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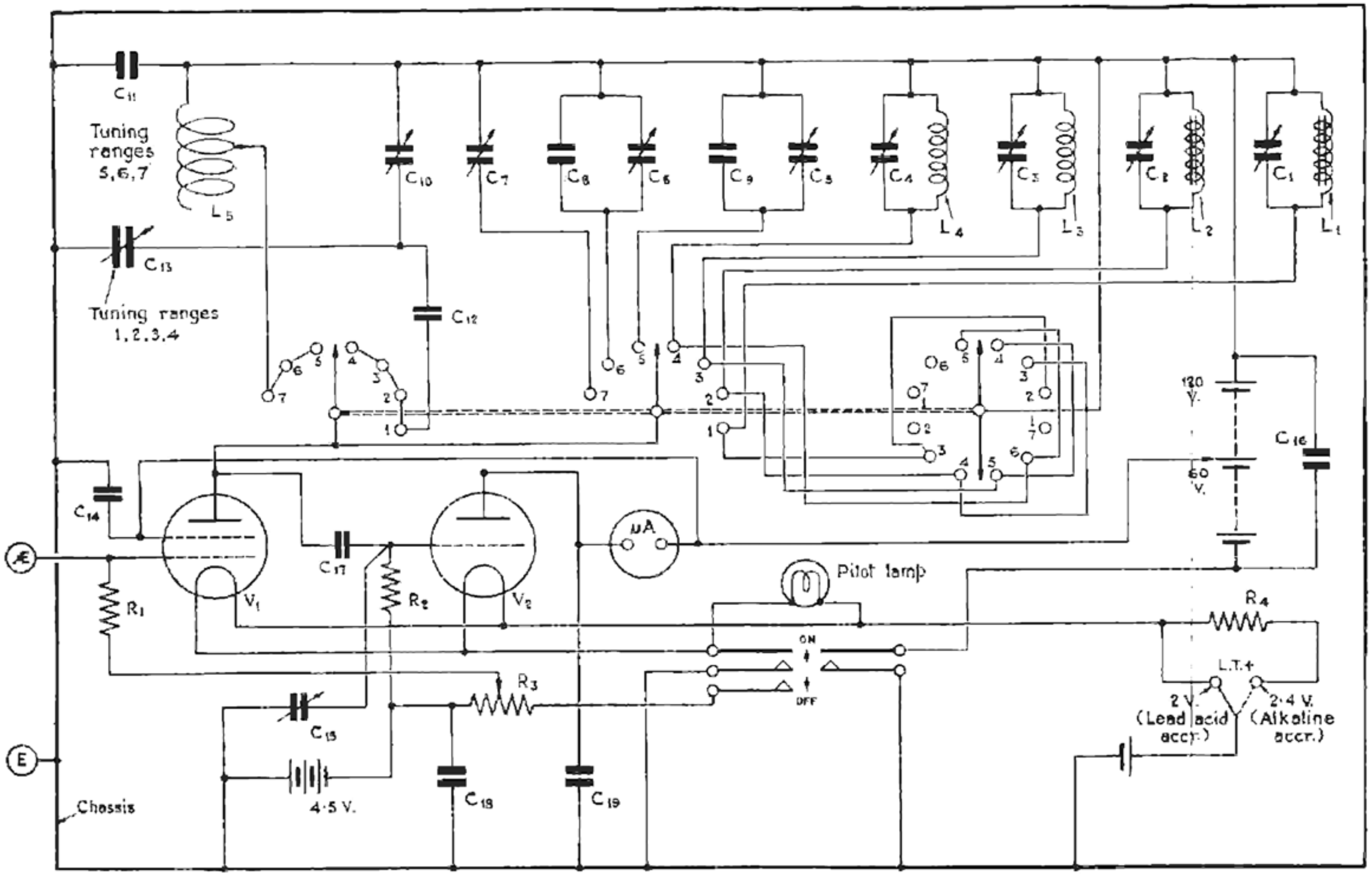
SECTION 5, CHAPTER 13

WAVEMETER W.1117

Contents

List of Illustrations



Condensers	
C_1	3 to 17 μμF
C_2	3 to 17 μμF
C_3	3 to 17 μμF
C_4	3 to 17 μμF
C_5	3·5 to 35 μμF
C_6	3 to 17 μμF
C_7	3 to 17 μμF
C_8	160 μμF
C_9	1050 μμF
C_{10}	3·5 to 35 μμF
C_{11}	·01 μF
C_{12}	·05 μF
C_{13}	500 μμF
C_{14}	·01 μF
C_{15}	3 to 17 μμF
C_{16}	·01 μF
C_{17}	·001 μF
C_{18}	·01 μF
C_{19}	·01 μF
Resistances	
R_1	1 MΩ
R_2	2 MΩ
R_3	50,000 Ω
R_4	5 Ω
Inductances	
L_1	2,800 μH
L_2	700 μH
L_3	176 μH
L_4	44 μH
L_5	0–6 μH
Valves	
V_1	VM 48
V_2	VM 36

FIG. 1. THEORETICAL CIRCUIT DIAGRAM

WAVEMETER W.1117

(Stores Ref. 10D/10220)

INTRODUCTION

1. The wavemeter W.1117 is designed primarily for the purpose of tuning master-oscillator controlled aircraft transmitters on the ground, and may also be used on board aircraft carriers and in W/T vehicles. It will eventually replace wavemeter W.1081. The instrument covers the whole frequency range from 125 kc/s to 20 Mc/s. On frequencies below 6 Mc/s, it is capable of indicating a difference of ± 2 kc/s. On higher frequencies, the discrimination is not quite equal to this, but is of the highest order attainable in a portable instrument of this kind.

2. The overall dimensions of the instrument are approximately 16 in. by 14 in. by 8½ in. and its weight, complete with valves and batteries, is approximately 33¾ lb. A transit case is provided with each instrument. Its dimensions are 26¼ in. by 15¾ in. by 10¾ in., and its weight 27 lb. The lid of the transit case may be used to mount the wavemeter on a camera tripod.

3. The wavemeter consists essentially of seven calibrated oscillatory circuits, any one of which may be selected by means of the range switch.

4. The frequency cover of the respective ranges is :—

Range 1	250 to 125 kc/s
Range 2	500 to 250 kc/s
Range 3	1,000 to 500 kc/s
Range 4	2 to 1 Mc/s
Range 5	5 to 2 Mc/s
Range 6	10 to 4.5 Mc/s
Range 7	20 to 8 Mc/s

5. On the ranges 1 to 4 the calibration is recorded with reference to the setting of a continuously variable condenser which is associated with a different fixed inductance for each range, whilst on ranges 5 to 7 the setting of a continuously variable inductance, associated with a different capacitance for each range, is used.

6. Resonance is indicated by an uncalibrated valve voltmeter consisting of a triode rectifier valve in association with a moving-coil micro-ammeter. In order that the constants of the selected tuned circuit shall not be affected by the degree and method of coupling to the transmitter, an isolator valve is interposed between the " pick-up " or input circuit and the calibrated circuit of the wavemeter.

GENERAL DESCRIPTION

7. The circuit diagram of the wavemeter is given in fig. 1. The pick-up or input circuit comprises a small open aerial, which is connected to the terminal marked AE and a resistance R_1 which renders the aerial aperiodic and is completed through the grid-bias potentiometer R_3. The metal chassis of the wavemeter acts as a counterpoise to the aerial, but an earth terminal is also provided in order that a direct ground connection may be made.

8. The resistance R_1 couples the aerial to the control grid of the isolator valve V_1 and also acts as a grid leak resistance. The control grid-bias is determined by the setting of the potentiometer R_3, which is connected across the grid-bias battery when the instrument is switched on. The gain of the isolator valve varies with the control grid-bias, being a maximum with zero bias and decreasing as the negative bias is increased. The sensitivity of the wavemeter varies in the same manner.

9. The isolator valve V_1 is a tetrode; its screening grid is maintained at a suitable mean potential (60 volts positive to filament) by a tapping on the common H.T. battery. Its oscillatory potential is maintained at approximately zero value by the condenser C_{14}.

10. The isolator valve anode is maintained at 120 volts positive to the filament. It is connected through the appropriate calibrated oscillatory circuit, as selected by the range switch, to the H.T.+terminal of the battery.

11. On the two lowest frequency ranges, 1 and 2, the calibrated circuit consists of an iron-dust core inductance (L_1 and L_2 respectively), in conjunction with the variable condenser C_{13}. In order that the moving vanes of this condenser may be maintained at earth potential a blocking condenser C_{12} is fitted in series. A trimming condenser C_{10} is included in the circuit for calibration purposes only. This condenser is, in effect, in parallel with the tuning condenser C_{13}. Trimming condensers (C_1 and C_2 respectively) are also shunted across the inductances L_1 and L_2, for calibration purposes only. The calibrated circuits of ranges 3 and 4 are similar to those of ranges 1 and 2, except that air core inductances (L_3 and L_4) are employed, which are shunted by trimming condensers C_3 and C_4 respectively, used for calibration purposes only.

12. On the higher frequency ranges, 5, 6 and 7, the calibrated circuit consists of a selected pre-set capacitance, in parallel with the continuously variable inductance L_5. On range 5, the selected capacitance consists of a fixed condenser C_8 and a pre-set condenser C_5 in parallel. Range 6 is similar to range 5, the capacitance being constituted by condensers C_8 and C_6. On range 7 the capacitance consists of a pre-set condenser C_7 only.

13. The range switch is arranged in three banks. Referring to fig. 1, that on the left changes over the main tuning device, *i.e.*, from the main variable condenser to the variable inductance or *vice versa*. The middle bank changes the fixed inductances in parallel with the variable condenser on ranges 1 to 4, or the pre-set capacitance in parallel with the variable inductance on ranges 5 to 7. The right-hand bank is provided to short-circuit certain of the inductances operative on lower ranges than that in use, to remove any possibility of error due to subsidiary resonances in tuned circuits which are normally out of action. Thus, on range 2, inductance L_1 is short-circuited. On range 3 inductances L_2 and L_1 are short-circuited. On range 4, inductances L_3 and L_2 are short-circuited. On range 5, inductances L_4 and L_3 are short-circuited, and on range 6, inductance L_4 is short-circuited.

14. The anode of the isolator valve is coupled to the grid of the voltmeter valve V_2 by the condenser C_{17}. The grid-bias voltage of V_2 is derived directly from a dry battery (4½ volts) *via* the resistance R_2. The grid-bias battery is shunted, for R/F currents, by the condenser C_{18}.

15. A micro-ammeter is included in the anode circuit of this valve to act as a resonance indicator. The condenser C_{19}, which is directly connected between the anode and the chassis, acts as a radio-frequency by-pass. The anode voltage of the voltmeter valve is derived from the 60-volt tapping on the H.T. battery.

16. A pre-set condenser C_{15} is connected between the grid of the voltmeter valve and the chassis for calibration purposes only.

17. The ON-OFF switch performs three functions, firstly, it connects filament negative line to LT—(chassis), secondly it completes the circuit from grid-bias battery to the potentiometer R_3, and thirdly, it connects HT— to LT—.

18. Two LT+terminals are provided. The first is connected directly to the filament positive line, and is used when the L.T. supply is derived from a 2-volt lead-acid accumulator. The other is connected to the filament positive line through a resistance R_1, and is used only when the L.T. supply is derived from a 2.4-volt alkaline accumulator.

19. A reservoir and by-pass condenser C_{16} is connected across the 120-volt H.T. battery terminals.

CONSTRUCTIONAL DETAILS

20. Fig. 2 shows the general appearance of the wavemeter. The micro-ammeter (1) is removable. It is normally held in position by the turn-button (2) and is fitted with plugs which enter sockets carried on a small platform (*see* fig. 4). Since the wavemeter may on occasion be used in such a location that the micro-ammeter cannot conveniently be observed if mounted in the normal position, a pair of leads, type 10 (micro-ammeter extension. Stores Ref. 10H/8414), is provided, so that the meter may be removed to a more convenient position and re-connected to the appropriate sockets.

21. To the right of the micro-ammeter is the tuning condenser scale (3) and control knob (4). The semi-circular scale is engraved in arbitrary units from 0 to 100. A combined slow-motion drive and vernier adjustment (5) is provided. To obtain a free dial, the vernier control knob is pulled forwards; this releases the gearing between the slow-motion spindle and the main condenser spindle, so that the latter may be turned by means of the control knob (4). If, when the condenser is in the free dial condition, the catch (6) is pushed upwards towards the vernier control knob, the latter moves backwards under the control of a spring and the slow-motion drive is again engaged. The vernier control knob is engraved with a scale showing tenths of a scale unit. An index line is engraved on the catch (6). It will be noticed that the slow-motion spindle, when viewed from above, is not perpendicular to the instrument panel, being slightly canted from this position.

22. Below the condenser dial is a spring-hinged door (7) fitted with a ruby glass, through which the pilot lamp is visible when the instrument is switched on. The ON-OFF switch (8) is seen below the micro-ammeter.

23. The variable inductance control is mounted on the left of the micro-ammeter. The fixed scale (9) is engraved in degrees from 0 to 360. In line with the 0° position is a small window, through which the lettering on a movable scale is seen. This movable scale is lettered A to P (omitting I) each letter corresponding to one turn on the variable inductance, so that in conjunction with the circular scale, the setting of the inductance can be recorded. In fig. 2 the reading is K.255. The extension handle (11) is provided for adjusting the inductance, in order to avoid errors due to the proximity of the operator.

24. The sensitivity control (12) is engraved with an arrow to indicate the direction of increasing sensitivity, and controls the grid-bias on the isolator valve as already stated. Adjacent to it is the range switch (13), which has a position for each range, but no " off " position. The aerial and earth terminals are clearly seen, the former near the top centre, and the latter at the right lower corner of the panel.

25. Fig. 3 is a bench wiring diagram, and fig. 4 is a view of the interior. In the latter the micro-ammeter mounting (1), variable inductance (2), and variable condenser (3) are easily recognized. The range switch (4) consists of three banks on the usual service mounting, *i.e.*, actuated by a flat bar passing through the centre of each bank.

26. The right-hand valve-holder (5) carries the isolator valve, the anode connector (6) completing the circuit to the top cap of the valve. The condenser (7) is the anode-to-grid coupling, and (8) is the grid leak for the voltmeter valve. The latter is fitted in the valve-holder (9). The resistance (10) is connected between the grid of the isolator valve and the variable tapping on the sensitivity control and corresponds to R_1 of fig. 1.

27. The fixed-value tuning inductances (L_1, L_2, L_3, L_4 of fig. 1) are mounted on a base plate of composite insulating material, and are denoted by (11), (12), (13) and (14) in fig. 4. The adjusting knobs of the nine trimming condensers are annotated as follows:—Condenser C_{10}, which is in parallel with the main tuning condenser, and is therefore in circuit on ranges 1 to 4, (15); condenser C_1, in parallel with inductance L_1, (16); condenser C_2, in parallel with

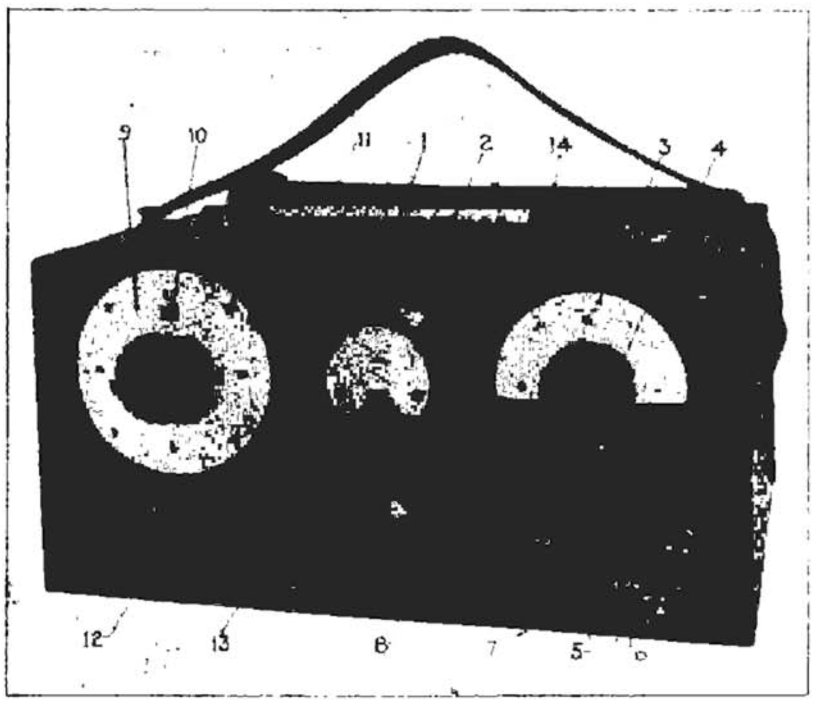


FIG. 2—WAVEMETER W1117, FRONT VIEW

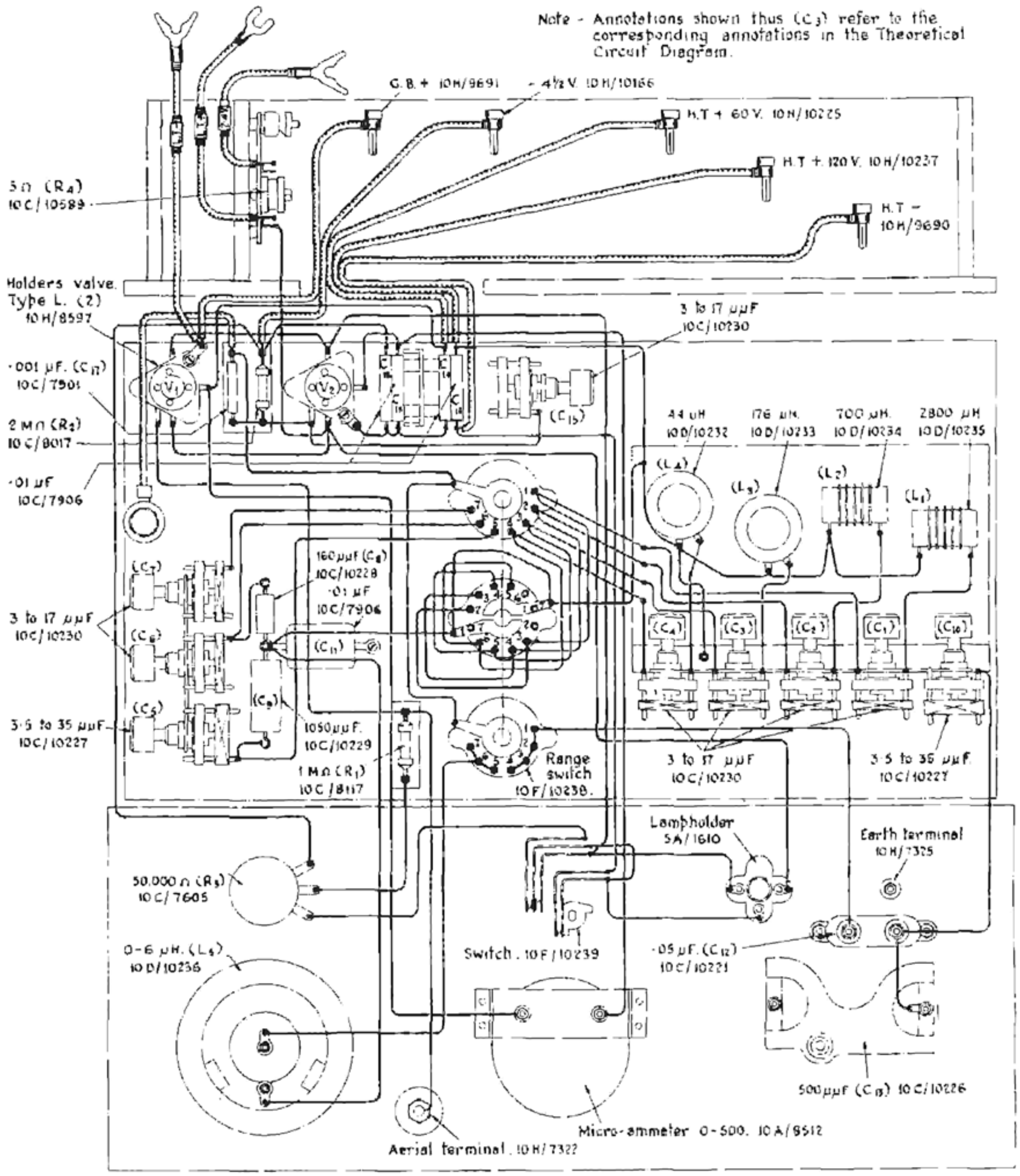


FIG. 3. BENCH WIRING DIAGRAM

inductance L_2, (17); condenser C_3, in parallel with inductance L_3, (18); condenser C_4, in parallel with inductance L_4, (19); condenser C_{15}, which is used to compensate for a change of voltmeter valve, (20); condenser C_5, which is operative only on range 5, (21); condenser C_6, operative on range 6, (22); and condenser C_7, operative on range 7, (23). It must be clearly understood that all the above mentioned trimming condensers are fitted for calibration purposes only, and must on no account be interfered with by Service personnel. After calibration the moving members are locked in the correct position by small screws, clearly visible on items (22) and (23).

28. Underneath the trimming condenser (20) four 0.01 μF condensers are mounted. These are (24), which is connected between the H.T. – and 120+ battery leads; (25), which is connected between the 60+ battery lead and the chassis and is the screen decoupling condenser; (26), which is connected between the anode of the voltmeter valve and the chassis, and (27) which is connected across the grid-bias battery leads.

29. The fixed 16 $\mu\mu$F and 1,050 $\mu\mu$F condensers (C_8 and C_9) are mounted on a small insulating platform underneath items (21), (22) and (23), the fixed 0.01 μF condenser C_{11} being mounted on the base of the instrument adjacent thereto. The fixed 0.05 μF condenser C_{12} is mounted underneath the variable condenser (3). None of these components is visible in the photograph.

30. The instrument case is designed to house the wavemeter and its associated batteries in separate compartments. Flexible leads terminating in battery plugs are taken through holes in the rear of the battery compartment to the appropriate components of the wavemeter. In order to remove the batteries, the retaining arm is released by a catch on the right-hand side of the compartment.

31. Access to the batteries is obtained through the rear wall of the case, which is hinged along the bottom and held in the closed position by means of two spring catches. The calibration book (14, fig. 2) is normally held by means of spring clips on the outside of the rear wall. Each wavemeter has its own calibration book, which is engraved with the serial number of the wavemeter to which it applies. Access to the valves is obtained through a trap door in the top of the case.

32. The transit case contains nine compartments, the eight small compartments housing the extension handle, the valves and the special plug and socket connection used when the micro-ammeter is removed from the wavemeter. The lid is detachable by sliding to the left to disengage the two parts of the hinges, and may be used as a support for mounting the wavemeter on a tripod.

33. A standard S.4 camera tripod is used. The screw on the tripod engages a boss in the lid of the transit case. The wavemeter is placed in the lid and held in position by means of two elastic cords, which are threaded through the carrying strap and then secured in the special blocks provided in the lid.

VALVES AND BATTERIES

34. The isolator valve is a valve V.W. 48 (Stores Ref. 10E/10585), and the voltmeter valve, a valve V.W. 36 (Stores Ref. 10E/9851). Each instrument is supplied with a set of three valves of each type, *i.e.*, six valves in all. The three valves of each type are carefully matched, and are marked with the serial number of the wavemeter with which they are issued for use. The cartons in which the valves are supplied are similarly marked. The calibration of the wavemeter is not affected by the exchange of a valve for another of the same type issued for use with the same wavemeter, but no other valves are to be used.

35. In case of valve failure, the following procedure should be adopted. When one isolator valve and/or one voltmeter valve becomes unserviceable, no immediate action is required, but

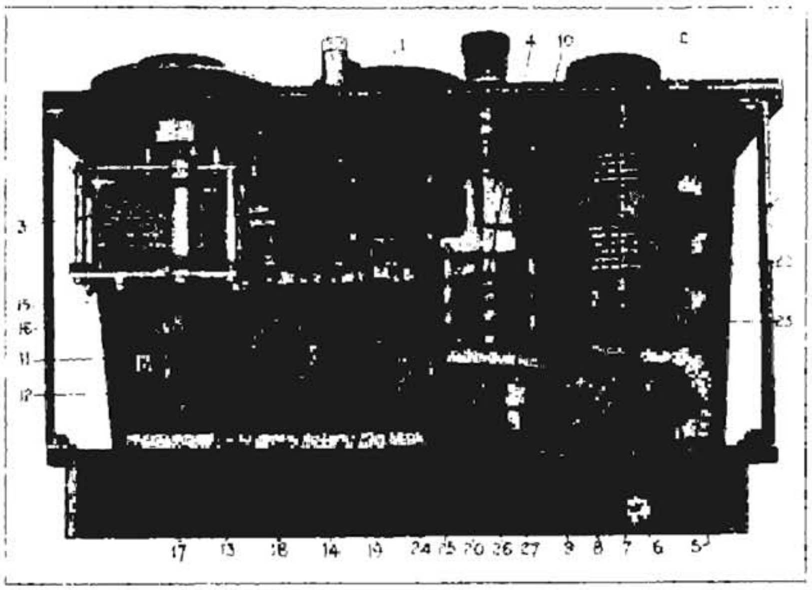


FIG. 4. WAVEMETER W-1117 INTERIOR

immediately any two valves of the same type fail, a replacement wavemeter should be requisitioned. On receipt of the replacement wavemeter and its accessories, the original equipment should be returned. This equipment comprises:—

(i) the wavemeter and its transit case

(ii) the calibration book

(iii) the three valves, V.W. 48, and three valves V.W. 36, those valves which are serviceable being clearly labelled.

With the exception of the transit case none of the above items may be exchanged separately.

36. The L.T. supply is obtained from a 2-volt 7 Ah. accumulator (Stores Ref. 5A/1514) and the H.T. supply from a 120-volt dry battery (Stores Ref. 5A/1333 or 5A/1615). Grid-bias supply is obtained from a 4·5-volt dry battery (Stores Ref. 5A/1383). Access to the batteries is obtained by opening the hinged door at the back of the wavemeter.

OPERATION

General

37. Before commencing any operation, see that the batteries are in position, and that they are connected correctly. Test all batteries by means of a voltmeter. It is most important to ensure that the grid-bias battery is in good condition, and that its connections are properly made, otherwise the micro-ammeter may be damaged. Insert a valve, VW 48, in the left-hand holder and a valve, VW 36, in the right-hand one, and set the range switch to the appropriate range. Switch the wavemeter on; the micro-ammeter should then show a very small standing anode current, not exceeding 4 micro-amperes. If this reading is correct, switch off the wavemeter until it is actually required.

To set a transmitter to a definite frequency

38. By reference to the calibration chart for the particular frequency range, and being careful to apply the correction from the curve, set the appropriate tuning control to the desired frequency. The wavemeter is then placed near the transmitter and a length of insulated wire connected to the aerial terminal. The length of aerial required to give a suitable deflection on the micro-ammeter must be found by trial. For an aircraft transmitter T.1083, about 8 feet of uniflex 4 cable is suggested. This may be suspended from the aeroplane fuselage in such a manner as to hang clear of it, except at the point of attachment. If the wavemeter is stood on the ground, it will not be necessary to make an earth connection. If, however, the wavemeter is used on a tripod mounting, a length of similar wire may be attached to the earth terminal and allowed to lie along the ground to form a " capacitance earth."

39. Set the sensitivity control to " minimum " and switch on the L.T. Adjust the transmitter while watching the micro-ammeter for maximum deflection. If, as resonance is approached, the micro-ammeter deflection exceeds 450 micro-amperes, signal to the person tuning the transmitter to switch it off. The wavemeter pick-up should then be reduced, *e.g.*, by shortening the aerial. The ideal conditions for tuning are obtained when the pick-up is just sufficient to give a deflection of 400 to 450 micro-amperes at resonance, with the sensitivity control at the middle of its travel.

40. When the sensitivity has been correctly adjusted, the transmitter should be adjusted until the maximum deflection is obtained; it is then operating at the desired frequency.

41. The exact resonance point may appear to be rather flat, owing to the very fine adjustment of which certain modern transmitters are capable. If this is so, the following procedure should be adopted. Suppose the optimum reading of the micro-ammeter is 456 micro-amperes

and this reading appears " flat " over some few degrees of transmitter adjustment :—de-tune the transmitter, in the direction of a decreasing scale reading, until the micro-ammeter reads about 450 micro-amperes ; note the transmitter setting, *e.g.*, N 150. Then readjust the transmitter tuning through the resonance setting, until the micro-ammeter again reads 450 micro-amperes ; again note the transmitter setting, *e.g.*, N 162. The correct transmitter setting is midway between the two, *i.e.*, N 156. When this method is adopted, the amount of transmitter de-tuning, on either side of resonance, must be such that the micro-ammeter reads within 10 micro-amperes of its optimum reading

To measure the frequency of a transmitter

42. Set the transmitter in operation, place the wavemeter near the transmitter, and adjust the pick-up and sensitivity as explained in para. 39. Adjust the wavemeter tuning until an optimum micro-ammeter reading is obtained. Observe the wavemeter adjustment and determine the transmitter frequency by reference to the calibration book.

PRECAUTIONS AND MAINTENANCE

43. As this wavemeter is an instrument of high precision, its calibration is a long and expensive operation. Every care must therefore be taken to protect it from rough handling, since mechanical shocks are liable to affect the more delicate components in such a manner as to destroy the accuracy of the calibration. The wavemeter must be used only with a pair (*i.e.*, one V.W. 36 and one V.W. 48) of the valves supplied.

44. In order to ensure as long a life as possible and thus avoid the necessity for premature re-calibration, great care must be taken of the valves, both mechanically and electrically. They must not be used for any purpose other than that for which they are supplied.

45. On no account must the current through the micro-ammeter be allowed to exceed 500 micro-amperes, otherwise the pointer may be bent or broken, and the springs and pivots of the moving element may be damaged.

46. With no R/F input to the isolator valve, the normal current through the micro-ammeter is about 4 micro-amperes. An excessive current in this condition is an indication that the grid of the voltmeter valve (V.W. 36) is insufficiently biassed. When this fault is present switch off the wavemeter, test the voltage of the grid-bias battery, and ensure that the plugs are making good connections in the sockets. If the voltage and connections are correct, the fault may be in the voltmeter valve itself, and one or more spare valves should be tried.

47. If the fault still persists, the probable cause of the failure is an external or internal leakage path across the grid condenser (C_{17} of fig. 1). This may be tested by removing the plug from the 120+ socket on the H.T. battery, and switching on the wavemeter. If the fault lies in the grid condenser, the micro-ammeter should now show the normal reading, *i.e.*, about 4 micro-amperes. The grid condenser should be examined, and any dust or dirt carefully wiped away, before replacing the H.T. 120+ plug and again switching on.

48. After each occasion of use, unless it is known definitely that the wavemeter will be in use within a few days, the H.T. battery should be removed and placed with its sockets upwards. This procedure prevents the possible displacement of the electrolyte in the cells, which might otherwise give rise to erratic behaviour. The L.T. battery must be re-charged periodically. The voltages of all three batteries should be checked periodically, as well as immediately before use.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Quantity	Remarks
10D/10220	Wavemeter W.1117	1	Without valves
	Principal components :—		
10D/10222	Book, calibration	1	
	Case :—		
10D/10223	Battery	1	
10D/10224	Wavemeter	1	With leather strap
	Condenser :—		
10C/7901	Type 120	1	0.001 μF
10C/7906	Type 125	5	0.01 μF
10C/10229	Type 412	1	1050 μμF
10C/10230	Type 413	7	3 to 17 μμF pre-set
10C/10221	Type 414	1	0.05 μF
10C/10226	Type 415	1	0.0005 μF variable
10C/10227	Type 416	2	3.5 to 35 μμF pre-set
10C/10228	Type 417	1	160 μμF
10A/10231	Dial, slow motion, type 2	1	
10H/8597	Holder, valve, type L	2	4-pin
	Inductance, fixed :—		
10D/10235	L1	1	Iron core
10D/10234	L2	1	Iron core
10D/10233	L3	1	Air core
10D/10232	L4	1	Air core
10D/10236	Inductance, variable, L5	1	With counting mechanism
5A/1610	Lamp-holder, miniature, Edison screw	1	Batten type
10A/8512	Micro-ammeter, type B	1	0 to 500 μA., fitted with plugs
10A/8513	Mounting, micro-ammeter	1	With sockets
	Plug :—		
10H/9690	Type 90	1	Engraved H.T. —
10H/9691	Type 91	1	Engraved G.B. +
10H/10166	Type 102	1	Engraved —4½
10H/10225	Type 111	1	Engraved H.T. 60V
10H/10237	Type 112	1	Engraved H.T. 120V
	Resistance :—		
10C/7605	Type 75	1	50,000 ohms, variable
10C/8017	Type 109	1	2 megohms, ½ watt
10C/8117	Type 123	1	1 megohm, ½ watt
10C/10589	Resistance-unit, type 2	1	
	Switch :—		
10F/10239	Type 155	1	S.P., 3-way, cam type
10F/10238	Type 156	1	7-position, 3-tier, rotary range
	Accessories :—		
	Accumulator :—		
5A/1514	Lead, acid, *or*	1	2 volt, 7 Ah., L.T.
5A/1961	Alkaline	1	2.4 volt, 2 Ah., L.T.
	Battery, dry :—		
5A/1383	4.5 volt	1	G.B.
	120 volt :—		
5A/1333	Type A *or*	1	H.T. Home
5A/1615	Type B	1	H.T. Overseas

Ref. No.	Nomenclature	Quantity	Remarks
10D/10220	Wavemeter W.1117 (*continued*)		
	Accessories (*continued*)		
10D/10581	Case, transit	1	For wavemeter, 6 valves, extension lead and extension handle
14A/690	Case, tripod	1	Camera, ground. S.4 equipment. For use when required
14A/694	Tripod	1	
10A/11336	Handle, extension	1	
5A/361	Lamp, filament, 3.5 volt	1	Pilot lamp
10H/8414	Lead, micro-ammeter extension	1	Complete with plug and socket
	Valve :—		
10E/9851	Type V.W.36	3	One in wavemeter, two spares
10F/10583	Type V.W.48	3	One in wavemeter, two spares