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SECTION 5

TESTING AND MEASURING INSTRUMENTS

SECTION 5

TESTING AND MEASURING INSTRUMENTS

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SECTION 5, CHAPTER 1

WAVEMETER W.42 AND WAVEMETER W.42A

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WAVEMETER W.42

(Stores Ref. 10A/7252)

INTRODUCTION

1. The wavemeter W.42 is a sub-standard wavemeter designed for use in main ground stations, such as control stations. It is a precision instrument of high accuracy and should only be used under conditions requiring such accuracy and even then, with great care. Essentially it is a C.W. valve generator, but in addition the C.W. can be modulated to produce Tonic Train. The chief use of the instrument is for measuring the wavelength or frequency of a distant or local transmitter, but if required it may be used for the purpose of adjusting a receiver to a definite frequency or wavelength. Wavemeter W.42.A is a modified form of this wavemeter. The nature of the modifications are explained at the end of this chapter.

2. The frequency band covered by the instrument is 8,000 to 15 kc/s (37·5 to 20,000 metres) divided into six ranges by the use of plug-in coils. The ranges are approximately as follows :—

Range.	Frequency in kc/s.	Wavelength in metres.
1	8,000 to 6,000	37·5 to 50.
2	6,000 to 2,000	50 to 150.
3	2,000 to 500	150 to 600.
4	500 to 120	600 to 2,500.
5	120 to 30	2,500 to 10,000.
6	30 to 15	10,000 to 20,000.

The highest frequency shown is 8,000 kc/s, but if it is required to use the instrument on higher frequencies, harmonics can be utilized as explained in para. 33 *et seq.*

3. The overall accuracy of the instrument is 1 in 1,000, although it is possible, at many points on the range of the instrument, to set the variable condenser to a much greater accuracy than this.

4. The instrument employs two valves, one an oscillating valve and the other a modulating valve. The anode and grid circuit of the oscillating valve are coupled by means of two windings on a plug-in coil unit. The coil is tuned by means of a variable condenser having a capacitance of from 70 to 1,250 $\mu\mu$F, and which may be read accurately to ·1°. The scale is so divided that one degree represents approximately 7 $\mu\mu$F. The capacitance can be increased by means of five fixed condensers which may be connected in parallel with the variable condenser by means of five separate switches. On range 1, a small condenser is inserted in series with the variable condenser.

5. The modulating valve is provided for the purpose of producing a modulated radiation for setting up a non-oscillating receiver. The modulation is at about 300 cycles per second and is produced by coupling the anode and grid circuits of the modulating valve through a special iron-cored transformer.

6. A change-over switch puts the modulating valve in or out of action, and a second change-over switch connects the milliammeter across the H.T. or L.T. supply for check purposes.

GENERAL DESCRIPTION

7. A theoretical circuit diagram of the wavemeter showing the arrangement for Ranges 2 to 6 is shown in fig. 2. The instrument employs two valves, one an oscillating valve V_1, and the other a modulating valve V_2. The anode and grid circuits of the valve V_1 are coupled

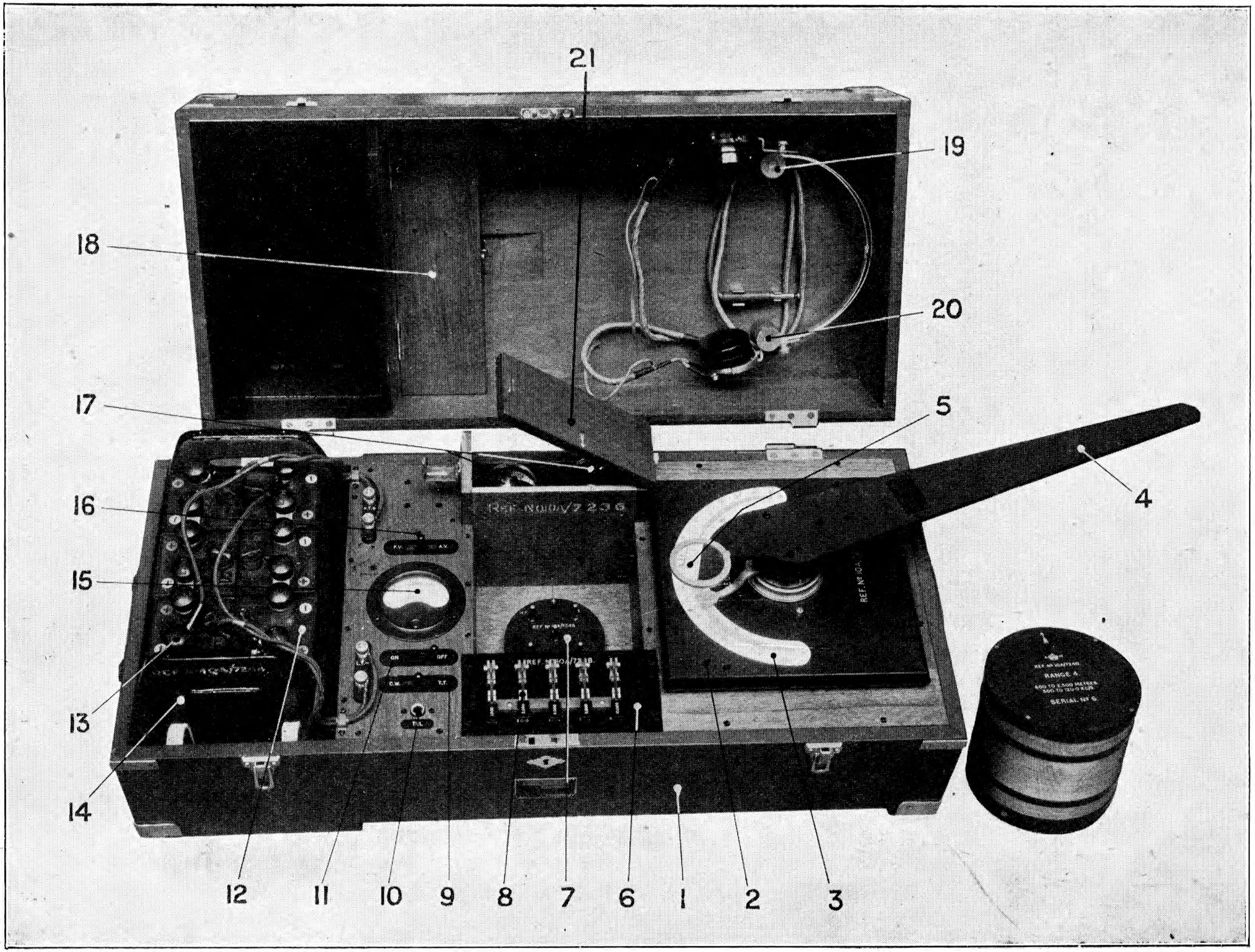

FIG. 1. Wavemeter with lid removed.

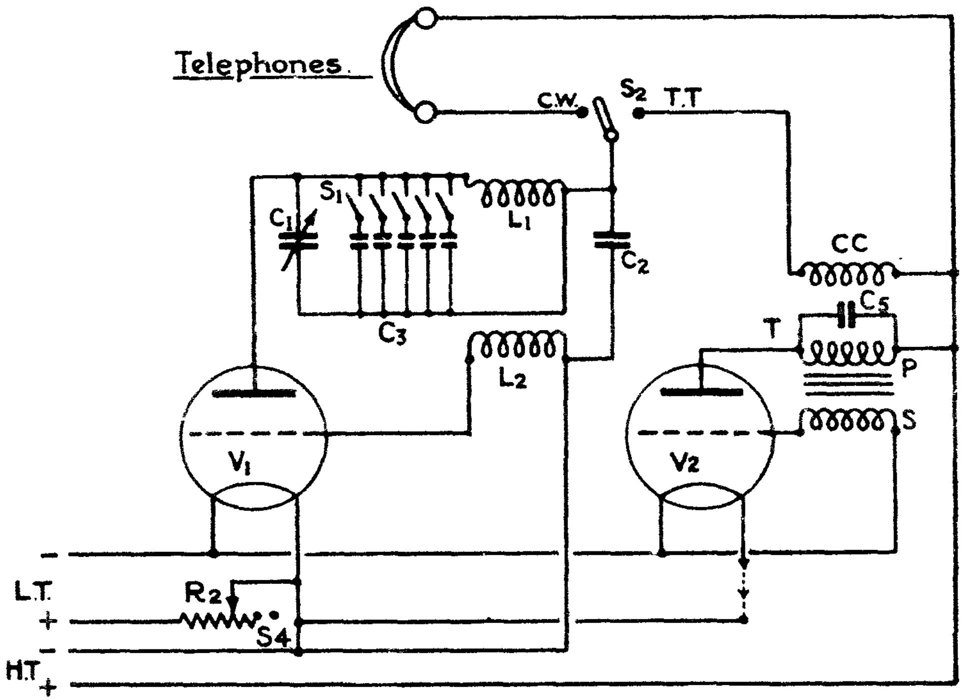

FIG.2. THEORETICAL CIRCUIT DIAGRAM

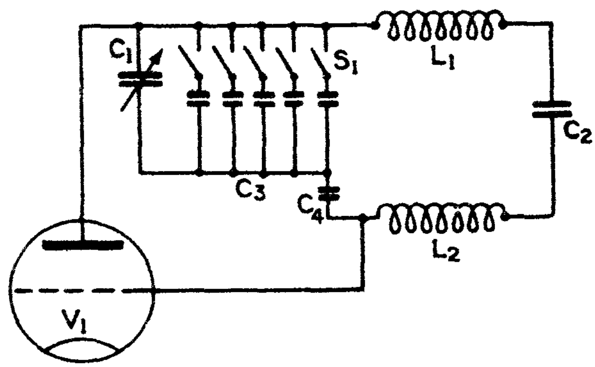

FIG.3. CIRCUIT ARRANGEMENT OF RANGE I.

by means of two windings L_1 and L_2 on a coil unit of the plug-in type. C_2 is a blocking condenser. For the ranges 2 to 6 the anode coil L_1 is tuned by the variable condenser C_1. The capacitance is increased by switching into circuit fixed condensers, in such a way that they are in parallel with the condenser C_1.

8. The arrangement of the coils and condensers for Range 1 is shown in fig. 3. It will be seen that, in addition to a change in the circuit arrangement, a fixed condenser C_4 has been introduced in series with the variable condenser C_1.

9. The modulating valve V_2 has its anode and grid circuits coupled by the primary winding P and the secondary winding S of a special modulating transformer T. A fixed tuning condenser C_5 is connected across the primary winding. Connected in this way, the valve generates A.C. at a frequency of about 300 cycles per second and by means of a coupling coil CC (incorporated in the special transformer) a small A.C. voltage is introduced into the anode circuit of the oscillating valve.

10. A change-over switch S_2 enables either C.W. or Tonic Train to be obtained. With the switch in the Tonic Train or "T.T." position, the coupling coil CC is connected in the anode circuit of the valve V_1, and the filament circuit of the valve V_2 is completed. The latter connection is effected by the switch S_2, but in fig. 2 it is shown only as a dotted line in the connection to the filament of the valve V_2. When the switch is in the "C.W." position the anode circuit of the valve V_1 is completed through the telephones instead of through the coupling coil CC, and the filament circuit of the valve V_2 is broken.

11. A milliammeter M is incorporated in the instrument and, by means of a change-over switch and resistances, serves as H.T. and L.T. voltmeter to reproduce the calibration conditions.

12. A diagram of connections is given in fig. 4, which shows the coil holder H having five pins, the telephone jack J, the milliammeter M with change-over switch S_3, and resistance R_1 and, in more detail than in fig. 2, the change-over switch S_2 and the modulation transformer T. The filament rheostat has an "off" position shown at S_4.

CONSTRUCTIONAL DETAILS

13. Two views of the instrument are shown in fig. 1 and fig. 6, fig. 1 being a top view showing the cover removed, and fig. 6 a view of the underside of the instrument with the bottom of the casing removed. Fig. 5 gives an illustration of the coil and valve-carrying case, showing the range coils and valves in position. The approximate dimensions of the wavemeter are 12 in. wide × 11 in. deep × 26 in. long, and its approximate weight including the coils and cases but without the accumulators is 63½ lb.

14. Referring to fig. 1, parts of the instrument are mounted in compartments in a casing (1) which is made of wood and provided with carrying handles. In the right-hand compartment is fitted a panel of insulating material (2) on which is mounted the variable air condenser (2, fig. 6) and the scale (3). Moving over this scale is a vernier pointer attached to an arm (4) which is fixed to the condenser spindle. A lens (5) through which the scale and vernier may be read is also carried on the arm. The arm is made 18 in. long, to facilitate adjustments and is in two pieces hinged together so that it can be folded over to enable the cover to be placed on the instrument. To the underside of the panel is fixed a metal screening plate (1, fig. 6).

15. Five knife switches (8) are mounted on the panel (6) underneath which are mounted the five condensers (5, fig. 6). Behind the switches may be seen the coil-holder (7). The two valves (17) are housed in a special compartment and access may be obtained to the valves by raising the hinged cover (21).

16. The panel adjacent to the coil and valve compartment carries the following :—the telephone jack (10), the switch (9) extending through the panel and marked for the two positions T.T. and C.W., the filament rheostat (11). In the "off" position this opens the filament circuit completely and when moved towards the "on" position gradually decreases the amount of resistance in the filament circuit. A milliammeter (15) is also provided. The two-position switch (16) is engraved FV (filament volts) and AV (anode volts). When the switch is in the F.V.

position, the milliammeter is connected in series with a resistance across the valve filament terminals, and when in the latter position, the milliammeter and resistance are connected across the H.T. supply.

17. On the left of the wooden panel are the terminals for the H.T. and L.T. batteries. The low tension accumulator (12) and the high tension accumulator (13), complete in their crate (14), are placed in a compartment on the left.

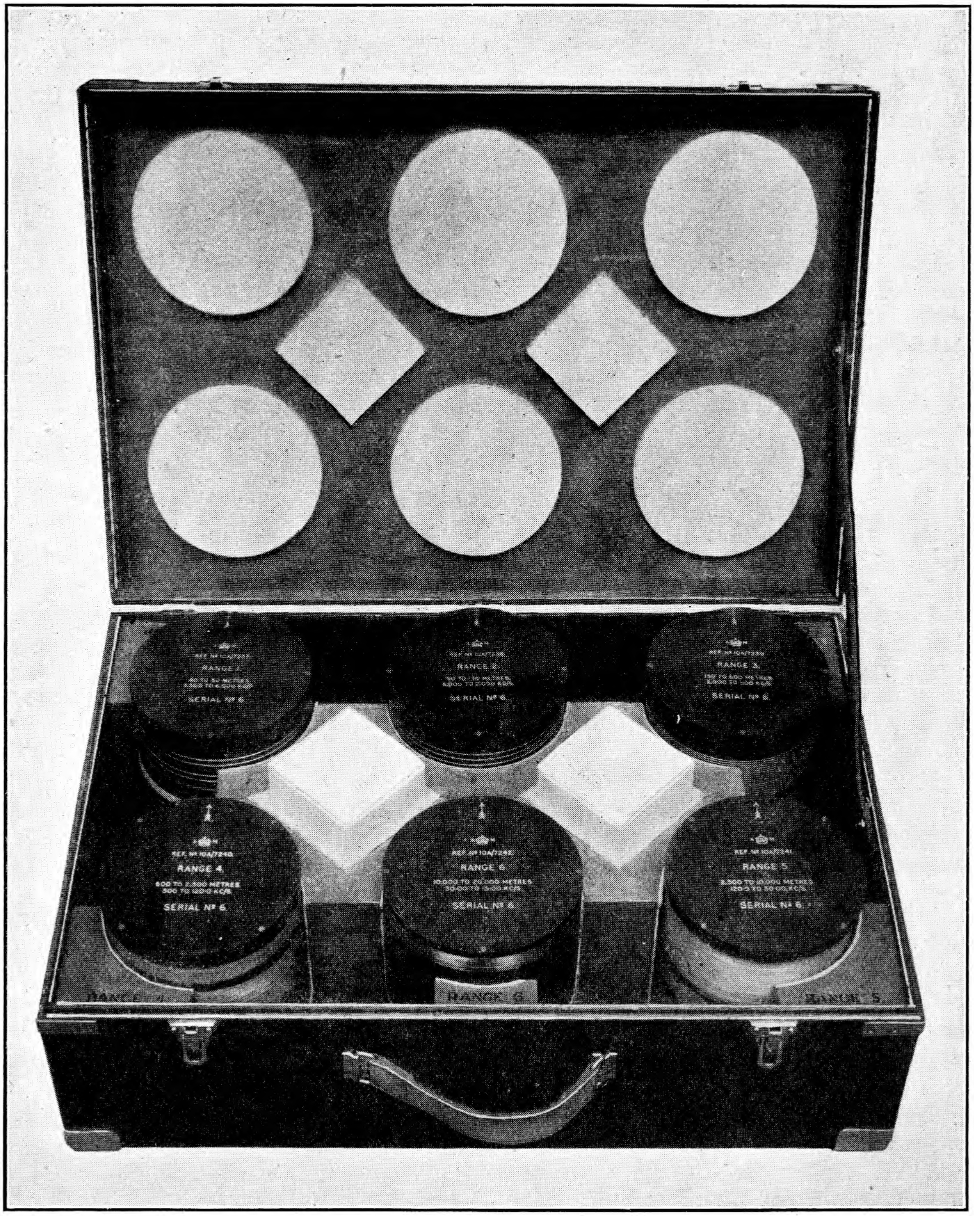

FIG. 5. Carrying case for coils and valves.

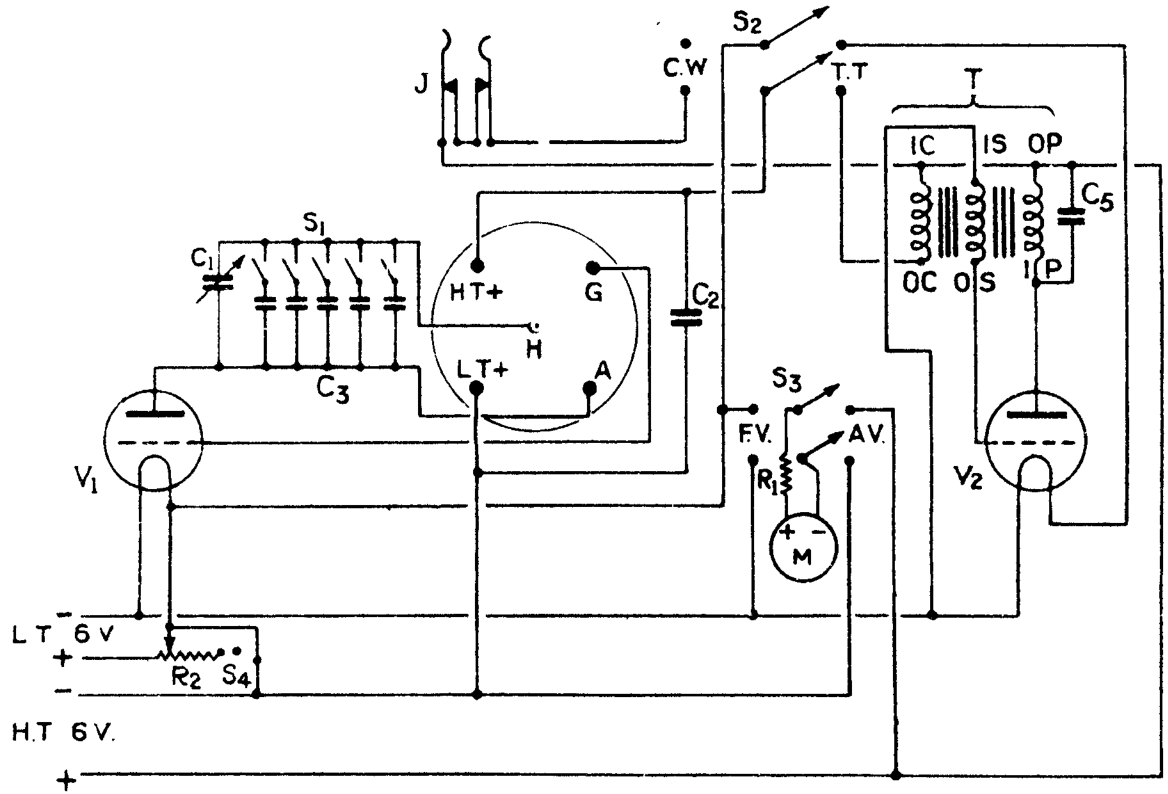

FIG. 4 DIAGRAM OF CONNECTIONS

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Facing para 17

18. The cover of the instrument is provided with recessed posts (19 and 20) and clips to accommodate the telephones. The telephones are Browns 60 ohms per earpiece. The hinged lid (18) shown in the illustration is for the purpose of holding the calibration book when not in use.

19. Referring to fig. 6 which is an underside view of the wavemeter with the cover removed, the metal screening plate referred to in para. 15 can be seen at (1). The variable condenser (C_1, fig. 4) is seen at (2). The central panel (3) carries the valve-holders (4). The five fixed condensers (5) are connected, by five separate switches, in the anode circuit of the oscillator valve. Reading from the left the values are 0·001μF, 0·002μF, 0·002μF, 0·005μF and 0·01μF. The five switch handles are correspondingly engraved.

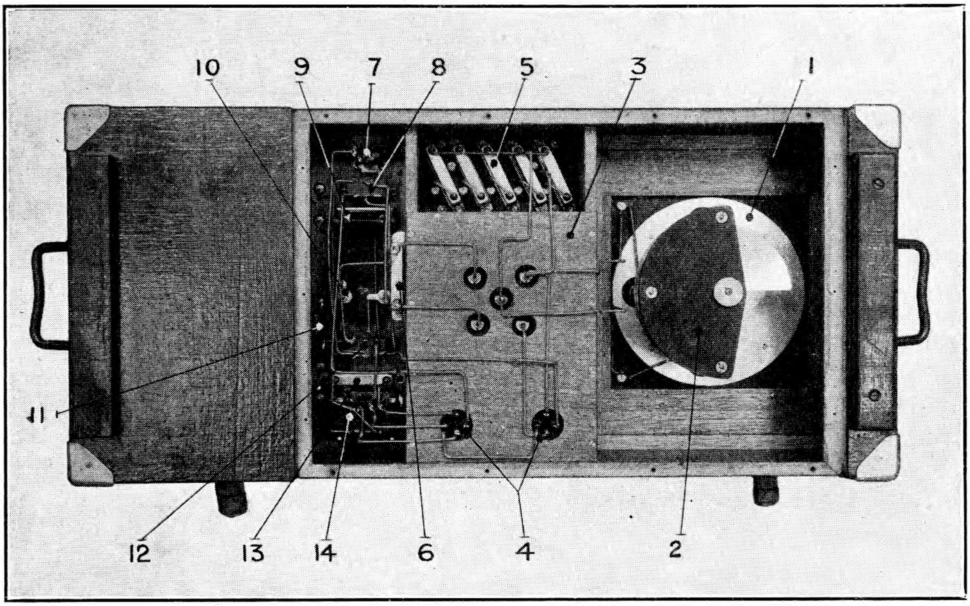


FIG. 6. Wavemeter viewed from underneath with bottom of casing removed.

20. The components on the left of the panel (3) comprise, the blocking condenser (6), the telephone jack (7), the C.W.–T.T. change-over switch (8) and the on-off switch (9). The milliammeter (10) and series resistance (11) may be seen to the left of the blocking condenser (6). The switch (12) connects the milliammeter in either the H.T. or L.T. circuit. The transformer (14) is represented by T in the theoretical circuit diagram, fig. 2. The condenser (13) is connected across the primary winding of (14).

VALVES AND BATTERIES

21. The valves normally used in the wavemeter are D.E.5B. valves, but a P.625 valve is used for the oscillator in the special circumstances mentioned in para. 38. All the valves have a maximum filament voltage of 6 volts.

22. A 6-volt accumulator, *i.e.* three cells (Stores Ref. 5A/2), is used for the low tension, and a similar accumulator provides the anode voltage for the valves. Reference should be made to para. 38, *re* extra anode voltage for Range 2.

23. A separate case (fig. 5) is provided for the coils and valves for transit purposes. Six cylindrical wells in this are arranged for the accommodation of the coils, and two square wells to take the cartons containing the D.E.5B. valves.

OPERATION

Setting up of wavemeter

24. (i) Insert the valves provided into their correct positions, *i.e.* oscillating valve in the valve-holder next to the variable condenser, and the modulating valve in the remaining valve-holder. The valves are marked O and M respectively and are numbered, instructions for the insertion of the valves being contained in the calibration book provided with each instrument.

(ii) Insert the required range coil. It is essential that the range coil be inserted so that the arrow on the top of the coil corresponds to the arrow on the lid of the valve compartment. When possible always employ the range coil which allows the maximum capacitance to be used.

(iii) See that the filament rheostat switch is in the " off " position. Connect one of the 6-volt accumulators to the terminals H.T. + H.T. —, and the other to the terminals L.T. + L.T. — Leads are provided for each accumulator, marked + and — and bound with red and black cotton respectively.

(iv) With the switch (16, fig. 1) in the " F.V." position, move the filament rheostat gradually from the " off " position, watching the needle of the milliammeter at the same time. The needle should coincide with the green line marked F.V.

(v) Move the switch into the " A.V." position and check the H.T. voltage. It should not be less than that indicated by the red line marked A.V. Return the switch to the position marked F.V. The switch should not be placed in the " A.V." position if a higher anode voltage is used as described in paras. 38 and 41.

(vi) Insert the telephones in the jack.

25. Calibration charts in the form of a book are provided for each instrument. The calibration book is marked with the serial number of the instruments and only the appropriate book should be used.

Use of wavemeter

26. The wavemeter W.42 is intended to be used mainly for two purposes, either to enable the frequency or wavelength of a local transmitter to be adjusted to a definite value, or to enable the frequency or wavelength of a local or distant station to be measured. There are three methods of using the wavemeter :—

(i) By means of the double beat method, when on ranges from 15 to 1,000 kilocycles per second.

(ii) By the ordinary zero beat method, when on ranges from 1,000 to 8,000 kilocycles per second.

(iii) By the use of harmonics.

Zero beat method

27. Dealing firstly with the ordinary zero beat method. The wavemeter is set up as detailed in para. 24, and assuming that the frequency to be checked lies between 8,000 kc's and 1,000 kc's, the wavemeter is adjusted while the C.W. transmitting station is in operation. As the wavemeter condenser is adjusted, a heterodyne note will be heard in the wavemeter telephones, and this note should be brought lower and lower until finally it becomes too low to be heard. Note the reading

on the condenser, and the desired frequency can be determined by referring to the chart supplied. The wavemeter is capable of being used for the setting of a non-oscillating receiver to a definite frequency, but its use for this purpose is not recommended. If available, wavemeter W.39 should be used, as this will give the desired accuracy. (*See* Chapter II, Section V.)

Double beat method

28. The double beat method is a very accurate means of adjusting or measuring the frequency of a transmitter; the principle may be explained as follows. If two transmitters generating C.W. are coupled to a common self-oscillating receiver so that each transmitter produces a heterodyne note with the receiver, then the two heterodyne notes will combine together to produce beats of a third frequency. Consequently, if the two transmitters are oscillating at the same frequency the third beat frequency will be zero. The third frequency may also be zero if the frequency of one transmitter is the same amount above the frequency of the self-oscillating receiver as the other transmitter is below it. The existence of this last condition, however, can be determined by altering the frequency of self-oscillation of the receiver, as in such circumstances, the heterodyne note frequency of one transmitter alone with the receiver will increase, whilst with the other it will decrease. In the former case, however, when the frequencies are the same, alteration of the frequency of the receiver will not affect the third beat frequency, which will remain at zero. Consideration of the following will show why the double beat method gives greater accuracy than the ordinary heterodyne method.

29. In the case of the ordinary heterodyne method, two relatively high frequency alternating currents produce, in the telephone receiver, an audible heterodyne note, but the effect of each high frequency current separately is not audible. The frequency of the note produced is equal to the difference between the frequencies of the two components, and below a certain frequency, say, about 100 cycles per second, the note is inaudible, that is to say, the " null " band is obtained. The possible error in a determination of frequency by the ordinary heterodyne method is therefore of the order of 100 cycles per second. With the double beat method the beats are produced between two frequencies which are themselves audible, that is to say, each is of some relatively low frequency, say, 1,000 cycles per second. Between these two audible notes, beats may be heard down to a beat frequency of, say, one beat every second, i.e. one cycle per second instead of 100 cycles per second. Consequently, the percentage error in the determination of a frequency is much less than with the ordinary heterodyne method. From this explanation it will be seen that, to maintain the same percentage error, the more accurate double beat method must be employed with the lower frequencies or longer wavelengths.

30. The double beat method is utilized with wavemeter W.42 in the following manner :—

(i) *To adjust the frequency of a local transmitter to a definite value.*—The wavemeter is set up as detailed above in para. 24, the correct wavemeter setting being found by reference to the appropriate chart of those supplied with the instrument. For the self-oscillating receiver required, a type R.1082 may be employed. The following procedure is adopted :—

(*a*) Listen in the telephones of the receiver and adjust the frequency of self-oscillation of the receiver until the heterodyne note produced with the wavemeter W.42 becomes very low and finally inaudible (" zero " note).

(*b*) Similarly adjust the frequency of the transmitter until the heterodyne note heard in the telephones of the receiver is also the " zero " note.

(*c*) Alter the frequency of oscillation of the receiver until the heterodyne notes between the transmitter and receiver, and between the wavemeter and receiver, are of a frequency, say, of about 1,000 cycles per second. In general there will be two heterodyne notes heard in the receiver telephones owing to the transmitter not being of exactly the same frequency as the wavemeter.

(*d*) Alter the frequency of oscillation of the transmitter gradually so that the beat frequency (third frequency) between the two heterodyne notes referred to in (*c*) gradually decreases and finally becomes zero, this final condition being one which holds when the frequency of the transmitter is equal to that of the wavemeter.

(*e*) It is now necessary to ensure that the setting is such that the frequency of the wavemeter and transmitter are not equally spaced above and below the frequency of the self-oscillating receiver. To do this, alter the frequency of the self-oscillating receiver whilst listening in the telephones of the latter. If the heterodyne note produced between the wavemeter and receiver, and transmitter and receiver, changes in frequency, but the third beat does not re-appear, then the frequency of the transmitter is equal to that of the wavemeter.

(ii) *To ascertain the frequency of a transmitter.*—This is carried out in exactly the same way as described in sub-para. (i) for the setting of the transmitter to a definite frequency, with the exception that the frequency of the wavemeter W.42 is altered instead of that of the transmitter.

31. In all cases care should be taken that the coupling between the wavemeter and the self-oscillating receiver (or transmitter) is such that the " null " band of the heterodyne is not too broad, *i.e.* the coupling should be reduced to an absolute minimum.

Use of harmonics

32. As mentioned in para. 26 (iii), it is possible, by means of harmonics, to use the wavemeter for frequencies higher than 8,000 kc/s, and provided care is exercised and figures checked, accurate results may be obtained. The method of use will be described in terms of frequency, but the actual operation will be simplified if wavelengths instead of frequencies are used.

33. It must be remembered that, besides the fundamental frequencies, the characteristics of the wavemeter are such that harmonics also exist, and it is by making use of these, that frequencies higher than 8,000 kc/s can be measured. Suppose the frequency to be measured is of the order of 15,000 kc/s. This frequency will produce a heterodyne note in the telephones of the wavemeter, whenever the harmonics of the latter are of the same order of frequency. Thus, if the wavemeter is set at approximately 7,500 kc/s, the second harmonic of this being 15,000 kc/s, will combine with the 15,000 kc/s radiation from the transmitter, to produce a heterodyne note. Similarly, if the wavemeter is set to approximately 5,000 kc/s, the third harmonic of this being approximately 15,000 kc/s, a heterodyne note will again be heard. Settings of approximately 3,750, 3,000, 2,500 kc/s, etc., will each in turn produce heterodyne notes. The fourth, fifth, sixth, etc., harmonics of these frequencies amount to 15,000 kc/s.

34. The procedure to be adopted when using the wavemeter for this purpose is as follows. Assuming that the transmitter is operating, listen in the wavemeter telephones and note the successive settings of the wavemeter at which heterodyne notes are heard. By minute adjustment of the wavemeter condenser, reduce these to zero frequency. For example, suppose that the successive settings of the wavemeter are 7,200, 4,800, 3,600, 2,880, 2,400 kc/s. Then multiplying :—

$$7{,}200 \times 2 = 14{,}400 \text{ kc/s}$$
$$4{,}800 \times 3 = 14{,}400 \text{ kc/s}$$
$$3{,}600 \times 4 = 14{,}400 \text{ kc/s}$$
$$2{,}880 \times 5 = 14{,}400 \text{ kc/s}$$
$$2{,}400 \times 6 = 14{,}400 \text{ kc/s.}$$

As the second, third, fourth, etc., multiples of the successive settings give a constant frequency of 14,400 kc/s, this is evidently the frequency to be determined. Again, suppose the wavemeter settings obtained are 7,200, 5,760, 4,800, 4,114 or 3,600 kc/s, then, since the frequency being determined is a harmonic of these frequencies, it is necessary to multiply the observed frequencies by 2, 3, 4, 5 . . . or 3, 4, 5, 6 . . . or 4, 5, 6 . . . until the result of such multiplication gives a constant value, which is the frequency to be determined. In the example just given multiplication by 4, 5, 6, 7 and 8 gives a frequency of 28,800 kc/s.

35. As mentioned in para. 32, the method is simplified if wavelengths instead of kilocycles are used. Thus, in the last example, wavelength settings of the wavemeter correspond to approximately 41·65, 52·0, 62·5, 72·8 and 83·3 metres. The successive differences between

these settings are approximately 10·4 metres. This wavelength corresponds with the frequency 28,000 kc/s, which was to be determined. It will be noted that the wavelength obtained is the fourth, fifth, sixth, seventh and eighth harmonic respectively, of the wavelength obtained on the wavemeter.

36. The necessity for checking over readings is emphasized in para. 32, because fractional harmonics may cause confusion. These fractional harmonics are due to the fact that the transmitter itself radiates harmonics, and these combine with the harmonics of the wavemeter. Suppose heterodyne notes are heard at the settings corresponding to the wavelength of 30, 40 and 50 metres, then between these readings other but weaker harmonics will be heard, and we may take, for example, a heterodyne note heard at the 35-metre setting. This heterodyne is due to the second harmonic of the transmitter combining with the seventh harmonic of the wavemeter, i.e. 5 metres. The transmitter wavelength is 10 metres. Care must therefore be exercised that the readings obtained are in correct progression, and that the main harmonics are not confused with the weaker fractional harmonics.

Special calibrations to enable harmonics to be used

37. In order that the frequency of a transmitter operating in the 13,500, 10,000 or 6,750 kc/s band may be set or determined with an accuracy of the order of 1 part in 10,000, Range 2 of the wavemeter is specially calibrated from 1,400 kc/s to 1,200 kc/s in steps of 10 kc/s. The average number of degrees per 10 kc/s is 6·6, and as the condenser can be set to 0·1 degree the accuracy of setting is therefore $\frac{10}{66}$ kc/s in 1,300 kc/s or 1 part in 8,500. This accuracy of setting, which is just outside the C.C.I.R. limits of 1 part in 10,000, is obtained in general use. By interpolation between the vernier readings, *i.e.* by reading to 0·05 degrees, the accuracy of setting is one part in 17,000.

38. In order that the wavemeter may oscillate on these frequencies on Range 2, and to ensure that the harmonics up to the 10th are of sufficient strength to be heard in a receiver operating at frequencies corresponding to the harmonics, it is necessary to use a more powerful valve than the D.E.5B. in the oscillator position, and therefore a special valve (P.625) is provided. It is also necessary to increase the H.T. voltage to 40 volts. The special valve and higher H.T. voltage are only to be used for this special purpose, *i.e.* determining or setting the accuracy of a transmitter operating on the 13,500, 10,000 or 6,750 kc/s bands, and the procedure for setting up the wavemeter as given in the calibration book must be carefully followed. The special H.T. voltage required should be obtained from H.T. accumulators as the current consumption of the wavemeter is too great for ordinary dry batteries. A variation of five volts in the H.T. supply produces a change of frequency which is less than can be read on the instrument, but the voltage of the H.T. accumulator should not be allowed to fall to less than 35 volts before recharging. It will be necessary to check this with a separate voltmeter, as the milliammeter on the wavemeter must not be used across this higher anode voltage.

39. To use the instrument for this special purpose the wavemeter is set up as detailed in the calibration book and operated as far away from the transmitter as possible in order that the "null" space should not be too broad. The operations are as follows :—

(i) Adjust proximity of the wavemeter to the receiver so that the harmonic required can be heard in the receiver, *i.e.* if the receiver is operating at a frequency of 13,500 kc/s, then heterodynes should be heard at condenser settings corresponding to 1,350 kc/s (10th harmonic) and 1,227 kc/s (11th harmonic).

(ii) Adjust receiver to give zero heterodyne note (or null note) with the transmitter.

(iii) Adjust wavemeter to give zero note in receiver. If wavemeter setting occurs at 1,350 kc/s then the frequency is 13,500 kc/s (confirm by heterodyne at 1,227 kc/s).

(iv) If the transmitter is to be set up to a definite frequency, say 13,495 kc/s, then the wavemeter is set at 1,349·5 kc/s and the receiver adjusted to give zero heterodyne note. Confirm that receiver is at a frequency of 13,495 kc/s by swinging wavemeter to 1,227 kc/s and obtaining heterodyne note in receiver.

(v) Adjust transmitter to give zero heterodyne note in the receiver.

40. The following table gives suitable harmonics to use.

Frequency required.

13,500 kc/s	..	..	..	10th harmonic of 1,350 kc/s
10,000 kc/s	..	..	..	8th ,, ,, 1,250 kc/s
6,750 kc/s	..	..	..	5th ,, ,, 1,350 kc/s.

Special Note.—

41. When the change is made from 6 volts H.T. to 40 volts H.T. for the above operations, the filament switch should be first placed in the "off" position. *Before switching on again make quite certain that the correct leads have been changed over, as otherwise the valve will be burnt out and the calibration rendered useless.* Owing to the higher anode voltage now applied, the milliammeter switch must *never* be placed in the "A.V." position, otherwise the meter will be almost certainly burnt out.

METHOD OF USE OF CALIBRATION CHARTS, ETC.

42. For each instrument a book marked with a serial number corresponding to that of the instrument is provided, giving charts showing the relation between readings on the scale of the variable condenser and corresponding frequency values in kilocycles per second. Marked on each chart is the total value of the fixed condenser to be employed for the particular range and coil. When setting up the capacitance, it is essential to use the individual condensers as shown in the table.

43. If it is required to use wavelengths in metres instead of frequencies in kilocycles per second, it will be necessary to convert by means of the formula given below :—

$$\text{Wavelength in metres} = \frac{300{,}000}{\text{kilocycles per second}}$$

44. Opposite each chart is given a table for the particular range, showing the relation between frequency in kilocycles per second, and condenser readings. Suppose, for example, the values given in the table were as shown below :—

Kilocycles per sec.	Condenser Reading.
987·5	98·2
975·0	104·7
952·5	111·4
950·0	118·3

Then to find, say, the frequency in kilocycles per second corresponding to a condenser reading of 100 the following is the procedure. The value of 100 occurs between 98·2 and 104·7, the difference being 6·5. The difference of 6·5 corresponds to a difference in frequency of 12·5 kc s. The difference therefore of 4·7 (104·7 — 100) in the condenser reading to obtain 100 will mean the addition to 975 of $\frac{4 \cdot 7}{6 \cdot 5} \times 12 \cdot 5 = 9 \cdot 03$, so that the value in kilocycles per second corresponding to the condenser reading of 100, is $975 + 9 \cdot 03 = 984 \cdot 03$ (984 kc/s). The values given in the tables opposite each chart have been obtained by actual calibration and it is mainly for this reason that greater accuracy is obtained by the use of the tables, as compared with the curves. The figures given above are merely examples and it does not necessarily mean that this degree of accuracy can always be obtained in practice.

PRECAUTIONS AND MAINTENANCE

45. The accuracy of the instrument depends on the correct voltages being used and upon the following conditions being observed :—

(*a*) Voltmeter switch at F.V.

(*b*) Telephones in circuit.

(*c*) Change-over switch at position marked C.W.

(*d*) The milliammeter needle should be on the green line marked F.V.

46. The valves or telephones provided must not be used in any other instrument. When inserting or removing the range coils, care must be taken to avoid damage to the valves or other adjacent parts. The extension handle of the condenser must always be used. This is fitted to enable the condenser to be adjusted minutely, and also to minimize body capacity effect. When operating, the body should be kept as far away from the instrument as possible. It should always be borne in mind that the wavemeter W.42 is a precision instrument, and therefore should be handled with care. The condenser should not be slammed hard up against its stops at 0° and 180°. Damage to any of the components may necessitate re-calibration.

47. The necessity for extreme care in handling the valves cannot be too strongly emphasized, since the calibration of the instrument is correct only if the valves supplied with the instrument are used.

48. Two D.E.5B. " O " valves for use as oscillators on range 1 to 6 and two P.625 valves for use as oscillators on the specially calibrated range 2, accompany each issue of the wavemeter. Calibration charts for all four oscillator valves are provided. Full details of the method of using these will be found in the calibration book accompanying each wavemeter.

49. The failure of an oscillating valve will not necessitate the immediate return of the wavemeter for calibration, but the other valve should be put into use. Nevertheless, at the time of taking this valve into use, a complete replacement wavemeter with all accessories (with the exception of the 2-volt accumulator) must be demanded from No. 1 Equipment Depot. On receipt of the replacement wavemeter, the original wavemeter with its equipment must be returned.

50. When the wavemeter is not in use, the filament switch must be put in the " off " position and the telephones removed and placed in the compartment provided. The calibration book should also be placed in its compartment, the cover replaced and the instrument kept free from dust and stored in a dry place. No adjustment for any fault in the instrument may be made, beyond the possible replacement of the modulating valve referred to above.

WAVEMETER W.42.A

(Stores Ref. 10A 9778)

51. The wavemeter, type W.42.A, has now been introduced, and will ultimately replace wavemeter, type W.42. The two wavemeters are exactly similar as regards appearance, the difference however being in the circuit arrangements, and in the use of 2-volt valves instead of 6-volt valves. The same general remarks as regards delicate mechanism and careful handling apply.

52. The best results on frequencies above 3,000 kc/s are obtained by using harmonics of frequencies between 1,200 kc/s and 1,400 kc/s. The use of these harmonics is made easier in the type W.42.A wavemeter by the substitution of an amplifier stage for the modulator stage.

53. Referring to fig. 7, which is a circuit diagram of W.42.A, it will be seen that the circuit comprises an oscillating-detector-stage transformer coupled to an amplifier stage. Telephones are connected directly in the anode circuit of the amplifier stage. A double-pole double-throw switch enables a 0-10 milliammeter to be used as voltmeter either for the oscillator filament battery or the oscillator anode battery.

54. The anode and grid circuit of the oscillator valve V are coupled by means of two windings on a plug-in coil unit, the coil-holder for which is represented at H in the figure. The coil is tuned by the condenser C_1, the capacitance of which may be increased by connecting one or more condensers C in parallel. Switches S are provided for this purpose. C_2 is a $0 \cdot 01 \mu F$ blocking condenser as before. H.T. (10 volts) for the valve V is fed through the primary of the transformer T.

55. A telephone jack J is connected directly in the anode circuit of the amplifier valve V_1, and H.T. is fed from a 60-volt battery. A milliammeter M and a D.P.D.T. switch S_1 enable either the filament voltage or the H.T. voltage of the oscillator to be read. The switch is engraved in its two positions F.V. (filament voltage) and A.V. (anode voltage). A 19-ohm resistance R is permanently in series with the milliammeter, but when the switch S_1 is in the "A.V." position a further resistance R_1 of 800 ohms is included in series.

56. The filament "on-off" switch S_2 is in effect a 6-ohm rheostat. In the "off" position the filament circuit is opened. When the switch handle is gradually moved towards the "on" position, the resistance is gradually cut out.

57. Accommodation is provided within the case of the instrument for three batteries. The L.T. for both valves is obtained from a 2-volt, 14Ah. accumulator. The H.T. for the oscillator valve V is obtained from a 10-volt, lead-acid accumulator, and the H.T. for the amplifier valve V_1, from a 60-volt dry battery.

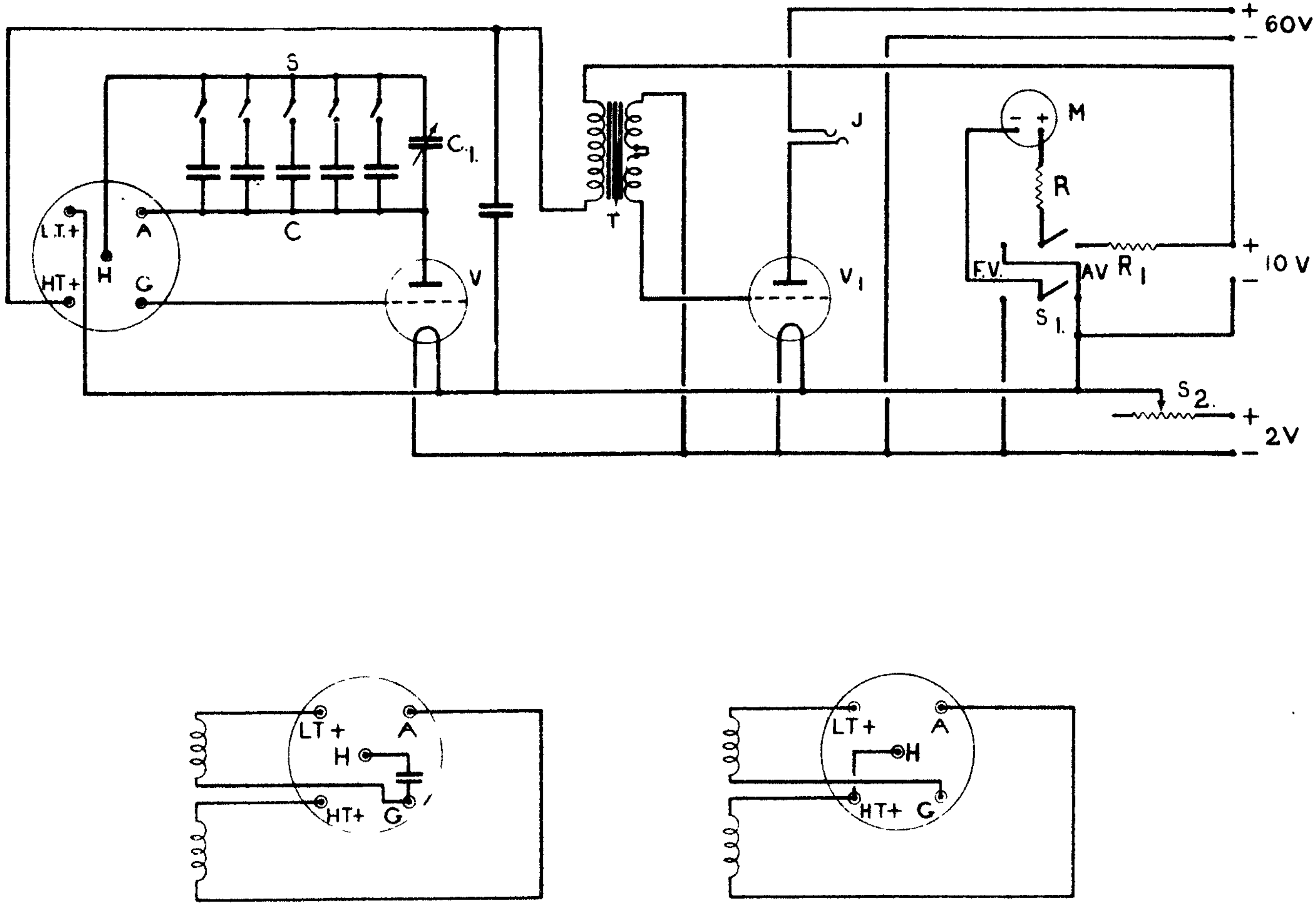
58. There are four valves, type 210 H.L., supplied with each instrument. Two are in the coil transit case and two are in a special transit case (Stores Ref. 10A/8412). Two of the valves are intended for use as oscillators, and are marked on the bases with the serial number of the instrument, and the letters OA or OB corresponding to the calibration book. Amplifier valves are also marked with the serial number of the wavemeter, but may be exchanged independently. The greatest care is to be taken of the valves in order to avoid damage, especially the oscillator valves, as the cost of calibration is heavy.

59. With the exception of ranges 5 and 6, coils are provided as in the case of the W.42, and they cover the same frequency. When it appears from the calibration book that a coil covers frequencies below the lower frequency engraved on it, it is desirable to use the extended frequency band rather than the next coil. Each instrument is provided with its own calibration book in which are recorded calibrations for each of the oscillators A and B.

60. The only telephones which may be used are receivers, telephone, type B (Stores Ref. 10A/8542). The low impedance telephones (Stores Ref. 10A/4462), issued with the wavemeter W.42, are not suitable.

61. As regards the operation of the instrument, the same remarks as for W.42 apply, except that no modulation is available. The oscillator anode and filament voltages are important. The H.T. battery voltage must be maintained at a value such that the pointer will coincide or pass beyond the green line of the voltmeter. The L.T. voltage must be adjusted so that the pointer will be coincident with the red line. The amplifier anode voltage should never be less than 50 volts.

62. Three slightly different forms of wavemeter, type W.42.A are in existence. The operation and performance of all of these are, however, identical. As the differences are a matter of construction only, no mention is made of them here.



Coil range. 1

Coil ranges. 2. 3. 4. 5. & 6.

FIG 7 CIRCUIT DIAGRAM OF WAVEMETER W 42A

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.
10A/7252	Wavemeter, type W.42 :—		
	Principal components :—		
10A/7234	Book, calibration	1	
	Case		
10A/7235	Coil	1	To hold six coils and two valves
10A/7236	Wavemeter	1	
	Coil		
10A/7237	Range 1	1	
10A/7238	Range 2	1	
10A/7239	Range 3	1	
10A/7240	Range 4	1	
10A/7241	Range 5	1	
10A/7242	Range 6	1	
	Condenser		
10A/7204	Type 56	1	0·005 μF.
10A/7174	Type 57	1	0·01 μF.
10A/7249	Type 59	1	70–1,250 μμF, variable.
10A/7244	Container, accumulator	1	
	Holder		
10A/7245	Coil	1	
10A/7221	Valve, type B	2	
10A/1739	Jack, telephone, type A	2	
10A/7250	Milliammeter 0 to 10	1	
	Resistance		
10A/7246	Type 12	1	6 ohms, variable.
10A/7243	Type 45	1	600 ohms.
10A/2262	Switch, type 15	1	
10A/7167	Transformer, L/F, type C	1	
10A/7248	Unit, condenser	1	Consisting of five fixed condensers five switches and base.
	Accessories :—		
5A/2	Accumulator, 2-volt	3	L.T. supply.
5A/2	Accumulator, 2-volt	3	H.T. supply.
10A/117	Cord, telephone, type A, with plug.		
10A/8144	Case, transit	1	
10A/4462	Receiver, telephone, head	1	
	Valve		
10A/7176	Type D.E.5B.	1	Modulator.
10A/7253	Type D.E.5B.	2	Oscillator.
10A/7524	Type P.625	2	Special application on range 2.
10A/9778	Wavemeter W.42.A :—		
	Principal components :—		
10A/7234	Book, calibration	1	
	Case		
10A/9800	Coil	1	
10A/9801	Wavemeter	1	
	Coil		
10A/7237	Range 1	1	
10A/7238	Range 2	1	
10A/7239	Range 3	1	
10A/7240	Range 4	1	
10A/7241	Range 5	1	
	Range 6	1	
	Condenser		
10A/7174	Type 57	1	0·01 μF.
10A/7249	Type 59	1	70–1,250 μμF, variable.

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Wavemeter W.42 A—*continued*		
	Principal components—*continued*		
	Holder		
10A/7245	Coil	1	
10A/7221	Valve, type B	2	
10A/1739	Jack, telephone, type A	1	
10A/7250	Milliammeter 0 to 10	1	
	Plug		
10A/9112	Type 82	2	
10A/9113	Type 83	2	
	Resistance		
10A/7246	Type 12	1	6 ohms, variable.
10A/9802	Type 297	1	190 ohms, wire wound.
10A/9803	Type 298	1	800 ohms, wire wound.
10A/2262	Switch, type 15	1	
10A/7167	Transformer, L F, type C	1	
10A/7248	Unit, condenser	1	Consisting of five fixed condensers, five switches and base board.
	Accessories :—		
5A/1386	Accumulator, 2-V, 14 Ah.	1	L.T.
5A/1891	Accumulator, 10-V, 5,000 mAh. ..	1	Oscillator H.T.
5A/1334 *or* 5A/1613	Battery, dry, 60-volt, type A or type B	1	Amplifier H.T.
10A/8144	Case, transit	1	
10A/8542	Receiver, telephone, head, 1,750 ohms, type B.	1	
10A/117	Cord, instrument, type A.		
10A/7064	Headband..	1	
10A/9797	Valve, type 210 H.L.	4	Two in coil case, and two in special valve transit case 10A/8412.

SECTION 5, CHAPTER 2

WAVEMETER W.39 AND WAVEMETER W.39A

Contents

List of Illustrations

WAVEMETER W.39

(Stores Ref. 10A/7156)

INTRODUCTION

1. The wavemeter W.39 is an instrument for use on the ground only and is capable of generating pure or modulated C.W. of low power for use as—

(i) a meter for measuring the frequency of a transmitter;

(ii) a separate heterodyne. Its use for this purpose is to be discouraged (*see* para. 20);

(iii) a source for adjustment of a receiver to a definite frequency.

This wavemeter must be considered as a delicate instrument and great care should be exercised in its use. The calibration is accurate to approximately 2 per cent.

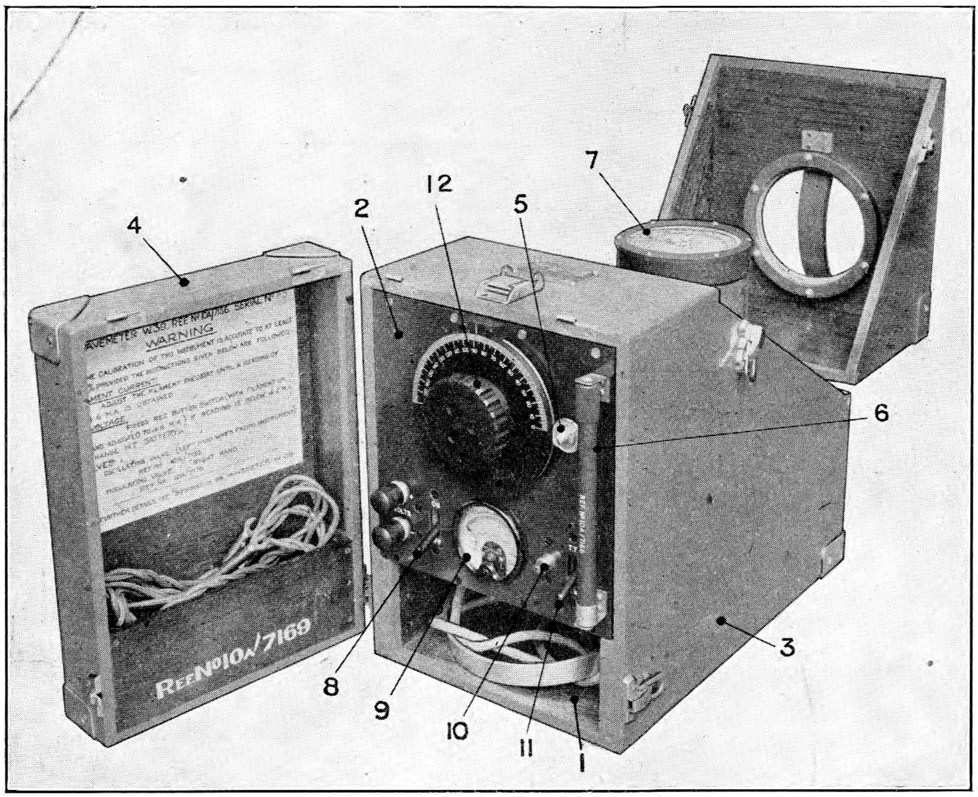


FIG. 1. Wavemeter W.39 with case open.

2. The frequency covered by the instrument is 6,700 to 25 kc/s (45 to 12,000 metres) in six ranges obtained by the use of plug-in coils. The ranges are approximately as follows :—

Range.	Frequency in kc/s.	Wavelength (metres).
1	6,700 to 2,400 ..	45 to 125.
2	3,000 to 857 ..	100 to 350.
3	1,000 to 300 ..	300 to 1,000.
4	400 to 125	750 to 2,400.
5	200 to 60	1,500 to 5,000.
6	75 to 25	4,000 to 12,000.

The scale for range 1 is graduated down to 8,750 kc/s (35 metres). Wavemeter W.39.A is a modified form of this wavemeter. The nature of the modifications are explained at the end of this chapter.

GENERAL DESCRIPTION

3. A theoretical circuit diagram of the wavemeter is shown in fig. 2. The instrument employs two valves, one an oscillating valve V_1 and the other a modulating valve V_2. The anode and grid circuits of the valve V_1 are coupled by the halves of a " split coil " L_1, L_2 (of the plug-in type) the

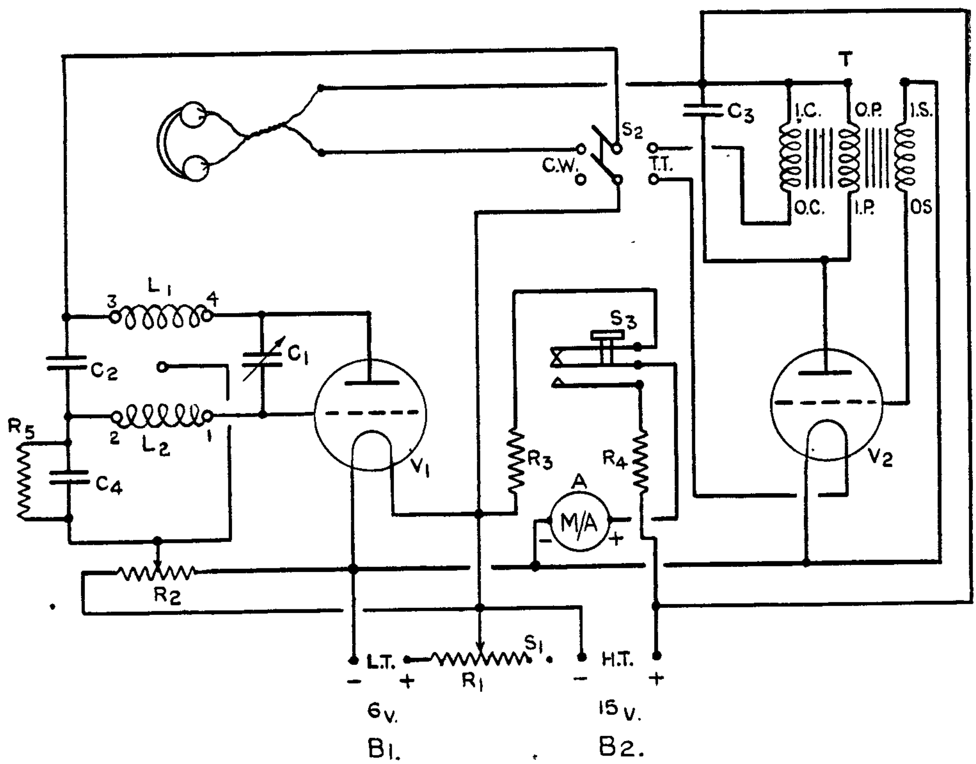


FIG. 2. Theoretical circuit diagram.

two parts of which are connected in series through the blocking condenser C_2, and tuned by the variable condenser C_1. This type of circuit is particularly applicable to higher frequencies and has the virtue of low residual capacitance, enabling a large frequency range to be obtained with the tuning condenser.

4. The modulating valve V_2 has its anode and grid circuits coupled by the primary winding P and the secondary winding S of a special modulating transformer T. A fixed tuning condenser is connected across the primary winding. Connected in this way the valve generates A.C. at a frequency of about 300 cycles per second, and by means of a coupling coil CC (incorporated in the special transformer) a small A.C. voltage is introduced into the anode circuit of the oscillating valve.

5. A change-over switch S_2 enables either C.W. or Tonic Train to be obtained. With the switch in the Tonic Train position (T.T.), the coupling coil C.C. is connected in the anode circuit of the valve V_1, and the filament circuit of the valve V_2 is completed. The latter connection is effected by the switch S_2. When the switch is in the C.W. position the anode circuit of the valve V_1 is completed through the telephones instead of through the coupling coil CC, and the filament circuit of the valve V_2 is broken.

6. A resistance R_2 is connected across the filament circuit and from it a tapping is taken to the grid coil L_2 *via* the resistance R_5, shunted by the condenser C_4, so that the adjustment of the filament voltage determines the grid potential of the valve V_1. On ranges 1 and 2, the condenser and leak resistance are short-circuited by a link on the coil. This is shown in fig. 2, as a dotted line between the sockets on the coil engraved 5 and 2.

7. In the diagram may also be seen the coil-holder H, the milliammeter A with the push-switch S_3, the resistances R_3 and R_4, the change-over switch S_2 and the modulation transformer T. The filament rheostat R_1 has an " off " position shown at S_1.

8. The milliammeter (0-5 mA.) shown at A in fig. 2 is incorporated in the instrument and by means of a push-switch and resistances serves as H.T. and L.T. voltmeter, to reproduce the calibration conditions.

9. A separate case is provided for the coils and valves for transit purposes ; six cylindrical wells are arranged in this for the accommodation of the coils, and two square wells to take the cartons containing the valves.

CONSTRUCTIONAL DETAILS

10. Various views of the wavemeter are given in figs. 1, 3 and 4, fig. 1 being a view of the wavemeter open, fig. 3 a view of the case and fig. 4 an interior view with the case removed, showing the wavemeter components mounted on a base board. In this figure can also be seen the rear of the front panel.

11. Referring to fig. 3. The case (1) is built up of linen covered mahogany painted grey. The approximate dimensions are 14 in. × $7\frac{3}{4}$ in. × $10\frac{3}{4}$ in. and the weight of the instrument without the external 6-volt accumulator is $14\frac{1}{2}$ lb. The rear lid (2) is hinged and normally held in position by means of two spring catches, one of which (3) may be seen on the side of the case. The carrying handle (4) is secured at one end to the lid (2), the other end of the handle being normally held in position by the spring catch (5). The lid (6) is mounted on detachable hinges and if it is moved bodily to the right, it may be removed from the case as shown in fig. 1. The lid is held in position by two spring catches, one of which (7) may be seen on the side of the case.

12. Fig. 1 shows the case open and the lid removed. One of the plug-in coils has been inserted in position. The front panel (2) is secured to the case (3) by means of four screws on the top. When the panel is in position a recess (1) is formed in which the telephones are housed. The battery leads are housed in a compartment formed in the lid (4).

13. The fine tuning device (5) coupled to the condenser control (12) is operated by the insulated handle (6) which when not in use, is held in spring clips on the side of the panel. The interchangeable range coil (7) may be seen towards the rear of the instrument. When the hinged lid is in the closed position, the engraving on the coil may be read through a glass window in the lid. The filament switch (8) opens the filament circuit completely in the " off " position and when moved towards the " on " position, gradually reduces the amount of resistance in circuit.

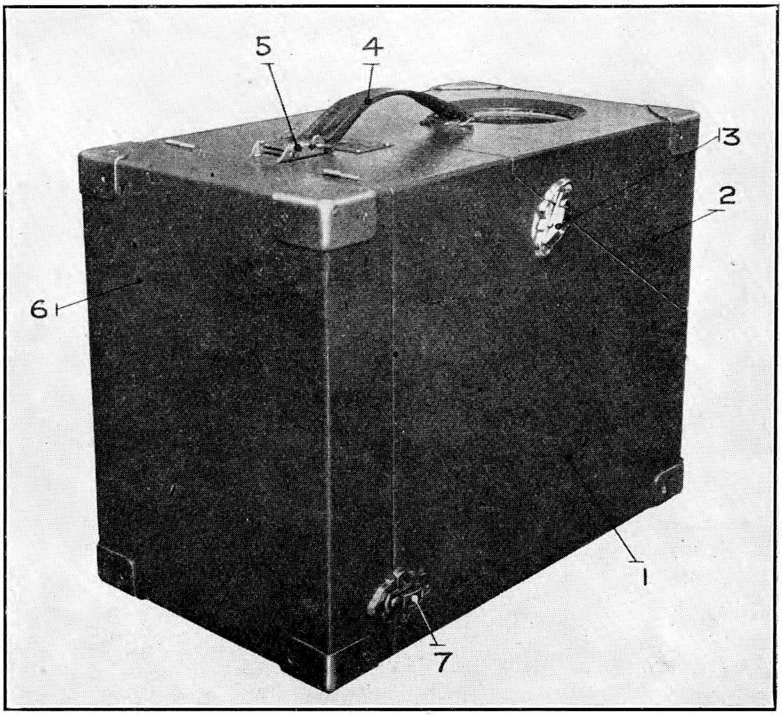


FIG. 3. Wavemeter W.39 in its case.

14. The milliammeter (9) in conjunction with the push-switch (10) is capable of reading the H.T. or L.T. voltage. In the normal position of the switch, the milliammeter reads the voltage applied to the filaments, and when the switch is pressed, it reads the combined voltage of the filament and H.T. supply. The switch (11) in the right-hand corner is engraved T.T. and C.W. In the bottom left-hand corner of the panel may be seen two terminals to which the battery leads should be connected before the instrument is put into operation.

15. As shown in fig. 4, the various components are mounted on a base board (1) to which the front panel (2) is also secured. The variable condenser (3) is the tuning condenser. Below it is the transformer (4). The resistance (5) at the back of the transformer has a value of 4,800 ohms and is included in the milliammeter circuit when the L.T. voltage has to be measured. The L.T. terminal pillar (6) may be seen in front of the filament rheostat (7). The H.T. terminal pillar (8) is to the right of the coil-holder (9). The $\cdot 01\ \mu F$ condenser (10) near the coil-holder is represented by C_2 in fig. 2. The $\cdot 005\ \mu F$ condenser (11) shunted by the 80,000-ohm resistance (12) is in the grid-filament circuit of the valve V_1. They are represented by C_2 and R_5 respectively in fig. 2.

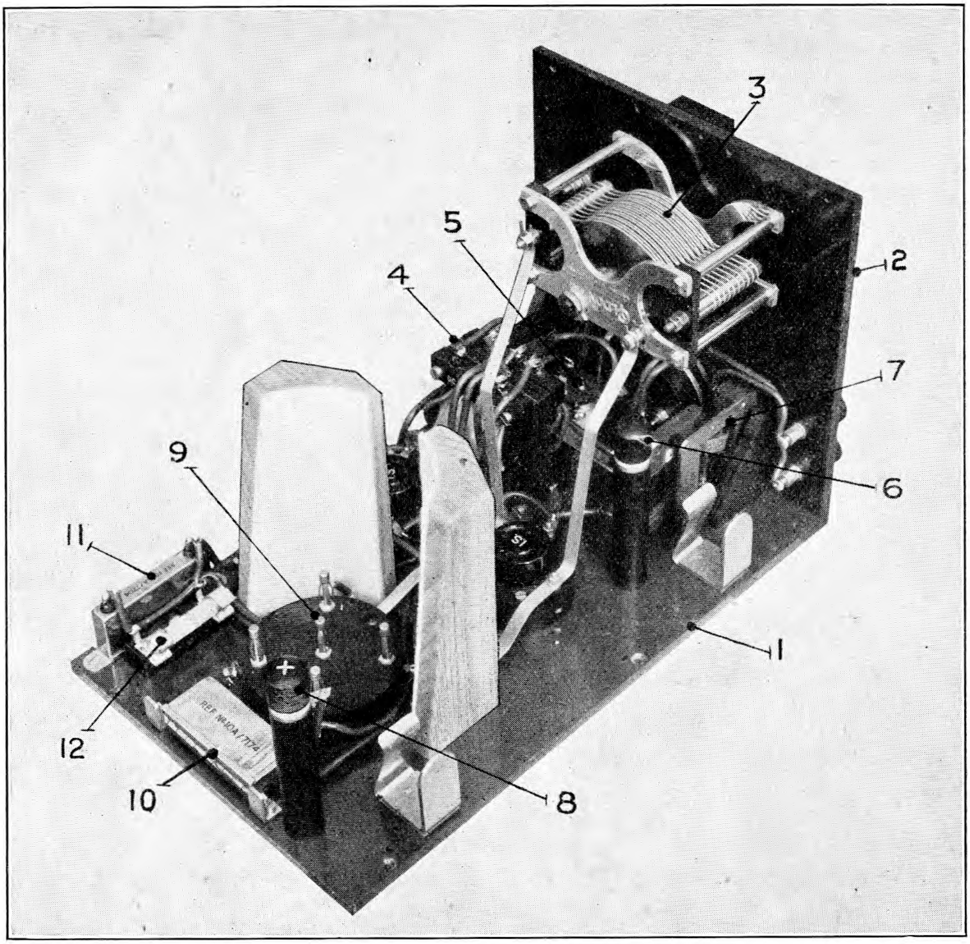


FIG. 4. Interior view of W.39 with case removed.

VALVES AND BATTERIES

16. The valves used in the wavemeter W.39 are D.E.5B. valves, and have a maximum filament voltage rating of 6 volts. A 6-volt accumulator which may, for example, consist of three cells (Stores Ref. 5A/2), is used for the low tension supply and a 15-volt high tension unit (Stores Ref. 5A/50) provides the anode voltage.

OPERATION

General

17. The procedure when using the wavemeter is as follows :—

(i) Insert the valves provided in their correct positions, *i.e.* oscillating valve in the left-hand valve-holder and the modulating valve in the right-hand valve-holder, as viewed from the front of the instrument. The valves are marked O and M respectively and are numbered. Instructions for the insertion of the valves are fixed inside the front cover of the instrument.

(ii) Insert the required range coil, taking care that the word RANGE on the scale of the coil is the right way up for reading, as viewed from the front of the instrument. This is essential.

(iii) See that the filament rheostat switch (8, fig. 1) is in the " off " position. Connect the 6-volt accumulator to the terminals marked 6 VOLTS + and — on the front panel. The flexible leads provided for this purpose will be found in a compartment in the front cover. The sleeves on the ends of the leads are clearly marked + and and care should be taken that the polarity is correct.

(iv) Move the switch (8, fig. 1) gradually from the " off " position, noting the reading on the milliammeter at the same time. The filament rheostat switch must be adjusted so that the reading is 4·6 mA.

(v) Check the H.T. voltage by momentarily pressing the push-switch. A reading of not less than 4·2 mA. should be obtained. A lower reading may indicate that the H.T. battery voltage is insufficient.

To generate C.W.

18. If the instrument is required to generate C.W. either for the measurement of the frequency of a transmitter or that of an oscillating receiver, put the switch on the right of the panel into the position marked C.W.

19. If the frequency of a transmitter or an oscillating receiver is to be determined, listen in the telephones and adjust the condenser approximately by the dial and accurately by the fine adjustment handle, until the heterodyne note becomes lower and lower, and finally becomes too low to be heard. Note the reading of the condenser. Find the corresponding reading on the top of the range coil, and adjacent to this, on the inner scale can be read the required wavelength. The frequency in kilocycles can be read on the third set of graduations. The orientation of the instrument with respect to the transmitter is unimportant, but its distance from the transmitter should be chosen so that the " null " band of the heterodyne is not too broad, and the distance for greatest accuracy should be as great as possible, consistent with an audible signal in the telephones.

As a separate heterodyne

20. If the instrument is to be used as a separate heterodyne, the following procedure should be adopted :—

(i) On top of the range coil, against the wavelength required, read off the corresponding condenser setting.

(ii) Set the condenser dial to this reading.

(iii) While listening in on the receiver telephones make slight adjustments to the wavemeter condenser to obtain the heterodyne note required. As this is a delicate instrument its use as a separate heterodyne should be discouraged, owing to the possibility of rough handling.

Tonic Train

21. If tonic train is required for tuning a non-oscillating receiver or super-heterodyne receiver to a definite frequency the following procedure should be adopted :—

(i) Put the change-over switch to the position marked T.T. and again adjust the filament rheostat switch until a reading of 4·6 mA. is obtained.

(ii) From the scale on the range coil read off the condenser setting for the frequency required, and set the wavemeter condenser accordingly.

(iii) Place the instrument as far away as possible from the receiver to be tuned, consistent with an audible signal in the receiver telephones.

Harmonics

22. It is possible to use the wavemeter for frequencies higher than 8,000 kilocycles per second, and provided care is exercised and the readings and figures checked over, accurate results may be obtained. The method of use will be described first in terms of frequency, but the actual operation will be simplified if wavelengths instead of kc/s are used.

23. It must first of all be remembered that besides the fundamental frequencies, the characteristics of the wavemeter are such that harmonics also exist, and it is by making use of these that frequencies higher than 8,000 kc/s can be measured. Suppose the frequency to be measured is of the order of 15,000 kc/s. This frequency will produce a heterodyne note in the telephones of the wavemeter whenever the harmonics of the latter are of the same order of frequency. Thus if the wavemeter is set at approximately 7,500 kc/s, the second harmonic of this, being 15,000 kc/s, will combine with the 15,000 kc/s radiation from the transmitter, to produce a heterodyne note. Similarly if the wavemeter is set to approximately 5,000 kc/s the third harmonic of this being approximately 15,000 kc/s, a heterodyne note will again be heard. Settings of approximately 3,750, 3,000, 2,500 kc/s, etc., will each in turn produce heterodyne notes. The fourth, fifth, sixth, etc., harmonics of these frequencies amount to 15,000 kc/s.

24. The procedure to be adopted when using the wavemeter for this purpose is as follows. Assuming the transmitter is operating, listen in the wavemeter telephones and note the successive settings of the wavemeter at which heterodyne notes are heard. By minute adjustment of the wavemeter condenser, reduce these to zero frequency. For example, suppose that the successive settings of the wavemeter are 7,200, 4,800, 3,600, 2,880, 2,400 kc/s. Then multiplying

$$\begin{aligned} 7{,}200 \times 2 &= 14{,}400 \text{ kc/s} \\ 4{,}800 \times 3 &= 14{,}400 \text{ kc/s} \\ 3{,}600 \times 4 &= 14{,}400 \text{ kc/s} \\ 2{,}880 \times 5 &= 14{,}400 \text{ kc/s} \\ 2{,}400 \times 6 &= 14{,}400 \text{ kc/s} \end{aligned}$$

it will be seen that the second, third, fourth, etc., multiples of these settings give a constant frequency of 14,400 kc/s, which is therefore the frequency to be determined. Again, suppose the wavemeter settings obtained are 7,200, 5,760, 4,800, 4,114, 3,600 kc/s, then, since the frequency being determined is a harmonic of these frequencies, it is necessary to multiply the observed frequencies by 2, 3, 4, 5 . . . or 3, 4, 5, 6 . . . or 4, 5, 6 . . . until the result of such multiplication gives a constant value, which is the frequency to be determined. It will therefore be seen that in the example just given multiplication by 4, 5, 6, 7 and 8 gives a frequency of 28,800 kc/s.

25. As mentioned in paragraph 22, the method is simplified if wavelengths instead of kilocycles are used. Thus in the last example, wavelength settings of the wavemeter correspond to approximately 41·65, 52·0, 62·5, 72·8, and 83·3 metres. The successive differences between these settings are approximately 10·4 metres. This wavelength corresponds with the frequency 28,800 kc/s, which was to be determined. It will be noted that the wavelength obtained is the fourth, fifth, sixth, seventh, and eighth harmonic respectively of the wavelength obtained on the wavemeter.

26. The necessity for checking over readings is emphasized, because fractional harmonics may cause confusion. These fractional harmonics are due to the fact that the transmitter itself radiates harmonics, and these combine with the harmonics of the wavemeter. Suppose heterodyne notes are heard at the settings corresponding to wavelengths of 30, 40, and 50 metres, then between these readings, but weaker, will be heard other heterodynes, and we may take for example a heterodyne note heard at the 35 metre setting. This heterodyne is due to the second harmonic of the transmitter combining with the seventh harmonic of the wavemeter, *i.e.* 5 metres. The transmitter wavelength is 10 metres. Care must therefore be exercised that the readings obtained are in correct progression, and that the main harmonics are not confused with the weaker fractional harmonics.

PRECAUTIONS AND MAINTENANCE

27. (i) As the accuracy of the calibration is dependent on the correct voltages being used, the low tension accumulator (6 volts) should be maintained fully charged, and the H.T. battery (15 volts) kept at sufficient voltage. When testing the H.T. battery the switch should not be kept depressed for a longer time than is necessary to take the reading. The H.T. reading should always be taken after having made certain that the correct voltage is being applied to the filament of the oscillating valve, as when the switch is depressed the milliammeter indicates the H.T. battery voltage plus the L.T. filament voltage.

(ii) The valves or telephones must not be used in any instrument other than the particular wavemeter.

(iii) The condenser should not be slammed hard up against its stops at 0° and 180°. On shorter waves especially, delicacy of touch is necessary in operating the condenser.

28. (i) In the case of valve failure, the correct valve *must* be substituted. The oscillator valve is a D.E.5B. marked O and the modulator is a D.E.5B. marked M.

(ii) No adjustment for any fault in the instrument may be made, beyond the renewal of the H.T. battery and the replacement of the valves referred to under (i).

(iii) To renew the H.T. battery the front end of the carrying handle should be detached and the corner piece of the lid swung back ; the battery can then be withdrawn from its clips.

WAVEMETER W.39.A

(Stores Ref. 10A/10300)

29. Owing to the fact that the stocks of D.E.5B. valves are exhausted and no replacements are available, future issues of the instrument will employ 2-volt valves and it will be known as Wavemeter, type W.39.A. Instructions have been issued to units to modify existing wavemeters, type W.39, and re-mark them W.39.A. The conversion will be carried out when no further supplies of D.E.5B. valves are available at Units.

30. Wavemeter W.39.A. employs a V.W.42 valve as an oscillator and a V.R.21 or V.R.27 as a modulator. A 2-volt accumulator is used for the filament supply, and an additional fixed condenser of $3\mu\mu F$ is connected across the variable condenser. The filament rheostat is used only as a filament switch, *i.e.* it is always used in the " full on " position (handle uppermost). The push-button switch, as in wavemeter, type W.39, enables either the L.T. voltage or the combined voltage of the L.T. and H.T. to be measured. The latter is read on the milliammeter when the push-button switch is depressed, and the former when the switch is released.

31. With the filament switch in the " full on " position, the milliammeter should not read less than 1·5 mA. If it reads less than this, it indicates that the filament battery requires re-charging. With the filament switch in the " full on " position and the push-button switch depressed, a reading of not less than 3·2 mA. should be obtained. A reading of less than this indicates that the H.T. battery requires renewal.

32. When the instrument is used for checking and measuring frequencies a V.W.42 valve must be used in the oscillator position (left-hand when facing the instrument). A V.R.21, a V.R.27 or a V.W.42 valve may be used in the modulator position. If the instrument is to be employed for purposes where the calibrations are not important (*e.g.* independent heterodyne), any of the three valves, types V.R.21, V.R.27 or V.W.42, may be used as an oscillator.

33. In certain units the W.39A is modified to enable it to be used as a crystal monitor for setting ground station R/T transmitters to the required frequency and for listening to the speech, a crystal adaptor being inserted in the oscillator valve-holder, and a V.T.20 valve inserted in the valve pin sockets provided in the adaptor.

34. Before using it for this purpose, the W.39A is set up to the required frequency, the appropriate crystal inserted, the H.T. positive plug removed from the 15-volt battery, and a testmeter type C (set to the 0–30 mA scale) connected between the positive plug and the positive socket of the battery. The wavemeter variable condenser is then set to the frequency corresponding to the frequency of the crystal. The condenser is adjusted to give the minimum reading on the testmeter scale. The final setting is 50 kc/s higher than this and is made by referring to the scale on the coil.

35. Having set up the wavemeter, the testmeter is disconnected and the H.T. positive connection re-made. To monitor the transmitter, the switch on the wavemeter is set to the C.W. position and the frequency of the transmitter adjusted in the normal manner to produce an ultimate nullpoint in the beat note heard in the telephones of the wavemeter.

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 mentioned.

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/7156	Wavemeter W.39 and		Without valves or batteries.
10A/10300	Wavemeter W.39.A :—		
	Principal components :—		
	Case		
10A/7157	Coil	1	With lid.
10A/7158	Wavemeter	1	
	Coil		
10A/7160	Range 1	1	
10A/7161	Range 2	1	
10A/7162	Range 3	1	
10A/7163	Range 4	1	
10A/7164	Range 5	1	
10A/7165	Range 6	1	
	Condenser		
10A/7173	Type 55	1	·0005 μF, variable.
10A/7204	Type 56	2	·005 μF.
10A/7174	Type 57	1	·01 μF.
10A/8804	Type 230	1	·0005 μF. Used on W.39.A in place of 10A/7173.
10A/10301	Type 390	1	3·0 μμF. For W.39.A only.
10A/7225	Cord, telephone, type D	1	
10A/7166	Handle, fine tuning	1	
10A/7175	Holder, valve, type A	2	
10A/7168	Leads, L.T. supply	1	
10A/7169	Lid, wavemeter case	1	
10A/7177	Milliammeter (0–5 mA.)	1	
10A/7279	Mounting resistance	1	
10A/3461	Plug, spring, type B	1	
10A/7226	Plug, spring, type L	1	
10A/4462	Receiver, telephone, head, 60-ohm	1	
10A/4118	Headband	1	
	Resistance		
10A/3344	Type 5	1	3 ohms, variable, flat wire-wound.
10A/7278	Type 28	1	80,000 ohms, 1-watt, rod type.
10A/7171	Type 34	1	4,800 ohms, wire-wound, bobbin.
10A/7172	Type 35	1	1,900 ohms, wire-wound, bobbin.
10A/7170	Type 55	1	300 ohms, wire-wound, bobbin.
	Switch :—		
10A/2262	Type 15	1	Double-pole, 2-way.
10A/7178	Type 42	1	Two position, push operated.
10A/7167	Transformer, L/F, type C	1	
	Accessories :—		
5A/2	Accumulator, 2-volt, 13 Ah.	3	
5A/50	Battery, 15-volt	1	
	Valve		
10A/7176	D.E.5B. (M)	1	Modulator valve.
10A/7253	D.E.5B. (O)	1	Oscillator valve.
5A/1514	Accumulator, 2-volt, 7 Ah.	1	For W.39.A.
	Valve		
10A/10299	V.W.42	1	Oscillator valve, for W.39.A.
10A/7738	V.R.21	1	Modulator valve, for W.39.A.
	or		
10A/8239	V.R.27	1	

SECTION 5, CHAPTER 3

WAVEMETER W.66.

Contents

List of Illustrations

WAVEMETER W.66

(Stores Ref. 10A/7640)

INTRODUCTION

1. The wavemeter W.66 has been designed for use in aircraft to measure the frequency of the aeroplane transmitter or to set the aeroplane transmitter to a definite frequency, and is of the type which employs a Neon lamp to indicate resonance. The dimensions are approximately $6\frac{1}{2}$ in. $\times$ $6\frac{1}{2}$ in. $\times$ $6\frac{1}{2}$ in., and the weight, complete with carrying case, is approximately 7 lb. 5 oz.

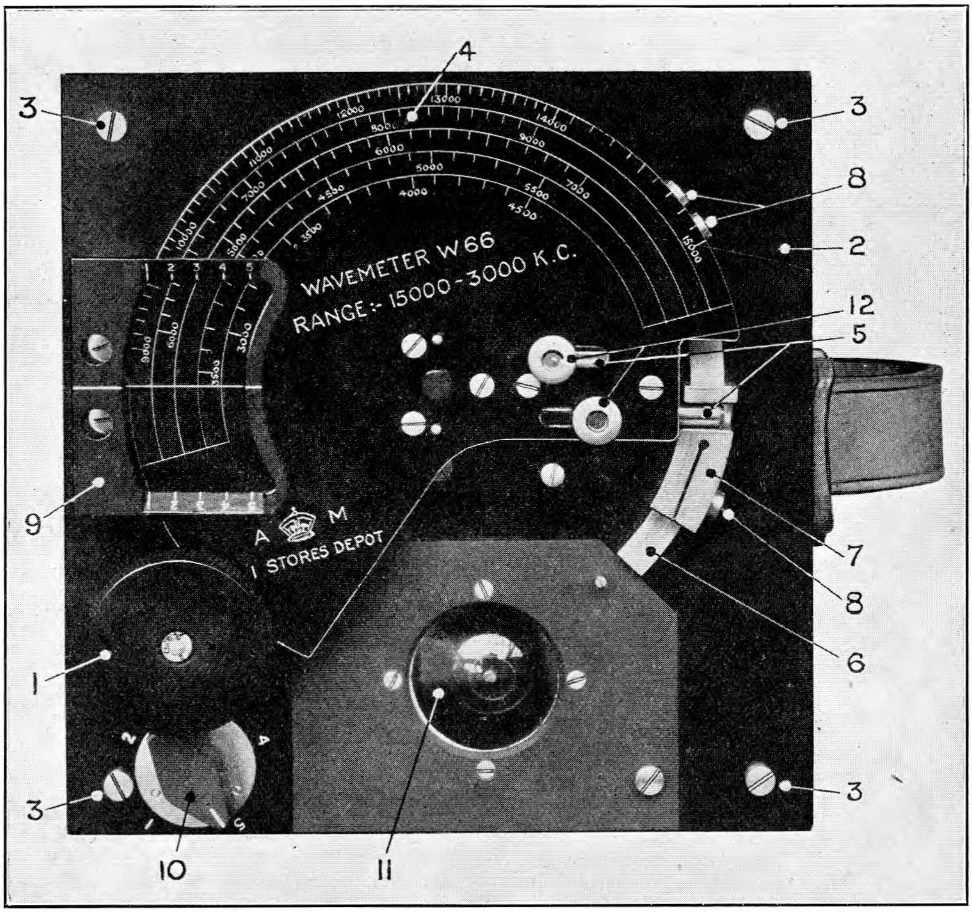


FIG. 1. Plan view of instrument.

2. The wavemeter covers the frequency band 15,000 to 3,000 kc/s (20 to 100 metres) in five ranges, the required range being selected by means of a rotary cam switch with five positions. The frequency of the wavemeter circuit is adjusted by means of a variable condenser having a metal dial on which the five scales corresponding to ranges 1, 2, 3, 4 and 5, are engraved in kilocycles, and a slow-motion device acting on the dial operates the condenser. A special locking device is incorporated in the instrument and this enables the dial to be set and locked in either

of two positions, corresponding to selected frequencies. The locking device consists of movable socket blocks on the panel in conjunction with bolts on the dial. The blocks are capable of being slid around a ring on the panel and clamped in any desired position, to allow engagement with the bolts on the dial. The dial may thus at any time be returned to and locked in a pre-determined position without any reference to scale markings.

3. A leather strap is provided on the instrument case to enable the wavemeter to be held in proximity to the transmitter, the Neon lamp being viewed through a window fitted in the panel.

GENERAL DESCRIPTION

4. A theoretical circuit diagram of the wavemeter is given in fig. 2. L is an inductance tapped at five points for the five ranges. The inductance is shunted by a fixed condenser C_1 having a capacitance of $0{\cdot}0002\mu F$. Any one of five oscillatory circuits may be brought into use by means of the switch S. In the diagram the switch is in position 3 and it will be seen that the oscillatory circuit includes the portion of the inductance below No. 3 tapping and the condenser C_1, the upper portion of the inductance being short-circuited. This oscillatory circuit is connected in parallel with the variable condenser C and the Neon lamp.

5. The maximum value of the variable condenser C is $0{\cdot}0005\mu F$ and the total value (switch in position 5) of the inductance L is such that a variation of the condenser between its minimum and maximum values varies the resonant frequency of the circuit between 4,500 and 3,000 kc/s. Placing the switch in position 4 reduces the amount of inductance across the variable condenser and Neon lamp, and setting of the condenser now adjusts the resonant frequency of the wavemeter between the limits of 5,000 and 3,500 kc/s. The amount of inductance included in the circuit is successively reduced through the ranges 3, 2, and 1, the frequencies covered being respectively 7,000 to 5,000 kc/s, 9,000 to 6,000 kc/s and 15,000 to 9,000 kc/s.

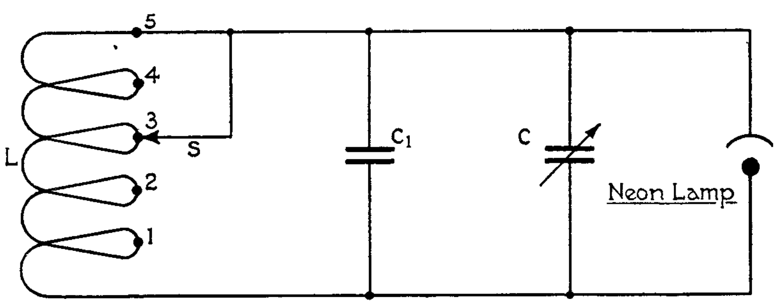


FIG. 2. Theoretical circuit diagram of Wavemeter W.66.

6. When the wavemeter is placed in proximity to a source of R/F energy (for example, a transmitter) the oscillatory current flowing in the wavemeter will increase as the wavemeter circuit is brought into resonance with the transmitter. The voltage generated across the coil causes the Neon lamp to glow and the point of exact resonance will be indicated by a maximum glow of the lamp.

7. Referring to fig. 1, which gives a view of the top of the instrument, it will be seen that the condenser is provided with a dial operated by a slow-motion knob. This dial, which is of metal, is engraved with the five frequency scales of ranges 1 to 5. The inductance, fixed condenser, variable condenser and Neon lamp are all housed inside the instrument. On the panel can be seen the handle which operates the switch S and the window through which the Neon lamp is viewed.

CONSTRUCTIONAL DETAILS

Wavemeter

8. Three views of the instrument are given in figs. 1, 3 and 4. Referring to fig. 1, the slow-motion drive (1) for the variable condenser is mounted on the panel (2) which is moulded from high-grade phenolic resin compound and is secured to the case by four screws (3). The variable condenser which is mounted on the rear of the panel, is of the "square law" type and is provided at its upper extremity with an ebonite bush to which is fixed an engraved dial (4) of nickel silver, finished black. To the underside of this dial two steel bolts (5) are fitted, each bolt being provided with a brass knob (12) protruding through a slot in the dial. Each knob has a recess in its head filled with enamel, one being coloured red and the other green.

9. On the moulded panel is fitted a brass trammel (6) on which slide two brass trammel blocks, one of which (7) may be seen, the other being obscured by the dial. Slots are cut in the trammel blocks with which the bolts engage. The blocks are provided with dimples coloured red and green respectively, to correspond with the colours on the blocks. The screws (8) are for the purpose of clamping the trammel blocks in the desired position. As will be seen from the illustration the trammel block under the dial is provided with a second clamping screw, as in certain positions of the block, the first screw may be inaccessible.

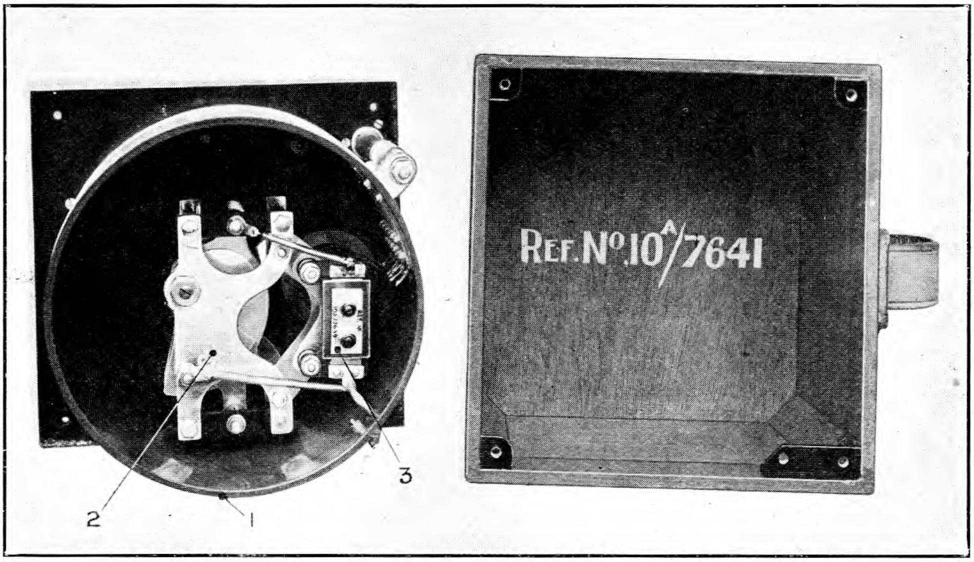


FIG. 3. Interior of instrument.

10. The fine tuning handle (1) is mounted on a brass spindle rotating in a boss in the moulded panel, and is provided with two phosphor-bronze spring discs which engage with the metal dial and rotate it slowly and precisely as the knob is turned. The indicator (9) mounted on the panel is of brass, finished black, and is provided with a white cursor line against which the scale markings are read. In addition, the indicator is marked along its side with the numbers 1, 2, 3, 4 and 5 to correspond with the five scales on the dial.

11. The five-way switch (10) which effects change-over from one range to another is of special construction. It consists of a brass spindle running the full depth of the coil former and capable of being rotated by means of a knob on the panel. Six spring contacts situated on the coil former ride on the spindle. The uppermost spring is merely a locating spring which falls into place in one of five grooves cut axially in the spindle to register engagement in the successive

positions of the switch. The spring beneath this is for the purpose of establishing a permanent brush contact with the spindle for connecting up the switch to the other parts of the circuit. The four contacts immediately beneath are engaged successively during the rotation of the spindle by four brass cams fitted on the spindle with their projecting faces separated by 72 degrees of arc.

12. When the switch is in position 5 none of the cams make contact and the whole of the inductance is connected across the condenser. The rotation of the switch to position 4 establishes connection between one of the cams and one of the spring contacts, and as the spindle (and the cams) are in electrical connection with one end of the coil, one-fifth (approximately) of the coil is short-circuited and four-fifths left in circuit. Rotation of the switch to position 3 causes the first cam to leave its contact, and the next cam to establish contact with the next spring, and as a result two-fifths (approximately) of the coil is short-circuited and three-fifths left in circuit and so on to the highest frequency (position 1) range where four-fifths (approximately) of the coil is short-circuited and one-fifth left in circuit.

13. The window (11) is of safety glass, the glass being held by a clamping ring in a cover of insulating material which is fitted over a hole in the panel and held down by two screws. Immediately beneath this window and inside the wavemeter is mounted the Neon lamp.

14. Fig. 3 gives a view of the interior of the instrument. The coil is wound on a paxolin former (1) inside which is the variable condenser (2), fixed condenser (3) and Neon lamp. The winding on the former consists of $4\frac{3}{4}$ turns of 22 s.w.g. bare tinned copper wire, looped and soldered to the various contacts. The Neon lamp is accommodated in a holder of the screw-in type and this holder and the fixed condenser are carried on a bracket fitted to the base plate of the variable condenser.

Carrying case

15. A carrying case is provided for housing the instrument when not in use. As shown in fig. 4, the case (1) is constructed of canvas-covered mahogany painted grey. The lid (2) of the case is hinged and is held shut by a press-catch (3) in which is incorporated a locking nut to prevent accidental opening. Inside the lid is housed a spare Neon lamp (4), this being screwed into a dummy socket in the corner.

OPERATION

16. The scale of range 1 is calibrated from 9,000 to 15,000 kc/s. The first calibration point is at 9,000 kc/s, and calibration points are marked at every 1,000 kc/s around the dial up to 15,000 kc/s. The distances between the 1,000 kc/s calibration are divided up into ten equal parts, thus making possible a setting at intervals of 100 kc/s.

17. The first calibration point on the scale of range 2 is at 6,000 kc/s and calibration points are marked around the scale for every 1,000 kc/s up to 9,000 kc/s. The distances between the 1,000 kc/s calibration are divided into ten equal parts, thus making possible a 100 kc/s setting on this scale. The calibrations on range 3 are from 5,000 to 7,000 kc/s at intervals of 1,000 kc/s and the space between, divided up into ten equal parts to give a 100 kc/s setting. Range 4 is calibrated from 3,500 to 5,000 kc/s in steps of 500 kc/s and the space between each calibration is divided into five equal parts to give 100 kc/s setting. Range 5 is calibrated from 3,000 to 4,500 in steps of 500 kc/s and the spaces are similarly divided into five equal parts to give 100 kc/s settings.

18. The operation of determining the frequency by the wavemeter is carried out in the following way :—The wavemeter is placed in inductive relation with the aerial coil of the transmitter and, the range switch having been set to the position corresponding to the required frequency, the slow-motion knob is turned until a maximum glow is obtained in the Neon lamp. Opposite the fine indicator line the frequency in kilocycles is then read from the appropriate scale on the dial. When checking or setting the frequency of the transmitter the dial of the

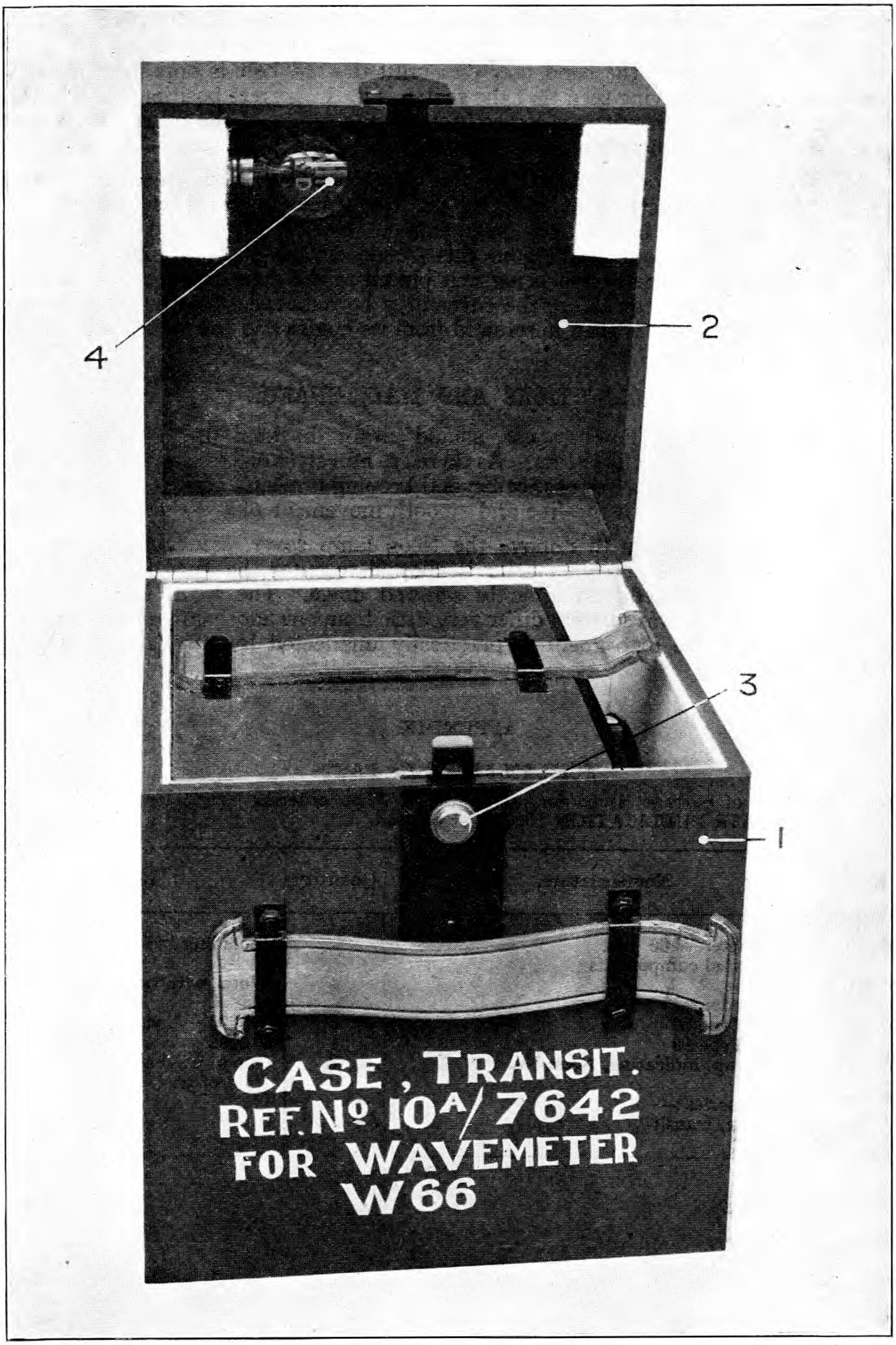


FIG. 4. Wavemeter W.66 in transit case.

wavemeter is set to the frequency required and one of the trammel blocks (say the one coloured red) is slid around to the position where it can be engaged by the red bolt. The block is then clamped in position by means of the clamping screw. For subsequent checks on this frequency it is only necessary to rotate the condenser dial until the red bolt is opposite the red block, engage the bolt and, after having seen that the switch is in the correct position, observe the glow of the Neon lamp. If the transmitter is correctly tuned a variation of the transmitter variometer will result in a decrease in the glow of the lamp.

19. Provision is made for " locking " the wavemeter at one other frequency in common use on the transmitter. Setting or checking the frequency is carried out as before except that after the wavemeter has been set the green trammel block is slid around opposite the green bolt and clamped. Subsequent settings on this frequency are made by engaging the green bolt with the green socket, the switch being first placed in the appropriate range position. In the event of failure of the Neon lamp, the cover may be removed from the panel by undoing two screws. The faulty lamp is then unscrewed from its holder and the spare lamp substituted.

PRECAUTIONS AND MAINTENANCE

20. The wavemeter, when not in use, should always be kept in its carrying case, and should not be subjected to knocks or jars. As there are no valves or batteries to deteriorate, the instrument requires very little maintenance beyond keeping it clean and dry. Dirt or grit must not be allowed to interfere with the free and smooth movement of trammel blocks and bolts.

21. Should it be necessary to remove the Neon lamp cover, care must be exercised to ensure that no dust or other foreign matter is allowed to enter the instrument, and that the cover is immediately replaced and securely screwed down. The Neon lamps (Stores Ref. 10A/7474) used with these wavemeters differ very little from one another in internal capacitance, and the calibration of the instrument is practically unaffected by substitution of the spare lamp supplied.

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.
10A/7640	Wavemeter W.66		Including inductance and switch
	Principal components :—		
10A/7641	Case	1	Wood, with leather carrying handle
	Condenser		
10A/7469	Type 80	1	$0{\cdot}0005$ μF, variable.
10A/7639	Type 93	1	$0{\cdot}0002$ μF
10A/7474	Lamp, indicating, Neon No. 1	2	One in wavemeter and one spare in lid of transit case.
	Accessories :—		
10A/7642	Case, transit	1	

SECTION 5, CHAPTER 4

WAVEMETER W.69

Contents

List of Illustrations

WAVEMETER W.69

(Stores Ref. 10A/7730)

INTRODUCTION

1. The wavemeter W.69 has been designed for use on the ground for setting low-power transmitters, such as the battery operated transmitter unit of transmitter-receiver T.R.9, and is of the type which employs a valve voltmeter to indicate resonance.

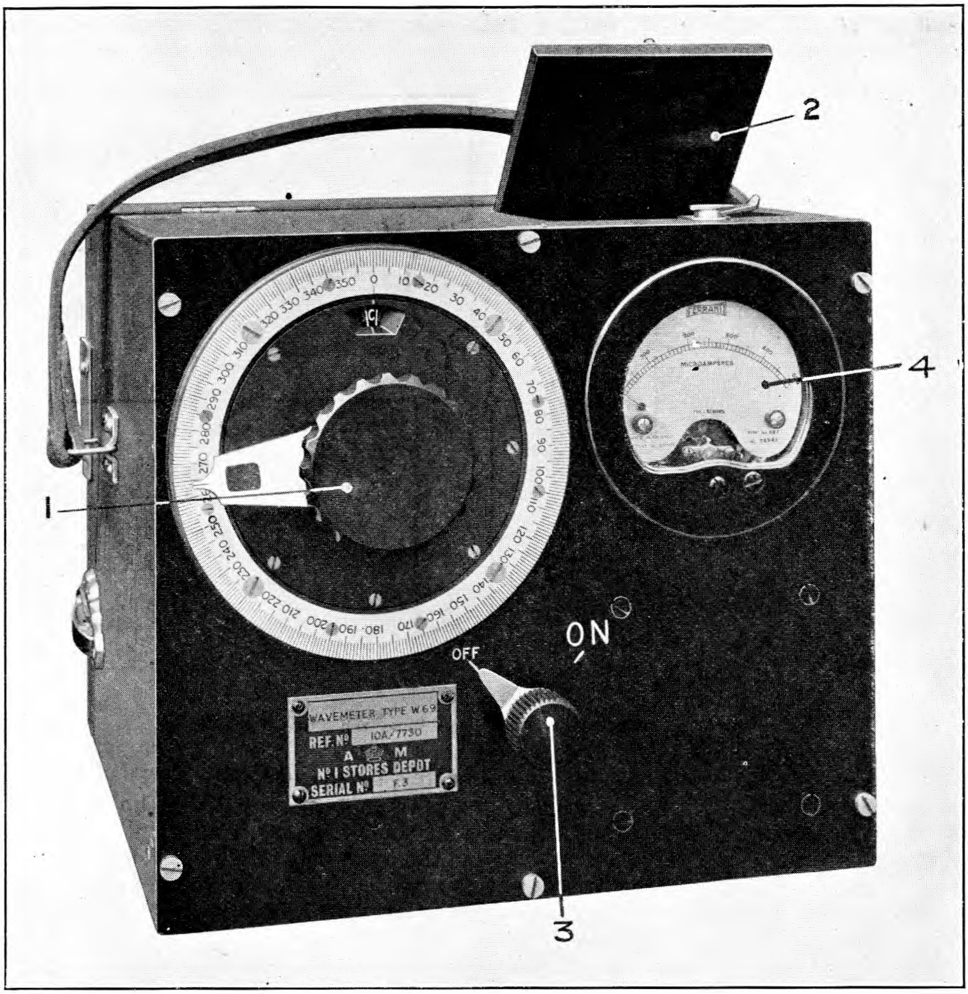


FIG. 1. Wavemeter W.69, front view.

2. The wavemeter covers the frequency 7,000–4,000 kc/s (43–75 metres), the desired frequency being obtained by means of a variable inductance in conjunction with a fixed condenser. The inductance is varied by rotating a handle on the front of the instrument, and adjacent to the handle is a microammeter, the dial of which reads from 0–500 microamps.

3. The wavemeter is entirely self-contained, the valve, H.T. battery and grid bias battery being housed in the case. The weight of the complete instrument is approximately 14 lb. 12 oz., and the dimensions approximately $8\frac{3}{4}$ in. $\times$ $7\frac{1}{2}$ in. $\times$ $9\frac{1}{2}$ in.

GENERAL DESCRIPTION

4. A theoretical circuit diagram of the wavemeter is given in fig. 2. L is an inductance provided with a variable tapping T, the effective portion of the inductance being shunted by the fixed condenser C having a capacitance of 122 $\mu\mu$F and a semi-variable condenser C_2 (6·5 to 10 $\mu\mu$F). The oscillatory circuit so formed is connected in the grid circuit of the valve V, and a grid bias battery, shunted by the condenser C_1 (·01 μF), is included between the low potential end of the inductance and the negative side of the filament circuit. The filament circuit is made and broken at the switch S, this being the only switch on the wavemeter. In the anode circuit is a 60-volt H.T. battery and a microammeter M of a specially damped type suitable for use as a resonance indicator.

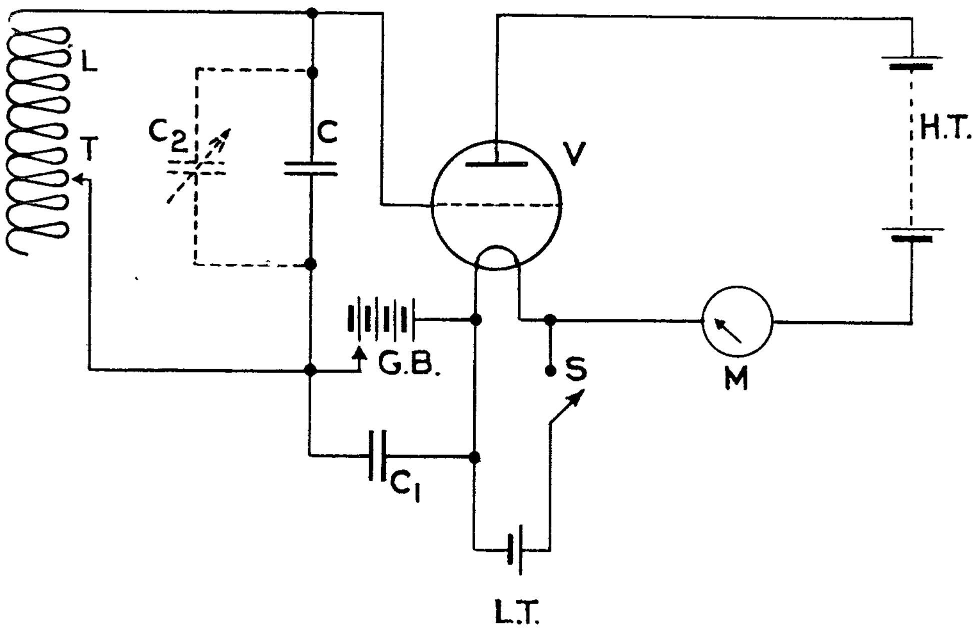


FIG. 2. Theoretical circuit diagram of Wavemeter W.69.

5. When a Cossor 210 H.F. valve is used with an anode voltage of 60 and a grid bias adjustment of —3 volts, the valve functions as an anode-bend rectifier. The standing anode current under these circumstances is of the order of 50 microamps., and a full-scale deflection is obtained on the microammeter when a voltage of the order of 2 to 3 volts R.M.S. is impressed on the grid. The calibration of the instrument as a valve voltmeter, however, is not necessary for the operation of the wavemeter since an indication of maximum current only is required. It will be apparent that the values of filament, anode and grid voltages are not critical, bias adjustment merely being provided to enable a convenient range of the microammeter scale to be used.

6. The microammeter reading increases as the wavemeter is brought into resonance with the transmitter, and at the optimum reading the tuning dial of the wavemeter, when compared with the calibration chart of the instrument, gives the frequency. As the variation of frequency is accomplished entirely by the use of a variable inductance capable of very fine adjustment, it is possible to obtain a high degree of precision in setting the wavemeter without the aid of slow-motion devices and vernier scales. The inductance consists of 15 turns of silver-plated copper tubing, any part of which may be tapped by means of a rotatable brush, and with the valve voltmeter resonance indicator described, a discrimination of ± 2 kc s can be obtained on a low-power transmitter of the type referred to above.

7. The inductance adjustment handle is provided with a pointer having a fine line engraved on it. A small window is also provided in the pointer. Near the zero on the scale is a small window at which is displayed a letter, the letter changing for each complete turn of the inductance. For the 15 turns the letters are A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q respectively, and the letter changes automatically as the pointer passes the 360 degree engraving on the scale. It will be seen that the amount of inductance in circuit may be observed at a glance, the letter indicating the number of complete turns, and the pointer reading on the 360 degree scale, the fraction of the turn. Thus A 180 indicates that there is only half a turn in circuit, whilst G 180 indicates that there are $6\frac{1}{2}$ turns in circuit. To facilitate setting and reading, the letters are coloured alternately white and yellow. Thus A, C, etc., are coloured white and B, D, etc., are coloured yellow. The line to the left of each letter is coloured the same as the letter. For the frequency band covered, the turns A to J are used.

8. The pointer can be set to within 0·5 degrees. As each turn is divided into 360 degrees there are 5,400 degrees passed through on the scale for the full range of the inductance. For the frequency range 7,000–4,000 kc/s (the range for which W.69 is used) less than 9 turns are used, and the number of degrees passed through is of the order of 3,000 degrees. An accuracy of setting within $\pm$ 2 kc/s at any frequency within the range is ensured.

9. The calibration book which has engraved on its cover the serial number of the wavemeter to which it applies, is carried in clips at the rear of the instrument. The calibrations have been carried out with the individual valve in the wavemeter. Two spare valves, matched to that in use are provided in case of breakages, and the calibrations will be entirely valueless with any valve other than those supplied.

10. The procedure in case of failure is as follows: If one of the valves should fail, no immediate action is necessary. If a second valve fails, a replacement wavemeter should at once be requisitioned. On receipt of the new wavemeter and its accessories the original equipment should be returned. It should be noted that this equipment comprises :—

The wavemeter and its case.
The calibration chart.
The valves in their transit case.

The serviceable valve must be labelled. With the exception of the transit cases, none of the above-mentioned items may be exchanged separately.

CONSTRUCTIONAL DETAILS

11. Referring to fig. 1, the case is constructed from mahogany, covered with fabric and painted grey. It is divided by means of a vertical wooden panel into two compartments. In the front compartment are located the valve and components of the wavemeter. In the rear compartment are the accumulator, and H.T. and grid bias batteries, connection to these being made by means of flexible leads brought through bushed holes in the wooden panel. Access to the batteries is obtained by undoing two catches and swinging back the hinged portion of the case. Access to the valve is obtained by undoing the catch on the top of the case and opening a small door.

12. The panel which is of duralumin carries a sub-panel at right angles to its inner face and about these panels all the components are mounted, the whole being secured to the wooden case by means of six screws. The variable inductance complete with its indicating device is bolted to the panel. The handle is equipped with a pointer which travels over a 360 degree scale. Behind the cover of the inductance unit is mounted a circular metal disc engraved with the letters A to Q, omitting I and O. The disc, the periphery of which is toothed, is mounted in such a way as to be rotatable by means of a pin on the main shaft, one letter forward for every revolution of the handle. The letters appear in succession at a small window cut in the cover of the inductance. The switch handle (3) which can be seen at the lower part of the panel operates a cam behind the panel, opening and closing two bronze contact arms fitted with gold-silver contacts. The microammeter (4) is of a specially damped type suitable for use as a resonance indicator. It has a resistance of less than 100 ohms and a scale reading of 0–500 microamps.

13. Behind the panel (*see* fig. 3) is the inductance (1) which is tuned by rotation of the handle (1, fig. 1). The inductance comprises 15 turns of silver-plated copper tube held between circular end pieces of composite insulating material which are held together by three pillars of similar material. A screw passes through the axis of the coil. Working upon this screw and operated by the handle is a nut to which are attached two spring blades which make contact with the turns of the inductance. The pitch of the screw is the same as the pitch of the coil, and rotation of the handle causes the spring blades to travel around the turns of the inductance. The valve-holder (2) which is carried on a platform immediately below the door (2, fig. 1) is moulded from a high-grade phenolic resin compound and is provided with a rubber cushion in the base.

14. The fixed condenser (3) associated with the tuning inductance has a value of 122 $\mu\mu$F and is of high-grade construction. It comprises a base plate of paxolin carrying two brass studs with distance pieces. On these studs and clamped down to the distance pieces by means of nuts and spring washers, are two brass plates between which are the plates of the condenser. The plates are of copper and the dielectric of best quality ruby mica. The fixed condenser (4) shunted across the grid bias battery is a standard commercial condenser having a value of 0·01 μF.

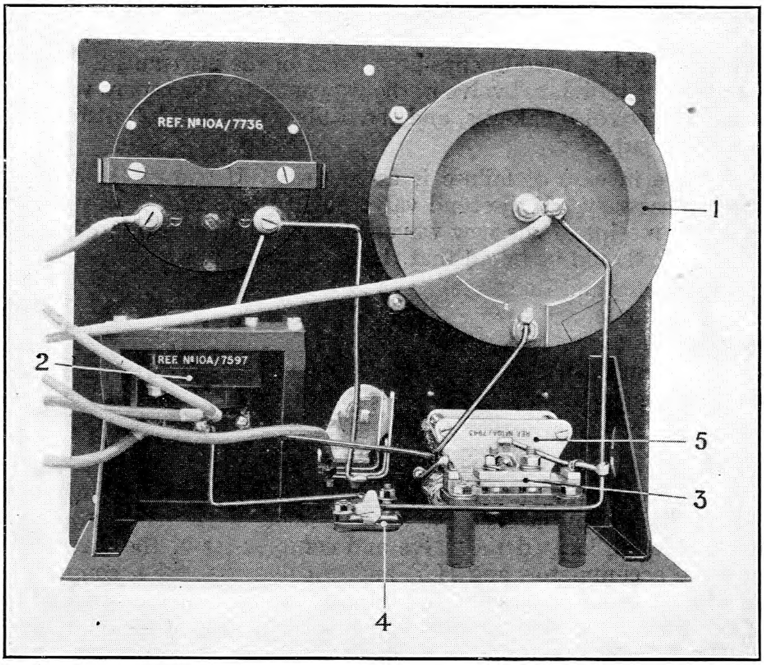


FIG. 3. Interior view.

15. The variable condenser (5) which is also in parallel with the fixed condenser (3) is for calibration purposes only. It is of the air-dielectric type having a single moving vane between two fixed vanes. It has a minimum capacitance of approximately 6·5 $\mu\mu$F and a maximum capacitance of approximately 10·0 $\mu\mu$F.

16. A transit case is provided for stowage of the wavemeter. It is constructed of wood and is provided with two strong leather carrying handles. The lid is hinged and normally held closed by two screws, but is so arranged that it can be detached from the case and fitted to a tripod. This is made possible by providing the lid with a detachable hinge and a metal boss internally threaded. The lid is placed on a standard S.4 Camera tripod and the tripod screw engaged with the threaded boss.

17. Fig. 5 shows the wavemeter in position on the lid, the latter being fitted to the tripod in the manner described. The transit case for the wavemeter may also be seen in the same illustration.

FIG. 4. Wavemeter W.69, rear view.

VALVES AND BATTERIES

18. The valve used in the wavemeter is a 210 H.F. Each wavemeter is issued with three matched valves which are stamped with the serial number to which they refer. In no circumstances must any valve other than one of those supplied be used. When replacements become necessary, the procedure outlined in para. 10 should be adopted. The H.T. is supplied from a 60-volt dry battery, the L.T. from a 2-volt unspillable accumulator, and the grid bias from a 6-volt dry battery.

OPERATION

19. *To set a transmitter to a definite frequency.*—(i) Ascertain from the calibration book the setting of the wavemeter for the required frequency.

(ii) Place the wavemeter, on its tripod, at a distance of about six feet from the transmitter and place the switch in the " on " position.

(iii) Adjust the transmitter until a maximum deflection of the wavemeter microammeter needle is obtained. If it is apparent that the reading is approaching the limit of its scale the wavemeter should be moved a little further away. Where possible, it is preferable to work with an optimum reading of about 450 microamperes.

FIG. 5. Wavemeter W.69, mounted on tripod.

(iv) Where a very precise setting of the transmitter is required the mean of two transmitter settings which give similar wavemeter indications may be taken. For example, if an optimum reading on the wavemeter microammeter of say 456 is obtained over a few degrees of adjustment of the transmitter, then two transmitter settings should be sought each of which gives a reading of say 450. The correct transmitter setting is then the mean of these two settings. When adopting this method the two transmitter settings chosen to obtain the mean should be such as to give a difference of no more than 10 microamperes from the first optimum reading.

20. *To measure the frequency of a transmitter.*—(i) Start the transmitter radiating.

(ii) Place the wavemeter in proximity to the transmitter as described in para. 17 (ii).

(iii) Rotate the tuning handle of the wavemeter until an optimum reading is obtained on the microammeter, adopting similar precautions regarding maximum scale readings as mentioned in para. 17 (iii).

(iv) Observe the reading on the wavemeter scale and compare this with the calibration book. The frequency shown opposite the wavemeter reading is the frequency being radiated by the transmitter.

PRECAUTIONS AND MAINTENANCE

21. As this wavemeter is a precision instrument having a mean discrimination of the order of 1 part in 2,500 it should be treated with great care. Mechanical shocks are liable to affect the inductance coil and so destroy the accuracy of calibration. The three valves supplied with the instrument are matched for grid-filament capacitance and the greatest care should be taken of them. Replacement by another valve even of similar type will destroy the accuracy of calibration. As the standing anode current is of the order of only 50 microamps., the electrical life of the valve should be very great, the actual life being limited by mechanical breakage.

22. Care should be taken to see that the microammeter is not overloaded as this is liable to break off the pointer or damage the spring and pivots. The instrument should be used in a position of very loose coupling to the transmitter until approximate resonance has been determined. The coupling can then be increased to give a workable deflection near the maximum of the microammeter.

23. The voltages of the batteries should be checked periodically and the batteries renewed when necessary. Care should be taken to see that the switch is in the " off " position when the wavemeter is not in use to avoid unnecessary discharge of the batteries and shortening of the life of the valve.

24. The microammeter reading for steady anode current with no high frequency voltage applied is given on the calibration chart. If the reading of the microammeter is seriously (say 25 per cent.) less than this figure, it means that either the L.T. or the H.T. battery is running down. A permanent deflection of the microammeter of greater than 500 microamps., indicates either a disconnection in the valve grid circuit or incorrect value of grid bias. The grid bias voltage should be checked and also the fit of the plugs in the battery sockets.

25. If, on switching on, an anode current reading is not obtained, the cause may be either a totally run down L.T. or H.T. battery, a disconnection in the battery circuits (other than the grid circuit), or valve failure. These points are easily checked.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/7730	Wavemeter W.69	1	Complete.
	Principal components :—		
10A/7731	Case	1	Wood with leather handle.
10A/7942	Chart, calibration	1	Each wavemeter is calibrated separately, and the charts must be used only with the appropriate wavemeter.
	Condenser		
10A/7906	Type 125	1	$0 \cdot 01$ μF, G.B shunt.
10A/7943	Type 126	1	$6 \cdot 5$ to 10 $\mu\mu$F, variable (for calibration only).
10A/7735	Type 103	1	122 $\mu\mu$F.
10A/8411	Inductance, variable	1	With indicating mechanism
10A/7736	Microammeter, type A	1	0–500
	Plug		
10A/9689	Type 89	1	Engraved H.T.+
10A/9690	Type 90	1	Engraved H T −
10A/9691	Type 91	1	Engraved G.B.+
10A/9692	Type 92	1	Engraved G B.−
10A/7737	Switch, type 55	1	Filament switch " on–off ".
10A/7597	Valve-holder, type C	1	
	Accessories :—		
5A/1386	Accumulator, 2-V, 20Ah.	1	For L.T.
5A/1251	Battery, dry, 6-volt	1	For grid bias
5A/1334	Battery, dry, 60-volt	1	For H.T. (10A/1613 for overseas use).
	Case, transit		
10A/7945	Wavemeter	1	With detachable lid.
10A/8412	Valves	1	To hold three valves
14A/690	Case, tripod	1	
14A/694	Tripod	1	S.4 Camera
10A/7946	Valve, 210 H F	3	One in wavemeter, and two spares.

SECTION 5, CHAPTER 5

WAVEMETER W.75

Contents

List of Illustrations

WAVEMETER W.75

(Stores Ref. 10A/8113)

INTRODUCTION

1. The wavemeter W.75 has been designed for use on the ground for setting low-power transmitters, such as the battery operated transmitter unit of transmitter-receiver T.R.11, and is of the type which employs a valve voltmeter to indicate resonance.

2. The wavemeter covers the frequency 4,300–3,000 kc/s (70–100 metres), the desired frequency being obtained by means of a variable inductance in conjunction with a fixed condenser. The inductance is varied by rotating a handle on the front of the instrument, and adjacent to the handle is a microammeter, the dial of which reads from 0–500 microamps.

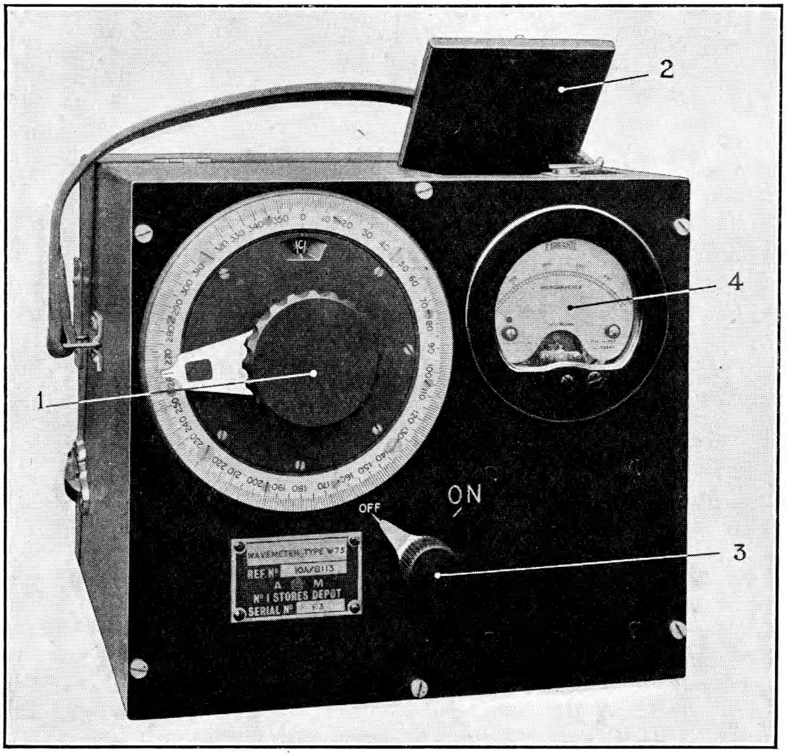


FIG. 1. Wavemeter W.75, front view.

3. The wavemeter is entirely self-contained, the valve, H.T. battery and grid bias battery being housed in the case. The weight of the complete instrument is approximately 14 lb. 12 oz., and the dimensions approximately $8\frac{3}{4}$ in. $\times$ $7\frac{1}{2}$ in. $\times$ $9\frac{1}{2}$ in.

GENERAL DESCRIPTION

4. A theoretical circuit diagram of the wavemeter is given in fig. 2. L is an inductance provided with a variable tapping T, the effective portion of the inductance being shunted by the fixed condenser C, having a capacitance of 250 $\mu\mu$F, and a semi-variable condenser C_2 (6·5 to 10 $\mu\mu$F). The oscillatory circuit so formed is connected in the grid circuit of the valve V, and a grid bias battery, shunted by the condenser C_1 (·01 μF), is included between the low potential end of the inductance and the negative side of the filament circuit. The filament

circuit is made and broken at the switch S, this being the only switch on the wavemeter. In the anode circuit is a 60-volt H.T. battery and a microammeter M of a specially damped type suitable for use as a resonance indicator.

5. When a 210 H.F. valve is used with an anode voltage of 60 and a grid bias adjustment of —3 volts, the valve functions as an anode-bend rectifier. The standing anode current in these circumstances is of the order of 50 microamps., and a full-scale deflection is obtained on the microammeter when a voltage of the order of 2 to 3 volts R.M.S. is impressed on the grid. The calibration of the instrument as a valve voltmeter, however, is not necessary for the operation of the wavemeter since an indication of maximum current only is required. It will be apparent that the values of filament, anode and grid voltages are not critical, bias adjustment merely being provided to enable a convenient range of the microammeter scale to be used.

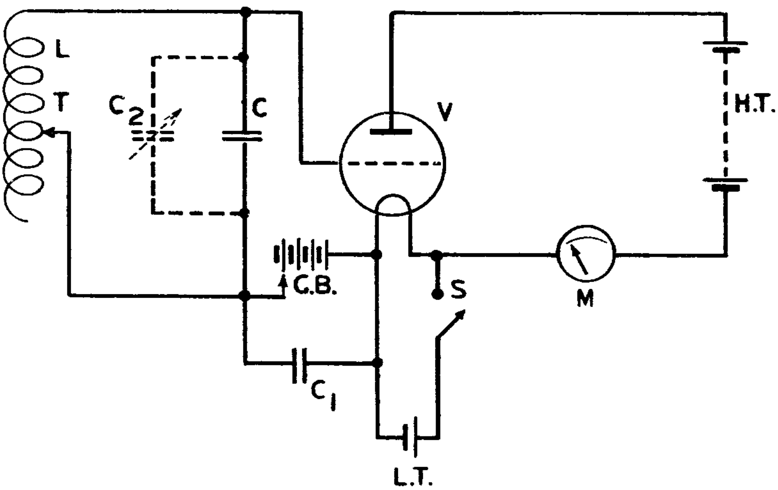


FIG. 2. Theoretical circuit diagram.

6. The microammeter reading increases as the wavemeter is brought into resonance with the transmitter, and at the optimum reading, the tuning dial of the wavemeter, when compared with the calibration chart of the instrument, gives the frequency. As the variation of frequency is accomplished entirely by the use of a variable inductance capable of very fine adjustment, it is possible to obtain a high degree of precision in setting the wavemeter without the aid of slow-motion devices and vernier scales. The inductance consists of 15 turns of silver-plated copper tubing, any part of which may be tapped by means of a rotatable brush, and with the valve voltmeter resonance indicator described, a discrimination of $\pm$ 2 kc/s can be obtained on a low-power transmitter of the type referred to above.

7. The inductance adjustment handle is provided with a pointer having a fine line engraved on it. A small window is also provided in the pointer. Near the zero on the scale is a small window at which is displayed a letter, the letter changing for each complete turn of the inductance. For the 15 turns the letters are A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q respectively, and the letter changes automatically as the pointer passes the 360 degree engraving on the scale. It will be seen that the amount of inductance in circuit may be observed at a glance, the letter indicating the number of complete turns, and the pointer reading on the 360 degree scale, the fraction of the turn. Thus A 180 indicates that there is only half a turn in circuit, whilst G 180 indicates that there are 6½ turns in circuit. To facilitate setting and reading, the letters are coloured alternately white and yellow. Thus A, C, etc., are coloured white and B, D, etc., are coloured yellow. The line to the left of each letter is coloured the same as the letter. For the frequency band covered turns, H to P are used.

8. The pointer can be set to within 0·5 degrees. As each turn is divided into 360 degrees there are 5,400 degrees passed through on the scale for the range of the inductance. For the

frequency range 4,300–3,000 kc/s (the range for which W.75 is used) less than 7 turns are used, and the number of degrees passed through is of the order of 2,500. An accuracy of setting within $\pm$ 2 kc/s at any frequency within the range is ensured.

9. The calibration book which has engraved on its cover the serial number of the wavemeter to which it applies, is carried in clips at the rear of the instrument. The calibrations have been carried out with the individual valve in the wavemeter. Two spare valves, matched to that in use, are provided in case of breakages, and the calibrations will be entirely valueless with any valve other than those supplied.

10. The procedure in case of failure is as follows. If one of the valves should fail, no immediate action is necessary. If a second valve fails, a replacement wavemeter should at once be requisitioned. On receipt of the new wavemeter and its accessories the original equipment should be returned. It should be noted that this equipment comprises :—

The wavemeter and its case.
The calibration chart.
The valves in their transit case.

The serviceable valve must be labelled. With the exception of the transit cases, none of the above-mentioned items may be exchanged separately.

FIG. 3. Wavemeter W.75, rear view.

CONSTRUCTIONAL DETAILS

11. Referring to fig. 1. the case is constructed from mahogany, covered with fabric and painted grey. It is divided by means of a vertical wooden panel into two compartments. In the front compartment are located the valve and components of the wavemeter. In the rear

compartment are the accumulator, and H.T. and grid bias batteries, connection to these being made by means of flexible leads brought through bushed holes in the wooden panel. Access to the batteries is obtained by undoing two catches and swinging back the hinged portion of the case. Access to the valve is obtained by undoing the catch on the top of the case and opening a small door.

12. The panel which is of duralumin carries a sub-panel at right angles to its inner face and about these panels all the components are mounted, the whole being secured to the wooden case by means of six screws. The variable inductance complete with its indicating device is bolted to the panel. The handle is equipped with a pointer which travels over a 360 degree scale. Behind the cover of the inductance unit is mounted a circular metal disc engraved with

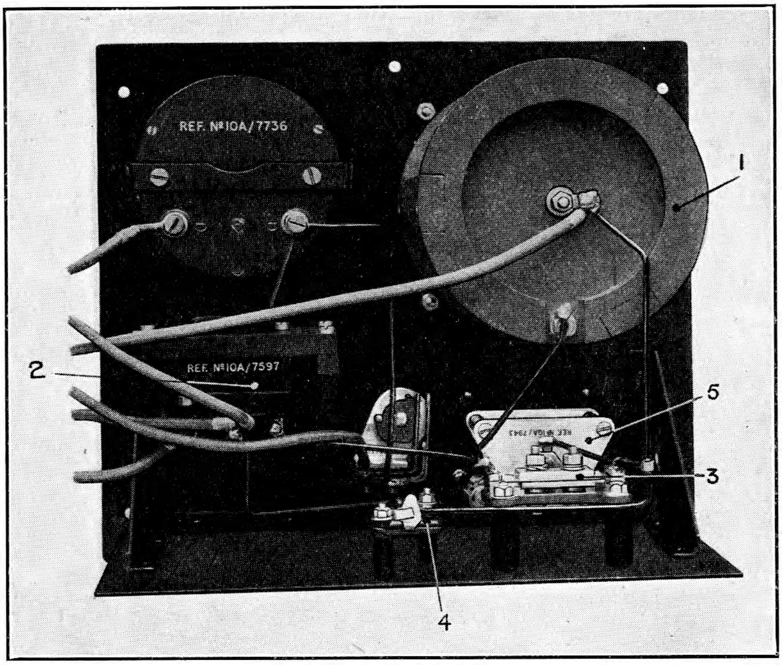


FIG. 4. Interior view.

the letters A to Q, but omitting I and O. The disc, the periphery of which is toothed, is mounted in such a way as to be rotatable by means of a pin on the main shaft, one letter forward for every revolution of the handle. The letters appear in succession at a small window cut in the cover of the inductance. The switch handle (3) which can be seen at the lower part of the panel operates a cam behind the panel, opening and closing two bronze contact arms fitted with gold-silver contacts. The microammeter (4) is of a specially damped type suitable for use as a resonance indicator. It has a resistance of less than 100 ohms and a scale reading of 0–500 microamps.

13. Behind the panel (*see* fig. 4) is the inductance (1) which is tuned by rotation of the handle (1, fig. 1). The inductance comprises 15 turns of silver-plated copper tube held between circular end pieces of composite insulating material which are held together by three pillars of similar material. A screw passes through the axis of the coil. Working upon this screw and operated by the handle, is a nut to which are attached two spring blades which make contact with the turns of the inductance. The pitch of the screw is the same as the pitch of the coil, and rotation of the handle causes the spring blades to travel around the turns of the inductance.

The valve holder (2) which is carried on a platform immediately below the door (2, fig. 1) is moulded from a high-grade phenolic resin compound and is provided with a rubber cushion in the base.

14. The fixed condenser (3), associated with the tuning inductance, has a value of 250 $\mu\mu F$ and is of high-grade construction. It comprises a base plate of paxolin carrying two brass studs with distance pieces. On these studs and clamped down to the distance pieces by means

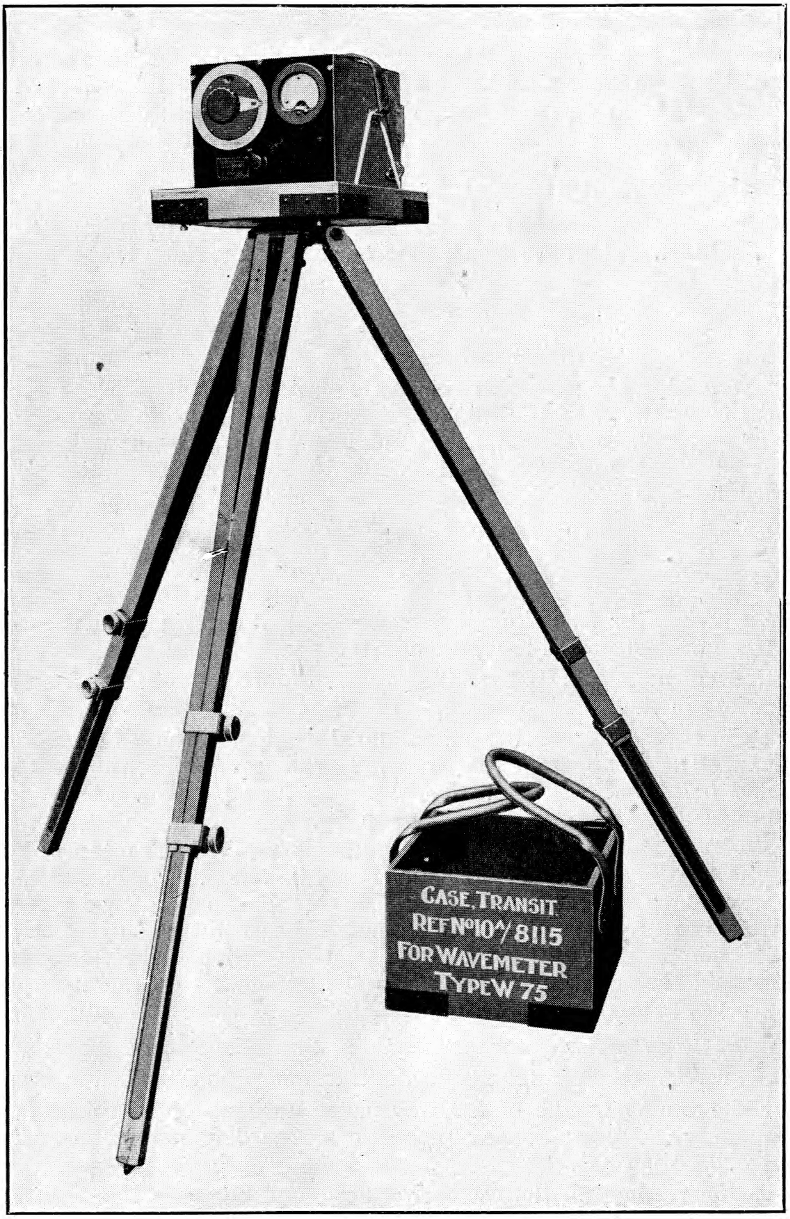


FIG. 5. Wavemeter W.75, mounted on tripod.

of nuts and spring washers, are two brass plates between which are the plates of the condenser. The plates are of copper and the dielectric of best quality ruby mica. The fixed condenser (4) shunted across the grid bias battery is a standard commercial condenser having a value of $\cdot 01\ \mu F$.

15. The variable condenser (5) which is also in parallel with the fixed condenser (3) is for calibration purposes only. It is of the air-dielectric type having a single moving vane between two fixed vanes. It has a minimum capacitance of approximately $6\cdot 5\ \mu\mu F$. and a maximum capacitance of approximately $10\cdot 0\ \mu\mu F$.

16. A transit case is provided for the stowage of the wavemeter. It is constructed of wood and is provided with two strong leather carrying handles. The lid is hinged and normally held closed by two screws, but is so arranged that it can be detached from the case and fitted to a tripod. This is made possible by providing the lid with a detachable hinge and a metal boss internally threaded. The lid is placed on a standard S.4 Camera tripod and the tripod screw engaged with the threaded boss.

17. Fig. 5 shows the wavemeter in position on the lid, the latter being fitted to the tripod in the manner described. The transit case may be seen in the same figure.

VALVES AND BATTERIES

18. The valve used in the wavemeter is a valve type 210 H.F. Three matched valves are supplied with each wavemeter and in no circumstances must any other valve be used. When replacements are required, the procedure set out in para. 10 must be adopted. The H.T. is supplied from a 60-volt dry battery, the L.T. from a 2-volt accumulator, and the grid bias from a 6-volt dry battery.

OPERATION

19. *To set a transmitter to a definite frequency.*—(i) Ascertain from the calibration book the setting of the wavemeter for the required frequency.

(ii) Place the wavemeter (on its tripod) at a distance of about six feet from the transmitter and place the switch in the " on " position.

(iii) Adjust the transmitter until a maximum deflection of the wavemeter microammeter needle is obtained. If it is apparent that the reading is approaching the limit of its scale the wavemeter should be moved a little further away. Where possible, it is preferable to work with an optimum reading of about 450 microamperes.

(iv) Where very precise setting of the transmitter is required the mean of two transmitter settings which give similar wavemeter indications may be taken. For example, if an optimum reading on the wavemeter microammeter of say 456 is obtained over a few degrees of adjustment of the transmitter, then two transmitter settings should be sought each of which gives a reading of, say 450. The correct transmitter setting is then the mean of these two settings. When adopting this method the two transmitter settings chosen to obtain the mean should be such as to give a difference of no more than 10 microamperes from the first optimum reading.

20. *To measure the frequency of a transmitter.*—(i) Start the transmitter radiating.

(ii) Place the wavemeter in proximity to the transmitter as described in para. 19 (ii).

(iii) Rotate the tuning handle of the wavemeter until an optimum reading is obtained on the microammeter, adopting similar precautions regarding maximum scale readings as mentioned in para. 19 (iii).

(iv) Observe the reading on the wavemeter scale and compare this with the calibration book. The frequency shown opposite the wavemeter reading is the frequency being radiated by the transmitter.

PRECAUTIONS AND MAINTENANCE

21. As this wavemeter is a precision instrument having a mean discrimination of the order of 1 part in 2,500 it should be treated with great care. Mechanical shocks are liable to affect the inductance coil and so destroy the accuracy of calibration. The three valves supplied with the instrument are matched for grid-filament capacitance and the greatest care should be taken of them. Replacement by another valve even of similar type will destroy the accuracy of calibration. As the standing anode current is of the order of only 50 microamps. the electrical life of the valve should be very great, the actual life being limited by mechanical breakage.

22. Care should be taken to see that the microammeter is not overloaded as this is liable to break off the pointer or damage the spring and pivots. The instrument should be used in a position of very loose coupling to the transmitter until approximate resonance has been determined. The coupling can then be increased to give a workable deflection near the maximum of the microammeter.

23. The voltages of the batteries should be checked periodically and the batteries renewed when necessary. Care should be taken to see that the switch is in the " off " position when the wavemeter is not in use in order to avoid unnecessary discharge of the batteries and shortening of the life of the valve.

24. The microammeter reading for steady anode current with no high frequency voltage applied is given on the calibration chart. If the reading of the microammeter is seriously less than this figure (say 25 per cent.), it means that either the L.T. or the H.T. battery is running down. A permanent deflection of the microammeter of greater than 500 microamps., indicates either a disconnection in the valve grid circuit or incorrect value of grid bias. The grid bias voltage should be checked and also the fit of the plugs in the battery sockets.

25. If, on switching on, an anode current reading is not obtained, the cause may be either a totally run down L.T. or H.T. battery, a disconnection in the battery circuits (other than the grid circuit), or valve failure. These points are easily checked.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/8113	Wavemeter W.75	1	Complete.
	Principal components :—		
10A/7731	Case	1	Wood with leather handle.
10A/8299	Chart, calibration	1	Each wavemeter is calibrated separately, and the charts must be used only with the appropriate wavemeter.
	Condenser		
10A/7906	Type 125	1	0·01 μF, G.B. shunt.
10A/7943	Type 126	1	6·5 to 10 μμF variable (for calibration only).
10A/8116	Type 147	1	250 μμF.
10A/8411	Inductance, variable	1	With indicating mechanism.
10A/7736	Microammeter, type A	1	0–500.
	Plug		
10A/9689	Type 89	1	Engraved H.T.+
10A/9690	Type 90	1	Engraved H.T.−
10A/9691	Type 91	1	Engraved G.B.+
10A/9692	Type 92	1	Engraved G.B.−
10A/7737	Switch, type 55	1	Filament switch " on-off ".
10A/7597	Valve-holder, type C	1	
	Accessories :—		
5A/1386	Accumulator, 2-V., 20 Ah.	1	For L.T.
5A/1251	Battery, dry, 6-volt	1	For grid bias.
5A/1334	Battery, dry, 60-volt	1	For H.T. (10A/1613 for overseas use).
	Case, transit		
10A/8115	Wavemeter	1	With detachable lid.
10A/8412	Valves	1	To hold three valves.
14A/690	Case, tripod	1	
14A/694	Tripod	1	S.4 Camera.
10A/7946	Valve, 210 H.F.	3	One in wavemeter, and two spares.

SECTION 5, CHAPTER 6

WAVEMETER W.1081

Contents

List of Illustrations

WAVEMETER W.1081

(Stores Ref. 10A/8405)

INTRODUCTION

1. Wavemeter W.1081 has been designed for use on the ground with aircraft transmitters to cover the two frequency bands 15,000 to 3,000 kc/s and 500 to 135 kc/s. The instrument is capable of being adjusted to indicate a difference of $\pm$ 2 kc/s from 6,000 kc/s downwards. The frequency discrimination is as fine as possible from 6,000 kc/s up to 15,000 kc/s.

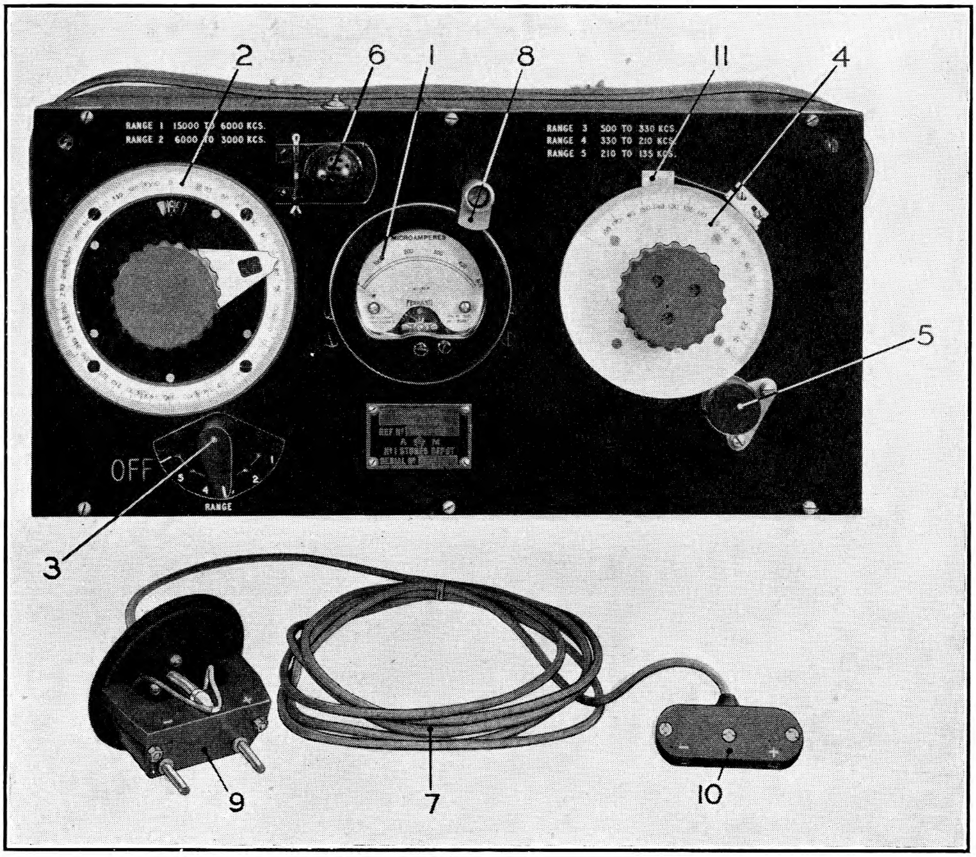


FIG. 1. Wavemeter W.1081.

2. The two frequency bands are sub-divided into five ranges, any one of which may be obtained by means of a selector switch on the front panel. The frequency band 15,000 to 3,000 kc/s is covered by ranges 1 and 2, thus range 1 covers 15,000 to 6,000 kc/s, and range 2 covers 6,000 to 3,000 kc/s. The other frequency band is split up into three ranges as follows :—Range 3 is 500 to 330 kc/s, range 4 is 330 to 210 kc/s, and range 5 is 210 to 135 kc/s.

3. For the frequency band 15,000 to 3,000 kc/s there is provided an oscillatory or resonant circuit comprising a variable inductance and a fixed condenser, and for the frequency band 500 to 135 kc/s, there is provided an oscillatory circuit comprising one of two inductances and a variable tuning condenser which is provided with a fine tuning control and vernier index.

4. Resonance is indicated by means of an anode-bend detector valve, in the anode circuit of which is a microammeter. This microammeter is removable from the wavemeter, being locked into position normally by means of a turn-button on the front of the instrument. When removed, the microammeter can be connected to the wavemeter by means of a pair of leads and a specially designed plug and socket. This arrangement allows the microammeter to be placed in a convenient position for taking readings remote from the wavemeter.

GENERAL DESCRIPTION

5. A front view of the wavemeter is given in fig. 1 and a theoretical circuit diagram in fig. 2. Referring to fig. 2, it will be seen that the circuit comprises an inductance and a condenser forming an oscillatory circuit across which is connected a resonance indicator, the indicator being a specially damped microammeter M (reading 0 to 500 microamperes) in the anode circuit of the anode-bend rectifying valve V.

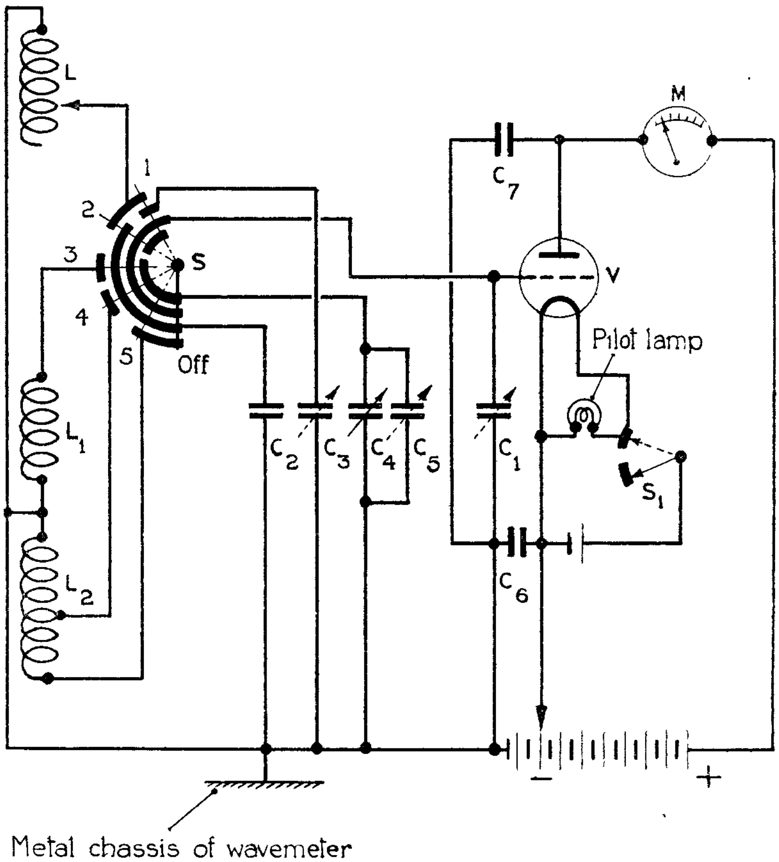


FIG. 2. Theoretical circuit diagram of Wavemeter W.1081.

6. For the frequency band 15,000 to 3,000 kc/s, covering the ranges 1 and 2, the oscillatory circuit is composed of the variable inductance coil L and alternative condensers C_3 and C_2. For the frequency band 500 to 135 kc/s which is sub-divided into three ranges (3, 4 and 5), oscillatory circuits are provided comprising an inductance coil L_1, a tapped inductance coil L_2, and a variable tuning condenser C_4. For range 3, the inductance L_1 and condenser C_4 are used and for range 4, the tapped portion of the inductance L_2 and the condenser C_4. For range 5,

the whole of the inductance L_2 and the condenser C_4, are employed. A pre-set condenser C_5 is connected across the condenser C_4 for calibration purposes. The condenser C_2 which is introduced for range 2 is also connected across the tuning condenser C_4 for the ranges 3, 4 and 5.

7. Any of the ranges may be selected by means of the switch S which alters the coil and condenser connections. This switch is mechanically coupled to the switch S_1, and when S is in the " off " position, the filament circuit of the valve is opened. Connection is made from the various oscillatory circuits, to the grid of the valve V through the switch S, and to the filament of the valve through a grid bias battery, across which is connected a by-pass condenser C_6. The switch S is arranged to change over the grid circuit of the valve from the high frequency coil to the low frequency coils without opening the grid circuit, in order to avoid abnormally high anode currents and consequent damage to the indicator.

8. A trimming condenser C_1, common to both frequency bands, is provided to enable an adjustment to be made to compensate for a possible change in the inter-electrode capacitance of the substituted valve. Three valves are provided, however, of similar inter-electrode capacitance, and this trimming condenser will require no adjustment during the life of these three valves. In any event no adjustment must be made to this condenser except by authorized personnel.

CONSTRUCTIONAL DETAILS

Wavemeter

9. Three views of the wavemeter are given in figs. 1, 3 and 4. Referring to fig. 1 which is a view of the wavemeter from the front, the approximate weight of the instrument is $19\frac{1}{2}$ lb. and its dimensions are 17 in. $\times$ 12 in. $\times$ $7\frac{1}{2}$ in. This weight is inclusive of the batteries.

10. The microammeter (1) is removable. It is held in position normally by means of the turn-button (8). When the microammeter is removed, it is replaced by the plug (9) which is connected by a pair of leads (7) to the socket (10). This arrangement is provided so that the microammeter can be conveniently read should it be necessary to place the wavemeter in such a position that, if the microammeter were in the instrument, the reading could not be conveniently observed.

11. To the right of the microammeter (1) is the condenser control knob. It is fitted with a circular scale (4) engraved in degrees from 0 to 180. Ten additional divisions are provided after the 180° mark. The slow-motion drive (5) consists of two friction discs, and a vernier (11) allows readings of $\frac{1}{10}$th of a degree to be obtained.

12. On the left-hand side of the front panel is mounted the variable inductance control. The fixed scale (2) is engraved in degrees from 0 to 360. Near the top of the scale is a small window through which a letter is visible. As there are 15 turns on the inductance, 15 letters namely: A, B, C, D, E, F, G, H, J, K, L, M, N, P and Q are engraved on a rotatable scale. The letters are filled in alternately white and yellow, thus A, C, etc., are white, and B, D, etc., are yellow. The line engraved to the left of each letter is the same colour as the letter. As the pointer passes over the 360° mark the letter changes automatically. It is thus possible to know the number of complete turns and fractions of a turn in circuit. Thus as shown in the illustration there are 2·2 or nearly $2\frac{1}{4}$ turns in circuit.

13. The perforated metal dome (6) covers the pilot lamp. This lamp is in the valve filament circuit and serves as a visible indication that the filament switch is on. The range change switch (3) in the bottom left-hand corner has six positions, one for each of the five ranges and an " off " position. In the " off " position the filament circuit is broken.

14. The interior view of the wavemeter given in fig. 3, shows the components mounted under the front panel. The variable inductance (1) can be seen in the top right-hand corner. It consists of 15 turns of copper tubing, any part of which may be tapped by means of a rotatable laminated brush. The small pre-set condenser (2) below the inductance has a value of between 23 and 29 $\mu\mu$F and is represented by C_3 in the theoretical circuit diagram, fig. 2. It forms, with the variable inductance, the oscillatory circuit for range 1.

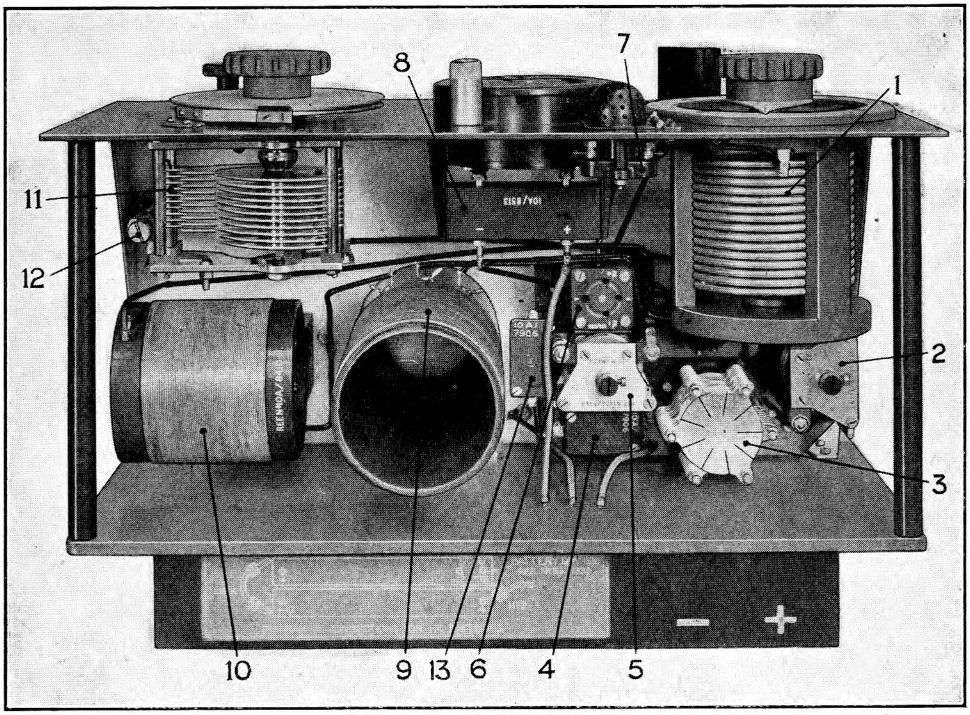


FIG. 3. Interior view.

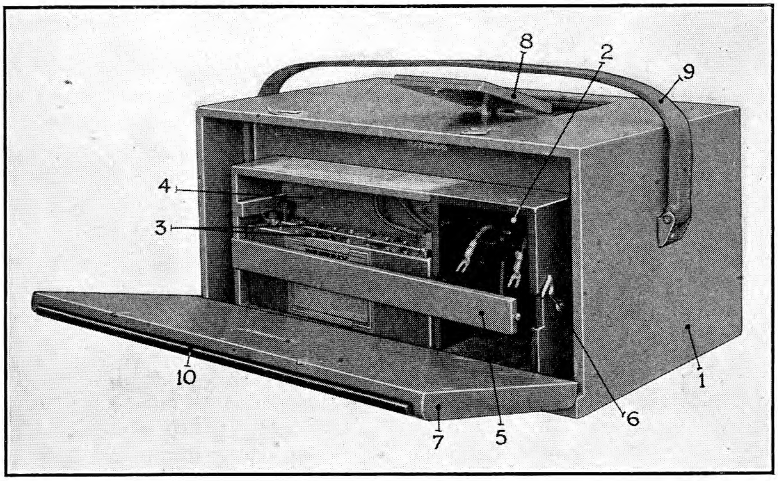


FIG. 4. Rear view of Wavemeter W.1081

15. The 225 $\mu\mu$F condenser (3) is represented by C_2 in fig. 2. To the left of it is a fixed ·01 μF condenser (4) which acts as the grid bias shunt. The pre-set condenser (5) above it has a value of 10 $\mu\mu$F (max.). This is the valve compensating condenser and is used for calibration purposes only. It must not be interfered with in any circumstances, otherwise the calibration of the wavemeter will be affected for all ranges. The valve-holder (6) can be seen above the condenser (5). The pilot lamp fitting (7) is mounted under the front panel. To the left of the valve-holder (6) can be seen the ·01 μF condenser (13) which is connected between the anode terminal of the valve and the chassis.

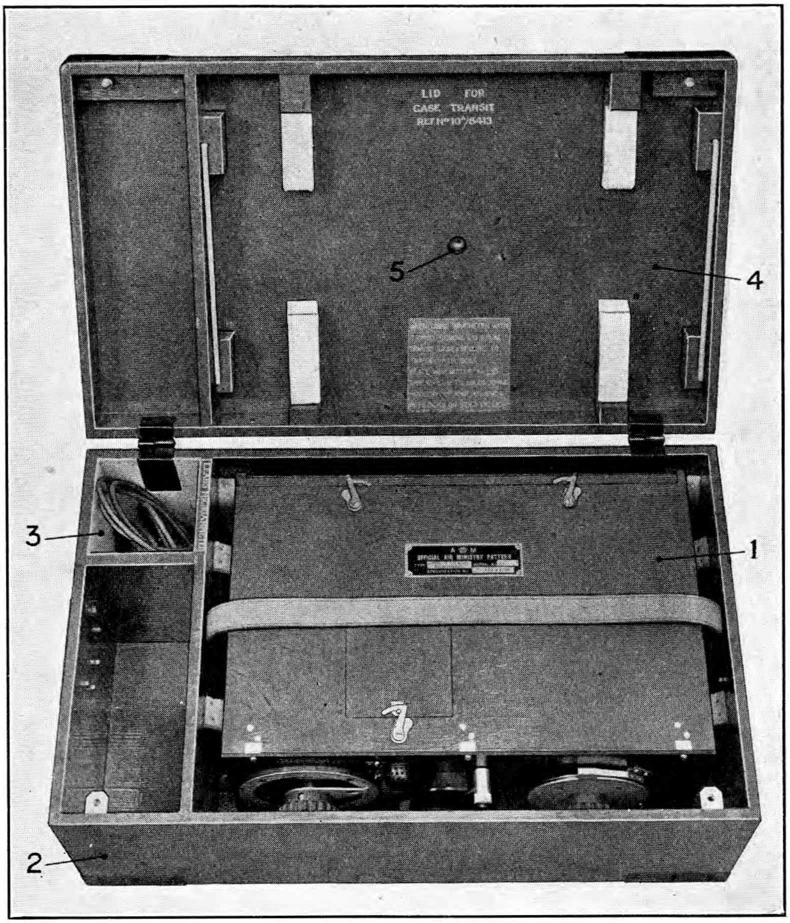


FIG. 5. Wavemeter W.1081 in its transit case.

16. The block (8) seen under the microammeter is provided with two sockets. When the microammeter is in position, two plugs fit into these sockets. When the microammeter is removed, the two prongs on the plug (9, fig. 1) fit into the sockets, and the microammeter plugs are inserted in the socket (10, fig. 1).

17. The tapped inductance (9) is used on ranges 4 and 5. It consists of a former of synthetic-resin varnish paper tube and is wound with 212 turns of 28 s.w.g. double silk-covered copper wire and tapped at 109 turns from the start. The tapped portion is used on range 4 and the whole coil on range 5. The inductance (10) is used on range 3. It consists of $70\frac{1}{2}$ turns of 24 s.w.g. double silk-covered copper wire wound on a former similar in construction to that of (9), but mounted at right angles. Above the inductance (10) is the variable condenser (11). It has a value of 510 $\mu\mu$F (max.) and is represented by C_4 in the theoretical circuit diagram, fig. 2. To the left of condenser (11) is a small pre-set condenser (12), represented by C_5 in fig. 2.

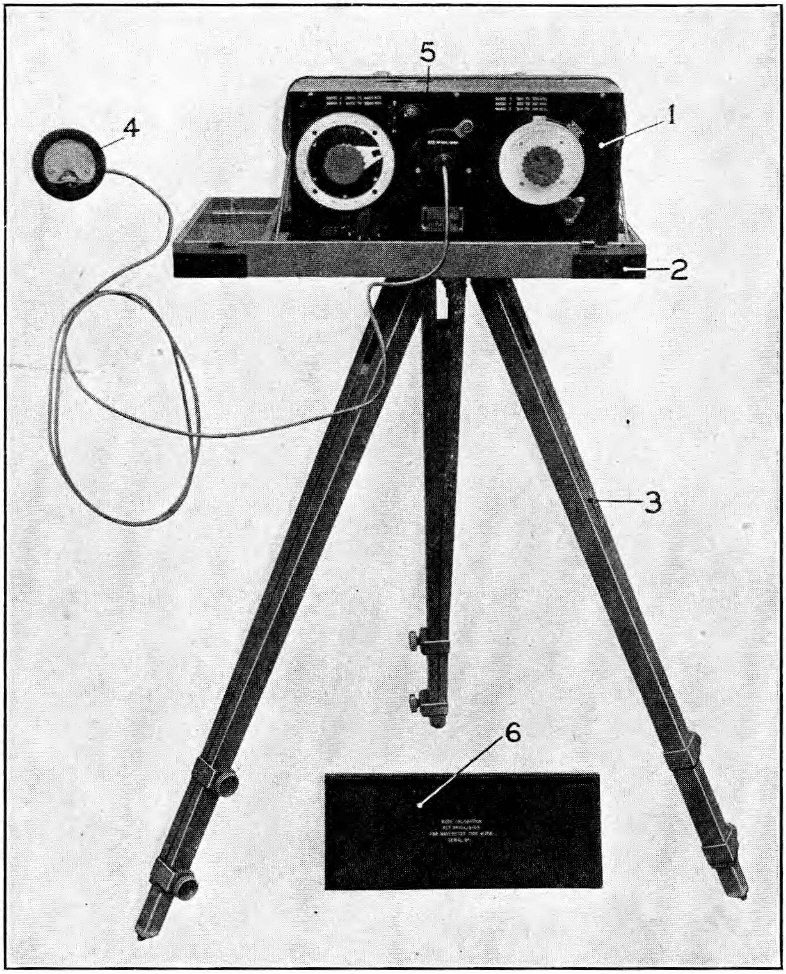


FIG. 6. Wavemeter W.1081 on tripod.

Case

18. Fig. 4 is a view of the wavemeter from the rear. As can be seen from the illustration, the case (1) is designed so as to house the wavemeter and its associated batteries. The 2-volt accumulator is contained in the compartment (2) on the right and the two 15-volt units (3) are on the left. Flexible leads are taken through holes in the rear of the battery compartment (4) to the appropriate components of the wavemeter.

19. When it is desired to remove the accumulator or the dry batteries, a catch (6) on the right-hand side of the compartment (4) is undone, and the retaining arm (5) may then be moved about its hinge. The cover (7) which also forms the rear wall of the wavemeter is held in the closed position by means of two spring catches, provided on the top of the wavemeter. The calibration book (10) is normally held by means of spring clips on the underside of the cover (7). Access to the valves is obtained through the trap door (8). The leather carrying strap (9) is secured to each side of the wavemeter by means of a bolt which passes through the loop in the strap and also through the bracket. This new method is a modification of the old type of fixture whereby the strap was secured to the bracket by a wire link. All wavemeters in service should be modified to incorporate the new fixture (*see* A.P.1186, D.9).

Transit case

20. The complete wavemeter (1), housed in its transit case (2), is illustrated in fig. 5. Of the two compartments on the left, the upper compartment (3) houses the special plug and socket connection used when the microammeter is removed from the wavemeter. The lid (4) is detachable. If it is moved to the left the special hinges come apart. This arrangement is provided in order that the lid may be used as a support for mounting the wavemeter on a tripod.

21. A standard S.4 camera tripod is used. The screw on the tripod is engaged with the internally threaded boss (5) 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.

22. Fig. 6 shows the wavemeter (1) and lid (2) mounted on the tripod (3). The microammeter (4) has been removed and the plug (5) inserted in its place. Underneath the tripod can be seen the calibration book (6). Each wavemeter has its own calibration book which is engraved with the serial number of the wavemeter to which it applies.

VALVES AND BATTERIES

23. The valve used in the wavemeter is a valve type V.W.36. Each instrument is supplied with three valves, the three being " matched ", so that if any one of the valves is used the calibration will remain correct. In no instance must any other valve, but one of the three supplied be used, as the calibration will suffer if a valve having a different inter-electrode capacitance is used. The valves, valve cartons and valve transit case are engraved with the serial number of the wavemeter for which they are intended.

24. The procedure in case of failure is as follows :—Should one valve become unserviceable, no immediate action is necessary. If a second valve fails, a replacement wavemeter should be requisitioned at once. On receipt of the wavemeter and its accessories, the original equipment should be returned. It should be noted that this equipment comprises :—

The wavemeter and its case.

The calibration chart.

The three valves in their transit case (the serviceable valve being labelled).

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

25. The L.T. supply is obtained from a 2-volt, 7 Ah. accumulator, and the requisite grid and anode voltages from two 15-volt batteries connected in series. The H.T.— and H.T. 1 leads are connected respectively to the 15-volt and 12-volt (negative) sockets of the first battery. The H.T. 2 lead is connected to the 0 (positive) socket of the second battery. The 0 (positive) socket of the first battery and the 15-volt (negative) socket of the second battery are connected together.

26. These connections will give an effective grid voltage of —3 volts, and an anode voltage of 27 volts with respect to the negative end of the valve filament. The batteries are contained in a compartment in the case of the instrument, access to them being obtained by opening a hinged cover at the back of the wavemeter. Access to the valve is obtained by opening a hinged cover in the top of the instrument (*see* fig. 4).

OPERATION

27. Before commencing any operation, see that the batteries are in position and that they are connected up correctly. This is important, for if the grid bias connection is left off, the microammeter may be damaged. Insert one of the three valves in the valve-holder. Set the range switch to the appropriate range.

To set a transmitter to a definite frequency

28. (i) The settings for the appropriate controls on the wavemeters are first found by referring to the calibration chart under the desired frequency. The controls are set and the wavemeter placed about six feet from the transmitter. The L.T. should now be switched on.

(ii) Adjust the transmitter so that a maximum deflection is obtained on the microammeter. It is essential to position the wavemeter so that the maximum deflection does not exceed 500 microamperes. If the reading is approaching the limit of the scale, the wavemeter should be moved further away. An optimum reading of about 450 microamperes is the most favourable condition.

(iii) When it is desired to obtain a very precise setting of the transmitter, the mean of two transmitter settings is obtained. These two settings should be the same, one on each side of the desired setting. If for example an optimum reading of 456 microamperes is obtained on the microammeter over a few degrees of adjustment of the transmitter, two transmitter settings should be found, each of which gives 450 microamperes. The mean of these two is then the correct transmitter setting. When employing this method, a difference of not more than 10 microamperes from the first optimum reading should be arrived at.

To measure the frequency of a transmitter

29. (i) Start the transmitter radiating.

(ii) Place the wavemeter in proximity to the transmitter as described in para. 28 (ii).

(iii) Adjust the wavemeter controls until an optimum reading is obtained on the microammeter, using the same precautions as in para. 28 (iii).

(iv) Observe the wavemeter settings and determine the radiated frequency by reference to the calibration chart.

PRECAUTIONS AND MAINTENANCE

30. As the wavemeter is a precision instrument having a maximum discrimination of the order of 1 part in 2,500, it should be treated with great care. Mechanical shocks are liable to affect some of the components and destroy the accuracy of calibration. As the grid-filament capacitance of the valve enters into the calibration, the wavemeter must be used *only* with one of the three valves supplied. In order to avoid the necessity for recalibration, great care should be taken of the valves, both mechanically and electrically, to ensure as long a life as possible.

31. The full scale reading of the microammeter should never be exceeded. This condition might arise if the instrument were overloaded, or the wavemeter too tightly coupled with the transmitter, or should any defect occur in the grid-filament circuit with the valve switched on. Any of the above causes may result in the pointer of the microammeter being bent or broken off, or damage may be sustained to the spring and pivots.

32. The voltage of the batteries should be checked periodically, as if the grid bias voltage is low, a large deflection will be obtained on the microammeter. When not in use the wavemeter should be switched off, in order to avoid unnecessary discharge of the batteries. A pilot lamp is connected across the valve filament.

33. A permanent deflection in the microammeter greater than 500 microamperes points to a disconnection in the valve grid circuit, or incorrect value of grid bias. The grid bias voltage should be checked and also the fit of the plugs in the battery sockets.

34. The switch spindles of Wavemeters W.1081, serial numbers from 1 to 190 inclusive, are weak and are liable to break. Any units holding any of the above-mentioned wavemeters must demand new spindles from No. 1 Equipment Depot, and make the necessary alteration if they have not already done so.

35. As the wavemeter is a delicate instrument great care must be taken to ensure that the calibration is not upset when the new spindles are being fitted. The following sequence of operations should be observed. Withdraw the chassis from the case. Put the switch to range 5, lining up the edge of the brush with the upper edge of the contact segment. During subsequent operations, it is essential that the brush does not move from this position.

36. Withdraw the screws which secure the ends of the spindle to the sleeve. Withdraw the screw from the switch knob and remove the knob, taking care not to lose the spring and plunger from within the knob. Remove the switch locating plate and short spindle, and remove the spindle or broken parts. Insert the new spindle with the drilled end adjacent to the switch, aligning the hole in the spindle with that in the switch sleeve, and temporarily replace the screw to ensure correct alignment. Re-assemble the locating plate, short spindle, knob, screw, spring and plunger, with the tapped hole of the sleeve on the short spindle on the same side of the spindle as the index line on the knob.

37. Secure the indicating plate to the panel by two screws and set the knob at range 5. Carefully mark the undrilled end of the new spindle to show where the securing screw will pass through it. Remove the switch knob, locating plate and new spindle and using a No. 42 drill, make a ·0935 in. dia. hole, where marked. Remove any burrs. Replace the new spindle and secure it to the switch sleeve. Replace the locating plate and knob complete and secure the plate by two screws. Fit the securing screw through the short spindle and the new spindle. Remove the knob, spring and plunger. Replace the two remaining screws which hold the locating plate to the panel. Replace the knob, spring, plunger and securing screw, and replace the chassis in the case. All wavemeters numbered 191 and onwards will have the new spindle fitted before issue.

38. On some instruments the maximum value of the variable condenser is not great enough to give 330 kc/s on range 3. In such cases the wavemeter is calibrated at 335 kc/s instead of 330 kc/s. The actual error at 335 kc/s is shown on the correction chart, and the curve or error is continued onwards beyond 335 kc/s towards 330 kc/s. On some instruments this means that 330 kc/s is shown as being obtainable at a condenser reading greater than the maximum obtainable. Such indications are to be disregarded. On range 4, 330 kc/s is always obtainable, but on some instruments there is a gap between range 3 and 4. This gap is never more than 3 kc/s.

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.
10A/8405	Wavemeter W.1081	1	Without valves.
	Principal components :—		
	Case		
10A/8406	Battery	1	
10A/8407	Wavemeter	1	With leather strap.
10A/8408	Chart, calibration	1	
	Condenser		
10A/7906	Type 125	2	·01 μF.
10A/8487	Type 179	1	·000225 μF, fixed circular plates.
10A/8488	Type 180	1	·00001 μF, pre-set.
10A/8489	Type 181	1	·000029 μF, pre-set.
10A/8804	Type 230 . .	1	·0005 μF, variable.
10A/9688	Type 328 .. .	1	·000007 μF, variable screw adjustment.
10A/8511	Holder, valve, type K	1	4-pin, rigid type.
10A/8409	Inductance, fixed, No. 1 ..	1	Ranges 4 and 5.
10A/8410	Inductance, fixed, No. 2	1	Range 3.
10A/8411	Inductance, variable	1	Ranges 1 and 2.
5A/1610	Lampholder, miniature, Edison screw..	1	Batten type.
10A/8512	Microammeter, type B	1	Ferranti 99 F, fitted with plugs.
10A/8513	Mounting, microammeter	1	With sockets.
	Plug		
10A/7899	Type 60	2	
10A/9690	Type 90	1	Engraved H.T.—
10A/9695	Type 95	1	Engraved H.T.1.
10A/9696	Type 96	1	Engraved H.T.2.
10A/8535	Switch, type 83	1	6-position, with radial contacts.
	Accessories :—		
5A/1514	Accumulator, 2-volt, 7 Ah.	1	L.T.
5A/1338	Battery, dry, 15-volt	2	For H.T. and grid bias.
	Case, transit		
10A/8412	Valve	1	For 3 valves.
10A/8413	Wavemeter	1	
14A/690	Case, tripod	1	Camera, ground, S.4 equipment. For use when required.
14A/694	Tripod	1	Camera, ground, S.4 equipment. For use when required.
5A/1117	Lamp, filament, 2-volt, clear	1	Pilot lamp.
10A/8414	Lead, microammeter extension ..	1	Complete with plug and socket.
10A/9851	Valve, type V.W.36	3	One in wavemeter, two spares.

Section 5, Chapter 7

TESTER R/T, TYPE 1

Contents

List of Illustrations

TESTER R/T, TYPE 1

(Stores Ref. 10A/7182)

INTRODUCTION

1. The R/T tester is a compact portable testing set complete with all necessary batteries and accessories. It comprises two units. One employs a screened oscillator which can be made to produce either a modulated or unmodulated oscillation, the frequency of which can be set between the limits of 6,600 and 2,500 kc/s. The other unit incorporates a rectifying valve, in the anode circuit of which is a milliammeter. The oscillator is provided with a screened lead and coupling coil to enable it to be connected up to the input of a receiver under test, while the other unit is connected to the output of the receiver by means of a plug-and-socket connection. Used in this way the tester enables a comparison to be made between the relative efficiencies of two receivers.

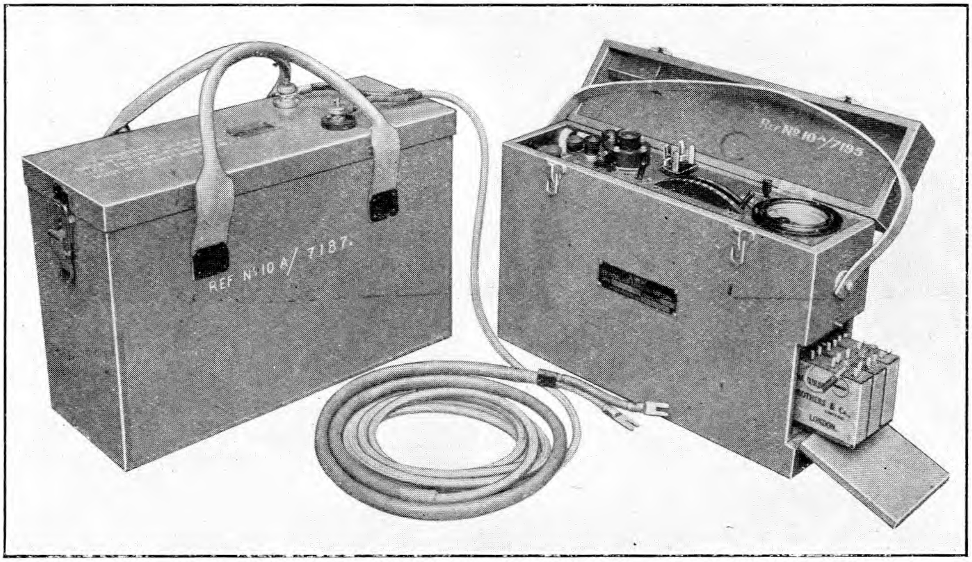


FIG. 1. Units A and B with connecting cable.

2. The oscillator unit may also be used independently as a syntonizer, and the other unit may be used independently to test valves for anode current emission.

GENERAL DESCRIPTION

Unit A

3. A circuit diagram of Unit A is included in fig. 2. This unit is a shielded oscillator capable of producing modulated or unmodulated waves on the frequency band 6,600 to 2,500 kc/s. Two valves V_1 and V_2 are employed, V_1 acting as an oscillator and V_2 as a modulator. The anode and grid circuits of the valve V_1 are coupled by the coils L_1 and L_2 connected in series through the blocking condenser C_2. The circuit is tuned by the variable condenser C_1, the dial of which is graduated in wavelengths and kilocycles. The dial may be locked at any desired setting. The modulating valve V_2 has its anode and grid circuits coupled by the primary winding P and

the secondary winding S of a special modulating transformer T. Incorporated in this transformer is the coupling coil CC, the ends of which are connected to the inner contacts of the telephone jack J. The outer contacts of the jack are connected in the anode circuit of the valve V_1. A condenser C_3 of ·005 μF capacitance is connected directly across the 60-volt H.T. battery.

4. A change-over switch S_1 enables either C.W. or tonic train to be obtained. With the switch in the " C.W. " position, the low tension and high tension circuits of the valve V_1 are completed, and by inserting telephones in the jack J the instrument can be used as a receiving syntonizer. When the switch is in the " T.T. " position, the circuits of both valves are completed, and by removing the telephones the coupling coil CC is inserted in the anode circuit of the valve V_1, enabling tonic train to be obtained. Loosely coupled to the coils L_1, L_2 is a coil L consisting of a single turn, one terminal of which is earthed to the shielding case in which the instrument is mounted.

5. In order to ensure that the coupling conditions between two receivers under comparison shall be exactly similar, Unit A is completely shielded. Pick-up by the receiver from the oscillator can therefore only take place through the coupling coil unit, and not directly from Unit A. It is very important that no pick-up should be obtained from the coupling coil cable, as this would vary with its degree of proximity to the receiver, upsetting the value of the comparison. The coupling coil cable is therefore encased in braided metal, and this covering is earthed to the case of the unit.

Unit B

6. A circuit diagram of Unit B is included in fig. 2. This unit comprises a rectifying valve V_3, in the anode circuit of which is a milliammeter MA, reading 0–2 mA. A switch S_3 is included in the L.T. circuit. The input to the grid of the valve is supplied through a standard inter-valve transformer T_1, the primary winding of which is shunted by a variable resistance R of approximately 1,000 ohms. A switch S_2, having two positions marked ANODE CURRENT and EMISSION, is incorporated in the instrument.

7. In the " anode current " position the grid circuit is completed through the secondary winding of the transformer T_1 and the grid leak condenser arrangement R_1—C_4, to L.T. The value of the grid leak resistance is 2 megohms, and the capacitance of the condenser ·01 μF. With the switch in this position, the circuit is that of a rectifying valve voltmeter, a drop in the anode current being observed on the milliammeter when a signal voltage is applied to the input terminals.

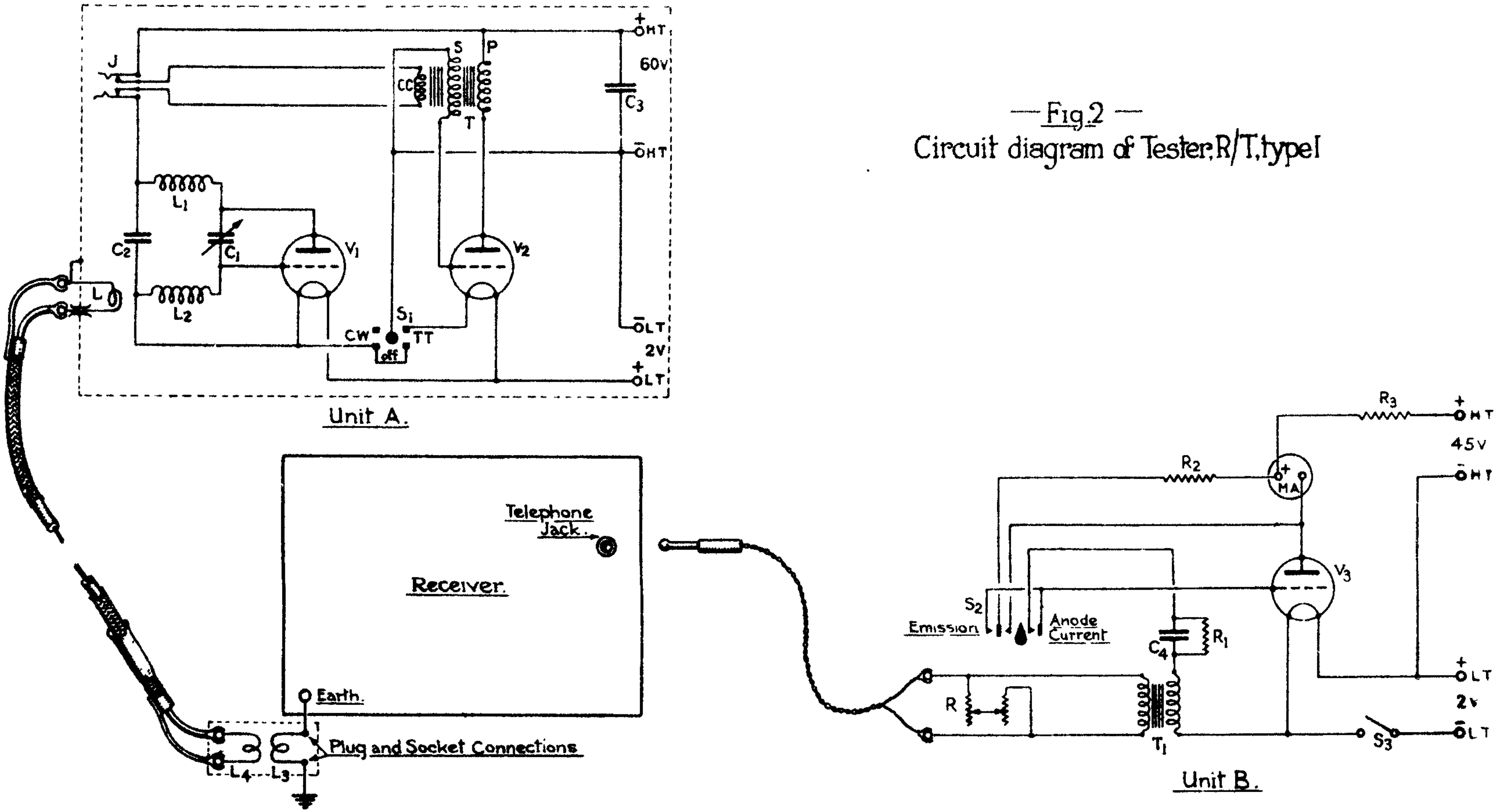
8. In the " emission " position of the switch, the grid of the valve is disconnected from the filament circuit and connected to the anode, the milliammeter first being shunted by a resistance R_2 so that the full-scale reading indicates 40 mA., i.e. 20 times the scale reading. The instrument can be used in this way to obtain a figure which represents the emission of the valve under test, for the particular anode and filament voltages in use.

9. A resistance of 1,500 ohms is permanently in circuit with the milliammeter and H.T.+ so that, in the event of a heavy current flow, the voltage drop across the resistance will safeguard the milliammeter. If this were not arranged in circuit, it might be possible to damage the milliammeter by plugging in a faulty valve.

10. A standard valve-holder is connected in parallel with an inter-service holder, enabling valves with either type of cap to be tested. A standard telephone plug with leads is provided for connecting the receiver under test to the input terminals of the unit. The instrument is mounted in a wooden case which also carries the L.T. and H.T. batteries.

Receiver coupling coil unit

11. In order that the tester may be conveniently coupled to a receiver, a coupling coil unit has been designed and is intended for use in all aircraft receivers. It can be inserted in the earth circuit of the receiver by means of a plug and socket arrangement, two terminals providing the means for coupling to the tester.



— Fig. 2 —

Circuit diagram of Tester, R/T, type I

Connecting cable

12. This cable, which is shown in fig. 7, consists of an insulated conductor encased in braided metal, and has end connections in the form of spade terminals. In order to insulate the braiding from parts of the aircraft with which it might accidentally come into contact, an insulating sleeve covers a portion of the cable at the coupling coil end.

CONSTRUCTIONAL DETAILS

13. Various views of the instrument are shown in figs. 1, 3, 4, 5 and 6; figs. 1 and 3 show different views of Units A and B; fig. 4 shows Unit A withdrawn from its case and figs. 5 and 6 show the underside of the panels. The cables and coupling unit are shown in fig. 7.

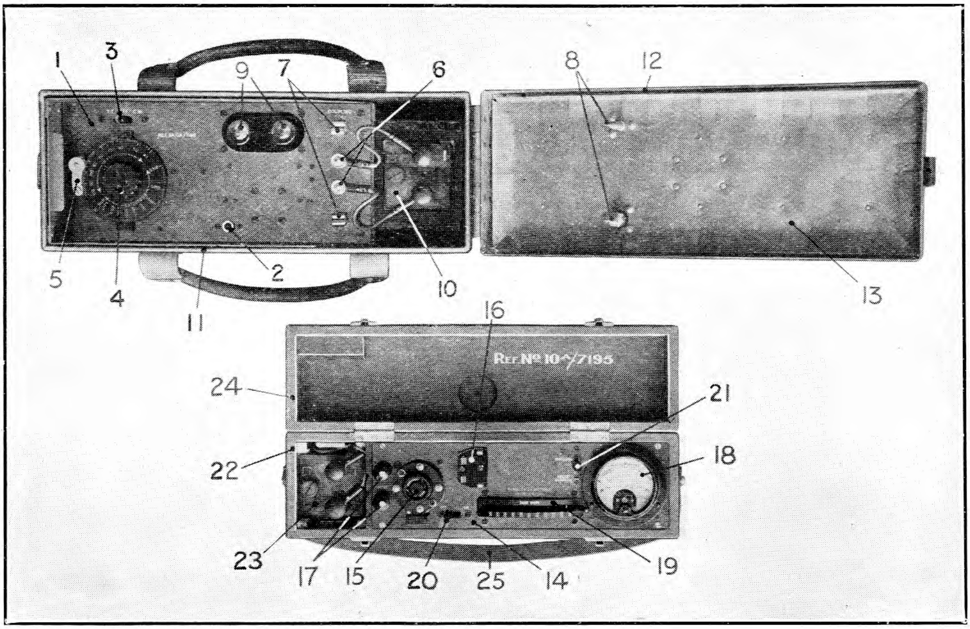


FIG. 3. Plan view of Units A and B showing panels

Unit A

14. The upper portion of fig. 3 shows a plan view of Unit A with the cover raised. The components are mounted on an insulating panel (1). On the front of the panel may be seen the telephone jack (2), the " C.W.—T.T. " switch (3), graduated dial (4), locking device (5) and the terminals (6) for the L.T. battery (10).

15. The unit is carried in a shielding case (11) having a hinged cover (12) fitted with a metal lining (13) which is slotted to form a spring-contact surface for engagement with the brass edge of the shielding case when closed. In the lid are two knife contacts (8), one of which is insulated from, and the other connected to the lining (13). When the lid is closed these two knife contacts engage with the spring contacts (7). The two valves (9) which are inserted through a recess in the panel, may also be seen in this figure.

16. In fig. 4 which shows Unit A withdrawn from its case, the metal containing case (1) is provided at one end with a wooden container in which the L.T. battery (2) is carried. The case also houses the H.T. battery (3). Some of the components may be seen above the H.T. battery, while the two valves (4) may just be seen above the container.

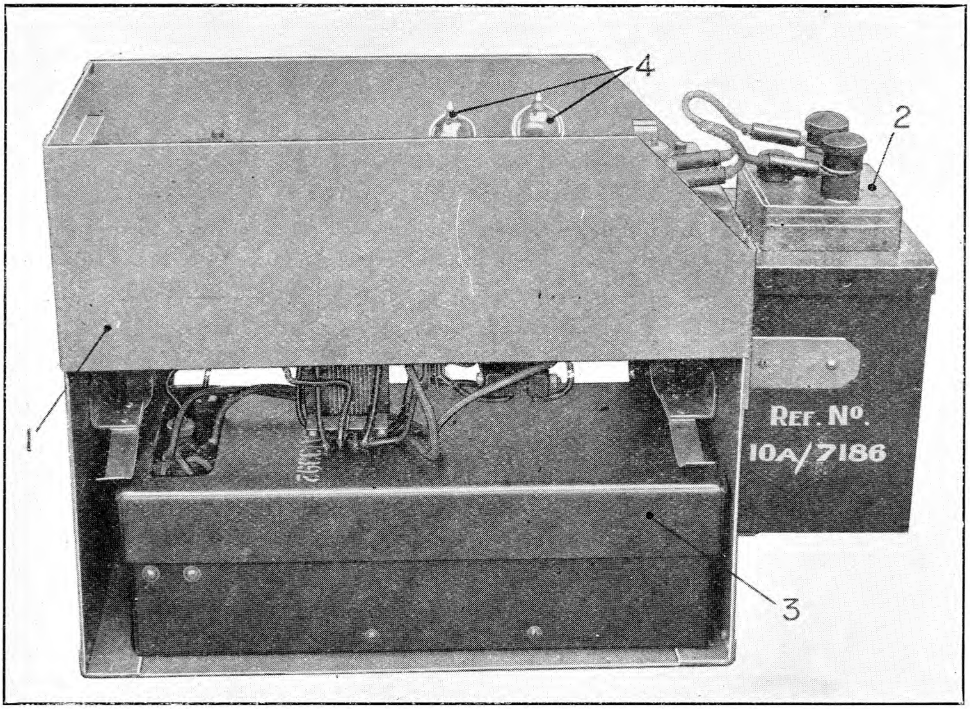


FIG. 4. Unit A withdrawn from case.

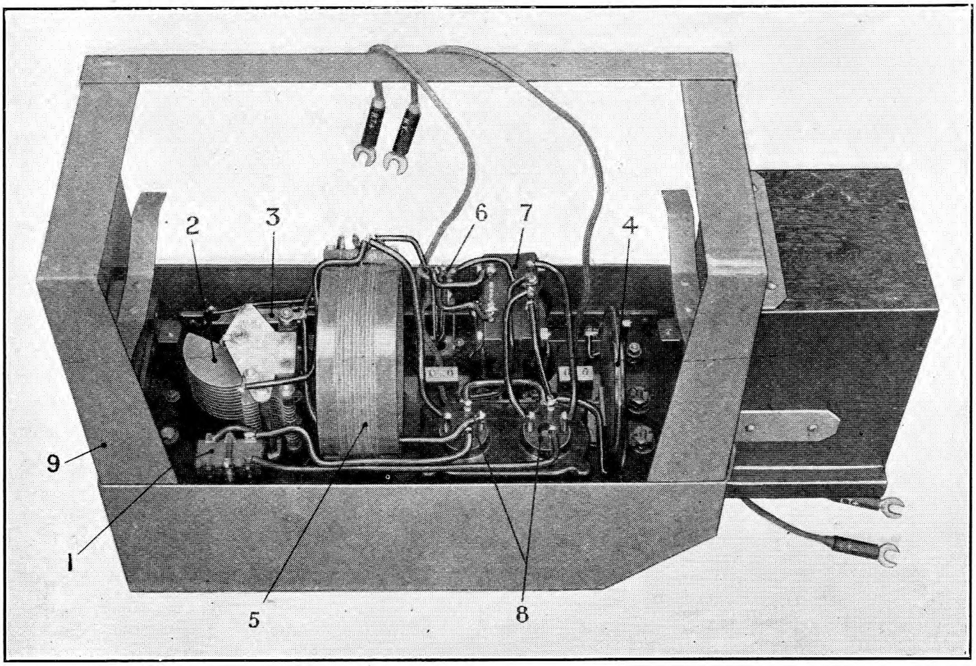


FIG. 5. Unit A, underside of panel.

17. Referring to fig. 5 which is an underside view of Unit A with the H.T. battery removed the components mounted on the underside of the panel (1, fig. 1) may be clearly seen. The "C.W.—T.T." change-over switch (1) is in the bottom left-hand corner and above it is the tuning condenser (2). The fixed coupling condenser (3) behind it has a value of ·01 μF and is represented by C_2 in fig. 2. The coupling coil (4), represented by L in fig. 2, is on the extreme right of the illustration. The oscillator coils (5) are in the centre, and to the right of them the telephone jack (6), transformer (7) and valve-holders (8) are shown.

Unit B

18. A plan view of Unit B is illustrated in the lower portion of fig. 3. The various components are mounted on an insulating panel (14). On the left may be seen the standard valve-holder (15). It is wired in parallel with the valve-holder (16). To the left of the valve-holder (16) are the terminals (17) to which are connected the leads from the input plug. The milliammeter (18) is on the right. The rheostat (19) is represented by R in the theoretical circuit diagram, fig. 2. The filament "on—off" switch (20) and "emission—anode current" switch (21) may also be seen. The case (22) has a compartment provided for the L.T. battery (23). The lid (24) covers the components when the unit is not used and is held in position by two spring catches. A leather carrying strap (25) is also provided.

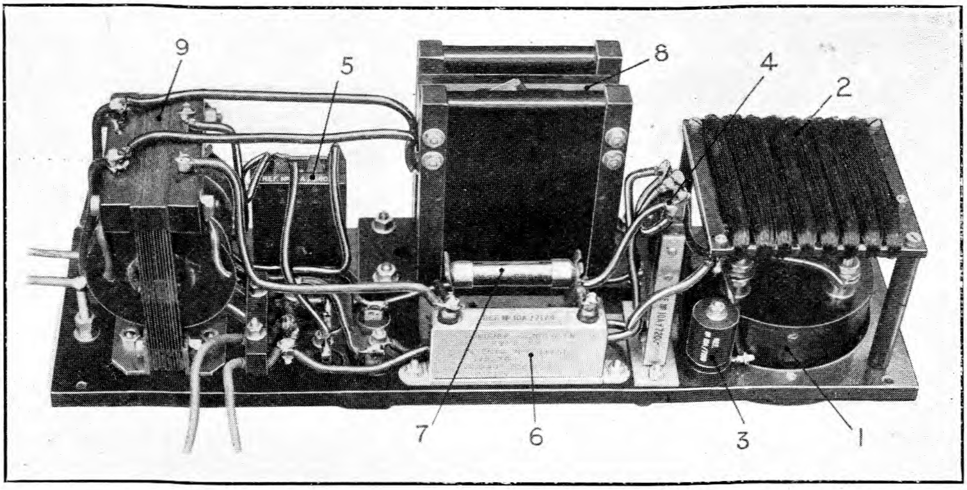


FIG. 6. Unit B, underside of panel.

19. Referring to fig. 6 which is an interior view of the Unit B showing the components mounted on the underside of the panel (14, fig. 3), the milliammeter (1) is on the right, above it is the series resistance (2) and to the left of it the shunt (3). The switches (4) and (5) are represented by S_2 and S_3 respectively in the theoretical circuit diagram fig. 2. The condenser (6) in the foreground has a value of ·01 μF and is shunted by the 2-megohm resistance (7). Both these components are in the grid circuit of the valve V_3, fig. 2, the large resistance (8) to the rear being represented by R in the same figure. On the left-hand side of the illustration may be seen the transformer (9). The weight of the two units complete with batteries is approximately 42 lb. Unit A measures approximately 16 in. × 12 in. × 6 in., and Unit B measures approximately 15 in. × $11\frac{1}{2}$ in. × $6\frac{1}{2}$ in.

Coupling coil unit

20. The coupling coil unit shown in fig. 7 consists of an insulated former (1) inside which the two single-turn coils are mounted, and is intended for use in all aircraft receivers. Four connections are brought out to one face of the unit, two of these (2) having insulated terminals and the other two (3) consisting of a plug on the right and a socket on the left.

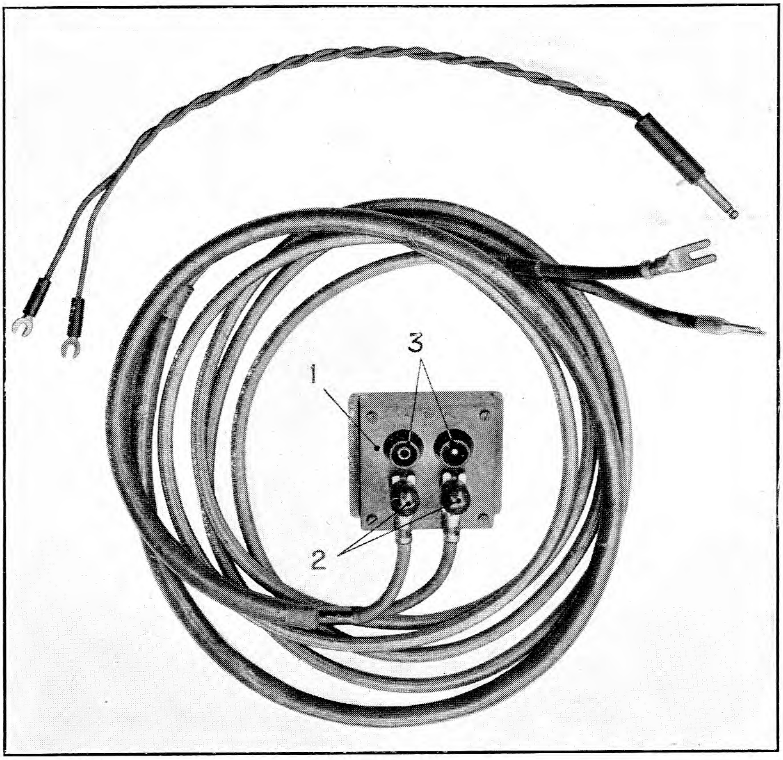


FIG. 7. Coupling coil unit, cable, and telephone plug and lead.

VALVES AND BATTERIES

21. When using Unit B as a valve voltmeter to compare the efficiency of receivers, a standard V.R.12F. valve is employed, and a proper comparison can only be obtained if the same valve is retained in the unit for each test.

22. A 2-volt accumulator (Stores Ref. 5A/2), is provided with each unit and is used for the L.T. supply. The battery should be maintained in a charged condition and should not be used when the voltage has fallen below 1·8 volts.

23. The anode voltage for the valves in Unit A is obtained from four 15-volt batteries (Stores Ref. 5A/50), and for the valve in Unit B, three of these units are used. The H.T. voltage for the valve in Unit A should not be below 55 volts and that for Unit B, 40 volts.

OPERATION

24. Before carrying out any test, the voltage of the high tension and low tension batteries should be checked by means of a voltmeter. Batteries which have run down should not be employed. This is particularly important when the tester is being used to compare the efficiency of two receivers.

25. In the following paragraphs on the use of the instrument, reference is made to certain receivers and transmitters, but the Tester R/T, type 1, may be used wherever its frequency limitations permit.

To compare the efficiency of a receiver with that of a standard receiver

26. For this purpose Unit A, Unit B, the coupling coil unit, and connecting cable are employed. Fig. 2 shows the units connected up in the required manner. The procedure is as follows :—

(i) Adjust Unit A to the frequency at which the comparative test is to be made by means of the variable condenser, locking the dial in position by means of the locking device.

(ii) Set the switch S_1 to " TT " (Tonic Train).

(iii) Close the screening cover on Unit A. Close the spring clip, thereby holding the cover firmly down on the screening case. If the cover is properly closed no signals should be received on the receiver on tuning through the signal frequency.

(iv) See that the coupling coil unit is in position in the earth lead of the receiver, and connect up the screened cable from the terminals of Unit A to the terminals on the coupling unit, taking care that the braiding of the cable is connected to the earth terminal of the two terminals on Unit A. On tuning the receiver, a signal should now be heard. The signal should be tuned to a maximum.

(v) Place the switches S_3 and S_2 on Unit B, in the " on " and " anode current " positions respectively, and note the milliammeter reading.

27. Unit B should then be connected to the receiver by means of the plug and lead (fig. 7), the plug being inserted in the telephone jack in the receiver, in place of the telephones. On connecting Unit B as just described, a drop in the milliammeter reading will be noted ; the tuning condenser of the receiver and also the stabilizer should then be re-adjusted to make this drop a maximum. The extent of drop may be reduced to a convenient value, *e.g.*, 0·2 milliamps by adjustment of the variable resistance R. The value of this resistance should be noted. The same procedure should be carried out with the standard receiver, and the resistance adjusted to give the same drop. The value of this resistance should again be noted. The relative efficiences can then be calculated approximately from the following formula :—

$$\frac{\text{Overall efficiency of receiver under test}}{\text{Overall efficiency of standard receiver.}} = \frac{\text{Value of resistance R with standard receiver.}}{\text{Value of resistance R with receiver under test.}}$$

28. For example, if the resistance value in the case of the standard receiver was 300 ohms, and in the case of the receiver under test 600 ohms, then the overall efficiency of the latter is about half that of the former.

29. Where alternative circuit arrangements or tuning alternatives to cover the same frequency are available on the receivers under test, care should be exercised to ensure that similar conditions exist on each receiver or the value of the comparison will be lost.

30. The standard receiver may of course be calibrated in advance, a tabulated list being prepared of the resistances required to give a standard or definite drop in milliammeter readings on Unit B, for given conditions on this receiver.

31. The reason for the special screening methods employed is that, in order to compare the output signals for the two receivers, it is essential that the pick-up from the oscillator should be due to the coupling through the coupling coil unit only. The receiver should not pick up, either directly from the oscillator or from the connecting cable, since any pick-up from the latter would vary with the position of the connecting cable, and conditions could not be duplicated for two different receiver installations. The effectiveness of the screening may be demonstrated by disconnecting the inner conductor at either end of the connecting cable, when the signal will be

found to be reduced to zero or to a negligible minimum, thus showing that no signal transference is being obtained from the outer earthed braiding. On the other hand, disconnecting either end of the braiding does not diminish the intensity of the received signal, showing that the latter is being transmitted along the inner screened conductor.

To test valves for emission

32. For this purpose Unit B only is employed, and the standard V.R.12F. valve is removed. The valves to be tested are plugged in, one by one, into the appropriate valve-holder ; at the same time the switch is pushed into the " emission " position and the milliammeter reading noted. The total " emission " is obtained by multiplying the scale reading by 20. It will be observed that the switch has to be held over in the " emission " position against the action of a light spring. This prevents the switch being left in the " emission " position longer than is absolutely necessary to read the milliammeter, and thus a heavy drain on the H.T. battery is avoided.

To check the frequency of a transmitter

33. When a wavemeter is not available the R T tester may be employed for this purpose. It is not, however, intended as a substitute for an accurately calibrated wavemeter. When checking the frequency, Unit A only is employed and the procedure is as follows :—

(i) Plug a pair of standard telephones into the jack of Unit A.

(ii) Set the switch on Unit A to " C.W."

(iii) While listening in on the telephones connected to Unit A, adjust the frequency of the tester until a zero beat note is obtained. When testing aircraft transmitters on the ground the H.T. supply to the transmitter will normally be obtained from a motor generator driven from the aeroplane battery supply. It will be unnecessary to run up the aero-engine, and quiet conditions may be obtained for the test.

To set a receiver to a particular frequency

34. In the absence of a wavemeter the R T tester may be employed to set up a receiver. Unit A is employed and the procedure is as follows :—

(i) Open the cover of Unit A.

(ii) Set the switch to " T.T." (Tonic Train).

(iii) Adjust the variable condenser to the frequency corresponding to that required, locking the dial in position.

(iv) Place Unit A in the vicinity of the receiver.

(v) Tune the receiver until the signal strength heard in the telephones is a maximum, taking care, however, that the adjustment is not so critical that the receiver is on the threshold of oscillation.

35. When adjusting receiver units of transmitter-receivers it is possible to use the R/T tester without depending upon its calibration. If the transmitter unit has previously been set to the frequency required by means of an absorption wavemeter, the R/T tester can be brought into resonance with the un-modulated radiation of the transmitter. The tester is then switched over to give a modulated radiation to which the receiver can be set. The operation is carried out in the following way :—

(i) Place the Unit A close to the transmitter, connecting a pair of telephones to it, and switch to C.W.

(ii) With the transmitter radiating the desired frequency, tune the tester to obtain a zero beat frequency. Switch off the transmitter.

(iii) Lock the dial of the R/T tester and move the switch to " T.T."

(iv) Listen on the receiver and tune for maximum signal.

36. Certain modifications of the R T tester have been authorised which enable a crystal to be employed. The modifications consist of mounting a crystal adaptor (Stores Ref. 10A/11160) inside the unit A and connecting it in the grid circuit. The two V.R. 12F valves normally used are replaced by one V.T. 20 in the oscillator valve-holder and one V.R.21 in the modulator valve-holder.

37. The method of setting up the unit to a particular frequency is as follows :—Insert a crystal of the desired frequency into the adaptor. Using the telephone plug and lead supplied with the tester, connect a testmeter, type C to the jack in the instrument panel. Set the test-meter to the 0–30mA scale. Place the switch on the Unit A in the " TT " position. Adjust the variable condenser until the reading of the testmeter is a minimum, this is a critical adjustment but it is facilitated by the fact that the kc/s engraved on the condenser dial at this setting, should agree approximately with the frequency of the crystal. Having determined this minimum point, re-adjust the condenser to give a dial reading 15 kc/s higher. Lock the condenser in this position. Remove the plug which connects the testmeter type C to the Unit A. The Unit A having been set up in this way, will then radiate a modulated C.W. signal, the frequency of which is stabilized by the crystal. In this state it may be used for setting up a receiver, on the ground before flight, to this particular frequency.

PRECAUTIONS AND MAINTENANCE

38. In all cases, filament and anode batteries should have their voltages checked before making a test. This applies especially to tests of relative efficiency of receivers. To prevent running down of batteries, the valves should always be switched off when not in use. Owing to the valves in Unit A not being visible when the screening cover is in position, there is a possibility of the valves in this unit being left switched on. This must be avoided.

39. Care should be taken, when testing a receiver in an aircraft, that the braided covering of the connecting cable does not come into contact with the metal counterpoise system of the aircraft. The receiver end of the cable is covered with an insulated sleeving, with a view to preventing accidental contact being made.

40. In aircraft using trailing aerials, it should be borne in mind that the frequency of the receiver, or the transmitter, will be different with the aerial unwound and that, therefore, any setting made on the ground will not hold exactly for the aircraft when flying. Even with fixed aerials, there may be a slight change in frequency on leaving the ground.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/7184	Tester R/T, type 1 :—		
	Consisting of :—		
10A/7185	Unit A	1	
10A/7194	Unit B	1	
	Unit A :—		
	Principal components :—		
10A/7187	Case, outer	1	With lid.
10A/7188	Case, inner	1	With fittings.
10A/7186	Case, accumulator	1	
	Condenser		
10A/7203	Type 54	1	·0003 μF, variable.
10A/7204	Type 56	1	·005 μF.
10A/7174	Type 57	1	·01 μF.
10A/7189	Coil, anode and grid	1	Wound on one former.
10A/7190	Coil, coupling	1	Fitted inside unit.
10A/7175	Holder, valve, type A	2	
10A/1739	Jack, telephone	1	
10A/7201	Lead, screened	1	
10A/2262	Switch, type 15	1	3-position, with six contacts.
10A/7167	Transformer, L/F, type C	1	
	Unit B :—		
	Principal components :—		
10A/7195	Case	1	With lid.
10A/7174	Condenser, type 57	1	·01 μF.
10A/7207	Milliammeter, 0–2 mA.	1	
	Holder, valve		
10A/3467	Receiving	1	
10A/7175	Interservice pattern, type A	1	
10A/7197	Plug, telephone	1	With leads.
	Resistance		
10A/7198	Type 11	1	1,000 ohms, variable.
10A/2312	Type 26	1	2 MΩ, 1-watt, rod type.
10A/7205	Type 33	1	1,500 ohms, wire wound-bobbin.
10A/7199	Shunt, milliammeter	1	2·63 ohms.
10A/3402	Switch, type 21	1	Two-position " on " " off ".
10A/7200	Switch, type 51	1	Two position, five contact.
10A/3290	Transformer, L F, type A	1	
	Accessories :—		
5A/2	Accumulator, 2-volt, 13 Ah.	2	One for Unit A, one for Unit B.
5A/50	Battery, dry, 15-volt	7	Four for Unit A, three for Unit B.
10A/3392	Box, battery, fibre, 60-volt	1	For Unit B.
10A/7233	Unit, coupling coil	1	For fitting to receiver.
10A/5000	Valve, type V.R.12F.	3	Two for Unit A, 1 for Unit B.

SECTION 5, CHAPTER 8

WAVEMETER W. 1095

Contents

List of Illustrations

WAVEMETER W.1095

(Stores Ref. 10A/9143)

INTRODUCTION

1. The wavemeter W.1095 has been designed primarily for use on the ground for setting aircraft transmitters to an accuracy of 2 kc/s. The instrument covers the frequency bands 3,410 to 2,000 kc/s and 1,540 to 1,220 kc/s. A switch on the front panel selects either of the two bands referred to above.

2. The wavemeter is of the resonance indicating type and a resonant circuit consisting of a fixed inductance and a variable tuning condenser is provided for each frequency band. The two inductances are wound on the same former and the tuning condenser is provided with a slow motion drive and a vernier index. Adjacent to the handle of the tuning condenser is a micro-ammeter, the dial of which reads from 0 to 500.

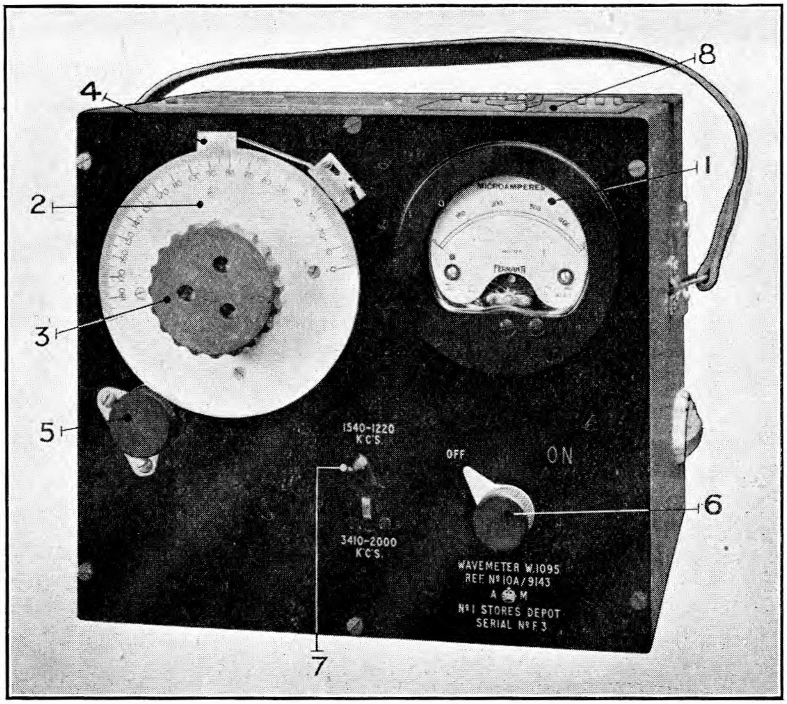


FIG. 1. Wavemeter W.1095, front view.

3. Resonance is indicated by means of an anode-bend rectifying valve, in the anode circuit of which is a microammeter of a specially damped type. The valve used is a triode, L.T. supply for which is provided by an accumulator, whilst H.T. and the necessary grid bias are obtained from dry batteries.

4. The wavemeter is entirely self-contained, the valve, H.T. battery, accumulator and grid bias battery being housed in the case of the instrument. Access to the valve may be obtained through a hinged cover in the top of the case, and to the batteries by means of a hinged cover at the back of the instrument. This cover is retained in position by two spring catches on the side. The various components are mounted on the back of a metal panel which is secured to the case by six screws.

GENERAL DESCRIPTION

5. A theoretical circuit diagram of the wavemeter is given in fig. 2. It will be seen that it is similar to that of wavemeter W.69 in that an oscillatory circuit is connected between the grid and filament of the valve, in the anode circuit of which is a microammeter. Instead of a variable inductance being used, however, two separate fixed inductances are provided, with a change-over switch. The appropriate inductance (shunted by a fixed condenser) for the frequency band required, is selected by the switch S and is tuned by a variable condenser. Referring to the diagram it will be seen that with the switch in the left-hand position as shown, L_1C_1 in conjunction with C_3 forms an oscillatory circuit across the grid and filament of the valve V. In the right-hand position L_2C_2 in conjunction with C_3 forms the oscillatory circuit. A small pre-set condenser C_4 is connected in parallel with the condenser C_3. It is fitted inside the wavemeter and is used only for the purpose of adjusting the calibration of the wavemeter. It should *not* be interfered with in any circumstances.

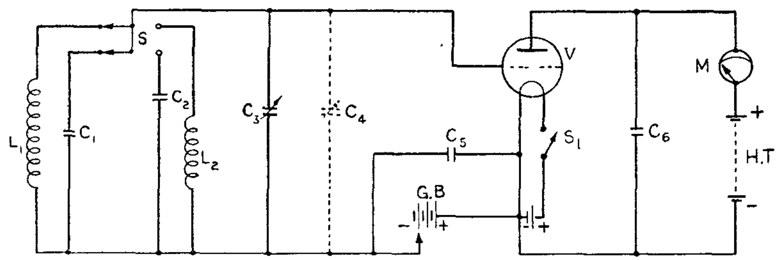


FIG. 2 Theoretical circuit diagram.

6. With suitable anode and grid bias voltages applied to the valve it functions as an anode-bend rectifier, and a steady anode current is indicated on the microammeter scale. If the oscillatory circuit is brought into resonance with a transmitter a R F. voltage is impressed upon the grid of the valve, and the anode current increases. The bias adjustment enables a convenient range of the microammeter scale to be used.

7. When using the wavemeter, the oscillatory circuit is adjusted until an optimum figure is obtained on the microammeter. This indicates resonance, and the reading on the tuning dial of the wavemeter, when compared with a calibration chart supplied with the instrument, gives the frequency.

8. The grid bias battery, which is shunted by the condenser C_5 is connected between the junction of the two inductances and the negative side of the filament circuit. The filament circuit for the valve V includes a switch S_1 which makes or breaks the circuit to the L.T. battery. The H.T. battery is connected in the anode circuit of the valve through the microammeter M, and a condenser C_6 is shunted across the microammeter and H.T. battery.

CONSTRUCTIONAL DETAILS

Case

9. Two interior views of the wavemeter are given in figs. 3 and 4. The approximate dimensions are 8 in. × $8\frac{3}{4}$ in. × 9 in., and the weight complete with batteries is 16 lb. Referring to fig. 3, which is a view of the wavemeter case, the case (1) is constructed from mahogany, covered with fabric and painted grey. It is divided into two compartments by a vertical wooden panel. The front compartment houses the wavemeter components, and the rear compartment the various batteries. The rear compartment is sub-divided into two compartments by the wooden panel (2). One contains the L.T. accumulator (3), and the other contains the grid bias battery (4) and the H.T. battery (5). A hinged cover (6) encloses this rear compartment, and when the batteries are in position the whole instrument forms a compact unit. The hinged cover is secured by means of two spring catches, one of which (7) may be seen in the illustration. The leads for the various batteries are brought through holes formed in the dividing partition. A leather strap (8) secured to the case is provided for transportation. Access to the valve is obtained through the hinged cover (8, fig. 1).

Wavemeter

10. The front panel, which is of duralumin and is secured to the case by six screws, carries all the wavemeter components. In fig. 1 can be seen the operating handles for the various controls and switches. In the top right-hand corner may be seen the microammeter (1). It has a resistance

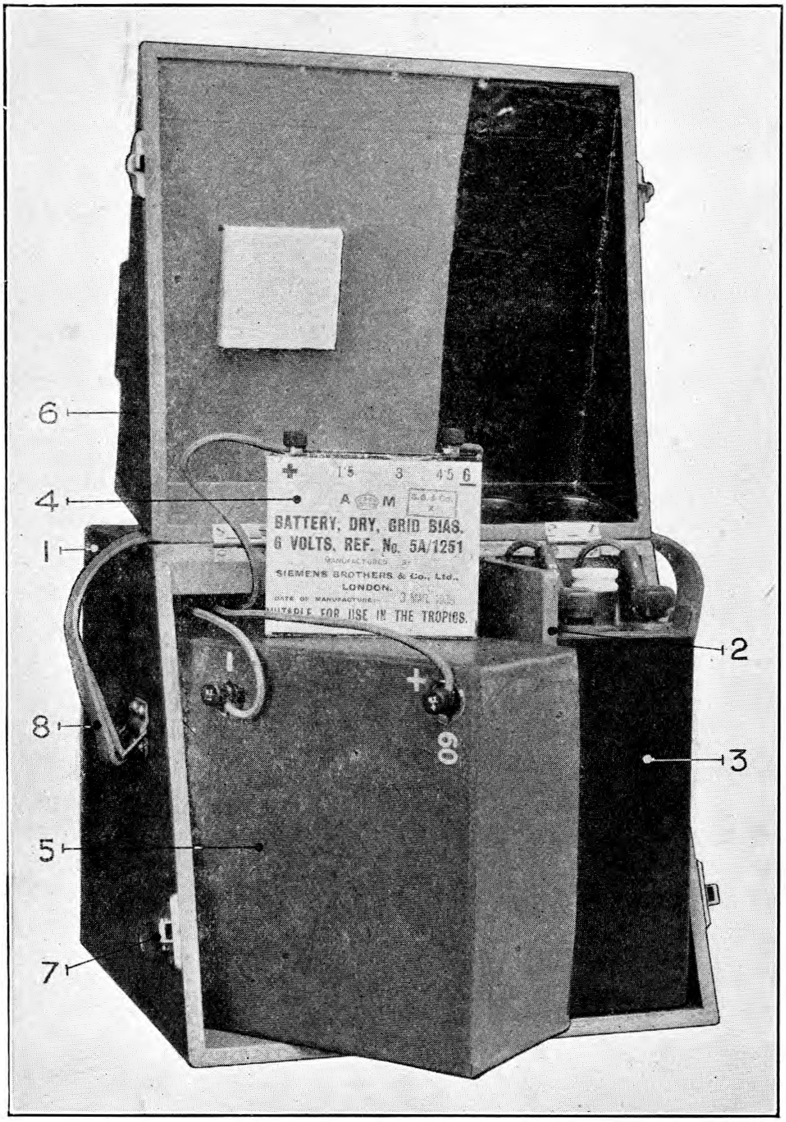


FIG. 3. Rear view of W.1095 showing batteries.

of less than 100 ohms and a scale reading of 0 to 500 microamperes. To the left of this is the tuning condenser control (2). It consists of a disc engraved in degrees from 0 to 180, to which is secured a knob (3) of composite insulating material. Above the disc is a vernier (4) capable of giving a reading of $\frac{1}{10}$th of a degree. The fine tuning adjustment (5) which can be seen on the left of the disc employs a friction drive. One complete revolution of the knob (5) moves the condenser control through 7 degrees. In the bottom right-hand corner can be seen the " on-off " filament switch (6), and adjacent to it is the range-change switch (7). This switch has two positions, up and down. In the up position the instrument covers the band 1,540 to 1,220 kc/s, and in the down position (the handle horizontal) the instrument covers the band 3,410 to 2,000 kc/s.

11. Fig. 4 is an interior view of the wavemeter showing the components secured to the rear of the panel. On the right can be seen the tuning condenser (1) and to the left of it the small pre-set condenser (2) represented by C_4 in the theoretical circuit diagram, fig. 2. The two condensers (3) are mounted on the frame of the tuning condenser (2). The one on the right has a value of ·000415 μF and the one on the left has a value of ·000135 μF. These two condensers are associated with the fixed inductances (4) which can be seen in the bottom right-hand corner.

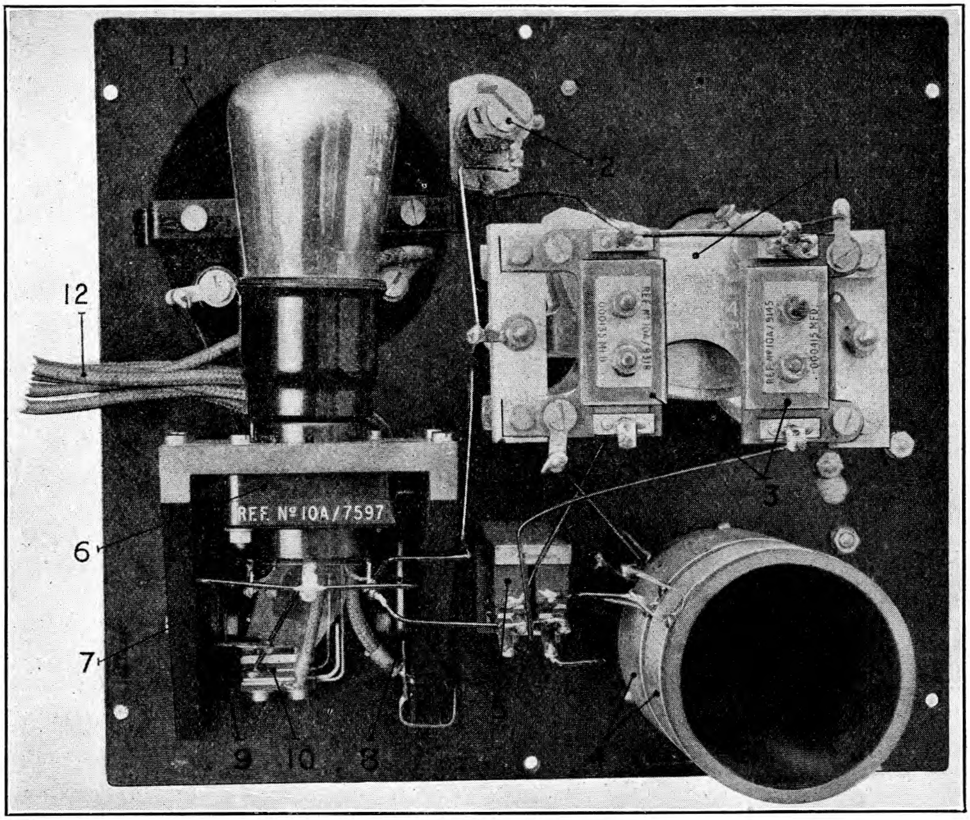


FIG. 4. Interior view W.1095.

12. To the left of the fixed inductances can be seen the range-change switch (5). This switch is similar to Post Office switch No. 68 and consists of four fixed contacts, and two movable contacts, so arranged that the two movable contacts may engage either the two upper or the two lower fixed contacts. The switch is wired-up as shown in fig. 2.

13. The valve-holder (6) is mounted on a bracket (7) of composite insulating material, and two condensers (8) and (9) are mounted on the inner sides of the arms of this bracket. The one on the right has a value of ·01 μF and is connected across the grid bias battery. The one on the left also has a value of ·01 μF and is shunted across the microammeter and H.T. battery.

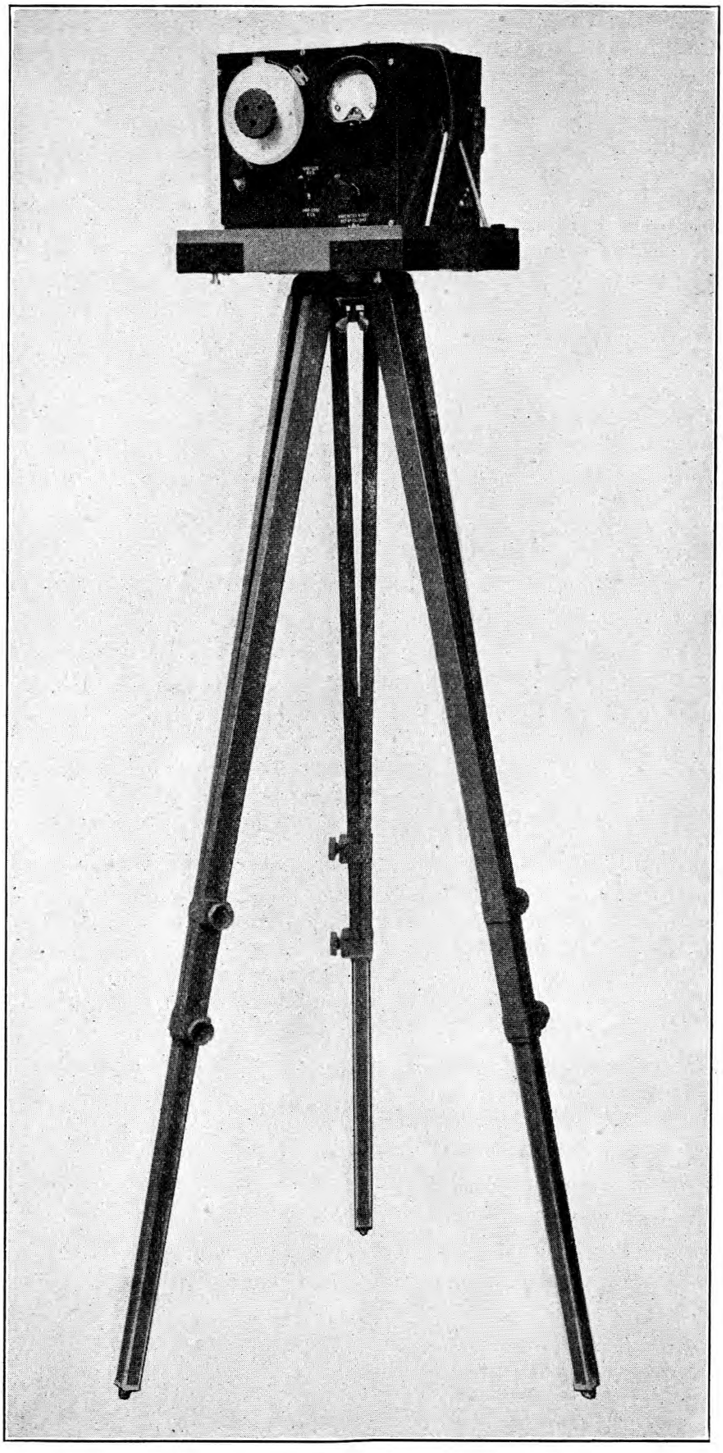


FIG. 5. Wavemeter mounted on tripod.

It is represented by C_6 in fig. 2. The " on-off " filament switch (10) can be seen beneath the valve-holder. It consists essentially of two phosphor-bronze contact arms having gold-silver contacts and operated by a cam secured to the knob (6, fig. 1) on the front of the panel. Behind the valve can be seen the microammeter (11).

14. In the bottom right-hand corner are the fixed inductances (4). These inductances consist of two windings wound on a common hollow former of composite insulating material. The machined grooves on the former are wound clockwise with 20 s.w.g. bare tinned copper wire. One has 13 turns and the other has 22 turns. The " start " of each winding is taken to a separate contact on the range-change switch and the "finish" of each winding is joined together and connected to the moving vanes of the variable condenser. These various connections are clearly shown in the theoretical circuit diagram, fig. 2. The group of leads (12) seen behind the valve are taken through the dividing partition and are connected to the various batteries contained in the rear of the case.

Transit case

15. A transit case is provided for the wavemeter. It is constructed of wood covered with fabric and is provided with two leather carrying handles. The lid of the case is hinged and is held in the closed position by two screws. The provision of special hinges enables the lid to be detached, by raising it and moving it bodily to the left. The lid may then be used, in conjunction with a tripod, as a support for the wavemeter. A metal boss is provided on the lid to facilitate this. The tripod used is the standard S.4 camera tripod and the screw supplied with this is used to secure the wavemeter lid by engaging with the boss previously referred to.

16. The instrument so mounted is illustrated in fig. 5. Two elastic cords are provided on the lid. After the instrument has been placed in position the cords are threaded through the handles on the side and then engaged with the blocks on the lid. A further small wooden case is supplied with each instrument in which the spare valves are carried.

VALVES AND BATTERIES

17. The valve used in the wavemeter is a valve type 210 H.F. Each instrument is supplied with three valves which are " matched " and the base of each valve is stamped with the serial number of the wavemeter with which it is intended to be used. The three valves, in their cartons, are carried in the appropriate valve transit case, which also has the serial and type number of the wavemeter painted on it. In no instance must any other valve but one of the three supplied be used, as the calibration of the instrument will be affected if a valve having a different inter-electrode capacitance is used.

18. The procedure in case of failure is as follows. If one of the valves should fail, no immediate action is necessary. If a second valve fails a replacement wavemeter should at once be requisitioned. On receipt of the wavemeter and its accessories the original equipment should be returned. It should be noted that this equipment comprises :—

The wavemeter and its case.

The calibration book.

The three valves in their transit case, the serviceable valve being labelled.

With the exception of the transit cases none of the above-mentioned items may be exchanged separately.

19. Two dry batteries and an accumulator are required for each instrument. The grid bias battery is a 6-volt dry cell (Stores Ref. 5A/1251). The H.T. is supplied from a 60-volt dry battery (Stores Ref. 5A/1334). The L.T. for the valve filament is supplied from a 2-volt accumulator (Stores Ref. 5A/1386).

OPERATION

To set a transmitter to a definite frequency

20. (i) Set the wavemeter to the required frequency by reference to the calibration chart. Place the wavemeter about 6 ft. from the transmitter and switch on the filament circuit of the valve.

(ii) Adjust the transmitter until a maximum deflection is recorded on the wavemeter microammeter. It is essential to position the wavemeter so that the maximum deflection does not exceed 500 microamperes. If the reading is approaching the limit of the scale, the wavemeter should be moved further away. An optimum reading of about 450 microamperes is the most favourable condition.

(iii) When it is desired to obtain a very precise setting of the transmitter, the mean of two transmitter settings is obtained. These two settings should be the same ; one on each side of the desired setting. If, for example, an optimum reading of 456 microamperes is obtained on the microammeter over a few degrees of adjustment of the transmitter, two transmitter settings should be found, each of which gives 450 microamperes. The mean of these two is then the correct transmitter setting. When employing this method, a difference of not more than 10 microamperes from the first optimum reading should be aimed at.

To measure the frequency of a transmitter

21. (i) Start the transmitter radiating.

(ii) Place the wavemeter in proximity to the transmitter as described in para. 20 (i).

(iii) Rotate the condenser tuning handle (3, fig. 1) until an optimum reading is obtained on the microammeter, using the same precautions as in para. 20 (ii).

(iv) Observe the wavemeter scale reading and determine the radiated frequency by reference to the calibration chart.

22. The calibration book has horizontal scales, one being graduated in kilocycles per second and the other in wavemeter dial settings. A correction curve, however must also be used in conjunction with these scales and the method of making the correction is described in the following paragraphs.

23. *Setting the wavemeter.*—Suppose the frequency desired is 2,500 kc/s. The wavemeter calibration scale reading for this figure is 109·5. The correction for 2,500 kc/s (obtained from the curve) is + 1. The correct setting of the wavemeter for this frequency, therefore, is 109·5 + 1, which equals 110·5. When working on the range 1,540 to 1,220 kc/s if the frequency desired is 1290, the wavemeter scale reading for this figure from the calibration chart is 126·5. From the correction curve, the correction figure for 1,290 kc/s is + ·5. Therefore, the true scale reading for 1,290 kc/s is 126·5 + ·5, which equals 127.

24. *Measuring the frequency.*—Assume the range-change switch is set to the 3,410 to 2,000 kc/s range and the reading of the wavemeter dial is found to be 82 for a maximum deflection. On the calibration chart, 82 represents a frequency of 2,830 kc/s. Look up 2,830 kc/s on the correction curve ; this gives a correction of + 1·4. Therefore, the true scale reading is 82 — 1·4, which equals 80·6, and the correct frequency of the transmitter read from the calibration scale at 80·6 is 2,848 kc/s. If the range-change switch is set to the 1,540 to 1,220 kc/s range, the procedure is the same. For example, if the reading of the wavemeter dial is 70, this represents, on the calibration chart, a frequency of 1,480 kc/s. On the correction curve, 1,480 gives a figure of + 1·9. The true scale reading, therefore, is 70 — 1·9, which equals 68·1, and the correct frequency of the transmitter read from the calibration scale at 68·1 is 1,485.

25. A typical calibration chart with correction curves is given in fig. 6. It should be noted that this chart is only given as an example and that all wavemeter settings or measurements of radiated frequencies should be made with reference to the chart supplied with each instrument. As can be seen from the illustration, the chart is divided into halves and pasted into the calibration book cover, which will be found on the back of each wavemeter.

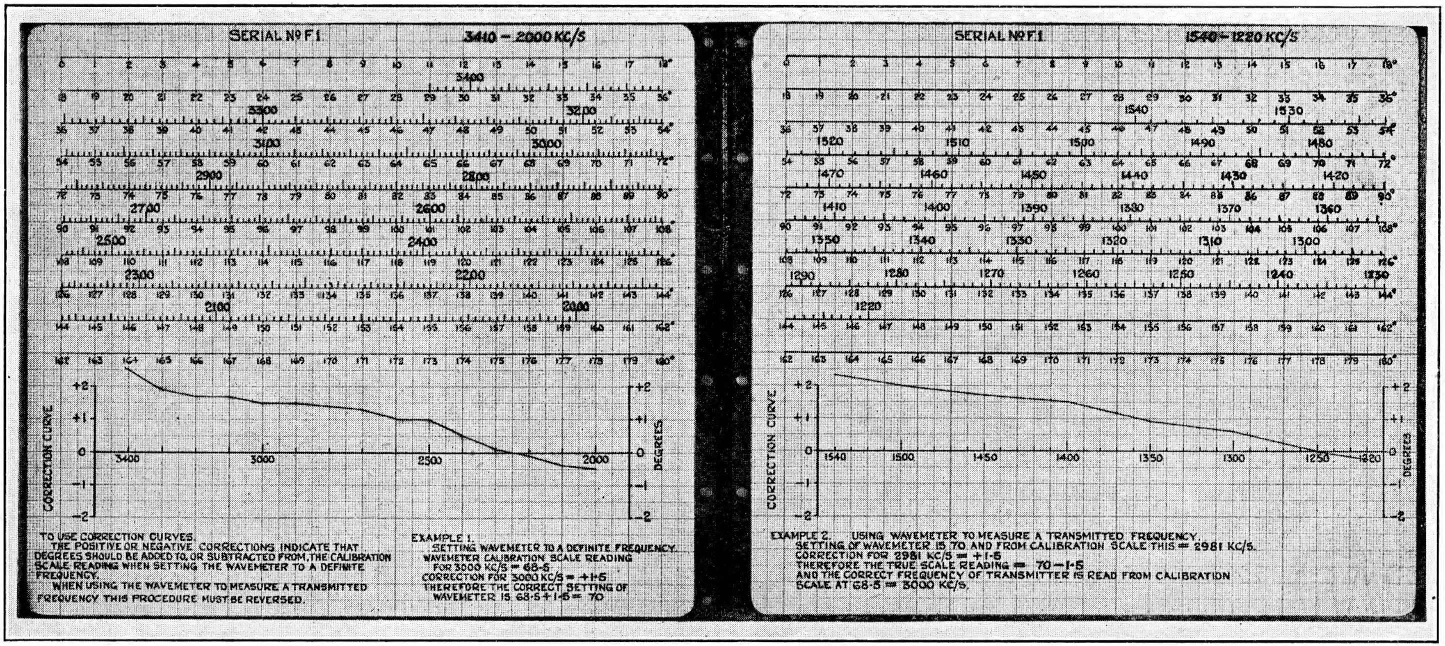


FIG. 6. Calibration Book.

Each cover is stamped with the serial number of the wavemeter to which it refers. In addition to the four examples given in paras. 23 and 24, two further examples are given on the chart. It should be noted that both these latter examples refer to the left-hand chart, i.e. the 3,410 to 2,000 kc/s range.

PRECAUTIONS AND MAINTENANCE

26. As this wavemeter is a precision instrument having a maximum discrimination of the order of 1 part in 2,500, it should be treated with care. Mechanical shocks are liable to affect the apparatus and destroy the accuracy of calibration. As the grid-filament capacitance of the valve enters into the calibration, the wavemeter must be used *only* with one of the three valves supplied. In order to avoid the necessity for recalibration, great care should be taken of the valves, both electrically and mechanically, to ensure as long a life as possible.

27. The full-scale reading of the microammeter should never be exceeded. This condition might arise if the instrument were overloaded, or the wavemeter too tightly coupled with the transmitter, or should any defect occur in the grid-filament circuit with the valve switched on. Any of the above causes may result in the pointer of the microammeter being bent or broken off, or damage may be sustained to the spring and pivots.

28. When changing over from one range to another, it is advisable to switch off first, because if the range-change switch is accidentally held in an intermediate position, the grid circuit of the valve will be opened and the microammeter will be overloaded. For the same reason the voltage of the batteries should be checked periodically, as if the grid bias voltage is low a large deflection will be obtained on the microammeter. When not in use the wavemeter should be switched off in order to avoid unnecessary discharge of the batteries.

29. A permanent deflection in the microammeter greater than 500 microamperes points to a disconnection in the valve grid circuit, or incorrect value of grid bias. The latter can be remedied by inserting the plug in a different socket in the grid bias battery. The plugs and sockets for connecting up the various batteries should be inspected to see that they fit properly and form good contacts.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/9143	Wavemeter W.1095		Without valve or batteries.
	Principal components :—		
10A/9684	Case	1	
10A/9144	Chart, calibration	1	
	Condenser		
10A/7906	Type 125	2	·01 μF.
10A/8379	Type 169	1	·00005 μF (variable).
10A/9145	Type 261	1	·000145 μF.
10A/9146	Type 262	1	·00051 μF (variable).
10A/9318	Type 265	1	·000135 μF.
10A/7597	Holder, valve, type C	1	
10A/9228	Inductance, fixed	1	For long and short wave.
10A/7736	Microammeter, 0–500, type A	1	
	Plug		
10A/9689	Type 89	1	Type 60 plug, engraved H.T.+
10A/9690	Type 90	1	Type 60 plug, engraved H.T.−
10A/9691	Type 91	1	Type 60 plug, engraved G.B.+
10A/9692	Type 92	1	Type 60 plug, engraved G.B.−
	Switch		
10A/7737	Type 55	1	" On-off " switch.
10A/8142	Type 77	1	Range switch.
	Accessories :—		
5A/1386	Accumulator, 2-volt	1	For L.T.
5A/1251	Battery, dry, 6-volt	1	For grid bias.
5A/1334	Battery, dry, 60-volt	1	For H.T.
	Case, transit		
10A/9149	Wavemeter	1	
10A/8412	Valve	1	
10A/7946	Valve, type 210 H.F.	3	One valve in use, two spare.

SECTION 5, CHAPTER 9

MODULATION INDICATOR, TYPE 1 AND MODULATION INDICATOR, TYPE 2

Contents

List of Illustrations

MODULATION INDICATOR, TYPE 1

(Stores Ref. 10A/8219)

INTRODUCTION

1. The modulation indicator, type 1, is an instrument for measuring the percentage modulation of an R/T transmitter so that the transmitter may be adjusted to give maximum modulation with reasonable lack of distortion.

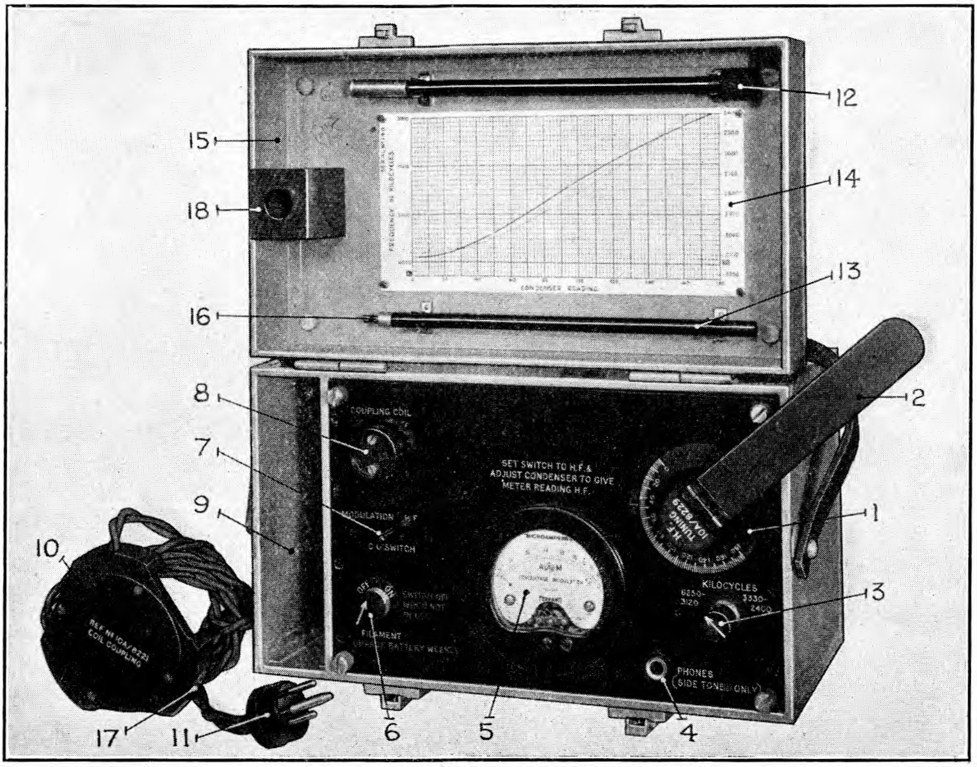


FIG. 1. Modulation Indicator, Type 1.

2. A microammeter, the dial of which is calibrated and engraved directly in percentages of modulation, is employed to give the readings. In order to reproduce the R/F input conditions of calibration, the coupling between the instrument and the transmitter must first be adjusted to bring the pointer of the microammeter up to a datum line on the scale.

3. The method employed is to provide an oscillatory circuit capable of being tuned to the frequency of the carrier wave of the transmitter. In this circuit is a diode rectifier working into a resistance load. The microammeter may be connected by means of a switch, across a portion of this resistance, and the rectified R/F component due to the unmodulated carrier can

thus be measured. Across the resistance, in series with a condenser, is another resistance which (when the carrier is modulated) carries the audio-frequency component. This is rectified by means of a copper-oxide rectifier and measured by transferring the microammeter to this circuit.

4. Actual measurements of the voltages are not necessary and in fact the microammeter dial is calibrated in "percentage modulation", but the R/F input conditions obtained during calibration must be simulated in order to obtain correct "modulation" readings. This is achieved by the simple expedient of providing a datum line upon the scale of the microammeter. When (in the first position of the switch) the component due to the unmodulated carrier produces a deflection of the microammeter pointer corresponding to the datum line, the calibration conditions are reproduced. This initial deflection is, of course, obtained by varying the coupling between the instrument and the transmitter.

GENERAL DESCRIPTION

5. Referring to fig. 2, L is the coupling coil which is tuned by means of the variable condenser C. An additional condenser C_1 may be switched into circuit by means of the switch S in order to provide the required frequency cover. The choke L_1 and the condensers C_2 and C_3 are provided in order to reduce the H/F ripple to a minimum when the carrier is unmodulated. The diode V is virtually in series with the inductance L, the choke L_1 and the resistances R and R_1. The switch S_1 in its "H/F" position connects the microammeter across R_1, and in its "mod." position connects the microammeter across the metal rectifier W. The metal rectifier itself is connected across R_3 which is in series with R_2 and C_4.

6. The telephone jack J is for the purpose of plugging in telephones in order to judge the quality and strength of speech. The coupling coil L is provided with a flexible lead terminating in a two-point plug. It is connected up by inserting the plug into a two-point socket on the instrument. A handle, approximately 16 inches long, is supplied for attachment to the coupling coil to enable the coil to be mounted conveniently.

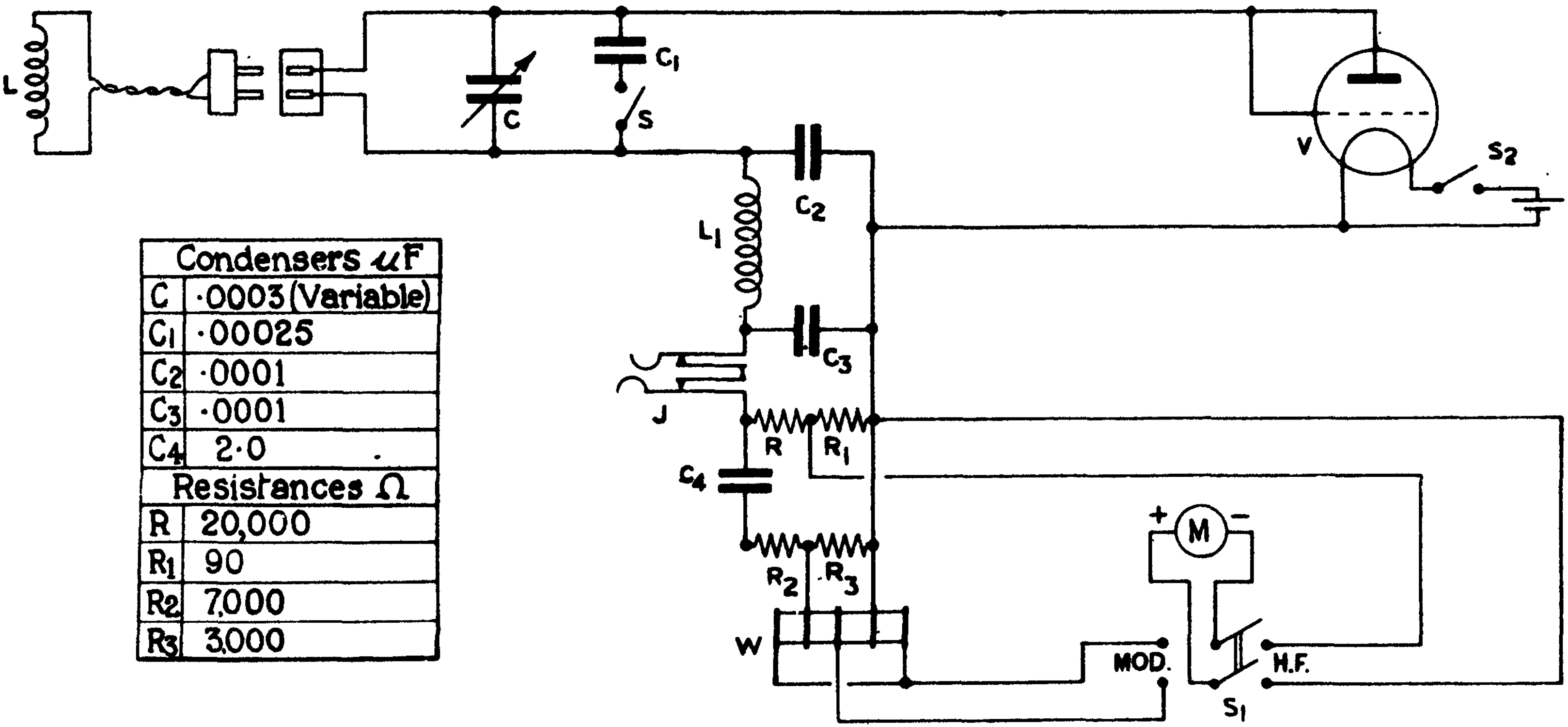
7. The tuning condenser is also provided with an extension handle to facilitate adjustment. This, as will be seen from fig. 1, is hinged so that it may be folded back to occupy less space when the lid of the case is closed.

8. The condenser dial is engraved from 0 to 180 degrees, and in the lid of the case is a chart giving the condenser settings for the required frequencies. The actual range covered is from 2,400 kc/s to 6,250 kc/s. This range is split into two, a switch on the panel of the instrument giving in one position, a cover of from 2,400 to 3,330 kc/s and in the other position, a cover of 3,120 to 6,250 kc/s. Both curves are on the same chart but are in different colours. The higher frequencies are read on the left ordinate and the lower frequencies on the right. Only one battery is employed. This is a two-volt accumulator housed in the instrument case. A switch S_2 is included in the positive filament lead.

9. The dimensions of the instrument are approximately $11\frac{3}{8}$ in. $\times$ $6\frac{7}{8}$ in. $\times$ $7\frac{3}{8}$ in., and the weight, complete with accumulator and valve, is $11\frac{1}{2}$ lb.

CONSTRUCTIONAL DETAILS

10. Three views of the modulation indicator, type 1, are given in figs. 1, 6 and 7, and a bench wiring diagram in fig. 3. Referring to fig. 1 which is a view of the instrument from above, the tuning condenser control (1) may be seen in the top right-hand corner. It is provided with a scale engraved from 0 to 180°. The folding extension handle (2) can be laid back over the top of the condenser when not in use. Below the condenser (1) is the range-change switch (3). It is engraved 6,250—3,120 and 3,330—2,400 KILOCYCLES. The telephone jack (4) is mounted



Condensers μF	
C	·0003 (Variable)
C1	·00025
C2	·0001
C3	·0001
C4	2·0
Resistances Ω	
R	20,000
R1	90
R2	7,000
R3	3,000

FIG. 2, THEORETICAL CIRCUIT DIAGRAM - MODULATION INDICATOR TYPE I

Note – Annotations shown thus (C_4) refer to the corresponding annotations in fig. 2.

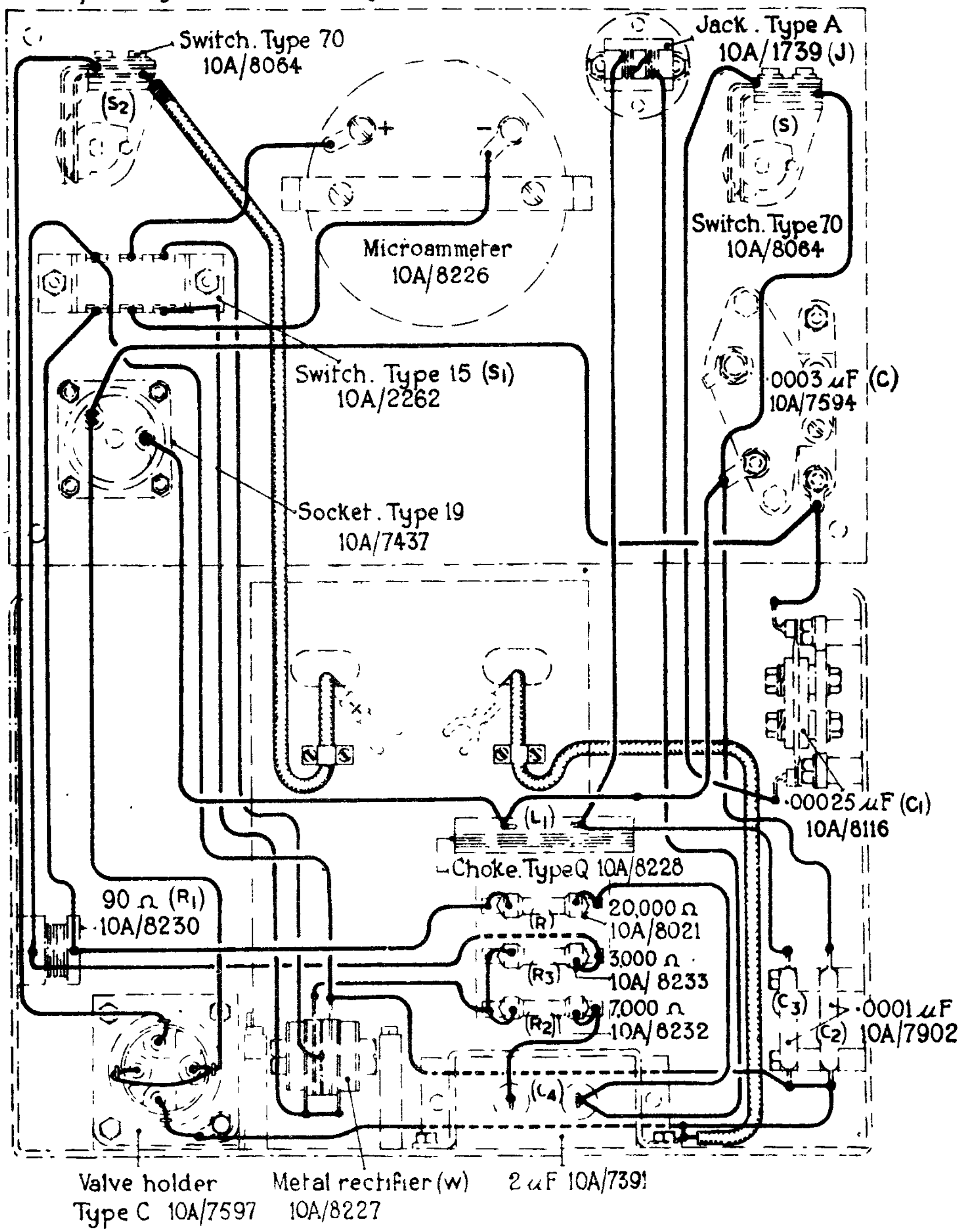


FIG. 3. BENCH WIRING DIAGRAM – MODULATION INDICATOR TYPE I

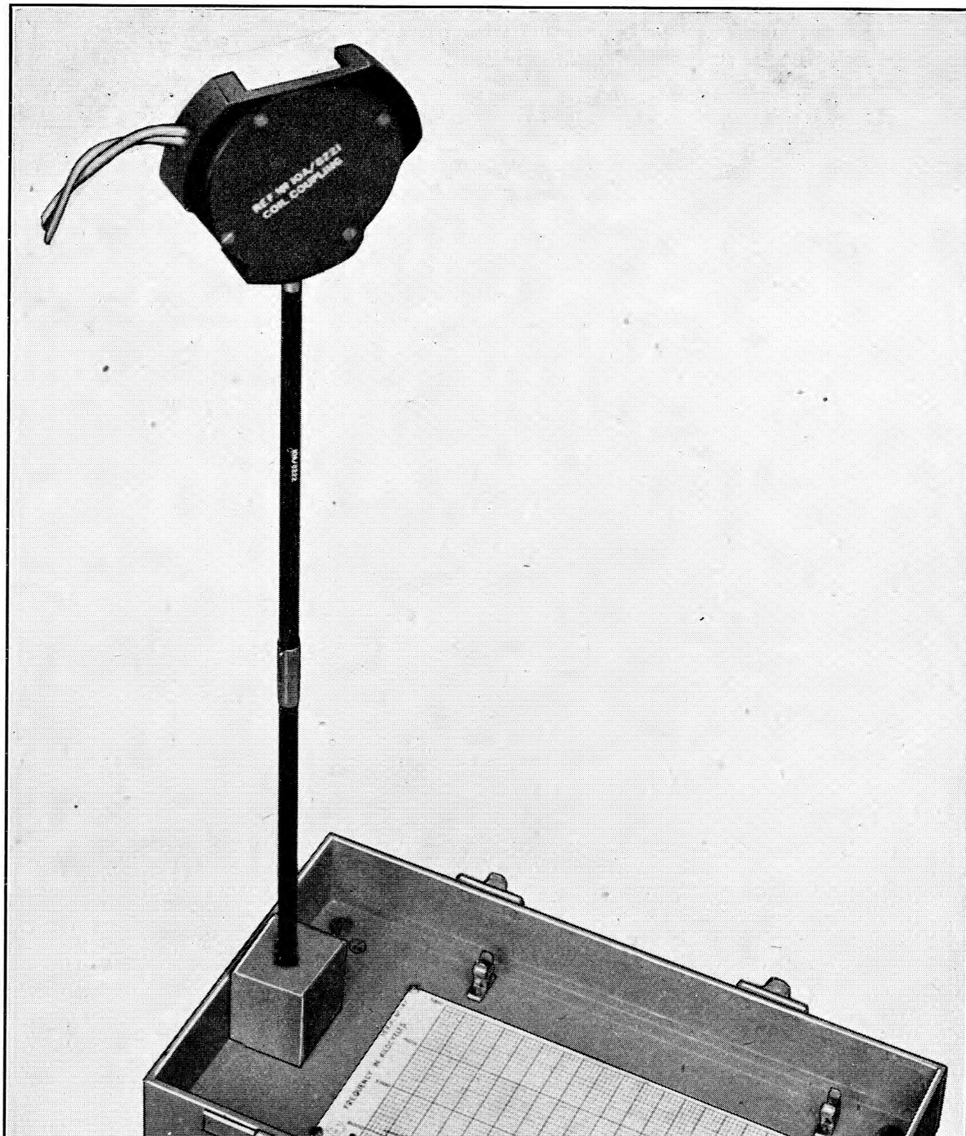


FIG. 4. Coupling coil mounted in lid of case.

below the switch (3). The microammeter (5) is in the centre of the panel. To the left of it is seen the valve filament " on-off " switch (6). The two-way switch (7) is for the purpose of switching the microammeter from one part of the circuit into the other. The coupling coil socket (8) is in the top left-hand corner.

11. The space (9) on the left is provided for stowing the support (1, fig. 5) and coupling coil (10) along with its flexible lead and plug (11). In the lid of the case is mounted the handle (12) and extension handle (13). These two items are stowed in clips when not in use. Also in the lid

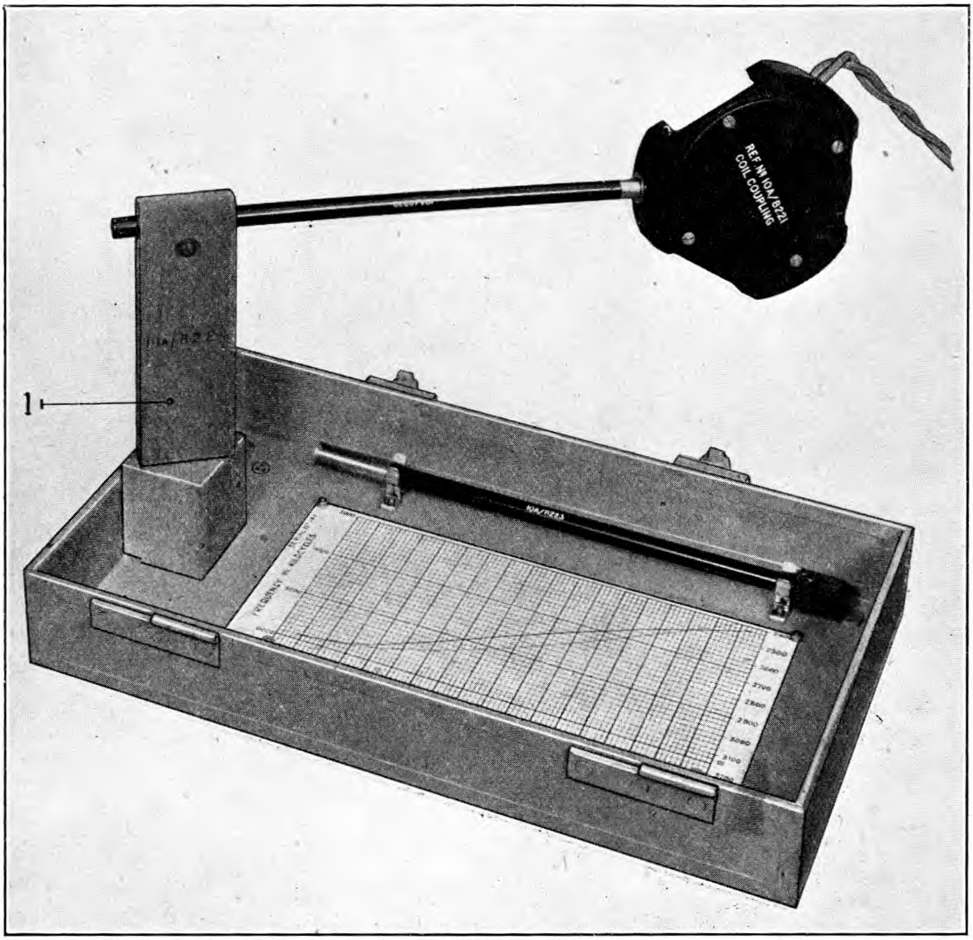


FIG. 5. Coupling coil mounted on support.

of the case is the calibration chart (14). Each modulation indicator is provided with its own chart. The two curves are coloured black and red, and correspond to the colour indication seen on the respective frequencies. The black curve refers to the frequencies on the left, namely 3,000 to 6,000 and the red curve refers to the frequencies on the right, namely 2,400 to 3,200.

12. The lid (15) of the case may be detached by moving it to the right when it will slide off the hinges. Four rubber pads, which act as supports, are provided on the lid. The handle (12) and extension handle (13) may be joined together and the screwed portion (16) engaged with

the coupling coil at (17). The whole unit so formed is mounted in the wooden block (18), (*see* fig. 4). The detached lid thus forms a support for the coupling coil. If it is desired to mount the coupling coil horizontally, the extension handle is pushed through the hole in the support (1, fig. 5), and the coupling coil mounted on the handle as before. The support is then mounted on the wooden block (18). It is shown mounted thus in fig. 5.

13. An interior view of the modulation indicator is given in fig. 6. The wooden compartment in the foreground houses the 2-volt accumulator. The connections are made to the valve filament circuit by means of flexible leads terminating in spade connectors. In order to insert the accumulator in position, it will be necessary to remove the panel from the case. This can be done after undoing the four screws which are situated one at each corner.

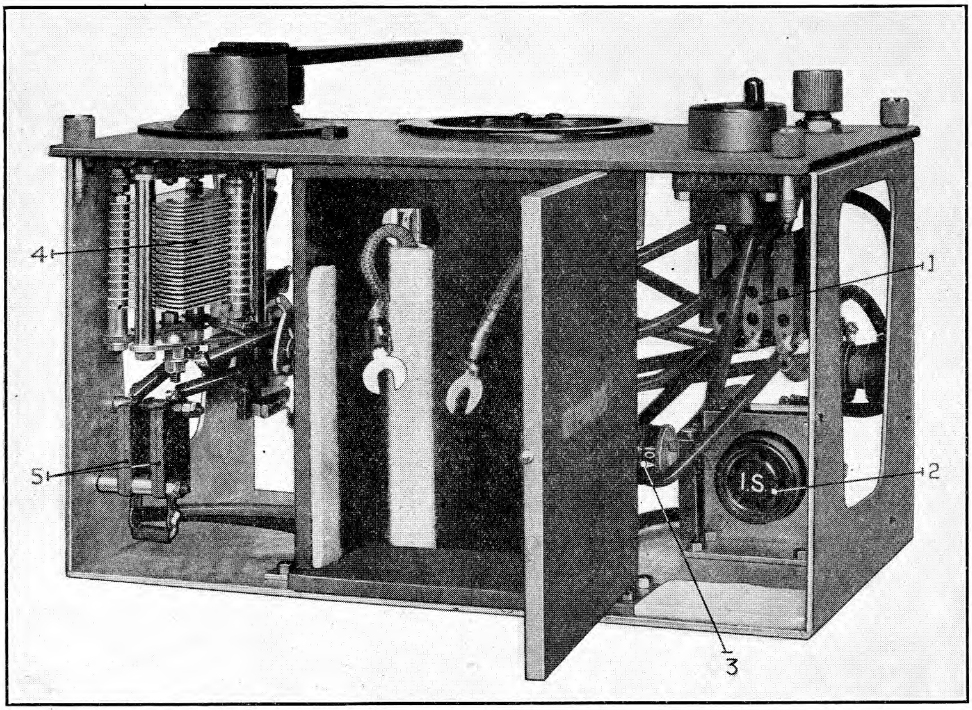


FIG. 6. Interior view of Modulation Indicator (rear).

14. On the right-hand side of the illustration can be seen the range-change switch (1) and below it the valve-holder (2). The rectifier (3) lies to the left of the valve-holder. In the top left-hand corner is the tuning condenser (4). The two ·0001 μF condensers (5) below the tuning condenser are represented by C_3 and C_4 in the theoretical circuit diagram, fig. 2.

15. Another interior view is given in fig. 7. Below the tuning condenser (1) can be seen a ·00025 μF condenser (2). This condenser is represented by C_2 in fig. 2. It is connected in series with the switch (3) across the tuning condenser. The telephone jack (4) is connected on one side to the choke (5) and on the other side to the 20,000-ohm resistance (6). The 7,000-ohm resistance (7) and the 3,000-ohm resistance (8) are represented by R_2 and R_3 in fig. 2. The 2 μF condenser (9)

is connected between the resistance (7) and the resistance (6). In the foreground of the illustration is the rectifier (10) and to the left of it the valve-holder (11). The wire wound resistance (12) above the valve-holder, has a value of 90 ohms and is represented by R_1 in the theoretical circuit diagram, fig. 2.

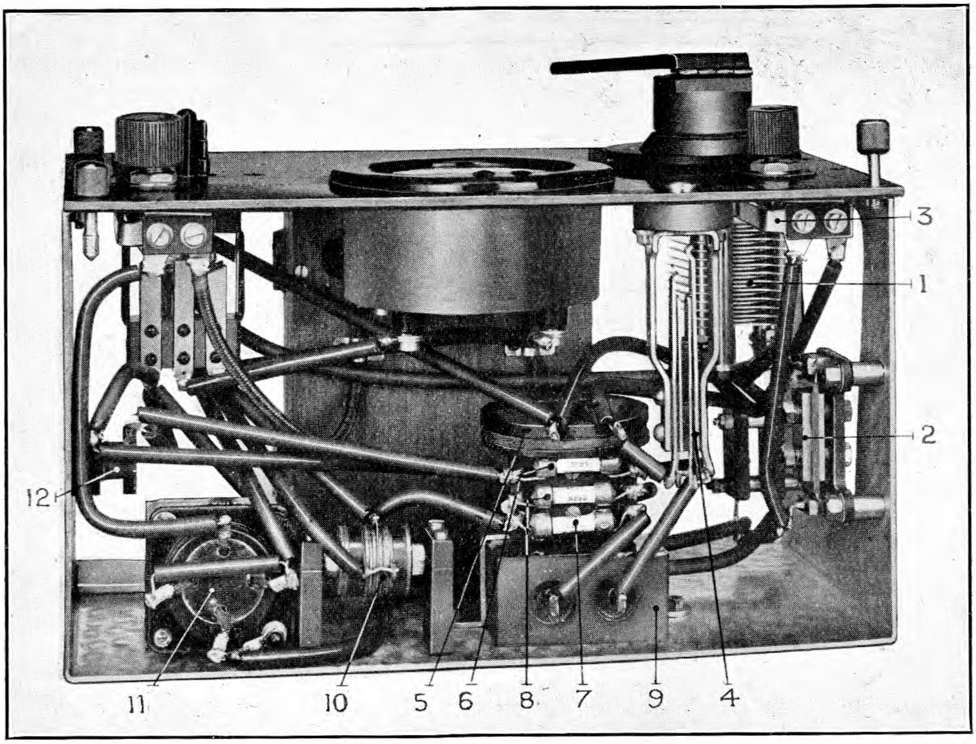


FIG. 7. Interior view (front).

VALVE AND BATTERY

16. A V.R.21 metallized valve is employed as a rectifier, the valve-holder connections being arranged to bridge grid and anode so that the valve operates as a diode. Only one accumulator is required. This is a 2-volt, 7 ampere-hour accumulator, housed in a container in the case of the instrument.

OPERATION

17. The instrument should be removed from its case by undoing the four screws at the corners of the panel. A two-volt accumulator (Stores Ref. 5A/1158) should be inserted in the space provided at the rear of the instrument and the spade terminals connected up.

18. After replacing the instrument in its case the coupling coil should be connected up by means of the plug-and-socket connection. The handles should be removed from their stowage in the lid, assembled and screwed into the coupling coil.

19. Now couple the coil to the transmitter by one of the methods shown in figs. 4 or 5; set the change-over switch to H/F and the filament switch to ON. Set the frequency-change switch to the appropriate position, and the variable condenser to the setting obtained from the chart

for the frequency being radiated by the transmitter. Watching the needle of the microammeter, make fine adjustments of the variable condenser to obtain an optimum reading, and then adjust the coupling coil until the needle of the microammeter coincides with the line marked H/F on the scale. It is preferable to commence with a weak coupling, obtaining an optimum reading on the lower portion of the microammeter scale by adjusting the variable condenser and then subsequently increasing the coupling to bring the needle on to the H/F engraving.

20. The instrument is now correctly set to measure the modulation. Set the change-over switch to MODULATION and start the transmitter radiating the modulated transmission it is desired to measure. The percentage modulation will be indicated directly on the microammeter scale. It should be borne in mind that with normal speech, the modulation varies, even falling to zero during pauses. A continuous note produced in front of the microphone will facilitate the procedure.

21. The quality of speech may be judged by inserting telephones in the jack. The telephones should not be in circuit when measurements of percentage modulation are being made, as the calibration of the instrument will not then be correct.

22. Since the instrument may have to be used with different types of transmitters, the method of coupling will differ. Six feet of flexible cable is provided on the coupling coil so as to enable it to be placed in any convenient position, and a wooden socket is provided on the detachable lid of the box in which the coupling handle is accommodated. If the instrument is sufficiently near to the transmitter it will then be possible, by rotating the coupling coil in this socket, to vary the amount of coupling.

PRECAUTIONS AND MAINTENANCE

23. The instrument requires very little maintenance in service. When not in use the lid of the carrying case should be kept shut and the instrument stored in a clean dry place.

24. Before closing the lid, after using the instrument, look at the filament switch and ensure that this is in the " off " position. If the precaution of examining this switch is not taken, the switch may easily be left on, with a consequent discharging of the accumulator.

25. Variations of filament voltage within ordinary limits will not affect the calibration. The accumulator should be removed and charged weekly, however, to ensure that it is kept in good condition. In the event of failure of the V.R.21 valve it should be replaced by a similar one. The grid and anode pins on the valve-holder are bridged underneath so as to operate the valve as a diode. Owing to the horizontal mounting of the valve-holder and the proximity of the valve to the bottom of the case, care should be exercised when removing the valve from its holder. A screwdriver, inserted between the face of the valve and the holder, may be used to ease the valve out.

26. It should be noted that any slight changes in the H/F. calibration which may occur as a result of changing a valve are not important, since the calibration curve gives the approximate setting for the frequency, and the tuning condenser is subsequently adjusted until an optimum reading is obtained.

MODULATION INDICATOR, TYPE 2

(Stores Ref. 10A/10971)

27. This instrument is a modified form of Modulation Indicator, type 1, several components of which have been replaced. A theoretical circuit diagram of Modulation Indicator, type 2 is given in fig. 8. The filament " ON-OFF " switch and " MOD-H/F " switch provided in Modulation Indicator, type 1 (*see* 6 and 7 respectively, fig. 1), are now combined and replaced by P.O. switch, type 212, which has three positions engraved MOD, OFF, and H/F. In either the MOD, or H/F position, the filament circuit of the valve is completed. The microammeter A, fig. 8, is unchanged and serves the same purpose.

28. The wiring of some of the components has been altered. Reference to fig. 8 will show that the condensers remain the same as before. The resistance R is still 20,000 ohms, but R_1 is now 100 ohms. R_2 and R_3 (10,000 and 20,000 ohms, respectively) are now in series in the rectifier circuit. When the switch S is in the MOD. position, the microammeter A is connected in series with the D.C. side of the rectifier W, and the filament circuit of the valve V is closed. In the H/F position, the switch S closes the valve filament circuit and connects the microammeter across the resistance R_1.

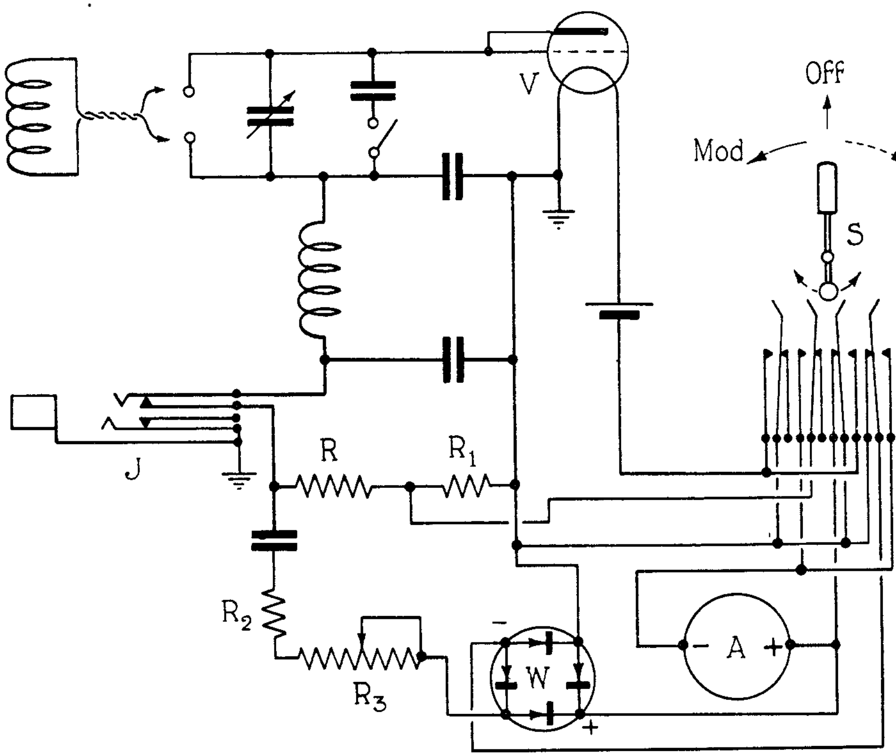


FIG. 8. THEORETICAL CIRCUIT DIAGRAM - MODULATION INDICATOR, TYPE 2

29. The bench wiring diagram, fig. 9, shows the manner in which the components of Modulation Indicator, type 2, are wired up and also the relative position of these components. The annotations used in fig. 8 are repeated here and refer to corresponding items.

30. In Modulation Indicator, type 2, one side of the circuit is connected to the chassis as before. In addition, an earth terminal is provided for connecting it to ground. It will be seen that one side of the telephone jack J is earthed, so that when the plug is inserted, the quality of speech can be checked, but at the same time the microammeter is disconnected. This effectively prevents readings being taken with the telephones in circuit. Such readings would of course be erroneous.

31. The method of setting up and operation are the same as for Modulation Indicator, type 1, and the same remarks as regards maintenance also apply. It should be noted that the pre-set resistance, type 395, is for calibration purposes only and should not be interfered with. It is adjusted before the instrument is sent out to service and then sealed.

Note - Annotations shown thus (R_3) refer to the corresponding annotations in Fig. 8

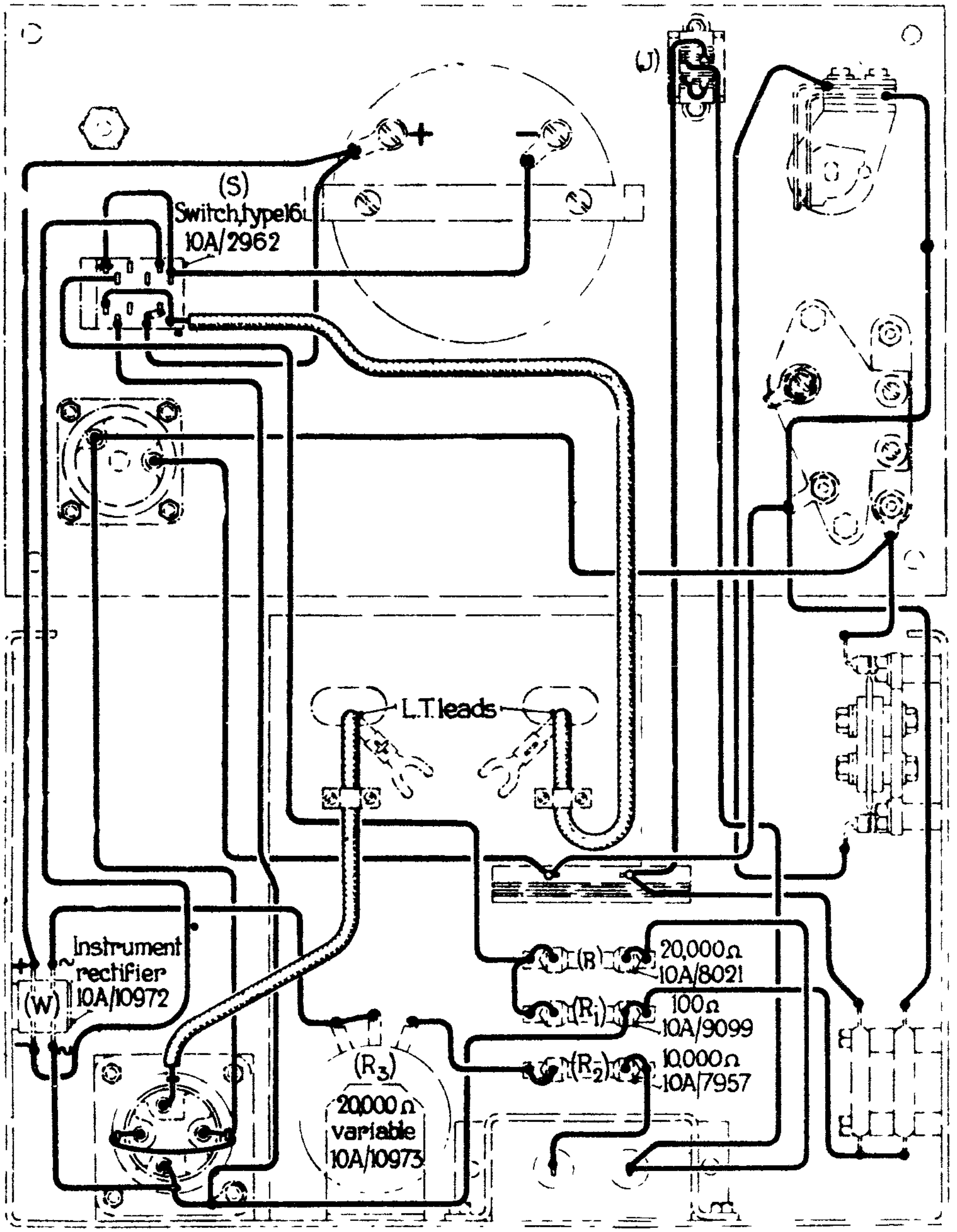


FIG. 9, BENCH WIRING DIAGRAM - MODULATION INDICATOR TYPE 2

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/8219	Indicator, modulation, type 1	1	Without valve and battery.
	Principal components :—		
10A/8220	Case	1	With lid.
10A/8228	Choke, H/F, type Q	1	
10A/8221	Coil, coupling	1	With lead and one plug, type 51.
10A/8222	Extension, handle	1	With screwed end.
10A/8223	Handle	1	With ebonite knob.
10A/8224	Support	1	
	Condenser		
10A/7391	Type 74	1	$2 \cdot 0$ μF.
10A/7594	Type 86	1	$\cdot 0003$ μF. variable.
10A/7902	Type 121	2	$\cdot 0001$ μF.
10A/8116	Type 147	1	$\cdot 00025$ μF.
10A/8225	Container, accumulator	1	
10A/8229	Handle, condenser, direct drive, type B	1	
10A/7597	Holder, valve, type C	1	
10A/1739	Jack, telephone, type A	1	
10A/8226	Microammeter, 0–500	1	$2\frac{1}{2}$ in. dial, flush type, with special calibration.
10A/8227	Rectifier, metal	1	
	Resistance		
10A/8021	Type 113	1	20,000 ohms, $\frac{1}{2}$-watt, rod type.
10A/8230	Type 132	1	90 ohms, wire wound bobbin.
10A/8232	Type 134	1	7,000 ohms, $\frac{1}{2}$-watt, rod type.
10A/8233	Type 135	1	3,000 ohms, $\frac{1}{2}$-watt, rod type.
10A/7437	Socket		
	Type 19	1	
	Switch		
10A/2262	Type 15	1	
10A/8064	Type 70	2	
	Accessories :—		
5A/1514	Accumulator, 2-volt, 7 Ah.	1	
10A/7738	Valve, type V.R.21	1	
10A/10971	Modulation indicator, type 2 :—		
	Principal components :—		
10A/8220	Case	1	With lid.
10A/8228	Choke, H/F, type Q	1	
10A/8221	Coil, coupling	1	With lead and one plug, type 51.
10A/8222	Extension, handle	1	With screwed end.
10A/8223	Handle	1	With ebonite knob.
10A/8224	Support	1	
	Condenser		
10A/7391	Type 74	1	$2 \cdot 0$ μF.
10A/7594	Type 86	1	$\cdot 0003$ μF. variable.
10A/7902	Type 121	2	$\cdot 0001$ μF.
10A/8116	Type 147	1	$\cdot 00025$ μF.
10A/8225	Container, accumulator	1	
10A/8229	Handle, condenser, direct drive, type B	1	
10A/7597	Holder, valve, type C	1	
10A/1739	Jack, telephone, type A	1	
10A/8226	Microammeter, 0–500	1	$2\frac{1}{2}$-in. dial, flush type, with special calibration.
10A/10972	Rectifier, instrument	1	1 mA.

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Modulation Indicator, Type 2—*continued*		
	Principal components—*continued*		
	Resistance		
10A/7957	Type 104	1	10,000 ohms, ½-watt, rod type.
10A/8021	Type 113	1	20,000 ohms, ½-watt, rod type.
10A/9099	Type 263	1	100 ohms, ½-watt, rod type.
10A/10973	Type 395	1	20,000 ohms, variable.
10A/7437	Socket, type 19	1	
	Switch		
10A/2962	Type 16	1	P.O. switch type 212.
10A/8064	Type 70	1	" On–off ".
	Accessories :—		
5A/1514	Accumulator, 2-volt, 7 Ah.	1	
10A/7738	Valve, type V.R.12	1	

SECTION 5, CHAPTER 10

TESTER, VALVE, TYPE 2

Contents

List of Illustrations

TESTER, VALVE, TYPE 2

(Stores Ref. 10A/9751)

INTRODUCTION

1. The valve tester, type 2, has been introduced to provide service units with a means whereby the standard 2-volt types of directly-heated receiving valve may be tested for general efficiency with a sufficient degree of accuracy for practical purposes. Provision is made for testing diodes, triodes, tetrodes and output valves of the class B and Q.P.P. (pentode) types. The instrument is in portable form, measuring $14\frac{1}{4}$ in. by 7 in. by 10 in. and contains the necessary H.T., grid bias, and filament heating batteries. Its weight complete with batteries is $22\frac{3}{4}$ lb., and that of the transit case $8\frac{1}{2}$ lb. The dimensions of the latter are $16\frac{1}{4}$ in. by $8\frac{3}{4}$ in. by 12 in. The general appearance of the instrument and its transit case may be gathered from fig. 1.

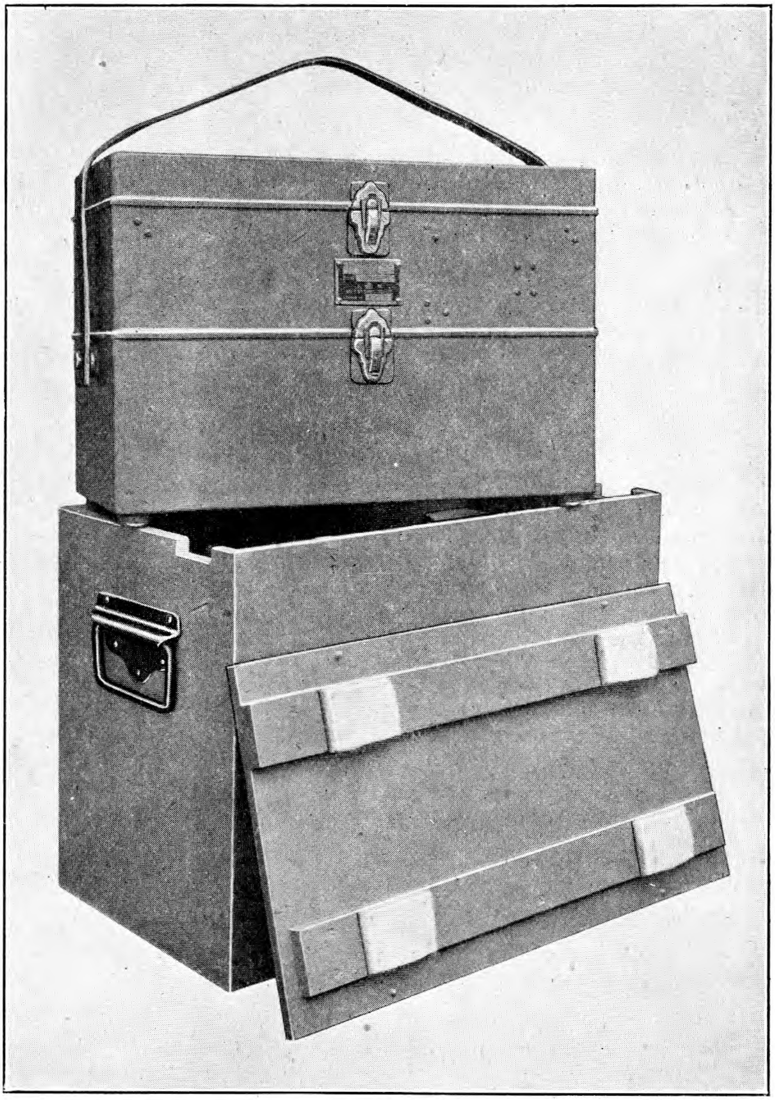


FIG. 1. Valve tester, type 2, with transit case.

GENERAL DESCRIPTION

2. The valve tester, type 2, consists of an assembly of valve-holders, switches and resistances, which are used in conjunction with an indicating instrument by which the various measurements are made. The disposition of the various components will be explained with reference to the theoretical circuit diagram, fig. 2. Although four valves are shown (in dotted line) in this diagram, it must be clearly understood that on no account should more than one valve be inserted at a time. The valve-holder marked CLASS B may be used to test either Class B triodes or Q.P.P. pentodes. The latter type of valve is actually shown in the diagram.

3. The filament sockets of all four valve-holders are connected in parallel, except that a resistance R_1 of 0·75 ohms, is permanently connected in series with the L.T. — socket of the diode valve-holder. The anode connector for a tetrode valve is fitted to a length of flexible cable (uniflexed 4), the connector being held by a special type of spring fitting on the panel when not in use. The anode sockets of the triode and class B valve-holders, and the flexible top anode connector for the tetrode, are directly connected, a cylindrical condenser C (0·01 μF, paper dielectric) being connected between the triode anode socket and L.T.—. The control grid sockets of the triode and tetrode valve-holders and both control grid sockets of the class B valve-holder are similarly inter-connected.

4. The screening-grid socket of the tetrode valve-holder is connected, *via* a decoupling resistance R of 10,000 ohms, to the mid-point, i.e. the 60-volt tapping, of the H.T. battery, while the corresponding socket of the class B valve-holder is connected through the resistance R_6, also of 10,000 ohms, to the 120-volt tapping point on the H.T. battery.

5. The indicating instrument (M) is a microammeter, maximum scale deflection corresponding to a current of 100 microamperes. By means of a number of interchangeable shunt and series resistances, the instrument is provided with eleven current and voltage ranges. The function of the instrument is changed over from milliammeter to voltmeter, and the appropriate series or shunt resistances inserted in the circuit, by means of the meter range switch S_1.

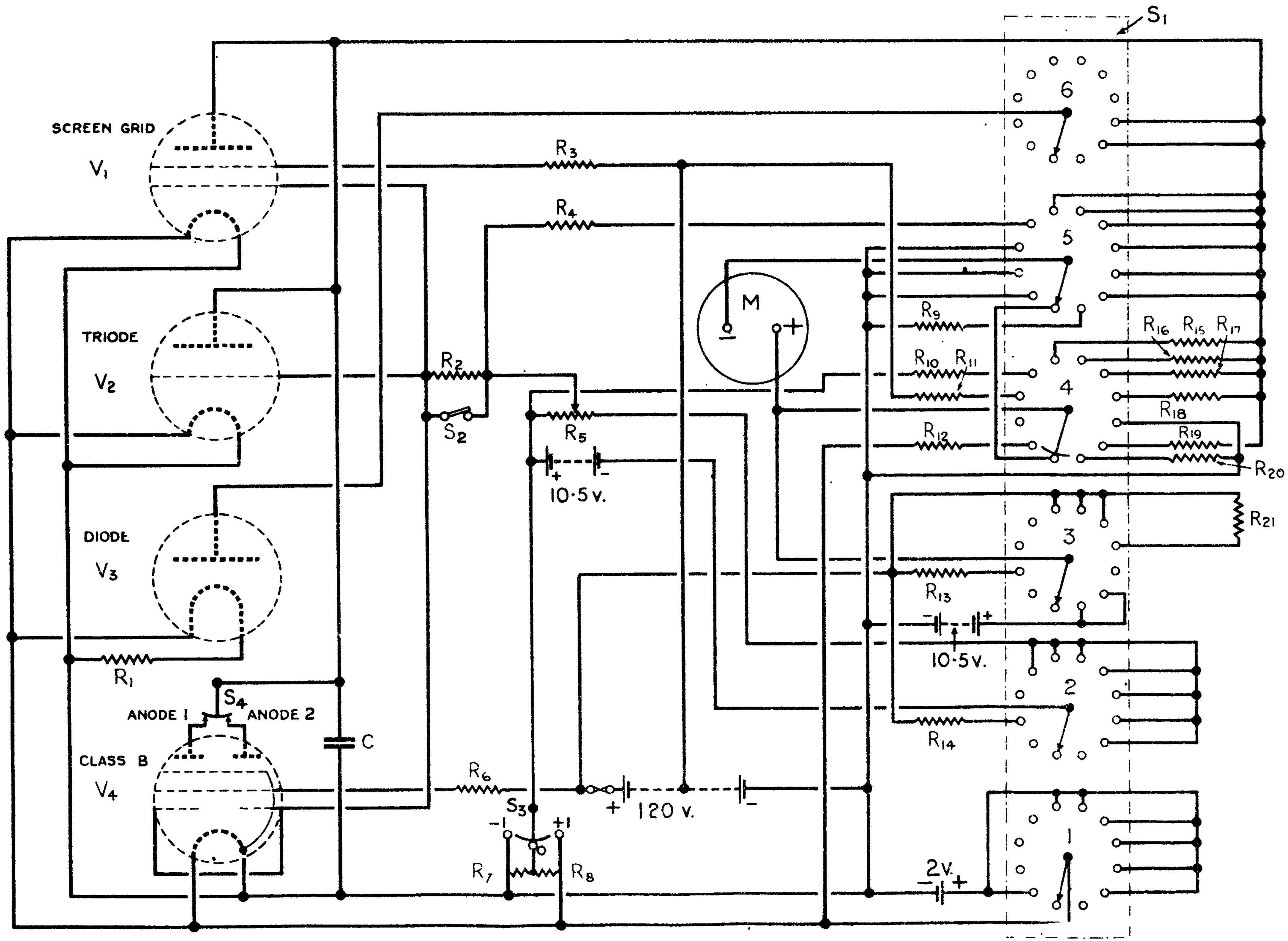
6. The meter range switch is a 6-pole, 12-way rotary switch operated by a suitable knob on the panel. The functions of the six poles are broadly as follow. No. 1 closes the filament circuit on certain ranges. No. 2 closes the circuit of the grid bias potentiometer. No. 3 selects the point to which the negative terminal of the microammeter is connected, while No. 5 performs a similar operation with respect to the positive terminal of the microammeter. No. 4 selects the appropriate series or shunt resistance for the particular measurement to be performed. No. 6 is operative only for current measurements upon a diode. It connects the anode of the valve to the anode condenser C and to poles Nos. 4 and 5 of the switch.

7. The anode current of a triode, tetrode, class B or Q.P.P. valve is measured at the usual service voltage, i.e. 120 volts. Provision is made for this measurement to be performed with a suitable grid bias, corresponding with that at which the particular type of valve is usually operated. This is achieved by means of a grid bias battery of 10·5 volts, which supplies current to a 5,000 ohms potentiometer R_5. A second, fixed, potentiometer R_7, R_8, consisting of a centre-tapped resistance of 50 ohms, is connected across the filament sockets. This is used in conjunction with the key switch S_3 when testing the mutual conductance as described later.

8. Between the grid sockets and the moving contact of the potentiometer, a grid leak R_2 of 0·5 megohms is fitted, but is normally short-circuited by the key switch S_2. It serves to give an indication of the efficiency of a valve when used as a grid detector.

9. When the valve under test is a diode, the 120-volt battery is not used. The anode current is supplied by a second 10·5-volt battery which is brought into operation by pole No. 3 of the meter range switch.

10. The key switch S_4 is of the three-way locking type and is used when testing class B or Q.P.P. valves. According to the position of the key, either of the two constituent electrode assemblies, or the two in parallel, may be tested.



CONDENSER.

C	0·01 μF

RESISTANCES

R_1	0·75 μF	R_{12}	20,000 Ω
R_2	0·5 MΩ	R_{13}	2 MΩ
R_3	10,000 Ω	R_{14}	20,000 Ω
R_4	50,000 Ω	R_{15}	2·63 Ω
R_5	5,000 Ω	R_{16}	5·31 Ω
R_6	10,000 Ω	R_{17}	13·6 Ω
R_7	25 Ω	R_{18}	28·9 Ω
R_8	25 Ω	R_{19}	0·521 Ω
R_9	100,000 Ω	R_{20}	500 Ω
R_{10}	50,000 Ω	R_{21}	100,000 Ω
R_{11}	1 MΩ		

10 mA. O O 5 mA.
G.V. O O 2 mA.
S.G V O O 1 mA.
ANODE V. O O DIODE 1.
FILT. V O O DIODE 2.
OFF O O DIODE V.

POSITIONS OF METER RANGE SWITCH

FIG. 2, VALVE TESTER TYPE 2. THEORETICAL CIRCUIT DIAGRAM

Facing paras 2-10

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11. The H.T. and grid bias batteries are connected to the instrument proper by means of flexible leads and service type battery plugs ; the L.T. battery leads are fitted with spade terminals. Each lead carries an insulating sleeve which is suitably engraved in order that it may be identified. As there are two pairs of 10·5-volt leads, particular care must be observed in connecting up these units. The engraving of the grid bias battery leads is filled in with white, and that of the diode anode battery leads in black material. A 100-milliampere fuse is fitted in the H.T.+ lead, two spare fuses being conveniently fitted in dummy holders on the inside of the case, below the panel.

CONSTRUCTIONAL DETAILS

12. The construction of the instrument will be described with reference to the illustrations, figs. 3, 4, 5, and the bench wiring diagram, fig. 6. Fig. 3 shows the upper panel of the instrument and the instruction card which is fitted inside the lid. The case (1) (Stores Ref. 10A/9754) is of aluminium sheet with welded joints, and is finished in Air Ministry standard grey colour. It consists of two compartments, the lower of which contains the batteries. The instrument panel is of a synthetic resin material and carries the whole of the electrical components of the instrument proper. On the left are the valve-holders. The upper one (3) is a five-socket holder, type S

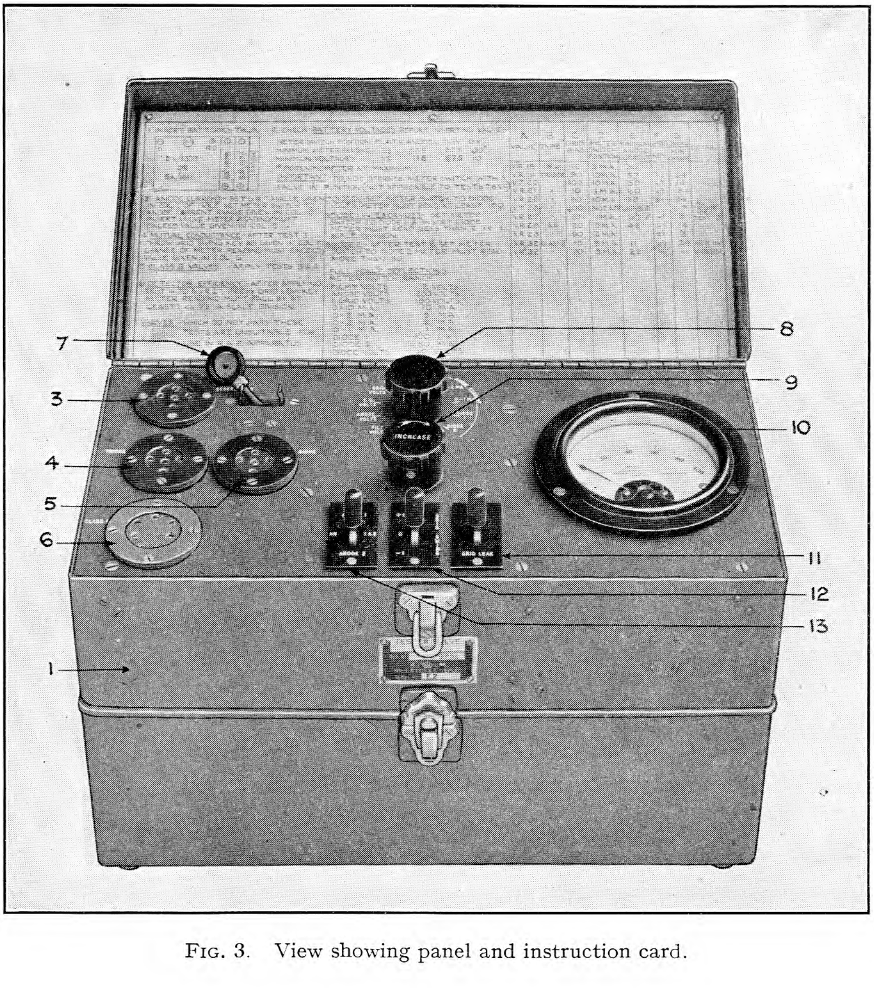

FIG. 3. View showing panel and instruction card.

(Stores Ref. 10A/9615), the wiring being arranged for testing tetrodes such as the valves, receiving, V.R.18 and V.R.28. On the centre line are two valve-holders, type S (4 and 5), the former being wired for testing triodes and the latter for testing diodes. The lower valve-holder (6) is a valve-holder, type U (Stores Ref. 10A/9756) ; it has seven sockets and is used in testing Class B or Q.P.P. (double pentode) valves. The connector (7) is the anode connector for use in conjunction with the valve-holder (3) when testing tetrodes.

13. The knob of the meter range switch (8) (switch, type 120, Stores Ref. 10A/9767) occupies the upper centre portion of the panel. Below it is the knob (9) of the grid bias potentiometer, carrying an arrow to indicate the direction in which the bias voltage is increased. Below this are three G.P.O. key switches. When depressed the right-hand switch (11) (switch, type 122, Stores Ref. 10A/9769) inserts the grid leak resistance. The middle switch (12) (switch, type 121, Stores Ref. 10A/9768) is provided for the mutual conductance test. Both the switches (11) and (12) are of the non-locking type. The left-hand switch (13) (switch, type 16, Stores Ref. 10A/2962) is of the locking type. It selects for test either or both elements of any valve inserted in the holder (6). The indicating instrument (10) is seen on the right. It is actually a moving-coil microammeter (Stores Ref. 10A/9757), but the scale is merely engraved 0–100 without reference to any electrical unit. It is fitted with a zero correcting device, actuated by a small screw of insulating material, the head of which can be seen in the illustration.

14. Fig. 4 is a view of the instrument with the lower compartment open, and shows the various batteries in position. The teak battery box (2) (Stores Ref. 10A/9752) is prevented from excessive deterioration due to chemical action by a coating of acid-resisting paint. The under sides of the valve-holders (3, 4, 5 and 6) can be seen on the left.

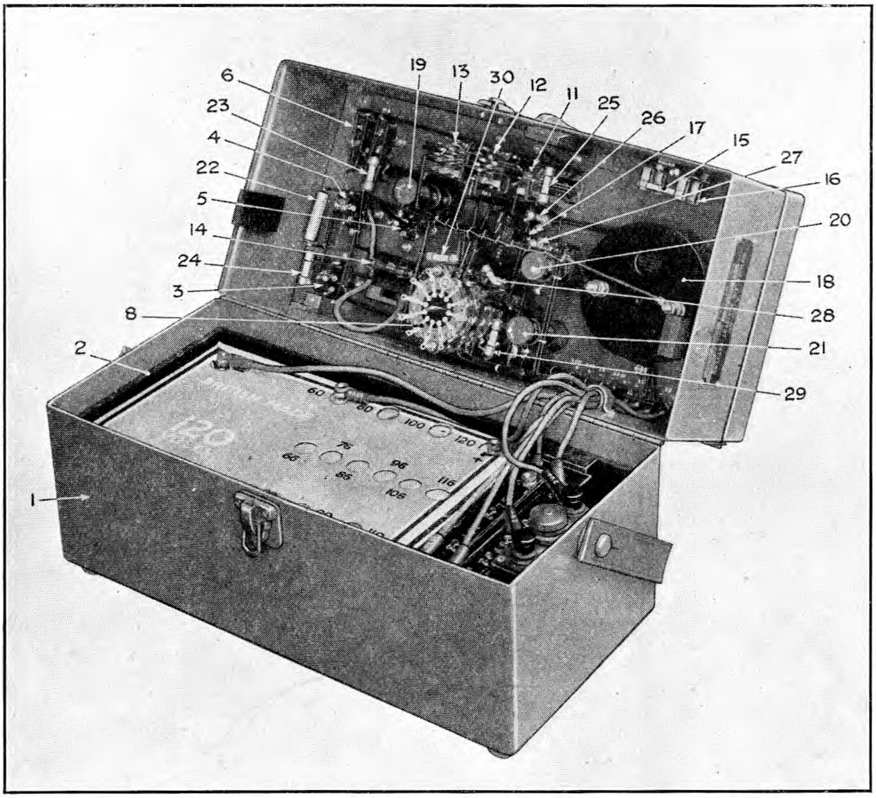

FIG. 4. Lower compartment, with batteries.

15. The construction of the meter range switch (8) may also be seen from this and the following illustration. It consists of a metal base plate mounted on the under side of the panel and carrying two metal pillars. Upon these pillars are mounted six thin annular rings of insulating material. Each of these carries twelve spring contacts, arranged radially in such a manner as to project inwards. The circular space inside each ring is filled by a disc, also of insulating material. This disc carries a contact, over which the fixed spring contacts ride when the disc is rotated. The six insulating discs are rotated by means of a flat bar passing through a rectangular slot in each disc. This bar is turned by means of the switch knob on the front of the panel. A pair of travelling arms are attached to the bar, each of which carries a small roller upon its outer end. This roller engages in any one of twelve recesses in the base plate and so locks the switch in any position in which it is set. The base plate and several of these recesses can be seen in fig. 5.

16. Near the meter range switch is seen the H.T. fuse (14) (fuse, 100mA, Stores Ref. 10A/10152) which is enclosed in a glass tube with metal ends, and is carried by the standard type of cartridge fuse-holder (Stores Ref. 10A/10153). Two spare fuses (15, 16) are fitted in similar but dummy holders inside the case. Above the meter range switch is the grid bias potentiometer (17). This is a resistance type 287, (Stores Ref. 10A/9766) of graphitic material, enclosed in a circular insulating case. The under side (18) of the indicating instrument is seen on the extreme right.

17. Three sets of wire-wound resistances, carried upon cylindrical formers of composite insulating material, are also seen in figs. 4 and 5. The resistance (19), above the diode valve-holder is a resistance type 286, (Stores Ref. 10A/9765) and consists of three separate windings. The two sections nearest the panel are each of 25 ohms (R_7, R_8, of figs. 2 and 7) and form a centre-tapped, fixed potentiometer across the L.T. battery. The other section of the winding has a resistance of 0·75 ohms and is in series with the negative L.T. socket of the diode valve-holder. The upper one (20) of the two on the right is a resistance type 285 (Stores Ref. 10A/9764) ; it carries three windings of 28·9, 13·6 and 5·31 ohms respectively. The lower one (21) is a resistance type 284 (Stores Ref. 10A/9763), and has two windings of 2·63 and 0·521 ohms respectively. The windings of the two last-mentioned resistances function as shunts for the indicating instrument for various anode current ranges.

18. On the left-hand side of the panel, in fig. 4, the tubular condenser (22), type 332, 0·01 μF, paper dielectric (Stores Ref. 10A/9755), can be seen. Close to it are two resistances (23 and 24) of the $\frac{1}{2}$-watt rod type. The upper one (23) is a resistance type 104, 10,000 ohms (Stores Ref. 10A/7957), and is the screen feed resistance for the valve-holder, type U. The lower one (24) is a resistance of the same type and acts as a screen feed resistance for the tetrode valve-holder. The $\frac{1}{2}$-watt rod (25) has a resistance of 0·5 megohms and is a resistance type 281 (Stores Ref. 10A/9760). It is directly connected between one fixed and one moving blade of the key switch (11), the other blades being unused. It functions as the grid leak in the test for detector efficiency.

19. Several other resistances of the $\frac{1}{2}$-watt rod type remain to be pointed out. These are all grouped round the meter range switch. In fig. 4 (26 and 27), are resistances type 400, 50,000 ohms (Stores Ref. 10A/11026). Together, these form a 100,000 ohm voltmeter series resistance for the " Grid volt " range. The resistance (28) is a type 100, 500 ohms (Stores Ref. 10A/7953) acting as a load resistance when measuring " Diode volts." On the lower right-hand side of the meter range switch, the $\frac{1}{2}$-watt rod (29) is a resistance type 282, 100,000 ohms (Stores Ref. 10A/9761), acting as an anode resistance when measuring current in the 0–1 mA. range. Immediately above the switch is the resistance (30), also a type 282, acting as a series voltmeter resistance on the " Diode volts " range. The remainder of the $\frac{1}{2}$-watt rod resistances are shown in fig. 5 only. Beneath the meter range switch, the resistance (31) is a type 279, 2 megohms (Stores Ref. 10A/9758), acting as a voltmeter series resistance on the "Anode volts" range. The resistance (32) is a type 280, 1 megohm (Stores Ref. 10A/9759) acting in a similar capacity

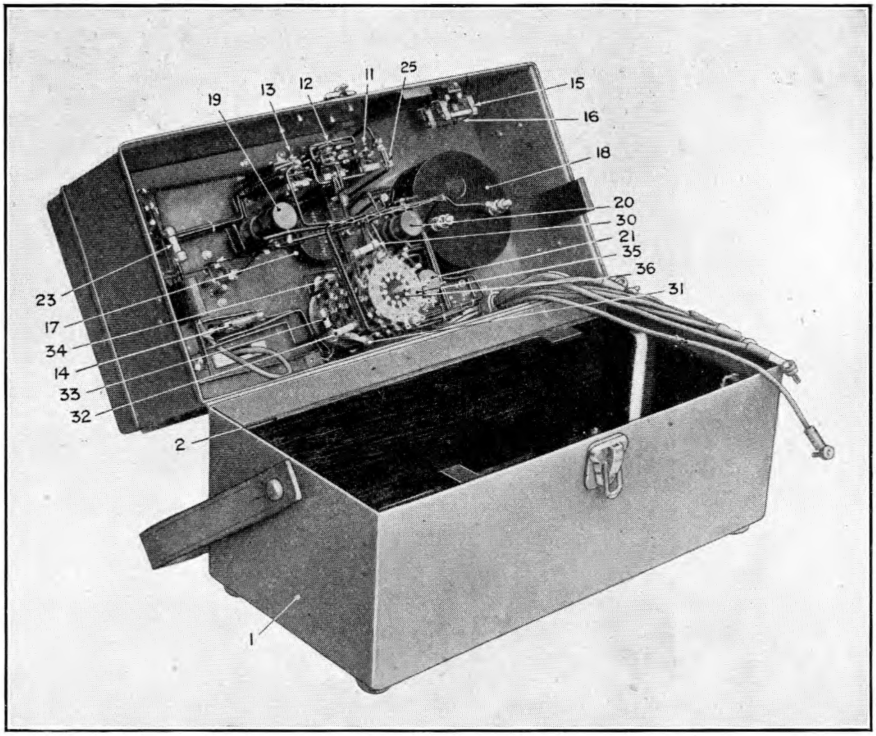

FIG. 5. Lower compartment, without batteries.

in the " S.G. volts " range. The resistance (33) is a type 283, 20,000 ohms (Stores Ref. 10A/9762), acting as the load resistance in the "Anode volts " range, while (34) is a resistance of the same type and is in series with the voltmeter on the " Filt. volts " range.

20. The fixed annular rings of the meter range switch, with their radial contacts, are clearly seen in this illustration, particularly the outer one (35) and its moving disc (36). The end of the flat bar, operated by the knob of the switch, is seen protruding slightly through the slot of the outer disc.

OPERATION

21. The method of using the instrument is summarized in an instruction card which is fitted inside the lid of the case. The H.T. battery should be placed in position first, and then the two 10·5-volt batteries, which must be lowered into the battery box at the extreme right and then moved to the left so that they fit snugly against the end of the H.T. battery. They are then prevented from vertical movement by a small wooden projection. Finally, the L.T. battery should be slid into place between the two felt-faced battens. Care must be taken that the +120-volt and negative tappings of the H.T. battery, and the negative tappings of the two 10·5-volt batteries, are towards the rear of the box, as indicated on the instruction card. The battery connections are just sufficiently long to reach their correct tappings on the batteries when the latter are properly inserted. Care should be taken that the two leads engraved 10·5 volts, in black, are used for one 10·5-volt unit, and those engraved in white for the other.

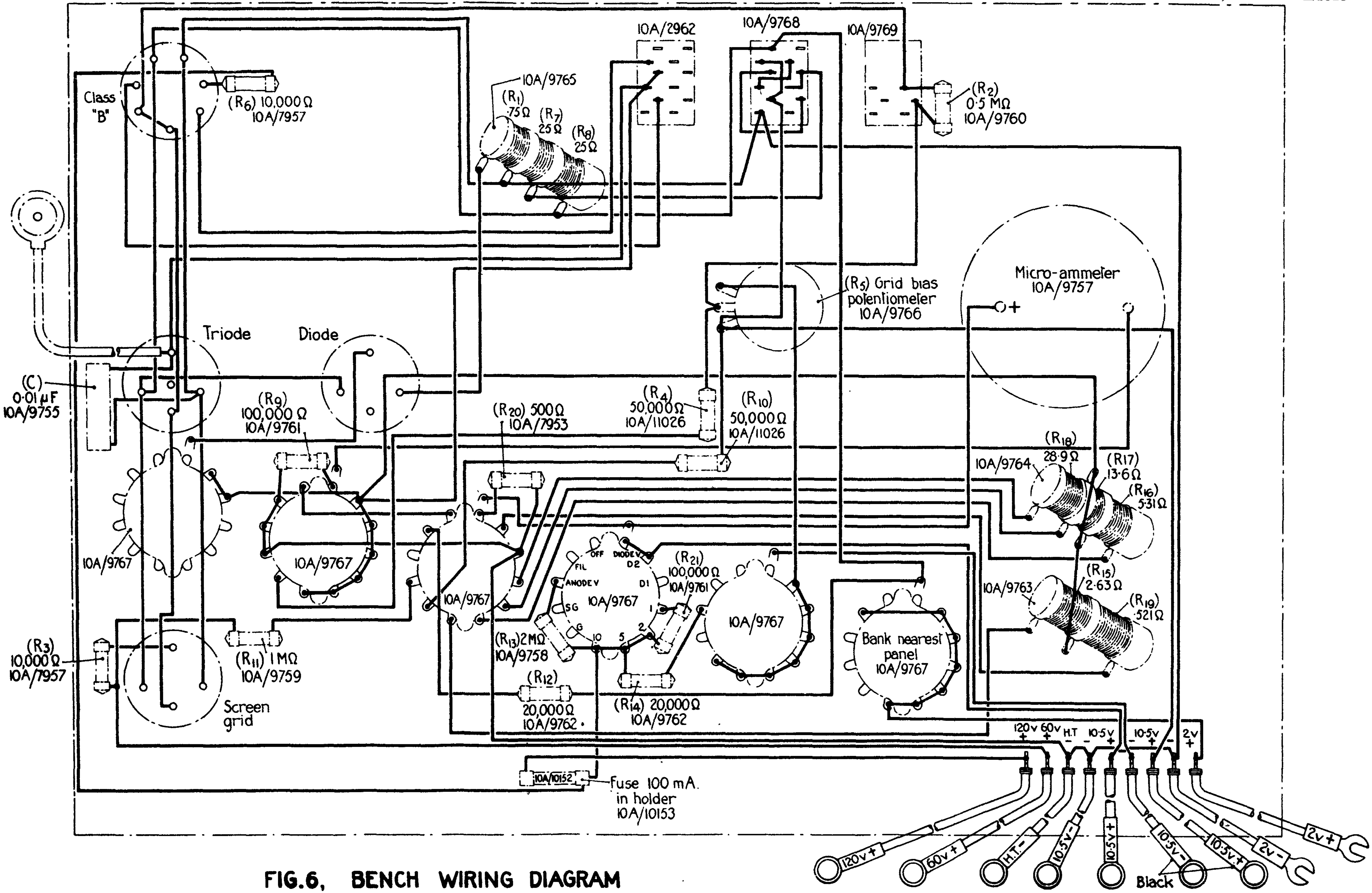

FIG. 6, BENCH WIRING DIAGRAM

Checking battery voltages

22. The meter range switch must not be operated with triode, tetrode or class B valve in position, and all voltages should be checked before inserting a valve for test. First place the meter range switch in the " Filt. volts " position. The contacts closed by this operation produce the circuit shown diagrammatically in fig. 7a. It will be seen that if the terminal voltage of the L.T. battery is E, the current through the meter is, very nearly, $\frac{E}{20,000}$ amperes, or 50 E microamperes. Hence, if the terminal voltage is 2, the meter will give full-scale deflection. If the reading is less than 95 scale divisions (=1·9 volts), it indicates that the L.T. battery is run down and should be replaced by a fully charged one.

23. The voltage of the anode battery should then be checked by moving the meter range switch to the "Anode volts " position. The circuit diagram, with the operative switch contacts, is shown in fig. 7b. It will be observed that during this test the battery is giving a load current of about 6·5 milliamperes. The various resistances in circuit are such that the meter reading must be multiplied by 2 to give the anode voltage. If the scale reading is less than 57·5, the battery voltage, on load, is below 115·0 volts, in which circumstances the battery should be replaced.

24. The screening grid voltage is checked in a similar manner, by moving the meter range switch to the " S.G. volts " position, but as the series resistance is only 1 megohm on this range (fig. 7c), the instrument scale is direct reading in volts. If the S.G. voltage is below 57·5, the battery should be replaced.

25. The grid bias voltage is checked by moving the meter range switch into the " grid volts " position. Referring to fig. 7d, it will be seen that two 50,000-ohm resistances are now connected in series with the meter. The voltage measured is that between the centre point of the fixed potentiometer and the moving contact of the variable potentiometer. Starting with the latter turned in the counter-clockwise direction as far as possible, the instrument should read zero. The indicated voltage should increase smoothly as the knob is turned in a clockwise direction, giving 100 scale degrees when the knob is hard over. The actual voltage is obtained by dividing the scale reading by 10, and if the maximum grid bias voltage is less than 10 volts, the battery needs replacement.

Testing triodes, tetrodes, Q.P.P. and class B valves

26. The above tests are preliminary to the true purpose of the instrument, namely, to test a given valve for its suitability for service use. Three tests are employed, namely—

(i) anode current at working grid bias ;

(ii) mutual conductance at working grid bias ;

(iii) detector efficiency, where applicable.

For test (i) first adjust the grid bias to the normal working value for the particular type of valve. Set the meter range switch to the correct range, i.e. 0–10 mA., 0–5 mA., 0–2 mA., or 0–1 mA. Then insert valve, note scale reading, and withdraw valve.

27. The actual value of the anode current, in milliamperes, is obviously obtainable by dividing the scale reading by a constant depending upon the setting of the range switch as follows—

0–10 mA.	divide scale reading by	10.
0·5 mA.	,, ,, ,,	20.
0–2 mA.	,, ,, ,,	50.
0–1 mA.	,, ,, ,,	100.

The circuit diagrams, with the meter range switch in these positions, are given in figs. 7e and 7f. The 0–1 mA. range is chiefly used for testing detector valves, and gives the anode current under

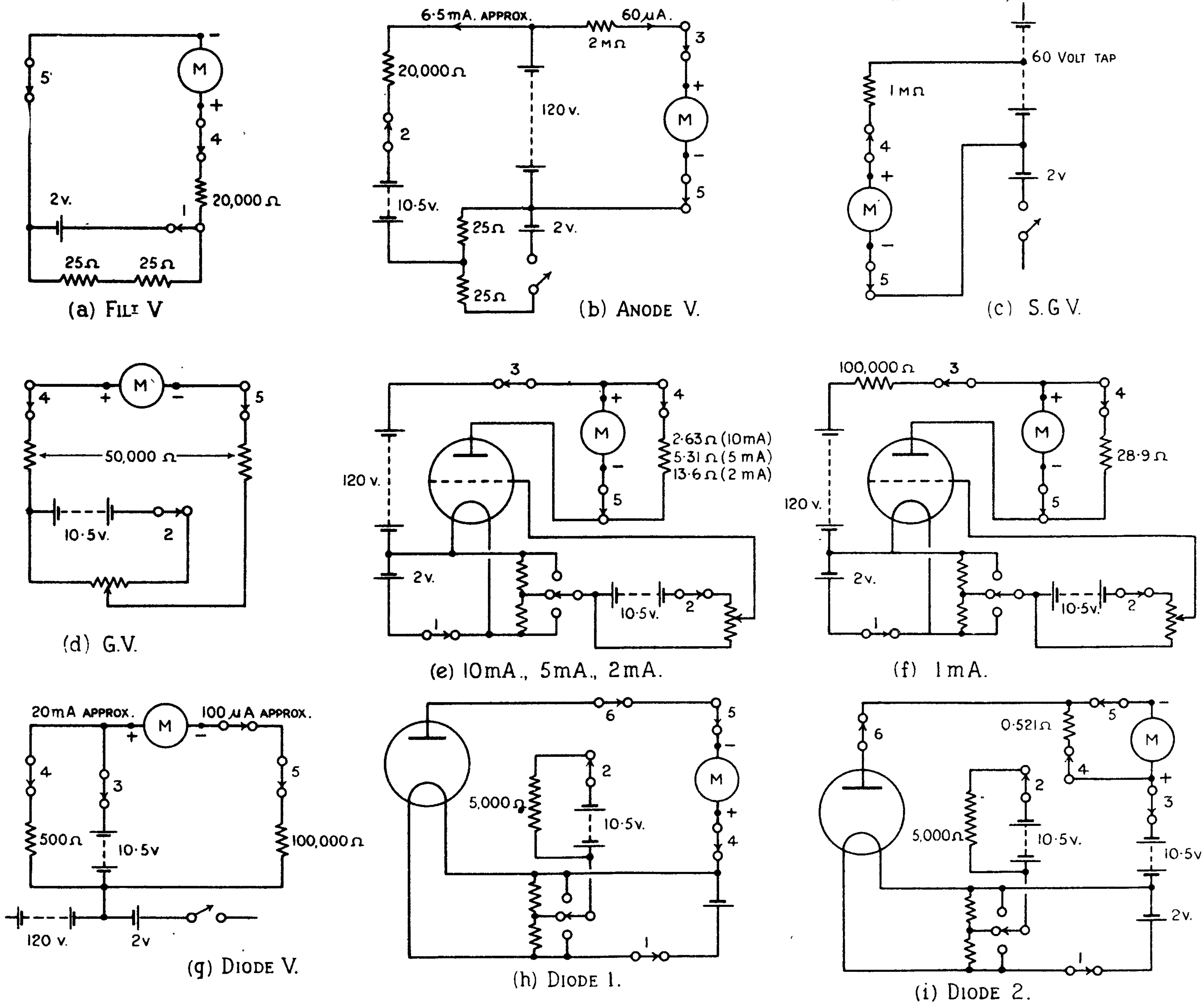

FIG. 7. ACTION OF METER RANGE SWITCH

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Diode valves

33. Two tests may be applied to a diode, namely (i) for anode current, when the anode is at the same potential as the negative end of the filament, and (ii) for anode current with a positive voltage of 10 volts applied to the anode. Before testing a diode, the voltage of the diode anode battery voltage is checked by moving the meter range switch to " Diode Volts." The connections are then as shown in fig. 7g, a load resistance of 500 ohms being imposed during the test. The series voltmeter resistance is 100,000 ohms, so that the maximum scale reading of the micro-ammeter corresponds to a voltage of 10 volts. The battery should be replaced if its voltage falls below this value.

34. To test for anode current with no applied anode voltage, the meter range switch is placed in the position " Diode 1 " and the valve inserted. The anode current should not exceed two microamperes, i.e. one division on the scale. A valve in which the anode current is in excess of this will cause a loss of signal strength if employed in the listening-through device such as is fitted in the receiver R.1082 and should, therefore, be rejected. If the valve is satisfactory in this respect, it is tested with an anode voltage of 10 volts by moving the meter range switch to " Diode 2." The meter range is then 0–50 mA. and the anode current should exceed 25 milliamperes, i.e. more than 50 scale divisions. A valve taking less current than this, if fitted in the listening-through device, will not give sufficient protection to the receiver, and should be rejected. The circuit diagrams in the " Diode 1 " and " Diode 2 " positions are shown in figs. 7h and 7i.

BATTERIES

35. The batteries required for use in the tester valve, type 2, are :—

(i) L.T. supply. One accumulator, 2 volt, 7 ampere-hours (Stores Ref. 5A/1514).

(ii) H.T. supply for diode and grid bias supply. Two batteries, dry, $10\frac{1}{2}$ volt (Stores Ref. 5A/1878).

(iii) H.T. supply for other valves. One battery, dry, 120 volt (Stores Ref. 5A/1615 or 5A/1333).

PRECAUTIONS AND MAINTENANCE

36. (i) The instrument requires very little maintenance in service. When not in use the lid should be kept shut and the instrument stored in a clean, dry place.

(ii) After using the instrument, ensure that the meter range switch is in the " off " position before closing the lid. Failure to do this may cause damage to components of the instrument.

(iii) Care should be taken that the battery plugs make good electrical contact in the battery sockets. When opening the case for inspection or removal of any battery, care must be taken to support the upper portion in such a manner that no strain is imposed upon the battery leads and plugs. If for any reason it is desired to allow the upper portion to fall back as far as it will go, the positive plugs should be removed from the sockets of the two 10·5-volt batteries. Later instruments have been fitted with a webbing strap to prevent the upper portion falling back too far.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/9751	Tester valve, type 2	1	Complete.
	Consisting of :—		
10A/9752	Box, battery	1	
10A/9754	Case	1	
10A/9755	Condenser, type 332	1	0·01 μF, cylindrical, paper dielectric.
10A/10152	Fuse, 100 mA.	3	Cartridge type (2 spare).
10A/10153	Holder, fuse, S.P.	3	
10A/9615	Holder, valve, type S	3	5-socket.
10A/9195	Plate, guard	3	
10A/9196	Plate, guide	3	
10A/9756	Holder, valve, type U	1	7-socket.
10A/9771	Plate, guard	1	
10A/9772	Plate, guide	1	
10A/9757	Microammeter, 0–100 mA.	1	3¼ in. dial, flush type.
10A/8204	Plug, type 63	7	(*See* note below).
10A/7953	Resistance, type 100	1	500 ohms.
10A/7957	Resistance, type 104	2	10,000 ohms.
10A/11026	Resistance, type 400	2	50,000 ohms.
10A/9758	Resistance, type 279	1	2 megohms, ½-watt, rod type.
10A/9759	Resistance, type 280	1	1 megohm, ½-watt, rod type.
10A/9760	Resistance, type 281	1	0·5 megohm, ½-watt, rod type.
10A/9761	Resistance, type 282	2	100,000 ohms, ½-watt, rod type.
10A/9762	Resistance, type 283	2	20,000 ohms, ½-watt, rod type.
10A/9763	Resistance, type 284	1	2·63+0·521 ohms, shunt, on cylindrical former.
10A/9764	Resistance, type 285	1	28·9+13·6+5·31 ohms, shunt, on cylindrical former.
10A/9765	Resistance, type 286	1	7·5+25+25 ohms, shunt, on cylindrical former.
10A/9766	Resistance, type 287	1	5,000 ohms, potentiometer.
10A/2962	Switch, type 16	1	3-position, lever key type, locking, 12 blades.
10A/9767	Switch, type 120	1	Multiple contact, rotary.
10A/9768	Switch, type 121	1	3-position, lever key type, non-locking, 12 blades.
10A/9769	Switch, type 122	1	2-position, lever key type, non-locking, 6 blades.
	Accessories :—		
5A/1514	Accumulator, 2 V 7 AH.	1	
5A/1615 or 5A/1333	Battery, dry, 120 V.	1	
5A/1878	Battery, dry, 10½ V.	2	
10A/9770	Case, transit	1	

Note.—Instead of plugs, type 63, 7 in number, certain instruments may be supplied with plug, type 82 (Stores Ref. 10A/9112), 4 in number, for 10½-volt batteries, and plug, type 83 (Stores Ref. 10A/9113), 3 in number, for 120-volt battery. These articles will also be supplied in replacement of plugs, type 63, which may become defective. Where plugs, type 63, are fitted, the retaining springs are removed.

December, 1938

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SECTION 5, CHAPTER 11

MICROPHONE TESTER, TYPE 1, AND NOISE GENERATOR

Contents

List of Illustrations

MICROPHONE TESTER, TYPE 1

(Stores Ref. 10A/8243)

AND

NOISE GENERATOR

(Stores Ref. 10A/10154)

INTRODUCTION

1. The microphone tester, type 1, has been introduced to provide a simple means of comparing the sensitivity of a carbon microphone with that of a similar instrument which is known to give a satisfactory performance. It is not suitable for testing electro-magnetic microphones. The instrument is used in conjunction with the noise generator ; the latter provides a source of sound which is, for practical purposes, of the same average intensity on all occasions, and so removes the variability attaching to successive tests by the human voice. The microphone tester measures $6\frac{1}{2}$ in. by 5 in. by 5 in. and weighs approximately $3\frac{1}{4}$ lb., while the noise generator measures approximately 2 in. by 2 in. by $1\frac{3}{4}$ in. and weighs about 8 oz.

GENERAL DESCRIPTION

Microphone tester

2. The circuit diagram of the microphone tester is shown in fig. 1. It consists of a standard type of microphone transformer, Tr_1, the secondary winding of which normally works into a load consisting of four resistances in parallel. Of these the resistance R_1 is permanently connected across the secondary winding. Two of the other resistances R_2, R_3 are connected across the inner

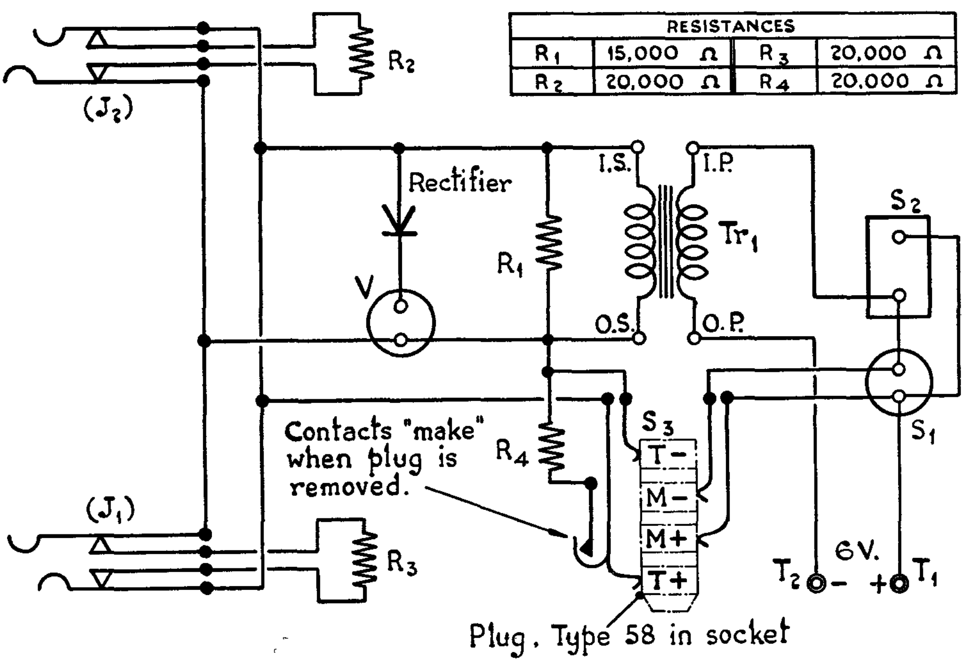


FIG. 1. Theoretical circuit diagram.

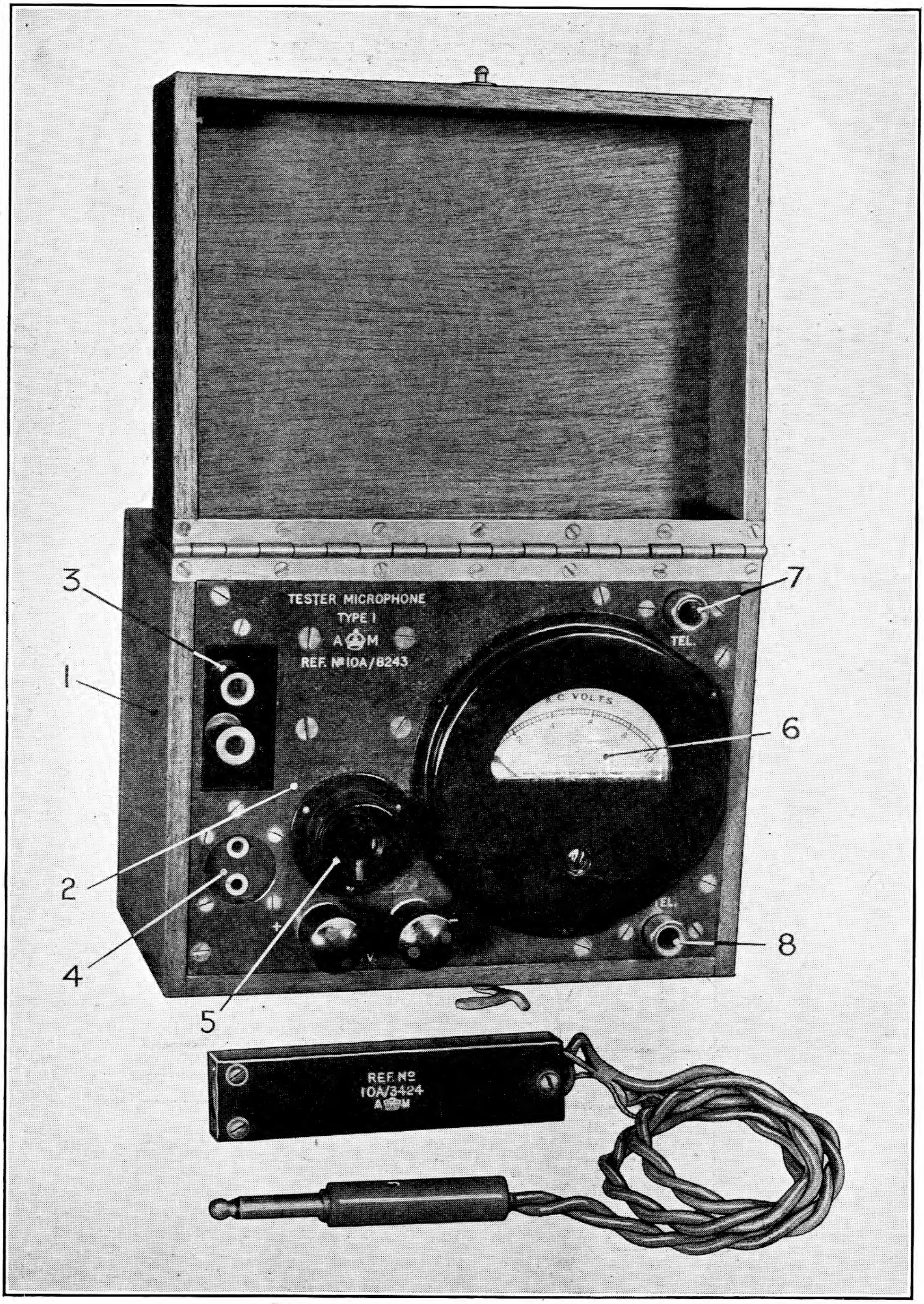


FIG. 2. Microphone tester, type 1.

spring contacts of the standard telephone jacks J_1, J_2, while the fourth, R_4, is connected to the socket S_3. The latter is a standard type of combined microphone-telephone socket. The sockets S_1, S_2, are provided for connecting in circuit a microphone which is fitted with any type of plug other than a combined microphone-telephone plug.

3. When the microphone under test is connected to either of the three sockets, and is acted upon by a source of sound, its relative sensitivity is indicated by the voltmeter V. This is a moving coil instrument, but measures the alternating P.D. across the secondary terminals of the transformer. This is achieved by connecting a half-wave rectifier of the enclosed metal-oxide type in series with the meter. The latter is calibrated to read R.M.S. volts, the accuracy being of the order of $\pm$ 5 per cent.

4. A pair of terminals, T_1, T_2, is provided by which a suitable battery is connected. These terminals are marked 6 VOLTS (+ and —), but when microphones designed for 2-volt circuits are under test the correct voltage should be used. The object of providing telephone jacks is to enable the quality of speech to be judged, as distinct from the microphone sensitivity. An extension lead is provided in order that the speaker and listener may be separated by a distance of 20 ft. or so.

Noise generator

5. The noise generator consists of a metal box containing a small clockwork motor. One side of the box is fitted with a thin metal diaphragm. This diaphragm is protected by a grille, against which the microphone under test is placed. When in operation, the clockwork motor causes the rotation of a circular cage carrying a number of steel balls. As it rotates, the steel balls strike the apex of the conical diaphragm setting it into vibration so that it becomes a source of sound. The sound emitted is a noise which contains a wide range of components of varying frequencies and decrements. When this source of sound is used to test a microphone in conjunction with the microphone tester, the A.C. voltmeter indicates the R.M.S. value of the transformer secondary voltage due to the combination of all these components, and may therefore be taken as a measure of the average response of the microphone to a very complex sound wave.

CONSTRUCTIONAL DETAILS

Microphone tester

6. The external appearance of the microphone tester, type 1, may be seen from fig. 2. The case (1) is of varnished mahogany. The panel (2) is of a phenolic resin composition and carries the whole of the electrical components. The sockets (3), (4), are types 34 and 35 respectively, while (5) is a socket, type 36, designed to take the current types of combined microphone-telephone plug, i.e. type 58 and type 119. The A.C. voltmeter (6) is seen on the right. Above and below it are the two standard telephone jacks (7), (8).

7. The underside of the panel is shown in fig. 3, in which (3) and (4) are the undersides of the sockets, types 34 and 35. The microphone transformer (1) is of a standard service pattern, the windings being assembled on stalloy stampings with a small air gap. The resistance (2) of 15,000 ohms, is of the half-watt rod type. The three resistances (9), (10), (11) are of the same type but are each of 20,000 ohms resistance. The underside (5) of the micro-telephone socket, type 36, is also visible. The rectifier (12) is connected in series between one terminal of the A.C. voltmeter (6) and the upper terminal of the transformer secondary. The jacks (7), (8), with resistances (9), (10) connected across the inner springs, are seen on the extreme left of the panel. Fig. 4 is a bench wiring diagram of the instrument.

Noise generator

8. Fig. 5 is an external view of the noise generator. The metal grille (2) is seen on the front face, the winding key (3) and release button (4) being on the end of the case (1). The mechanism of the instrument is shown in fig. 6. The clockwork motor (1) is on the right, driving the cylindrical cage (2) containing a number of steel balls. Although of no importance in practical use,

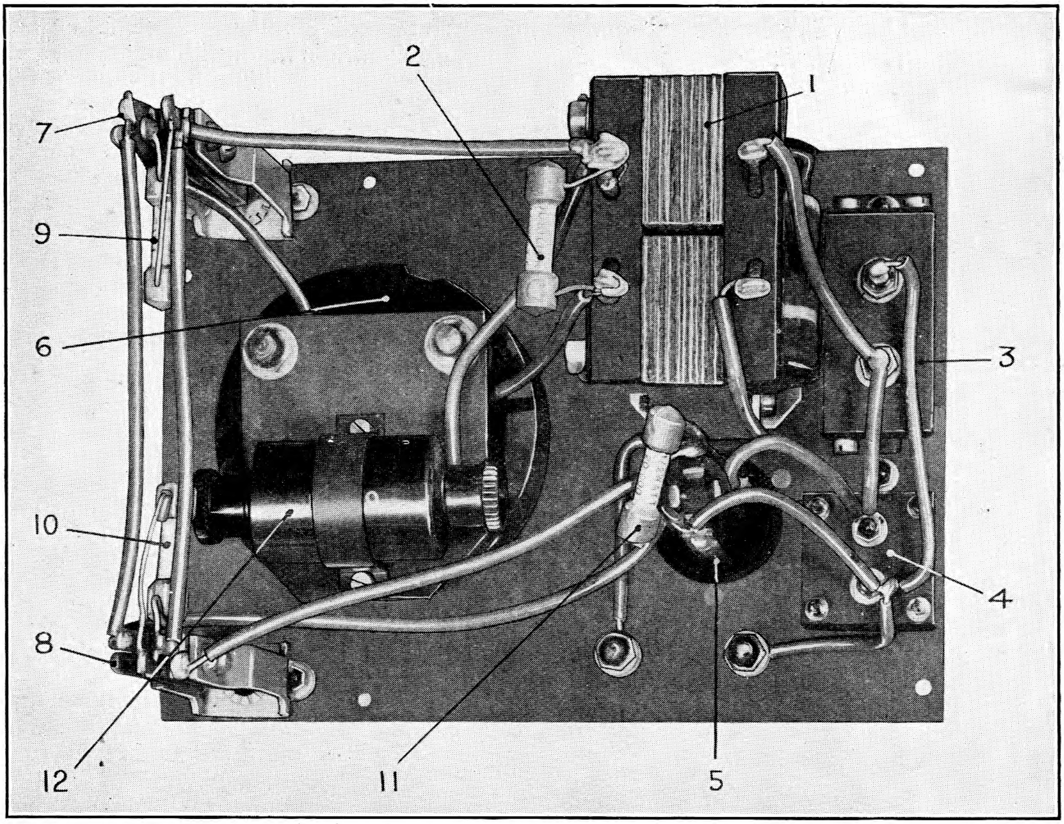
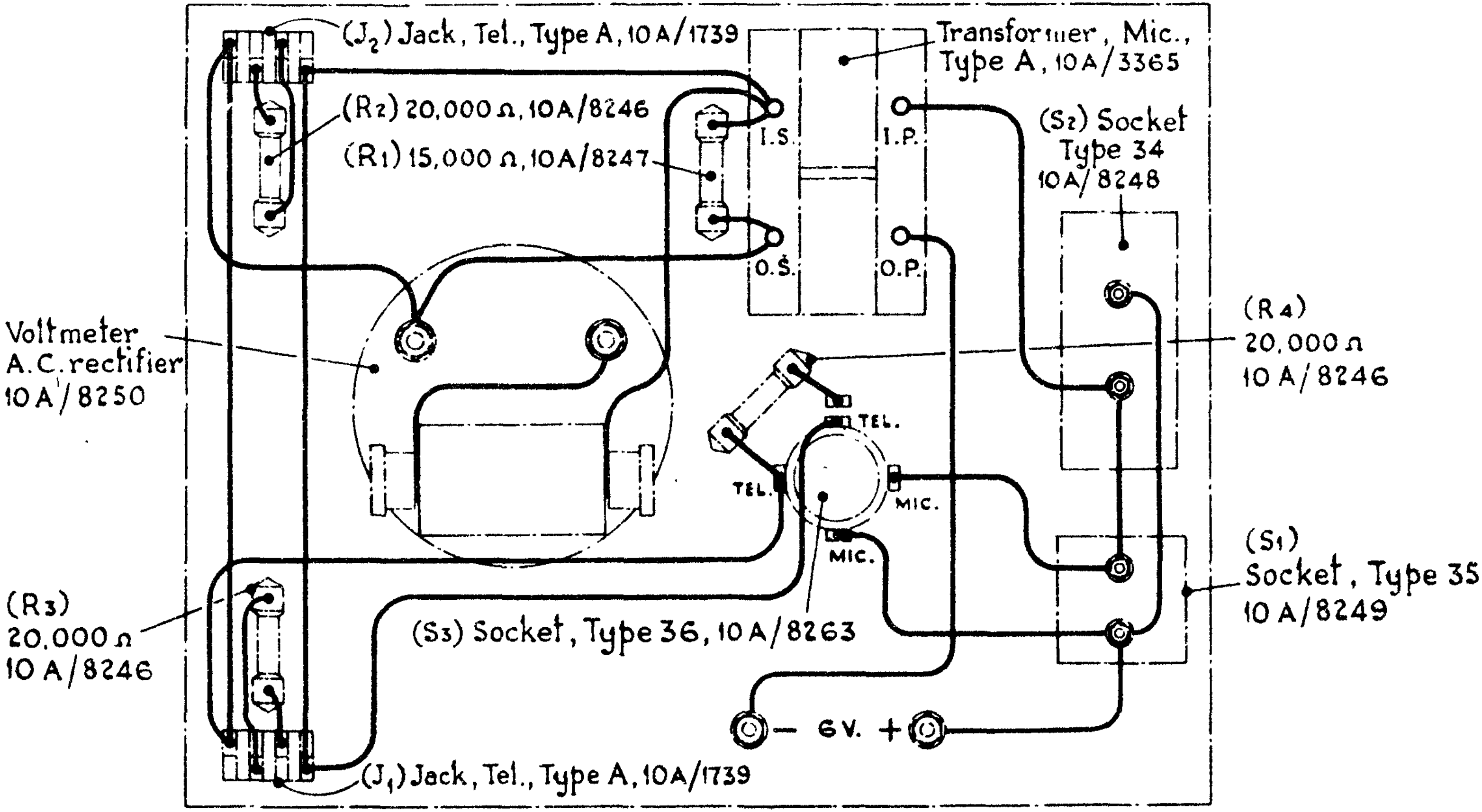


FIG. 3. Underside of panel.

it is of interest to note that the balls are not evenly spaced round the circumference of the cage. When the cage is in rotation each ball in succession strikes the apex of the conical diaphragm (3) and so sets it in irregular vibration.

9. The assembly of the instrument is shown in fig. 7. The front of the diaphragm (1) is protected by the metal grille (2), which is secured to the case by four screws. Between the grille and the case is a rubber packing piece (3) having a circular orifice concentric with the diaphragm. Eight rectangular fillets, which are moulded on the surface of this packing piece, protrude through rectangular holes in the grille. In use, the microphone under test is pressed against the protruding ends of these fillets so that the testing positions of successive microphones is always the same. A piece of brass gauze (4) covers this orifice to prevent small particles of solid matter falling through the grille and impeding the motion of the diaphragm.

10. The start-stop arrangement is very simple. The spring drives the shaft carrying the cage through toothed wheels with a high velocity ratio. The shaft carries another toothed wheel on the end remote from the cage, and this toothed wheel in turn drives a wormed shaft. Under normal conditions this worm is prevented from rotation by a detent on the end of the release push, and so the cage is kept stationary, even if the spring is fully wound. On pressing the release button, the detent is shifted clear of the worm which is then free to revolve, and the spring takes charge, driving the cage as long as the release button is depressed.



Note :- Notation in parenthesis corresponds with that of the theoretical circuit diagram (Fig. 1)

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FIG. 4. BENCH WIRING DIAGRAM

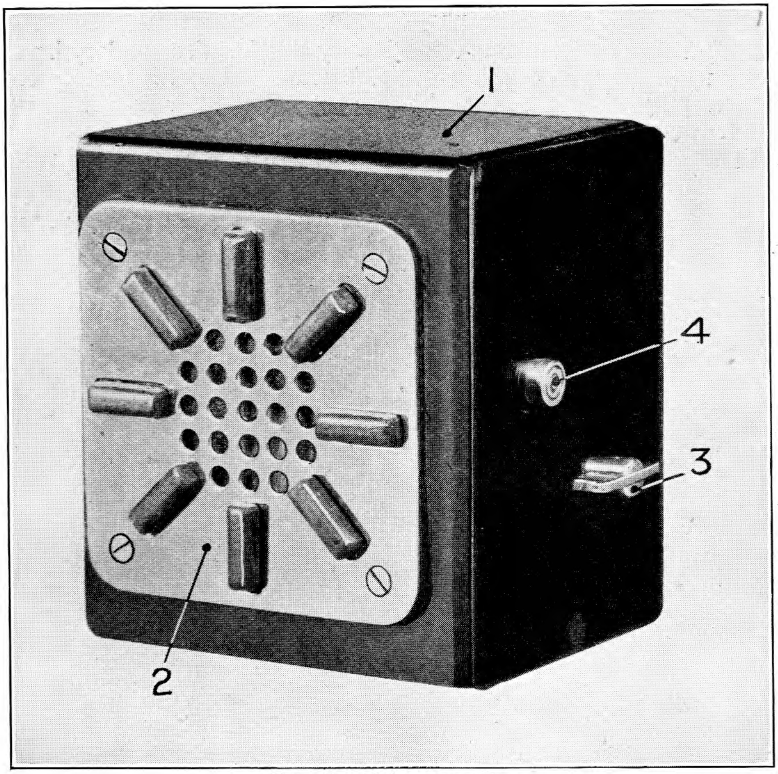


FIG. 5. Noise generator.

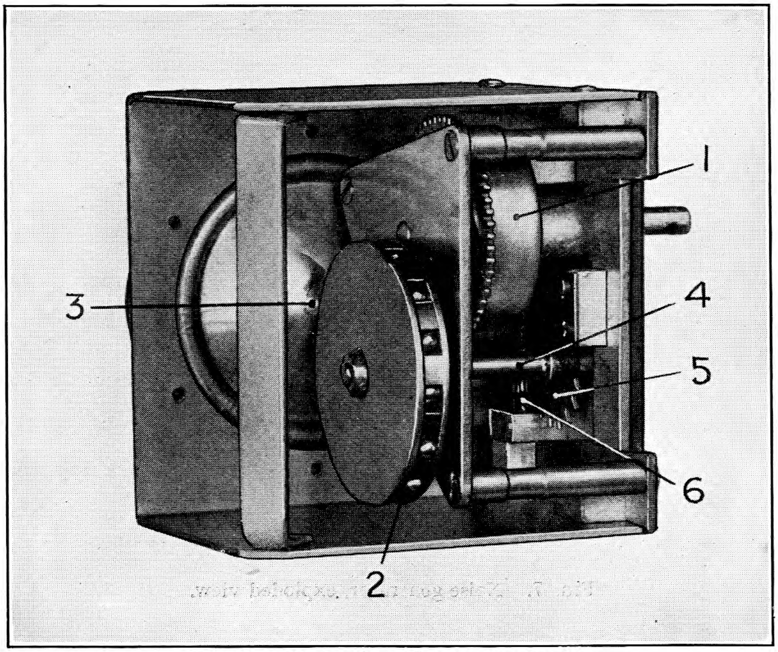


FIG. 6. Mechanism of noise generator.

OPERATION

11. The operation of the microphone tester is very simple. A secondary battery of suitable voltage, depending upon the type of microphone, is connected to the battery terminals. The microphone is then plugged into one of the three sockets, and is held in one hand with the diaphragm in its normal position, which is usually vertical. The noise generator is held in the other hand and is pressed firmly against the microphone casing so that the rubber fillets bear against the casing. The release button of the noise generator is then held down. The A.C. voltmeter will indicate the secondary voltage of the microphone transformer. The mask microphone, type E (Stores Ref. 10A/9003), which is designed for use with a 2-volt battery, should give an output voltage of about 5 volts. The microphone must be removed from the mask for the purpose of testing.

12. The 20 ft. extension lead may be plugged into one of the jacks, a pair of service telephone receivers being plugged into the jack, type B, on the other end. This provision enables the microphone to be tested for speech quality immediately after the sensitivity test.

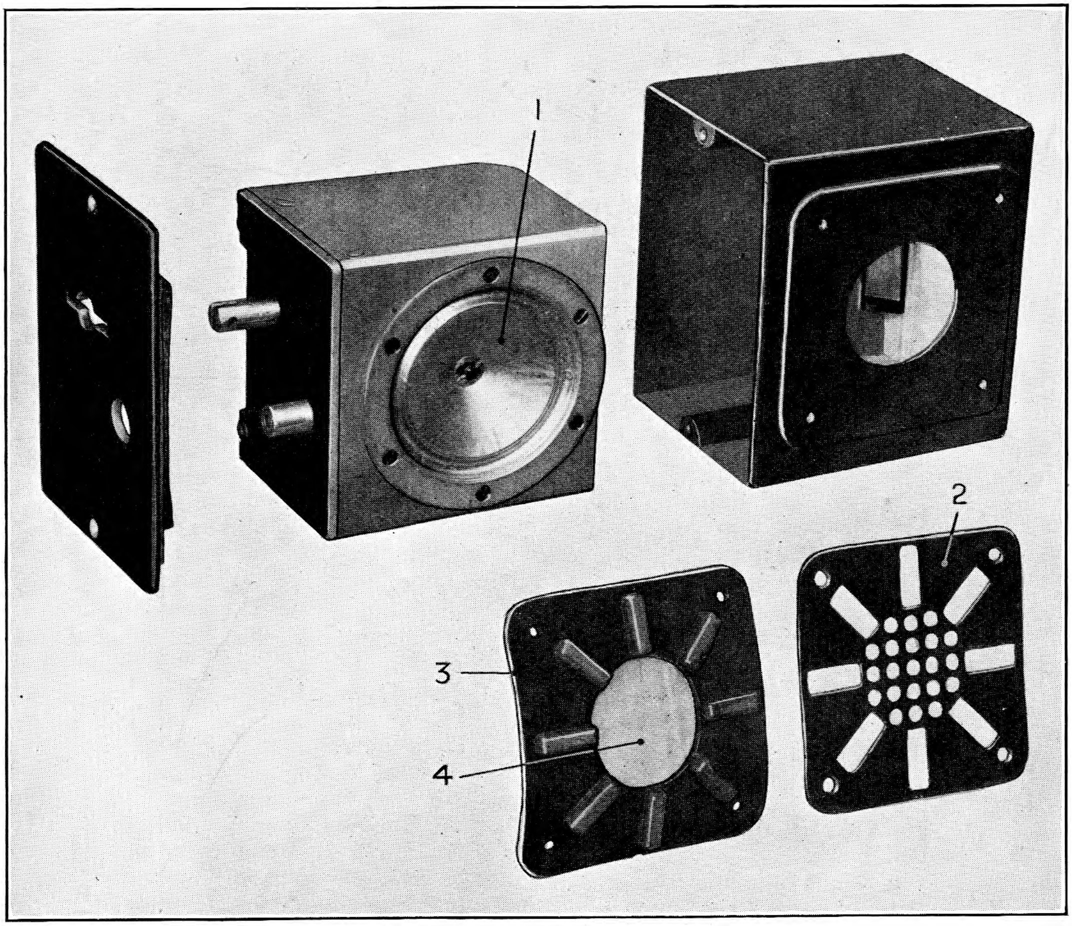


FIG. 7. Noise generator, exploded view.

Maintenance and Precautions

13. The instrument requires no maintenance, provided it is stored in a clean dry place when not in use. The A.C. voltmeter is a delicate instrument and the tester should not be subjected to rough handling. The noise generator is very robust and a broken spring is the only defect liable to be encountered, although this is very unlikely. A single drop of anti-freezing lubricating oil, type A (Stores Ref. 34A/43 or 34A/46), should be applied occasionally to the worm.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information. When ordering spares for this microphone tester, the appropriate section of Air Publication 1086 must be used.

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/10154	Generator	1	
10A/8243	Tester, microphone, type 1		
	Principal components :—		
10A/8244	Case	1	
10A/8245	Covers, voltmeter	1	
10A/1739	Jack, telephone, type A	2	
10A/8246	Resistance, type 136	3	20,000 ohms.
10A/8247	Resistance, type 137	1	15,000 ohms.
10A/8248	Socket, type 34	1	
10A/8249	Socket, type 35	1	
10A/8263	Socket, type 36	1	
10A/7227	Terminal, 4 B.A., type C	2	
10A/3365	Transformer, microphone, type A ..	1	
10A/8250	Voltmeter, A.C. rectifier	1	0–10 volts.
	Accessories :—		
10A/8251	Lead, extension	1	20 ft. fitted with plug, type 1, and telephone jack, type B.

SECTION 5, CHAPTER 12

CRYSTAL MONITOR, TYPE 1

Contents

List of Illustrations

CRYSTAL MONITOR, TYPE 1

(Stores Ref. 10A/10941)

INTRODUCTION

1. The crystal monitor, type 1, is designed for the rapid adjustment and subsequent frequency monitoring of ground station transmitters, such as the transmitters, types T.70 and T.1087, in which the oscillator frequency is not crystal-controlled. The transmitter oscillation is brought into resonance with an oscillation generated by the converse piezo-electric effect of a quartz crystal fitted within the monitor. Resonance is obtained by adjusting the frequency of the transmitter until the zero heterodyne beat condition is attained.

2. The monitor consists of a crystal-controlled valve oscillator covering six selected frequencies in the band from 7·0 Mc/s. to 3·0 Mc/s. The heterodyne beats between this oscillator and the transmitter are rectified by a detector valve and the resulting audio-frequency oscillation is fed to an output valve and rendered audible by means of a loud-speaker incorporated in the equipment.

3. The power supply for the monitor is obtained from A.C. mains (50 cycles per second) and a rectifier panel forms part of the instrument. Normally the supply voltage is 230 volts. The rectifier unit is described in detail, as part of the Ground Station Remote Controls, in this publication.

4. The whole of the equipment is mounted upon a rack and measures approximately 5 ft. 11 in. high by 1 ft. 9 in. wide by 11 in. deep. The monitor and the rectifier are mounted the one above the other. The loud speaker is centrally placed in a panel beneath these. The weight of the apparatus without valves is approximately 2 cwt. The general appearance of the monitor is shown in fig. 1.

GENERAL DESCRIPTION

5. The monitor consists of the monitor panel, the rectifier panel and a loud-speaker panel. The last-named carries the loud-speaker and also the connexions to the supply mains. The interconnexion of the respective panels is made by means of plugs and sockets.

6. A theoretical circuit diagram of the monitor and the rectifier is shown in fig. 2. A simplified theoretical circuit, omitting the switching arrangements, is given in fig. 3. The annotational references of fig. 2 are preserved throughout fig. 3 and, where applicable, in other illustrations of this text. The constants of the various components are set out, in tabular form, on fig. 2.

7. The oscillator valve V_1 is an indirectly-heated triode. The frequency of the oscillator circuit is determined by one of the six crystals X as selected by a switch S_1. The oscillator circuit is of a conventional type in which the input and output voltages divide across the inter-electrode capacitance (anode-cathode and grid-cathode) of the valve. The grid excitation is limited to a suitable amplitude by the condenser C_1 with which is associated the grid-leak resistance R_1.

8. The anode circuit load impedance of V_1 is composed of the condenser C_2 and the resistance R_2 in parallel. The oscillator stage receives its H.T. supply from the tapping H.T.1 of the rectifier panel *via* a decoupling resistance R_3. The oscillator is switched on or off by S_3 in this line. Coupling between the anode circuit of the oscillator valve and the input, that is the grid-cathode, circuit of the detector valve V_2 is effected by the condenser C_{13} and the grid-anode capacitance of the detector valve.

9. The transmitter oscillation is received on a short rod aerial which is connected to the aerial terminal of the monitor panel. This aerial is capacitance coupled by the low-capacitance fixed condenser C_{14} in series with a tuned circuit formed by the inductance L_1 and the condenser C_4, which may be in any one of six pre-set variable condensers selected by the switch S_2. This selector switch and the switch S_1 are coupled on the same spindle, each condenser therefore corresponding to a particular crystal position.

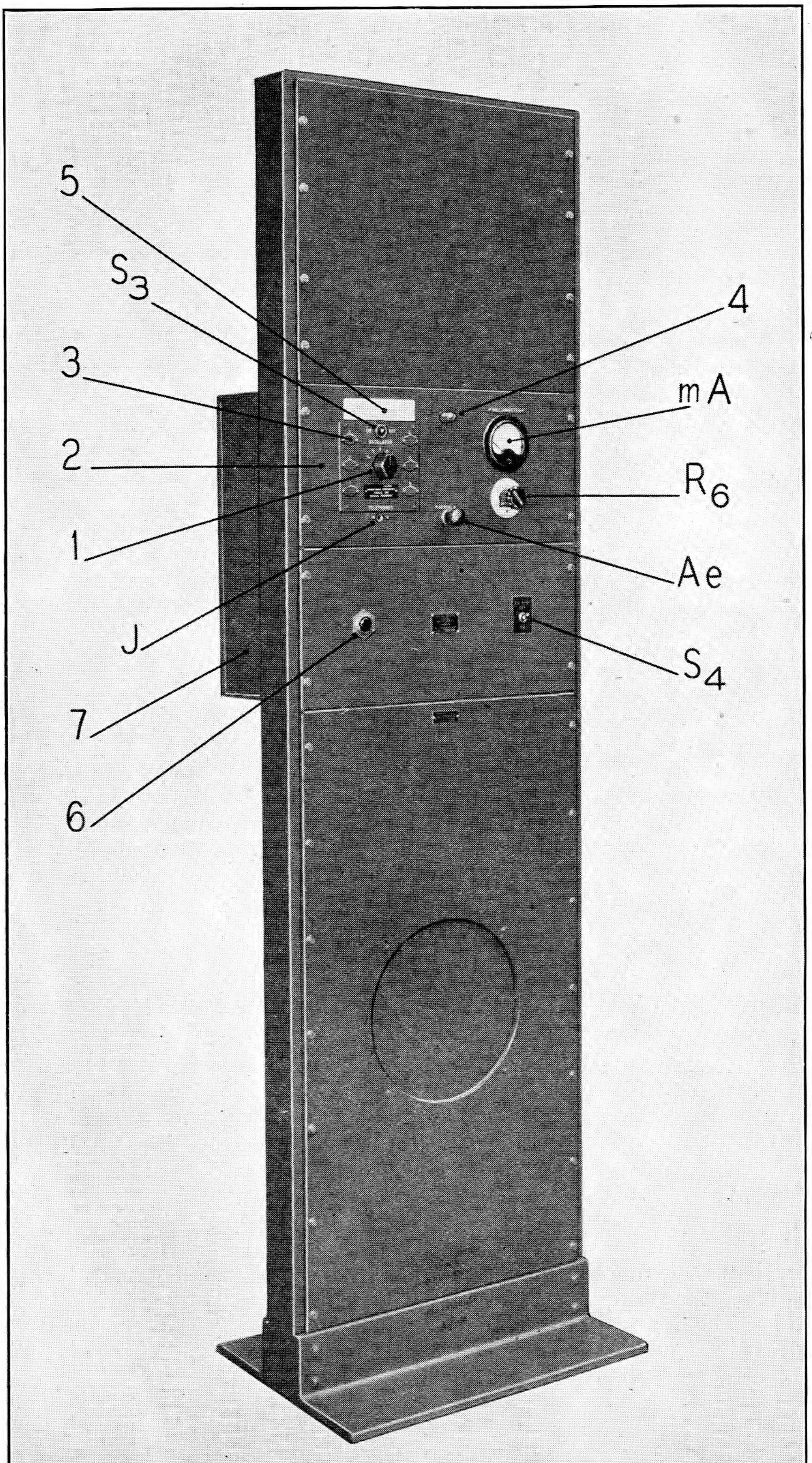
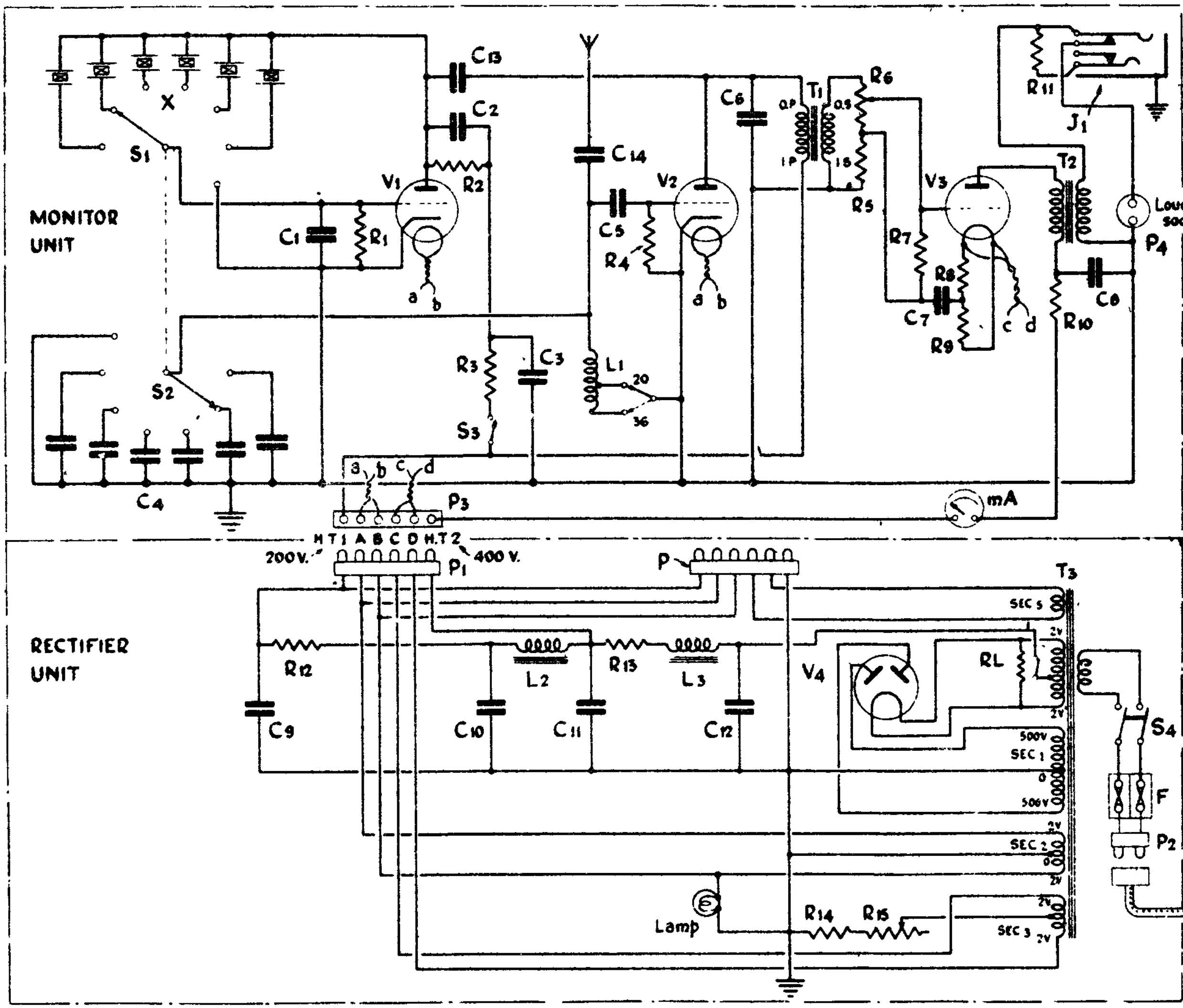


FIG. 1. Crystal monitor, type 1.

C_4 C_9 C_1 C_2 C_{13} C_{10} C_3 C_{14} C_{11} C_5 C_{12} C_6 C_7 C_8	CONDENSERS
R_{12} R_1 R_2 R_3 R_{13} R_4 R_{14} R_5 R_6 R_{15} R_7 R_8 R_9 R_{11} R_{10}	RESISTANCES
S_1 S_2 X P_1 P_3 V_1 L_2 L_1 L_3 V_2 P T_1 V_4 V_3 RL T_3 S_4 P_4 P_2 F	MISCELLANEOUS



RESISTANCES.	
R_1	20,000 Ω
R_2	10,000 Ω
R_3	10,000 Ω
R_4	0·5 MΩ
R_5	40,000 Ω
R_6	500,000 Ω
R_7	1 MΩ
R_8	50 Ω
R_9	50 Ω
R_{10}	1,500 Ω
R_{11}	20 Ω
R_{12}	30,000 Ω
R_{13}	500 Ω
R_{14}	250 Ω
R_{15}	500 Ω

CONDENSERS	
C_1	10 μμF
C_2	30 μμF
C_3	·01 μF
C_4	100 μμF (6)
C_5	25 μμF
C_6	100 μμF
C_7	2 μF
C_8	1 μF
C_9	2 μF
C_{10}	2 μF
C_{11}	2 μF
C_{12}	4 μF
C_{13}	100 μμF
C_{14}	10 μμF

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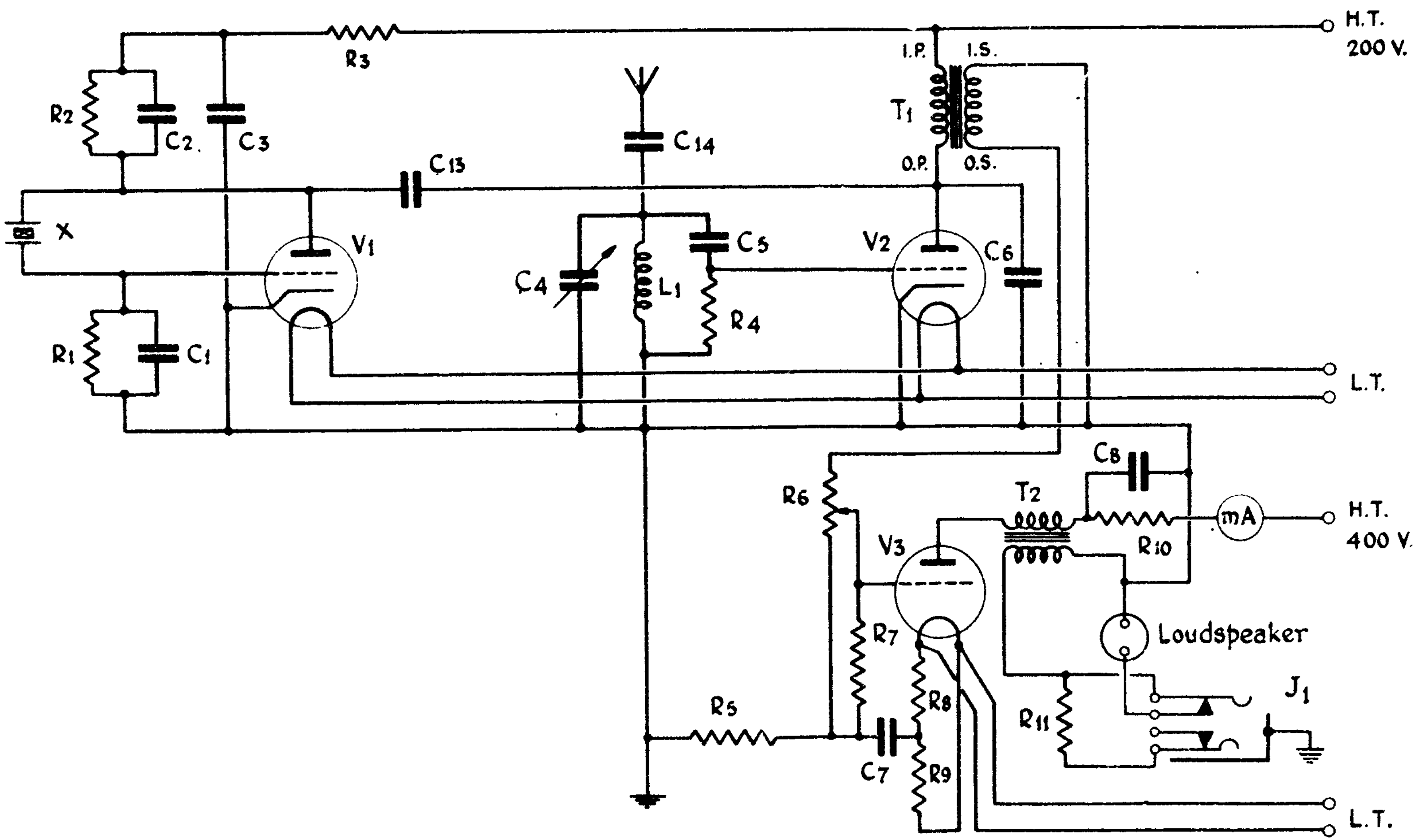
FIG. 2. THEORETICAL CIRCUIT, MONITOR AND RECTIFIER



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To Follow Fig. 2

FIG. 3. SIMPLIFIED THEORETICAL CIRCUIT OF MONITOR.

10. The detector valve V_2 receives grid-cathode excitation from the tuned circuit *via* the condenser C_5. Rectification takes place according to the cumulative grid process and the resistance R_4 is a grid-leak. The inductance L_1 has two tappings, all the turns being used when working on frequencies between 4·5 Mc/s. and 3·0 Mc/s. and approximately 55 per cent for frequencies between 7·0 Mc/s. and 4·0 Mc/s.

11. The detector valve V_2 is an indirectly-heated triode, its heater being connected in parallel with that of V_1 and across the centre-tapped secondary winding Sec_2 of the mains transformer in the rectifier panel. This winding delivers four volts. The anode is fed through the primary winding of the L/F transformer T_1, from the H.T.1 tapping on the rectifier system.

12. The primary winding of T_1 also provides the coupling between V_2 and the output amplifier V_3. A R/F by-pass condenser C_6 is included in this circuit. The secondary winding of T_1 supplies excitation to the grid-filament circuit of the valve V_3 which is a directly-heated triode, the filament being supplied from the secondary winding Sec_3 of the mains transformer. This winding also delivers four volts. The output level of this stage is controlled by the setting of a potentiometer consisting of the resistances R_5 and R_6, shunting the secondary winding of the transformer T_1. The resistance R_6 is variable from zero to 500,000 ohms. The safety resistance R_7, shunted across R_6, enables the monitor to function, but without control of the output volume, should the winding of the resistance R_6 become defective.

13. Due to the fact that the filament of the valve V_3 is directly heated by alternating current, it is necessary to connect the low potential end of the input circuit to a point about which the filament circuit is electrically symmetrical. Two resistances R_8 and R_9 of equal value are, therefore, connected in series across the filament terminals. The input circuit is joined to the mid-point of R_8 and R_9, *via* the condenser C_7. The electrical mid-point of the winding Sec_3 of the mains transformer, is also connected to the earthed end of the secondary winding of the inter-valve transformer T_1 through the resistances R_{14} and R_{15} in the rectifier.

14. The anode of the valve V_3 is fed from the tapping H.T.2 (400 volts) on the rectifier system through a decoupling resistance R_{10} associated with a decoupling condenser C_8. This circuit also includes a milliameter mA and the primary winding of the transformer T_2. The secondary winding of T_2 is connected to a two-pole socket by means of which the loud-speaker may be introduced into the circuit. Provision is also made for the use of telephone receivers which are plugged into a jack J, the casing of which is earthed. When telephones are used, the loud-speaker is disconnected from the circuit and is replaced by a loading resistance R_{11} connected across the telephones.

CONSTRUCTIONAL DETAILS

15. Three views of the crystal monitor are given in figs. 1, 4 and 5, of which fig. 1 is a general view of the instrument, fig. 4 is a plan view of the monitor portion and fig. 5 a rear view of the rectifier. A bench-wiring diagram of the monitor is shown in fig. 6. The monitor and rectifier are separate entities connected together by a six-pole plug and socket. The two assemblies are mounted, the monitor above the rectifier, on the same frame. The loud-speaker is carried on a panel below the rectifier.

16. The various control features of the instrument are shown in fig. 1. The control (1) associated with the mechanically-coupled selector switches S_1 for the crystal and S_2 for the pre-set condenser, may be seen on the left of the monitor panel (2). Grouped around this control there are six shielded apertures (3) only one of which is annotated on the illustration. Through these apertures access is provided to vary the capacitance of the six variable condensers C_4, the variation being effected by the use of a screwdriver.

17. On the monitor panel there are also the ON-OFF switch S_3, the telephone jack J, milliameter mA and volume control R_6. Centred at the bottom of this panel is the terminal Ae to which is attached the short rod aerial (not in position). The anti-vibration support (4) for this aerial is shown vertically above the terminal Ae. A metal plate (5) for the temporary indication of frequencies surmounts the switch control.

18. The rectifier panel carries only one control, namely that associated with the mains switch S_4. On the left-hand side of this panel there is a small ruby window (6) through which can be viewed the pilot lamp incorporated in the secondary winding Sec_2 of the A.C. mains transformer T_3. The rheostat R_{15} is contained within the rectifier and can only be adjusted when the perforated metal guard (7) is removed.

19. A plan view of the monitor panel, fig. 4 shows the constructional features of the switch S_2 and the mechanical linkage (1) between it and the crystal selector switch S_1. The disposition of the monitor components can be plainly seen in this figure. On the crystal-holder panel (2), no crystals are shown in position but the twelve sockets are visible. The three valve-holders are respectively, V_1 at (3), V_2 at (4) and V_3 at (5). The correct positions of the valves are indicated by a legend (6) on the rear rim of the tray. The position of the other components is set out on a list (7) pasted on the back of the panel. The telephone jack J is directly beneath the switch S_2 and leads (8) from it are attached to the 20-ohm resistance R_{11}. A lead (9) from the secondary winding of the transformer T_2 which has a ratio of 1 : 15, is also connected to R_{11}.

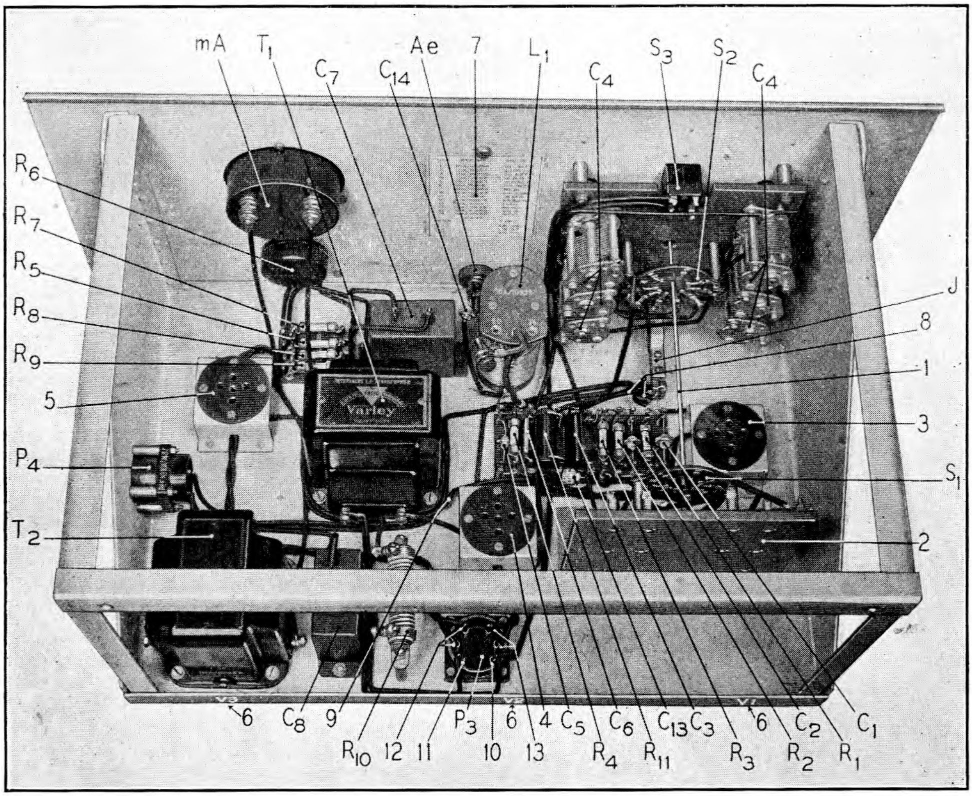

FIG. 4. Monitor unit, plan view.

20. The 1 μF condenser C_8 and the 1,500-ohm resistance R_{10} which serve to decouple the anode circuit of the valve V_3 are adjoining the transformer T_2. Centred at the rear of the tray there is the power input socket P_3 which affords the only channel of electrical connexion between the monitor and the rectifier. From the H.T.1 socket (10) on P_3 there are two leads, one of which goes to the ON-OFF switch S_3 situated above the block of pre-set condensers C_4 and the other to the primary winding of the inter-valve transformer T_1. The H.T.2 socket (11) of P_3 has a lead to

the milliameter mA on the front panel. The two pairs of twisted leads from P_3 are the filament heater leads, those (12) in the left-hand side being associated with the valve V_3 and the winding Sec_3 of the rectifier transformer T_3 and those (13) on the right-hand side with V_1, V_2 and the winding Sec_2.

21. The two-pole socket P_4 to accommodate the loud-speaker plug, may be seen on the left-hand side of the illustration. The aerial terminal Ae at the bottom centre of the front panel is joined through the 10 $\mu\mu$F condenser C_{14} to the tuning inductance L_1 with which the six pre-set condensers C_4 are in parallel. L_1 consists of forty-two spaced turns of wire on a paxolin former of $1\frac{1}{2}$ in. diameter, the tapping from the twenty-third turn being labelled 20 on the socket panel at the top end of the coil. The tapping labelled 36 embraces the whole of L_1.

22. On a small paxolin panel, between the centre of the tray and the holder for the valve V_1, are five condensers and five resistances. In the position labelled 10 on this panel there is the 25 $\mu\mu$F condenser C_5 having next to it the 500,000-ohm resistance R_4. These components together form the rectifying elements of the grid filament circuit of the valve V_2. The 100 $\mu\mu$F, R/F by-pass condenser C_6 is adjacent to the resistance R_{11}. The position labelled 6 is occupied by the $0{\cdot}01$ μF decoupling condenser C_3, one end of which is joined to the 10,000-ohm decoupling resistance R_3 in the lead from H.T.1.

23. Between the anode of V_1 and the resistance R_3 there is a 10,000-ohm resistance R_2, having the 30 $\mu\mu$F condenser C_2 in parallel with it. The grid-filament circuit components C_1 (10 $\mu\mu$F) and the resistance R_1 (20,000 ohms) complete the panel assembly. The 100 $\mu\mu$F condenser C_{13}, suspended between the crystal-holder panel and the condenser C_6, effects the coupling between the valves V_1 and V_2.

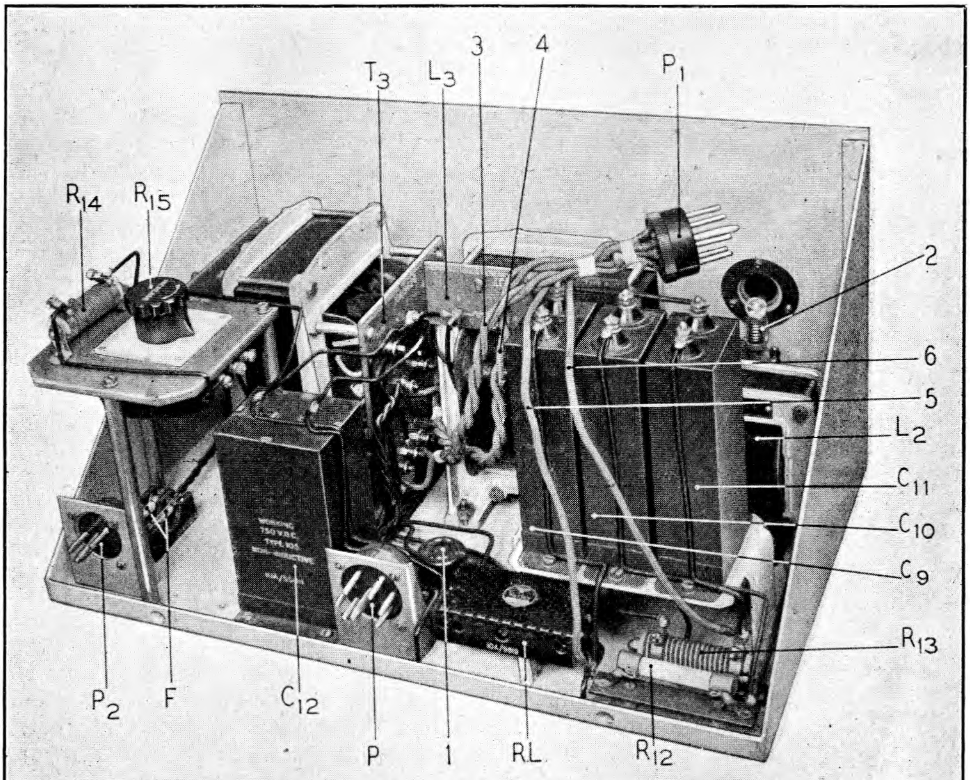

FIG. 5. Rectifier unit, rear view.

24. Immediately below the 500,000-ohm volume control resistance R_6 can be seen a small panel having a bank of four resistances. At the forward end of this panel there is the safety resistance R_7 of 1 megohm shunted across R_6. Next to R_7 there is the 40,000-ohm resistance R_5 which, with R_6, constitutes the potentiometer for the output level of the final stage. The two filament centre-pointing resistances R_8 and R_9 each of 50 ohms, are also on this panel. Associated with R_8 and R_9 is the 2 μF condenser C_7 situated between the inductance L_1 and the small panel.

25. Referring to fig. 5 which is a rear view of the rectifier, the double diode valve V_4 is not in position in its holder (1). There are only two panel features on this unit, namely the ON-OFF switch S_4 and the pilot lamp. The latter (2) is visible in the illustration, the switch S_4 being immediately behind the mains transformer T_3. The twisted leads (3) from the lower terminals of T_3 are those associated with the secondary winding Sec_3 and the filament of V_3. The other twisted leads (4) are those of the heater-circuit for the valves V_1 and V_2 from the secondary winding Sec_2 of T_3. The rectifier pilot lamp is connected between one side of this winding and earth. The remaining leads of the six-pole plug P_1 are those to the H.T.1 (5) and to H.T.2 (6). This plug engages with the underpanel portion of the socket P_3 in the monitor.

26. The lead (5) from the H.T.1 socket is joined to a 30,000-ohm fixed resistance R_{12}, behind which there is a 500-ohm spiral wound resistance R_{13}. The iron-cored L/F chokes L_2 of 300 henrys and L_3 of 30 henrys are situated behind the block of three 2 μF condensers C_9, C_{10} and C_{11} which form the condenser unit type 4.

27. On the left-hand side of fig. 5 there is a raised platform which carries the 500-ohm rheostat R_{15} and the 250-ohm fixed resistance R_{14} which are joined in series to the centre-point of the secondary winding Sec_3 and to earth. The six-pole plug P at the rear of the rectifier tray is not used in connexion with this crystal monitor. The two-pole plug P_2 beneath the rheostat platform constitutes the input channel for the A.C. mains supply. Behind P_2 are the supply line 2-amp fuses F. The thermostatic relay RL, incorporated in the circuit of the secondary winding Sec_4, and the rectifier valve V_4 are at the rear of the tray.

VALVES AND POWER SUPPLY

28. The power supply of the crystal monitor type 1 is derived from the A.C. mains *via* the rectifier panel of the Amplifier A.1104. The circuit diagram of the rectifier, as used with this monitor, is given in fig. 2, together with a table of componential values. This rectifier is described in greater detail elsewhere in this publication.

29. The rectifier supplies 200 volts H.T. to the anodes of the valves V_1 and V_2. The resistance R_{10} in the primary circuit of the output transformer T_2 reduces the 450 volts (approximately) delivered from winding Sec_1 to the anode of V_3, to the requisite 400 volts specified as the anode rating of the valve used. Four volts L.T. are used for both the heaters of the indirectly-heated cathodes of V_1 and V_2 and for the filament of V_3. Control of the anode current (normally 55 mA) is effected by the rheostat R_{14} contained inside the rectifier unit.

30. Four valves are used in the Crystal Monitor, type 1. The crystal-controlled oscillator valve is an indirectly-heated triode of the type V.R.38, having an anode rating of 200 volts. The heater current is 1 amp. The detector stage has a valve type V.R.37 having similar anode voltage and filament current ratings but with an increased impedance (11,100 ohms) and mutual conductance factor. The output stage is a directly-heated A.C. valve of the type V.R.40 having the following characteristics :—anode watts, 25 ; anode volts, 400 ; filament current, 2 amps ; impedance, 1,265 ohms and mutual conductance 7.5. The rectifier is a diode of the type V.U.39.

PRECAUTIONS AND MAINTENANCE

31. On no account should any attempt be made either to take down or to repair crystal mountings. In the event of a crystal failing to function and, in consequence, being suspected of fracture or of faulty internal contact, the usual tests should be applied. The crystal holder should be inserted in positions other than that originally allocated to it. · Failure of this apparatus is of rare occurrence having regard to the fragility of the element. The current involved in this crystal monitor is relatively small and very little difficulty should be experienced with failure of components.

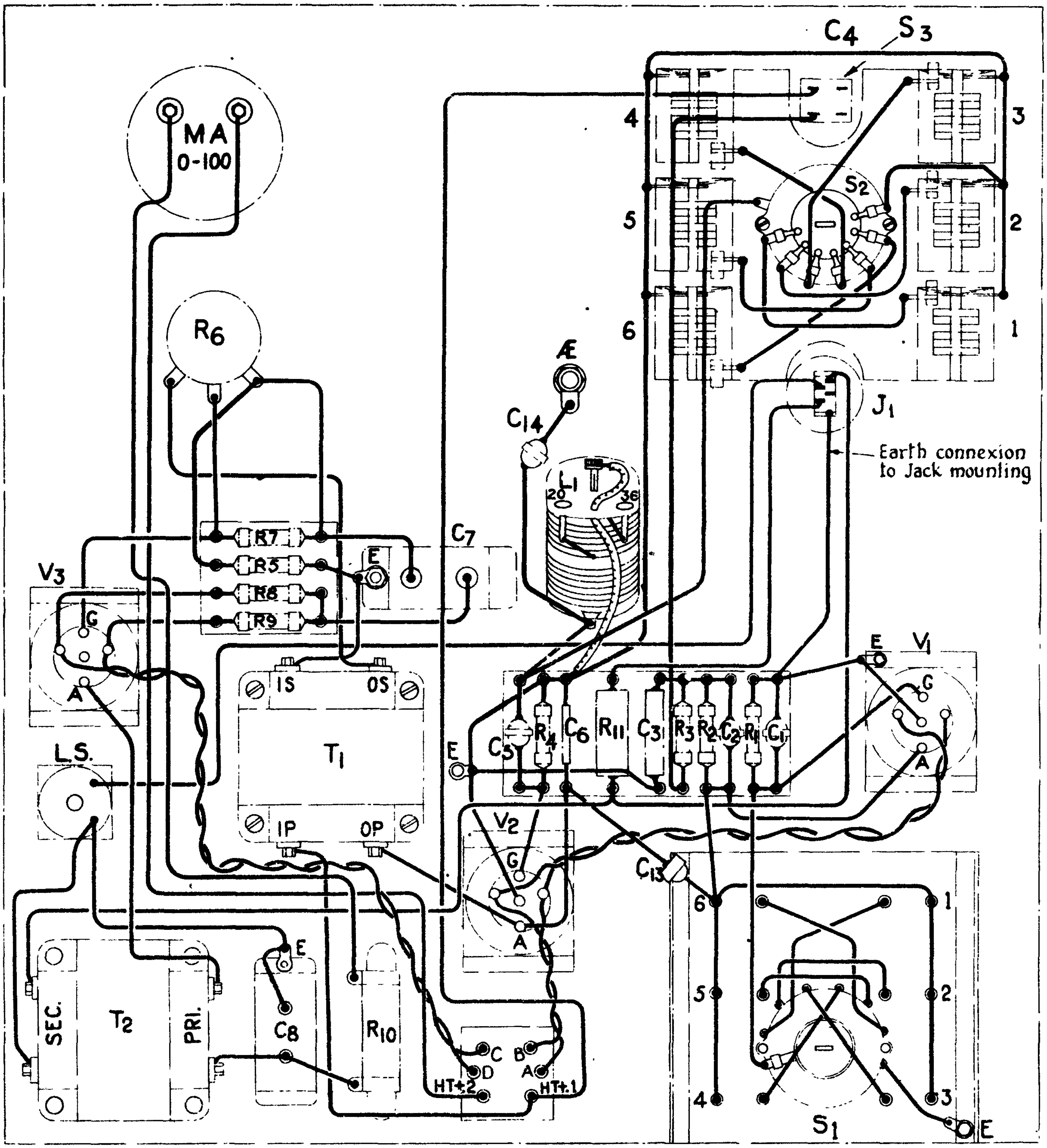

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FIG. 6. CRYSTAL MONITOR TYPE 1 - BENCH WIRING DIAGRAM

32. The necessity for adjustment of the rheostat inside the rectifier, to be made *before* the perforated metal guard is replaced, imposes the need for great caution during the operation. The mains should be switched OFF before the guard is replaced after the rheostat has been satisfactorily set to provide for delivery of the 55 mA necessary.

OPERATION

Preliminary

33. The crystal monitor should be placed in a position convenient to the transmitter. Before making any adjustments care should be taken to ensure that the mains switch S_4 on the rectifier panel is in the OFF position. Then remove the perforated metal cover (7, fig. 1) which is secured by four screws. The three valves of the monitor portion should be placed in their holders. The respective positions of the monitor valves are indicated on the rear edge of the tray (6, fig. 4). See that the pilot lamp, fuses and valves are inserted in the rectifier.

34. Reference should be made to fig. 1 for the annotations in this and succeeding paragraphs. Approximately two feet of 12 gauge (S.W.G.) copper wire will be suitable as an aerial for the monitor. This is inserted through a hole on the anti-vibration spacer (4) and firmly secured by the aerial terminal Ae. Place the appropriate crystal in position on the panel at the rear of the monitor tray. Adjust the control knob (1) to the number corresponding to the relevant crystal position. It should be noted that a seventh OFF position is provided. By leaving the mains switch ON and placing the selector switch to OFF the monitor can be left in what is virtually an inactive state ready for instant use. Place the plug of the tuning inductance in the socket engraved 20 when using frequencies from 7·0 Mc/s. to 4·0 Mc/s. The socket marked 36 must be used for the band from 4·5 Mc/s. to 3·0 Mc/s.

35. Connect the six-pole plug from the rectifier unit to the socket centred at the rear of the monitor tray. The six-pole plug at the rear of the rectifier tray can be disregarded, having no application in this installation. Connect the loud-speaker plug to the two-pole plug at the side of the monitor. At the bottom of the rack there are four terminals and the upper two of these are the mains extensions to be connected to the two-pole plug at the rear of the rectifier. The A.C. mains are joined to the lower two terminals.

36. Switch on the mains by means of S_4. Adjust the rheostat mounted on a platform on the left-hand side of the rectifier tray. As mentioned in para. 32, particular care should be exercised in performing the operation, due to the fact that the perforated metal cover cannot be placed in position. The resistance should be set to give an anode current reading of 55 mA. Switch off the mains and replace the perforated metal cover. Always check the operation of the mains switch ON or OFF against the pilot lamp (6).

Calibration

37. Having warmed up the transmitter for a sufficiently long period, normally from 10 to 15 minutes, to attain frequency stability, calibration may be commenced. The master-oscillator of the transmitter should be adjusted until an audible note is produced in the loud speaker of the crystal monitor.

38. Six variable condensers, each associated with a particular crystal position, are used to tune the receiver circuit of this monitor. The control (1) of the crystal selector switch S_1 also controls the condenser selector switch S_2 situated inside the monitor. The six condensers are adjustable by means of a screwdriver inserted through the ports grouped around the switch control. These ports are numbered from 1 to 6 (number 3 is annotated in fig. 1) and are covered by dust seals. The capacitance of the selected condenser should be varied until the audible note reaches a maximum. During this operation the control of the potentiometer R_6 must be adjusted to suit the position of the monitor in regard to the transmitter. No definite rule can be laid down having regard to the varied accommodation of operating stations.

39. Adjust the various controls of the transmitter to arrive at the frequency settings corresponding to the selected crystal. These will be indicated by the " dead space " of the beat note produced in the loud-speaker. Record the transmitter settings in tabular form. Repeat the operations detailed in these paragraphs for each of the crystal positions of the monitor. Having

completed these calibration adjustments the operator will have available two records of comparative settings for each frequency : firstly, the settings of the transmitter controls and secondly, the corresponding positioning of the switch control (1) on the monitor panel.

Frequency monitoring

40. The transmitter frequency may be monitored in the following manner :—Switch on the crystal monitor at S_3, set the selector switch control (1) to the position corresponding to the frequency and, if necessary, adjust the transmitter controls to the " dead space " of the beat note produced in the loud speaker.

Frequency changing

41. With practice a change of frequency can be effected in less than sixty seconds, even in the extreme cases in which the number of adjustments involved is a maximum. The sequence is as follows :—Switch on the crystal monitor at S_3, set the selector switch control (1) to the desired frequency position, set the transmitter controls in accordance with the calibration table and adjust for the " dead space " of the beat note.

To set up the transmitter type T.70

42. Table 1 shows typical sets of adjustments of the controls of transmitter T.70 for four frequencies between 4·3 Mc/s. and 6·0 Mc/s. A similar table should be prepared for each transmitter for the particular frequencies on which it is to be worked and the table should be prominently displayed near the transmitter.

43. The modulator grid bias control of transmitter T.70 should be set to the maximum. The unmodulated carrier emitted, as read from aerial current indicated by the thermo-ammeter on T.70, should be not less than 2 amperes for each frequency adjustment. The normal master-oscillator tuning of T.70 may possibly be too broad to set the transmitter for " dead space " of the beat note. If this is found to be the case a final frequency adjustment of about 2 kc/s. may sometimes be achieved by a slight alteration of the amplifier grid coupling.

To set up the transmitter type T.1087

44. The adjustments specified for the operation of any transmitter are designed to secure the highest efficiency of power output as indicated by ratio of aerial to anode current. Such adjustments normally occupy much longer than the time available under conditions demanding rapid changes of frequency. It will be found that, with a small sacrifice of output, the essential changes associated with T.1087 can be reduced to a maximum of five and, with practice, it is possible to change to any frequency, for which the adjustments are known, in about 15 seconds.

45. Table 2 shows a typical set of adjustments for five frequencies between 4·3 Mc/s. and 6·0 Mc/s. A similar table should be prepared for each transmitter and should be prominently displayed near the instrument.

46. With transmitter T.1087 the occasions upon which it is necessary to switch off the H.T. in order to make adjustments inside the transmitter are limited. The amplifier bias tap, stud 4, is such that the frequency may be safely changed without altering either the bias tap, or the H.T. tap which may be left on stud 2 whilst tuning. The aerial current should not be less than 1·9 amperes.

TABLE 1

TYPICAL SETS OF ADJUSTMENTS—TRANSMITTER T.70

Frequency	Master-Oscillator Condenser	Grid Coupling Coil		Amplifier Tuning Condenser	Aerial Coupling Condenser	Neutral-ising Condenser	Aerial Tuning Coil		Series Aerial Condenser
kc/s.	Degrees	Tap	Degrees	Degrees	Degrees	Degrees	Turns	Degrees	Degrees
4,300	180	3	27	163	90	47	8	0	250
5,000	107	3	25	92	90	40	5	0	150
5,500	69	3	37	60	90	44	3	50	150
5,750	53	2	17	46	90	44	1	86	150

TABLE 2

TYPICAL SETS OF ADJUSTMENTS—TRANSMITTER T.1087

Frequency	Master-Oscillator Condenser		Amplifier Anode Coil and Tuning				Bias Stud	Output Transformer		Aerial Tuning Condenser
kc/s.	Turns	Degrees	Anode Taps	Closed Circuit Taps	Condenser Fixed	Condenser Variable		Input	Output	Degrees
4,338	4	65	CF	L	C	5–46	4	DD	EE	180
4,500	4	33	CF	L	C	6–75	4	GG	EE	180
5,000	3	61	CF	L	B	7–62	4	GG	EE	180
5,500	3	50	CF	L	B	3–90	4	GG	EE	180
6,000	2	63	CF	L	A	8–05	4	GG	EE	180

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Ref. in Fig. 2.	Remarks.
10D/10941	Monitor, crystal, type 1.			
	Consisting of :—			
	Connector :—			
10H/11011	Type 11	1		
10H/11012	Type 12	1		
10A/10980	Loud-speaker, type D	1		
10D/10933	Panel, type 18	1		For detail see below
10A/10942	Rack, type 2	1		

APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Ref. in Fig. 2.	Remarks.
10D/10933	Panel, type 18			
	Principal components :—			
	Choke, L/F :—			
10C/9606	Type R	1	L_3	
10C/9607	Type S	1	L_2	
10D/10939	Coil, aerial	1	L_1	
	Condenser :—			
10C/8275	Type 164	1	C_7	2 μF.
10C/9185	Type 286	1	C_3	0·01 μF.
10C/9608	Type 320	1	C_{12}	4 μF.
10C/10394	Type 404	1	C_1	10 $\mu\mu$F.
10C/10395	Type 405	1	C_2	30 $\mu\mu$F.
10C/10553	Type 422	1	C_6	100 $\mu\mu$F.
10C/10975	Type 430	1	C_5	25 $\mu\mu$F.
10C/10937	Type 431	1	C_8	1 μF.
10C/10938	Type 432	6	C_4	100 $\mu\mu$F, variable.
10C/10545	Condenser, unit, type 4	1		Fitted with C_9, C_{10} and C_{11}.
10A/10940	Contact-plate, switch	2	S_1, S_2	
10D/10947	Cover	1		
10H/10269	Fuse, type 13	2	F	2 amps.
	Holder :—			
10H/9614	Fuse, D.P., type A	1		
10H/8597	Valve, type L	1		
10H/9615	Valve, type S	3		
10H/1739	Jack, telephone, type A	1	J_1	
10D/9595	Lamp-fitting, signal	1		
10A/1504	Milliameter, 0–100, type A ..	1	mA	
	Plug :—			
10H/7433	Type 52	1	P_1	
10H/9112	Type 82	1		
10H/9617	Type 87	1	P_2	
10H/9618	Type 88	1	P,	
10F/9619	Relay, thermostatic, type B ..	1	R.L.	
	Resistance :—			
10C/7957	Type 104	2	R_2, R_3	10,000 ohms.
10C/7973	Type 105	1	R_5	40,000 ohms.
10C/8016	Type 108	1	R_4	0·5 megohm.
10C/8021	Type 113	1	R_1	20,000 ohms.
10C/8117	Type 123	1	R_7	1 megohm.
10C/9621	Type 268	1	R_{12}	30,000 ohms.
10C/9623	Type 270	1	R_{13}	500 ohms.
10C/10550	Type 393	2	R_8, R_9	50 ohms.
10C/10974	Type 396	1	R_{10}	1,500 ohms.
10C/10936	Type 397	1	R_6	0·5 megohm, variable.
10C/10982	Type 398	1	R_{11}	20 ohms.
10C/10547	Resistance-unit, type 1	1		Fitted with R_{14} and R_{15}.
	Socket :—			
10H/7437	Type 19	2	P_4	
10H/7439	Type 20	1	P_3	
	Switch :—			
10F/9624	Type 116	1	S_4	
10F/10338	Type 152	1	S_3	
	Transformer :—			
10A/10934	Type 20	1	T_1	
10A/10935	Type 21	1	T_2	
10A/9626	Type 43	1	T_3	
	Accessories :—			
10X/As required	Crystal unit			
5A/361	Lamp, filament, 3·5 volts	1		
	Valve :—			
10E/9598	V.R.37	1	V_2	Detector.
10E/9599	V.R.38	1	V_1	Oscillator.
10E/9601	V.R.40	1	V_3	Amplifier.
10E/9600	V.U.39	1	V_4	Rectifier.

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SECTION 5, CHAPTER 13

WAVEMETER W.1117

Contents

List of Illustrations

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 $\pm$ 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 $8\frac{1}{2}$ in. and its weight, complete with valves and batteries, is approximately $33\frac{3}{4}$ lb. A transit case is provided with each instrument. Its dimensions are $26\frac{1}{2}$ in. by $15\frac{3}{4}$ in. by $10\frac{3}{4}$ 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

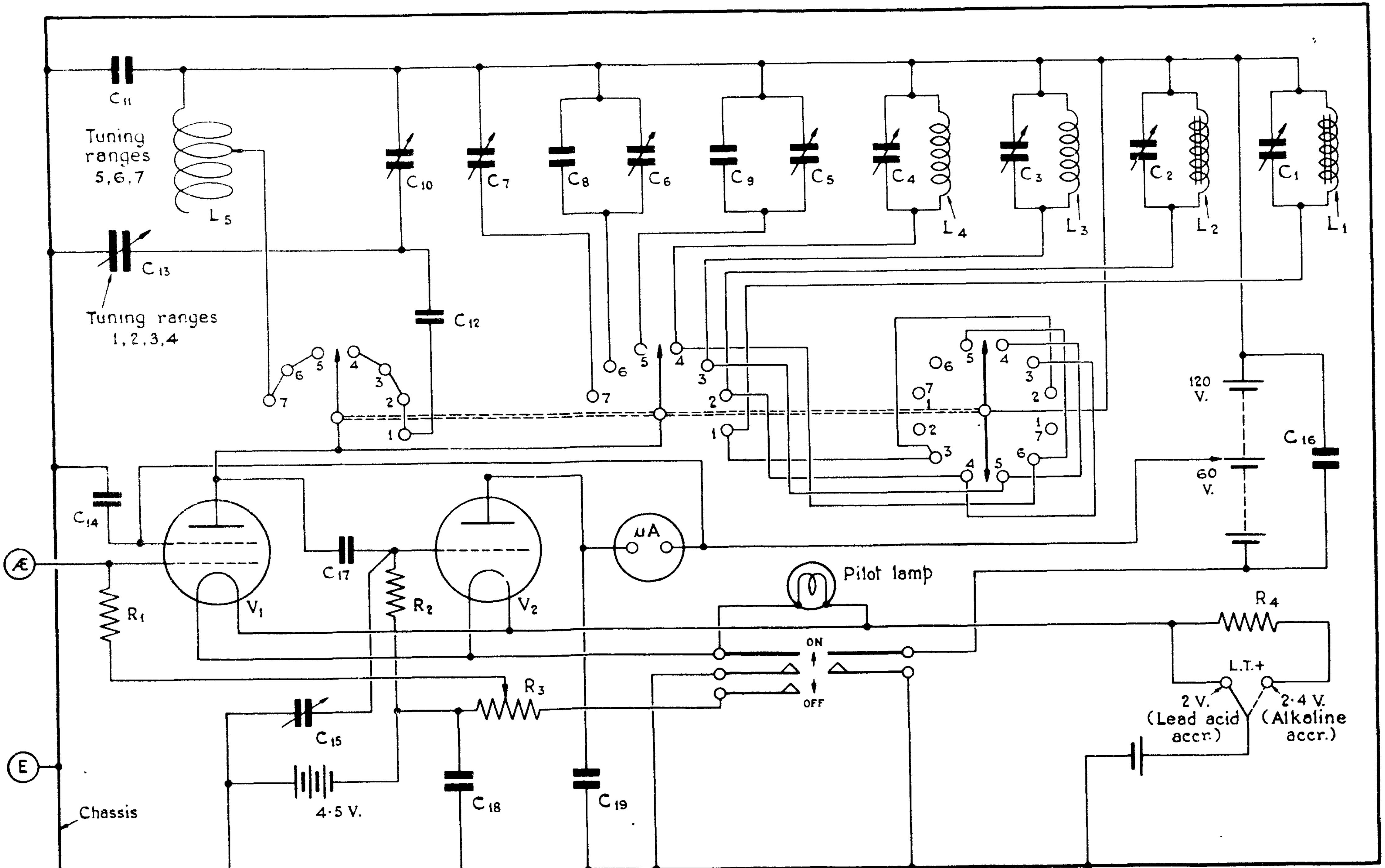
5. On the ranges 1 to 4 the calibration is recorded with reference to the setting of a continuously variable condenser which is associated with a different fixed inductance for each range, whilst on ranges 5 to 7 the setting of a continuously variable inductance, associated with a different capacitance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



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

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_9 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 inductance 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 ($4\frac{1}{2}$ 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 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_4, 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 0^0 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-valve 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

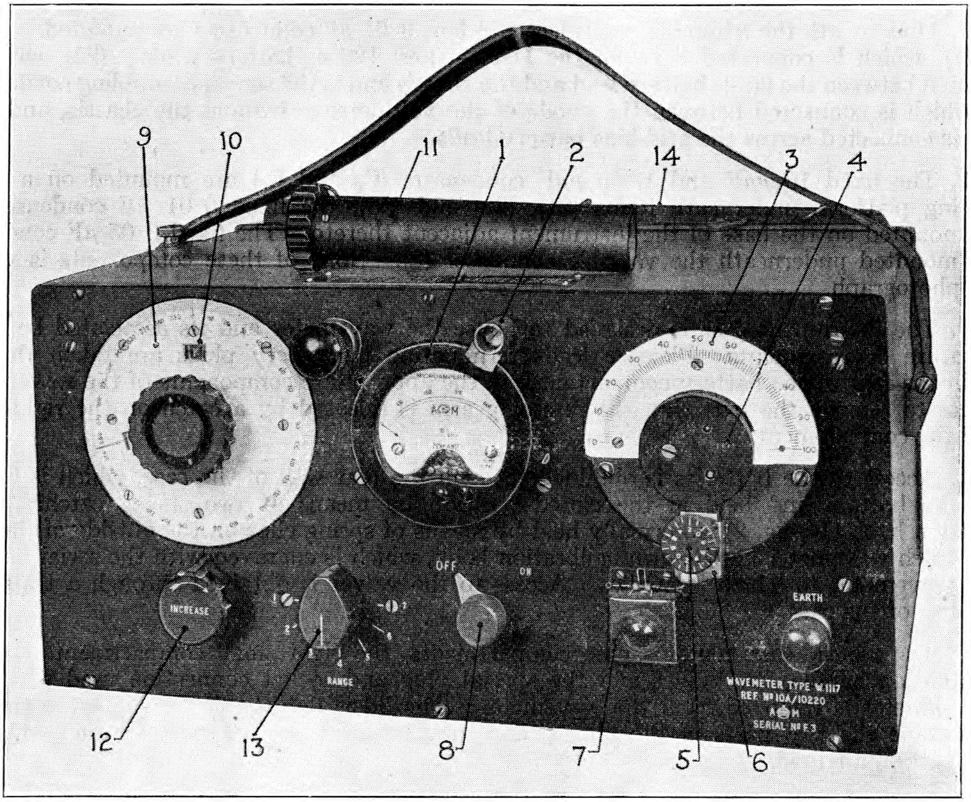


FIG. 2. Wavemeter W.1117, front view.

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 μμF and 1,050 μμF 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.

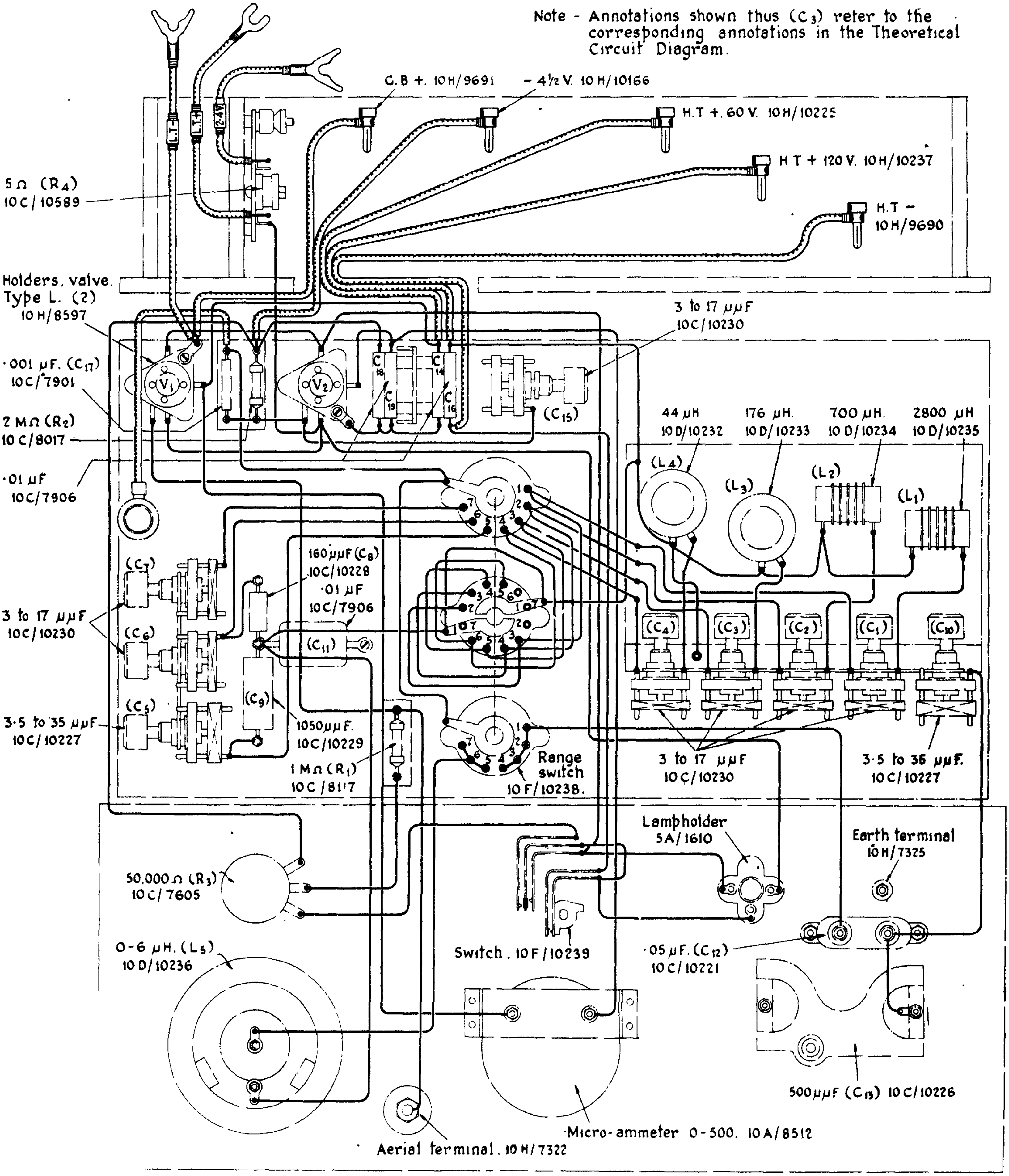
33. A standard S.4 camera tripod is used. The screw on the tripod engages a boss in the lid of the transit case. The wavemeter is placed in the lid and held in position by means of two elastic cords, which are threaded through the carrying strap and then secured in the special blocks provided in the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

Note - Annotations shown thus (C_3) refer to the corresponding annotations in the Theoretical Circuit Diagram.



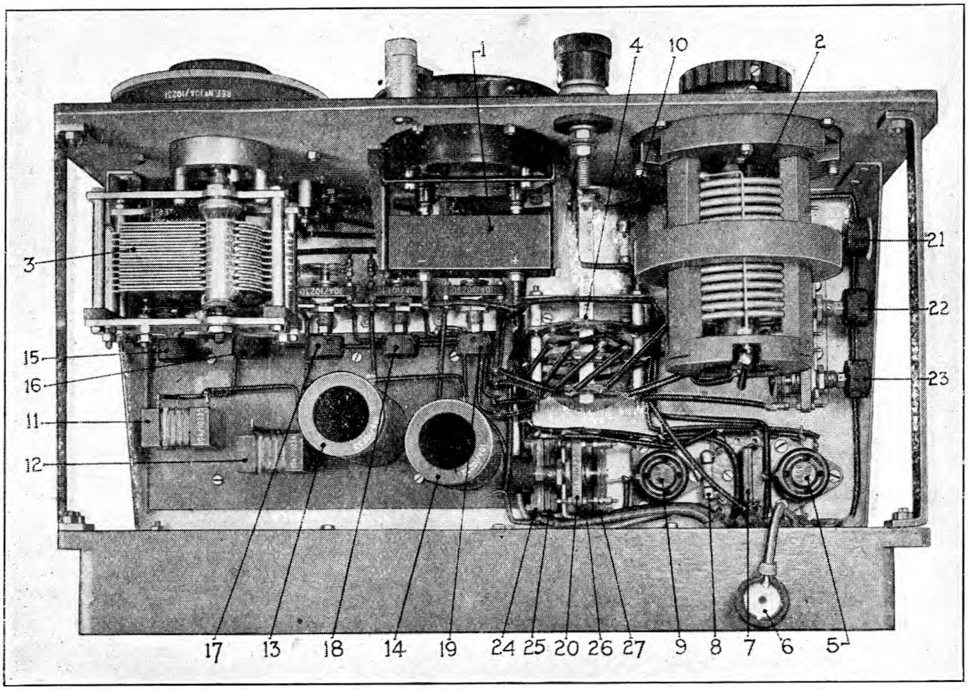


FIG. 4. Wavemeter W.1117 interior.

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 most accurate conditions for tuning are obtained when the pick up is just sufficient to give a deflection of 300 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 310 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 300 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 300 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	L.1	1	Iron core.
10D/10234	L.2	1	Iron core.
10D/10233	L.3	1	Air core.
10D/10232	L.4	1	Air core.
10D/10236	Inductance, variable, L.5	1	With counting mechanism.
5A/1610	Lamp - holder, miniature, Edison screw.	1	Batten type.
10A/8512	Micro-ammeter, type B	1	0 to 50 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	Typs 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.
10D/10581	Case, transit	1	For wavemeter, 6 valves, extension lead and extension handle.
14A/690	Case, tripod	1	Camera, ground. S.4 equipment.
14A/694	Tripod	1	For use when required.
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.
10E/10585	Type V.W.48	3	One in wavemeter, two spares.

SECTION 5, CHAPTER 14

CRYSTAL MONITOR, TYPE 2

Contents

List of illustrations

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.

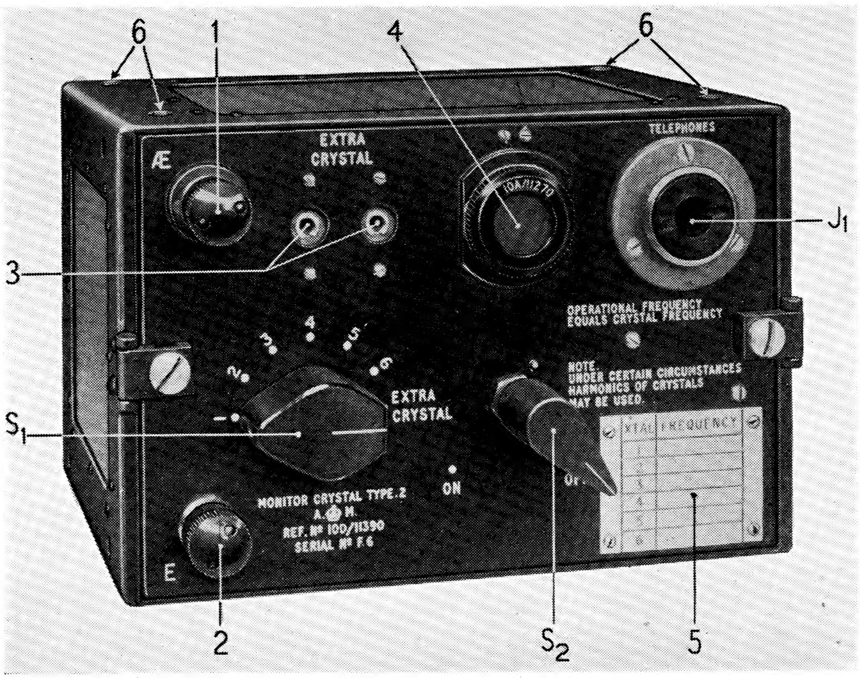
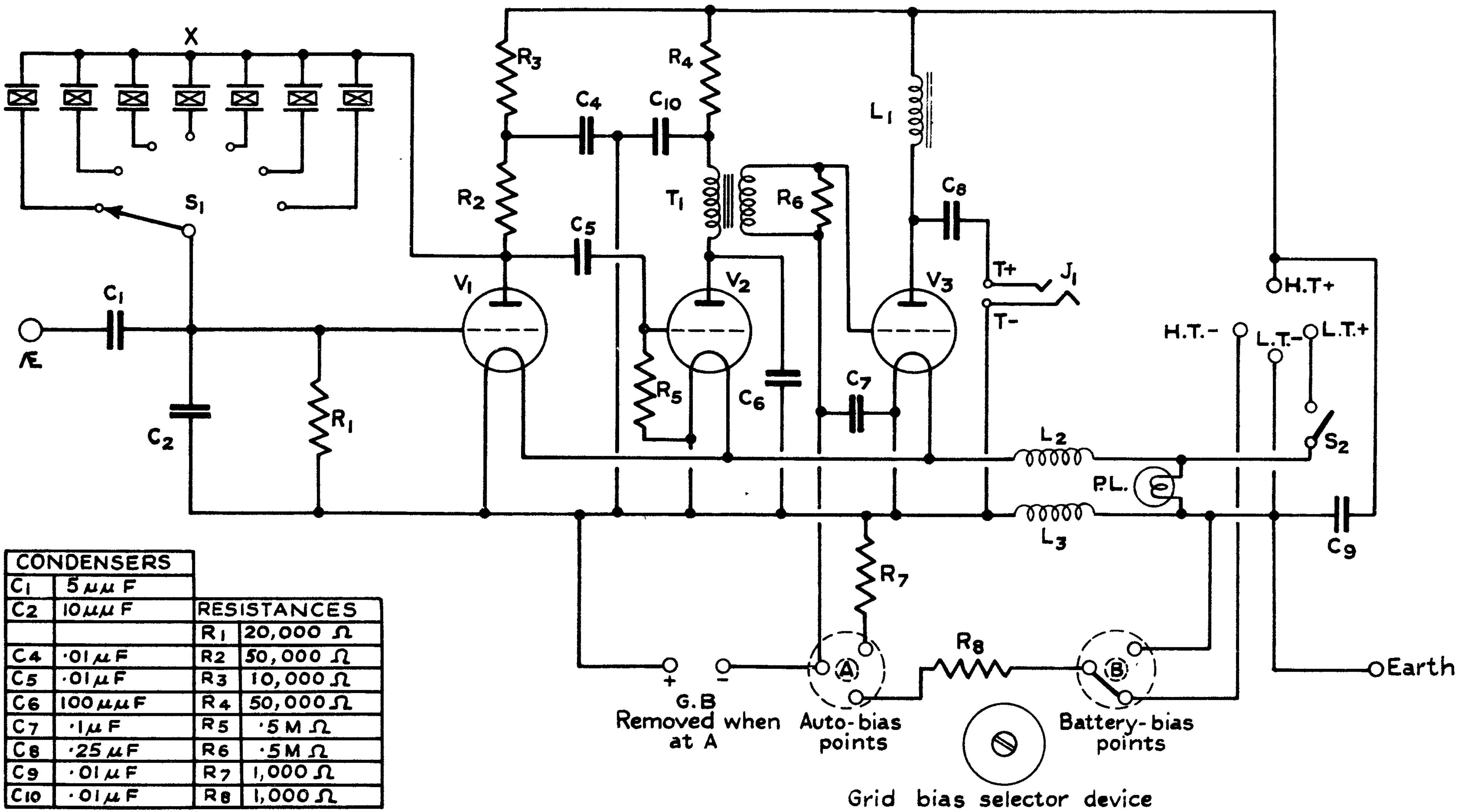


FIG. 1—CRYSTAL MONITOR, TYPE 2

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.

C1 C2 C4 C5 C10 C6 C7 C8 C9	Condensers
R1 R2 R3 R5 R4 R6 R7 R8	Resistances
X S1 V1 V2 T1 L1 V3 J1 L2 L3 P.L. S2	Miscellaneous



CONDENSERS	
C_1	5 µµF
C_2	10 µµF
C_4	·01 µF
C_5	·01 µF
C_6	100 µµF
C_7	·1 µF
C_8	·25 µF
C_9	·01 µF
C_{10}	·01 µF

RESISTANCES	
R_1	20,000 Ω
R_2	50,000 Ω
R_3	10,000 Ω
R_4	50,000 Ω
R_5	·5 M Ω
R_6	·5 M Ω
R_7	1,000 Ω
R_8	1,000 Ω

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

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_6 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_8 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.

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

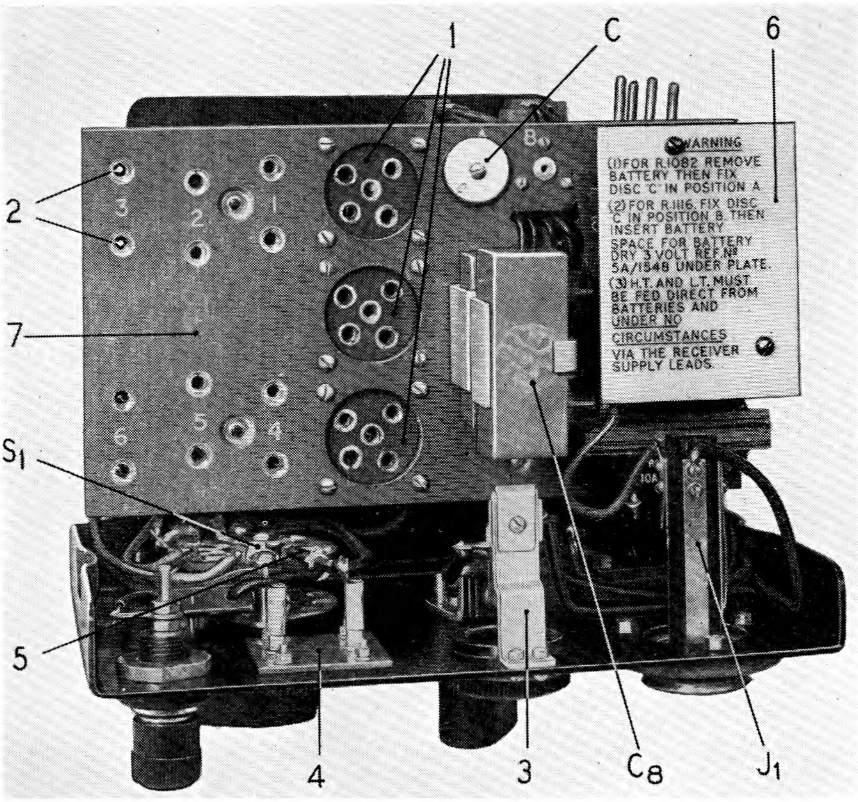


FIG. 3—PLAN VIEW OF MONITOR

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.

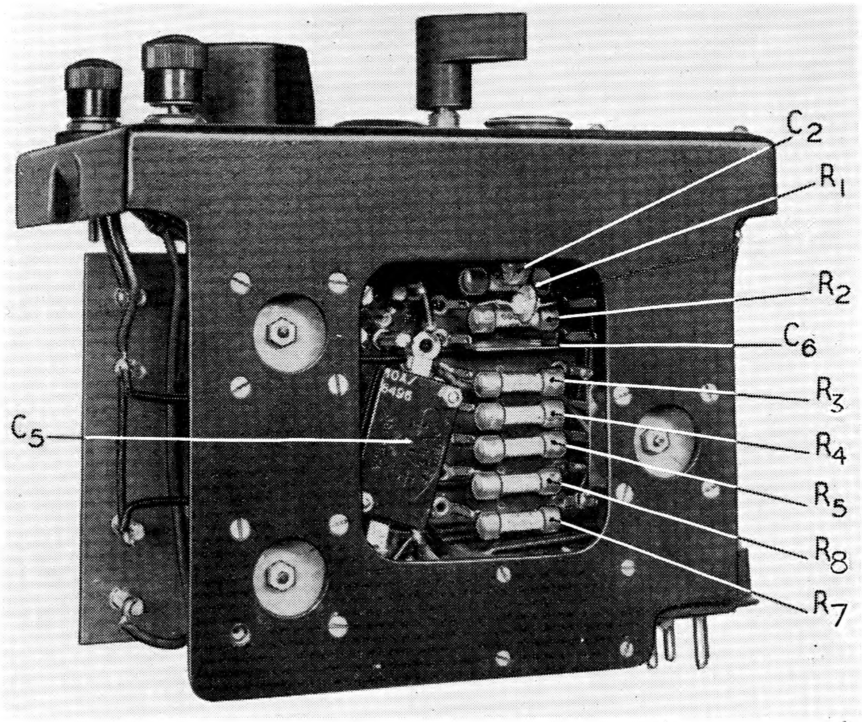


FIG. 4—UNDERSIDE OF TRAY

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_e 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.

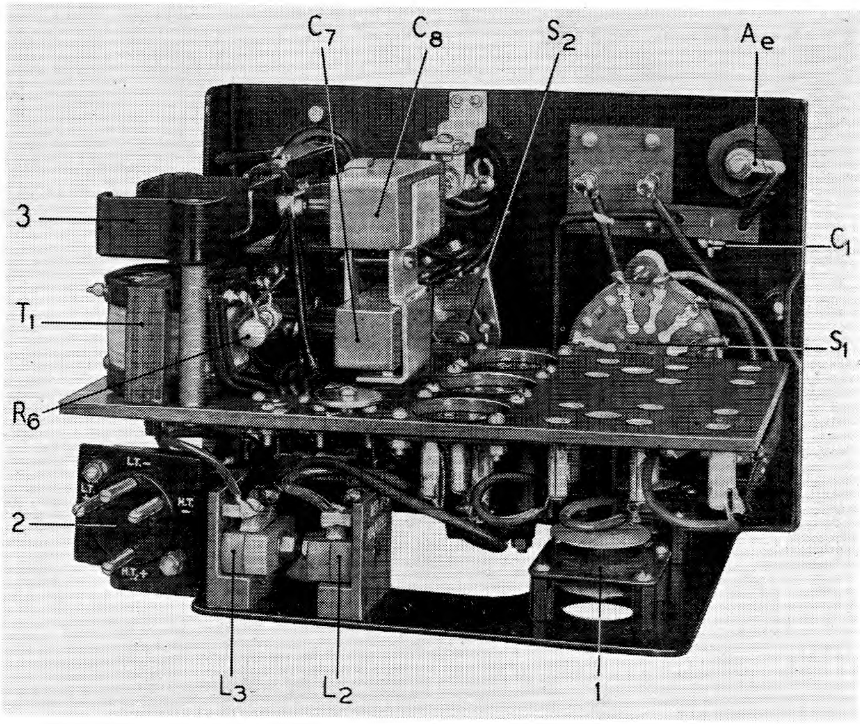


FIG. 5—REAR VIEW OF THE MONITOR

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.

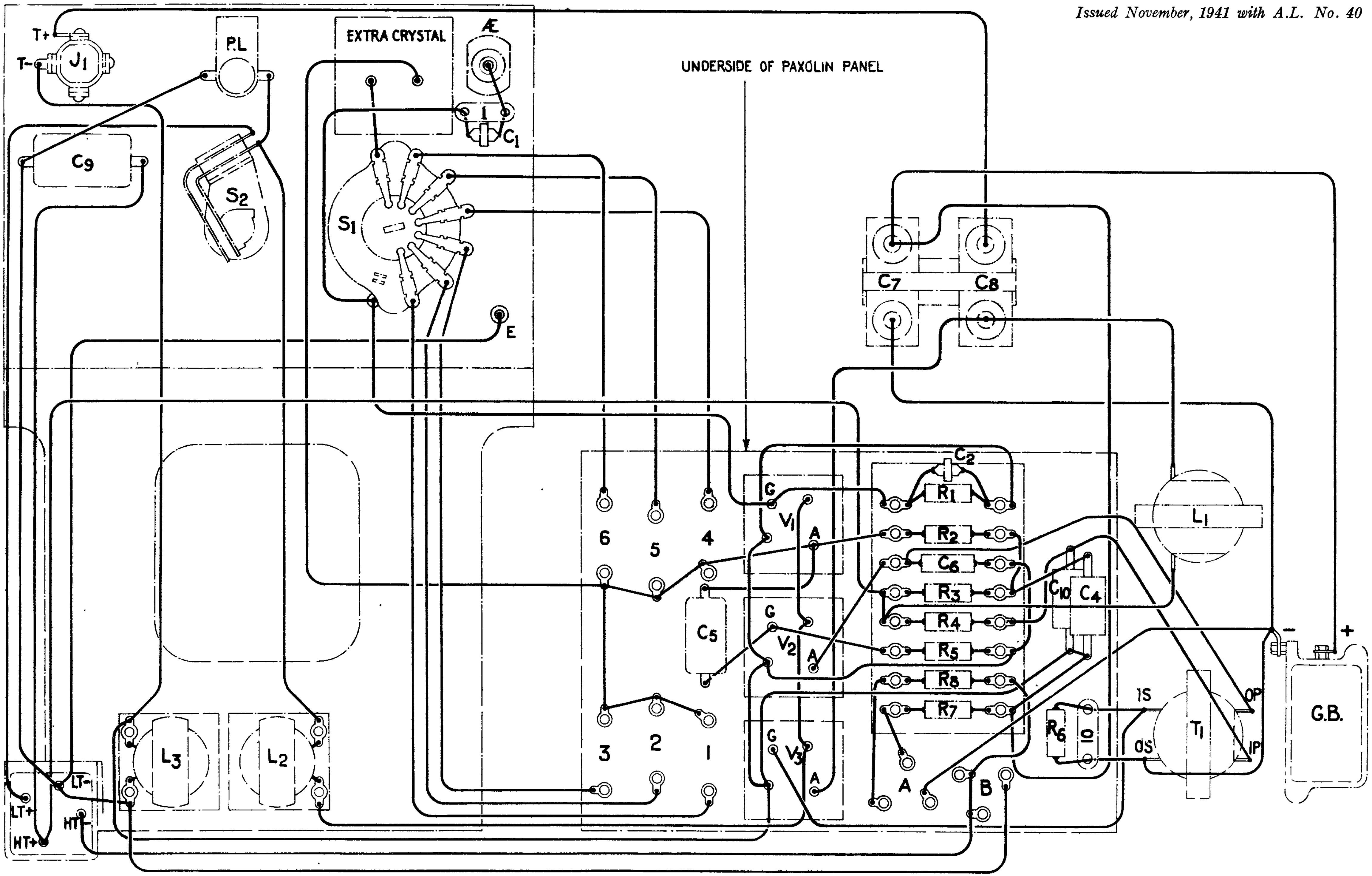


FIG. 6. CRYSTAL MONITOR TYPE 2 - BENCH WIRING DIAGRAM

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.

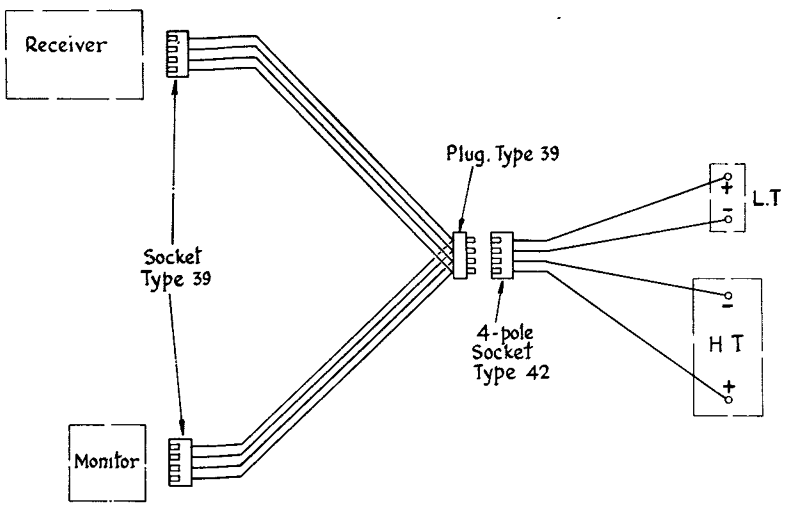


FIG. 7—BATTERY CONNECTIONS OF CRYSTAL MONITOR TYPE 2—SCHEMATIC DIAGRAM

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.

To set up receiver R.1082

36. Plug the telephones into the receiver and put the receiver battery switch and the monitor switch S_2 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_9, 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	

(*Issued January*, 1941, *with A.L. No.* 27)

SECTION 5, CHAPTER 15

OSCILLATOR UNIT, TYPE 12

Contents

List of Illustrations

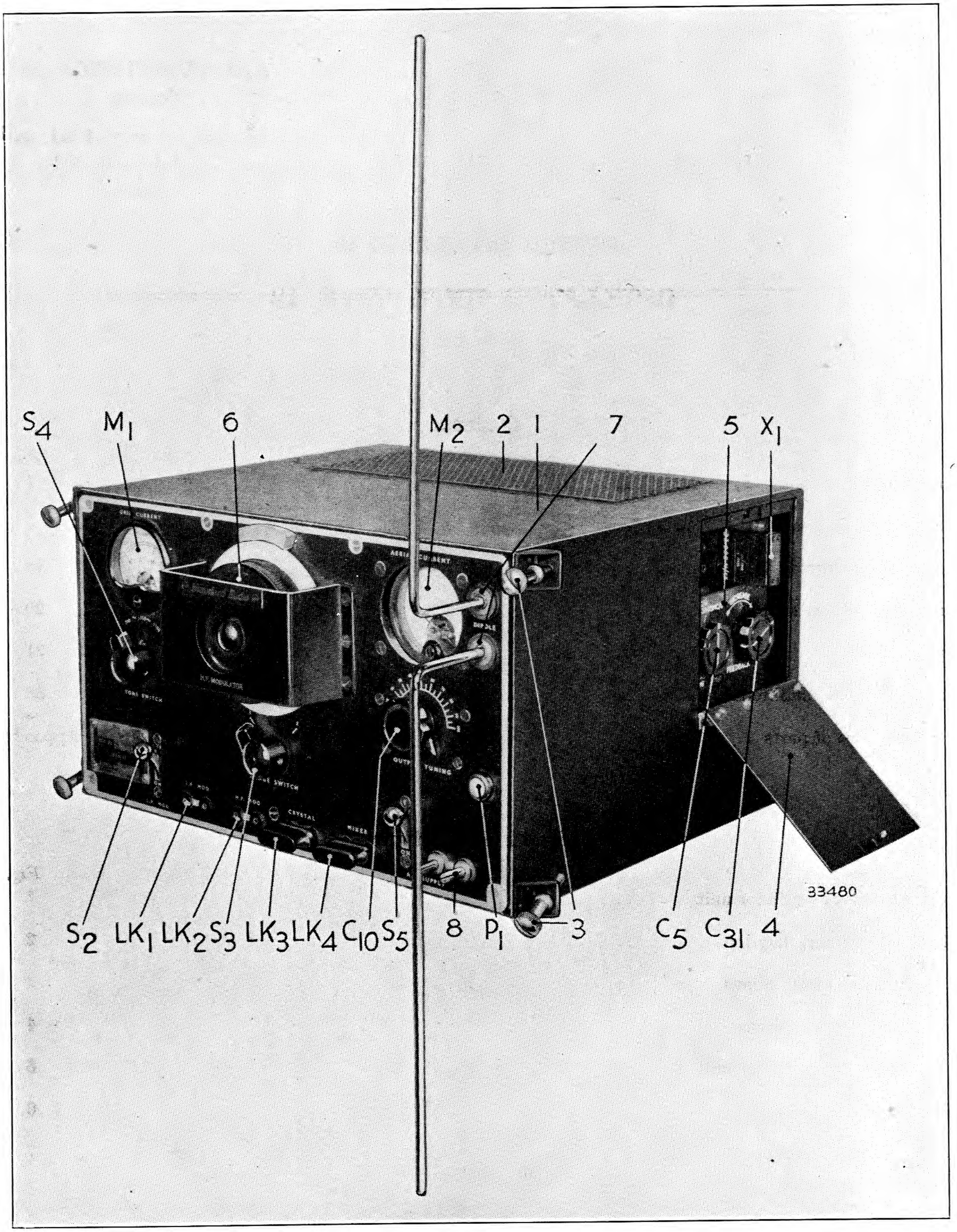


FIG. 1. General view of oscillator unit.

OSCILLATOR UNIT, TYPE 12

(Stores Ref. 10V/45)

INTRODUCTION

1. The oscillator unit, type 12, is a miniature, portable, variable frequency signal generator operating over the range 30·5 to 40·5 Mc/s, primarily designed for lining up the receivers, type R. 1124A and R. 1125A, of the blind approach system. The output, which may be modulated at 700, 1,150 or 1,700 c/s by means of a self-contained A/F oscillator controlled by a three position switch, is delivered to a small dipole aerial plugged into sockets on the front panel of the instrument.

2. The frequency band is covered in six steps, employing three interchangeable plug-in crystals of frequencies 33·0 Mc/s, 35·6 Mc/s and 38·05 Mc/s, intervening frequencies being obtained by means of a R/F modulator with a frequency range of from 2·5 to 5·5 Mc/s. The R/F modulator is tuned by a calibrated variable condenser with a vernier scale, the tuning range being extended when required by the addition of a fixed condenser, connected in parallel with the variable condenser by means of a switch. Due to this feature, and to the crystal control, great accuracy is obtained in the selection of the required frequency, the frequency stability being approximately 200 parts in 1,000,000.

3. The oscillator is primarily designed for operation from 50 c/s A.C. mains of any voltage between 200 and 250, a rectifier and mains transformer for H.T. and L.T. supply being incorporated. A portable motor-generator, working off a 12-volt battery, is supplied for use where A.C. mains are not available.

4. Five valves are employed, the R/F circuits consisting of a crystal oscillator valve and an R/F modulator, the combined output of which is rectified by a triode mixer and output valve. A triode oscillator valve acts as A/F modulator, and a full-wave rectifier valve provides the H.T. supply.

5. The size of the instrument is approximately 7½ in. by 13 in. by 11 in. and its weight 37 lb. exclusive of the transit case. The weights of the transit case and of the motor generator are respectively 25 and 35 lb. A general view of the instrument, without the transit case, is given in fig. 1.

GENERAL DESCRIPTION

6· Referring to the theoretical circuit diagram, fig. 2, the signal generator consists of the crystal-controlled oscillator valve V_1, and of the R/F modulator valve V_3, the combined outputs of which are applied to the grid-cathode circuit of the mixer valve V_2, which supplies the output. Audio-frequency modulation is also applied to the grid of the valve V_2, by the A/F oscillator valve V_4. The H.T. supply is obtained from the directly heated full-wave rectifier valve V_5, in conjunction with the mains transformer T_1, which also supplies heater current for the rectifier and for the other indirectly heated valves.

7. The crystal oscillator valve V_1 is connected in a tuned grid, tuned anode circuit. The grid-earth circuit consists of the crystal X_1, shunted by the grid leak resistance R_1, which supplies part of the necessary grid bias. The high potential terminal of the crystal is connected to the grid through the feedback inductance L_1, which is magnetically coupled to the anode inductance L_2. The anode circuit is tuned by the condenser C_5 and damped by the resistance R_{10} which is connected in series with the variable condenser C_{41}. This condenser provides a means of adjusting the damping of the tuned circuit, and thus enables the feedback applied to the crystal to be controlled. Additional grid bias is provided by the cathode resistance R_{11}, by-passed by the condenser C_4, to protect the valve against possible breakdown due to a fault in the crystal circuit. The H.T. feed to the anode is obtained from the rectifier valve V_5 through the removable link LK_3, the voltage dropping resistance R_2, and an R/F filter consisting of the choke CH_1, by-passed by the condenser C_2. The output of the valve V_1 is applied to the grid of the mixer valve V_2 from a tapping on the inductance L_2, through the coupling condenser C_6.

8. The R/F modulator valve V_3 is connected in a Hartley oscillator circuit. The inductance L_4 is tuned by the condenser C_{19}, with the condenser C_{20} connected in parallel. The condenser C_{16} is also added in parallel with the others by the operation of the switch S_3 when it is necessary to increase the tuning range. One end of the inductance L_4 is connected to the anode of the valve V_3, the other is connected to the grid, through the condenser C_{17} and the stopper resistance R_6, which, in conjunction with the resistance R_5, forms a grid leak and produces automatic grid bias. One tapping on the inductance L_4 is connected to the H.T. supply through the link LK_2 *via* the voltage dropping resistance R_{12} and the R/F choke CH_5, which is by-passed by the condenser C_{18}. A further tapping is connected through the choke CH_2 to the grid of the valve V_2 *via* the condenser C_{21}.

9. The A/F oscillator valve V_4 is also connected in a Hartley circuit, the A/F choke CH_6 being tuned by pairs of condensers as selected by the switch S_4, which determines the modulation frequency. The condensers C_{32} and C_{23} are selected to tune the circuit to a frequency of 1,700 c/s, the condensers C_{33} and C_{24} being used for 1,150 c/s. The remaining condensers C_{25} and C_{31} are selected for 700 c/s operation. The grid of the valve V_4 is connected to earth through the grid leak resistance R_9, which provides grid bias, and to one end of the choke CH_6 through the stopper resistance R_8 and the coupling condenser C_{26}. The H.T. is supplied to the choke CH_6, at a tapping which is earthed by the condenser C_{27}, through the link LK_1 and the switch S_2. The anode of the valve V_4 is also connected to the choke CH_6, and through the resistance R_7 and the coupling condenser C_{22}, to the grid circuit of the mixer valve V_2.

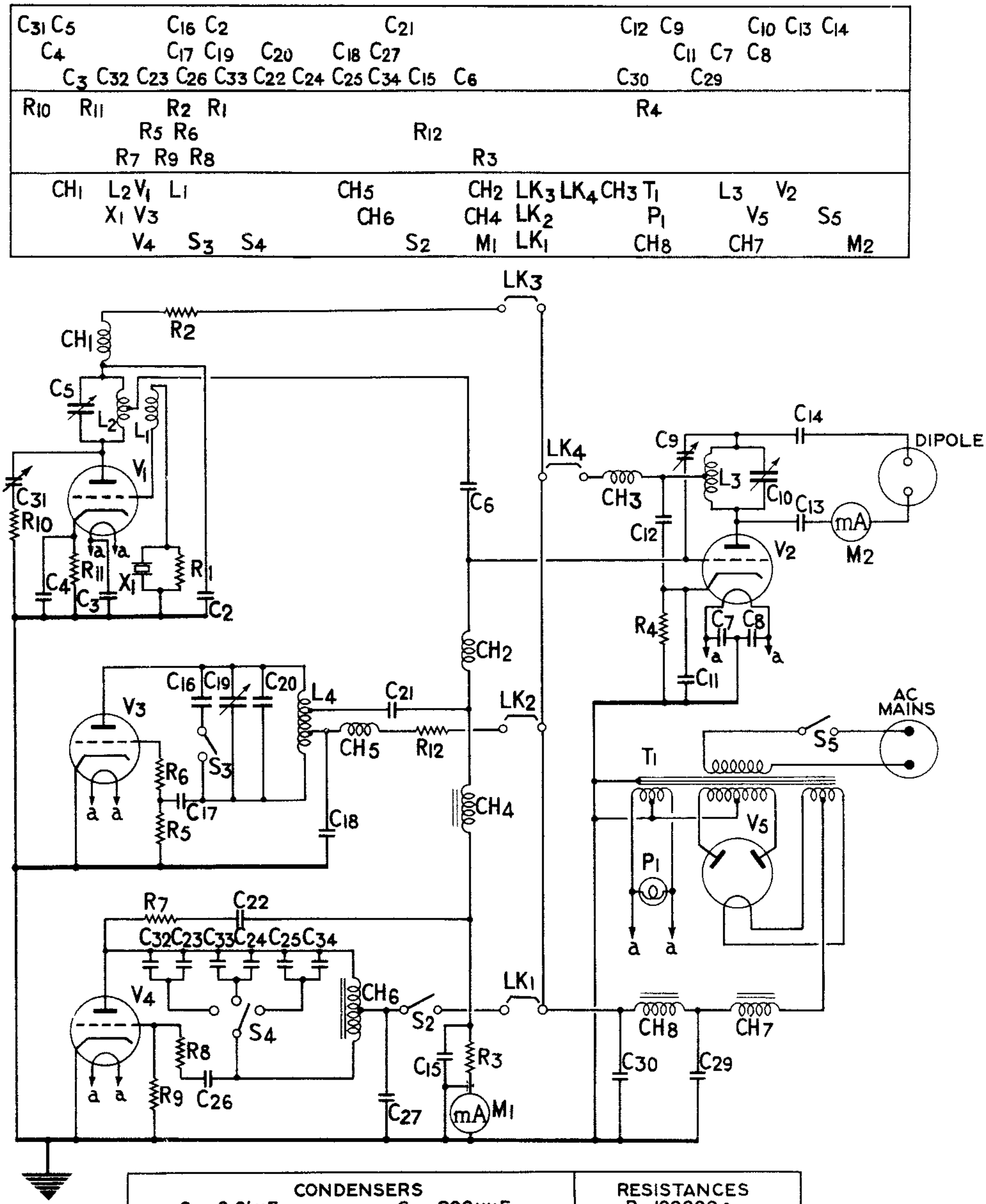
10. The input to the mixer valve V_2 consists of the output of the three oscillator valves V_1, V_3 and V_4. These outputs are all applied in parallel to the grid-earth circuit of the valve. As previously described, the grid is coupled directly to the crystal oscillator valve V_1, through the condenser C_6, and also to the R/F modulator through the condenser C_{21} and the R/F choke CH_2, which prevents interaction between the two oscillators. The grid circuit is continued through the A/F choke CH_4 which separates the outputs of the valves V_3 and V_4 and is completed to earth *via* the resistance R_3, by-passed by the condenser C_{15}, and the grid current meter M_1.

11. Grid bias for the valve V_2 is provided by the cathode resistance R_4, which is by-passed by the condenser C_{11}. The H.T. supply is furnished *via* the link LK_4 and the R/F choke CH_3, which is by-passed to the cathode by the condenser C_{12}, to the centre tapping of the anode tuning inductance L_3.

12. The anode circuit of the valve V_2 is tuned by the condenser C_{10} to a heterodyne frequency equal to the sum or difference of the output frequencies of the crystal oscillator and R/F modulator stages, and the valve is neutralised by the condenser C_9. The output contains modulation components due to the A/F modulator valve V_4, and is connected to the sockets of the dipole aerial through the coupling condensers C_{13} and C_{14} and the thermo-ammeter M_2.

13. The primary winding of the mains transformer T_1 is connected to the A.C. supply through the switch S_5. The 6·3-volt secondary winding supplies the heaters of the indirectly heated valves V_1, V_2, V_3 and V_4, and also the pilot lamp P_1 through the leads a. One terminal of the heater of the valve V_1 is earthed through the condenser C_3; the heater of the valve V_2 is centre-pointed to earth by the condensers C_7 and C_8. The centre tapping of the heater winding of the transformer T_1 is also connected to earth.

14. The H.T. secondary winding is connected to the anodes of the full-wave rectifier valve V_5, the centre tapping being earthed. The filament of this valve is supplied by a separate 4-volt secondary winding of the transformer, whose centre tapping is connected through the smoothing choke CH_7 to a filter consisting of the choke CH_8 and the condensers C_{29} and C_{30}, and thence to the four links LK_1, LK_2, LK_3 and LK_4 which supply H.T. to the valves V_4, V_3, V_1 and V_2 respectively.



CONDENSERS

C2	0·01 μF	C17	200 μμF
C3	0·005 μF	C18	0·01 μF
C4	0·005 μF	C19	VAR.
C5	VAR.	C20	50 μμF
C6	50 μμF	C21	200 μμF
C7	0·005 μF	C22	0·1 μF
C8	0·005 μF	C23	0·0275 μF
C9	VAR.	C24	0·06 μF
C10	40 μμF	C25	0·165 μF
C11	0·01 μF	C26	0·04 μF
C12	0·01 μF	C27	2·0 μF
C13	100 μμF	C29	6·0 μF
C14	100 μμF	C30	4·0 μF
C15	0·07 μF	C31	10 μμF
C16	200 μμF	C32	0·002 μF

RESISTANCES

R1	100,000 Ω
R2	2,000 Ω
R3	25,000 Ω
R4	1,000 Ω
R5	5000 Ω
R6	20 Ω
R7	7,500 Ω
R8	20,000 Ω
R9	20,000 Ω
R10	20 Ω
R11	500 Ω
R12	10,000 Ω

C33 0·006 μF
C34 0·01 + 0·01 μF

THEORETICAL CIRCUIT DIAGRAM, OSCILLATOR UNIT, TYPE 12

FIG. 2

FIG. 2

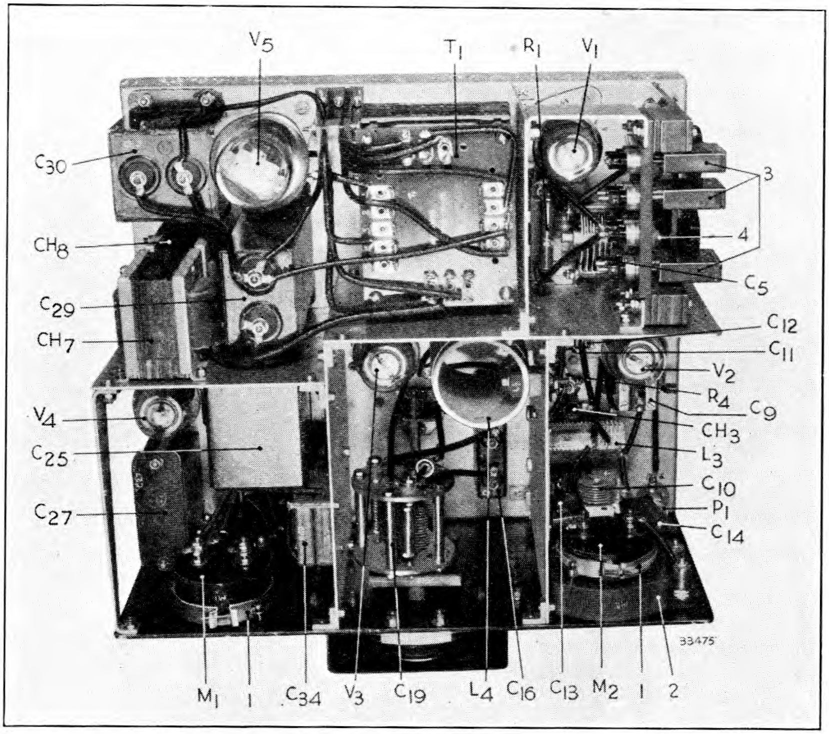
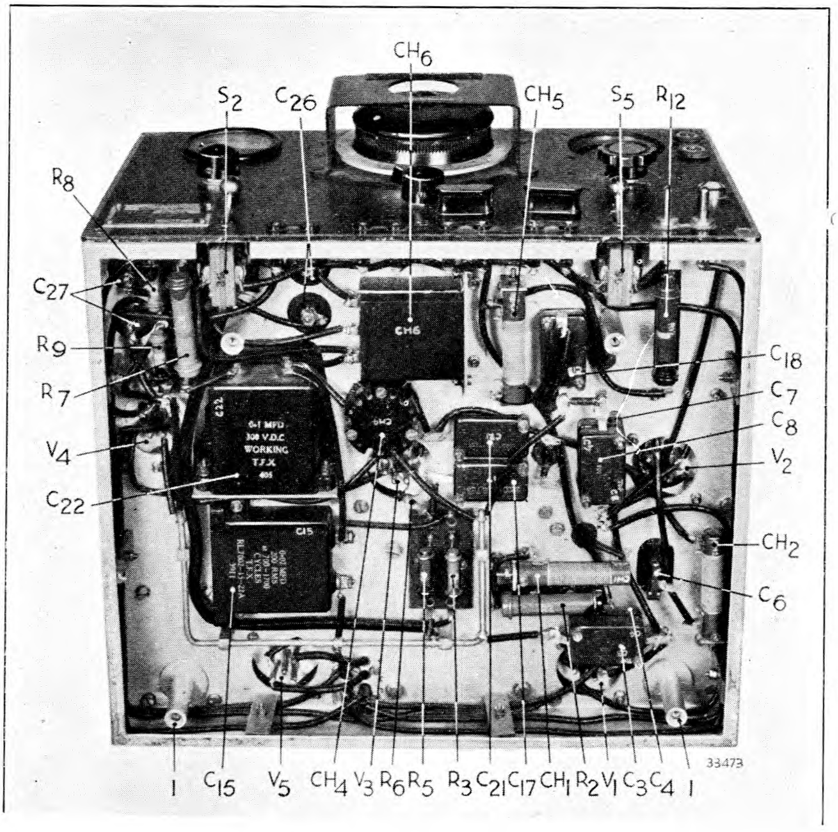


FIG. 3. View of chassis from above.



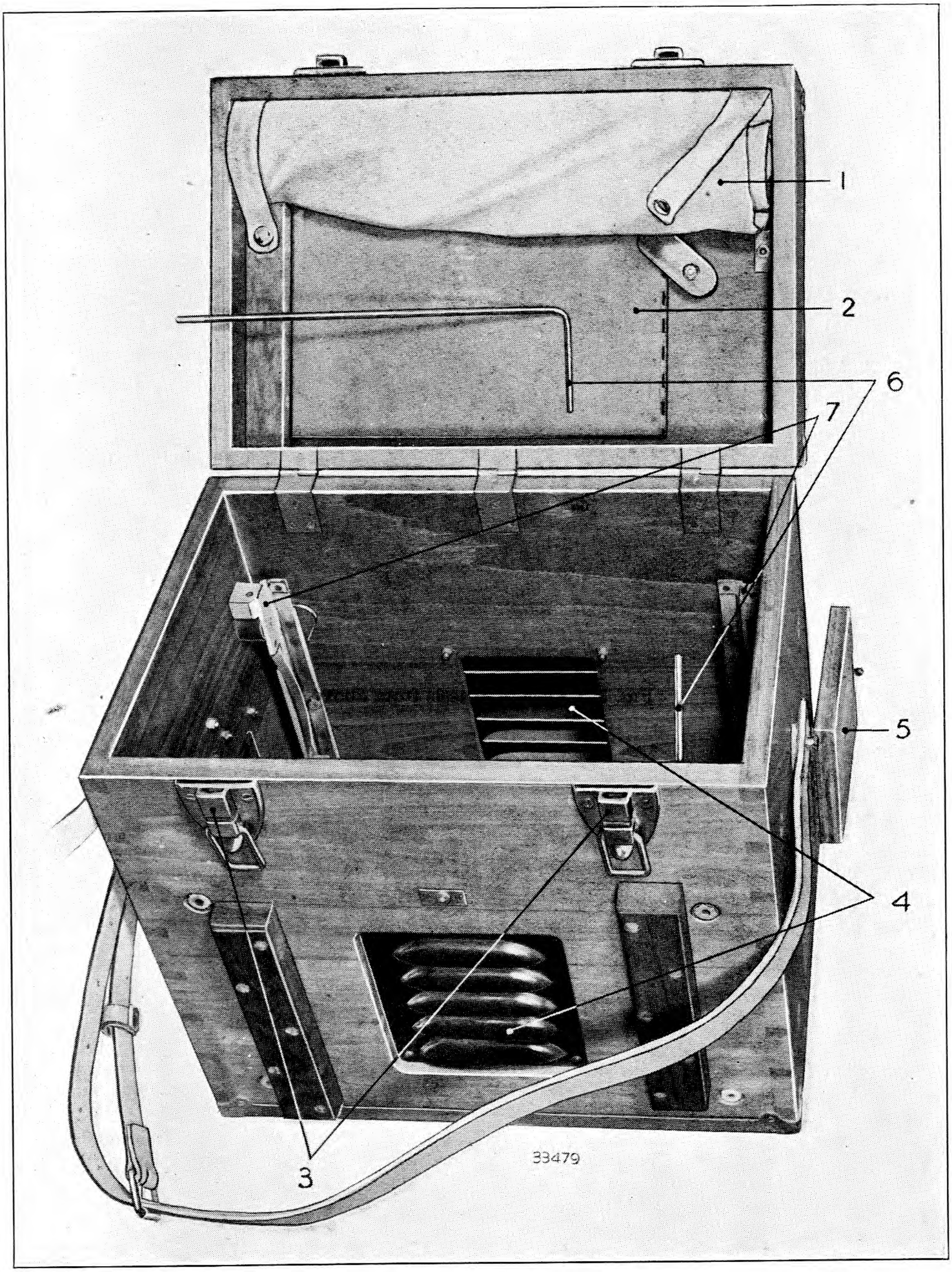


FIG. 5. Transit case for oscillator unit.

CONSTRUCTIONAL DETAILS

15. Referring to fig. 1, the oscillator unit, type 12, is seen to consist of a metal housing (1) which is provided with ventilating grilles (2) at opposite sides. The housing is secured in the transit case by means of four coin-headed captive screws (3) which are attached to brackets. A hinged door (4) provides access to the controls of the crystal oscillator circuit, which are mounted on a side panel (5) which forms part of the chassis of the instrument. Four sets of crystal sockets are provided, three being unconnected, and the fourth is engraved CRYSTAL IN USE and is connected to the valve circuit. The TUNING control operating the condenser C_5 has the three main tuning positions, engraved with the nominal crystal frequencies. The remaining control, the condenser C_{31} is marked FEEDBACK.

16. The meters M_1 and M_2 on the front panel are engraved GRID CURRENT and AERIAL CURRENT respectively. The slow motion control (6) is marked H.F. MODULATOR and

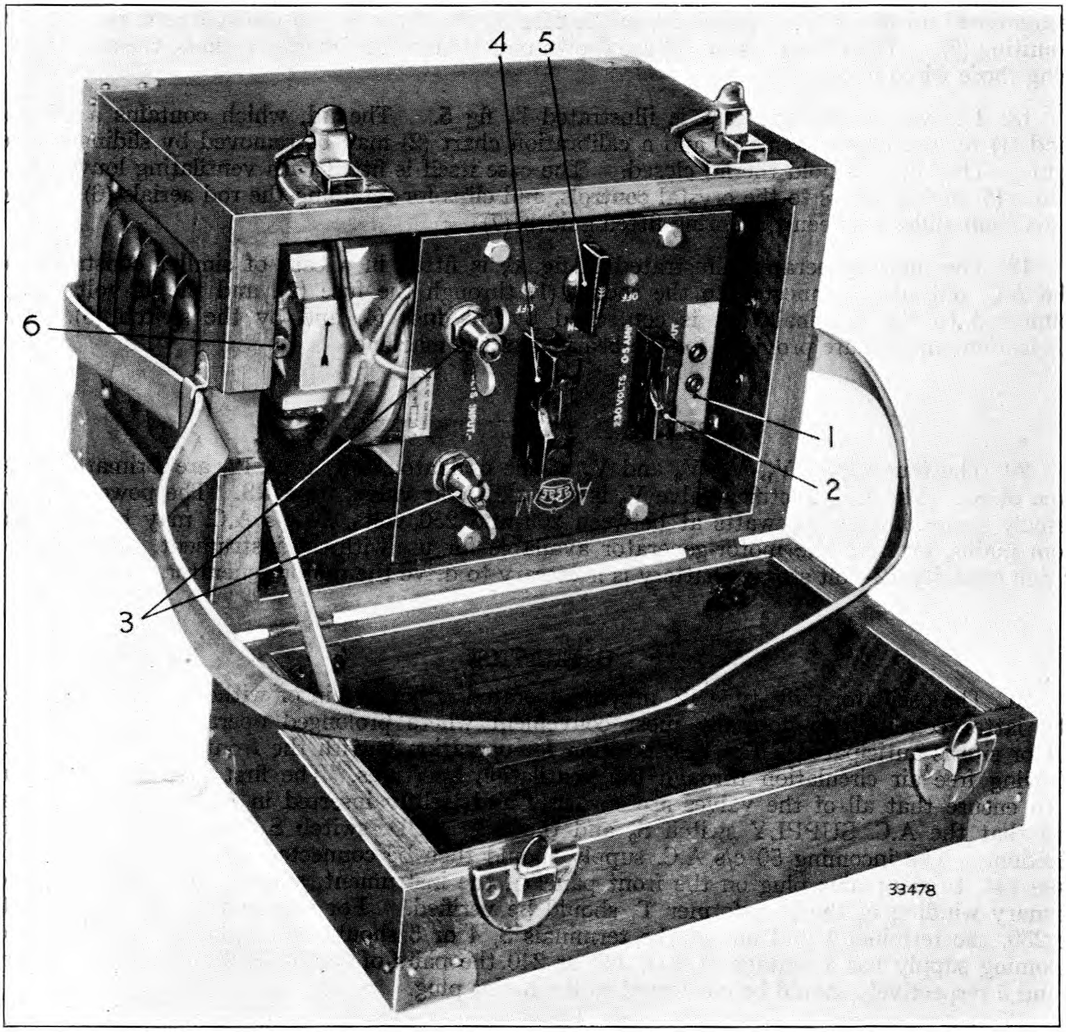


FIG. 6. Portable motor generator.

operates the variable condenser C_{19}. The scale is engraved in degrees, subdivided into tenths with the aid of a vernier, and is protected from mechanical damage by a bracket. The two rods which constitute the output terminals of the instrument are shown mounted in the DIPOLE sockets (7) ; the input is connected to the plug (8) which together with the switch S_5 adjoining, is marked A.C. SUPPLY. Two of the four links LK_1, LK_2, LK_3 and LK_4 are shown in position, the remaining two being removed to expose the sockets, which are engraved respectively L.F. MOD. H.F. MOD. CRYSTAL, and MIXER. The remaining controls on the panel, namely the switches S_4, S_1 and S_3 and the condenser C_{10} are respectively the TONE SWITCH, the L.F. MOD. SWITCH, the RANGE SWITCH and the OUTPUT TUNING control.

17. Views of the chassis from above and below are given in figs. 3 and 4, and a bench wiring diagram in fig. 7. The annotations correspond with those of the theoretical circuit diagram, fig. 2. In fig. 4 the tapped pillars (1) accommodate the four screws fixing the chassis to the housing. In fig. 3 the fixing of the meters M_1 and M_2 by means of the metal bands (1) should be noted. These bands include screwed brackets, which enable the meter flanges to be tightened up to the front panel, or, in the case of the meter M_2, to the synthetic resin meter mounting (2). The three crystals (3) are shown mounted in the dummy sockets, the sockets (4) being those wired in circuit.

18. The wooden transit case is illustrated in fig 5. The lid, which contains a canvas hood (1) for use in wet weather, and a calibration chart (2) may be removed by sliding to the right. The clips (3) hold the lid closed. The case itself is fitted with ventilating louvres (4), a door (5) giving access to the crystal controls, and clips for retaining the rod aerials (6). The instrument slides between the spring fitted guides (7).

19. The motor-generator, illustrated in fig. 6, is fitted in a case of similar construction. The A.C. output is connected to the socket (1) through the fuse (2), and the 12-volt input, connected to the terminals (3), is controlled by the fuse (4) and by the switch (5). The lubrication cups (6) are provided for the bearings of the machine.

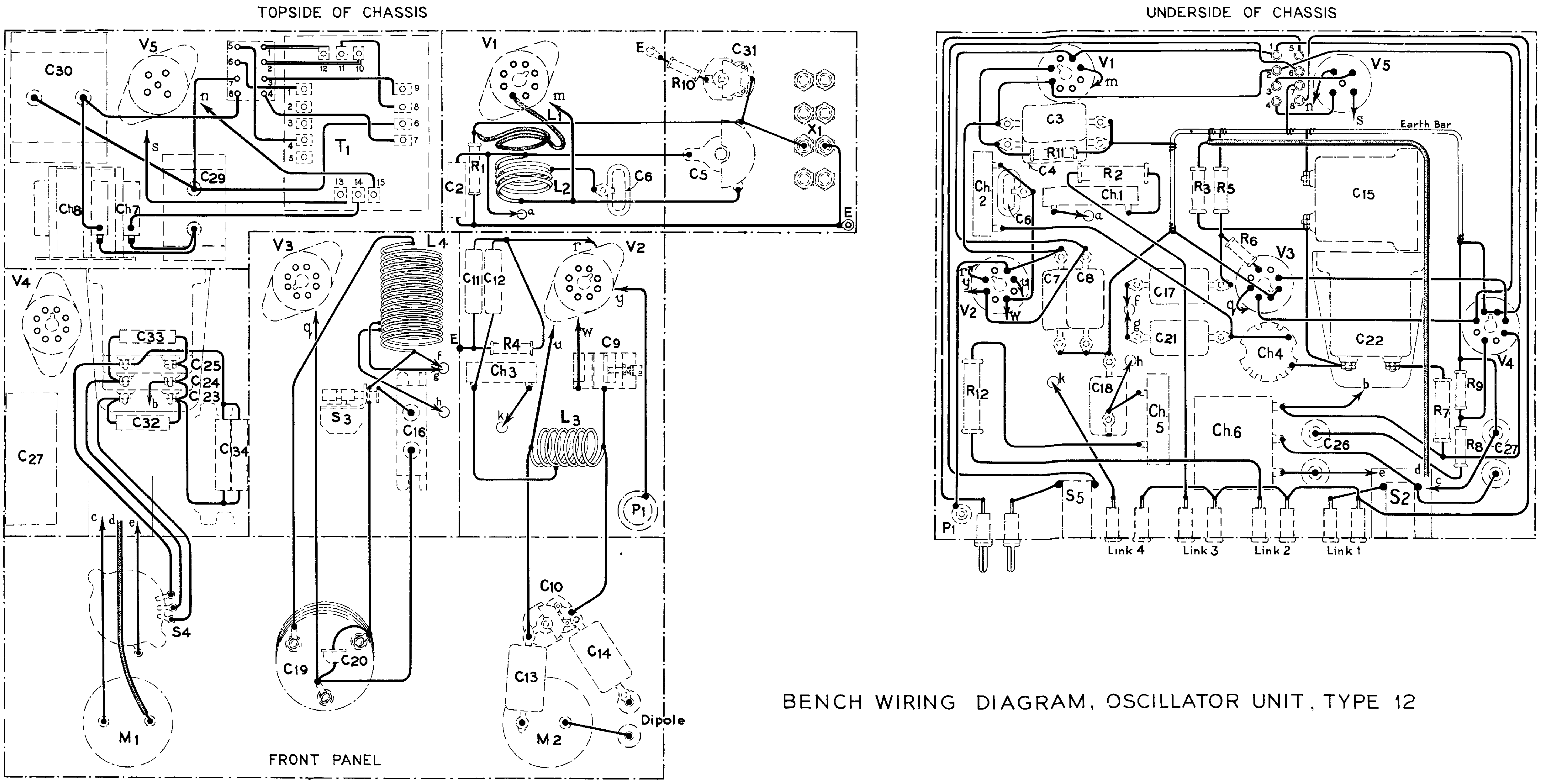
VALVES AND POWER SUPPLY

20. The four valves V_1, V_2, V_3 and V_4 of the oscillator unit, type 12, are Brimar valves, type 6C5G. The H.T. rectifier valve V_5 is also a Brimar valve, type R3. The power supply, namely approximately 60 watts at between 200 and 250 volts, 50 c/s A.C. may be obtained from mains, or from the motor-generator available for use with the instrument. In this case a high capacity 12–volt storage battery is necessary to drive the motor generator.

OPERATION

21. The oscillator unit, type 12, may be operated either within or without its transit case. The latter condition is normally most convenient where prolonged operation on the same indoor site is anticipated. The best position for operation is with the front panel uppermost, allowing free air circulation through the ventilation apertures. The first step in operation is to ensure that all of the valves are correctly and tightly inserted in their correct sockets, and that the A.C. SUPPLY switch S_5 and the L.F. MOD. switch S_2 are both in the OFF position. The incoming 50 c/s A.C. supply should then be connected by means of a socket, type 144, to the mains plug on the front panel of the instrument, and the connections to the primary winding of the transformer T_1 should be verified. For supply voltages of 210, 230 or 250, the terminal 1 and one of the terminals 3, 4 or 5 should be employed. Where the incoming supply has a voltage of 200, 220 or 240 the pairs of terminals 2 and 3, 2 and 4, or 2 and 5 respectively should be connected to the mains plug.

22. When A.C. mains are not available, the transformer T_1 should be set for 230–volt operation, and the leads from the socket, type 144, connecting the oscillator to the A.C. supply



BENCH WIRING DIAGRAM, OSCILLATOR UNIT, TYPE 12

FIG. 7

lead, should also be connected to the A.C. terminals of the motor-generator. The 12-volt terminals of the motor-generator should be connected by means of the leads supplied, to a 12-volt storage battery of high capacity, great care being taken to make the connections firm, and to obtain a large contact area between the leads and the terminals both of the motor generator and of the battery. To avoid wastage of battery power, it is advisable to leave the L.T. supply to the motor generator switched off until the oscillator is actually ready for operation.

23. The dipole aerial rods should now be fitted into the output sockets, and the instrument set up so that the rods are in line, and are parallel to the aerial of the apparatus under test. Where the latter is fitted with a vertical aerial, it may be necessary to instal the test oscillator with the front panel in a vertical plane, and to support it so as to allow ample clearance between the aerial rods and surrounding objects. When the oscillator is used without its transit case, the shorter ends of these rods should be inserted in the output sockets ; but in other circumstances it may be necessary to insert the longer ends into the sockets, which will reduce the radiated field strength.

24. Having determined the required operating frequency of the oscillator, the appropriate crystal should be inserted into the sockets marked CRYSTAL IN USE in the side control panel of the oscillator. Where the operating frequency lies between 30·1 and 33·1 Mc/s, the 35·6 Mc/s crystal should be selected, and the upper sideband of the resulting output frequencies should be employed. For frequencies between 32·55 and 35·55 Mc/s, the 38·05 Mc/s crystal should be put into service, and the lower sideband of the output frequencies selected. By selecting the upper sidebands and employing the 33 Mc/s or the 35·6 Mc/s crystal, the frequency bands between 35·5 Mc/s and 38·5 Mc/s, or between 38·1 Mc/s and 41·1 Mc/s may be covered. The exact operating frequency of the crystal, which is painted in white at the side of the crystal, should be noted. The crystals, which should normally be kept in the spare sockets adjacent to the sockets marked CRYSTAL IN USE, are identified by the engraved number following the stores class. This number represents the nominal operating frequency in kc/s ; for instance a crystal engraved 10K 35,600 will possess a nominal operating frequency of 35,600 kc/s, or 35·6 Mc/s. Great care should be exercised in the handling of the crystal units. They should only be removed one at a time, and they should not be twisted, or unnecessary force exerted in withdrawing them. When inserting them in the sockets, the ends of the pins should be placed carefully over the socket openings, and the crystal units then gently pushed into position, ensuring that the pins are neither entering the socket crookedly, nor distorted by twisting.

25. The links on the front panel, marked L.F. MOD., H.F. MOD., and MIXER, which are represented in the theoretical circuit diagram, fig. 2, by the symbols LK_1, LK_2 and LK_4 should then be removed, the necessary precautions as to their removal and replacement being the same as for the crystal units. The main ON-OFF switch S_5 should then be set into the ON position, after setting the motor generator in operation if an A.C. main supply is not available. The pilot lamp P_1 should immediately light up. After a lapse of between 20 and 30 seconds, the valves should be sufficiently heated for satisfactory emission to be obtained. The anode circuit of the valve V_1 should then be roughly tuned by rotating the control of the CRYSTAL TUNING condenser C_5 until the white marking on the control knob is in line with the engraving corresponding to the frequency of the crystal in use. The OUTPUT TUNING condenser C_{10} should be set in to the maximum position by clockwise rotation of the control. The tuning should then be finely adjusted until the grid current of the valve V_1, indicated on the GRID CURRENT meter M_1, reaches a maximum. The FEED BACK control of the condenser C_{31} should then be adjusted by rotating it until the peak value of the grid current lies within the limits 0·2 and 0·5 mA. This operation may necessitate a slight alteration of the setting of the tuning condenser C_5. The setting of the feedback control should be such that when the anode circuit of the valve V_1 is off-tune, the value of the grid current is zero, and rises to its peak value very sharply when the anode tuning condenser approaches the setting corresponding to resonance.

26. The neutralising condenser C_9, of the mixer valve V_2 should only need adjustment when the oscillator is first used, or if the valve V_2 has subsequently been renewed. The neutralisation may be tested, after tuning the crystal stage as previously described, by gradually rotating the OUTPUT TUNING control while examining the reading of the GRID CURRENT meter M_1. If the setting of the neutralising condenser is correct, no alteration in the grid current of the valve V_1 should be observed at any setting of the OUTPUT TUNING condenser C_{10}. If the neutralisation is incorrect a decrease in the grid current of the valve V_1 will be observed as the condenser C_9 passes through the setting corresponding to resonance of the anode circuit of the mixer valve V_2. If this is the case, adjustment of the neutralising condenser C_9 is necessary, and to obtain access to the control the chassis of the instrument must be removed from its housing, as described in the ensuing paragraph.

27. To remove the transit case, the four captive screws securing it to the oscillator housing should be unscrewed until they swivel loosely in their retaining brackets. The metal door of the oscillator housing, protecting the crystals, should be closed. Holding the transit case firmly, the oscillator may then be withdrawn by gripping the metal housing between the fingers of both hands, or by pulling the captive screws. On no account should the oscillator be withdrawn by pulling any of the controls or the protective bracket over the H.F. MODULATOR control.

28. Before removing the oscillator chassis from the metal housing, it is necessary to disconnect the mains socket from the front panel of the instrument, and also to remove the three crystals from their sockets to protect them from damage. The four screws on the underside of the metal housing, which secure it to the oscillator chassis, should then be removed. The chassis is extracted from the housing, first by gentle leverage exerted between the front panel and the housing, and then by gripping the edges of the front panel while holding the housing firmly and withdrawing.

29. After reconnecting the mains supply and the selected crystal, the anode circuit of the valve V_1 should be returned, and the neutralising condenser C_9 should be adjusted until no alteration of the grid current of the valve V_1 is observed, when the output tuning condenser passes through its resonance position, or until the alteration observed has the lowest possible value. When this adjustment is completed, the chassis should be reinserted in the housing, and, if desired, in the transit case, by reversing the procedure advocated for removal. The remaining crystals should then be replaced and the oscillator should be switched on. The crystal circuit should then be returned.

30. On completion of the tuning operation, after neutralisation where this has been necessary, a link should be placed in the socket marked MIXER on the front panel. The necessary precautions have been described in an earlier paragraph. The OUTPUT TUNING control of the condenser C_{10} should then be adjusted until the anode circuit of the valve V_2 is resonant at the crystal frequency. This is indicated when the reading of the AERIAL CURRENT meter M_2 reaches a maximum. This maximum value should lie between the limits 100 and 150 mA. The setting of the OUTPUT TUNING control, corresponding to resonance, should be noted.

31. The frequency necessary for the setting of the R/F modulator should next be determined. Having ascertained the required output frequency of the oscillator, the difference between this frequency and the correct operating frequency of the selected crystal, should be found. If the necessary output frequency exceeds the crystal frequency, the upper sideband should afterwards be selected. If the reverse condition obtains, the lower sideband will be selected. For example, if the output frequency necessary is exactly 38·0 Mc/s, and the exact operating frequency of the 33·0 Mc/s crystal, as painted on the crystal unit, is 33·053 Mc/s, the difference will be 38·0–33·053 = 4·947 Mc/s, and the *upper* sideband of the output should be selected. Reference to the calibration chart of the R/F modulator should now be made to determine the setting of the H.F. MODULATOR tuning dial, and of the RANGE switch S_3.

32. Having read from the calibration chart the range and the setting of the R/F modulator controls, the RANGE switch S_3 should be set into the correct position. The setting of the tuning control should be read from the curve to within one-tenth of a degree. The H.F. MODULATOR control should then be adjusted to the setting required with the aid of the vernier control. As a preliminary, the tuning control should be rotated until the marking 0 on the small upper, or vernier scale, corresponds approximately to the required setting of the large lower, or main scale. For instance, if the required setting is 68·3 degrees, the tuning scale should be rotated until the marking 0 on the vernier scale lies between the 68 degrees and 69 degrees markings on the main scale. The final adjustment should be such that the vernier marking corresponding to the decimal registers exactly with the marking on the main scale which exceeds the integral number of degrees by the number of degrees corresponding to the decimal. In the example selected, the final setting of the tuning control should be such that division 3 on the vernier scale exactly corresponds with $68 + 3 = 71$ degrees on the main scale.

33. A link should then be replaced in the sockets LK_4 marked H.F. MOD., on the front panel of the oscillator, with the precautions previously referred to. When the OUTPUT TUNING condenser C_{10} is rotated, it will be found that the AERIAL CURRENT meter M_2 indicates aerial current at only three positions of the tuning control. One of these positions corresponds with resonance at the crystal frequency; another, corresponding to a lower scale reading of the OUTPUT TUNING control, indicates resonance at the lower sideband frequency; the third, corresponding to a higher scale reading of the tuning control, indicates resonance at the upper sideband frequency. The readings of the AERIAL CURRENT meter M_2 in the two latter cases should be approximately 50 mA and 60 mA respectively. In certain conditions, one or the other of the indications of resonance at the sideband frequencies may be absent. The OUTPUT TUNING control should be carefully adjusted to give the maximum output at the required frequency, whether at the upper or at the lower sideband frequency, as previously determined.

34. If a modulated output is required, the link should be replaced in the sockets marked L.F. MOD. on the front panel of the instrument, and the L.F. MOD. switch S_4 should be set into the position engraved with the required modulation frequency, namely 700~ for use with circuits to be aligned for use with outer marker beacons, 1,700~ for use with inner marker beacons, and 1,150~ for use with main beacons, of the blind approach system. After switching on the A/F modulation the grid current of the valve V_1 should increase; the aerial current read on the meter M_2, may or may not alter. It is inadvisable to use the oscillator unit for alignment purposes unless at least 15 minutes have been allowed for warming up, more especially when accuracy of the A/F modulation frequency is necessary.

35. The use of the oscillator for the alignment of the receivers, types R.1124A and R.1125A and of the blind approach system, has been described in Sect. 3, Chap. 7. If there is reason to doubt the accuracy of the test oscillator, it may be checked against the main beacon transmitter in the following manner. Switch off the modulation of, and start up, the transmitter. Place the test oscillator on the floor of the transmitter hut with the dipoles horizontal. Now position the test set, type 6, with respect to the oscillator so that one of the test set dipoles is parallel, and as close as possible, to the oscillator dipoles. Tune the test set to the frequency of the transmitter, if necessary reducing the sensitivity of the test set by means of the switch provided. Switch on the oscillator and leave it to warm up for 15 min. Tune the test set to the frequency of the transmitter in the usual manner. The A/F modulation of the oscillator should not be switched on. Plug in a pair of headphones to the test set and return it to full sensitivity. If the frequency of the oscillator is within approximately 5 kc/s of that of the transmitter, a beat note will be heard in the telephones and the oscillator may be considered satisfactory. If a beat note is not heard, the H.F. modulator dial of the oscillator should be slowly turned clockwise or counter-clockwise until zero beat is obtained. From the calibration chart obtain the H.F. modulator frequency for this dial reading. If the difference between this frequency and the original modulator frequency is greater than 10 kc/s, the oscillator should be returned for re-calibration. The crystal stage of the oscillator should now be detuned by alteration of the tuning and feedback controls, readjusted, and the above operation repeated, using, if possible, a different amount of feedback. The output frequency of the oscillator may now have a different value but it should not differ from that of the main beacon by more than ±10 kc/s.

PRECAUTIONS AND MAINTENANCE

36. When using the oscillator unit, type 12, care should be taken that the instrument is not jarred, more especially when the transit case has been removed. Any violent impact will damage the metal housing, involving difficulty in extracting the chassis, in addition to damaging the valves and other components mounted on the chassis. Reference has previously been made to the need for care in the handling of the crystals and of the H.T. links.

37. The sockets should periodically be cleaned by means of a matchstick, or splinter of wood moistened with carbon tetrachloride or with another non-inflammable cleaning solvent. The plugs should be cleaned with a cloth moistened with the same liquid, and after cleaning may be lubricated by means of a trace of vaseline or other grease applied with the finger tip. The cloth should be clean and free from dampness or loose fluff.

38. The front panel of the instrument should be kept free from dust by wiping periodically with a clean dry cloth free from fluff. Cleanliness of the sockets of the H.F. links, of the aerial output sockets, and of the crystal sockets is especially necessary.

39. No dust should be allowed to accumulate within the chassis, and it is therefore necessary periodically to remove the chassis from the housing, and to blow out any dust with clean dry compressed air. Great care should be exercised to avoid touching the vanes of the variable condensers, more especially those of the R/F modulator. Any deformation of the R/F modulator tuning condenser will render valueless the calibration curves of the instrument, and, should any damage be suspected, the oscillator should not be used until it has been recalibrated. Equal care is necessary to ensure that none of the leads or coils are displaced. The rear of the dipole sockets should be wiped carefully, and also the synthetic resin mounting of the output meter M_2. The switch contacts should also be cleaned with clean cloth or a wooden splinter moistened with carbon tetrachloride.

40. Should it be necessary to renew any of the crystal units, it is essential that the crystal unit used as replacement should be accurately calibrated. The correct operating frequency should be given to within one kilocycle. As previously described, the calibration value should be painted in white on the side of the crystal unit.

41. If the output of the oscillator, as measured by the output current meter, is low, the output voltage of the rectifier should be measured between one of the left-hand sockets of the pairs of link sockets on the front panel, and the chassis. The voltage should be 275, plus or minus 10 per cent. If this voltage is low, the input voltage should be measured by means of an A.C. voltmeter, and the primary connections of the transformer should be checked to ensure that they correspond with the mains voltage.

42. If the motor generator is used, and the output voltage is low, the connections to the battery and to the motor generator should be examined, including the fuse links and contacts, and the commutator and slip rings should be cleaned with fine glass paper. The brushes should also be renewed if they show signs of wear, and care should be taken that they slide freely in their holders, otherwise they should be slightly reduced in size by careful rubbing with glass paper until all danger of sticking is obviated. The battery voltage on load should also be checked, and if this is below 12 volts, the battery should immediately be disconnected for recharge, and a fully charged battery substituted. If no output is obtained from the motor generator, the A.C. fuse link should be examined, by sliding it upwards and withdrawing. If necessary, the fusible unit should be renewed, using 36 s.w.g. lead wire. If the motor generator will not start, if the L.T. connections are satisfactory and the switch is in the ON position, the L.T. fuse should be examined, and, if necessary, renewed, using 26 s.w.g. copper wire.

43. A low output voltage may also be caused by ageing of the rectifier valves V_5, and the effect of renewing this valve should be tried. If the output voltage is correct, the fault may lie in one of the other valves. If the output current with the R/F modulator unconnected, and the anode circuit of the valve V_2 tuned to the crystal frequency alone, is considerably less

than 100 mA, the crystal oscillator valve V_1 should be renewed. If this measure is ineffective, the mixer valve V_2 should be renewed. This will probably necessitate altering the setting of the neutralising condenser C_9. When the sideband output is below its normal value, the fault will probably lie in the R/F modulator valve V_3 which should be renewed. If the measured output is satisfactory, but the modulated signal output appears weak, the renewal of the A/F oscillator valve V_4 may be necessary. Before renewing any valve, it is advisable to ensure that the valve fits tightly in its socket, and also to clean the pins and sockets. If necessary the pins may also be adjusted to ensure a good contact in the socket. Apparent deterioration of all the valves simultaneously may be due to a low L.T. voltage. If the heater voltage measured across the pilot lamp P_1 is considerably less than 6·3 volts, or the voltage measured across the heater sockets of the rectifier valve V_5 is less than 4 volts, the transformer T_1 may be at fault, and the insulation resistance between each of the windings and the core plates should be tested, or the component should be renewed.

44. Failure of the pilot lamp P_1 will be indicated by the absence of indication when the oscillator is switched on, if a satisfactory R/F output is indicated on the meter M_2. The pilot lamp may have become loose in its socket, in which case it will need to be screwed in, or the component may need renewal. If no output is obtainable, although the L.T. and H.T. supplies are found to be in order, the fault may lie in the crystal oscillator or mixer stages. The anode currents of the valves V_1 and V_2 should be measured by means of a milliameter plugged into the sockets marked CRYSTAL or MIXER in the front panel of the instrument. The fault may lie in the thermo-ammeter M_2 which may be carefully tested on D.C. by means of a low voltage battery and a resistance of such value as to reduce the current to about 100 mA. The meter should be renewed if it fails to give an indication when thus tested. Complete failure of the R/F modulator or A/F modulator circuits will be indicated respectively by absence of sideband readings in the meter M_2, or by absence of audible modulated signal on a receiver under test. A check may be made by measurement of the anode circuit of the valves V_3 and V_4 by a method corresponding to that indicated for the valves V_1 and V_2, and the valves should be renewed if cleaning and adjustment of the valve pins and sockets are ineffective. If the valves in any circuit suspected of being faulty, are found to be in order, a careful check of the wiring should be made with a view to locating a broken lead or a faulty soldered joint, and, if necessary, the components should be tested systematically.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Ref. in fig. 3	Remarks
10V/45 ..	Oscillator unit, type 12	1		
	Principal components :—			
	Condenser :—			
10C/9805 ..	Type 338	1	C_{30}	4·0 μF.
10C/10392 ..	Type 402	2	C_{17}, C_{12}	200 μμF.
10C/10393 ..	Type 403	6	C_2, C_{11}, C_{12}, C_{18}, C_{34} (2 off).	0·01 μF.
10C/10741 ..	Type 455	1	C_5	7·25 to 45·5 μμF.
10C/10742 ..	Type 456	1	C_{16}	200μμF.
10C/10743 ..	Type 457	1	C_{19}	25 to 300μμF.
10C/10748 ..	Type 458	1	C_6	50μμF.
10C/10749 ..	Type 459	2	C_{13}, C_{14}	100μμF.
10C/10875 ..	Type 491	4	C_3 C_4, C_7, C_8	0·005 μF.
10C/10877 ..	Type 493	1	C_{26}	0·04 μF.
10C/10879 ..	Type 495	1	C_{15}	0·07 μF.
10C/10883 ..	Type 496	1	C_{22}	0·1 μF.

Ref. No.	Nomenclature.	Qty.	Ref. in fig. 3.	Remarks.
	Oscillator unit, type 12—(*contd.*)			
	Principal components—(*contd.*)			
	Condenser—(*contd.*)			
10C/10885 ..	Type 498	1	C_{27}	2·0 μF.
10C/10887 ..	Type 500	1	C_{29}	6·0 μF.
10C/241 ..	Type 632	1	C_{23}	0·0275 μF.
10C/242 ..	Type 633	1	C_{24}	0·06 μF.
10C/243 ..	Type 634	1	C_{25}	0·165 μF.
10C/10740 ..	Type	1	C_{10}	40 μμF. max.
10C/10738 ..	Type	1	C_9	Neutralising condenser.
10C/102 ..	Type	1	C_{33}	0·006 μF.
10C/10507 ..	Type	1	C_{31}	10 μμF. max.
10C/2230 ..	Type	1	C_{20}	50 μμF.
10C/10391 ..	Type	1	C_{32}	0·002 μF.
	Inductance :—			
10C/510 ..	Type 29	1	L_3	Tuning coil.
10C/511 ..	Type 30	1	CH_4	A/F choke
10C/10888 ..	Type 40	1	L_1, L_2	Crystal oscillator coil.
10C/10890 ..	Type 41	1	L_4	R/F modulator.
10C/10891 ..	Type 42	4	CH_1, CH_2, CH_3, CH_5	R/F choke.
10C/10805 ..	Type 43	2	CH_7, CH_8	Smoothing chokes.
10C/11791 ..	Type 139	1	CH_6	A/F oscillator coil.
	Milliammeter :—			
10A/10905 ..	0·3, Type A	1	M_1	Grid current.
10A/12128 ..	0–150, Type D ..	1	M_2	With built-in thermocouple.
	Resistance :—			
10C/7316 ..	Type 30	1	R_1	100,000 Ω.
10C/8021 ..	Type 113	2	R_8, R_9	20,000 Ω.
10C/10847 ..	Type 430	1	R_{10}	20 Ω.
10C/10896 ..	Type 441	1	R_4	1,000 Ω.
10C/10998 ..	Type 443	1	R_5	5,000 Ω.
10C/10900 ..	Type 445	1	R_3	25,000 Ω.
10C/10895 ..	Type	1	R_{11}	500 Ω.
10C/11805 ..	Type	1	R_7	7,500 Ω.
10C/10897 ..	Type	1	R_2	2,000 Ω.
10C/167 ..	Type	1	R_{12}	10,000 Ω.
10C/10894 ..	Type	1	R_6	20 Ω.
	Switch :—			
10F/135 ..	Type 225 ..	2	S_2, S_5	Arrow type.
10F/10903 ..	Type 250	1	S_3	Range switch.
10F/10904 ..	Type 251	1	S_4	3-way.
10K/10893 ..	Transformer, type 148 ..	1	T_1	Mains transformer.
	Accessories :—			
10K/4 ..	Brush	2	—	For motor generator.
	Crystal unit :—			
10X/33000 ..	Type B	1	X	Exact frequency marked.
10X/35600 ..	Type B	1	X	Exact frequency marked.
10X/38050 ..	Type B	1	X	Exact frequency marked.
5A/2130 ..	Lamp, 8 v. 0·3 A ..	1	P_1	Pilot lamp.
10K/11984 ..	Motor generator, type 39	1	—	
	Valve :—			
10E/10733 ..	Type 6C5G	4	V_1, V_2, V_3, V_4	Brimar triodes.
10E/10734 ..	Type R.3	1	V_5	Brimar rectifier.

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SECTION 5, CHAPTER 16

TEST SET, TYPE 6

Contents

List of Illustrations

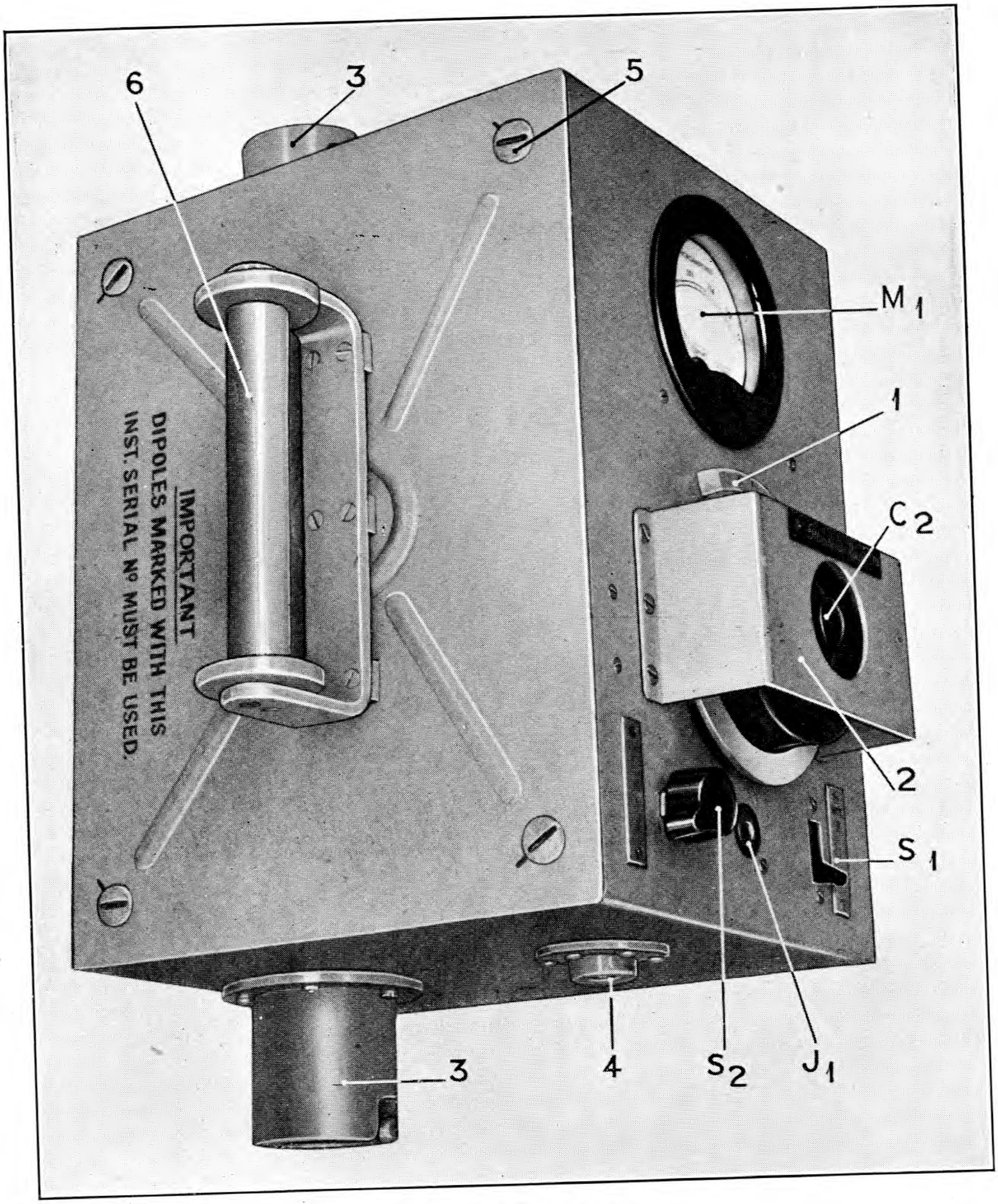


FIG. 1.—General view.

TEST SET, TYPE 6
(Stores Ref. 10S/11859)

INTRODUCTION

1. The test set, type 6, is a portable calibrated single-valve receiver having a frequency range from 30·5 to 40·5 Mc/s, designed for use with the blind approach transmitter equipment, primarily for examination of the radiation field pattern or for roughly checking the frequency of the transmitters. It acts as an absorption wavemeter or as a field strength comparison meter. The use of the instrument for these purposes is described elsewhere in this publication in the chapters dealing with the blind approach transmitter equipment, and in that dealing with the oscillator unit, type 12.

2. The instrument is suitable for the reception of I.C.W., M.C.W. or R/T signals, either by means of telephones or using the meter incorporated in the test set. The receiver, together with the two dry cells which alternatively supply the L.T. for the valve, is housed in a metal case fitted with a carrying handle. Its overall size is 14 in. by 10 in. by 8 in., and its weight approximately 7 lb. The ancillary equipment consists of the two-section dipole aerial 39 in. by 1½ in. diameter, a tripod for mounting the instrument for use with vertically-polarized waves, a calibration chart, and a pair of telephones if required. The combined weight of these items is approximately 9 lb.

3. A general view of the test set is given in fig. 1. Apart from the detachable dipole aerial, which is not shown in the illustration, the instrument consists of a calibrated tuned circuit connected through a full-wave R.F. rectifier valve acting as detector, to a microammeter with three ranges selected by a switch, or to a pair of telephones inserted in a jack.

GENERAL DESCRIPTION

4. Referring to the theoretical circuit diagram, fig. 2, the receiver is seen to consist of a double-diode detector valve, V_1, whose anodes are connected to tappings on the aerial inductance L_1 symmetrically placed with reference to the centre tapping which is earthed by the condenser C_1. Two further symmetrical tappings are connected to the dipole aerial, and the circuit is tuned by means of the variable condenser C_2, which is connected across the extremities of the inductance L_1.

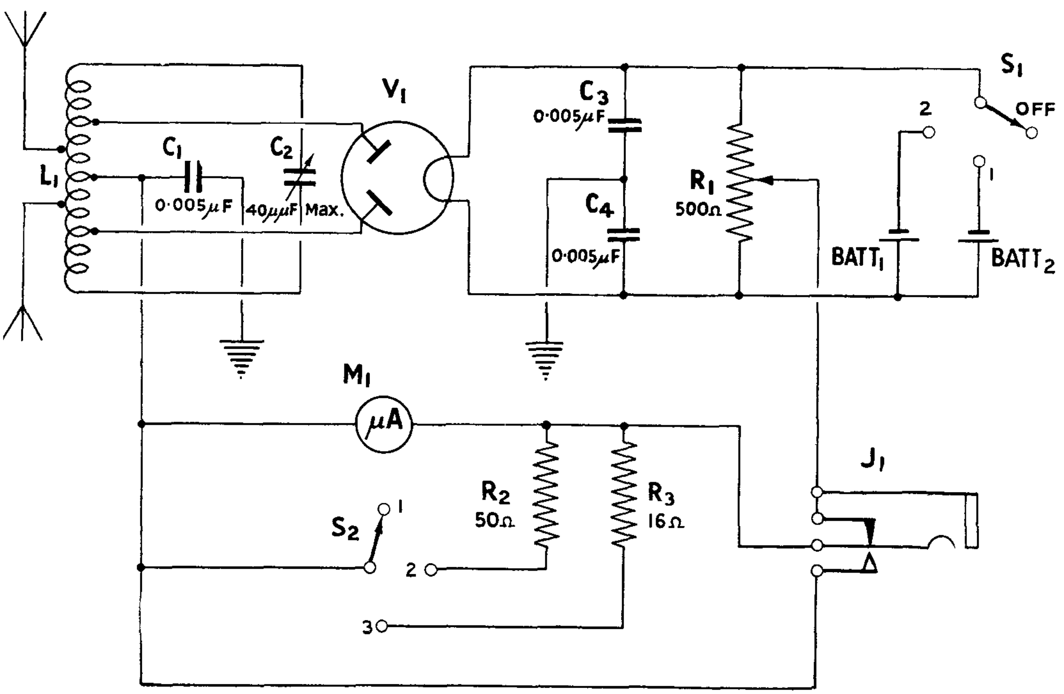


FIG. 2.—Theoretical circuit diagram.

5. The filament of the valve V_1 is heated by one or other of the batteries $BATT_1$ or $BATT_2$, as selected by the switch S_1, and is centre pointed to earth by means of the condensers C_3 and C_4 and the potentiometer resistance R_1. The centre points of the aerial inductance L_1, and of the potentiometer resistance R_1, are normally connected through the contacts of the jack J_1, to the microammeter M_1 which measures the anode current of the detector valve V_1.

6. Three ranges are provided on the meter M_1 by means of the selector switch S_2, which allows the anode current of the valve to flow through the meter alone, or provides an alternative path across the meter through one of the meter shunt resistances R_2 or R_3. If a plug ended telephone set is inserted in the jack J_1, the telephone is connected directly across the centre points of the aerial and of the valve filament circuit, the tip contact of the jack being so connected as to short circuit the meter when a plug is inserted.

CONSTRUCTIONAL DETAILS

7. Views of the exterior and interior of the instrument are given in figs. 1, 3 and 4 respectively. Referring to fig. 1, the controls on the front panel are seen to consist of the switches S_1 and S_2, which are engraved BATT, 1, 2, and OFF, and RANGE 1, 2 and 3 respectively, together with the slow motion control of the tuning condenser C_2 which is provided with a scale engraved in degrees used in conjunction with the vernier scale (1). The bracket (2) protects the control knob and scale of the condenser from mechanical damage.

8. The bayonet sockets (3) serve to attach the dipole aerials. The aerials themselves consist of copper tubes which make their electrical connection to small plugs contained within the sockets. The insulating tubes, in which the aerials are mounted, are secured in position by pins engaging in the sets of the bayonet sockets. The screwed bush (4) engages with a screw on the tripod. The dimensions of the dipoles are 39 in. long by 1½ in. diameter.

9. The ribbed sheet metal sides of the test set are each fixed in position by four dzus screws (5), and are each provided on the interior with clamps for securing the batteries. The left-hand side of the instrument, which is seen in the illustration, is provided with a carrying handle (6).

10. The arrangement of components in the interior of the instrument is shown in figs. 3 and 4, the sides having been removed for illustrative purposes. The case is of sheet metal, the components of the A.F. section being mounted behind the front panel and separated from the R.F. components in the rear compartment, by a partition. Referring to fig. 4, the terminal block (1) serves to interconnect the stiff wiring of the R.F. components to the flexible silk covered leads used for wiring the A.F. section, and at (2) is seen the rear connection of the plug engaging with the dipole aerial. This is mounted on a synthetic resin panel forming the end of the bayonet fitting.

VALVES AND POWER SUPPLY

11. Only one valve, Mazda type D.D.207, is used in the test set, type 6. The batteries used for L.T. are 1·5-volt dry cells, only one being in use at a time. No H.T. supply is necessary.

OPERATION

12. When the instrument is to be used for receiving vertically polarized waves, it may be screwed on the boss of the tripod platform. The tripod should then be erected in a suitable position, and the dipoles fixed in their sockets. Care should be taken that the serial number of the dipoles, which is marked on them, corresponds with that of the instrument. A further important point is to ensure that they are mounted in their correct positions ; they are clearly marked TOP and BOTTOM. This precaution is necessary because the lower dipole has an appreciably greater capacitance to earth than that of the upper dipole, and its dimensions are adjusted accordingly.

13. To insert the batteries and the valve, it is necessary to remove the sides of the instrument. For this purpose, the four dzus fasteners are loosened by counter-clockwise rotation through a right angle and the sides are then withdrawn. The batteries are inserted in the circular clamps, which are then tightened by means of the screws joining their extremities. The battery leads, which are terminated by annular cord tips, are then fixed on the battery terminals. On the completion of this operation, and after the insertion of the valve the sides may be replaced. To refix the fasteners, they should be turned slowly until they fall into place, then turned through about 90 degrees, when they close up with a snap.

14. The instrument is prepared for operation by setting the switch S_1 either to position 1 or to position 2. The signal to be received should then be tuned in by means of the condenser C_2, either aurally, with a telephone headset plugged unto the jack J_1, or visually. For visual tuning indication, no plug must be inserted in the jack, and the switch S_2 should in the first place be set in the position RANGE 3. The other ranges may be used in the order 2 and 1 should the visual indication obtained on the previous range be insufficient for accurate observation.

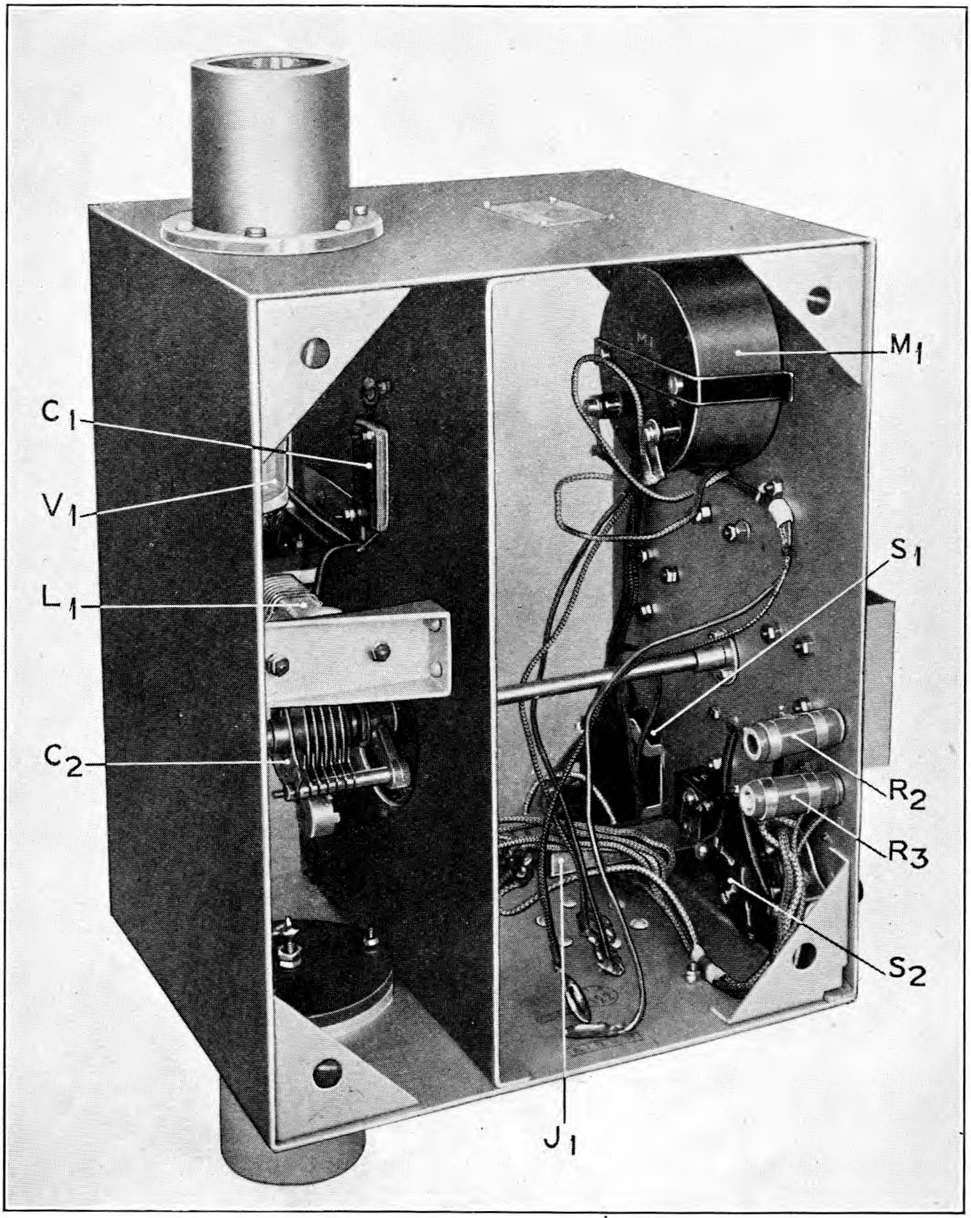


FIG. 3.—Interior view from the left.

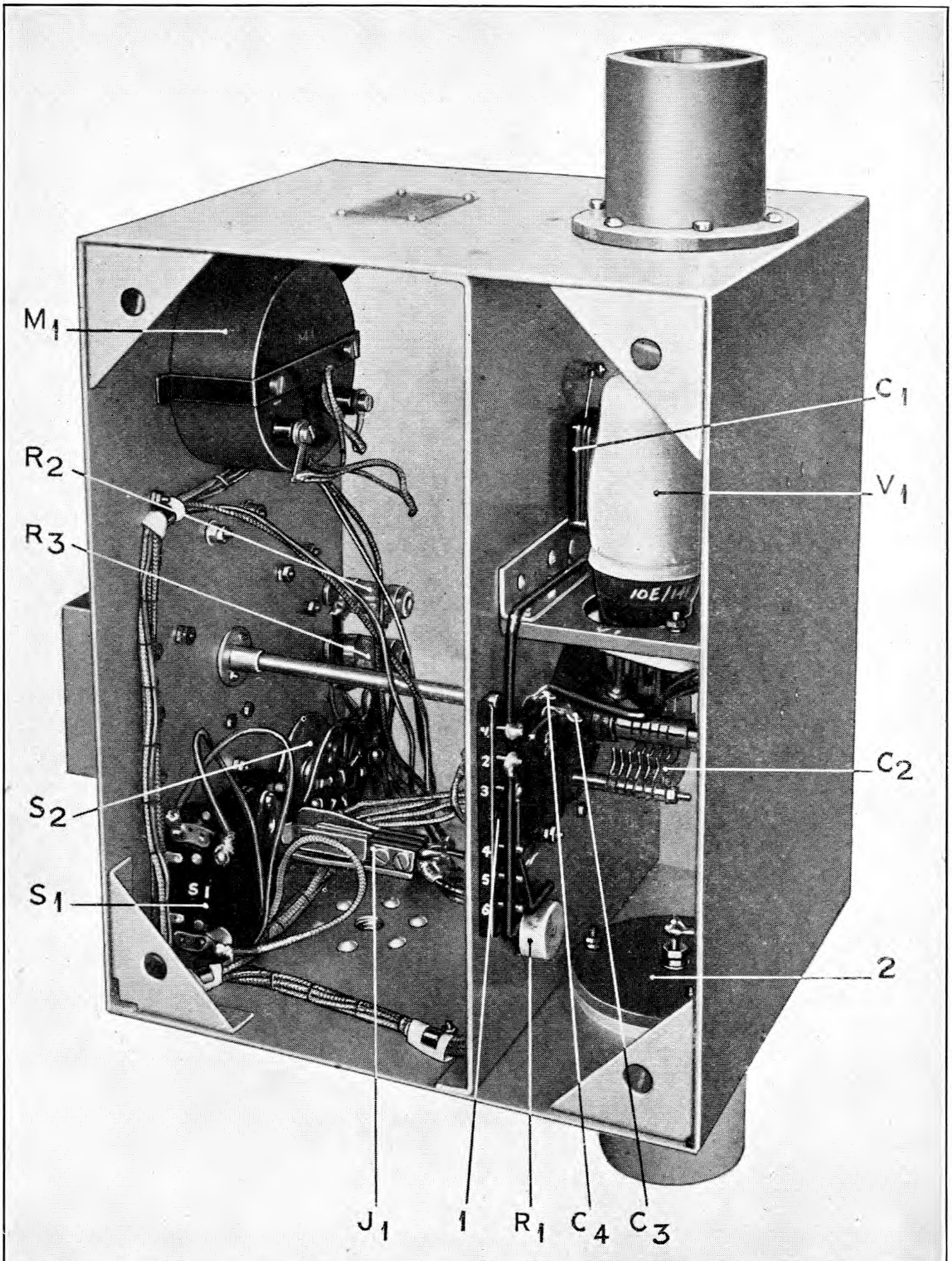


FIG. 4.—Interior view from the right.

15. When reading the scale of the tuning condenser, a preliminary observation of the position of the marking 0 on the upper or vernier scale, should be made. This will in general lie somewhere between two degree markings on the main scale. The lower of these gives the whole number of degrees in the reading. A further observation will show that one of the other markings of the vernier scale registers exactly with a marking on the degree scale below. The number of this marking on the vernier scale gives the decimal number of degrees. For example, if vernier marking 0 falls between 62 and 63 degrees, and vernier marking 7 coincides exactly with a degree marking on the main scale, the exact condenser scale reading is 62·7 degrees. The calibration chart supplied with the instrument, and marked with the same serial number, gives the frequency corresponding to this setting.

16. The test set is not capable of a very high degree of accuracy, and for making accurate frequency measurements, it should be used in conjunction with a precision heterodyne oscillator, such as the oscillator unit, type 12, described in another chapter of this publication. In the event of a discrepancy between results obtained from the calibration of this test set and the oscillator unit mentioned, greater reliance should be placed on the calibrations of the latter instrument.

17. When it is necessary to make a number of successive measurements in different locations, as when plotting field strength curves, the instrument may be carried in the hand instead of being erected on its tripod. In this case it is essential that the plane of the dipole aerials be maintained the same for all observations which are to be used comparatively, and also that the angle between the dipoles and the line joining their centre to the transmitting aerial remain the same. This condition is best satisfied when the transmitter and test set aerials are parallel. The highest reading of the field strength meter is also obtained when the dipole is parallel to the transmitting aerial, but it should be noted that this condition is not always desirable when using the instrument for frequency checking in conjunction with a standard oscillator. This matter is dealt with in greater detail in a chapter of this publication which deals with the oscillator unit, type 12.

18. The handle of the instrument is so placed as to be equally suited for use with the dipole horizontal or vertical. The operator should, however, be careful not to screen the dipole with his body during any field strength comparison measurements. In making measurements of this type, an effort should be made to keep the aerials in the same position relative to the ground, to the transmitter, and to the operator's body, throughout the period of the tests.

19. During prolonged testing, it is advisable to use the same battery. If there is any great discrepancy between the readings of the meter M_1 on changing over batteries, it is advisable to renew the battery giving the lower reading.

PRECAUTIONS AND MAINTENANCE

20. The test set, type 6, should be kept in good, clean condition throughout, any dust in the interior being blown out by clean, dry compressed air. The switches should be cleaned periodically with carbon tetrachloride, applied with a clean cloth free from fluff, or with a splinter of wood. This applies also to the pins and sockets of the valve and the dipoles, and to the jack contacts.

21. Care should be taken that the variable condenser and the coil are not subjected to mechanical damage, either during cleaning, or by rough usage. Such damage will invalidate the calibration, as will any deformation of the calibrated condenser dial.

22. Precautions in the use of the instrument have been dealt with in an earlier paragraph, but it is necessary to add that the dipoles should be handled with care, especially when fitted in the instrument, and should not be jarred in any way. The screws retaining the sides of the receiver should be firmly screwed in, especially when the instrument is to be carried, as otherwise the test set might become detached from the side to which the handle is fixed and suffer damage from falling.

23. The battery voltages, on load, should be tested before putting the instrument into service. They should be renewed if the voltage falls below 1·5. The batteries should be kept in a cool, dry place, and, if the test set is to be out of use for a long period they should be removed and put to some other use. The employment of aged batteries, especially where field strength comparison measurement is concerned, is inadvisable.

24. The only faults to which the instrument is liable are battery failure and valve failure. The former should be guarded against by the precautions described in the preceding paragraph. If the readings of the output meter appear low, and the batteries are found to be in order, the valve should be renewed. Jack contact failure is repaired by cleaning and/or adjustment.

25. It is advisable periodically to check the instrument calibration by means of a few "spot" tests performed by receiving the signals of a crystal controlled oscillator or monitor. If any marked discrepancy is observed between the observed results and the calibration chart, the instrument should be returned to a maintenance depôt for examination.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Quantity	Ref. in fig. 2	Remarks
10S/11859 ..	Test set, type 6	1		
	Principal components :—			
	Condenser			
10C/10164 ..	Type 385	3	C_1, C_3, C_4	0·005 μF.
10C/351 ..	Type 669	1	C_2 ..	40 μμF MAX.
10S/12042 ..	Dipole, aerial	2		
10D/12041 ..	Inductance, type 23	1		
10H/1749 ..	Jack, telephone, type A	1	J_1 ..	
10A/12040 ..	Microammeter, 0 to 250	1	M_1 ..	
	Resistance			
10C/348 ..	Type 755	1	R_1 ..	500 Ω potentiometer.
10C/349 ..	Type 756	1	R_2 ..	50 Ω.
10C/350 ..	Type 757	1	R_3 ..	16 Ω.
	Switch			
10F/95 ..	Type 210	1	S_1 ..	2 position and off.
10F/10904 ..	Type 211	1	S_2 ..	3 position rotary.
	Accessories :—			
5A/1630 ..	Cell, dry, 1·5 v	2	B_1, B_2 ..	Bluebell type.
10E/141 ..	Valve, D.D.207	1	V_1 ..	Mazda.

SECTION 5, CHAPTER 17

OUTPUT METER, TYPE 4

Contents

List of illustrations

OUTPUT METER, TYPE 4
(Stores Ref. 10S/70)

INTRODUCTION

1. The moving coil output meter, type 4, which is of conventional design, has been provided for the purpose of aiding the alignment of the beam-approach receivers, types R.1124A and R.1125A. Although it has been designed primarily for use with the above-mentioned receivers it may be used to advantage with any other apparatus developing an A.C. output voltage, which does not exceed the full scale deflection of the output indicator.

2. It will be observed by reference to fig. 1 that the output meter is housed in a suitable wooden case having a detachable lid and a removable carrying strap, thus making the instrument readily portable. The length of the cable, which is 30 ft., allows the instrument to be removed a considerable distance from the apparatus when operating conditions make this necessary.

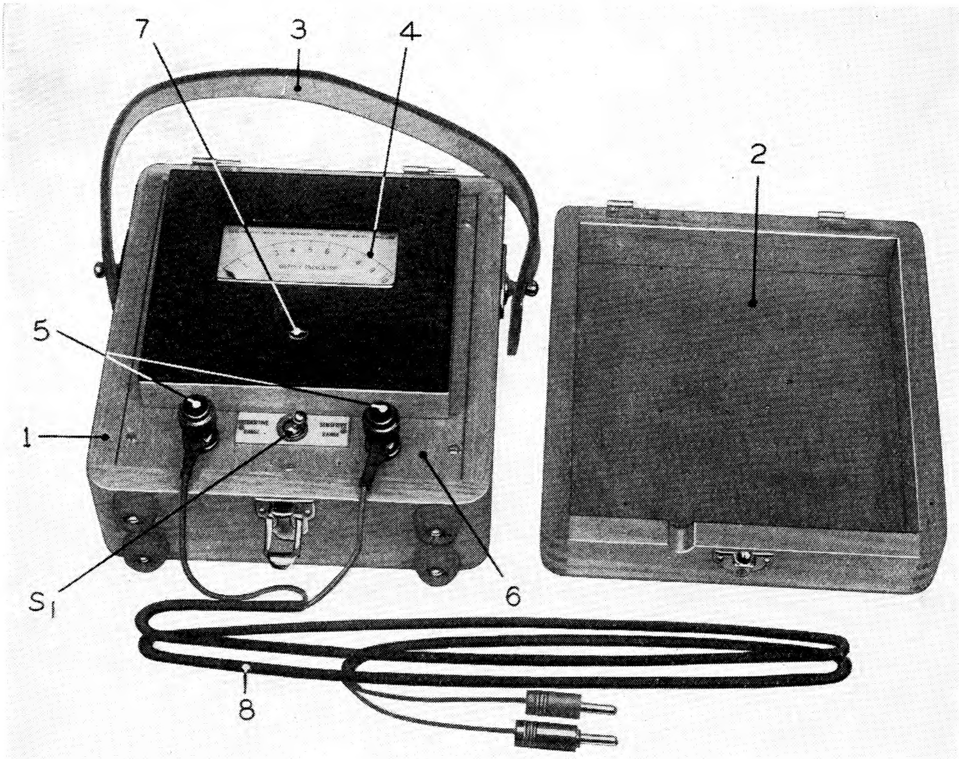


Fig. 1—General view of output meter, type 4

GENERAL DESCRIPTION

3. A theoretical circuit diagram of the output meter is shown in fig. 2 and it will be seen that it comprises a 900 μA micro-ammeter which is operated by the D.C. developed by the Westinghouse full-wave rectifier W_1. The metal rectifier consists of four rectifier elements. During that half-cycle of the output transformer secondary voltage, which makes the terminal B positive, current flows from B through the element 3 and the voltmeter, back to the receiver *via* the resistance R_1, the element 2, the resistance R_3 and the terminal A. During the next half-cycle, current flows from the point A through the resistance R_3, the rectifier element 1 and the meter to the point B, *via* the resistance R_1 and the element 4. During this period the elements 3 and 2 are idle.

4. The movement of the output meter is of the orthodox moving-coil type, having a scale calibrated in ten equal divisions. This instrument is not intended to indicate an accurate measure of the output and indications should not be taken as such.

5. The resistance R_3 reduces the A.C. input to the rectifier to within the limits required for the safe working of the microammeter. It will be observed that a fixed shunt resistance R_2 is provided and this is connected across the moving coil instrument by means of the switch S_1. When the shunt

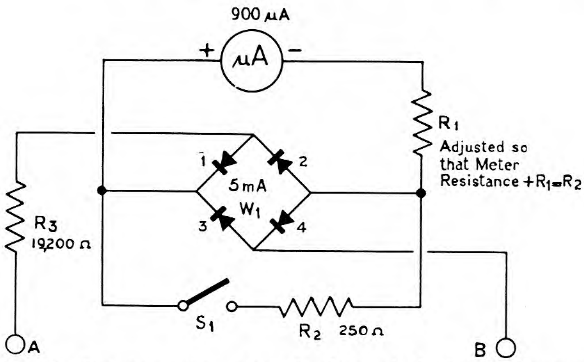


Fig. 2—Output meter, type 4, theoretical circuit diagram

resistance is in use the current indications are half and the power indications a quarter of those indicated when the shunt is not in use. The power input to the meter on the insensitive range must not exceed 80 milliwatts, and when on the sensitive range, the power should not exceed 20 milliwatts.

6. The multiplier resistance R_1 is connected in series with the microammeter and is adjusted during manufacture so that the meter resistance and R_1 together have a value of 250 ohms. It is included to enable the instrument to cover the required OUTPUT range. The output meter has an impedance of approximately 20,000 ohms.

CONSTRUCTIONAL DETAILS

7. A general view of the output meter is shown in fig. 1 and an underside view of the removable instrument panel, to which the output indicator and all the associated components are mounted, is given in fig. 3. Referring to fig. 1 it will be observed that the output meter comprises a wooden

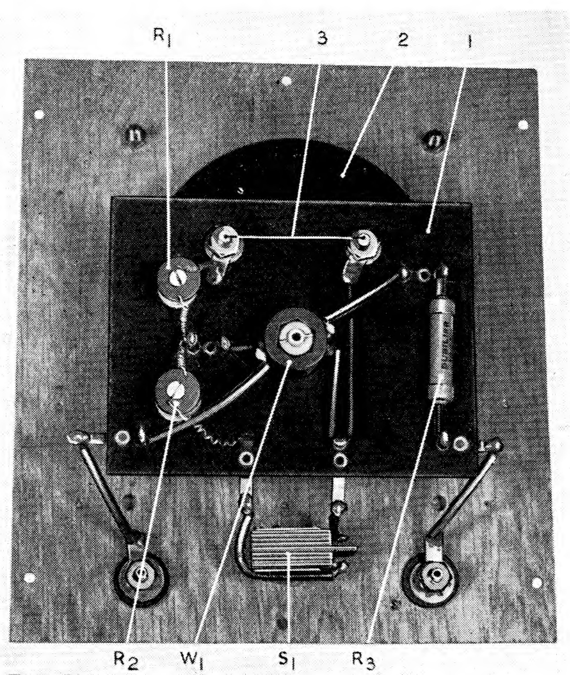


Fig. 3—Underside view of instrument panel

carrying case (1), which is provided with a detachable lid (2) and carrying strap (3). The output indicator (4), together with the sensitivity switch S_1 and connecting terminals (5), are mounted on the detachable wooden panel (6), which is secured with five screws. The scale of the output meter is calibrated in ten equal divisions and engraved 0–10. The pointer is adjusted for zero by means of the slotted screw head (7).

8. A lead (8), 30 ft. long, is supplied for connecting the instrument to the receiver output stage; this lead is provided with spade connections at one end for connecting to the output meter, and plugs at the other for connection to the beam approach control unit or receiver to be tested.

9. The underside view of the panel, which is illustrated in fig. 3, shows the paxolin mounting platform (1). This is fixed to the back of the output indicator (2) and is secured by means of the indicator input terminals (3). On the left-hand side of the platform will be seen the two wire-wound fixed resistances R_1 and R_2 and the Westinghouse metal rectifier W_1 is attached to the centre of the platform The fixed resistance R_3, shown on the right-hand side, is soldered to conveniently situated tags. The sensitivity switch S_1 and the terminals for connecting the output indicator to the receiver are shown mounted on the wooden panel.

OPERATION

10. When utilizing this output meter to aid the alignment of the beam approach receivers R.1124A and R.1125A, the spade tags of the lead (8 in fig. 1) must be connected to the input terminals of the meter and the plugs on the opposite ends of the leads must be connected to the telephone sockets on the beam approach receiver control unit.

11. During alignment, the receiver output must not exceed the full scale deflection of the output indicator when the range switch is in the sensitive position and the receiver volume control turned fully clockwise. As a precautionary measure, the meter sensitivity switch should be placed in the insensitive position and final alignment, as described in A.P.1186, Vol. I, Sect. 3, Chap. 7, carried out on the sensitive range.

12. *Purposes other than beam-approach receiver alignment.*—If the instrument is to be used in conjunction with any other apparatus, it should normally be connected across the secondary of the output transformer. *Care must be taken to ensure that the instrument is not overloaded.*

13. In use, circuit resonance is normally indicated by the maximum deflection of the pointer in the right-hand direction and if a greater pointer deflection is required for a given input, the sensitivity switch S_1 should be placed in the SENSITIVE RANGE position. Care should be taken (e.g. by reducing the receiver output to a minimum) before moving the switch, that the power input does not overload the instrument. Neglect of this precaution will result in the meter being seriously damaged.

PRECAUTIONS AND MAINTENANCE

14. The pointer of the output meter may require adjustment periodically for accurate zero alignment This is effected by the raised slotted screw (7 in fig. 1); the blade of a small screwdriver is inserted in the slot and *a gentle* turn to the left or right, will correct for zero error.

15. Care should always be exercised when using this output indicator, that the range switch S_1 is in the appropriate position for the power input being applied to the instrument, and if this precaution is neglected, the meter may sustain serious damage. Repairs to the instrument must not be undertaken by unauthorized persons.

SECTION 5, CHAPTER 18

TEST SET, TYPE 65

Contents

List of Illustrations

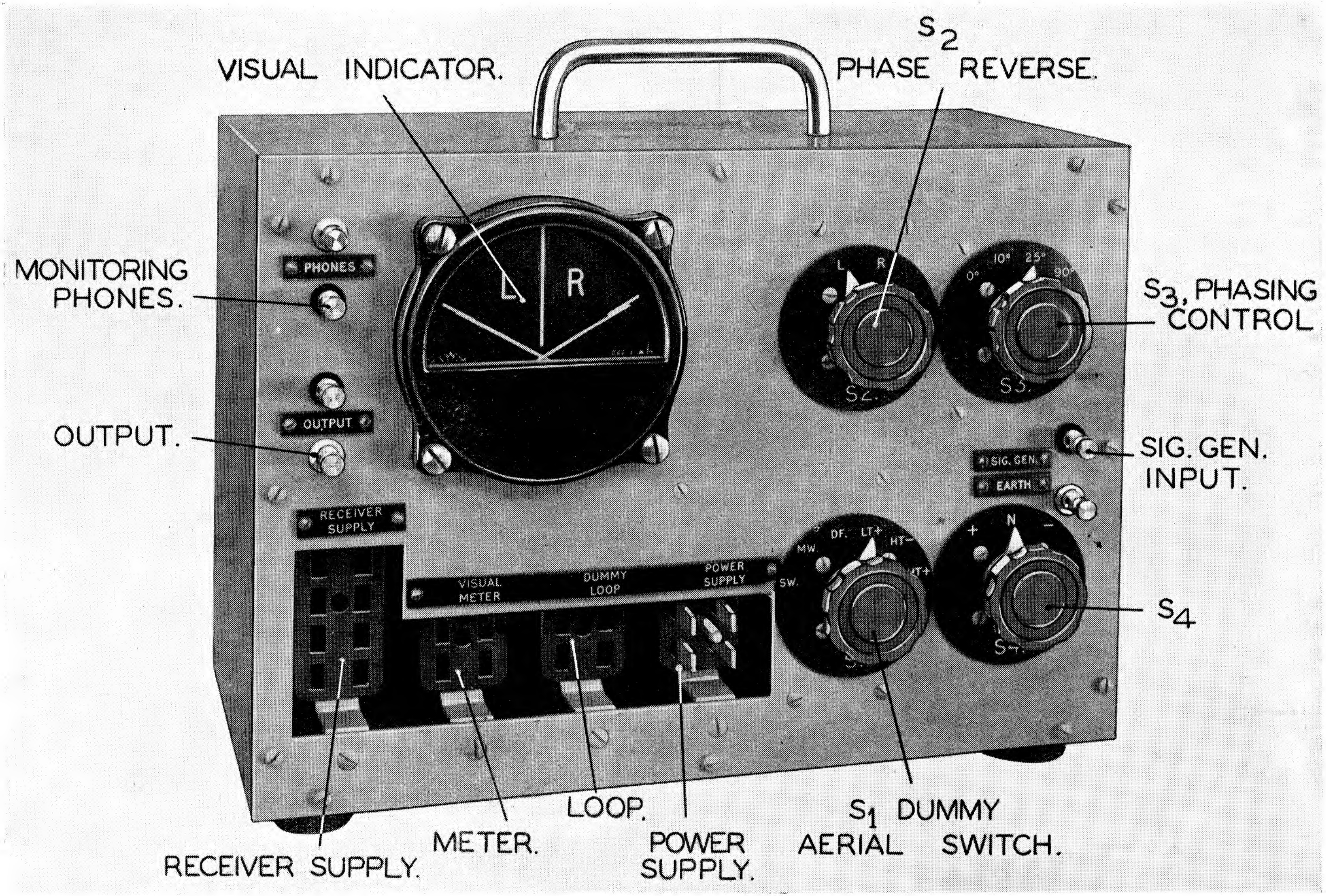


Fig. 1.—View of test set, type 65

TEST SET, TYPE 65

(Stores Ref. 10S/137)

INTRODUCTION

1. The test set, type 65, described in this chapter is intended for testing the communication and direction-finding receiver R.1155. It provides simulation of all the working conditions necessary for checking both communication reception and D/F. reception, any condition being easily selected by means of switches on the front panel of the set.

2. A view of the test set is given in fig. 1 and it will be seen that a meter and all controls and terminals are on the front panel and that they comprise:—

(i) Visual indicating meter (type 1).

(ii) Four switches for selecting the test conditions.

(iii) Four plug connections for connecting the receiver and power supplies to the set.

(iv) Terminals for connecting a signal generator, output meter and telephones.

GENERAL DESCRIPTION

3. The theoretical circuit of the test set is given in fig. 2. A1 and A2 are dummy aerials consisting of pure capacitances of 140 and 425 micro-microfarads respectively. The total amount of screened lead between these condensers and the receiver plug must present a further capacitance of 100 micro-microfarads to earth. This is provided in the special leads supplied with the instrument.

4. The dummy loop (D.L.) consists of a primary of 5 turns of 36 gauge D.S.C. wire, wound over a secondary of 90 turns of the same gauge on a $\frac{7}{16}$ in. diameter former with a dust iron core. A $100\mu\mu$F fixed condenser and a $100\mu\mu$F variable condenser are wired in parallel with the secondary. The input coupling coil (I.C.) consists of a 7-turn primary (24 gauge s.w.g.) over which is wound a secondary of 15 turns (36 gauge s.w.g.) also on a dust iron core former. An input correction coil (C.C.) with a $50\mu\mu$F condenser in parallel is wired in series with the secondary of the input coupling coil and the primary of the dummy loop. This coil consists of 20 turns of 28 gauge D.S.C. wire with a dust iron core.

5. Switch S_1 has six positions: S.W., M.W., D.F., L.T.+, H.T.−, and H.T.+. In the first three positions, the switch connects the signal generator to the correct dummy aerial for H.F., M.F. and D/F. working respectively. The three remaining positions concern special tests in connection with the manufacture of the receiver and should be disregarded during use of the instrument for ordinary test purposes.

6 In addition to performing the foregoing functions, switch S_1 is arranged so that in the D.F. position, the H.T.+ supply lead is connected to pin No. 5 of the receiver power plug (i.e. the interlocked H.T. connection). In the S.W. and M.W. positions of the switch, the H.T.+ is connected to pin No. 7 of the receiver plug. In the remaining three positions of the switch, the H.T.+ is connected both to pin No. 7 and to pin No. 5.

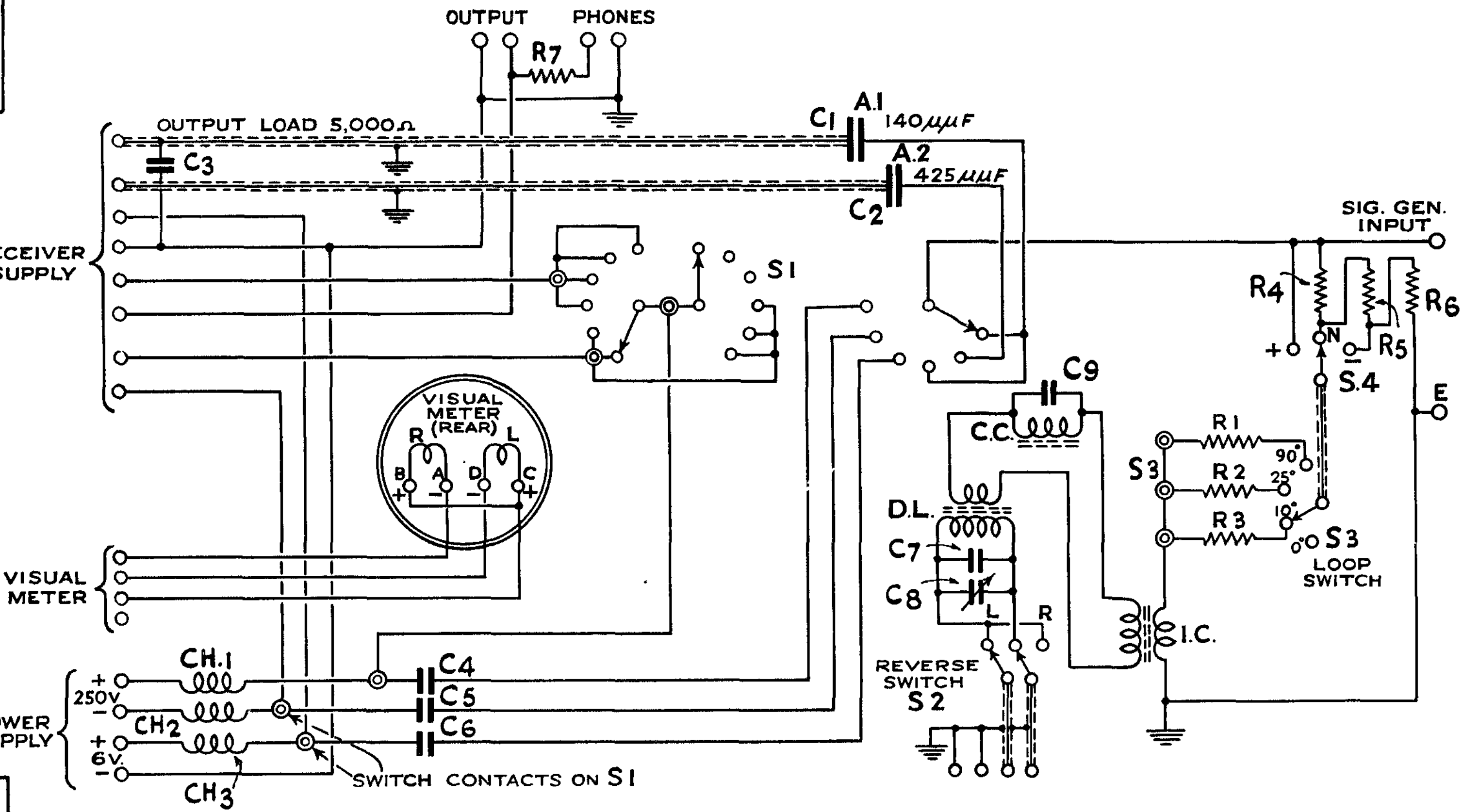
7. Switch S_2 simply reverses the connections from the dummy loop aerial D.L. to the receiver, thus providing a 180-deg. phase change of the dummy loop voltage.

8. Switch S_3 selects three different phasing resistances R_1, R_2, R_3 and it has an open-circuit or infinite resistance position. These resistances, in conjunction with the input coupling coils (I.C.) provide a network for the injection of the signal generator voltage such that the actual reception condition of the D/F. loop relative to the vertical aerial can be accurately simulated. The open-circuit position of the switch corresponds to the "on-course" or zero signal position of the loop and the remaining three positions of the switch correspond to angles of deviation of approximately 10 deg., 25 deg. and 90 deg. from the "on-course" position.

9. Switch S_4 has three positions, marked "N", "+" and "−". It provides a slight variation of the ratio of vertical-to-loop aerial voltage, which variations are set to enable the user to determine that the performance of the receiver under test on visual D/F. is within specification limits.

10. The telephone terminals are provided for monitoring purposes and are fed through a 50,000-ohm resistance so that any load placed across them will have a negligible effect on the reading of the output meter which is connected to the output meter terminals. The output meter load resistance should be 5,000 ohms. The output impedance of the signal generator used should be low and of the order of 10 ohms.

FIG. 2



TEST SET TYPE 65, CIRCUIT

FIG. 2

11. The power supply required for the receiver is 70 milliamps at 250 volts for the H.T. and 6 volts (4 to 5 amps. D.C. or 50-cycle A.C.) for the heaters. An A.C. power unit can be used for these supplies. It is most important that there is no connection between H.T. and L.T. supplies other than that provided in the receiver. Also, H.T.— must not be earthed.

CONSTRUCTION

12. The test set is contained in a metal case measuring 10½ in. wide, 7½ in. high and 5 in. deep. All the components are supported on a metal panel secured to the case by twelve screws round the edge and by the removal of these, the instrument may be withdrawn intact (*see* fig. 3). On the front of the panel are all the terminals, switches, cable connections and indicator meter necessary for the use of the instrument. These comprise telephones, output and signal generator terminals, visual indicator for direction-finding tests, four switches S_1, S_2, S_3 and S_4 and the plug connectors for the following:—receiver supply, visual indicator, loop and power supply. An earth terminal is also fitted. The functions of the switches have already been described in paras. 5 to 9. The connecting cables supplied with each instrument are numbered to correspond with the instrument number and it is important that they should not be interchanged with cables supplied with other instruments of the same type.

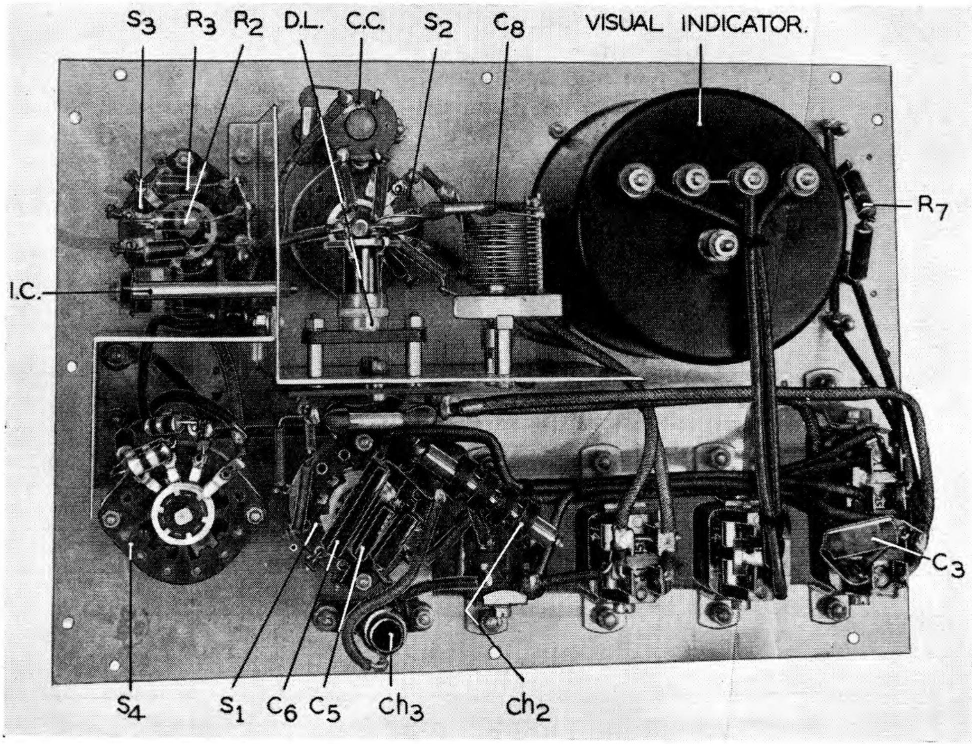


Fig. 3.—Back-of-panel view of test set

OPERATION

13. This unit has been specially designed for carrying out certain tests of the R.1155 receiver These tests include all conditions of communication and D/F. reception all of which are capable of simulation by means of suitable operation of the instrument. In the following paragraphs details of actual tests and tabulated results are given. Slight variation of the figures may in some cases be expected as they will depend on the signal generator employed. In any case, deviation from these figures should be small and if the difference is considerable, irrespective of the type of signal generator used, it should be assumed that a fault exists. The test set has been lined up in comparison with a standard instrument and unless it has received mechanical damage it is likely to remain

constant over a long period. The frequency bands covered by the R.1155 receiver are in five ranges as given below and the numbers relating to these are used in the descriptions of tests which follow:—

Range 1 (H.F.) 18·5 Mc/s to 7·5 Mc/s.
Range 2 (H.F.) 7·5 Mc/s to 3 Mc/s.
Range 3 (M.F.) 1,500 kc/s to 600 kc/s.
Range 4 (M.F.) 500 kc/s to 200 kc/s.
Range 5 (M.F.) 200 kc/s to 75 kc/s.

Overall sensitivity: 2nd channel signal ratios: I.F. break through:

14. For overall sensitivity, 2nd channel signal ratios and I.F. break through measurements two dummy aerials are required, one to represent the trailing aerial and the other the fixed aerial. Suitable dummy aerials and connecting leads are incorporated in the test set and are selected by means of the switch S_1.

15. *Conditions of test.*—Receiver switch in the "Omni" position.
L.F. filter "out".
Deflection sensitivity switch in "high" position.
Heterodyne switch "off" except for C.W. working.
H.T. volts 250.
L.T. volts 6.
Output load 5,000 ohms.
Test set switch S_1 in the M.W. position for ranges 3, 4 and 5.
Test set switch S_1 in the S.W. position for ranges 1 and 2.
Test set switch S_3 in the 0-deg. position.

16. The figures in Tables 1 and 2 are representative of those obtained from a number of receivers. Tests should be made at two frequencies in each band.

TABLE 1

Range	Frequency kc/s.	(A) noise output (Milliwatts)	(B) Modulated input (Microvolts)	(C) Tolerance figures (Microvolts)	(D) C.W. input (Microvolts)	Image frequency (kc/s)	(E) Image signal ratio (db.)	(F) I.F. break through (db.)
	74	7·0	31		14	1194	77	64
	*80	8·0	25	40	11	1200	77	64
5	130	10·0	12.		5·3	1250	70	54
	*185	40·0	6·5	11	2·9	1305	63	53
	202	45·0	6·0		2·7	1322	55	50
	198	5·0	5·5		2·4	1318	77	74
	*210	5·0	5·0	10	2·2	1330	75	72
4	350	1·0	4·6		2·0	1470	57	46
	450	2·0	2·8		1·2	1570	56	38
	*500	2·0	2·2	5	1·0	1620	54	31
	600	0·6	8·0		3·5	1720	74	38
	*650	1·0	4·0	8	1·8	1770	74	50
3	1000	2·0	1·6		0·7	2120	63	72
	*1430	1·1	2·5	6	1·1	2550	46	71
	1615	1·0	3·0		1·3	2635	44	71

(A) Noise output with volume control at maximum and carrier off.

(B) Input required, modulated 30 per cent at 400 cycles to give 50 milliwatts output. Signal/noise ratio equal to or greater than 10 db. (Volume control adjusted so that the noise output with the carrier on and modulation off is equal to 5·0 milliwatts. Where the noise output with volume control at max. carrier on and modulation off is less than 5·0 milliwatts, the volume control should be turned to maximum).

(C) The figures are the tolerances on the figures in column (B).

(D) Input required, C.W. (heterodyne switch on, modulation off) to give 5·0 milliwatts output. Volume control adjustment same as for (B).

(E) Image signal ratio in db. relative to input (B). Volume control adjustment same as for (B).

(F) I.F. break through in db. relative to input (B). Volume control adjustment same as for (B).

(*) Frequencies at which ganging adjustments are carried out.

TABLE 2

Range	Frequency Mc/s.	(A) Noise output (Milliwatts)	(B) Modulated input (Microvolts)	(C) Tolerance figures (Microvolts)	(D) C.W. input (Microvolts)	Image frequency (Mc/s.)	(E) Image signal ratio (db.)	(F) I.F. break through (db.)
2	2·95	0·1	3·5		1·6	4·07	50	greater than 100
	*3·3	1·5	4·5	9	2·0	4·42	60	greater than 100
	5·0	0·25	6·5		2·9	6·12	33	greater than 100
	*7·0	1·0	0·6	2	0·3	8·12	39	greater than 100
	7·6	1·0	0·7		0·3	8·72	31	greater than 100
1	7·4	0·1	20·0		9·0	8·52	43	greater than 100
	*8·0	0·2	7·2	14	3·2	9·12	41	greater than 100
	13·0	0·25	6·2		2·8	14·12	31	greater than 100
	*16·0	0·35	3·0	6	1·3	17·12	32	greater than 100
	18·5	0·2	6·6		3·0	19·62	22	greater than 100

(*) Frequencies at which ganging adjustments are carried out.
Test set switch S_1 in the S.W. position (dummy fixed aerial in circuit).

A.V.C. characteristics

17. Signal generator connected *via* the dummy trailing aerial (i.e. test set switch S_1 in the M.W. position and switch S_3 in the 0-degree position.)

Conditions of test.—Receiver switch in the A.V.C. position.
Receiver tuned to 350 kc/s.
L.F. filter switched out.
Deflection sensitivity control in "high" position.
Heterodyne switch "off".

18. The carrier should be modulated 30 per cent at 400 cycles and the signal generator level set to 100 microvolts. Adjust the receiver volume control so that an output of 10 milliwatts is obtained. Increase the input level to 10,000 microvolts. The output should now not be greater than 25 milliwatts.

Tests for D/F. reception

19. The general performance tests for D/F. reception are divided into two groups as under:—
Group 1.—Tests which are all taken at the same frequency.
Group 2.—Tests which are taken at predetermined spot frequencies, on each of the D/F. tuning bands.

20. *Group 1.*—The signal generator is connected to the receiver *via* the test set and the receiver and test set are initially set as follows:—

Conditions of test.—Receiver wavechange switch on range 4.
Signal generator is set to 210 kc/s., carrier modulated 30 per cent at 400 cycles.
Volume control at convenient level for monitoring.
L.F. filter switched "in".
Heterodyne switch "off".
Switching oscillator control in "slow" position.
Test set switch S_1 in "D/F." position.
Test set switch S_4 in "N" position.

21. *Test 1. Set the vertical aerial trimmer condenser and check the visual D/F. sense.*—
Put the receiver switch in the "balance" position.
Set the signal input level at 200 microvolts.
Adjust the meter amplitude control so that the visual indicator meter needles are at a convenient height.
Adjust the balance control until the visual indicator needles intersect on the centre line of the scale.
Turn the receiver switch to the "visual" position.
Then turn the meter amplitude control to the maximum clockwise position.

(*a*) Put the test set switch S_3 in the 10-deg. position. Turn the deflection sensitivity control to the "low" position. It should now be possible to obtain three-quarters full deflection and quarter full deflection of the visual indicating meter, within the limits of adjustment of the aerial trimmer condenser C_2. Full deflection of the visual indicator needles is such that the lower needle is over the zero mark on the meter scale and the upper needle is well up near its upper limit.

(*b*) With the test set switch S_3 still in the 10-deg. position, turn the deflection sensitivity control to the "high" position, put switch S_2 in the "L" position. Adjust receiver aerial trimmer (C_2) to give full scale deflection, which should be to the left. The aerial trimmer is now correctly set. Put S_2 in the "R" position and check that the meter gives full scale deflection to the right within the limits of the switch S_4.

22. *Test 2. Check that the visual indicator needle does not rise again at 90 deg. off course.*—
With the operational switch in the balance position of the previous test:—
Turn meter amplitude control to "minimum" position.
Check balance.
Input level 200 microvolts.
Move operational switch to "visual" position.
Put test set switch S_3 in 90-deg. position.
The needles should now be fully deflected within the $\pm$ limits of the switch S_4 for both the "L" and "R" positions of the test set switch S_2. The deflection sensitivity control must be in the "high" position for this test.

23. *Test 3. Check deflection sensitivity control.*—
With the input level still at 200 microvolts:—
Return the receiver operational switch to the "balance" position.
Adjust the meter needle intersection to some convenient height by means of the meter amplitude control.
Check the balance.
Turn the meter amplitude control to maximum.
Turn the receiver operational switch to "visual".
Put the deflection sensitivity control in "low".
Put the test set switch S_3 in the 25-deg. position.
The indicator needles should show full-scale deflection, within the $\pm$ limits of the test set switch S_4 for both positions of the switch S_2.

24. *Test 4. D/F. sensitivity measurements at slow and fast switching speeds.*—Sensitivity measurements are made in the following manner.

Conditions of test. Volume control turned down to some convenient level for monitoring.

L.F. filter switched "in".

Heterodyne switch "off".

Switch S_1 in the "D/F." position.

Switch S_4 in the "N" position.

Meter amplitude control at maximum.

Receiver operational switch in the "visual" position.

Deflection sensitivity control in the "high" position.

Switch S_3 in the 25-deg. position.

Adjust input level so that the indicator needles intersect at a distance of approximately $\frac{5}{16}$ in. from the centre line.

Put the operational switch in the "balance" position.

Adjust the balance control so that the intersection of the needles occurs on the centre line of the scale

Return the operational switch to the "visual" position.

Readjust input level so that the intersection of the indicator needles is a distance of $\frac{5}{16}$ in. from the centre line.

The intersection should now be the same distance from the centre line for both positions of S_2 i.e., $\frac{5}{16}$ in. to the left of the centre line for the "L" position of S_2 and $\frac{5}{16}$ in. to the right of the centre line for the "R" position of S_2. If the deflections are not the same they must be made to agree and be equal to $\frac{5}{16}$ in. by slight adjustments to the balance control and to the input level. The input required to satisfy these conditions is taken as the visual D/F. sensitivity figure.

(*a*) Sensitivity at slow switching speed. Put the switching speed control to "slow" and increase the D/F. sensitivity as described above. The input required for $\frac{5}{16}$ in. sideways deflection should be less than 25 microvolts.

(*b*) Sensitivity at fast switching speed. Measure the sensitivity with the switching speed control in the "fast" position. The input required for $\frac{5}{16}$ in. sideways deflection should be within $\pm$ 50 per cent of the figure obtained for (*a*).

25. *Test 5. Check limiter.*—Return the switching speed to "slow" and with the operational switch in the "balance" position turn amplitude control to minimum and adjust meter balance control for balance. Put in a signal of 1 volt R.M.S. carrier. The indicator needles should not come higher than the bottom of the L and R markings on the meter scale.

26. *Test 6. Check the balance control.*—

Adjust signal input level to 200 microvolts.

Adjust the meter needle intersection to some convenient height by means of the meter amplitude control.

Move the balance control to the limit in both the clockwise and counter-clockwise directions and note limiting positions of the intersection of the needles. The intersections should not be less than $\frac{1}{4}$ in. from the centre on either side.

27. *Test 7. Check the H.T. interlocking.*—Turn the test set switch S_1 to the M.W. position. It should now not be possible to operate the receiver in the "Balance", "Visual" or "Figure of eight" positions of the receiver operational switch.

28. *Test 8. H.F. break through via the H.T. supply leads.*—This test is for checking condensers C_{108} (H.T.$-$) and C_{31} (H.T.$+$).

Conditions of test.

Carrier frequency 210 kc/s.

Carrier modulated 30 per cent at 400 cycles.

Receiver operational switch on "omni".

Volume control at maximum.

Heterodyne switch "off".

L.F. filter "out".

Test set switch S_1 in the M.W. position.

Test set switch S_3 in the 0-deg. position.

Adjust input level to give 50 mW.

Switch modulation off and note the noise level. (This should normally be between 1 and 10 mW.). With the modulation still off, inject 20-volt 50-cycle A.C. by means of a transformer winding connected between the H.T. positive terminal of the power unit and the H.T. terminal of the D/F. test set (i.e. in series with the H.T. feed). The test requirement is that the output should not increase by more than 2 to 3 mW. when the 20 volts A.C. is applied. If the output increases to 30 mW. or more, one or other, or both the condensers C_{108} and C_{31} are faulty. To find which condenser is the faulty one, the following procedure may be adopted:—Clip a $4\mu F$ condenser between receiver chassis and H.T.+ on the receiver. If the output drops to about 5 mW. (10 mW. in the case of more noisy receivers) this indicates that C_{31} across H.T. + is faulty. Clip a $4\mu F$ condenser between receiver chassis and H.T.— on the receiver. If the output drops to about 5 mW. (10 mW. in the case of more noisy receivers) this indicates that C_{108} across H.T. — is faulty. If the output falls by only a few db when $4\mu F$ is put across H.T.+, or *rises* by a few db when $4\mu F$ is put across H.T.—, then both condensers are faulty.

29. *Test 9. Check aural sense switch.*—With the adjustments exactly as in the previous test, put the test set switch S_2 in the "L" position and move the receiver aural sense switch backwards and forwards between the "L" and "R" positions. The signal as heard in the monitoring telephones or as indicated on the output meter should be considerably louder in the "L" position of the handswitch than in the "R" position. Move the test set switch S_2 to the "R" position and repeat the test. The signal should now be lowest in the "R" position of the handswitch.

30 *Group 2.* *Test 10. Sensitivity for figure-of-eight reception.*
Test 11. Visual D/F. sensitivity.
Test 12. Check for symmetry and sense of the visual D/F. indicator.

Details of these tests are given in Tables 3 and 4. The signal generator is connected to the receiver *via* the test set.

TABLE 3

	Test 10	Test 11	Test 12
Receiver operational switch	Figure-of-eight	Visual	Visual
Switching oscillator speed		Slow	Slow
Deflection sensitivity	High	High	High
Meter amplitude control		Max.	Max.
L.F. filter switch	Out	In	In
Heterodyne switch	Off	Off	Off
Volume control	At max. if noise less than 0·5 milliwatt with carrier on, modulation off. If noise greater than 0·5 milliwatt, set volume control so that noise is equal to 0·5 milliwatt, i.e. 20 db. below 50 milliwatts	Adjusted to any convenient level for monitoring.	Adjusted to any convenient level for monitoring.
Test set switch S_1	D/F.	D/F.	D/F.
Test set switch S_2	—	L and R	L and R
Test set switch S_3	90 deg.	25 deg.	10 deg.
Test set switch S_4	N.	N.	Between + and — limit positions
Output	50 milliwatts	$\frac{5}{16}$ in. sideways deflection of intersection of needles	Full deflection of visual indicator within $\pm$ limits of S_4. Deflection should be to the left when S_2 is at L and to the right when S_2 is at R

TABLE 4

Range	Frequency	Test 10 Figure-of-eight sensitivity (microvolts)		Test 11 Visual D/F. sensitivity (microvolts)		Test 12 Check for full deflection and sense		
		A Typical	B Tolerance	C Typical	D Tolerance	Input level (microvolts)	Check with switch S in "L" position	Check with switch S in "R" position
5	74	300		31		300		
	*80	250	300	26	40			
	130	180		17				
	185	160	200	12				
	202	160		13				
4	198	120		14		200		
	*210	110	140	12	25			
	350	100		14				
	450	83		8·5				
	500	86	100	7·0				
3	600	105		24		200		
	*650	90	110	15	25			
	1,000	80		13				
	1,430	70	90	13				
	1,515	70		12				
2	2·95	2,800		2,500		10,000		
	*3·3	1,200	2,000	430	3,000			
	5·0	3,000		1,100				
	7·0	1,000	1,500	400				
	7·6	500		210				

* Frequencies at which Test 12 should be carried out.

31. The figures given in columns A and C of Table 4 are representative of those obtained from tests carried out on a number of receivers. Tests should be made at the frequencies indicated, i.e. two frequencies in each band for Test 10 and one frequency in each band for Test 11. The figures obtained should not be greater than those given in columns B and D. In addition the receiver should pass the check test (12) at the frequencies indicated by the asterisks in Table 4.

Lining up H.F. circuits

32. The signal generator is connected to the appropriate terminals on the test set. As the R.1155 is primarily a D/F. receiver on the M.W. and L.W. ranges (3, 4 and 5) and primarily a communication receiver on the S.W. ranges (1 and 2) it is essential that the receiver be lined up under these actual operating conditions. It must not be lined up with the operational switch in either the "Omni" or "Omni A.V.C." positions on ranges 3, 4 and 5 nor on the short wave ranges (1 and 2) with the switch in any of the D/F. positions. Ganging on the S.W. ranges 1 and 2 follows conventional practice, but on ranges 3, 4 and 5 special methods for injecting the signal which simulate actual D/F. operating conditions must be employed.

33. Two methods can be used, both employing the dummy aerial contained in the test set. The second method given below has the advantage that it is not necessary to hold the D/F. switch over when lining up.

Method 1

(i) Connect signal generator to the fixed aerial (S_1 at SW).
(ii) Set receiver operational switch in "figure-of-eight" position.
(iii) Hold aural sense switch over to either "left" or "right" position.

Method 2

(i) Inject signal generator voltage into dummy loop circuit.
(ii) Set receiver operational switch to the "figure-of-eight" position.

34. The following test conditions are necessary:—
(i) Volume control at maximum so adjusted that the noise level does not exceed 1 milliwatt.
(ii) L.F. filter switched out.
(iii) Deflection sensitivity control in the "high" position.

Wave range	Position of receiver operational switch	Position of aural D/F. hand switch	Position of test set switch S_1	Position of test set switch S_3
M.W. and L.W. ranges 3, 4 and 5. Method 1	Figure-of-eight	Held over	D/F.	0 deg.
M.W. and L.W. ranges 3, 4 and 5. Method 2	Figure-of-eight	Normal	D/F.	90 deg.
S.W. ranges 1 and 2	Omni	Normal	S.W.	—

35. The ganging operation follows normal practice. The signal generator carrier is modulated 30 per cent at 400 cycles and the output meter is used as a tuning indicator. The input level should be such that the output meter reading is of the order of 10 milliwatts.

APPENDIX

NOMENCLATURE OF PARTS

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

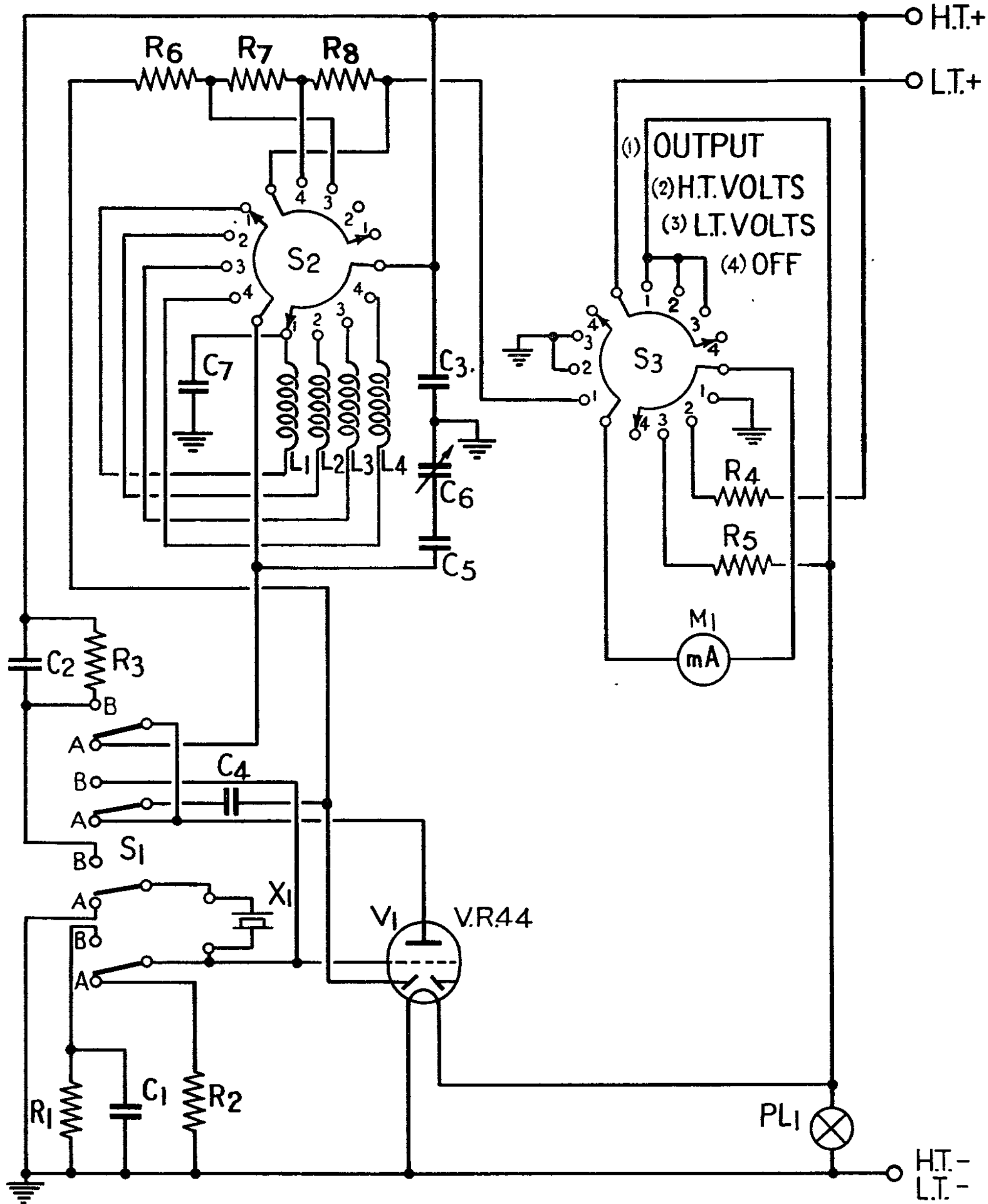
Ref. No.	Nomenclature	Qty.	Ref. in fig. 2	Remarks
10S/137	Test set, type 65			
	Principal components			
	Choke			
	Type	1	Ch.1	1,250μH
	Type	1	Ch.2	1,250μH
	Type	1	Ch.3	3μH
	Coil			
	Type	1	DL	Dummy loop
	Type	1	CC	Correction coil
	Type	1	IC	Input coil
	Condenser			
	Type	1	C_1	140$\mu\mu$F
	Type	1	C_2	425$\mu\mu$F
	Type	1	C_3	40$\mu\mu$F
	Type	1	C_4	0·0003μF
	Type	1	C_5	0·0003μF
	Type	1	C_6	0·002μF
	Type	1	C_7	100$\mu\mu$F
	Type	1	C_8	100$\mu\mu$F (variable)
	Type	1	C_9	50$\mu\mu$F
	Resistance			
	Type	1	R_1	150 ohms
	Type	1	R_2	300 ohms
	Type	1	R_3	820 ohms
	Type	1	R_4	20 ohms
	Type	1	R_5	20 ohms
	Type	1	R_6	100 ohms
	Type	1	R_7	50,000 ohms
	Switch			
	Type	1	S_1	6 positions
	Type	1	S_2	Reverse
	Type	1	S_3	3 positions
	Type	1	S_4	3 positions

SECTION 5, CHAPTER 21

TEST SET, TYPE 7

CONTENTS

LIST OF ILLUSTRATIONS



C_1	$10\mu\mu F$	C_5	$0{\cdot}01\mu F$	R_1	20 K	R_5	2 K
C_2	$30\mu\mu F$	C_6	$0{\cdot}0005\mu F$	R_2	30 K	R_6	30 K
C_3	$0{\cdot}01\mu F$	C_7	$0{\cdot}1\mu F$	R_3	7 K	R_7	20 K
C_4	$0{\cdot}0001\mu F$			R_4	0·2 M	R_8	50 K

TEST SET TYPE 7, CIRCUIT DIAGRAM

FIG. 1

FIG. 1

TEST SET, TYPE 7

(CRYSTAL TESTING)

(Stores Ref. 10S/10500)

INTRODUCTION

1. The test set, type 7, is introduced to provide a means whereby standard crystals may be tested for general activity and serviceability. The instrument is portable and measures 14 in. by $6\frac{9}{16}$ in. by $3\frac{7}{8}$ in. The case contains the H.T. battery and the filament heating accumulator. The general appearance of the instrument is shown in fig. 2.

GENERAL DESCRIPTION

2. A theoretical circuit of the test set, type 7, is shown in fig. 1. The valve V_1 (V.R.44) is a double-diode triode, the triode serving as an oscillator controlled by the crystal under test, a single diode being utilised as a rectifier of output current. The rectified current is measured by the D.C. milliammeter.

3. The switch S_1 is a 4-pole 2-way rotary switch with positions, "TEST A" and "TEST B". In position "TEST A" the crystal under test is connected between grid and filament of the valve V_1, whilst the range switch S_2 and the oscillatory circuit are included in the anode circuit of the triode portion of the valve.

4. The range switch S_2 is a 3-pole, 4-way rotary switch and has four frequency ranges covering 1 to 10 Mc/s. Its function is to select a suitable value of inductance which together with the variable condenser C_6 will constitute an anode load that can be tuned to resonance with the frequency of the crystal under test. This condition will give maximum R.F. voltage applied *via* the coupling condenser C_4 to the diode of valve V_1, and the rectifying properties of this diode will give a proportionate output of direct current. The value of the diode loading resistance is varied according to the position of the frequency range switch S_2, R_8 being short-circuited in position 3 and R_7 R_8 being short-circuited in position 4.

5. In position "TEST B" of the switch S_1 the crystal under test is connected between anode and grid of the valve V_1, and an aperiodic load consisting of the resistance R_3 and the condenser C_2 is connected in the anode circuit of the triode of the valve V_1.

6. The milliammeter M_1 can be adapted to measure the rectified diode current, the H.T. battery voltage, or the accumulator voltage. Modification of the milliammeter connections is made by the various switch positions marked "OFF" (4), "L.T. VOLTS" (3), "H.T. VOLTS" (2) and "OUTPUT" (1) respectively. In the first position of the switch the power supplies are disconnected. With the switch in the "L.T. VOLTS" position, the valve filament and the milliammeter are connected across the accumulator, the resistance R_5 being connected in series with the milliammeter to obtain a full scale reading of 2 volts. The accumulator is therefore tested on load in this position of the switch. The valve filament remains connected to the accumulator in the next position of the switch "H.T. VOLTS", and the milliammeter is connected in series with the resistance R_4 across the H.T. battery. Full scale deflection in this position is 200 volts and the H.T. battery is tested on load. The fourth position of the switch "OUTPUT" connects all supplies, and the milliammeter, as such, is in series with the diode load. In this position the meter measures from 0 to 1 milliampere, and indicates the output of the test set with the selected crystal in position.

7. The position "TEST B" of the switch S_1 is provided so that the crystal may be tested under simulatory conditions of the equipment with which it is used; but the position "TEST A" should normally be employed, and resonance obtained with the use of the range switch S_2 and the variable condenser C_6. In both tests comparison should be made with a standard crystal.

8. The resistances R_6, R_7 and R_8 represent the diode load and are selected according to the position of the range switch S_2. A pilot lamp PL_1 is connected in parallel with the filament and indicates when the test set is switched on.

9. When the crystal is connected between anode and filament of the valve V_1, grid bias is provided by the resistance R_1 which is by-passed by the condenser C_2. The resistance R_2 provides the grid bias when the crystal is connected between grid and filament.

10. The triode portion of the valve V_1 is coupled to the active diode by means of the condenser C_4. The condenser C_7 is an H.F. by-pass condenser provided on the lowest frequency range. The condensers C_3 and C_5 are H.T. blocking condensers provided to enable the spindle of the variable condenser C_6 to be earthed.

11. The H.T. battery and L.T. accumulator are connected to the instrument proper by means of flexible leads, the H.T. leads are fitted with service type plugs, and the L.T. leads with spade terminals. Each lead can be identified by an insulating sleeve which is suitably engraved.

CONSTRUCTIONAL DETAILS

12. The construction of the instrument will be described with reference to the illustration. Fig. 2 shows the panel of the instrument and the instruction card inside the lid. The case (1) is of steel sheet with welded joints and is finished in black. It consists of two compartments, the lower of which contains the batteries. The instrument panel carries the whole of the electrical components of the instrument proper. On the left of the panel is the milliammeter (2) which is a direct current moving-coil instrument with a scale reading of 0 to 1 milliampere. Below the milliammeter is the

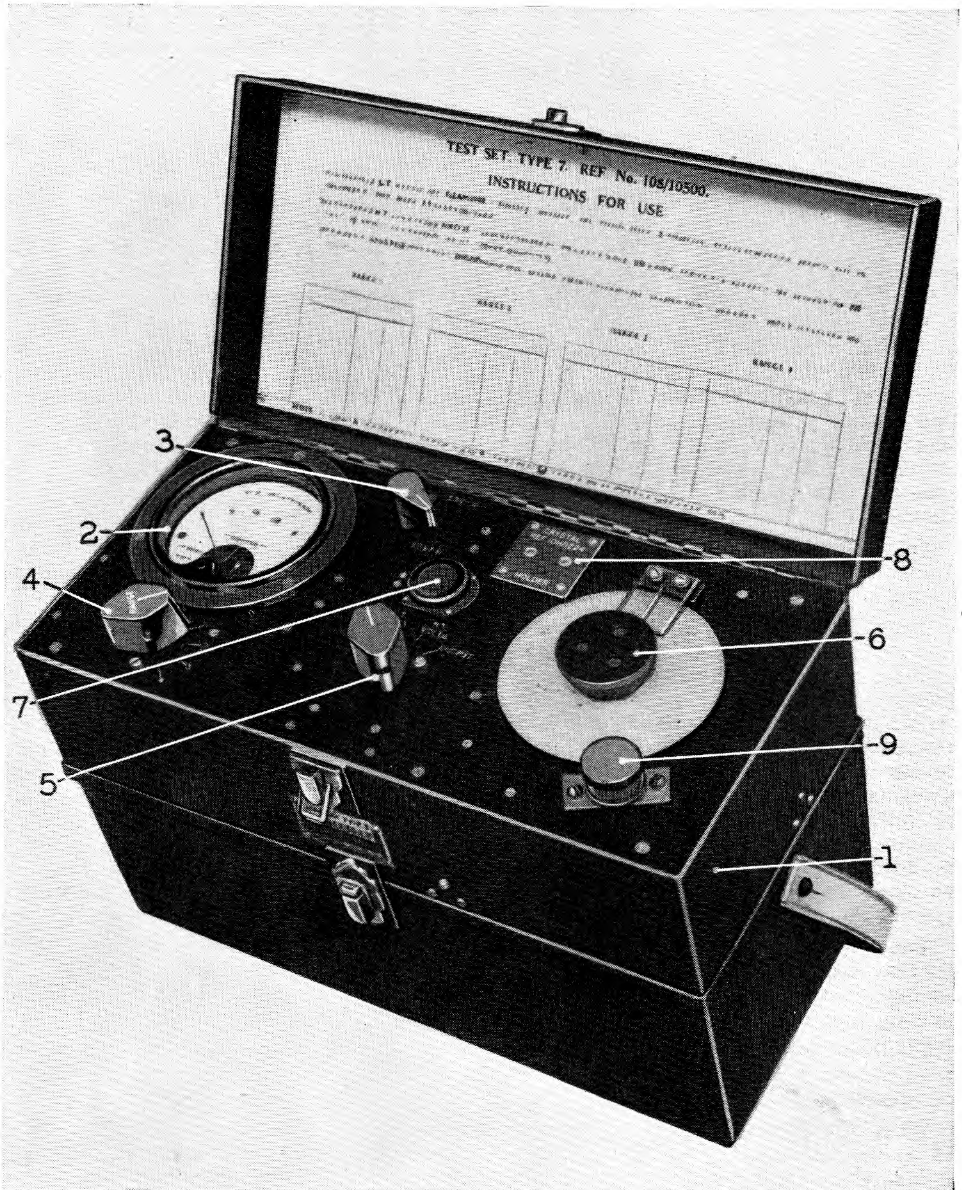


FIG. 2.—VIEW SHOWING PANEL AND INSTRUCTION CARD

range switch (4). To the right of the milliammeter is the test switch (3) marked "TEST A" and "TEST B". The crystal-holder (8) is situated at the top centre of the panel and directly below is the pilot-lamp cap (7). At the bottom centre of the panel is the output switch (5), the remaining feature being the variable-condenser control (6) which is fitted with a slow-motion control (9) and a scale marked 0–100 divisions, this is located on the right-hand side of the panel.

13. Fig. 3 is a view of the instrument with the lower compartment open with the batteries removed. The components on the underside of the panel are shown and reference should be made to fig. 1 for circuit annotations. The smaller components are annotated, and listed on a paper slip pasted on the inside of the case.

OPERATION

14. Test the accumulator on load with the switch S_3 in position "L.T. VOLTS". The full scale deflection is 2 volts and the accumulator should not be allowed to drop below 1·9 volts on load.

15. With the switch in the "H.T. VOLTS" position the full scale deflection is 200 volts and the H.T. voltage should be adjusted as nearly as possible to 100 volts by means of the battery taps.

16. With the switch in the "OUTPUT" position the diode output current is measured by the milliammeter, with a scale reading of 0 to 1 milliampere.

17. Comparison tests should be made as follows:—Place a standard crystal in the crystal holder of the test set, type 7, switch S_1 to "TEST A", select the appropriate frequency range in S_2 and switch S_3 to "OUTPUT". Tune the variable condenser C_6 to resonance i.e. maximum reading in milliammeter. Make a note of the reading obtained and remove the standard crystal. Place the crystal for test in position and carry out the tuning procedure as described above. The reading obtained should not be less than that obtained for the standard crystal. For "TEST B" the switch S_2 should be in position 1.

18. If desired, a useful tabulation of standard readings can be made on the instruction card provided inside the lid of the test set.

19. Due to deterioration of valves and H.T. batteries, incorrect readings may be obtained when testing crystals for output, with consequent possibility of rejection of serviceable crystals. It is therefore necessary to obtain standard measurements from crystals which have given satisfactory results in particular types of equipment.

20. The following procedure should be carried out in order to eliminate any error due to ageing of the test set.

(i) Several crystals which have been found to give satisfactory results in particular types of equipment are to be measured for output in the test set, type 7, and a standard minimum output limit crystal established for each type of equipment. These standard crystals should be retained and used as follows when testing other crystals.

(ii) The standard crystal for the particular equipment concerned is to be measured for output in the test set, type 7.

(iii) The activity figures so obtained are to be used as the minimum output limit for the new crystals intended for use in the same equipment.

21. The standard crystals should be checked from time to time in the apparatus from which they were originally selected to ensure that they still function correctly.

BATTERIES

22. The batteries required for use in the test set, type 7, are as follows:—

(i) L.T. supply. One accumulator, 2 volt, 7 ampere-hours.

(ii) H.T. supply. One battery, dry, 120 volt, type B.

PRECAUTIONS AND MAINTENANCE

23. The instrument requires very little maintenance in service. After using, ensure that it is switched off before closing the lid. Failure to do this may result in damage to components of the instrument.

24. When not in use, the lid should be closed and the instrument kept in a clean dry place.

25. Care should be taken that the battery plugs make good electrical contact in the battery sockets. When opening the case for inspection or removal of any battery, care must be taken to support the upper portion in such a manner that no strain is imposed on the battery leads and plugs. The valve V.R.44 should be tested periodically for emission, as deterioration of the filament with age may cause inaccurate readings whilst testing crystals.

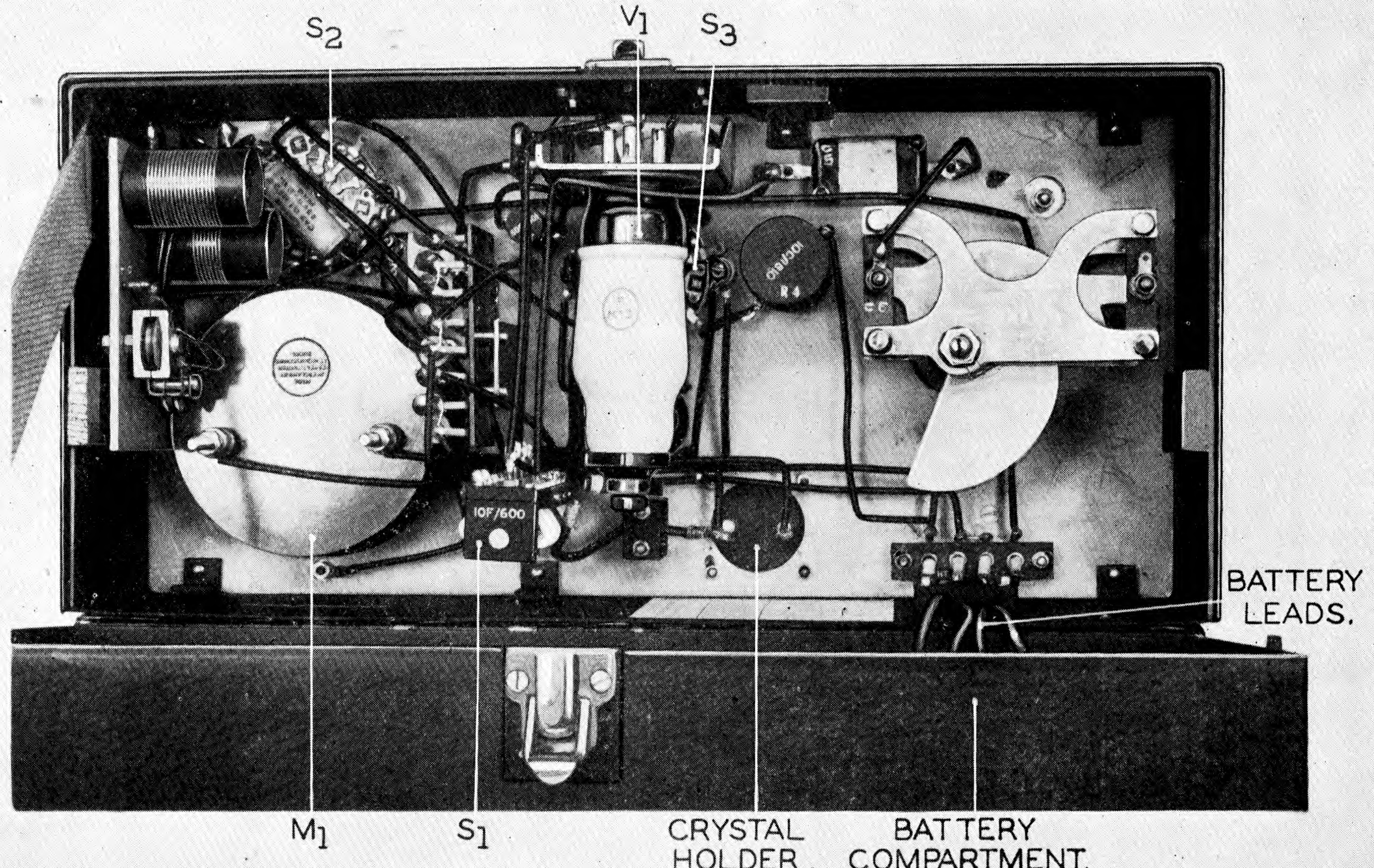


FIG. 3 LOWER COMPARTMENT AND UNDERSIDE OF PANEL

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Ref. in fig. 1	Remarks
10S/10500	Test set, type 7 (Crystal testing)	1		1 to 10 Mc/s.
	Consisting of:—			
10A/9752	Boxes, battery	1		Teak, painted acid-resisting black, 14 in. by 6 $\frac{9}{16}$ in. by 3$\frac{7}{8}$ in.
	Cap			
10A/11270	Lamp, type 11	1		Signal lamp.
10A/12775	Valve, type 10	1		Steel clip.
10A/11970	Case	1		18 s.w.g. steel sheet.
10S/48	Case, transit	1		For test set and 3 valves.
10S/45	Coil-panel-assemblies	1	L_1, L_2, L_3, L_4	Fitted with 2 coils, air core; and 2 coils, iron-dust core.
	Condenser			
10C/7906	Type 125	2	C_3, C_5	0·01 μ F.
10C/8804	Type 230	1	C_6	0·0005 μ F, variable, air dielectric.
10C/10394	Type 404	1	C_1	10 $\mu\mu$ F.
10C/10395	Type 405	1	C_2	30 $\mu\mu$ F.
10C/11034	Type 437	1	C_4	0·0001 μ F.
10C/10165	Type 386	1	C_7	0·1 μ F.
10X/	Crystal	As reqd.	K_1	
	Holder			
10H/1224	Crystal, type 9	1		
10H/9615	Valve, type S	1		5 pin.
	Knob			
10A/11838	Type 10	1		Moulded ebonite.
10A/11839	Type 11	1		Phenolic resin.
10A/11272	Lampholder, type 4	1		Spring-grip.
5L/360	Lamp, filament, 2·5 volts, 0·3 amp.	1	PL_1	
10A/12777	Milliammeter 0·1 mA, type K	1	M_1	Moulded phenolic resin.
	Plug			
10H/9112	Type 82	1		Battery, red.
10H/9113	Type 83	1		Battery, black.
	Resistance			
10C/6148	Type 6148	2	R_2, R_6	30,000 ohms.
10C/9762	Type 283	1	R_1	20,000 ohms.
10C/1708	Type 1708	1	R_8	50,000 ohms.
		1**	R_5	2,000 ohms.
		1**	R_4	200,000 ohms.
10C/1541	Type 1541	1	R_7	20,000 ohms.
10C/237	Type 689	1	R_3	7,000 ohms.
	Switch			
10F/600	Type 500	1	S_1	5-pole, rotary, 2-way.
10F/601	Type 501	2	S_2, S_3	3-pole.
10E/10542	Valve, type V.R.44	1*	V_1	
	Accessories:—			
5A/1514	Accumulator, 2 volts, 7 Ah.	2		Celluloid case.
5A/1615	Batteries, 120 volts, type B	1		Dry.

* The valve V.R.44 is being replaced by valve 210 DDT, Stores Ref. 10E/337; incorporating valve adaptor, type 30, Stores Ref. 10A/12885 (*see* A.P.1186/D).

** Adjusted during final test. Test set should be returned to Maintenance Unit when replacements required.

SECTION 5, CHAPTER 22

THE OSCILLOSCOPE, TYPE 7

(Stores Ref. 10SB/102)

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LIST OF ILLUSTRATIONS

INTRODUCTION

1. The oscilloscope, type 7, is a portable cathode ray oscillograph using a $3\frac{1}{2}$ in. diameter single beam tube and is intended to give a graphical representation, as a function of time, of any effect which can be made to produce an equivalent electrical effect irrespective of whether the initial effect is of an essentially electrical character or not. It provides qualitative information given by the instantaneous two-dimensional recording facilities of a cathode ray tube. When suitably calibrated, quantitative results may also be obtained.

2. The instrument is fitted with a recurrent linear time base circuit of three valves, operating over a range from 5 to 250,000 c/s, permitting the continuous visual examination of repeating waveforms up to frequencies of the order of 3 to 5 Mc/s. The time base is of the hard valve type designed to give stability and positive synchronization at the highest frequencies without loading the work circuits under test. Provision is also included to enable photographic recording of transient traces by adapting the time base for single stroke operation.

3. Self-contained resistance-capacitance coupled amplifier circuits are included to provide either a single asymmetrical stage or a single stage symmetrical input and output amplifier. Alternately the two valves may be connected in cascade to provide a two stage asymmetrical amplifier to enable measurements to be made of voltages of the order of 10 mV and over. A 10 cm. graticule is provided. Seven valves in all are employed, four pentodes, a triode and two rectifiers.

4. The cathode ray tube has a screen diameter of 88 mm. and the fluorescent screen is of the "D" type with green response. The Y–plate sensitivity is of the order of 1·3-volt D.C. or 0·45-volt R.M.S. per millimeter; the X–plate sensitivity is 2·8-volt D.C. or 1-volt R.M.S. per millimeter approx. Calibration is of the order of 50 volts peak to peak and 17·7 volts R.M.S.

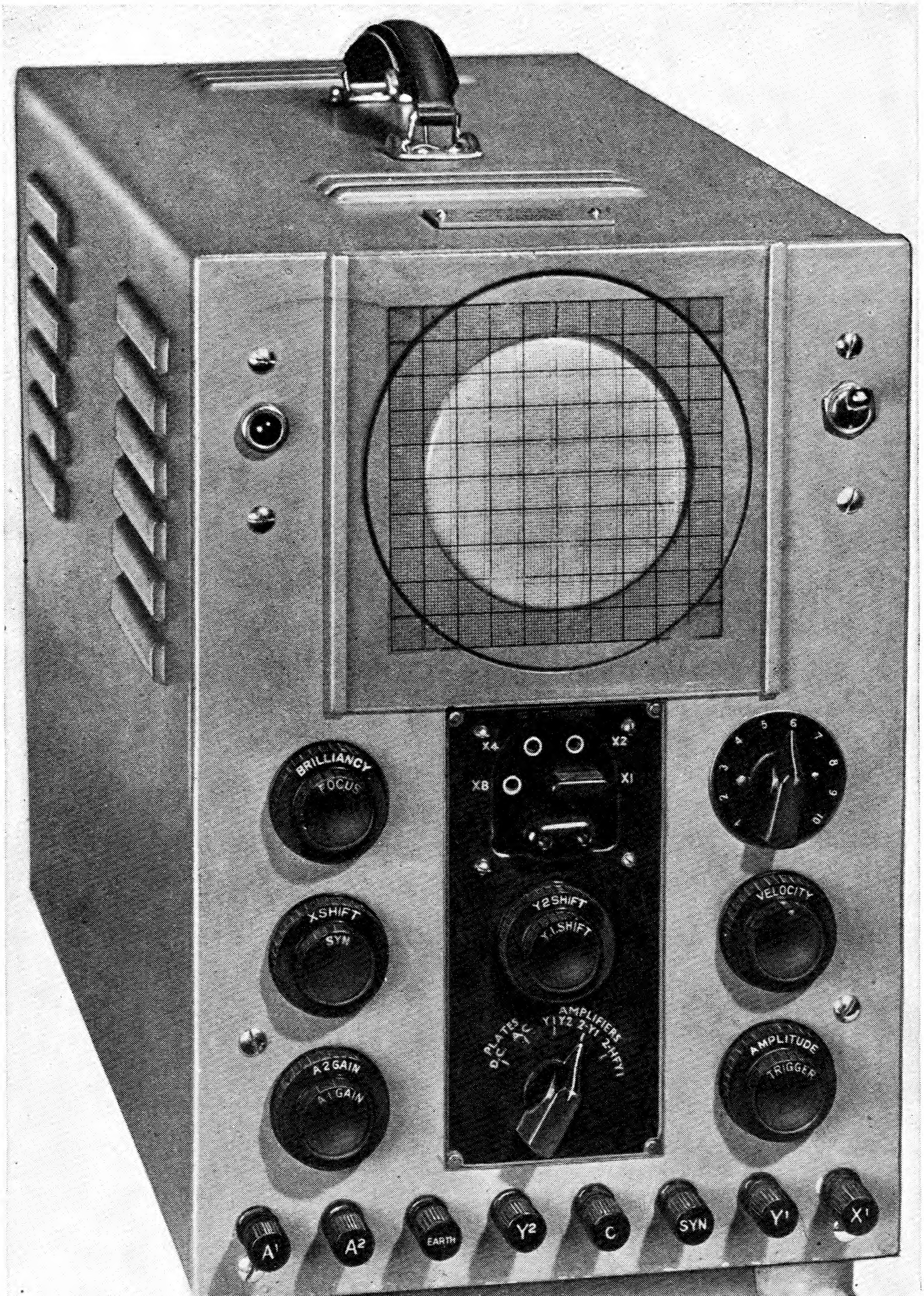

Fig. 1.—Oscilloscope, type 7

5. Power supplies for the instrument are obtained from the single phase A.C mains of 40 to 100 c/s and provision is made for inputs of 110 and 200 to 250 volts. Independent power supplies are provided for the cathode ray tube and the time base and amplifier. The first supplies 1,100 volts D.C., at low current rating, and shift voltages for the tube; the second provides 500 volts D.C. at high current for the two amplifiers and the time base. The power consumption is approximately 120 watts.

6. An illustration of the oscilloscope, showing the panel controls, is given in fig. 1. The overall dimensions are, approximately, 13¼ in. (34 cm.) high, 8¾ in. (22 cm.) wide and 19½ in. (49 cm.) long. The weight of the complete instrument is 40 lb.

GENERAL DESCRIPTION

7. A complete circuit diagram of the oscilloscope, type 7, is shown in fig. 2. It should be noted that the various component parts of the instrument, such as the time base and the amplifier are really independent circuits which are available for application to the cathode ray tube when required. As supplied, the standard instrument has those connections made according to the conventions of general practice, that is, the time base is applied to the horizontal axis for deflection from left to right and the amplifier is applied to each singly or, in cascade, to a single deflector plate of the C.R.O. for vertical deflection.

Time base

8. The time base circuit consists of two indirectly-heated pentode valves V_4 and V_5 with a triode V_3. In order to apply a time base deflection to an oscillograph it is generally desirable to obtain a linear saw-tooth voltage wave-form. Such voltages are obtained from relaxation oscillators producing saw-tooth wave-forms derived from sequential gradual charging of a condenser through a high resistance and its sudden discharge. The simplified diagram of fig. 3 will help to an understanding of the processes. In this diagram, so far as possible, the annotations of fig. 2 have been preserved but in certain instances these represent "lumped" components.

9. Referring to fig. 3, the time base condenser C will charge linearly through the indirectly-heated pentode V_4 which forms part of a constant current device operating over the flat part of the V_a/V_1 characteristic. This process carries the cathode of an indirectly-heated triode V_3 increasingly negative relative to its anode. The grid of V_3 is, however, appreciably negative relative to the anode due to voltage drop in R_c produced by the anode current of an indirectly-heated pentode V_5.

10. As soon as the cathode of the triode V_3 has travelled sufficiently negative to approach the potential present on the grid of that valve it will commence to pass current and a voltage drop will be present across the combined resistance R_2 (variable) and R_{46}. This will swing the suppressor grid of V_5 negative causing the anode of V_5 and, in consequence, the grid of V_3 to travel positive. This action is cumulative and the condenser C therefore discharges rapidly through V_3 until, when it becomes discharged, no further current flows through R_2–R_{46} and the cycle repeats.

11. The value of R_2 plus R_{46} has a lower limit set by R_{46} and is adjustable by R_2. This value affects the amplitude of the triggering impulse present in the grid circuit of V_5. Due to its presence in the discharge path it also modifies the flyback period. This control of R_2 is designated TRIGGER.

12. The voltage developed across the condenser C before each successive discharge through V_3 is dependent upon the extent by which the grid of that valve is maintained negative relative to its anode by the voltage drop across the variable resistance R_1. Adjustment of the magnitude of this resistance, therefore, provides control of AMPLITUDE.

13. Synchronization of the time base is effected by injecting a fraction of the work voltage into the control grid of V_5. The rate of charge of the condenser C depends upon the capacitance of C and the current flowing through V_4. In the circuit diagram of fig. 2 the condenser C is represented by the bank of nine condensers C_6 to C_{13} and C_{28}, selected by the switch S_1. This selection gives rough control whilst a progressive adjustment is provided in the form of a VELOCITY control potentiometer R_{43} varying the screen volts on the pentode charge valve V_4.

14. The switch S_1 is part of a control labelled CONDENSER, and it selects the various time base condensers in descending order of capacitance. In the last position only the circuital stray capacitances remain in the circuit. On the fastest two time base speeds, as imposed by the condenser C_{13} and the "strays", a negative signal is injected into the grid of the C.R.T. during the time base flyback in order to suppress the return trace during this period. In the same way, *via* R_{39} and R_{40} through the switch S_3 a positive impulse of an amplitude which increases with frequency is applied to the same circuit so as to increase the brilliance with increase in speed without necessitating manual adjustment of the BRILLIANCE control R_{36}.

Single stroke time base

15. For certain applications, however, it is far more convenient to operate the time base once only at a chosen time. Such conditions apply particularly to the investigation of transients. For this purpose it is essential that the time base sweep should be capable of initiation at the appropriate point in time, and a recurrent sweep would, in any case, introduce confusion of the final trace.

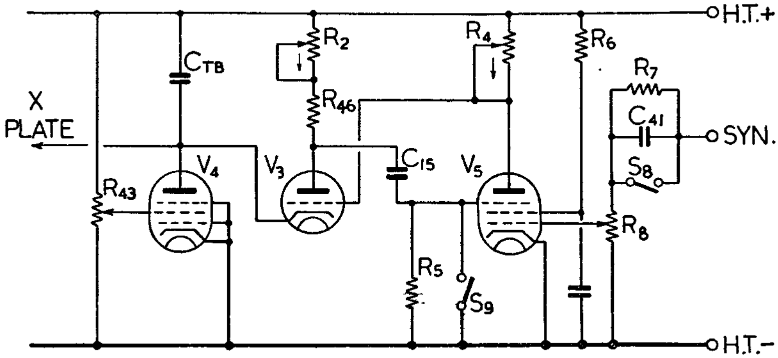

Fig. 3.—Simplified time base circuit

16. Referring to fig. 3, the injection into the grid of V_5 of the voltage drop produced across R_2–R_{46} when the condenser C becomes charged to a voltage sufficient to cause current to flow through the triode V_3, allows the time base to become self-running. Thus, if arrangements are made to prevent this voltage from being applied to the pentode V_5, by short-circuiting the grid of that valve with the switch S_1, the time base will no longer repeat.

17. After switching ON, the voltage across C will gradually increase until it carries the cathode of V_3 to a value sufficiently near the voltage drop across R_4 for V_3 to pass an anode current equal to that flowing through V_4. Once this condition has been realized the voltage across C will remain constant at an equilibrium value which corresponds to slightly more than full screen deflection on the cathode ray tube.

18. All that is now needed in order to produce a single stroke sweep is to discharge the condenser C very rapidly and it will then charge up to the equilibrium value again at a speed which depends upon the setting of the VELOCITY control R_{43} and the value of the condenser C. This rapid discharge of the condenser C, prior to the effective time base sweep, can be achieved very simply by injecting a negative pulse to the synchronizing terminal.

19. In order to reduce the required injection voltage to a minimum, a further switch S_2 is included in the circuit. This short-circuits the resistance-capacitance filter which is normally included in the synchronizing circuit. The contacts of the switches S_1 and S_2 are mounted on a single switch wafer and this is, in turn, mounted in such a way that it can be operated automatically when the trigger control is rotated to its limit of travel in an anti-clockwise direction.

20. It will be appreciated that the negative pulse applied to the synchronizing terminal SYN causes anode current in V_5 to cease, thus permitting the grid of V_3 to assume the voltage of the H.T. positive line. This brings about almost complete discharge of the condenser C.

21. For most purposes, however, it is essential that the single stroke sweep should occur as quickly as possible after the application of the control pulse. It will be realized that C cannot commence to charge and, thus, produce the single stroke, until anode current has again been restored in the valve V_5. The negative pulse applied to the SYN terminal should, therefore, be of only sufficient duration to discharge C fully and the grid of V_5 must then return to earth in order to allow the sweep to occur. A condenser of suitable value is, to allow for this, connected externally between the SYN terminal and the negative supply providing the control pulse.

Amplifiers

22. The amplifier pentode valves V_6 and V_7 are utilized in a conventional resistance-capacitance coupled circuit. Inductance compensation by the coils L_3 and L_4 is introduced for the wide band frequency range. The valves, type V.T.60A, have a large dissipation and high slope and this provides the frequency range and voltage swing required.

23. The amplifier circuits are associated with a single control switch providing five different circuit combinations. The single control governs switch contacts of S_4, S_5, S_6 and S_7. The five positions are labelled "PLATES–D.C.", "PLATES–A.C.", "AMPLIFIERS, Y1, Y2", "AMPLIFIER, 2Y1" and "AMPLIFIER, 2HFY1".

24. When the switch is in the "PLATES–D.C." position the condensers C_{39} and C_{38}, which normally isolate the Y1 and Y2 deflector plates from the terminals Y1 and Y2, are short-circuited. A direct connexion is thus provided which enables measurements to be made in either Y1 or Y2 with both direct voltages and alternating voltages of low periodicity, provided the voltages to be measured are of sufficient amplitude to produce an adequate deflection. It is assumed that the low potential end of the voltage source is applied to the EARTH (E) terminal.

25. In addition to the direct connection to the terminals, each plate is also connected through a resistance R_{30} for Y1 and R_{31} for Y2. These resistances are of a value in the region of 3 megohms and it is important to remember this condition when making quantitative measurements from D.C. sources, more particularly if the source has impedance comparable with that value. These considerations will be dealt with more fully in the operational portion of this chapter.

26. When the switch is at "PLATES–A.C.", a coupling condenser C_{38} or C_{39} is interposed between the terminals Y1 and Y2 and the corresponding plates. Observations on A.C. voltages of the same order as the D.C. voltages available (para. 24–25) may be made and the beam deflection represents peak to peak voltage and not R.M.S.

27. At the position of "AMPLIFIERS–Y1, Y2", the Y1 and Y2 plates are each connected to the output of the single stage amplifier. Input to the Y1 amplifier is then made *via* the terminal A1. Likewise the signal from the Y2 plate is made *via* A2. Work voltage is therefore applied symmetrically across A1 and A2. The gain of the two amplifiers is adjusted independently by means of R_{18} for A1 and R_{25} for A2. The maximum gain from each in this switch position is of the order of 28 times. The time base is synchronized to which ever work voltage may be required by connecting either of the terminals Y1 or Y2 to the SYN terminal.

28. By changing the switch to the position "AMPLIFIER–2Y1", the valve which was previously employed between A2 and Y2 is transferred to the Y1 circuit and connected in cascade with the other amplifying valve to provide a two-stage high gain amplifier between terminal A1 and terminal Y1. The Y2 plate is connected *via* the isolating condenser C_{38} to the terminal Y2 and should be externally joined to the Earth terminal.

29. In this switch position both the GAIN controls R_{18} for V_6 and R_{25} for V_7 are applicable to the same beam and a maximum gain of the order of 900 times is available. To synchronize the time base Y1 is connected to SYN terminal.

30. The general circuit arrangement is basically the same as the foregoing when the switch is in position 5 or "AMPLIFIER, 2HFY1", that is to say, two stages in cascade, apply between terminals A1 and Y1 whilst the Y2 plate may be used without amplification. The anode loads of V_6 and V_7 are, however, modified so that the useful band-width is extended to approximately 2 Mc/s. The gain is reduced to 106 times, but this drop in gain does not preclude the examination of R.F. signals of relatively small amplitude, the sensitivity being still sufficient for this purpose.

31. To synchronize the time base the SYN terminal is connected to either Y1 or Y2. The maximum time base available is above 250 kc/s and it is, accordingly, possible to carry out waveform examinations on signals of frequencies of from 2 to 5 Mc/s.

32. It is possible to use the AMPLIFIER 2HFY1 position of the amplifier as an aperiodic R.F. amplifier in investigations, and when necessary, by re-arranging connections. In this event a rectifier, which may be either of the thermionic or of the barrier-layer type, is inserted in the Y1 sockets provided.

Y2 Attenuator

33. An attenuator device is incorporated in the circuit to be used at mains and audio frequencies to reduce the input in fixed ratios of $\times 2$, $\times 4$ and $\times 8$. This attenuator is associated with the resistance potentiometer of R_{48}, R_{49}, R_{50} and R_{51}. The device is not frequency compensated. The movable arm or link is connected to the Y2 plate and the full resistance end to EARTH through the condenser C_{34}. The attenuator application will be more fully dealt with under the operational notes of this chapter.

CONSTRUCTIONAL DETAILS

34. The illustration of fig. 1 shows the general arrangement of the oscilloscope with front panel controls and terminals. All the operational controls and terminals are mounted on the front panel of the instrument and, wherever possible, tandem controls have been used. The oscilloscope

consists of two parts, comprising the instrument proper and its outer case. The latter holds the carrying handle and is fitted with ventilating louvres and a detachable rear panel. The instrument slides into the case and is secured thereto by means of two 2 B.A. rear fixing screws, the edge of the front panel locating the open end of the case.

35. A top view of the instrument, as arranged for the VCR138, with cover removed is given in fig. 4. The instrument is built on a chassis with the front panel secured to one end and the C.R.T. supporting bulkhead a short distance from the opposite end. Beyond the bulkhead is located the mains transformer T_1 and rear connection panel. A mu-metal shield is mounted, at one end, on a bracket fixed to the bulkhead and, at the opposite end, to a cylindrical tube locating collar fixed to the front panel. Extra shielding is obtained by means of a mu-metal foil wrapped round the tube neck.

36. The C.R.T. is supported at the rear by a tube holder mounted on a plate fitted with a central spindle. The spindle is located in a bush on a metal adaptor flexibly mounted to the bulkhead by fixing through rubber bushes. The central spindle is fitted with a locking screw which can be loosened to enable the C.R.T. to be rotated and secured in the required position. The C.R.T. is supported in the front by the cylindrical rubber escutchen which fills the gap existing on the front panel between the sides of the tube locating collar and the tube bulb itself.

37. The 10 cm. graticule fits into a camera guide (*see* fig. 1) and can be inserted irrespective of whether a viewing hood is used or not. It is only removed when the camera is inserted. The correct axial position of the tube is with the crown of its screen set flush with the surface of the front panel so that the transparent 10 cm. scale rests lightly against the tube bulb when placed in position, the horizontal sweep of the time base being parallel with the horizontal ruling on the graticule.

38. Referring to fig. 4 it will be seen that, on the two sides of the C.R.T. and between the front panel and the bulkhead, are located the valves. An illustration showing the C.R.T. and shield removed is given in fig. 5. Underneath the mu-metal screen are located the various high voltage electrolytic smoothing condensers of the low voltage power supply, whilst the canned paper condensers for the high voltage C.R.T. supply are mounted on the back of the bulkhead above the transformer T_1 which is chassis mounted and has all its connections taken to a panel located on the underside of the chassis as shown (TP) in fig. 6. A diagram showing the numbered tags of this panel is shown as an inset to fig. 2.

39. The majority of the instrument connections are made on the underside of the chassis through the centre of which is located the amplifier switch (S_4, S_5, S_6 and S_7) serving to re-arrange the various circuits to the front panel terminals and tube electrodes. Parts of the chassis underside are subdivided for screening purposes.

40. The mains connection is made *via* a lead permanently fixed to the instrument and entering through a rubber grommet on the left-hand side of the chassis close to the front panel. The mains switch and a pilot lamp (PL_1) are fitted on the top corners of the front panel, the switch being to the right and PL_1 to the left (fig. 1). A two-pole switch (S_8 and S_9) is mounted on the TRIGGER control and is used solely for single-stroke facilities of the time base.

VALVES AND POWER SUPPLIES

41. The following Table A gives a list of the valves used in this apparatus:—

TABLE A

VALVE SCHEDULE

ANNOT.	A.M. TYPE	STORES REF.	FUNCTION
C.R.T.	V.C.R.138	10E/407	High vacuum oscilloscope
V_1	5Z4G	10E/598	Full-wave rectifier
V_2	V.U.120	10E/121	Half-wave rectifier
V_3	6J5G or	110E/68	I.H. triode discharger (time base)
	V.R.67	10E/11448	
V_4	V.R.56	10E/11402	I.H.H.F. pentode charger
V_5	V.R.56	10E/11402	I.H.H.F. pentode aux. discharge valve
V_6	V.T.60A	110E/8	I.H. pentode amplifier
V_7	V.T.60A	110E/8	I.H. pentode amplifier

The cathode ray tube and valve bases are shown as insets to fig. 2.

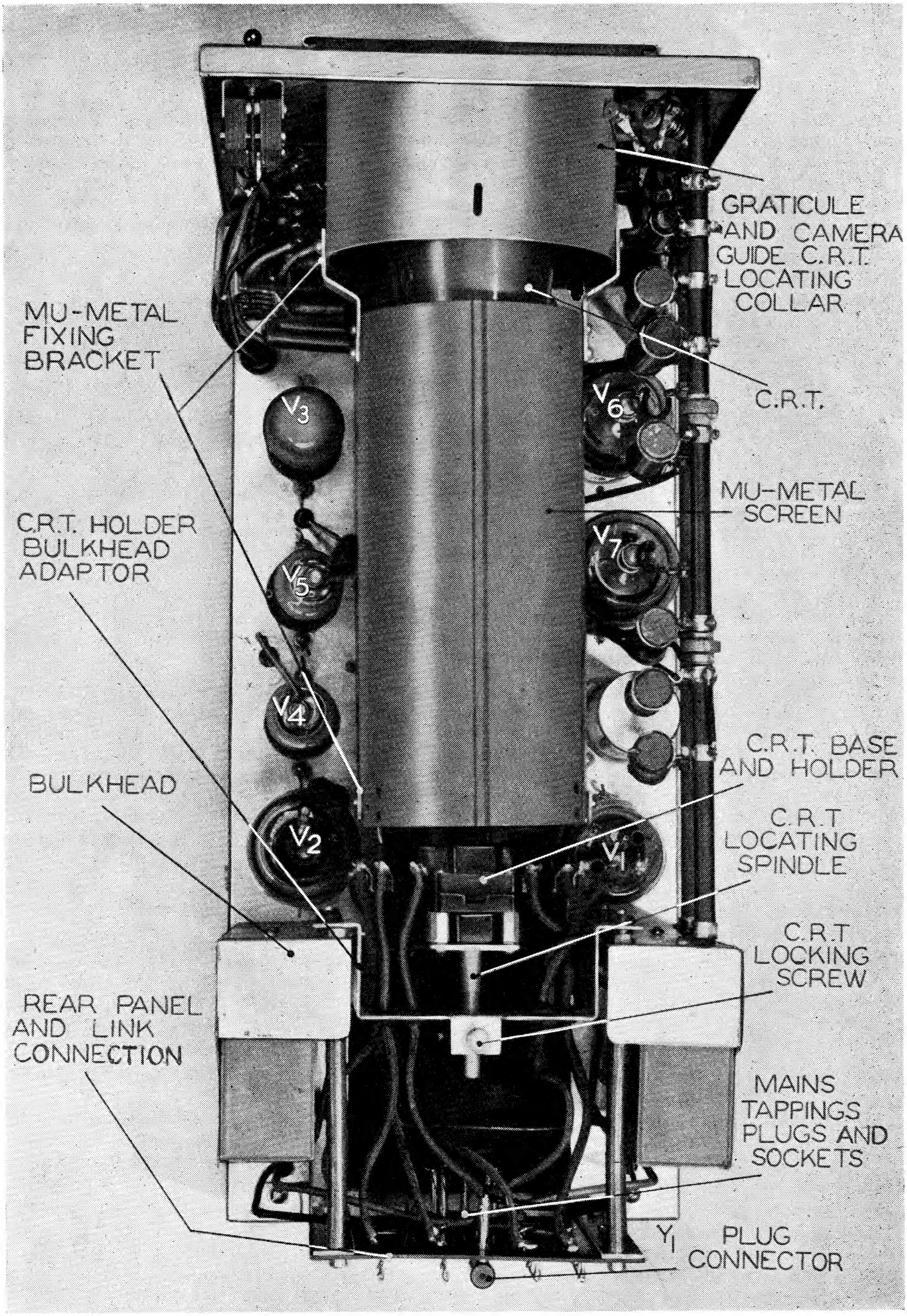

Fig. 4.—Chassis top deck view, cover removed with V.C.R.138

42. The power supplies are derived from the single-phase A.C. mains and transformer input tappings provide for voltages of 110, and 200 to 250 volts at 40 to 100 c/s. The approximate power consumption for the seven valves is 120 watts. The C.R.T. draws 1,100 volts and the V.T.60A valves 500 volts maximum. The C.R.T. type V.C.R.138 is shown in fig. 7. The screen diameter is 88 mm., overall length 332 mm.

OPERATION

43. The operation and general use of the instrument is discussed in the following paragraphs. Because difficulties are only likely to be encountered when endeavouring to apply the instrument to the best advantage to a specific test, it has been thought preferable to cover all the likely connections met in the practical use of the instrument under the heading "General Operation". These instructions are designed to follow the normal operating sequence, and the consideration covering all likely cases are thus discussed as a matter of course as and when they apply to any given control, terminal or connection. When deemed necessary or useful, repetitions have been made.

44. *Rear plate.*—A detachable plate secured by small instrument screws is located towards the top at the rear of the case. Removal of this plate gives access to a bakelite panel on which are mounted (*a*) the mains voltage selector, (*b*) the tube connecting links, of which the one corresponding to Y1 is formed by three sockets in a line and the 2-pin shorting plug, and (*c*) two cylindrical fuse holders containing a fuse for each H.T. supply. The 2-pin shorting plug of (*b*) is normally connected across the top and central sockets. Refer to illustration of rear chassis shown in fig. 8.

45. *Mains supply.*—Before the instrument is switched on, it is most important that the mains voltage selector be set to the position appropriate to the mains supply available. A mains switch and pilot lamp are located on the front panel.

46. *Mu-metal shield.*—The cylindrical mu-metal shield is provided to surround the tube as a precaution against external magnetic fields and those due to the instrument itself. A further screening is provided by the aid of a length of mu-metal foil wrapped round the lower end of the tube neck. The shield is fixed by means of small brackets to the front panel cylindrical tube guide, and, in the same manner, to the rear bulkhead. The tube can be placed in position without removing this shield. The necessity for its removal should therefore never arise in practice, even when servicing the instrument. Should this be attempted for any reason, or in any other circumstances in which the chassis is being handled, care must be taken to avoid the possibility of a sharp knock on the shield, as this is liable to alter its magnetic characteristics.

47. *Earth.*—The EARTH terminal serves essentially to connect to the oscillograph the return or "earthy" side (low potential end) of the external circuits, or apparatus, with which the instrument is being operated. The oscillograph will generally operate satisfactorily without being connected to a true earth point, although whenever it is convenient, such a connection should be made. This applies particularly when the instrument is operating permanently on a given bench, or when the instrument is installed on a rack. The independent earth connection is particularly advantageous when the instrument is being used in a strong interference field or when the amplifiers are being used at high gain. In general, all effects due to mains pick-up can be avoided or reduced by the use of a good earth.

Tube controls

48. The following controls affect the C.R.T.:—

(i) Y SHIFT.—Two are provided, one for each Y plate, and these enable the spot independently to be positioned vertically on the tube screen. Should either or both of these beams produce no visible trace, the concentrically-mounted Y SHIFT control knobs should be set to the mid-point of their travel. This will ensure that the beams are not deflected beyond the limits of the screen diameter whilst the other adjustments are being made.

(ii) X SHIFT.—Provides the means of positioning the spot or trace in the horizontal direction, and should be adjusted in the same manner.

(iii) BRILLIANCE.—This control should be advanced gradually in a clockwise direction to show up the spot if no trace is visible notwithstanding the central positioning of the SHIFTS. The BRILLIANCE control varies the negative bias applied to the grid of the tube and should be set always at a position that provides just sufficient brightness for the work in hand.

(iv) FOCUS.—This control may then be adjusted to its optimum value. It operates by varying the voltage on the 2nd anode of the cathode ray tube.

NOTE.—Slight readjustment of both the FOCUS and BRILLIANCE controls may be found desirable when the instrument is actually being used, as at high writing speeds greater beam current, and therefore a more advanced setting of the latter control, is necessary in order to produce sufficient luminosity of the trace.

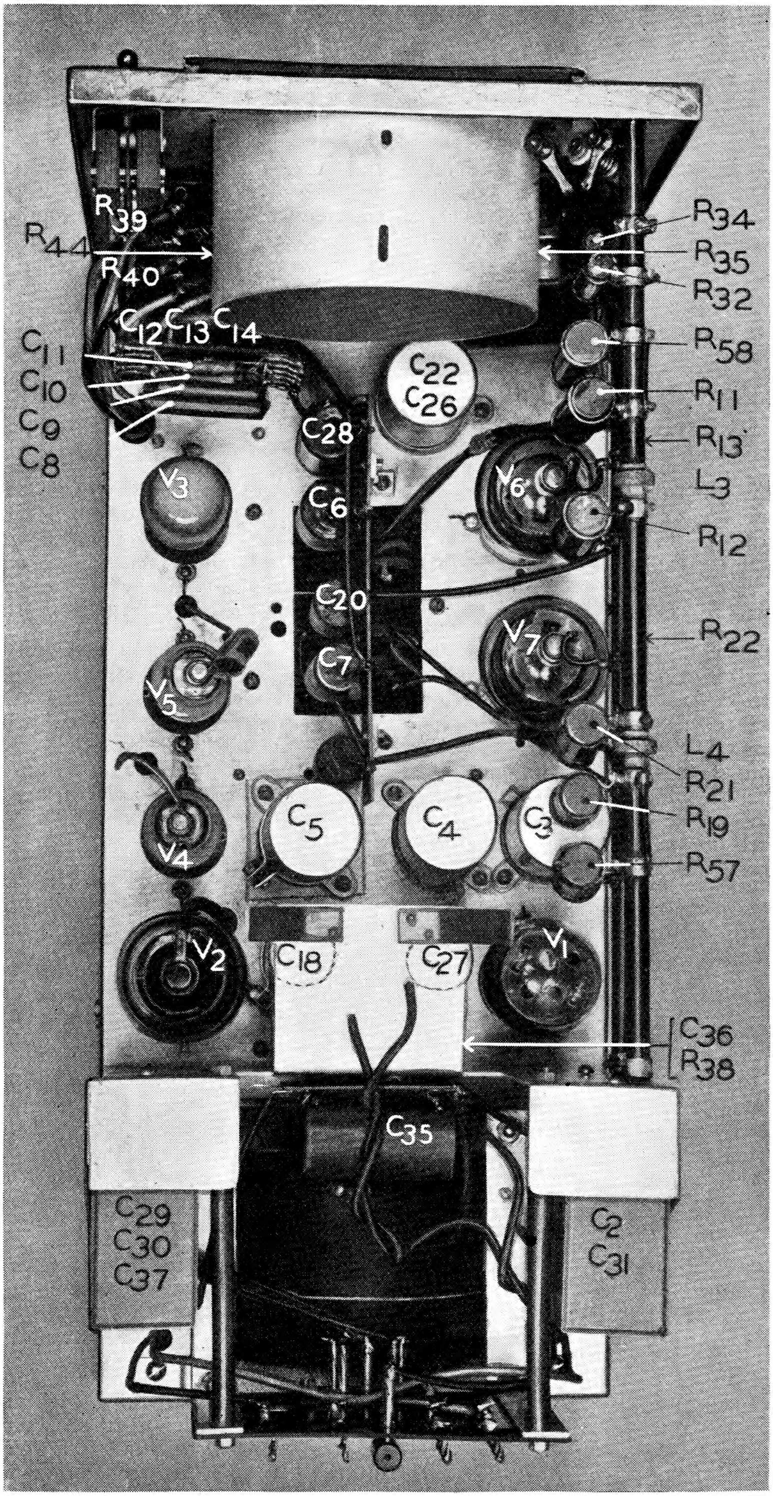

Fig. 5.—Chassis top deck view, C.R.T. removed

Horizontal or X axis controls

49. All the controls and circuit conditions which affect the operation of the cathode ray tube in the *horizontal* direction will be discussed in the following paragraphs 50 to 69.

50. X SHIFT.—The X SHIFT control provides the means of placing the trace in any required position on the horizontal axis. The X shift voltage is applied to the X2 deflector plate of the cathode ray tube, whilst the time base (or external X deflection, if applied via the X1 terminal on the front panel) is applied to the X1 deflector plate.

51. The X shift may, therefore, be used irrespective of the nature of the X-axis signal whether it be A.C. or D.C. This arrangement is made possible by the adoption of an electrode construction in the tube which gives correction for trapezium distortion and allows the use of an asymmetric time base which thus frees one of the X plates for shift purposes only.

52. *X1 terminal.*—The X1 plate is available for external use when the condenser switch is rotated fully anti-clockwise and the time base thus rendered inoperative. In this position the X1 plate is entirely disconnected from all the internal circuits but remains applied to the X1 terminal on the front panel. This permits injection of any external X deflection voltage and enables phase shift and other composite X- and Y-axis tests to be conducted. With the condenser switch in any other position, that is, with the time base working, the time base voltage is present at the X1 terminal and may be used externally. An instance of this latter application is the use of the time base for frequency modulation with the R.F. alignment oscillator.

53. The use of this terminal with the time base inoperative is particularly indicated for D.C. voltage measurements, not only because of the high input impedance, but also because the independent shift on the X2 plate enables the spot to be placed at such a position on the screen as to make use of its full diameter when unidirectional (D.C.) voltages are applied. Unidirectional voltages up to 250 may be measured. When accurate quantitative results are required it is advisable to calibrate each axis separately, as the sensitivity in the X-axis is less than that of the Y-axis.

54. As the X1 terminal has no direct connection to earth within the instrument when the time base is switched off, no error is introduced by the use of a relatively high resistance potentiometer should it be desired to increase the range of direct voltage which can be measured. It is essential that an external path for direct current should exist between the X1 and EARTH terminals when an outside signal is being applied, or the trace will not represent the true conditions. Such an external path can be provided by connecting across the X1 and EARTH terminals a high resistance of the order 1–3 megohms maximum. When the time base is inoperative and no voltage is applied to the X1 terminal, as in the case of the photography of slow transients, the EARTH and X1 terminals should be short-circuited.

55. When it is necessary to measure large direct voltages, these can be applied in the X direction, using an external potentiometer to extend the range. This step is not necessary with A.C., as voltages corresponding to more than normal full screen X-axis deflection may be measured or investigated in the Y-axis by use of the Y2 input potentiometer.

56. *Time base controls.*—The time base incorporated in this instrument is of the hard valve type. On this instrument the controls affecting the time base are engraved CONDENSER, VELOCITY, AMPLITUDE, TRIGGER AND SYN. (representing SYNCHRONIZATION).

57. The CONDENSER control takes the form of a switch which, in its fully anti-clockwise position, disconnects the time base from the X1 deflector plate. A spark internal to the instrument may be expected when moving the control to this position. Clockwise rotation of the CONDENSER control selects the various time base condensers in descending order of capacitance, until at the last position only the "strays" are left in circuit. This switch therefore provides a coarse control of time base frequency. Full clockwise rotation produces the highest time base speed, whilst the last position but one in the anti-clockwise direction produces the slowest time base speed.

58. On the fastest two ranges a negative signal is injected into the grid circuit of the cathode ray tube during the time base flyback in order to suppress the return trace during this period. In the same way a positive impulse of an amplitude which increases with frequency is applied to the same circuit so as to increase the brilliance with increase in speed without necessitating manual adjustment of the BRILLIANCE control R36 for this purpose.

59. The VELOCITY control R43 provides the means of obtaining a continuous variation of time base frequency over the entire range. The adjustment is sufficient to ensure frequency overlap between the ranges covered by the adjacent condenser switch position. The VELOCITY control takes the form of a voltage control in the screen circuit of the time base condenser charge valve. Clockwise rotation of the control increases the anode current of the charging valve, and therefore increases the time base speed.

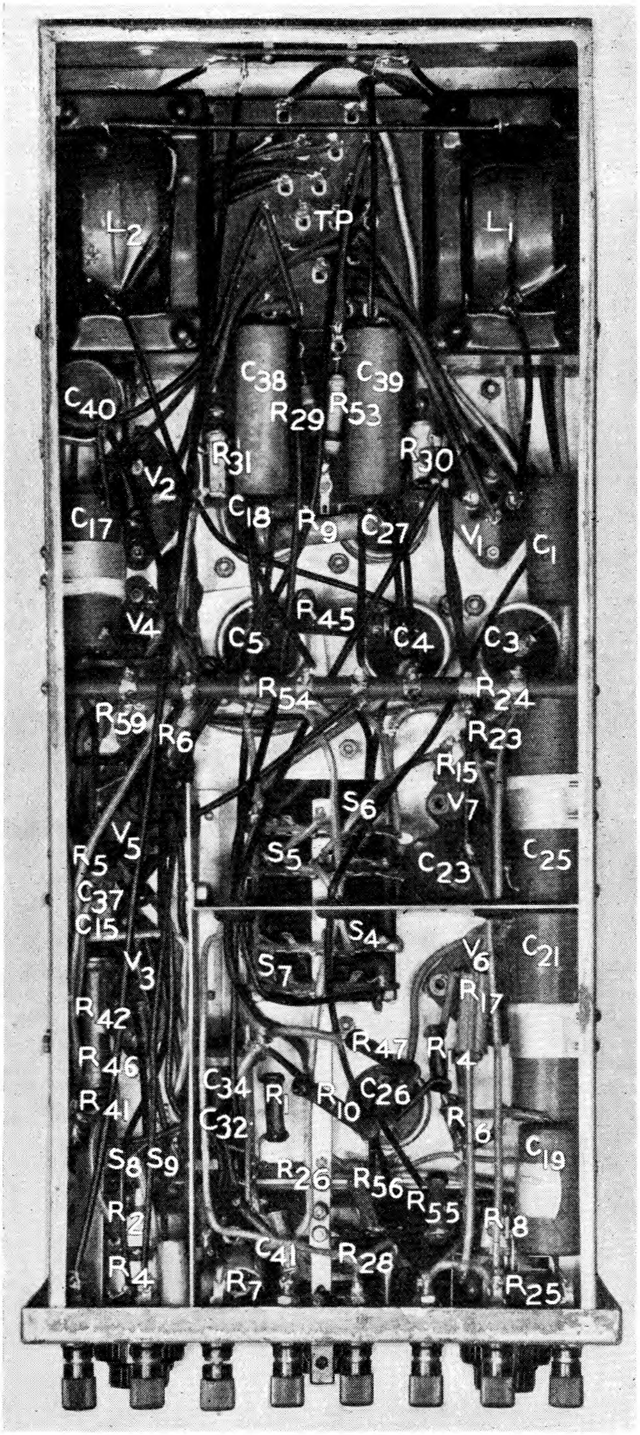

Fig. 6.—Chassis underside view

Fig. 7.—C.R.T. type V.C.R.138

60. The AMPLITUDE control R4 provides maximum amplitude when set fully clockwise, and its action will be appreciated when reference is made to the description of the time base circuit. This control enables the length of the X-axis deflection produced by the time base to be adjusted.

61. The TRIGGER CONTROL R2 is mounted concentrically with the AMPLITUDE, and the amount of trigger increases with clockwise rotation. The TRIGGER resistance controls the degree of coupling between the discharge and auxiliary discharge valves in the time base and varies the flyback time. This adjustment is not critical and, in general, the control should be rotated as far anti-clockwise as is consistent with regular operation of the time base. The fact that the TRIGGER control varies the flyback time may be made use of at high sweep frequencies, when it will be found to provide a smooth, fine adjustment of frequency.

62. The minimum trigger control setting is consistent with maximum linearity of time base traverse. In the fully anti-clockwise position this control operates the trigger switch.

63. The TRIGGER SWITCH serves a double purpose. In the off position it prevents recurrence of the time base, a fact which is used for single stroke operation of the time base itself. In the on position, and in conjunction with the consequent operation of the trigger control, it starts off the time base on a recurrent traverse. This item is comprised by a double switch S_8 and S_9 mounted on an extension spindle of the trigger control. In the off position, that is, fully anti-clockwise rotation of the trigger control, switch S_9 serves to short-circuit the fixed resistance R_5 in the grid of the auxiliary discharge valve and the other (S_8) to short-circuit the small series condenser C_{16} in the synchronising input control network.

64. The synchronizing control engraved SYN is mounted concentrically with the X SHIFT, and controls the attenuation between the SYN terminal and that electrode of the time base auxiliary discharge valve by which synchronism is achieved. Connection to the synchronizing circuit at a separate terminal allows of flexibility in operation as the time base may be synchronized with any desired signal, such as the work voltage, mains frequency, or any independent or master frequency. Clockwise rotation increases the applied signal and the control should always be kept as far anti-clockwise as possible in order to avoid introducing distortion of the trace due to velocity modulation of the time base.

65. The procedure which should be adopted is to set the SYN, control in its fully anti-clockwise position and adjust the velocity control until the time base is operating as nearly as possible at the frequency to which synchronism is required. Slight rotation of the SYN. control in a clockwise direction will then suffice to lock the time base.

66. The injection of excessive synchronizing voltage causes the time base traverse to shorten and will also tend to produce non-linear and generally erratic behaviour of the time base. This is particularly the case if for any reason the time base is operated at a frequency higher than that of the work voltage. Consequently, the most satisfactory results are obtained at the lowest SYN. control setting which is consistent with stable synchronism.

67. The synchronism attainable with the time base is of a positive nature, and is characterised by two other features of importance. Firstly, the synchronizing circuit is isolated from the time base by a valve, and in consequence does not inject saw-tooth time base voltages into the work source, whilst secondly, the input impedance of this circuit is high, and remains sensibly constant irrespective of the setting of the SYN. control.

68. Where it is desired to synchronize the time base from the incoming work voltage applied to the A1 or A2 terminals, that is, when an amplifier is being used the SYN. terminal should always be connected to the output of the appropriate amplifier, and not to the input, that is, the SYN. terminal should be connected to the corresponding Y1 or Y2 terminal. This applies particularly under high gain conditions, as in these circumstances the input may be so small as to be quite incapable of affording satisfactory synchronism.

69. A link is provided, connected to the SYN. terminal, which can be swung on to either the Y1 or CAL. terminals situated at either side for synchronizing either to the work circuit or to the A.C. mains frequency in the manner prescribed. It is understood in the former case that the circuit to which the time base is to be synchronized is applied to the A1 or Y1 terminal.

Vertical or Y-axis controls

70. The controls and circuit conditions which affect the operation of the cathode ray tube in the vertical direction will be discussed in the following paragraphs 70 to 102. It will be found that the Y-axis controls are concentric, in particular the Y1 and Y2 shifts and the A1 and A2 gain.

71. *Y1 and Y2 shifts.*—Two Y shift controls are provided operating respectively on the Y1 and Y2 deflector plates. With the single beam tube fitted to the instrument, the two potentiometers should be manipulated as one. Their relative position is set in a manner to provide a balanced Y shift which reduces astigmatism and also, to some extent, deflection defocussing. To secure this it is sufficient to rotate the controls to the limit of their travel in one direction and the two knobs are interlocked by means of a countersunk screw.

72. Another method of doing this is described in the paragraph 76 on "Position 1—plates D.C." In practice, the positions of the respective controls in relation to the fixing pin have been set to ensure the best condition to avoid the effects mentioned above, and it will be found that these controls are permanently locked in the manner stated. It may be found that, as a result of the setting obtained it may not be possible to adjust the shifts to the same extent as when set independently.

73. *Y1 and Y2 terminals.*—These two terminals are connected directly to their respective deflector plates with the amplifier switch in the first position ("Plates—D.C.") and are connected to the deflector plates through the medium of isolating condensers in every other position of the amplifier switch. In the fourth and fifth positions of this switch the Y1 terminal is also connected to the output of the two amplifier valves in cascade should it be desired to use these externally. In the third position the Y1 and Y2 terminals are connected to the outputs of the A1 and A2 amplifiers respectively.

74. *A1 and A2 terminals.*—In positions 3, 4 and 5 of the amplifier switch, terminal A1 is connected through an isolating condenser to the grid of the amplifier applied to the Y1 deflector plate. In the third position terminal A2 is connected through a condenser to the input of that amplifier connected with the Y2 plate; in the first, second, fourth and fifth positions the A2 terminal is inoperative.

Amplifier switch

75. The amplifier switch has been designed to provide a single control by which the instrument can be set to any required operating condition. The switch provides five different circuit combinations. In the information given below the anti-clockwise limit of rotation of the switch is regarded as position 1, and the limit of clockwise travel as position 5.

76. *Position 1, "plates–D.C."*—With the switch in this position the condensers isolating the Y1 and Y2 deflector plates from the terminals carrying these markings are short-circuited. A direct connection is thus provided which enables measurements to be made on either Y1 or Y2 with both direct voltages and alternating voltages of low periodicity, provided the voltages to be measured are of sufficient amplitude to produce an adequate deflection. It is assumed that the low potential end of the voltage source is applied to the EARTH terminal. In addition to direct connection to the terminals, each plate is also connected through the medium of a 3-megohm resistance to its appropriate shift potentiometer, and it is important to remember this condition when making quantitative measurements from D.C. sources. This applies particularly when the source has an impedance comparable with 3 meghoms.

77. When the input D.C. source is of low resistance its effect is, virtually, to short-circuit the shift voltage on the Y1 and/or Y2 deflector plate used. The corresponding SHIFT control is therefore inoperative. However, for D.C. measurements it is in any case advisable to operate the plates with no shift potential. This condition may be arrived at by connecting the Y1 and Y2 terminals to earth and setting the two Y shift potentiometers independently to the positions at which there is no displacement of the beams when the amplifier switch is moved alternately to positions 1 and 2.

78. When applying an asymmetric work voltage in the Y direction it can be connected to either Y1 or Y2. The resulting deflection when applied to one plate is spatially 180° out of phase when applied to the other plate. The plate which is inoperative should be joined to earth by the EARTH terminal of the instrument via a large condenser. The shift voltage which will then be effective is the one operating on this plate.

79. Full screen deflection can be used for testing unidirectional or D.C. voltages if the working Y plate has zero shift, and shift, if required, is applied by means of the other Y plate.

80. For other waves of low periodicity, as would be applied in this position, a maximum equivalent to 40 v. R.M.S. is possible, but in this case the peak to peak deflection covers the whole screen (at 0·45 v. R.M.S. per mm.).

81. *Position 2, "plates–A.C."*—(a) *External signals on Y1 and/or Y2.*—A coupling condenser is between the Y1 and Y2 terminals and the appropriate plates with the switch at this setting. With the instrument set in this way all the usual voltage observations may be made on A.C. over the same

voltage values as specified for D.C. (position 1). The deflection obtained will represent the peak to peak voltage and not its R.M.S. value. In this switch position only alternating voltages down to a frequency of about 20 c/s can be tested; on the other hand the input capacitance of the instrument provides the first factor limiting the highest frequency which can be investigated in this position.

82. The work voltage can be applied either to the Y1 or Y2 terminal. There is a 180° phase shift between the trace obtained on each. In the case of A.C. work voltage, to whichever deflector plate it is applied the other should be joined directly to the EARTH terminal. The isolating condenser in the deflector plate leads inside the instrument will avoid the shift voltage being short-circuited in the A.C. position of the amplifier switch.

83. For A.C. voltages greater than 100 v. R.M.S. the Y2 attenuator should be used. When it is desired to synchronize the time base to either the signal applied to Y1 or that applied to Y2, the terminal marked SYN. should be connected to the corresponding terminal.

84. (*b*) *External signals on X and Y*.—When it is desired to apply two separate external signals of the same frequency in the X and Y directions, as in the case of phase shift tests, this may be done by stopping the time base and following the instructions given later (para. 88) covering the case of an external voltage applied in the X direction.

85. *Position 3, "amplifier–Y1Y2"*.—(*a*) *Normal setting—amplifiers on Y1 and Y2*.—In this central position of the switch the Y1 and Y2 deflector plates are each connected to the output of the single stage amplifier, the input to the Y1 amplifier being made via terminal A1. Likewise, the signal for the Y2 plate is made via A2. The work voltage is accordingly applied symmetrically across A1 and A2. Although the gains of the two amplifiers may be controlled independently they must be adjusted to give the same deflection for the same input voltage on A1 and A2. The maximum gain from each in this switch position is of the order of 28 times.

86. The maximum deflection obtainable in this position without distortion covers well over the full screen diameter. The time base is synchronized to either work voltage by connecting the SYN. terminal either to Y1 or Y2. This amplifier switch position provides balanced amplified deflection from any signal source which is balanced about earth, a condition which reduces deflection defocussing and residual astigmatism in the tube.

87. Another advantage of this method of operation is in the observation of voltages across two points which are both of a high impedance with reference to earth and cannot therefore be applied without provoking distortions both in amplitude and phase, chiefly of the higher components of the wave, brought about by the different capacitances to earth of the usual input terminals A1 and EARTH used with normal asymmetrical working

88. (b) *Abnormal setting—amplifiers applied to X and Y*.—It may happen that for some applications it is necessary to apply an external signal to both the X- and Y-axes, and that both these signals have to be amplified, using the amplifiers within the instrument. When two separate external signals of the same frequency are applied in the X and Y direction, as in the case of phase shift tests, it will entail connecting the Y2 amplifier to the X1 plate by rearranging the rear panel connections, as discussed later.

89. The time base, which is not used when an external voltage is applied to the X-axis, is made inoperative by rotating the CONDENSER control to the fully anti-clockwise position. This frees the X1 deflector plate, which remains directly connected to the X1 terminal.

90. To apply the two signals to the X- and Y-axes, the X1 tag is then connected to the lower Y2 tag on the rear panel, the link removed from the Y2 plate and the latter earthed. A one to three megohm resistance must be joined between the X1 and EARTH terminals. Any input signal applied at A2 will then be present amplified at the X1 terminal, and thus produce the X deflection on the tube, the other signal being applied to the A1 terminal.

91. *Position 4, "amplifier–2Y1"*.—By changing the switch to this position the valve which was previously employed between A2 and Y2 is transferred to the Y1 circuit and connected, in cascade, with the other amplifying valve to provide a two-stage high gain amplifier between terminal A1 and terminal Y1. The Y2 plate is connected, *via* an isolating condenser, to the terminal of the same designation, and should be joined to the EARTH terminal.

92. With this switch position both the amplifier gain controls are, of course, applicable to the same beam, and a maximum gain of the order of 900 times is available. Also the maximum deflection obtainable in this position without distortion covers well over the full screen diameter. It must be appreciated that, with gains of the order mentioned, the greatest care is necessary in connection with the input wiring in order to avoid excessive hum pick-up. To synchronize the time base, as usual, connect SYN to Y1. The procedure with separate external signals on the X- and Y-axes has already been given.

93. *Position 5, "Amplifier–2HFY1".*—The general circuit arrangement is fundamentally the same with this switch position as in position 4. That is to say, two stages, in cascade, apply between A1 and Y1, whilst the Y2 plate may be employed without amplication. The anode loads of the amplifiers are, however, modified so that the useful band-width is extended to approximately 2 megacycles. The gain obtainable is 106. This results in a corresponding drop in gain, but the sensitivity is still sufficiently great to enable radio frequency signals of relatively small amplitude to be investigated.

94. On account of the high maximum time base speed available (above 250 kc/s.), it is possible to carry out wave-form examination on signals having frequencies of 2 to 5 Mc/s. To synchronize the time base, connect SYN to either Y1 or Y2. The maximum deflection obtainable, without overload, with the amplifiers in this position is almost full scale. The procedure with separate external signals on the X- and Y-axes has already been given.

95. It is possible to use the 2HFY1 position of the amplifier as an aperiodic H.F. amplifier in high frequency investigations and when necessary, by re-arranging the rear panel connections, to interpose a rectifier for detecting the low frequency envelope or modulation, before application to the tube deflector plates. The detector can be of the thermionic or barrier-layer type, inserted in the Y1 sockets provided.

Amplifier gain controls (A1 and A2)

96. These two concentrically mounted controls affect the gain of the two amplifier valves independently. With the amplifier switch in the third position the foremost knob is that controlling the amplifier feeding the Y1 deflector plate. In the case of the fourth and fifth positions, both knobs affect the gain to the Y1 deflector plate.

97. Any signal of such an amplitude as to require a gain of less than two times to prevent over-sweeping of the screen of the cathode ray tube is, necessarily, sufficiently large to give a serviceable image with no amplifiers at all (position 2), and by taking advantage of the fact it has been possible to adopt a form of gain control having no undesirable effect upon the frequency response of the amplifiers. As a result of this, not only is there the usual higher limit to the voltage amplitude than can be applied to the amplifier input without overload, but the GAIN control is not designed to reduce the output deflection to zero or thereabouts with input signals of sufficient amplitude to provide half-screen deflection without amplification.

98. The gain controls are always effective independently for each amplifier valve, irrespective of the position of the amplifier switch, and care should be taken in their adjustment to avoid overloading of either stage in the cascaded positions 2Y1 and ZHFY1. The maximum gain control setting which can be applied, in any given case, without causing overload, is readily determined by trial, the setting chosen being, preferably, as much as possible below the point at which distortion appears on the trace. It is better to operate the first amplifier at near its maximum gain without overloading the second amplifier, which is adjusted to the required level

Y2 attenuator

99. This device is located on the small multi-socket panel at the top of the front panel escutcheon. The two lower sockets, into which is fitted a special plug, are intended solely for the deflector coils; the spacing of the sockets is such as to make it impossible to interconnect these with the attenuator sockets. These latter are situated above, and the central socket is connected directly to the Y2 deflector plate of the cathode ray tube, while the X1 socket is connected to the Y2 terminal on the front panel of the instrument. An inset to fig. 2 shows the details of this circuit. The short-circuiting or link plug would, normally, be connected between the centre socket and the X1 socket, so that the voltage applied to the Y2 terminal goes direct to the corresponding deflector plate of the tube (as is always the case with the Y1 terminal).

100. When the input voltage has to be reduced the link plug is withdrawn and inserted between the centre socket and one of the remaining three surrounding sockets, providing the required reduction ratio The factor for each position is engraved on the escutcheon itself. Because the cathode ray tube cannot be damaged by an overload of the order involved, a mistaken connection will not produce ill effects.

101. The Y2 terminal is used because it is free from the amplifier at all positions of the amplifier switch except position 3, giving a Y1Y2 condition of operation. After using the attenuator it is important to return the link plug to the X1 setting whenever position 3 of the amplifier switch is in use. Unless this is done the full output and gain of the Y2 amplifier will not be utilised.

102. With shifts applied to each Y plate, the shift circuit resistances, and therefore also the position of the shift control, materially affect the reduction ratio of the attenuator, more especially on the high reduction ratio steps, and whilst the attenuator itself can be used to reduce the amplitudes of very low frequencies, it cannot serve for quantitative measurements on these same low frequencies or D.C. The attenuator is not frequency compensated, and cannot be used at frequencies much higher than the audio frequency range.

Calibration

103. In order to provide an approximate means of calibrating the deflector plates for quantitative work a calibration winding (17–18, fig. 2) is included in the instrument. This winding has an output of 50 volts peak to peak, and one side (17) is connected internally to the chassis of the instrument, the live end (18) being terminated at the "C" terminal. It will be appreciated that as this voltage is derived from the mains transformer, measurements based upon it are subject to errors due to mains voltage variations. In the majority of cases, however, an accuracy within 10% may be expected. For accurate work the calibration voltage can be determined for a given mains voltage by means of an accurate voltmeter, and by using the 10 cm. scale graticule as shown in the illustration of fig. 1.

104. A protecting resistance R_{54} is connected in series with the calibration winding to avoid the risk of damage to the mains transformer T_1 should the lead from the "C" terminal accidentally touch the chassis or other earth point.

105. It will be noted that the trace of the voltage obtained from the calibration terminal shows small kinks not present on the A.C. mains voltage when applied directly (attenuated if required) to the Y2 terminal. These kinks are due to the current changes resulting from the action of the instrument's rectifiers, which operate from the same mains transformer. This effect is of no practical consequence.

OPERATING CONDITIONS

106. This section is devoted to a discussion of the less obvious points connected with the operation and conditions of use of the oscillograph, points which are certain to arise in practice, and where difficulties are likely to be encountered, particularly with users who have not considerable experience with the use of oscillographs.

107. *Amplifiers.*—One factor which should be remembered in connection with the amplifiers used in this instrument is that they impose a virtually constant load on the input source irrespective of the gain control setting. In addition, any phase distortion introduced in the amplifiers is minimised by reduction of the gain, and where very low frequency phenomena are being observed it is frequently advantageous to tolerate a slightly smaller picture and reduce the gain setting on account of the improvement in amplifier performance thus produced, at both low and high frequency ends of the characteristic.

108. *Use as a high frequency amplifier.*—The inevitable limitations of the amplifier performance at very low frequency and at D.C. can be circumvented in all those cases where the effect investigated is made to modulate an R.F. carrier, such as on radio circuits (for oscillator tracking and modulation tests) or on R.F. polarized pressure indicating devices and bridge circuit measurements. The necessary amplification can be done by the instrument at R.F. and a rectifier added to operate directly at the deflector plates.

109. A circuit inset to fig. 2 shows an arrangment using two type WMX281 rectifiers as voltage doubler replacing the rear panel Y1 link. The addition of a low capacity 2.P.D.T. switch would allow the device to be used as a permanent fitting. The dotted wiring in the diagram indicates existing instrument circuits. For carrier waves using a supersonic frequency up to 100 kc/s., customary in mechanical investigations, the Y1Y2 or 2Y1 position of the amplifier can be used. When higher carrier frequencies are used, such as are common in radio practice, the 2HFY1 position of the amplifier is necessary.

110. To simplify the connections and procedure in this important case, instead of a soldered link being used for the Y1 connections three sockets in line and a 2-pin shorting plug are provided on the rear panel. This latter is withdrawn from its normal position across sockets 1 and 2 from the top and the circuit is connected as shown.

111. A cathode ray tube probably disturbs the conditions of electrical circuits less than any other measuring instrument. Nevertheless, for accurate work, particularly at radio frequencies, due allowance should always be made for such circuit disturbances as are produced.

112. In those cases where the impedance of the test circuit is high and the one megohm input resistance of the instrument is still liable to affect the result, a series resistance of from one to five megohms can be added to the lead. This expedient should also be adopted when, as in the case of alignment of intermediate frequency circuits, a low frequency signal comprised by the rectified

modulation envelope of the R.F. carrier is obtained from the R.F. circuit. In this case the series resistance serves to remove the input capacitance, due to the instrument and leads, from affecting the test circuit. The series resistance should then be applied at the free end of the screened input lead of the oscillograph.

113. When applying signals to either the Y1 or Y2 terminals the resistive component of the input impedance is sufficiently high (three megohms) to be disregarded for most work.

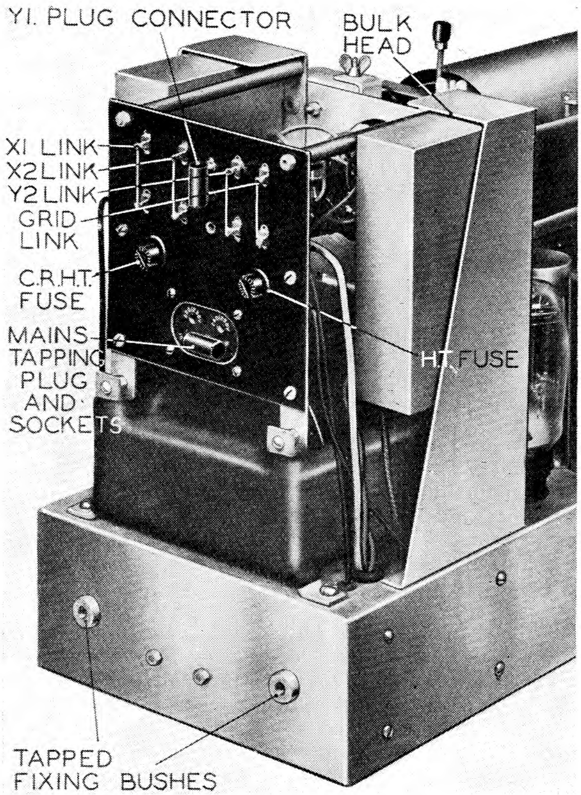

Fig. 8.—Chassis, rear view

114. Although the capacitance imposed, in shunt, across the external circuit may be disregarded for most work at power and audio frequencies, its effect on radio frequency circuits, and more especially on those of a resonant nature, may be considerable. This condition frequently arises in connection with the same alignment tests mentioned above when it is desired to inspect the selectivity of radio frequency and intermediate frequency transformers by examining the modulated radio frequency envelope present across the windings.

115. In such cases the fifth position of the amplifier switch may be used ("2HFY1"), when it will be found that the gain is sufficient to allow the connection from the oscillograph lead to the actual test point to be made with a very small condenser of 1 or 2 $\mu\mu$F. It will be appreciated that when this is done the change in the resonant frequency of the tuned circuit will be very slight, particularly in the case of intermediate frequency transformers, as such circuits usually employ tuning capacities which are very large by comparison with 1 $\mu\mu$F.

116. It must be remembered that the effect of this latter is to reduce the effective signal input to the oscillograph in proportion to the ratio between the equivalent impedance of this small series capacitance (at the required frequency) and the impedance corresponding to the sum of the capacitance of the instrument input and connecting leads.

117. When the amplifiers are being used and the time base is being synchronised with the work voltage, the synchronising circuit loading does not appear across the work circuit, as the SYN. terminal is connected to the output of the amplifier. On the other hand, when the signal is being applied straight to the plates without the intermediate use of an amplifier, any synchronism with the incoming signal necessitates the presentation of the synchronising circuit impedance across the source.

118. In this instrument not only is this loading very slight but in a number of cases it will be found possible to obtain perfectly satisfactory synchronism with a high value of resistance as the connection between the SYN. terminal and the work voltage. As much as 5 megohms may frequently be employed and the effect of a load of this order is completely negligible on most circuits.

Rear panel link strip

119. For certain work it will be found convenient to make use of the link panel at the rear of the instrument (*see* fig. 8). The links carried by this panel serve to connect the four deflector plates and grid of the cathode ray tube to those parts of the oscillograph circuit with which they are normally associated. These links may be disconnected by unsoldering when it is desired to have direct access to these tube electrodes. The top tags go to the cathode ray tube socket and lower tags to the instrument circuits and terminals.

120. The flexibility allowed by this arrangement permits a number of practical applications with the oscillograph, and such applications generally fall under one of the following headings:—

(i) Measurements for which it is essential to present a minimum of capacitive loading across the external circuit.

(ii) Applications, chiefly on symmetrical work circuits, where the instrument is used simply as a cathode ray tube unit and none of the internal circuits are required.

(iii) Applications which call for rearrangement of the instrument circuits.

121. Examples of the first class of application are the taking of measurements at high radio frequencies (and with intermediate frequency and video amplifiers), or the use of the grid connection for beam triggering, for time marking purposes on transients and for general photographic investigations. The most usual case of the second class is when the work circuits provide large voltages, usually of the push-pull type, which can be applied directly to the tube. A further important case is the study of the relative timing of events using the circular time base.

Grid connection

122. Reference should be made to the use of the grid connection because this is often required in practice—chiefly for beam switching and for timing purposes, usually in connection with photographic recording. In such cases use should be made of the rear panel link strip. In all the applications the resultant action involves a change of intensity in the cathode ray tube beam, that is, both timing and beam switching are obtained by intensity modulation. This may be achieved by removing the grid link and replacing it by a resistance. As in the case of plate return resistances, the value must be chosen with regard to the work on hand, but, in general, a 100,000-ohm resistance may be used.

123. The intensity modulation voltage should be applied to the upper of the two grid tags through a condenser capable of withstanding the full tube voltage of 1,100 volts. Caution should be observed when making any adjustments to these links, as, even after the instrument has been switched off for some seconds, an unpleasant shock may still be obtained from certain parts of the circuit due to the retention of charge by various smoothing condensers. This general precaution applies particularly in the case of alterations in the grid circuit of the cathode ray tube, as this point is 1,100 volts negative with regard to earth, and almost 2,000 volts negative relative to the time base and amplifier anode supply.

Time base

124. Practical application of the time base occurs on frequency comparison tests. The procedure and adjustments remain the same, irrespective of the size and shape of the recurrent trace and whether one or more waves are to be inspected at the same time, and whether their frequency is 50 c/s or 5,000,000 c/s. The only slight difference is at the higher frequencies, where recourse can be made to the trigger rather than the velocity control for adjusting to exact synchronism, because of the finer means of adjustment it provides.

125. It should be remembered that the fundamental relation of all time base circuits makes the capacitance, charging resistance, voltage amplitude and frequency directly dependent on one another. This means that interdependence of the time base controls is unavoidable, and that from the practical point of view the change in amplitude will affect frequency, and vice versa. This latter fact is useful on investigations at very high frequencies, because it makes possible the examination of a single wave by reduction of the sweep amplitude, which provides a higher sweep frequency.

126. By reduction of the amplitude control to zero or thereabouts and using the Y2 amplifier by rearranging the rear panel links, it is possible to use the time base of the instrument in the third position of the amplifier switch Y1Y2 as an amplified time base in those applications which require the possibility of changing the amplitude without change of frequency and thus readjustment of the other time base controls.

Single stroke time base

127. The switching arrangements included in the instrument in order to enable the operator to use the time base circuit for producing a single stroke traverse have already been described in principle. There are, however, a number of points which must be remembered when making use of this facility. The necessity to provide a negative pulse of the correct duration has already been mentioned and the following suggestions may be followed. In the ordinary way, a 16-volt negative supply will be adequate and may be provided conveniently by two 9-volt grid bias batteries in series. This voltage may then be applied between the SYN. terminal of the instrument and EARTH, through a series condenser, the capacitance of which should be varied to suit the sweep speed required.

128. It has already been mentioned that it is not necessary to provide a different capacitance condenser for each of the time base COND. switch positions, and a 0·005 μF condenser will be found suitable for the slowest three condenser speeds on the time base, whilst a 0·0002 μF condenser will cover the next three faster speeds. Above the sixth condenser stud, the discharge of the time base condenser prior to the single sweep becomes rather long compared with the sweep speed, and single stroke operation on the fastest three time base condenser switch positions is not normally to be recommended. A 5-megohm resistance should be connected in parallel with the injection condenser so that this condenser may discharge automatically between successive sweeps.

129. In order to use this single stroke facility the TRIGGER control should first be rotated to its limit of travel in an anti-clockwise direction. This will cause the time base to cease recurring. The X SHIFT control should then be rotated in a clockwise direction until the beam is deflected just beyond the right-hand limit of the screen diameter.

130. The time base speeds obtained under single stroke working will be similar to the speeds obtained at the corresponding CONDENSER and VELOCITY settings when the time base is operating under recurrent conditions, and from a consideration of the work in hand, a decision can be made as to which condenser switch position should be used.

131. Having decided this point the appropriate injection condenser value suggested above may be adopted, and the application of the negative voltage through such a condenser will produce rapid discharge of the time base, causing the spot to travel from right to left across the screen, followed by the actual single stroke from left to right.

132. The behaviour of the time base will, however, depend somewhat critically on the setting of the SYN. control. This should first be rotated to its fully anti-clockwise position, at which setting the time base will not operate at all. This control should then be rotated slowly in a clockwise direction whilst negative pulses are applied at frequent intervals.

133. As the SYN. control is advanced it will be seen that successive applications of a negative pulse produce an increasing length of sweep until eventually a setting of the SYN. control will be found at which the spot just traverses a complete screen width. This is the correct setting of the SYN. control for the particular velocity conditions, and the same adjustment technique may be adopted whenever the CONDENSER or VELOCITY controls on the time base are adjusted. The AMPLITUDE control should be kept at maximum (i.e., fully clockwise) whenever the single stroke facility is being employed.

134. The applications for which this type of time base is most suitable are the visual investigation of slow transients and for photographing relatively fast transients, such as those associated with the make and break of circuits during short circuit tests. A long afterglow tube, if available, should be used in the former case.

135. For convenience in reference the following average specification figures are summarized. They are, of course, approximate and the normal production tolerances may be expected:—

(1) *Input impedance*:—

	Capacity $\mu\mu$F.	*Resistance megohms*
To input terminals	70	3·0
Direct to tube panel	20	As required
Through amplifier	40	1·0
Synchronisation (added)	20	2·0

(ii) *Calibration*:—

50 volts peak to peak
17·7 volts R.M.S.

(iii) *Y2 attenuator*:—

Maximum voltage range	400 v. A.C. R.M.S.
Frequency range for A/C only ...	From 30 c/s to 15,000 c/s. Not frequency compensated
Reduction ratios	×1, ×2, ×4, ×8

(iv) *Time base*:—

TABLE B

Sweep Frequency Ranges

Frequency range

Condenser Switch Position	Velocity control	
1	Time Base	Inoperative
	Min	Max
2	6	15
3	11	60
4	50	270
5	250	1,000
6	850	3,500
7	3,000	13,000
8	10,000	30,000
9	20,000	70,000
10	50,000	250,000 and above

(v) *Amplifier*:—

	Gain (approx.)	Frequency Band in c/s ± 3 db.	Sensitivity in mV R.M.S./mm. VCR.138 tube
1 stage	30	10–100,000	15
2 stage:—			
High gain position .	900	10–100,000	0·5
Wide band position ...	106	10 to above 2.000,000	4·25

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SECTION 6

W/T AND R/T ANCILLARY EQUIPMENT

SECTION 6

W/T AND R/T ANCILLARY EQUIPMENT

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SECTION 6, CHAPTER 1

RECTIFIER, TYPE B

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RECTIFIER, TYPE B

(Stores Ref. 10A/8067)

INTRODUCTION

1. The rectifier, type B, has been designed primarily to provide H.T. and L.T. supplies for ground station transmitters such as transmitter, type T.70. It is composed of two units, a smoothing unit and a rectifying panel. The rectifying panel may be either, panel, rectifying, type A (Stores Ref. 10A/8068) or panel, rectifying, type B (Stores Ref. 10A/11156). When the apparatus is connected to a standard A.C. supply system, it provides a rectified and smoothed H.T. supply at 3,000 volts, ·5 amps. and an A.C. filament supply of 20 volts, 20 amps. In addition a 14-volt A.C. supply is available.

2. The apparatus has been so adapted that it may be controlled from some remote operating station or, alternatively, it may be locally controlled at the W/T station. Provision has been made whereby the filament supply may be switched on to the transmitter independent of the H.T. supply. Two 14-volt terminals have been added to provide a convenient source of supply for A.C. keying, or any other suitable purpose.

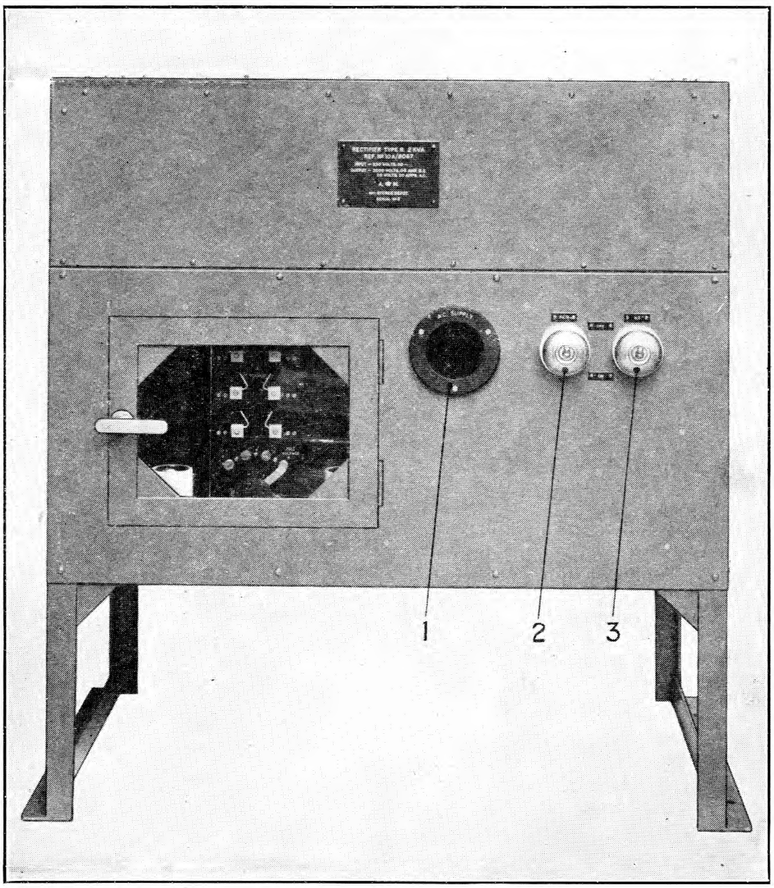

FIG. 1. Rectifier, type B, front view.

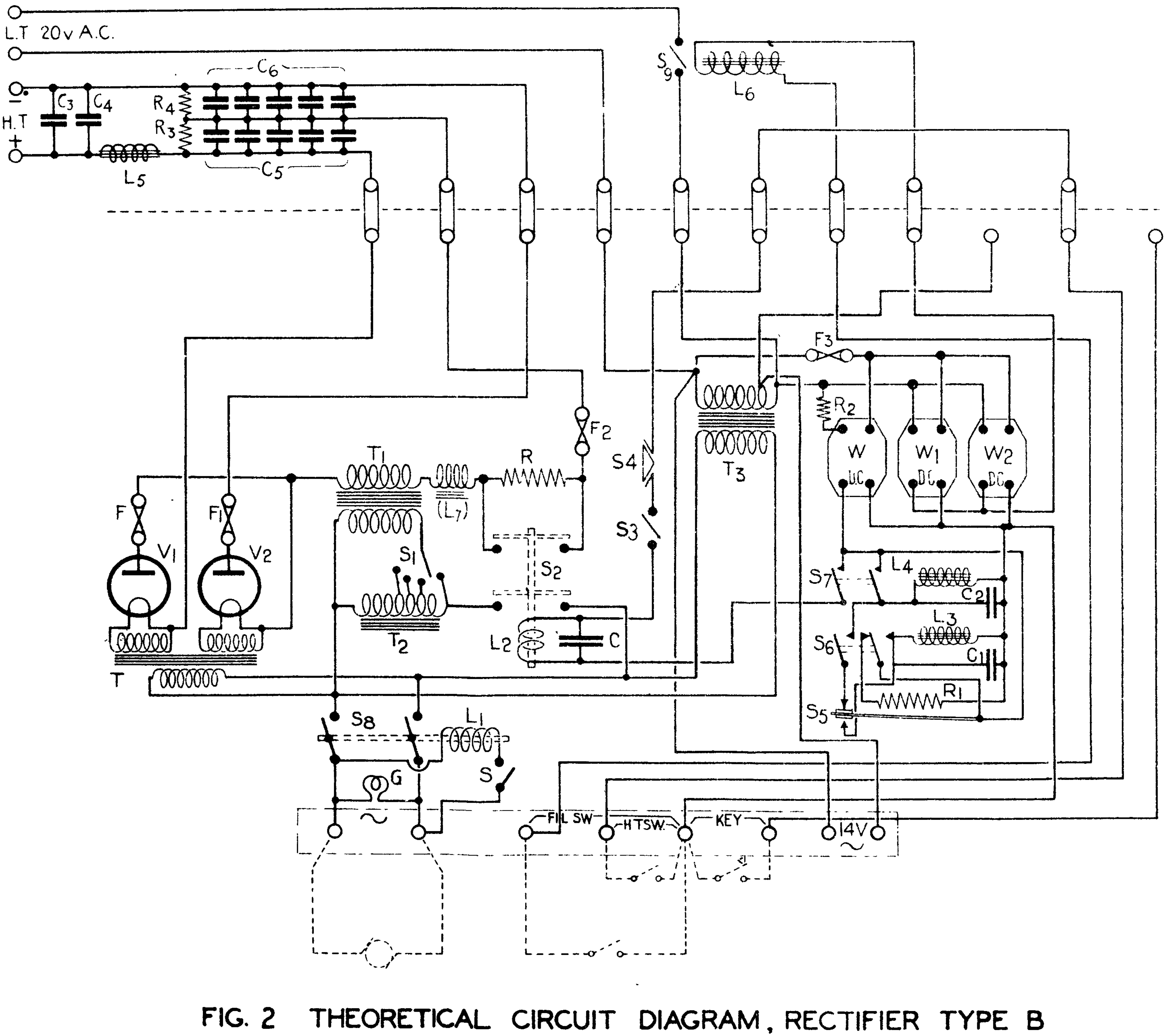

FIG. 2 THEORETICAL CIRCUIT DIAGRAM, RECTIFIER TYPE B

GENERAL DESCRIPTION

3. In fig. 2 is given a theoretical circuit diagram of the complete rectifier. The portion below the dotted line is " Panel, Rectifying, type A " and the portion above the dotted line is the smoothing unit, the two being connected together by means of links to form rectifier, type B.

4. Two valves V_1 and V_2 are employed for rectification. The filaments of the valves are heated by means of a transformer T having two secondary windings, one for each filament. The H.T. A.C. supply to the rectifying valves is provided by the auto-transformer T_2 and a step-up transformer T_1. A fourth transformer T_3 is incorporated to provide a transmitter filament supply, the secondary being tapped for 14 and 20 volts. The 20-volt tapping also supplies the metal rectifiers W, W_1 and W_2. The rectifier W, which has a resistance inserted in the A.C. side, is for the purpose of providing D.C. at 12 volts for the operation of the group of relays shown immediately below. These relays ensure a delayed action of the H.T. switch S_2, the transformers T_2 and T_1 being energized some 30 seconds after the filaments of the rectifying valves V_1 and V_2 have been heated.

5. The rectifying valves used are of the gas-filled type which, on account of their low resistance, give improved regulation. The liability of these valves to flash over on high reverse voltage, however, imposes limitations and they are therefore connected as a voltage doubling arrangement.

6. The filaments of the valves are coated and precautions must be observed during operation to safeguard these from " stripping ". One of the precautions is the employment of the delayed action H.T. switch mentioned in para. 2, the H.T. being applied to the valves 30 seconds after the filaments have been connected.

7. The main A.C. line switch S_8 is actuated by a magnetic relay when the switch S, which is designated " Filament switch ", is closed. The switch S_3, which is designated " H.T. switch ", is in series with the actuating coil of the magnetic relay L_2–S_2. Also in series with this coil is the gate switch S_4, the purpose of which is to prevent the H.T. circuit being closed when the door of the rectifier cabinet is open.

8. Referring to the smoothing unit circuit (above the dotted line) C_3, C_4, C_5 and C_6 are banks of condensers; L_5 is the smoothing choke and R_3 and R_4 are resistances across the condenser banks C_5 and C_6.

9. The terminal board at the lower portion of the diagram is arranged for convenient connection to a remote control system. The pair of terminals on the extreme left are connected to the standard A.C. 230 volts 50 cycle supply. The terminals marked FIL. SW. are connected by cable to the remote position thus giving control at the operating office of the main A.C. switch S_8 (local filament switch S being closed). The terminals marked H.T. SW. are similarly connected to the remote position thus giving the operating office control of the magnetic relay L_2–S_2, local switches S_3 and S_4 being closed. Of the two key terminals one is connected to the metal rectifiers W_1 and W_2, the other is taken to a terminal on the output terminal bar. When the key terminals are connected by cable to the remote operating office, a 12-volt D.C. supply is provided which can be keyed to operate a local signalling relay connected to the appropriate terminals (sixth and ninth from the left) on the output terminal bar. The two right-hand terminals are engraved 14 VOLTS A.C.

10. Tracing the general circuit it will be seen that when the A.C. is connected the lamp G will light up. When the circuit through the magnetic relay coil L_1 is completed the primaries of the transformers T and T_3 are energized, the filaments of the valves V_1 and V_2 are switched on and the 20-volt A.C. supply to the transmitter valve filaments is established.

11. Before the auto-transformer T_2 and the step-up transformer T_1 can be energized to supply H.T. to the rectifying valves, the switch S_2 must be closed. The switch is operated by the coil L_2 from a 12-volt D.C. supply obtained from one of the metal rectifiers W. The circuit

of the coil is normally opened at the points S_3 and S_7. The switch S_3 may be closed by hand. The switch S_7 is closed automatically but only after the lapse of 30 seconds. The action may be explained in the following way.

12. The metal rectifier W is permanently connected across the secondary of the transformer T_3, and the transformer becomes energized immediately the main A.C. switch is closed. A rectified current therefore flows in the circuit which can be traced from the right-hand D.C. terminal of the metal rectifier W through the heating element R_1, through the closed contacts of S_6 and back to the left-hand side of the rectifier. The heating element R_1 is wound on a bi-metal strip one end of which is anchored while the other end lies between two contacts. The heating of the strip causes it to break with the top contact of S_5 and make with the bottom contact of S_5. After the circuit through R_1 has been completed for some seconds, therefore, the lower contacts of S_5 are closed and a circuit is completed from the right-hand side of W through the relay coil L_3 and through the metal strip back to the left-hand side of W. The relay L_3 now being energized, both moving contacts of S_6 are operated. Movement of the right-hand contact immediately breaks the connection to the heater winding and then makes a connection which joins the coil L_3 directly across the metal rectifier thus locking the relay.

13. It will be observed that, although the left-hand contact of S_6 is closed, the top contact of S_5 is still open and since this is in series with the winding L_4 this remains un-energized. After the lapse of a few seconds, however, the heater coil R_1 cools (as its circuit has been broken) and the strip resumes its original position. The upper contact of S_5 now closes, completing the circuit through S_6 and the winding L_4 across the metal rectifier, and both contacts of S_7 are thereby closed. The right-hand contact connects the winding L_4 directly across the metal rectifier thus locking the relay. The left-hand contact of S_7 completes a circuit which can be traced from the left-hand D.C. terminal of the metal rectifier W, through S_7, through the coil L_2, through the switches S_3 and S_4 and the remote H.T. switch, back to the right-hand terminal of the metal rectifier. The energizing of L_2 causes the contacts S_2 to close. The lower contacts complete the circuit of the auto-transformer. The upper contacts short-circuit the resistance R in series with the secondary winding of the transformer T_1, and the H.T. is thus applied to the rectifying valves V_1 and V_2 approximately 30 seconds after the valve filaments are connected.

14. The anode of the valve V_1 is connected to the filament of the valve V_2, and from this point a connection is taken to one side of the secondary of the transformer T_1. The other side of the secondary winding is taken *via* the resistance R and fuse F_2 to the junction point of two condenser banks C_5 and C_6, which are connected in series between the filament of the valve V_1 and the anode of the valve V_2. The rectified H.T. supply is taken from across the condenser banks. Across these condenser banks are two large resistance units R_3 and R_4 each of which has a value of 50,000 ohms, and in series with the H.T. positive line is connected a smoothing choke L_5. Beyond this are two smoothing condensers C_3 and C_4 in parallel across the supply.

15. Fuses F and F_1 are included in the anode circuits of the rectifying valves, and fuses F_2 and F_3 are included in the A.C. H.T. line and the 20-volt input circuit of the metal rectifiers respectively. All four fuses are conveniently grouped on a fuse board located behind a glass door on the front of the rectifier. The condensers C, C_1 and C_2, which shunt the windings L_2, L_3 and L_4, respectively, are all of similar capacitance and are carried behind the relay panel.

16. In the circuit diagram, fig. 2, the exterior connections to the terminal board have been shown dotted to make clear the method of operation. It will be seen that the only switch on the main A.C. supply is the local switch S. The remote filament switch in this circuit is connected (shown dotted) across the third and fifth terminals from the left. Tracing this circuit inside the rectifier it will be seen that when the switch is closed the relay winding L_6 is placed across the D.C. terminals of the rectifiers W_1 and W_2. The contacts S_9 operated by this relay are in the A.C. filament supply line. The rectified H.T. circuit may still be remotely controlled as before by means of the switch shown dotted across the fourth and fifth terminals, the only difference being that the D.C. operating circuit passes through the output terminal panel, the sixth and

tenth terminal from the left being connected together by means of a jumper connection. The remote key connections remain unchanged, and when a local signalling key is connected across the appropriate terminals (eighth and eleventh from the left) on the output terminal board of the rectifying panel, the relay is operated by the remote key.

CONSTRUCTIONAL DETAILS

17. A front view of the complete rectifier in its cubicle is given in fig. 1. The cubicle consists of a duralumin frame closed on all sides by bolted-on duralumin panels. The overall dimensions are approximately 2 ft. 10 in. by 1 ft. 8 in. by 2 ft. 6 in., and the weight is roughly 2½ cwt. The rectifier is housed in the lower and the smoothing unit in the upper part of the cubicle. Access to the cubicle is obtained through a glass door on the front panel, the fuse board and voltage tapping switch being located immediately behind it.

18. To the right of the door is a circular window fitted with red glass behind which is mounted the pilot lamp, to give visible warning that the main A.C. supply switch is closed. The two tumbler switches on the right of this are the filament and H.T. switches respectively. Incorporated in the door is a safety switch (shown at S_4 in fig. 2) which ensures that the H.T. circuit is broken when the door is open.

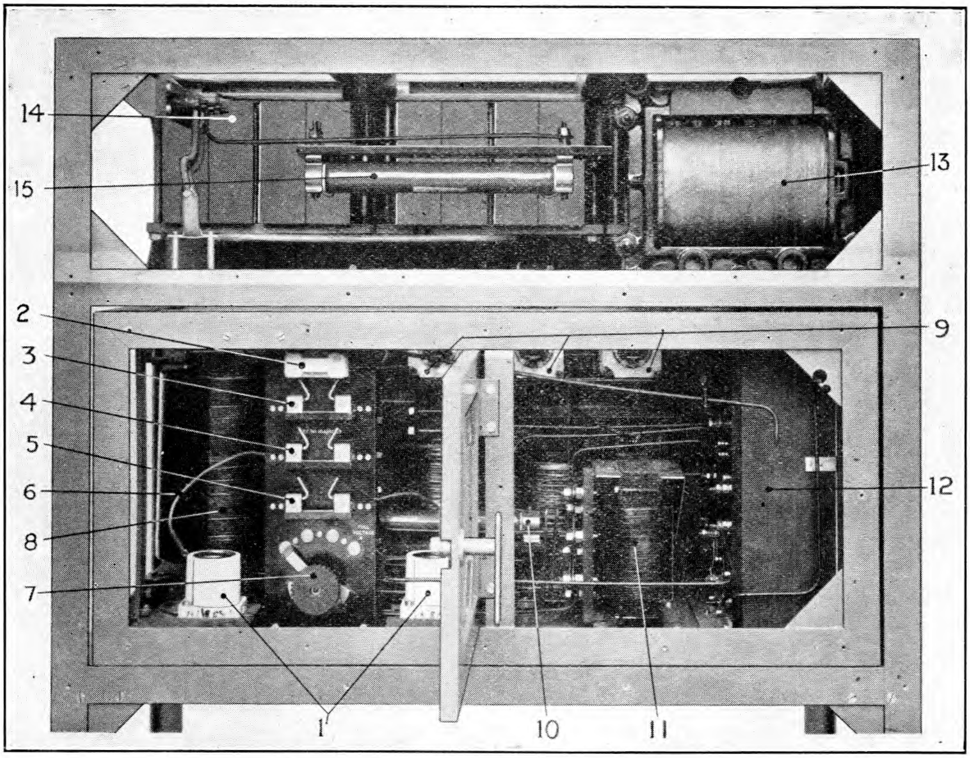

FIG. 3. Rectifier, type B, front view, panel removed.

Rectifying panel, type A

19. Referring to fig. 3, the valve-holders (1) can be seen to the right and left of the fuse panel. The fuse (2) is of the porcelain carrier type and is in the common A.C. lead between the secondary of the 20-volt transformer and the three metal rectifiers. The fuse (3) is in series with the secondary side of the H.T. transformer, and the two fuses (4) and (5) immediately below this are in the anode circuits of the rectifier valves. The flexible lead (6) is the detachable connection to the anode of the valve. Below the fuses can be seen the tapping switch (7) of the auto-transformer. The four positions of the switch correspond to transformer input voltages of 110, 150, 190 and 230. On the left of the fuse board can be seen the H.T. transformer (8) and at the top and to the rear of the compartment are the three metal rectifiers (9). The resistance (10) is in series in the secondary circuit of the H.T. transformer. To the right of this can be seen the transformer (11) which supplies the heating current for the rectifier filaments. The relay panel (12), which consists of a rectangular hardwood box with an ebonite back and a glass front, is shown in greater detail in fig. 10.

20. In fig. 5 is given a view of the rectifier with the top panel (and smoothing unit) removed, the door being partly open. The contact piece (1) on the door engages with two contacts located under the metal plate (2) making and breaking the operating winding of the H.T. switch with the closing and opening of the door. This safety switch is shown in the theoretical diagram, fig. 2, at S_4. In fig. 7 the rectifier panel is shown removed bodily from the cubicle and viewed from the rear. Owing to the weight of the rectifier, rollers (1) are provided to facilitate assembly and removal at repair depôts. The engravings on the rear terminal board (2) can be clearly seen. The upper terminal board with its slotted jumper connections can also be seen in this

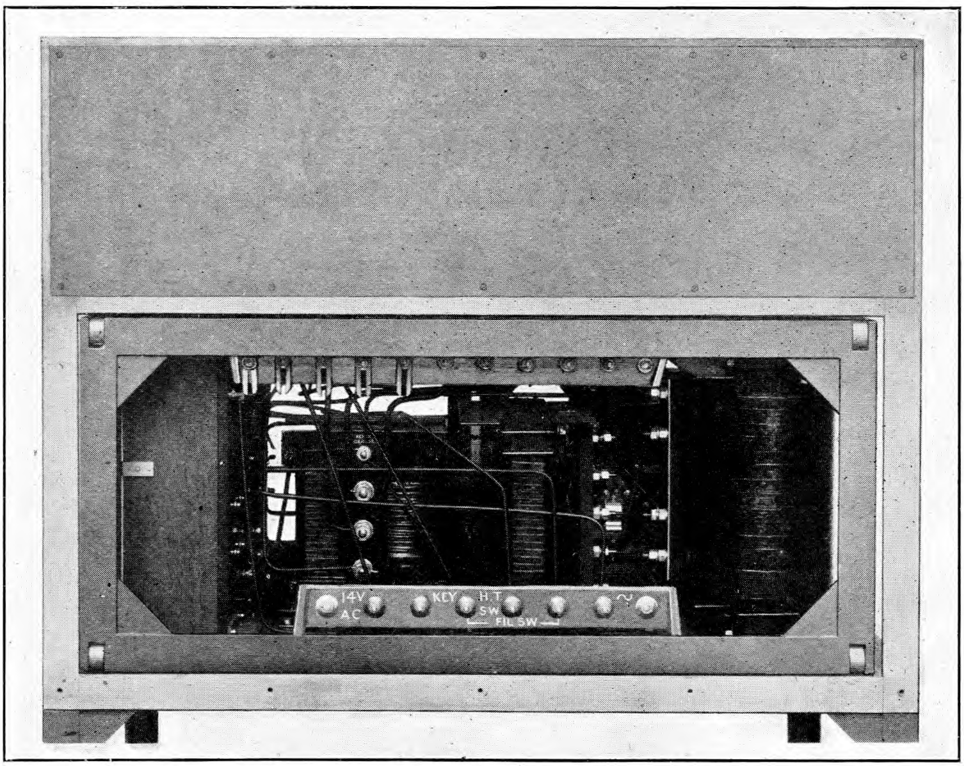

FIG. 4. Rectifier, type B, back view.

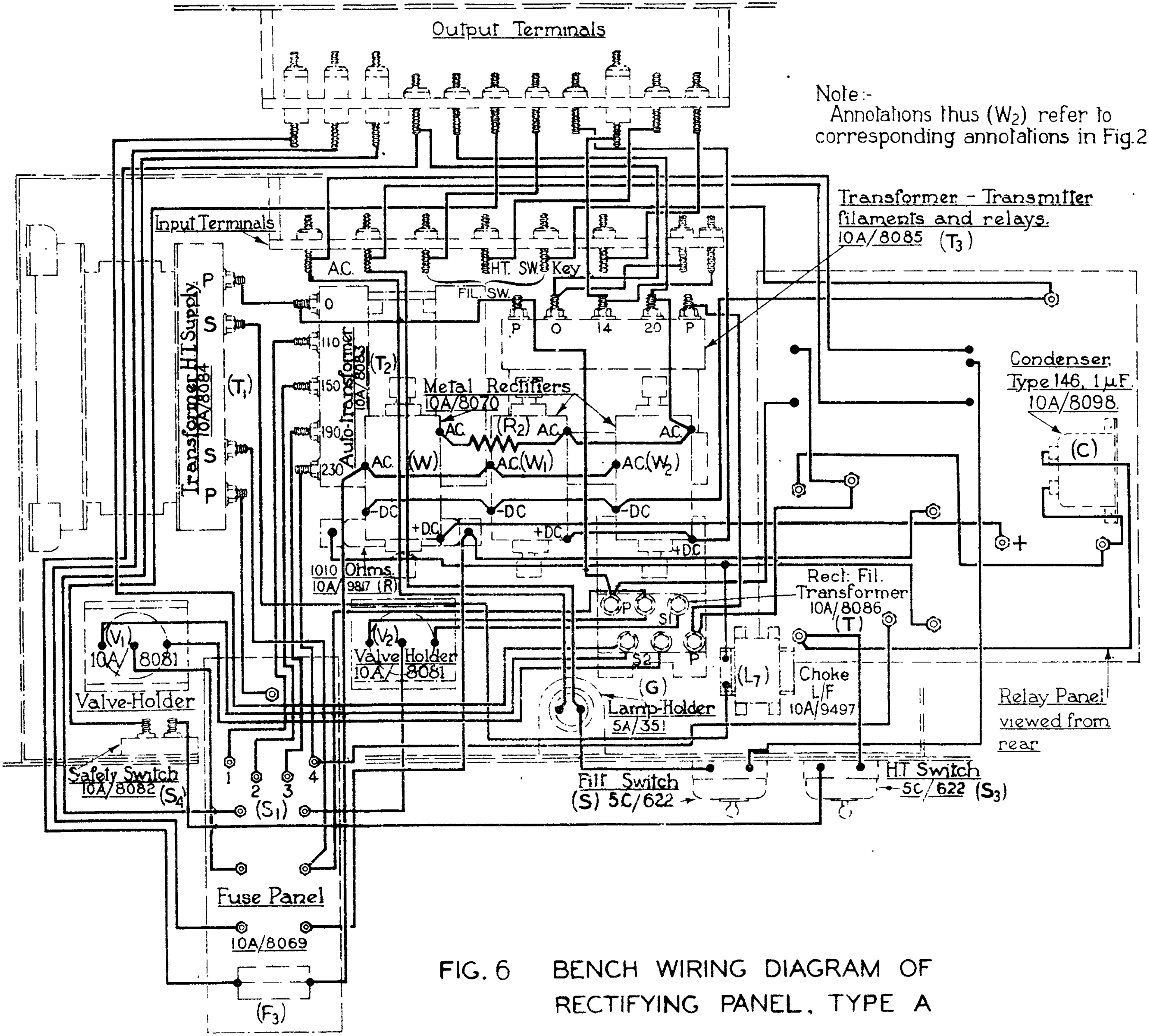

FIG. 6 BENCH WIRING DIAGRAM OF RECTIFYING PANEL, TYPE A

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illustration. These latter terminals are not engraved but the connections may be seen from an examination of fig. 2. It should be noted when comparing these, that in fig. 7 the panel is viewed from the rear, whereas in the theoretical circuit diagram, fig. 2, the panel is assumed to be viewed from the front. The terminal boards and connections can be seen from an examination of the bench wiring diagram, fig. 6, and the theoretical diagram, fig. 2.

21. The transmitter filament transformer (3), auto-transformer (4), and H.T. transformer (5), can be clearly seen (in order from left to right) in fig. 7. The five terminals on the transmitter filament transformer are provided with engravings to indicate the connections. The outer two are marked P indicating primary, and the three between these are the secondary tappings marked 0, 14 and 20. The metal rectifiers are connected across the 20-volt section, and the 14-volt tapping is connected up to two of the terminals on the output terminal board of the rectifier. The terminals on the auto-transformer can also be seen in this illustration. Four of these are taken to the tapping switch at the front of the panel, the fourth tapping (engraved 230) is also taken through the magnetically-operated H.T. switch to the A.C. mains switch. The fifth terminal on the transformer (engraved 0) is taken to the primary of the H.T. transformer and to the other side of the A.C. mains switch.

22. Of the four terminals on the H.T. transformer the outer two are the primary terminals (marked P) and the inner two are the secondary terminals.

23. Referring to fig. 10, which shows the relay panel, the relay, type K, (1) consists of an electro-magnet which operates a spring-loaded plunger mounted vertically. This plunger carries two laminated contact bars. When the circuit of the electro-magnetic winding is completed through the H.T. switch, the electro-magnet is energized by the direct current from the metal rectifiers and the plunger is drawn downwards. The lower contact bar which is anchored at the

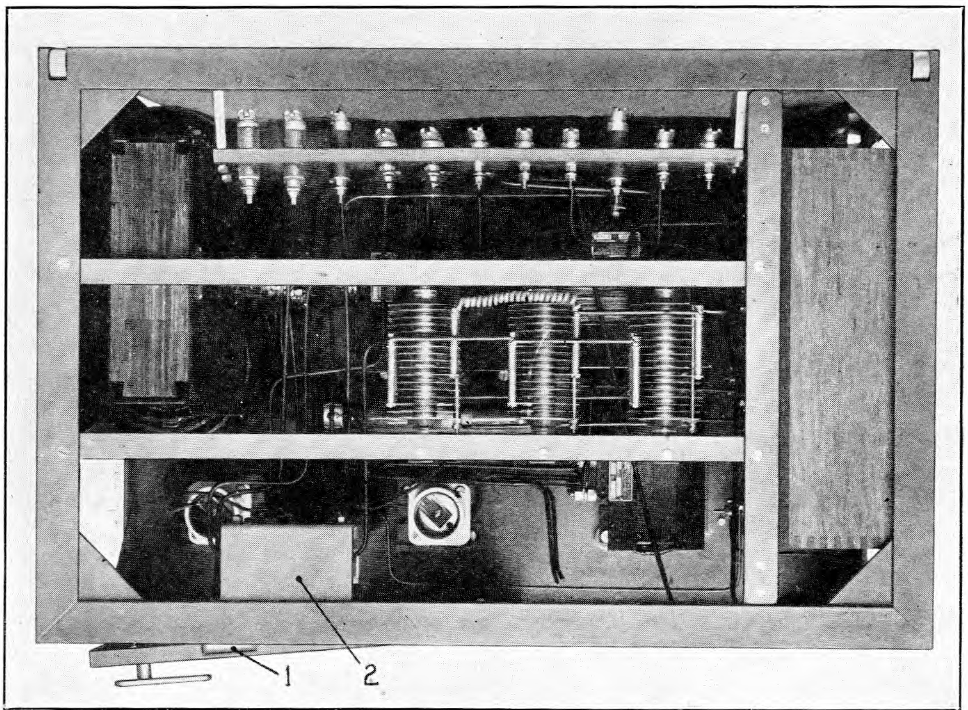

FIG. 5. Rectifying panel, type A, removed from cubicle.

left-hand side immediately makes contact at the right-hand side with an adjustable contact and closes the circuit of the auto-transformer across the main A.C. supply. A fraction of a second later the upper contact bar bridges the two contacts immediately beneath it, short-circuiting a resistance in the circuit of the secondary of the H.T. transformer. The effect of this delay in short-circuiting the secondary resistance is to limit the charging of the condensers and prevent damage to the coating of the rectifier valve filaments.

24. The magnetic relay (2) is of the A.C. contactor type. There are five connections to it, three at the top and two at the bottom. The two bottom connections are taken direct to the primaries of the rectifier filament transformer and the transmitter filament transformer. The outer two of the upper three are taken direct to the main A.C. terminals, and between the left-hand connection and the intermediate connection is wired the filament switch (2, fig. 1).

25. The actuating coil of the relay is internally connected across the intermediate connection and the right-hand connection. When the filament switch (2, fig. 1) is closed, therefore, the actuating coil is connected across the A.C. mains and the spring-loaded arm is attracted, making contact between the upper left-hand connection and the lower left-hand connection, and between the upper right-hand connection and the lower right-hand connection, energizing both rectifier filament transformer and transmitter filament transformer.

26. The telephone-type relay (3) is wound for 12 volts. It has six connections, two for the actuating winding and four for the contacts. The connections are shown in fig. 11 and the action is explained elsewhere. The relay makes two contacts, and the direct current for operating it is obtained from the metal rectifiers.

27. The telephone-type relay (4) is also wound for 12 volts, and the direct current for operating it is also obtained from the metal rectifiers. The relay has eight connections, two for the actuating winding and six for the contacts. The relay makes two contacts and breaks one. The actual connections are shown in fig. 11.

28. The 12-volt thermostatic relay (5) has five connections, two for the heating winding and three for the contacts. The heating winding is wound around the centre contact and normally the centre and left-hand contacts are closed. The connecting of the heating winding into circuit, however, causes the centre contact to break (after the lapse of some seconds) its connection with the left-hand contact and make contact with that of the right-hand. Actually it remains in this position only for a few seconds because the current through the heater winding is immediately broken and the contact cools and resumes its original position. It is adjusted so that 30 seconds elapse between moving over and returning.

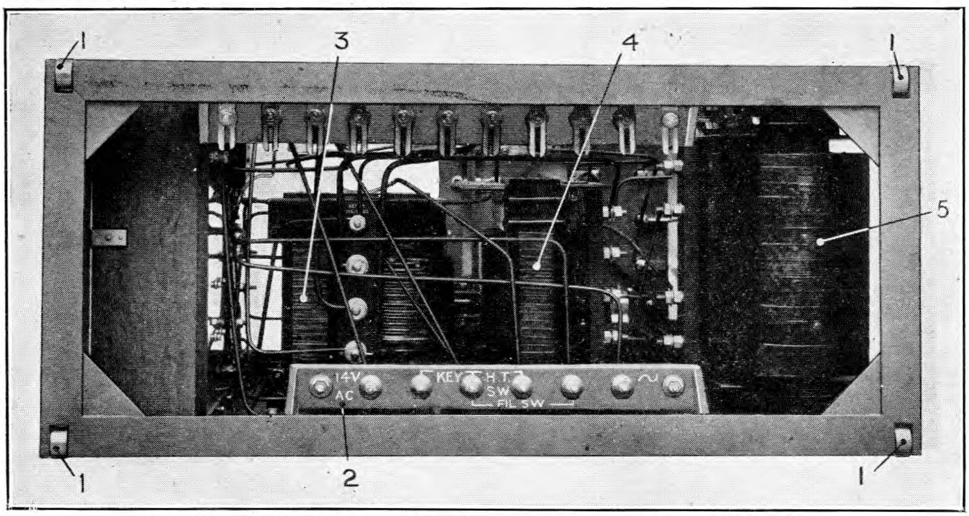

FIG. 7. Rectifying panel, type A, removed from cubicle, back view.

Note:- Annotations in parenthesis refer to the corresponding annotations in Fig.2.

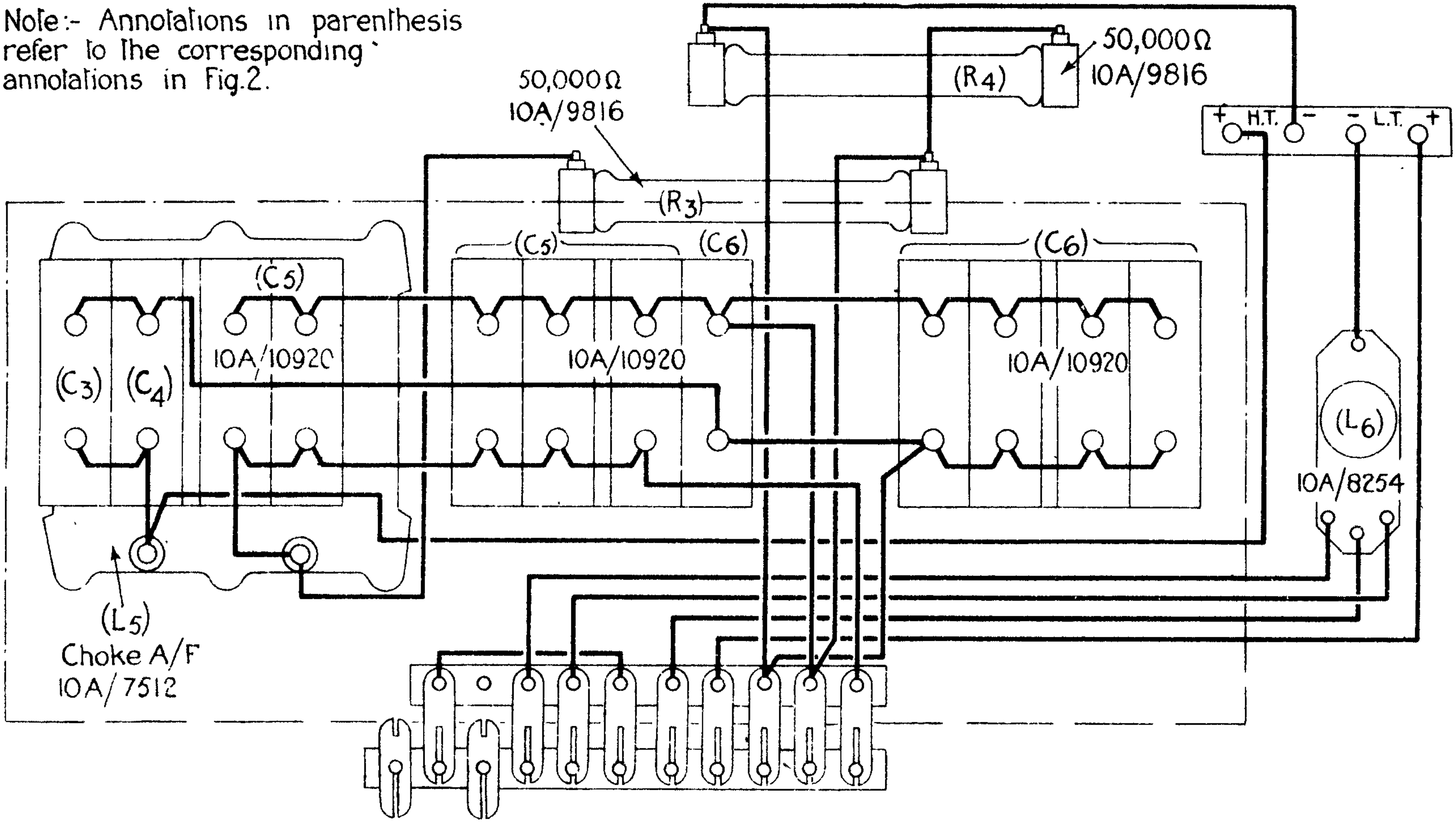

FIG. 9, BENCH WIRING DIAGRAM, SMOOTHING UNIT

Smoothing unit

29. The smoothing unit is housed in the upper portion of the cubicle. Referring to fig. 3, the output choke (13) is connected in the H.T.+ output line. In front of the banks of smoothing condensers (14) are two clip-in holders each of which carries a large 5,000-ohm vitreous-embedded resistance. These are connected across the condenser banks as shown at R_3 and R_4 in the theoretical diagram, fig. 2.

30. A view of the top of the cubicle (rectifying panel removed) is given in fig. 8. The terminal board (1) at the left is the output terminal board. Of the four terminals, two are H.T. terminals and two are L.T. terminals and the board is engraved with the symbols + and – adjacent to the terminals.

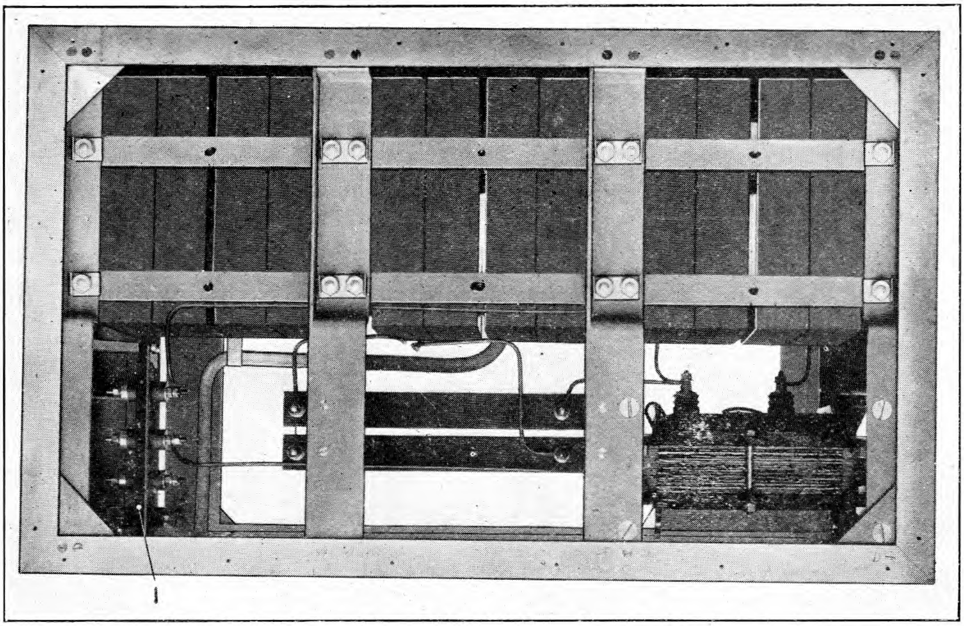

FIG. 8. Smoothing unit viewed from above.

31. The engravings at the L.T. terminals do not of course indicate polarity, as the supply is 20 volts A.C. They are provided for convenience when using the panel with D.C., a dummy panel being used in conjunction with the smoothing unit in these circumstances.

32. A relay (not shown in fig. 4) is fitted near the output terminal panel, it is described as " Relay Magnetic Type M " and is shown on the theoretical diagram, fig. 2. It is essentially a magnetically-operated single-pole switch. The electro-magnet is operated from the 12-volt D.C. supply obtained from the metal rectifier. Of the four terminals on the relay, two are the connections to the operating coil and two are the contact connections. Of the two former, one is joined directly to the metal rectifier and the other is taken through the filament switch to the other side of the metal rectifier. The contact connections are connected in series with the secondary of the transmitter filament transformer.

33. The connections of the relay and the terminal board are shown in fig. 2, from which it will be seen that it is possible to break the circuit of the transmitter filaments without interfering with the rectifier circuits.

OPERATION

34. When used with a transmitter such as type T.70 the rectifier is usually installed alongside the transmitter, and the sounder relays and apparatus for remote signalling are mounted on top of the rectifier cubicle. The electro-magnetic switches and relays on the rectifier are of robust construction and should require little or no attention after initial adjustments have been made. The relay, type K (5, fig. 10), is correctly adjusted when a delay of 30 seconds occurs between the closing of the filament switch and the application of the H.T. to the rectifying valves.

35. After seeing that the valves and fuses are in position, that the door of the cubicle is shut and the tapping switch in its correct position, the A.C. supply to the rectifier may be switched on. The pilot lamp behind the red glass window on the rectifier should immediately light up.

36. If remote control is being employed the local filament and H.T. switches should be closed as they are in series with the remote switches. If, on the other hand, local operation is required it will be necessary to ensure that the remote switches are closed to make the local ones operative.

37. It is important to note that the rectifier filament switch is not in series with a remote switch, and the rectifier filaments are therefore switched on and off at the local filament switch and that (unless special provision is made) control of the rectifier filament is not possible at the remote office.

38. Instead of a rectifier filament control, the operating office is now provided with a switch which controls (through a relay) the transmitter filament circuit. No change is, however, made in the wiring of the remote H.T. switch which is still wired in series with the local H.T. switch and, as before, the local switch must always be closed for local operation.

39. It will be seen that for local operation it will be necessary after switching on the A.C. supply to the rectifier to close the filament switch, close the H.T. switch and close the circuit of the additional relay.

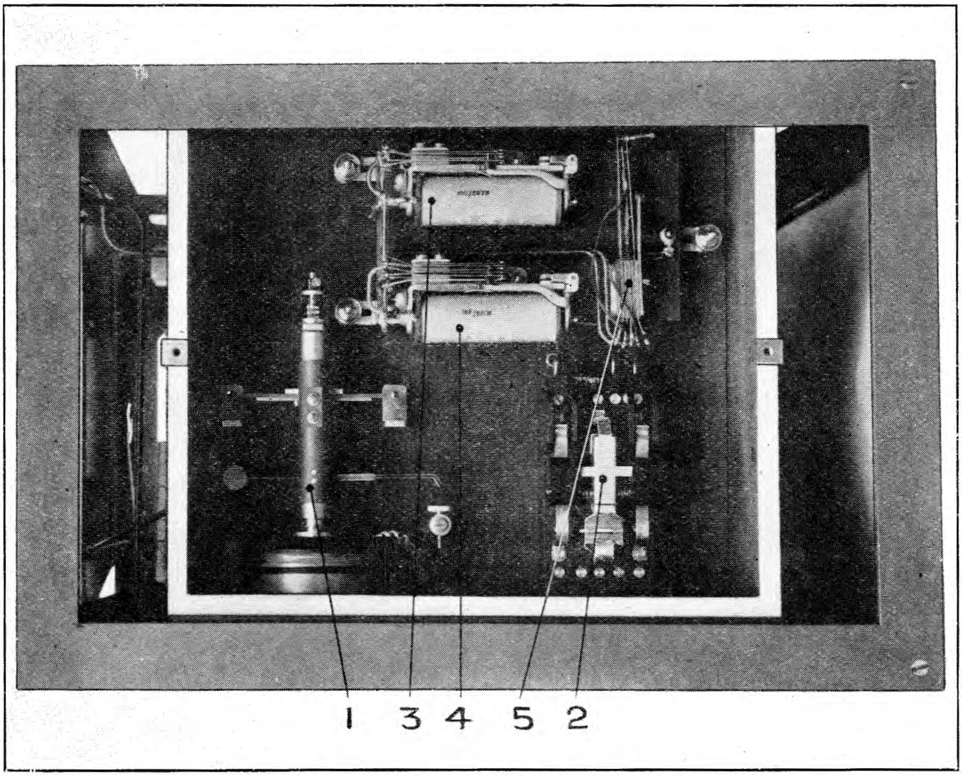

FIG. 10. Relay panel of Rectifier.

PRECAUTIONS AND MAINTENANCE

40. The tapping switch located behind the glass door is for the purpose of varying the H.T. output for the different requirements of the transmitter. The switch has four positions, the voltages applied to the primary of the H.T. transformer being respectively 110, 150, 190 and 230. The ratio of the transformer is approximately 6·5 to 1 and the secondary voltages for the four positions are therefore approximately 720, 980, 1,240, 1,500 volts. Owing to the voltage doubling connections of the rectifying valve the voltage available at the output terminals of the rectifier is approximately 1,440, 1,960, 2,480 and 3,000. The switch should always be placed in the low voltage position when frequency adjustments are being made to the transmitter.

41. In the event of the failure of a rectifying valve the faulty valve can easily be unscrewed from the " Goliath " screw valve-holder. The type of valve used, however, requires a " conditioning " period of approximately 30 minutes before being put into operation. In order that the delay occasioned by such a failure shall be reduced to a minimum it is desirable that a spare valve which has previously been " conditioned " should be kept ready.

Note :-
Annotations in parenthesis refer to the corresponding annotations in Fig. 2

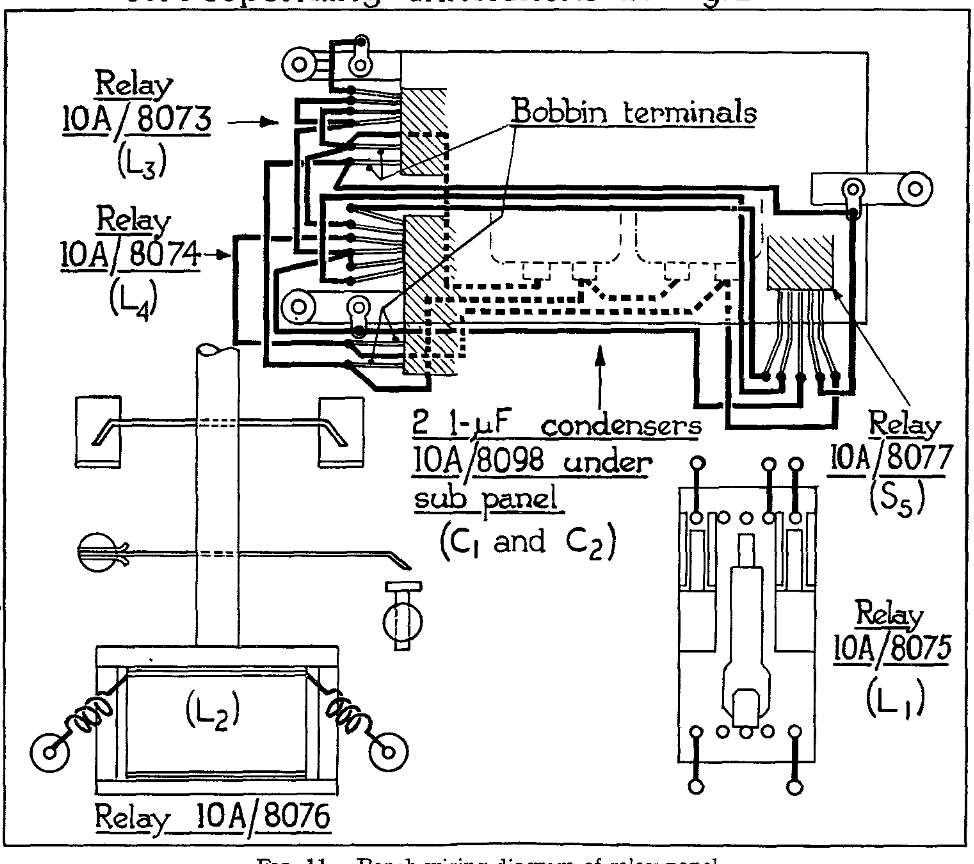

FIG. 11. Bench wiring diagram of relay panel.

42. Rectifier valves of this type may be considerably damaged if H.T. is applied while mercury is in contact with the filament. If at any time, therefore, a valve or the panel is shifted in a way likely to cause mercury to reach the filament, the filament current should be switched on for 10 minutes before the H.T. is switched on.

43. Care should be exercised that the correct fuses are fitted. There are four of these and each one carries two strands of 33 s.w.g. tin wire.

PANEL, RECTIFYING, TYPE B

(Stores Ref. 10A/11156)

44. This unit is a modified form of panel, rectifying, type A. Some of the components have been altered in order that the operation shall be more satisfactory and free from trouble. In outward appearance, panel, type B, is very similar to panel, type A. The dimensions are identical and the only apparent difference is that the panel, type B, has two coupled tumbler switches in place of the switch (2, fig. 1). A bench wiring diagram of panel, type B, is given in fig. 13, and a theoretical circuit diagram in fig. 12.

45. Referring to fig. 12, it will be seen that the difference in the two panels is mainly in the secondary circuit of the H.T. transformer, and also in the manner in which the main A.C. supply is switched on. The double-pole relay (L_2, fig. 2) is now replaced by a single-pole relay L_1. The primary of the auto-transformer T_1 is controlled by a relay L_2, and the main A.C. supply is now switched on manually instead of by the relay (L_1, fig. 2).

46. The sequence of operations is now as follows. The main A.C. supply is connected to the terminals engraved 230 VOLTS, and the lamp G lights up. When the switch S_1 is closed, both the filament transformer T_2 and the output transformer T_3 are energized simultaneously. The rectifiers W, W_1 and W_2 become energized and a 14-volt A.C. supply becomes available at the terminals engraved accordingly.

47. The transmitter filaments are switched on as before by closing the switch (S_9, fig. 2). The operation of the H.T. relay is now somewhat different. As soon as the switch S_1 is closed, the rectifier W is energized and the sequence of operations connected with the thermal delay relays begins. After a period of 30 seconds the switch S_3 closes. It is only after S_3 has closed that the H.T. supply to the rectifier valve can be switched on. Assuming that the remote H.T. switch is closed, a circuit can be traced from the positive terminal of the rectifier W, through S_3, through the relay L_2, switch S_2, and back *via* the remote H.T. switch to the negative side of W.

48. When the three-pole relay L_2 becomes energized, the auto-transformer T_1 is connected across the main A.C. supply. The circuit for the relay L_1 is also completed at this stage. It should be borne in mind, however, that the two outer contacts of L_1 close a fraction of a second before the circuit for L_1 is made. This is arranged in order that the H.T. supply is switched on before the resistance R is short-circuited.

49. The smoothing unit is identical with that in panel, type A, so that the same values of H.T. and L.T. supply are available. To switch off the H.T. it is only necessary to break S_2 or the remote H.T. switch. The transmitter filaments may be switched off by opening the remote filament switch. It is obvious, however, that if the switch S_1 is opened, both H.T. and L.T. are switched off. It should be noted in this connection, that once S_1 is opened, the H.T. cannot be switched on again until the thermal delay sequence is finished, i.e. after a delay period of 30 seconds. The transmitter filaments, however, can be switched on as soon as S_1 is closed.

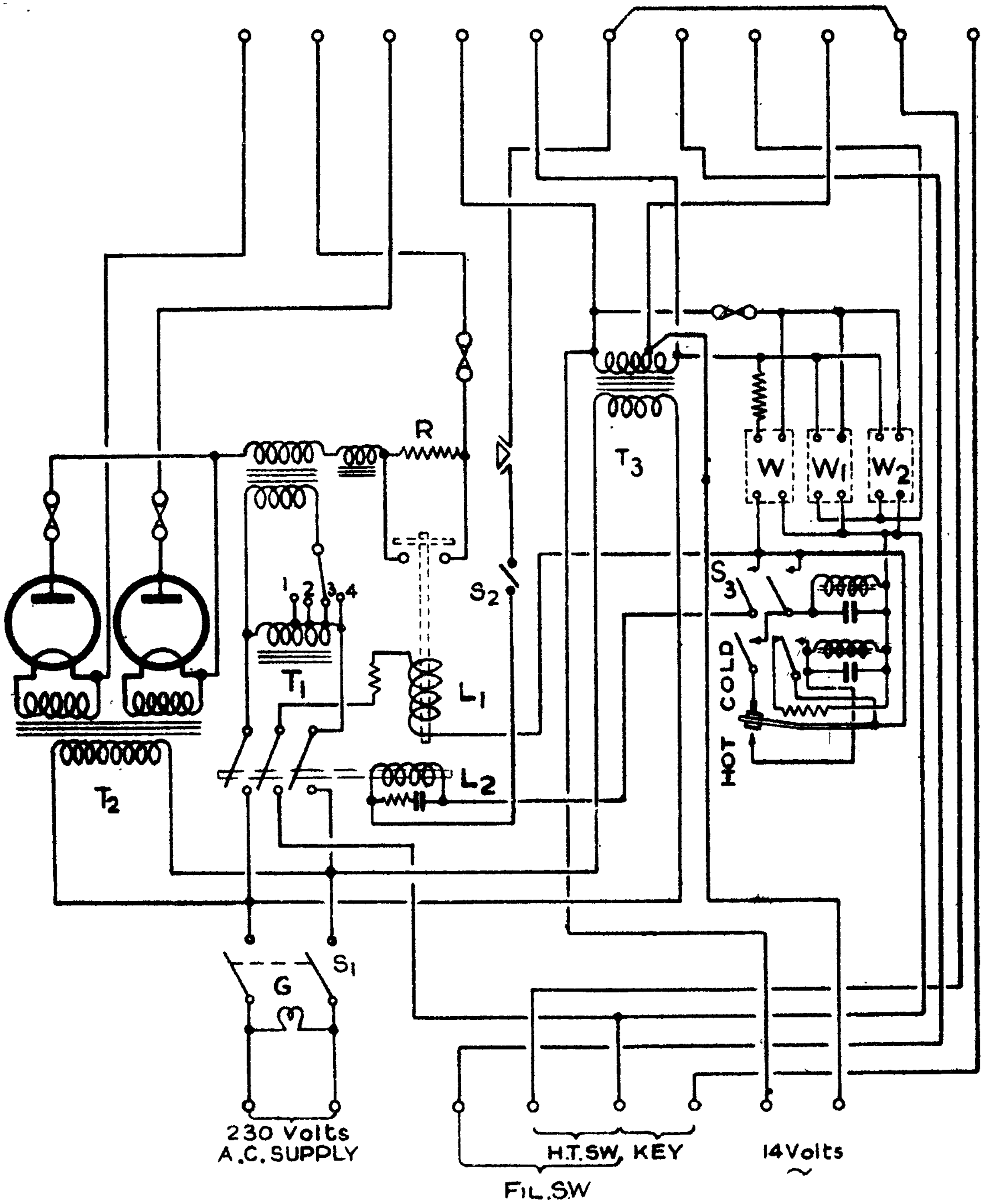

FIG. 12. THEORETICAL CIRCUIT DIAGRAM PANEL RECTIFYING, TYPE B.

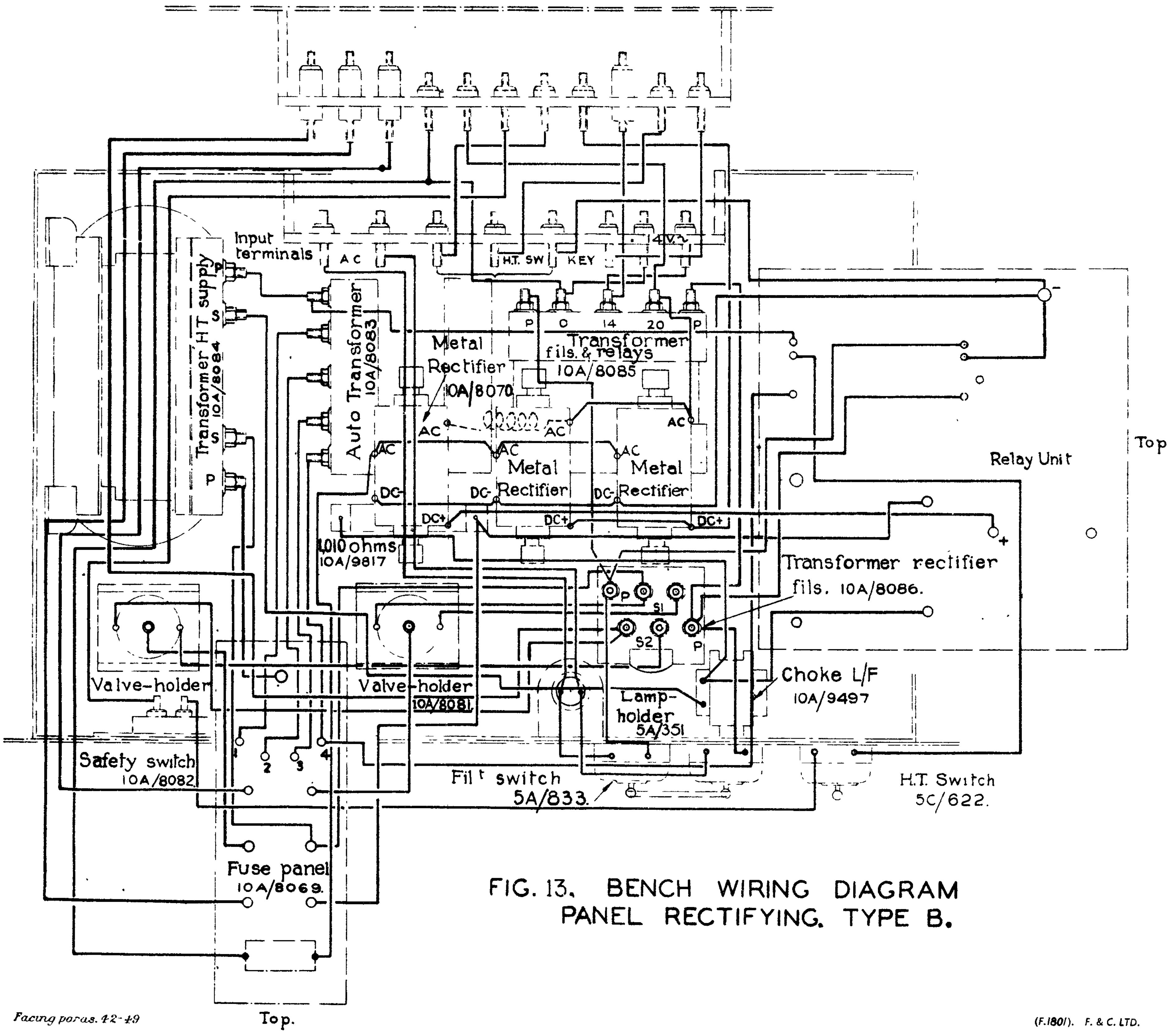

FIG. 13. BENCH WIRING DIAGRAM PANEL RECTIFYING. TYPE B.

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APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/8067 ..	Rectifier, type B		
	Principal components		
10A/7512 ..	Choke, L/F, type C	1	
10A/10920 ..	Condenser, type 428	12	1·5 μF
10A/8068 ..	Panel, rectifying, type A	1	For components *see* below
	or		
10A/11156 ..	Panel, rectifying, type B	1	
10A/9816 ..	Resistance, type 302	2	50,000 Ω.
10A/8254 ..	Relay, magnetic, type M	1	15 amp., single-pole
	Panel, rectifying, type A		
	Principal components		
10A/9497 ..	Choke, L/F, type N	1	
10A/8098 ..	Condenser, type 146	3	1·0 μF., on relay panel.
10A/8081 ..	Holder, valve, type F	2	Goliath screw.
5A/351 ..	Lampholder, bayonet, batten .. .	1	For pilot lamp
10A/8069 ..	Panel, fuse and switch	1	
10A/8070 ..	Rectifier, metal	3	22 volts A.C., 12 volts D C.
	Relay, magnetic		
10A/8073	Type G	1	Two-contact, 12 V. D.C. operated
10A/8074 .	Type H	1	Makes two contacts, breaks one.
10A/8075 .	Type J	1	230 V. A.C. operated.
10A/8076	Type K	1	Three-contact, 12 V. D.C. operated.
10A/8077 .	Relay, thermostatic, type A .. .	1	
10A/9817 .	Resistance, type 303	1	1,010 ohms
5C/622 .	Switch, tumbler	2	
10A/8082	Switch, type 75	1	Safety switch
10A/8083 .	Transformer, auto, type A . ..	1	1·6 kVA.
10A/8084	Transformer, H.T., type C . ..	1	1·6 kVA.
10A/8085 .	Transformer, L.T., type A	1	·4 kVA
10A/8086 .	Transformer, L.T., type B . ..	1	·072 kVA.
	Accessories		
5A/1219	Lamp, filament	1	230 volts, 16 c.p.
10A/8087	Valve, type V.U.29	2	Gas-filled type.
	Panel, rectifying, type B		
	Principal components		
10A/9497 ..	Choke, L/F, type N	1	
10A/8098 ..	Condenser, type 146	3	1·0 μF., on relay panel
10A/8081 ..	Holder, valve, type F	2	Goliath screw.
5A/351 ..	Lampholder, bayonet, batten	1	For pilot lamp.
10A/8069 ..	Panel, fuse and switch	1	
10A/8070 ..	Rectifier, metal	3	22 volts A C., 12 volts D.C.
	Relay, magnetic		
10A/8073 ..	Type G	1	
10A/8074 ..	Type H	1	
10A/11157 ..	Type 45	1	12 volts D.C. operated for A.C. supply.
10A/11158 ..	Type 46	1	12 volts D.C. operated or H.T. switching.
10A/8077 ..	Relay, thermostatic, type A	1	

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Panel, rectifying, type B—*contd.*		
	Principal components—*contd.*		
	Resistance		
10A/7766 ..	Type 82	5	Five 40-Ω resistances in parallel.
10A/9099 ..	Type 263	1	100 ohms.
10A/9817 ..	Type 303	1	1,010 ohms.
5C/622 ..	Switch, tumbler	1	5 amp., S.P.
5A/833 ..	Switch, tumbler	1	10 amp., D.P.
10A/8082 ..	Switch, type 75	1	Safety switch.
10A/8083 ..	Transformer, auto, type A	1	1·6 kVA.
10A/8084 ..	Transformer, H.T., type C	1	1·6 kVA.
10A/8085 ..	Transformer, L.T., type A	1	·4 kVA.
10A/8086 ..	Transformer, L.T., type B	1	·072 kVA.
	Accessories		
5A/1219 ..	Lamp, filament	1	230 volts, 16 c.p.
10A/8087 ..	Valve, type V.U.29	2	Gas-filled type.

SECTION 6, CHAPTER 2

VALVE TYPE BUZZER

Contents

List of Illustrations

VALVE TYPE BUZZER

(Stores Ref. 10A/7292)

GENERAL DESCRIPTION

1. The valve type buzzer is intended to be used for instructional purposes in Morse signalling. It is so arranged that when a key or automatic sender is connected to the appropriate terminals, and the line feeding the various telephones is connected to the output, Morse signals of pure tone are heard. The instrument is capable of giving signals of sufficient strength in approximately 20 pairs of telephones. Any one of six different signal notes may be selected by means of a six-position switch, and a volume control is also incorporated to enable the requisite signal strength to be obtained.

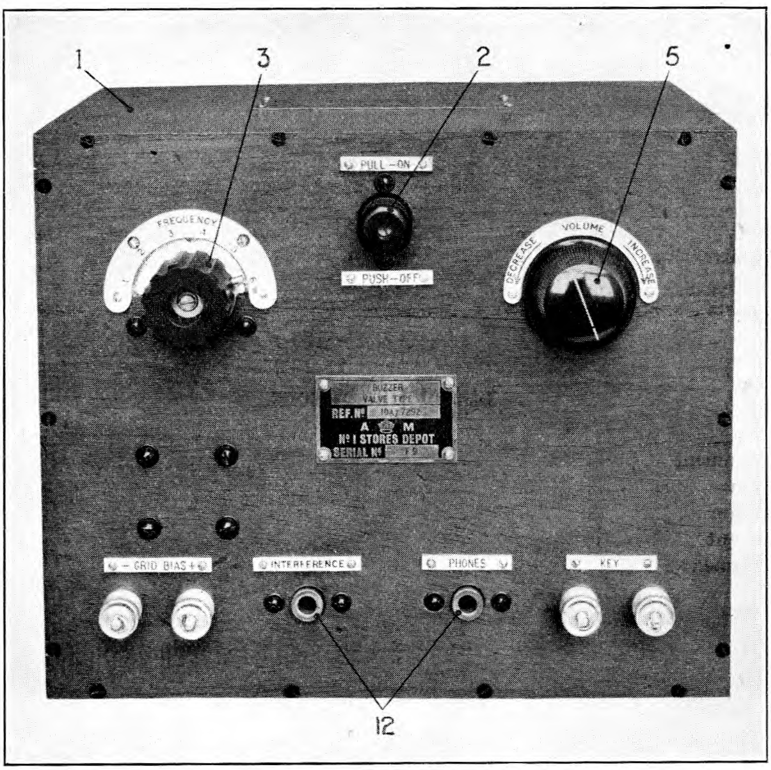

FIG. 1. Front view of Instrument.

2. The instrument employs two valves, one of which acts as a low-frequency oscillator and the other as an amplifier, the telephone circuit being connected into the anode circuit of the latter. The operation of the key makes and breaks the anode circuit of the oscillator valve.

3. In fig. 2 is given a diagram of the circuit arrangement, from which it will be seen that the oscillator valve V_1 has its anode and grid circuit coupled by means of the primary and secondary windings of a special transformer T, and this results in the generation, when the key is closed.

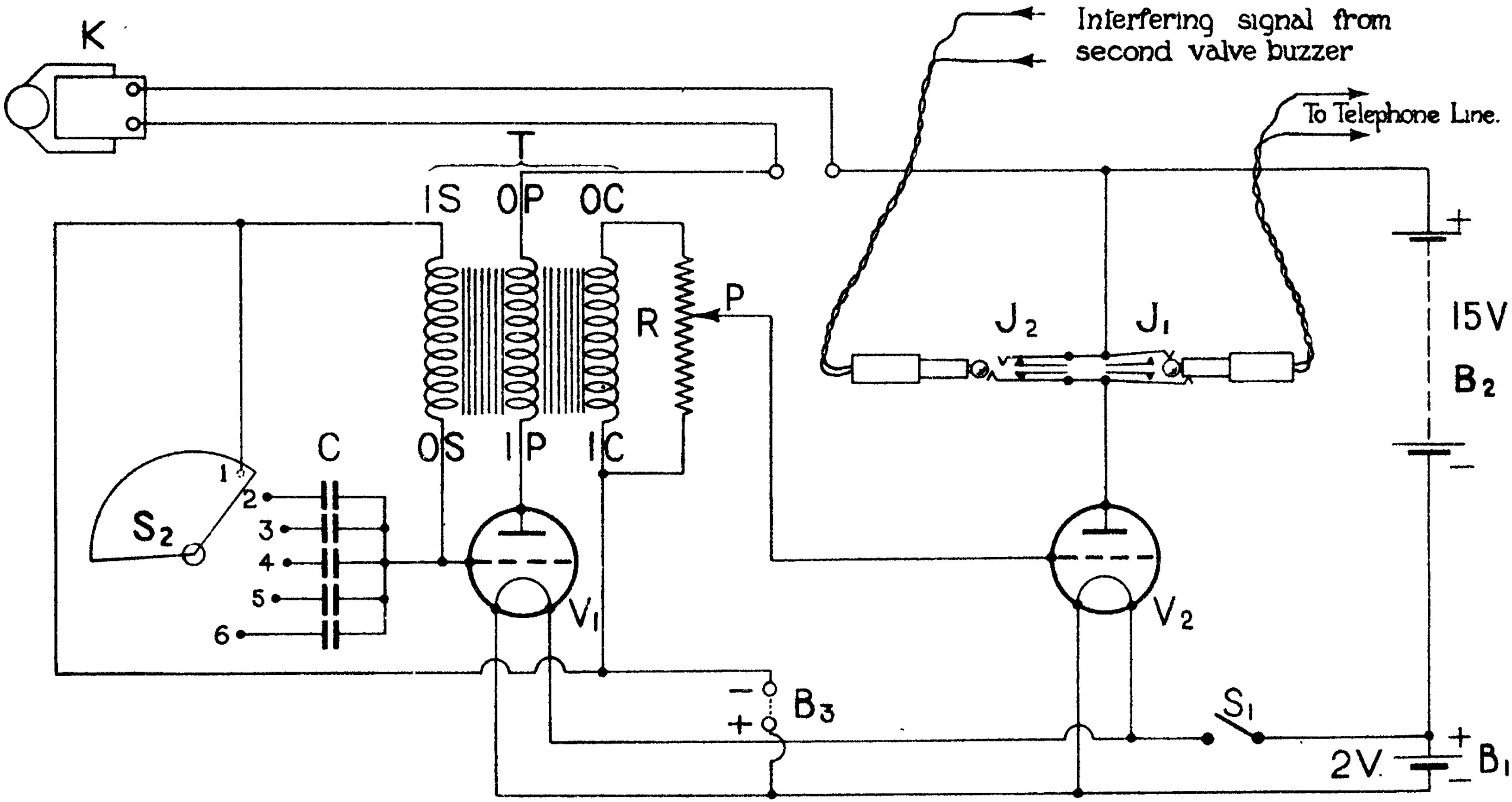

FIG.2. THEORETICAL DIAGRAM.

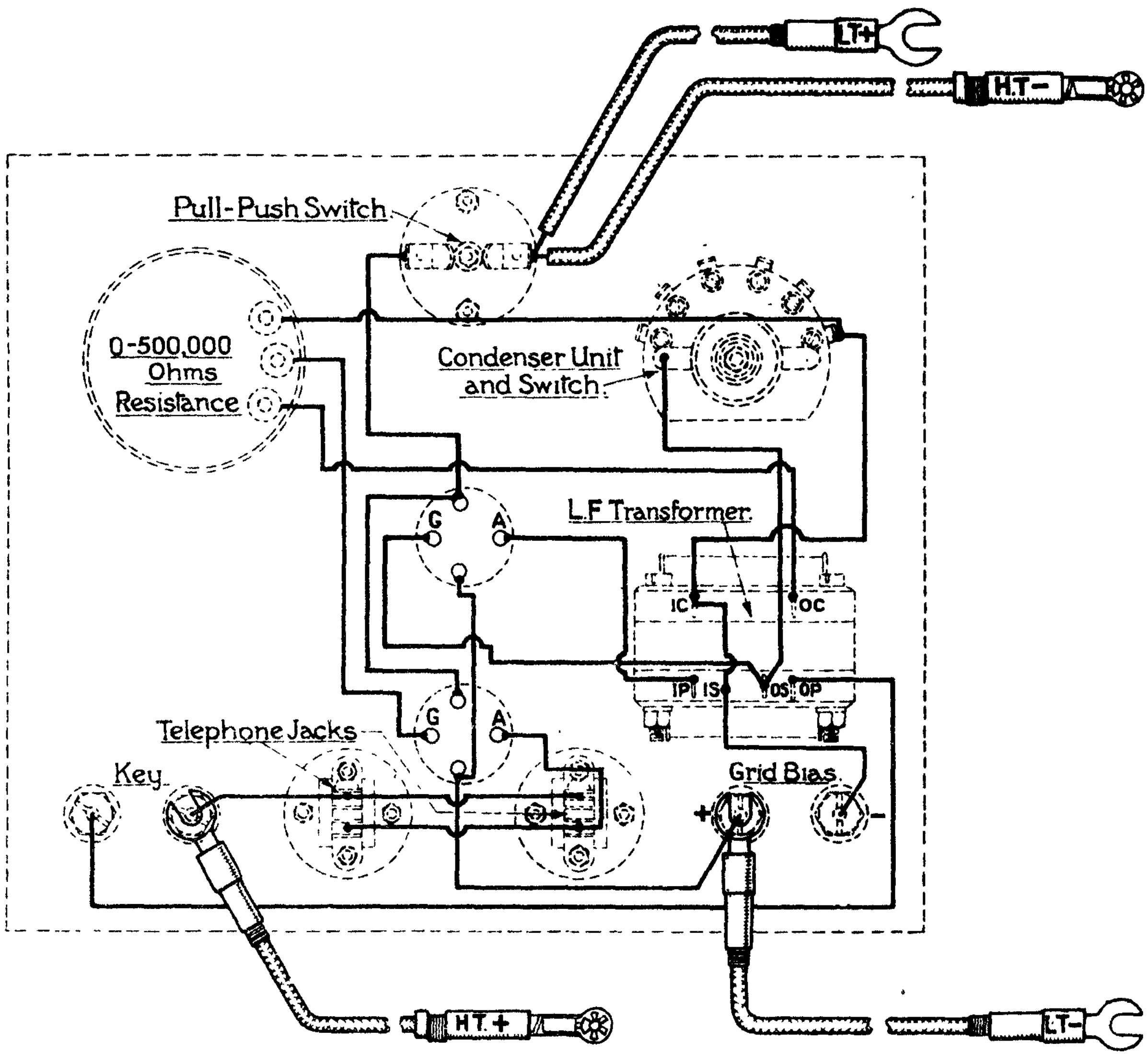

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Fig.3. Bench Wiring Diagram.

of oscillations of audio frequency. A third winding (I.C. O.C.) on the transformer is coupled to the grid-filament circuit of the amplifier valve V_2 and the audio-frequency voltages are thus amplified and appear as audio pulses in the anode circuit of the amplifier valve, giving rise to a pure musical note in the telephones. Across the winding (I.C. O.C.) is connected a resistance R of 500,000 ohms, over which the sliding contact P moves. The slider is connected directly to the grid of the amplifying valve, and thus, by moving the sliding contact, smooth control of volume is obtained, varying from a maximum when in a position at the higher end to a minimum when at the lower end of the resistance.

4. The six-position switch S_2 brings into circuit condensers in parallel with the secondary winding (I.S. O.S.) of the transformer, thus varying the frequency of oscillation of the valve V_1. A high-pitched note is produced when the switch is in position " 1 ", and no condenser is connected, but the note drops progressively as the switch is moved over the stops. At position " 2 " a condenser of the value of ·004 μF. is brought into circuit. At position " 3 " a second condenser of the value of ·002 μF. is added in parallel, and so on through positions " 4 " and " 5 " where values of ·002 and ·001 respectively are added until at position " 6 " a further ·001 is added and the maximum capacitance is in circuit.

5. The grids of both valves are connected through the respective transformer windings to a common negative grid bias terminal. Normally, the grid bias terminals are short-circuited but an improvement in the purity of tone may be effected by connecting a single dry cell to these terminals. Two jacks (J_1 and J_2) are included in the anode circuit of the amplifying valve, one of which is for the purpose of plugging into circuit the telephone line, and the other is provided in order that an interfering signal of suitable intensity from a second valve buzzer or other source may be made to occur simultaneously in the telephones worn by the personnel under instruction. The switch S_1 is of the push-pull type and is connected in the positive side of the filament circuit. No L.T. rheostat is provided, the necessary filament current supply being obtained from a 2-volt accumulator (B_1). The H.T. supply (B_2) to the anodes is obtained from a 15-volt dry battery. Both of these batteries are housed within the case of the instrument.

CONSTRUCTIONAL DETAILS.

6. Three views of the instrument are given in figs. 1, 4, and 5, and a bench wiring diagram in fig. 3. Fig. 1 shows the instrument viewed from the front, and figs. 4 and 5 show the interior.

7. The case (1) is constructed entirely of mahogany, finished inside and out with varnish. The back of the case (10) is held in position by means of four spring clips (6), and a chain (11) anchors the back to the case. Mounted on the front panel are the frequency control unit (3), the volume control (5), the push-pull switch (2), and the jacks (12).

8. It will be observed from fig. 1 that there are only four terminals on the front of the instrument, *viz.*, the grid bias terminals and the key terminals. The connections for the H.T. and L.T. batteries are brought out to short flexible leads which can be seen in the illustration, fig. 4. The L.T. flexible leads terminate in spade lugs, and the H.T. flexible leads terminate in claw-type terminals with 6 B.A. clearance holes. The flexible leads are provided with sleeves clearly marked H.T. + and −, and L.T. + and −, respectively. The frequency control unit (3) is composed of five condensers and a six-position switch built up as one unit, the knob of the switch projecting through the panel and indicating on a scale marked FREQUENCY. This unit may be seen in fig. 4, the condensers being of circular form and assembled on a brass rod. In this illustration can be seen also the volume control (5) and the transformer (7).

9. The transformer consists of three windings on a laminated core. The primary and secondary windings each consist of 3,000 turns of 42 s.w.g. D.S.C. and the third or coupling

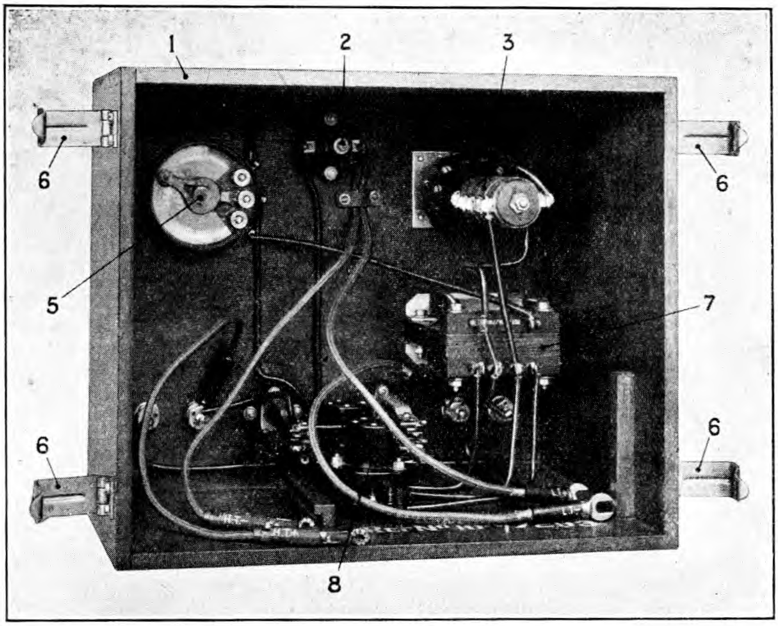


FIG. 4. Interior of Instrument.

winding consists of 1,000 turns of 42 s.w.g. D.S.C. wire. The valve-holders (8) are of the standard type, as also are the jacks (12). The inner contacts of the jacks, as will be seen from the illustration in fig. 2, are not in circuit. The accumulator container (4) is constructed of mahogany and is held in position by a grooved piece of wood mounted in the base of the case, so that it can be easily slid into position. The H.T. battery occupies a position across the back of the instrument as shown in fig. 5, and is prevented from moving, when the back is in position, by the wooden stop (9) and the felted wooden strips on the back.

OPERATION

10. Place V.R.12F. valves in the valve-holders ; if such valves are not available, a V.R.21 valve should be placed in the " oscillator " position, and a V.R.22 valve in the " amplifier " position. After placing a 2-volt accumulator (Stores Ref. 5A/2) in the accumulator crate, connect up the respective L.T. terminals. Place a 15-volt battery (Stores Ref. 5A/50) in position in the back of the case and connect up the H.T. leads. Care should be exercised during this operation that the L.T. leads are not allowed to fall on to, or come in contact with, the H.T. connections. The push-pull switch should be " off ", i.e. pushed in, while making connections. Replace the back of the case and secure by means of the four clips.

11. Normally the grid bias connections may be short-circuited by means of a short piece of wire. A key or automatic sender should be connected to the terminals marked KEY and the plug from the telephone line should be plugged into the jack marked PHONES. Where a number of high-resistance telephones are in use, they should be connected in parallel or series-parallel. If low-resistance telephones are used they should be connected in series. When it is

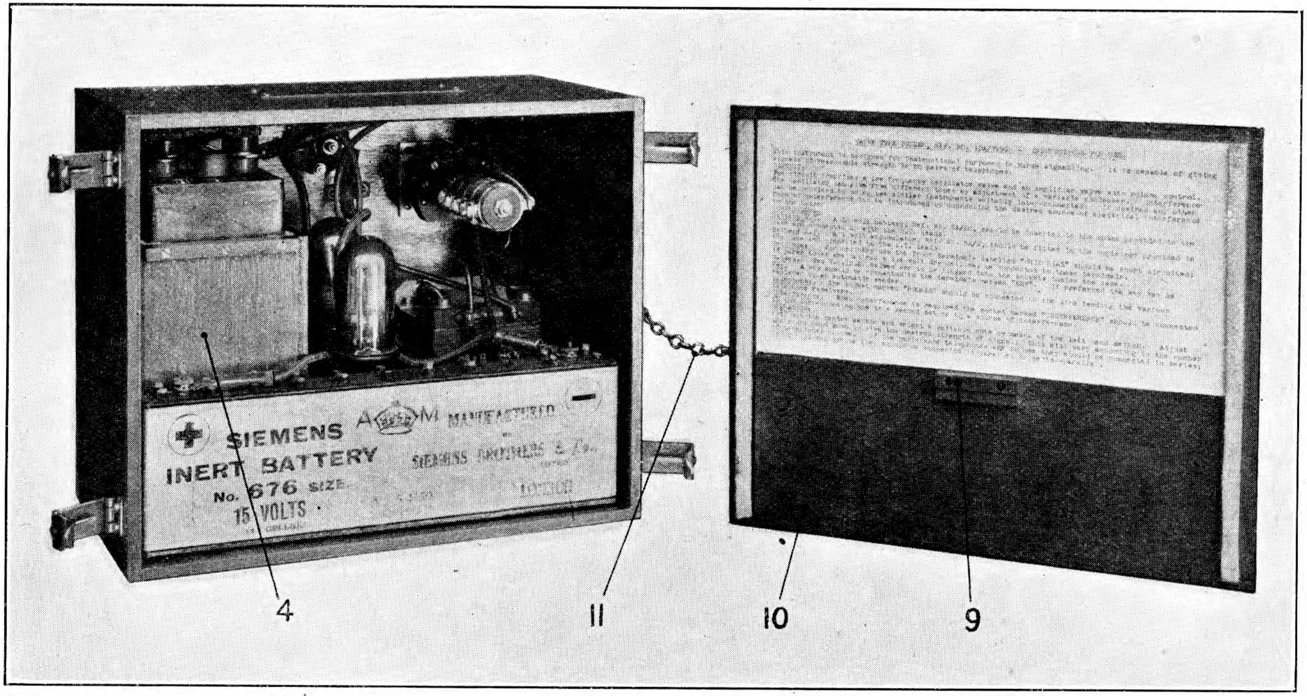


FIG. 5. Rear view of Instrument.

required to transmit signals, the push-pull switch should be pulled out, and a suitable note selected by means of the " frequency " control. The signal strength may now be adjusted, by means of the volume control, to suit the number of telephones in circuit.

12. For the purpose of producing artificial interference a second valve buzzer may be connected up in a similar manner, the " phones " jack of the second buzzer being connected up to the " interference " jack of the first buzzer by means of a short length of twin flex terminating at each end in a standard plug.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information. In ordering spares for this valve type buzzer, the appropriate section of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/7292	Buzzer, valve type, consisting of :—	1	Complete.
10A/7293	Case	1	
10A/7294	Container, accumulator	1	
10A/2123	Valve-holder	2	
10A/1739	Jacks, telephone, standard	2	
19A/7295	Resistance	1	0–500,000 ohms.
10A/7296	Switch	1	Push-pull type.
10A/7167	Transformer, L.F.	1	Type C.
10A/7297	Condenser unit and switch	1	Including 2–·002 μF., 2–·001 μF., 1–·004 μF. condensers.
	Accessories :—		
5A/2	Accumulators, 2-volt	1	
5A/50	Batteries, inert, 15-volt	1	
10A/7228	Valves, V.R.12F.	2	V.R.12F. valves on becoming unserviceable are to be replaced by 10A/7738 V.R.21 (oscillator) and 10A/7958 V.R.22 (amplifier).

SECTION 6, CHAPTER 3

BUZZER, VALVE, TYPE 2

Contents

List of Illustrations

BUZZER, VALVE, TYPE 2

(Stores Ref. 10A/10158)

INTRODUCTION

1. The buzzer, valve, type 2, is intended to be used for instructional purposes in Morse signalling. It is so arranged that when a Morse key is connected by means of a standard type of telephone plug, and a line feeding a number of pairs of telephones is plugged into the output jack, Morse signals of pure tone may be transmitted and received. The instrument is capable of giving signals of adequate strength in twenty pairs of telephones. Means are provided for varying the pitch of the note, and a volume control is incorporated to enable the signal strength to be adjusted as required. Arrangements are made by which two or more instruments may be coupled together so that interfering signals may be obtained, giving practise in " over-reading ". The weight of the instrument, without batteries, is approximately 7 lb., and with batteries approximately 15½ lb. It measures 9¾ in. by 8¾ in. by 8 in. The transit case measures 11¾ in. by 11¼ in. by 10 in. and weighs 7 lb.

GENERAL DESCRIPTION

2. The instrument employs two valves, one of which acts as an audio-frequency oscillator and the other as an amplifier, the telephone circuit being coupled to the anode circuit of the latter by a suitable transformer. The operation of the Morse key makes and breaks the anode circuit of the oscillator valve. The theoretical circuit diagram is given in fig. 1. Associated with the oscillator valve V_1, is the three-winding transformer Tr_1. The first winding is connected between grid and filament of the valve, the second is in series with the anode of the valve, and the third is connected between the grid and filament of the amplifier valve V_2, a suitable condenser C_3, being inserted in series with the grid. These windings may be referred to as the grid, anode and output windings respectively. When the filaments are heated by completing the L.T. circuit, and the H.T. circuit is completed by means of a Morse key plugged into the jack J_1, the anode circuit of the oscillator valve is set in oscillation at a frequency which is mainly determined by the oscillation constant (L C value) of the anode circuit. The L C value may be varied between certain limits by means of the capacitance C_1, which is adjustable in five steps, inclusive of a position in which only the distributed capacitance is operative. The inductance and distributed capacitance is such that the highest obtainable frequency is well within the limits of audibility, and an increase of capacitance causes a reduction of frequency.

3. Since the output winding is coupled to the anode winding, audio-frequency voltages are applied between the grid and filament of the amplifier valve V_2. The magnitude of this grid swing is controlled by means of a potentiometer R_1, across the output winding. The primary winding of the output transformer Tr_2, is in series with the anode of the amplifier valve, and two jacks J_2, J_3, are connected across the secondary winding. The instructional telephone line is plugged into one of these, and the other is available to plug an interference buzzer into the line. A 4½-volt grid bias battery is provided in order to adjust the mean grid potential of the amplifier valve for best operating conditions. With a fully charged H.T. battery, the correct bias is —3 volts.

CONSTRUCTIONAL DETAILS

4. Three views of the instrument are given in figs. 2, 3 and 4, and a bench wiring diagram in fig. 5. Fig. 2 is an exterior view showing the front panel. The case (1) is of mahogany, and is

fitted with a carrying strap of tanned hide. The outside of the case is covered with linen fabric. Both the inside and the outside are painted in standard Air Ministry grey colour and then varnished, with the exception of the battery compartment, which is painted with two coats of acid-resisting black paint. The whole of the electrical components are assembled upon a mild steel chassis which is zinc sprayed all over, the face and edges of the front panel (2) being finished in standard grey stove enamel or cellulose paint. The panel carries the filament switch (3) (Switch, type 70, Stores Ref. 10A/8064). This is a single-pole rotary, cam-operated switch, consisting of two contact arms fitted with gold-silver contacts. Above this switch is a ruby

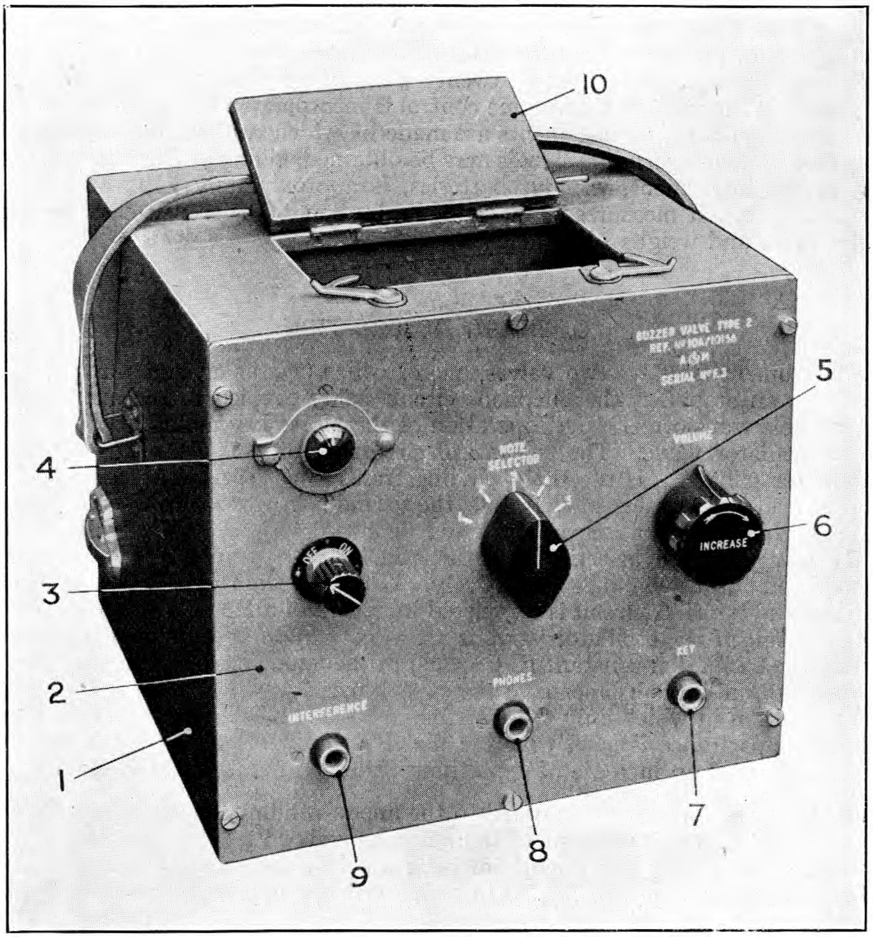


FIG. 2. External view.

lens (4), through which a pilot lamp indicates when the instrument is switched on. The lens is mounted in a pivoted cover which allows access to the pilot lamp. The knob (5) of the note selector switch occupies the centre of the panel. On the right of this is the knob (6) of the volume control potentiometer, while the outer portions of the jacks (7), (8), (9) can be seen near the bottom of the panel. A small hinged door (10) allows access to the interior for the insertion of valves.

5. Fig. 3 shows the components above the shelf of the chassis. The terminal block (1) (Stores Ref. 5C/432) carries the H.T.—, G.B.+, H.T.+ and G.B.— terminals, to which are connected a set of flexible leads (uniflex red 4) fitted with appropriately engraved battery plugs. Behind this terminal block is the oscillator transformer (2). The core of this transformer is of radio-metal, and has a small air gap. Behind the oscillator transformer is the volume control potentiometer (3). This is a resistance, type 75 (Stores Ref. 10A/7605), of 50,000 ohms, the whole of which is in parallel with the output winding. The centre one of the three terminal lugs is connected internally to the rotary contact arm, and externally, *via* the grid condenser, to the grid socket of the amplifier valve-holder.

6. The two valve-holders (4) and (5), are marked V.R. 21 and V.R. 22 respectively; the former is for the oscillator and the latter for the amplifier valve. On the right of the shelf can be seen a terminal block (6) (Stores Ref. 5C/430) carrying the L.T.+ and L.T.— terminals. Flexible leads (uniflex red 4) terminating in spade terminal lugs are provided for connecting the L.T. accumulator.

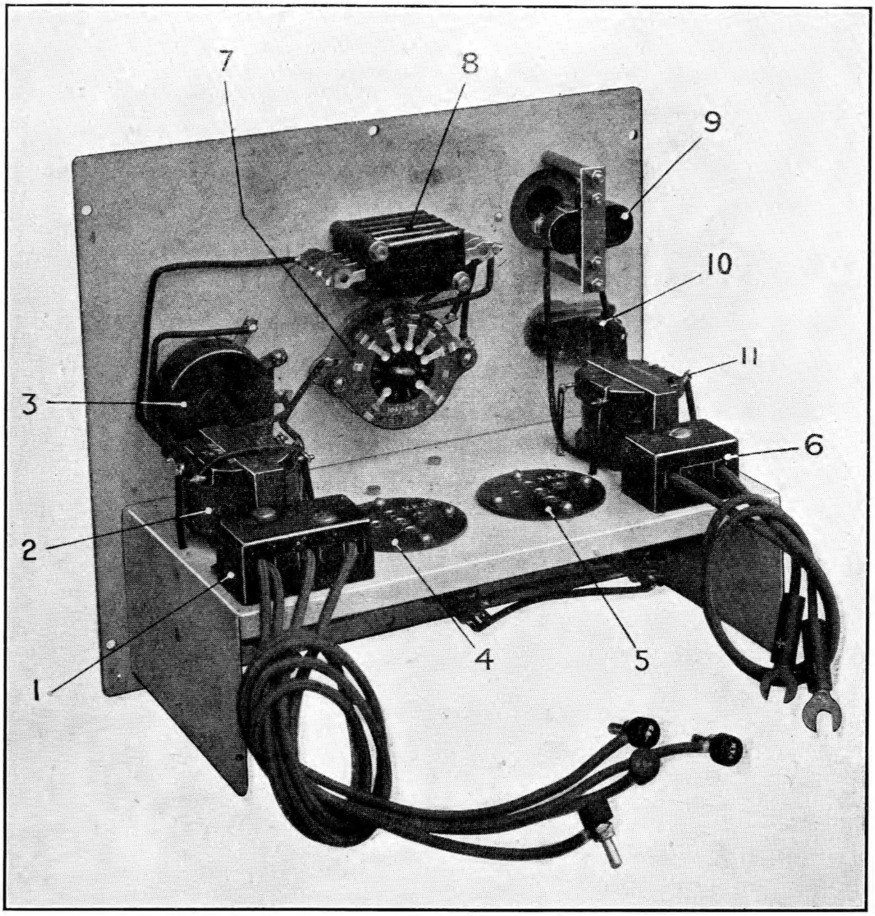


Fig. 3. Panel, rear view.

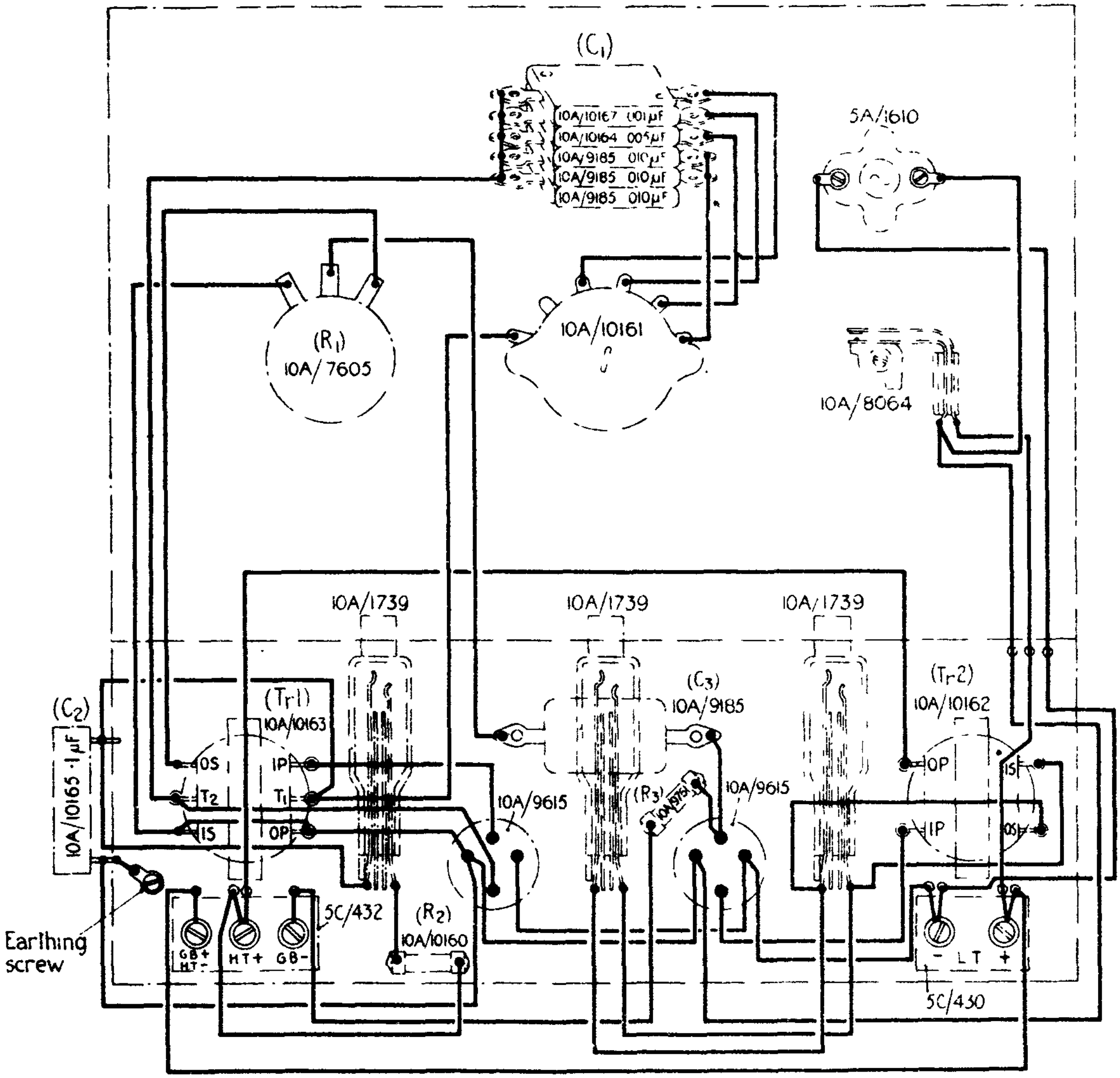


FIG. 5, BENCH WIRING DIAGRAM

a single capacitance of ·02 μF. The miniature Edison screw-holder (9) for the pilot lamp is mounted on a metal bracket. The pilot lamp is rated at 3·5 volts and therefore glows with somewhat less than half its normal brilliancy when the L.T. circuit is closed by means of the L.T. switch (10). On the right of the shelf is the output transformer (11) which has a closed core of low hysteresis steel.

9. Fig. 4 shows the components under the shelf. The mains condenser (1) is a condenser type 386, ·01 μF., paper dielectric (Stores Ref. 10A/10165). Adjacent thereto is a ½-watt rod resistance (2) (type 372, 80,000 ohms, Stores Ref. 10A/10160) which is in series with the anode of the oscillator valve, reducing the mean anode-filament P.D. to about 40 volts. The jack (3) is the one provided for the insertion of the Morse key into the anode circuit. The two remaining jacks (4) and (5), are connected in parallel across the secondary winding of the output transformer. All three jacks are of the standard service type (Stores Ref. 10A/1739). The grid condenser (6), which is mounted on the underside of the shelf, is a condenser type 286, ·01 μF. The ½-watt rod resistance (7) (type 282, 100,000 ohms, Stores Ref. 10A/9761) is the grid leak for the amplifier valve.

VALVES AND BATTERIES

10. The L.T. supply is derived from a single 2-volt lead-acid accumulator (Stores Ref. 5A/1514), the H.T. supply from a 60-volt dry battery (Stores Ref. 5A/1334), and the grid bias voltage from a 4½-volt dry battery (Stores Ref. 5A/1383). The oscillator valve is a valve, receiving, V.R.21 (Stores Ref. 10A/7738) and the amplifier valve is a valve, receiving, V.R.22 (Stores Ref. 10A/7958).

OPERATION

11. To bring the instrument into use, first see that the filament switch is in the " off " position. Insert the pilot lamp into its holder through the aperture normally covered by the ruby lens, place a suitable 2-volt accumulator in the battery compartment, and connect up the L.T.+ and L.T.— leads. On moving the L.T. switch to the " on " position the pilot lamp should glow. Switch off the L.T. switch, place the authorized types of 60-volt H.T. and 4½-volt grid bias batteries in the battery compartment, connecting these in circuit by means of the flexible leads. The grid bias should normally be —3 volts. Close the cover of the battery compartment and secure it by means of the catches.

12. Plug a pair of service high-resistance telephones into the telephone jack and a Morse key into the key jack. With the L.T. switch in the " off " position insert a valve V.R.21 into the right-hand valve-holder and a valve V.R.22 into the holder on the left. Close the L.T. switch and press the Morse key. A clear musical note should be heard in the telephones. The pitch and intensity of this note should be variable by manipulating the note selector switch and volume control respectively.

MAINTENANCE AND PRECAUTIONS

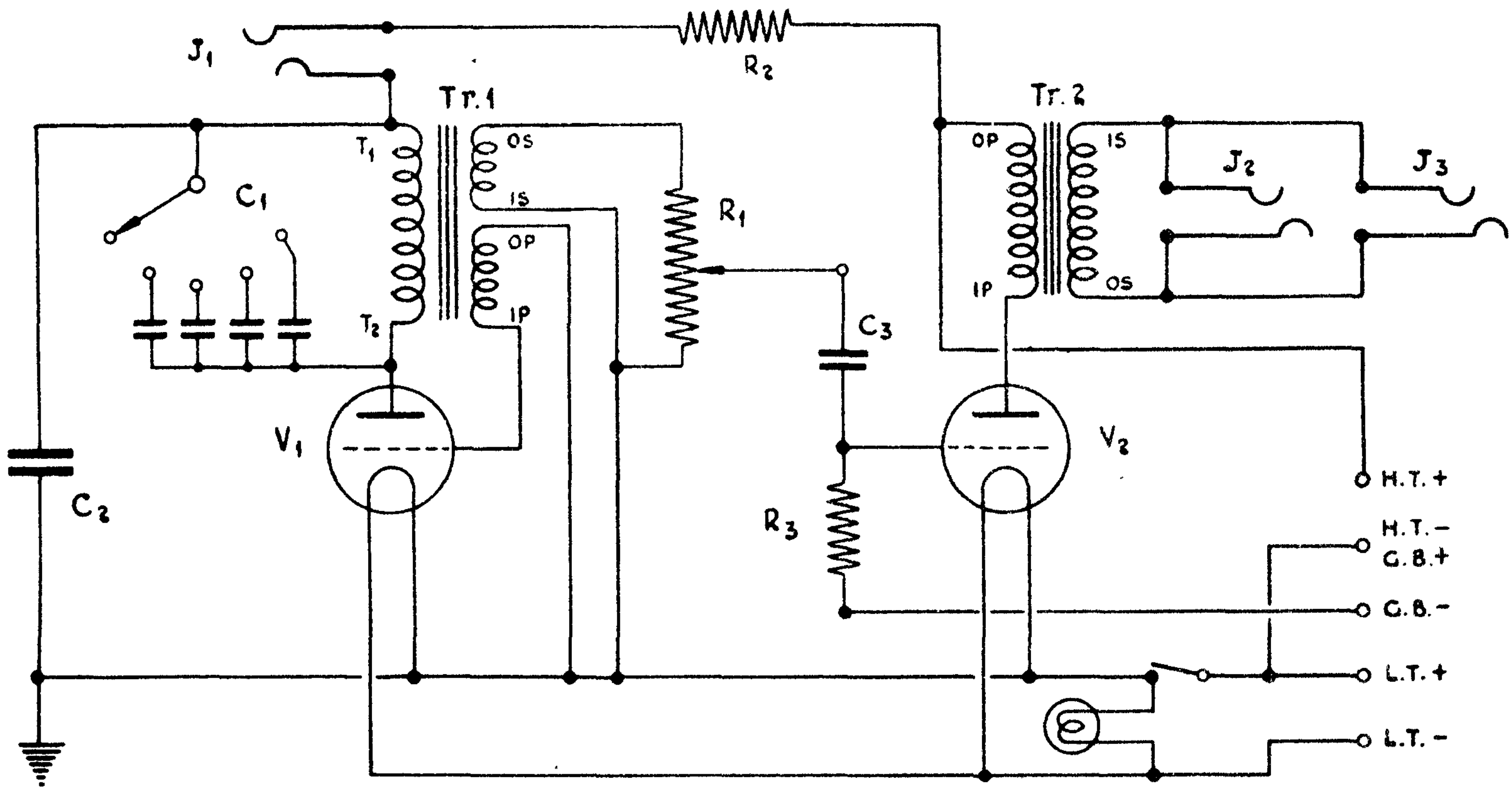
13. The instrument requires very little attention. When not in use it should be stored in a clean dry place. The L.T. battery must be periodically recharged in accordance with the routine in force at the particular station. Unless the instrument is in regular use it is advisable to remove the L.T. battery when Morse practice is completed.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/10158 ..	Buzzer, valve, type 2		
	Consisting of :—		
5C/430 ..	Block, terminal, type B, 2-way No. 1..	1	
5C/432 ..	Block, terminal, type B, 3-way No. 1 ..	1	
10A/10159 ..	Case	1	
10A/10165 ..	Condenser, type 386	1	·1 μF., paper dielectric, cylindrical.
10A/10167 ..	Condenser, type 384	1	·001 μF. ± 5 per cent. mica, moulded.
10A/9185 ..	Condenser, type 286	4	·01 μF.
10A/10164 ..	Condenser, type 385	1	·005 μF., mica, moulded.
10A/9615 ..	Holder, valve, type S	2	
10A/1739 ..	Jack, telephone, type A	3	
5A/1610 ..	Lampholder, miniature Edison screw, batten.	1	
10A/9689 ..	Plug, type 89	1	Engraved H.T.+.
10A/9690 ..	Plug, type 90	1	Engraved H.T.—
10A/9691 ..	Plug, type 91	1	Engraved G.B.+.
10A/9692 ..	Plug, type 92	1	Engraved G.B.—.
10A/7605 ..	Resistance, type 75	1	50,000 ohms, potentiometer.
10A/9761 ..	Resistance, type 282	1	100,000 ohms, ½-watt rod.
10A/10160 ..	Resistance, type 372	1	80,000 ohms, ½-watt rod.
10A/8064 ..	Switch, type 70	1	Cam-operated, L.T.
10A/10161 ..	Switch, type 141	1	5-position selector switch.
10A/10162 ..	Transformer, L/F., type H	1	
10A/10163 ..	Transformer, L/F., type J	1	
	Accessories :—		
5A/1514 ..	Accumulator, lead-acid, 2 V., 7 Ah. ..	1	
5A/1383 ..	Battery, dry, 4½ V.	1	
5A/1334 ..	Battery, dry, 60 V.	1	
10A/10298 ..	Case, transit	1	
5A/361 ..	Lamp, filament, 3·5 V.	1	
10A/7738 ..	Valve, V.R.21	1	Oscillator.
10A/7958 ..	Valve, V.R.22	1	Amplifier.



RESISTANCES (OHMS)		CONDENSERS (μF)	
R_1	50.000	C_1	·001, ·005, ·01, ·02.
R_2	80.000	C_2	0·1
R_3	100.000	C_3	·01

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FIG. 1, THEORETICAL CIRCUIT DIAGRAM

December, 1938

Issued June, 1939, *with A.L. No.* 5

SECTION 6, CHAPTER 4

AERIAL WINCH, TYPE 5

Contents

List of Illustrations

AERIAL WINCH, TYPE 5

(Stores Ref. 10A/9005)

INTRODUCTION

1. The aerial winch, type 5, is fitted in aeroplanes for the purpose of manipulating the trailing aerial. It is mounted in the fuselage in a position convenient for handling by the radio operator. The winch carries an easily removable reel for the accommodation of the aerial wire. Provision is made for this reel to be in any one of three states, viz., (i) free to rotate in either direction on its spindle, (ii) free as in (i) but under the control of a hand brake, and (iii) under the control of a pawl and ratchet for winding in.

2. The winch also provides for clamping the wire in sound electrical contact with the aerial lead to the wireless installation, and for earthing the aerial before disconnecting this lead (*see* para. 10).

3. The space occupied by the winch (with reel of aerial wire in position) is approximately 18 in. by 9 in. by 4 in. The weight, including reel, but not the aerial wire itself, is 4 lb. $5\frac{1}{2}$ oz.

4. The winch is adapted for carrying either of two types of reel, viz., reel, type A, for use with a trailing aerial of aerial wire R4, or reel, type B, for use with stainless steel aerial wire. The latter wire is much less bulky than the former, and the winding space on the type B reel is reduced accordingly, thus allowing a corresponding increase in the length of the insulating path between any wire on the reel and the metal work of the winch.

GENERAL DESCRIPTION

5. The details of the winch will be explained with reference to figs. 1 and 2. Fig. 1 shows the winch itself and also an aerial reel, type B, as viewed from the rear, while fig. 2 shows the winch with an aerial reel, type B, mounted thereon. Referring to fig. 1, the winch consists of an aluminium alloy plate (1) carrying a hub (2) upon which the reel rotates. The state of the winch, i.e. free, free but braked, or ratchet-controlled, is governed by the pawl (3) which is loaded by a spiral spring (4). The pawl is also controlled by the lever (5) which pivots about the hub (2) and may be locked in either the " free " or " ratchet-controlled " state by means of the spring-loaded plunger (6). When this plunger is depressed, the lever (5) tends to move to the " braked " position under the control of the spiral spring (7). The lever carries a pin (8) upon which the pawl abuts. When the lever is in the " ratchet " position, the pin allows the pawl to fall under the control of the spiral spring (4), and to engage with the ratchet on the reel. In the " brake " position the pin lifts the pawl clear of the ratchet and forces its upper end into contact with the brake drum. When the lever is in the " free " position the pin holds the pawl in such a position that it is clear of both the ratchet and the brake drum.

6. The hub is not of uniform diameter over all its length, but has an inner (13) and outer (14) bearing surface. Between these surfaces, the hub is turned down about 0·01 in., forming a grease trap by which efficient lubrication is maintained.

7. The reel, type B (Stores Ref. 10A/9123), (9) is of ebonite, machined from the solid. In order to reduce the weight, material has been removed from the central portion. The reel has a steel bush and carries on the rear side a steel brake drum (10) and ratchet (11). The reel is held in position on the winch by means of two spring clips (12), over which it is easily slipped. To remove the reel, the clips must be pressed together by finger and thumb.

8. The winch embodies a clamp for the aerial wire. Referring to fig. 2, this consists of a heavy ebonite block (1) carrying a stainless steel anvil, to which is attached a plug. The aerial lead (2) of the transmitter may be connected to this plug by means of a socket, type 40. The aerial wire passes through a rectangular orifice in the ebonite block and is pressed against the anvil by a stainless steel roller. This roller is mounted in a sliding frame which is carried by a spring-loaded plunger. This plunger is enclosed in a steel sleeve, in which it has a travel of

about $\frac{3}{32}$ in., against the action of the spring. In order to allow the plunger to be withdrawn sufficiently to allow a bead weight, type 1, to pass between roller and anvil, the outer end of the sleeve carries an external screw-thread (3) and the ebonite block is fitted with a fixed metal plate carrying a female thread. The sleeve may be rotated by a knurled ebonite knob (4). When the above-mentioned screw threads are engaged, the roller is moved forward towards the anvil by rotating this knob in the clockwise direction. To pass the bead weight, type 1, through the orifice, the knob is rotated in the counter-clockwise direction until the threads disengage, when the roller may be still further withdrawn by sliding the unthreaded portion of the sleeve through the fixed plate.

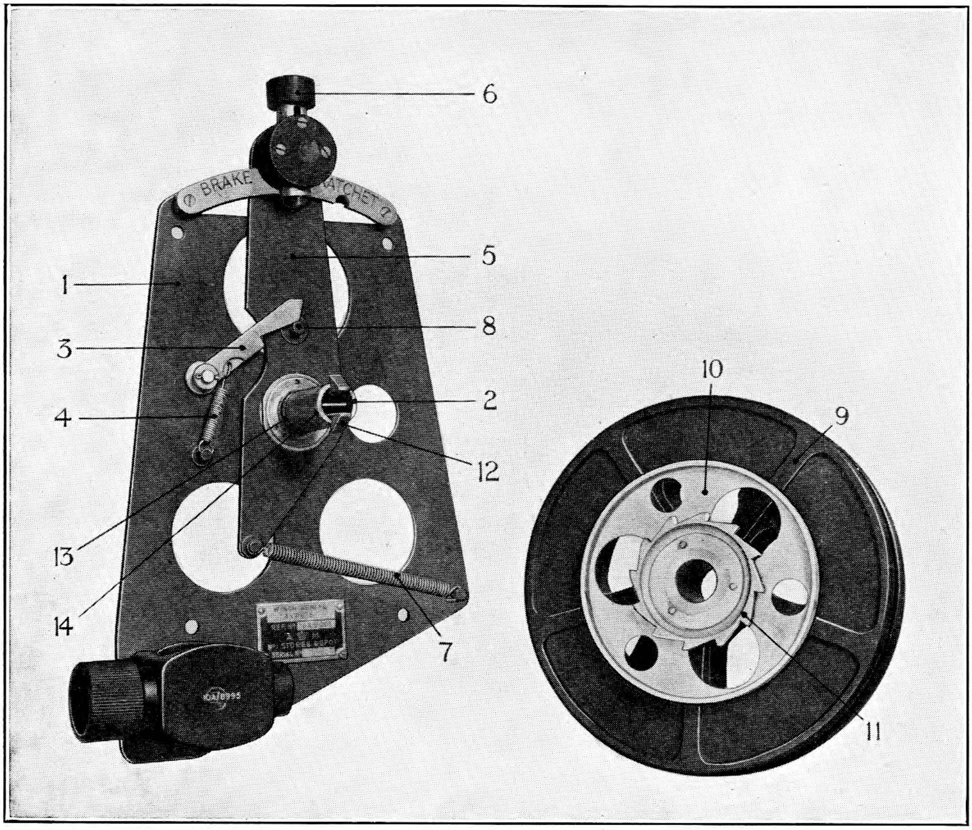


FIG. 1.—Aerial winch, type 5, and reel, type B.

9. The aerial wire is not attached directly to the reel, but in the following manner. A length of kite cord about 42 in. long, fitted with an eye splice at one end, and having a small metal thimble spliced into the other, is clove-hitched round the winch. The standing part of the kite cord is then held by passing a metal screw through the eye splice, a metal washer being interposed to prevent the eye from riding over the head of the screw. The screw engages with a metal nut which is located in the body of the reel. The aerial wire is attached to the kite cord by clove-hitching it tightly round the metal thimble, as shown in fig. 2, taking the end of the wire about twelve turns round the standing part, and nipping the end tightly round the wire in order to avoid "brushing" from the sharp ends. A west-country whipping of waxed twine is then placed on the wire, over a length of $\frac{1}{4}$ in. above and below the end of the twisted portion.

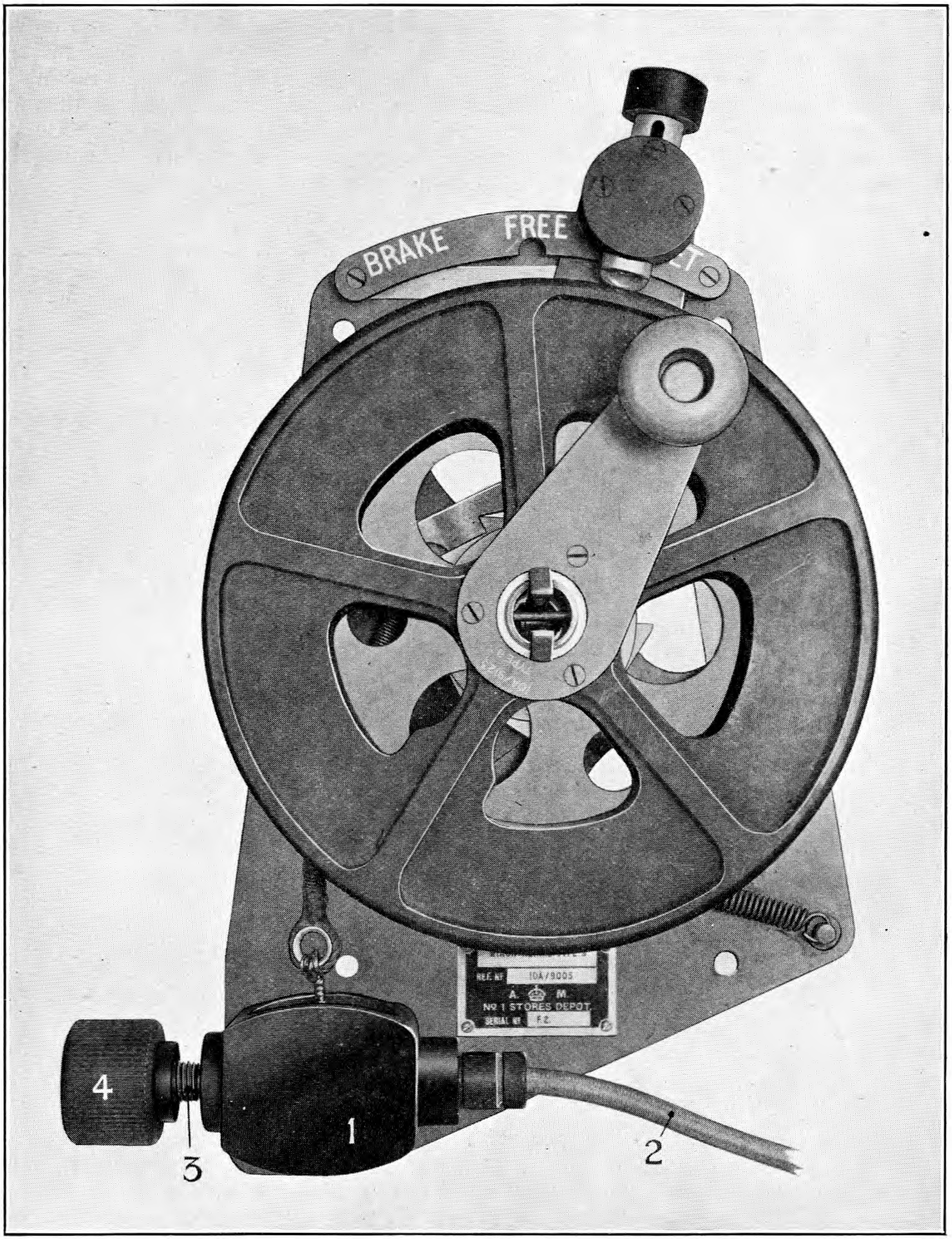


FIG. 2.—Reel, type B, assembled on winch.

10. The knurled head (4, fig. 2) is hollow, and contains a spill similar to the plug by which the aerial lead of the transmitter is connected to the aerial wire. The aerial may be earthed by means of this spill, and a short earthing lead, fitted with a socket, type 2, is supplied with the winch for this purpose. The earthing spill was not incorporated in the original design, but has

been added in order that the aerial may be earthed without previously disconnecting the transmitter, and so completely isolating the aerial from earth for a short period. If a winch drawn from store is found to be without the earthing spill, it should be modified as described in the following paragraph before being installed, or at the first opportunity.

11. The earthing spill (Stores Ref. 10A/10358) is fitted in the following way :—

(i) Remove the coin-slotted disc on the end of the knurled knob (4, fig. 2).

(ii) Remove the three screws at the bottom of the cavity thus revealed.

(iii) Insert the earthing spill, and secure it in position by three brass screws (countersunk, 8B.A. $\times \frac{3}{8}$ in. (Stores Ref. 28/2123). The heads of the screws should be touched with shellac varnish to prevent subsequent movement.

(iv) Drill a $\frac{9}{16}$ in. hole in the centre of the coin-slotted disc, and replace in its original position.

PRECAUTIONS AND MAINTENANCE

12. Care must be taken that the winch is very well bonded to earth. When a reel, type B, is in use on a type 5 winch, it is permissible to leave turns of aerial wire upon the winch, where the total length of wire, and the operational frequency so necessitate. This practice is not permissible with earlier types of winch, nor with the winch, type 5, if a reel type A is fitted.

13. After reeling out the aerial, care must be taken that the plunger grips the aerial wire below the short whipping on the joint at the thimble of the kite cord. The whipping itself must on no account be gripped. Except when the winch is actually being operated, for the purpose of reeling in or out, the brake lever should always be maintained in the " ratchet " position.

14. When the aerial is weighted by means of an aerial weight, type 1, the aerial, on reeling in, is to be drawn up until the first two or three beads are above the plunger, and the latter is then to be closed, so as to grip the tail upon which the beads are threaded.

15. Each reel should be tested occasionally for freedom of movement. The reel should have a just perceptible amount of end play on the spindle. The reel should spin freely when the brake lever is in the " free " position. Any stiffness should be eliminated by careful removal of material from the reel, but not from the spindle. In the unlikely event of either end of the pin across the outer bearing being slightly proud of the bearing surface, however, the surplus material should be carefully removed.

16. The grease trap on the centre portion of the spindle should be examined periodically for dryness. If necessary it should be cleaned and smeared with anti-freezing grease. Surplus dirty grease should not be allowed to accumulate.

17. It is advisable to clove-hitch the kite cord round the reel before the eye of the cord is secured by means of the washer and screw, taking particular care that, in the event of the eye breaking, the clove-hitch will hold the aerial. If the clove-hitch is made with the eye secured in place it is quite easy to pass the cord wrongly so that a true clove-hitch is not made.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Qty.	Remarks.
10A/9005	Winch Aerial, type 5	1	With earthing lead fitted with socket type 2.
	Components :—		
10A/8995	Blocks, contact	1	
10A/10358	Spill, earthing	1	
	Accessories :—		
10A/7183	Reel, type A	1	
	or		
10A/9123	Reel, type B	1	

SECTION 6, CHAPTER 5

AERIAL, SCREENED LOOP, TYPE 1

Contents

List of Illustrations

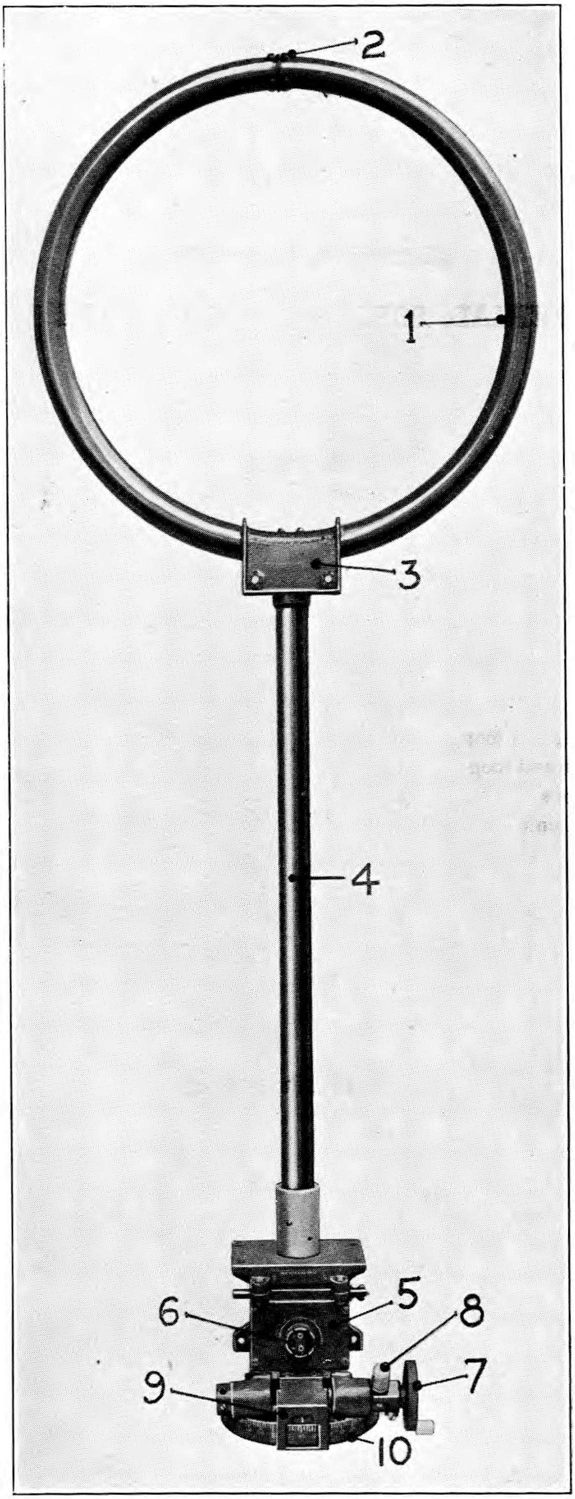


Fig. 1. Aerial, screened loop, type 1.

AERIAL, SCREENED LOOP, TYPE 1

(Stores Ref. 10A/8478)

INTRODUCTION

1. The screened loop aerial type 1 is designed for installation in aeroplanes. It is used in conjunction with a suitable radio receiver for the purpose of obtaining D/F bearings.

2. The apparatus consists of a tube of non-magnetic material bent into a circular form. Within this tube is mounted an insulated winding forming the loop aerial. The tube is mounted on a hollow shaft which projects through the fuselage. The ends of the loop aerial are carried through this shaft and are connected to the receiver *via* suitable wire contacts.

3. The loop may be rotated from within the aeroplane, either through a geared handle operating upon the end of the shaft, or by means of a remote control device. Where such remote control apparatus is fitted, a bearing indicator is provided at the control position, so that the orientation of the loop at any particular moment is known to the operator.

4. When the loop aerial is connected to the radio receiver, the operator is able to rotate the loop while listening to the signals emanating from a distant radio transmitter. The orientation of the loop giving minimum signal strength is noted. The bearing indicator then gives the apparent relative bearing of the transmitter, with an ambiguity of 180°. After certain corrections have been applied, the bearing of the radio transmitter may be laid off on a chart or map.

CONSTRUCTIONAL DETAILS

Aerial loop, type 1

5. A view of the screened loop aerial is given in fig. 1. The coil portion is circular in shape, having a mean diameter of 18 in., and comprises 12 turns of 24 s.w.g. enamelled copper wire wound within a tungum tube (1) of $1\frac{1}{2}$ in. diameter. The tube forms an electrostatic screen. In order to prevent short-circuit currents around the tube, the continuity of the tube is broken by a $\frac{1}{8}$ in. gap at the top. This gap is filled in with insulating material (2) and the joint made watertight. The weight of the loop including plugs, leads and bolts is about 11 lb.

6. The tube (1) is mounted in a cradle (3) which is supported by the tube (4), extending through a casing (5) and mounted on ball bearings at the top and bottom of this casing. The two ends of the coil winding are brought out through two slip rings mounted on the rotatable tube (4), and brushes bearing on these slip rings are connected to the socket (6). It is thus possible to connect the coil to a suitable receiver by inserting a plug in the socket. A slot is cut in the side of the socket in which a projection in the plug engages. This is provided in order that the coil will be connected to the receiver input in the correct sense.

7. The casing (5) is rigidly mounted on the aircraft and the loop may be rotated in the casing by means of the handle (7). A system of worm gearing is employed, and the worm may be brought into or out of the mesh with the wormwheel by means of the knob (8). A fixed datum line on a pointer (9) shows the amount of movement of the scale (10), which is engraved in degrees from 0 to 360 and which is secured to the rotatable tube (4). Two scales are provided, one for D/F and one for sense, coloured white and red respectively. Provision is also made whereby the loop may be operated from some remote position. A remote indicator is also provided for this purpose.

8. Two enlarged views of the casing are given in figs. 2 and 3. Referring to fig. 2, the rotatable portion of the loop (1) may be seen above the casing (2) which is secured to the aircraft and carries the socket (3) and guide tube (4) for the remote operating shaft. When it is desired

to operate the loop by means of the gear wheel, the spring-loaded knob (5) is pulled up and pushed towards the rear of the casing. Two holes are provided in the bracket (6) and when the knob enters the rear hole, the worm is engaged with the wormwheel. Rotation of the handwheel (7) now results in the loop being rotated and the amount of movement is apparent on the scale engraved on the indicating drum (8).

9. In fig. 3, which is a view of the worm gear, the pointer has been removed in order to show the manner in which the worm gearing rotates the loop when it is operated by the handle (1). The worm (2) is in mesh with the wormwheel (3), beneath which can be seen the wheel (4) which drives the shaft for the remote indicator. The cover of the gear casing has been removed in order to show the two slip rings (5) and the two connections (6) from the ends of the coil. Above the slip rings may be seen the wheel (7) with which the shafting from the remote controller is engaged. The guide tube (8) is provided with two bolts (9) to facilitate alignment of the shafting. An earth terminal (10) is also provided on the side of the casing.

10. To the left of the casing may be seen the brush gear. The brush holders (11) are mounted on an insulating block (12). The brushes (13) consist of two pieces of phosphor-bronze wire bent in such a manner that when the cover (14) is placed on the casing, the brushes will bear against the slip rings (5). Since it is important that the socket is connected to the coil in the correct sense, two dowel pins (15) are provided on the cover. These pins engage the holes (16) in the casing when the brush gear is assembled. The brushes may be renewed by releasing the two screws (17) and removing the plate (18), a piece of 16 s.w.g. phosphor-bronze silver-plated wire is bent to the shape desired and the plate re-assembled.

11. An underside view of the casing is given in fig. 4. The handle (1) and worm (2) are on a common spindle which is mounted in an eccentric sleeve (3) carried in the bearing (4). The knob (5) is secured to the eccentric sleeve by means of the bracket (6). By releasing the screw (7), which fits into a slot in the eccentric sleeve, the latter may be withdrawn from the bracket (6) and inserted into the bracket (8). The screw (7) is then inserted into the hole (9). The alternative driving position is provided in order to facilitate mounting. The wheel (10) for driving the remote indicator shafting may be seen in this view, also the guide tube (11) in which the shafting runs. The guide tube (12) for the controller shafting is at the other side of the casing. The machined surface (13) provides an alternative mounting position for the pointer. The casing is secured rigidly to the aircraft structure by bolts passed through the holes (14).

12. As shown in fig. 2, two sets of scales are provided on the drum (8) one set on the periphery and one on the face. The scale on the periphery is used when the loop is mounted above, and that on the face when the loop is mounted below the structure. It should be noted that the two scale readings increase in opposite directions. In some instances when remote control is not in use, the indicating drum may be used as a handwheel for rapid rotation of the loop, but before this can be accomplished the worm and wormwheel must be disengaged as described in para. 15.

Controller

13. The controller, which is illustrated in fig. 5, is used when it is desired to operate the loop remotely, and is mounted in a convenient position in the aircraft. The handle (1) is secured to a pinion which is geared to a spur wheel. On the spur wheel is mounted the toothed wheel which is adapted to operate the flexible shaft for driving the loop. An adjustable guide tube (2) is fitted at the top of the controller to facilitate the engagement of the shafting with the toothed wheel. In view of the fact that the gear ratio of the controller is of the order of 4 : 1, great care must be taken to ensure that the controller handle is not turned beyond the limit of the stops, otherwise the cable and associated parts will be damaged.

Indicator

14. The indicator, which is also illustrated in fig. 5, is used in conjunction with the controller for remote operation of the loop. The circular dial is divided into degrees. The pointer (3) is used for the bearing and the pointer (4) for sense directions. The guide tube (5) may be

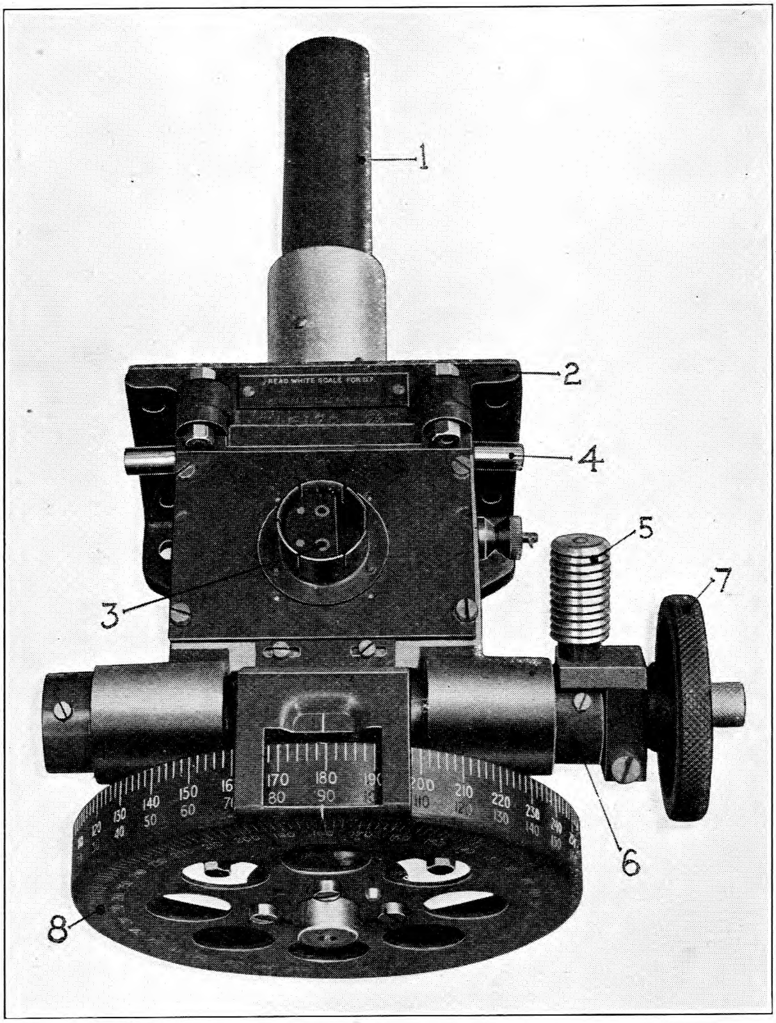


FIG. 2. Gear box end of loop

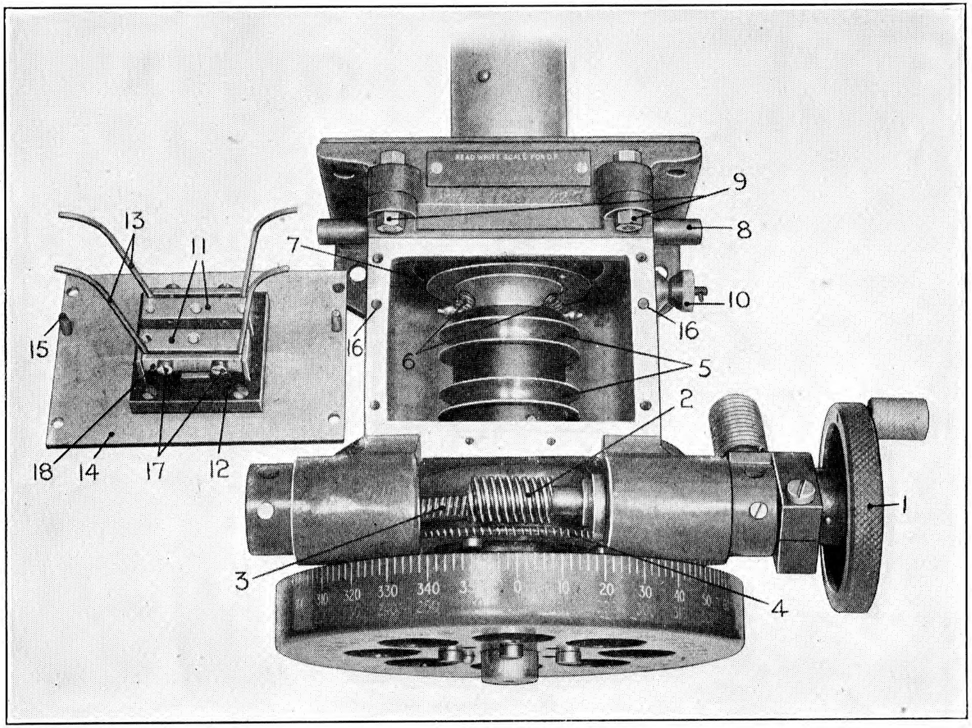


Fig. 3. Cover removed to show slip rings.

removed by releasing the two screws (6) to facilitate the engagement of the shaft with the loop. Two lines are engraved on the face of the dial, the left-hand one is red and the right-hand one green. They refer to the position of the stops and are dealt with under the particulars of installation. The adjustment (7) is for the final alignment of the indicator dial with that of the loop. Inside the indicator is a coiled spring which is in tension, and serves to take up any backlash or lost motion of the operating cable. The indicator is secured to the aircraft structure at any convenient position, by means of bolts passed through the lugs (8).

INSTALLATION

15. The D/F. loop will normally be installed in the aeroplane by the contractor. The following information is given as a guide in the event of subsequent adjustments being required. It is extremely important that the instructions be followed carefully, and a check made by taking an actual bearing and ensuring that this is correct, paying particular attention to the sense indication.

Remote operation

16. After deciding the position of the controller and the indicator, the run of casing should be installed. Care must be taken that there are as few bends as possible, and, where bends are essential, that they are of a large radius. Always bend the casing with the shafting in position, using the appropriate tools. Before making any connection to the remote apparatus make sure that the handle (1, fig. 3) is free. If it is not free, then lift the knob (5, fig. 2) and move it towards the operator till the spring plunger engages the appropriate hole. The diagrammatic arrangement shown in fig. 6 is for an installation where the loop is mounted above the aircraft. If the loop is mounted below the aircraft, the casings between the controller and indicator must be assembled at the opposite end of the loop guide tube to that shown in the figure.

17. The casing must be bonded at the end and at as many intermediate points as possible. Determine the length of shafting necessary from the table in fig. 6, cut off the desired length and grind the end to the shape of a cone. Push the shafting through the casing, taking care that no dirt or grit is picked up.

Connecting up controller and loop

18. First see that all four guide tubes (*i.e.* two guide tubes on the loop, one on the controller, and one on the indicator) are free. See that the indicator dial adjusting screw is fixed centrally in its slot, rotate the loop by means of the scale (8, fig. 2) until the loop reads the same as the indicator (about 45°), then screw down the guide tube on the controller at the top of the loop gear box.

Connecting up indicator and loop

19. With the loop still adjusted to read the same as the controller, see that a length of 12·67 in. of shafting projects from the indicator guide tube (or from the bend attached to it, if one is used) and then screw down the lower guide tube on the loop only. Move the controller handle slightly ; determine and note in which direction the handle must be moved, in order that the shafting which projects from the indicator guide tube will move towards the indicator. Re-adjust the loop by means of the controller handle so that the reading on the loop is the same as that on the indicator, and then screw down the indicator guide tube.

Adjustment of main stops

20. Fix extension tubes over the projecting ends of the shafting, taking care to move the controller handle in the direction previously determined. Rotate the loop to approximately 40°, so that the red line on the indicator face coincides with the line on the indicator stop. In this position, push the stop-rod (1, fig. 6) into the loop extension tube until the end of the shafting is reached. Drill a hole through the tube and stop-rod and secure in position with a rivet.

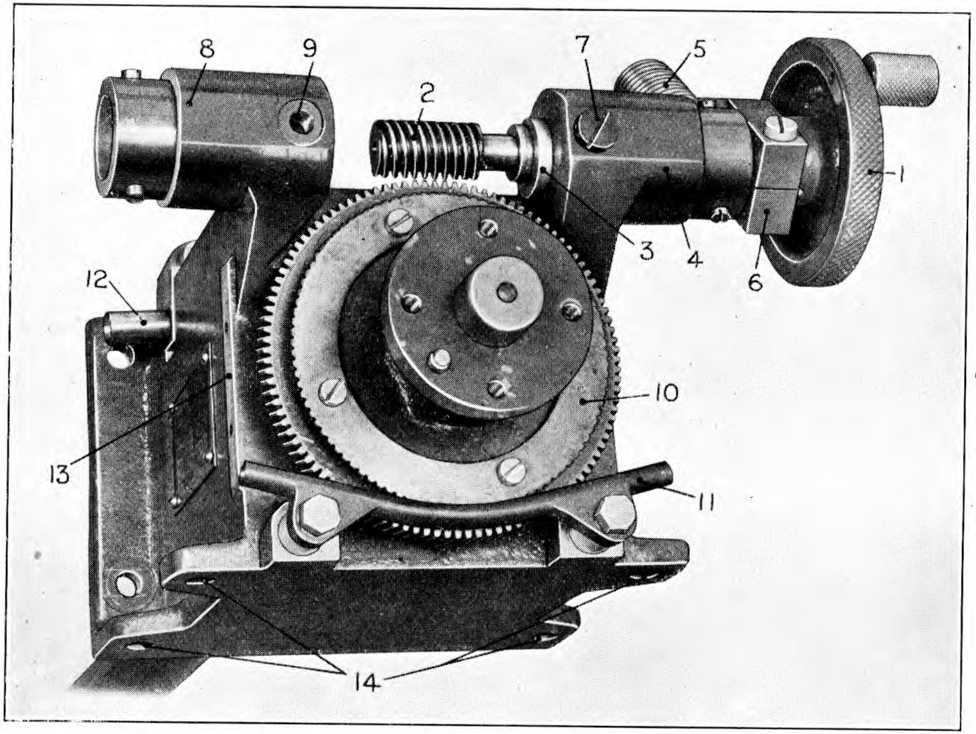


FIG. 4. Underside of gear box.

Continue to rotate the controller handle in the same direction until the green line on the indicator face is coincident with the line on the indicator stop. Push the stop-rod (2) into the extension tube at the controlling end until the end of the shafting is reached, and rivet the stop-rod in this position. Care should be exercised during assembly that no strain is put on the indicator stops by moving the controller handle in the wrong direction. Using the controller, move the loop to zero, and if necessary, adjust the indicator dial by means of the screw (7, fig. 5) to give the same zero reading. After the adjustment has been made, see that the locking washer is lipped up against the edge of the hexagon screw head.

Fixing of anti-torsional unit

21. In order to prevent any tendency on the part of the indicator shafting to twist in operation, anti-torsional units are fitted at the ends of the indicator casing. They consist of extension tubes at each end having elliptical instead of circular bores. A metal bead secured to the shafting which runs in this extension tube also has an elliptical cross section and slides smoothly in the elliptical bore of the casing. Any tendency of the shafting to twist is thus prevented.

22. To fix the anti-torsional unit proceed as follows. Rotate the controller to the end of its movement and fix the clamp on the end of the casing by tightening the screw (3). Starting with the end of the shafting which has the minimum projection, slide the special bead on to the shafting. The bead is provided with a small screw which, when withdrawn, allows the split bead to grip the shafting. This screw should be removed after pushing the bead up the shafting until it is approximately $\frac{1}{8}$ in. from the clamp. Now push the end tube over the bead, engage it in the clamp, and tighten the second clamp nut (4). Rotate the controller to the other end of its travel and repeat the above procedure at the other end of the shafting.

OPERATION

23. The loop is connected up by means of a plug and socket. When used with receiver R.1082 the plug from the loop is inserted in a socket on the sense unit of the receiver. The *fixed* aerial is also connected up to the sense unit by means of a plug and socket, for sense-finding purposes. The trailing aerial is not to be used for sense-finding.

24. The sense unit (*see* fig. 7) is provided with two switches and a variable resistance. One switch has three positions and is engraved D/F, SENSE and TRAFFIC. The other is a two-position switch engraved BEARING and RECIPROCAL. The three-position switch when placed in the D/F. position disconnects the fixed aerial enabling the loop to be used alone. When placed in the SENSE position the fixed aerial is connected to the receiver through the variable resistance. When placed in the TRAFFIC position the fixed aerial is connected directly to the receiver. The two-position switch enables the connections of the loop to be reversed.

25. The detailed operations for obtaining D/F. bearings with any given receiver will be found in the chapter appropriate to that receiver, but the method of using aerial, screened loop, type 1 as given below is applicable generally.

26. The loop may be used directly or through remote control. In the event of its being used directly, the position of the receiver will be sufficiently close to enable the operator to make simultaneous adjustments of both receiver and loop. Referring to fig. 2 and assuming the loop to be so mounted as to project vertically upwards, *i.e.* with the loop itself above the aircraft, the operator will read the scale on the periphery of the drum (8) whilst turning the handle (7). In the event of the loop being mounted so as to project downwards, *i.e.* with the loop itself below the aircraft, the scale on the face of the drum will be used.

27. When used with remote control the controller and indicator shown in fig. 5 will be installed near the receiver and the operator will rotate the loop by means of the controller and observe the indicator readings.

28. The operation of taking an ordinary D/F. bearing resolves itself into the simple process of identifying and tuning in a suitable transmitter and, with the loop connected to the receiver,

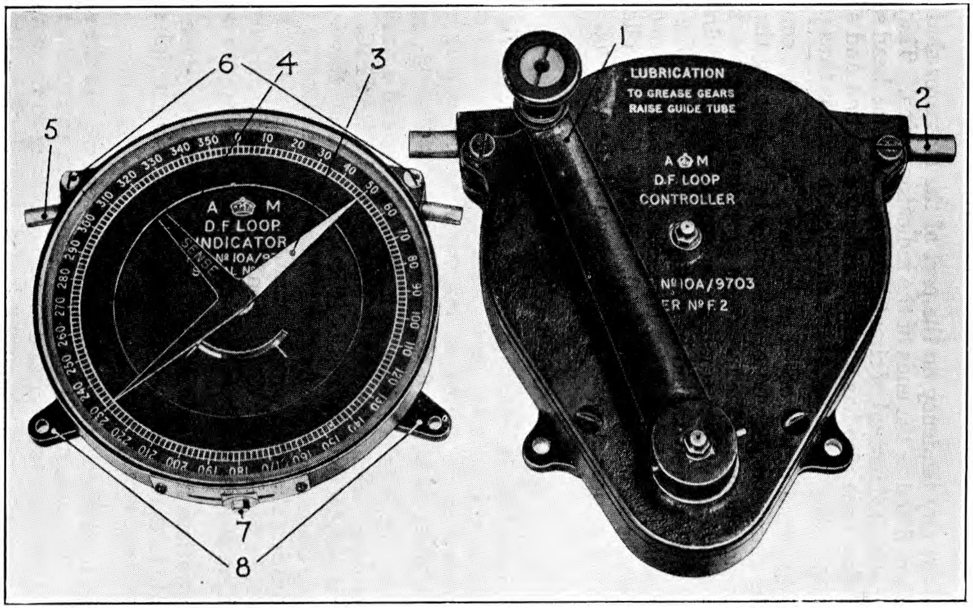
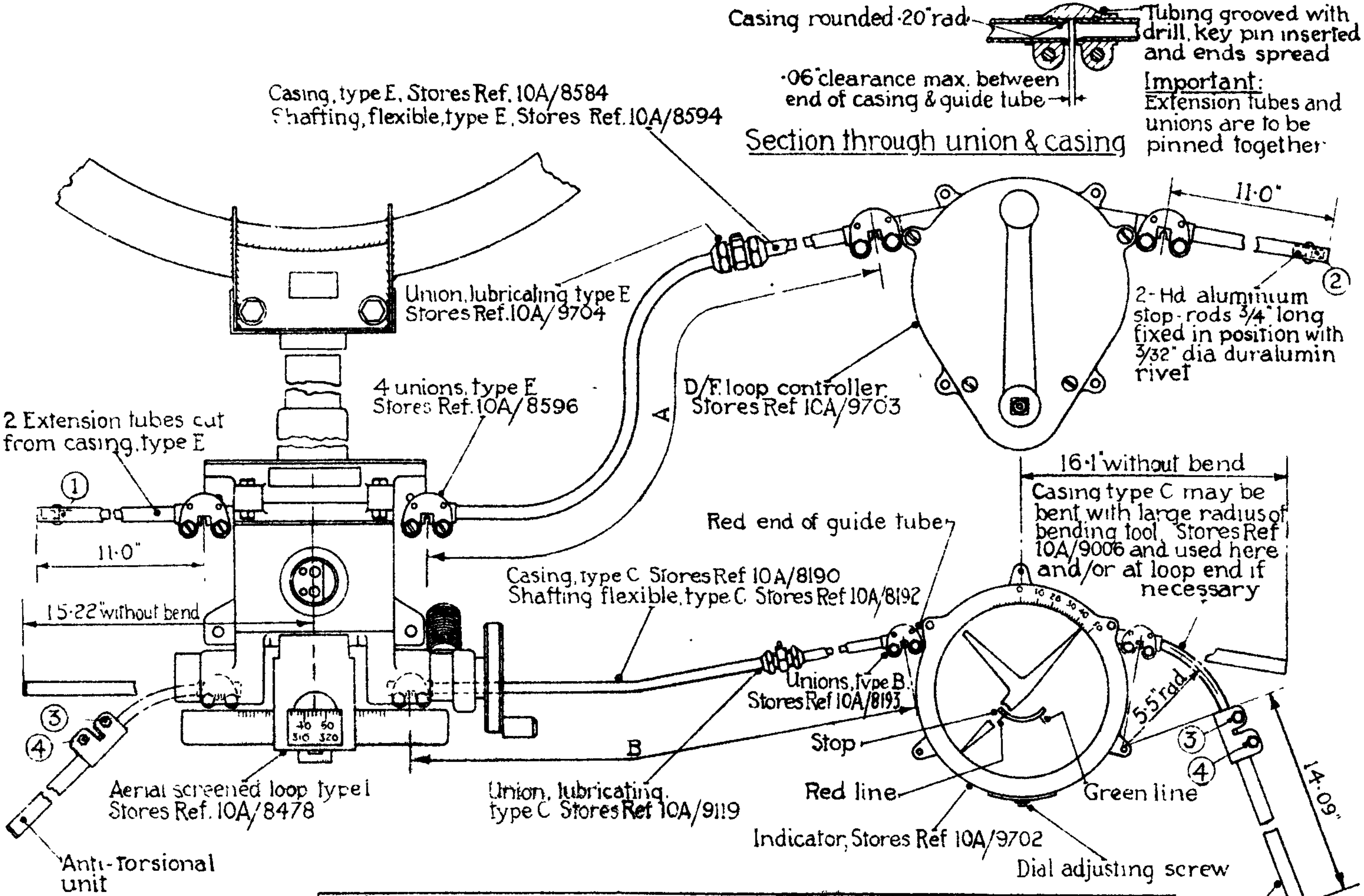


FIG. 5. Indicator and controller.



Service	Casing	Shafting total length, with or without bend between guide tube & anti-torsional unit. Without bend	With bend
Controller-loop	Dimn A	Dimn. A + 21"	
Loop-indicator	Dimn B	Dimn. B + 23·7"	Dimn. B + 23·7" + shafting contained in bend or bends

FIG. 6. INSTALLATION DIAGRAM

rotating the loop whilst listening-in simultaneously. The strength of the signal heard in the telephones will vary as the loop is rotated and at two points in each revolution of the loop the signal will fall to a minimum. If the scale on the indicator is observed it will be found that the two readings at which these minima occur are separated by 180°. One of these is the bearing and the other the reciprocal of the bearing.

29. The ambiguity of 180° can be resolved by dead reckoning. It may also be resolved by obtaining a second bearing of the same transmitter a few minutes later or by obtaining a bearing of another transmitter. In order to resolve this ambiguity at the same time as the bearing is taken, however, sense-finding arrangements are provided.

30. The method of determining sense may be described in the following way. Having obtained two minima as described in para. 27, the sense aerial is connected up through an adjustable resistance to the receiver whilst retaining the loop aerial connection. This has the effect of altering the polar diagram from figure-of-eight form (two minima and two maxima) to a cardioid form (single minimum). This sense minimum, however, is not located with sufficient accuracy to be employed for an actual bearing, but it does enable the ambiguity between the bearing and its reciprocal to be resolved, because it always has a relation of $\pm 90°$ to the bearing. The sign of this depends upon such factors as the connection of the loop and the relation of the loop to the sense aerial. For example the loop may be above or below the aircraft and the sense aerial may be above or below the aircraft. It will be seen that for a given installation the sign may be predetermined and provided no changes are made, this sign will remain constant. Thus, if the sign were positive, no doubt would exist as to which of the two minima obtained above was the bearing. It would be that one which was 90° less than the sense figure. Having thus discriminated between the two figures it is now only necessary to read the bearing figure accurately with the loop alone in use.

31. In practice, however, sense determination is facilitated in the following manner. It will be seen that the indicator illustrated in fig. 5 has, mounted at an angle of 90° to the main pointer, a short pointer engraved SENSE. Similarly the drum (8, fig. 2) has a lower scale (coloured red to distinguish it from the upper scale which is white) displaced by 90°. The practical application is then as follows.

Bearing

32. Identify and tune in a suitable transmitting station with the switch in the TRAFFIC position. Disconnect the fixed aerial at the receiver. Listen to the station with only the loop connected. Swing the loop through 360°, observing on the indicator the readings of the two minima. When using the remote indicator always read from the yellow pointer. Very broad minima should not be used if another suitably located transmitter can be selected which will give better minima. It should be borne in mind that the broader the minima the less will be the accuracy. Having obtained satisfactory minima note carefully the mid-point of one. This may be either the bearing or its reciprocal.

Determination of sense

33. Proceed as above and after noting the reading obtained, swing the loop so as to bring the sense pointer into the position previously occupied by the yellow pointer (or when using the loop without remote control, until the red engraving on the loop reads the figure obtained from the white scale). Re-connect the fixed aerial and turn the switch to SENSE. Now reverse the connection of the loop by means of the switch provided on the sense unit, repeatedly changing over and observing the change in signal strength from one position to the other. The variable resistance incorporated in the sense unit and connected in series with the fixed aerial may require adjustment to produce the maximum change.

34. The reversing switch is engraved in white characters, at one position BEARING, and at the other RECIPROCAL. If the minimum occurs at BEARING then the figure noted (*see* para. 33 above) is the bearing. If minimum occurs at RECIPROCAL then the figure is the reciprocal.

FIG. 7. Sense unit.

35 It is opportune here to emphasize what has already been said in an earlier paragraph regarding the assumed constant installation conditions. It is essential to remove any doubts about a new or modified installation by making a check as early as possible on a station whose bearing is known.

Calibration

36. After installation, and at certain subsequent periods (*see* para. 42) the D/F. equipment must be calibrated in order to ascertain the magnitude and distribution of the errors due to distortion of the electro-magnetic field of a received wave by the metallic structure of the aircraft. These errors vary in magnitude, reaching a maximum value in each quadrant of relative bearing, and are therefore usually referred to as quadrantal errors. The maximum errors rarely occur exactly at the quadrantal points.

37. The calibration must be performed by competent personnel with a knowledge of navigation. The first requirement is a suitable site, and the second, suitable sources of radio signals. With regard to the former the apparatus required and the method of choosing a suitable site are dealt with in chapter 9, section 6, of this Air Publication. As signal sources, broadcasting stations are usually satisfactory. If possible, stations within 150 miles, but not in the immediate vicinity, should be selected. The sources chosen, with their frequencies, should be noted for future use.

38. A complete calibration (*i.e.*, on more than 24 points) must be performed on either (*a*) the 150–500 kc/s band, or (*b*) the 500–1,200 kc/s band. If the complete calibration is made on (*a*), it must be carefully checked, on not less than 8 points on (*b*), and *vice versa*.

39. Having chosen the signal source or sources to be employed, measure accurately by means of a suitable map and protractor the *true* bearing at the position where calibration is to take place. The true bearing, thus found, must be converted into the *magnetic* bearing by applying the magnetic variation, the value of which is usually given on the map from which the bearings are taken. The magnetic bearing must be used for the purpose of calibration.

40. Immediately before the calibration, the aircraft compass must be swung on 16 points and a deviation card compiled. The following preliminary tests of the D/F. equipment must also be made :—

(i) Ensure that the D/F. loop rotates easily on its bearings without play.

(ii) The scale and index should be examined for security, and to verify that they are easily read without parallax error. Where a remote indicator is also fitted, see that the two readings agree substantially at several points on the scales.

(iii) See that the D/F. loop is properly connected to the receiver, and that the latter is working normally. In particular, pay close attention to the following :—

- (*a*) The connections and cleanliness of the plugs and sockets at loop and receiver.
- (*b*) The electrical contact between the metal earthing flange on both loop and receiver, and the metal screening of the cable connecting the two.
- (*c*) The earthing of the D/F. loop at its point of attachment to the structure.
- (*d*) The necessity for a good bearing surface, free from the possibility of intermittent connection, at the slip-rings of the D/F. loop, if such slip-rings are fitted.
- (*e*) Continuity in both leads of the cable connecting loop and receiver.

(iv) With the aircraft clear of hangars, etc., and the tail plane at flying level, tune in one of the signal sources and test the quality of the minima on both true and reciprocal readings. For this test the aircraft should be heading approximately toward the signal source. The minima should be sharp enough to read to an accuracy of $\pm\frac{1}{2}°$ and the reciprocal bearing should be 180° from that of the true, to an accuracy of the same order. If these conditions are not satisfied, take an observation on another signal source and if this also proves unsatisfactory examine the installation for the following possible defects :—

(*a*) The loop not properly earthed to the structure.

(*b*) A higher resistance (due to faulty connections, etc.) in one side of the loop circuit than in the other.

(*c*) The electrical centre of the loop (if the loop is of the type in which the mid-point is earthed) incorrectly determined.

(v) Where a fixed aerial is also carried make the above tests with the fixed-trailing aerial switch open and closed, and if there is debasing of the minima and/or shift of bearing with the latter condition, arrange to calibrate and use the D/F. loop with this switch *open*.

41. Having ascertained that the complete installation is satisfactory, calibration may be commenced.

(i) Calibration *must* be undertaken during the period two hours after sunrise to two hours before sunset.

(ii) The aircraft to be calibrated must be equipped with its full military load.

(iii) The aircraft with the tail flying level, should be wheeled to a level spot on the aerodrome, well clear of metal hangars or other high metallic objects (the compass swinging base will be suitable only if it satisfies such conditions).

(iv) The aircraft should be lined up, by its compass, on the measured bearing of the source, the deviation being taken into account and the D/F. reading observed. The accuracy to be desired is 0° to $\pm\frac{1}{2}°$; if it differs by more than 1° from zero the discrepancy may be due to the following :—

(*a*) Site error.

(*b*) Index incorrectly set.

(*c*) The D/F. loop being fitted asymmetrically with respect to the framework of the aircraft.

(v) Where the site is well chosen, accept the measured as the reference bearing and set the index accordingly.

(vi) The aircraft is then swung through an angle of 360° in steps of 12° to 15°, the compass and D/F. scale readings being noted and recorded at each point. The true reading of the D/F. scale should always be taken, *not* the reciprocal.

(vii) If the compass readings are taken from the pilot's compass, make certain that the control (steering) column is in the normal flying position, and lightly tap the compass bowl before taking a reading in case the pivot is sticky. Also, avoid bringing any loose metal objects, *e.g.*, keys, screwdrivers, pairs of telephones and so forth within three feet of the compass when taking readings.

(viii) The readings thus obtained may now be tabulated according to the example given in the table below. It should be noted that the compass reading corrected for deviation is added to the *D/F. scale reading* to produce the *W/T observed bearing* (*Magnetic*). Where the result of this addition produces a figure of more than 360° subtract 360 to determine the correct figure.

Aircraft : No. : Where swung : Stn. on which calibrated :

Frequency : Date :

Compass Reading.	Deviation.	Aircraft Head (Magnetic).	D/F Scale Reading.	W/T Bearing (Magnetic) Observed.	W/T Bearing (Magnetic) Measured.	Error.	Remarks.
12°	+1°	13°	47°	60°	62°	−2°	Sharp
34°	+1½°	35½°	24°	59½°	62°	−2½°	—

A separate table should be completed for observations on the other frequency band (*see* para. 36).

(ix) From the table a curve of errors (*see* fig. 8) should be drawn on squared paper, the error being plotted against the D/F. scale reading. In cases where some of the points (errors) do not lie on a smooth curve it is advisable to check these points, paying particular attention to the compass readings. Observations taken on the other frequency band must then be checked against the curve to confirm that they agree substantially. In most cases it is advisable to plot a curve of the compass deviation as errors may arise in interpolation.

(x) From the complete curve the corrections to be applied when using the loop may be tabulated against the scale readings on the card (Form 2026) supplied for the purpose. Remember that the *Correction* is the inverse of the *Error* : *e.g.* if the error is +3°, the correction to appear on Form 2026 will be −3°. Also, remember to fill in Form 2026 completely : *i.e.* on both sides.

42. (i) The calibration so obtained must be checked in flight on several points.

(ii) A re-calibration must be carried out :—

(*a*) If a serious discrepancy is revealed between the ground calibration and the results obtained in the air.

(*b*) When any major modification is made to the aircraft structure, for example, a change of engine or fuel tank within the fuselage, the addition or removal of a fixed W/T aerial or aerial mast, etc.

(*c*) When a compass has been re-swung (in accordance with K.R. & A.C.I. 762).

(*d*) In the case of an aircraft of wooden or composite construction, when any modification or repair is made to the aircraft bonding system.

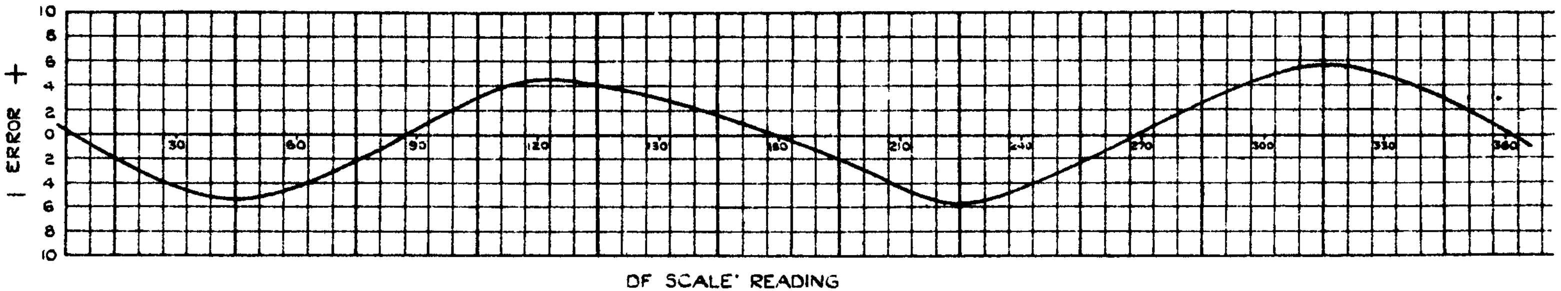
(*e*) Every three months.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information. In ordering spares for this apparatus, the appropriate section of AIR PUBLICATION 1086 must be used :—

Ref. No.	Nomenclature.	Qty.	Remarks.
10A/8478 ..	Aerial, screened loop, type 1	–	Non-retractable 18-in. tungum.
	Principal components :—		
10A/9740 ..	Carrier, brush	1	With connector socket.
10A/8747 ..	Gear box	1	
10A/8749 ..	Loop	1	With vertical connecting tube.
	Accessories,		
5A/1854 ..	Cable, Dulocapmet, 2·5	10 ft.	
10A/11008 ..	Cover	1	For R.A.F. Form 2058.
10A/9872 ..	Plug, type 101	2	2-pole, screened, polarized.
	Controls, remote, type C :—		
	Comprising :—		
10A/8190 ..	Casing, rigid	–	As required.
10A/8585 ..	Cleat	–	For 10A/8190 as required.
10A/1107 ..	Fitting, anti-torsional, No. 1	2	
10A/9702 ..	Indicator, type C.1	1	For use with D/F loop.
10A/8192 ..	Shafting	–	As required.
10A/8193 ..	Union, casing	3	
10A/9119 ..	Union, lubricating	1	
	Controls, remote, type E :—		
	Comprising :—		
10A/8584 ..	Casing, rigid	–	As required.
10A/8577 ..	Cleat	–	For 10A/8584 as required.
10A/9703 ..	Controller	1	For use with D/F loop.
10A/8591 ..	End-piece, casing	2	
10A/8594 ..	Shafting	–	As required.
10A/8596 ..	Union, casing	3	
10A/9704 ..	Union, lubricating	1	
10A/11120 ..	Sense unit, type 1	1	



AIRCRAFT____________ Nº _______ FREQUENCY _________ Kc/s STATION____________ DATE __________

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FIG. 8. CURVE OF ERRORS

SECTION 6, CHAPTER 6

GROUND STATION REMOTE CONTROLS

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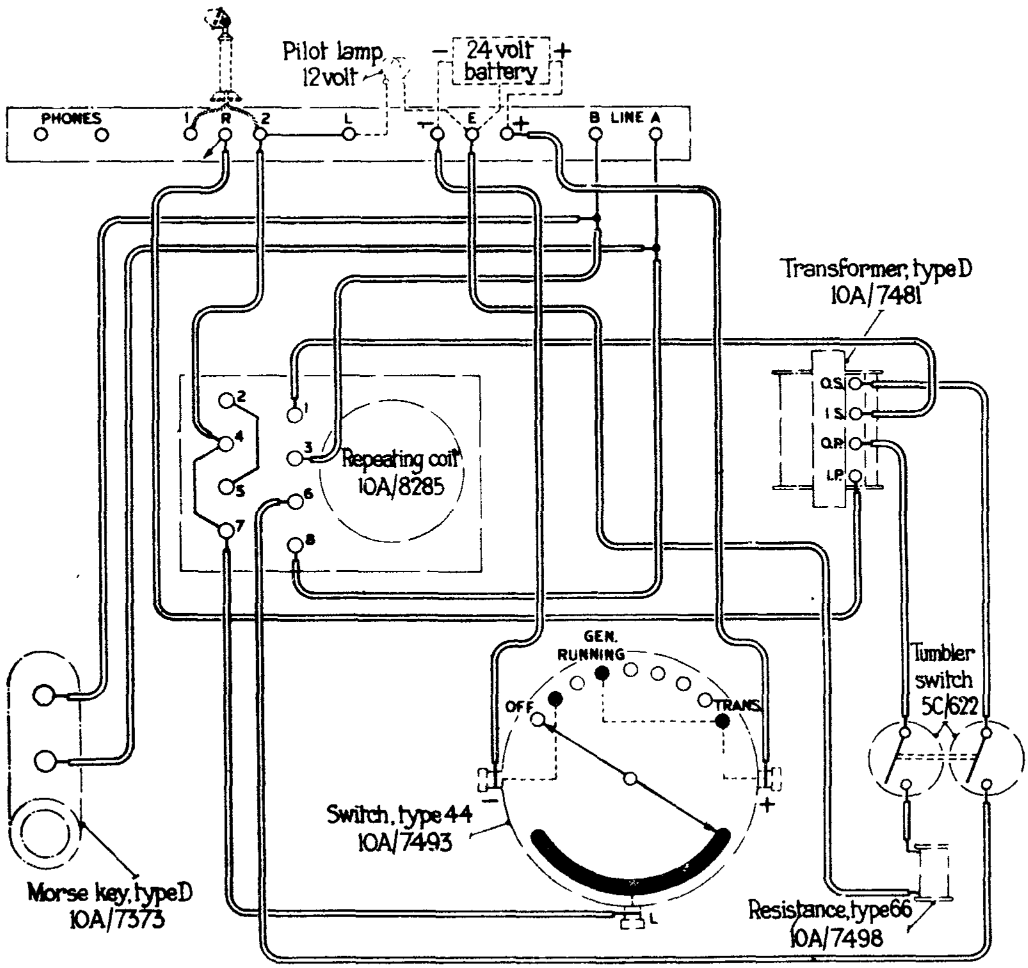

FIG. 1, BENCH WIRING DIAGRAM OF APPARATUS AT SIGNALS OFFICE END FOR OPERATING REMOTE CONTROLS, TYPES 2, 3, 4 AND 5

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GROUND STATION REMOTE CONTROLS

INTRODUCTION

1. When a considerable volume of traffic is to be handled on several channels it is often necessary for the transmitting and receiving stations to be situated some distance apart. The usual arrangement is for the receivers to be located in the signals office, which may be at headquarters. Between the signals office and the transmitting station land lines are provided so that all the operations can be performed at the signals office, thus making it possible for transmission and reception to be carried on simultaneously from the same signals office.

2. In the simplest form of remote control, two relays are connected in parallel across the lines. One controls the transmitter keying relay and the other a switch. Modern remote controls, however, require more elaborate apparatus, since provision must be made for keying the transmitter and for switching the filament and H.T. circuits. Provision must also be made for speech input, in order to transmit radio telephony.

3. One of the most noteworthy improvements in the remote controls described in this chapter is the reduction of interference which was previously caused to neighbouring receivers by the remote keying of the transmitter. The earlier systems required the charge and discharge of an $8\mu F$ condenser at keying speed. Corresponding impulses were passed to the line and used to operate a relay at the transmitting station. The transient nature of these impulses caused interference. In the more recent methods alternating current is employed for keying. The alternating current supply is located at the transmitting station end of the controls. The keying is effected by short-circuiting the lines at the signals office end, causing the impedance of the rectifier circuit at the transmitter end to vary. This varies the current through the keying relay. The depression of the key therefore causes the relay to move over to " mark " and the release of the key causes it to move over to " space."

4. A further advantage of the new system is that the adjustment of the keying relay is not critical, as it sometimes was with the old system. During a morse element the tongue was held over to " mark " only by the permanent magnetism of the relay. With the new arrangement the relay is continuously energized from the rectifier during a morse element and greater latitude is therefore permissible in the adjustment of the gaps and of the spring tension.

5. Controls, remote, ground station, types 2, 3, 4 and 5, are all of the " controlled end " class, that is to say they are installed at the transmitter, and are designed to carry out certain functions at the transmitter, when operated by lines from the remote signals office. The apparatus which is used at the signals office end for remotely operating any of these controls is grouped on a table, a bench wiring diagram of which is given in fig. 1. A simplified diagram showing the method of linking this apparatus with remote controls, types 2, 3, 4 or 5, is given in fig. 2. Controls, remote, ground station, type 7, is also for installation at the transmitter end, but the apparatus at the remote signals office for operating it is known as controls, remote, ground station, type 6. The simplified diagrams of all five types of controls may be seen in the same illustration in fig. 2.

6. At both the signals office end and at the transmitter end a distribution box is provided. This box consists of a wooden frame carrying a panel of insulating material on which are mounted three rows of jacks. Referring to fig. 23, and considering the box installed at the signals office end, the jacks in the row marked " control " are connected to the various control desks in the signals office. The jacks in the middle row are connected to the outgoing lines from the signals office, and connection may be made between any lines and any desk by means of a flexible lead terminating at each end in a telephone plug. The row of test jacks are wired in parallel with the line jacks, so that the circuits may be " tapped." The distribution box at the transmitting station end is similar, the row of jacks marked " control " being connected to the various transmitters, and the middle row to the ends of the incoming lines. Test jacks are again available

for " tapping " at this end. The type of box illustrated is the 10-pair box (Stores Ref. 10A/7407). A 16-pair box (Stores Ref. 10A/7519) is also available. This has 16 line jacks, 16 test jacks and 10 control jacks.

7. The cables which connect the signals office and the transmitter are laid in earthenware pipes. These cables are terminated at each end at a junction box which is in turn connected up to the distribution box. Each jack on the distribution box is provided with a long spring and a short spring. Line A is always connected to the long spring and line B to the short spring. The long spring at the transmitting station is connected to the long spring at the receiving station and the short to the short.

8. In order to provide telephone communication between signals office and transmitter, a portable telephone set (Stores Ref. 5B/68) is provided. This consists of a wooden box in which is housed a hand microphone set, a magneto ringer, a bell, a battery and a transformer. A flexible lead terminating in a telephone plug makes the necessary connection to the line. The plug is inserted in the jack of one of the spare lines. At the transmitter end a similar telephone set is plugged into the corresponding jack on the distribution box at that end. A call is made by turning the handle of the magneto ringer which causes the bell, in the telphone box at the other end, to ring.

GENERAL DESCRIPTION

Type 2

9. Type 2 or type 4 controls are generally used for the purpose of controlling a transmitter employed for C.W. telegraphy. No provision is made for R/T or I.C.W. (or M.C.W.) in the controls. Type 2 controls are obsolescent and will, as opportunity arises, be replaced by type 4. Both types have the same basic features, but type 4 controls are arranged in a more convenient form, that is, mounted on a vertical rack. A simplified diagram of the system is given at A in fig. 2.

Type 3

10. Type 3 controls are more elaborate than type 2, and enable remote operation of the transmitter to be carried out for either R/T or W/T. They do not, however, provide for remote change over from W/T to R/T or vice versa (*see* paras. 35 to 40 on controls, type 7). A schematic diagram of the type 3 controls is given in fig. 3, and a simplified diagram at B in fig. 2. The apparatus at the signals office end is also included.

11. For W/T the controls operate in the following way. The switch S (fig. 3) at the signals office is opened and the switch S_1 at the transmitter end is placed in the position shown in full. The battery switch S_2 at the signals office may now be operated. When the switch is moved from OFF to GEN. RUNNING, it passes over two live studs connected to opposite sides of the 24-volt battery, before coming to rest upon an insulated stud. As it passes over the first live stud an impulse is sent round the line-earth circuit, and as it passes over the second live stud, an impulse is sent in the opposite direction. The first impulse is in the direction which moves both switch relays R, R_1 to " space." Since neither relay has any connection on the " space " contact no circuits are completed at the transmitter. The second impulse, of opposite sign, however, moves both relays to " mark." Since the L.T. relay R has neutral bias, it remains at " mark " and closes the L.T. filament circuits of the transmitter. The H.T. relay, being biased to " space," remains at " mark " only for the duration of the impulse, returning to " space " immediately, and the transmitter H.T. switch will therefore be open. This condition at the transmitter (filament burning but no H.T.) is one which is frequently required, for example, when reception is taking place during a pause in transmission.

12. It will be seen that when transmission has to be resumed there is no delay period required for warming up the transmitter filaments. To switch on H.T. for transmission the switch S_2 is moved to TRANS. and both relays R, R_1 are energized and remain so while the switch S_2 is in this position. The tongue on the H.T. relay is held in the " mark " position,

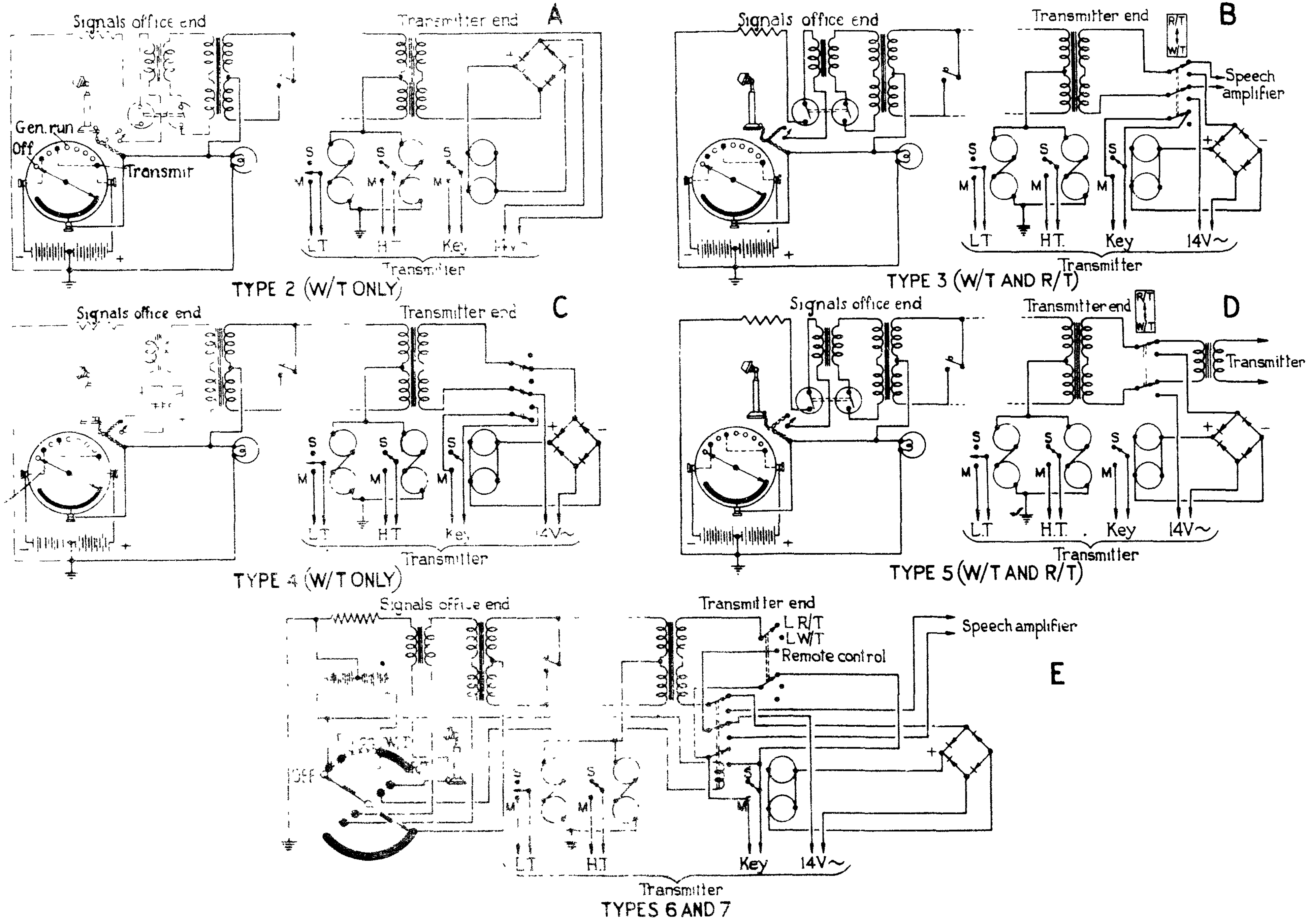

FIG. 2, SIMPLIFIED DIAGRAMS OF REMOTE CONTROLS

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causing the H.T. relay switch on the transmitter to close. The former condition (filaments burning but no H.T.) can be resumed by turning the switch to GEN. RUNNING. When it is required to shut down the transmitter, the switch S_2 is turned to OFF and passes over the two live studs, and two impulses are sent round the line-earth circuit. The first impulse is in a direction to move both relays R, R_1, to "mark," but the second impulse is in the opposite direction and moves the relays to "space," and the filament circuits of the transmitter are opened.

13. It will be observed that the switching of the transmitter is carried out through a line and earth circuit. Keying of the transmitter, however, is carried out entirely on the lines. Actually the key K is connected across the lines and a short-circuit occurs when the key is depressed. Referring to the diagram, alternating current is applied to a rectifier W in series with the primary winding P_1 of the repeating coil T_1. The output of the rectifier is connected to the keying relay R_2 which is biased to "space." When the secondary winding of the coil T_1 is closed through a high impedance, such as the secondary winding of the repeating coil at the signals office end, the winding P_1 offers a high impedance (about 5,000 ohms) to A.C., and the output of the rectifier is too small to operate the keying relay.

14. By short-circuiting the secondary winding the output of the rectifier is raised to a value sufficient to operate the relay. The short-circuit is actually made by the key K which is connected across the secondary winding of the repeating coil at the signals office end. When the key is depressed the effective impedance of P_1 falls to about 150 ohms and the relay is operated. The winding P_2 of the repeating coil T_2 is always on open circuit for W/T. Energy fed from the rectifier to the relay is in the form of unidirectional pulses at 100 cycles per second, and to prevent any possibilty of the relay tongue following these, the keying relay is slugged by adding copper sleeves to the bobbins.

15. For R/T the controls operate in the following way. The switch S at the signals office end is closed and the switch S_1 at the transmitter end is moved into the position shown dotted. The switch S_3 at the transmitter end is moved to "600-ohm input" position and the plug (6, fig. 13) is inserted in the transmitter. It will be seen that when the transmitter is started up (switch S_2 in TRANS. position) the microphone circuit, including the primary P_3 of the transformer T_3, is closed across one side of the battery and earth. Speech currents are transmitted through the repeating coil T_2, lines A and B, repeating coil T_1, transformer T_4, connector J and variable input attenuator, to the grid-filament circuit of the first valve of the amplifier. This is transformer-coupled to two valves in push-pull, the output from which is taken *via* a connector to the transmitter, which is thus modulated in accordance with the speech transmitted from the microphone at the signals office. The transmitter may be started up and shut down in the usual way by means of the switch S_2.

16. The transmitter may be modulated with a 1,000-cycle note and keyed for M.C.W. transmission. This is accomplished by plugging in the amplifier connector (6, fig. 13) as before, and placing the switch S_3 in the oscillator position which brings into circuit the oscillator valve V_2 across the input of the amplifier. The switch S is opened ,and the switch S_1 placed in the position as illustrated. Operation of the key now causes M.C.W. to be radiated.

17. There are two positions of the switch S_3 which have not been referred to above. They are marked LOCAL MICROPHONE and DIRECT GRID. The former position, as will be seen from the diagram, places the secondary winding of the transformer T_5 across the input of the amplifier. The primary of this transformer is connected to a microphone installed at the transmitter end. The necessary supply for this microphone is obtained from a local rectifier and smoothing circuit. This arrangement provides for modulating the transmitter locally for R/T test purposes.

18. When the switch S_3 is in the DIRECT GRID position the transmitter may be connected to a Post Office line for R/T modulation from some position other than the signals office. It will be seen that with the switch in this position the input of the amplifier is connected directly to two terminals engraved 50,000 OHMS DIRECT GRID.

19. A theoretical circuit diagram of the amplifier A.1104 is given in fig. 4. It actually consists of three units :—An amplifier, a rectifier, and a local control panel. The two former units together are known as the Panel, amplifier (Stores Ref. 10A/9589) and the latter unit is known as Panel, local control (Stores Ref. 10A/9590). All three units have been grouped together in the illustration, but a reference to fig. 8 will show their relative positions.

20. Five valves are employed altogether in amplifier A.1104. The valve V_1 is the input valve. It is transformer-coupled to two valves V_2 in push-pull, the output from which is fed to the transmitter. The amplification is sensibly level over a range of 0-10,000 cycles. Ten watts output in a load of 12,000 ohms is obtained with a 0·5-volt input into 50,000 ohms. The valve V is the rectifier valve which rectifies the A.C. supply and provides an H.T. supply for the amplifier. V_3 is an oscillator valve which can be switched into circuit so as to produce a 1,000-cycle note for modulating when M.C.W. transmission is required, this particular note being chosen to give the best response in the filter circuits and telephones of service receivers.

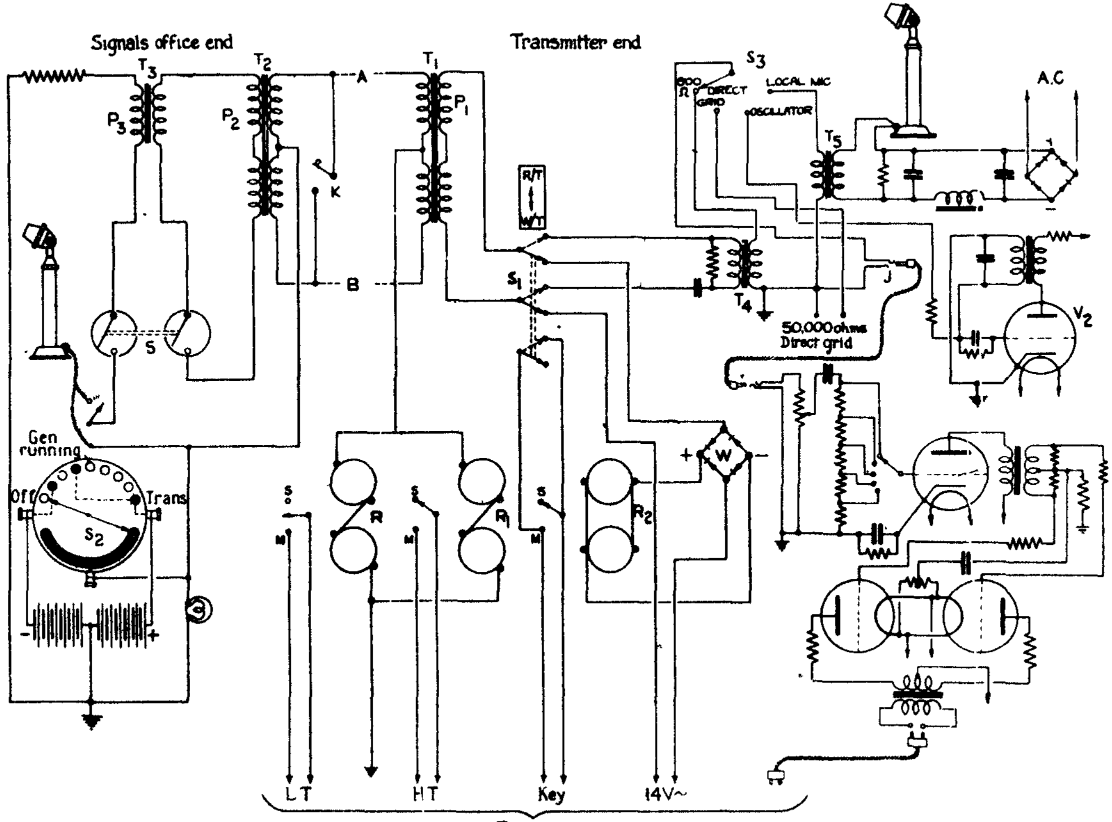
21. Referring to the rectifier circuit in fig. 4, the mains transformer T has five secondary windings. The primary winding is connected to the A.C. mains by means of a plug and socket, a pair of fuses F and a switch S being included in the circuit. Of the five secondary windings on the mains transformer, one is a 10-volt winding which supplies the rectifier W in the local control panel. One is a 4-volt winding which supplies the filament circuit of the rectifier valve V. Across this winding is connected a thermal delay switch R.L. which delays the operation of the valve until the filaments have been switched on for a predetermined time. A 1,000-volt centre-tapped winding supplies the H.T. for the rectifier valve V.

22. Two further 4-volt windings are provided. One supplies the filament circuits of the indirectly heated valves V_1 and V_3, and the other supplies the filament circuits of the "push-pull" output valves V_2. The centre-point of this latter winding is connected to earth through the resistance R and the variable resistance R_{16} in series. The centre-point of the other 4-volt winding is also earthed, and a pilot lamp P.L. is connected across one side of the winding and earth.

23. The condensers C_1 and C_2 in conjunction with the choke L and dropping resistance R_1, form the smoothing circuit for the H.T.2 line. The two condensers C_3 and C_4, along with the choke L_1 and dropping resistance R_2, form the smoothing circuit for the H.T. 1 line. A tapping is taken from the H.T. 1 line and fed through a plug and socket connection and through the switch S_1 on the local control panel to the anode of the oscillator valve V_3.

24. The two H.T. lines, in addition to the two L.T. circuits from both 4-volt secondary windings on the transformer T, are taken through a 6-point plug and socket connection to the amplifier unit. The H.T.1 line is fed through the primary winding of the coupling transformer T_1 to the anode of the input valve V_1. The grid-filament circuit includes the attenuator unit, comprising tapped resistances R_{17} and a condenser C_{12}, and the potentiometer R_3, while a telephone jack J is connected across the potentiometer, one side of which is connected to earth. The heating element of the valve V_1 is supplied with A.C. of the appropriate voltage from the transformer T. A resistance R_4, shunted by the condenser C_5, is connected between the cathode and earth.

25. The two resistances R_5 and R_6 are connected in series across the secondary winding of T_1, and the centre-point of the winding and the junction of the two resistances are connected to earth through the resistance R_{18}. The junction of the two resistances R_{19} and R_{20} is connected through the condenser C to the resistance R_{18}. The free ends of the two resistances R_{19} and R_{20} are connected across the filament supply to the push-pull valves V_2, the filaments of which are connected in parallel and fed from the transformer T. The two ends of the secondary winding of the transformer T_1 are connected through two non-parasitic resistances R_7 and R_8 to the grids of the push-pull valves. The H.T. for the output valves is fed from the line H.T.2 through the milliammeter M to the centre-point of the primary winding of the output transformer T_2. The two ends of the primary winding are connected through the two non-parasitic resistances R_9 and R_{10} to the anodes of the valves. The two ends of the secondary winding



-FIG. 3. SCHEMATIC DIAGRAM OF REMOTE CONTROLS. TYPE 3

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are connected to a two-pin socket on the side of the panel. Another two-pin socket is mounted on the other side of the panel and is connected in parallel with the first socket by means of a screened cable. The output from the amplifier may be taken from either of these sockets and fed to the transmitter.

26. Referring to the circuit for the local control panel, a six-pole plug-and-socket connection is made between this unit and the rectifier unit. The H.T.1 line is taken to the switch S_1. The 10-volt supply from the transformer T is taken *via* a pair of fuses, F_1, and a D.P. switch S_2 to the metal rectifier W. The output side of the rectifier is fed into the smoothing circuit, consisting of the condensers C_6 and C_7 and the choke L_2. The discharge resistance R_{11} is connected across the condenser C_7.

27. The local microphone is connected by means of a jack J_1 to one side of the primary winding of the microphone transformer T_3. The other side of the primary winding is connected to the rectified supply. The secondary winding of T_3 is connected between the stud engraved LOCAL MICROPHONE on the switch S_1, and the earthed side of the jack J_2. A flexible lead terminating at each end in a telephone plug can thus connect the output of the microphone transformer T_3 to the input side of the amplifier unit. The other side of the telephone jack J_2, is connected to the moving arm of the switch S_1. It should be noted that the two switches S_1 and S_2 are mechanically coupled and that S_2 is closed only when S_1 is in the LOCAL MICROPHONE position.

28. To provide for M.C.W. a special circuit, capable of generating a 1,000 cycle per second oscillation, is incorporated in the local control panel. The H.T. for the oscillator valve V_3 is fed *via* the selector switch S_1 through the anode resistance R_{12} in series with the primary winding of the coupling transformer T_4 to the anode of the oscillator valve V_3. The secondary of the transformer T_4, shunted by the condenser C_8, is connected in series with the resistance R_{13}, shunted by the condenser C_9, in the grid circuit of the valve, to enable the necessary audio-frequency oscillations to be generated. The heating element of the valve is fed from the transformer T. The condenser C_{10} with the resistance R_{12} forms the usual anode de-coupling circuit.

29. The selector switch S_1 has four positions, engraved LOCAL MICROPHONE, OSCILLATOR, DIRECT GRID and 600 OHM INPUT. When the switch S_1 is in the position engraved OSCILLATOR, the grid of the valve V_3 is connected through the resistances R_{13} and R_{14} to the telephone jack J_2, and from there to the input of the amplifier.

30. When the switch S_1 is in the position engraved DIRECT GRID, the terminals engraved 50,000 OHMS DIRECT GRID are connected to the input side of the amplifier. In the 600 OHM INPUT position, the switch S_1 connects the secondary winding of a matching transformer T_5 to the input of the amplifier. The primary of the transformer T_5, shunted by the resistance R_{15} is connected in series with a condenser C_{11} across a pair of terminals engraved 600 OHM INPUT. A further pair of terminals engraved A.C. MAINS, have the lead for the primary winding of the transformer T connected to them. The A.C. mains supply is also connected across this pair of terminals.

Type 4

31. A simplified diagram of remote controls, type 4, is given at C in fig. 2. The apparatus at the signals office end is also included. As previously mentioned, remote controls, type 4, are employed only when C.W. is required. Actually the unit consists of the remote control panel of controls, type 3, mounted by itself on a rack. The coupled switches on the front of the panel marked W/T-R/T are inoperative in the R/T position.

32. Referring to diagram C in fig. 2, it will be seen that with the switch in the W/T position the controls function in the same way as type 3 when used for W/T. The microphone, microphone transformer and R/T switch are included as part of the standard equipment on the bench at the signals office end, but these circuits are shown dotted since they are not brought into use. Switching of H.T. and L.T. on the transmitter and keying of the transmitter are performed in the same way as for type 3 controls.

Type 5

33. A simplified diagram of type 5 controls, including the apparatus at the signals office end, is given at D in fig. 2. Type 5 controls are used both for W/T and R/T. In appearance type 5 controls are similar to type 2, the sounder relays, repeating coils, metal rectifier, etc., being arranged on a horizontal wooden board. As will be seen from the diagram, the system resembles that used for type 3, except that a two-pole two-way switch is provided for the R/T-W/T change-over. In the W/T position the primary of the repeating coil at the transmitter end is connected, as in the controls previously described, to a metal rectifier and A.C. supply for keying purposes. In the R/T position, however, the repeating coil is connected to a special transformer, the secondary winding of which is connected to the modulating circuits of the transmitter. For example, when used with transmitter T.70, the secondary winding is connected direct to two terminals on the transmitter marked LINE, which are in turn connected through a switch and potentiometer to the sub-modulator valve. If this switch (engraved LOCAL LINE) has previously been placed in the LINE position the signals office microphone modulates the transmitter for R/T.

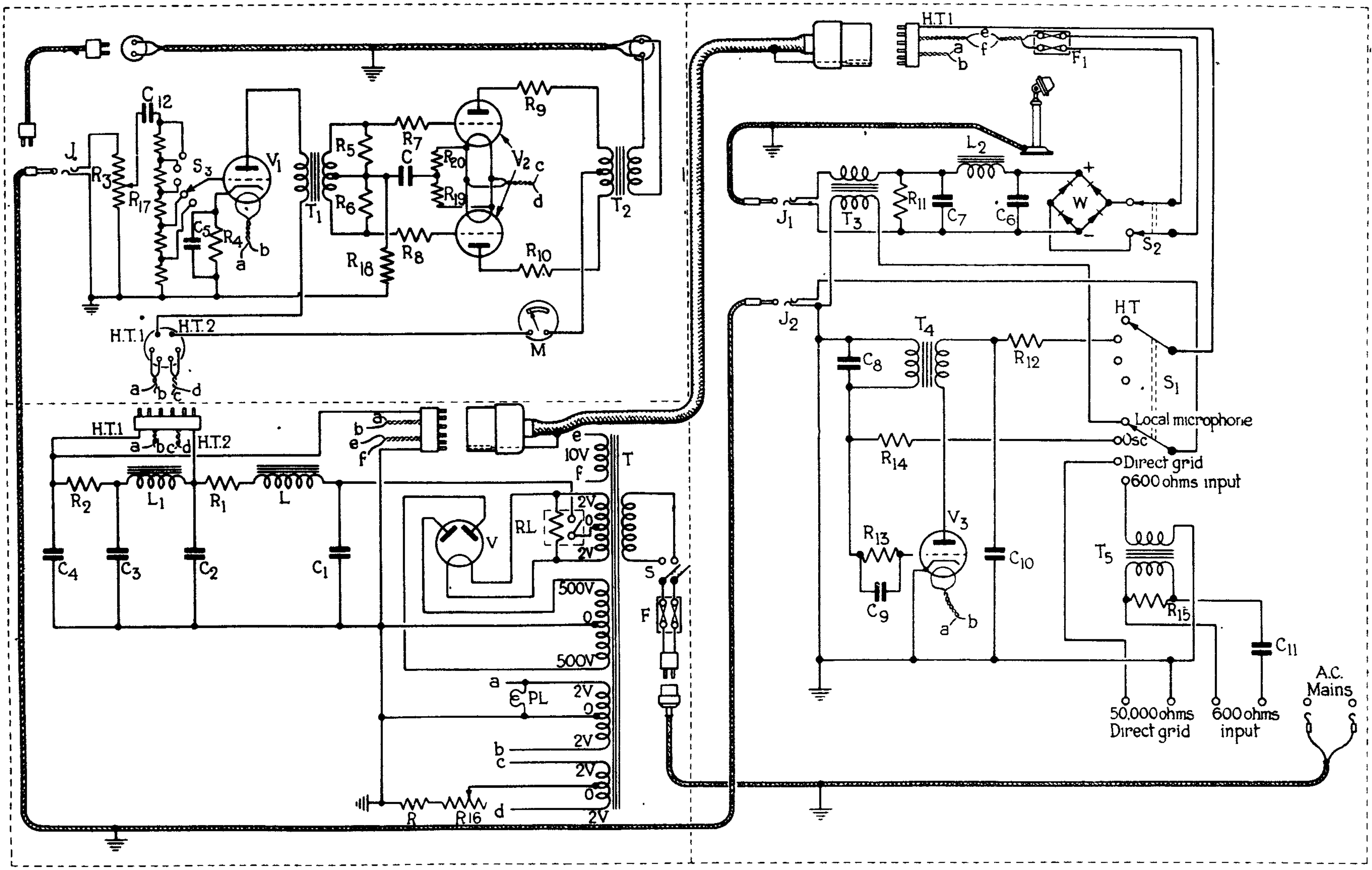
34. When this system of controls is in use with transmitter T.70, it is necessary for the selector switch on the transmitter to be moved to the appropriate position, *viz.*, R/T, C.W., or I.C.W. In the first position the key at the transmitter is short-circuited and therefore no provision is made for doing this on the remote control unit. In the C.W. position of the transmitter selector switch, the short-circuit is removed and the key at the signals office keys the transmitter for C.W. In the I.C.W. position of the switch a rotary interrupter situated in the transmitter is brought into circuit, and the key at the signals office keys the transmitter for I.C.W.

Types 6 and 7

35. As has been previously mentioned, controls, types 6 and 7, are at the signals office end and the transmitting station end respectively, of a system of remote controls, which are intended for carrying out switching, keying, and change-over from R/T to W/T. Referring to the schematic diagram, fig. 5, it will be seen that two line circuits A and B, and C and D are employed between the signals office and the transmitter. Switching of the transmitter is performed as before between A and B lines and earth; keying is carried out on A and B lines, and change over from W/T to R/T on the C and D lines. It will be seen that the A and B lines terminate at a repeating coil at each end as in the controls previously described. When the switch S_2 is in the REMOTE CONTROL position, alternating current is applied to the winding P_2 of the repeating coil T_2 in series with the rectifier W. The output of the rectifier is connected to the keying relay R_2 which is biased to "space."

36. The short-circuit of the lines by the key K, keys the transmitter. Switching is performed as before by altering the direction of the current in the line-earth circuit, a switch S, similar in appearance to switch, type 44, being used, but having four positions engraved OFF, FIL. ON, W/T and R/T. When the switch is moved from OFF to FIL. ON it passes over two "live" studs before coming to rest upon an insulated one. As it passes over the first live stud an impulse is sent around the line-earth circuit, and as it passes over the second live stud an impulse is sent in the opposite direction.

37. The first impulse is in the direction which moves both switching relays R and R_1 to "space." Since neither relay has any connection on the "space" contact, no circuits are completed at the transmitter. The second impulse, however (opposite sign) moves both relays to "mark." The L.T. relay R moves to "mark," and since it has neutral bias, remains there and closes the L.T. filament circuits of the transmitter. The H.T. relay being biased to "space," remains at "mark" only for the duration of the impulse, returning to "space" immediately. When the switch is moved over the next set of contacts and comes to rest in the W/T position, the H/T relay R is held over to "mark" and so the transmitter H.T. is switched on. In this position keying of the transmitter may be carried out.



Condensers	µF	Condensers	µF
C	2	C7	1,000
C1	4	C8	·2
C2	2	C9	002
C3	2	C10	2
C4	2	C11	2
C5	50	C12	·0003
C6	1,000		

Resistances	Ohms	Resistances	Ohms	Resistances	Ohms
R	250	R7	2,000	R14	250,000
R1	500	R8	2,000	R15	1,000
R2	30,000.	R9	100	R16	500
R3	50,000	R10	100	R17	Various
R4	1,000	R11	8	R18	40,000
R5	250,000	R12	50,000	R19	50
R6	250,000	R13	5,000	R20	50

FIG. 4. THEORETICAL CIRCUIT DIAGRAM, A.1104

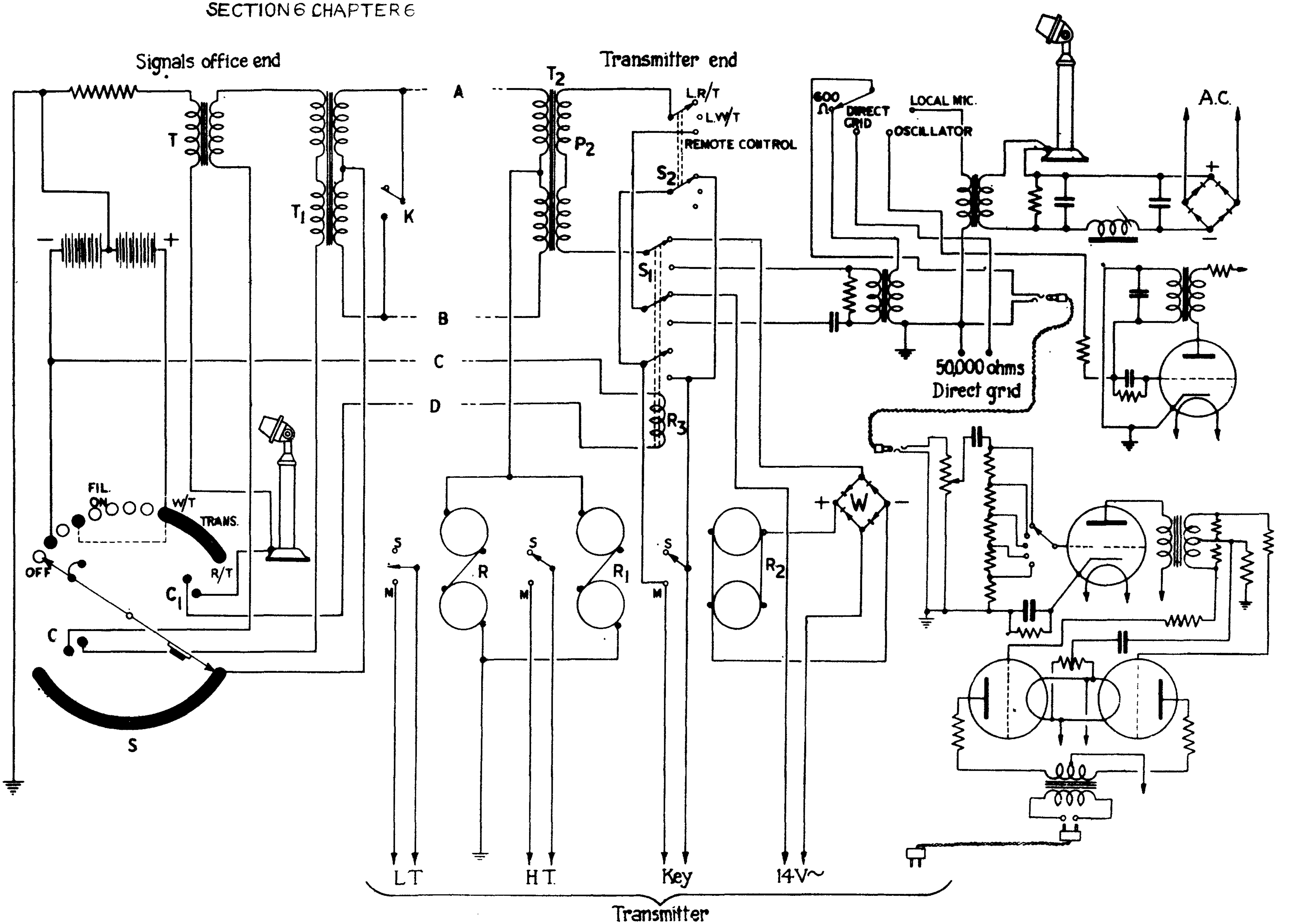


FIG. 5. SCHEMATIC DIAGRAM OF REMOTE CONTROLS. TYPES 6 AND 7

38. A further movement of the switch to the R/T position short-circuits a pair of contacts C which connects the secondary winding of the microphone transformer T in series with the primary winding of the repeating coil T_1. Another pair of contacts C_1 is also bridged in this position. The microphone is thus connected in series with the primary winding of T and a resistance across the positive side of the battery and earth. At the same time the 24-volt battery is connected across the lines C and D, the effect of which is to operate the relay K_3 at the transmitter end, and change over the three-pole two-way switch S_1. It will be seen that the primary P_2 of the repeating coil T_2 is now connected to the speech amplifier instead of to the rectifier circuit, and the tongue and mark terminals of the keying relay are short-circuited. It will be seen that, provided the switch on the amplifier at the transmitter is at the 600 OHMS INPUT position, speaking into the microphone at the signals office will result in R/T radiation.

39. When returning the switch S to the OFF position it passes through the W/T position and the FIL. ON position. As it leaves the R/T position the microphone circuit is broken and also the magnetic relay circuit, causing the primary winding P_2 of the repeating coil T_2 to be disconnected from the speech amplifier circuit and connected to the metal rectifier circuit. When the switch arm leaves the W/T position the line-relay-earth-battery circuit is broken and the H.T. relay R_1 is opened. Just before the switch arm reaches the OFF position the battery is momentarily connected but in the opposite direction. This trips the L.T. filament relay R and the filament circuits of the transmitter are broken.

40. A two-pole 3-position switch S_2 is provided at the transmitter end engraved at its three positions LOCAL R/T, LOCAL W/T, REMOTE CONTROL. In the first position, the tongue and marked terminals of the keying relay R_2 are short-circuited so as to keep the transmitter in the radiating condition for modulation by the local microphone. In the second position, this short-circuit is removed in order that the transmitter may be keyed locally. In the third position, the primary P_2 of the repeating coil T_2 is connected to the centre arm of the switch S_1, so that by energizing the relay R_3 from the signals office end, P_2 may be switched into either the speech amplifier circuit, or the A.C. side of the metal rectifier circuit. The local switching on the speech amplifier is exactly the same as described for type 3.

CONSTRUCTIONAL DETAILS

Type 2 (Stores Ref. 10A/9009)

41. A plan view of remote controls, type 2, is given in fig. 6, and a bench wiring diagram in fig. 7. As will be seen from the illustration the apparatus consists of a number of components mounted on a dished metal base (6), 2 ft. $3\frac{1}{2}$ in. × 1 ft. 6in. × 8 in. The whole unit weighs approximately 30 lb. The filament relay (1) is at the top, the H.T. relay (2) is near it and the keying relay (3) is in the foreground. The tumbler switches (4) and (5) in front of the relays are connected across the tongue and mark terminals of the filament and H.T. relays respectively. A push button (7) is connected in a similar manner to the tongue and mark terminals of the keying relay and is used for testing. A metal rectifier (8) can be seen behind the L.T. relay and below it is a repeating coil (9).

42. To the left of the board is a terminal strip (10) with eight terminals engraved from the bottom A, B, EARTH, H.T. SW., FIL. SW., two terminals engraved COMMON, and KEY. Another terminal strip (11) having two terminals engraved 14 VOLTS A.C. can be seen in the top corner. These two terminals are connected to the 14-volt terminals on the rectifier unit incorporated in the transmitter. The terminals A and B are connected to the incoming lines from the signals office. The " machinery " earth is connected to the terminal engraved EARTH. The terminals engraved H.T.S.W., FIL. SW. and KEY are connected to the corresponding terminals on the transmitter. It should be noted that this type of control is used for controlling transmitters operating on W/T, but not R/T.

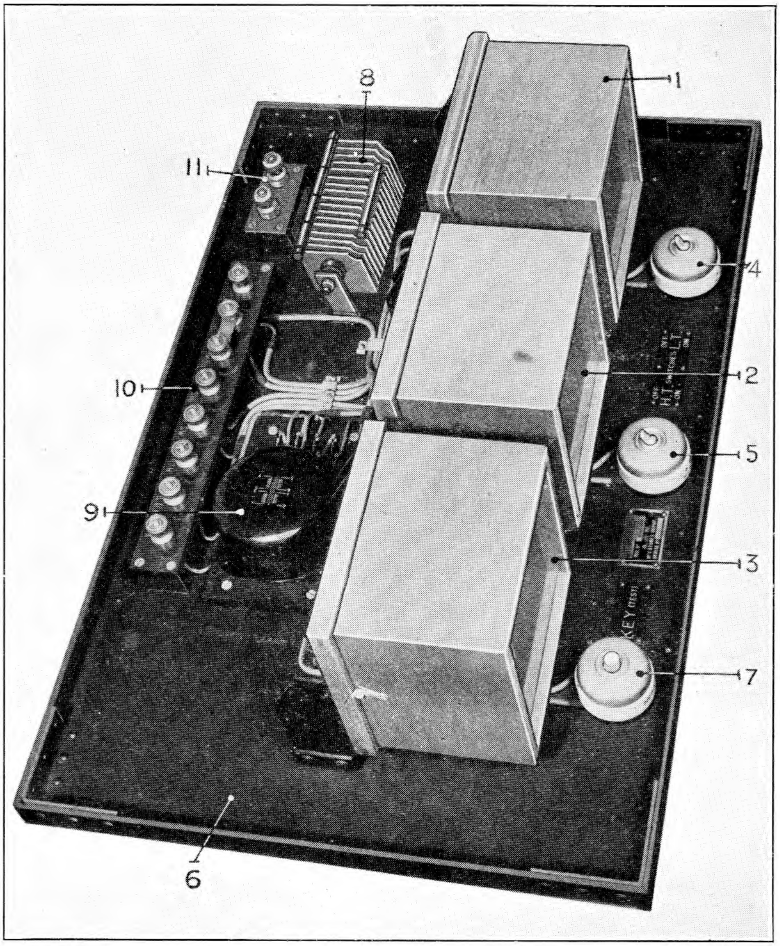


FIG. 6. Remote controls, type 2.

Type 3 (Stores Ref. 10A/9521)

43. A front view of Ground Station remote controls, type 3, is given in fig. 8. The equipment consists of a vertical aluminium alloy rack carrying five panels. The lines from the signals office terminate in a junction box which is connected by a cable to a Box, distribution 10-pair line (Stores Ref. No. 10A/7407) or 16-pair line (Stores Ref. No. 10A/7519), which in turn is connected to one of the panels on this rack. The remote control unit which is installed near the transmitter, is connected to it by means of a flexible cable having a plug and socket connection. The approximate dimensions are 5 ft. 6 in. high, 1 ft. $4\frac{1}{2}$ in. deep, and 1 ft. $8\frac{1}{2}$ in. wide. The weight, including the amplifier unit, is 13 stone 7 lb.

44. The upper panel (1) is the amplifier panel which carries a speech amplifier consisting of an indirectly-heated triode, transformer-coupled to an output stage consisting of two triodes in push-pull. As may be seen in fig. 8, the front of the panel carries a milliammeter (5), a volume control knob (6) and an attenuator control knob (15). The milliammeter reads from

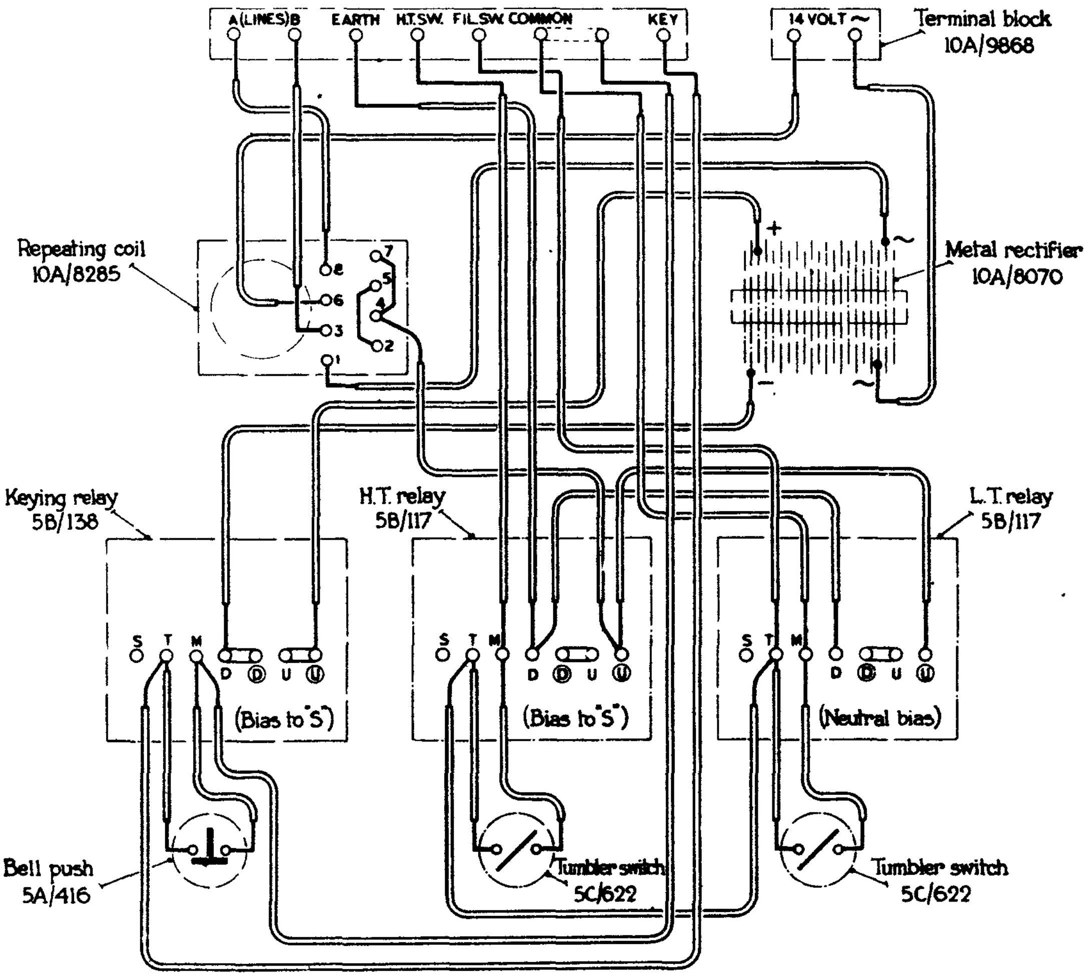


FIG. 7. **BENCH WIRING DIAGRAM - REMOTE CONTROLS TYPE 2**

0 to 150 mA. and is connected in the H.T. feed to the output stage of the amplifier. The knob (6) controls the input potentiometer, and the attenuator knob (15) controls the switch (S_3, fig. 4). The grid of the input valve is connected by this switch to the various tappings of the resistance (R_{17}, fig. 4). In the rear view of fig. 10 may be seen the milliammeter (4), the potentiometer (5) and part of the attenuator unit (41). The inter-valve transformer (6), across the secondary of which are connected two 250,000-ohm resistances, is also seen in this illustration. The centre tapping on the transformer secondary and the junction of the two resistances are connected to earth through the 40,000-ohm resistance of the resistance unit (42), and also to the junction of the two 50-ohm resistances of the unit (42) through the 2μF condenser (43). The free ends of the two 50-ohm resistances are connected to the filament sockets of the 6-pole socket (11). The ends of the secondary winding of the transformer (6) are connected through two 2,000-ohm resistances, one of which (7) may be seen in front of the transformer, to the grid connections of the valve-holders (8). The other transformer (9) is the output transformer, the ends of the primary winding of which are connected through two 100-ohm resistances, one of which (10) may be seen in front of the transformer, to the anodes of the push-pull output valves. A centre tapping on the primary winding is taken through the milliammeter (4) to one of the pins on the socket (11) from which the H.T. supply is obtained.

45. On the extreme right may be seen the 50μF condenser (12) and 1,000-ohm resistance (13) which are in parallel and connected between the cathode of the indirectly heated input valve and earth. The two-pole sockets (14) and (15) are wired in parallel and connected across the secondary winding of the output transformer. The six-pole socket (11) receives the six-pole plug (16) and through this is provided the H.T. and L.T. supply to the valves. The input jack (17) which is connected through the potentiometer to the grid-filament circuit of the first valve is just perceptible behind the input valve holder (18). The manner in which the various components are wired is shown in the bench wiring diagram (fig. 9).

46. The panel (2, fig. 8) is the rectifier panel. The front of the panel carries a switch (7) and a pilot lamp (8). The rear of this panel is shown in fig. 10. The mains transformer (19) has five secondary windings. Of these, three are 4-volt windings, one is a 500-0-500-volt winding and the remaining one is a 10-volt winding. The 500-0-500-volt winding is connected to the anodes of a double-wave rectifying valve, the output of which incorporates a smoothing circuit consisting of two chokes (one of which (20) may be seen next to the mains transformer), the 500-ohm and 30,000-ohm resistances (21), the three 2μF condensers (22) and the 4μF condenser (23). The resistance unit (44), comprising a 250-ohm and a 500-ohm variable resistance in series, is connected between earth and the centre point of the 4-volt filament supply to the amplifier output valves.

47. In front of the condensers (22) is seen the thermal delay switch (26) which delays the connection of the H.T. output load on the rectifier until the filament circuit has been closed for a predetermined period. The plug (27) is the connection through which the A.C. mains supply is taken into the unit. The plug (28) is for the purpose of leading away from the panel, a 10-volt A.C. supply, a 4-volt A.C. supply, and a rectified and smoothed H.T. supply. The manner in which the various components are wired is shown in the bench wiring diagram (fig. 9).

48. The panel (3, fig. 8) is the local control panel, on the front of which is a telephone jack (9) and a knob (10) controlling a four-way switch. The telephone jack is for plugging in the local microphone, and the switch is engraved 600 OHM INPUT, DIRECT GRID, OSCILLATOR and LOCAL MICROPHONE. Referring to fig. 10 in which the back of the panel may be seen, the plug (29) is connected by a cable and socket to the plug (28) referred to above. The 10-volt A.C. supply, 4-volt A.C. supply and rectified H.T. supply, referred to in the preceding paragraph, are thus led into the local control panel. The 10-volt supply is taken to the metal rectifier (30) and the D.C. output is taken to the smoothing circuit consisting of the choke (31) and the two 1,000μF condensers (32).

49. The microphone transformer (33) has one end of its primary winding connected to the telephone jack on the front of the panel and its other end connected to the rectified supply.

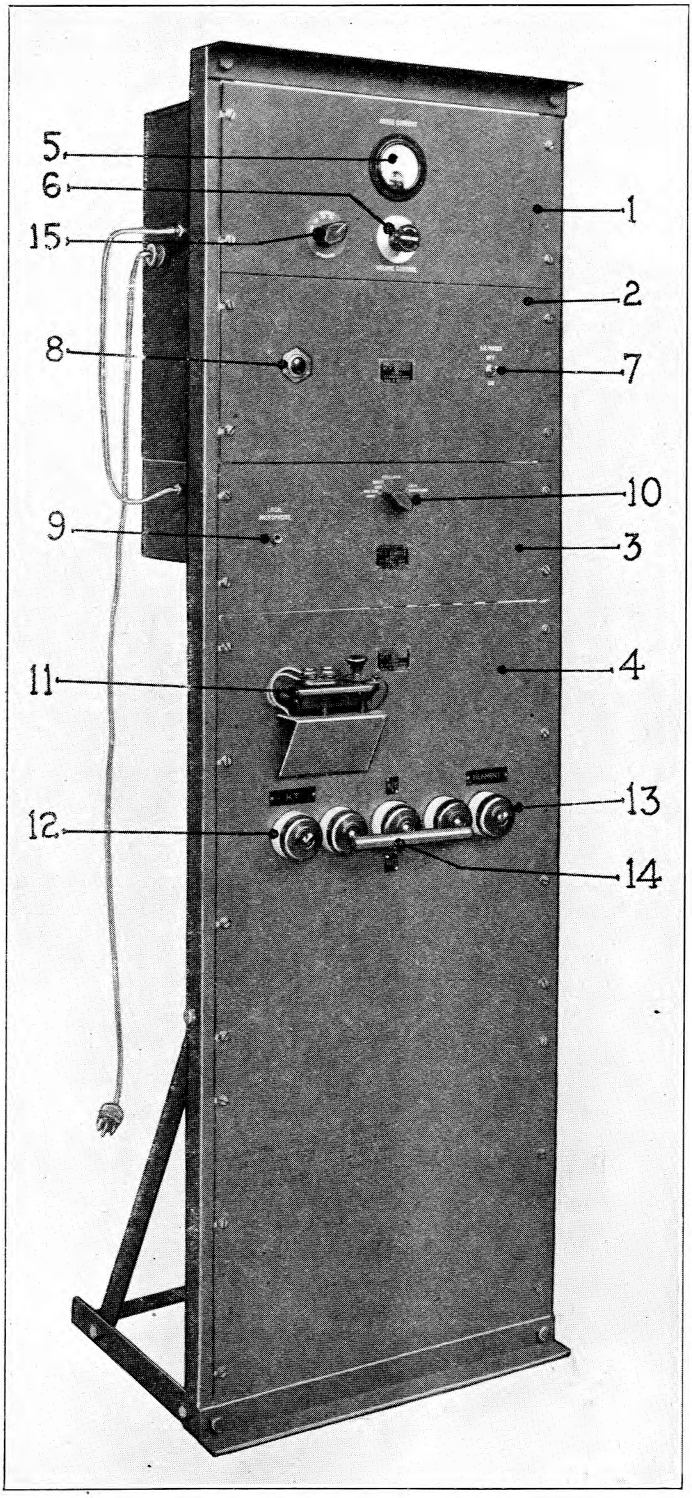
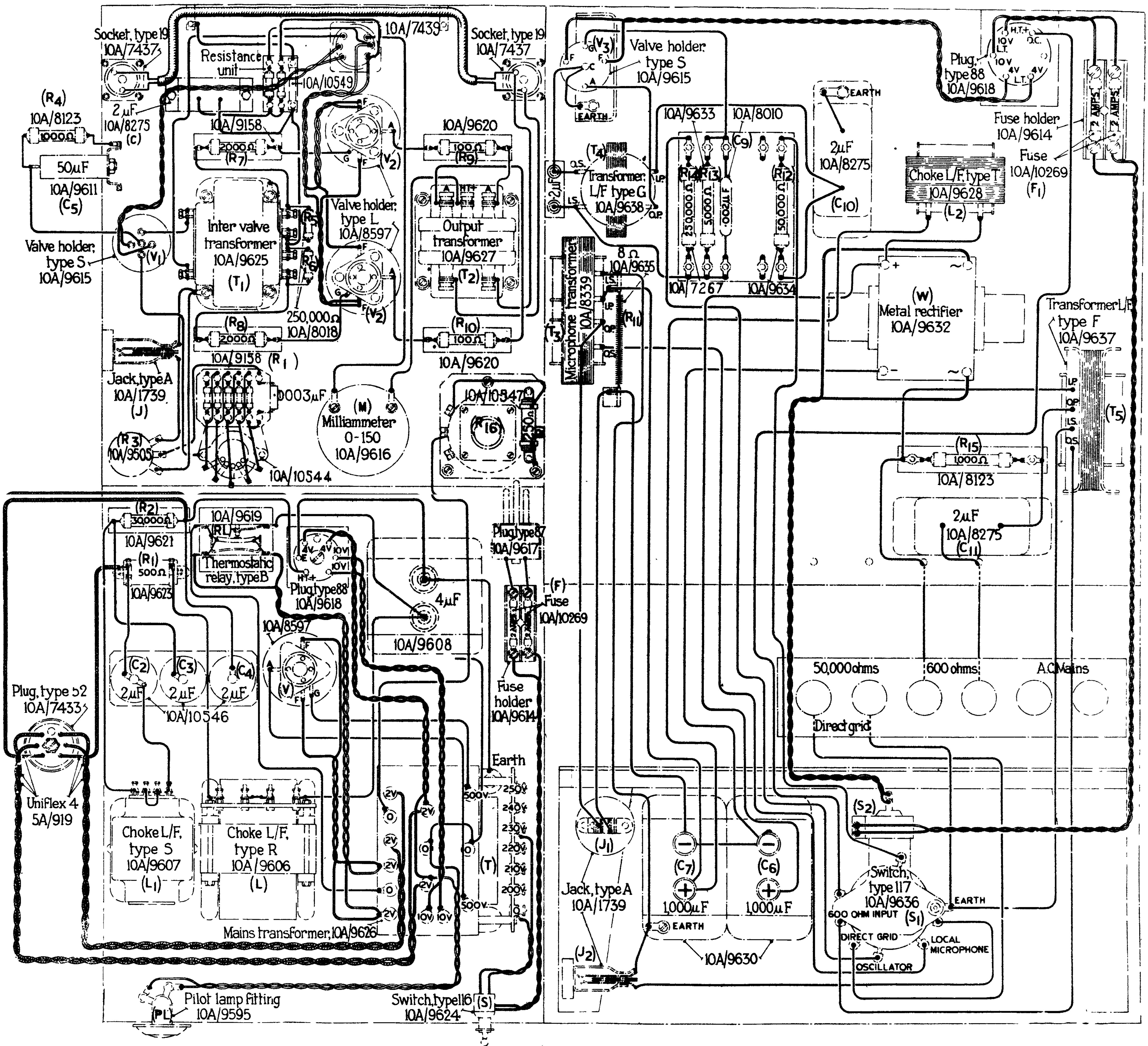


FIG. 8. Remote controls, type 3.



NOTE: Annotations in parenthesis, for example (C_7) refer to the corresponding annotations in Fig. 4

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FIG. 9. BENCH WIRING DIAGRAM. AMPLIFIER A.1104.

When the local microphone is plugged in, it is connected in series in this circuit. The secondary of the transformer has one end earthed and also connected to one side of a telephone jack (7, fig. 13) on the side of the panel. The other end of the secondary is taken to the selector switch (10, fig. 8) on the front of the panel, and when this switch is placed in the LOCAL MICROPHONE position, the secondary of the transformer is connected across the telephone jack. The valve-holder (34) carries an indirectly heated triode which, with its associated circuit, functions as a 1,000 c/s. oscillator.

50. The grid-anode coupling transformer (35) for this oscillator can be seen near the valve-holder. The transformer (36) is the matching transformer for the incoming signals office line. The primary, shunted by a 1,000-ohm resistance (37), is connected through a $2\mu F$ condenser (38) across two terminals at the base of the unit marked 600 OHM INPUT. The secondary of this transformer has one end earthed. The other end is connected to the selector switch (10, fig. 8) in such a way that when the switch is in the 600 OHM INPUT position, the secondary is connected across the telephone jack (9, fig. 8).

51. On the small panel (39) is a group of three resistances and one condenser. The resistance on the extreme left is a 250,000-ohm resistance connected at one end to the oscillator terminal of the selector switch and at the other end to the adjacent resistance and condenser. These have values of 5,000 ohms and $0{\cdot}002\mu F$ respectively, and are connected in parallel in the grid circuit of the oscillator valve. The third resistance of 50,000 ohms is in the H.T. supply lead to the anode of the oscillator valve, while the $2\mu F$ condenser (40) forms the decoupling unit. The $0{\cdot}2\mu F$ condenser (45) is connected across the secondary winding of the oscillator coupling transformer. The manner in which the various components are wired is shown in the bench wiring diagram (fig. 9).

52. The fourth panel (4, fig. 8) is the remote control panel. On the front of this panel is mounted the morse key (11), the H.T. switch (12), the filament switch (13) and the three coupled switches (14). The rear of this panel may be seen in fig. 11, and a bench wiring diagram in fig. 12. The relay (1) is the keying relay which effects the keying of the transmitter. The relay (2) immediately below this is the H.T. relay which switches the H.T. supply to the transmitter. The relay (3) on the left of this is the filament relay which closes the filament circuits of the transmitter. To the left of the relay (1) is seen the repeating coil (4) and metal rectifier (5).

53. The switch (14, fig. 8) is a three-pole two-position switch. Two of the poles change over the connections of the repeating coil secondary from the amplifier input to the 14-volt A.C. supply and rectifier. The former is the R/T position and the latter the W/T position. The third pole merely short-circuits the " tongue " and " mark " terminals of the keying relay in the R/T position.

54. Referring to fig. 11, it will be seen that a row of six terminals is provided at the top of the remote control panel for convenient linking up with a corresponding row at the bottom of the local control panel. The first pair on the left is connected directly to the A.C. supply, and is engraved accordingly. The remaining two pairs are engraved 600 OHMS and 50,000 OHMS respectively.

55. At the bottom of the remote control panel is a row of eleven terminals, engraved from left to right as follows :—First two 14V. A.C., the next one E, the next one FIL. SW., the next one H.T. SW., the next two KEY ; the next two are engraved B and A respectively and the last two terminals P.O LINES. The 14-volt terminals are connected to the 14-volt A.C. terminals on the transmitter rectifier ; the terminals A and B are connected to the incoming signals office lines. The terminals P.O. LINES are for use in connection with remote R/T modulation from special lines. The remaining five terminals are connected up to the appropriate terminals on the transmitter.

56. Connections between the various panels are made by means of plugs and sockets and links. Referring to fig. 13, the microphone (1) is connected by a screened lead terminating in a plug (4) which engages with the socket (9, fig. 8). The screened lead (8) effects the connection between the output of the amplifier and the modulating circuit of the transmitter. The screened

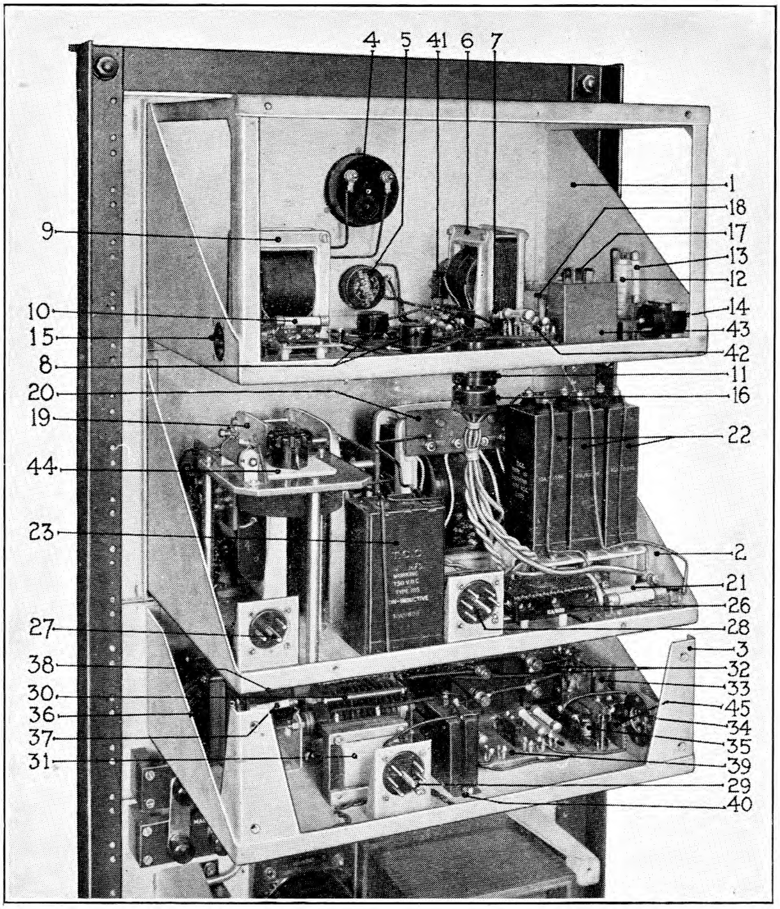


FIG. 10. Rear view of amplifier A.1104.

cable (9) terminates at each end in a six-point socket. These sockets engage with plugs, one of which is situated on the amplifier and the other on the rectifying panel. This cable carries the filament A.C. supply for the oscillator valve, the A.C. supply to the microphone rectifier, and the smoothed H.T. supply for the oscillator anode circuit. The screened cable (10) is connected at one end to the A.C. mains terminals, and terminates at the other end in a two-point socket which engages with a two-point plug connected to the primary winding of the rectifier transformer. The screened cable (3) terminates at each end in a plug. One plug is inserted into a jack (17, fig. 10) on the amplifier and the other is inserted into a jack on the local control panel. This provides the connection between the input of the amplifier and the output of the local control panel. The form of the output may be either speech or a 1,000 c/s modulating frequency for the production of M.C.W.

Type 4 (Stores Ref. 10A/9522)

57. Two views of the type 4 remote controls are given in figs. 14 and 15, and a bench wiring diagram in fig. 12. It should be noted that the bench wiring diagram given for the type 4 controls is the same as that given for the remote control panel used in the type 3 controls. The

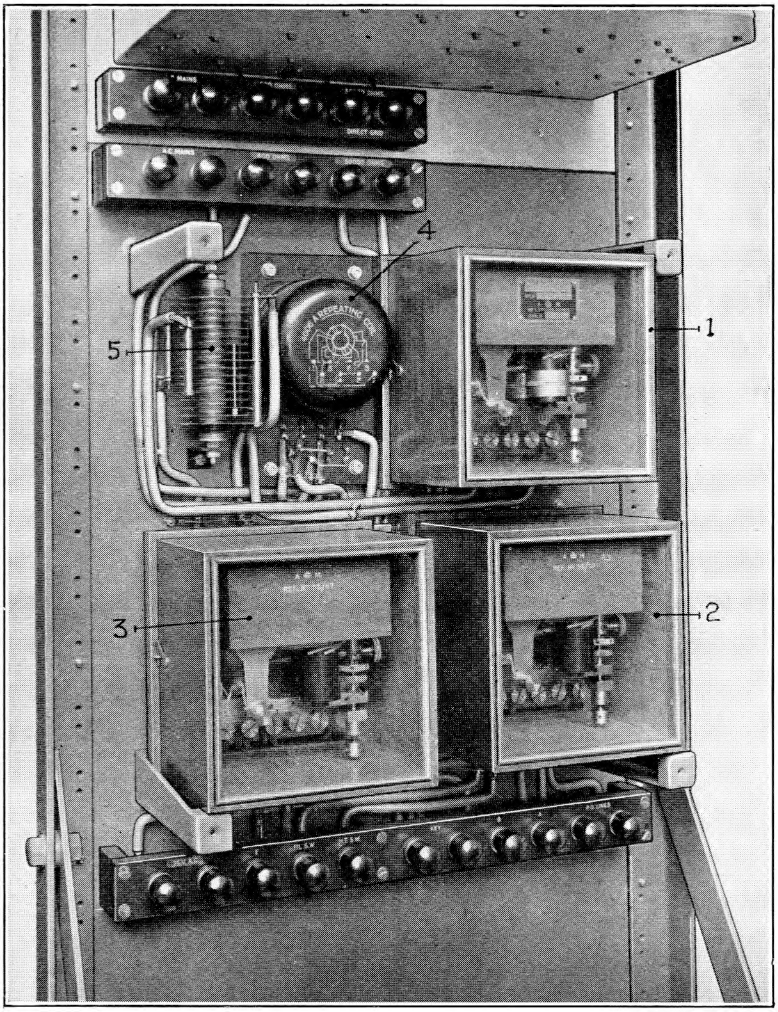


FIG. 11. Rear view of remote control panel.

difference, however, being that for the type 4 controls, the three coupled switches on the front of the panel are inoperative in the R/T position.

58. Referring to fig. 14 which is a front view of the remote controls, type 4, as employed at the transmitter end, a remote control panel (1) (Stores Ref. 10A/9588), and a dummy panel (2) are mounted on a rack (3) (Stores Ref. 10A/9591). The key (4) is mounted above the tumbler switches which can be seen in the centre of the panel. The switch (5) on the left is the H.T. switch, and the switch (6) on the right is the L.T. switch. The three coupled switches (7) in the middle are engraved R/T and W/T in the " up " and " down " positions respectively, but only the W/T position is used. The weight of the complete unit is approximately 7 st. 7 lb., and the dimensions of the panels and rack the same as for type 3.

59. The rear of this panel is seen in fig. 15. The keying relay (1) is in the top right-hand corner and below it is the H.T. relay (2). To the left of the H.T. relay is the L.T. relay (3).

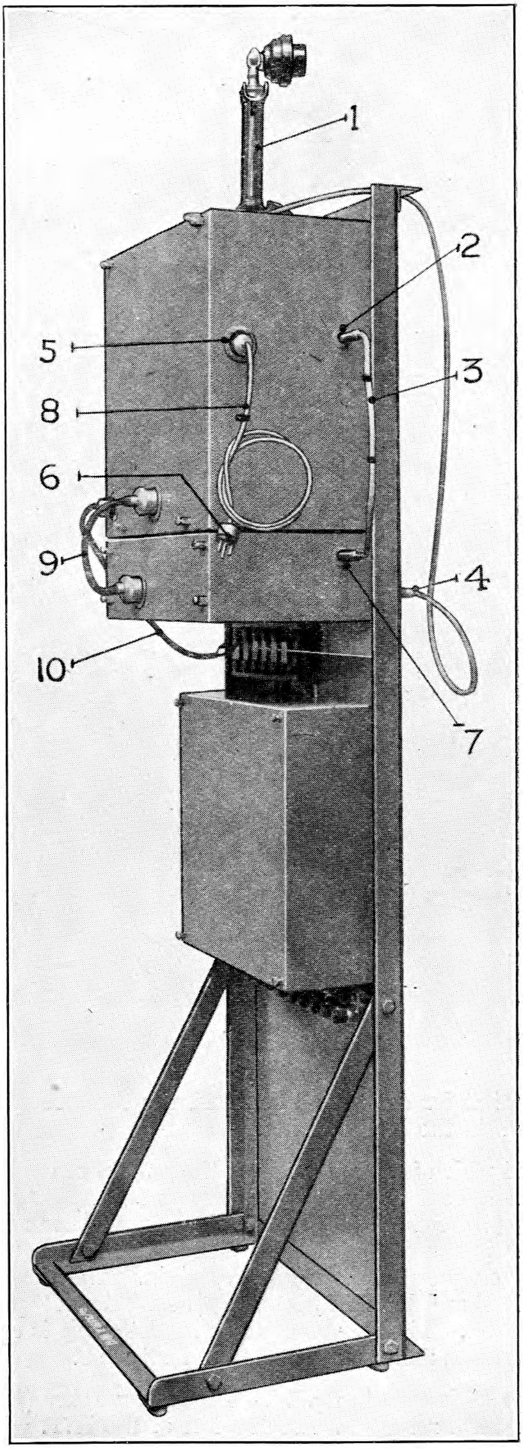


FIG. 13. Rear view of remote controls, type 3.

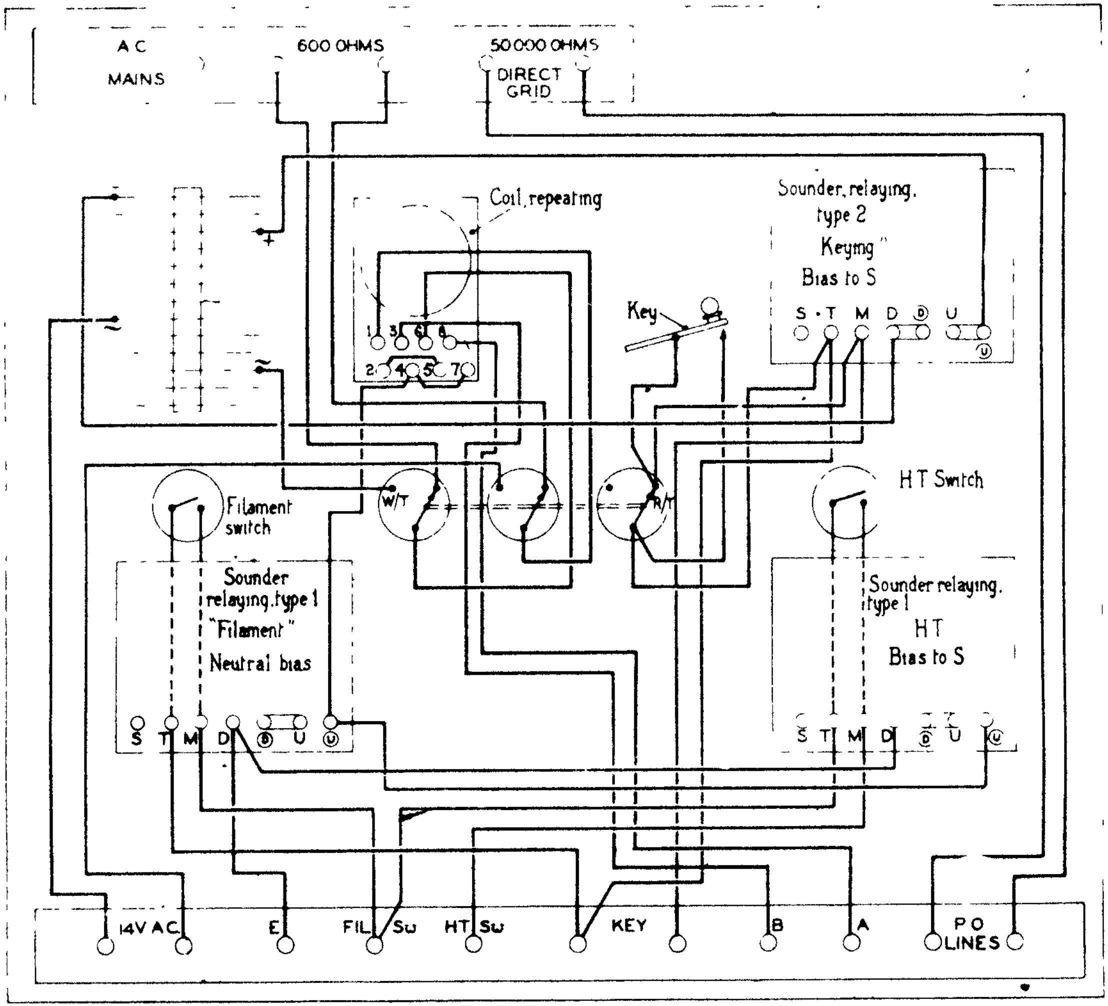
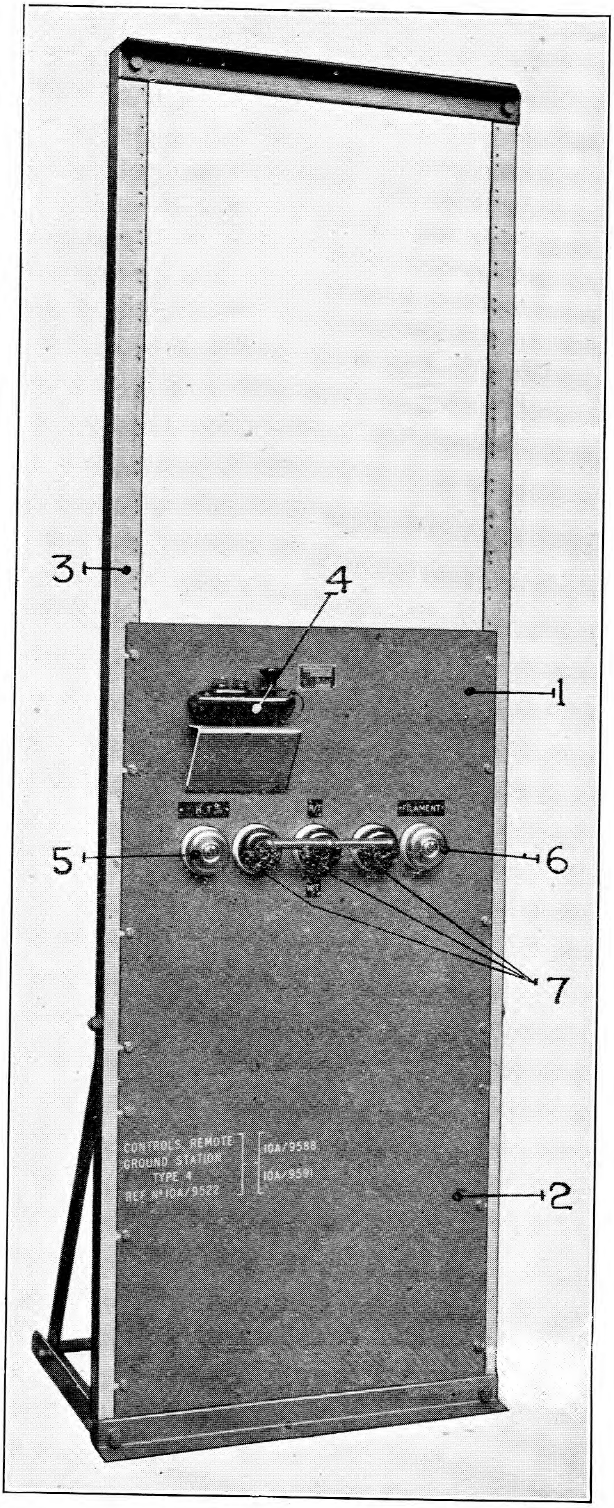


FIG 12 REMOTE CONTROL PANEL (WIRING DIAGRAM)



(63125-C) Fig. 14. Remote controls, type 4

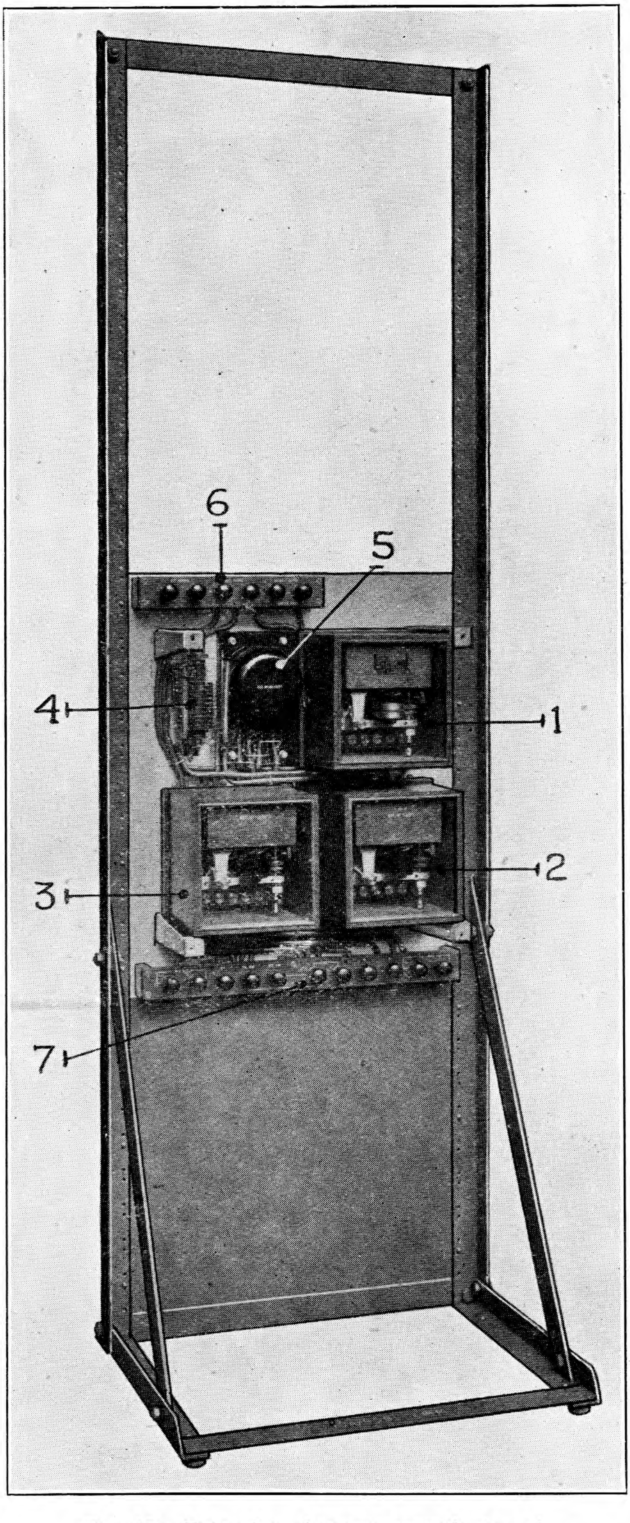


FIG. 15. Rear view of remote controls, type 4

The metal rectifier (4) is in the top left-hand corner while the repeating coil (5) is to the right of it. The terminal strip (6) carries six terminals engraved as follows :—First two on the left, A.C. MAINS ; next two, 600 OHMS ; and the last two, 50,000 OHMS DIRECT GRID. Another terminal strip (7) having eleven terminals can be seen at the bottom of the panel. The first two terminals on the left are engraved 14V, A.C., the next terminal is engraved E, the next one FIL. SW., the next one H.T.SW., the next pair KEY, the next two B and A respectively, and the last two are engraved P.O. LINES.

60. The 14V. A.C. supply from the transformer incorporated in the rectifier panel of the transmitter is connected to the first pair of terminals. The next pair of terminals is connected to the " machinery earth." The filament switch terminals on the transmitter are connected to the fourth and sixth terminals, while the transmitter H.T. terminals are connected to the fifth and sixth terminals. The winding of the electro-magnetic key on the transmitter is connected across the pair of terminals engraved KEY. The lines from the signals office are connected to the two terminals engraved B and A. The terminals engraved P.O. LINES are for remote modulation on a special pair of lines. They are connected directly to the right-hand pair of terminals in the upper terminal strip (6).

Type 5 (Stores Ref. 10A/9523)

61. A plan view of type 5 remote controls is given in fig. 16 and a bench wiring diagram in fig. 17. Referring to fig. 16, the filament relay (1) may be seen on the right and next to it is the H.T. relay (2). The keying relay (3) is on the left. The tumbler switch (4) on the right is connected across the tongue and mark terminals of the L.T. relay while the tumbler switch

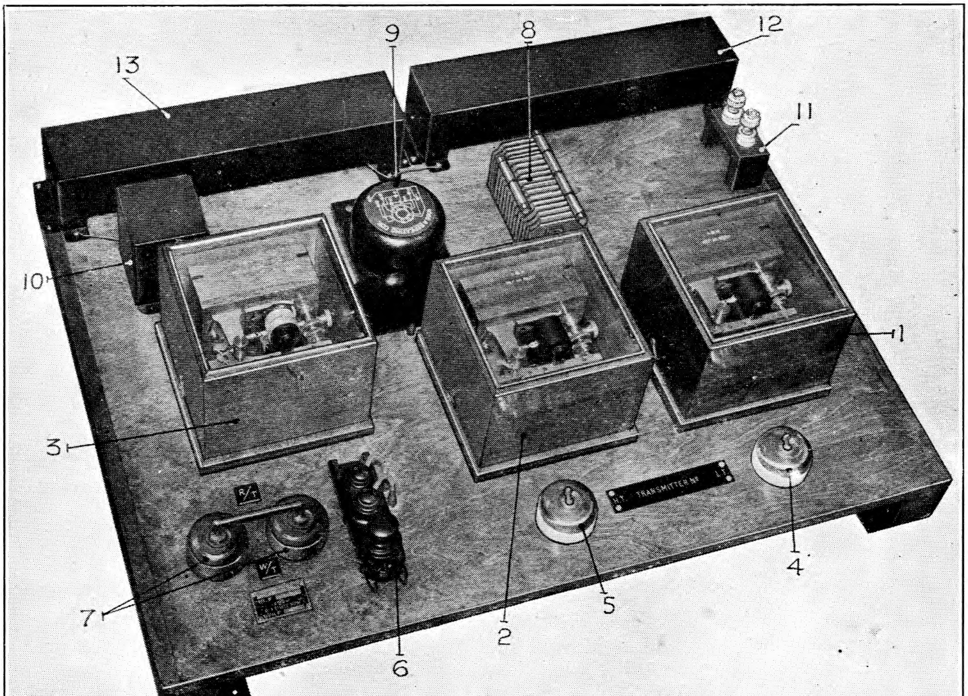


FIG. 16. Remote controls, type 5.

(5) is connected across the " tongue " and " mark " terminals on the H.T. relay. The key (6) is connected across the " tongue " and " mark " terminals of the keying relay. The coupled tumbler switches (7) are for the purpose of changing over from R/T to W/T and are engraved accordingly. The manner in which they are connected up may be seen in fig. 17. The metal rectifier (8) and repeating coil (9) can be seen above the relays. The transformer (10) is used for R/T and its secondary winding is connected to the modulating circuit of the transmitter. The terminal block (11) on the right has two terminals to which a 14-volt A.C. supply is connected. The terminal strip under the cover (12) has six terminals engraved from the right FIL., H.T., and LINES. B.A. The terminal strip under the cover (13) is provided with five terminals which are engraved from the right, E, LINES, and KEY. When remote controls, type 5, are used with transmitter T.70, for example (except for lines A and B), all these terminals are connected to the corresponding terminals on the transmitter. All the apparatus is mounted on a wooden board, 2 ft. 7 in. wide by 2 ft. 0 in. deep, and the weight is approximately 50 lb.

Type 6 (Stores Ref. 10A/9873)

62. Referring to fig. 18 which is a front view of remote controls, type 6, the key terminals may be seen on the left and the microphone terminals on the right. The uppermost terminal has no internal connection (*see* fig. 19). The switch in the centre is engraved OFF, FIL. ON,

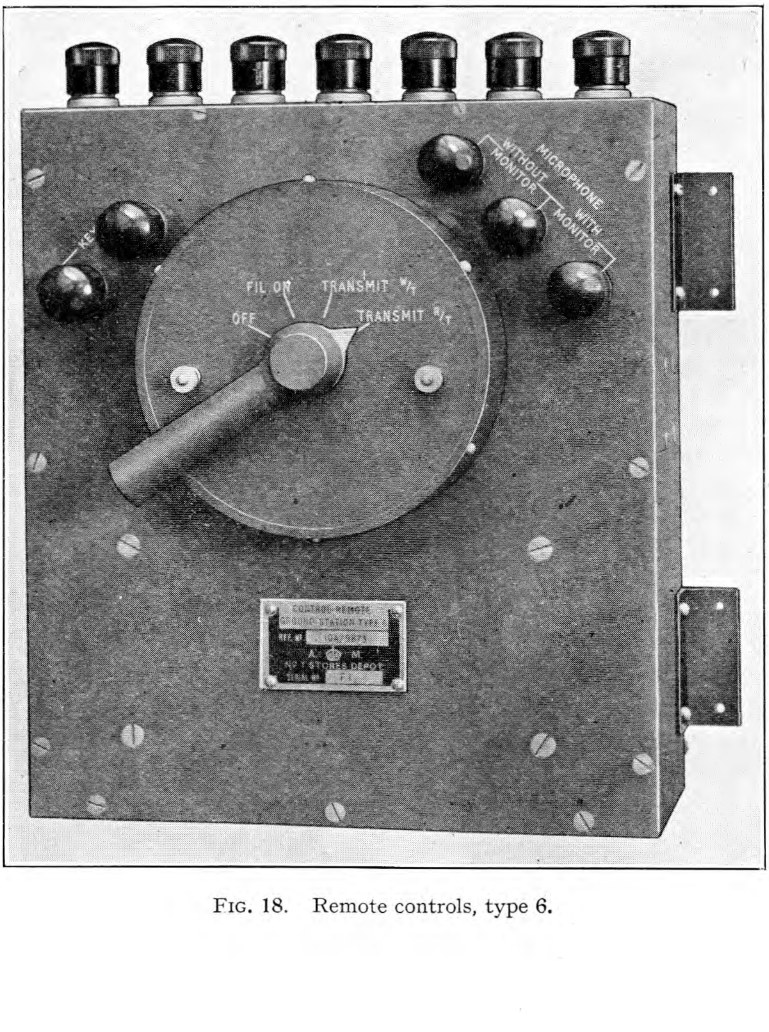


FIG. 18. Remote controls, type 6.

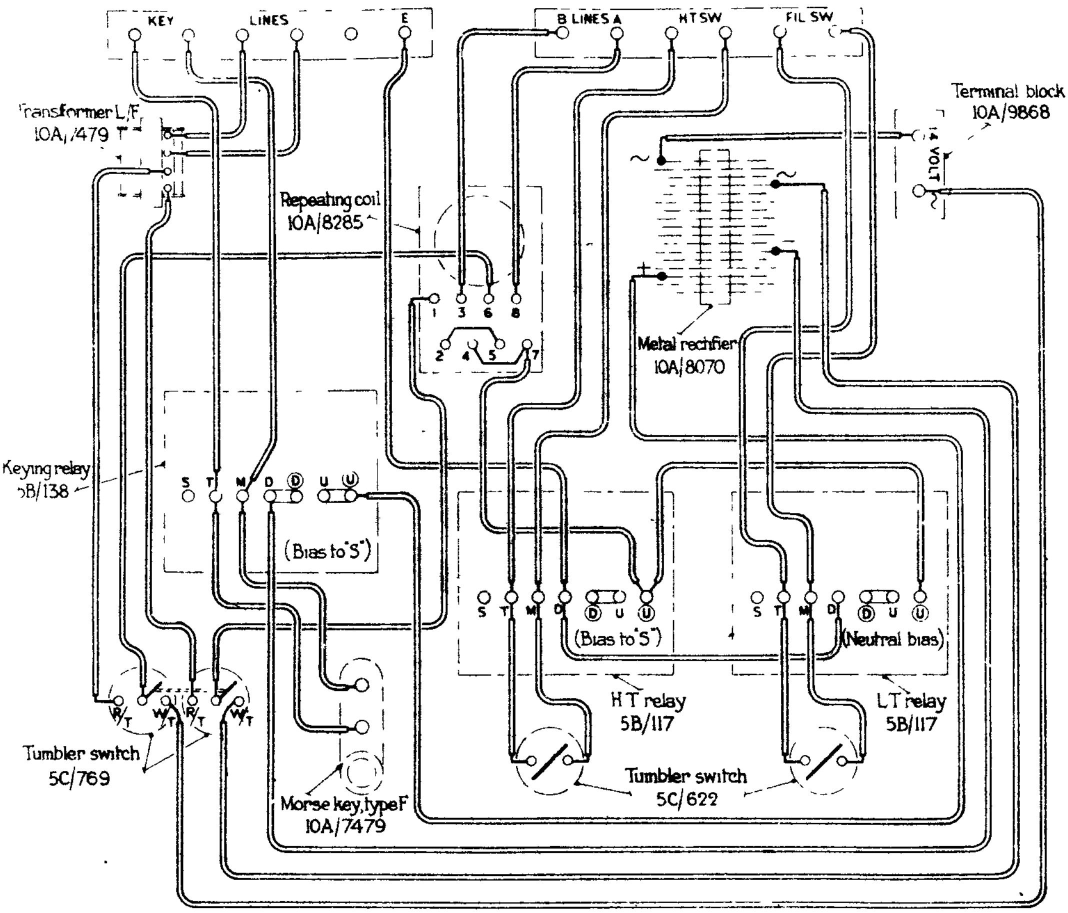


FIG. 17. BENCH WIRING DIAGRAM - REMOTE CONTROLS TYPE 5

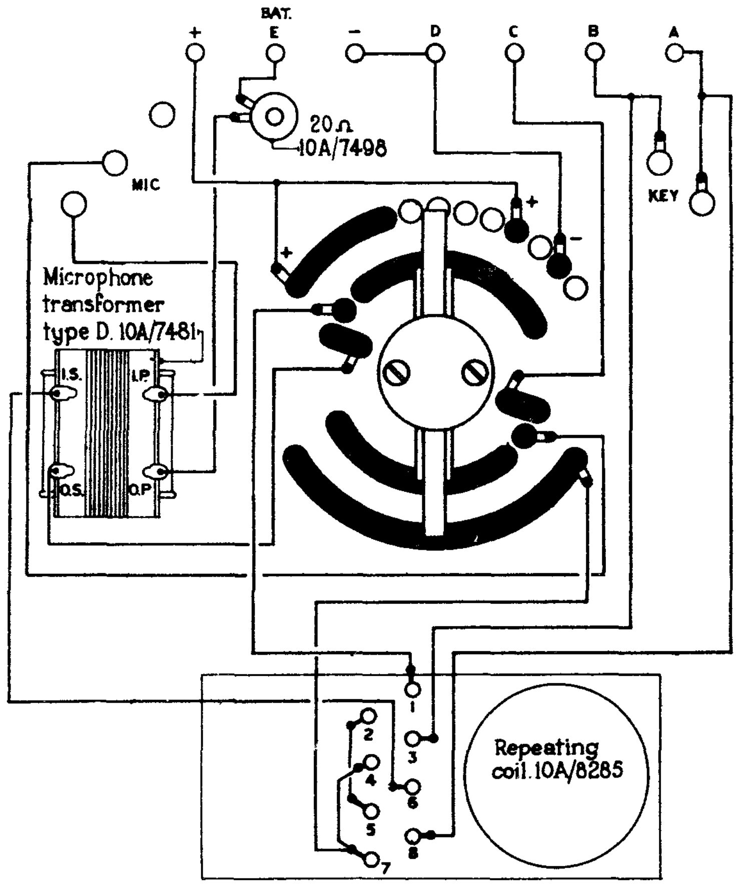


FIG. 19. BENCH WIRING DIAGRAM — REMOTE CONTROLS, TYPE 6

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TRANSMIT W/T and TRANSMIT R/T. The seven terminals at the top are engraved from the right +, $\frac{\text{BAT}}{\text{E}}$, −, D, C, B and A. A battery is connected across the terminals engraved + and − and the terminals engraved C, D, A and B are connected to the remote control lines. The whole unit is built up in a wooden box 11 in. by 9 in. by 5 in. deep, having a synthetic resin top panel on which the switch, key and microphone terminals are mounted. The weight is approximately 8½ lb. A bench wiring diagram is given in fig. 19.

Type 7 (Stores Ref. 10A/9884)

63. Remote controls, type 7, a front view of which is given in fig. 20 and a rear view in fig. 21, is very similar in appearance to type 3, except that the remote control panel (1) has two coupled switches instead of three. The dimensions and weight are roughly the same as type 3. The amplifier portion comprising the panels (2), (3) and (4) are the same as in type 3.

64. The apparatus shown in fig. 21, which is a rear view of remote controls, type 7, with the covers removed, clearly shows, as regards the upper portion, the similarity with type 3. The lower portion is also very similar, except that an additional relay has been added and two terminals on the bottom terminal strip have been relettered. As before, (1) is the keying relay, (2) is the H.T. relay, and (3) the L.T. relay. The repeating coil (4) and rectifier (5) are mounted in the same way as on type 3. The additional relay (6) has been introduced in order to effect the change-over from W/T to R/T and *vice versa*. The terminal strip (7) at the top remains the same, and is linked up with the corresponding terminals in the amplifier panel. The terminal strip (8) at the bottom has the last four terminals on the right engraved C LINES D and B LINES A. The remaining seven terminals are the same as for type 3. The bench wiring diagram (fig. 22) shows the manner in which the various items are connected up.

65. Referring to fig. 20, it will be seen that the coupled switches (5) on the front of the panel (1) form a two-pole three-position switch, and a plate on the front of the panel is suitably engraved to indicate the three positions. In the remote control position the change-over from W/T to R/T or *vice versa* is effected by the relay (6, fig. 21) which is energized from the remote signals office. In the centre position (local W/T), the primary winding of the repeating coil (T_2, fig. 5) is opened and, as a result, no transmitting operations can be carried out from the remote station. The key (6) on the remote control panel (1, fig. 20) now controls the transmitter. When the coupled switches are in the local R/T position, the tongue and mark terminals on the keying relay are short-circuited, and the primary winding of the repeating coil open-circuited. Here again no R/T can be transmitted from the remote station, but the local microphone may be used. It will be obvious from the above that, if it is desired to control the transmitter entirely from the remote signals office end, the two coupled switches (5) on the front of the panel (1) must be left in the remote control position.

PRECAUTIONS AND MAINTENANCE

Type 2

66. Very little maintenance is required on the type 2 controls beyond seeing that the sounder relays are properly adjusted. A properly constructed sounder relay correctly adjusted should retain its adjustment for many months without attention. If constant adjustment of a sounder relay is necessary, first ensure that the adjustments are being carried out in the correct manner. If trouble is still experienced, the instrument should be regarded as defective and replaced by a serviceable one. The process of cleaning and truing of contacts is among those operations which need to be carried out only infrequently, but the proper tools should be employed. Table I gives a list of tools provided in a special kit at the signals office. When adjustments are necessary the appropriate tools from this kit should be used.

67. Each sounder relay has two windings, the ends of which are brought out to terminals arranged in a convenient way so that the windings may be connected either in series or parallel. The terminals are marked D, D, U, U. When D and D are connected together and U and U

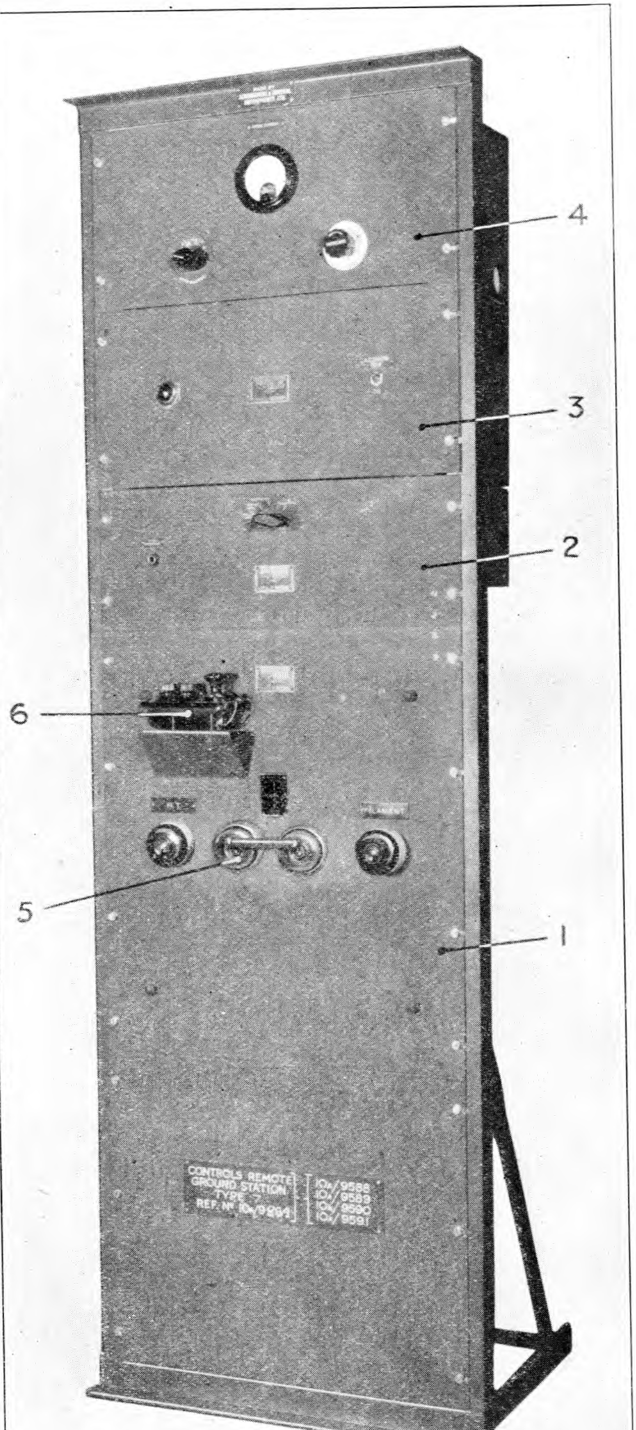

FIG. 20. Remote controls, type 7.

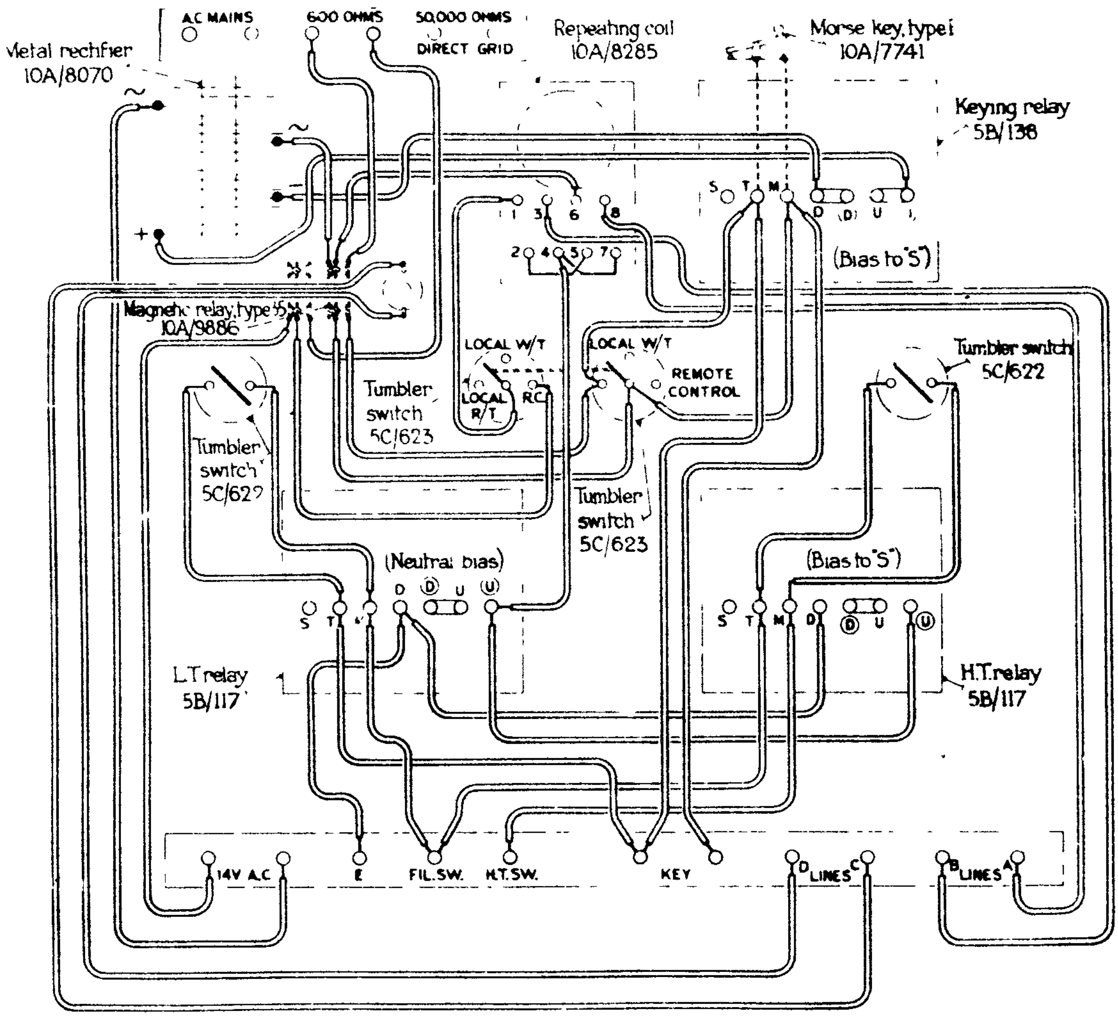

FIG. 22. BENCH WIRING DIAGRAM - REMOTE CONTROL PANEL, TYPE 7

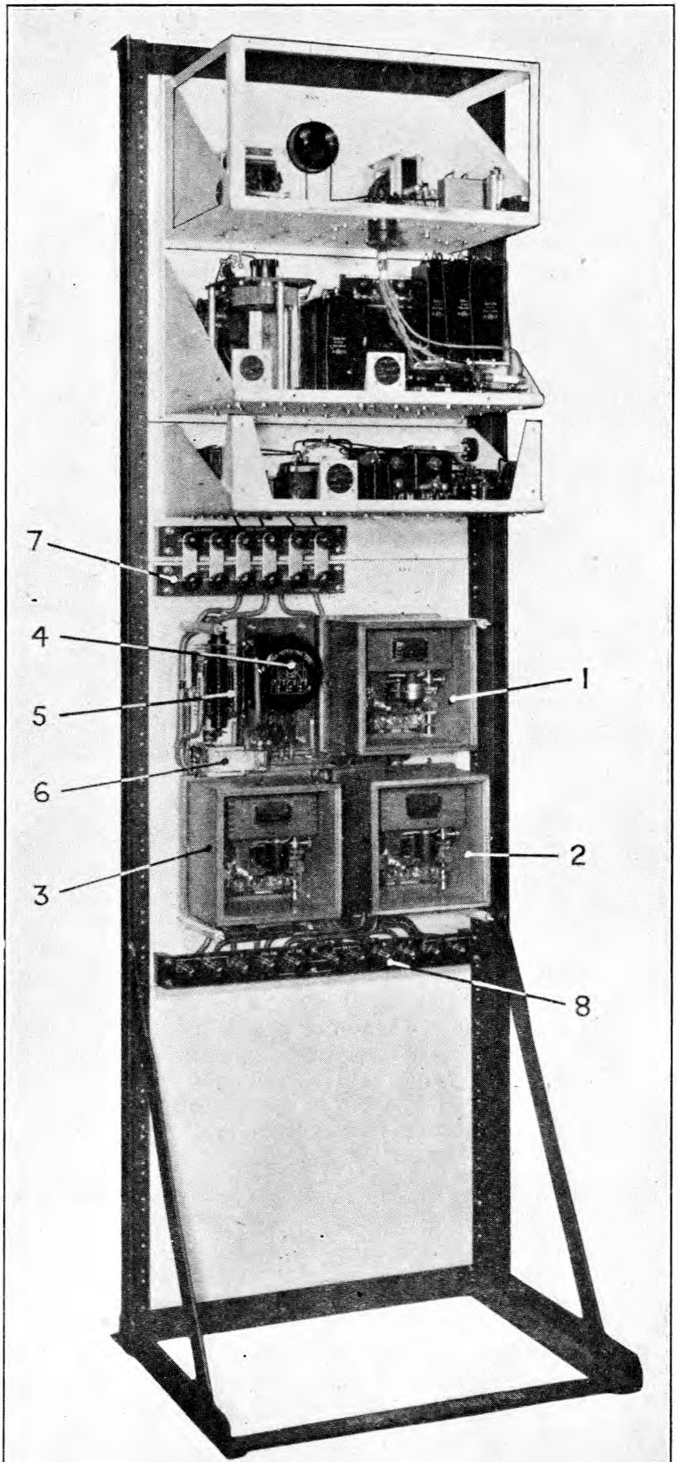

FIG. 21. Rear view of remote controls, type 7.

are connected together the windings are in parallel. When D and U are connected together a series connection of the windings is obtained. The relay is connected to its appropriate circuit by taking exterior connections to D and U in both cases.

68. Of the three sounder relays employed on the remote controls two of them, H.T. and L.T. (Stores Ref. 5B/117) have their windings connected in series. The keying relay (Stores Ref. 5B/138) has its windings connected in parallel, since it is in circuit with a rectifier (*see* fig. 7).

69. Keying and H.T. relay should be adjusted in the following way :—Holding the tongue to "mark," adjust the "mark" contact until a gap of 0·004 in. is obtained between the armature and the pole pieces. Lock the "mark" contact. Again holding the tongue to the "mark" contact, adjust the "space" contact until there is a gap between tongue and "space" contact of 0·005 in. Lock the "space" contact. Adjust the bias spring by means of the knurled knob to give a bias to "space." The relays may now be operated remotely and the spring adjusted, if necessary, to obtain the best operation. The keying relay requires careful adjustment in this respect, and morse should be made on the remote key while carrying out the final adjustments. The procedure for adjusting the contact gaps of the L.T. relay is the same as for the other two relays, except that the spring tension is adjusted by means of the bias screw, so that the tongue will stay positively in either "mark" or "space" position when placed there. A momentary current through the relay winding in one direction should send the tongue to one contact, while a momentary reverse current should send the tongue to the other.

70. The sounder relay contacts carry only low voltage D.C. and they will normally operate for thousands of hours without replacements. In the event of a replacement being required the stores reference numbers are given in the appendix at the end of this chapter. In the earlier types of relays only the "space" and "mark" contacts were replaceable. In later issues the tongue contact is also capable of replacement.

71. When checking the operation of the relays ensure that the sequence is correct. On moving the signals office switch from OFF to the GEN. RUNNING position the H.T. relay is momentarily flicked to "mark," and returns, and the L.T. relay is moved to "mark" and remains there. When the signals office switch is moved further to the TRANSMIT position the H.T. relay should move to "mark" and remain there.

Type 3

72. The remote control portion of the type 3 controls is similar to type 2, and the same general remarks apply regarding the adjustment of the relays. Since, however, a number of valves are employed in the amplifier panel and in the rectifier panel, periodic attention will be required. The valve in the first stage of the amplifier is a V.R.38, and the valves employed in the output stage are both V.R.40. The last stage incorporates a milliammeter and some indication of the condition of these valves will be obtained by checking that this current is normal: a current of 94 to 126 mA may generally be expected. If correct modulation is not being obtained, make sure that the connector between the amplifier and the transmitter is making proper contact.

73. The connector which supplies the H.T. and L.T. to the amplifier unit should also be checked to see that the pins are making proper contact. There are four fuses in the controls each of which are 2 amp. Two of these are situated in the rectifier unit and two in the local control panel. Failure of the fuses in the rectifier unit will be indicated by an absence of glow in the pilot lamp on the front of the panel. The oscillator valve is a V.R.37 and the H.T. supply for this, together with the L.T. supply for the valve and for the microphone, are obtained through a 6-pole plug and socket. These connections should be checked first in the event of failure of this valve to operate. The rectifier employs a V.U.39 valve, and a thermal relay is also provided which gives a delay of a few seconds in the making of the H.T. output connection after switching on the filament current.

74. Bad contact of valve pins in valve sockets are a frequent cause of failure. The metal covers of the apparatus are perforated, and an indication that the heater circuits are normal may be obtained by observing the glow. If a faulty contact at one of the valve pins, other than the filament, is suspected, the cover should be removed and the fit of the pins in their sockets checked. It should be noted that when handling the fuses in the rectifier panel it is not sufficient merely to break the switch on this panel, since the fuses are connected between this switch and the mains. Before touching the fuses switch off at the main A.C. switch.

75. The valves used in the output stage of the amplifier are supplied in matched pairs and care should be exercised that they remain in their pairs when stored. In the event of failure of one of these valves (V.R.40), both should be removed and a new matched pair should be substituted.

76. Referring to fig. 23, certain tests may be carried out by means of a pair of telephones and the 15-0-15 voltmeter provided. It will be seen that with the line plugged in on the distribution box and the circuit working, the test jack is always available for testing purposes. If headphones are plugged into the test jacks, the telephones are connected across the lines, and if the circuit is being keyed, " back morse " will be heard, *i.e.*, a 50-cycle note every time the key is at " space." Irregularity in the keying can therefore be detected.

77. The voltmeter has one side connected to earth and the other side to the tip of the plug. By inserting the plug into the jack either partly or fully home the tip is connected to either one side of the line or the other, and the voltmeter is thus connected between earth and the A line or between earth and the B line. Switching voltages applied by the battery to the lines can therefore be checked for sign and magnitude.

78. The local microphone circuit receives its supply from a rectifier connected to a 10-volt winding on the transformer in the rectifier unit. If it is desired to check this the microphone plug may be withdrawn and the voltage across the jack measured. This should be approximately 4·5 volts. The 15-0-15 voltmeter (Stores Ref. 10A 7990) may be used to make this measurement but, since the voltmeter is wired in such a way as to connect it between earth and tip of plug, it will be necessary to disconnect it and wire it to a spare plug in the normal manner, *i.e.*, one side of the voltmeter to tip of plug and the other to sleeve. On inserting this plug into the local microphone jack and placing the selector switch on the controls in the LOCAL MICROPHONE position, the voltmeter will read the voltage of the microphone supply.

Type 4

79. The same general remarks apply here as for type 2, the only difference being that as the controls are mounted on a rack with a metal cover it will be necessary to remove the latter when adjustments to relays are necessary.

Type 5

80. Similar remarks apply to type 5 as for types 2 and 4. The apparatus is mounted on an open board and is easily accessible for adjustments.

Type 6

81. If it is necessary to inspect the switch contacts the inspection can be carried out by undoing the two knurled nuts on the top, after which the cover complete with the handle may be removed, revealing the contact arm and the contacts. A dog coupling is provided between the handle and the contact arm. The arm consists of two laminated blades which form four brushing contacts. Three of these contacts are on one blade and the fourth contact which moves with the arm, but is entirely insulated from it, acts as a short-circuiting contact (R/T position) on two adjacent contact studs. For efficient operation the contact studs should be smooth and clean and the space between the studs free from metal dust or foreign matter.

Type 7

82. The same remarks as to maintenance apply as for type 3. An additional relay (Relay, magnetic, type 35, Stores Ref. 10A/9886) is provided. This is of the post office type (*see* 6, fig. 21) and should normally require no attention.

83. If any adjustment is required, only the proper tools should be used (*see* Table 1). The armature stop-screw (which limits the travel of the armature when the relay is energized) is a cheese-headed screw with a screwdriver slot and is provided with a locknut. The movement of the armature in the opposite direction is limited by a light metal lug on the body of the relay. No adjustment of this is possible except by bending.

84. The relay is designed to operate satisfactorily with a current of the order of 10 milliamps and since it has a resistance of 200 ohms, and 24 volts is applied to the line, there is ample margin to ensure satisfactory operation of the relay without critical adjustment. Before any attempt is made to readjust the relay therefore, an investigation should be made to ensure that the reason for faulty operation is not an unduly low current through the relay winding due to a high resistance fault. In the event of a relay being burnt out, a spare relay can be substituted by unsoldering the connections and removing the relay which is held to the panel by a bracket.

85. It should be remembered that although the controls are designed to change over from R/T to W/T it will not be possible, without some further adjustment, to obtain the highest efficiency. For example, if the bias on the transmitter is adjusted correctly for C.W. and a change-over of the switch to R/T is made at the signals office end, the adjustment will be incorrect for R/T. In practice, if advantage is to be obtained from the change-over device the transmitter will be biased to give efficient R/T and when the change over is made to C.W. this transmission will be at something less than full efficiency. To obtain greater efficiency it will be necessary to give supplementary instructions by telephone to the transmitter attendant to make the necessary readjustments.

TABLE 1

Tools

G.P.O. No. 81	..	Pliers, taper nose, $5\frac{1}{2}$ in.
G.P.O. No. 225	..	Screwdriver, offset.
G.P.O. No. 119	..	Mirror, inspection.
G.P.O. No. 108A	..	Spanner, box, $\frac{1}{4}$ in. $\times$ $\frac{9}{32}$ in.
G.P.O. No. 108B	..	Spanner, box, $\frac{5}{16}$ in. $\times$ $\frac{11}{32}$ in.
G.P.O. No. 108C	..	Spanner, box, $\frac{3}{8}$ in. $\times$ $\frac{13}{32}$ in.
G.P.O. No. 108D	..	Spanner, box, $\frac{7}{16}$ in. $\times$ $\frac{15}{32}$ in.
G.P.O. No. 106A	..	Spanner, double ended, $\frac{5}{32}$ in. $\times$ $\frac{3}{16}$ in.
G.P.O. No. 106B	..	Spanner, double ended, $\frac{7}{32}$ in. $\times$ $\frac{1}{4}$ in.
G.P.O. No. 106C	..	Spanner, double ended, $\frac{9}{32}$ in. $\times$ $\frac{5}{16}$ in.
G.P.O. No. 106D	..	Spanner, double ended, $\frac{11}{32}$ in. $\frac{3}{8}$ in.
G.P.O. No. 106E	..	Spanner, double ended, $\frac{13}{32}$ in. $\times$ $\frac{7}{16}$ in.
G.P.O. No. 98	..	Adjuster No. 14.
G.P.O. No. 136	..	Adjuster, back-stop, No. 1.
G.P.O. No. 137	..	Adjuster No. 4.
G.P.O. No. 224	..	Gauges, feeler No. 1 (Stores Ref. 10A/9541).
G.P.O. No. 155	..	Cleaner, contact No. 1 (burnisher).
G.P.O. No. 234	..	Cleaner, contact No. 24.
G.P.O. No. 6	..	Screwdriver, offset.
G.P.O. No. 91	..	Screwdriver, instrument No. 1.
G.P.O. No. 92	..	Screwdriver, instrument No. 2.
G.P.O. No. 93	..	Screwdriver, instrument No. 3.
G.P.O. No. 94	..	Screwdriver, instrument No. 4.
G.P.O. No. 95	..	Screwdriver, instrument No. 5.
G.P.O. No. 85	..	Pliers, duck-bill, $5\frac{1}{2}$ in.
G.P.O. No. 90	..	Pliers, duck-bill, bent, $5\frac{1}{2}$ in.
		Pins, adjusting, 4 in. (Stores Ref. 1B/3591).

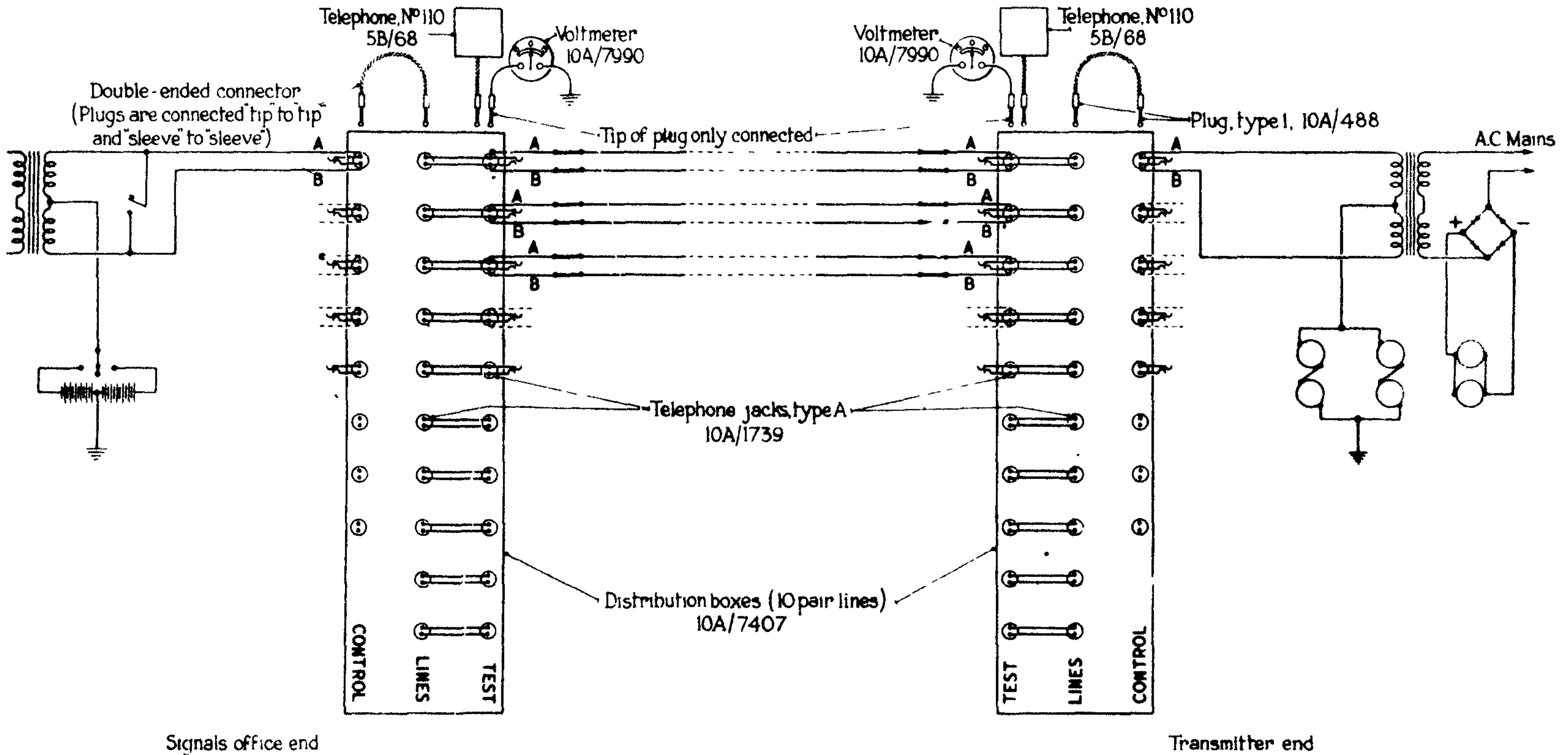

FIG. 23. DISTRIBUTION BOXES WITH TEST ARRANGEMENTS

APPENDIX

NOMENCLATURE OF PARTS

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

Ref No.	Nomenclature.	Quantity		Remarks.
10A/9009	Controls, remote, ground station, type 2.	–	—	At transmitter end.
	Principal components :—			
10A/9868	Block, terminal	1	—	Complete with two terminals, 2 B.A.
10A/8285	Coil, repeating	1	—	
5A/416	Push, bell, circular	1	—	For testing.
10A/8070	Rectifier, metal	1	—	
5B/117	Sounder, relaying, type A	2	—	H T. and L.T.
5B/138	Sounder, relaying, type B	1	—	Keying (complete with slugs).
5C/622	Switch, tumbler, 5 amp., S.P. ..	2	—	
5A/471	Terminal, instrument, single, 2 B.A.	8	—	
10A/9521	Controls, remote, ground station, type 3	–	—	
	Consisting of :—			
10A/9520	Amplifier, type A 1104 .. .	1	Ref. in Fig 4	Comprising 10D 9589, 10D/9590 and 10A/9591. For details see below.
10A/9588	Panel, type 5	1	—	For details see below
10A/9589	Panel, type 6	–	—	
	Principal components —			
10A/10544	Attenuator-unit	1	—	Fitted with C_{12} and R_{17}.
	Choke, L/F —			
10A/9606	Type R	1	L	Iron cored.
10A/9607	Type S	1	L_1	Iron cored, metal case
10A/8275	Condenser : Type 164	1	C	2μF.
10A/9608	Type 320	1	C_1	4μF.
10A/9611	Type 323	1	C_5	50μF.
10A/10545	Condenser unit, type 4	1	—	Fitted with C_2, C_3, C_4.
10A/9612	Cover	1	—	
10A/10269	Fuse, type 13	2	F	2 amp.
10A/9614	Holder, fuse D P., type A ..	1	—	
10A/8597	Holder, valve, type L	3	—	4-pin.
10A/9615	Holder, valve, type S	1	—	5-pin.
10A/1739	Jack, telephone, type A	1	J	
10A/9595	Lamp-fitting, signal	1	—	
10A/9616	Milliammeter, type C (0–150) ..	1	M	
	Plug :—			
10A/7433	Type 52	1	—	6-pole. To engage with 10H/7439.
10A/9617	Type 87	1	—	2-pole. For panel mounting.
10A/9618	Type 88	1	—	6-pole. For panel mounting.
10A/9619	Relay, thermostatic, type B ..	1	R L.	
	Resistance .—			
10A/8018	Type 110	2	R_5, R_6	0·25 M Ω, ½ watt, rod type
10A/8123	Type 124	1	R_4	1,000 ohms 1-watt, rod type.
10A/9158	Type 234	2	R_5, R_8	2,000 ohms 1-watt, rod type.
10A/7605	Type 75	1	R_3	50,000 ohms variable potentiometer.
	or			
10A/9505	Type 253	1		

Ref. No.	Nomenclature.	Quantity.		Remarks.
	Controls, remote, ground station, type 3—*contd.*			
	Panel, type 6—*contd.*			
	Principal components—*contd.*		Ref. in fig. 4	
	Resistance—*contd.*			
10A/9620	Type 267	2	R_9, R_{10}	100 ohms, 1-watt, rod type.
10A/9621	Type 268	1	R_2	30,000 ohms 2 watt, rod type.
10A/9623	Type 270	–	R_1	500 ohms, 20-watt.
	Resistance unit :—			
10A/10547	Type 1	1	—	Fitted with R and R_{16}.
10A/10549	Type 5	1	—	Fitted with R_{18}, R_{19}, R_{20}.
	Socket :—			
10A/7437	Type 19	2	—	2-pole.
10A/7439	Type 20	1	—	6-pole.
	Switch :—			
10A/9624	Type 116	1	S	Double - pole, " On - Off," quick break.
	Transformer .—			
10A/9626	Type 43	1	T	Mains.
10A/9625	Type 56	1	T_1	Input. Push - Pull. Ratio 2·5–1.
10A/9627	Type 58	1	T_2	Output. Push - Pull. Ratio 1–1·5.
10A/9590	Panel, type 7	–	—	
	Principal components :—			
10A/9628	Choke, L.F., type T.	1	L_2	
	Condenser :—			
10A/8010	Type 133	1	C_9	0·002μF.
10A/8275	Type 164	2	C_{10}, C_{11}	2μF.
10A/9630	Type 325	2	C_6, C_7	1,000μF.
10A/10297	Type 389	1	C_8	0·2μF.
10A/9631	Cover	1	—	
10A/10269	Fuse, type 13	2	F_1	2 amp.
	Holder :—			
10A/9614	Fuse, D.P.	1	—	
10A/9615	Valve, type S	1	—	5-pin.
10A/1739	Jack, telephone, type A	2	J_1, J_2	
10A/9618	Plug, type 88	1	—	6-pole, for panel mounting.
10A/9632	Rectifier, metal, type 6	1	W	6-volt, 1-amp., D.C. 11-volt, A.C.
	Resistance :—			
10A/7267	Type 29	1	R_{14}	250,000 ohms 1-watt, rod type.
10A/8123	Type 124	1	R_{15}	1,000 ohms 1-watt, rod type.
10A/9633	Type 271	1	R_{13}	5,000 ohms 1-watt, rod type.
10A/9634	Type 272	1	R_{12}	50,000 ohms 1-watt, rod type.
10A/9635	Type 273	1	R_{11}	8 ohms, former wound.
10A/9636	Switch, type 117	1	S_1	Multiple contact selector switch.
10A/7325	Terminal, 2 B.A., type C ..	6	—	On terminal strip.
	Transformer :—			
10A/9637	Type 10	1	T_5	L/F.
10A/9638	Type 11	1	T_4	L/F.
10A/8539	Type 52	1	T_3	Microphone.
10A/9591	Rack, type 4	1	—	
10A/9588	Panel, type 5	–	Ref. in Fig. 3	Remote control.
	Principal components :—			
10A/8285	Coil, repeating	1	—	
10A/7741	Key, morse, type F	1	—	
10A/8070	Rectifier, metal, type 1	1		W

Ref. No.	Nomenclature.	Quantity.		Remarks.
	Controls, remote, ground station, type 3—*contd.*			
	Consisting of—*contd.*			
	Panel, type 5—*contd.*		Ref. in Fig. 2	
	Principal components—*contd.*			
	Sounder, relaying :—			
5B/117	Type A	2	R, R_1	H.T. and L.T.
5B/138	Type B	1	R_2	Keying (complete with slugs).
	Switch, tumbler, S.P., 5 amp. :—			
5C/622	1-way	2	—	H.T. and L.T.
5C/769	2-way	3	S_1	Coupled R/T and W/T, no "Off" position.
10A/7325	Terminal, 2 B.A., type C ..	17	—	6 on top terminal strip 11 on bottom terminal strip.
	Accessories :—			
	Connector :—			
10A/9592	Type 5	1	—	Input. Fitted with two plugs, type 85.
10A/9593	Type 6	1	—	Local control. Fitted with two sockets, type 49.
10A/9594	Type 7	1	—	Mains. Fitted with one socket, type 50.
10A/9596	Type 8	1	—	Output. Fitted with two plugs, type 86.
			Ref. in Fig. 4	
5A/361	Lamp, filament, 3·5 volts ..	1	P.L.	
10A/9597	Microphone, desk, type 3 ...	1	—	Complete with connector and plug.
	Valve :—			
10A/9598	V.R.37	1	V_3	Oscillator.
10A/9599	V.R.38	1	V_1	Input.
10A/9601	V.R.40	2	V_2	Output.
10A/9600	V.U.39	1	V	Rectifier.
10A/9522	Controls, remote, ground station, type 4.			
	Consisting of :—			
10A/9588	Panel, type 5	1	—	For details, *see* 10D/9588, under "Controls, remote, type 3"
10A/9591	Rack, type 4	1	—	
10A/9523	Controls, remote, ground station, type 5.			
	Principal components :—			
10A/9868	Block, terminal, type 2	1	—	Complete with 2 B. A. terminals.
10A/8285	Coil, repeating	1	—	
10A/7741	Key, morse, type F	1	—	
10A/8070	Rectifier, metal	1	—	
5B/117	Sounder, relaying, type 1	2	—	H.T. and L.T.
5B/138	Sounder, relaying, type 2	1	—	Keying (complete with slugs).
	Switch, tumbler, S P., 5 amp. ..	2	—	H.T. and L.T.
5C/622	1-way	–	—	
5C/769	2-way	2	—	Coupled. R/T and W/T, no "Off" position.
10A/7479	Transformer, L/F, type 5	1	—	
10A/9873	Controls, remote, ground station, type 6.	–	—	Signals office end. Suitable for operating remote controls, type 7.
	Principal components :—			
10A/8285	Coil, repeating	1	—	

Ref. No.	Nomenclature.	Quantity.		Remarks.
	Controls, remote, ground station, type 6—*contd.*			
	Principal components—*contd.*			
10A/7498	Resistance, type 66	1	—	Wire wound bobbin, 20 ohms.
N.I.V.	Switch, 4 - position, radial stud, lever handle.	1	—	Modified, type 44.
10A/7325	Terminal, 2 B.A., type C	12	—	
10A/7481	Transformer, microphone, type 48 ..	1	—	
10A/9884	Controls, remote, ground station, type 7.	–	—	At transmitter end for W/T and R/T, and remote change-over from W/T to R/T and *vice versa*.
	Consisting of :—			
10A/9520	Amplifier, type A.1104	1	—	For details, *see* controls, remote, type 3.
10A/9885	Panel, remote control, type 9 ..	1	—	
	Principal components :—			
10A/8285	Coil, repeating	1	—	
10A/7741	Key, morse, type F	1	—	
10A/9886	Relay, magnetic, type 35	1	—	4-pole, change-over.
10A/8070	Rectifier, metal, type 1	1	—	
	Sounder, relaying :—			
5B/117	Type A	2	—	H.T. and L.T.
5B/138	Type B	1	—	Keying (complete with slugs).
	Switch, tumbler, S.P. :—			
5C/622	5-amp.	2	—	
5C/623	5-amp., 3-position	2	—	Linked.
10A/7325	Terminal, 2 B.A., type C ..	17	—	
	Accessories (general) :—			
	Sounder relay contact :—			
5B/129	Upper	1	—	
5B/128	Lower	1	—	
5B/651	Tongue	1	—	
10A/7407	Box, distribution (10-pair lines) ..	2	—	
N.I.V.	Box, junction..	2	—	Henley's Cat. No. 3167.
5B/68	Telephone No. 110	2	—	
10A/7990	Voltmeter, 15–0–15 volt	2	—	
10A/488	Plug, telephone, type 1	4	—	

APPENDIX 2

REMOTE CONTROLS, TYPE 10
(Stores Ref. 10J/112)

INTRODUCTION

1. Remote controls type 10 are designed to work in conjunction with control unit type 88 (Stores Ref. 10L/37), the associated transmitter T1190 or T1190A being keyed by an audio-frequency tone generated in the control unit, and sent over landlines to the remote controls at the W/T transmitting station. A description of the control unit type 88 is given in Section 6, Chapter 14 of this publication. By the method just described, known as tone-to-line keying, control can be obtained over far greater distances than is possible with impedance keying as used in remote controls types 2, 3, 4, 5, 6 and 7.

2. In general layout and construction, remote controls type 10 are similar to remote controls type 3, but the amplifier A1104 has been modified so that the valve V_3, which in the type 3 controls acted as a local oscillator for M.C.W., can now be used as a pre-amplifier when working over long lines, and M.C.W. is no longer available. The amplified keying tone is passed from the amplifier A1104 to a metal rectifier, the output of which operates the keying relay. Arrangements for H.T. switching are the same as in the type 3 controls, but the relay for remote filament switching and its associated local control switch have been omitted. The 24 volts for operation of the H.T. relay are fed from the battery supply of the control unit type 88 over the A and B lines to the remote controls.

GENERAL DESCRIPTION

3. It will be seen from fig. 1 that the circuit of the valve V_3 in the local control panel of the amplifier A1104 has been modified so that it works as an A/F amplifier instead of as an oscillator as before, the transformer T_4 which formerly provided anode-to-grid feedback having its windings connected in series so as to act as an anode choke. The A and B lines from the W/T cabin are connected to the corresponding terminals on the strip at the base of the remote control panel (fig. 2) and across these is the primary winding of the repeating coil. In this winding are present both the audio-frequencies (speech or keying tone) and the 24 volts d.c. for the H.T. relay. Only the audio frequencies appear in the secondary, and are taken to two terminals on a strip at the top of the remote control panel, engraved 600 OHMS. Links connect these terminals to a pair similarly marked on a terminal strip at the base of the local control panel.

4. The input to the local control panel is taken from the 600 OHM terminals to the primary of a matching transformer (T_5, fig. 1). When the switch S_1 on the panel is at 600 OHMS INPUT the secondary of this transformer is connected to a telephone jack J_2 at the side of the panel and fed over an external flexible connector to a similar jack, J_1, in the input circuit of the amplifier panel, see fig. 4 of main chapter. When the switch is at PRE-AMPLIFIER the transformer secondary voltage is applied to the grid of the valve V_3, and the amplified voltages in the anode circuit of this valve are passed to the output jack and thence to the amplifier panel. H.T. is permanently on the anode of V_3, whereas in the type 3 controls it was applied only when S_1 was at OSC.

5. The circuit arrangements with the switch in the LOCAL MICROPHONE and DIRECT-GRID positions are the same as those described in paras. 26, 27 and 30 of the main chapter. It should be noted, however, that if for any reason high input impedance R/T modulation is required with these controls, the modulation source must be connected direct to the terminals marked 50,000 OHMS DIRECT GRID on the local control panel, as the P.O. LINES terminals provided on the remote control panel of the type 3 controls are omitted in the present version. In these circumstances the A and B lines are used only for remote H.T. switching.

6. With high impedance R/T lines on the 50,000 OHM DIRECT GRID terminals and the switch S_1 at DIRECT GRID, the line matching transformer T_5 and the pre-amplifier stage are out of circuit and the input is taken direct *via* J_2 to the grid of V_1 in the amplifier A1104.

7. The secondary of the output transformer of the amplifier A1104 is connected to two two-pole sockets in parallel, from either of which an external flexible connector can be taken to two terminals marked OUTPUT A1104 on the terminal strip at the top of the remote control panel. When the ganged W/T–R/T switches on this panel are at R/T, these terminals are connected to the two terminals marked INPUT TRANSMITTER on the strip at the bottom of the same panel. When the switches are at W/T, the output of the amplifier is applied to the metal rectifier (fig. 2), the d.c. output of which operates the keying relay.

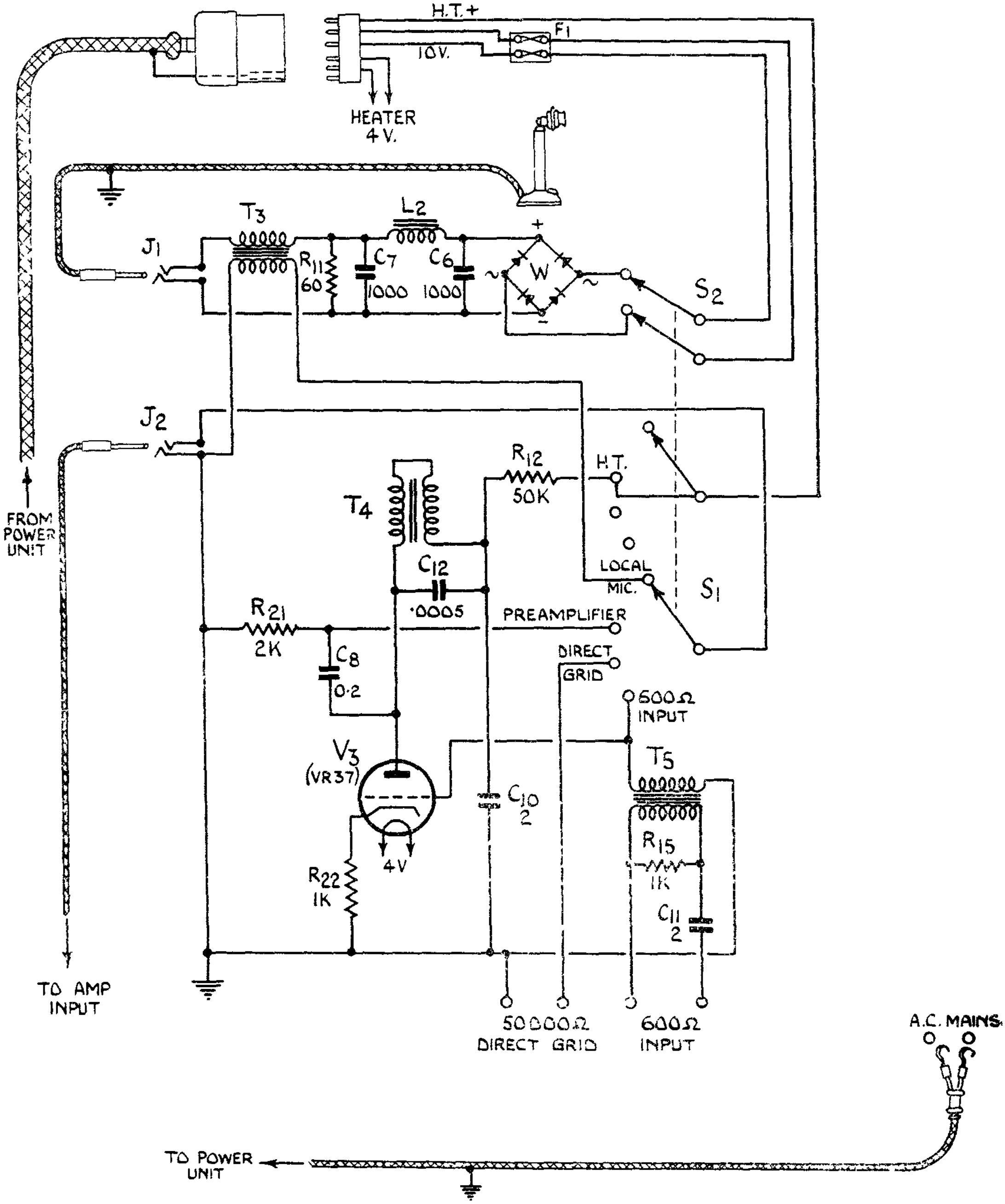

Fig. 1.—Circuit of local control panel, A 1104, as used in remote controls, type 10

8. For R/T operation the INPUT TRANSMITTER terminals mentioned in para. 7 are connected to the transmitter by a flexible connector type 683 (Stores Ref. 10H/1916) which terminates at the transmitter end in a two-way plug type 86 (Stores Ref. 10A/9603) with a central pin for operating the switch socket on the transmitter.

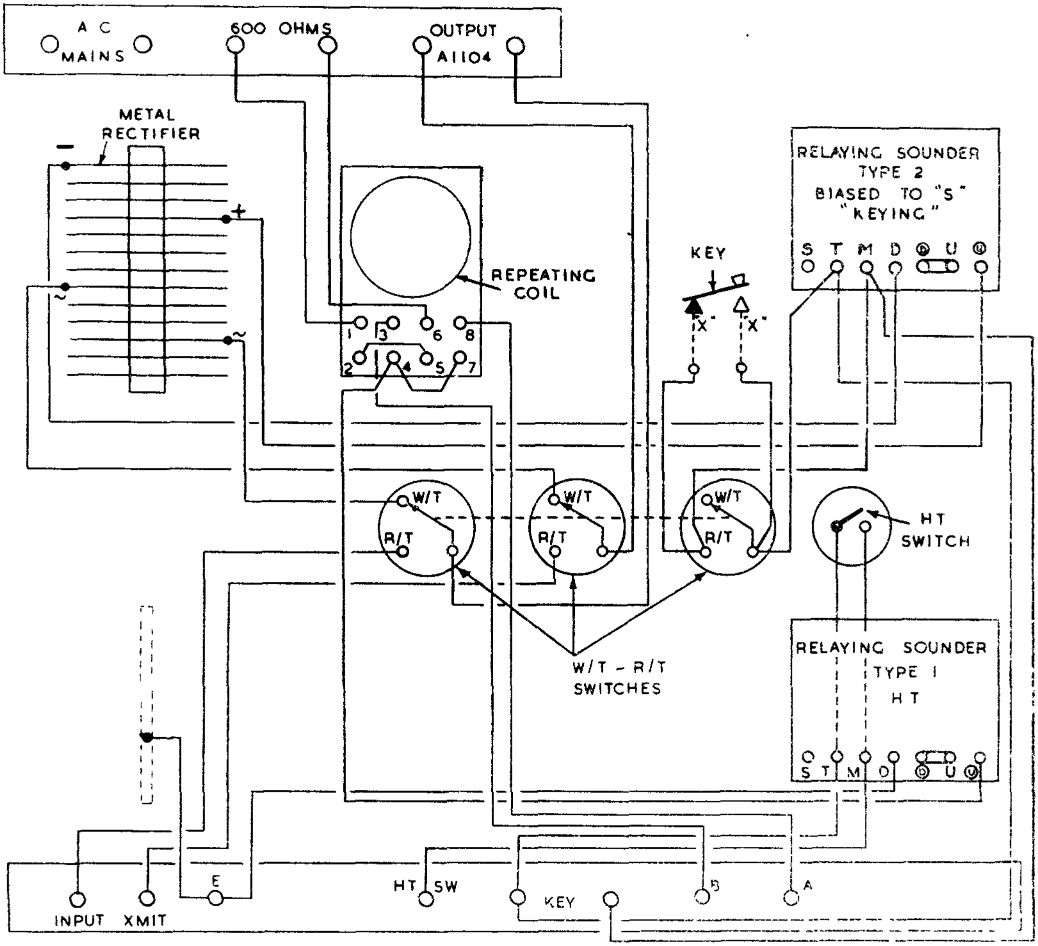

Fig. 2.—Diagram of rear of remote control panel showing location of parts

OPERATING INSTRUCTIONS

9. Paragraphs 72 to 78 of the main chapter apply in the main to remote controls type 10, but the normal reading of the milliammeter M should be 110mA unmodulated, this being set by the variable bias resistor R_{16} (fig. 4, main chapter). The control knob of this resistor is seen at (44) in fig. 10 of the main chapter.

10. To produce reasonably distortionless output from the amplifier A1104 the milliammeter reading should not vary more than 10 to 15 mA during modulation. The attenuator switch S_3 should be set at a position where the volume control R_3 allows this condition to be obtained. Component references in this paragraph are to fig. 4, main chapter.

11. It should be noted that if high impedance R/T modulation is used, as described in para. 5, the control unit type 88 can still be used for remote H.T. switching over the normal A and B lines. In no circumstances should the control unit type 88 be used connected to the 50,000 OHMS DIRECT GRID terminals.

12. The switch S_1 need be turned to PRE-AMPLIFIER only if keying is found unsatisfactory when working over long lines.

13. The terminals on the strip at the bottom of the remote controls (except the A and B and INPUT TRANSMITTER terminals) are connected to terminals correspondingly marked on the transmitter T1190 or T1190A. Terminals marked 14 V A.C. on the transmitter are left blank and the terminal marked FIL SW on the transmitter must be connected to the transmitter terminal marked H.T. SW.

14. The power supply for the remote controls is connected to the two terminals marked A.C. MAINS on the strip at the top of the remote control panel (see fig. 2). These are linked to terminals similarly marked (see fig. 1) on a strip at the bottom of the local control panel, whence a flexible connector type 7 is taken to a two-pin plug on the rectifier panel of the amplifier.

15. In a certain number of local control panels (panel, type 7, Stores Ref. 10D/9590) the connection was omitted which maintains the H.T. supply to V_3 irrespective of the position of S_1 (see para. 4). The pre-amplifier is thus left without grid bias and the grid and cathode form a diode circuit across the input, causing severe distortion. Instructions for examination of the panel and insertion of the connection if omitted are given in Vol. II, leaflet A.P.1186/K1. The following items of equipment are required:—

Stores Ref.	*Nomenclature*	*Quantity*
5E/1780	Wire, copper, H.C., No. 20 s.w.g.	As reqd.
5F/2121	Tubing, insulating, H.T., Grade E, 1 mm.	As reqd.

16. The sequence of operations is as follows:—

(i) Remove panel, type 7, from the rack.

(ii) Identify the resistance panel to the rear, and slightly to the left, of the tray. The right-hand resistance is of value 50,000 ohms. If from the rear end of this resistance two leads are connected, one to the switch on the front panel and one to the six-pole plug on the rear panel, the wiring is correct and no action is called for. If, however, the latter connection is absent, proceed as follows.

(iii) Bare and tin ½ in. of wire on the existing plug-to-switch connection and solder an insulated lead from the rear end of the 50,000 ohm resistance to this point.

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December, 1938 *Issued May*, 1939, *with A.L. No.* 3

SECTION 6, CHAPTER 7

MICROPHONE EQUIPMENT IN AIRCRAFT

Contents

List of Illustrations

MICROPHONE EQUIPMENT IN AIRCRAFT

INTRODUCTION

Flying masks

1. In service types of oxygen breathing apparatus the oxygen is supplied to each member of the crew of an aeroplane by means of a mask which fits over the lower part of the face. Telephonic communication between members of the crew, and operation of an R/T transmitter by certain members, both entail the use of a microphone, and where oxygen supply is required, it becomes necessary to mount the microphone in the mask. It is also found convenient to mount the microphone in a mask even where oxygen supply is not required, because the hands of the wearer are then free for the performance of other duties while actually using the microphone.

2. Flying masks at present in use in the service may be classified as follows :—

(i) Oxygen masks, which are primarily intended for the supply of oxygen. Provision is generally made for fitting a suitable microphone if required. Certain types of oxygen mask are described in Air Publication 1275 (Instrument Manual).

(ii) Microphone masks, which are used purely as a convenient means of mounting a microphone.

Microphones which are specially designed for mounting in either form of mask are referred to as mask microphones. It should be particularly noted that for Stores accounting purposes, the nomenclature used is that of Air Publication 1086 (Priced Vocabulary of R.A.F. Equipment), i.e. the noun substantive precedes all qualifying adjectives and is written in the plural. Thus microphone masks are indexed as " masks, microphone, type . . . . " and mask microphones as " microphones, mask, type . . . .". Fig. 1 shows a typical mask microphone (microphone, mask, type E) mounted in an oxygen mask (mask, oxygen, type D) as described in later paragraphs.

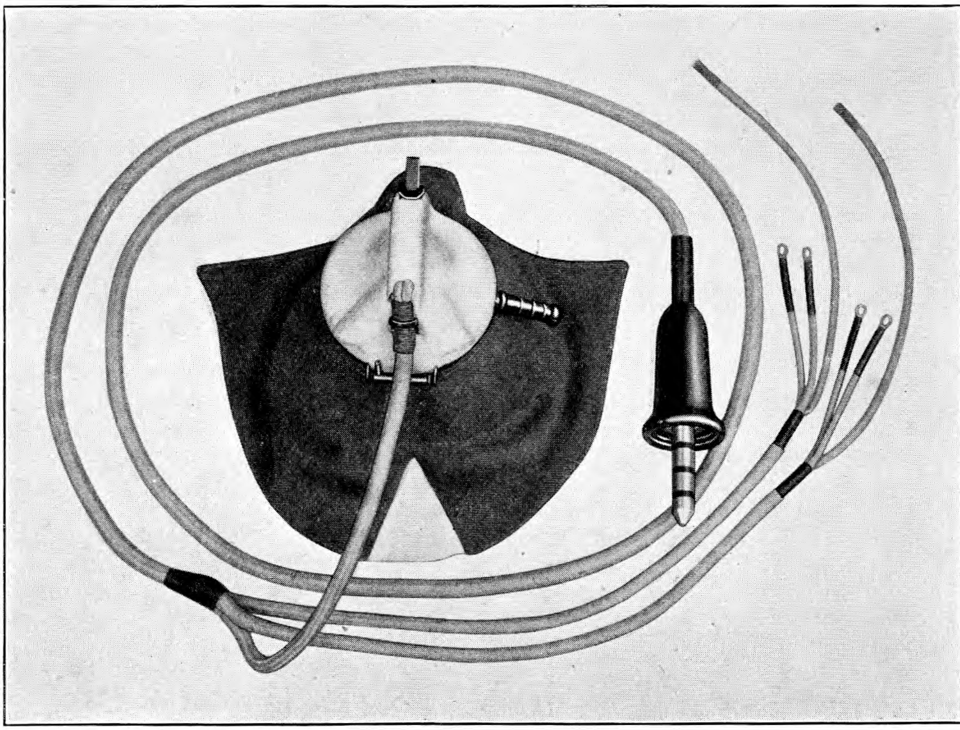


FIG. 1. Microphone mounted on oxygen mask.

3. Various alternatives to the employment of a mask microphone have been subjected to exhaustive trials, but have been found to be unsatisfactory for use in aeroplanes, both from a technical and a physiological aspect. For example, although a specially designed microphone may be worn on the neck in such a manner that it is affected by the vibration of the vocal cords, the speech quality so obtained is far inferior to that obtained with the mask microphone. Physiologically, it is found that since a throat microphone must be strapped very tightly to the neck, the unequal pressures on the two sides of the neck may lead to actual deformation of the larynx, ending possibly in a partial or total loss of voice. It is also found that the wearer of a throat microphone experiences considerable discomfort if it becomes necessary to put the aeroplane into a steep dive.

Mask microphones

4. The requirements of a mask microphone are (i) that it shall be easily fitted to and detached from the mask, (ii) that it will function satisfactorily in any position which the wearer may be required to assume during the performance of his duties, e.g. the bomb aimer may be called upon to use his microphone while lying in a prone position.

5. The first of the two requirements referred to above is met by suitably designing the mask. The mask is made of fabric, either stiffened so as to be self-supporting or fitted with wing-shaped wire supports. In either case the mask may be moulded to fit the wearer's face. A circular orifice is cut in the mask in line with the mouth, and a metal mounting ring about $2\frac{1}{2}$ inches in diameter is fitted in the orifice. The mask microphone is mounted on a ring which fits that of the mask, and is therefore readily detachable. Various types of mask differ in the means adopted for securing the mask microphone to the ring of the mask. In the case of oxygen masks, if any particular wearer is not required to use a microphone, the orifice is closed by a cap which fits over the mounting ring.

6. The second requirement is met by suitably designing the microphone. Mask microphones at present in use in the service may be divided into two principal classes, namely :—

(i) carbon microphones,

(ii) electro-magnetic microphones.

The manner in which the second requirement is met, in the respective classes, is explained later.

7. In addition to the two requirements which are peculiar to mask microphones, there is a further one to be fulfilled, which is applicable to practically all types of telephonic installation. If only a single microphone is connected to the input winding of a microphone transformer (in series with a suitable battery) there is rarely any necessity to insert a switch in the primary circuit, since the current taken from the battery is usually very small, and is rather beneficial than otherwise to the microphone, tending to warm it sufficiently to prevent moisture from condensing. When two or more microphones are to be used in conjunction with the same transformer, however, a switch must be fitted in series with each. Such microphones must be switched off when not in use. If this practice is not followed, the additional microphones are capable of picking up noise, which will be transmitted, and therefore the noise level at the receiver will be considerably higher than if only one microphone is connected. A further disadvantage is that the microphone in use is working into an incorrect load, e.g. where two microphones are fitted, into the resistance of one microphone in parallel with the transformer load, instead of into the latter alone. The speech output will therefore be less than normal. Since the speech level is reduced and the noise level increased, the signal-noise ratio is very greatly reduced by the inadvertent switching-on of unnecessary microphones.

CARBON MICROPHONES

8. The general principles of the carbon microphone are dealt with in Chapter I, and more fully in Chapter XII, of Air Publication 1093, Signal Manual, Part II. In the carbon types of mask microphone the second of the stated requirements is met by the adoption of a double diaphragm, and by so designing the microphone that the diaphragms are mounted edge on to the mouth of the wearer.

Microphone, mask, type E (Stores Ref. 10A/9003)

9. This instrument is of the carbon type and consists of three principal components, namely, an unmounted microphone, type C (Stores Ref. 10A/9004), a combined microphone-telephone plug, type 58 (Stores Ref. 10A/7836) and an instrument cord, type F (Stores Ref. 10A/7835). The unmounted microphone, type C, is shown in fig. 2 and its constructional details may be seen in fig. 3. In the following description the numerical references are to fig. 2.

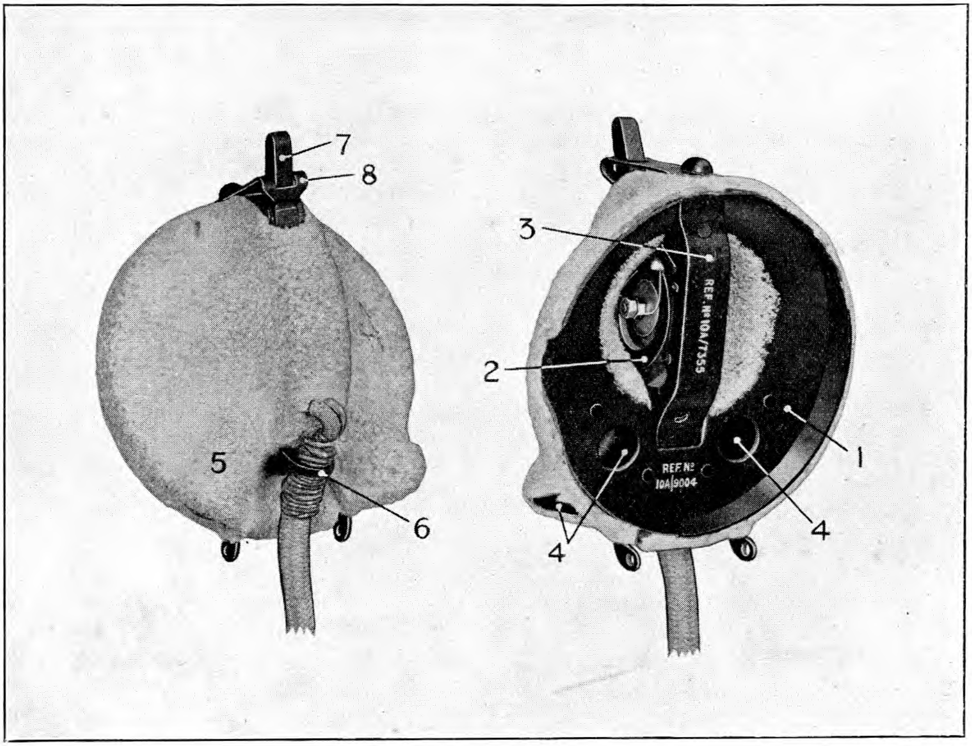


FIG. 2. Microphone, mask, type E.

Construction

10. The microphone consists of an aluminium capsule carrier (1), which is approximately bell-shaped. The capsule container (2) is a plate of insulating material, suitably machined to allow the assembly of the diaphragms and granules. The container is supported by a framework (3) in such a position that in normal use, the diaphragms are approximately vertical and are " edge on " to the mouth of the speaker. The assembly of the microphone capsule is clearly shown in fig. 3C. Each carbon electrode is mounted on a mica diaphragm. A perfectly flat brass washer is placed immediately against the diaphragm and a dished washer of nickel silver over it, the

assembly being then held in position on the diaphragm by a brass nut. A second nut is provided to act as a terminal for the electrical connection. The space between the electrodes contains a definite quantity of carbon granules.

11. The framework also carries the spring contacts of the microphone switch, which is of the cam-operated type. Its operation is easily appreciated from figs. 3A and 3B. A flat spring is arranged to bear upon machined flats on the switch lever (7), in such a manner that the lever is firmly held in either the " on " or " off " positions, as required. When only a single microphone is connected, the switch may be retained in the " on " position by means of a locking plate (8), as shown in fig. 2 and fig. 3A.

12. Two breathing tubes (4) are fitted in the capsule carrier. A portion (5) of the inner surface and the whole of the outer surface are covered with powdered cork, which acts as a heat insulator, prevents excessive condensation of moisture, and also assists in excluding extraneous noise. The outside of the carrier is covered with a chamois leather jacket (5). The bent plate (6) serves to anchor the instrument cord and prevents any strain being taken by the microphone leads. It is important that the whippings on either side of this plate should be maintained in position for this purpose.

13. The framework (3) carrying the complete capsule container may be removed from the carrier in the following manner. Place the microphone switch in the " off " position. At the anchor plate, remove the outer whipping from the instrument cord, and remove the round-headed screw which holds the anchor plate in position. This screw also secures the framework at one point. Slip the anchor plate down the cord and remove the other whipping. Finally, remove the round-headed screw holding the locking plate in position ; this screw also secures the framework at one point, and on its removal, the framework may be withdrawn from the carrier. Care must be taken in this operation. On no account must the capsule be held, the fingers must grip the framework only. The instrument cord must be eased gently through the orifice in the carrier as the capsule container is withdrawn.

14. The microphone is reassembled in the reverse order, care being taken that the switch is in the " off " position. Before attaching the anchor plate, the inner whipping must be replaced on the instrument cord, care being taken that it will prevent any strain on the cord. After attaching the anchor plate, the outer whipping must be replaced.

15. Although the method of construction results in an instrument which, in relation to its sensitive character, must be considered to be fairly robust, it must be appreciated that its good electrical performance is entirely dependent upon highly accurate workmanship. On no account must any attempt be made to dismantle any portion of the capsule container, or to remove the latter from the framework.

Mounting

16. The microphone is mounted in a suitable mask, e.g. the oxygen mask, type D (Stores Ref. 6D/105). The method of mounting is shown in fig. 4. The mask is fitted with a metal orifice ring (1) which is so gauged as to fit snugly inside the outer ring (2) of the capsule carrier of the microphone. The orifice ring is fitted with two hinge pins (3) (4), one of which (3) is capable of a small axial movement, against the action of a spring contained in the barrel (5). This hinge pin can be withdrawn into the barrel by a small metal handle (6). The microphone is fitted with two metal hinges (7) (8). The microphone is fitted to the mask by slipping the hinge (8) over the hinge pin (4). The hinge pin (3) is then drawn into the barrel by means of the handle, allowing the other hinge (7) of the microphone to be placed in position. On releasing the handle (6) the loading spring returns the hinge pin (3) to its normal position and the microphone is held on the lower edge of the orifice ring as shown in fig. 5.

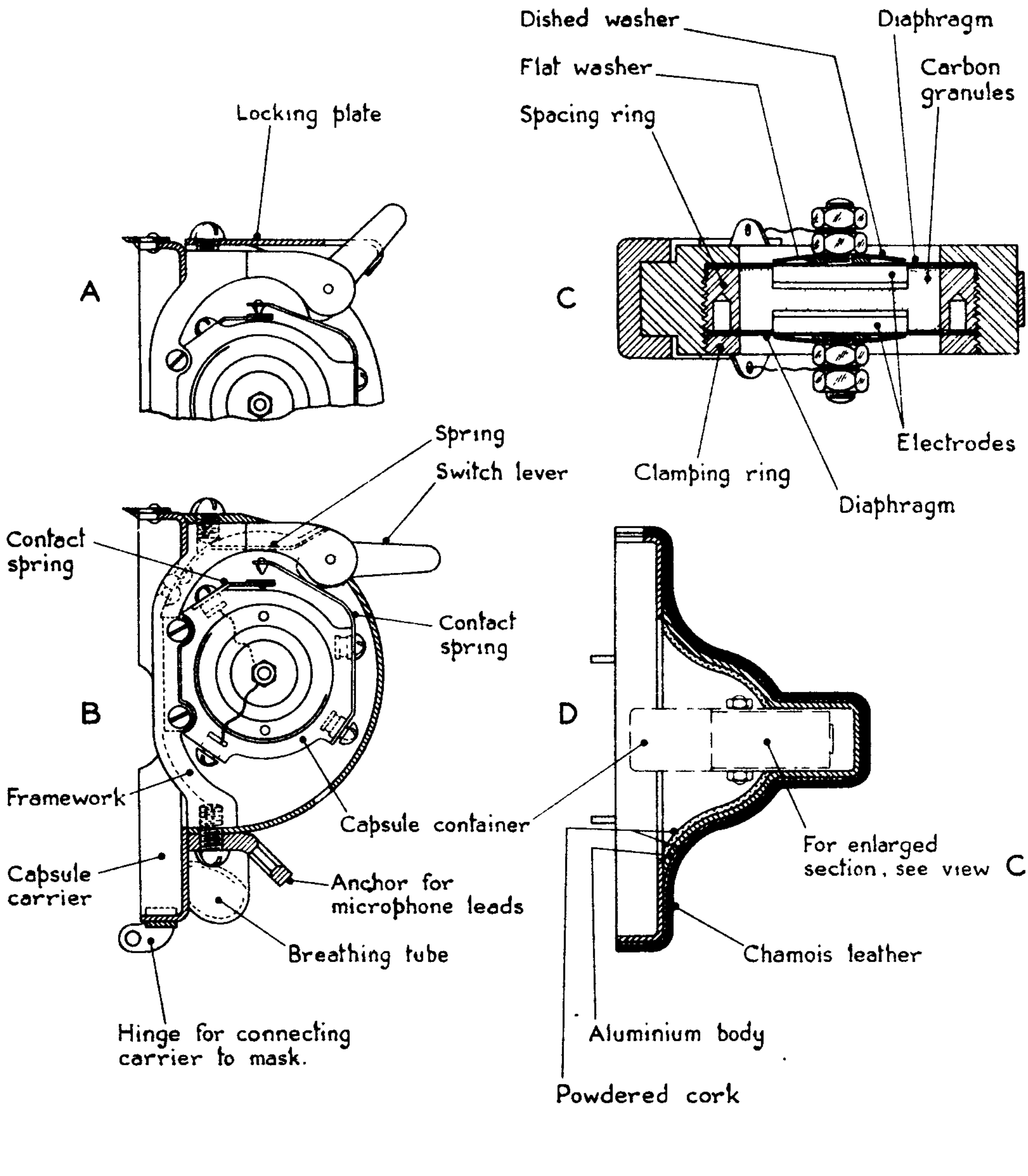


FIG. 3. UNMOUNTED MICROPHONE TYPE C

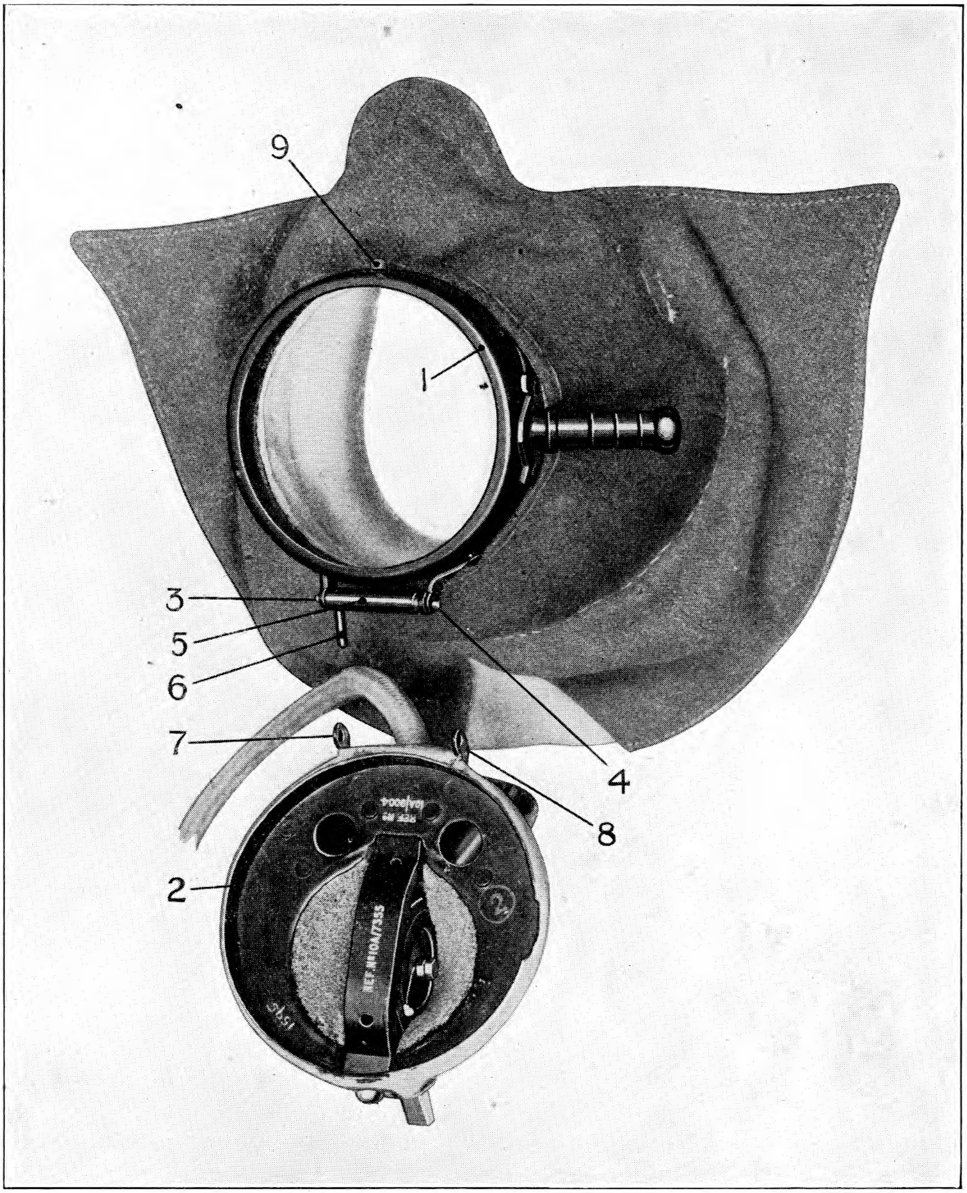


FIG. 4. Mask and microphone, showing hinge.

17. During the above operation the microphone should be held as nearly as possible in its final position, but the ring of the capsule carrier should not be engaged with the orifice ring of the mask. When the lower edges are held by the hinge, the two rings may be engaged and will then be held together at the upper edge by the spring catch (9). The microphone is removed from the mask by performing the above operations in reverse order. This method of mounting

the microphone allows it to be lowered in such a manner as to expose the mouth to the outer air, by a pull of about $2\frac{1}{2}$ lb. exerted upon the upper rim. This permits conversation on the ground and is a convenience in the case of air sickness.

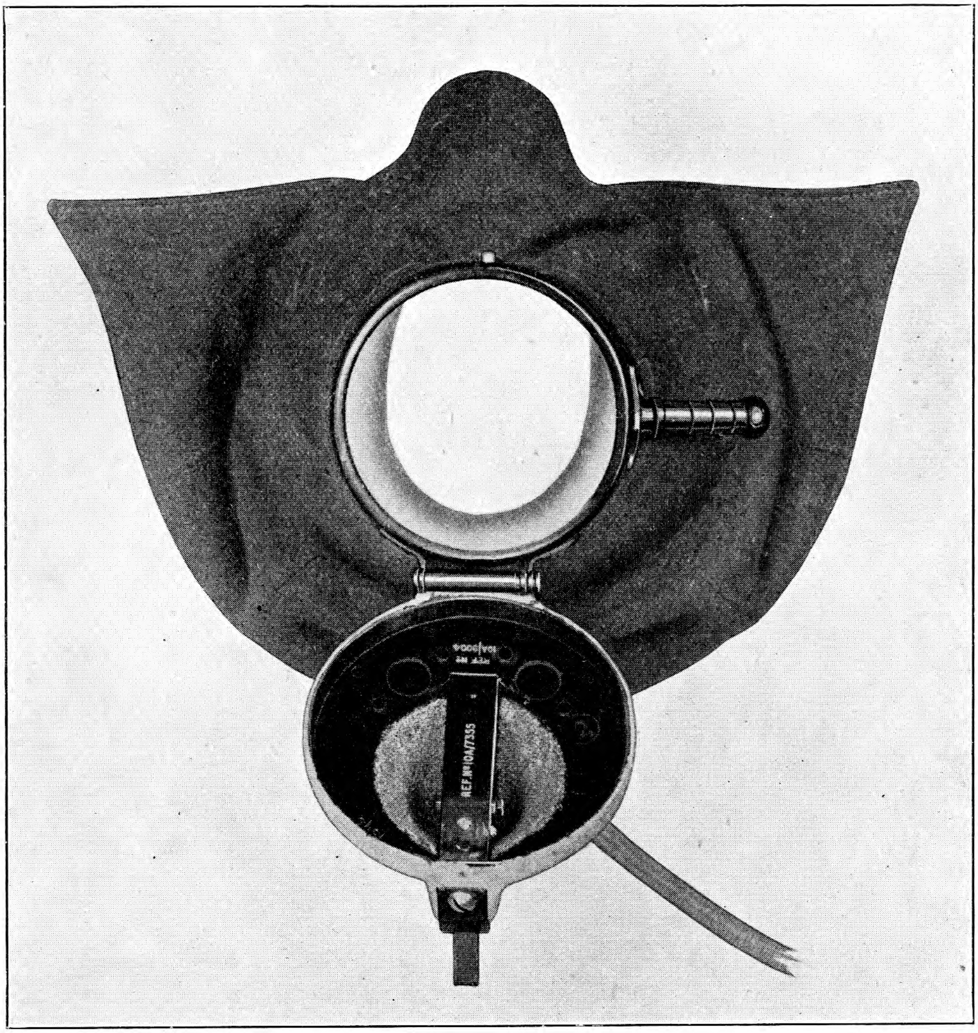


FIG. 5. Mask and microphone mated.

ELECTRO-MAGNETIC MICROPHONES

18. The electro-magnetic microphone was introduced in order to provide an instrument suitable for use in aircraft, but less subject to distortion due to intermodulation (*see* Air Publication 1093, Chapter XII) than is the carbon microphone. This necessitates that the microphone should have a linear relationship between the applied sound pressure and the electrical output. In addition, it is highly desirable that the microphone should possess a level response-frequency characteristic over a certain frequency range.

19. Several forms of microphone, e.g. the moving-coil and condenser types, possess a near approach to the desired linear output-pressure characteristic, but are unsuitable for use in an aeroplane. The moving coil microphone, for example, is extremely bulky, heavy, insensitive, and possesses a powerful external magnetic field which absolutely prohibits its employment in the vicinity of a magnetic compass. Its response-frequency characteristic can be made substantially level over a very wide range, i.e. some 50–8,000 cycles per second. For the transmission of speech of good intelligibility, as distinct from high fidelity, a much more restricted range is sufficient. Experiment shows that for service R/T communication it is sufficient to transmit only the range 800–2,000 cycles per second. The quality of reproduction under these conditions is very different from that of the original sound, but the intelligibility is practically unimpaired.

20. The service electro-magnetic microphone gives a practically level response-frequency curve over the range 500–2,000 cycles, with a sensitivity approximately equal to that of a moving-coil microphone. It has a comparatively weak magnetic field and, as will be obvious from the following paragraphs, the limitations to be placed upon its employment near a magnetic compass are of the same order as those for the service types of telephone receiver. The poor response to frequencies below 500 cycles per second prevents the transmission of noises such as are caused by the airscrews and slip-stream.

Principle of electro-magnetic microphone

21. The electro-magnetic microphone is actually an inversion of the principle of the telephone receiver. It is well known that if an audio-frequency current is applied to the windings of this instrument the changes in magnetic flux cause the diaphragm to be set into vibration at the same frequency. Conversely, if the diaphragm is set into vibration by a sound wave, the resulting changes of magnetic flux cause the induction of an E.M.F. in the windings.

22. The response-frequency characteristic of an ordinary telephone receiver is substantially of the same shape in whichever way it is used. It usually possesses a pronounced resonance at some frequency in the neighbourhood of 1,000 cycles per second, and one or more subsidiary peaks. A characteristic of this shape is unsuitable for an electro-magnetic microphone. It can, however, be considerably improved by a reduction in the internal volume of air subjected to the action of the diaphragm, by adjustment of the dimensions and position of the orifice or orifices by which the sound wave reaches the diaphragm, and by mounting in a mask enclosing a certain volume of air. In fig. 6 the response-frequency characteristic of a typical telephone receiver is

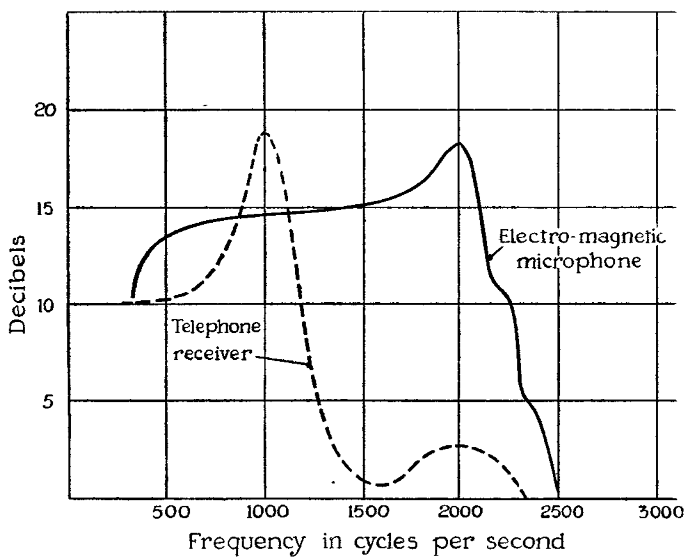


FIG. 6. Response-frequency curves of telephone receiver and E.M. microphone.

shown in dotted line, and the corresponding characteristic of the same instrument, adapted for use as an electro-magnetic microphone in accordance with the above principles, is shown in heavy line.

23. The sensitivity of the electro-magnetic microphone is very much lower than that of a carbon microphone, and it is necessary to amplify the audio-frequency output voltage before sufficiently deep modulation of a transmitter can be effected. Since the microphone is in the grid circuit of the first stage of this amplifier, while the telephone receivers are usually in the output circuit in order to provide side-tone (and also for inter-communication purposes), there is a tendency to set up a continuous audio-frequency oscillation. This possibility is removed by completely screening and earthing the metal case of the microphone, and enclosing the whole of the microphone wiring in a screening cover of flexible metal braiding. The electro-magnetic microphone functions equally well in any position, i.e. the fulfilment of the second requirement is inherent in the design.

Interchangeability with carbon microphone

24. Electro-magnetic and carbon microphones are not inherently interchangeable. It is essential that no such interchange shall be attempted unless suitable provision has been embodied in the design of the transmitter or transmitter-receiver, and then only after ensuring that any necessary circuit alterations have been made. An outline of the nature of the alterations generally required is given in the following paragraphs for information only.

25. A transmitting circuit designed for use with an electro-magnetic microphone invariably includes some form of sub-modulator stage, the normal gain of which is too high to permit of the simple substitution of a carbon microphone. If such a substitution is permissible, means will be provided by which either the sub-modulator stage is entirely removed from the circuit, or its gain drastically reduced.

26. The action of an electro-magnetic microphone does not depend upon the passage of a direct current through its windings. In a transmitter or transmitter-receiver designed primarily for use with an electro-magnetic microphone, the primary circuit of the microphone transformer may not include any battery. It follows, therefore, that a carbon microphone cannot be directly substituted for the electro-magnetic type. If such substitution is permissible suitable arrangements will be made to supply the carbon microphone with a direct current.

27. The circuit alterations for any particular type of transmitter or transmitter-receiver will be found in the appropriate chapter of this Air Publication. If such information is not given, the transmitter or transmitter-receiver is suitable for use with only one type of microphone, and this type must be used exclusively.

Microphone, electro-magnetic, type 19 (Stores Ref. 10A/10989)

28. This instrument consists of an electro-magnetic microphone, type 18 (Stores Ref. 10A/10990), complete with instrument cord, type Q (Stores Ref. 10A/10353), and plug, type 119 (Stores Ref. 10A/10991). The main features of the microphone, type 18, may be seen in figs. 7 and 8, the former being a sectional sketch and the latter a view of the exterior. The general resemblance to a standard type of telephone receiver is obvious.

Construction

29. The constructional details of the microphone, type 18, are most easily appreciated if considered merely as modifications to a standard low-resistance telephone receiver. The chief alterations are in (i) the case, and (ii) the cap. The mounting is also a distinctive feature.

30. *Case.*—The case is of aluminium alloy, completely enclosed in a thin, closely-fitting jacket of soft iron, which forms a magnetic screen. This jacket is coated externally with aluminium by a spraying process. The object of this screen is to prevent disturbance of the magnetic compass when the microphone is worn in proximity. The modification to the case consists chiefly of the insertion of a wax filling, which is introduced in order to raise the resonant frequency of the instrument to about 2,000 cycles per second. The wax insert is in the form of a disc, and is melted into the case by a special process in order to provide the best possible seal between its circumference and the inner wall of the case. This also ensures that a clearance of 0·01 in. between the upper surface of the wax and the under surface of the diaphragm can be uniformly maintained in production.

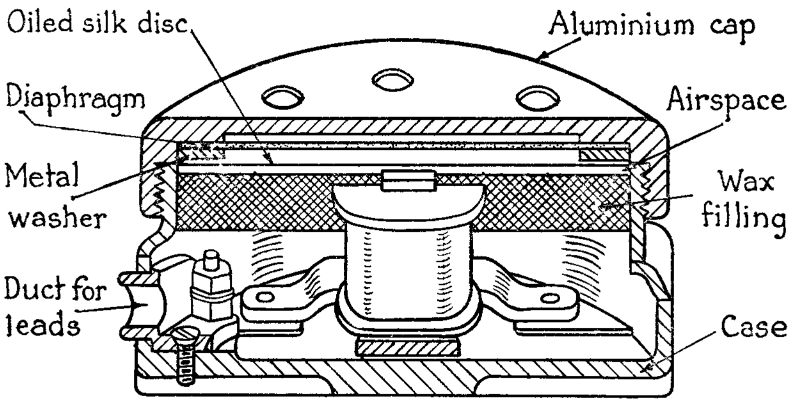


FIG. 7. Construction of electro-magnetic microphone.

31. The insert is composed of a special wax having a melting point above 120° C. The melting point is, however, below the temperature at which the retentivity of the magnetic system is affected. It is of the greatest importance that the microphone should not be treated in any manner which would cause any deformation of the wax surface, since a comparatively small deformation will have a marked effect upon the response-frequency characteristic. The external surfaces of the microphone are covered with powdered cork and the back and edges of the case are enclosed in a chamois leather jacket.

32. *Cap.*—The moulded insulating cap of the telephone receiver is replaced by an aluminium cap screwed to the case. Its face is drilled with eight holes as shown in fig. 8. A loose disc of oiled silk is retained in position inside the cap by a metal washer in order to exclude moisture and dust from the interior. In assembly, the cap is screwed tightly to the case by means of a special tool, and its removal should on no account be attempted by service personnel.

33. *Instrument cord and plug.*—To complete the assembly of the microphone, type 19, the microphone itself must be fitted with an instrument cord, type Q and plug, type 119. This instrument cord consists of a pair of microphone leads and a pair of telephone leads, a short bridle lead being incorporated in order that two telephone receivers may be connected in series, according to the normal practice. The microphone leads are enclosed in a flexible braided metal screening sleeve in a continuous run between the microphone itself and the plug, type 119. The case of the microphone is connected to a small, very flexible, extension of the screening sleeve by means of a small metal screw. The telephone leads, for the greater portion of their length, run parallel to the screened microphone leads. Over this portion, both telephone leads and screening sleeve are enclosed in a woven cover. The cord is water-proofed throughout its length, in order that its insulation resistance shall maintain a high value in a damp atmosphere (*see* paras. 43 to 45). At the plug, the metal screening sleeve is connected to the NEGATIVE TEL. contact ring. The complete assembly is shown in fig. 9.

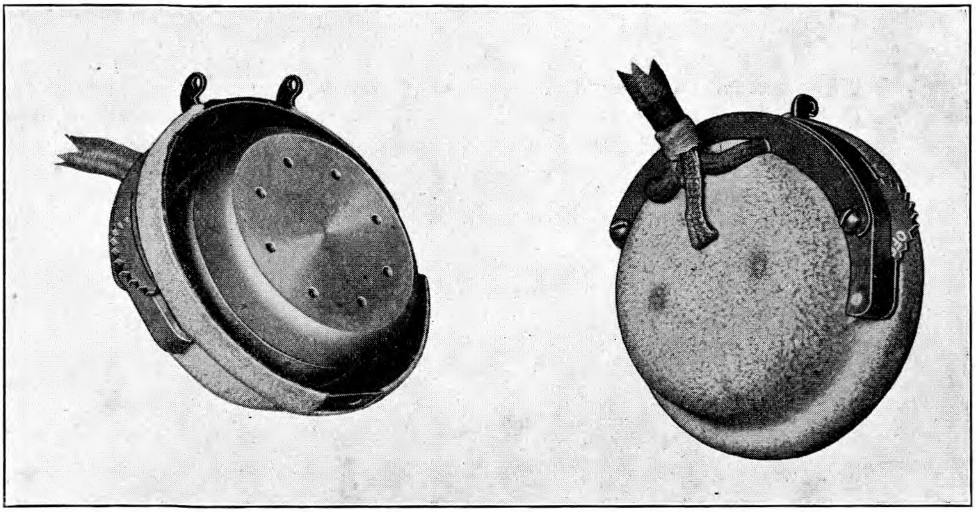


FIG. 8. Microphone, type 18.

34. An " on-off " switch is embodied in the microphone mounting. It consists of a pair of springs fitted with gold-silver contacts, and is of the cam-operated type, but a serrated disc is fitted instead of a control lever. When the microphone is used with certain installations in which the instrument is required to remain permanently in circuit, instructions may be given for this disc to be removed, thus converting the microphone to an unswitched instrument.

35. The microphone is fitted with a pair of metal hinges similar to those of the microphone, mask, type E, and is mounted in an oxygen mask, type D, in the same manner.

INSTRUMENT CORDS

36. The instrument cord, type Q, was introduced especially for use with electro-magnetic microphones, and on no account should an earlier type of cord be fitted to such an instrument. The instrument cord, type Q, may however be used with a carbon microphone in place of the instrument cord, type F, and the latter will eventually become obsolete. When the instrument cord, type Q, is fitted to a carbon microphone, the flexible extension of the screening, which in the electro-magnetic type is connected to the metal case of the instrument, must be bent back and secured to the cord by a whipping. At the plug end, the screening must be connected to the NEGATIVE TEL. terminal of the plug, type 58, or plug, type 119.

37. The plug, type 58, in its original form, is unsuitable for use with the instrument cord, type Q, owing to the greater diameter of the latter compared with the instrument cord, type F. Details of the method of modifying the plug, type 58, in order to accommodate instrument cord, type Q, will be found in Volume II of this Air Publication.

38. The colour code used to indicate the various leads in instrument cords, type F, and type Q, is as follows :—

Telephone +, RED.	Telephone —, BLUE.
Microphone +, YELLOW.	Microphone —, GREEN.

It should be noted that at the telephone receiver, the leads are also marked for polarity, the positive lead carrying a red whipping. In most service apparatus the telephone receivers carry no direct current and will not suffer deterioration if connected up with incorrect polarity.

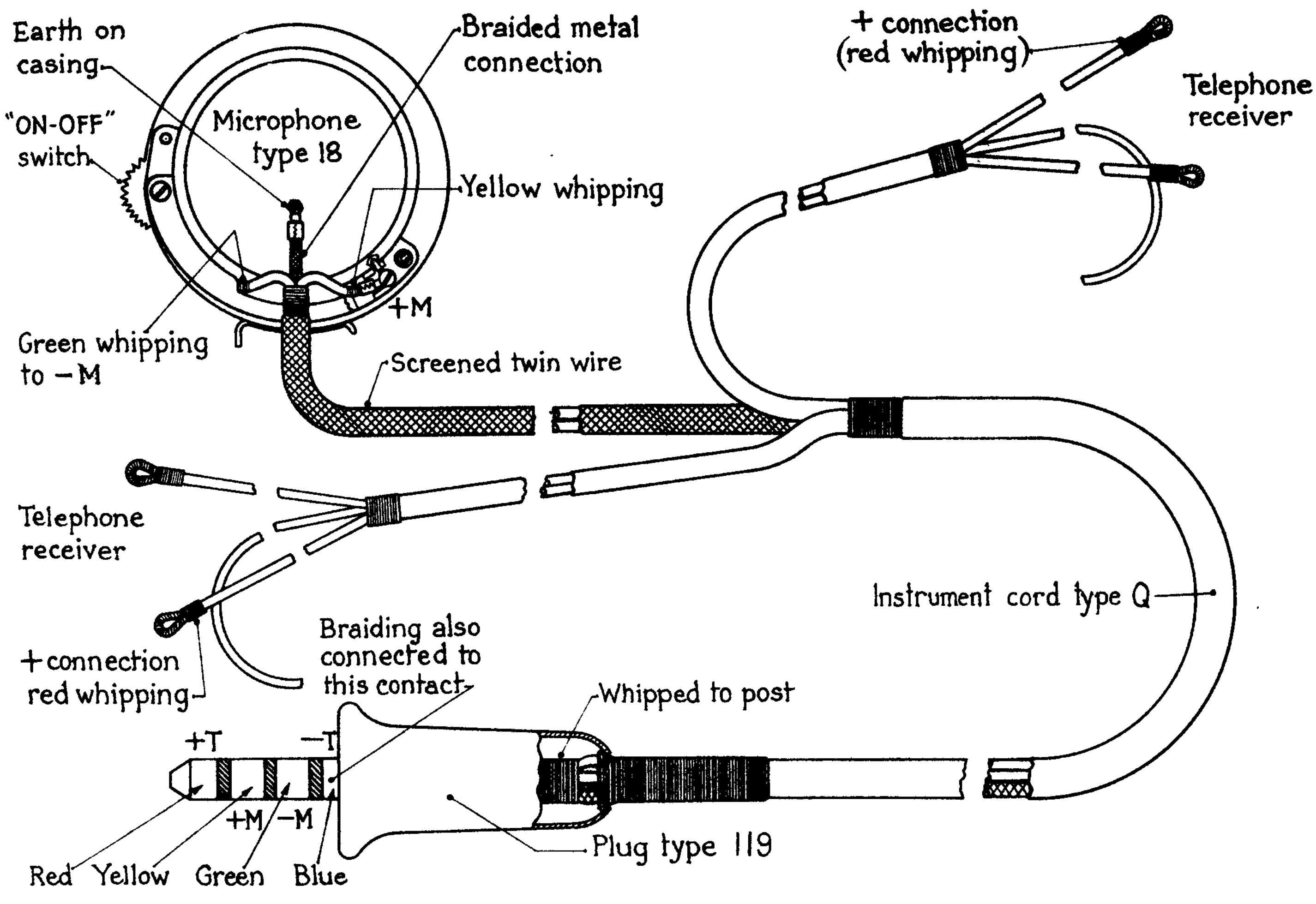


FIG. 9, ASSEMBLY OF MICROPHONE TYPE 19

Facing paras. 34-36

Since however there is always a possibility that the telephones may be used in a circuit where they will be called upon to carry D.C., the telephones should always be connected to the instrument cords as marked, i.e. at each earpiece, the lead with red whipping should be connected to the terminal marked " + ".

PRECAUTIONS AND MAINTENANCE

Microphones

39. The microphone, type 19, requires no maintenance beyond periodical inspection of the connections of the instrument cord to the microphone and microphone-telephone plug, and replacement of the cord when necessary. Since any deformation of the surface of the wax insert may seriously reduce the efficiency of the instrument, care must be taken to avoid any treatment which would have this effect, such as severe blows or exposure to a temperature greater than 110° C. On no account should any attempt be made to remove the cap or otherwise to obtain access to the interior.

40. If self-oscillation is set up in the audio-frequency circuits to which an electro-magnetic microphone is connected, the screening and earthing of the microphone leads should be suspected. The most likely fault is a disconnection of the flexible earthing lead at the case or of the screening from the NEGATIVE TEL. terminal of the microphone-telephone plug. Alternatively, it may be due to low insulation resistance in the microphone-telephone circuits or instrument cords.

41. Carbon microphones should occasionally be tested for sensitivity and articulation, the microphone tester, type 1 (Stores Ref. 10A/8243), and noise generator (Stores Ref. 10A/10154), being suitable for this purpose.

42. After use, every mask microphone should be wiped dry with a clean soft cloth before being stowed away.

Microphone and telephone wiring

43. It is most important that the insulation resistance of all microphone and telephone circuits is maintained at a high value. One pole of the transmitter filament battery must be at earth potential, the service practice being to earth the negative pole. Since, in installations designed for use with a carbon microphone, this battery also supplies the microphone feed current, an " earth " on the positive side of the microphone circuit will short-circuit the battery. Again, in certain transmitters, e.g. T.1083, R/F chokes are connected in series with the microphone, electrically adjacent to the battery, and on earthing the positive microphone lead the whole of the battery E.M.F. will be applied to the chokes, almost certainly burning them out.

44. The above dangers may or may not be present in a transmitter designed for use with an electro-magnetic microphone, depending in part upon the arrangements made for the alternative employment of a carbon microphone. Nevertheless, it is necessary to maintain the insulation resistance of the microphone and telephone circuits at an even higher standard than is required for carbon microphones. Unless this standard is maintained, the stability of the sub-modulator stage will be seriously affected ; in extreme cases a continuous A/F oscillation may be set up, giving rise to a continuous howl in the telephone receivers. The sub-modulator will be unstable, and will give rise to severe distortion, long before the insulation has deteriorated to this extent.

Instrument cords

45. The insulation resistance of all instrument cords should also be checked periodically and the cords replaced before they show signs of excessive wear. The resistance should be measured between either of the two microphone leads and either of the two telephone leads (or the earth screen where fitted), a 500-volt megger set being employed. The cord should be freely flexed throughout its length while the test is being made. It is important that this test is applied to the instruments of all the crew of an aeroplane and not merely to those of the pilot and radio operator.

46. The following standards of insulation resistance should be maintained. Where carbon microphones are fitted, the resistance, measured as detailed in the preceding paragraph, should be not less than 2 megohms. Where electro-magnetic microphones are fitted the insulation resistance should be not less than 10 megohms. These standards apply both to the fixed microphone-telephone wiring and the instrument cords.

47. Care should be exercised when entering or leaving an aeroplane, to avoid subjecting the moulded cap of the micro-telephone plug to heavy blows, or dropping and treading on it.

48. Since the leads in an instrument cord must be very flexible, they cannot be expected to withstand heavy tensional or torsional stresses. The plug should be withdrawn from its socket only by means of the moulded cap, and not by pulling on the cord. The instrument cord must not be twisted, e.g. by idly swinging the plug in the air.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/9003	Microphone, mask, type E	1	
	Components :—		
10A/9004	Microphone, unmounted, type C ..	1	
10A/7836	Plug, type 58	1	Micro-telephone.
10A/7835	Cord, instrument, type F	1	
	Principal component of microphone, unmounted, type C :—		
10A/7355	Microphone, unmounted, capsule ..	1	
	Component required to adapt plug, type 58, to take cord, instrument, type Q :—		
10A/10992	Guard, spring	1	
10A/10989	Microphone, electro-magnetic, type 19 :—		
	Principal components :—		
10A/10990	Microphone, electro-magnetic, type 18..	1	
10A/10991	Plug, type 119	1	Micro-telephone.
10A/10353	Cord, instrument, type Q	1	

SECTION 6, CHAPTER 8

GENERAL PURPOSE WIRELESS VEHICLE

Contents

List of Illustrations

FIG. 1. General purpose wireless vehicle.

GENERAL PURPOSE WIRELESS VEHICLE

INTRODUCTION

1. The general purpose wireless vehicle is designed to form a self-contained radio station maintaining a single channel of C.W., I.C.W., or R/T communication within the frequency bands of the transmitter and receiver installed in it. The present chapter deals with the general features of the installation as a whole. The following items of the equipment are dealt with elsewhere in this Air Publication, viz., transmitter T.1090 (including grid-bias and side tone units), Section 1, Chapter 6; receiver R.1084, Section 3, Chapter 3; receiver R.1093, Section 2, Chapter 3.

2. Fig. 1 is a general view of the vehicle. The body frame is of teak, and all panels are specially impregnated in order that the body will withstand severe climatic conditions, particularly exposure to a tropical climate. Teak is used for all woodwork incorporated in the various items of radio equipment, for the same reason. The body is mounted upon a standard Albion four-wheeled chassis, the weight, complete with all equipment and crew, being approximately 106 cwt. Stowage is provided for food, water, and the personal equipment of the crew; sleeping accommodation is also arranged, in order that the station may be maintained in isolated service for several days. A first aid box is also included in the equipment, particular provision being made for the immediate treatment of injuries caused by accumulator electrolyte.

3. The aerials are carried by a collapsible mast mounted on the roof. The entire metal-work of the chassis is bonded together and normally forms a counterpoise insulated from the ground, although of course the insulation resistance becomes low when the tyres are wet. Reception may be performed while the vehicle is in motion, and the mast lowered, but neither transmission nor charging should take place unless the vehicle is stationary.

4. A transmitter, type T.1090, is installed in the vehicle, and reception is normally performed by means of a receiver, type R.1084. A portable receiving station is also carried; this station is equipped with a receiver, type R.1094, which is identical with the receiver, type R.1093, except that it is fitted in a special metal case.

5. The receiver R.1094 may be removed from the portable station and installed in the vehicle as a stand-by receiver. The primary function of the portable station, however, is to act as a remote control station when necessary. A 10-core cable about 400 yards in length is provided for the control wiring, communication between the vehicle and the remote control station being maintained by means of field telephones connected to one pair of leads in the 10-core cable. The receiving aerial at the remote control station is supported by a 30-foot telescopic mast.

6. The vehicle may be connected up to any G.P.O. telephone exchange, in order to provide two-way communication *via* the vehicle station, between a distant radio station and any point on the G.P.O. telephone system. A special switchboard called the R/T line link unit is provided for this purpose.

7. The L.T. supply for the operation of the transmitter and receivers in the vehicle is derived from accumulator batteries, and the H.T. supply from motor generators, also driven from accumulator batteries. All accumulators used in the installation are of the alkaline type. It is convenient to refer to "numbered" and "miscellaneous" batteries, the latter being those provided for the operation of ancillary apparatus such as the wavemeters and the modulation indicator. The numbered batteries perform the following functions:—

(i) No. 1 battery (24 volts, 125 ampere-hours) provides the power supply to drive the 255-watt motor-generator.

(ii) No. 2 battery (14·4 volts, 70 ampere-hours) provides (*a*) the power supply to drive the 80-watt motor-generator and (*b*) the power for the operating-control system.

(iii) No. 3 battery (8·4 volts, 70 ampere-hours) provides the transmitter L.T. supply.

(iv) No. 4 battery (8·4 volts, 70 ampere-hours) provides the receiver L.T. supply.

A petrol electric charging set, type D (Stores ref. 42L/1), is installed for battery charging.

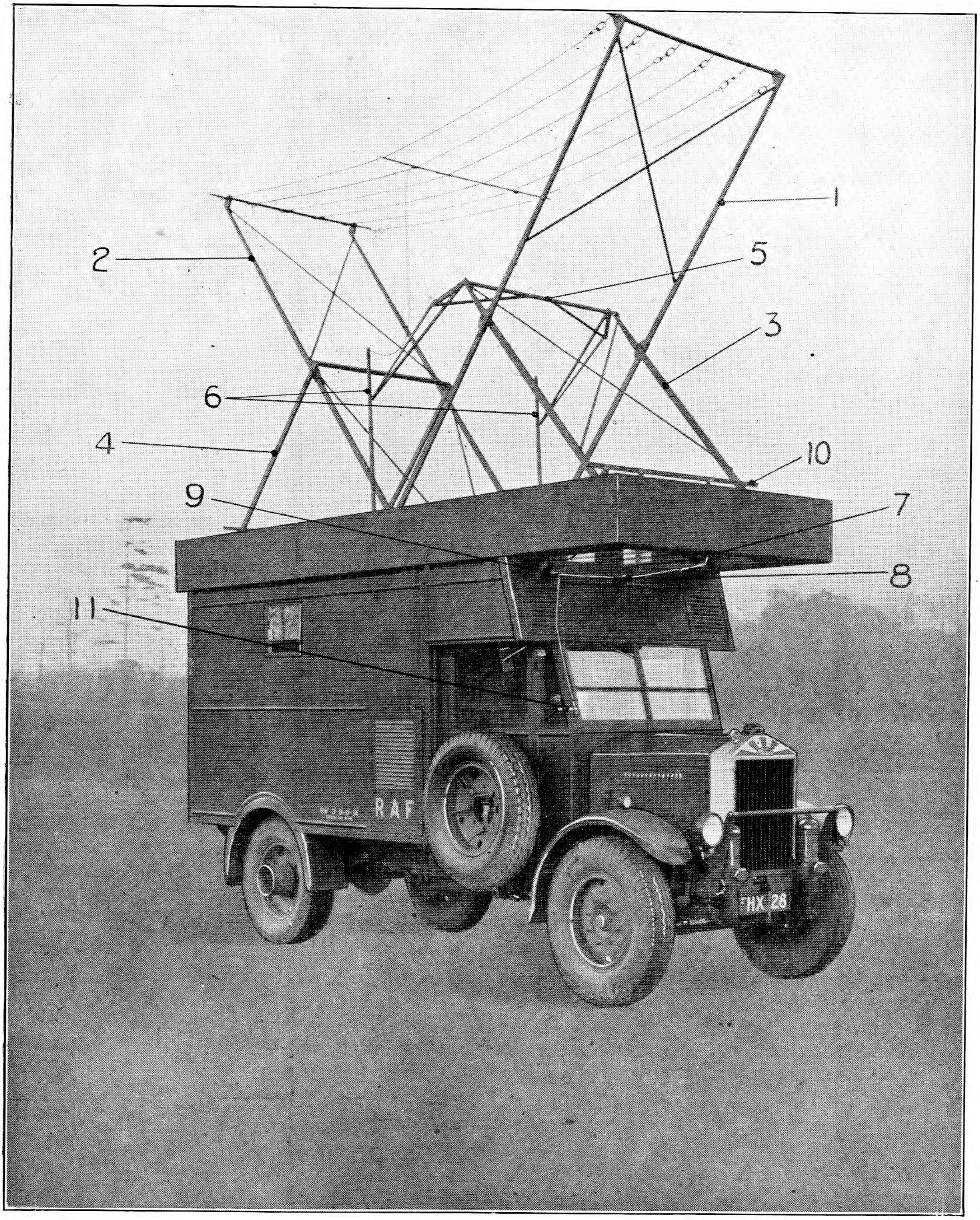
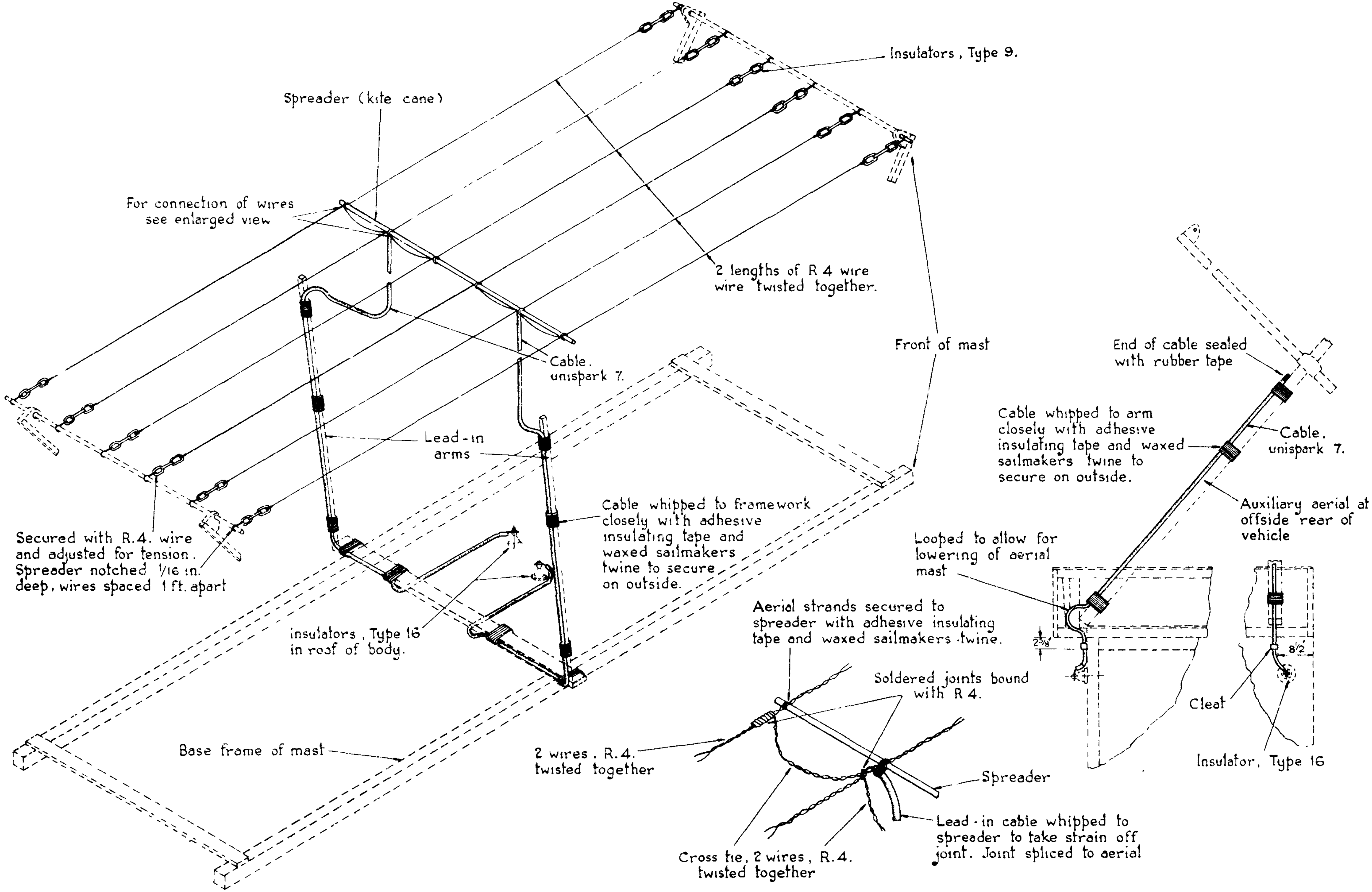


FIG 2. Vehicle with mast erected.



(F.1801). Wt.9053. 4250. 5/43. Gp.959. FOSH & CROSS LTD.

FIG. 3, AERIAL SYSTEM

ensure that the cord winds on to the winch in the form of a flat spiral. Thus the mechanical advantage of the winch and the velocity ratio of winding vary according to the number of turns on the winch. The outer turns of the cord are obviously of greater diameter than the inner turns so that the last few feet of cord come in with much greater rapidity than the first few. As a result, only about six turns of the winch are required to raise the mast from the fully lowered to the fully erected position.

Main aerial

13. The general arrangement of the main aerial is shown in fig. 3. The upper cross-bars of the front and rear long frames are of circular section, and each is notched at six points for the attachment of an insulator, type 9. Each member of the aerial consists of two lengths of aerial wire R4 (Stores Ref. 10A/4589) twisted together, and each group of three wires is connected to a separate lead-in consisting of a length of unispark 7 cable (Stores Ref. 5E/82). A light cane spreader ensures that the six wires maintain their correct spacing. Each lead-in is sufficiently long to ensure that it does not become foul during erection. When it becomes necessary to repair or replace the aerial, each defective portion should be measured, and replaced by new wire of exactly the same length. It is essential that any replacements should be soldered, bound and whipped exactly as shown in the diagram, otherwise the electrical efficiency may be impaired. It is particularly necessary to secure the aerial leads to the lead-in arms at exactly the same points.

Auxiliary aerial

14. The arrangement of the auxiliary aerial is also shown in fig. 3. It consists of a length of unispark 7 cable, whipped to the off side member of the rear short frame. In refitting, it is particularly necessary to ensure that a loop of cable is left at the lower end to allow for the movement of the frame, and that the upper end of the cable is sealed with rubber tape and solution to prevent the admission of water.

Interior

15. The arrangement of the apparatus in the fore end of the interior is shown in fig. 4. It will be seen that a bench extends across the fore end, immediately behind the partition of the driving compartment, and behind this is a shelf or rack for the stowage of certain instruments. The top of this bench forms the roof of a compartment containing the petrol-electric charging set; this compartment is accessible from the interior by the completely removable door (1). The bench is continued round the off side to the extreme rear. No bench is fitted on the near side, but the corresponding space is occupied by two bunks, the upper of which folds down when required, forming the back of a seat. The lower bunk forms the cover for two lockers, one of which contains a battery, while the other is used for stowage (*see* para. 27). Two cupboards are fitted at the rear end, near side, the upper one for W/T spares and loud speaker, the lower one for food. Beneath these cupboards is a compartment containing the remote control cable drum.

16. The transmitter (2) is fitted on an adjustable mounting, the normal or stowage position being such that the panel of the instrument is in the horizontal plane. The mounting may be secured in this position by means of knurled nuts. The transmitter should always be placed in its stowage position when the vehicle is in motion. When tuning or adjusting the transmitter, the adjustable mounting permits it to be tilted towards the operator so that the panel slopes at an angle of about 30°. Lock-nuts are provided to secure the transmitter in this position. The transmitter earthing terminal is situated behind the transmitter.

17. The two main lead-in insulators, type 16, carry the main aerial leads (3) through the roof, and are placed almost directly over the transmitter. These insulators are of glass, and are fitted with baffle discs in order to render them light-tight. An aerial condenser is mounted on the fore side of the support (4) the leads thereto being brought through a hole in the support. The latter also carries on its rear side a relay send-receive switch (5), which is operated electromagnetically by the action of the manually-operated send-receive switch. The latter will subsequently be referred to as the manual send-receive switch.

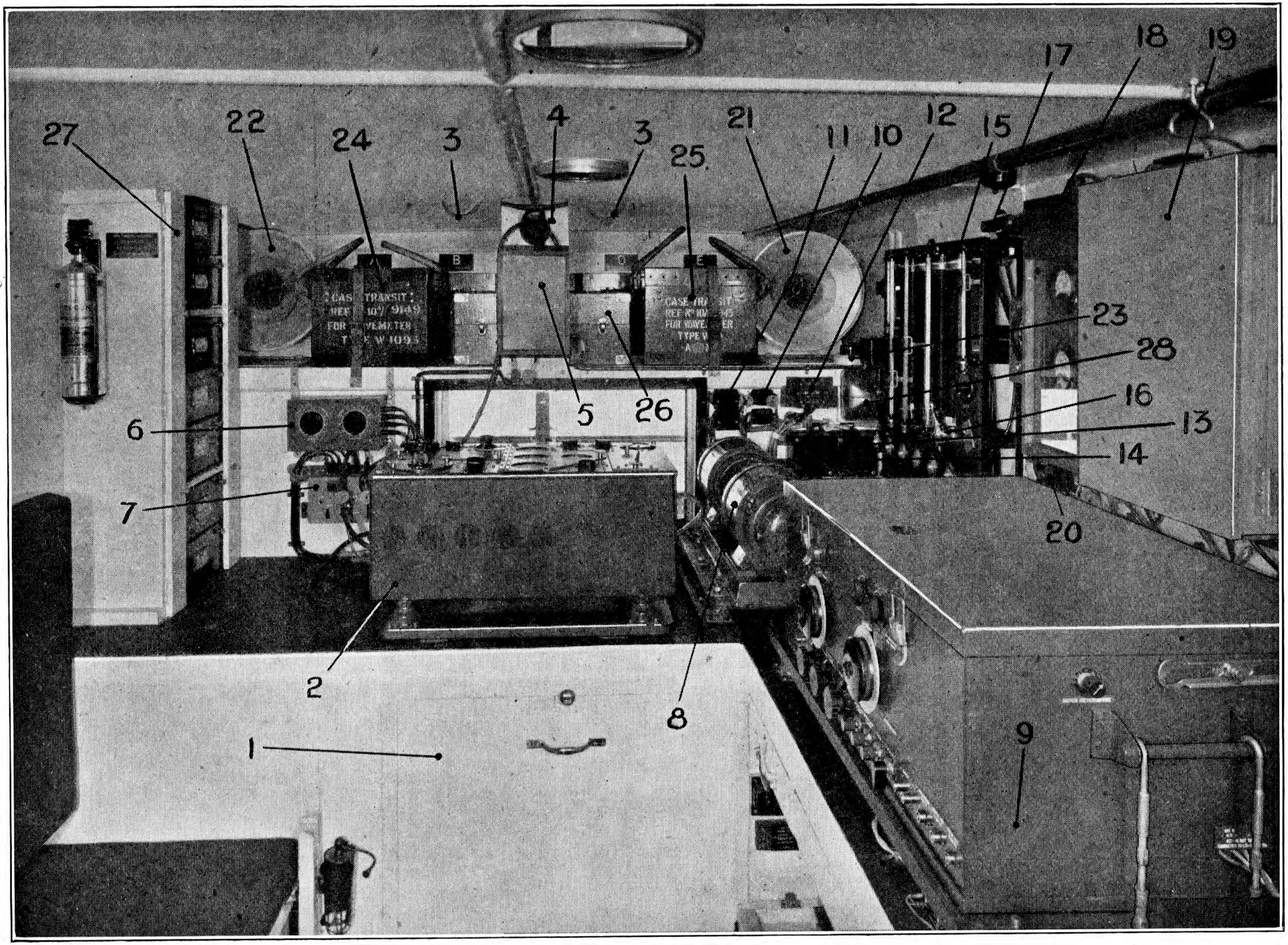


FIG. 4. Interior of vehicle, fore end.

18. The automatic grid-bias unit (6) and side tone unit, type D (7), are mounted vertically, to the left of the transmitter. In front of these, upon the bench, is space for a grid-bias battery box which may be used instead of the automatic grid-bias unit. Suitable clamps are provided for securing the grid-bias battery box in this position. An impedance matching unit is mounted vertically behind the transmitter and is not visible in the photograph. Its function is explained in para. 77.

19. Two motor-generators are mounted on the bench to the right of the transmitter. Only the larger of these, a 255-watt generator (8), can be seen. The other is to the right of this and is screened from view by the receiver R.1084 (9). Mounted upon the partition at the back of the bench are two fuse boxes, type A (10), and two fuse boxes, type B (11), carrying fuses in the supply leads to the two motor-generators and also a spare fuse in each box. To the right of these is an interrupter switch-box (12). Below the latter are the two automatic starters (13), (14) for the motor-generators. A 1,000 μF. electrolytic condenser is fitted below the automatic starters.

20. A charging switchboard (15), which operates in conjunction with the petrol-electric charging set, is fitted on the off side wall at the fore end. The bowden control lever (16) is fitted for stopping the engine when necessary, as described in para. 104. The 255-watt generator is fitted with a field regulator (17) for output voltage control. This is mounted between the charging switchboard and the instrument board. The left-hand portion of the instrument board (18) is fitted with two H.T. voltmeters, two H.T. milliammeters and a transmitter filament voltmeter. The right-hand side (19) of the instrument board carries a pair of H.T. selector switches. Since this switchboard carries direct current at a dangerously high voltage, it is fitted with a safety switch, so arranged that neither generator can run while the cover is open.

21. Both portions of the instrument board are fitted with glass panels in order that the instruments may be read, and the position of the H.T. selector switches readily observed, without stopping the generator. In the early vehicle used for illustration, however, the right-hand portion was fitted with a plain paxolin panel. On the off side wall, in rear of the receiver R 1084 is the switch, type 9 (20), which is used to change the aerial from one receiver to the other. It is not very clearly visible in the photograph. The aerial earthing relay for the R.1084 is on the bench between the 80-watt generator and the receiver itself and is not visible in the photograph.

22. The racks for range coils, etc., at the fore end, are occupied as follows. On each side, a certain space is occupied by the light-tight ventilators (21) (22), the ventilating fan itself being started and stopped from the interior of the vehicle by means of a tumbler switch (23). A radio interference suppressor for this fan is fitted near the switch. Five transit cases for transmitter coils are stowed on the main rack, their positions being indicated by the letters A B C D E. In front of these cases, on the left, is the transit case (24) for the wavemeter W.1095, and on the right the transit case (25) for the wavemeter W.69. The transit case (26) contains the range coils for the wavemeter W.39A. The small vertical rack (27) carries seven transit cases containing certain of the range coils for the receiver R.1084. Other coils are stowed elsewhere. Above the automatic starters, on the extreme right, is a fuse box (28) containing fuses for the ventilating fan and interior lighting.

23. Fig. 5 shows some of the components already mentioned, and also some of the items mounted on or near the floor. On the bench will be seen the receiver R.1094 (1) which, however, is normally fitted in the portable W/T station. The aerial earthing relay (2) for this receiver is mounted on the side of a box (3) which contains batteries for the R/T line link unit.

24. The R/T line link unit (4) is also mounted on the wall. On its panel, near the upper left-hand corner, may be seen the gain controls for an amplifier contained in the unit, and below these, a combined micro-telephone plug in a jack. This micro-telephone plug is connected to a breast plate microphone and a single earpiece telephone receiver which are lying on the bench. The automatic calling dial and certain switches are also seen. The meter to the right of the plug is a volume meter or decibelmeter and its function is explained in para. 80.

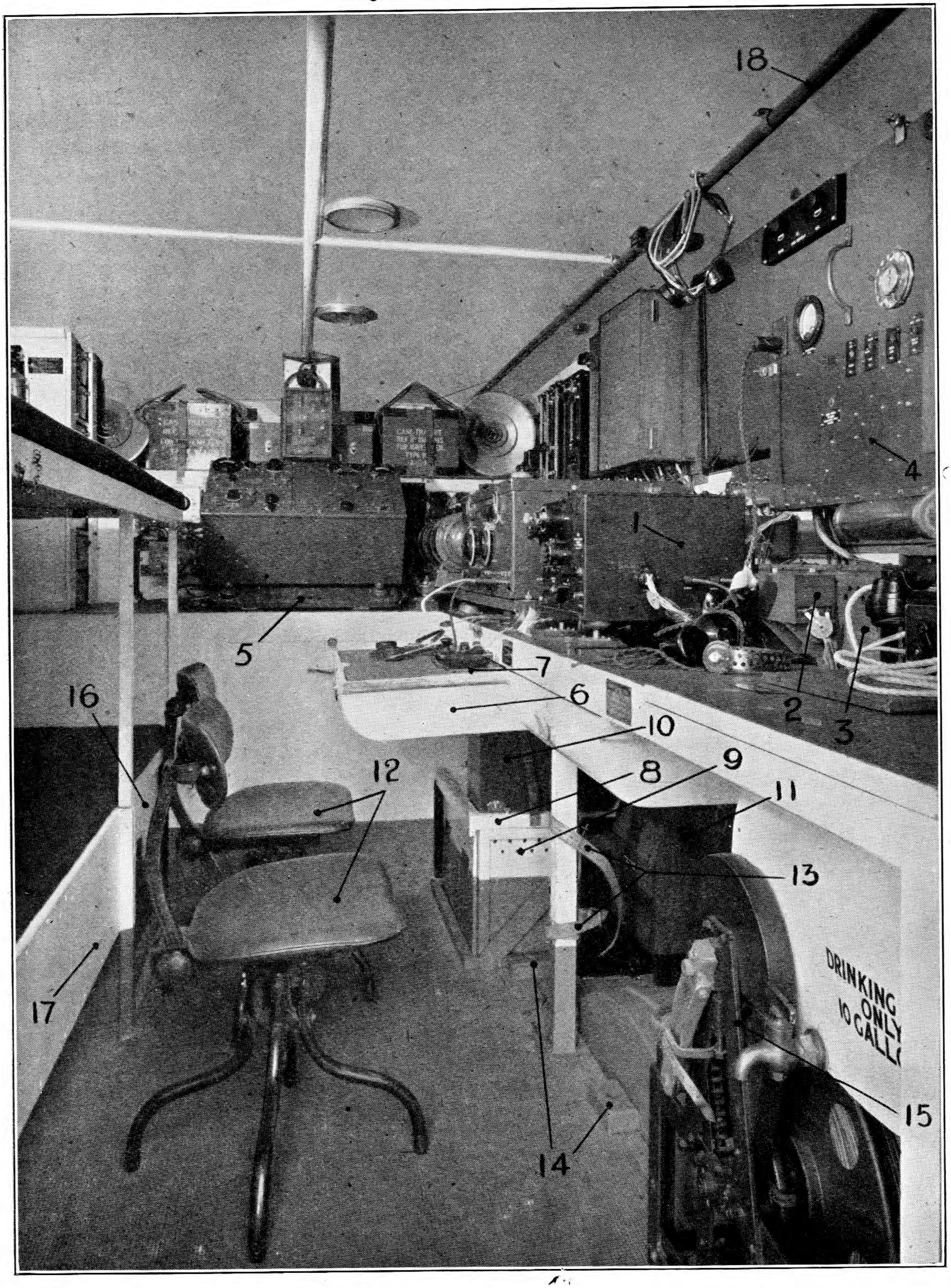


FIG. 5. General view of interior.

25. In this photograph the transmitter mounting (5) is canted into a position suitable for adjustment, etc. The drawer (6) beneath the receiver R.1084 is pulled out to form an operating table and the morse key (7) is mounted upon the table top in a special catch plate. The drawer beneath the receiver R.1094 can be used in a similar manner when required.

26. The cover (8) of the compartment (9) in which numbers 2, 3 and 4 batteries are fitted, is easily removable, although the modulation indicator and wavemeter W.39A (10) are normally stowed on top of the cover. The smoothing unit (11) is fitted in a wooden case with a removable cover, but on no account must a generator be started up while this cover is off, nor must it be removed while a generator is running, since a shock from the H.T. mains may have fatal results. Adjacent to the smoothing unit, but not clearly visible in the photograph, is a pair of radio-frequency chokes, also enclosed in a wooden cover, to which the same restrictions as to removal also apply. The filament battery for the wavemeter W.39A is fitted in a special wooden case carrying a small series resistance. This case is clamped to the floor near the R/F chokes by a single knurled screw, so that it is easily removable for use, or for charging. The receiver earthing terminal is mounted on the off side wall, beneath the bench.

27. The two adjustable chairs (12) may be secured when travelling over rough ground by means of the straps (13), and wooden chocks (14), one leg of each chair fitting in each chock. The cable-laying apparatus (15), with its drum of D.3 Mark VI telephone cable, is seen in its normal stowage position. The compartment (16) under the fore end of the lower bunk contains No. 1 battery, while the rear compartment (17) is divided into two, the front portion containing tools and the more robust W/T spares, while the rear portion is reserved for the personal equipment of the crew. The tube (18) running the whole length of the roof is of paxolin, and forms a fair-lead for the mast lifting cord.

28. Most of the components above the rear end of the bench are also seen in fig. 6. The hand press microphone, type B (1), is carried in a standard type of spring holder. Near to it is the receiver supply switch-box (2). The anode converter for receiver H.T. supply is fitted in a screening box (3), the input suppressor (4) and output suppressor (5) being mounted on battens very close to it. An impedance matching unit (6) is connected to the R/T line link unit by a length of screened cable which is plainly seen. In front of the bench is a catch plate (7) to hold the morse key when desirable. The manual send-receive switch (8) has an OFF position. When in local control, the transmitter filament supply is controlled by the tumbler switch (9).

29. The receiver R.1094 is shown in this photograph also; it will be seen to consist of a receiver R.1093 fitted in a skeleton outer case which provides a contact bar, filament ON-OFF switch, telephone jack, and the necessary socket connections for connection to the external circuits. Since the L.T. supply is derived from a 2·4-volt battery, a suitable series resistance is also embodied in this outer case. To the right of this receiver is the battery box (10) for the R/T line link unit (11), and to the right of this is a field telephone (12) for communication with the remote control station.

30. The relay panel (13) is situated under the bench near the smoothing unit. Since certain contacts in this relay are at a very high potential, safety arrangements are incorporated to ensure that no H.T. voltage can be generated unless the cover is fitted and is securely fastened.

31. The lead-in for the auxiliary aerial (14) is mounted on cleats and is brought to the manual send-receive switch. The lead-in insulator, type 16, is fitted with a light baffle similar to those fitted to the main aerial insulators.

32. The aerial erecting winch (15) is mounted on the rear wall, and the closeness of the cheeks, which causes the cord (16) to wind in a flat spiral, should be noted. The winch is fitted with a pawl, which can only be released by means of a catch fitted underneath the bench; this catch is accessible through a small orifice (17). The catch operates the pawl by a length of flexible wire carried in a metal tube (18). The pawl locks the mast in whatever state of erection

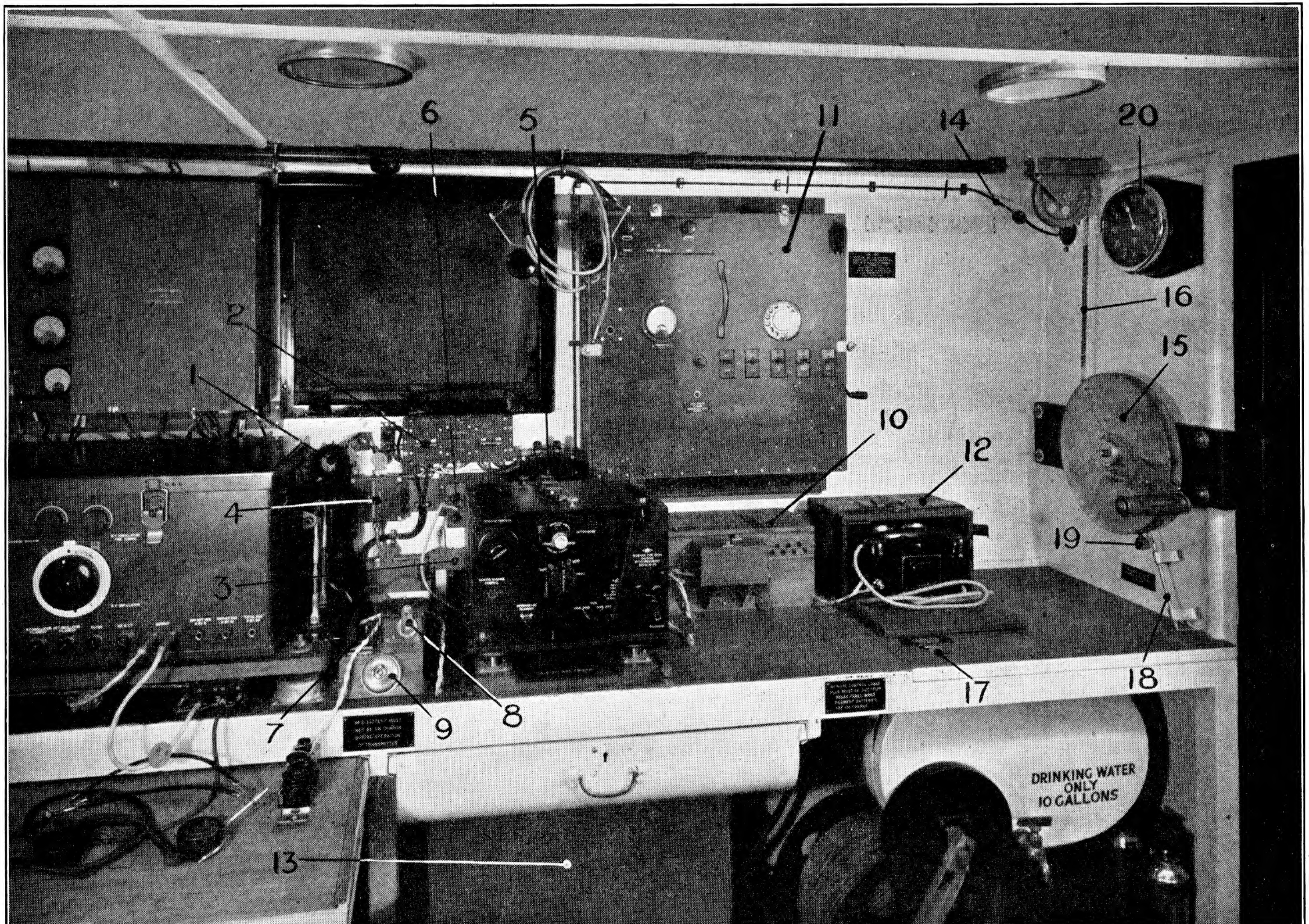


FIG. 6. Interior of vehicle, rear off side.

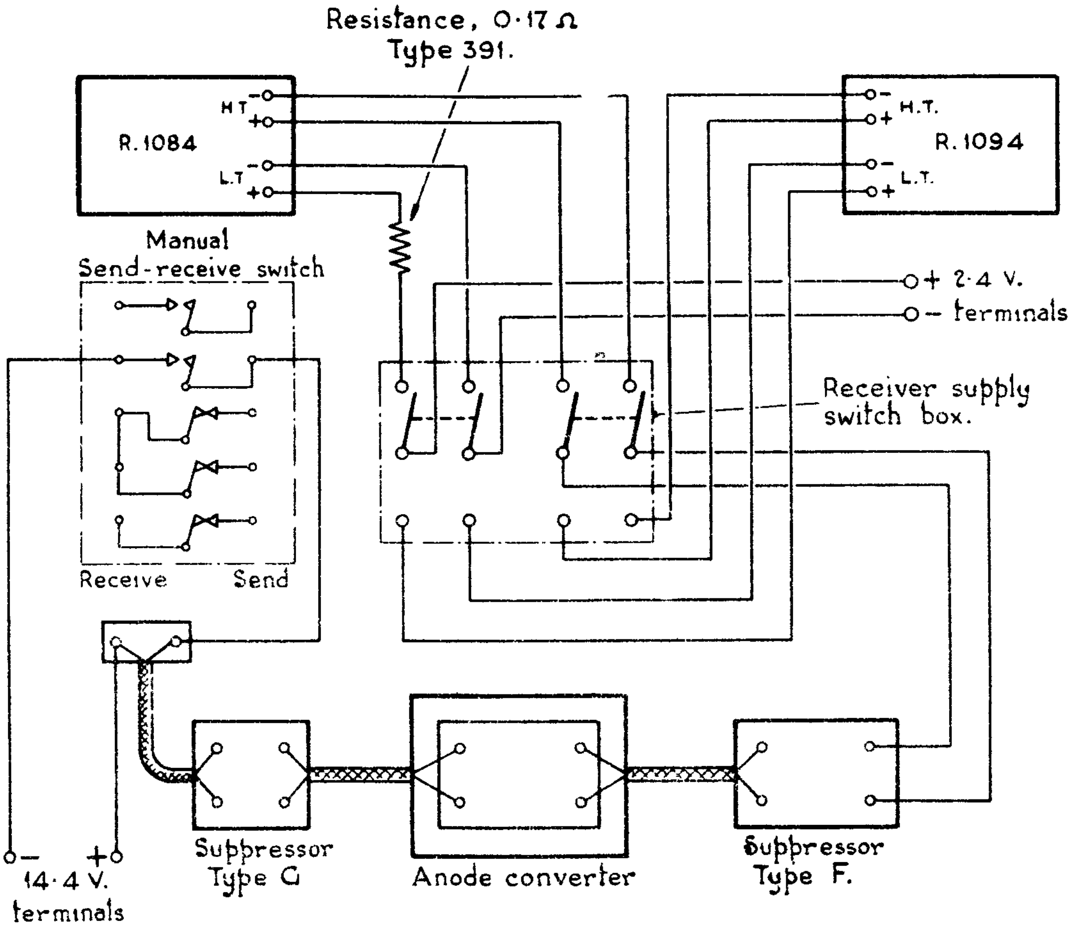


FIG. 7, RECEIVER H.T. AND L.T. SUPPLY CONTROL

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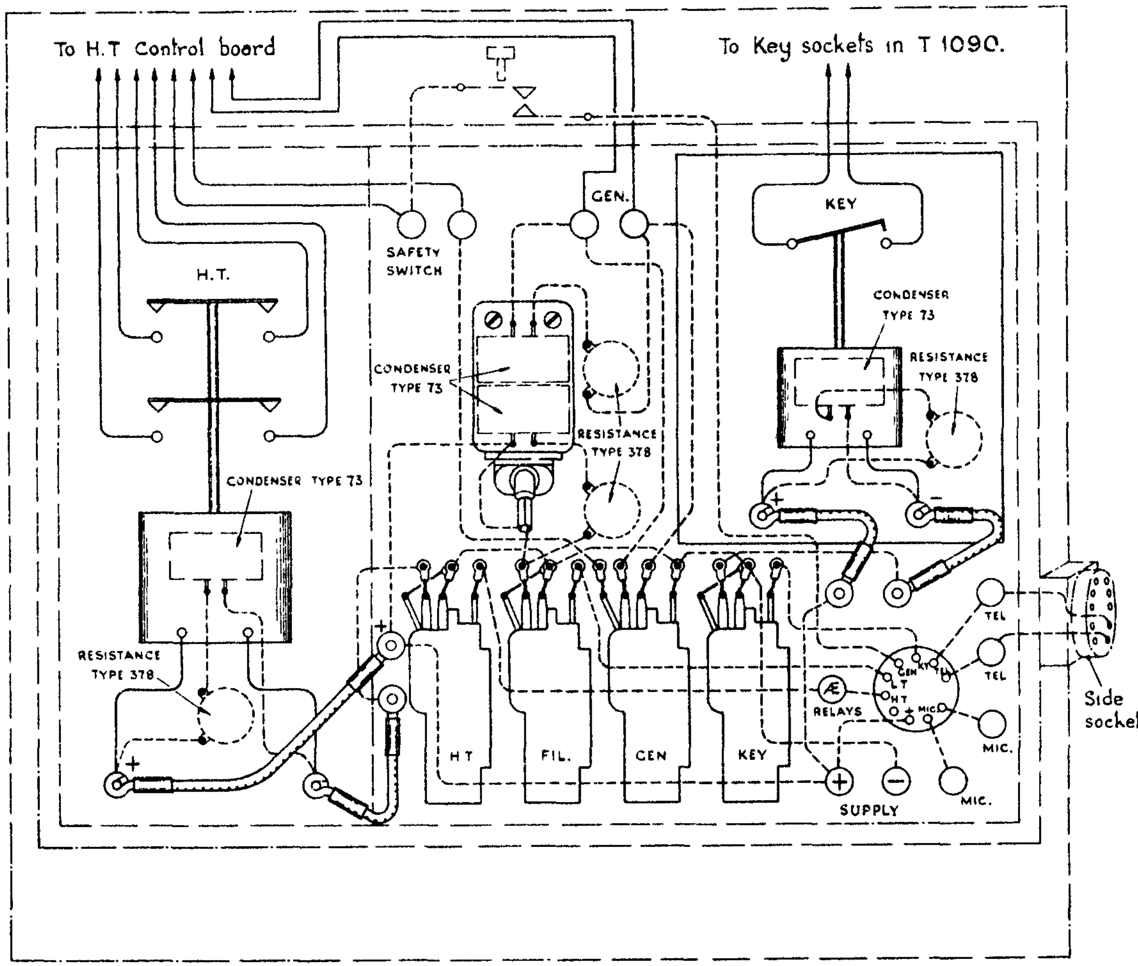

FIG. 8. WIRING OF RELAY PANEL

it may be, but must be released in order to lower it. The weight should be taken by the winch, operated with the right hand, and the pawl released by operating the catch with the left hand. The mast can then be " walked back " pawl by pawl or as rapidly as desirable, although it must not be allowed to collapse without check. When the mast is fully erected, the pawl must be locked by means of the screw (19).

33. An eight-day clock (20) is mounted on the rear wall. A 10-gallon water tank is fitted beneath the rear end of the bench, which is removable for the purpose of filling the tank.

ARRANGEMENT OF CIRCUITS

34. In order to provide a rapid and simple change-over from local to remote control, and *vice versa,* and also to ensure the maximum degree of safety to operators and freedom from fire risks, the transmitter is operated by means of a number of relays. Certain of these are mounted in convenient positions near the circuits or instruments they control, while the remainder are grouped together in the relay panel. Arrangements are made to prevent the H.T. generator from being started when either the H.T. control switch-board or the relay panel covers are removed. The safety switches are included in the cperating circuit of a relay which closes a relay switch in the generator circuit (*see* para. 55 *et seq.*).

35. The transmitter, type T.1090, incorporates a drum type switch which performs certain internal circuit changes and varies the type of wave emitted, i.e. C.W., I.C.W. or R/T as desired. W/T keying, both in local and remote control, is performed by means of relays which are incorporated in the relay panel (*see* para. 67).

36. The side tone unit, type D, provides side tone for C.W., I.C.W., or R/T transmission as desired. Since the interrupter is employed to give an audible side tone note on C.W., care must be taken to connect the appropriate interrupter—255 watt or 80 watt—to the transmitter by means of the interrupter switch-box, even if C.W. transmission is required.

37. A wiring diagram of the W/T installation proper, but not including the charging circuits, is given in fig. 24. The individual circuits will, however, be explained with reference to simplified circuit diagrams (figs. 7, 8, 10, 11, 12, 13, 14, 15, 17).

Receiver supply circuits

38. The H.T. and L.T. supply circuits to the receivers R.1084 and R.1094 are shown in fig. 7. The L.T. supply is derived from No. 4 battery (2·4 volts), and the H.T. supply from an anode converter, which is merely a specially designed motor-generator, the particular feature of which is the extremely low level of the commutator ripple voltage. The motor side of this machine is driven from No. 2 battery (14·4 volts), the negative supply lead passing through a pair of contacts on the manual send-receive switch. The generator is automatically started by placing this switch in the RECEIVE position. Radio interference suppressors are fitted in both input and output circuits. The 120-volt output from the suppressor supplies either the R.1084 or the R.1094, the selection being controlled by the receiver supply switchbox. The latter also controls the L.T. supply as shown in the diagram. It will be noted that an external resistance is fitted in the + L.T. supply lead to the receiver R.1084, in order to give the correct P.D. at the L.T. terminals. A corresponding resistance is embodied internally in the receiver R.1094.

39. The anode converter and both suppressors are contained in metal screening boxes and the connections between them are made with screened twin cable. The screening of the cables is bonded to the metal screening boxes by means of special glands. It is most important that the continuity of this screening shall be maintained over the whole system of suppressors and converter, otherwise the efficiency of the suppressors may be seriously reduced and considerable interference with reception will result.

Relay panel

40. The wiring of the relay panel is shown diagrammatically in fig. 8. It carries a double-pole magnetic relay, type 38 (Stores Ref. 10A/10191), which closes the H.T. supply to the transmitter, a single-pole magnetic relay switch, type D (Stores Ref. 5C/846), closing the L.T. supply to the transmitter, and a single-pole magnetic relay, type 41 (Stores Ref. 10A/10194), for keying purposes. The above instruments are operated by currents from No. 2 battery (14·4 volts) via the contacts of three magnetic relays, type G (Stores Ref. 10A/8073), which are also energized by currents from No. 2 battery. An additional relay, type G, making four in all, is also incorporated in the panel. The three first-named relays, type G, will be referred to as the H.T., L.T. and keying relays, while the fourth is referred to as the generator relay. The operating circuits of the type G relays are completed by various keys and switches, depending upon whether " local " or " remote " control is desired.

41. The actual control circuits are connected to the relay panel as follows. On the front of the relay panel, accessible by a small door in the cover, is a 10-point socket which will be referred to as the front socket. The door is indicated at (13) in fig. 18. The external operating circuits are connected to the front socket by means of a 10-point plug. There are two such plugs, one being connected to a 7-point junction box, and thence to the manual send-receive switch, transmitter L.T. supply switch, microphone and morse key in the vehicle, by means of a short length of 10-core cable, which will be referred to as the local control line. The other plug is also connected to a short length of 10-core cable which will be referred to as the remote control extension line. This line is carried in a metal conduit under the floor, to a point near the remote control cable drum, which carries the remote control cable proper. The drum is fitted with a 10-point socket to which the inner end of the remote control cable is connected. The outer end terminates in another 10-point plug which may be fitted to a corresponding socket at the remote control station.

42. When local control is desired, the local control line is plugged into the front socket of the relay panel. The operating circuits of the relay panel are then closed by the operation of switches in the vehicle itself. The remote control station may be in position ready for operation, although not actually in use, and provision is made for telephonic communication between the vehicle and the remote control station, in the following manner. A second 10-point socket, which is fitted externally on the right-hand side of the relay panel, is wired up to the field telephone terminals only. This is called the side socket. If the remote control extension line is plugged into the side socket therefore, the two stations may communicate by field telephone while the radio station is under operation by local control. The side socket also forms a stowage position for the 10-point plug when the extension line is not in use.

Remote control cable

43. The remote control cable is normally stowed on its drum, which is fitted on the floor at the extreme rear of the vehicle, on the near side, as shown in fig. 9. A special door is provided to give access to the cable while it is being laid, but when this operation is completed the door may be closed and secured. The door carries a warning to the effect that when laying the cable the drum must not be allowed to run free, nor must the unwinding be performed by hauling on the cable. The drum is designed to carry 440 yards of $\frac{9}{16}$ in. diameter cable, but in certain vehicles about 370 yards of $\frac{11}{16}$ in. diameter cable have been installed. The " drum end " (1) of the remote control extension line and its 10-point plug (2) are shown in their stowage positions. On no account should the plug be inserted into the socket (3) until the laying of the remote control cable has been completed.

44. The handle of the cable drum consists of a bar (4) which is a loose fit in a tube (5), the latter being rigidly attached to the axle of the drum. The wooden handgrip (6) is rigidly attached to the bar (4), and in the winding position, shown in the photograph, the bar (4) is locked to the tube (5) by the catch (7). In the stowage position, the tube (5) lies parallel to the rear member of the support. The catch (7) is released from the tube, and on turning the handgrip through 90°, the catch engages with the catch plate (8) so that the drum is no longer free to rotate.

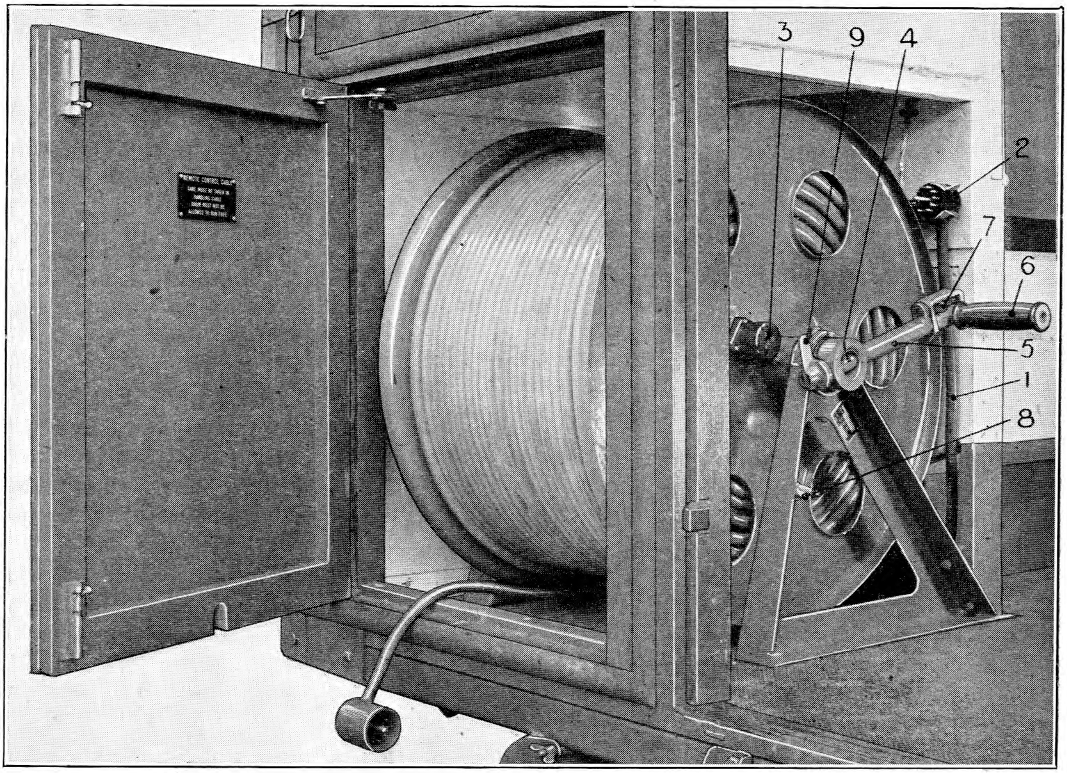

FIG. 9. Remote control cable and drum.

45. The bar (4) carries a lug (9) at the end opposite to that carrying the handgrip. When the handgrip is so turned that the bar and tube are locked together, this lug is clear of the socket (3) in all positions of the drum. When the tube is locked to the rear member of the support, however, this lug projects towards the drum. If the remote control extension line is plugged into the drum socket therefore, any attempt to turn the drum, e.g. by pulling on the cable, will cause the plug to abut upon the lug and prevent such rotation.

46. It is important to ensure that the handle is always locked in the stowage position, except during the actual operation of reeling off or winding in the cable.

Aerial send-receive switching system

47. The principal features of the aerial and send-receive switching system are shown in fig. 10. The main aerial leads are connected to two insulators in the roof, and thence to the transmitter, either directly or via the aerial condenser, by a flexible cable fitted with a plug. From the aerial condenser, connection is made to the send-receive relay switch by another flexible cable terminating in a similar plug. The send-receive relay switch has two aerial sockets marked 1 and 2. When in local control the appropriate plug is shipped in No. 1 socket, connecting the aerial to the moving blade of the relay. According to the position of the blade, the aerial is connected either to the transmitter, or to the centre point of a single-pole change-over switch, type 9 (Stores Ref. 10A/1276). The outer points of the latter are connected to the aerial sockets of the aerial earthing relays for the respective receivers, by means of suitable plugs.

48. When in remote control, the aerial on the vehicle is required only for transmission. The aerial (or aerial condenser) plug is transferred to socket 2 on the send-receive relay switch, so that the aerial is permanently connected to the transmitter. The windings of the send-receive relay switch are not energized during remotely controlled transmission.

49. When in local control, the windings of the send-receive relay switch are energized by a current from No. 2 battery (14·4 volts). The circuit may be traced as follows. From the +14·4 volt terminal block, through the solenoid of the send-receive relay switch, to the lower contacts of the manual send-receive switch. The latter contacts are closed when the switch is at SEND, and complete the circuit to the —14·4 volt terminal block. Thus, when the aerial plug is in socket 1, the action of moving the manual send-receive switch to SEND causes the aerial to be connected to the transmitter, and its return to RECEIVE causes the aerial to be connected to one of the two receivers, as selected by the single-pole switch, type 9.

50. In order to protect the receivers from stray R/F pick-up during transmission, two aerial earthing relays are provided, one for the receiver R.1084 and one for the receiver R.1094, in case this should be installed in the vehicle. The relays used for this purpose are known as relays, magnetic, type 37 (Stores Ref. 10A/10183), and consist of type G relays mounted in teak boxes, fitted with suitable sockets and terminals. The operating windings of these relays are connected in series and are energized when the manual send-receive switch is put to SEND (if in local control) or by the action of closing the H.T. control switch when in remote control.

51. The receiver aerial earthing relays are mounted as closely as possible to the " aerial " and " earth " terminals of their respective receivers. The contacts of these relays are connected directly to the aerial and earth terminals of the receivers and also to the above-mentioned single-pole switch and to the counterpoise (i.e. chassis). When the contacts are closed the aerial is connected directly to counterpoise, short-circuiting the input circuit of the receiver. The windings of the two relays are energized when the H.T. supply to the transmitter is completed as explained in paragraph 60.

52. The auxiliary aerial is provided for reception only, the aerial lead-in being taken to the upper contact of the manual send-receive switch. When the switch is at RECEIVE, the aerial is thereby connected to a socket, and flexible connections are provided to complete the aerial circuit to either of the aerial earthing relays. In certain circumstances, reception by means of this aerial will be found to give greater freedom from interference than the main aerial.

Manual send-receive switch

53. The functions of the remaining contacts of the manual send-receive switch are also shown in fig. 10. The local control line is brought to a junction box, the terminals therein being marked MIC., +, H.T., L.T., GEN., and KEY. When in local control, the relay circuit for the L.T. supply to the transmitter is completed by means of a tumbler switch, and is not controlled by the manual send-receive switch. The H.T., L.T., and generator relays are however subject to control by this switch.

Transmitter H.T. supply

54. The H.T. supply for the transmitter may be derived from either of two sources. For low power working, an 80-watt motor-generator is provided and for extreme ranges a 255-watt motor-generator is employed. Either generator may be used for any type of transmission, i.e. R/T., C.W., or I.C.W. The side tone unit, type D, enters into the switching arrangements as described later (*see* paragraph 69 *et seq.*).

Generator control system

55. A theoretical circuit diagram of the generator control system is given in fig. 11. Each generator has its own automatic starter, the 80-watt generator being controlled by a starter, type A, and the 255-watt generator by a starter, type D. These starters are of similar design,

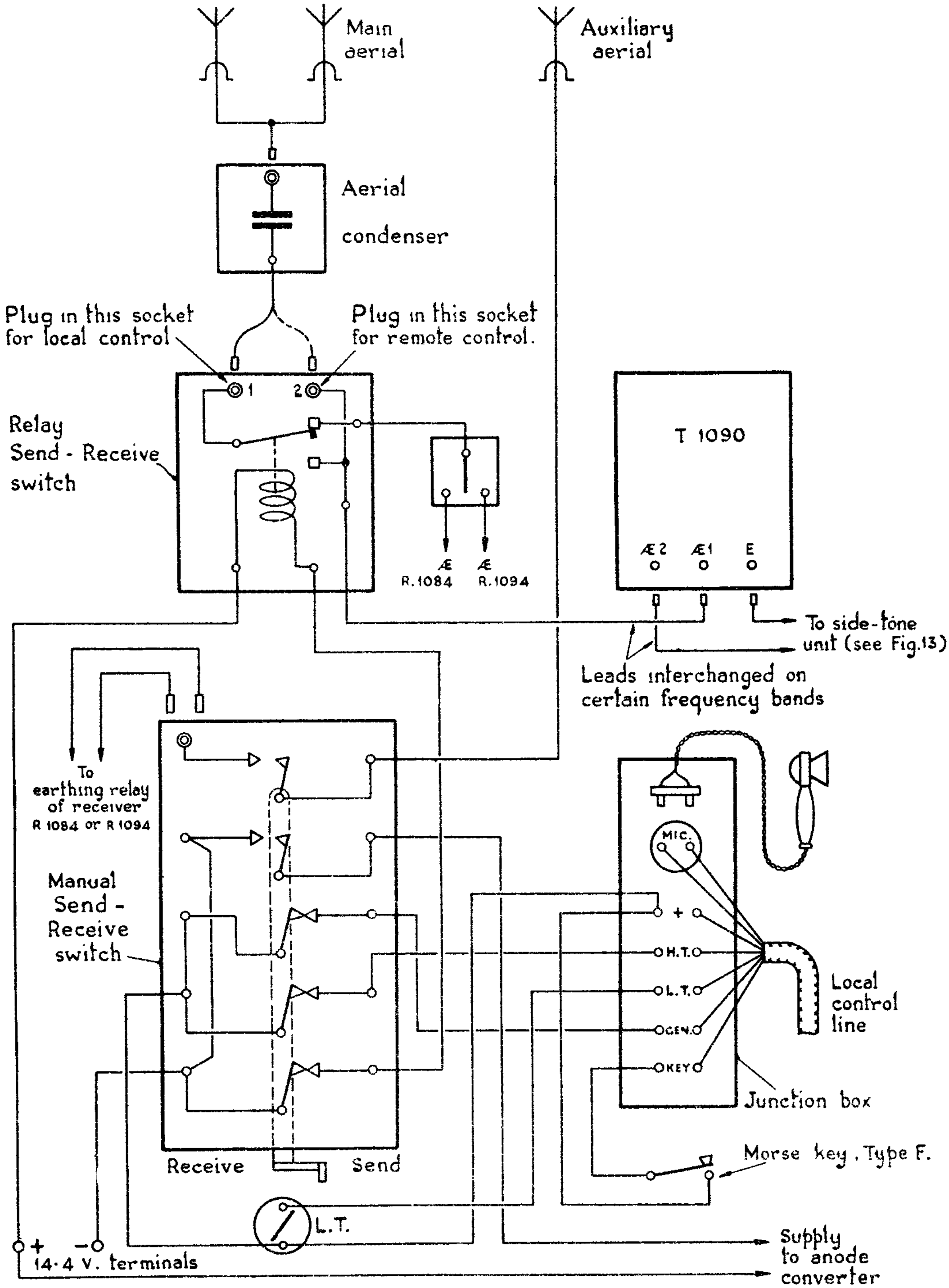

FIG. 10, SEND-RECEIVE SWITCHING SYSTEM (LOCAL CONTROL) the series (starting) resistances being, however, of different values. An electrolytic condenser of 1000 μF. is connected across the contacts of the starter, type D, to prevent the contacts fusing together. Referring to fig. 11 it is seen that the starter, type D, is supplied from No. 1 battery (24 volts) through a pair of fuses, type F, which will carry a starting current of 40 amperes, the control wiring being brought to the upper contacts of a double-pole change-over switch. Similarly, the type A starter is supplied from No. 2 battery (14·4 volts) through a pair of 20-ampere fuses, type A, and its control wiring is brought to the lower contacts of the same switch. The two centre arms of this switch are taken to the terminals engraved GEN, in the relay panel. The contacts of the generator relay are connected internally to these terminals.

56. The complete action of this form of automatic starter is given in Section VII, Chapter 11, of Air Publication 1095, Electrical Equipment Manual. Briefly, however, it may be said that when the contacts of the generator relay are closed the terminal C on the selected automatic starter is connected to the positive terminal of the appropriate battery, and the motor starts up.

57. The generator relay is energized by a current supplied by No. 2 battery (14·4 volts). The supply terminals of the relay panel are fed directly from the battery terminal blocks. When the local control line is plugged into the front socket on the relay panel the operating circuit is as follows. From the + supply terminal to the + socket on the plug, thence via the local control line to the junction box, which is fitted near the manual send-receive switch (*see* fig. 10). From this junction box the circuit is carried through the " generator " contact of the manual send-receive switch (provided the latter is at SEND), and back to the junction box. From this point the circuit returns along the local control line to the GEN point on the 10-point plug, entering the front socket on the relay panel.

58. From the front socket the circuit proceeds internally to one of the two terminals marked SAFETY SWITCH, and from thence round the safety contact on the door of the generator control board, back to the other terminal marked SAFETY SWITCH. The circuit then continues, through the safety contact on the cover of the relay panel itself, through the windings of the generator relay, and back to the — supply terminal. It is therefore obvious that when the manual send-receive switch is moved to SEND, the generator relay will be energized, and the control circuit of the generator completed, but only if the covers of both relay panel and generator control board are closed. It should be noted that the safety switches will not be closed unless the doors are properly secured by means of the appropriate clips.

59. When the remote control extension line is plugged into the front socket of the relay panel, the circuit and action is exactly the same as in local control, except that at the portable remote control station, the incoming + lead is taken to one pole of a tumbler switch, the other pole being connected to the outgoing " generator " core of the 10-core cable. The generator is started and stopped as necessary by operating this switch.

Transmitter H.T. supply control

60. A theoretical circuit diagram of the transmitter H.T. supply circuit is included in fig. 12. Each generator has its own H.T. voltmeter and milliammeter, which are fitted in the instrument board. The generator in use is connected to the smoothing unit by a double-pole change-over switch. From the smoothing unit, both the positive and negative leads are taken through the double-pole relay, type 38, in the relay panel. The positive H.T. lead is then taken through one of the two radio-frequency chokes and to the H.T.+ socket of the transmitter by means of a suitable plug. The negative H.T. lead is taken through the other radio-frequency choke to the unmarked socket on the automatic grid-bias unit, and from the + socket of the latter to the G.B.+ socket of the transmitter by means of the appropriate plugs. A grid-bias battery is provided as an alternative to automatic G.B. unit, but is not shown in the diagram. The internal and external connections of the grid-bias battery box and automatic G.B. unit are dealt with in Section 1, Chapter 6, of this Air Publication. It is generally found preferable to use the automatic G.B. unit with the 255-watt generator and the battery bias with the 80-watt generator, but this must not be regarded as a rigid instruction.

61. The double-pole relay, type 38, is energized by a current from No. 2 battery (14·4 volts) via the contacts of the H.T. relay, type G. The windings of the latter are energized by a current from No. 2 battery. When the local control line is plugged into the front socket of the relay panel the circuit may be traced, from the + supply terminal on the panel, out through the local control line to the junction box, to the H.T.+ contact of the manual send-receive switch and back to the H.T. terminal of the junction box. From this point the local control line carries the circuit back to the 10-point plug and the H.T. point on the front socket of the relay panel. From the latter point, the circuit may be traced internally through the windings of the relay, type G, and back to the — supply terminal.

62. On leaving the H.T. point on the front socket, a parallel circuit may be traced to the terminal marked AE RELAY. From this terminal, the circuit is carried to the windings of the aerial earthing relay for the receiver R.1094. From this point the circuit continues to the aerial earthing relay for the receiver R.1084, and thence to the " —14·4 volts " terminal block. It will be noted that the aerial earthing relay for the receiver R.1094 is always in circuit, whether the receiver itself is installed in the vehicle or elsewhere.

63. The action of the circuit when in remote control is precisely as given above, except that since the remote control extension line is plugged into the front socket of the relay panel, the H.T. relay circuits are closed by the operation of a tumbler switch at the portable remote control station.

Transmitter L.T. supply

64. The transmitter L.T. supply is derived from No. 3 battery (8·4 volts). From the positive terminal block a lead is taken directly to the L.T. + socket on the transmitter. The L.T. circuit is closed by a single-pole relay switch, type D, which is located in the relay panel; this switch completes the H.T. negative lead from the transmitter to the negative supply terminal. For convenience in wiring, the connection is actually made at the negative terminal of the filament voltmeter as shown in fig. 13. This voltmeter is fitted on the instrument board.

65. The windings of the magnetic switch, type D, are energized as follows. From the + supply terminal on the relay panel the circuit is taken to the + point on the front socket. Assuming the local control line to be plugged in, the circuit is carried to the junction box (+ terminal) as before. From thence it continues to one side of a tumbler switch which is mounted near the manual send-receive switch, and from the other side of this switch back to the L.T. terminal on the junction box. From this point the local control line carries the circuit back to the L.T. point on the front socket, whence it continues internally round the windings of the L.T. relay, type G, and back to the — supply terminal.

66. When the tumbler switch is closed, therefore, the L.T. relay is energized and its contacts are closed, completing the circuit from the + supply terminal, through the windings of the relay switch, type D, to the — supply terminal. The closure of the latter relay completes the L.T. supply to the transmitter as already stated. The action when remote control is in use is exactly the same as in local control, the remote control extension line being plugged into the front socket as already described.

Keying

67. Fig. 13 also shows the circuit used for the operation of keying when the appropriate switch on the transmitter is put to C.W. or I.C.W. The " key " leads are taken from the transmitter to the contacts of a single-pole relay, type 41 (Stores Ref. 10A/10194) in the relay panel. The winding of this relay key is energized by the closure of the contacts of the " keying " relay, type G, which in turn is energized from the same source of supply when the morse key is closed by the operator. The local and remote control circuits may be traced through the respective control lines as for the H.T. and L.T. supplies.

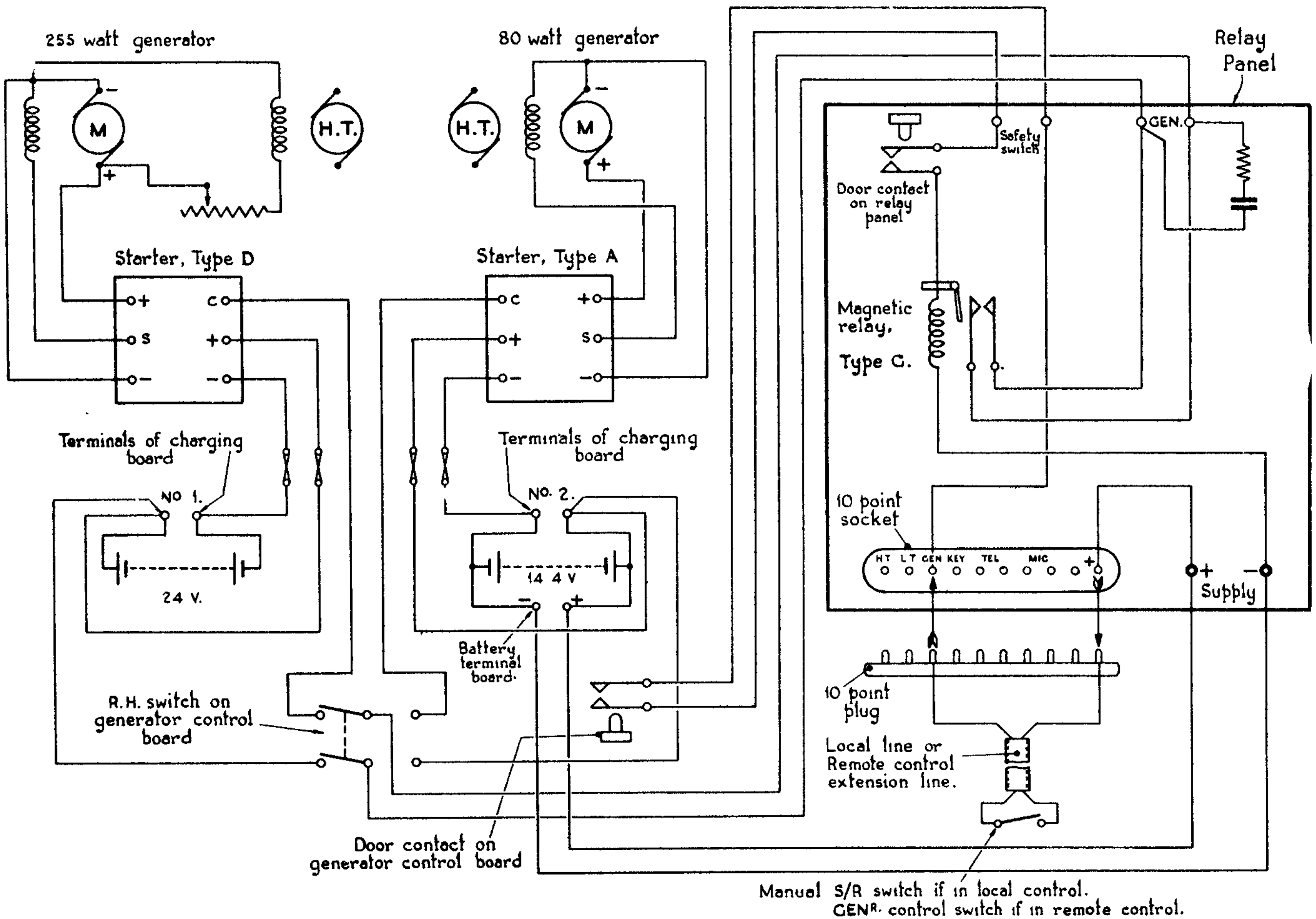

FIG. 11, GENERATOR CONTROL SYSTEM

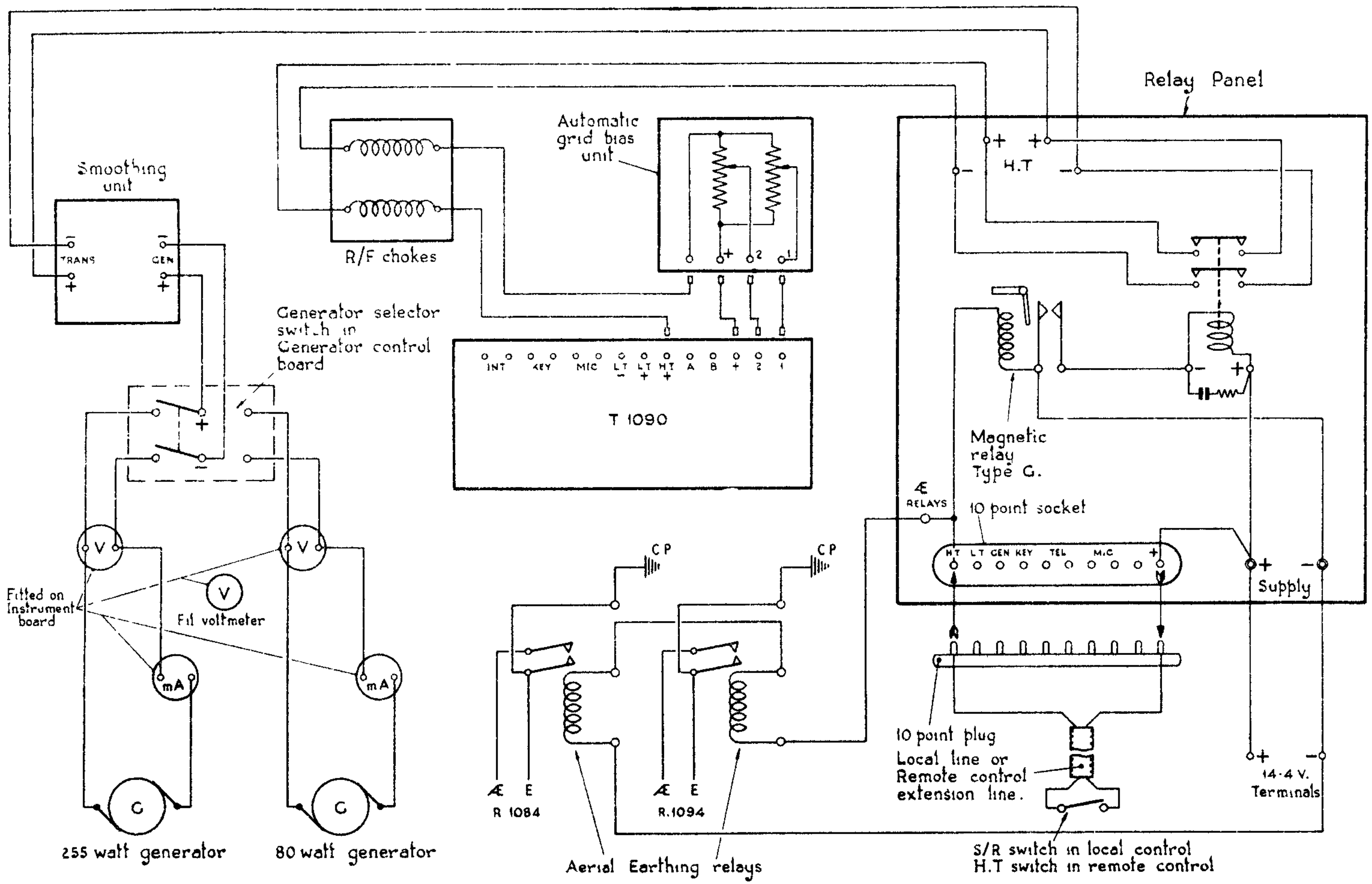

FIG. 12, TRANSMITTER H.T. SUPPLY CONTROL AND Æ EARTHING RELAYS

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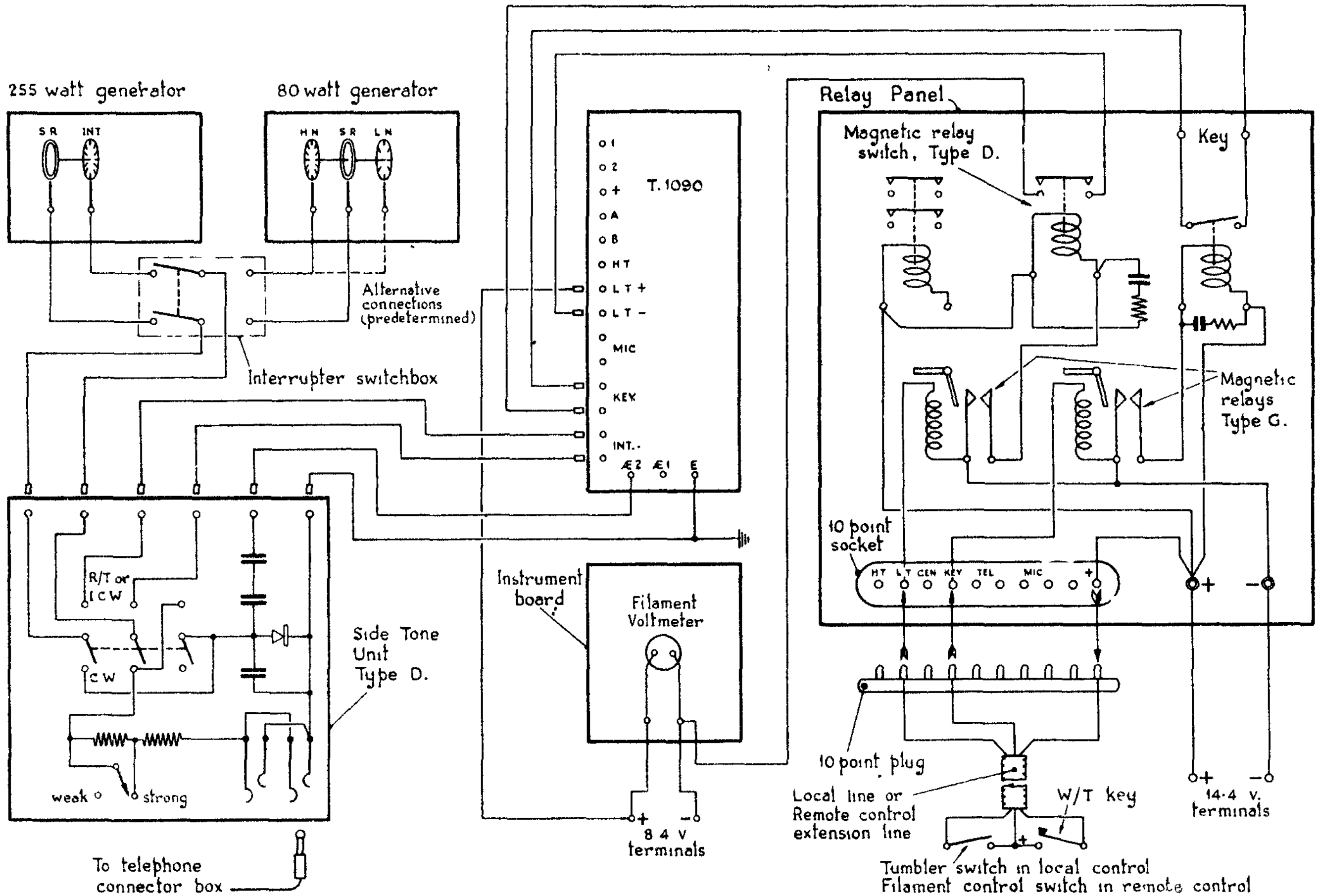

FIG. 13, TRANSMITTER L.T. SUPPLY CONTROL, W/T KEYING, INTERRUPTERS, AND SIDE TONE CONTROL.

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68. Referring again to fig. 8, it will be observed that shunt circuits are connected in parallel with the windings of (i) the double-pole H.T. relay, type 38, (ii) the single-pole key relay, type 41, and (iii) the L.T. relay switch, type D. Each shunt circuit consists of a condenser, type 73, and a resistance, type 378, connected in series, and its function is to prevent arcing at the contacts of the corresponding relay, type G. A fourth shunt circuit having similar components is connected internally across the GEN terminals. The shunt circuits mentioned at (i) and (ii) above are integral components of the respective relays, types 38 and 41, while the other two are components of the relay panel.

Interrupters and side tone

69. The arrangement for I.C.W. transmission and side tone are also shown diagrammatically in fig. 13. Only one interrupter disc is fitted on the 255-watt generator, whereas both high note (H.N.) and low note (L.N.) interrupters are fitted on the 80-watt generator. When the 80-watt generator is in use, either interrupter disc may be connected according to requirements by shifting the lead shown in dotted line in the diagram. The wiring from the interrupter discs of the respective motor-generators are taken to a double-pole change-over switch contained in the interrupter switch-box, and it is important that this switch shall be placed in the position corresponding with the generator in use, no matter what type of radiation is contemplated. The centre limbs of the interrupter change-over switch are connected to two terminals on the side tone unit, type D.

70. The side tone unit, type D, is described in Section 1, Chapter 6, of this Air Publication, dealing with the transmitter, type T.1090, but the internal circuit is shown in fig. 13 for ease of reference. The fundamental component of this unit is a metal rectifier which is connected between the aerial and earth terminals of the transmitter, a very small capacitance, consisting of two condensers in series, being connected in series with the rectifier in order that it shall not constitute an appreciable load on the aerial and so reduce the effective aerial current. A small condenser is also connected in parallel with the rectifier itself.

71. Two switches are provided on the face of the instrument. One of these has two positions, engraved C.W. and I.C.W. & R/T. When this switch is in the I.C.W. & R/T position the interrupter is connected to the interrupter terminals of the transmitter. The rectifier output consists of an audio-frequency current which flows through one or both of the resistances in the unit and to the telephone connecting box, via a twin core lead fitted with a standard telephone plug, which is inserted into one of the two jacks on the side tone unit. The other end of this twin lead is connected to the terminals of the telephone connecting box, and the telephones (or loud speaker) are plugged into one of the two jacks with which the box is provided. When the transmitter is radiating C.W., however, the output of the rectifier is a unidirectional current varying in amplitude only in accordance with the keying, and to obtain side-tone, this current is interrupted at audio frequency by the interrupter. The output from the receiver is also connected to the telephones (or loud speaker) at the telephone connecting box. The series resistances serve to prevent the rectifier from limiting the receiver output to any appreciable extent. Two values of resistance are provided, thus allowing " strong " or " weak " side-tone to be obtained by adjustment of the appropriate switch. It is most important that the side-tone unit shall be set to correspond with the type of emission for which the transmitter is adjusted.

R/T, local and remote control

72. The control circuits concerned in the transmission of R/T, in addition to the transmitter switching circuits already described, are shown in fig. 14. When local control is required, the local control line is plugged into the front socket on the relay panel, so that the various transmitter supplies, and the relay send-receive switch, are operated by the manual send-receive switch and filament tumbler switch. The microphone, which is fitted with a suitable plug, is plugged into a socket on the junction box. When the portable W/T station is in use the remote control extension line is plugged into the front socket.

73. It is necessary to arrange for communication between the vehicle and the remote control station at all times, since the portable remote control station may be erected and manned, although not actually handling the traffic. When in local control, the remote control extension line is plugged into the side socket on the relay panel; with the exception of the two " telephone " points, all the points on the side socket are entirely isolated. The telephone points on this socket are connected in parallel with the telephone points on the front socket. It follows therefore that, provided the remote control extension line is plugged into one of the sockets, communication between the two stations by field telephone is always possible. It is of course necessary to ensure that the remote control extension line itself is plugged into the 10-point socket on the drum after the remote control cable has been laid out, and that the far end of this cable is plugged into the appropriate socket on the portable station.

74. When using either local or remote operation, the sockets A B on the transmitter are interconnected externally by means of a short link fitted with suitable plugs. It will be observed that the transmitter impedance matching unit has been shown in fig. 14, although it does not enter into the action of the transmitter unless the R/T line link unit is in use. The disposition of the plug on the end of the lead marked " a " should be noted. This lead and plug are provided for connecting the impedance matching unit to the transmitter as explained later. When the R/T line link unit is not in use, however, the plug on lead " a " is inserted into a socket fitted to a very short length of cable, which is connected to terminal 3 on the impedance matching unit, so that in addition to providing a suitable stowage for the lead " a " the internal circuit between terminals 3 and 6 is short-circuited. When not plugged into the transmitter, the lead " a " should always be plugged into the stowage socket and not left lying idle.

R/T, local control, land line operation

75. Provision is made for R/T operation of the transmitter and receiver from any point in the G.P.O. telephone system. By operation, it is intended to imply merely the transmission and reception of messages, and it must be particularly noted that when used in this manner the actual control of the W/T station is performed by an operator in the vehicle, *all switching circuits being arranged for local control as previously described.* The vehicle is connected to the nearest G.P.O. telephone exchange, a drum of D3 telephone cable being carried in the vehicle in order to connect the vehicle to a convenient G.P.O. telephone line. The combination of D3 cable and G.P.O. telephone line will subsequently be referred to as the land line. The G.P.O. officials concerned will co-operate so far as the requirements of the telephone service are required. They will also furnish information as to the type of exchange to which connection is made, i.e. Automatic, Central Battery (C.B.), etc. When laid, the D3 telephone cable is connected to the terminals A and B upon a terminal block which is situated underneath the bench on the off side of the vehicle.

76. The connections between the land line and the radio installation are made via the R/T line link unit. The external connections of this instrument are shown in fig. 15. All the external wiring is carried to a terminal strip on the lower inside edge of the panel. The " earth " terminal of the R/T line link unit must be directly earthed, and not connected merely to the radio-frequency earth (i.e. chassis). A brass earth pin fitted with a suitable terminal is provided for this purpose.

77. In connecting the land line to the transmitter or receiver it is necessary to match the impedance of the land line to the input impedance of the modulator valve, or to the impedance of the output valve of the receiver, as the case may be. The transmitter and receiver impedance matching units are incorporated in the installation to meet these requirements. The transmitter impedance matching unit embodies an iron-core transformer of suitable turns ratio, which is substituted for the microphone transformer of the transmitter T.1090 when land line operation is required. Referring to fig. 15, the substitution is made as follows. The short connecting link between the sockets A and B of the transmitter is removed. The plug on the lead " a " is then inserted into socket A on the transmitter. The operative receiver (which may be either the R.1084 or the R.1094) and also the receiver impedance matching unit, are plugged into the telephone connecting box. The land line is then connected to the receiver or transmitter as requisite by the operation of a two-way key switch on the R/T line link unit.

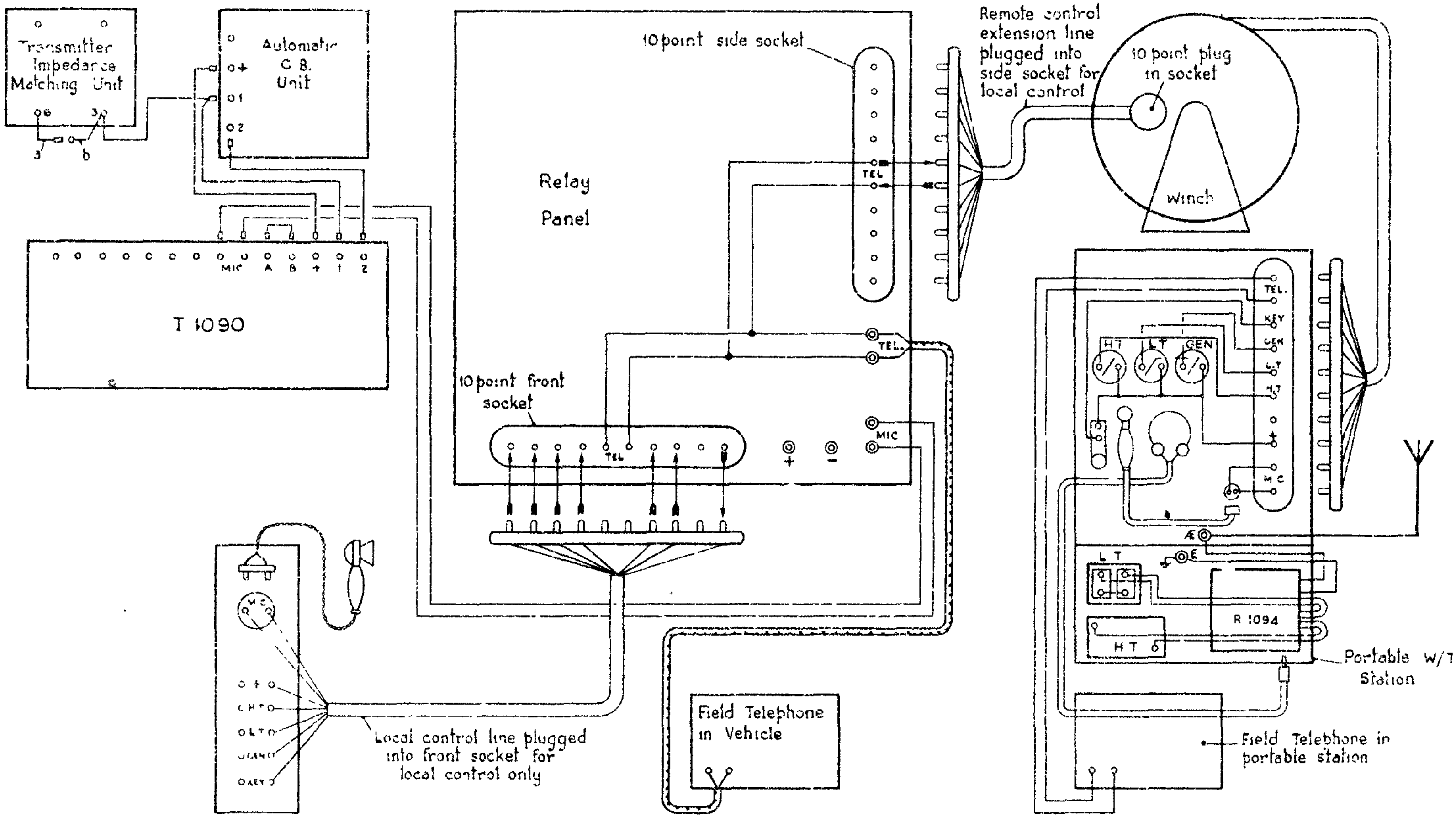

FIG. 14, R/T OPERATION, LOCAL CONTROL, AND PORTABLE W/T STATION.

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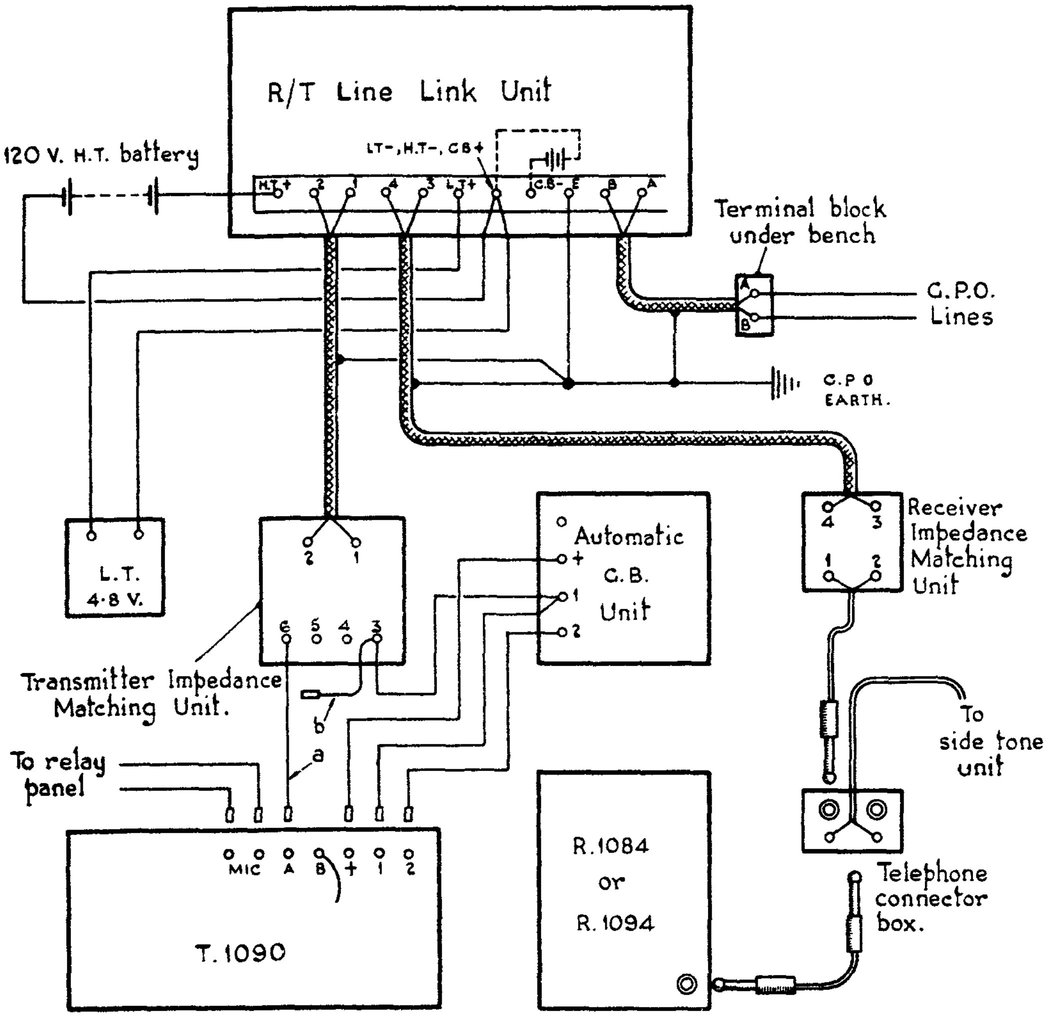


FIG. 15, R/T OPERATION, LAND LINE.

R/T line link unit

78. A theoretical circuit diagram of this unit is given in fig. 16. It is necessary to incorporate a certain degree of amplification between the land line and the R/T installation proper, during both reception and transmission, and this is provided by an amplifying unit contained in the R/T line link unit. The input terminals of the transmitter impedance matching unit are connected to the terminals 3, 4 (RETURN OUT), and the land line (via various switches) to terminals 7, 8, (RETURN IN) of the amplifying unit. During transmission, a single stage of amplification operates between the RETURN IN and RETURN OUT terminals, the gain of this stage being adjustable. During reception a similar stage of amplification operates between the terminals 1, 2 (GO IN) and the terminals 5, 6 (GO OUT) of the amplifying unit, the GO IN terminals being connected to the output terminals of the receiver impedance matching unit, and the GO OUT terminals to the land line via various switches. The land line is connected to the desired stage (GO or RETURN) by the two-way key switch previously referred to. This switch is engraved TRANS. and REC., and is one of the five key switches mounted upon the panel.

79. When a distant land-line operator is in R/T communication, the operator in the vehicle is called upon to operate two send-receive switches, namely the manual switch of the R/T installation proper, and the " transmit-receive " switch on the R/T line link unit ; it is therefore necessary for the vehicle operator to listen in to the traffic in both directions, operating these switches in accordance with the operating procedure. For this purpose, the operator is provided with a standard telephone exchange equipment, consisting of a breast-plate microphone and a headband carrying a single receiver ear-piece. This equipment, which is referred to as the breast set, is fitted with an instrument cord terminating in a combined microphone-telephone plug similar to that used in aircraft, and the operator's hands are entirely free to operate the various controls.

Gain controls

80. In order that the vehicle operator may speak to " radio ", " line ", or both, the breast-plate microphone is connected to the RETURN IN, i.e. land line side of the amplifying unit. The gain of the latter may be adjusted by means of the transmitting gain control to give sufficient depth of modulation when the distant land line operator is speaking. This control is situated on the upper left-hand corner of the R/T line link unit. The gain of the RETURN (i.e. transmitting) portion of the amplifying unit is adjusted to give a standard deflection on the decibel-meter, which is connected across the RETURN OUT terminals. This adjustment must be made while the distant land-line operator is speaking. The scale of the decibelmeter is calibrated, and the correct level is distinctly indicated by a coloured line.

81. Unless suitable precautions were taken, the speech level of the vehicle operator would probably over-modulate the transmitter, since his microphone voltages are amplified to the same extent as those due to the distant speaker. This possibility is avoided by reducing the sensitivity of the breast-plate microphone, when the vehicle operator is speaking to " radio ". This is accomplished by deriving the microphone voltage from a 200-ohm potentiometer, which is connected across the L.T. battery of the R/T line link unit. The variable tapping on this potentiometer may be adjusted by means of a slotted head which is flush with the front of the panel and may be set in the correct position with a screwdriver. The panel adjacent to the adjusting head is engraved LOCAL SPEECH TO RADIO TRANSMITTER LEVEL CONTROL. When once adjusted, this control should seldom require alteration.

82. During R/T reception, the gain of the GO (i.e. receiving) portion of the amplifying unit is adjusted to meet the requirements of the distant land-line operator. As the vehicle operator's breast set receiver is connected to the GO OUT side, the speech level therein will assist in this respect, but it must be remembered that the land line may have an attenuation of the order of one signal strength on the arbitrary " audibility scale ", for every three miles of line. If the line is more than 50 miles in length, however, it will probably include a G.P.O. repeater at some point, and the amplifying unit will give sufficient volume at the distant end if operated with maximum gain, or even less.

83. The L.T. supply for the R/T line link unit is derived from a 4·8-volt 10 Ah. alkaline battery consisting of two 2·4-volt units connected in series. These units are individually interchangeable with the unit supplied for use with the wavemeter W.39A (*see* paragraph 118). The H.T. supply is derived from a 120-volt dry battery. Both L.T. and H.T. batteries are housed in the battery case beneath the R/T line link unit. The grid bias is derived from a 9-volt dry battery which is fitted inside the R/T line link unit. The normal grid bias is 7·5 volts.

Operating controls

84. Referring to fig. 16, the operating controls of the R/T line link unit are as follows. A simple two-pole cam-operated switch, type 76, engraved ON-OFF, completes the H.T.+ and L.T.+ supplies to the amplifying unit. The L.T. battery also supplies the current for the breastplate microphone. Two three-position key switches, type 145, are mounted on the panel. The three positions of the first are engraved CALL AND SPEAK, MONITOR, and RECEIVE RING, the latter being the normal position when the land line is connected. The positions of the second switch are engraved LINE, LINE TO RADIO, and RADIO. This switch controls the connections of the breast set ; when the first switch is set to RECEIVE RING, the position of the second is immaterial.

85. The other controls are three two-position key switches, type 77. The first is engraved TRANS and REC ; it switches the line from the GO OUT to the RETURN IN terminals of the amplifying unit as already explained. The second switch is engraved HOLD LINE at the depressed position, and is depressed only when it is required to hold the line while making radio adjustments, etc. The third two-position key switch is provided for use when the vehicle is connected to a particular type of exchange working on what is known as the Common Battery Signalling, or C.B.S. system. The depressed position is engraved C.B.S. ONLY and the switch is maintained in this position during the whole period in which the vehicle is connected to an exchange of this type.

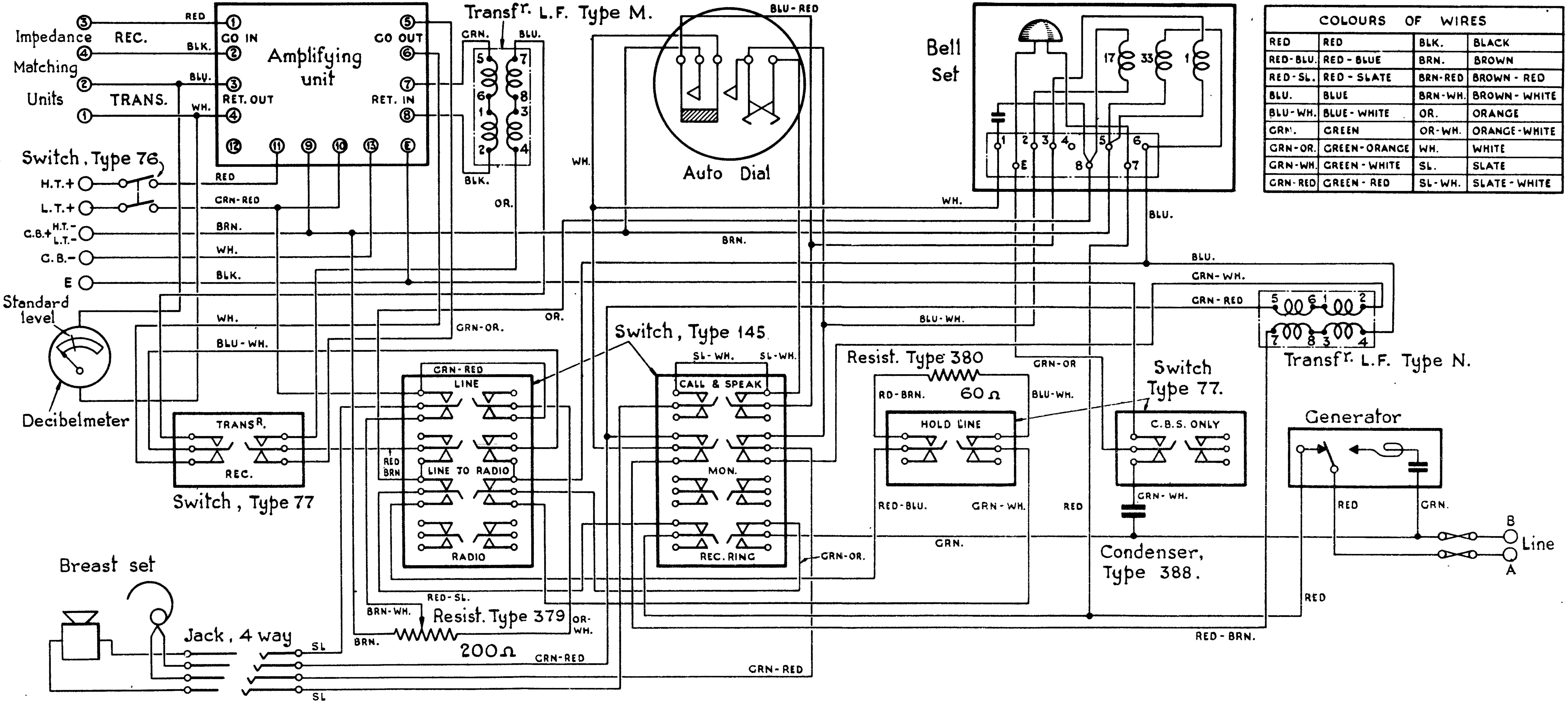
Calling devices

86. A manually-operated magneto generator is fitted for the purpose of calling an exchange in which this method of ringing is employed, and a standard type of automatic dial for calling when connected to an automatic exchange. C.B. and C.B.S. exchanges are called automatically when the appropriate key switch is moved to CALL AND SPEAK.

Action of control switches

87. The connections established by the various combinations of switches are shown in fig. 17. Referring to the first and second diagrams it will be observed that when connected to a C.B. exchange, the bell in the R/T line link unit is connected, in series with a D.C. blocking condenser, across the lines A and B, whereas when connected to a C.B.S. exchange, the bell is connected between line A and earth. This change is effected by the C.B.S. ONLY switch. When the initial connection is made to an exchange of this type it is important to ensure that the lines A and B are connected to the correct terminals and not reversely. The correct polarity may be ascertained by arranging for the exchange to call the vehicle, the correct switches being previously depressed. The ring will be received only if the lines are properly connected. A linesman will generally be in attendance for the purpose of connecting the D3 cable to the overhead (or possibly underground) G.P.O. line and where the polarity is of consequence, he will be able to identify the distant ends A and B of the D3 lines. The identification at the vehicle end is then a matter of simple continuity testing.

88. The remainder of the circuits shown in fig. 17 will now be briefly discussed. The third diagram (" call on magneto ") requires no comment. When calling on automatic dial, the three iron-core coils (17, 33 and 1 of fig. 16) are connected across the line, the breast set receiver and blocking condenser being in parallel with one of them, and the breast set microphone, with the L.T. battery in series, in parallel with another. All three coils are wound on the same core and



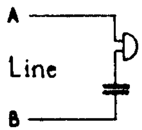
COLOURS	OF	WIRES	
RED	RED	BLK.	BLACK
RED-BLU.	RED - BLUE	BRN.	BROWN
RED-SL.	RED - SLATE	BRN-RED	BROWN - RED
BLU.	BLUE	BRN-WH.	BROWN - WHITE
BLU-WH.	BLUE - WHITE	OR.	ORANGE
GRN.	GREEN	OR-WH.	ORANGE-WHITE
GRN-OR.	GREEN-ORANGE	WH.	WHITE
GRN-WH.	GREEN - WHITE	SL.	SLATE
GRN-RED	GREEN - RED	SL-WH.	SLATE - WHITE

FIG. 16 R/T LINE LINK UNIT, CIRCUIT DIAGRAM.

Receive ring

Keys - "Rec ring"

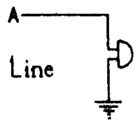
"C.B.S. only" normal



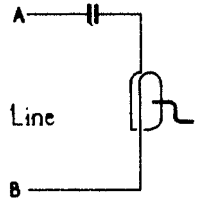
Receive ring on C.B.S.

Keys:- "Rec ring"

"C.B.S. only" depressed



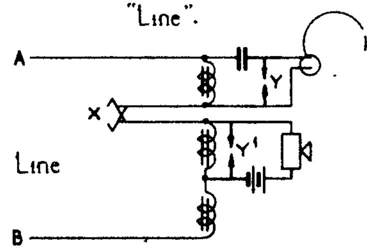
Call on magneto



Call on automatic dial

Keys:- "Call and speak"

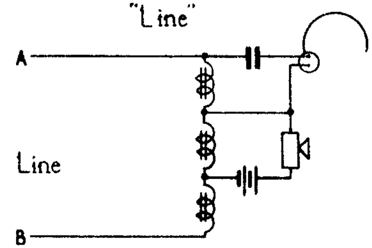
"Line".

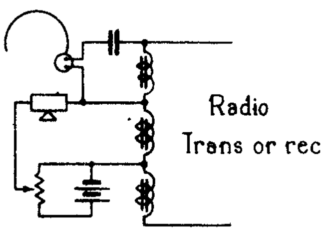


Speak to line

Keys:- "Call and speak"

"Line"



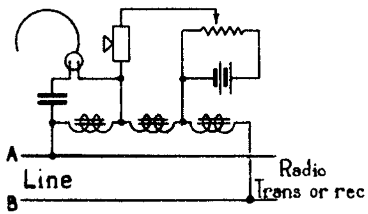


Speak to radio

Keys:- "Call and speak"

"Radio"

"Trans" or "rec"

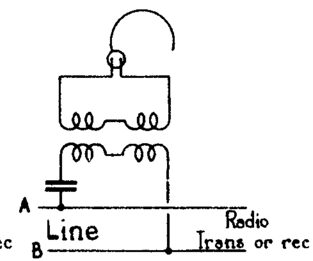


Speak to line and radio

Keys:- "Call and speak"

"Line to radio"

"Trans" or "rec"

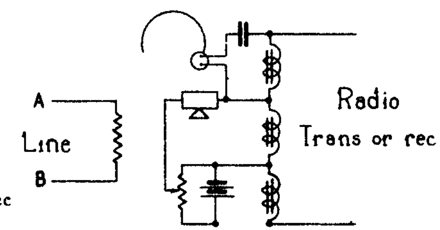


Monitor on line to radio

Keys:- "Mon"

"Line to radio"

"Trans" or "rec"



Hold line and speak to radio

Keys:- "Call and speak"

"Radio"

"Hold line depressed"

therefore constitute a three-winding transformer. The main contacts X of the automatic dial interrupt the circuit intermittently in a certain manner according to the number dialled. At the same time subsidiary contacts, Y, short-circuit the telephone receiver in order to eliminate the loud clicks which would otherwise be heard. A similar pair of contacts Y^1 short-circuits the microphone coil and prevent the microphone from becoming packed by heavy induced currents. As shown in the fifth diagram, the same circuit is operative during a two-way conversation on the line, except that as the calling dial is stationary, no interruptions take place. The same switch positions, viz. CALL AND SPEAK and LINE, are therefore applicable in both cases. It will be noted that when speaking to line, the full voltage of the L.T. battery is applied to the microphone circuit.

89. The sixth diagram shows the circuit used for speaking to, or receiving from, radio. The switch positions are CALL AND SPEAK, RADIO, and TRANS or REC as the case may be. The circuit is substantially as in the two previous instances, the only difference being the introduction of the attenuating potentiometer into the microphone circuit.

90. When it is required to speak to line and radio at the same time, the appropriate switch is moved to the LINE TO RADIO position, the circuit being then as shown in the seventh diagram. The line is connected directly to the GO or RETURN side of the amplifying unit by the TRANS—REC switch. When the latter is at TRANS, either the land-line operator or the vehicle operator may speak to radio, while if at REC. either the distant R/T radio operator or the vehicle operator may speak to line.

91. When the vehicle operator requires merely to listen to the two-way traffic without speaking, the appropriate three-position switch is moved from CALL AND SPEAK to MONITOR, the other remaining at LINE TO RADIO. The breast set microphone is then disconnected and the breast set telephone is connected to the secondary winding of an L/F transformer type N, the primary winding of which is connected, in series with a blocking condenser, across the lines. The circuit is therefore as shown in the eighth diagram.

92. The connections in the ninth diagram are exactly the same as in the sixth, but in addition, the lines A and B are connected to a resistance of about 60 ohms, i.e. equivalent to the resistance of the speaking-listening circuit. The substitution of this resistance therefore holds the line circuit closed and keeps alight the supervisory lamps in the exchange, while the vehicle operator is connected only to radio.

93. The exact procedure to be used in communication is a matter for Signals organization, but in outline is somewhat as follows :—Assuming that the vehicle is connected to a C.B. exchange, the R/T line link unit would normally be switched off, and the appropriate switch set to RECEIVE RING. On receiving a ring, the operator switches on the R/T line link unit, plugs in his breast set, moves one three-position switch to CALL AND SPEAK and the other to LINE. He is then " through " to the exchange who will connect him to the caller. The latter indicates the radio station with which communication is required. If radio communication is known to be easy to establish, the operator may depress the HOLD LINE key, place the second three-position switch to RADIO, and establish R/T communication, operating the manual send-receive switch and the TRANS–REC switch on the R/T line link unit, as necessary.

94. After telling the distant radio operator to stand by for a call, he is ready to put the two stations into communication. To do this he puts the first three-position switch to CALL AND SPEAK, the second three-position switch to LINE, and restores the HOLD LINE switch to normal. He may now inform the caller that the distant radio operator is listening, and then set the respective switches to LINE to RADIO, MONITOR and TRANSMIT, also moving the manual send-receive switch to SEND. The distant land-line operator is now " through " to radio, and the vehicle operator is monitoring, i.e. listening in to the conversation, in order that he may switch from " send " to " receive " as necessary. If the vehicle operator finds it necessary to break in on the conversation, he moves the appropriate switch from MONITOR to CALL AND SPEAK, and speaks either to the distant land-line operator (send-receive switches at RECEIVE) or to the distant radio operator and the land-line operator simultaneously (send-receive switches at SEND) as necessary.

Cable-laying apparatus

95. The cable-laying apparatus stows underneath the bench at the rear off side, but may be drawn forward for the purpose of handling the cable, as shown in fig. 18. In both stowage and working positions, the apparatus is secured to fixing plates on the floor of the vehicle by means of screws fitted with knurled heads and coiled springs, the latter lifting the screws clear of the floor as they are unscrewed. In the photograph the screw (1) is holding the apparatus in

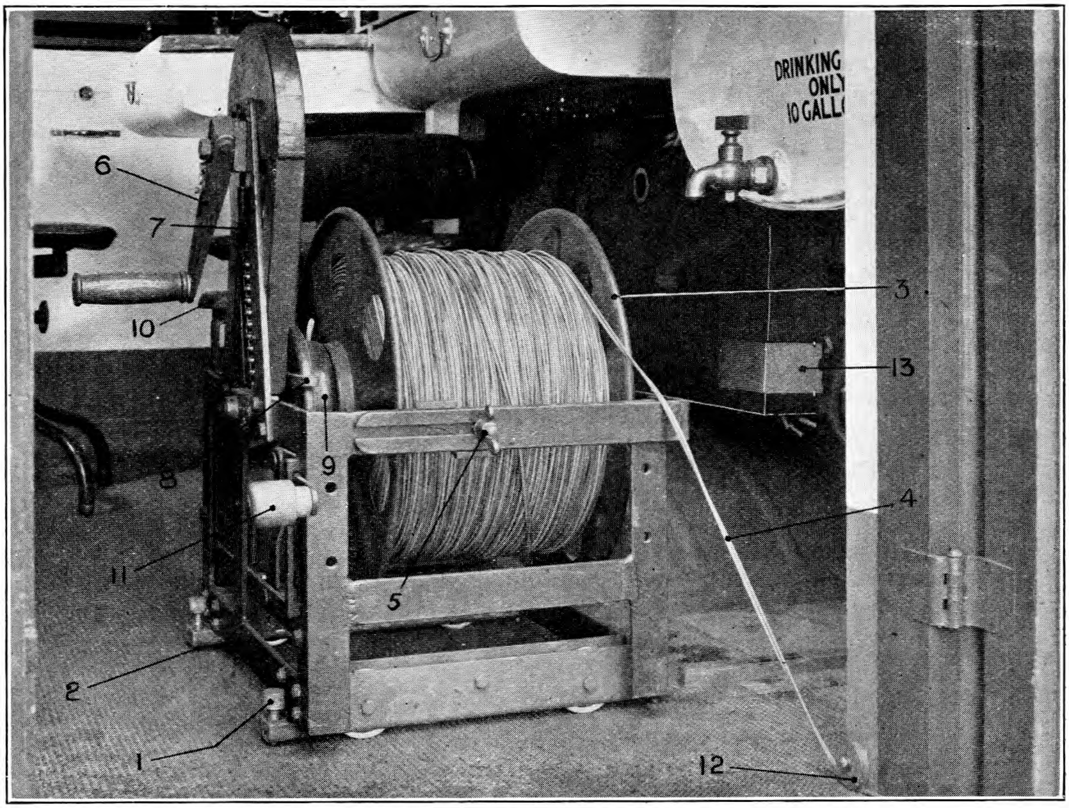


FIG. 18. Cable-laying apparatus.

position while the screw (2) is held clear of the floor by its spring. The cable drum (3) carries 880 yards of telephone line consisting of two parts of D3. Mk. VI cable. The drum has a rectangular hole along its axis, fitting the winding spindle of the cable-laying apparatus. The drum is easily removed by releasing two wing nuts (5), one of which is shown, and sliding the right hand portion of the cradle to the right.

96. The winding spindle is rotated by a handle (6) through a chain drive, four turns of the drum being obtained by a single revolution of the handle. The handle is reversible and is seen in the stowage position in fig. 5. Reverting to fig. 17, the tension of the driving chain may be adjusted by means of the screw (7) which is fitted with a lock-nut. The winding spindle is driven through a simple clutch operated by the short lever (8). When this lever is thrown upward and backward, the drum runs free, but may be controlled by means of a brake. The latter is of the internal expanding type, the exterior of the brake drum (9) being clearly seen in the photograph. The brake is operated by either of two handles (10), (11), that on the fore side of the winch being

conveniently situated for operation from the interior, and the other easily accessible from the ground. The small fibre disc (12) which is mounted eccentrically on the off side door post, is used to grip the cable after the required amount has been run off the drum.

97. Before the vehicle is first put into service, it is advisable to test through each of the two lengths of D3 cable, identifying each end by a suitable mark. This will greatly assist in connecting up to the line terminal block and the terminal pole of the G.P.O. line, if the exchange to be used is of the C.B.S. type.

Portable W/T station

98. The portable W/T station is fitted with a mounting board for the receiver R.1094, allowing the latter to be readily installed in either the vehicle or the portable station. The ancillary equipment includes a 70 ampere-hour 2·4 volt alkaline battery for L.T. supply, a 120-volt dry battery for H.T. supply, and one pair of telephones complete with headband, instrument cord, and telephone plug. The remote control equipment consists of a single tumbler switch for H.T. control and a pair of interconnected tumbler switches for generator and L.T. supply control. A hand-press microphone, type B, is fitted for R/T transmission, and a morse key, type F, for W/T transmission. Communciation is maintained with the vehicle by means of a field telephone as already explained. The 10-point socket for connecting up the remote control cable is situated on the outside of the case in which the above components are assembled. A Mark V aircraft watch is carried inside the case. A waterproof canvas cover is provided to protect the equipment during inclement weather, and an angle frame hinged in the lid forms a top support when the case is open for use. A roll-up flap in front allows access for operation.

99. Fig. 19 shows the portable station connected to the vehicle by the remote control cable, and with mast erected. The 30-ft. stainless steel telescopic mast is fitted with two sets of guys which are secured to four pickets. When not in use the guys are stowed in the front locker underneath the lower bunk, and the mast in a tube running along the chassis on the " off " side, while the pickets are stowed in the off side of the petrol-electric compartment. The aerial is attached to the top of the mast by an insulator, type 9, and usually consists of a single wire 40 ft. long or less (depending upon the frequency band to be received) sloping upwards from the station at an angle of about 60°. The lower insulator, type 9, is attached to a length of kite cord, and may be anchored by means of a spare picket. A copper gauze earth mat is used as a receiving earth. When not in use it is stowed in the off side of the petrol-electric compartment. When laying out the remote control cable great care must be taken to pay it off the drum only as fast as it is being laid ; the drum must be controlled so that it never runs free, otherwise the cable may be damaged. On no account must the cable be unwound by pulling it off the drum.

Field telephones

100. Referring to fig. 6, it will be seen that in the vehicle the field telephone is contained in a box which is secured in its stowage place by a strap. When in use, the box is opened and the telephone drawn forward so that the hand set may be lifted from the cradle. The telephone is connected to the relay panel by a screened twin cable, which must be disconnected before returning the telephone to the stowage position. The field telephone in the portable W/T station is precisely similar to that shown in fig. 6 but is held in position by means of two spring clips, and is connected to the 10-point socket by a pair of leads carried on cleats, which are disconnected from the telephone when the latter is in the stowage position.

101. The field telephone is held in its box by a spring clip in the bottom of the box. This clip is designed to hold the telephone firmly either when pushed right back into the box (stowage position) or when drawn forward into the working position. To remove the telephone completely from the box, this clip must be held down by a knife blade or similar tool.

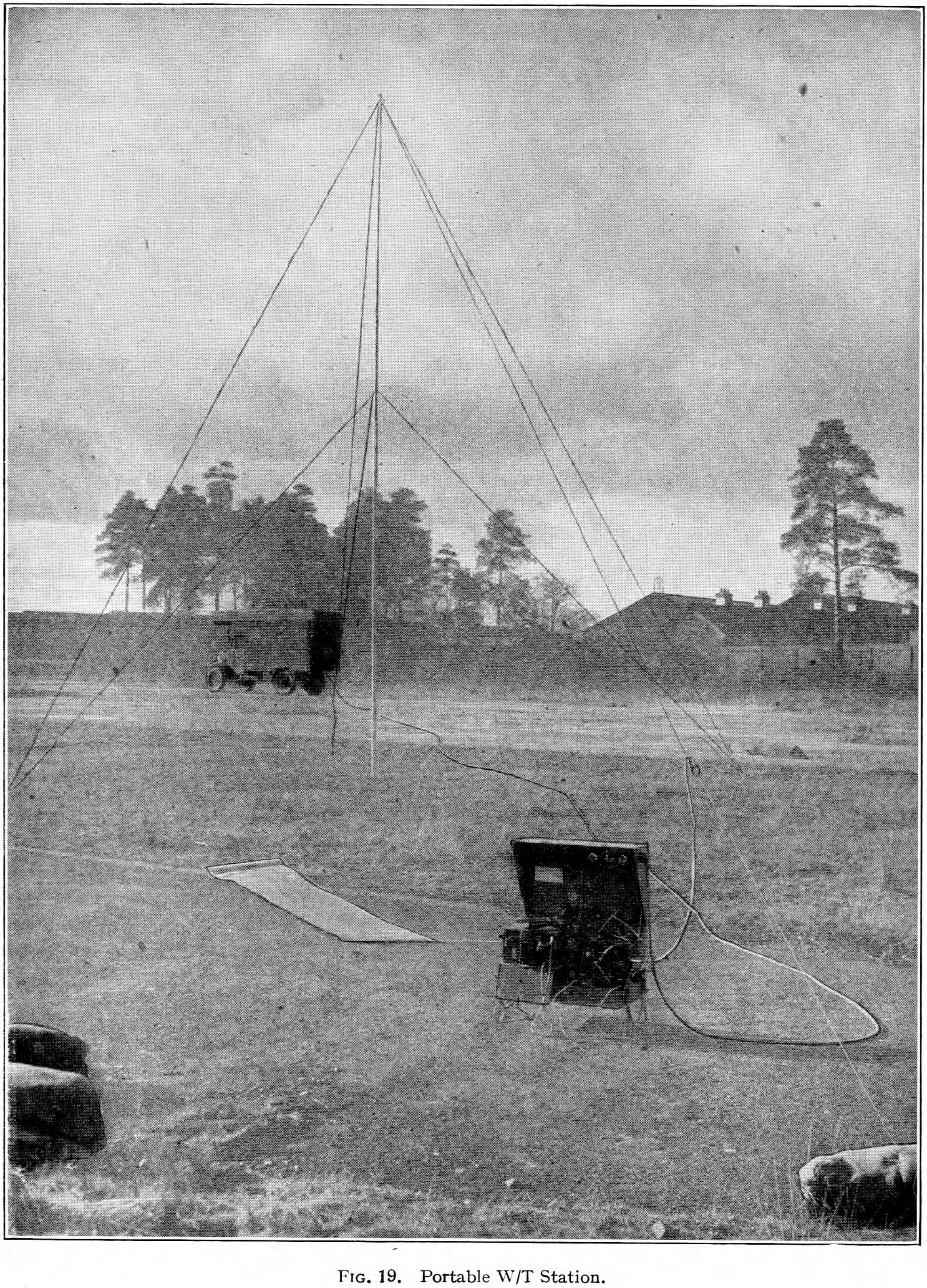


FIG. 19. Portable W/T Station.

102. The telephone contains its own speaking battery, which consists of two dry cells. Special cells, dry, X. Mark II (Stores Ref. 5A/1962) are supplied for this purpose. To insert the battery, withdraw the instrument completely and remove the hand set from the cradle. The top cover of the instrument, carrying the bell, is then easily lifted by releasing two screws fitted with knurled heads. A diagram showing the correct positions of the cells is pasted inside the lid. The cells must be inserted correctly, otherwise the leads may not reach the terminals.

103. The telephone is fitted with a magneto for calling ; its operation actuates a polarized bell at the distant station. This is the normal method of ringing, but a buzzer call is also provided to attract attention when a constant listening watch is being maintained on the field telephone.

BATTERY CHARGING ARRANGEMENTS

Petrol-electric charging set

104. The batteries are charged by a petrol-electric charging set, type D (Stores Ref. 42L/1). This consists of a 1260-watt, 35-volt shunt-wound D.C. generator driven by an air-cooled horizontally-opposed twin-cylinder engine having a total capacity of approximately 296 c.c. The normal speed is approximately 2,000 r.p.m. Lubrication is provided by a combined pressure and scavenging pump, the normal oil pressure at the gauge connection being 20 lb. per sq. in. The engine is fitted with a detachable starting handle, but when warm it may be started by electrical means as described later. An earthing switch is fitted on the contact breaker cover of the magneto, for the purpose of stopping the engine. This switch is operated from the charging switchboard by a bowden wire control.

105. The normal speed is controlled by a centrifugal governor driven from the front end of the crankshaft ; the controlled speed can, however, be rapidly adjusted for slow running by rotating a knurled knob. The fuel is carried in a tank attached to the framework over the engine, the capacity of the tank being 1½ gallons. The silencer is connected to the engine by a length of flexible tubing. The timing of the magneto is fixed in the most suitable position for continuous running at full load. The sparking plugs are fitted with screening cowls and the whole of the ignition wiring is completely screened in order to eliminate interference with radio reception.

106. Two knobs are provided for speed adjustment. The normal speed control is obtained by the rotation of a small knurled nut just above the carburettor. To increase the normal speed, rotate this nut in the counter-clockwise direction and *vice versa.* The larger knurled knob underneath the front end of the crankshaft is the slow-running control. Full slow running (approximately 800 r.p.m.) is obtained by turning the knob to the extreme right (facing starting handle) and *vice versa.* The total range of movement is 180° and a ball and spring locking device is provided at each limiting position of the knob.

107. The charging set is stowed in the petrol-electric compartment and the generator is easily accessible from the interior door, while access to the petrol engine is obtained by the near side exterior door. When in use, the charging set may be partly withdrawn, as shown in fig. 20. It is carried upon an aluminium bedplate (1) which is supported by a base frame (2). This frame slides over the floor, the weight being partly supported by a steel tube which prevents side motion. When in the stowage position the frame is secured by four hinged bolts (3) fitted with wing nuts. Only one of these bolts can be seen in the photograph. It is necessary to withdraw the charging set to the position shown in order to fill the fuel tank (4). The charging set must be clamped by all four of the hinged bolts before moving the vehicle. When stowing, care must be taken that the generator cable is not trapped.

108. The magneto (5) with the bowden cable control (6) for the stopping switch is mounted on the front of the engine. The starting handle (7) may be detached, or secured in place by a strap as shown. An air filter (8) is fitted. The air strangler (9) is fitted immediately below the air filter, and is closed by moving the lever upwards in the counter-clockwise direction. The carburettor (12) is also visible in the photograph.

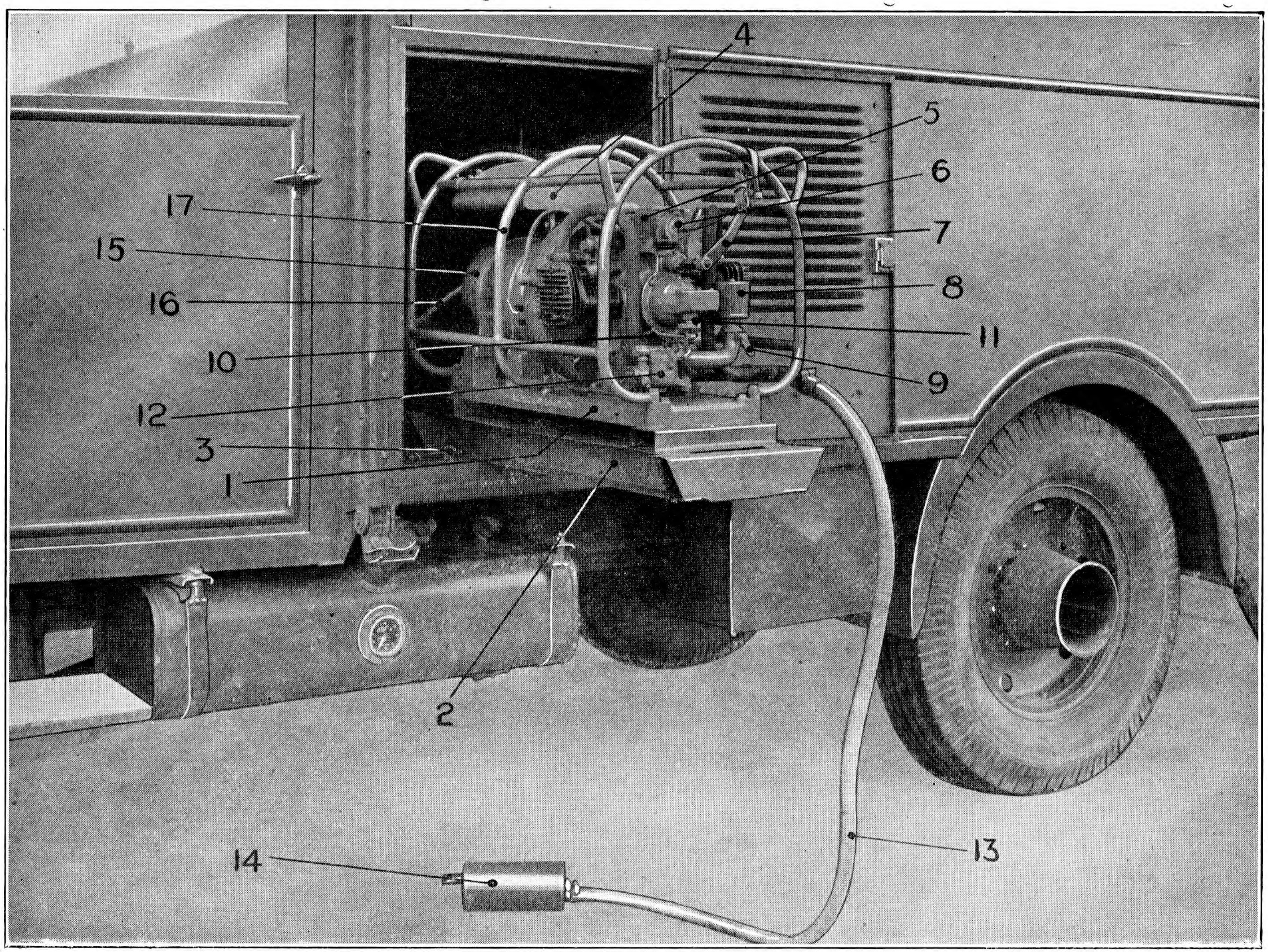


FIG. 20. Petrol-electric charging set

109. The two-speed controls are shown at (10) and (11). The former is the normal speed control, and the latter the slow-running control.

110. The flexible exhaust pipe (13) is connected to the engine by an elbow joint and can only be connected or disconnected when the charging set is sufficiently withdrawn. The exhaust pipe is fitted with a silencer (14). The generator (15) runs at engine speed, and although fully enclosed is ventilated in such a manner as to be suitable for service in tropical climates. The armature shaft runs in ball bearings. The latter are packed with a suitable lubricant, and must not be lubricated with oil or grease, otherwise the insulation of the armature windings may be damaged. The generator windings are brought to a special Niphan 4-point socket which is provided with a captive screw cap, and are connected to the radio interference suppressor, type C, by a length of screened 4-core cable (16) terminating, at the generator end, in the corresponding type of Niphan plug. The latter is secured in position by a guard ring.

111. The framework (17) which supports the fuel tank is sufficiently robust to take the weight of the whole assembly, and is fitted with handgrips for ease of transport.

112. To start the engine by hand, turn on fuel supply, flood carburettor, but not excessively, and close the air strangler lever on the air filter elbow. Ensuring that the ignition switch on the switchboard is in the " on " position, fit the starting handle to the shaft and engage dog with pin by pushing the handle in and so compressing the spring. Rotate handle smartly in the clockwise direction. When starting a warm engine it should not be necessary to close the strangler or to flood the carburettor. If warm starting is difficult, it is preferable to turn the slow-running control knob to the right as far as possible, when the engine will probably start easily.

Switchboard

113. The charging switchboard carries a four-point socket (into which the plug termination of the four-core cable from the charging set is normally inserted), a main switch, main fuse, accumulator cut-out, field regulator for regulating the voltage of the generator, and the starting switch for the charging set. In addition, five charging circuits are provided, each of which has its own fuse and ammeter. Numbers 2 to 5 circuits are also fitted with rheostats, and connection is made to the batteries to be charged by means of double-pole rotary switches operated by lozenge-shaped handles on the lower part of the switchboard. Number 1 circuit is fitted with a single-pole switch only. The terminal voltage of any battery, on charge, may be determined by a voltmeter which is fitted with a five-point switch having an off position. The correct fuses are :—No. 1, 40 amperes ; Nos. 2, 3 and 4, 25 amperes ; No. 5, 5 amperes.

114. Fig. 21 is a theoretical diagram of the charging arrangements. The generator is connected to the charging board, via the radio interference suppressor, type C, by the four-point plug and socket previously mentioned. It will be observed that the generator has two field windings, one having many turns and the other only a few. These are marked " shunt " and " starting " windings respectively in the diagram. When driven by the engine, the two windings are in series and connected across the armature so that the generator is in effect a simple shunt-wound one. The " starting " winding is provided to run the machine as a series-wound motor for the purpose of starting the engine, but only when the latter is warm. The power for this purpose is supplied by No. 1 battery (24 volts).

115. The action when starting is briefly as follows. The engine being at rest, and all charging switches to off, the main switch is first closed. Since the accumulator cut-out is unenergized, there is no circuit through the generator. On closing the " start " switch a circuit is completed from the positive terminal of No. 1 battery, through the starting winding and armature in series, and back to the negative terminal of the battery. The armature therefore starts to rotate, the direction of the starting winding being such that this rotation is that in which the engine runs. If the engine is correctly adjusted, it should start to fire, and the " start " switch should be immediately returned to its normal, i.e. " off " position.

116. When the generator is driven by the engine, the "shunt" and "starting" windings are energized in series, the magnetic field being maintained almost entirely by the ampere-turns of the shunt winding. As the voltage increases, the accumulator cut-out is energized by the voltage winding and closes the main charging circuit. The voltage of the generator may be adjusted within certain limits (24 to 35 volts approximately) by means of the field regulator. Any of the individual charging circuits may now be closed, and the charging current regulated by adjustment of the output voltage. The charging currents in circuits 2, 3, 4 and 5 may also be adjusted by means of the appropriate rheostat and ammeter.

117. Referring to fig. 21 it will be seen that a large double-pole tumbler switch is fitted in No. 2 charging circuit. This circuit may thus be used for charging either No. 2 battery or the vehicle battery. A similar switch is fitted in No. 3 circuit, by means of which numbers 3 and 4 batteries are connected in series for charging, and separated for discharge. It is most important that no attempt should be made to charge No. 2 battery while the transmitter is switched on, and that all charging circuits are broken before stopping the engine. The total charging current must not exceed 35 amperes. This allows for the simultaneous charging of the following combinations of batteries :—

(i) No. 1 circuit at 30 amperes, and No. 5 circuit at 5 amperes.

(ii) No. 2 circuit at 15 amperes, No. 3 circuit at 15 amperes, No. 5 circuit at 5 amperes.

(iii) No. 2 circuit at 15 amperes, No. 4 circuit at 15 amperes, No. 5 circuit at 5 amperes.

(iv) No. 3 circuit at 15 amperes, No. 4 circuit at 15 amperes, No. 5 circuit at 5 amperes.

118. The numbered batteries are charged *in situ*, but a special arrangement is provided for charging miscellaneous batteries. This is referred to as the accumulator charging case and consists of a teak crate which is arranged to accommodate the following batteries.

(i) One battery of 2 cells, 2·4 volts, 70 Ah. (spare L.T. for portable W/T station), which is charged from No. 4 circuit.

(ii) Two batteries of 2 cells each, 2·4 volts, 10 Ah. (for wavemeter W.39.A and R/T line link unit).

(iii) One battery of 2 cells, 2·4 volts, 7 Ah. (for wavemeters W.69 or W.1095).

(iv) One battery of 2 cells, 2·4 volts, 3 Ah. (for modulation indicator).

The batteries enumerated under (ii), (iii) and (iv) are charged from No. 5 circuit, the arrangement being shown in fig. 21. The three resistances there shown are of the vitreous type and are fitted on the back of the accumulator charging case. The latter item is installed in the off side of the petrol-electric compartment and is accessible by the off side door. The terminal block faces this door so that batteries are easily connected as required, while the resistances are accessible for inspection by the interior door.

ACCESSORIES AND STOWAGE

119. Three wavemeters are carried in the vehicle, namely types W.39A, W.69 and W.1095. The former is chiefly for use with the receivers and the two latter for use with the transmitter. The stowage positions of these wavemeters have already been indicated in figs. 4 and 5. The wavemeters W.69 and W.1095 are normally stowed complete with valve, H.T. battery and L.T. battery, the latter being of the 7 Ah. alkaline type, having a nominal voltage of 2·4. Special 5-ohm resistance units are therefore fitted.

120. The wavemeter W.39A is stowed with valves and 15-volt H.T. battery in position, but its L.T. battery, which is a 10 Ah. 2·4-volt alkaline accumulator, is carried in a separate wooden case which is fitted with a series resistance. The case has a stowage position on the floor, near the wavemeter and is locked in this position by a knurled nut. The modulation indicator stows near the wavemeter W.39A. It is fitted with a 5-ohm resistance unit in the L.T. circuit, the L.T. battery being a 3 Ah. 2·4-volt alkaline accumulator.

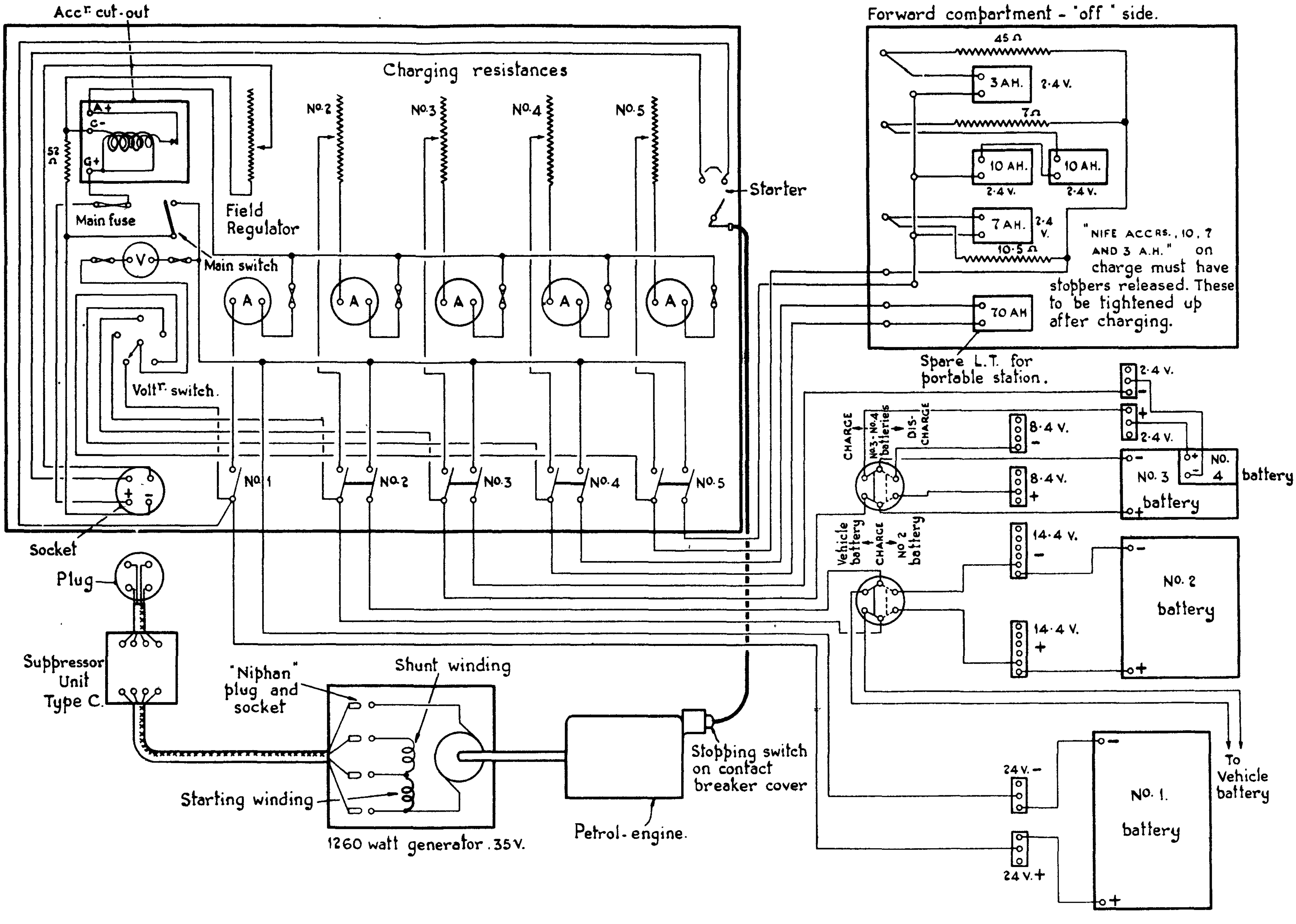


FIG. 21. BATTERY CHARGING ARRANGEMENTS

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121. Beneath the off side instrument bench are three drawers. The smaller one, at the fore end, accommodates the transmitter grid-bias battery box when not fitted on the front bench ready for use. The two drawers to the rear of this are adapted to form operating tables as already described, and are also used for the stowage of microphones, the breast set for use with the R/T line link unit, spare aerial insulators, and the receiving telephones. Hooks are also provided for hanging up the latter when temporarily out of use.

122. A set of remote controls is also carried, for use with the receiver R.1094 when the latter is fitted in the vehicle. These consist of a controller, which may be held in the left hand while the controls are manipulated with the right. The flexible control casing is four feet in length. This remote control system may be found useful when reception is performed while the vehicle is passing over rough ground, the chairs being secured in the stowage position and the operator sitting on the lower bunk. When not in use these controls are stowed in the rear drawer.

123. The upper of the two cupboards at the rear end of the off side is used for the stowage of various spares, including the following items :—Transit cases containing coils for the receiver R.1084, other than those stowed in the rack at the fore end ; the testing milliammeter and leads for use with this receiver, also in a transit case ; a testmeter, type B, for general testing ; transit cases containing spare valves for wavemeters ; signal office distinguishing lamps and flag ; spare valves for transmitter and receiver ; 4 message bags ; six ground strips ; cover for portable W/T station. Before moving the vehicle, it is absolutely necessary to see that the equipment in this cupboard is securely packed with felt, so that it will not be thrown about when travelling over rough country.

124. The following spares are carried in the front locker of the compartment beneath the lower bunk, viz., the guys for the portable mast ; reel carrying 500 yards of R4 aerial wire ; 1 length (8 yards) of balloon cord and 1 length (30 yards) of kite cord for the mast lifting apparatus; 1 length of kite cord for use with the receiving aerial at the portable station. As previously stated the larger (rear) locker under this bunk is allocated for the personal equipment of the crew and must not be used for indiscriminate stowage.

125. The stowage of the off side of the petrol-electric compartment is shown in fig. 22. The accumulator charging case (1) contains the accumulators specified in para. 118. Adjacent thereto, the following items are secured by leather straps to a flat board, viz., a pair of jointed crook-sticks (2), for use when laying D3 cable, lifting it over hedges, etc. ; an earth pin (3) for use as an earth for the R/T line link unit ; an earth mat (4) ; the portable W/T station (5). The latter is held in place by spring clips (6) secured with hexagon nuts (7). All the above items are clearly seen in the photograph. The pickets for the portable mast are held in a clamp (8) on the fore side of the compartment ; adjacent thereto is a mattock (9) for excavation purposes.

126. The portable telescopic mast is stowed in a tube running beneath the body of the vehicle and is easily removed through a pivoted cover at the rear end. A similar tube on the near side contains two 17-foot telegraph poles, each consisting of two sections. These tubes are closed at the fore ends by suitable stops.

127. Four 13-foot R.E. poles and six 14-foot lengths of wooden bracing are carried in brackets on the roof. The bracing is supplied in case it becomes necessary to repair the collapsible mast. Access to the roof is facilitated by the provision of a steel ladder, which is stowed beneath the body, between the two tubes referred to in the preceding paragraph.

128. A height gauge pole is provided for the purpose of ascertaining whether the vehicle will pass under any erection, e.g. a low telephone line or bridge. It consists of a pair of wooden battens clamped together at one end by a bolt and wing nut. The battens fold together and are normally stowed vertically on the near side of the rear end, outside the vehicle, by means of two lugs which engage with clips fitted to the body. They are secured in this position by a leather strap. To erect the height gauge the battens are removed from the vehicle, the wing nut eased back sufficiently to disengage the alignment device, and opened out until the alignment device

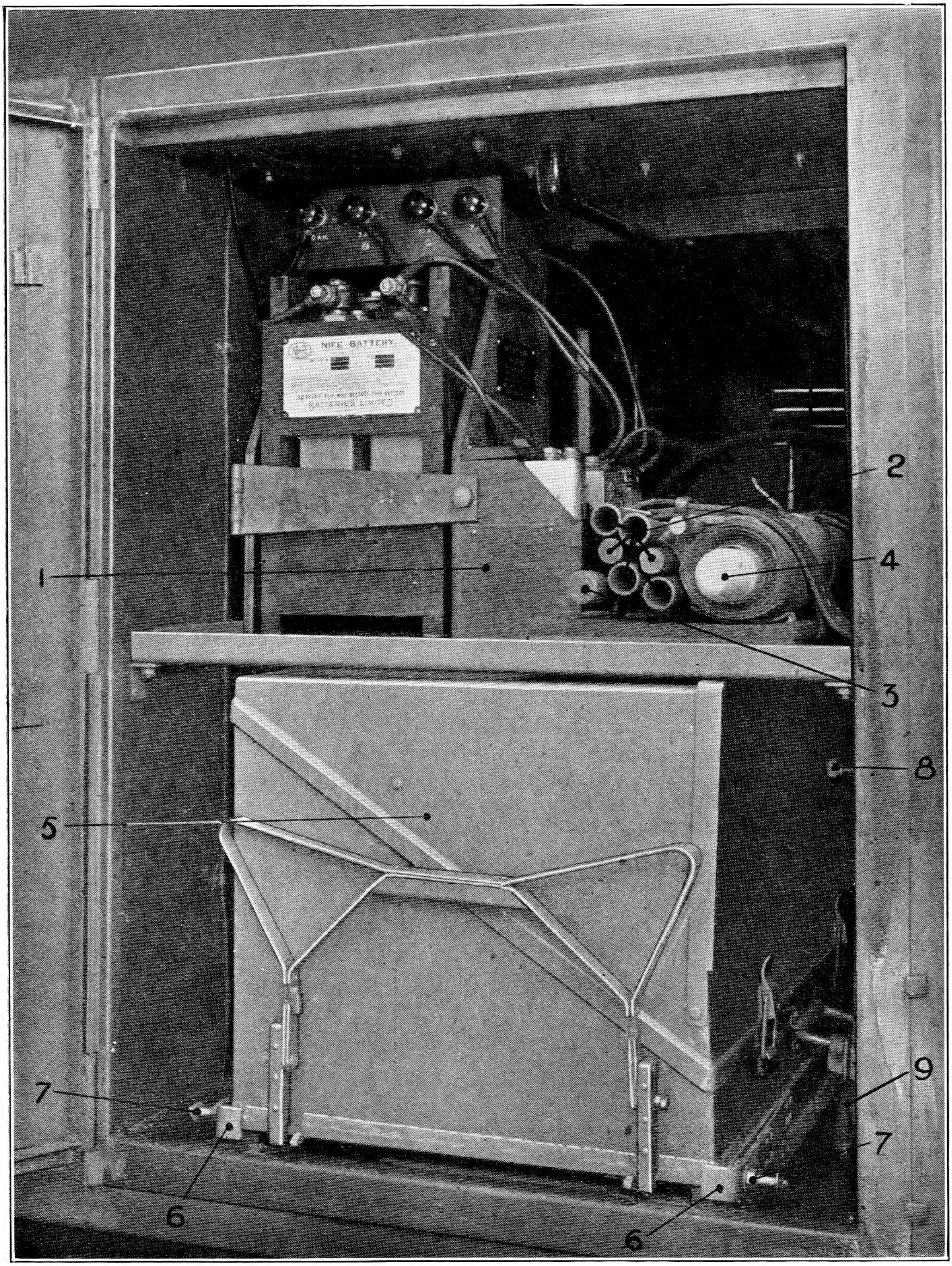

FIG. 22. Petrol-electric compartment, "off" side.

allows the two battens to close together, when the wing nut may be tightened up again. The alignment device consists of a grooved metal surround fitted on the hinged end of one batten, and a similar surround, but with a tongue instead of a groove, on the other.

129. The upper end of the height gauge pole is fitted with two metal plates with circular holes. The upper of the two plates is used for height measurement, the lower being disregarded. When the nature of the service requires, the signal office distinguishing flag (white over blue) is flown on the height gauge pole by day, and the signal office distinguishing lamps by night, the lamps being suspended (the white one above the blue) on the metal fittings. When used for this purpose the lugs on the pole are fitted into two clamps on the after end of the near side of the body.

130. A suitable socket and switch for connecting the signal office lamps is fitted in a covered box over the rear door, outside the vehicle. On no account must this socket be used for any appliance requiring a heavy current, e.g. a soldering iron. The two sockets situated near the interior door of the petrol-electric compartment are wired with heavy cable and are fitted with switches.. They may be used indiscriminately for the soldering iron or inspection lamp. The latter is stowed on the outside of the receiver range coil rack.

131. A steel locker is fitted beneath the body on each side of the vehicle. Each locker is sufficiently large to accommodate three 2-gallon cans, which may be used for the stowage of oil, water, and petrol as requisite.

BATTERIES

132. As already stated, No. 1 battery is fitted beneath the fore end of the lower bunk. It has a capacity of 125 ampere-hours and consists of four 2·4-volt units (Stores Ref. 5A/1937) and four 3·6-volt units (Stores Ref. 5A/1960) connected in series to give 24 volts. Each 2·4-volt unit comprises two alkaline cells fitted in a wooden case. Each pair of cells is connected in series by short connectors, and special long connectors are provided for joining the units. The 3·6-volt units are similar, but each comprises three cells.

133. No. 2 battery is stowed in the right-hand portion of the off side battery compartment and is made up of three 4·8-volt, 70 ampere-hour units (Stores Ref. 5A/1938). Each unit consists of four alkaline cells fitted in a wooden case, and connected in series by short connectors. Special long connectors are provided for joining the units. Numbers 3 and 4 batteries are contained in the left-hand portion of the off side battery compartment. No. 3 battery is made up of two 3·6-volt, 70 ampere-hour units (Stores Ref. 5A/1939), each consisting of three alkaline cells, connected in series with one cell of a similar unit, the remaining two of which are connected in series, and form No. 4 battery. The various units comprising No. 3 battery are connected in series by long and short connectors. Each of the above units is fitted with a pair of special terminal lugs, but in order to separate the single cell forming part of No. 3 battery from the two forming No. 4 battery, it is necessary to provide an additional pair of terminal lugs (Stores Ref. 10A/10378). If the 3·6-volt unit referred to is returned to store, these items must be detached and retained for connecting up the replacement unit.

134. If it is necessary to remove any unit of the above batteries for attention, care must be taken to insert the replacement in the same manner so that the connectors may be replaced without bending. It must be noted that the various long connectors are not interchangeable.

135. Certain of the miscellaneous batteries are normally stowed in the instruments for which they are provided, but provision is made for stowing two 2·4-volt 10 Ah. batteries, one 2·4-volt 7 Ah. battery, and one 2·4-volt 3 Ah. battery, in the accumulator charging case, even when they are not on charge. Each of the miscellaneous batteries consists of two alkaline cells permanently connected in series. They are not fitted in wooden boxes, but the 3 Ah. and 10 Ah. batteries are provided with rubber jackets.

PRECAUTIONS AND MAINTENANCE

136. The relevant Chapters of this Air Publication should be consulted with reference to the efficient working of the transmitter T.1090 and receivers R.1084 and R.1094. The commutators of the anode converter must be cleaned occasionally with a dry cloth ; a dirty commutator may set up considerable receiver noise. If an increased noise level is traced to the vehicle ignition ventilator fan, petrol-electric charging set or wind-screen wiper, a failure of the appropriate radio-interference suppressor, or of the screening thereof, is indicated.

137. On no account must transmission take place while the mast is fully lowered on to the roof, but reception may be performed in this condition, using either the main or the auxiliary aerial.

138. During normal handling of two-way traffic the transmitter filament supply should remain switched on in order to minimize frequency creep. When in remote control, this necessitates that the H.T. motor-generator is also kept running. Every effort must be made, however, to economize in battery power, and the transmitter L.T. supply and H.T. motor-generator should always be switched off when no immediate transmission is anticipated.

Power cables—risks

139. If it is necessary for the vehicle to pass below or approach within ten feet of any overhead power cable, the mast must be fully lowered. If this is not done there is considerable risk of damage and injury to personnel, not necessarily from direct contact with the power cable, but from " flash-over " from the cable to the aerial. Since the efficiency of reception may be considerably below normal when in the vicinity of such a line, the mast of the portable W/T station should be always sited as far as possible from any overhead line, power or otherwise, and in no case should any portion of the mast, guys or aerial, approach within ten feet.

Mast erection

140. When erecting the collapsible mast, the locking screw on the winch must be eased back, and the slack taken up. When the weight comes on the winch, proceed with caution in case one of the aerial leads may be foul. If any undue strain is felt, the mast should be examined before proceeding further. A foul lead-in is easily cleared by means of one of the crook-sticks. Fouling of an aerial lead during erection is not likely to occur if the mast is properly lowered on the previous occasion of use. On no account should it be allowed to collapse freely, but should be lowered slowly and carefully, keeping the winch well in check by hand.

141. The kite cord of the erecting gear should be frequently inspected so far as is possible without dismantling, and must be renewed if it shows signs of wear. It is important to observe that this cord is spliced to the balloon cord at such a point that the splice does not pass over any pulley. When the mast is erected, there is a considerable tension on this cord, and except in extreme urgency, it is inadvisable to move the vehicle without lowering the mast.

Charging set

142. The charging set must be inspected and attended to as laid down in the station Maintenance Orders. The chief points to receive attention are the cleanliness of the oil filter, renewal of lubricating oil in sump, cleanliness of petrol pipe, carburettor, air filter and crankcase breather pipe. Occasional decarbonizing of the engine is also necessary. The points of the sparking plugs must be cleaned periodically and afterwards set to the correct gap, which is 0·015 in.

143. To remove the oil filter, unscrew the hexagon-headed cap on the side of the crankcase under the left-hand cylinder. The filter may then be withdrawn by inserting a finger. It should

be cleaned with petrol only, taking great care not to perforate the gauze. Rags or cloth must never be used to clean the gauze. When replacing, see that the cap is screwed on tightly.

144. The oil may be withdrawn from the sump by means of a syringe, as no drain plug is provided. Before refilling, the sump should be washed out with a small quantity of lubricating oil. It should then be refilled with about one pint of the approved lubricating oil.

145. The fuel supply system is cleaned as follows. Unscrew the hexagon-headed filter screw from the carburettor end of the fuel pipe and withdraw the gauze sleeve. Clean the gauze sleeve and the filter screw with petrol. Open the tap on the fuel tank and allow a small quantity of petrol to flow through the tube to wash it out. The float chamber of the carburettor is removed by taking out two square-headed setscrews from the top of the float chamber cover, while holding the float chamber in the left hand. When the setscrews are removed the float chamber and the main jet stand will fall free and may be removed. The float should then be lifted out of the chamber. The pilot jet, which is of brass, is situated between the float chamber and the main jet on a level with the top of the float chamber. This should be removed. Next, proceed to remove the main jet cap by applying a suitable spanner to the upper hexagon. The float chamber petrol passage and the two jets may now be cleaned with petrol. Foreign matter may be removed from the jets by blowing, but on no account must any attempt be made to pass a piece of wire or similar body through the orifice.

146. After cleaning, the parts may be replaced in the following order :—Main jet, jet cap, pilot jet, float, float chamber to standing portion of carburettor, fuel pipe to carburettor (with filter screw and gauze sleeve), fuel pipe to tap union.

147. To renew the felt insert of the air filter, remove the round-headed screw from the top of the filter, take off the top cover and lift out the insert, replace by a new insert and reassemble in reverse order.

Tappet adjustment

148. The clearance between the head of each tappet and the foot of each valve is 0·003 in. measured when cold. Each pair of valves is enclosed in a metal cover, which is easily removed by slackening off a knurled screw. Each pair of tappets must be adjusted separately, with both valves closed. Before adjusting the clearance, see that both valves are seating properly, but observing that each tappet is capable of a slight longitudinal movement. Each tappet is provided with flats and may be held by means of a thin spanner, while the hexagon nut at the top of the tappet is slacked off. When the correct clearance has been obtained lock up the nuts on the tappets and recheck the clearance.

Failure to start

149. If the engine fails to start, and there is known to be sufficient fuel in the tank, the following possibilities should be investigated :—

(i) *Air lock in fuel system.* Remove the filter nut from the carburettor and allow a small quantity of petrol to run through the pipe. Replace the filter screw when the flow is satisfactory. A possible cause of the failure is a stoppage of the breathing hole in the filler cap of the fuel tank.

(ii) *Dirt in carburettor.* Clean as detailed in para. 145.

(iii) *Defective sparking plugs.* Clean plugs and set gap. If the engine still fails to fire with plugs of known efficiency, check the contacts in the magneto contact breaker with the points fully open. The gap should just admit a 0·012 in. feeler gauge. The points should be cleaned by drawing a piece of clean white paper between them. Clean cam ring with a clean cloth lightly moistened with petrol, and lubricate by wiping with a lightly oiled cloth, taking great care that no oil is deposited on the contact points.

(iv) *Lack of compression.* This may be due to insufficient tappet clearance, and is then remedied by readjusting the tappets. Test each cylinder head nut for tightness. All nuts should be equally tightened to prevent distortion of the cylinder head. The gasket may be defective and must then be replaced.

(v) *Dirt on valve seatings.* This defect will generally necessitate the removal of the valves and a thorough cleaning and re-seating.

Batteries

150. All members of the crew should be acquainted with the standing orders for the care and maintenance of alkaline accumulators, given on R.A.F. Form 480A. An abridgement of these orders will be provided on a card 16 in. square, for fitting inside the door of the upper stores cupboard. Special instructions will be promulgated, either on this card or elsewhere, regarding the first-aid treatment of alkaline burns received while the vehicle is on isolated service.

151. It is most important to maintain the various batteries in a well-charged condition, otherwise correct functioning cannot be expected. For example, if No. 2 battery is low, the various relays may be sluggish, or even fail to operate. It is, however, merely a waste of time to seek for faults in the operating circuits or relays, if the failure is due to a discharged battery.

152. Before commencing to charge numbers 2 or 3 and 4 batteries, care should be taken that neither the local control line nor the remote control extension line is plugged into the front socket of the relay panel. This precaution will ensure that transmission does not take place while these batteries are on charge. If the remote control station is erected, however, the remote control extension line should be plugged into the side socket in order to maintain telephonic communication. The charging set must not be run while the vehicle is in motion. When charging is taking place, the rear door and side windows must be fully open and the ventilating fan running. On no account must smoking be allowed in the vehicle during charging.

Relay panel

153. The type G relays require no maintenance whatever, but care must be exercised when replacing the cover of the panel, not to bend or otherwise damage any of the contact blades. It is rarely necessary to remove this cover since the front socket is accessible by a separate door.

R.T. line link unit

154. If the vehicle is connected to an automatic exchange, it is necessary to ensure that the operation of the calling dial will give the desired connection. The calling dial fitted to the R/T line link unit is of the type in almost universal use by the G.P.O. The operation of the dial makes and breaks a relay circuit in the exchange at a predetermined number of impulses per second. It is believed, however, that in a few exchanges in the United Kingdom the calling apparatus is designed to work with a different impulse rate from that finally standardized. If the vehicle should be connected to such an exchange, the automatic calling dial will not function correctly. If any difficulty is experienced, the local G.P.O. officials must be consulted.

155. The H.T., L.T. and G.B. batteries of this unit must be tested periodically and changed when necessary. The grid bias battery, which is enclosed in the unit, must on no account be neglected, otherwise considerable distortion may be experienced.

Rail or sea transport

156. The body of the vehicle may be removed from the chassis for rail or sea transport. If this becomes necessary the electrical bonding between body and chassis must be broken. There are four bonding points, a heavy braid connection being fitted at each. These are identified as 2, 3, 4, 5, in fig. 23. One end of each braid is connected to a terminal bolt on the body frame, and the other end to a similar bolt on the chassis. In addition the cables 1 and 6 connect the transmitter and receiver earthing terminals respectively to the chassis at the points indicated. The copper earth strip E is a portion of the body and must not be removed.

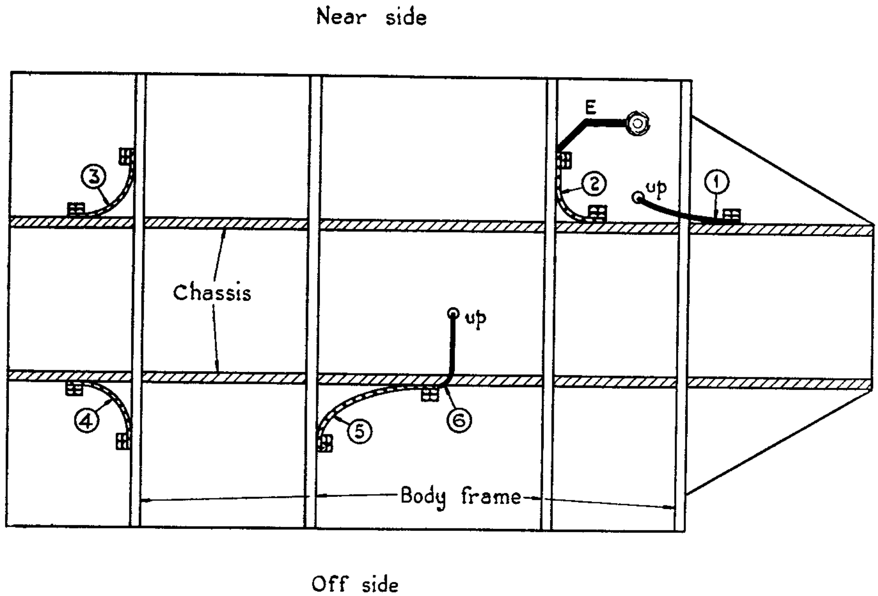

FIG. 23. Bonding of vehicle.

157. The procedure for lifting the body from the chassis is as follows :—
(i) Remove the eight clips holding the body on the chassis.
(ii) Remove the eight dash bolts, identified by being painted red.
(iii) Remove steering wheel from column.
(iv) Remove floor boards of cab.
(v) Disconnect the leads from the vehicle battery.
(vi) Disconnect the braids 2, 3, 4, 5, at the body end only.
(vii) Disconnect the cables 1, 6, from the chassis and tuck them away.
(viii) Remove the two external lockers referred to in paragraph 131 and stow them in the cab.
(ix) Sling the body by means of the lifting eyes provided.

158. When a vehicle is delivered in an unassembled condition care must be taken to replace all the connections referred to above, and also the external lockers, after the body has been correctly assembled on the chassis.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information. In ordering spares for this vehicle, the appropriate sections of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature.	Quantity.	Remarks.
5A/1937	Accumulator, alkaline 2·4 volts, 125 Ah.	4	
5A/1960	Accumulator, alkaline 3·6 volts, 125 Ah.	4	
5A/1938	Accumulator, alkaline 4·8 volts, 70 Ah.	3	
5A/1939	Accumulator, alkaline 3·6 volts, 70 Ah.	3	
5A/1940	Accumulator, alkaline 2·4 volts, 10 Ah.	3	1 for wavemeter W.39A. 2 for R/T line link unit.
5A/1942	Accumulator, alkaline 2·4 volts, 7 Ah.	2	1 for wavemeter W.69. 1 for wavemeter W.1095.
5A/1961	Accumulator, alkaline 2·4 volts, 3 Ah.	2	1 for modulation indicator. 1 spare.
4B/234	Bag, message	4	
5A/1333 or 5A/1615	Battery, dry 120 volt	1	For R/T line link unit.
10A/10187	Board, instrument	1	
	Principal components :—		
10A/3191	Milliammeter, 0–200, type A	2	
10A/10200	Switch, type 144	1	
10A/1846	Switch, type 2	1	
10A/2060	Voltmeter, electrostatic, type A ..	2	
10A/10218	Voltmeter, moving coil 0–12	1	
10A/2135	Box, connecting, telephone	1	
5C/445	Box, fuse, type A	2	
5C/549	Box, fuse, type B	2	
10A/10172	Box, junction	1	Fitted with socket, type 11.
10A/10173	Box, terminal, 6 point	2	
10A/10450	Box, terminal, 4 point	2	
10A/10174	Box, terminal, 3 point	2	
10A/10306	Bracing, mast, 14 ft. length	6	For mast repairs.
5C/430	Block, terminal, type B	1	
5A/192	Cable, electric, D3, Mk. VI, twisted (yds.)	880	On drum, Ref. No. 5B/142
5A/1941	Cable, 10 core, (7/0·012) (yds.)	440	On drum, Ref. No. 10A/10188.
5A/1941	Cable, 10 core, (7/0·012) (yds.)	10	Internal wiring.
5B/140	Cable laying apparatus	1	
10A/10466	Case, accumulator charging, fitted with:—	1	
10A/1041	Resistance, type 369, 7 ohms	1	Vitreous rod, 8½ in. long.
10A/10142	Resistance, type 370, 10·5 ohms. ..	1	
10A/10143	Resistance, type 371, 45 ohms ..	1	
10A/10369	Case, battery	1	
5A/1962	Cell, dry, X Mk. II	4	For field telephones.
21C/1359	Chair, adjustable	2	
10A/3004	Choke H/F., type 1	1	
10A/10307	Cover for H/F. chokes	1	
10A/10449	Clock, 8-day, cased	1	
10A/10467	Condenser, type 409, fixed	1	Aerial. In wooden case fitted with socket, type 40.
5A/1655	Converter, anode, type B	1	
10A/117	Cord, instrument, type A	2	
10A/10261	Cord, instrument, type P..	1	
10A/10199	Cover, portable station	1	
10A/10468	Case, accumulator, 10 Ah.	1	Fitted with 1·8 ohm resistance, for wavemeter W.39A.
10A/10352	Cover for smoothing unit..	1	
5B/141	Crook-stick, jointed	2	

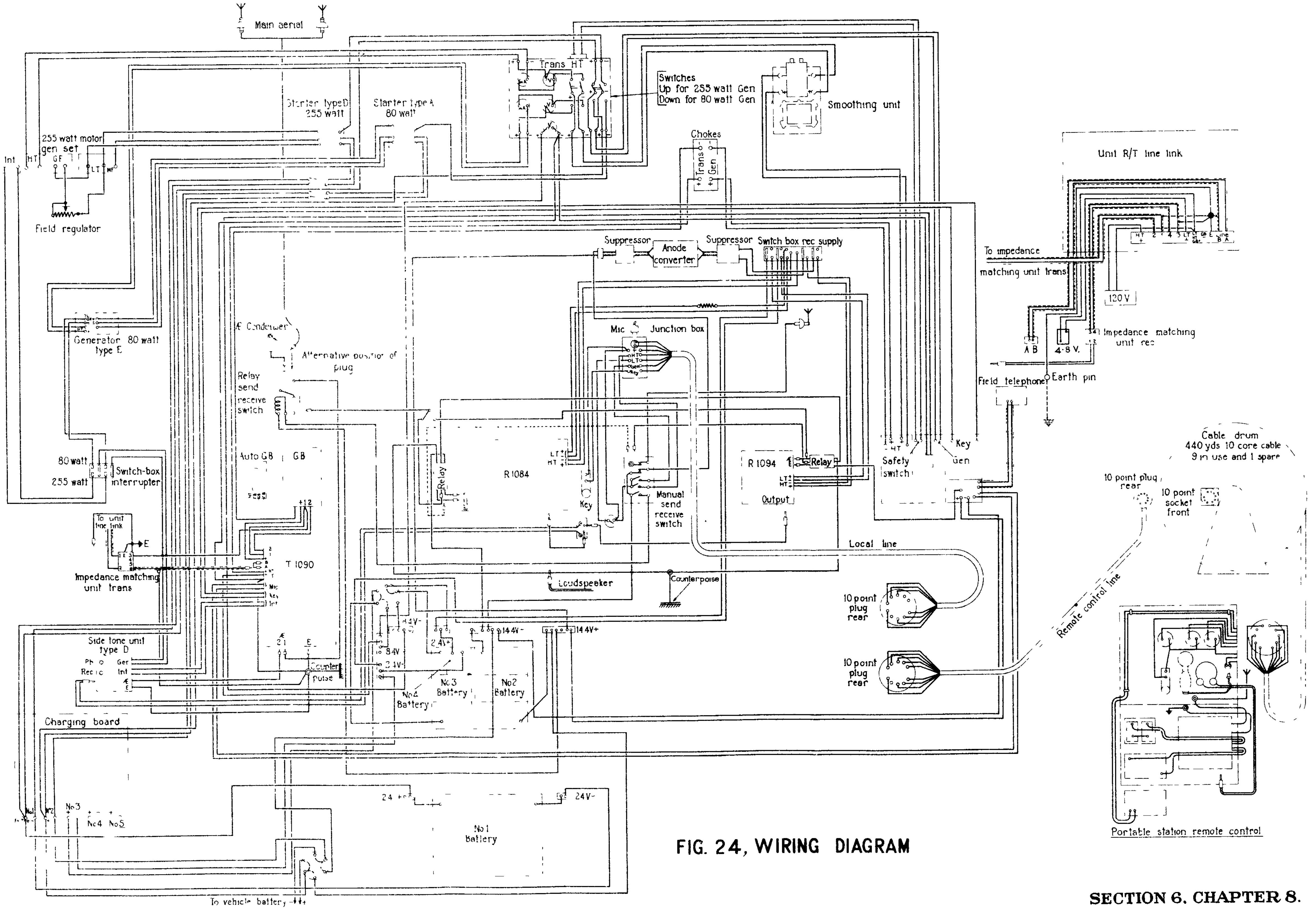

FIG. 24, WIRING DIAGRAM

SECTION 6. CHAPTER 8.

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APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Controls, remote, type C :—		
10A/8189	Casing, flexible	2	
10A/10175	Controller, hand held	1	
10A/8590	Coupling, tuning	1	
10A/8195	Handle, condenser unit	1	
10A/8192	Shafting, flexible	1	4 ft. length.
10A/8193	Union, casing	4	
5B/142	Drum, cable, D3, Mk. VI	1	Supplied with cable, Ref. No. 5A/192.
10A/10188	Drum, cable, remote control, fitted with:—	1	
10A/10184	Socket, type 55	1	10-pole circular, square base
20/412	Flag, distinguishing signal office	1	
10A/10171	Frame, mounting, T.1090	1	
10A/10176	Frame, mounting, R.1084	1	
5C/204	Fuse, type A	4	2 in each fuse box, type A.
5C/878	Fuse, type F	4	2 in each fuse box, type B.
10A/10248	Fuse, 1·5 amp	4	Spare for R/T line link unit.
5B/143	Guy, telepole	4	
10A/7852	Holder, spring	7	For microphone stowage.
10A/8219	Indicator, modulation, type 1	1	
	Accessories :—		
10A/7738	Valves, V.R.21	2	1 spare.
10A/10296	Unit resistance, 5 ohms	1	
10A/10302	Impedance matching unit, receiving	1	
10A/10303	Impedance matching unit, transmitting	1	
10A/1275	Insulator, type 9	14	
10A/8093	Insulator, type 16	3	Lead-in.
10A/7741	Key, morse, type F	1	
5A/1943	Lamps, signal office, pair	1	
5A/792	Lamp, filament, 12 volt 6 W spherical	1	Clear bulb, in upper signal office lamp.
5A/1944	Lamp, filament, 12–14 volt 12 W	1	Blue bulb, in lower signal office lamp.
10A/10308	Loud speaker, type C	1	
10A/10177	Mast, collapsible, 16 ft. base	1	
	Principal components :—		
10A/10441	Arm, lead-in	1	
10A/10377	Cord, kite, 30 yd. length	2	1 spare.
10A/10376	Cord, hemp, balloon No. 4, 8 yd. length	2	1 spare.
10A/10442	Frame, base	1	
10A/10443	Frame, lead-in.	1	
10A/10444	Frame, lifting	2	
10A/10445	Frame, long inner	1	
10A/10446	Frame, long outer	1	
10A/10447	Frame, short front	1	
10A/10448	Frame, short rear	1	
10A/8145	Mast, stainless steel, telescopic	1	For portable W/T station.
10A/4151	Mat, earth, copper	1	For portable W/T station.
5B/144	Mattock, tele-equipment	1	
10A/10263	Microphone, breast-plate, type B	1	
10A/7849	Microphone, hand press, type B	2	Fitted with cord instrument, type H and plug, type 34.
10A/10189	Motor-generator, 255 W	1	
10A/9654	Motor-generator, 80 W, type E	1	Complete with box, of interrupter discs, Ref. No. 10A/9674.
10A/10350	Mounting, generator 255 W	1	
10A/9854	Mounting, generator 80 W	1	
5B/146	Pole, telegraph, wood, 17 ft., Mk. II	2	
5B/122	Pole, R.E., 13 ft.	4	
10A/10178	Pole, height gauge	1	
10A/10291	Pin, earth	1	
5B/145	Picket, teleguy	4	
10A/488	Plug, type 1	6	
10A/8261	Plug, type 64	1	
10A/8262	Plug, type 65	1	

APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Remarks
10A/8516	Plug, type 68	4	
10A/10179	Plug, type 103	4	10 pole circular with shroud
10A/10252	Plug, type 104	1	For breast set.
10A/10309	Plug, type 106	1	For signal office lamps.
10A/7153	Plug, type 29	2	
10A/9602	Plug, type 85	1	
10A/10180	Pulley, mast lifting No. 1	1	With brackets.
10A/10181	Pulley, mast lifting No. 2	2	With brackets.
10A/10190	Panel, relay	1	
	Principal components :—		
10A/7390	Condenser, type 73	2	
10A/8073	Relay, magnetic, type G	4	
10A/10191	Relay, magnetic, type 38	1	Double-pole, H.T. circuit.
10A/10194	Relay, magnetic, type 41	1	Single-pole, keying.
10A/10195	Resistance, type 378	2	
10A/10184	Socket, type 55	1	
5C/457	Socket, 2-pin	1	
5C/846	Switch, relay magnetic, type D ..	1	L.T. circuit.
10A/8301	Receiver, type R.1084	1	
	Principal accessories :—		
5A/1251	Battery, dry, 6 volt	6	3 in receiver. 3 spare.
10A/8317	Case, transit 1 coil, containing the following item :—	1	Stowed in cupboard.
10A/8377	Coil, L.F. filter	1	
10A/8318	Coil, transit 4 coil, containing the following items :—	7	
10A/8329 10A/8330 10A/8331 10A/8332	Coils, range C..	1 1 1 1	Stowed in rack.
10A/8333 10A/8334 10A/8335 10A/8336	Coils, range D	1 1 1 1	
10A/8337 10A/8338 10A/8339 10A/8340	Coils, range E	1 1 1 1	
10A/8341 10A/8342 10A/8343 10A/8344	Coils, range F	1 1 1 1	
10A/8345 10A/8346 10A/8347 10A/8348	Coils, range G	1 1 1 1	
10A/8349 10A/8350 10A/8351 10A/8352	Coils, range H	1 1 1 1	
10A/8353 10A/8354 10A/8355 10A/8356	Coils, range J	1 1 1 1	

APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Remarks
	Accessories—*continued.*		
	Cases, transit 6 coil, containing the following items :—	2	
10A/8365	Coils, det, S/F and oscillator, 180 kc/s.	1	Stowed in cupboard.
10A/8366		1	
10A/8367		1	
10A/8368		1	
10A/8369		1	
10A/8370		1	
10A/8371	Coils, det, S/F and oscillator, 40 kc/s	1	
10A/8372		1	
10A/8373		1	
10A/8374		1	
10A/8375		1	
10A/8376		1	
5A/1117	Lamp filament, 2 volt, 0·2 amp. ..	2	
10A/8569	Case, transit, milliammeter, containing the following items :—	1	
10A/8398	Milliammeter 0–1	1	
10A/8402	Leads, milliammeter	1	
10A/7738	Valve, V.R.21	3	
10A/7958	Valve, V.R.22	1	
10A/8239	Valve, V.R.27	2	
10A/8399	Valve, V.R.28	7	
10A/7153	Plug, type 29	4	
10A/10264	Receiver, telephone head, 60 ohms, type B	1	Single earpiece with headband.
10A/8542	Receiver telephone head, 1,750 ohms, type B.	4	Assembled as 2 sets of head gear.
10A/7064	Headbands	2	
10A/10182	Relay, magnetic, type 36..	1	Send-receive.
10A/10183	Relay, magnetic, type 37..	2	Aerial earthing.
10A/10469	Resistance, type 391	1	For L.T. supply, R.1084, 0·17 ohm
42L/1	Set, generating, type D	1	Petrol-electric.
10A/7513	Smoothing unit, type B	1	
10A/8529	Socket, type 39	1	R.1094, supply.
10A/8530	Disc, indicating	1	
10A/7154	Socket, type 10	1	For impedance matching unit.
10A/8531	Socket, type 40	2	For main aerial.
10A/7997	Starter, type A	1	For 80 W generator.
10A/10267	Starter, type D	1	For 255 W. generator.
5B/149	Strap, crook-stick	2	
5B/453	Strip, signalling, ground	6	
5C/870	Suppressor, radio interference, type B..	1	For ventilating fan.
5C/872	Suppressor, radio interference, type C ..	1	For petrol-electric set
5C/873	Suppressor, radio interference, type D ..	1	For vehicle charging set.
5C/874	Suppressor, radio interference, type E	1	For windscreen wiper.
5C/875	Suppressor, radio interference, type F ..	1	For converter output.
5C/876	Suppressor, radio interference, type G ..	1	For converter input.
10A/10373	Switchbox, receiver supply	1	
	Fitted with :—		
10A/10375	Switch, type 153	2	
10A/10374	Switchbox, interrupter	1	Fitted with 1 switch, type 153.
10A/10185	Switch, type 143	1	Manual send-receive.
10A/1276	Switch, type 9	1	Aerial-receiver.
5C/622	Switch, tumbler S.P., 5 amp., 1 way ..	1	L.T.
10A/10498	Switch, type 154, 25 amp., D.P.C.O. ..	2	For Nos. 2 and 3 charging circuits.
10A/10196	Station, W/T portable, type 2	1	

APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Principal components :—		
10A/10197	Case	1	
10A/10921	Container, accumulator	1	
10A/117	Cord instrument, type A	1	
10A/10212	Cover, battery	1	
6A/269	Holder, watch, Mk. I	1	
10A/7741	Key, morse, type F	1	
10A/7849	Microphone, hand press, type B ..	1	
10A/7852	Holder, spring	2	
10A/8516	Plug, type 68	2	
10A/8261	Plug, type 64	1	
10A/8262	Plug, type 65	1	
10A/9332	Receiver, type R.1094	1	
10A/8542	Receiver telephone head, 1,750 ohms, type B.	2	Assembled as 1 set of head gear.
10A/7064	Head band	1	
10A/7276	Socket, type 11	1	
10A/8529	Socket, type 39	1	
10A/8530	Disc, indicating	1	
10A/10184	Socket, type 55	1	
5C/622	Switch, tumbler, S.P., 5 amp., 1 way	1	
5C/831	Switch, tumbler, D.P., 5 amp. ..	1	
5B/137	Telephone set, F, Mk. I	1	
5A/1945	Accumulator, alkaline, 2·4 volt, 70 Ah.	2	1 spare.
5A/1333 or 5A/1615	Battery, dry, 120 volt	2	1 spare.
10A/9572	Board, mounting, R.1094	1	
5A/1962	Cell, dry, X Mk. II	4	For field telephone.
10A/7607	Valve, V.R.18	4	Includes 2 spare.
10A/7738	Valve, V.R.21	6	Includes 3 spare.
10A/7758	Valve, V.R.22	2	Includes 1 spare.
10A/8238	Valve, V.R.27	2	Includes 1 spare
6A/150	Watch, aircraft, 30 hr., Mk. V, non-luminous.	1	
Form 96	Pad, message	1	
5B/137	Telephone set, F Mk. I	1	In vehicle.
5A/466	Terminal, double 2 B.A.	1	
10A/10378	Terminal	2	
10A/9337	Transmitter T.1090	1	
	Accessories :—		
5A/1338	Battery, dry, 15 volt	24	12 in box, G.B. battery. 12 spare.
10A/9357	Box, G.B. battery	1	
10A/9358	Case, transit coils	5	
	Containing the following items :—		
10A/9338 10A/9363 10A/9368	Coils, range A	1 1 1	Stowed in rack.
10A/9360 10A/9364 10A/9369	Coils, range B	1 1 1	
10A/9360 10A/9365 10A/9370	Coils, range C	1 1 1	
10A/9361 10A/9366 10A/9371	Coils, range D	1 1 1	
10A/9362 10A/9367 10A/9372	Coils, range E	1 1 1	

APPENDIX—*contd.*

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Accessories—*continued*		
10A/9826	Grid-bias unit	1	
10A/9639	Side tone unit, type D .. .	1	
10A/7312	Valves, V.T.25	4	
10A/10242	Unit, R/T line link	1	
	Principal components :—		
10A/10243	Bell set	1	
10A/10244	Condenser, type 388	2	
10A/10245	Clip	2	
10A/10246	Decibelmeter	1	
10A/10247	Dial, automatic	1	
10A/10248	Fuse, 1·5 amp.	3	Includes 1 spare.
10A/10250	Generator	1	
10A/9614	Holder, fuse, D.P.	2	
10A/10251	Jack, 4-way	1	
10A/10253	Resistance, type 379.. .. .	1	
10A/8204	Plug, type 63	2	
10A/10254	Resistance, type 380..	1	
10A/8132	Switch, type 76	1	
10A/8142	Switch, type 77	3	
10A/10255	Switch, type 145	2	
10A/10256	Mounting	5	
10A/10257	Transformer, L.F., type M ..	1	
10A/10258	Transformer, L.F., type N	1	
10A/10259	Unit, amplifying	1	
5A/1893	Battery, dry, 9 volt	2	Includes 1 spare.
10A/10260	Valve, G.P.O. No. 75	4	Includes 2 spare.
10A/10300	Wavemeter, type W. 39A	1	
	Accessories :—		
5A/50	Battery, inert, 15 volt	2	Includes 1 spare.
10A/8239	Valve, V.R.27	1	
10A/10299	Valve, V.W.42	1	
10A/7730	Wavemeter, type W.69	1	
10A/9143	Wavemeter, type W.1095	1	
	Accessories for W.69 and W.1095 :—		
5A/1251	Battery, dry, 6 volt	2	
5A/1334	Battery, dry, 69 volt	2	
10A/9149	Case, transit, wavemeter, W.1095 ..	1	
10A/9545	Case, transit, wavemeter, W.69 ..	1	
10A/8412	Case, transit, valve	2	
10A/10295	Unit, resistance, 5 ohms	2	
10A/7946	Valve, 210 H.F.	6	1 in each wavemeter. 2 in each transit case.
10A/10186	Winch, mast lifting	1	
10A/4589	Wire, aerial, R4, yds.	500	

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SECTION 6 CHAPTER 9

SITE-TESTING EQUIPMENT (D/F CALIBRATION)

Contents

List of Illustrations

SITE-TESTING EQUIPMENT (D/F CALIBRATION)

INTRODUCTION

1. The calibration of the rotating coil type of D/F apparatus, when fitted in a particular aeroplane, consists essentially of swinging the aeroplane on to various known compass bearings. On each of these bearings, the apparent bearing of a pre-selected signal source is obtained by means of the D/F apparatus. In general, the observed D/F bearing does not agree with the correct bearing, owing to certain effects of the aeroplane structure. The difference between the apparent and correct bearing is known as the quadrantal error, and is allowed for by what is termed the quadrantal correction. The object of calibration is to ascertain the quadrantal correction to be applied to the observed D/F bearing, and to tabulate this information for ease of reference.

2. For obvious reasons, calibration is usually performed on the ground, but it is important that the ground calibration shall be checked in flight. This is particularly necessary where the loop aerial is fitted below the structure. In the following paragraphs, the term calibration must be understood to refer to the ground calibration.

3. For the calibration to be accurate, it must be performed on a location which is free from site error. Site error exists if the direction in azimuth of the arrival of radio waves from the selected source does not coincide with the great circle joining the transmitter and the loop aerial, *i.e.*, if the wave does not travel by the shortest path possible over the curved surface of the earth. Site error may be introduced by topograpical features, such as a mountain or a large expanse of water between transmitter and receiver, and also by metallic structures in the proximity of the site. It is important that a site should not be regarded as suitable merely because such metallic structures are not visible. For example, in a certain instance, a site which appeared superficially to be ideal was found to be quite unsuitable, owing to the presence of buried electrical cables, so long disused that their existence had been forgotten.

4. The object of this chapter is to describe the equipment required to determine the suitability or otherwise of a proposed site for the performance of a D/F calibration, and the method of using this equipment.

EQUIPMENT

5. The essential components of the equipment are (i) a portable rotating loop D/F aerial, (ii) a radio receiver complete with valves, batteries and telephones, and (iii) a magnetic compass. The stranded aircraft D/F aerial (Stores Ref. 10A/8276) modified as described later, is suitable for the purpose, in conjunction with a receiver, type R.1082 (Stores Ref. 10A/8415) and a medium size landing compass (Stores Ref.6B/034). A complete list of the equipment is given in the appendix to this chapter.

6. The receiver R.1082 is described in Section 3, Chapter 2, of this Air Publication, and the landing compass is briefly described in Air Publication 1234 (Manual of Air Navigation, Vol. I).

Stranded aircraft D/F aerial

7. This apparatus consists of a rotatable loop aerial supported by a tripod, together with a seat upon which the receiver may be supported for manipulation. As originally designed for use in stranded aircraft an adjustable condenser, type 164, was included in the equipment, but this component is not required for the present purpose. The aerial and tripod are collapsible for ease of transport, and when not in use are stowed in separate canvas bags.

8. The aerial consists of ten turns of light insulated cable (uniflexed 4), supported on a framework built up of two vertical and two horizontal members. All four members are hinged together, spring-loaded bolts being provided to lock the two vertical members in position. The aerial is attached to the framework by means of wooden blocks to which the wires are secured. One such block forms a part of the upper vertical member, while two others are adapted to fit into the ends of the horizontal members. A tensioning device is provided on the lower vertical member.

9. The lower end of the vertical member forms a shaft which fits into bearings on the tripod. The primary winding of a radio-frequency transformer is wound axially on this shaft. The secondary winding of this transformer is mounted in the tripod, the primary and secondary windings being separated by an electrostatic screen.

10. The receiver may therefore be coupled to the aerial without any direct connection, thus avoiding the necessity for limiting stops or other devices to prevent the connecting leads being twisted, and enabling the shortest possible connecting leads to be employed. Provision is, however, made for the receiver to be directly connected to the aerial if so required.

11. The tripod is provided with hinged legs and carries a rotatable scale plate and an adjustable index. After mounting the aerial on the tripod, the aerial can be located on the scale plate by a pin on the shaft. This pin engages with a hole in the scale plate, so that the latter rotates with the aerial. The plate is engraved with a scale of degrees ; provided that the tripod is correctly placed, the bearing of a distant transmitter can be ascertained by reference to the index. The tripod is placed in the correct position with the aid of the landing compass.

12. The seat consists of a light piece of wood with a pivoted cross piece. Collapsible legs are fitted at one end and a loop of cord for attachment to a hook on the tripod at the other end. A removable board is also carried on the seat. This may be used to support the receiver, but is primarily intended to fit beneath the ends of the legs to prevent their sinking into the ground, where the soil is soft or sandy. The seat is fitted with an elastic cord by which the receiver, R.1082, is steadied in position on the seat.

13. The tripod is fitted with two lengths of cord. These were originally intended to retain the wireless receiver in position. When used for site selection, these cords may be used as guys in order to maintain the tripod in its correct position. Pickets are not provided for this purpose but may easily be improvised.

Constructional details

14. The following constructional details of the loop aerial are given in order that the method of assembly, and of modification for site-testing purposes, will be readily appreciated.

15. Fig. 1 shows the components of the loop aerial (with the exception of the adjustable condenser, type 165) laid out upon the ground ready for assembly. The upper portion (2) of the main frame is collapsed upon the lower portion (1). One of the horizontal members (3a) is clearly seen ; the other is beneath the first and is not visible in the photograph. The spring-loaded catches (4) operate bolts which engage with holes in the plates (5) when the upper vertical member is extended.

16. The ten turns of wire (6) which constitute the winding of the loop are maintained in parallelism by light fibre spreaders, and also by the wooden blocks (7). The square-section projections (8) upon these blocks fit into the hollow ends of the horizontal members.

17. The ends of the winding terminate upon terminals which are connected by short flat links to metal pillars adjacent to the terminals. These pillars are connected to the primary winding (10) of the coupling transformer. This winding is carried on the cylindrical shaft,

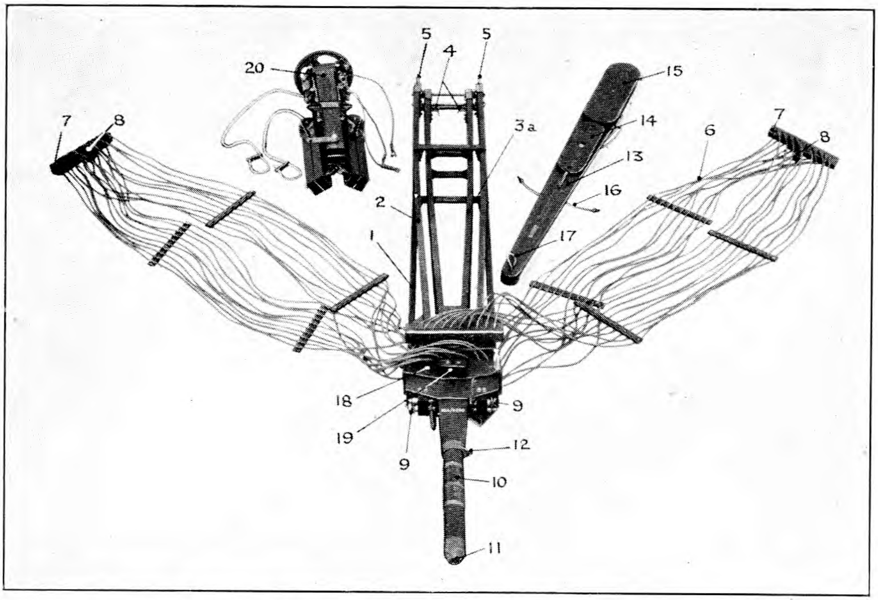

FIG. 1. Components of loop aerial.

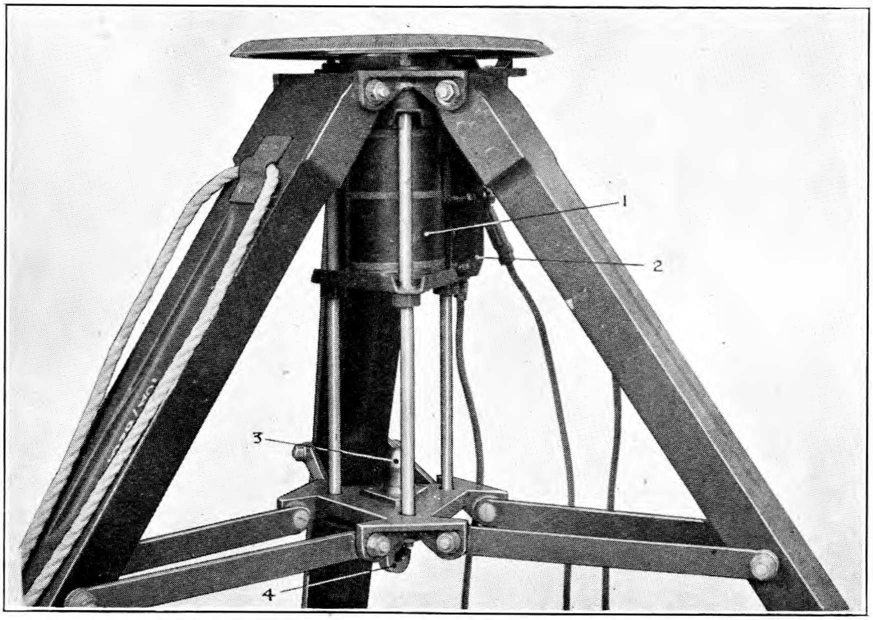

FIG. 2. Tripod head.

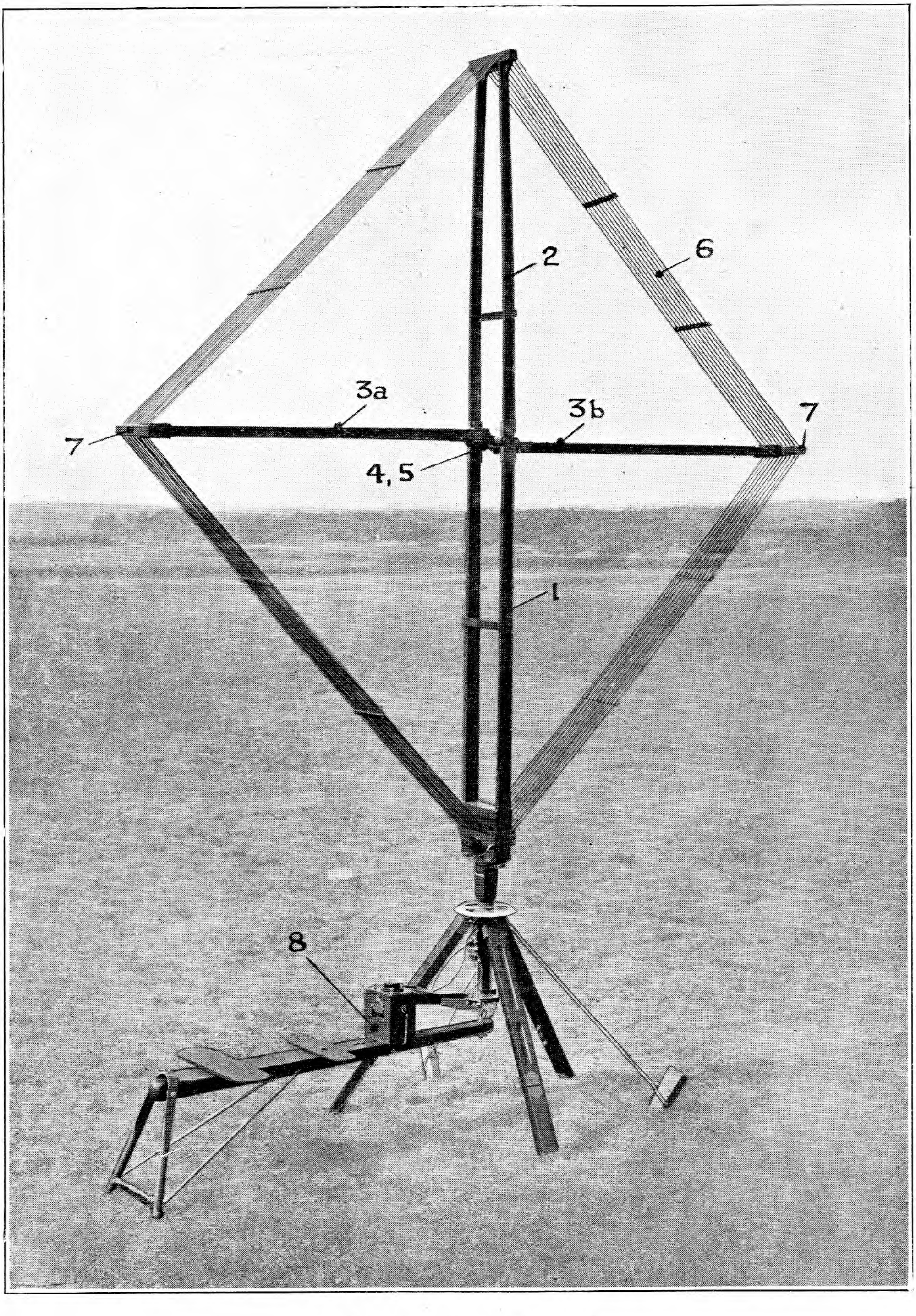

FIG. 3. Loop aerial erected.

which is supported on the bottom bearing (11) when the loop is mounted on the tripod (20). The pin (12) engages with a hole in the scale plate so that the latter rotates with the loop. The box-like structure (18) slides upon the rectangular portion of the lower vertical member and forms the tensioning device. When the wires are correctly tensioned the structure (18) is secured by means of a bolt which engages in a nut carried by the ebonite block (19). The head of this bolt is fitted with a wooden knob which is invariably to be used for swinging the loop.

18. The seat (13) carries a detachable board (14) which can be fitted beneath the legs of the seat. If not detached, however, it assists to support the receiver. The board (15) is pivoted and forms the seat proper. The elastic cord (16) was originally fitted to hold the condenser, type 165, in position. The seat is supported at the tripod by means of the loop of cord (17).

19. Referring to fig. 2, which shows certain details of the tripod, the secondary winding (1) of the coupling transformer is connected to a terminal block (2), and flexible leads are supplied with the latter for connecting to a radio receiver. For site-testing purposes these leads are removed (*see* para. 21). The lower bearing which supports the loop aerial is seen at (3) and the hook for supporting the seat at (4). Fig. 3 shows the loop aerial erected. References (1) to (7) are the same as in fig. 1. The condenser, type 165 (8), has been included in this photograph ; as already stated, it is not required for site-testing, but the receiver, R.1082, is placed in approximately the same position and may be held so by attaching the elastic cord to loops of wire slipped over the suspension spigots.

Modifications for site testing

20. For site-testing purposes the loop aerial must be modified by the provision of a centre tapping on the winding and a screened lead for connection to the receiver, type R.1082. For the former purpose an ebonite terminal block is to be constructed in accordance with the detail given in fig. 4A, and mounted on the framework of the loop as shown in fig. 5. The insulation must then be removed from the mid-point of the winding, over a length of about 1 in. Great care must be exercised in this process in order to ensure that no strand of wire is severed or damaged in any way. The exposed wire should be tinned, and a short lead of tinned copper wire soldered to it to form the centre tap. The exposed wire must then be insulated with rubber tape and solution. The centre tap is to be soldered to the soldering tag on the terminal block referred to above.

21. The connecting lead for the receiver R.1082 is to be constructed according to the detail given in fig. 4B. The inner conductors of the Dumet 4 Cable are to be connected to the terminals marked SECONDARY COIL on the terminal block which is mounted on the tripod. The short lead which is soldered to the outer screen of the Dumet 4 Cable is to be connected to the terminal marked SCREEN. The long lead from the outer screen of the Dumet 4 Cable is to be connected to the centre tap of the loop *via* the special terminal block referred to in para. 20 above.

Setting up

22. The apparatus is assembled as follows :—

(i) Unfold the tripod legs, extend them, and place tripod on the ground.

(ii) See that the adjustable index is set near the middle of its travel.

(iii) Unfold the aerial, extending and locking the upper vertical member to the lower one by means of the spring bolts.

(iv) See that the tensioning device is free to slide on the lower member.

(v) Raise the side members and insert into each, one of the free wooden blocks carrying the aerial.

(vi) Mount the coil on the tripod, taking care that the pin engages with the hole in the scale plate.

(vii) Press down the tensioning device until the wires are taut, but not unduly so, and lock it in position by means of the screw.

23. When the aerial has been assembled, it is necessary to orientate the tripod in such a manner that the scale, reading from the index, gives the magnetic bearing of any selected transmitter, operating as usual by the " minimum signal " method. This is performed in the following manner :—

(i) Set up the landing compass about 25 yards from the aerial. Sight the aerial by means of the compass and note the bearing, *e.g.*, 122°.

(ii) Rotate the D/F loop until the plane of the loop is pointing directly at the landing compass and note the scale reading, *e.g.*, 42°. For this purpose the ends of the horizontal members of the framework can conveniently be used as sights.

(iii) Move the adjustable index so that the scale reading obtained in (ii) and the compass bearing obtained in (i) differ by 90°. This difference arises because sighting is performed along the plane of the loop, whereas the zero signal line is perpendicular to this plane. The readings assumed above differ by only 80°, and the index must be shifted to read 32°. If it is not possible to do this by shifting the index alone, it will be necessary to turn the tripod round, care being taken to repeat the sighting operations (i) and (ii). In order to allow a margin for final adjustment (*see* para. 25), the tripod should always be turned round if adjustment by the index alone brings the latter within 5° of the limit of its travel.

(iv) When the tripod has been placed as above, fit the seat in position, place the receiver on the seat and connect up in accordance with the instructions in para. 21. The lengths of kite cord fitted to the tripod may be used as guys to prevent the tripod from accidental movement.

24. Since the landing compass tripod is only about 4 ft. high, the sighting operation detailed in para. 23 (ii) is not very accurate. It may be more convenient to mark the fifth turn inwards on each side of the frame by binding white tape round it at a convenient height from the ground, and to use the marked turns for sighting purposes. Care must be taken to remove all magnetic material, such as keys, knives, etc., from the person before approaching the landing compass. While taking a compass sight, the bowl should be tapped occasionally to eliminate errors due to a sticky pivot.

25. After the wireless receiver and batteries have been placed and connected, the accuracy of the index adjustment on the tripod should be checked, by an independent observer if possible, by repeating the operations detailed in para. 23 (i), (ii) and (iii). The D/F aerial may then be considered to be correctly set up to give the magnetic bearing of any transmitter by observing the scale reading when the aerial is turned to the position of minimum signal.

SELECTION OF CALIBRATION SITE

Preliminary survey

26. The preliminary stage in the selection of a calibration site is to select a piece of ground fulfilling the following requirements :—

(i) It must be level.

(ii) It must be easy of access for aircraft.

(iii) It must be well removed from metallic structures, buildings and trees. If buried pipes or cables are known to be present, an otherwise suitable site should be rejected without further investigation.

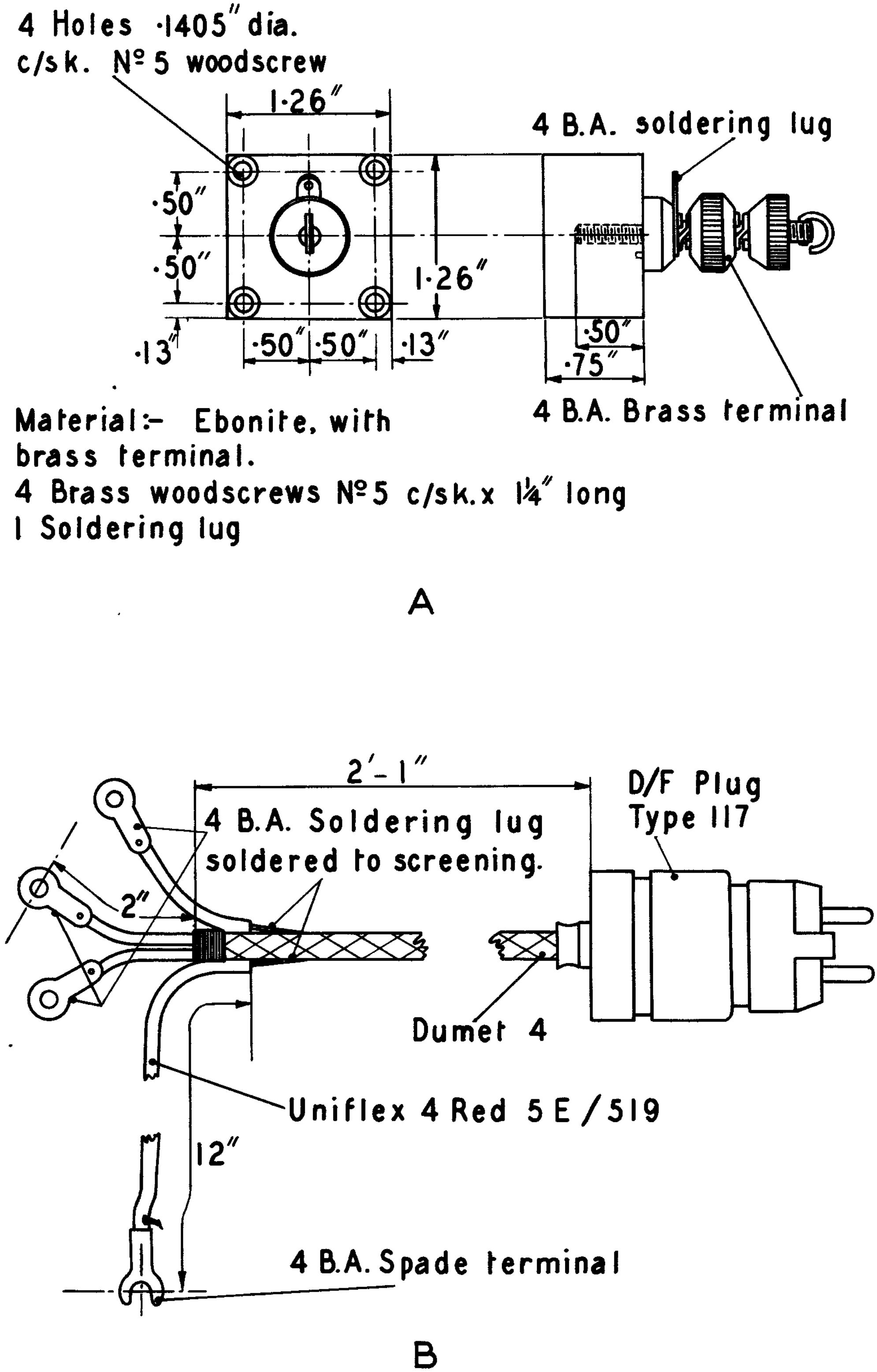

FIG. 4, DETAILS OF MODIFICATIONS

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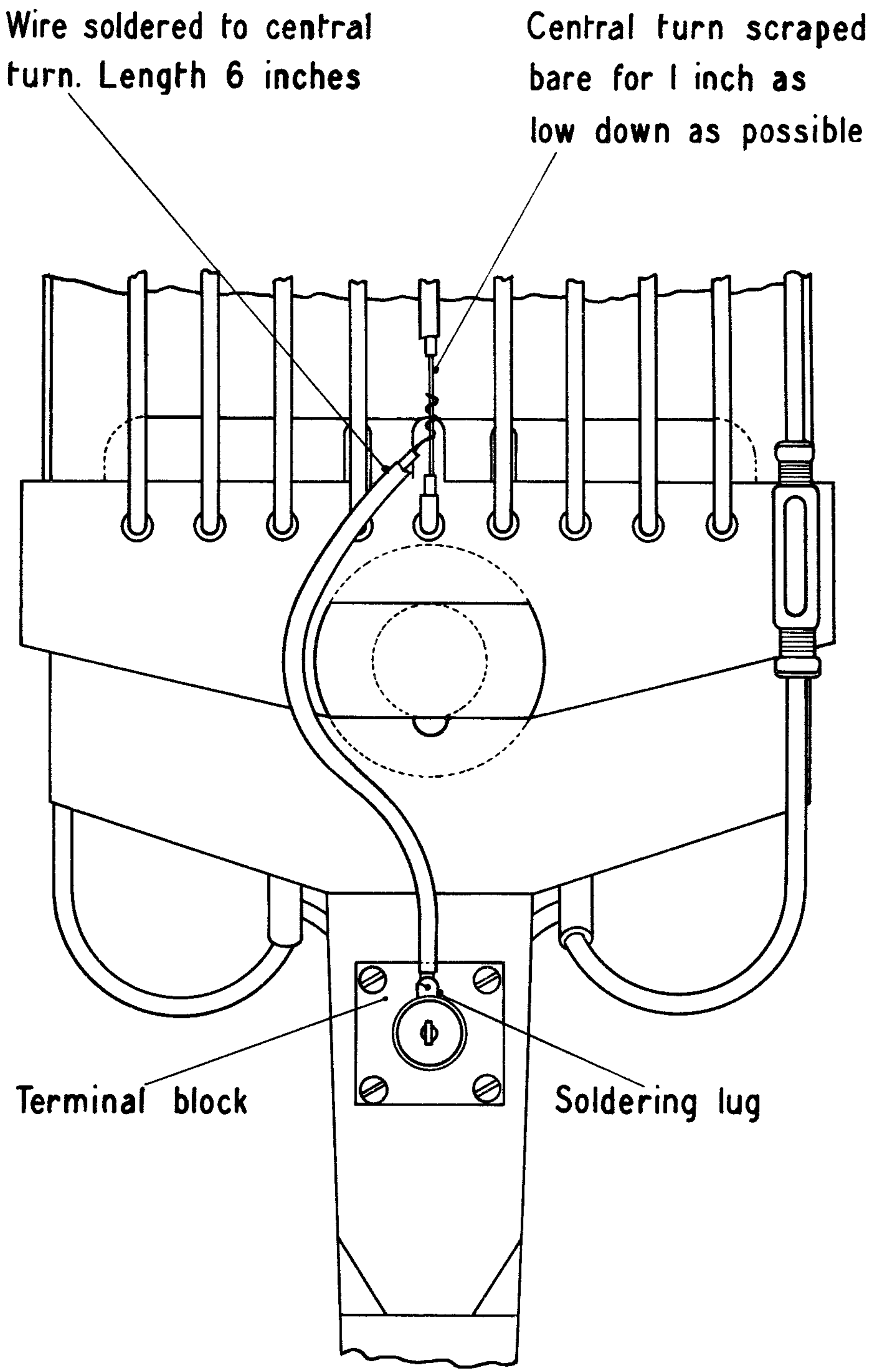

FIG.5, MODIFICATIONS TO AERIAL D.F. STRANDED AIRCRAFT

Preparations for site testing

27. Select a number of signal sources which are likely to provide reliable and constant signals. Broadcasting stations will usually provide satisfactory transmissions. If possible, the selected stations should be within 150 miles of the site, but should not be in the immediate vicinity. The true bearing of each station so selected should be determined from a suitable map, and the magnetic bearing obtained by the application of the magnetic variation.

28. The minimum number of selected stations is two, *viz.*, one transmitting in the 150–500 kc/s band and the other in the 500–1,200 kc/s band. If possible, however, additional stations should be selected in each band.

Site testing

29. The D/F equipment should be erected on the site as described in paras. 22 *et seq*, and D/F observations made on each of the selected stations. The time devoted to this should be centred on local noon as nearly as possible. Observations made within two hours of sunrise or sunset are of no value. Each observation should be extended over a considerable interval of time by taking repeated bearings of the transmitter alternating with reciprocal bearings. This procedure will ensure the detection of any change in apparent bearing due to polarization error. Since the loop aerial is unscreened, errors will be introduced if persons are allowed to move about in the immediate vicinity of the loop. No one except the observer should approach within 5 yards. The observer should seat himself in such a position that he can rotate the aerial with the left hand by means of the handle provided, while steadying the receiver with his right hand, and should then change his attitude, and particularly the disposition of his arms, as little as possible during a series of observations on a particular transmitter.

30. The observations should be tabulated according to the following pro forma :—

(1)	(2)		(3)	(4)	(5)	(6)	(7)
Transmitter.	Frequency.	No. of observations.	Magnetic bearing and reciprocal.	Observed bearing.	Observed reciprocal bearing.	Swing.	Remarks.
Droitwich	200 kc/s	1	330/150°	329	—	3°	Audible min.
		2	330/150°	—	148°	4°	
		3	330/150°	328	—	3°	
		4	330/150°	—	150°	3°	

The entry in column 6 should be half the total arc through which it is necessary to swing the loop aerial in order to obtain a bearing Column 7 should be used to record the presence of polarization error, if such is suspected. If the swing exceeds 3°, a note should be made in this column, indicating whether the broadness of swing is due to an audible minimum or to insufficient signal strength.

Approval of site

31. A site may be considered as satisfactory for the calibration of aircraft D/F installations, if at least one transmitter can be found in each of the bands (*a*) 150–500 k/cs and (*b*) 500–1,200 kc/s, satisfying the following conditions :—

(i) Bearing correct to within ± 2°.

(ii) Bearing and reciprocal agree to within 1°.

(iii) The swing required to determine the bearing does not exceed 5°.

(iv) There is no evidence of polarization error (*see* para. 29).

32. A site fulfilling these conditions with a particular transmitter is not necessarily satisfactory for calibration on a different transmitter. It is therefore desirable to check each site on as many transmitters as possible.

33. The observed bearing of each selected transmitter should be recorded and used for subsequent D/F calibrations in preference to the bearing obtained from the map.

34. Where a site is found to give flat minima, or incorrect bearings and reciprocals, separately or in combination, it should be rejected. The cause of these irregularities will probably be found in nearby metallic structures either above or below ground. A satisfactory site may still be found within the confines of the aerodrome, but more remote from the distorting structure.

35. Where a site appears unsatisfactory owing to insufficient signal strength, or to polarization error, a less distant transmitter must be chosen. If a less distant transmitter is not available, the only alternative is to reject the site, and to endeavour to find a suitable one less remote from the transmitter.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information only. In ordering equipment for site-testing purposes the appropriate sections of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature.	Quantity.	Remarks.
10A/8276	Aerial, D/F, stranded aircraft	1	
	Principal components :—		
10A/8279	Seat	1	
10A/8281	Tripod	1	
10A/8280	Frame aerial, folding	1	
10A/8277	Bag, towage, for frame and seat	1	
10A/8278	Bag, stowage, for tripod and condenser	1	
10A/8282	Condenser, type 165, variable (0·0007μF in wooden case).		Not required for site testing.
5E/1328	Cable, electric, L.T. Dumet 4 (feet)	2½	
5A/84	Cable, electric, L.T. Uniflex 4 (feet)	4	
5A/1493	Cable end, eye type, soldering, 4 B.A.	4	
5A/1603	Cable end, fork type soldering, 4 B.A.	1	
6B/034	Compass, landing, medium	1	
10A/117	Cord, instrument, type A	1	Assembled as 1 set of head gear.
10A/10155	Headband, type B	1	
10A/8542	Receivers, telephone, head, type B.	2	
5F/292	Ebonite sheet ⅜ in.		1¼ in. by 1¼ in.
10A/10953	Plug, type 117	1	
10A/8516	Plugs, type 68	2	
10A/8261	Plug, type 64	1	
10A/8262	Plug, type 65	1	
10A/8415	Receiver, type R.1082	1	
	Accessories :—		
5A/1387	Accumulator, 2 volt, 20 amp. hours	1	
5A/1615	Battery, dry, 120 volt	1	
10A/8420	Case, transit, coils	1	
10A/8421	Case, transit, receiver	1	
10A/9580	Coil, aerial range J*	1	
10A/9581	Coil, aerial, range K*	1	
10A/8432	Coil, aerial, range L	1	
10A/8533	Coil, aerial, range M	1	
10A/8534	Coil, aerial, range N	1	
10A/8535	Coil, aerial, range P	1	
10A/8447	Coil, anode, range J	1	
10A/8448	Coil, anode, range K	1	
10A/8449	Coil, anode, range L	1	
10A/8450	Coil, anode, range M	1	

Ref. No.	Nomenclature.	Quantity.	Remarks.
	Accessories—*contd.*		
10A/8451	Coil, anode, range N	1	
10A/8452	Coil, anode, range P	1	
5A/359	Lamps, filament, 2·2 volt, miniature festoon	2	
10A/8529	Socket, type 39	1	
28/2212	Screws, wood, brass, countersunk, No. 5 × $1\frac{1}{4}$ ..	4	
5A/467	Terminal, instrument, double, 4 B.A.	1	
10A/7607	Valve, V.R.18	1	
10A/7738	Valves, V.R.21	2	
10A/7958	Valve, V.R.22	1	
10A/8239	Valve, V.R.27	1	

SECTION 6, CHAPTER 10
AERIAL, SCREENED LOOP, TYPE 3

Contents

List of Illustrations

AERIAL, SCREENED LOOP, TYPE 3

(Stores Ref. 10B/10594)

INTRODUCTION

1. The screened loop aerial, type 3 is designed for installation in aeroplanes. It is used in conjunction with a suitable radio receiver for the purpose of obtaining D/F bearings.

2. The loop consists of a circular former about 10 in. diameter to which is attached a winding forming the loop aerial. The centre point of the winding is connected to earth. The loop aerial is mounted upon a rotatable base. It can be mounted within the aeroplane, or upon the fuselage in a suitable housing, either above or below the aeroplane. In certain instances the loop is mounted within the aeroplane, but outside of its metallic structure, and in such instances it is provided with an electrostatic screen. In whichever manner it is mounted, in either case the ends of the loop aerial are carried through the base by suitable conductors and are connected to the receiver.

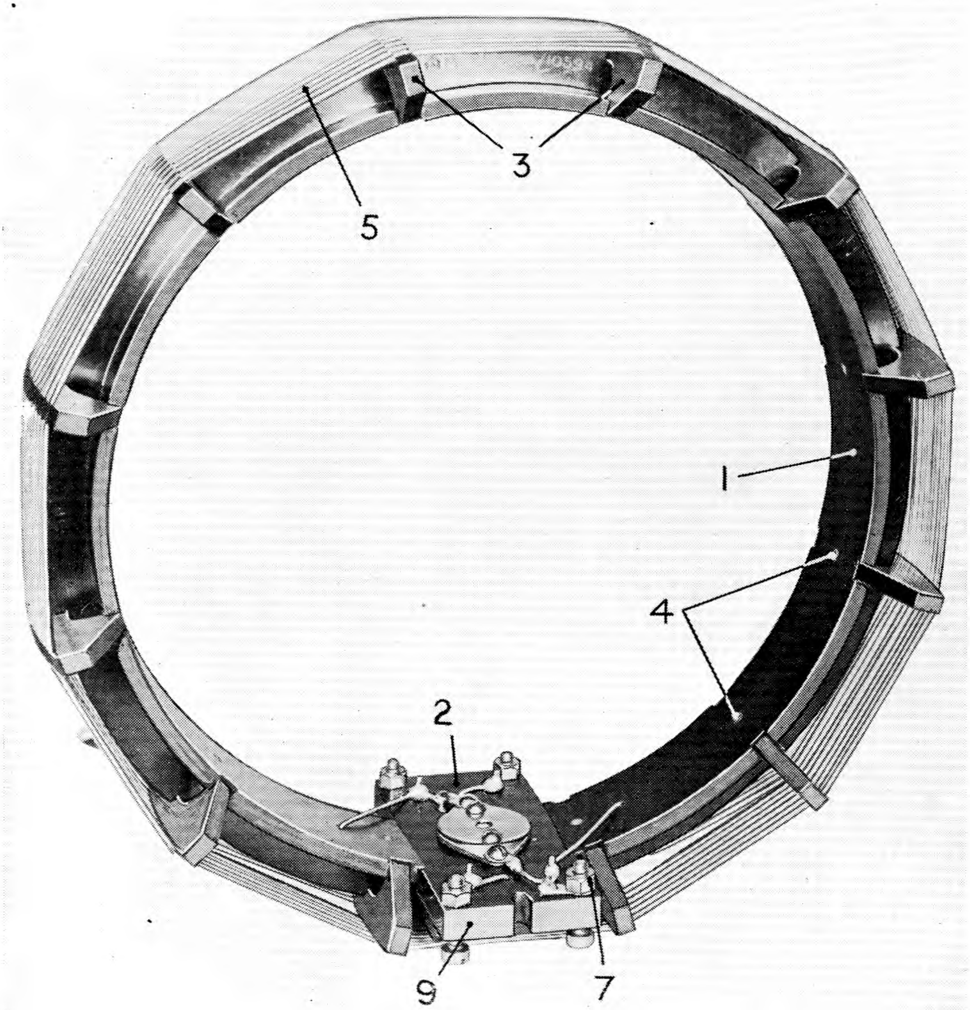

FIG. 1—AERIAL LOOP WINDING ON FORMER

3. The loop may be rotated from within the aeroplane, either through a handwheel directly connected to the rotatable feature of the base, or by means of a remote control device. Where such remote control apparatus is fitted, a bearing indicator is provided at the control position, so that the orientation of the loop at any particular moment is known to the operator.

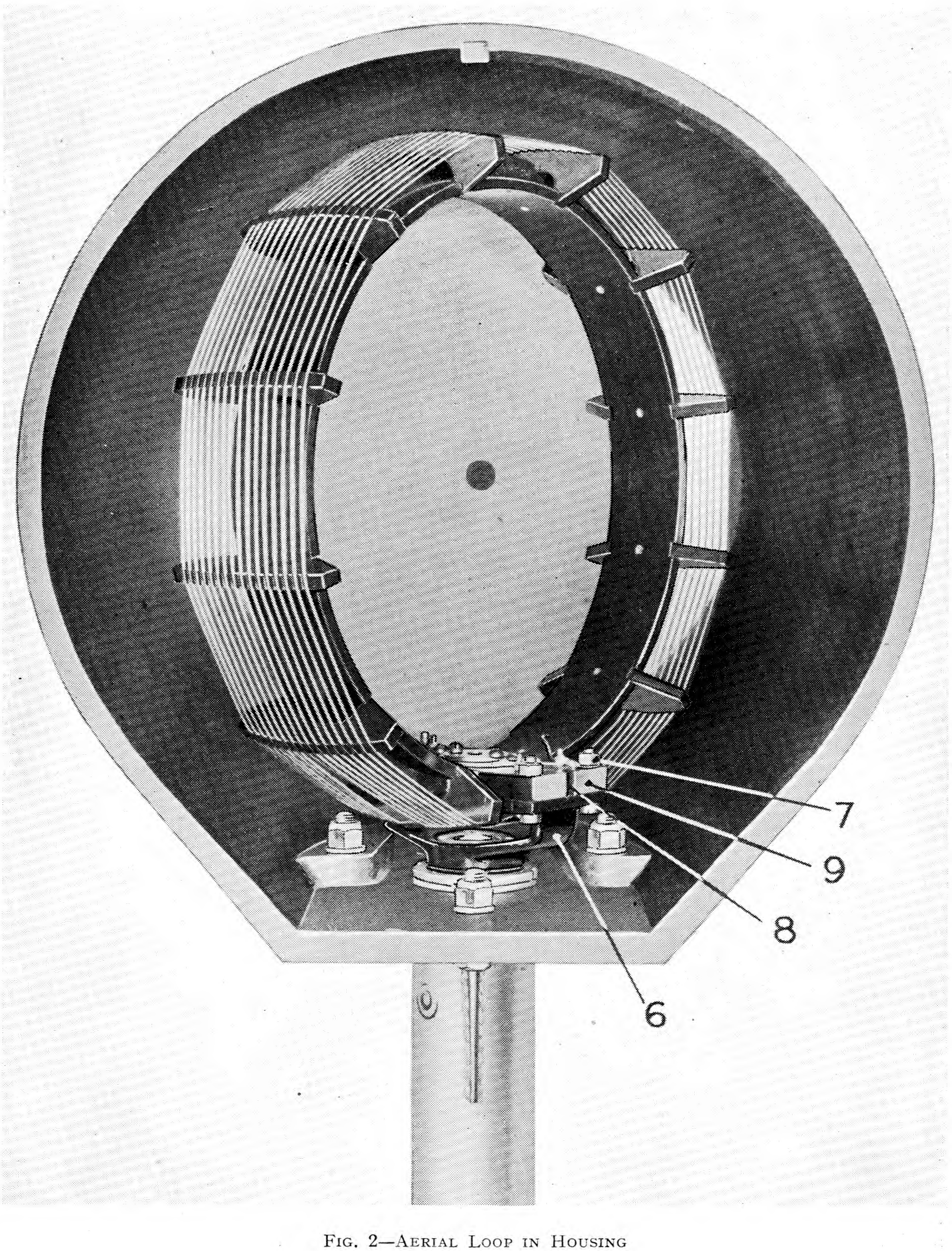

Fig. 2—Aerial Loop in Housing

4. When the loop aerial is connected to the radio receiver, the operator is able to rotate the loop while listening to the signals emanating from a distant radio transmitter. The orientation of the loop giving minimum signal strength is noted. The bearing indicator then gives the apparent relative bearing of the transmitter, with an ambiguity of 180°. After certain corrections have been applied, the bearing of the radio transmitter may be laid off on a chart or map.

CONSTRUCTIONAL DETAILS

Aerial loop, type 3

5. The loop, as illustrated in figs. 1 and 2, is mounted upon a former made of moulded composition. This former has a tube section with a supporting base and terminal plate (2) moulded integrally at one point of the circumference. Upon its periphery are mounted twelve slotted segments (3) which carry the loop windings. These segments are held in position temporarily by a single screw (4) at the mid-point of each. These screws are removed when the former has been wound. The former, with segments attached, supports two sets of loop windings (5) which consist of a total of 16 turns of 18 s.w.g. tinned copper wire. These windings are disposed so that 8 turns are held in the slots on each side of the central position. The inductance of the loop windings amounts to about 100 microhenries which gives a natural frequency of about 3·5 Mc/s. The ends of the two sets of windings are brought to the terminal plate (2) at the base of the loop former and attached by soldering to connection spills which are fixed in the terminal plate. The wound loop has an approximate overall diameter of 11 in. It is 3 in. wide, and is carried on a cradle of cast aluminium (6, fig. 2), to which it is attached by its base with four screws and nuts (7). A slot in the base of the former and a pin on one leg of the cradle, both of which can be seen at (8), locate the loop former with respect to the cradle. The edge (9) of the loop former base in which the slot is provided is painted red.

6. The requirements for mounting the loop are that it should be supported rigidly in position in the aeroplane whilst at the same time it is capable of being rotated about its vertical axis. This is achieved as is shown in fig. 3, by means of a tubular unit comprising an outer support tube assembly (1) which is rigidly fixed to the aeroplane by a suitable clamp, not shown in the illustrations, and an inner drive or torque tube (2) supported in the outer tube assembly by two ball bearings, the lower of which can be seen at (3). These ball bearings are packed with anti-freezing grease and are suitably spaced to give vertical rigidity to the inner tube. The loop is mounted by its cradle on to the end cap (4) which is brazed on to the drive or torque tube (2). To the other end of this tube the driving mechanism is attached with any necessary registering scales or remote control device which may form part of the particular installation. The cradle and tube mountings are fitted with dowel pins, slots and holes to locate them with respect to each other. This is to keep the correct sense of the assembly when orientated with respect to the aeroplane.

7. A short length of Dumet 4 cable (5) connects the loop windings to the cable run which in turn connects them to the radio receiver. This cable is clamped into the terminal plate at the base of the loop and passes down through the cradle and drive or torque tube to a plug connection (6), situated behind the point of emergence of the cable from the drive or torque tube. It is essential that this cable is kept short, a length of 18 in. is allowable from the end of the box drive. The cable is connected to the radio receiver by a suitable socket and plug and a length of Dulocapmet 2·5 cable, this type of cable being used in order to reduce capacitance effects to a minimum. The plug from the loop is connected into the socket and the plug at the other end of this cable connects directly into the receiver. Sockets and plugs have register guides and slots in order to keep the right sense in the electrical connections. The holder of the socket should be bonded to the metal frame of the aeroplane. All cable connections must be made colour for colour throughout the whole cable run, that is the same colours of the cable cores must be connected together at cable joints whether by plugs and sockets or direct connection.

8. The loop is mounted in a streamline housing on the fuselage, or within the skin but outside the metallic structure of the aeroplane. Within specified limits and the requirements set out in this Chapter, contractors are given a certain latitude in the manner in which the loop is mounted on the aeroplane. This includes also the actual mounting of the loop upon the tube assemblies which carry it and allow it to be rotated.

9. When the loop is mounted in a streamline housing on the fuselage of the aeroplane, this housing has to be of special design. Its general outline and design is shown in fig. 3. It is made of moulded composition in three portions, nose, centre and tail, which are fastened together. The centre section is illustrated in fig. 2. The centre and tail sections are coupled by screws round their periphery. The nose is clamped to the centre section by a single moulded composition screw at the nose. The housing is mounted on the aeroplane with its nose facing into the airstream.

Quadrantal error corrector

10. The quadrantal error correction device is illustrated in fig. 4 and is shown in position in the loop housing in fig. 3. It consists of two metal strips (7 and 8, fig. 4), forming a single turn loop, which are mounted in the streamline housing and surround the D.F. loop in a vertical plane containing the major axis of the loop. A variable inductance (9) is in series with these strips, which are made

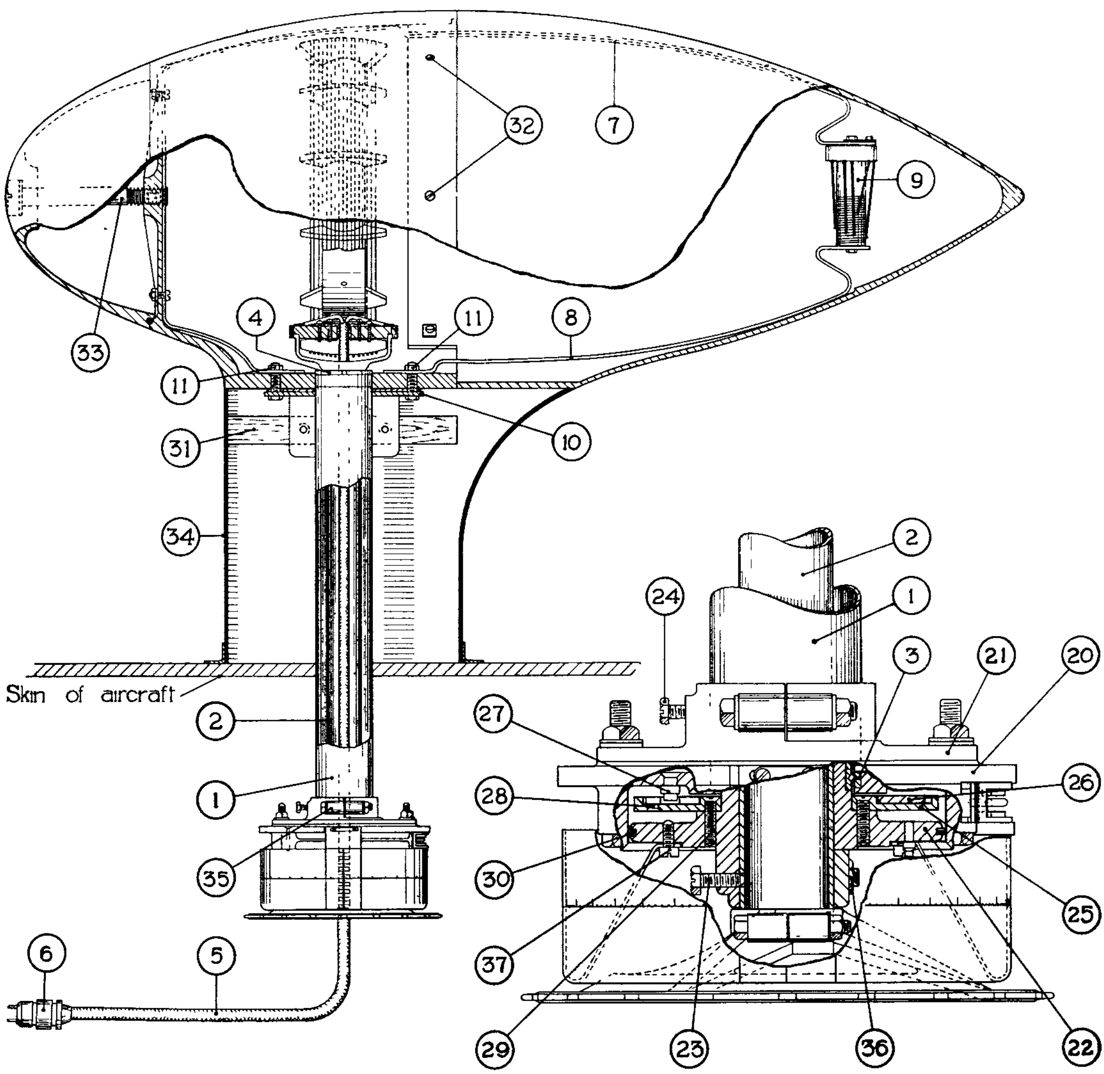

FIG. 3—AERIAL LOOP IN HOUSING MOUNTED ON AEROPLANE

electrically continuous and earthed through the metal plate (10) and bolts (11) which clamp the tube assembly to the housing (see fig. 3). By adjusting the value of the variable inductance, the loca field is modified in a manner which corrects, within 2 degrees, the quadrantal error due to the distortion of the field by the metallic structure of the aeroplane.

11. The quadrantal error correction inductance coil (9) fig. 4, consists of an ebonite or moulded insulation former about 1 in. dia. and 3½ in. long. It has a flange at one end about 1¾ in. dia. and ½ in. long. In this are set nine studs at positions (12) each of which is drilled and tapped to take a screw at the remote end. The remote end of the former flange in which these studs are fixed is recessed and has a disc of ebonite or moulded insulation material (13) which is attached in the recess by two screws (14). This disc serves to insulate the tapped studs from external contact, but access is given to them by holes (12) in the disc over each stud through which a screw can be introduced to make electrical contact with the stud. Each hole has engraved above it a number in the following clockwise sequence 0°, 10°, 12°, 4°, 14°, 16°, 6°, 2°, 8°.

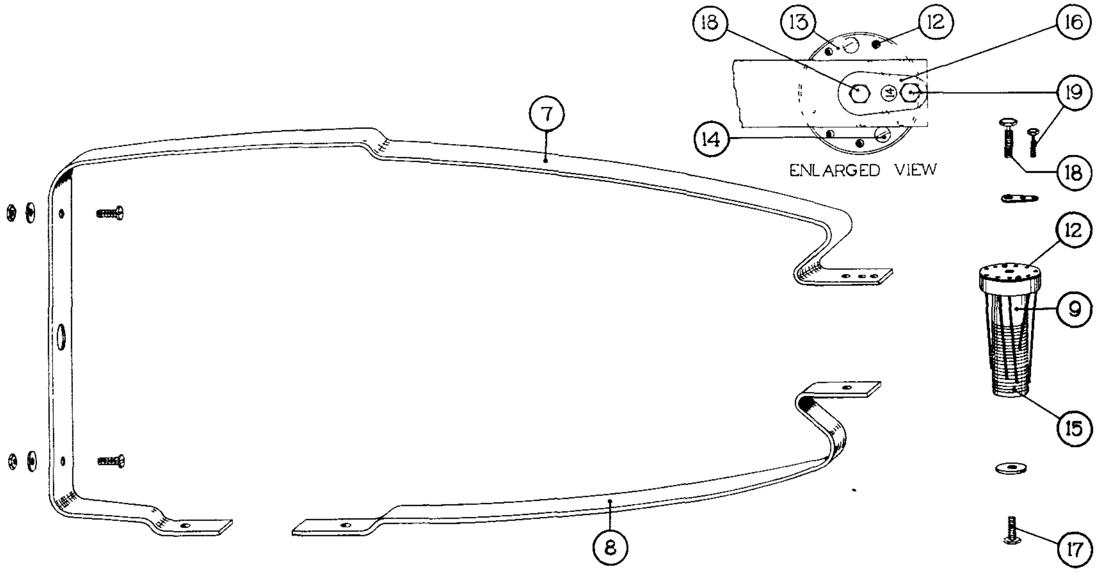

FIG. 4—QUADRANTAL ERROR COIL AND LOOP

12. The stock or cylindrical portion of the former remote from the flange, has a screw thread cut upon it for about 2⅝ in. of its length. In the slots of this thread is wound a coil of tinned copper wire (15) having 9 tappings at slected points. These tappings are connected by insulated wires to the studs in the flange of the former. The first tapping point, at the remote point of the coil is connected into a large brass insert which is screwed into the end of the former at its centre. This insert is tapped to take a screw connection. At the flange end, in a similar position, is another smaller insert similarly tapped. These tapped inserts are provided to make both mechanical and electrical connection with the quadrantal error correction strips which fit into, and are attached to, the loop housing. A shaped brass plate (16) about 1¼ in. long, having in it three holes, is also provided to enable tappings to be connected into the correction loop circuit. This plate is attached, by a hexagon-headed screw (18), to the centre stud on the flange of the former. Its centre hole is positioned so that the engraved numerals on the disc in the recessed portion of the flange can be read through the hole. The third hole is positioned so that a screw (19) entering it can engage the coil connection stud holes, through the disc.

13. The quadrantal error correction strips (7 and 8) which are associated with the quadrantal error correction coil are of brass, about 1 in. by ⅛ in. cross section. They are shaped to fit into the housing to which they are attached at the flat wall portion behind the nose by two sets of screws, washers and nuts (*see* fig. 3). A hole at the centre of this portion of the strip allows the nose fixing bolt (33) to pass through it. The tail end of the strips are shaped into a spring which when they are in position holds the strips rigidly in place by forcing them against the walls of the housing. The strips are clamped by the bolts attaching the loop to the housing. At the spring end of the strips the correction coil (9) is fitted. Details of these strips are illustrated in fig. 4. It is attached to the shorter strip by a hexagon screw (17) and washer fitting into the stud at the end remote from the flange in the former. The screw is locked by turning up the washer against one of its flats and punching the washer into a hole provided in the strip. The larger strip is attached by a hexagon headed screw (18) which when passed through the selection plate (16) enters the central stud in the flange of the former. Selection of the required tapping is explained in para. 29 and para. 58, (X), (c) and a further hexagon-headed screw makes the required connection. The nuts are locked in position by turning up a portion of the washer against a flat of the hexagon-headed screw.

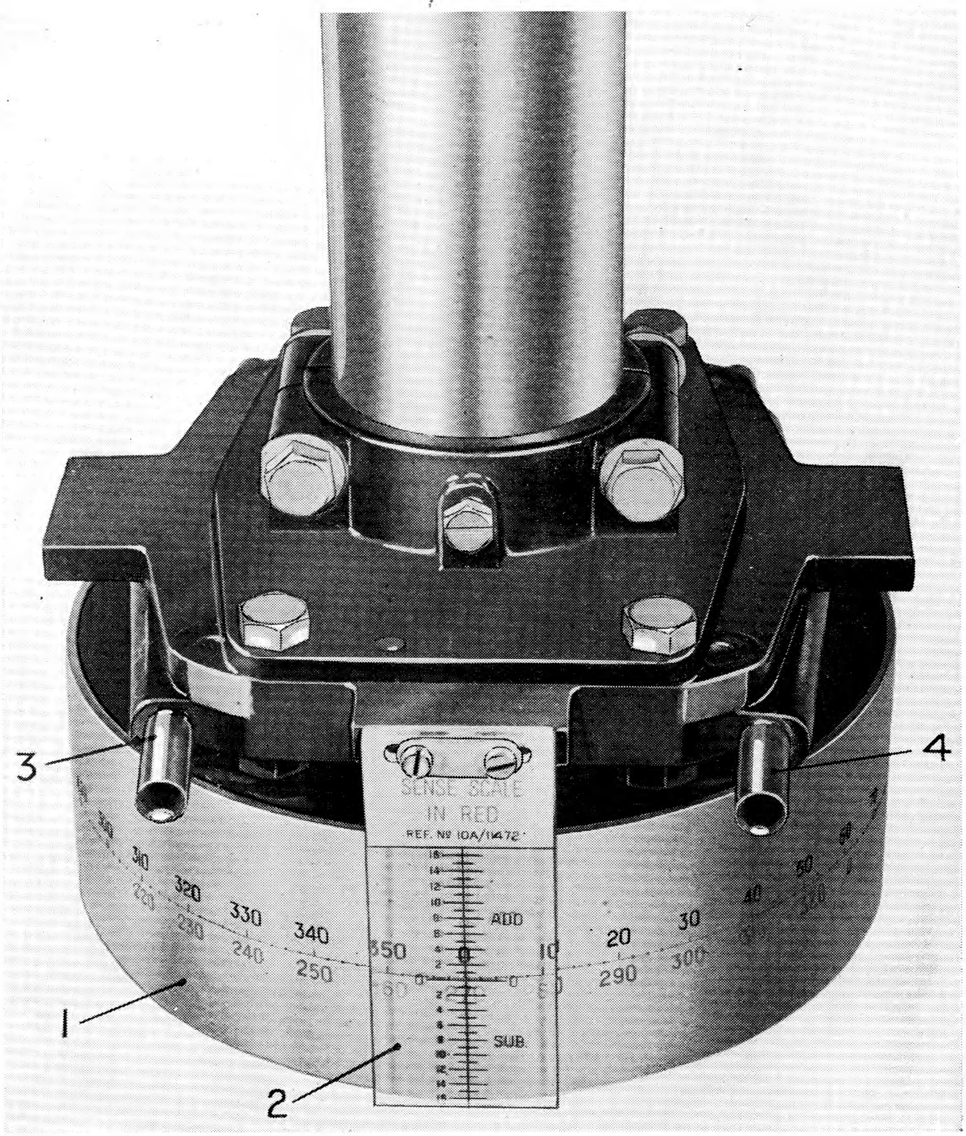

FIG. 5—BOX DRIVE, TYPE 1

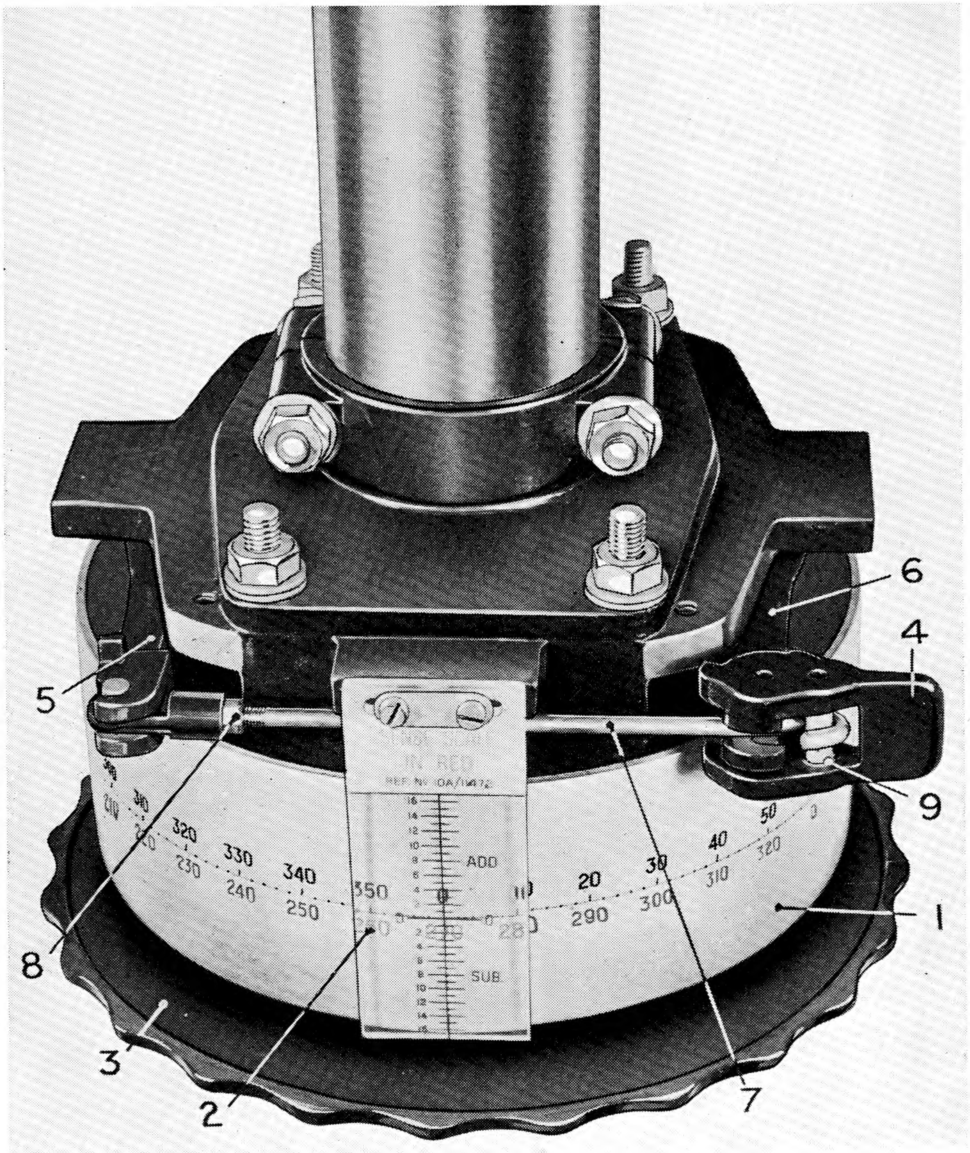

Fig. 6—Box Drive, Type 2

14. The corrector is designed to reduce quadrantal error, which is negative in the first quadrant, as is usual in most types of aeroplane. In cases where the error curve is positive in the first quadrant, as is expected in flying boats where the loop is mounted on the upper plane away from the hull, it is not possible to apply correction by means of this device. In such cases the coil should be locked at 0°, which is an open circuit.

15. A skirt-shaped scale ring, shown at (1) in figs. 5 and 6 is attached to the inner mountings of the box drive which is fixed to the end of the torque tube remote from the loop. The scale ring encloses this mounting. Its position and method of fixing is shown in the enlarged view in fig. 3. Two types of scale ring are provided, one for use when the loop is mounted above, and the other for use when the loop is mounted below the aeroplane, the latter has the engraving reversed for normal visual reading. Scale rings are engraved about their centre with a scale of degrees from 0 degrees to 360 degrees, one above and one below the centre, the latter filled in red and displaced 90 degrees for sense indication. Referring again to figs. 5 and 6 it will be seen that outside of this scale ring is a transparent cursor reading vertically up and down from a central zero, from 0° to 16° up and from 0° to 16° down. The up position is also engraved ADD, and the down position SUB meaning subtract. Its zero coincides with the scale line of the scale ring. The scale ring is finished to enable the quadrantal error correction to be plotted and drawn upon it in pencil. The cursor is attached to the outer or support tube mounting and thus is stationary relative to the scale ring.

Control

16. The drive, which imparts rotation to the loop, can be for either direct or remote operation. The direct operated drive illustrated in fig. 6 functions by means of a handwheel (3) which is attached to the end of the torque tube and is controlled by hand. A brake (4) which can be used to retard the movement or lock the loop in position is provided on the box drive. A remote control installation is illustrated in fig. 7. A shaft which runs within guide tubes (1), consists of a stranded core of steel wire on which is wound a helical tooth wire making about nine turns to the inch. This shaft is operated by a controller (2). A remote indicator (3) is provided to repeat the ndication given on the scale ring which is attached to the torque tube.

Controller

17. The controller is illustrated in fig. 8. It consists of a handwheel mounted upon an aluminium box which contains a chain of gear wheels giving a reduction of approximately 4½ to 1. This chain of gears drives a wheel which has teeth cut on its periphery and which engages with the shafting connecting the controller with the loop drive. The shafting is led past the toothed wheel by a guide tube (1), which is cut away about its lower centre in order to allow the shafting to mesh with the toothed wheel. This guide tube is detachable, and can also be swung clear to disengage the shafting from the toothed wheel for the purpose of adjustment during assembly, or any necessary subsequent calibration of the drive. Four lugs are provided for fixing the controller to the aeroplane structure.

Indicator

18. The indicator, which repeats the readings given on the scale ring mounted on the torque tube of the loop, is illustrated in fig. 9 It consists of a circular aluminium container housing a wheel which has teeth cut on its periphery, in a similar manner to that of the controller. A guide tube (1), of the same design and function as that provided for the controller, is attached to the top of the container above the toothed wheel and is similarly removable or can be swung clear for meshing or unmeshing the shafting. The front of the container is protected by a transparent covering of special design, to give clarity to the scale markings. It encloses a circular scale engraved in degrees, from 0 degrees to 360 degrees clockwise The scale is finished to enable the quadrantal error correction curve to be plotted and drawn upon it. A circular transparent cursor is attached to the fixed portion of the hub of the indicator by three screws in slots which are provided to facilitate zero adjustment. This cursor has a scale engraved upon it, up and down from a central zero, 0 degrees to 16 degrees up and 0 degrees to 16 degrees down. These markings are inverted on the other side of the central scale so as to facilitate reading when the cursor is rotated. The up position is also engraved ADD, and the down position SUB meaning subtract. The cursor has also a sense arrow engraved upon it at an angle of 90 degrees counter-clockwise to the cursor scale. It is filled in red and has the word SENSE engraved upon it. The lugs of the casting adjacent to the ends of the guide tubes are painted red and yellow respectively. The left-hand and right-hand lugs are painted at their edges red and yellow respectively. This is provided to facilitate the correct connection of the casing, as is described in para. 34. Three lugs are provided for fixing the indicator to the aeroplane structure.

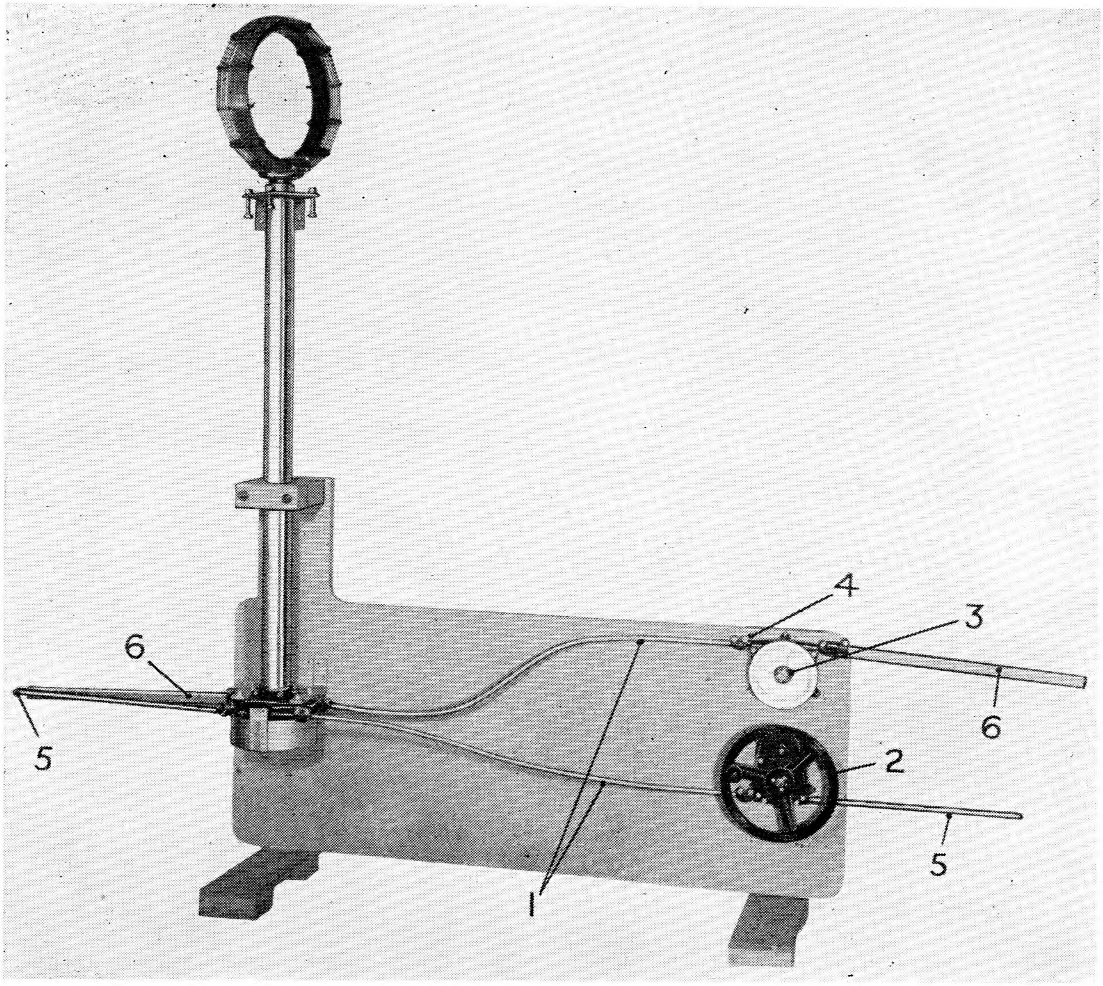

FIG. 7—REMOTE CONTROL LAYOUT

Box drive

19. The box drive forms an integral part of the assembly; two types are provided. Type 1, illustrated in fig. 5, is for remote control and type 2 illustrated in fig. 6 is for direct drive. Reference to fig. 3 will show that in each case the box drive consists of two aluminium castings which fit one within the other. On to the outer casting (20) the outer or support tube (1) of the loop tube assembly is fixed by means of a brass stamping (21) which is bolted to the casting. This casting carries the outer portion of the ball bearing (3) remote from the loop, which is secured in position by a retaining plate fastened with screws. Inside this casting and bearing assembly is another casting (22) which is clamped to the drive or torque tube (2) of the loop tube assembly. This casting carries the inner portion of the remote ball bearing (3) held in position and locked by two circular nuts and a locking washer. Two cone-ended screws are provided, one (23) for the inner and the other (24) for the brass stamping to register them to the inner and outer tubes of the loop tube assembly respectively. They are fixed into position when final adjustments have been made.

20. Between the inner and the outer castings is formed a chamber in which is housed either a brake wheel (25) or a toothed wheel, according to whether the box drive is type 1 or type 2, that is, for remote or direct control respectively. These wheels are of similar design and embody a stop plate (26) which is cut away for about 200 degrees of its circumference. Pins are attached, one (27) to the outer casting and one (28) to its toothed wheel or to the brake wheels. These pins project into the cut-away portion of the stop plate and are mounted so that they clear each other when the loop is rotated. A total rotation of 400 degrees is possible when the inner casting is rotated in

relation to the outer. The gear wheel or the brake wheel is attached by screws (29) to a suitable bearing surface on the inner casting and runs in the chamber which is formed between the inner and the outer castings. This chamber is completely enclosed by a felt washer (30) held in a groove in the edge of the inner casting closing the space between the inner and the outer castings. Type 1 box drive includes a toothed wheel and two guide tubes (3) and (4) which can be seen in fig. 5. These are similar in design and function to those of the controller and indicator. They are attached to the outer casting of the box drive and allow shafting from the controller in one instance and the indicator in the other, to be meshed with the toothed wheel. Similar detachable and meshing features are provided for these guide tubes to those of both controller and indicator. The casting adjacent to the ends of the guide tubes is painted red and yellow respectively. These indication colourings are diametrically opposite each other, the yellow being on the left-hand corner as seen in fig. 5.

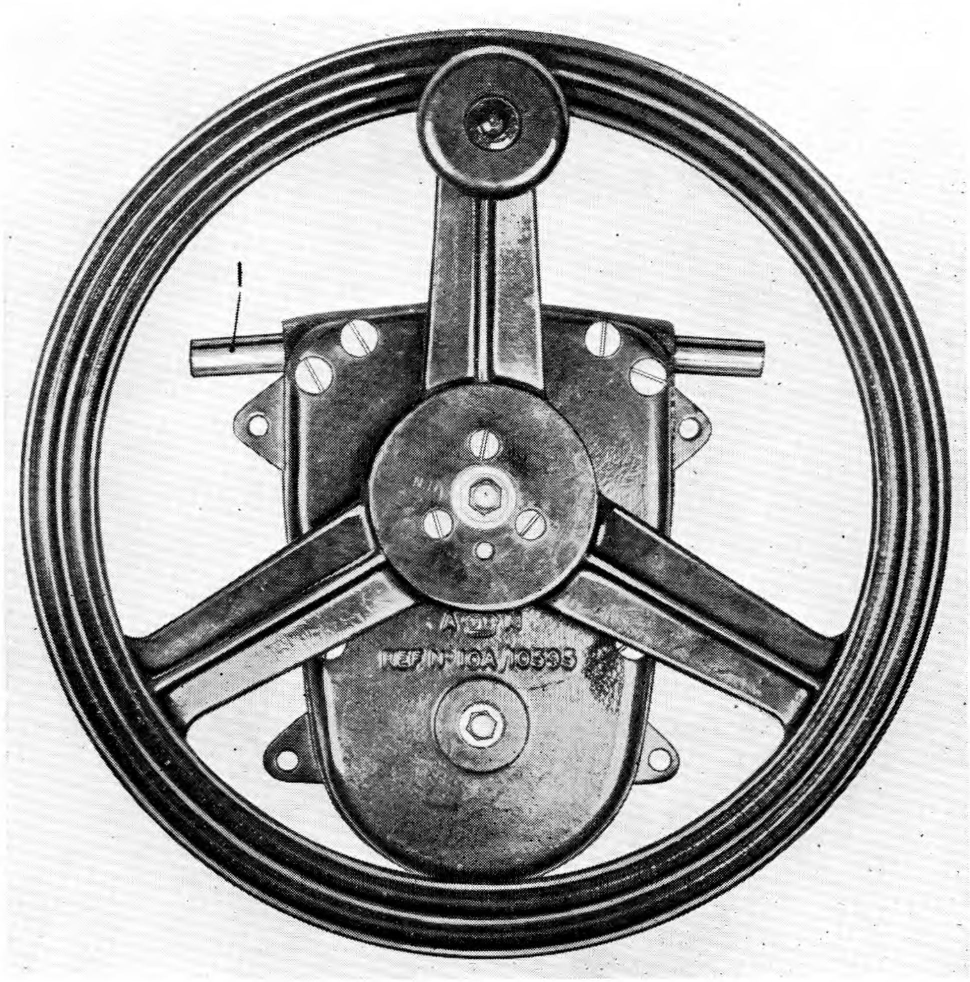

FIG. 8—CONTROLLER

21. Type 2 box drive includes a brake wheel, and referring to fig. 6 it will be seen that instead of the guide tubes which are incorporated in type 1, their place is taken by two brake levers (5) and (6) having cork brake blocks attached to them. These brake blocks press against the brake wheel through the cut-away portions in the casting through which the shafting engages the worm gear wheel in type 1. The brake levers are linked together by a connecting rod (7) and a toggle with a thumb locking lever (4). The connecting rod and toggle draw the levers together and press the brake blocks against the brake wheel. This brake locks the loop aerial in any desired position and can be used while taking a reading to prevent involuntary movement when a minimum has been obtained. Adjustment of the pressure on the cork brake blocks is made by loosening the

nut (8) and removing the rod from the pin (9). The rod may then be adjusted a turn either way, after which it should be locked by the nut (8). Type 2 also carries the skirt scale ring (1) on the inner casting. A cursor (2) is attached to the outer casting on the most convenient of any of the four lugs provided.

Shafting

22. The shafting which connects the controller to the box drive, and the indicator to the box drive is flexible and is known as shafting, flexible, Type E1. It carries a continuous helix upon its periphery which engages with the toothed wheel in the controller, indicator and box drive. It runs in tubular casing known as casing, rigid, Type E2. This casing which can be seen at (1) in fig. 7 is attached to the aeroplane structure by suitable cleats, and is bonded to the frame of the aeroplane at frequent intervals. Lengths of the casing are connected together and the casing is connected to the guide tubes of the controller, indicator and box drive by unions (4). Certain of these are lubricating unions, a number of which need to be incorporated in each run of casing depending upon its length. As the shafting does not revolve, but travels forwards and backwards in the casing, provision has to be made to house the overrun portion of the shafting. This is accomplished by attaching extension tubes (5) to each of the open ends of the guide tubes of the controller and the box drive. These extension tubes are formed by a suitable length of casing with the free end pinched.

Anti-torsional unit

23. The indicator shafting has an anti-torsional unit which is fitted to each of the free ends of the guide tubes of both the indicator and the box drive. These can be seen at (6) in fig. 7. Their purpose is to prevent any tendency on the part of the indicator shafting to twist in operation, a tendency which if allowed to operate would introduce an appreciable error between the readings of the scale on the box drive and the indicator scale. The anti-torsional unit consists of an extension tube which has an elliptical instead of a circular bore. A metal bead, also of an elliptical cross section, is secured firmly to the shafting and runs smoothly in the elliptical bore of the extension tube. Any tendency on the part of the shafting to twist is prevented by the bead which, whilst allowing free movement of the shafting to and fro in the casing, prevents the twisting action which may be imparted to it by reason of the worm gear wheels with which it is meshed.

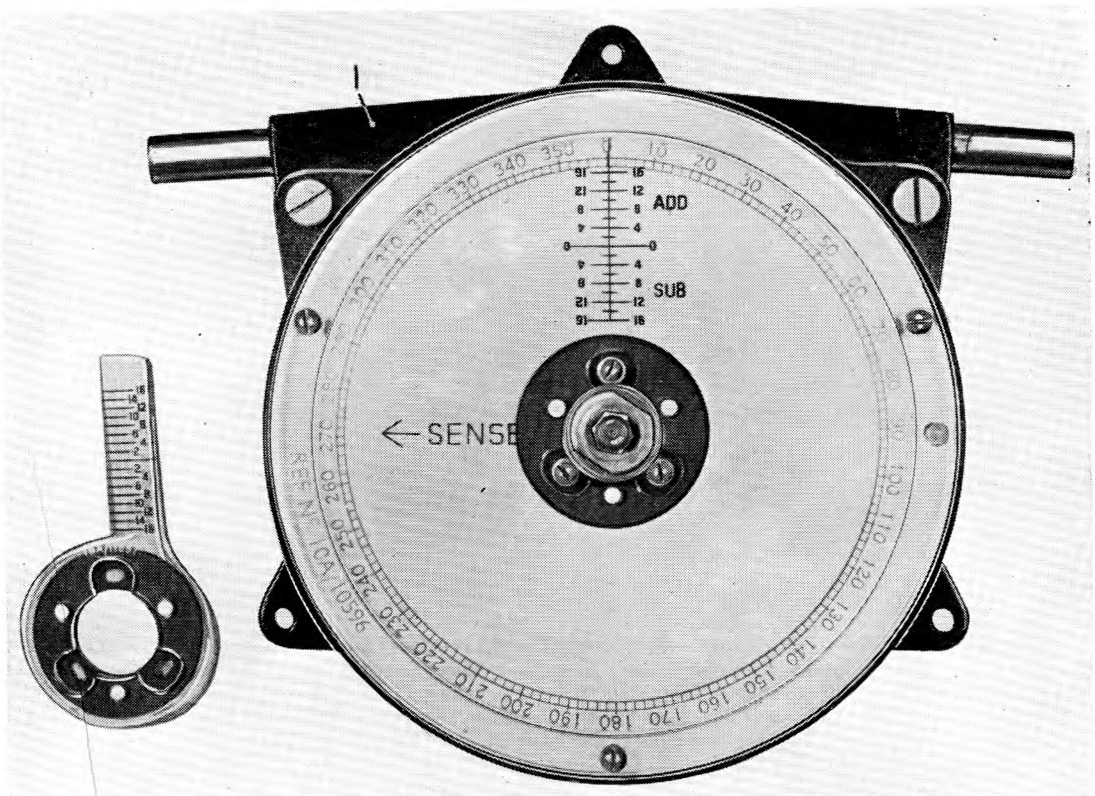

Fig. 9—Indicator

INSTALLATION

General

24. The exact disposition of the various parts of the loop and its control equipment cannot be given as this varies with each individual type of aeroplane. The method employed to rotate the loop depends on the position of the loop in relation to the W/T operator. The contractors are responsible for the actual fixing details in each aeroplane, within certain limits, but the basic requirements, as set out in this chapter, remain the same and are applicable to all types of aeroplane. In detail the actual fixing of the support tube of the tube assembly may vary in method, both as to how it is fixed to the structure of the aeroplane and to the housing fairing former, but there are certain specified strength requirements for this fixing which have to be fulfilled. This fixing also involves a variation of the actual distance between the loop cradle and the box drive which requires that in some instances the tube assembly shall be lengthened. When this becomes necessary, extension tubes each of the same length, are joined on to the support and torque tubes by muffing. These tubes are of steel 2 in. and 1·25 in. outside diameter respectively. The dumet 4 cable has also in such instances to be longer but the maximum allowable free portion outside the box drive remains 18.

Loop without housing

25. The box drive should first be fixed to the aeroplane structure, in a convenient position for the operation of the loop, by means of the four screws which project from it. It should be so disposed that when remote control is to be used the guide tubes are in a favourable position for the run of shafting to both controller and indicator, and the cursor so positioned that it can be read accurately. The tube assembly can then be slipped into the box drive and the top clamp tightened. The cradle should next be attached to the tube assembly. A locating dowel pin is provided on the cradle which should enter the hole provided on the tube assembly. The cradle should be locked into position by means of a fixing nut which screws on to the threaded portion at the top of the tube assembly. Two holes are provided in this fixing nut into which fits a pin spanner for tightening the nut, and two further holes are provided, tapped for grub screws which are fixed in position after the fixing nut is tightened.

26. The loop can now be attached to the cradle, but first the dumet 4 cable should be fitted. This cable is connected to the loop windings at the flat base portion of the loop former. This is illustrated in fig. 10. The braiding of the cable should be cut back $1\frac{1}{2}$ in. The circular plate (1)

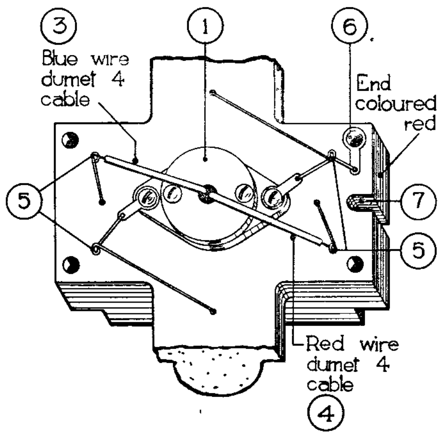

FIG. 10—TERMINAL PLATE OF LOOP

should be removed and the cable screwed up through the central sleeve until sufficient wire and about one inch of braiding has been screwed up past the top of the base. The braiding should be spread over the flat surface of the former base and the circular plate replaced and screwed down, thus clamping the braiding securely between the plate and the flat end of the sleeve. The cable wires (3 and 4) should be soldered to the tags or spills (5) on the inner flat surface of the loop former. The mid-point of the loop is connected to earth, that is the frame of the aeroplane, by a connection from the plate to one of the fixing screws (6) of the cradle, (*see* para. 1). The cable is threaded up through the tube assembly to the loop which is attached to the cradle by four screws with washers and nuts. A pin fixed into the cradle locates the position of the loop by fitting into a slot (7) in the base of the loop former.

Loop with housing

27. The support tube of the tube assembly is attached to the aeroplane by a suitable clamp at the end of the tube assembly which enters the aeroplane structure. This tube is then also attached to the housing fairing former at the loop end. Reference to fig. 3 will show the general features of this assembly and attachment. The housing fairing former (31) is of spruce and in two portions, split along the centre line. These two portions are clamped together, by two sunken bolts with nuts and washers, and grip the support tube. The cradle fixing nut should be removed from the drive or torque tube which should then be passed up into the support tube until its shoulder is against the ball race of the bearing. The cradle should then be replaced and the fixing nut fitted, tightened up and its grub screws put into position. The loop, with cable fitted, should now be assembled to the cradle, as explained in para. 26, the cable having previously been passed through the drive or torque tube.

Quadrantal error corrector

28. The quadrantal error correction device can now be fitted. Its general disposition in the housing is shown in fig. 3. The wooden spacing piece which is sometimes in position on delivery should be removed from between the tail ends of the strips of the corrector, and the coil (9) fitted into this space, i.e. between the free ends of the strips. It is fitted, with the engraved end farthest from the skin of the aeroplane, by means of the two larger screws which should be loosely fitted at this stage. Two soft metal washers are placed between the strips and the screw heads.

29. The coil can be rotated between the strips and being so rotated the markings 0, 8, 2, 6, 16, 14, 4, 12 or 10, which are engraved on the top of the coil, appear in turn in the hole in the long strip. These details can be seen in fig. 4. The markings tally with the threaded insert in which the third, or selector screw (19) is located. The coil should be rotated until the marking 0° appears, when the selector screw should be inserted into its socket. In this position the correction device is inoperative. When the selector screw (19) has been tightened it should be locked by turning up the end of the plate (16) against one of the sides of the hexagon head of the screw.

Housing

30. The housing is illustrated in fig. 3. The centre section is attached to the housing fairing former (31) by a bracket to which it is bolted and the nose and tail sections attached. The tail section is attached by screws (32) round its periphery and the nose section by a single screw (33) at its centre. The fairing (34) which encloses the tube assembly and is about 9½ in. high is of sheet aluminium 22 s.w.g. It is sometimes mounted upon an inner former, to keep its shape, and is fastened to the skin of the aeroplane by a suitable flange and to the housing, at the housing fairing former line. The housing is fixed in position so that the nose points to the front of the aeroplane.

31. When the housing is fixed in position with the fairing attached, the box drive should be clamped to the support tube of the tube assembly, inside the aeroplane. This should be positioned, whenever possible, so that when remote control is to be used, the guide tubes are in a favourable position for the run of shafting to the controller and indicator and the cursor so disposed that it can be read accurately. The tube assembly can now be tightened.

Adjustment

32. Referring again to fig. 3, the bolts (35) clamping the box drive to the support tube should be slackened and the box drive revolved until the cursor is in the best position for accurate reading. The clamping bolts should then be re-tightened. The loop should be set athwartships, with the red end of the former nearest to the tail of the aeroplane and held there. The portion of the box drive which is attached to the drive or torque tube should then be rotated, its clamping bolts (36) having previously been slackened. Rotation should be made until the cursor reads 180 degrees on the black marking of the scale ring, when the clamping bolts should be re-tightened. This adjustment is made to the nearest tooth of the toothed wheels and final exact adjustment is completed by loosening the fixing screws on the cursors of the indicator and box drive and setting them exactly. Both should read 0 degrees. The loop rotates approximately 400 degrees and is usually set to rotate 20 degrees on either side of 0 degrees in order to provide ample overlap. Set screws (23) and (24), to be found in each of the clamps, one on the support tube and one on the torque tube, should be removed and a No. 26 drill entered through the tapped holes and drilled through each tube. The scale ring will have to be removed, by unscrewing four screws (37) on the base of the box drive, for this purpose. The set-screws should then be replaced and screwed in firmly, after which the scale ring should be replaced.

Controller and indicator

33. When the loop and its drive equipment have been fixed into position and adjusted, the indicator and controller should be mounted in the aeroplane in a position that will be convenient for operation. Each is fixed to the aeroplane structure by screws, using the lugs provided. Convenience for fixing the tubing which carries the shafting is a factor of importance when locating the selector and controller.

Casing

34. The casing is attached to the aeroplane structure by cleats, and is joined to the guide tubes of the controller, box drive and indicator by unions and lubricating unions. It is essential when fixing the casing to give special attention to two points, namely, that no sharp bends are incurred, and that the total of all the bends between the controller and the box drive or between the box drive and the indicator do not exceed exceed 360 degrees. At the points where unions are used to join two pieces of casing together, or where unions join the casing to the guide tubes, the ends of the casing and guide tubes are bell-mouthed to ensure an absolutely free run for the shafting and to obviate any possibility whatsoever of the shafting catching or being subject to friction at any junction. All casing junctions are pinned to prevent disengagement or any extension in the length of the run by partial disengagement at a joint or joints. The connection of each unit to the other is normally by the rule of like colour to like colour, namely, yellow to yellow and red to red, but when the loop is mounted to project *below* the aeroplane, the casing has to be assembled between unlike colours on the box drive and indicator guide tubes.

Shafting

35. When the equipment has been assembled and the casing runs fixed, one screw should be removed from each of the four guide tubes and each tube, at the freed end, swung out clear of the worm gear wheel. The correct length of shafting is cut with a bolt cropper and the ends ground to a cone. Each length should then be inserted into its respective casing run, through the guide tubes, until an equal amount of shatfing extends from each guide tube. Both the loop and the indicator should then be rotated until they each register 0 degrees and, having made sure that in each case the shafting extends equidistantly from each guide tube, they should be swung back into position and the retaining screws replaced and screwed up. When swinging the guide tubes back into position care should be taken to ensure that the shafting and toothed wheel mesh properly. The protecting casing for the ends of the shafting which project from the guide tubes of the box drive—controller run can now be assembled and fixed.

Anti-torsional units

36. The drive box—indicator shafting requires anti-torsional units to be fitted to each of the free ends of the guide tubes of the box drive and indicator. These are attached by means of the unions provided which are clamped to the guide tubes. The beads are then assembled by clamping them one to each end of the shafting by the screws provided in each bead, after which the anti-torsional tubes are passed over the beads and clamped by the unions which receive them. Minor adjustments to give exact coincidence between cursor and dial should be made at this stage, after which all clamps and screws should be finally tightened and clamped.

37. All metal parts are zinc-sprayed and enamelled black. Certain metal parts are cadmium or zinc-plated. Care should be taken to ensure that cleanliness and free working conditions are maintained. Lubrication should be made in all cases by anti-freezing oil or grease according to the purpose of the part lubricated.

OPERATION

General

38. The loop is connected by means of the plug which is attached to the dumet 4 cable projecting from the box drive. This plug fits into a socket which is attached to the dulocapmet 2·5 cable run and terminates in another plug which is used to make direct plug-in connection with a sense unit in turn connected to the receiver. The *fixed* aerial of the aeroplane is also connected to the sense unit by means of a plug and socket, for sense finding purposes. The trailing aerial of the aeroplane is not to be used for this purpose.

39. The sense unit, which is used in conjunction with the receiver R1082, is illustrated in fig. 11. It comprises two switches (1) and (2) and a variable resistance, suitably housed and provided with a socket (3) to make connection with the loop connection plug, a plug (4) to make connection with the receiver, a socket (5) to take the plug connection from the fixed aerial, and a plug (6) to connect the fixed aerial with the receiver. The switch (1) has three positions engraved D/F, SENSE and TRAFFIC. The other switch (2) has two positions engraved RECIPROCAL and BEARING. This latter switch has SENSE engraved upon its operating handle, and a reminder, SELECT MINIMUM, is engraved on the case immediately above this handle. The resistance operating knob is engraved INCREASE.

40. The switches of the sense unit perform the following functions. When the three-position switch is placed in the D/F position it disconnects the fixed aerial enabling the loop to be used alone. When the switch is placed in the SENSE position the fixed aerial is connected to the receiver through the variable resistance, the loop still being connected. When placed in the TRAFFIC position, the fixed aerial is connected directly to the receiver. The two-position switch enables the connections of the loop to be reversed.

41. The detailed operations for obtaining D/F bearings with any given receiver will be found in the chapter appropriate to that receiver, but the method of using the screened loop aerial, type 3, as given in this chapter is applicable generally.

42. The loop may be used directly or through remote control. When used directly, the position of the receiver will be sufficiently close to enable the operator to make simultaneous adjustments of both receiver and loop. When used with remote control the controller and indicator will be installed near the receiver and the operator will rotate the loop, by means of the controller, and observe the indicator readings, whilst using the receiver.

43. Cursors are provided which are engraved to read above and below a zero line. These markings are universal in the case of indicator cursors, but are of two different types for the box drive scales, depending upon whether the loop is mounted above or below the aeroplane. For calibration purposes, special marking cursors are provided. They are fixed in place of the normal cursor during calibration, and removed and stowed away for future use when the calibration has been completed.

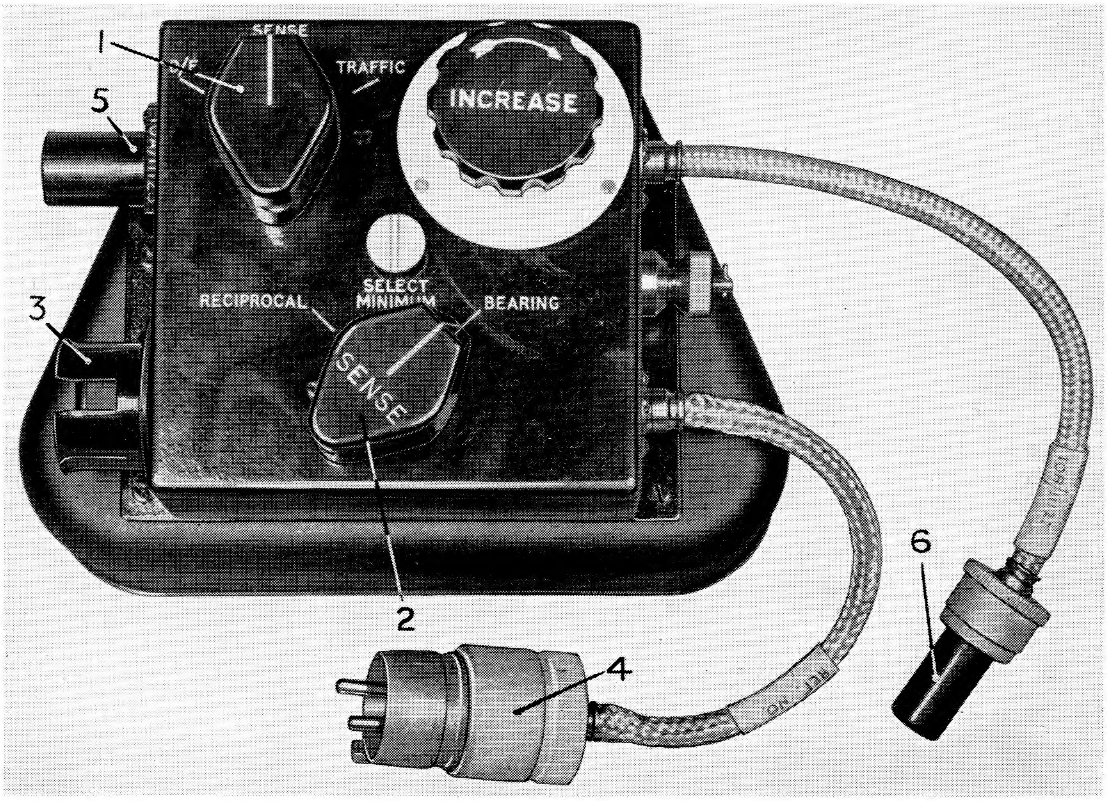

FIG. 11—SENSE UNIT

44. The operation of taking an ordinary D/F bearing resolves itself into the simple process of identifying and tuning the receiver to a suitable transmitter and, with the loop connected to the receiver, rotating the loop whilst simultaneously listening to the transmitter. The strength of the signal heard in the head receiver telephones will vary as the loop is rotated, and at two points in each revolution of the loop the signal will fall to a minimum. If the scale on the indicator is observed it will be found that the two readings at which these minima occur are separated by 180 degrees. One of these minima is the bearing of the station from the aeroplane heading and the other the reciprocal of the bearing.

45. The ambiguity of 180 degrees can be resolved by dead reckoning. It may also be resolved by obtaining a second bearing on the same transmitter a few minutes later or by obtaining a bearing on another transmitter. In order to resolve this ambiguity at the same time as the bearing is taken, however, sense-finding arrangements are provided.

46. With the loop aerial connected to the receiver, two signal minima are obtained, by rotating the loop, which are 180° apart. To determine which of these minima corresponds to the direction from which the signal has arrived, the sense aerial should also be connected to the receiver through an adjustable resistance. The combination of the signals picked up by the loop and the sense aerial then produces a heart-shaped or cardioid polar diagram in place of the figure-of-eight which is produced by the loop alone. The single minimum of the heart-shaped diagram is displaced by 90° from the two loop minima on the loop scale. By maintaining a series of fixed conventions for the loop aerial and the sense aerial connections and positions, it is possible to arrange that the heart-shaped minimum is always 90° *higher* than the loop bearing minimum and hence 90° *lower* than the reciprocal minimum or vice versa. The screened loop aerial, type 3, is connected so that with the sense switch in the "bearing" position the cardioid minimum is 90° higher than the loop bearing minimum on the loop scale, and the cardioid maximum 90° lower than the loop bearing minimum on the loop scale.

47. In practice, sense determination is facilitated in the following manner. The indicator has an arrow with the word SENSE engraved with it and filled in red. This arrow is at an angle of 90 degrees counter-clockwise to the main pointer. Similarly the scale ring attached to the box drive has two sets of scale markings, one under and one over the central scale. One of these scale markings is engraved in red and is 90 degrees clockwise advanced in phase with the other markings. The application of these scales to the determination of sense in practice is described in the following paragraphs.

Bearing

48. With the switch of the sense unit in the TRAFFIC position a suitable transmitting station should be identified and the receiver tuned to receive it. The fixed aerial should then be disconnected at the receiver and the station listened to with only the loop connected. The loop should now be swung through 360 degrees, observing at the same time, the readings of the two minima on the indicator. When using the remote indicator the readings should always be taken on the correction curve at the zero line intersection. Very broad minima should not be used if another suitable located transmitter can be selected which will give better minima. It should be borne in mind that the broader the minima, the less will be the accuracy. Having obtained satisfactory minima the mid-point of one should be carefully noted. This may be either the bearing or its reciprocal.

Determination of sense

49. The same procedure should be used as indicated for obtaining a bearing and after noting the reading the loop should be swung so as to bring the sense arrow into the position previously occupied by the main reading of the cursor, or when using the loop without remote control, until the cursor occupies a position which gives a similar reading on the red scale. The fixed aerial should then be re-connected and the switch turned to SENSE. The connection of the loop should now be reversed by means of the switch provided on the sense unit, repeatedly changing over and observing the change in the signal strength from one position to the other. The variable resistance incorporated in the sense unit and connected in series with the fixed aerial, may require adjustment to produce the maximum change.

50. The reversing switch is engraved in white characters, at one position BEARING, and at the other RECIPROCAL. If the minimum occurs at BEARING then the figure noted on the scale is the bearing. If the minimum occurs at RECIPROCAL then the figure is the reciprocal.

51. Whenever any modification is made to an installation, and in the case of a new installation, it is essential to remove any doubts in regard to sense and bearing by making a check as early as possible on a station whose bearing is known. Unless it can be assumed with confidence, by previous exact comparison, that the installation functions correctly, no reliance can be placed upon bearings obtained by this method. It is therefore essential to be able to assume constant installation conditions.

CALIBRATION

52. After installation, and at certain subsequent periods, the D/F equipment must be calibrated in order to ascertain the magnitude and distribution of the errors due to distortion of the electro-magnetic field of a received wave, by the metallic structure of the aeroplane. These calibrations must also be checked in flight.

53. A re-calibration must be carried out whenever any of the following conditions come into being:—

(i) If a serious discrepancy is revealed between the ground calibration and the results obtained in the air.

(ii) When any major modification is made to the aeroplane structure, for example, the addition of armour plating, a change of engine or fuel tank within the fuselage, the addition or removal of a fixed W/T aerial or aerial mast, or any structure external to the aeroplane.

(iii) When a compass has been re-swung (in accordance with K.R. and A.C.I.762), but this is not essential in time of war.

(iv) In the case of an aeroplane of wooden or composite construction, when any modification or repair is made to the aeroplane bonding system.

(v) Every three months.

54. The errors which can affect D/F readings vary in magnitude, reaching a maximum value in each quadrant of relative bearing, and are therefore usually referred to as quadrantal errors. The maximum errors, however, rarely occur exactly at the quadrantal points. They are usually from about 6 to 12 degrees and have the effect of giving a blurred minima. A complete calibration, that is, a series of readings on more than 24 points, must be performed on either the 150 to 500 kc/s band, or on the 500 to 1,200 kc/s band. If the complete calibration is made on one wave band, it must be checked carefully on not less than 8 points on the other wave band.

55. The calibration must be performed by competent personnel who have a knowledge of navigation. The essential requirements are, a suitable site and suitable sources of radio signals. With regard to site and apparatus required, Chapter 9, Section 6 of this publication should be consulted. As suitable sources of signals, broadcasting stations are usually satisfactory. If possible, stations within 150 miles, but not in the immediate vicinity, should be selected. The sources chosen, with their frequencies, should be noted for future use. In time of war a local oscillator such as a T1083 on low power should be used, provided it is ½ mile or more away and can be accurately sighted.

56. Having chosen the signal source or sources to be employed, the *true* bearing, at the position where calibration is to take place, should be measured accurately by means of a suitable map and protractor. The true bearing, thus found, must be converted into the *magnetic* bearing by applying the magnetic variation, the value of which is usually given on the map from which the bearings are taken. The magnetic bearing must be used for the purpose of calibration.

57. Immediately before the calibration, the aeroplane compass must be swung on 16 points and a deviation card compiled. The following preliminary tests of the D/F equipment should also be made.

(i) The D/F loop should rotate easily in its bearings without play.

(ii) The scale and cursor should be examined for security, and also to verify that they are easily readable without parallax error. Where a remote indicator is also fitted, the readings on the scale on the box drive and on the selector should agree substantially at several points on the scales.

(iii) The connections of the D/F loop to the receiver should be examined carefully and it should be ascertained that the combination of loop aerial and receiver is working normally. In particular, close attention should be paid to the following:—

(*a*) The connections and cleanliness of the plugs and sockets at the loop of the receiver.

(*b*) The electrical contact between the metal earthing flange on both loop and receiver and the metal screening of the cable connecting the two.

(*c*) The earthing of the D/F loop at its point of attachment to the structure.

(*d*) Continuity in both leads of the dumet 4 and the dulocapmet 2·5 cable connecting the loop and the receiver.

(iv) With the aeroplane clear of hangars, etc., and the tail plane at flying level, the receiver should be tuned to one of the signal sources and the quality of the minima on both true and reciprocal readings tested. For this test the aeroplane should be heading approximately toward the signal source. The minima should be sharp enough to read to an accuracy of $\pm \frac{1}{2}$ degree and the reciprocal bearing which should be 180 degrees from that of the true, to an accuracy of the same order. If these conditions are not satisfied, an observation should be made on another signal source, and if this also proves unsatisfactory, the installation should be examined for the following possible defects:—

(*a*) The loop not properly earthed to the structure.

(*b*) A higher resistance (due to faulty connection, etc.) in one side of the loop circuit than in the other.

(*c*) The electrical centre of the loop incorrectly determined.

(v) The fixed aeroplane aerial is connected to the sense unit and all tests should be made with the switch on the sense unit in the D/F position, i.e. with the aeroplane fixed aerial disconnected.

58. When it has been ascertained that the complete installation is satisfactory, calibration may be commenced.

(i) Calibration *must* be undertaken during the period two hours after sunrise to two hours before sunset.

(ii) The aeroplane to be calibrated must be equipped with its full military load.

(iii) The aeroplane, with the tail at flying level, should be wheeled to a level spot on the aerodrome, well clear of metal hangars or other high metallic objects. (The compass swinging base will be suitable only if it satisfies such conditions.)

(iv) The aeroplane should be lined up, by its compass, on the measured bearing of the source, the deviation being taken into account and the D/F reading observed. The accuracy to be desired is 0 degrees to $\pm \frac{1}{2}$ degree. If it differs by more than 1 degree from zero the discrepancy may be due to any one of the following:—

(*a*) Site error.

(*b*) Index incorrectly set.

(*c*) The D/F loop fitted asymmetrically with respect to the framework of the aeroplane.

(v) Where the site is well chosen, the measured bearing may be accepted as the reference bearing and the index set accordingly.

(vi) The aeroplane should then be swung through an angle of 360 degrees in steps of 12 to 15 degrees and the compass and D/F scale readings noted and recorded at each point. The bearing reading of the D/F scale should always be taken and *not* the reciprocal. It will be found helpful if the aeroplane is turned counter-clockwise, which causes the scale readings to increase from zero to 360 degrees.

(vii) If the compass readings are taken from the pilot's compass, care should be taken to see that the control (steering) column is in the normal flying position. The compass should be lightly tapped before taking a reading in case the pivot is sticking. Also, no loose metal objects such as keys, screwdriver, pairs of telephones and so forth may be brought within three feet of the compass when taking readings.

(viii) The readings thus obtained may now be tabulated, in the manner shown in the example given in the table below. It should be noted that the compass reading, corrected for deviation, is added to the *D/F scale reading* to produce the *W/T observed bearing, (magnetic)*. Where the result of this addition produced a figure of more than 360 degrees the correct figure can be determined by subtracting 360 from the addition. A separate table should be completed for observations on each frequency band.

Aeroplane:	No.:	Where swung:	Stn. on which calibrated:
		Frequency:	Date:

(*a*) Compass Reading	(*b*) De-viation	(*c*) Aeroplane Head (Magnetic) (a+b)	(*d*) D/F Scale Reading	W/T Bearing (Magnetic) Observed (c+d)	W/T Bearing (Magnetic) Measured	Error	Remarks
12°	+1°	13°	47°	60°	62°	−2°	Sharp
34°	$+1\frac{1}{2}$°	$35\frac{1}{2}$°	24°	$59\frac{1}{2}$°	62°	$-2\frac{1}{2}$°	—
301°	−2°	229°	126°	(425°−360°)	62°	+3°	—

(ix) From the table a curve of errors should be drawn on squared paper, the error being plotted against the D/F scale reading. In cases where some of the points (errors) do not lie on a smooth curve it is advisable to check these points, paying particular attention to the compass readings. Observations taken on each frequency band must be checked against the curve, which can be drawn together, to confirm that they agree substantially. In most cases it is advisable also to plot a curve of the compass deviations as errors may arise in interpolation.

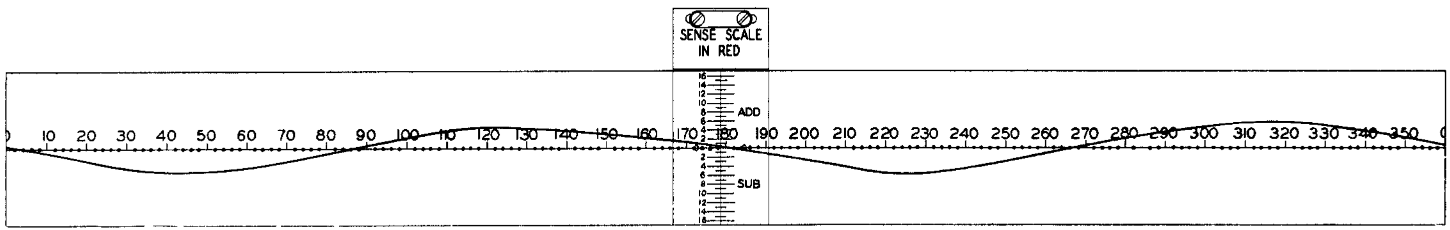

Fig. 12—Scale of Box Drive, with Q.E. Correction Curve

(x) The quadrantal error corrector should now be calibrated and a correction adjustment made in the following manner:—

(*a*) If the curve of errors shows a greater positive than negative degree of error, or vice versa, e.g. $+10$ degrees and $+11$ degrees with -5 degrees and -6 degrees, or -10 degrees and -11 degrees with $+5$ degrees and $+6$ degrees, the loop and its cursor are not correctly aligned. This fault should be rectified by moving the cursor, $+2\frac{1}{2}$ degrees respectively in the above example, and the calibration repeated.

(*b*) The average degree of error can be found by adding together the maximum error in each quadrant, irrespective of sign, negative or positive, and dividing by 4, e.g. -4 degrees $+4$ degrees -4 degrees $+4$ degrees $= 16$ degrees. The average is therefore 4 degrees.

(*c*) The average error having been found the selector screw (19) in fig. 4 should be removed and the corrector (9) rotated until the marking corresponding most nearly with the average error appears in the hole in the long strip. The selector screw should then be replaced and the three hexagon-headed screws (17, 18 and 19) tightened. After tightening, these screws should be locked by turning up the edges of the soft metal washers.

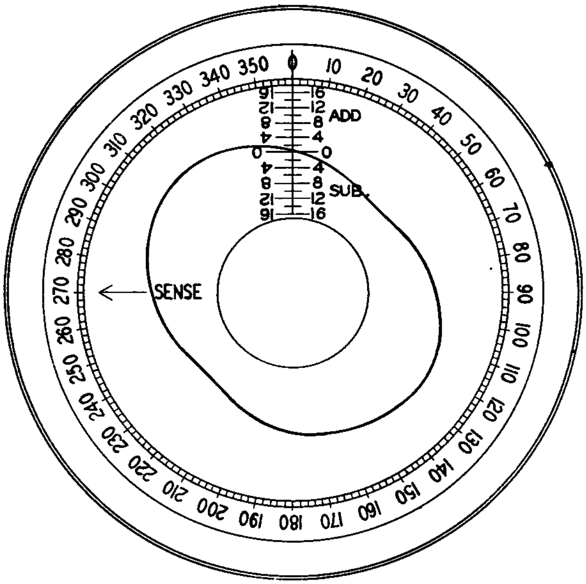

FIG. 13—SCALE OF INDICATOR, WITH Q.E. CORRECTION CURVE

(xi) The aeroplane must be re-calibrated and the residual errors plotted on the squared paper with the original curve.

(xii) From the completed curve the corrections to be applied when using the loop may be tabulated against the scale readings on the card (Form 2026) supplied for the purpose. This card should be placed in such a position in the aeroplane that it can readily be seen when taking D/F bearings. It must be remembered that the *correction* is the inverse of the *error*: e.g. if the error is $+3$ degrees the correction to appear on Form 2026 will be -3 degrees. The Form 2026 must be filled in completely, that is on both sides.

(xiii) With the normal working cursors removed and the marking cursors fitted in their place on the box drive and the indicator, the quadrantal error correction curve, as tabulated in (xii) above, should be plotted and drawn in pencil on the prepared surface of each of the scales on the box drive and the indicator, using the bevelled edge of the marking cursor as the reference line. This is illustrated in figs. 12 and 13. Fig. 12 shows the scale of the box drive developed to show the full scale with correction curve drawn upon it and fig. 13 that of the indicator also with its correction curve. A marking cursor is illustrated in fig. 9. Having completed the curve the marking cursor should be removed and the normal working cursor replaced in each instance. It is essential before changing cursors to lock the loop rotating drive, and to ensure that the reference lines on the cursors are set at the same figure on the scale in the box drive and the indicator. Bearing and correction can now be read directly on each scale.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is issued for information only. All the parts of the Loop Aerial or its accessories have not been listed, only those spares for which reference numbers have been allocated. Each installation requires certain groups of parts and accessories which are given in A.M.O. N. 937/39. In ordering spares the appropriate section of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature	Qty	Remarks
10B/10594	Aerial, loop, type 3		Wound moulded former only Including four cradle fixing screws and nuts
	Accessories:—		
	Box		
10B/10619	Drive, type 1	1	For remote control. Including two cursor fixing screws.
10B/11523	Drive, type 2	1	For direct drive, not for remote control. Including two cursor fixing screws
10B/21	Coil, Q.E. correction	1	
10A/11008	Cover, type 9	1	For R.A.F. Form No. 2058
10B/11053	Cradle, former	1	
	Cursor		
10B/11472	Type 1	1	For loop above aeroplane.
10B/11473	Type 2	1	For loop below aeroplane.
10B/11474	Marking, type 1		For loop above aeroplane. For initial calibration.
10B/11475	Marking, type 2		For loop below aeroplane. For initial calibration.
	Housing		
10B/10592	Centre section	1	
10B/10591	Nose section	1	With fixing bolt (10B/84) and spring washer (10B/141).
10B/10593	Tail section	1	With 6 fixing screws.
	Plugs		
10H/9872	Type 101	1	
10H/10953	Type 117	1	
	Scales		
10B/11470	Box drive, type 1	1	For remote control. Including four fixing screws. Screws suitably attached to scale.
10B/11471	Box drive, type 2	1	For direct drive. Including brake and four fixing screws Screws suitably attached to scale.
10H/11051	Sockets, type 63	1	
	Strips		
10B/19	Q.E. correction, long	1	Includes screws, nuts and washers.
10B/20	Q.E. correction, short	1	Includes screw and washer
	Tubes		
10B/11054	Driving (torque)	1	Complete with cradle fixing nut and grub screw.
10B/11524	Support	1	Complete with top bearing and including four bolts and nuts for fixing flange.
10B/11525	Wheel, hand	1	
	Remote controls:—		
10J/10602	Casing, rigid, type E2		As required.
10J/10595	Controller, type E2	1	
10J/10601	Fittings, anti-torsional type, E1	2	
10J/10596	Indicator, type E2	1	Complete with one cursor marking, type 3.
10J/11657	Cursor marking, type 3		For initial calibration.
10J/8594	Shafting, type E1		As required.
10J/11037	Union, lubricating type E2	8	
10B/22	Fitting, alignment		For aligning loop in housing.
	Cable		
5E/1854	Dulocapmet 2·5		As required.
5E/1328	Dumet 4		As required.

December, 1938

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SECTION 6, CHAPTER 11

H.T. ELIMINATORS, TYPES A, B AND C

Contents

List of Illustrations

H.T. ELIMINATOR, TYPES A, B AND C

(Type A, Stores Ref. 5A/1434)
(Type B, Stores Ref. 5A/1435)
(Type C, Stores Ref. 5A/1436)

INTRODUCTION

1. The H.T. eliminators, types A, B and C, have been introduced to supplement existing methods for the supply of anode current to ground station receivers. The general design of all three types is similar but manufacturers have been allowed considerable latitude in the actual production, provided that their instruments meet the requirements of the service. The particular eliminator illustrated must be regarded only as a typical one.

2. The type A eliminator is designed to operate on a supply at 200–250 volts, 50 cycles, the type B on 100–110 volts, 100 cycles, and the type C on 100–110 volts, 50 cycles. The output voltage is the same in all types, *viz.*, from 115 to 125 volts, when working into a D.C. load of 4,000 ohms. A neon lamp is incorporated in the eliminator to stabilize the output voltage, and consequently the rise of output voltage does not exceed 5 volts if the eliminator is used to supply a D.C. load of 12,000 ohms. Thus, the eliminator is capable of maintaining 120 volts at the H.T. terminals of a receiver taking a total anode current of 30 mA. If, however, it is used to supply a receiver taking only 10 mA, the H.T. terminal voltage will not exceed 125 volts.

3. The smoothing chokes and condensers incorporated in these eliminators are of generous dimensions, in order to reduce the A.C. ripple voltage to a very low value (below 0·01 volt R.M.S.). An eliminator designed solely for operating an ordinary broadcast receiver may have a much larger ripple voltage than this, and so be entirely useless for the reception of faint telegraphic signals.

4. The weight of the eliminator illustrated is 20 lb., its overall dimensions being approximately 10 in. by 8 in. by 9 in.

GENERAL DESCRIPTION

5. The theoretical circuit diagram is shown in fig. 1. The eliminator input is connected to suitable A.C. mains, the primary winding of the input transformer being fed through a double-pole " on-off " switch. Three tappings are provided on the primary winding, in order to allow each type to cover a certain voltage range, *e.g.*, in the type A instrument the tappings are engraved (i) 210 VOLTS ; (ii) 230 VOLTS ; (iii) 250 VOLTS. The secondary winding supplies an alternating voltage to a metal rectifier which is connected in a voltage-doubling circuit. Two 4μF condensers C_1, C_2, are connected in series across the outer terminals of the rectifier, acting as a reservoir from which the D.C. output is drawn. The secondary winding of the input transformer is connected between the mid-point of the rectifier and the mid-point of the two reservoir condensers.

6. The smoothing system consists of two iron-core chokes, L_1, L_2, and two condensers C_3, C_4. The inductance of each choke is of the order of 20 henries and in the particular eliminator illustrated each smoothing condenser has a capacitance of 2μF. As already stated, eliminators of different origin may differ slightly in such details. The output terminals of the eliminator are connected to the terminals of the second smoothing condenser. The neon lamp voltage stabilizer is connected across the output terminals, in series with a small safety resistance R_1, of the order of 120 ohms.

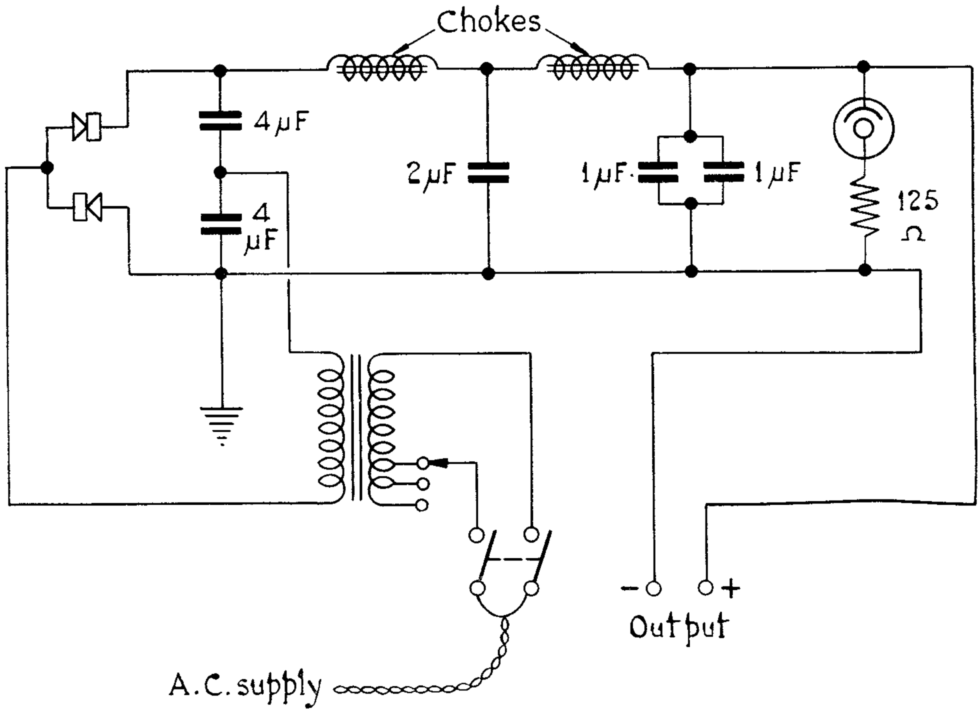

FIG. 1. Theoretical circuit diagram.

CONSTRUCTIONAL DETAILS

7. The external appearance of the eliminator is shown in fig. 2. The components are assembled on a mild steel base which is fitted with four rubber feet. The base also carries a small panel (1) of bakelized fabric board or a similar insulating material. This panel is bushed at (2) for the entry of the input leads which are of twin flexible cable. The switch (3) is of the double-pole type, the panel adjacent thereto being engraved to show the ON and OFF positions. The output terminals (4) are fitted with insulated binding screws. The eliminator is fitted inside a mild steel cover, which is generously perforated to allow for ventilation. The neon lamp may be withdrawn through an orifice which is covered by a square plate (5) secured by four screws. The whole cover is also readily removable by removing six small bolts which secure the cover to the base.

8. Fig. 3 shows the assembly of the components. The metal rectifier (1) is supported at one end by the panel, and at the other by a mild steel bracket. The input leads to the transformer (2) are soldered directly to tapping points on the windings. The voltage adjustment tappings are taken to three sockets and mounted on an insulating plate (3). Contact between the input lead and the appropriate transformer tapping is obtained by means of a screw which is inserted under the base.

9. The two smoothing chokes (4) (5) are connected in series in the positive output lead. The condenser block (6) contains the reservoir and smoothing condensers; the connections are shown in the bench wiring diagram, fig. 4.

10. The neon lamp voltage stabilizer (7) is fitted in a 4-pin valve socket. The electrodes are connected between the pins corresponding to "anode" and "grid" in a triode. The small series resistance (8) is connected between the "grid" and "filament" soldering tags on the valve-holder, but the latter is merely an anchoring point and has no internal connection with the neon lamp.

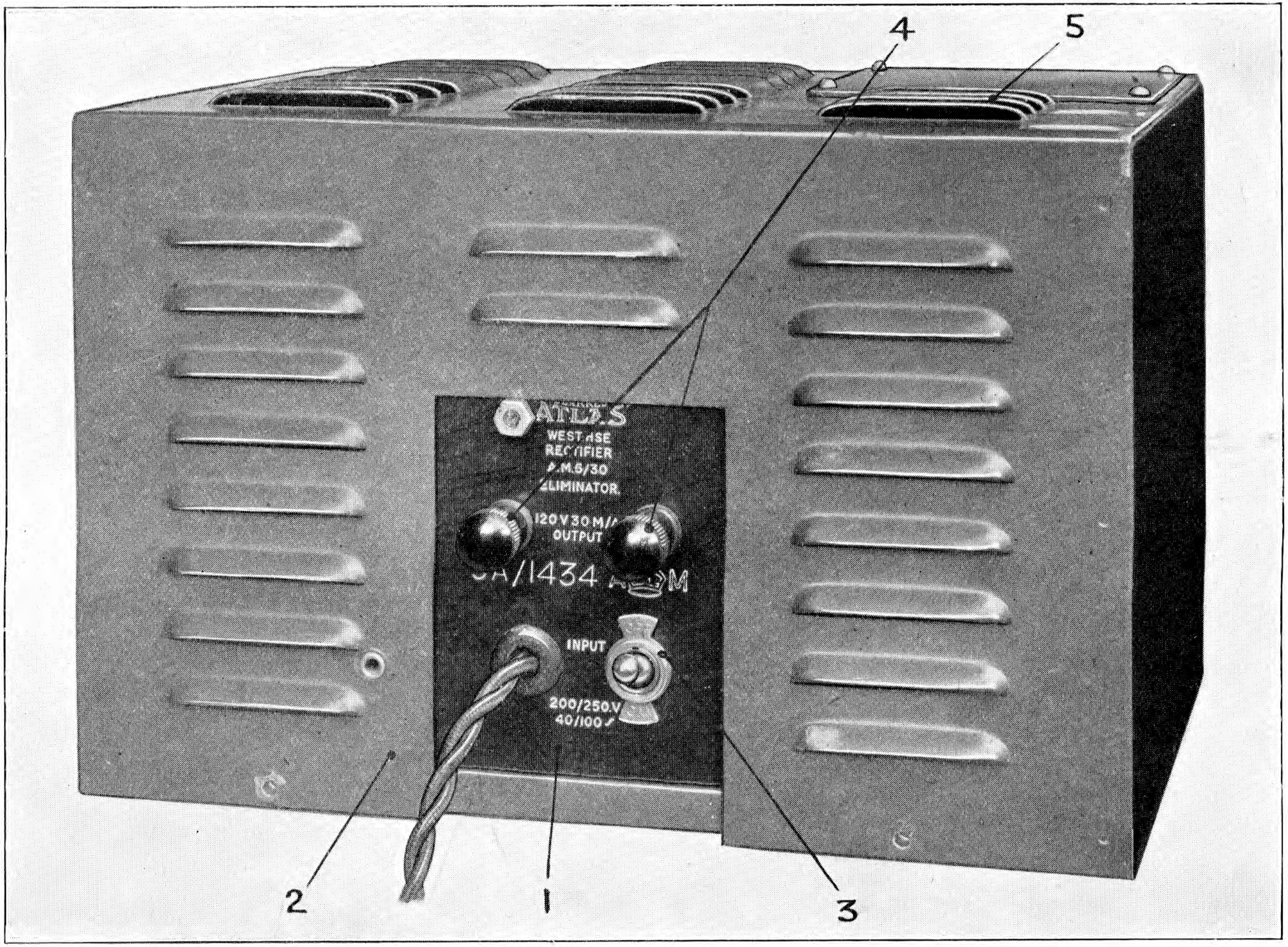

FIG. 2. External view.

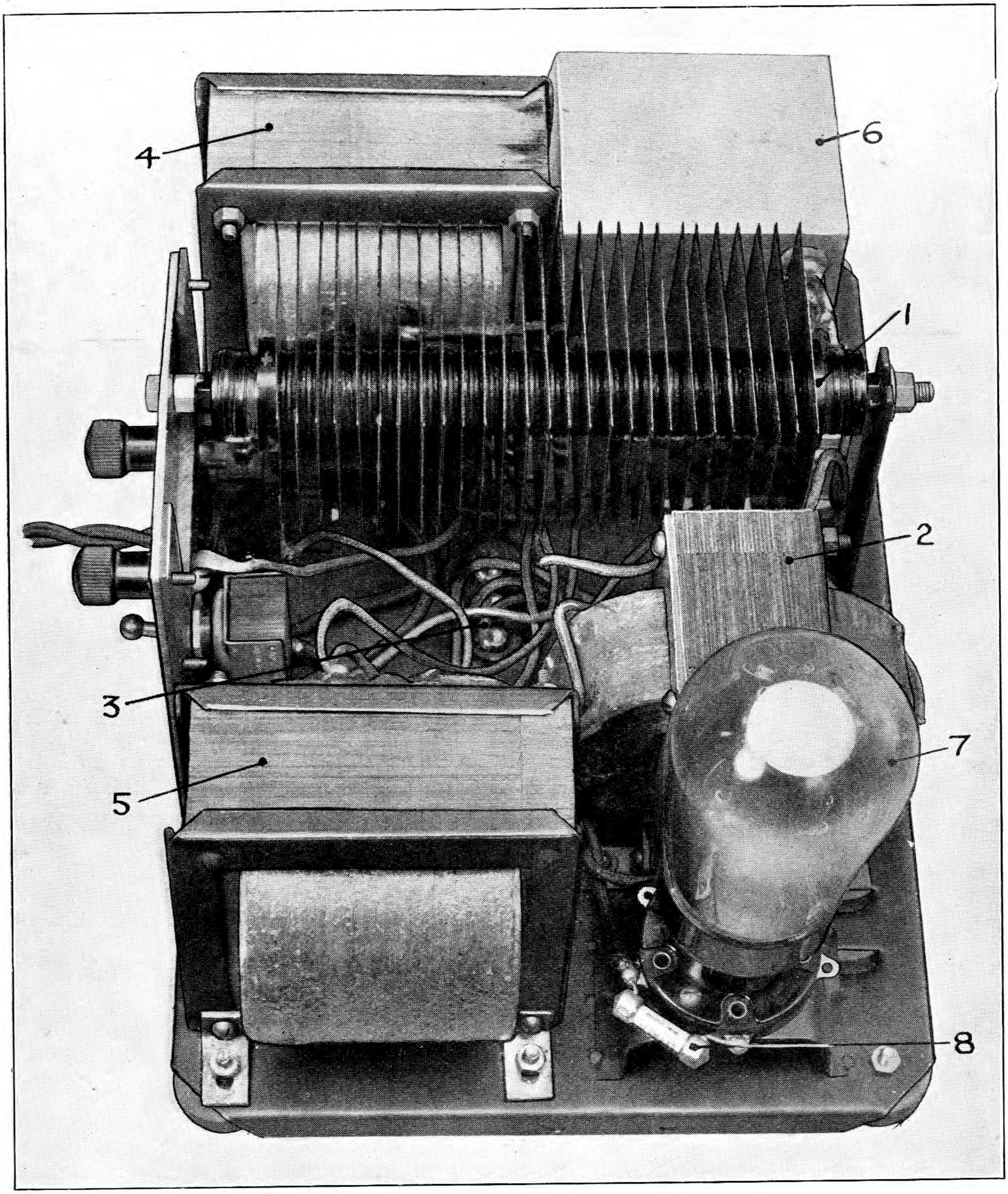

FIG. 3. Internal view.

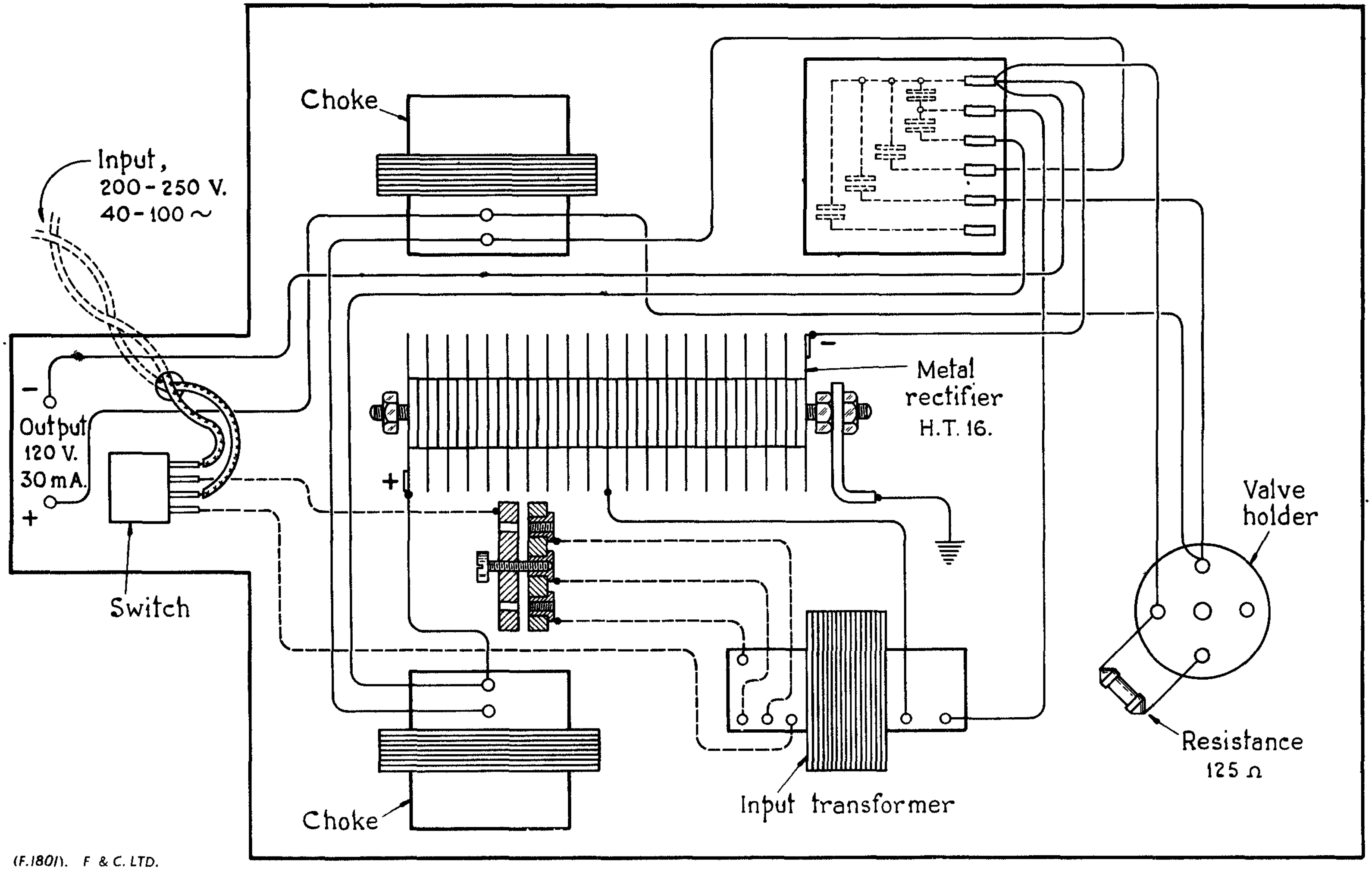

FIG. 4. H.T. ELIMINATOR TYPE 'A'—— BENCH WIRING DIAGRAM

OPERATION

11. Before connecting the eliminator to the supply, the transformer tap should be fitted into the correct socket, according to the mains voltage. The output terminals should then be connected to the receiver. Finally, the flexible input leads should be connected to the supply mains via 5-ampere fuses. Ensure that a neon lamp is inserted in the appropriate socket. On switching on the eliminator the neon lamp should glow ; this may be observed through the ventilating louvres. The receiver should then be switched on. If separate controls are provided, the L.T. circuit should be closed before the H.T. circuit.

12. It is important that the above procedure of switching on the eliminator *before* the receiver should be invariably adopted (*see* para. 17).

MAINTENANCE AND PRECAUTIONS

13. The eliminator must be fitted in such a position that a free circulation of air may take place around and through it, *e.g.*, it should not be installed in an unventilated cupboard. On no account must any object be placed on top of, or close to, the sides of the instrument.

14. The cover should be removed periodically for the removal of dust from the interior by means of bellows. Care must be taken not to bend or otherwise damage the radiating fins of the rectifier unit, or to break any soldered connections.

15. The life of the neon lamp is of the order of 1,000 hours of use. A record of the employment of each eliminator should be kept, and the neon lamp replaced accordingly.

16. The output voltage should be checked daily. For this purpose it is essential to use a high resistance voltmeter, *e.g.*, voltmeter 0–150 volts (Stores Ref. 5A/880). The voltage should not be above 130 volts off load nor below 110 volts on load.

17. Towards the end of its life, the neon lamp becomes " hard," and consequently requires a higher voltage to establish the initial current through it. This initial establishment of current is referred to as " striking." Once striking has occurred, an appreciably smaller voltage is sufficient to maintain the current through the lamp. Since the output voltage of the eliminator with no load is necessarily higher than when the load is connected, it is obvious that striking will more readily occur when the load is disconnected than when connected. For this reason the eliminator must always be switched on, and the lamp observed to glow, before switching on the receiver.

18. If the neon lamp fails to strike under the above method of operation, it has become too " hard " for service and must be replaced. If the output voltage is found to be above the higher limit given in para. 16, the neon lamp should be replaced by a new one and the output voltage again measured. If no improvement is effected, the voltage of the A.C. mains may be above its nominal value and the input voltage tap should be adjusted accordingly. On no account should any receiver be used with a higher voltage than that for which it is designed.

19. Care must be taken that the output terminals are never short-circuited while the input terminals are alive. In this connection it is important to note that the chassis and cover are connected to the negative output terminal. Such a short-circuit may completely destroy the rectifier and possibly damage the chokes, transformer and condensers. This possibility is almost entirely avoided by strict adherence to the routine of disconnecting the input terminals from the supply before connecting or disconnecting any leads in the output circuit.

20. At the time of making the daily voltage test, the leads from the eliminator to the receiver should be examined, taking care that the connections are sound and make good contact at all terminals, plugs and sockets. All leads connected to terminals should be fitted with cable-ends (either eye or fork type) into which all strands of the cable are properly soldered. Much receiver noise can often be traced to broken strands, loose terminals, corroded contact surfaces and similar faults.

APPENDIX

NOMENCLATURE OF PARTS

The following stores reference numbers are listed for information. When ordering, AIR PUBLICATION 1086 should be consulted.

Ref. No.	Nomenclature.	Remarks.
5A/1434	Eliminator, H.T., type A..	200–250 volts, 50 cycles.
5A/1435	Eliminator, H.T., type B..	100–110 volts, 100 cycles.
5A/1436	Eliminator, H.T., type C	100–110 volts, 50 cycles.
5A/1624	Lamp, neon	—

SECTION 6, CHAPTER 13

MICROPHONES, TYPE 21 and TYPE 26

Contents

List of illustrations

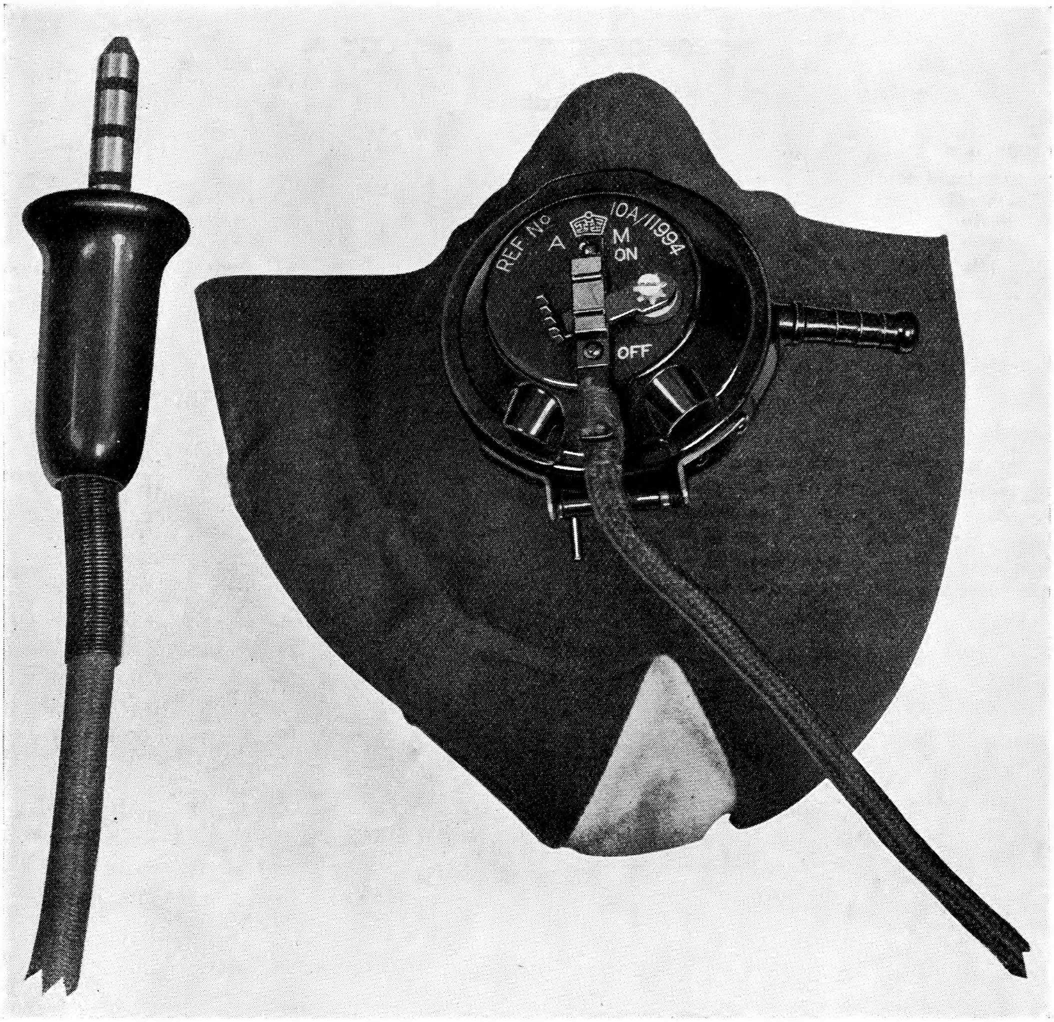

FIG. 1.—MICROPHONE, TYPE 21, WITH OXYGEN MASK, TYPE D

MICROPHONES, TYPE 21 AND TYPE 26

(Stores Ref. 10A/11994 and 10A/12571)

INTRODUCTION

1. The microphones, types 21 and 26, have been designed to supersede the microphone type 19. They have approximately the same overall sensitivity, and offer the following advantages:—

(i) Considerable reduction in weight and dimensions.

(ii) Greater response to the higher speech frequencies.

(iii) Improvements in various mechanical features.

2. The microphone, type 21, comprises the microphone, type 20, complete with a screened cord, type Q, and a plug, type 119. Similarly, the microphone, type 26, consists of a microphone, type 25, complete with plug and cord.

3. Microphones, types 21 and 26, are identical in construction except for certain mechanical features which render them suitable for operation in different types of mask. The microphone, type 21, has been designed for operation in conjunction with the mask, oxygen, type D, whilst the microphone, type 26, is intended for use with masks, oxygen, types E or F.

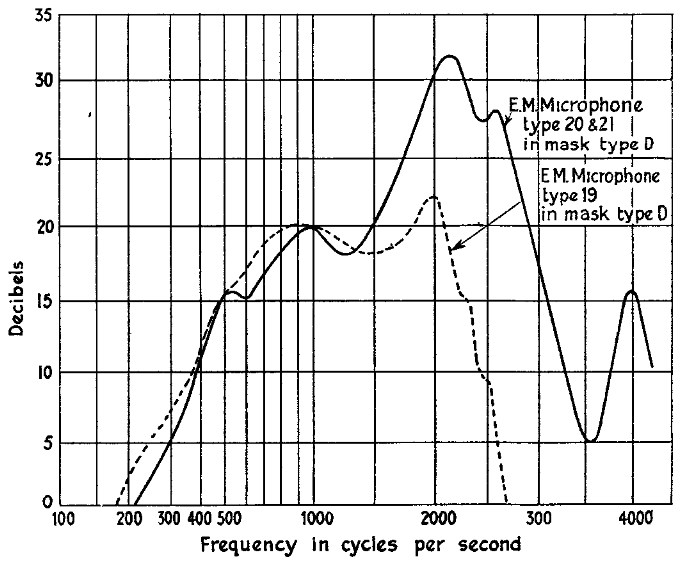

FIG. 2.—FREQUENCY RESPONSE CURVE OF MICROPHONE, TYPE 21

4. The microphones have been designed so as to give maximum response to speech frequencies between 400 and 3,000 cycles per second. Outside these limits the response falls off sharply.

5. The frequency response curves of these microphones, as measured in their appropriate oxygen masks are shown in figs. 2 and 3. For purposes of comparison, the response curve of the microphone, type 19, has been shown dotted in each diagram.

6. It will be seen that the major resonance has been shifted to a higher frequency in the later designs, resulting in an improved response at the higher voice frequencies. The acoustic coupling in the mask, type E, is tighter than that in the mask, type D, and this accounts for the slight differences in the response curves of the microphones, types 21 and 26. The D.C. resistance of the windings is approximately 50 ohms, and the impedance is 250 to 300 ohms at 1,000 cycles per second.

CONSTRUCTIONAL DETAILS

General

7. The description of the microphone is divided into three sections, the body, the cap and the casing of the instrument. Sectional views of the two microphones are given in figs. 4 and 5.

Body

8. The bodies of the microphones, types 20 and 25 are identical. They consist essentially of a moulding to which the magnetic system is attached by four screws which are screwed into lugs formed on the base of the nickel iron pole pieces. A screw through the back of the body secures the switch mechanism.

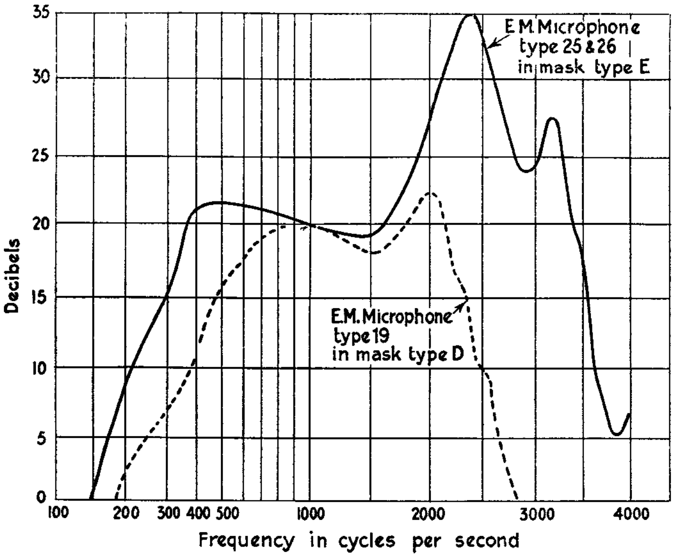

FIG. 3.—FREQUENCY RESPONSE CURVE OF MICROPHONE, TYPE 26

9. In order to seal the interior and ensure the correct air cavity at the back of the diaphragm, a disc of moulded material is fitted in the body so that it lies flush with the pole faces. All air leaks are carefully sealed with a small quantity of bakelite varnish, and the screw holes are filled in with wax.

10. The leads from the coil are secured to terminal posts which pass through the body moulding. The external cord connections to these terminals are protected by a rubber band. in order to exclude moisture.

Cap

11. The moulded cap of the microphone screws on to the body and secures the Stalloy diaphragm In order to prevent corrosion, the diaphragm is protected by a very thin disc of pliofilm. The cap of the microphone, type 25, is specially shaped so as to provide a pronounced lip for fitting into the aperture of the oxygen mask, type E or F.

Casing

12. A magnetic screen of soft iron forms the casing of the instrument. The case is secured to the body moulding by two screws, one of which provides the earthing terminal for the cord. An aluminium mounting disc is riveted to the casing of the microphone, type 20, in order to provide a means of attachment to the mask, type D. A bracket on the back of the mounting disc provides a whipping post for the cord, type P.

13. The microphone, type 25, is fitted to the mask by a different method and the mounting disc is much reduced in size. The terminals are protected by a moulded rubber band which fits over the edge of the cover into a groove in the cap.

14. The external dimensions of the microphone inserts, exclusive of the aluminium mounting discs, are as follows:—

Microphone, type 20	... ...	$1\frac{5}{8}$ in. dia by $1\frac{1}{8}$ in. deep
Microphone, type 25	... ...	$1\frac{7}{8}$ in. dia. by $1\frac{1}{4}$ in. deep

15. The weight of the microphone, inclusive of cord and plug is approximately $8\frac{1}{2}$ oz.

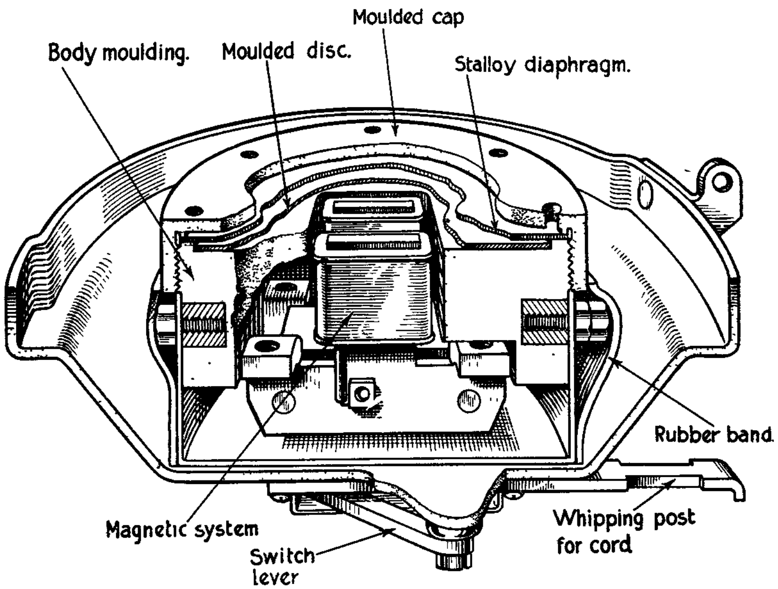

FIG. 4.—CONSTRUCTION OF MICROPHONE, TYPE 20

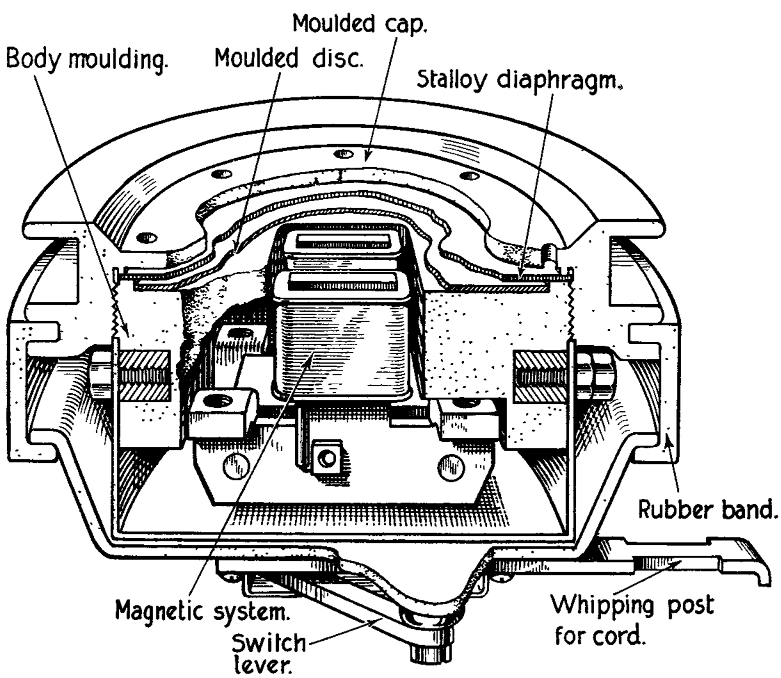

FIG 5.—CONSTRUCTION OF MICROPHONE, TYPE 25

PRECAUTIONS AND MAINTENANCE

General

16. These microphones require no maintenance, and no attempt should be made to remove the cap or cord. If any particular microphone gives rise to self oscillation of the A.F. circuits when it is plugged in, the connection of the screening sleeve to the microphone casing and to the MIC-TEL plug should be examined.

Prevention of ice formation

17. At low temperatures, it has been found that ice formation may interfere with the working of the microphone. If it is probable that these conditions will be encountered, the instrument should be protected by fitting the cap with a cover of 80-mesh copper gauze. Ice formation will then be prevented by covering the surface of the gauze with a thin layer of anti-freeze oil, type A.

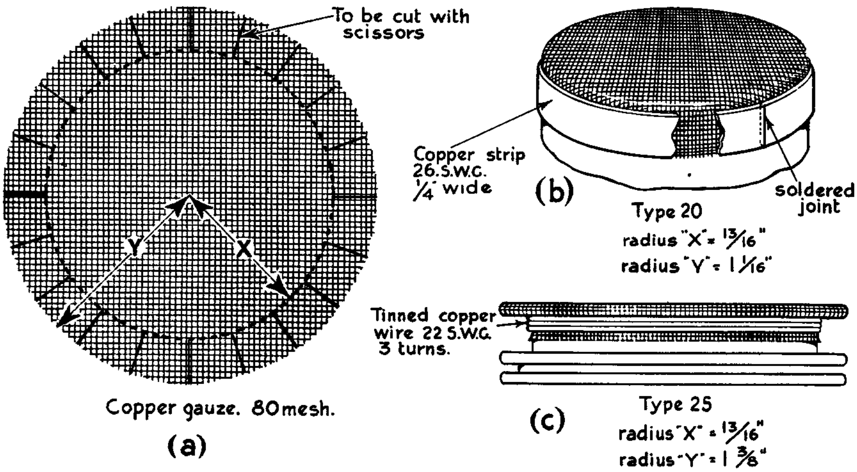

FIG. 6.—GAUZE COVER FOR PREVENTION OF ICE FORMATION

18. The construction of these covers, showing the manner in which they are fastened to the two microphones, is illustrated in fig. 6. It will be seen that the cover is made up from a gauze disc, which is cut in the manner shown in fig. 6a in order that it may be folded over the side of the microphone cap. The gauze is secured to the cap of the microphone, type 21, by means of a metal band, as shown in fig. 6b. The microphone, type 26, has a cap of a different shape, and the gauze is fastened by means of three turns of copper wire as illustrated in fig. 6c.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Remarks
10A/11994	Microphone, electro-magnetic, type 21		Complete with plug and cord
	Principal components		
10A/11993	Microphone, electro-magnetic, type 20	1	On-off switch incorporated
10A/11995	Tube, rubber	1	Microphone terminal cover
10H/10353	Cord, instrument, type Q	1	4-way MIC-TEL cord
10H/10991	Plug, type 119	1	4-way MIC-TEL
10A/12924	Cover, gauze, antifreezing, type 3	1	
10A/12571	Microphone, electro-magnetic, type 26		Complete with plug and cord
	Principal components		
10A/12570	Microphone, electro-magnetic, type 25	1	On-off switch incorporated
10A/12574	Cover, rubber	1	Microphone terminal cover
10H/10353	Cord, instrument, type Q	1	4-way MIC-TEL cord
10H/10991	Plug, type 119	1	4-way MIC-TEL
10A/12925	Cover, gauze, antifreezing type 4	1	

(Issued October, 1941 with A.L. No. 38)

SECTION 6, CHAPTER 14

CONTROL UNIT, TYPE 88

Contents

List of illustrations

CONCISE DETAILS OF CONTROL UNIT, TYPE 88

PURPOSE OF EQUIPMENT	To provide remote control of the ground station transmitters, types T.1087, T.1190 and T.1179
TYPE OF WAVE	—
FREQUENCY RANGE	—
FREQUENCY STABILITY	—
CRYSTAL MULT. FACTOR	—
PERCENTAGE MODULATION	—
MAXIMUM SENSITIVITY	—
SELECTIVITY	—
OUTPUT IMPEDANCE	—
AMPLIFIER CLASS	—
MICROPHONE TYPE	Desk microphone, type 3
VALVES	Tone generator valve V.T.20 (10E/7813)
POWER INPUT	—
POWER OUTPUT	—
STORES REF. NO.	10L/37
APPROXIMATE OVERALL DIMENSIONS	LENGTH 12 in. WIDTH 8 in. HEIGHT 7½ in
WEIGHT	Approximately 10 lb.
ASSOCIATED EQUIPMENT	Morse key, type F Telephones, head, type B Desk, microphone, type 3

CONTROL UNIT, TYPE 88

(Stores Ref. 10L/37)

INTRODUCTION

1. The control unit, type 88 (Stores Ref. 10L/37) shown in fig. 1 has been introduced to provide remote control of the ground station transmitters, types T.1087, T.1190 and T.1179. This control is possible over a distance of at least 20 miles when utilizing 10 lb. per mile G.P.O. telephone cable. The unit, which is normally mounted on the receiver bench, is intended for use with ground station receivers, types R.1084, R.1188 or R.1168.

2. Provision is made for the remote control of the transmitter H.T. supply thus enabling the operator to switch off the transmitter H.T. supply whilst receiving. For W/T operations a tone-to-line keying system is employed and for R/T operation speech currents are applied to the telephone line. Whilst transmission is in progress the sensitivity of the receiver is reduced, thus avoiding the possibility of the local transmission overloading the receiver. The unit requires a 24-volt D.C. supply.

3. At the transmitting end of the circuit the ground station remote control unit, type 3 is employed. This control unit is described in A.P.1186, Vol. I, Sect. 6, Chap. 6. Due to the introduction of tone-to-line keying and audio frequency modulation over long lengths of telephone line, it has become necessary to undertake certain modifications to this control unit. These modifications are fully described in A.P.1186, Vol. II, to which reference should be made for these details.

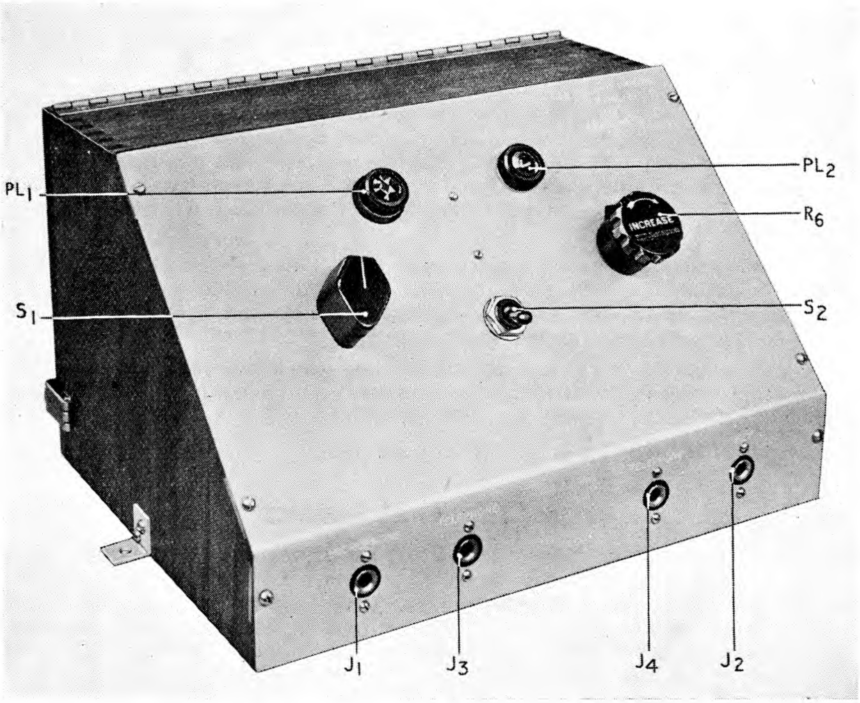

FIG. 1—CONTROL UNIT, TYPE 88, FRONT VIEW

4. The accessories required for use in conjunction with the control unit, type 88 are as follows:—

(i) Morse key, type F.

(ii) Telephones, head, type B.

(iii) Desk microphone, type 3.

These items are each fitted with cords which terminate in plugs, type 1.

GENERAL DESCRIPTION.

5. It will be seen by references to the theoretical circuit diagram shown in fig. 2 that the A and B telephone lines from the remote transmitting station are connected to the primary winding of the transformer T_1, which has a ratio of 1 to 1. When the switch S_2 is in the SEND position a positive potential of 24 volts is applied to the telephone lines by means of the centre tap of the primary winding on transformer T_1. The negative side of the 24-volt supply is connected to earth.

6. At the remote end of the circuit the telephone lines are connected to the primary winding of a transformer having similar characteristics to that of T_1; this transformer is not shown in fig. 2. The line current flowing in this circuit is used to operate the transmitter H.T. switching relay, which is connected between the centre point of the transformer primary winding and earth. As the current flows through the two sections of the primary winding of the transformer T_1 in opposite directions the possibility of the core becoming saturated does not arise.

7. When the send-receive switch S_2 is placed in the SEND position, the positive of the 24-volt supply is also connected to the primary of the microphone transformer T_2 and to one side of the morse key jack J_2.

8. The RT/WT switch S_1, when placed in the R/T position, connects the secondary of the microphone transformer T_2 to the line transformer T_1 and completes the microphone circuit to the negative of the 24-volt supply. The 500-ohm resistance R_1 is included in the microphone circuit to limit the activating current. Normally the microphone is connected to lines seven and eight of the cable form, but the break jack J_1 enables a local microphone to be used if required.

9. In the W/T position the switch S_1 transfers the connections of the line transformer T_1 from the microphone transformer T_2 to the coupling winding of the transformer T_3, which is associated with the type VT20 tone generator valve V_1. In addition, the microphone circuit is broken and the filament and anode circuits of the valve V_1 completed. The resistance R_2 is included in the circuit for the purpose of reducing the 24-volt supply to 2 volts across the filament of the valve V_1.

10. The primary of the transformer T_3 is connected in the anode circuit of the valve V_1; this circuit is completed by means of the contacts of the morse key which will eventually be inserted into the jack J_2. The secondary of the transformer T_3 is so connected *via* the condenser C_2 and the grid leak R_5 to the grid of the valve V_1 that it ensures oscillation. The primary of the transformer T_3 is tuned by the condenser C_1 to give oscillations at 1,500 cycles, and tone which may be keyed, is applied to the telephone lines. At the remote end of the circuit this tone is amplified and rectified and the D.C. output thus obtained, is employed to operate the keying relay. For this purpose the remote control, type 3, is employed, suitably modified in accordance with the leaflet mentioned in para. 3.

11. The variable resistance R_6 is provided as an extra bias resistance for the H.F. valves of the receiver and may be adjusted to suitably reduce the sensitivity of the receiver, during the period of transmission. This resistance is short-circuited by means of the switch S_2 when placed in the "receive" position, thus restoring the receiver to full sensitivity.

12. Two signal lamps PL_1 and PL_2 are included, one which is illuminated when the transmitter is operating, the other being controlled remotely and serving as a call lamp. The resistances R_3 and R_4 regulate the current flowing in these lamps to ensure long life.

13. The output of the receiver is fed into the unit and appears on jacks J_3 and J_4.

CONSTRUCTIONAL DETAILS

14. The control unit, type 88 shown in fig. 1 comprises a steel or wooden box having an inclined metal panel, attached to which, are the variable resistance R_6, send-receive switch S_2, indicating lamps PL_1 and PL_2, RT/WT switch S_1 and the jacks J_1 to J_4 which are mounted at the base of the front panel. The unit is shown removed from its case in fig. 3; the valve filament resistance R_2, the oscillator and line transformers T_3 and T_1 respectively, are mounted on the top of the chassis. An underside view of the chassis is illustrated in fig. 4, the microphone transformer T_2 and the several resistances, condensers and jacks (J_1 to J_4) are clearly shown.

15. Three flexible connectors are permanently attached to the unit as shown in fig. 3. The screened cable terminating in a 10-pole socket (1), serves to connect the unit to the telephone lines from the remote transmitter 24-volt D.C. supply, microphone, telephones and the call lamp switch. The lead (2) terminating in a plug, type 1, is connected to the output of the associated receiver and the remaining lead (3), is provided as a means of connecting the side tone control of the unit to the H.F. stages of the receiver.

16. The control unit is 12 in. long, $8\frac{1}{4}$ in. deep, $7\frac{1}{2}$ in. high and weighs 10 lb. Access to the interior of the unit for the purpose of replacing the valve is possible by removing the rear cover of the unit.

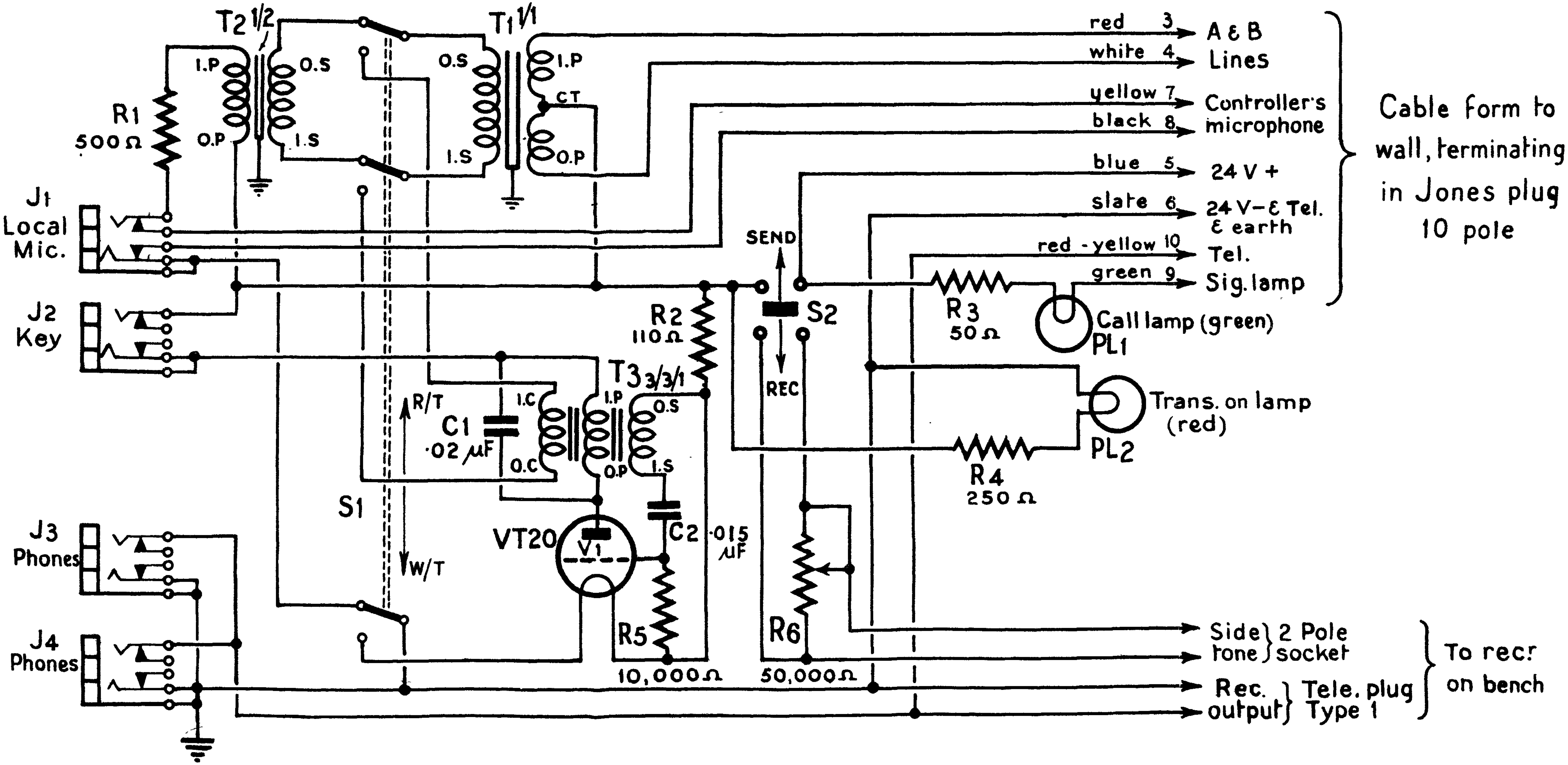

FIG. 2

CONTROL UNIT, TYPE 88, CIRCUIT DIAGRAM

FIG. 2

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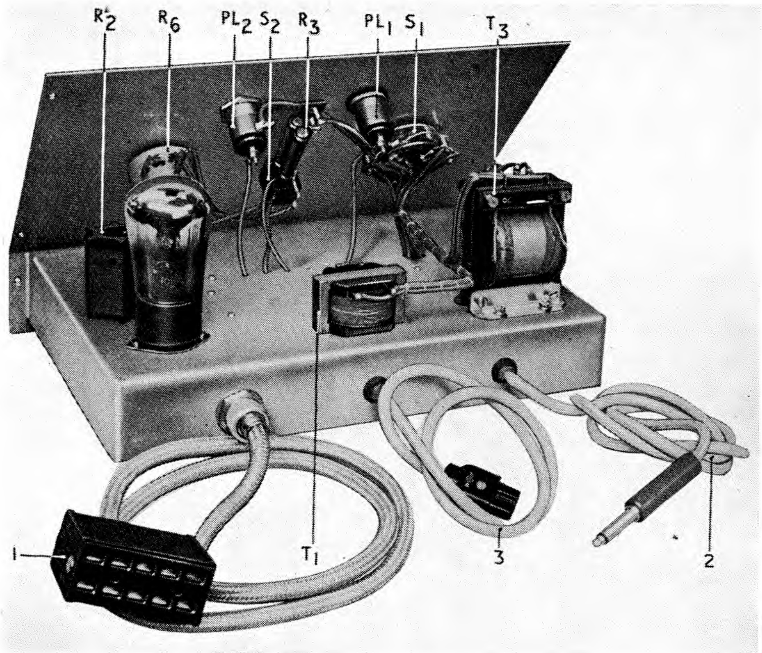


FIG. 3—REAR VIEW OF CHASSIS

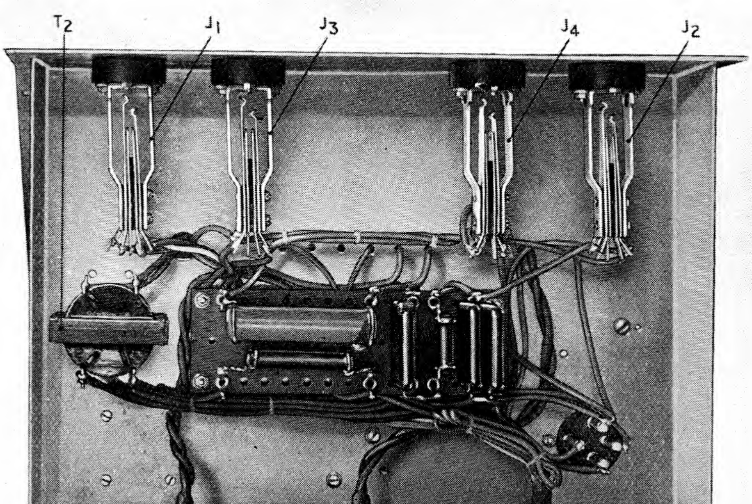


FIG. 4—UNDERSIDE VIEW OF CHASSIS

OPERATION

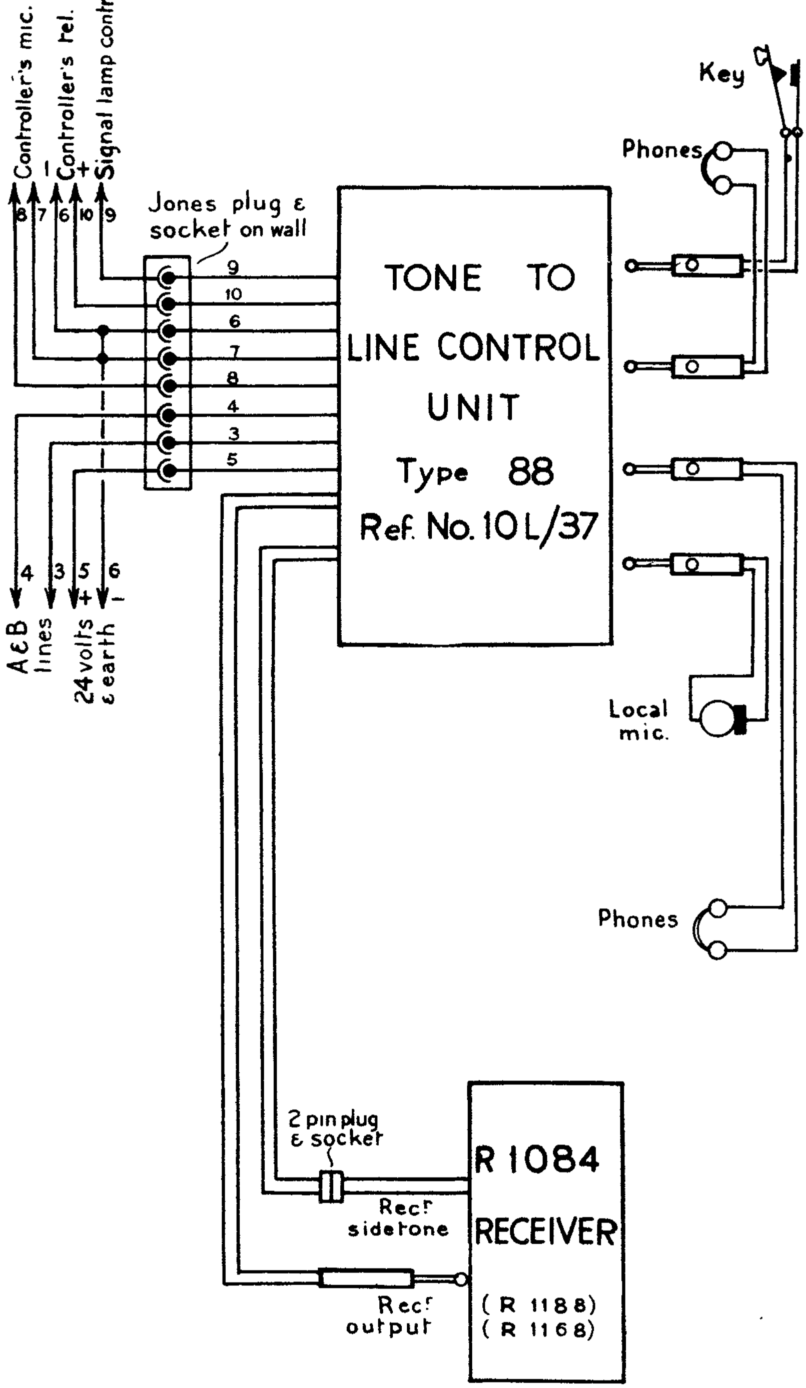
17. The unit should be connected to the associated receiver as shown in fig. 5, a pair of telephones must then be plugged into one of the jacks provided. For W/T transmission a morse key should be connected to the unit by means of the jack engraved KEY, and when it is desired to transmit R T a carbon microphone should be connected to the jack engraved MICROPHONE.

18. The WT/RT switch should then be moved to the appropriate position according to which method of transmission is being used, after which the send-receive switch may be operated to apply the H.T. to the transmitter. The side tone control should be adjusted to give a suitable signal level in the telephones when transmitting.

MAINTENANCE

19. Very little maintenance should be necessary with this unit and normally the valve should have a long useful life. The valve may be checked for oscillation by connecting a pair of telephones across the contacts 3 and 4 of the 10-pole connector and holding the morse key down, when a continuous note should be heard in the telephones.

20. Should the WT/RT switch contacts become dirty, a cure may usually be effected by applying a small quantity of carbon tetrachloride. This may conveniently be applied from a small clean can having a tapered spout. The 24-volt D.C. supply should also be checked periodically to ensure efficient operation.



PLAN OF CONTROL ROOM INTER-CONNEXIONS

FIG. 5

FIG. 5

PP2150 M28881/2459 4/43 4250 C & P Gp. 959(4)

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Ref. in fig. 2	Remarks
10L/37	Control unit, type 88			
	Principal components			
	Condenser			
10C/7906	Type 125	1	C_1	0·02 μ F
10C/964	Type 896	1	C_2	0·015 μ F
	Connector			
10H/1503	Type 491	1		
	Fitted with.—			
10H/1505	Plug, type 357			Ten pole, two locating pins
	Holder			
10H 1504	Valve, type 144	1		Four pins For valve, type V R 20
	Jack			
10H/1739	Type 1	4	J_1 to J_4	
	Knob			
10A/11839	Type 11	1		
10A/12082	Type 24	1		Engraved "INCREASE"
	Lampholder			
10A/12877	Type 51	1		Flush type, green glass
10A/12811	Type 47	1		Flush type, red glass
	Plug			
10H/488	Type 1	1		Telephone
	Resistance			
10C/7957	Type 104	1	R_5	10,000 ohms
10C/8017	Type 107	1	R_6	50,000 ohms variable
10C/530	Type 801	1	R_3	50 ohms
10C/1367	Type 1367	1	R_1	500 ohms
10C/1932	Type 1932	1	R_4	250 ohms
10C/6087	Type 6087	1	R_2	110 ohms, wound on former 1·8 in. long
	Socket			
5C/457	Type R	1		Two pole
	Switch			
10F/10338	Type 152	1	S_2	
10F/688	Type 541	1	S_1	Three pole, two-way, single wafer rotary
	Transformer			
10K/7167	Type 3	1	T_3	L.F. with coupling coil
10K/309	Type 400	1	T_2	L.F. microphone transformer
10K/310	Type 401	1	T_1	L.F. with centre tapped primary
	Valve			
10E/7813	VT.20	1	V_1	
	Lamp			
5L/1319	Indicator	2	PL_1, PL_2	
	Plug			
5C/455	Type R	1		Two pole

SECTION 6, CHAPTER 15

AERIAL SYSTEM, TYPE 18

(Stores Ref. 10B/299)

Contents

List of Illustrations

AERIAL SYSTEM, TYPE 18

(Stores Ref. 10B/299)

INTRODUCTION

1. The aerial system, type 18, is designed for transportable use in conjunction with the general purpose wireless vehicle or substitutes therefor. It is intended for army co-operational purposes and replaces the flat-top aerial array originally fitted to the vehicle as described in Section 6, Chapter 8 of this publication.

2. The aerial system is of the Marconi quarter-wave variety supported by a collapsible mast for which stowage is provided The system is associated with a radial earth which is the earth mat, type 7. Coaxial cable is used between the aerial and the transmitter T.1090 and receiver R.1084.

3. Replacement of the flat-top aerial array necessitates certain modifications to the vehicle and to the aerial relay box. To provide for coaxial feeding, modifications to the T.1090 and the R.1084 are necessary.

4. The aerial system consists of a 30-ft. telescopic steel mast which, in the erect position, is stayed by guys and associated equipment. For normal operation R4 aerial wire is provided, with a suitable field pole support and insulators, but for short distance working the mast constitutes a sufficient aerial system. In the normal system the aerial is inclined from the vertical.

5. The system may be used with a slightly directional characteristic if desired. The general appearance of the aerial array, when associated with the vehicle, is shown, in the operating position, in the diagram of fig. 1, and, in the stowage position, in an inset to that diagram.

GENERAL DESCRIPTION

6. For mobile application the earthed quarter-wave aerial has certain advantages over the original vehicular aerial array and, indeed, over the conventional Hertzian dipole. It is compact, easily erected and stowed, requires a shorter length of aerial wire, and for field warfare purposes, more effectively merges into the skyline, affording greater concealment.

7. A theoretical discussion of the quarter-wave system, with relevant polar diagrams, can be found in Air Publication 1093, and it is sufficient, here, merely to summarize certain aspects of the system. The Aerial Ae is, electrically, one-quarter wavelength and is resonated to the operating frequency, being excited or tapped by a non-resonant line Cb, constituted of coaxial cable, near the earthed end through a coaxial plug P_1. Physically Ae is slightly longer than a quarter wave and is shortened to an electrical quarter wave by a series capacitance in the transmitter and receiver aerial circuits.

8. The earth acts as though it were the lower half of a Hertzian dipole, current flowing into the earth instead of into a mirror quarter-wave section. The point of lowest impedance is at the base of the aerial and there is a linear rise of impedance towards a maximum at the elevated end. The major component of the aerial impedance is radiation resistance and, desirably, this is kept at a high value as it reduces the aerial current for a given power and minimizes the loss from earth resistance.

9. In order to keep the radiation resistance high the quarter-wave radiator is made slightly longer than the physical quarter-wave as mentioned in para. 7. This consideration gives rise to the formula $l = \frac{240}{Fmc}$ where l equals the actual aerial length in feet and Fmc the operating frequency in megacycles.

10. To lower earth resistance and so to prevent power loss through heating effects, a low-resistance earth system E is afforded by the use of eighteen radial wires spreading the earth contact over an area of approximately 2,800 sq. ft. The wires are each 30 ft. long. Theoretically the radials may be used as a counterpoise, when they are supported and insulated from earth, alternatively they may be laid on the surface, as is usual in mobile work, or buried.

11. Slightly directional effects may be observed if the earthed end of the inclined aerial is pointed in the direction of transmission and reception. It should be appreciated that this system has not been designed for optimum unidirectional effects, as there is only a directional tendency when the aerial is used as directed. The transmission aspect of this may possibly be somewhat augmented by a degree of parasitic reflector tendency of the aerial mast at certain frequencies of

operation and at certain distances of the aerial element from the mast, depending upon the angle of inclination of that element from the true vertical.

12. The aerial system is fed by low-impedance (40-ohm) coaxial cable which joins to the aerial terminal post at P_1 and leads to an aerial terminal on an aerial relay box in the vehicle. From this relay box untuned lines lead to coaxial sockets on the T.1090 and R.1084. Actuation of the relay therefore effects coaxial junction between the aerial and either the transmitter or the receiver. Reference to Sect. 6, Chap. 8 of this publication should be made for illustrations of the interior (unmodified) of the vehicle.

13. The utilization of the mast A as a radiator for short distance working creates a somewhat less efficient radiation system due to the shorter length involved, electrically, that is, having regard to the highest frequencies for which the T.1090 is designed. A certain compensation is brought about by the fact that the mast averages a higher elevation over the ground than the inclined radiator and is truly vertical. In this case the aerial is directly energized at a point SB which is approximately 22 per cent. up from the base. The earth system is in this application connected to the main earth of the vehicle.

CONSTRUCTIONAL DETAILS

14. The main features of the aerial system are shown in fig. 1. The mast A is constructed of three tubular rods of mild steel of diameters suitable to permit telescoping the sections to an overall length of 13 ft. 2 in. This is the length of the bottom section. The middle section is 8 ft. 6 in. and the top section 8 ft. 4 in. When extended the sections are rigidly secured by winged nuts at the ferruled ends (1) of the middle and bottom sections. The mast is fixed to the vehicle by a fibre bush (2) permitting a swivelling action. The base is a part of a bearing stud SB which leads through the vehicle and is, internally, secured by a hexagonal nut.

15. The mast is secured in its vertical position by a hinged vertical clamp (3) and when in the stowage position by two horizontal clamps (4). When erected it is stayed by two sets of guy ropes, two upper (5) from the top eye-bolt ring (6) and two lower (7) from a ring (1) on the middle section of the mast.

16. The aerial wire is insulated from the mast by a glass insulator (8) and a similar insulator (9) serves to insulate from a R.E. field pole (10) which acts as the lower end support for the aerial. The field pole is back-stayed (11). The earth end of the aerial wire is attached to a terminal post (12) on a plug P_1, type 13, clamped (13) to the side of the container of an earth mat, type 7 (14) which constitutes the radial earth. The earthing connexion is made from the body of the plug P_1 by a metallic strip (15). An illustration of the earth mat in fig. 1 inset shows this connexion in greater detail.

17. The plug, type 13, is modified to accommodate coaxial cable at its lower end and the manner of fixing this will be described later in this chapter. The coaxial cable Cb consists of a 120 ft. length which leads through an aperture (16) in the vehicle and terminates in the instrument end, in a plug type 160.

18. The plug, type 160, connects with a coaxial socket on a terminal unit, type 4, inside the vehicle. The terminal unit is mounted on an aerial relay box and consists of three coaxial sockets, one of which leads *via* a length of cable to a socket, type 306 on the T.1090. Both ends of this cable are fitted with plugs, type 160. The remaining coaxial aerial socket is similarly connected to a coaxial aerial socket, engraved AERIAL 1 on the receiver R.1084.

19. The portable earth mat, type 7, consists of eighteen radial wires each 30 ft. in length. The radials are wound on spools for stowage and fit into a containing box which is illustrated in the inset, fig. 1.

INSTALLATION

20. Certain modifications to transmitter T.1090 and receiver R.1084 must be carried out to provide for the coaxial feeding of these instruments. These modifications are detailed in Leaflets A.154 and B.16 of A.P.1186, Vol. II. It is essential that the modifications should be effected before attempting to use the aerial system, type 18.

21. The system is fed by 120 ft. of coaxial cable PT5RB or PT5C (40 ohms) led in through a hole in the vehicle from the aerial terminating post (plug, type 13) to the aerial terminal on the aerial relay box. Lengths of coaxial cable, fitted with plugs, type 160, lead to the transmitter and receiver coaxial sockets. The aerial relay box has to be modified in order that the three coaxial lines may be fitted to it.

Modification of aerial relay box (relay, magnetic, type 36)

22. In order to modify the aerial relay box, the steps set out below must be followed. Reference to the illustrations of Sect. 6, Chap. 8 of this publication will assist.

(i) Disconnect external wiring from the magnetic relay, type 36.

(ii) Take out four wood screws which fix the relay box to the side of the tender. Remove relay box.

(iii) Extract the ten wood screws which hold the back of the relay box and remove the box.

(iv) Fit a terminal unit, type 4, consisting of three coaxial sockets and an earth mounted on a metal bracket, so that it is below and towards the rear of the magnetic relay box. Secure it by six wood screws, three on either side.

(v) Drill three ¼-in. holes through the bottom of the box of the magnetic relay, so that they coincide with the three insulated pins of the coaxial sockets mounted on the terminal unit, type 4.

(vi) Connect a length of Uniplug 7 between the insulated pin of the left-hand (looking at the face of the magnetic relay, type 36) coaxial socket and the MAIN AE connexion on the magnetic relay. N.B. This connexion and those specified in (vii) and (viii) below are to be made inside the back of the magnetic relay and not on its face.

(vii) Connect a length of Uniplug 7 between the insulated pin of the centre coaxial socket of the terminal unit, type 4, and the TRANSMITTER connexion in the magnetic relay.

(viii) Connect a length of Uniplug 7 between the insulated pin of the right-hand coaxial socket on the terminal unit and the RECEIVER connexion in the magnetic relay.

(ix) Replace the back of the magnetic relay, type 36, and secure it into its original position in the vehicle.

Fitting the mast

23 The constituent parts of the aerial system, type 18, are shown in the Appendix to this chapter. The necessary steps for fitting are given in paras. 24 and 25.

24. Referring to fig. 1, two wooden battens are provided and the longer (17) of these should be fitted vertically to the outside of the vehicle; the shorter (18) occupies a reinforcing position inside the vehicle. Holes (19) are drilled for ⅜ in. chromium steel bolts (5 in. long).

25. A bearing stud is fitted in position indicated on the inset, fig. 1. Near the base of the long (outside) batten a hole is drilled for a vertical hinged clamp (3), this clamp serving to secure the mast when in the vertical position. Two stowage position clamps (4) are fitted horizontally to accommodate the mast in transit.

Using the mast as an aerial

26. To use the mast as an aerial for short distance working the following installation should be effected:—

(i) Connect a length (20) of cable, electric, H.T. Uniplug cotton No. 1, SE/917, between the inside hexagonal nut of the bearing stud SB and the MAIN AE connexion on the magnetic relay, type 36.

(ii) Connect a lead from the main earth of the vehicle to the EARTH terminal on the terminal box, type 4.

Operation of the aerial relay switch will now connect the 30 ft. rod aerial and earth to either the transmitter or the receiver.

Fitting the aerial system to substitute vehicles using the T.R.1091

27. Due to the different types of vehicles being used as substitutes for the general purpose vehicle, no standard method of fixing the aerial mast can be detailed. In most cases, however, the procedure will only differ from that previously detailed in that the longer wooden batten will need to be cut and shaped to meet the individual requirements of the vehicle concerned.

28. On substitute vehicles the end of the 120-ft. coaxial cable to which the plug, type 160, is fitted must be plugged into the coaxial socket on an impedance matching unit, type 87. The aerial plug from the transmitter-receiver is then plugged into a socket, type 72 (Stores Ref. 10H/9000) mounted on the impedance matching box and the T.R.1091 is fully fitted for coaxial feeding. The impedance matching box, type 87, may be fitted in any convenient position in the vehicle except that the socket, type 72, must be mounted within reach of the aerial plug of the T.R.1091.

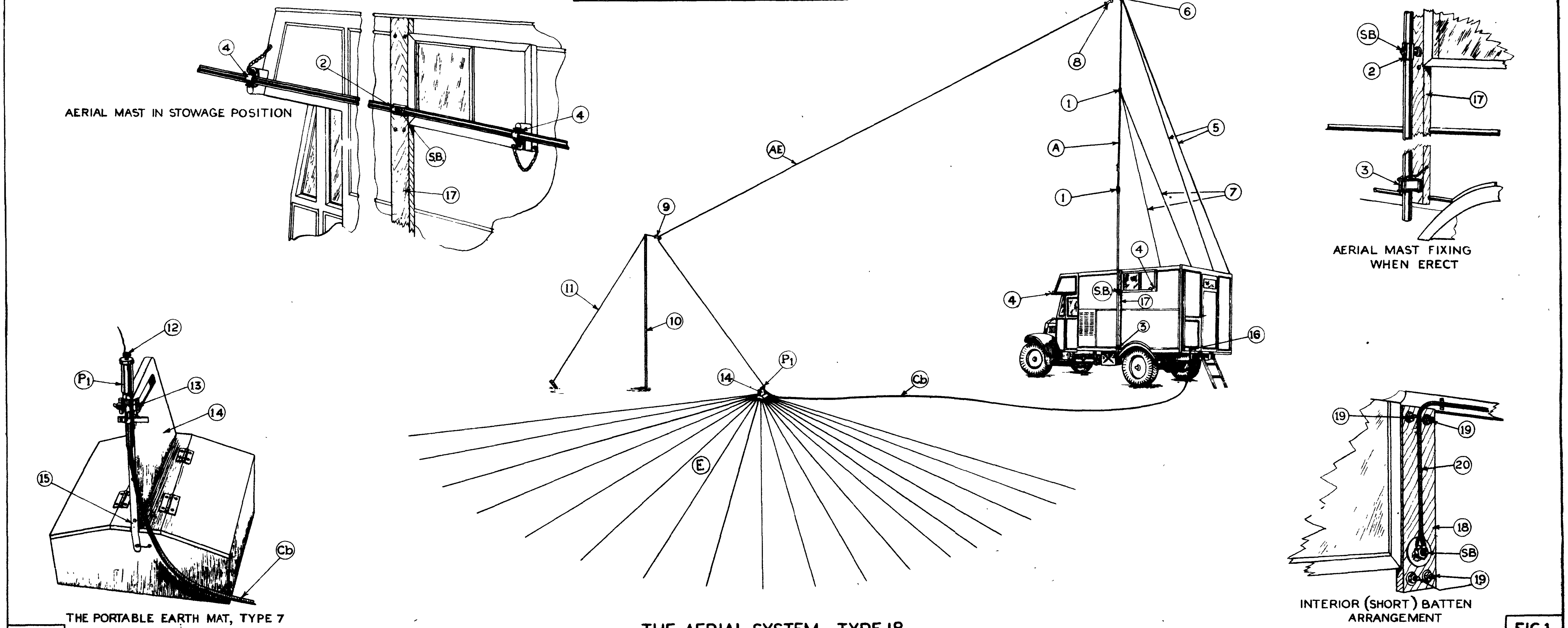
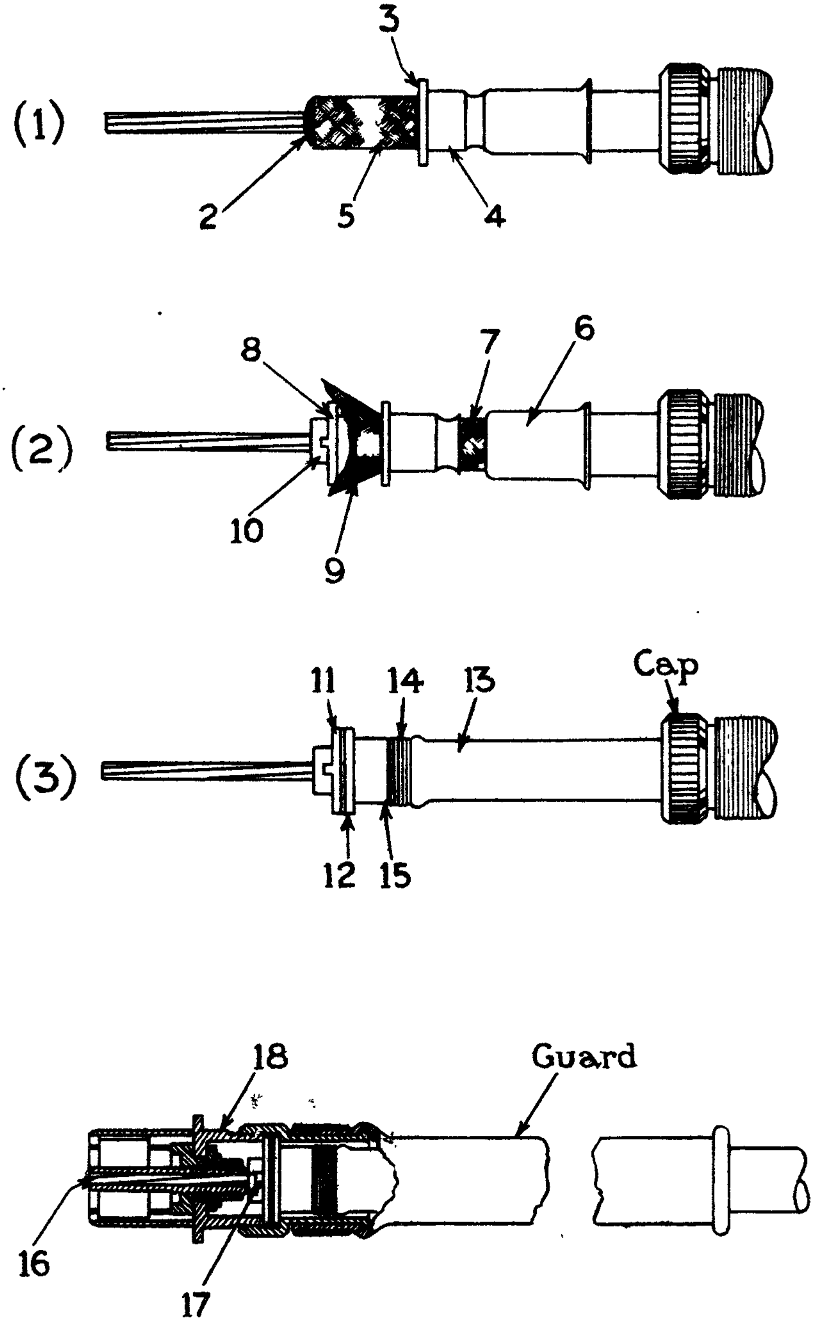


FIG.1

THE AERIAL SYSTEM, TYPE 18

FIG.1

REPRINT PP2150 M28881/2459 4/43 4250 C&P Gp.959(4)



PROCESS STAGES FOR CONNECTING PLUG, TYPE 160

FIG. 3

FIG. 3

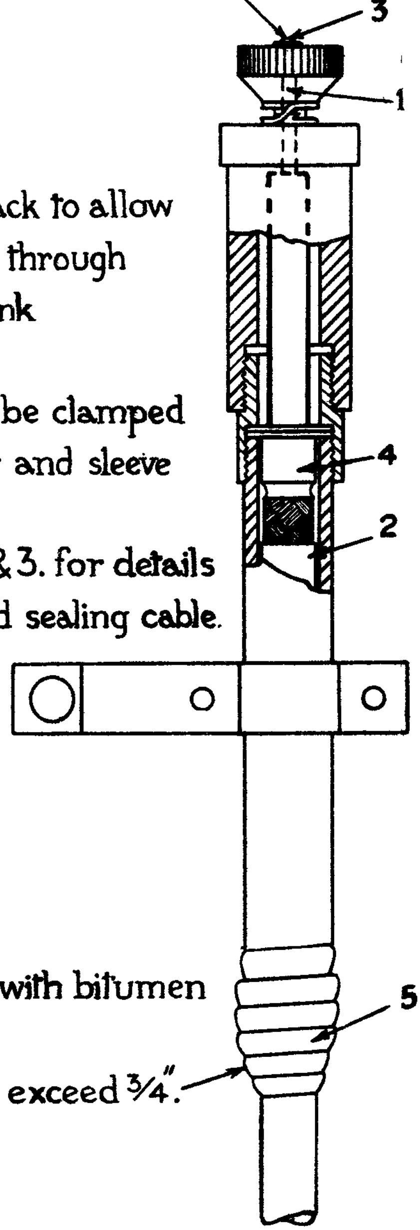


FIG.2 COAXIAL CONNEXION TO TERMINAL TYPE 13 FIG.2

Cable connexions to plug, type 13

29. The method of connecting terminal, type 13, to the coaxial cable is shown in fig. 2. The terminal shank (1) is drilled. The insulation of the cable is cut back (2) sufficiently (approx. 3½ in.) to allow the core conductor to project through the drilled terminal shank to the top end of which it is soldered (3). The braiding of the cable should be clamped between the inner and outer sleeves of the terminal (4) with pliers (Stores Ref. 37B/502). The bottom of the plug is securely bound to the cable form with bitumen tape (5) but the overall diameter must not exceed ¾ in.

30. For details of fitting sleeves and sealing cable, fig. 3 should be consulted. The process is divided into four stages. The first stage consists of the following operations:—

(i) The guard assembly is unscrewed from the plug and slipped over the cable.
(ii) The outer covering of the cable is cut back (2) 2 in. from the end and removed, care being taken not to damage the metal braiding.
(iii) The outer covering is rolled back a further ¾ in. to permit the sleeve assembly.
(iv) The outer sleeve (4) is slipped over the metal braiding (5) and to assist the operation, the braiding is smoothed out in the direction of travel.
(v) The metal braiding and insulation is then cut back to 1½ in. from the end and removed. Care must be taken not to damage conductors.
(vi) Insulation sealing at the end (2) is not necessary for solid core cable.

31. The processes of the second stage are as follows:—

(i) Roll back the outer cover (6) of the cable as shown in the diagram thus uncovering the metal braiding (7).
(ii) Insert the inner sleeve (8) between the metal braiding (9) and the insulation. The insulation should project (10) ⅛ in. beyond the end of the inner sleeve.

32. In the third stage proceed as follows:—

(i) Draw the inner (11) and outer (12) sleeves together by means of the pliers specified in para. 29. This operation anchors the metal braiding.
(ii) The projecting ends of the braiding should be trimmed off.
(iii) Roll the cable outer coverings (13) forward over the sleeves and bind in the groove on the outer sleeve, with waxed thread (14).
(iv) Turn back the outer covering to the end of the binding (15). The cap must pass easily over the binding.

33. The fourth stage consists of the following operations:—

(i) Clean the core conductor and pass through the drilled hole (16) in the plug.
(ii) The projection (17) on the inner sleeve is placed in the keyway on the screen (18) of the plug and the cap with guard screwed home.
(iii) The conductor is splayed out at the end and securely soldered (3, fig. 2).
(iv) The projecting end is now trimmed flush with the plug.

OPERATION

34. The first step to be taken prior to operation of the quarter-wave aerial is to remove the aerial and earth connexions to the relay, magnetic, type 36. Then pull out the telescopic aerial mast to its full length and tighten the wing nuts. Cut a length of aerial wire R4 to the correct length for the frequency to be operated (*see* para. 9) and fix to a glass insulator which is attached to the top of the mast. Swing the mast into a vertical position and tighten the winged vertical clamp. This will retain the mast in a vertical position. The guy ropes are then secured to suitable positions on the vehicle.

35. Run out the 150 ft. of coaxial cable from the tender and clamp the terminal, type 13 to the earth mat, type 7. The position can be seen in fig. 1. Next, erect the 13 ft. R.E. pole with glass insulator attached to the top. The pole must be placed at a suitable distance from the vehicle and the aerial wire passed through the insulator and secured to the terminal, type 13.

36. Connect the plug, type 160, of the coaxial cable, to the left-hand coaxial socket on terminal unit, type 4. Connect the coaxial feed from the T.1090 to the centre coaxial socket and the coaxial feed to the R.1084 to the right-hand coaxial socket on the terminal unit.

37. If directional effect be desired the end of the aerial attached to the terminal, type 13, should be pointed in the communicational direction. Operation with substitute vehicles is similar to that detailed for the general purpose vehicle.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Ref. in fig. 1	Remarks
10B/299	Aerial system, type 18			
	Principal components.—			
	Batten			
10B/474	Long	1	17	6 ft. 0 in. × 4 in × $\frac{3}{4}$ in.
10B/475	Short	1	18	1 ft. 7 in. × 4 in × $\frac{3}{4}$ in.
	Clamp, hinged			
10B/304	Vertical	1	3	
10B/305	Horizontal	2	4	
	Guy			
10B/473	29 ft. long	2	5	
	Rod			
10B/300	Bottom section	1	A	13 ft. 2 in. long
10B/301	Middle section	1		8 ft. 6 in. long
10B/302	Top section	1		8 ft. 4 in. long
10B/303	Stud, bearing	1	SB	
	Associated equipment —			
5E/917	Cable, electric, uniplug cotton No. 1	As reqd.	20	
5E/N.I.V.	Coaxial cable PT5RB or PT5C (40 ohms)	As reqd.	Cb	
10A/12919	Impedance matching unit, type 87	1		For T.1091
10B/8097	Insulators, type 17	2	8, 9	
10B/445	Mats, earth (portable), type 7	1	14	
10H/183	Plugs, type 160	5		
5F/451	Tape, insulating, adhesive	1		
10H/1962	Terminal, type 13	1	12	
10H/1621	Terminal unit, type 4	1		
10B/4589	Wire, aerial R4	As reqd.	Ae	

SECTION 6, CHAPTER 24

POWER UNIT, TYPE 301

INTRODUCTION

1. The power unit, type 301 is designed for use with the transmitter receiver, type T.R.1196 when employed on ground W/T Stations and replaces the power unit, type 87 for this purpose.

General description

2. The power unit, type 301 normally operates from a 200 to 260-volt single phase 50-cycle A.C. supply and provides all requisite supplies for operation of the transmitter-receiver as follows:—

(i) 2·8 amps. A.C. at 6·3 to 6·8 volts, required for filament heating.

(ii) 0·3 amps. D.C. at between 24 and 28 volts required for relay operation and the frequency selection mechanism.

(iii) 230 volts D.C. at 70 mA (approximately) required as H.T. supply for valve anodes. This is regulated so that, should the anode current drop to 30 mA, the anode voltage will not rise above 300 volts, and the supply is smoothed so that the ripple is less than 1 per cent. when on load.

Circuits

3. The power unit is connected to the mains *via* a 3-pin plug, type 292, the centre pin of which is connected to the mains transformer core and earth. This plug is located within the securing handle of the unit and must be removed before the unit can be withdrawn from the transmitter-receiver chassis assembly. A mains switch is provided adjacent to the mains plug and the power unit outputs are connected to the transmitter-receiver *via* a 6-pin Jones type plug. This plug has the same terminal outputs as the power unit, type 87 except in that the two terminals previously used for supplying the rotary transformer in the power unit, type 87, now provide a 24-volt D.C. output for relay operation.

4. By referring to the circuit diagram (fig. 1) it will be seen that the input supply is connected to the transformer T_1 *via* the double pole switch S and two fuses, type 5. The transformer T_1 has four secondary windings:—

(i) A 6·3-volt winding providing 2·8 amps. A.C. for heating the transmitter-receiver filaments. A pilot lamp is connected across this winding.

(ii) A 250–0–250-volts winding which is connected to the anodes of the rectifier valve, type 6X5G, which provides the requisite H.T. D.C. for the transmitter-receiver valve anodes.

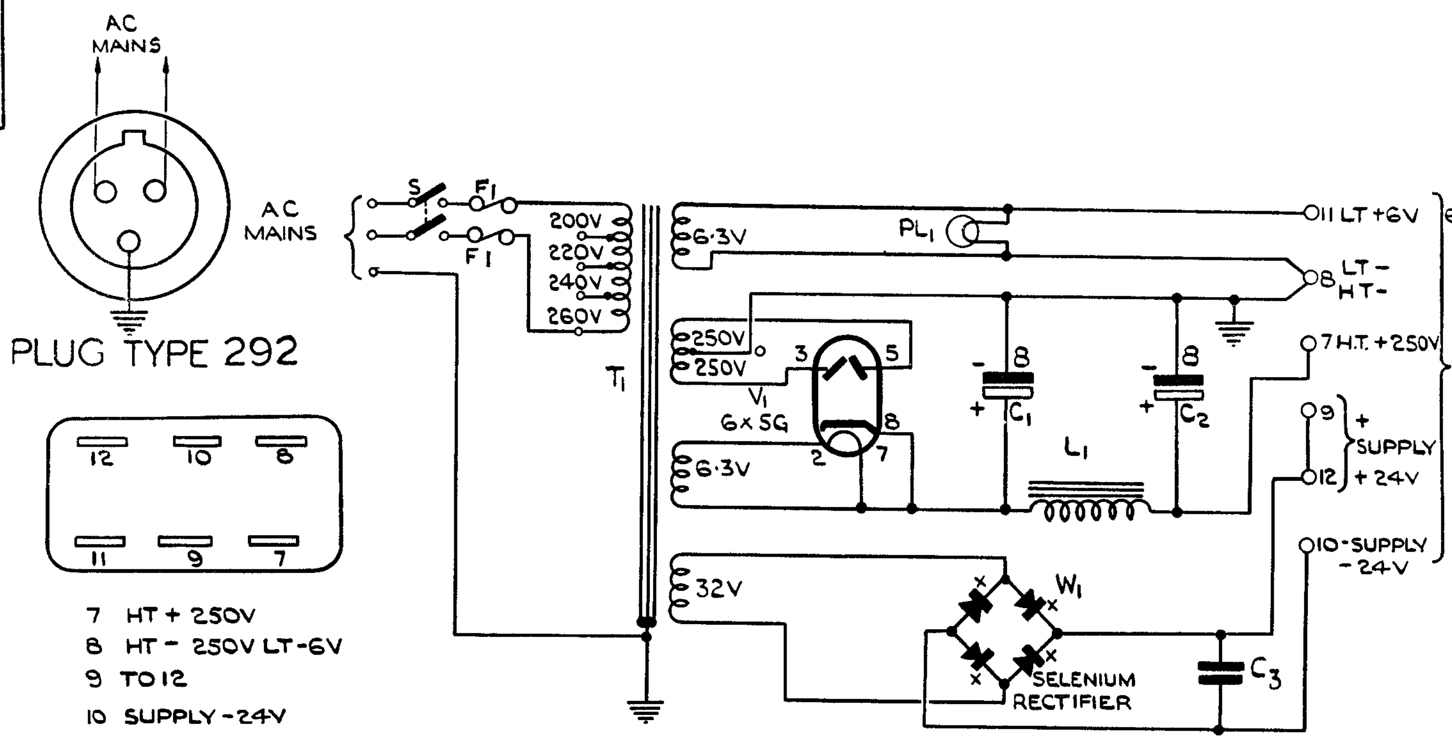
(iii) A 6·3-volt winding providing 0·6 amp. A.C. for heating the filament of the rectifier valve.

(iv) A 32-volt winding connected to the selenium bridge type rectifier which provides 24 volts D.C. required for operating the transmitter-receiver relays. The condenser C_3 is included in the output circuit to protect the rectifier W, from switching surges.

5. The rectified H.T. supply is smoothed by the two electrolytic condensers C_1 and C_2 and by the choke L_1.

6. The dimensions of the complete unit are the same as those of the power unit, type 87, with which it is interchangeable, but it should be noted that when the power unit, type 301, is used with the T.R.1196, an extra connection is required in the chassis assembly between pin No. 12 of the power unit Jones plug and pin No. 2 of the 2-way W-type plug. This modification has been incorporated in all chassis assemblies, type 7, after No. 278, but a circuit check between these two points before inserting the power unit may be considered advisable.

FIG. 1



7 HT + 250V
8 HT − 250V LT − 6V
9 TO 12
10 SUPPLY − 24V
11 LT + 6V
12 SUPPLY + 24V

JONES PLUG

POWER UNIT TYPE 301

STORES REF: 10K/946.

V_1 REF NO: 10T/582
L_1 CHOKE TYPE 336 (5HY)
C_1 & C_2 CONDENSERS TYPE 3507
W_1 RECTIFIER TYPE 114
F_1 TYPE 5 (1 AMP)

A.P. 1186 SECT.6, CHAP.24

FIG. 1

P2590 M35484/435 7/43 13000 C & P Gp. 1

SECTION 7

VISUAL SIGNALLING APPARATUS

SECTION 7

VISUAL SIGNALLING APPARATUS

CONTENTS

SECTION 7, CHAPTER 1

ALDIS SIGNALLING LAMP

Contents

List of Illustrations

THE ALDIS SIGNALLING LAMP

(Stores Ref. 5A/760)

INTRODUCTION

1. The Aldis signalling lamp is intended for signalling between aircraft, with either one or both in flight and also for ground signalling purposes. It may be used either in daylight or darkness. The lamp is designed primarily for hand use, but in some instances a socket for a standard heliograph tripod is fitted to the lower part of the body for use on the ground. It is not possible to give any definite indications regarding the maximum range obtainable, as this depends on many variable conditions. It may be assumed, however, that the lamp can be used with success in daylight at any range within which aircraft are visible.

2. The beam of light from the lamp is focussed by means of a mirror, and has a very small angle of divergence. Signalling is carried out by displacement of the mirror axis with respect to the axis of the lamp. This has the effect of changing the direction of the beam, enabling it to be directed on to, or away from, the receiving station. In order that the receiving station may be kept in the field of the lamp, a combined peep and telescopic sighting device is provided. This device is known as the aeroscope and is mounted on the upper part of the lamp casing.

3. When signalling, the lamp is connected to the aircraft supply by means of a flexible lead terminating in a two-pin plug. The lamp is then held by the handle and the receiving station sighted in the aeroscope. One of the triggers in the handle is now depressed, closing the circuit and illuminating the lamp. Whilst this trigger is maintained in this position the second trigger is operated to produce the morse signals, being pressed to direct the beam on to the receiving station for a " mark " and released to produce a " space ".

CONSTRUCTIONAL DETAILS

The Lamp

4. The lamp is illustrated in figs. 1 and 2. The lamp body is a cup-shaped aluminium casting on the side of which is riveted a small housing which contains the mounting for the bulb. This mounting consists of a spring blade, insulated from the body, and making contact with the base of the bulb stem when the latter is screwed home in its socket. The socket is also insulated from the body. The two supply leads are taken to a trigger switch in the handle and thence to the blade and bulb socket respectively. The bulb socket is threaded externally to take a knurled union nut (1), by means of which the bulb is retained in the socket. On the inner side of the socket is cut a small keyway which registers with a pin on the stem of the bulb. This prevents rotation of the bulb during fixing, and ensures correct fitting.

Handle and operating gear

5. The handle is of the pistol-grip type and is constructed in two portions. The main portion is riveted to the body of the lamp, while the other part may be detached by removing two setscrews, thus giving access to the connections and trigger mechanism which are contained inside the handle.

6. Referring to fig. 2 the mechanism consists of a spring trigger (1) and a handle switch (2). The handle switch (2), when depressed, completes the lamp-battery circuit, and is so arranged that it is kept depressed when the lamp is held in the hand. The upper trigger (1) actuates the mirror tilting mechanism as described in para. 3. The socket (3) through which the supply cable is led into the handle is of the two-pin type. Into this is plugged the two-pin plug (1, fig. 3), and the ring nut (2, fig. 3) is screwed on to the externally threaded union (3). From the socket one lead is taken direct to the lamp socket, and the other is taken through the contacts of the handle switch (2), to the other side of the lamp socket.

FIG. 1. Aldis Lamp.

Mirror

7. The reflecting element consists of a Mangin mirror (2, fig. 1), which is a combined lens and mirror. The mirror is mounted in a light brass spinning and is pivoted on pin centres, the conical ends of which are case-hardened and ground. The pin centres are mounted in split lugs provided with clamping screws. One of the pin centres (4, fig. 2) has a slotted end for adjustment purposes.

8. The mirror tilting device is operated by the trigger lever (1, fig. 2), and gives a movement of approximately $4\frac{1}{2}°$ to the mirror which corresponds to 9° deflection of the beam. The upper end of the lever is fitted with a roller to reduce wear on the brass spinning in which the mirror is

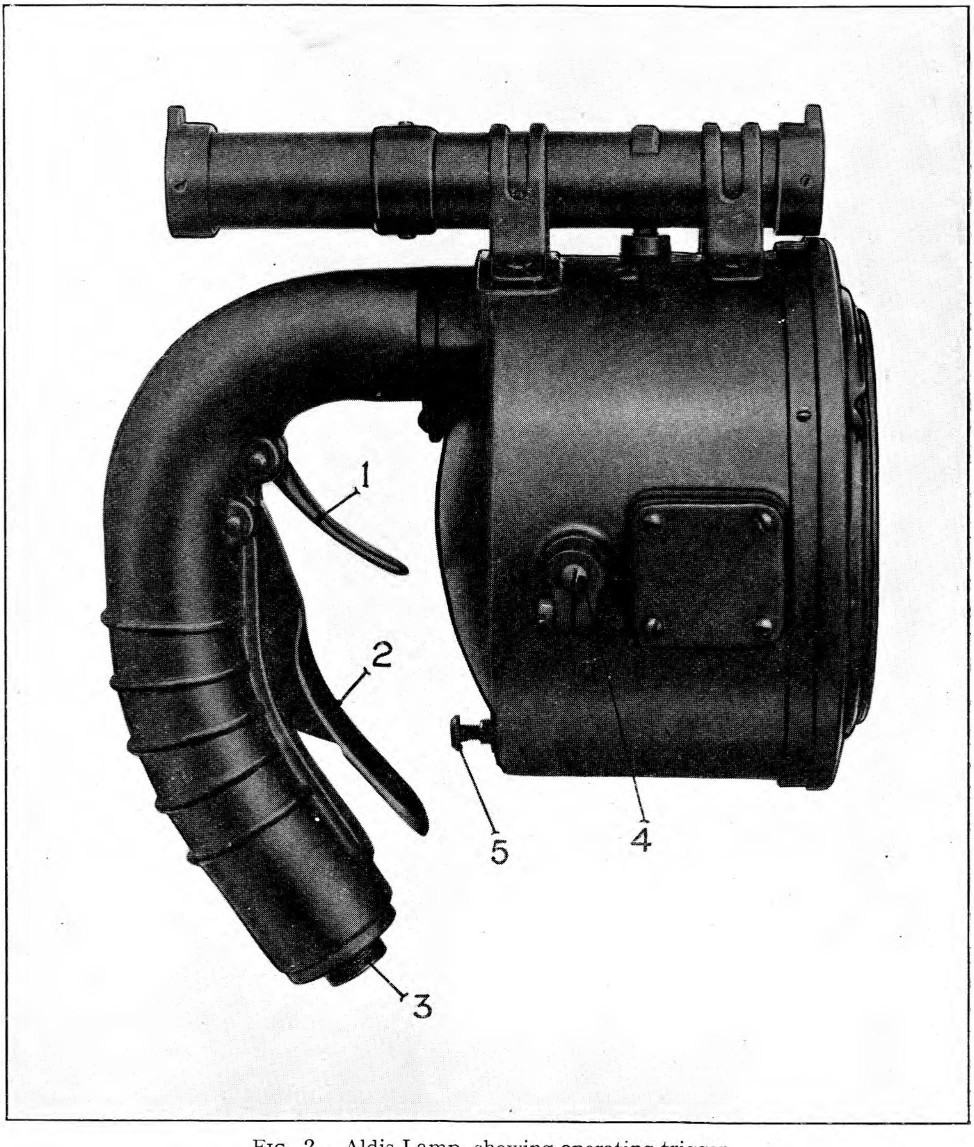


FIG. 2. Aldis Lamp, showing operating trigger.

mounted. Depression of the trigger causes the roller to press forward the upper part of the mirror against the action of a control spring. A small plate is riveted to the spinning to provide additional protection against the wear due to the roller. The two extreme positions of the mirror (i.e. with the trigger at rest and depressed) are fixed by two stops. The stop limiting the amount of forward tilt of the mirror consists of an adjustable milled-headed screw (5, fig. 2) with an external locknut. The second stop is accessible only when the detachable part of the handle is removed. It consists of a brass screw, the end of which is slotted for adjustment and provided with a locknut. This stop determines the mirror position when the trigger lever is free.

Cover glasses

9. The cover (3, fig. 1) consists of an annular metal plate or bearer ring in which is fitted a plain glass disc. In the bearer ring are cut three equally spaced key-hole slots, for attachment to a ring plate fitted with three mushroom-headed studs, mounted on the front of the casing. At one of the key-holes is fitted a spring clip with a dimple in it. This rides over one of the mushroom-headed studs and prevents the cover from being accidentally released. The cover glass has no part in the optical arrangement of the lamp and is provided to protect the bulb and mirror from the weather. The optical efficiency of the lamp will not be affected if the cover glass is broken. The clear cover glass may be removed and a red or green glass substituted.

Bulb

10. This bulb has been specially designed for use with the Aldis lamp and is of the gas-filled type. The correct bulbs for use are " Lamps, filament, 12 volts, 36 watts " (Stores Ref. 5A/367), or " Lamps, filament, 24 volts, 36 watts " (Stores Ref. 5A/1900). In place of the normal bayonet or screw fitting, the bulb has a special union and stem attachment. At the base of the stem a shouldered plug is secured, and above this a union nut is mounted loosely on the stem. The position of the bulb is located by registration of a pin and keyway, so that when the bulb is in its socket, the two horizontal coils which comprise the filament are in line with the receiving station. The bulbs are carefully standardized for focus and sighting during assembly.

Aeroscope

11. The aeroscope (4. fig. 1) consists of a five-combination lens telescope, in which four cross hairs are mounted to include a central rectangle which is the field of view. The receiving station must be kept in this rectangle while signals are being transmitted. For close working, a peep-sight view-finder is formed on one side of the telescope. A V-type back and foresight is also provided. The aeroscope may be adjusted to suit individual eyesight by means of the adjusting collar (5).

Cable

12. A length of 2-core, 23/36 cable (Stores Ref. 5A/397) (fig. 3), is supplied with each lamp. One end of the cable carries the plug portion of a two-pin plug-and-socket union, the plug (1) being secured to the socket by means of a union nut (2). The other end of the cable carries a two-pin plug (3) (Stores Ref. 5C/959).

PRECAUTIONS AND MAINTENANCE

Sighting adjustment

13. The lamp should be periodically tested for sighting adjustment. This may be accomplished in the following manner :—A stationary object, at a distance of 30 to 50 feet from the lamp, should be sighted in the central rectangle of the telescopic sight. When the switch and mirror-operating triggers are depressed the beam should fall directly on the object viewed. If the beam falls short of or beyond the object, the lamp requires adjustment.

14. This is effected by means of the lower stop (5) shown in fig. 2. This setscrew determines the extreme position taken up by the mirror when the trigger is depressed. The locknut on this adjustment must first be slackened off and the setscrew adjusted until the beam falls directly

on the object sighted. The locknut must then be tightened up. *In no circumstances should any attempt be made to adjust the lamp by altering the position of the aeroscope,* which is pinned to the lamp body.

Fitting new bulbs

15. When a new bulb is being fitted it should be turned so that the small locating pin at the base of the stem is towards the back of the lamp. Press the stem well down in the socket taking care, before so doing, that the pin engages with the socket keyway. The bulb should be held down in the socket with one hand while the union nut is tightly screwed up with the other. Make sure that the bulb stem is firm in the socket and *take care to avoid bending the bulb stem.* Do not replace unserviceable bulbs in the carrying case ; they should be discarded.

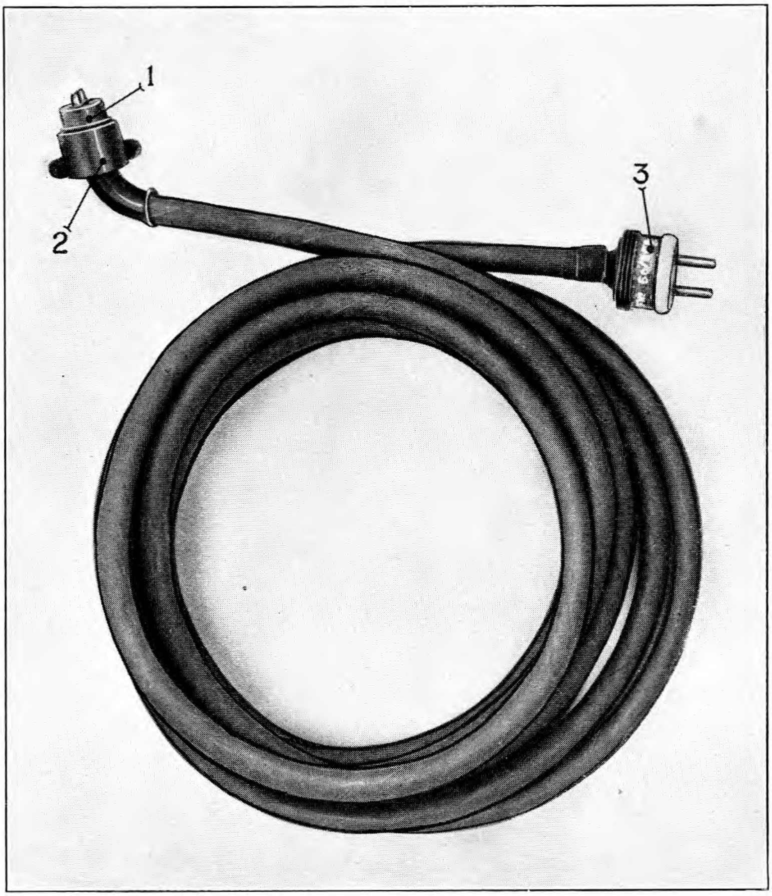


FIG. 3. Connecting cable.

Precautions

16. The filaments of the bulbs used for the Aldis lamp are specially designed, and have a high intrinsic brilliance. They are intended for intermittent use only and are actually overrun when used on the aircraft supply. A short life only, therefore, can be expected. For this reason the lamp must never be used as a spot-light or flood-light or for inspection purposes. Bulbs having bent stems should never be employed, as it is essential that the bulb filament is located at the focus of the mirror. It is important to keep the lens mirror, bulb and front cover glass free from steam or moisture, as this produces diffusion and scattering of the beam and renders the lamp inefficient.

APPENDIX

NOMENCLATURE OF PARTS

The following list of parts is given for information. In ordering spares for this lamp, the appropriate section of AIR PUBLICATION 1086 must be used.

Ref. No.	Nomenclature.	Quantity.	Remarks.
5A/760	Lamp, signalling.		4 in. Aldis type. Complete with aeroscope, lamp, filament (Stores Ref. 5A/367), and connecting cable (Stores Ref. 5A/397).
	Spares :—		
5A/397	Cable, connecting.	1	Complete with plug (Stores Ref. 5C/959).
5A/1320	Glass, clear.	1	
5A/1900	Lamp, filament 24-volt.	1	For use when aircraft supply is 24 volt.
	Accessories :—		
5A/396	Box.	1	For complete lamp.
5A/1674	Box.		For one each of Stores Ref. Nos. 5A/1151 and 5A/1152.
	Glass :—		
5A/1151	Green.	1	
5A/1152	Red.	1	

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SECTION 7, CHAPTER 2

SIGNALLING LAMP, TYPE B

(Stores Ref. 5A/2334)

Contents

List of Illustrations

SIGNALLING LAMP, TYPE B

(Stores Ref. 5A/2334)

INTRODUCTION

1. The signalling lamp, type B, is intended for visual signalling between aircraft in flight, or for air to ground signalling, by day or by night. When used in aircraft the lamp is plugged into a socket connected to the general services supply, and when used on the ground it is connected across a standard 12-volt or 24-volt accumulator depending on the rating of the lamp filament supplied.

2. The beam of light is focussed by means of sights attached to the lamp body. Signalling is carried out by breaking the current to the lamp filament by means of a trigger switch on the right-hand handle, the time taken for the filament to light up and black out being sufficiently short to permit signalling at a speed of between 8 to 10 words per minute.

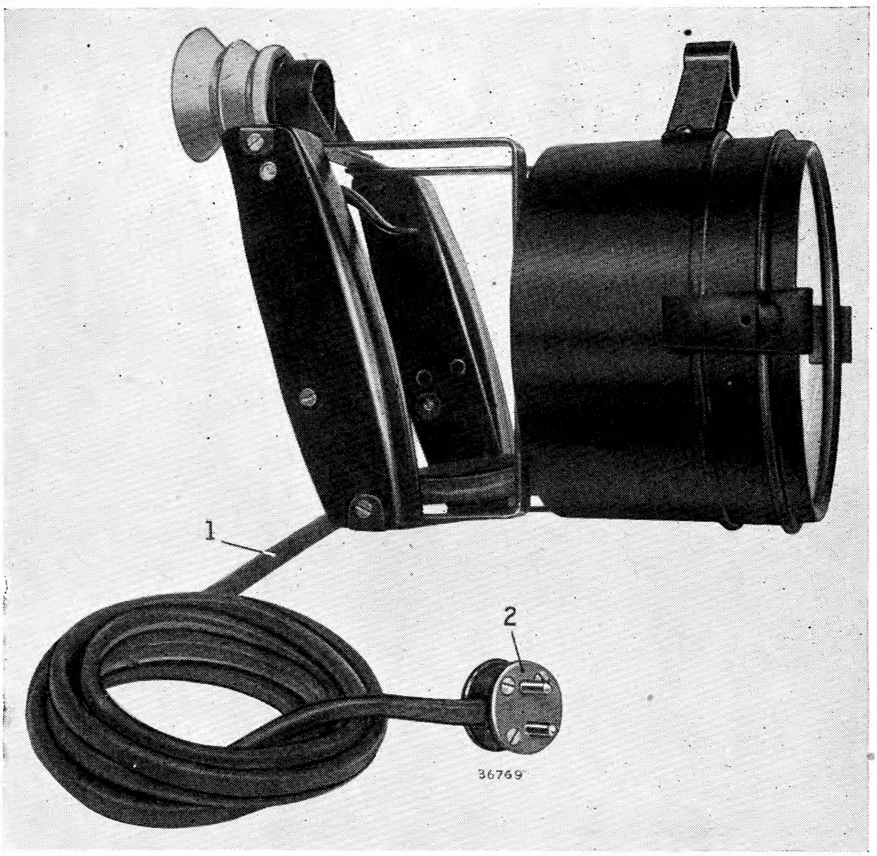

Fig. 1—Signalling lamp, type B

OPERATION

3. When signalling, the lamp which is connected to the source of supply by means of a flexible lead terminating in a 2-pin plug, is held in both hands with the corrugated rubber eye-piece against one of the eyes. The other eye is closed and the target is brought to the centre of the foresight, and held there. For day signalling, the target should, as far as possible, be held in the inner ring, as this is the part of the beam with the greatest intensity. The eye should be placed so that the circumference of the back-sight is approximately concentric with the rings of the backsight. For night signalling it is only necessary to keep the target within the outer ring, which is made visible by a coating of

luminous paint. The rings of the foresight are raised above the lamp body to give a clear view all round the sight, so that if the target is lost owing to sudden movement of the aircraft, it can be quickly regained. A disc of clear synthetic material is fitted inside the rubber eyepiece to prevent a jet of air impinging on the eyeball when the lamp is used in a strong wind.

CONSTRUCTIONAL DETAILS

The lamp

4. The lamp is illustrated in figs. 1 and 2. It consists of a paraboloidal reflector with a filament lamp and lamp holder enclosed in the cylindrical body, to the back of which is attached a pair of handles. On the top of the body is mounted a pair of open sights in alignment with the axis of the reflector.

5. Referring to fig. 2, the lamp body (6), the cover (11), and the brackets (4) on which the handles and backsight are mounted are made of steel. The edge of the reflector (10) is folded back and slips over the rim of the lamp body and is held in position by the cover which is in turn secured by means of the diametrically opposite spring clips (8) hinged to the lamp body.

Reflector

6. The reflector (10) is of aluminium, treated to increase the reflectivity and protect the surface against abrasion and corrosion. The centre of the reflector is shaped to take the lampholder, the connections to the lamp being made one through a phosphor-bronze spring and the other through the terminal tag (9).

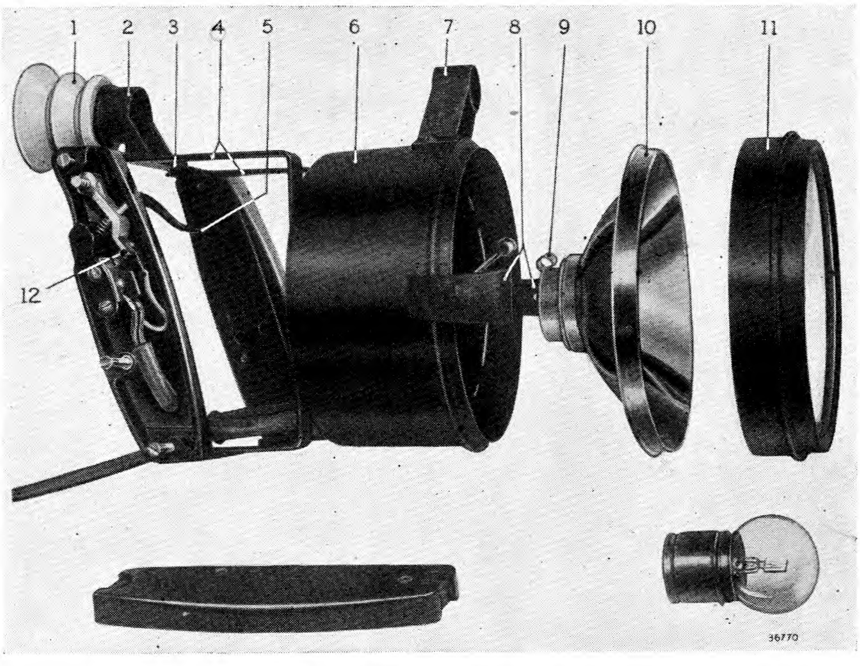

Fig. 2—Details of lamp

Sights

7. The sights are made of zinc base alloy, the foresight (7) being riveted to the lamp body and the backsight (2) to the bracing strut (3) between the brackets for the handles. The backsight is circular, the diameter of the hole being approximately that of the pupil of the eye in daylight. The foresight consists of two concentric rings, the diameter of the outer ring being 6 deg. when viewed from the backsight. This is approximately 1 deg. more than the angle of the divergence of the beam, and the whole of the beam should therefore fall evenly inside the outer ring.

8. A rubber eye-piece (1) is fitted to the backsight to enable the sight to be held firmly against the eye without discomfort or injury, and to exclude extraneous light when signalling at night.

Front cover

9. The cover (11) (Stores Ref. 5A/2335) consists of an annular steel plate in which is fitted a disc of clear glass. If necessary a cover (Stores Ref. 5A/2336) containing a green disc or a cover (Stores Ref. 5A/2337) containing a red disc, may be fitted, these discs may be of glass or synthetic resin material.

Handles

10. The handles which are of moulded insulation material are constructed in two portions the whole being screwed to the bracing struts which are spot welded to the brackets, and the bracket, are spot welded to the lamp body.

Switch

11. The switch housed in the right-hand handle is operated by means of the trigger (5) and is of the single pole type, having contacts of gold silver alloy. The contacts are rigid in order to give a definite make and break.

Filament lamp

12. The correct lamp to be used is "Lamp, filament, 12 volts, 30 watts" (Stores R3f. 5A/2339) or "Lamp, filament, 24 volts, 30 watts" (Stores Ref. 5A/2340). The filament lamps are correctly focussed during manufacture and no adjustment is recessary when a new filament lamp is inserted. As the lamps are intended for use on a flashing circuit, their continuous life is short, viz. approximately 25 hours at 13 or 26 volts for lamps normally rated at 12 and 24 volts respectively. The lamps should therefore never be used as a spot light except in a real emergency.

Cable

13. A length of Dusheath 4, small, twin core cable (1, fig. 1, (Stores Ref. 5E/1611), is permanently attached to the lamp body and a standard 2-pin plug (2, fig. 1) is connected to the free end of the cable. Abrupt bending of the cable at the point of entry to the lamp body is prevented by a rubber sleeve.

PRECAUTIONS AND MAINTENANCE

General

14. If the lamp has been damaged in any way it should be tested to ensure that the signals are in alignment with the beam. This may be accomplished in the following manner. A stationary object, at a distance of approximately 50 ft. from the lamp, should be sighted in the centre of the foresight inner ring when viewed through the backsight. When the switch is operated the beam should fall directly on the object viewed. If the beam does not fall on the target, the lamp should be returned to a maintenance unit for repair.

15. The reflecting surface of the reflector may be cleaned by wiping with a clean cloth, or, if necessary, by washing with non-alkaline soap and water.

16. The switch contacts (12, fig. 2) should require to be cleaned only at rare intervals, if at all. If the contacts have been cleaned, care should be taken to ensure that full surface contact is obtained.

17. In early models a spare filament lamp is carried in a clip inside the carrying case, but in later models the spare filament lamp is carried in a clip in the lamp body. Do not replace unserviceable filament lamps in the carrying case, they should be discarded. It is important to keep the reflector, bulb, and front cover free from steam or moisture, as this produces diffusion and scattering of the beam and renders the lamp inefficient.

APPENDIX

NOMENCLATURE OF PARTS

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

Ref. No.	Nomenclature	Qty.	Remarks
5A/2334	Lamp, signalling, type B		Complete with front cover, clear, cable connecting (Stores Ref. 5E/1611)
	Spares:—		
5E/1611	Cable, connecting	1	Complete with plug (Stores Ref. 5C/959)
5A/2335	Front, clear	1	
5C/959	Plug, 2-pin, type A	1	
	Accessories:—		
5A/2338	Box	1	For complete lamp
5A/2368	Box	1	For coloured fronts
5A/2336	Front, green	1	
5A/2337	Front, red	1	
5L/2339	Lamp, filament, 12-volt, 30 watts	1	Spare lamp for carrying case (in early models) or for lamp body (in later models)
	or		
5L/2340	Lamp, filament, 24-volt, 30 watts	1	

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