20%	
C10	100pF			"
C11	50pF			"
C12	3-30pF			Trimmer
C13	50pF			Variable
C14	50pF			"
C15	50pF			"
C16	50pF			"
C17	20pF		± 5%	

MISCELLANEOUS

Circuit reference	Type	Circuit reference	Type
T1	Mains transformer	LP1	Pilot lamp 6.3V
S1	Switch, double-pole, single-throw	M1	0-100 microammeter 3½ in. moving-coil
S2	Switch, change-over	V1	AW4
W1) W2)	Rectifier, selenium, half-wave	V2	ARP35

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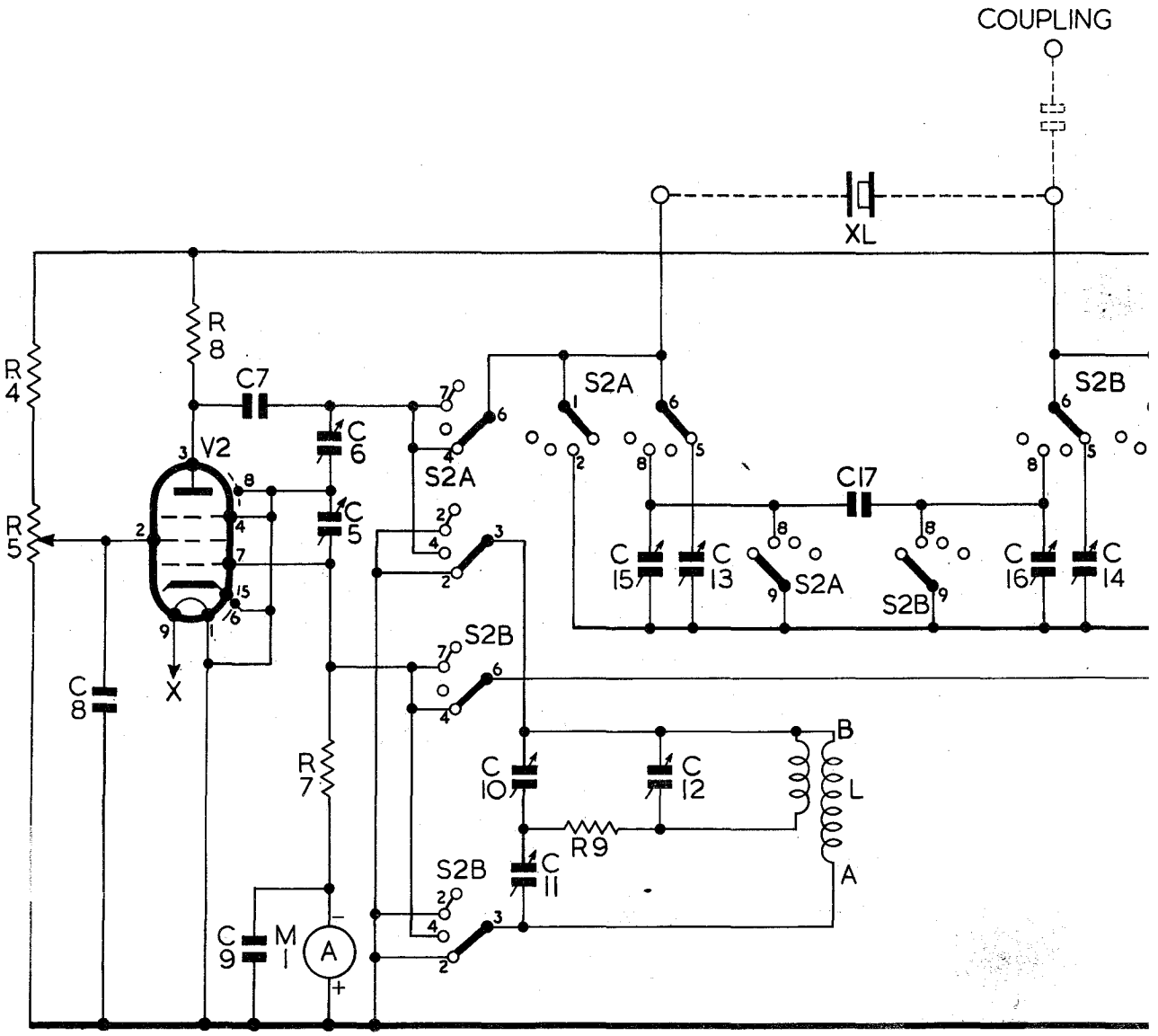
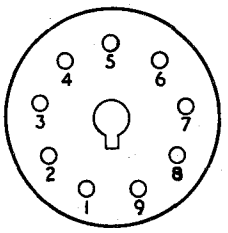
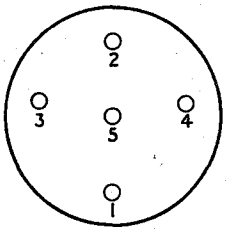




†Z-562/1 / 1-1002 V2 CV1091 (ARP 35)



V1 CV1068 (AW4)

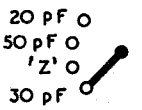


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Fig. 1002 - Ci

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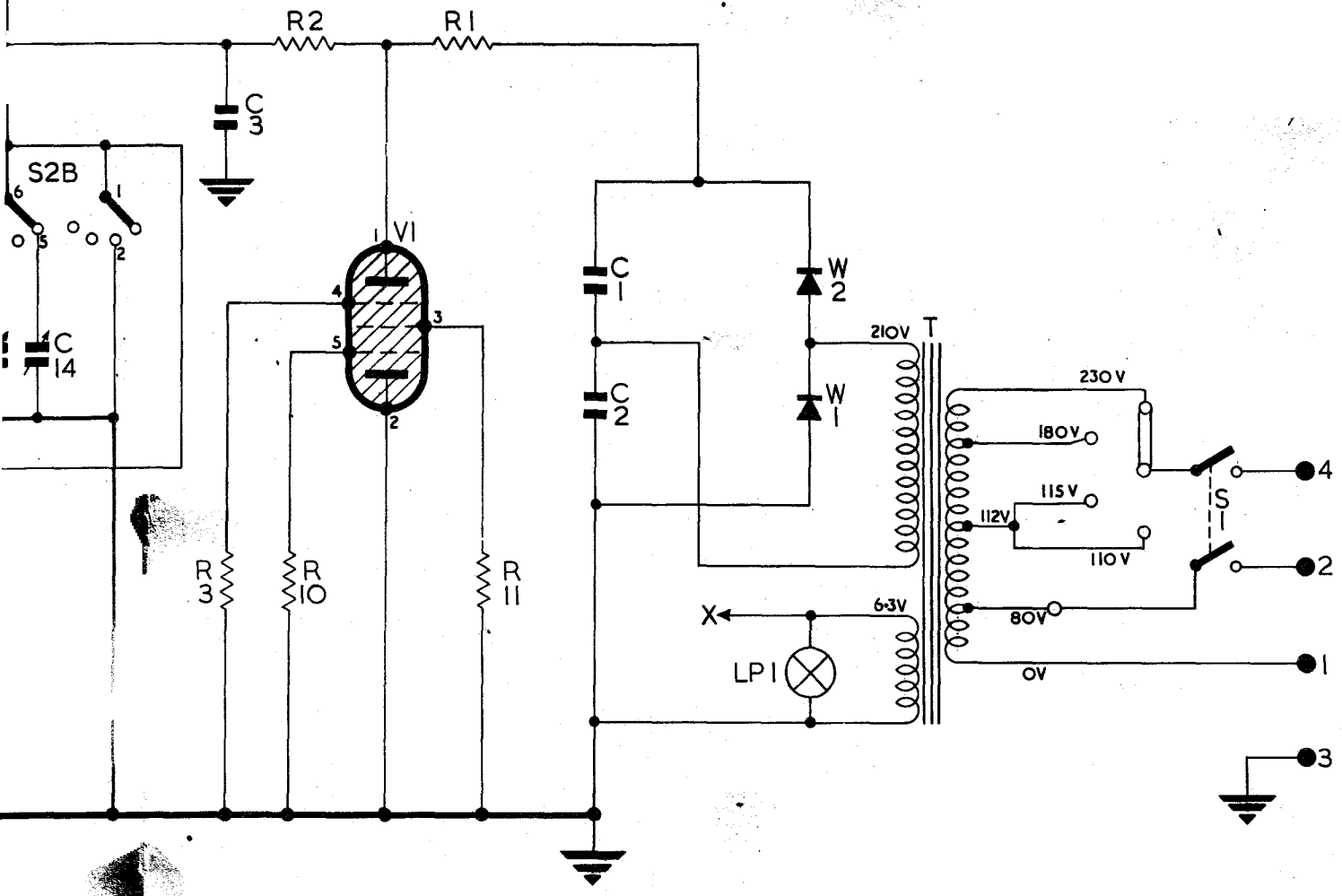

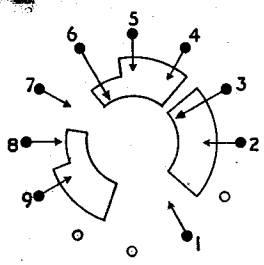

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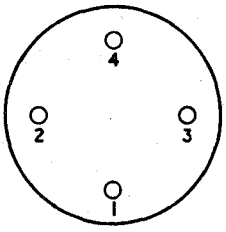

W TYPE PLUG

002 - Circuit diagram

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CRYSTAL TEST SET, TYPE A.M. 193

FIRST ECHELON WORK

ROUTINE MAINTENANCE

1. Routine maintenance is limited to ensuring that plugs and sockets are kept clean and that the various control knobs are not allowed to work loose. It is important that the calibrated dial EQUIVALENT PARALLEL RESISTANCE is not readjusted in any way.

Repairs

2. The valve V2 may be changed without affecting the performance of the equipment.

3. If the valve V1 is changed, it will be necessary to check the H.T. voltage. This should be 280V ± 5V.

4. No other adjustments are permitted. On no account may any of the preset or trimmer condensers be changed or readjusted.

END

CRYSTAL, TEST SET, TYPE A.M. 193

TECHNICAL HANDBOOK - SECOND TO FOURTH ECHELON WORK

Note: This issue, Pages 1 to 4, and 1001 to 1004 supersedes Pages 1 to 3 and 1001 to 1004 of Issue 1, dated 20 May 1946, which has been amended throughout.

MECHANICAL ADJUSTMENTS

1. Since all mechanical adjustments are quite straightforward no detailed information is given. (Layout diagrams, coil and transformer winding details are given in Figs. 1002-1005 and Table 1002).

ALIGNMENT AND CALIBRATION

2. The following apparatus is required:-

(a) One set of nine coils (Coils, calibrating, Nos. 4-12).
(b) One differential capacity meter. This should be manufactured locally; circuit and component details are given in Fig. 1001 and Table 1001.
(c) One radio receiver covering the frequency band 3-10Mc/s.
(d) One wavemeter covering the band 3-10Mc/s and of greater accuracy than 10 parts in 10^6. (Wavemeter, standard, No. 2).
(e) One output meter for use with the receiver, as described in sub-para. 2(c).

3. Each of the set of coils has been accurately checked, and a table, giving details of their relevant electrical characteristics, is pasted inside the lid of the box. The electrical quantities concerned are:-

(a) The equivalent parallel resistance (E.P.R.).
(b) The frequency of oscillation in a standard Crystal test set, type A.M. 193.

The table shows these values for each coil at each setting of the switch S2.

4. The alignment and calibration of the test set is divided into two stages:-

(a) Adjusting and balancing the input capacities tuning the crystal.
(b) Calibrating the EQUIVALENT PARALLEL RESISTANCE scale.

Input capacity adjustments

5. The simplified input circuit is shown in Fig. 1. The instrument caters for three separate input capacities, 20, 30 and 50pF so that CK and CY have values of 40, 60 and 100pF accordingly. Since CK and CY are also affected by the Miller effect of the valve and other stray capacities, they must be adjusted, finally, under normal working conditions. This stage in the alignment thus falls into two operations:-

(a) Measuring and balancing CK and CY under COLD conditions.
(b) Final trimming of CY under working conditions.

The actual condensers involved in these adjustments are shown in the simplified circuit diagrams in Tels. Z 562/1.

Measured values of CK and CY

6. To allow for stray capacities, etc., the trimmer condensers should be adjusted to the following values:-

Switch position	CK, CY	Condensers involved
		CK CY
20pF	39.5pF	C6 and C5
30pF	59.1pF	(C6+C15) and (C5+C16)
50pF	71.0pF	(C6+C13) and (C5+C14)

7. These adjustments can be made by means of a capacity bridge, or Q meter, measuring the capacitance between each terminal of the crystal socket and the chassis. In the case of CK, however, the anode load resistor, R8, together with C3 provides a shunt impedance of approximately 51kΩ at normal operating frequencies. It is desirable to measure CK without removing R8, and this can be done by means of the differential capacity meter described in para. 16.

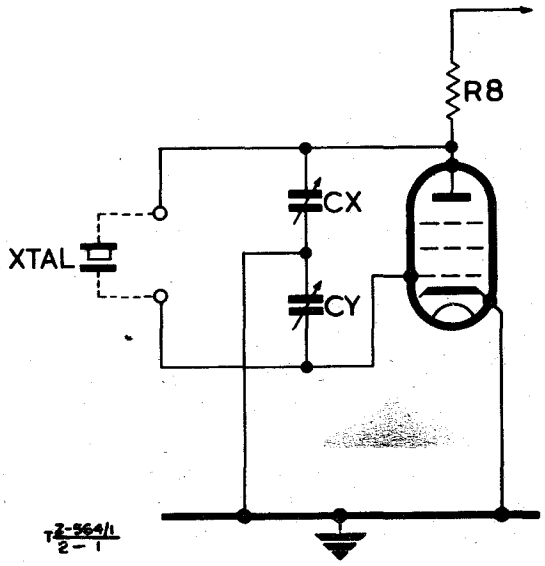

Fig. 1 - Simplified circuit of input condenser

Final trimming under working conditions

8. Switch on the test set and allow it to warm up for 15 minutes. Plug coil No. 4 into the crystal socket, and with switch S2 on the position '20', adjust the amplitude control, R5, to give a reading of 50μA, or maximum grid current.

9. Note the frequency of oscillation of the coil, for this setting of S2, from the table. Set the wavemeter accurately to this frequency. Using the receiver as a normal detector, beat the wavemeter with the test set signal, via the COUPLING socket. Adjust the trimmers, C5 and C6, until the test set oscillatory circuit is tuned exactly to the wavemeter. The amplitude control R5 should be varied, if necessary, in order to maintain the grid current at 50μA, or maximum. The capacitors, C5 and C6, should be adjusted so as to be approximately equal in value, in order to balance the capacities from anode/ground and grid/ground.

10. When the correct frequency has been obtained, lock the trimmers.

11. Switch S2 to the position '30', set the wavemeter to the corresponding coil frequency and repeat the procedure, adjusting trimmers, C15 and C16, and leaving C5 and C6 unaltered. Lock C15 and C16 when the correct setting has been found.

12. Repeat the procedure for S2 in the position '50', adjusting by means of trimmers, C13 and C14, at the appropriate coil frequency. Other trimmers should be unaltered and trimmers, C13 and C14, locked when the correct setting has been found.

Calibration of EQUIVALENT PARALLEL RESISTANCE

13. The EQUIVALENT PARALLEL RESISTANCE scale is calibrated from 4kΩ to 150kΩ, and the accuracy of calibration should be checked periodically, or following any major repairs or adjustments to the trimmers.

14. Adjustments to the reference 'loss' circuit to correspond with the calibration of the scale can be effected by means of the trimmers C11 and C12, and resistor R9. By using the calibrating coils a number of points on the scale for each value of input capacitance can be obtained. Thus, the scale can be adjusted at a number of widely separated readings.

15. The procedure for calibration is as follows:-

(a) Switch the test set ON. Remove the press stud over the trimmer, C11.
(b) Close the vacuum of the variable condenser, C10, and make sure the dial reads maximum. If not, adjust it to do so.
(c) Select a coil of low E.P.R., note its value at 30pF, from the table, and insert it in the crystal sockets. Set the switch S2 to position '30' and adjust the AMPLITUDE control until the meter reads a grid current of 50μA, or maximum, whichever is the lower.
(d) Switch to position 'Z' and set the EQUIVALENT PARALLEL RESISTANCE dial to the appropriate E.P.R. value for the coil. Adjust C11 by means of an insulated screwdriver until the meter again reads 50μA.
(e) Return S2 to the '30' position, and ensure that the meter reading is still 50μA, adjusting the AMPLITUDE control if necessary, and repeat as described in sub-paras. (d) and (e).
(f) Replace the press stud and turn the amplitude control to minimum.
(g) Select a coil of high E.P.R., note its value at 30pF and insert it in the crystal sockets. Proceed as detailed in sub-para. (c).
(h) Switch to position 'Z' and set the EQUIVALENT PARALLEL RESISTANCE dial to the appropriate E.P.R. value for the coil. Adjust the cylindrical trimmer, C12, until the meter reads 50μA.
(j) Repeat as detailed in sub-paras. (c)-(h) to ensure that adjustment of C12 has not upset the adjustment of C11.
(k) Insert a coil of E.P.R. value, at 30pF, equal to approximately mid-scale, and check that the mid-scale value is correct. Adjustments to the mid-scale calibration can be made by changing resistor R9. If this is done, details as described in sub-paras. (c)-(h) will have to be repeated.
(l) Using all the coils in turn, check the calibration for as many points as possible for all three positions of S2, i.e., '20', '30' and '50'. Any adjustments necessary should be made by the trimmer, C11, for low values of E.P.R., and by the trimmer, C12, for above mid-scale values of E.P.R.

Differential capacity meter

16. The differential capacity meter is an instrument capable of ensuring accurately the values of capacities up to 100pF (having very poor power factors); the accuracy is ± 0.2pF. In principle, the meter consists of an oscillator, preferably crystal-controlled, of the Colpitts type feeding R.F. at 750kc/s into a tuned circuit, the resonance of which is indicated by the valve voltmeter across the tuning capacitor as shown in Fig. 1001. Across the tuning capacitor is another 100pF polar variable

capacitor for zero adjustment, and also the terminals to which the external capacitance to be measured can be connected. The coil (L_1) is wound on a No. 2 Trolitul former and mounted on a No. 2 Gecalloy iron core, and it tunes to 750kc/s with 200pF. Its Q is about 300. One of the two variable capacitors is fitted with a 0-100 slow-motion dial. In the calibration procedure this is set to the 0 position with the capacitor vanes fully meshed, and the apparatus tuned to resonance by means of the other variable (set zero) capacitor. The capacitor to be measured is then connected to the position marked X in Fig. 1001 and the slow-motion dial is varied to retune to resonance. This dial can be calibrated to give direct readings in pF; the difference between its zero setting and new position thus indicates the capacity across the input terminals. In practice, this device has been found to give accurate readings when the parallel resistance across the capacitor is only a few thousand ohm.

Use of set of three coils (Coils calibrating Nos. 4, 8 and 12)

17. In order to check the input capacity and E.P.R. of Crystal test set, type A.M. 193, a set of three coils only, Coils calibrating Nos. 4, 8 and 12, is available. These three coils will give three widely spaced points on the E.P.R. scale for each setting of C2. The method of calibration is identical with that already outlined.

Note: The next page is Page 1001.

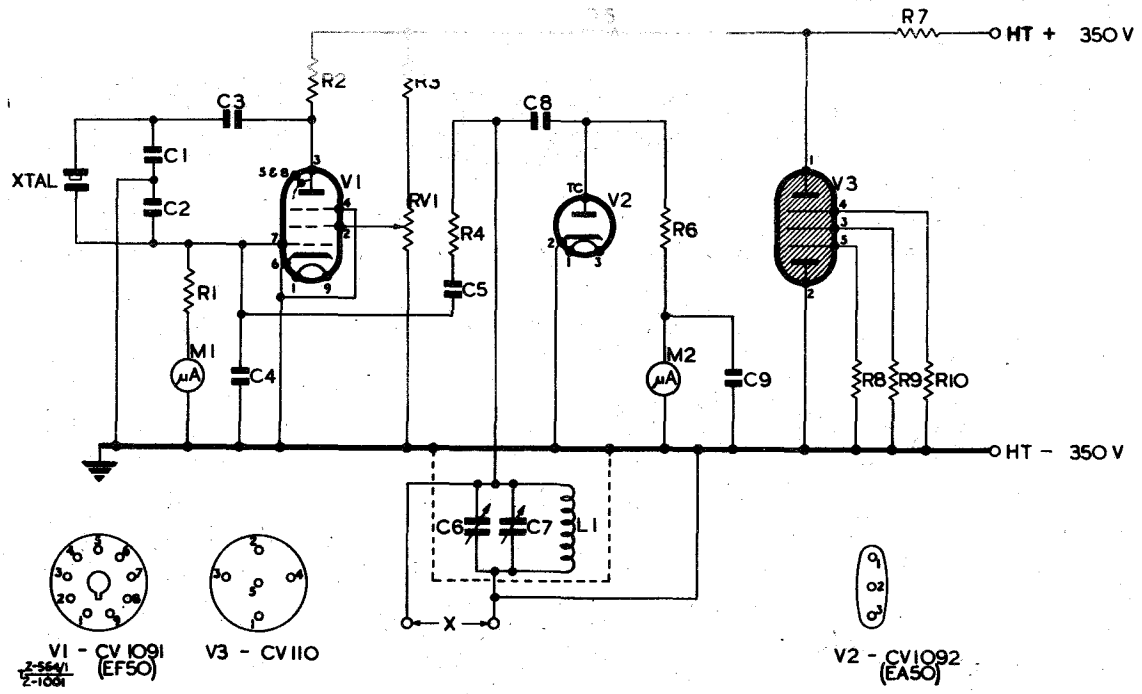

Fig. 1001 - Circuit of differential capacity meter

Circuit reference	Value	Tolerance	Rating	Circuit reference	Value	Tolerance	Rating
Condensers							
C1	50pF	± 5%		C6	100pF	Variable	
C2	50pF	± 5%		C7	100pF	Variable	
C3	0.001uF	± 20%	350V	C8	100pF	± 20%	
C4	0.1uF	± 20%	250V	C9	0.1uF	± 20%	250V
C5	0.001uF	± 20%	250V				
Resistors							
R1	100kΩ	± 10%	½W	R7	2kΩ	± 20%	10W
R2	50kΩ	± 20%	1W	R8	57kΩ	± 20%	½W
R3	100kΩ	± 20%	1W	R9	100kΩ	± 20%	½W
R4	50kΩ	± 5%	½W	R10	200kΩ	± 20%	1W
R5	2kΩ	± 20%	10W	RV1	100kΩ	Potentio-meter	
R6	100kΩ		½W				
Inductors							
L1							
Crystal							
XTAL	750kc/s						
Meters							
M1	0-250uA						
M2	0-100uA						
Valves							
V1		CV 1091		V3		CV 110	
V2		CV 1092					

Table 1001 - List of components

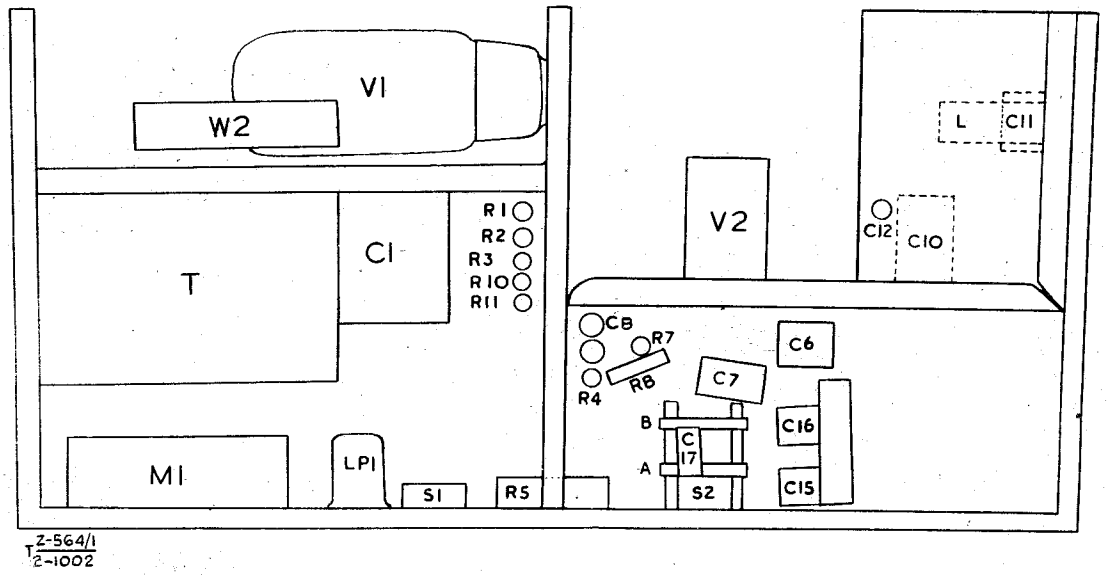

Fig. 1002 - Component layout

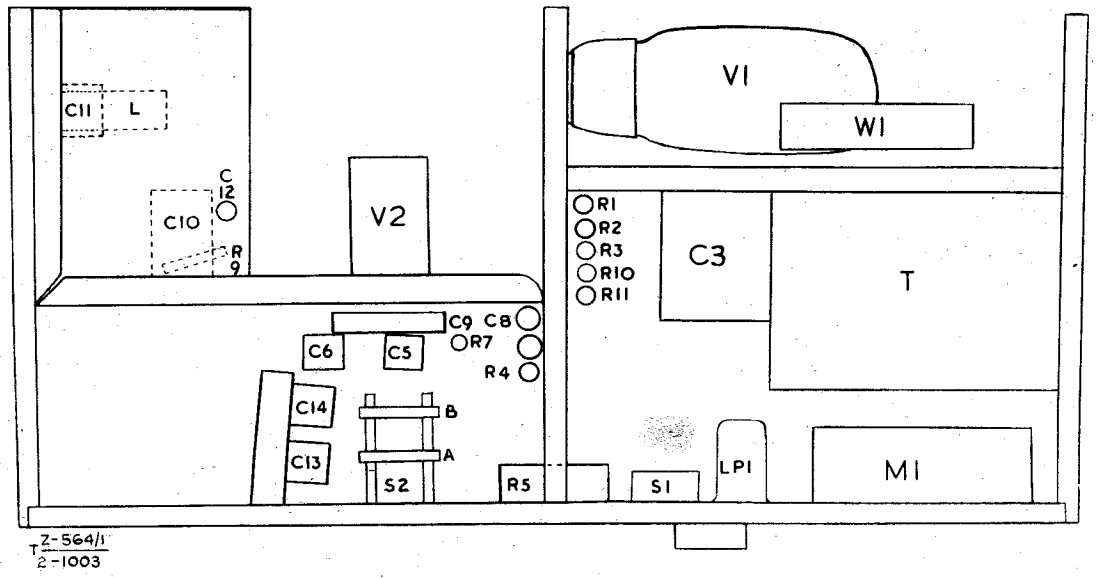

Fig. 1003 - Component layout

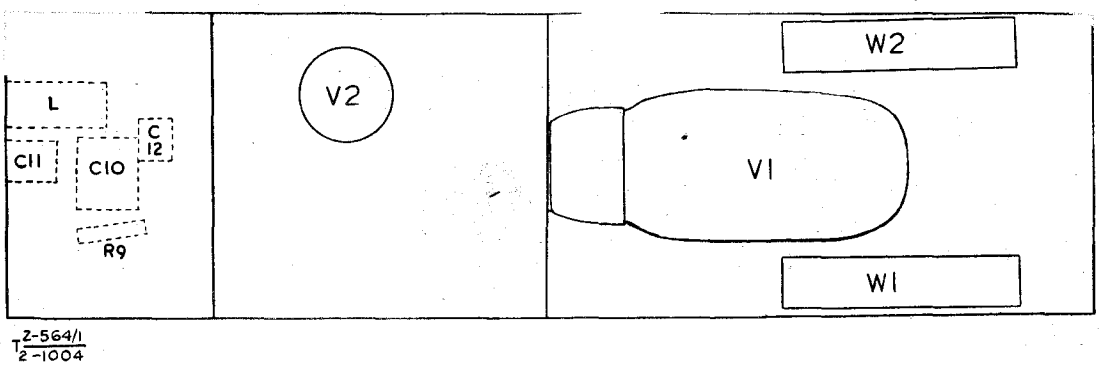

Fig. 1004 - Component layout

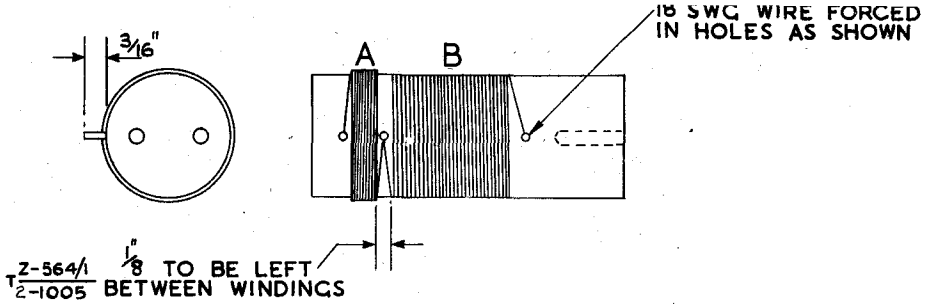

Fig. 1005 - Winding details of coil L_1

Transformer T		
Secondary	Winding 1	52 turns 18 S.W.G. enamelled copper wire - 6.75V, 0.6A
	Winding 2	1,870 turns 38 S.W.G. enamelled copper wire - 230V, 40mA
	Winding 3	Screen
Primary	Winding 4	560 turns 28 S.W.G. enamelled copper wire + 1,155 32 S.W.G. enamelled copper wire, tapped at 240 and 765 turns
Laminations		M and EA 24A
Tolerances	6kΩ load 11.25Ω load	230V ± 2% on 40mA 6.75V ± 2% on 0.6A
Coil L_1 (see Fig. 1005)		
Section A	To be wound on 1 in. diameter former with 20 turns of 36 S.W.G. enamelled copper wire with turns touching	
Section B	To be wound with 50 turns of 30 S.W.G. enamelled copper wire in opposite direction to section A	

Table 1002 - Winding details of coil L_1 and transformer T

END

ELECTRICAL AND MECHANICAL
ENGINEERING REGULATIONS
(By Command of the Army Council)

TELECOMMUNICATIONS
Z 689 Misc Inst No. 1

TEST SET, CRYSTAL, TYPE AN 193

TECHNICAL HANDBOOK - MISCELLANEOUS INSTRUCTION

Redesignation of EMERs

Information

1. To maintain the proper sequence of EMER numbers, it is intended that:-

   (a) all future issues of EMERs on this equipment will be published in the series Tels Z 680 - Z 689 and

   (b) the current EMERs will be redesignated.

Action

2. The following EMERs will be redesignated as shewn.

	Present designation				New designation
	EMER designation (a)	Pages (b)	Issue No. (c)	Date (d)	(e)
1	Tels Z 560/1	1	1	16 May 46	Tels Z 680
2	Tels Z 561/1	1 - 2	1	1 Jul 46	Tels Z 681
3	Tels Z 562/1	1 - 3 1001 - 1002	1 1	20 May 46 20 May 46	Tels Z 682
4	Tels Z 563/1	1	1	30 Jun 46	Tels Z 683
5	Tels Z 564/1	1 - 4 1001 - 1004	2 2	15 Sep 49 15 Sep 49	Tels Z 684

57/Maint/6670

END