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TRAINER, TYPE 48

Prepared by direction of
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of the Air Council

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AIR MINISTRY

NOTE TO READERS

The subject matter of this publication may be affected by Air Ministry Orders, or by Volume II, Part 1, leaflets in this A.P., in the associated publications listed below, or even in some others. If possible, Amendment Lists are issued to correct this Volume accordingly, but it is not always practicable to do so. When an Order or leaflet contradicts any portion of this publication, the Order or leaflet is to be taken as the overriding authority.

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LIST OF ASSOCIATED PUBLICATIONS

	A.P.
AMES Type 7,000	2556M
GEE Mk 2 Airborne Equipment (ARI 5083)	2557A
Gee Mk. II (tropical)	2557B
Gee navigation attachment	2560D

TRAINER, TYPE 48

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Stores Ref.	*10D/1164*
Weight	*64 lb. (approx.)*
Dimensions (with aerial folded)	*$24\frac{1}{2}$ in. × $14\frac{1}{2}$ in. × $10\frac{3}{8}$ in.*
Mains supply	*230 ± 15 volts at 50 c/s*
Output	*1 watt approx. at 47 Mc/s.*
Desirable range of trainer from receiver	*Minimum, 2 yds.* *Maximum, 30 yds.*

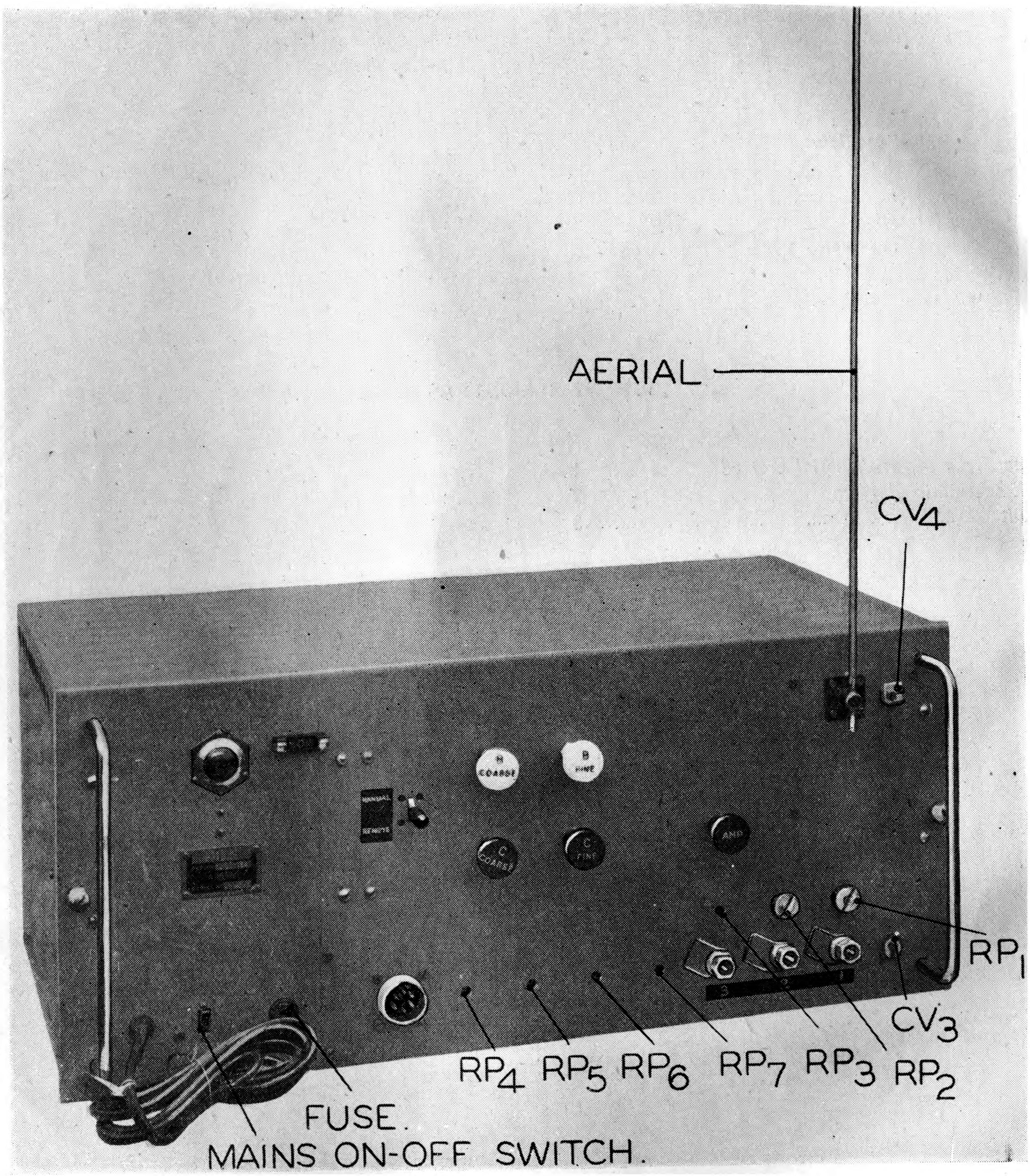

Fig. 1—TRAINER TYPE 48, WITH AERIAL ERECTED

Introduction

1. Trainer Type 48 is a portable trainer for use with Gee airborne equipment, namely, ARI.5718 (A.P.2557B) and ARI.5083 (A.P.2557A). For the principle of the Gee system the reader is referred to A.P.2557A, which covers the airborne equipment, and A.P.2556M, Chap. 1, which deals in a general manner with ground station equipment.

2. The trainer produces " A," " Ghost A," " B " and " C " pulses similar to those received by the standard airborne ARI.5718 and 5083, and is intended for the ground training of operators in the use of this equipment.

3. A miniature transmitter incorporated in the trainer radiates appropriately timed bursts of oscillations which can be received by any number of nearby standard receivers.

4. The pictures obtained on the receivers are similar in regard to pulse position to those received from the three 7000 Type ground transmitters. The tuning, gain, and timebase controls on the receiver all function in the normal operational manner, and the usual receiver noise appears on the trace.

5. Manual delay controls are provided on the trainer. An instructor, by manipulating these controls, can adjust the pictures received by the trainees operating the receivers to correspond with any fix which may be obtained in operation. The trainees follow the normal operational procedure and fix the position of their imaginary aircraft. The instructor checks their results on a separate monitoring receiver.

DESCRIPTION

General

6. The trainer, illustrated in *fig.* 1, is housed in a rectangular metal case. A pivoted rod aerial is mounted on the front of the case; this aerial is moved to the vertical position when the trainer is in use, and to the horizontal position, where it is retained by a clip, for stowing.

7. In addition to the aerial with its clip and two carrying handles, the following are provided on the front of the trainer case :—

(1) Indicator lamp, which lights up when the mains on-off switch is switched on.

(2) Mains on-off switch.

(3) Two-amp. fuse, which is connected in the primary winding of the mains transformer.

(4) MANUAL-REMOTE switch, by which either the controls on the trainer or remote controls may be used to operate the trainer.

(5) B COARSE control. This is coloured *white* and provides a coarse control over the position of the B pulse.

(6) B FINE control; also coloured *white*, and provides a fine control over the position of the B pulse.

(7) C COARSE control. This is coloured *red* and provides a coarse control over the position of the C pulse.

(8) C FINE control; also coloured *red*, and provides a fine control over the position of the C pulse.

(9) AMP control which is coloured *red*. Its use enables the amplitude of the transmitter pulse to be varied.

(10) Six-way W-plug, which provides the connection whereby the positions of the B and C pulses may be remotely controlled by a navigational attachment when the MANUAL-REMOTE switch *sub-para.* (4), is in the REMOTE position. A description of this navigational attachment will be issued later.

(11) Three co-axial inspection plugs each numbered 1, 2, or 3. These provide inspection points whereby the waveform at three points in the circuit may be examined using the indicator unit on the ARI.5718 or 5083.

(12) Presets. These are annotated in *fig.* 1, and their functions are described later.

(13) Mains lead.

8. A block schematic diagram of the trainer is shown in *fig.* 2, while the complete circuit is given in *fig.* 3. Briefly, the operation of the trainer may be described as follows. A 150 kc/s crystal-controlled oscillator valve V1 has its output squared by V2, and then frequency-divided to produce a 500 c/s output. This output is used, in part, directly to produce the "A" pulse and, in part, after frequency halving, to produce the " GHOST A," " B " and "C" pulses. The required delays in these latter

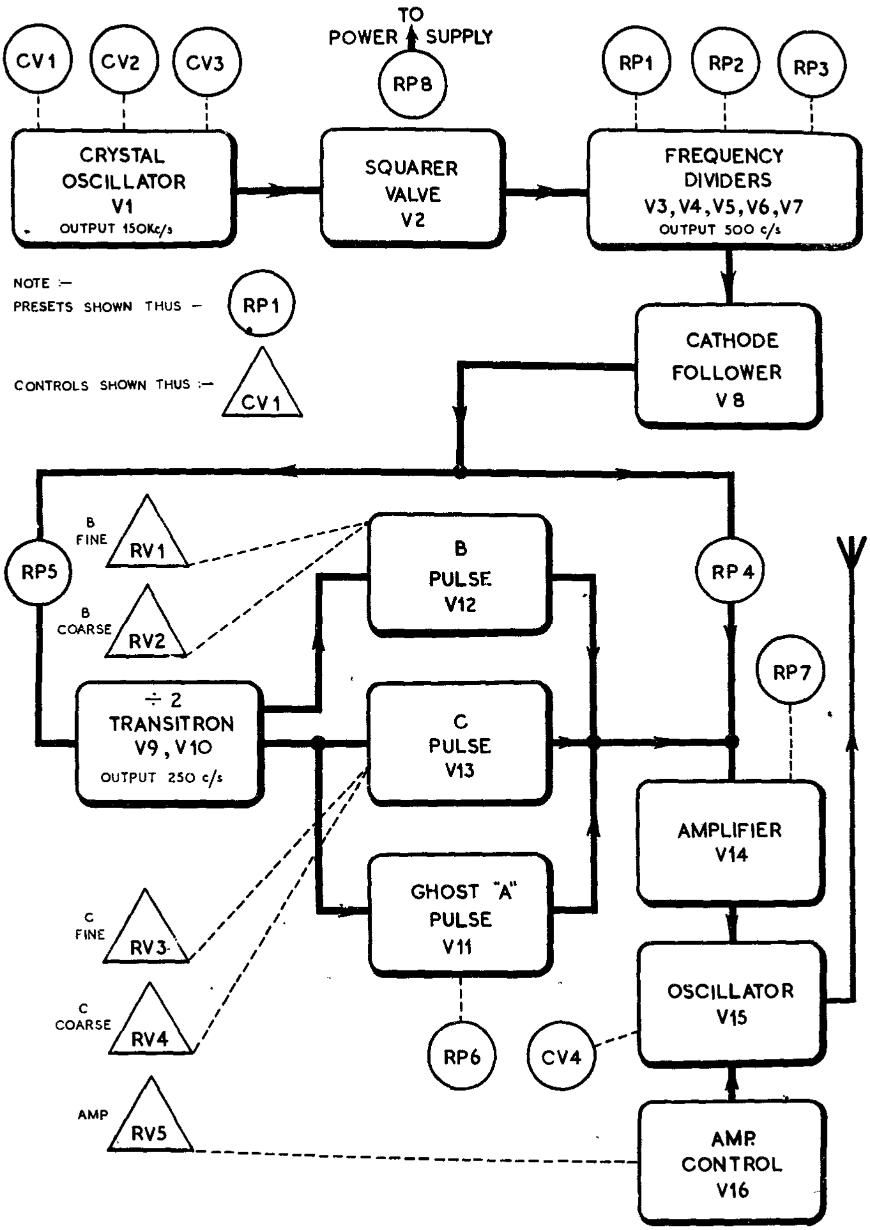

Fig. 2—BLOCK SCHEMATIC DIAGRAM

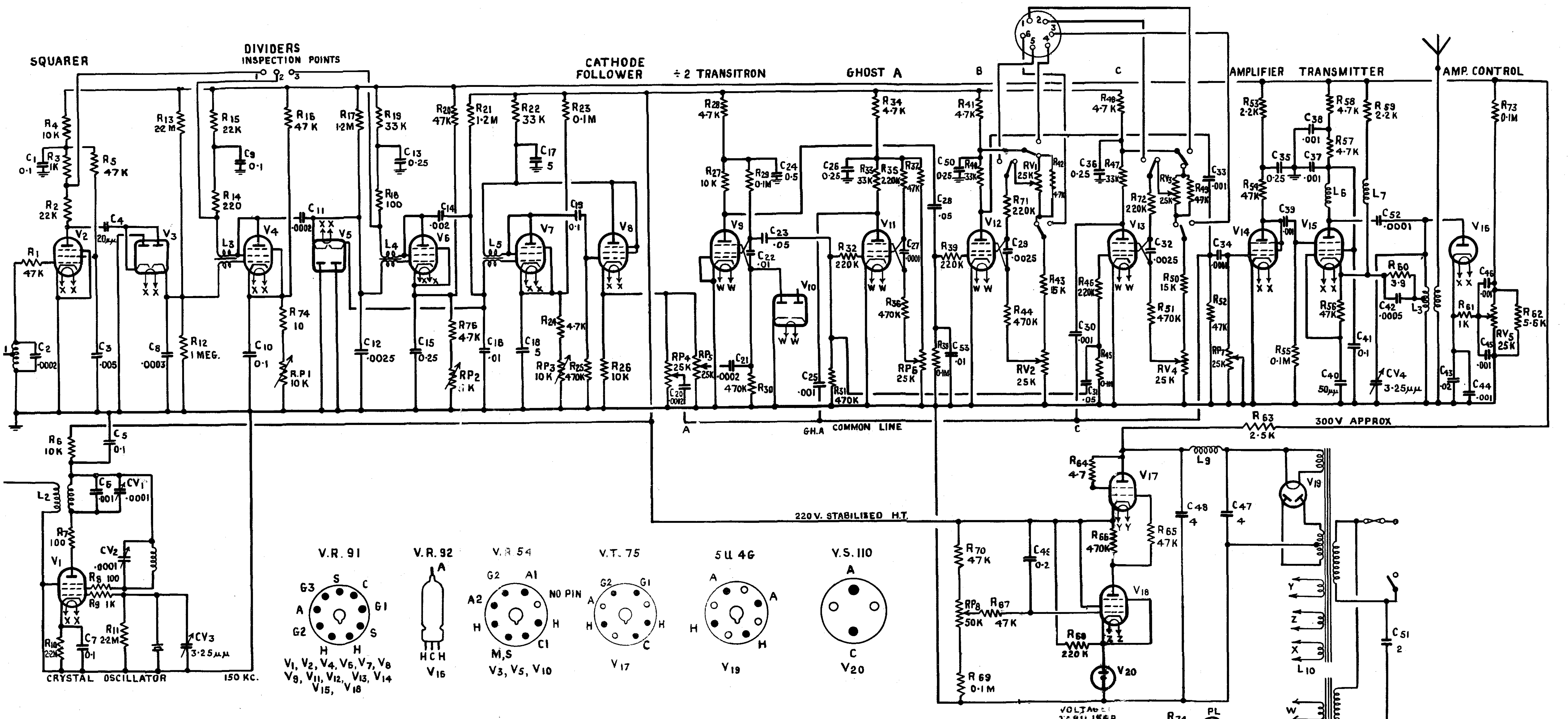

FIG.3 - CIRCUIT

G 781 M04846 8/48 450 C.B.& S.LTD. GP.55.

three pulses are obtained by the use of transitrons. The four pulses are mixed and fed to a transmitter.

Crystal controlled oscillator

9. Valve V1 is a standard P.O. crystal oscillator of the same type as that used in the airborne equipment. It provides, at a coupling coil, sine waves of frequency 150 kc/s and small output.

10. This valve V1 is a combined oscillator and frequency doubler. A 75 kc/s crystal is connected in the control grid circuit of this valve, and the screen grid circuit is tuned to approximately the same frequency. Oscillation occurs at this fundamental frequency in these tuned circuits because of the interelectrode capacitance between G1 and G2. The anode circuit of V1 is tuned to 150 kc/s and, because of the asymmetrical valve characteristic, frequency doubling occurs. The output from L2 is thus at 150 kc/s.

Squarer valve

11. The output of the crystal oscillator is stepped up in voltage by the auto-transformer L1 and applied to the control grid of V2. Since the applied voltage is greater than the grid base of the valve, and the high resistance R1 is included in the grid circuit to prevent the grid from being driven positive by grid current, the anode waveform will be a square, or more exactly a rectangular wave of large amplitude.

Note . . .
This waveform may be inspected at inspection plug 1 by taking the lead from the signal input socket (i.e., blue) of the indicator unit.

Frequency dividers

12. Frequency division occurs in three stages: in the first stage the frequency is divided by 10, in the second stage a further division by 10 occurs, and in the third stage the frequency is finally divided by 3. The output is thus 500 c/s. Part of this output is passed to a transitron where the frequency is further divided by 2 (*para.* 21 and 22).

13. Valves V3 and V4 form the first divider circuit, and provide at the anode of V4 a sharp pulse every time ten square waves are passed through the diode V3. The action may be explained as follows. Suppose the condenser C8 is uncharged, then because of the presence of R12 and R13 it will charge exponentially to a steady potential determined by R12, R13, and the HT voltage. But on this exponential rise is superimposed a stepwise rise due to the charging of the condenser by square waves fed through V3. The voltage of the cathode of V4 is adjusted by RP1 so that when ten steps are present on the potential rise curve of C8, the grid potential is such that V4 can oscillate. Since the anode is tightly coupled back to the grid, after one oscillation the grid is driven considerably negative, returning immediately to earth potential by the action of V5, and the oscillation stops. The condenser charging cycle then commences again.

14. The anode waveform of V4 may be examined on the indicator unit by connecting it to inspection plug 2. When the main timebase is used, pulses occurring at every calibration point should be obtained. A more detailed examination may be made on the strobe timebase, and here a waveform every ten divisions should be seen.

15. RP1 is provided to enable the frequency division ratio to be corrected as necessary. Adjustment of RP1 should be made until the divider pulse recurs every ten strobe timebase divisions.

16. Valve V6 with the LH side of V5 divide the output of V4 by 10, and V7 with the RH side of V4 divide the output of V6 by 3. The dividers V6 and V7 operate in a similar manner, except that instead of the potential on the condenser C12 or C16 increasing exponentially with superimposed steps due to input square waves, it increases exponentially with superimposed pulses due to the single cycle of oscillation of the preceding valve.

17. The cathode bias of V6 is adjusted by RP2 so that the tenth oscillation of V4, when added to the charging curve of C12, causes V6 to oscillate once, when the cycle starts again. The division ratio may be inspected at inspection plug 3 using the main timebase when a pulse should be seen every ten calibration divisions.

18. Valve V7 operates in a similar fashion to V6 except that it oscillates once every three pulses from V6. No connection is brought out from the anode of V7 but the correct operation of this divider stage may be checked as follows: when the trainer is correctly connected up and transmitting, the trainer pulses seen on the indicator of the receiver are examined, and RP3 adjusted as necessary until the picture is steady and the correct number of pulses is obtained.

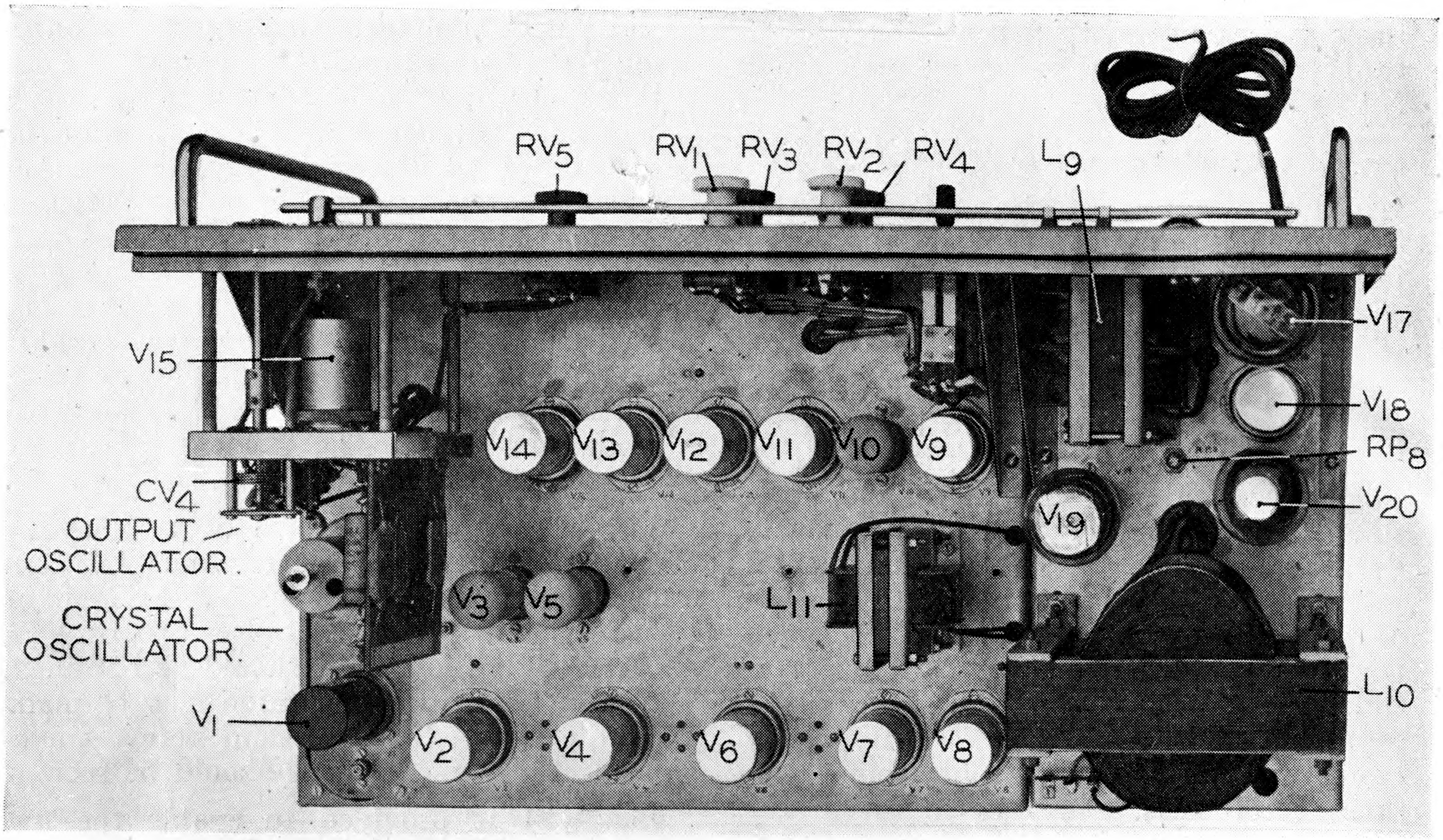

Fig. 4.—Top of chassis

19. The output of V7 is applied to the cathode-follower V8. The low impedance 500 c/s output appearing across the cathode of V8 is suitable for triggering the subsequent circuits. The shape of the output waveform is a rapid single oscillation, the negative half cycle occurring first.

" A " pulse formation

20. The 500 c/s output from V8 is used directly for providing " A " pulses, being applied through RP4, C20 and C34 directly to the grid of the modulator valve V14. RP4 serves an amplitude control of the " A " input to V14 and in effect acts as an independent width control on the " A " pulses.

Action of the squarer valve V9

21. Owing to the high capacitance of C22, V9 is in effect a transitron of very long delay period compared with 1/500 sec. The output from V8 is applied to the suppressor grid of V9 which is prevented from going positive by the action on V10. When the suppressor is made negative by the triggering waveform, the anode current decreases and its voltage rises sharply; the screen current increases (owing to the reciprocity of screen and anode currents in a pentode having constant G1 bias) and its voltage decreases, thus pushing G3 more negative where it will remain because of the large time constant circuit C22, R30.

22. But when the next pulse from the dividers arrives, the positive-going portion is sufficient to bring the suppressor and screen positive enough to allow the anode to draw current again, when the action reverses sharply and the valve reverts to its normal state. Thus symmetrical square waves in opposite phase are obtained from the anode and screen of V9. In each case, the mark-to-space ratio (i.e., the ratio of the duration of positive-going to negative-going portions of the wave) is unity.

Formation of the B pulse

23. The circuit comprising the valve V12 is used to form the " B " pulse. The function of this circuit is, briefly, to produce a suitably shaped pulse at a suitable controlled interval after the production of the " A " pulse.

24. Valve V12 is a transitron which is triggered from the control grid. The valve is biased so that anode current flows only during the period of the positive part of the square wave fed into the control grid from the anode of V9 at a frequency of 250 c/s. At the beginning of the square wave, anode current commences to flow and at the same time screen current flows so that the screen potential falls, thus driving the suppressor negative through the condenser C29 and decreasing the anode current. This fall in anode current results in an increase in screen current with a further fall in screen and suppressor potentials and this action goes on rapidly until the screen is bottomed and the anode is at the supply voltage.

25. Thereafter, the suppressor voltage rises exponentially as C29 charges through R44 at a rate determined by the setting of RV2 and RV1 until the suppressor bias is removed and the anode recommences to draw current. At the same time the screen will draw less current and its potential will rise, thus raising the suppressor potential. This action is cumulative until the equilibrium state is reached again, and a square wave is developed on the anode, its width depending on the setting of RV1 and RV2. The variable negative-going edge is fed to the common line and ultimately differentiated into a narrow pulse by C34, RP7.

26. The switching in the screen and suppressor circuits of V12 enable remote controls to be connected to the six-way W plug and used in place of RV1, the " B " COARSE control, and RV2, the " B " FINE control.

Formation of the C pulse

27. The circuit comprising the valve V13 is used to form the " C " pulse. The action is similar to that of V12 in the formation of the " B " pulse (*para.* 23 to 26) except that the triggering of the transitron V13 is done from the screen waveform of V9 in order to ensure that the " C " and " B " pulses follow alternate " A " pulses.

Formation of the " Ghost A " pulse

28. The circuit comprising the valve V11 is used to form the " Ghost A " pulse. The action is similar to the formation of the " B " pulse except that the triggering of the transitron V11 is done from the screen waveform of V9, and also the delay is kept small and may be adjusted between fine limits by RP6. Thus the " Ghost A " pulse follows very closely after alternate " A " pulses.

Mixing and amplifying

29. The outputs of all the pulse-forming valves are fed on to a common line together with the " A " pulses. This line runs between C20 and C34. Differentiation of each waveform takes place in C34, RP7 and the result is amplified in V14 thus producing large positive-going pulses at its anode. This output is used to bring on the output oscillator at the required times.

Output oscillator

30. Valve V15 is an oscillator of frequency approximately 47-48 Mc/s, its frequency being adjusted by CV4. Normally, the suppressor is biased sufficiently negative to prevent oscillation, but at the arrival of each positive pulse from V14, short bursts of oscillation takes place for the duration of the pulse. These oscillations are radiated from the aerial which is coupled to the grid coil.

31. The amplitude of the oscillations may be varied by alteration of the bias of the limiter V16 connected to the live end of the tuned circuit, that is by adjustment of the amplitude control RV5.

POWER SUPPLIES

General HT

32. The 50 c/s AC mains input is transformed, rectified by the full-wave rectifier valve V19, and smoothed by the filter C47, L9, and C48. This DC output is fed partly to a stabilizer circuit and partly to some of the valves directly through a voltage dropping resistor R63.

Stabilized HT

33. Certain of the valves, namely V1, V7, V9, V11, V12 and V13, are supplied with stabilized HT which remains constant should the mains voltage alter. This stabilization is effected by means of the stabilizing circuit comprising the valves V17 and V18, and neon lamp V20. Variations in the supply voltage of this stabilizing system alter the DC impedance of V17 so that its cathode voltage remains constant.

34. The output voltage of the stabilizer is adjusted by means of RP8. Smoothing of ripple in this output is effected by means of C49 which feeds some of the ripple on to the grid of V18 and re-appears 180 deg. out of phase on its anode. This ripple voltage is, in effect, cathode-followed by V17, resulting in effective cancellation of the ripple in the output.

Heater voltages

35. The heater supplies are made in the normal way from 6·3-volt windings on the transformer for all valves except V9, V10, V11, V12 and V13; a change of heater voltage on these valves would result in instability

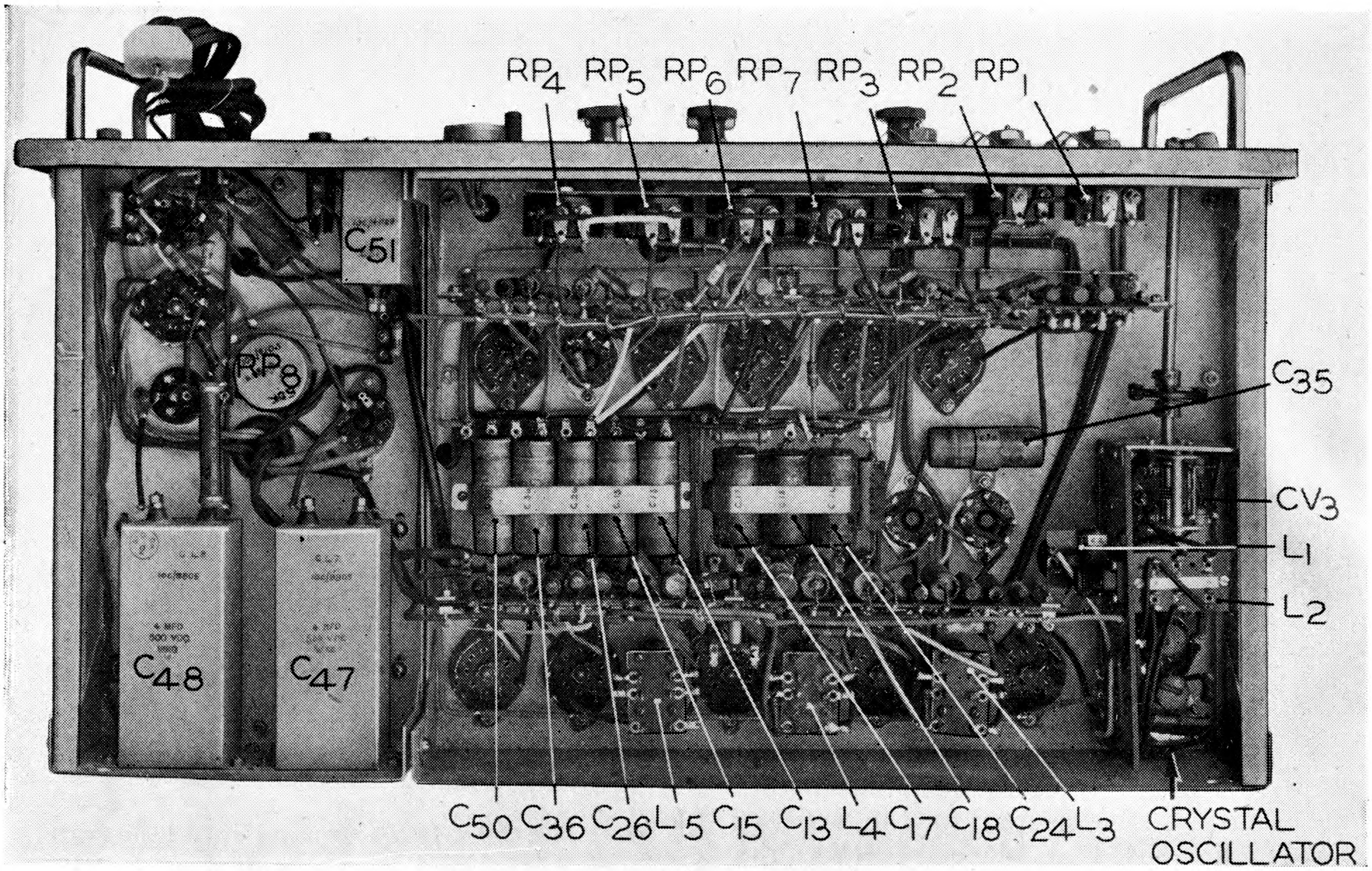

Fig. 5.—Underside of chassis

of the trainer output. A small special saturated transformer L11 fed through C51 is therefore used to supply heater current to these valves, and effects a stabilization to the extent that changes in input voltages are reduced in the ratio of approximately 5 to 1 ; this reduces any pulse shifts due to unstable heater voltages to negligible proportions.

Note . . .

L11 runs hotter than the normal mains transformer on account of the saturation of the core.

INSTRUCTIONS FOR SETTING-UP

General

36. Connect the trainer to 230-volt, 50 c/s, AC supply mains. Switch on and verify that the indicator lamp lights up. Allow a few moments for the valves to warm up.

Note . . .

The mains frequency must not depart appreciably from 50 c/s if the saturated transformer L11 is to function satisfactorily.

37. Erect the aerial.

38. Switch on the ARI.5718 or 5083, and examine the pulses on the indicator unit main timebase.

Note . . .

Instructions for operating and setting-up the ARI.5718 and 5083 are provided in A.P.2557B or A.P. 2557A, respectively.

39. If no pulses are seen, adjust the preset condenser CV4 to tune the trainer to the receiver until the maximum amplitude of signal is obtained. Turn up the amplitude control to maximum.

40. If the pulses are unsteady or too numerous, adjust the trainer dividers as follows :—

(1) Detach the lead to the blue socket on the receiver and connect it to inspection plug 1 on the trainer; square waves of small amplitude should now be seen on the strobe timebase. With the crystal oscillator control on the indicator unit in the central position, adjust CV3 on the trainer until the square waves do not drift across the field.

(2) Connect the lead now to inspection plug 2, and check that pulses are seen on the strobe timebase. Adjust RP1 as necessary until these pulses occur at intervals of ten divisions.

(3) Connect the lead now to inspection plug 3, and check that pulses are seen

on the main timebase. Adjust RP2 as necessary until these pulses occur at intervals of ten divisions.

(4) Return the lead to the receiver, and adjust RP3 until a steady picture is seen. If this is not found possible, adjust RP3 and RP5 in conjunction with one another.

41. Verify that the controls for " B " and " C " pulses and amplitude all operate normally.

42. Adjust the position of the " Ghost A " pulse by means of RP5 until it is in its normal position, i.e., about two main timebase divisions from the " A " pulse.

43. With the " B " and " C " pulses in the middle of the timebase, strobe them and view all three pulses on the strobe timebase.

44. Adjust the width of the pulses to approximately one division by means of RP7.

Note . . .

Independent control of the width of the " A " pulse is obtained by means of RP4.

45. Should any doubt arise as to the setting of the stabilized voltage, this should be adjusted to 220V by means of RP8.

46. Should jitter be observed on either the " B " or " C " pulses, the replacement of V12 or V13 respectively should be carried out.

47. The adjustment of this trainer for use with the navigational attachment is dealt with in the instructions appertaining to that apparatus, namely A.P.2560D.

48. The positions of the main components of the trainer are shown in fig. 4 and fig. 5 to facilitate the identification of any component to which access is required for the purposes of inspection or renewal.

Part 3

FAULT DIAGNOSIS

LIST OF CONTENTS

Introduction

1. The faults listed herein are those which may be easily identified and which can be cured by simple methods. Any faults which cannot be traced by the aids to diagnosis given, and the remedies suggested here, or which cannot be remedied or attempted due to lack of spares, should be left to Third line Servicing parties.

2. Before attempting to diagnose a fault, the equipment should have its dust cover removed, be placed on a bench front panel downwards, and be switched on, taking care to keep the aerial clear of the bench. One of the sets of receiving equipment used with the trainer should be lined up and, if possible, tested by direct reception from a Type 7,000 chain.

No signals

General

3. Absence of signals may, broadly speaking, be due to one of the following causes :—

(1) Failure of the power supplies

(2) Failure of the oscillator valve V15

(3) Failure of the modulation circuits

Power supplies

4. The power supplies should first be tested as described in para. 22 onwards.

RF faults

5. If the power supplies are satisfactory (N.B. The HT voltages may be rather higher than normal), remove the valve V15 from its holder. If this cures the trouble, try:

(1) Renewing V16

(2) Testing the resistances R61, R73, RV5, R62. The values should be within 20 per cent. of the values shown in fig. 3. N.B. After testing, it will be necessary to swing over the full tuning range after each renewal of components, etc., to make sure of tuning-in any signal

6. If no fault is found by the tests of para. 5, try renewing the valve V15. If this is unsuccessful set the AMP control to maximum and test the voltages on pins A and G2 of the base of V15; these should be about +150 +250 volts. That on pin C should be about +150 volts. These annotations refer to the inset on fig. 3 labelled VR91.

7. If the voltage readings are unsatisfactory, test the resistances R56, R57, R58 as described in para. 5(2), and check that L6, L7 and both halves of L3 show a very low resistance.

Modulation faults

8. If the power supplies and RF circuits seem satisfactory, detach the lead normally connected to the BLUE socket on the receiver and connect it instead to plug 1 on the trainer. Square waves should be seen on the strobe CRT trace, or can be made visible and stationary by adjustment of the control CV3, bottom right of the front panel of the trainer.

9. If no pulses can be seen, try the effect of changing the valves V1 and/or V2 and checking the associated resistances.

10. If visible pulses are obtained from test point 1, check similarly at test point 2, when pulses should be seen. If failure results at this point, try changing V3 and/or V4 and measuring the resistances associated with them.

11. Similarly, if test point 2 gives satisfactory results, try test point 3, which should yield pulses visible on the main timebase trace. If not, V5 V6 or their associated circuits should be checked as before.

12. If the pulse circuits up to test point 3 are in order, and there is still no output, the fault must lie in V8 or V14 and their associated circuits and wiring.

Unsteady or too many pulses

13. If the pulses tend to jitter, and cannot be steadied on the trace by adjustment of CV3, or if there are too many of them, test the supply voltages (*para.* 22 *on*). If these are satisfactory, the most probable fault is in the adjustment of the divider circuits. Proceed as follows:—

14. Set up as described in para. 8.

15. Transfer the Pye plug lead to test point 2 and adjust the control RP1 just above plug 1 until the pulses occur at intervals of ten divisions on the strobe timebase. Adjust the control first right and then left until the pulses jump, and leave the control finally mid-way between these two positions.

16. Repeat the operation of para. 15 on test point 3, adjusting RP2 (above plug 2) similarly to get the pulses occurring every ten divisions on the main timebase and again leaving the control set half-way between the " 9 " and the " 11 " position.

17. Disconnect the Pye lead from point 3 and reconnect to the BLUE plug on the receiver. Adjust RP3 (in conjunction with RP5 if necessary) until a steady picture is obtained.

18. If these adjustments fail to ensure steady pictures, proceed as follows:—

(1) If all pulses are unsteady, test the mains voltage; if this is outside the limits of 215 and 245 volts (for 230-volt transformer setting), this may be the cause. If not, try changing V9 or V10; failing these, the transformer L11 may be at fault.

(2) If only some pulses are unsteady, try the effect of changing V11 (Ghost A pulse), V12 (B pulse), V13 (C pulse).

Poor signals

19. If the signal strength at all the receivers is inadequate, proceed as follows:—

(1) Inspect the aerial and its insulator.

(2) Check the power supplies (*para.* 22).

(3) Check the circuits of the RF valves as described in para. 5, 6 and 7.

(4) Check the valves V8 and V14 and their circuits.

20. If the volume control is ineffective, try renewing V16 and cleaning RV5.

21. If one of the pulses is weaker than the others, or missing, try changing valves and measuring resistance values as follows: for Ghost A, V11; for B pulse, V12; and for C pulse V13. Note that RP6 adjusts the spacing of the Ghost pulse, RP7 sets the width of all pulses, except the A pulse which is adjusted by RP4.

Power supplies

22. Test the mains voltage, which should not be outside the limits 215-245 volts; unless it is exactly 230 volts the other voltages in the trainer, except for the stabilized 220-volt supply, will be a corresponding percentage high or low.

23. Test the unstabilized HT voltage (*Vol.* 5, *Sect.* 3, *para.* 3).

(1) If the voltage is much above 350 volts, try renewing the condensers C47 and/or C48 which may have become internally disconnected.

(2) If the voltage is much below 250 volts, try renewing the rectifier valve V19 and/or the condensers C47 and C48 which may have developed short circuits.

24. Test the stabilized 220-volt supply (*Vol.* 5, *Sect.* 3, *para.* 5). If there is difficulty in adjusting this to give 220 volts, try the effect of renewing the valves V17, V18 and/or V20. If this is ineffective, measure the values of the resistances associated with them.