CRYSTAL MONITOR, TYPE 2

(Stores Ref. 10D/11390)

INTRODUCTION

1. The Crystal Monitor, type 2, is designed for use in aeroplanes to facilitate the initial adjustment and subsequent monitoring of C.W. transmitters and receivers. The instrument enables a rapid and accurate shift of operational frequency to be made. It also provides a convenient method of checking the frequency stability of installations and of making the necessary adjustments for the correction of any frequency drift which may occur during flight.

2. The instrument operates on any one of six "spot" frequencies in the range from 7·5 Mc/s to one Mc/s. Six quartz crystals of the appropriate frequencies are fitted in the instrument and a seventh, or "extra" position is provided on the panel of the instrument. Any one of these crystal positions may be selected by means of a rotary switch.

3. The power supplies for the instrument are normally derived from the receiver, H.T. and L.T. batteries, but with certain installations, for which instructions will be promulgated, separate batteries may be used. Provision is made for either battery or automatic grid bias to the output stage. Three triodes are used, one as an oscillator and two for audio-frequency amplification.

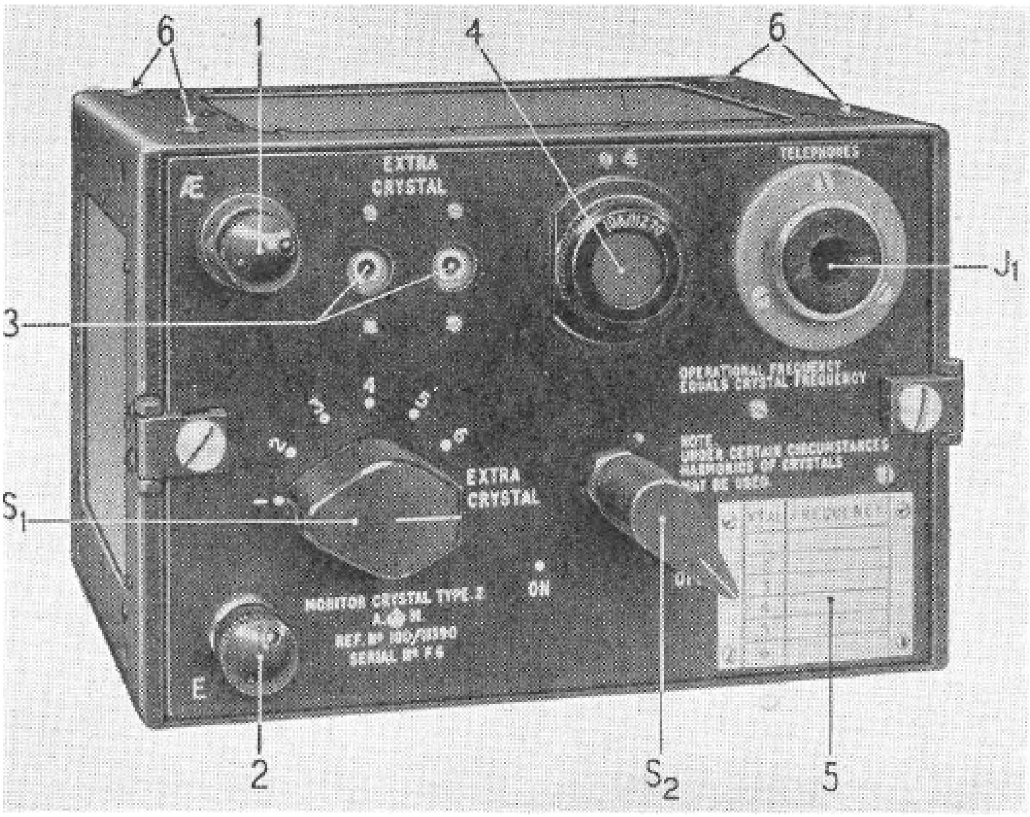


FIG. 1—CRYSTAL MONITOR, TYPE 2

4. The dimensions of the monitor are 7 in. × 5 in. × 5 in. and its weight is approximately 5 lb. Fig. 1 shows a general view of the instrument. A transit case is provided but the method of component suspension adopted renders any special form of mounting unnecessary.

GENERAL DESCRIPTION

5. The circuit of the monitor (see fig. 2) consists of a crystal-controlled oscillator followed by two stages of audio-frequency amplification. The oscillations are maintained by the valve V_1 at a frequency determined by a quartz crystal. A small aerial picks up the radiation from the oscillator to be monitored and also provides the necessary emission when the monitor is used to set up receivers. If the frequency received differs slightly from the frequency of the crystal, heterodyne beats will be produced which are rectified and amplified by the succeeding stages of the monitor. The circuit to be monitored may therefore be brought within approximately 50 c/s of the crystal frequency by the zero-beat method. At 4·5 Mc/s this represents an error of only one part in 90,000.

6. Referring to the theoretical circuit diagram, fig. 2, the oscillator frequency determining element is any one of the seven crystals as selected by the switch S_1. The crystal is connected between the grid and the anode of the valve V_1, its R/F output being divided between the grid-filament and anode-filament capacitances. The aerial is also coupled to the grid circuit *via* the condenser C_1. The grid is maintained at a suitable potential by the leak resistance R_1, in association with the condenser C_2. The anode circuit A/F impedance consists of the resistance R_2. The stage is decoupled from the succeeding stages by the resistance R_3 and condenser C_4.

7. The A/F voltages across the resistance R_2 are impressed upon the grid-filament circuit of the amplifying valve V_2 *via* the grid condenser C_5, the required grid bias being maintained by the leak resistance R_5. The anode circuit load impedance is constituted by the inter-valve transformer T_1, the primary winding of which is fed *via* the decoupling resistance R_4, with which is associated the decoupling condenser C_{10}. The condenser C_8 is a radio-frequency by-pass. The secondary winding of the inter-valve transformer is loaded by the resistance R_6. The A/F voltages across this resistance are applied between grid and filament of the valve V_3 *via* condenser C_7, which is a by-pass for the grid-bias battery or automatic bias resistance (*see* paragraph 11).

8. The anode circuit of the valve V_3 is fed through the A/F choke L_1, the output circuit proper consisting of the D.C. blocking condenser C_3 and the telephone receivers, which are normally plugged into the socket J_1.

9. A reservoir condenser C_9 is connected between the H.T. positive and L.T. negative terminals. To provide decoupling for the L.T. supply when used in common with that of the receiver installed in the aeroplane, R/F chokes L_2 and L_3 are inserted in the positive and negative supply leads to the filament of the valves V_1, V_2 and V_3. The switch S_2 completes the L.T. circuit to all three valves.

10. Two sources of grid bias are provided, namely battery and automatic. In general, it may be stated that automatic bias must be used when the monitor is supplied in parallel with a receiver, such as the R.1082, which employs automatic bias, and battery bias when this form is used in the receiver, such as the R.1116.

11. The manner in which the grid-bias supply system is charged is shown in fig. 2. The wiring is brought to two assemblies A and B, each of which has three points. A metal disc C may be fitted over either A or B, so that the three points of the selected assembly become, electrically, a single point. When battery bias is required, the grid-bias battery is connected to the points marked G.B.+, G.B.—, and the metal disc is placed on assembly B. This connects the terminals L.T.—, H.T.—. When automatic bias is required, the grid-bias battery is removed and the metal disc is placed on assembly A. The L.T.— and H.T.— terminals are now connected, not directly, but *via* the resistances R_7 and R_8 in series. The values of these resistances are so chosen that when combined with the receiver bias resistance the IR value does not alter the receiver voltages. The combined resistances thus share, proportionately, the currents of the monitor and the receiver valves. The grid of the output valve V_3 is connected, *via* the transformer secondary winding, to the midpoint between R_7 and R_8. The resistance R_7 automatically controls the value of the anode current, for should the anode current rise the drop through R_7 will rise in proportion and the negative bias will be increased.

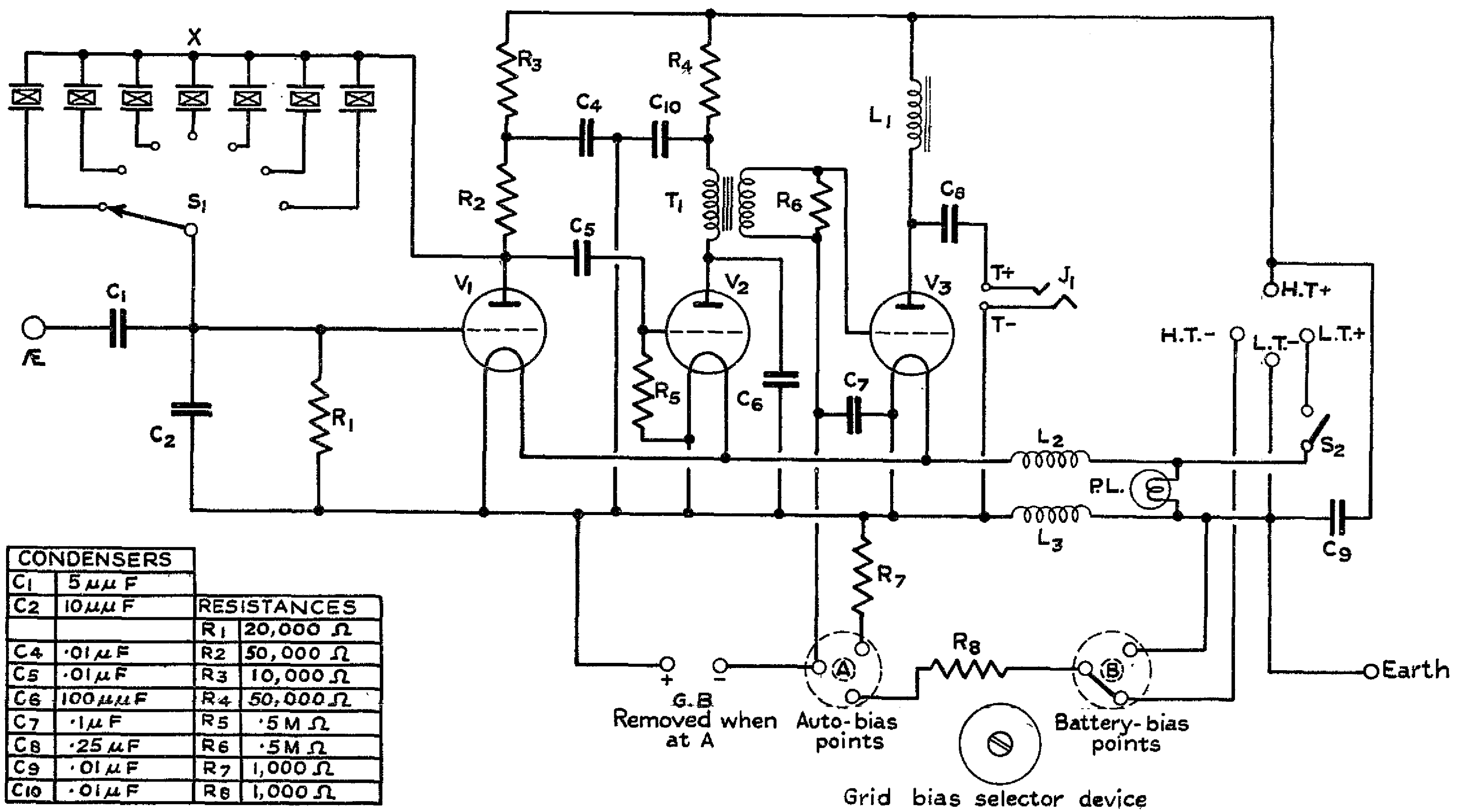
12. The chokes L_2 and L_3 inserted in the filament leads effect the necessary decoupling between the monitor and the receiver *via* the battery leads when common batteries are used. The switch S_2 makes and breaks the positive filament supply to the three valves.

CONSTRUCTIONAL DETAILS

13. Several views of the crystal monitor type 2 are shown in figures 1, 3, 4 and 5, and a bench wiring diagram fig. 6 illustrates the location of the various components. The annotation of these figures corresponds wherever possible to the annotation used for the components on fig. 2.

14. The instrument is composed of two main parts, the case and the tray carrying the components. The case is made up of an aluminium frame on a solid base, the remaining sides having paxolin panels inset. The tray is made of aluminium and slides into the case on guides. It is secured in position by two quick-release clamps. The metal frame work is finished with black, semi-gloss enamel.

C_1 C_2 C_4 C_5 C_{10} C_6 C_7 C_8 C_9	Condensers
R_1 R_2 R_3 R_5 R_4 R_6 R_7 R_8	Resistances
X S_1 V_1 V_2 T_1 L_1 V_3 J_1 L_2 L_3 P.L. S_2	Miscellaneous



CONDENSERS		RESISTANCES	
C1	5 μμF		
C2	10 μμF		
		R1	20,000 Ω
C4	·01 μF	R2	50,000 Ω
C5	·01 μF	R3	10,000 Ω
C6	100 μμF	R4	50,000 Ω
C7	·1 μF	R5	·5 M Ω
C8	·25 μF	R6	·5 M Ω
C9	·01 μF	R7	1,000 Ω
C10	·01 μF	R8	1,000 Ω

FIG. 2. CRYSTAL MONITOR TYPE 2 — THEORETICAL CIRCUIT DIAGRAM

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15. The components, with the exception of the filament lead chokes and battery plug, are mounted upon a paxolin panel which is secured to the base by three anti-vibrational mountings. The chokes and battery plug are fixed to the base.

16. A general view of the instrument is given in fig. 1 which illustrates the front panel features. The aerial and earth terminals (1) and (2) are on the left. Next to the aerial terminal are the two sockets (3) to accommodate the seventh (or "extra") crystal and the knob S_1 indicates, on the selector engraving, this position. The pilot lamp indicating window (4) is situated above the ON-OFF switch S_2. In the top right-hand corner there is the telephone socket J_1 and below it the frequency plate (5) for the recording of crystal frequencies.

17. The method by which the components are suspended in the instrument renders unnecessary any special form of mounting. Four threaded insets (6 B.A.) are provided on each of the top, bottom and two ends of the case thus affording four possible bases for mounting the instrument. The four insets (6) on the top panel may be seen in the illustration.

18. Fig. 3 is a plan view of the instrument with valves removed and no crystals in position. The three valve holders (1) and the pairs of sockets (2) for the crystal holders, together with the D.C. blocking condenser C_8, are provided on the panel (7). The bracket (3) holds the pilot lamp and the two sockets (4) are associated with the seventh or "extra" crystal. Leads (5) from these sockets to the crystal selector switch S_1 can be seen.

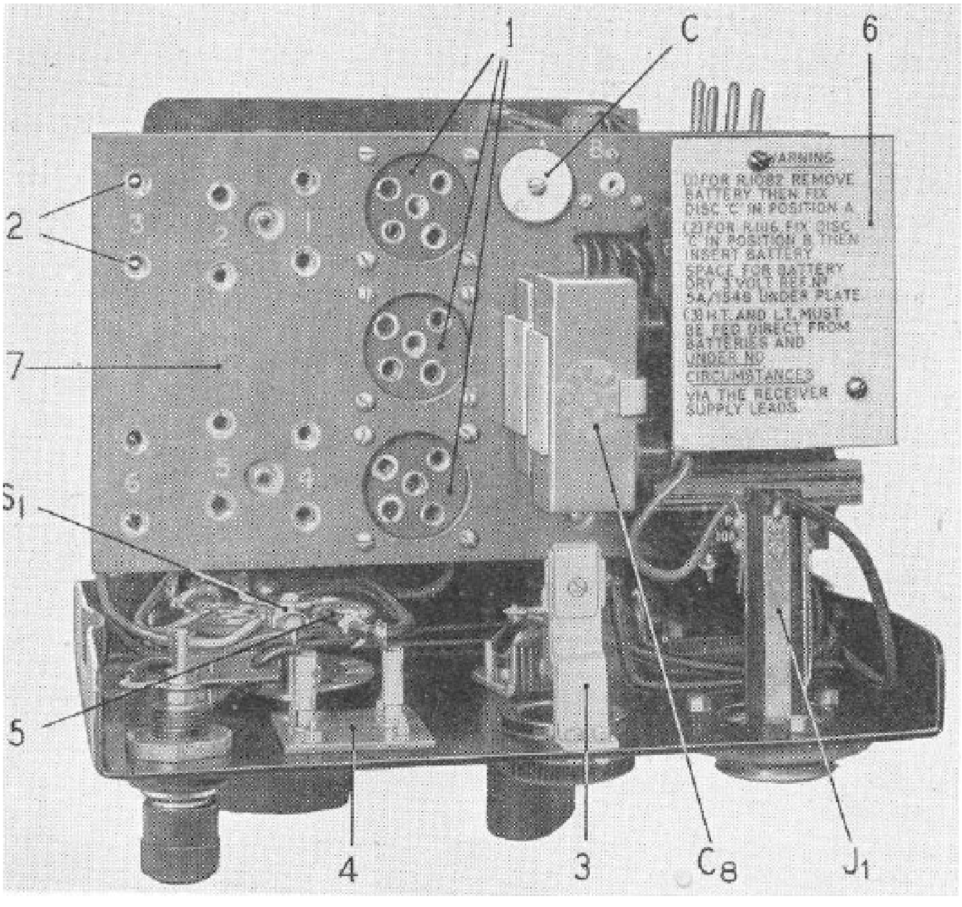

FIG. 3—PLAN VIEW OF MONITOR

19. A feature of fig. 3 is the grid-bias arrangement, the construction being clearly brought out. The disc "C" is in position in the "A" or "automatic" position. This arrangement is explained on the ivorine warning plate (6) situated above the grid-bias battery container. This plate is secured by two screws and must be removed to insert the battery for which it serves as a retaining plate. The negative terminal strip of the battery passes through a slot in the end of the case to make connexion with the head of a brass screw outside. The positive terminal strip is bent over, when inserting the battery in position, to make contact with the brass screw head inside the forward end of the case.

20. An underside view of the monitor tray, fig. 4, shows the location of various condensers and resistances. On the left-hand side of the opening cut out from the tray there is the 0·01μF condenser C_5 associated with the input to the grid-filament circuit of the first L/F amplifier valve V_2. A grid leak resistance R_5 of 0·5 megohm for this stage is mounted on a small paxolin panel opposite C_5. R_5 is centrally placed amongst the bank of five resistances forming the lower portion of the panel. Immediately below R_5 there are the 1,000 ohms series resistances R_7 and R_8 which form part of the special grid-bias assembly dealt with in the previous paragraph. Reading from the top of the opening, the 10$\mu\mu$F condenser C_2 is mounted above the 20,000 ohms grid leak R_1 with which it is coupled to constitute the grid-filament input circuit to the heterodyne detector valve V_1. Immediately below R_2, which is the 50,000 ohms anode resistance for V_1, can be seen the R/F by-pass condenser C_6 having a value of 100$\mu\mu$F. The 50,000 ohms resistances R_4 and the 10,000 ohm resistance R_3, decouple the anodes of the valves V_2 and V_1 respectively.

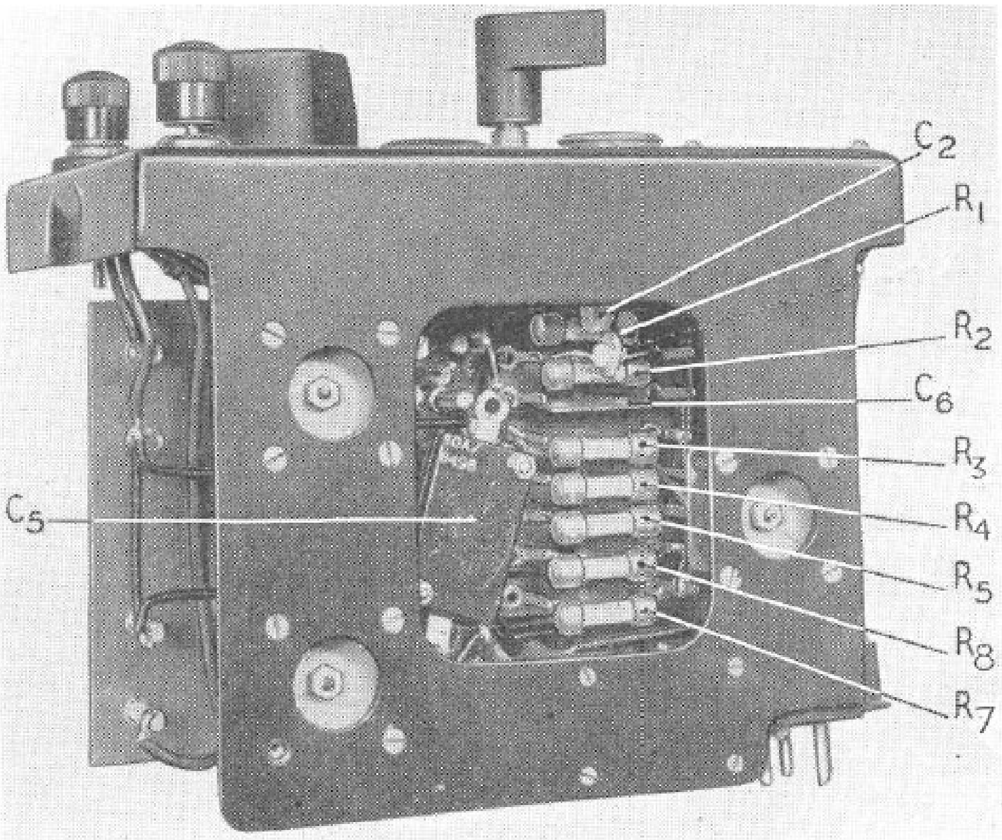

FIG. 4—UNDERSIDE OF TRAY

21. Referring to fig. 5, which is a rear view of the monitor with the case removed, one of the anti-vibrational mountings (1) is shown in the bottom right-hand corner. It consists of an upper member, or plunger, attached to the main paxolin panel and a bottom member consisting of a small platform with a circular rubber inset joined to the rubber buffer of the plunger. The filament lead R/F chokes L_2 and L_3 are mounted on the metal tray and adjoin the type 67 plug (2) by means of which the monitor is joined to the battery supplies. In this illustration the ivorine warning plate has been removed in order to illustrate the construction of the grid-bias battery holder (3). The 0·25μF D.C. blocking condenser in the output circuit of the second L/F amplifier valve V_3 is mounted above the 0·1μF condenser C_7 which serves as a by-pass for the grid-bias arrangement. Across the secondary winding of the transformer T_1 is fixed the 0·5 megohm resistance R_6. In the aerial lead from the terminal A_6 seen at the top right-hand corner of the main panel, the small aerial coupling condenser C_1 of 5$\mu\mu$F is visible beneath a numerical indicator tag. Similar tags and positional references have been instituted in this monitor to facilitate, in conjunction with a printed legend on the inside of the case, the location of components. In this illustration the construction of the selector switch S_1 can be clearly seen.

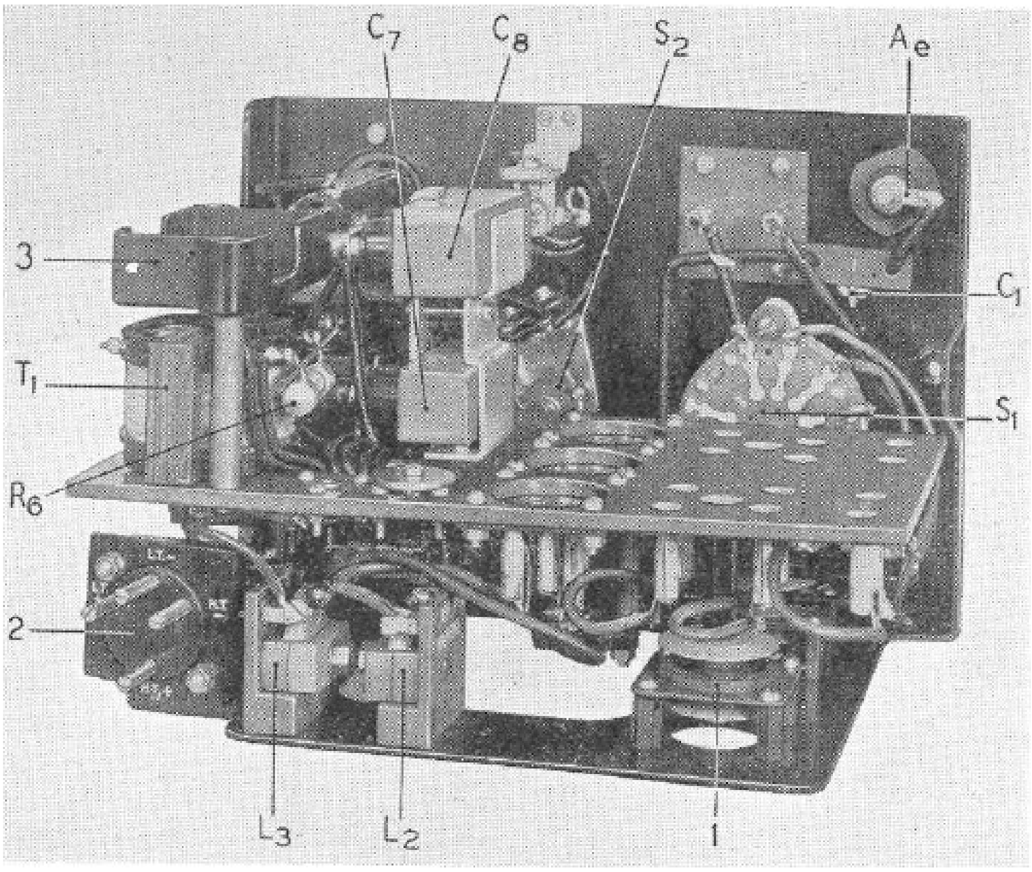

FIG. 5—REAR VIEW OF THE MONITOR

VALVES AND BATTERIES

22. Three triodes of the same type, V.T.50, are used in the monitor. These valves have an anode rating of 150 volts with 2 volts (0·1 amp.) on the filaments. The normal current consumption is, anode, 3·5 mA. and filament 0·3 to 0·5 amps.

23. The power supplies for the monitor are derived, in general, from existing aeroplane sources, that is to say the receiver 120 volt H.T. battery and the 2 volt L.T. accumulator. Alternative sources of grid-bias are, however, provided, namely battery bias from an integral grid-bias battery or automatic bias from the junction between two resistors connected in the L.T. negative and H.T. negative lead. The method of selection of either of these sources is detailed in para. 11.

PRECAUTIONS AND MAINTENANCE

24. The fragile nature of the crystal and the precision associated with the internal mounting make it necessary to stipulate that on no account should crystal mountings be taken down or repaired at stations.

25. The defined operating conditions should be observed as to power supplies. The normal anode current is 3·5 mA and the filament current from 0·3 amps. to 0·5 amps. The H.T. and L.T. supply leads must be connected directly between the batteries and the plug and socket on the monitor and must not be taken *via* the receiver battery leads. It is advisable to check, by inserting each valve separately into its holder, for filament and anode current. When doing this the Switch S_1 should be turned to the EXTRA CRYSTAL position but with no crystal inserted. Any excessive current, particularly in V_1, should be met by valve replacement. Approximately 1·5 mA anode current should be regarded as a maximum for this stage.

26. The frequent use of the monitor imposes an additional drain on the receiver batteries. It will be appreciated, therefore, that the precaution of testing the H.T. battery with a view to replacement should not be omitted. Normally the battery should be replaced when the voltage, on load, drops to 105 volts.

27. Ensure that the grid-bias battery is removed when the shorting plate "C" is in the "A" position.

28. In the event of the crystal refusing to oscillate when the monitor switch is ON, check over for circuit failure by testing any of the other crystals, which are in position. When a spare crystal is available the use of the EXTRA CRYSTAL sockets on the monitor panel facilitates testing. If no oscillation is obtained in this position check for valve failure or bad pin contact in the usual manner.

OPERATION

29. Before attempting to use the monitor, care must be taken to ensure that the valves and necessary crystals are in position. The position of the crystal selector switch S_1 should be noted and the necessary legend recorded on the "Frequency Plate". The monitor is not screened and it is fixed at the most convenient distance from the transmitter and receiver with which it is used.

30. The aerial for the monitor consists of a suitable length of flexible cable. The exact length is not critical and may in some instances be as much as ten feet. The position of the aerial in relation to the transmitter, to provide the required coupling, is a matter which depends upon the layout of the instruments. So far as the receiver is concerned sufficient coupling is supplied through the common portion of the leads from the batteries.

31. The H.T. and L.T. supplies for the monitor should be connected directly to the terminals of the battery supplying the receiver and not to the plug end of the battery leads. In certain installations a common terminal block can be used providing it is situated not more than 12 inches from the batteries. A schematic diagram of a suggested layout is given in fig. 7.

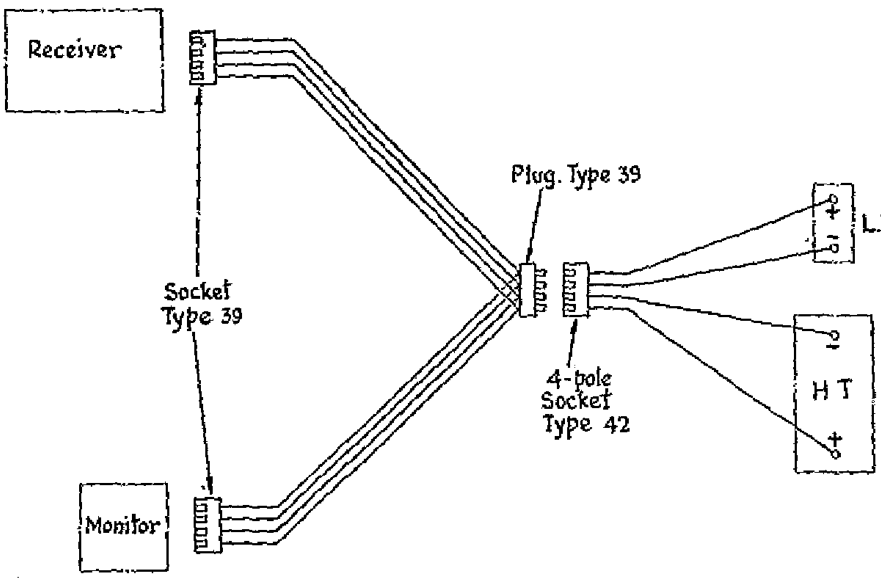

FIG. 7—BATTERY CONNECTIONS OF CRYSTAL MONITOR TYPE 2—SCHEMATIC DIAGRAM

32. The disc "C" inside the monitor must be screwed into the appropriate socket "A" or "B" depending upon the source of grid bias to be used. If a separate grid-bias battery is used it must be placed in its bakelite holder. Before this can be done the ivorine WARNING plate which acts as a securing piece for the battery must be removed. The negative terminal strip of the battery passes through a slot in the forward end of the holder to make connexion with the head of a brass screw outside. The positive terminal strip is bent over, when inserting the battery, to make contact with the brass screw inside the holder. Ensure that the terminal strips are making good contact and replace the ivorine tablet.

33. It should be noted that in position "A" of the grid-bias arrangement, when the monitor is employed with receiver R.1082, it is important to ensure that the grid-bias battery is removed. In position "B", when separate battery supplies are used as a supply to this monitor, the grid-bias battery must be fitted as detailed in the preceding paragraph.

34. Full use should be made, in the initial settings, of the calibration charts or tables provided with the transmitters and receivers.

35. Connect the battery socket to the plug at the rear of the monitor. Then, by reference to the "Frequency Plate" (5, fig. 1), select the appropriate crystal by means of the switch control S_1. These preliminary operations are implied in the succeeding paragraphs. In order to determine if the monitor is oscillating, plug the telephones into the socket J, switch on S_2 and tap the aerial terminal (1), when a clicking noise should be heard in the telephones.

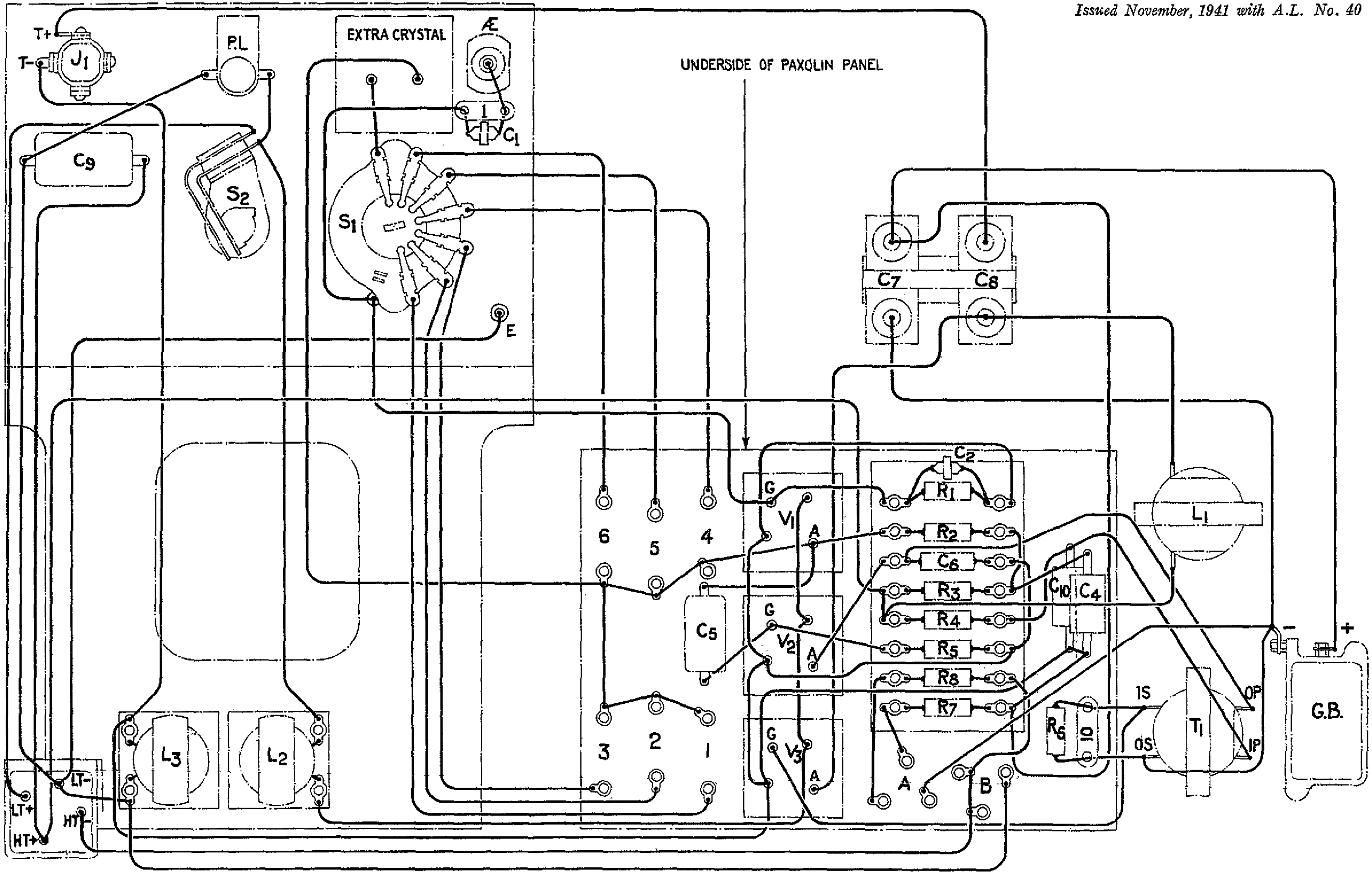

FIG. 6. CRYSTAL MONITOR TYPE 2 - BENCH WIRING DIAGRAM

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To set up receiver R.1082

36. Plug the telephones into the receiver and put the receiver battery switch and the monitor switch S_3 to the ON positions. Set the reaction control of the receiver to the point at which oscillation commences and place the volume control to about fifty per cent. of full volume.

37. Tune the receiver, by means of the anode condenser, until a beat note can be heard in the telephone. Next, increase the receiver volume control, at the same time adjusting the aerial condenser with maximum output. Probably some slight readjustment of the anode condenser may be necessary during the operation. Adjust the pitch of the zero beat note as required by means of the anode tuning condenser. Switch off the monitor.

To set up receiver R.1116

38. Plug the telephones into the receiver. Set the battery switch and the monitor switch to ON placing the receiver heterodyne switch in the C.W. position and the receiver volume control to MINIMUM. Increase this control until the receiver background is audible in the telephones.

39. Tune in the signal on the H.F. oscillator dial, setting it to give a highly-pitched beat note on the louder side of the "dead space". Adjust the aerial tuning condenser to give the loudest signal. If a point is found at which, coincident or nearly so with maximum volume, there is a marked change in the pitch of the beat note, it should be passed over. Another point will be found at which maximum volume is obtained with little, if any, change in the beat note. This represents correct setting of the aerial tuning. The change of beat note occurs only if the aerial circuit is tuned to the same frequency as the oscillator, which is not the correct working condition. Ensure that the oscillator is tuned to that side of the "dead space" which gives the louder signal.

40. When tuning the receiver R.1116, spurious tuning adjustments may be found at which the monitor signals are detected but with poor strength. Care must be taken to reject these in favour of the correct settings which will be recognized by the comparative loudness of the signals and by the readings on the calibrated oscillator dial.

To set up transmitter T.1083

41. Plug the telephones into the monitor. Set the grid-bias switch and the neutralizing unit of the transmitter to the TUNE position and switch on the transmitter.

42. Switch on the monitor and whilst listening for the monitor output set the coupling to the desired point and adjust the master-oscillator tuning control of the transmitter until the beat note is heard, taking care to keep the grid tuning so as to give maximum current in the master-oscillator stage. Readjust slightly until the oscillator setting is estimated to be in the middle of the "dead space". Any subsequent movement of the coupling or grid tuning will alter the frequency and render a readjustment of the master-oscillator tuning necessary. Should it be necessary to provide a greater degree of coupling between the monitor and the transmitter to overcome aeroplane noise background, this may be done by inserting the end of the monitor aerial in the master-oscillator valve chamber. This should be removed when the final transmitter adjustment is being made.

43. Tune the amplifier circuit of the transmitter to the master-oscillator frequency by observation of the thermo-ammeter, and neutralize in the normal manner. Set the bias switch and neutralizing unit of the transmitter to TRANSMIT. Press the key and readjust both the master-oscillator and the amplifier circuits to the "dead space". Switch off the monitor.

44. The transmitter, type T.1083, may be subject to slight frequency drift with temperature variation. When handling traffic, the monitor should be used, whenever opportunity occurs, in order to detect this drift, slight adjustment being made to the oscillator circuit as the transmitter warms up.

To set up transmitter T.1115

45. Plug the telephone into the monitor. Switch on the transmitter and the monitor. Tune the master-oscillator and the intermediate circuits of the transmitter to the "dead space" of the beat note in the telephones.

46. Complete the setting-up of the transmitter in the normal manner. Finally, when the transmitter is prepared for transmission, trim the master-oscillator intermediate and power amplifier tuning to the "dead space". Switch off the monitor.

47. If the associated receiver is already adjusted to the same frequency and is switched on during the tuning of the transmitter, it will also give rise to a heterodyne beat note in the telephones. This note will be considerably weaker than that caused by the transmitter and should not give rise to any difficulty in tuning.

48. Operational instructions for this crystal monitor, when used in conjunction with transmitter, T.1154 and the receiver, R.1155, will be promulgated in due course.

49. In order to ensure that the crystal monitor, type 2, oscillates at frequencies of 6 Mc/s and over, certain modifications of the circuit, as shown in fig. 2, have been found desirable. The necessary instructions and sequence of operation to effect this change have been issued.

50. The modifications entail the removal of the R.F. by-pass condenser C_3, type 405, and the interchange of the 10,000 ohm resistance R_2, type 104, with the 50,000 ohm resistance R_3, type 231. These components may be identified by reference to the amended annotation of fig. 4.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information only. When ordering spares for the transmitter, the appropriate section of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature	Qty.	Ref. in Fig. 2	Remarks
10D/11390	Monitor, crystal, type 2			
	Principal components :—			
10A/11391	Box, battery	1		
10A/11270	Cap, signal lamp	1		
10A/11392	Case	1		
10C/7384	Choke, L.F., type B	1	L_1	
10C/11393	Choke, H.F., type 44	2	L_2, L_3	
	Condenser,			
10C/8496	Type 188	4	C_4, C_5, C_0, C_{10}	0·01 μ F
10C/9717	Type 329	1	C_1	5 $\mu\mu$ F
10C/10394	Type 404	1	C_2	10 $\mu\mu$ F
10C/11292	Type 436	1	C_7	0·1 μ F
10C/11394	Type 524	1	C_8	0·25 μ F
10C/11486	Type 537	1	C_6	100 $\mu\mu$ F
10H/11706	Holder, valve, type Z	3		
	Knob,			
10A/11838	Type 10	1		
10A/11839	Type 11	1		
10A/11272	Lampholder, M.E.S.	1		
	Mounting,			
10A/11778	Type 24	2		
10A/11779	Type 25	1		
10H/8515	Plug, type 67	2		
	Resistance,			
10C/7954	Type 101	2	R_7, R_8	1,000 ohms.
10C/7957	Type 104	1	R_3	10,000 ohms.
10C/9134	Type 231	2	R_2, R_4	50,000 ohms.
10H/8241	Socket, type 33	1		
	Switch,			
10F/11397	Type 163	1	S_1	
10F/6	Type 175	1	S_2	
10H/7227	Terminal, 4 B.A., type C	2		
10A/7396	Transformer, L.F. type D	1	T_1	
	Accessories			
5A/1548	Battery, dry 3-volt	1		
10A/11780	Case, transit	1		
10X/as required	Crystal-unit, type A	7		
5A/361	Lamp, filament 3·5-volt	1		
10E/10945	Valves, V.T.50	3	V_1, V_2, V_3	