TRAINEE NOTES

TRANSMITTER (VFT) TYPE 15149

(HL 13)

AND

RECEIVER (VFT) TYPE 15150

(HL 14)

This training note is issued for the guidance of trainees during training at R.A.F. Locking. No amendments will be issued in respect of modifications introduced to the equipment referred to in this note.

This note is not intended as a substitute for Air Publications 2922 Z and 2922 ZA and must not be regarded as authority for modifications, servicing procedures, etc.

March 1963.

TRAINEE NOTES

MULTI-CHANNEL VOICE FREQUENCY TELEGRAPH TRANSMITTING/RECEIVING EQUIPMENT

(Transmitter Type 15149 - HL13 : Receiver Type 15150 - HL14)

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MULTI-CHANNEL VOICE FREQUENCY TELEGRAPH TRANSMITTING/RECEIVING EQUIPMENT

(Transmitter Type 15149 - HL13 : Receiver Type 15150 - HL 14)

Introduction

1. This equipment is used on long-range radio links, where d.c. telegraph signals are converted for transmission and reception as two-tone voice frequency signals. The two equipments will first be dealt with separately, and later, their function "back-to-back" will be discussed.

TRANSMITTER (VFT) TYPE 15149

(Marconi HL 13)

Purpose

2. The two-tone voice frequency (v.f.) telegraph equipment described in the following paragraphs is designed to convert double-current telegraph signals, such as are associated with teleprinters, into two-tone voice frequency signals, suitable for modulating a radio carrier wave. The equipment is intended to be operated in conjunction with the Receiver Type 15150 (Marconi HL 14). The purpose and operation of the latter is described in a later section of these Trainee Notes.

Concise Details

3. The specifications given below are not rigid, the figures given are only typical examples.

(a) Bandwidth: 300 - 2420 c/s.

(b) Tone Frequencies: The lowest and highest frequencies are 425 c/s and 2295 c/s respectively, the tone separation being 170 c/s. Outside the above limits, the harmonics of the tone oscillators, the sum and differece products of the common amplifier and other unwanted frequencies are lower than - 40 dB relative to the level of any tone carrier. For the allocation of tones to channels see the Tone Interval Selection Chart (fig. 2).

(c) Input: 30-0-30 to 80-0-80 V square or sine wave keying. The input impedance is 4.7 kilohms and the sensitivity $\pm$ 15 V.

(d) Keying Speed: 50 - 100 bauds, synchronous or non-synchronous. Optimum performance is within the range 80 - 100 bauds.

(e) Modulation: Two-tone ON/OFF.

(f) Output Level: + 10 dBm to - 15 dBm (in 1 dB steps) into 600 ohms balanced.

(g) Frequency Stability: Frequency variation of the tone oscillators is less than $\pm$ 2 c/s for an ambient temperature change of $\pm$ 10° C together with a $\pm$ 10% change in mains voltage.

(h) Filters: The passband of the filters is as narrow as possible, consistent with a keying speed of 100 bauds.

(j) Power Supply: 110 V or 200 - 250 V, 40 - 60 c/s single phase a.c. Consumption 400 watts at 0.95 power factor.

General Description

4. Mechanical. The entire equipment for a six-channel terminal is mounted in a 7 foot cabinet which is divided into shelves front and rear. Across the shelves are mounted narrow etched-wiring boards, which have their associated valves, switches, etc., mounted on the front panel. Each etched-wiring board is easily removable, external connections being made by plugs on the boards which automatically "mate" with sockets at the rear of the shelf when the units are inserted in position. Units (such as oscillators, modulators and filters) of one channel may be removed without affecting the remaining channels.

5. Electrical. The block schematic diagram (fig. 1) gives an overall picture of the operation of the HL 13. The operation of the individual channels is identical. The d.c. input is applied to the transmitter input unit which provides an output of approximately ± 8 V, the waveform being almost trapezoidal to prevent transients in oscillator switching. The two tones, provided by high stability oscillators, are keyed in modulator unit by the output of the transmitter input unit, the space tone being OFF when the mark tone is ON, and vice versa. The outputs of the modulator unit are fed to the bandpass filters to reduce the spectrum spread. After filtering, the two tones are combined and amplified; channel gains are provided so that equal outputs may be obtained from the channels. After amplification, the channels are combined by paralleling the anode loads of the channel amplifier valves as each channel is switched in. The result of this is to reduce the output per channel so that the peak power of the common output is constant regardless of the number of channels in use. After combining, the composite signal is amplified and passed to line via a calibrated attenuator.

DETAILED DESCRIPTION

Transmitter Input Unit (fig. 3)

6. The d.c. telegraph signal from line is connected via PLA 15 to a contact of the "Mark/Space/Traffic" switch SWA. On position 3 ("Traffic"), the signal is applied via R6 to the grid of V1A. V1A/V1B is a trigger valve with a sensitivity of ± 15 volts. Both grids are returned to - 150 V stabilised h.t. via R5 and the potentiometer RV1. The latter is connected between - 150 V and (via R4) earth, and may be adjusted to give equal positive and negative sensitivity to the trigger stage. Positions 1 ("Mark") and 2 ("Space") of SWA are test positions and enable the trigger to be locked in either condition for setting up and test purposes. In the first case, the grid of V1A is connected to + 150 V h.t. via R3, and in the second case, to - 150 V via R2. These positions therefore cater for positive mark and negative space convention. It should be noted that Service use calls for negative mark and positive space, and in order to comply with this convention, the connections from SWA to R2 and R3 are reversed.

7. The anode of V1A is connected to the grid of V1B via R12 and inverse outputs may be taken from either anode of V1. There is a link in the anode of each half of V1, and either anode may be selected by changing over these links. It is essential that the output of the transmitter input unit is positive mark and negative space polarity (as will be seen when the following unit is described) and the correct settings of the links for these conditions will be:-

2 to 3 and 5 to 6.

Thus, the anode of V1A is connected via R15 to the grid of V2A.

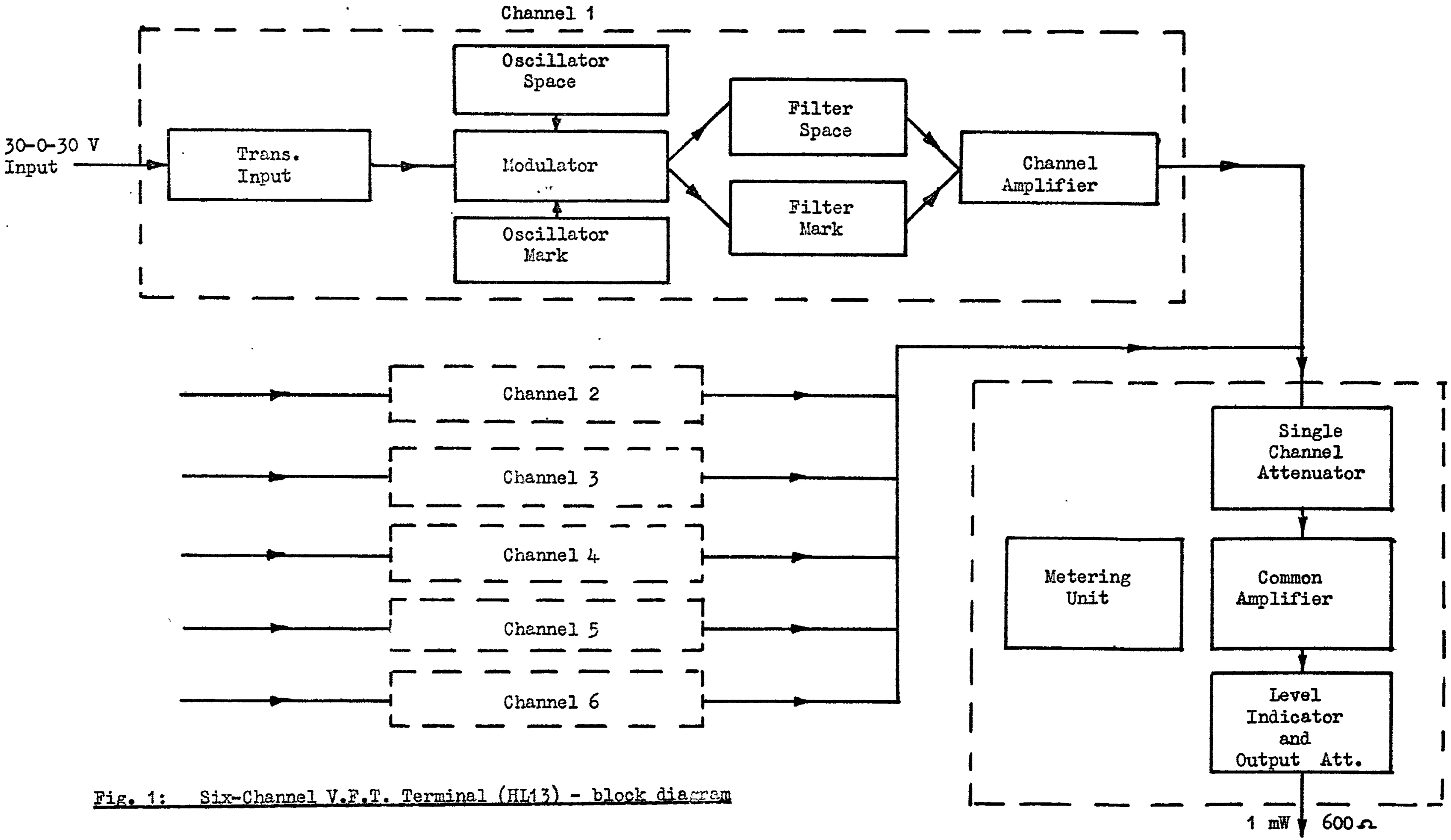
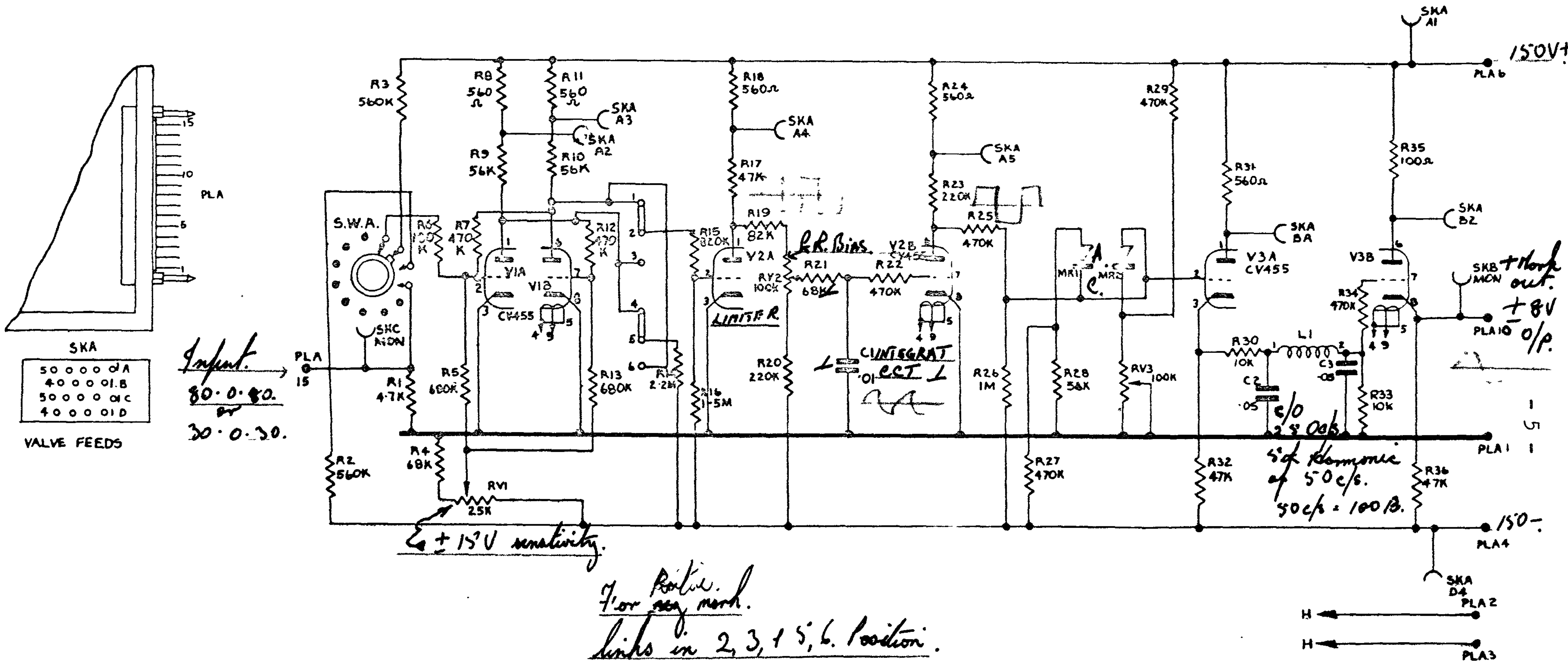


Fig. 1: Six-Channel V.F.T. Terminal (HL13) - block diagram

	170 c/s Spacing						340 c/s Spacing						510 c/s Spacing						1020 c/s Spacing					
	Channel						Channel						Channel						Channel					
Freq. c/s	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
425	S						S						S						S					
595	M							S						S						S				
765		S					M								S						S			
935		M						M					M									S		
1105			S						S					M									S	
1275			M							S					M									S
1445				S					M							S			M					
1615				M						M							S			M				
1785					S						S							S			M			
1955					M							S				M						M		
2125						S					M						M						M	
2295						M						M						M						M

Fig. 2: Tone Interval Selection Chart



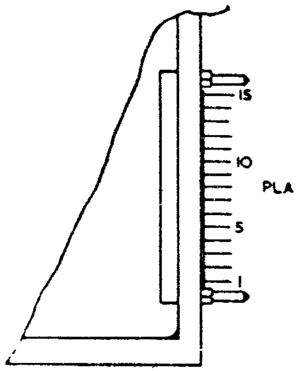
ROTARY SWITCH SWA. IS SHOWN IN POSN. 1. WHICH IS THE EXTREME ANTICLOCKWISE POSITION WHEN VIEWED FROM HANDLE END

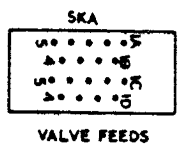
	POSN. 1	POSN. 2.	POSN. 3.
SWA	MARK	SPACE	TRAFFIC.

Fig. 3:

CIRCUIT DIAGRAM
TRANSMITTER INPUT UNIT
WZ. 20697/B Sh. 1. Iss. 3.

OSC. FREQ C/S	C1 µF	C2 µF	C3 µµF	C4 µµF	C5 µµF	C6 µµF
425, 595, 765, 935, 1105	·03	·0047	680	470	330	220
1275, 1445, ·615, 1785, 1955	·02	·0015	470	330	220	150
2125, 2295, 2465, 2635, 2805, 2975	·01	·0022	330	270	150	47





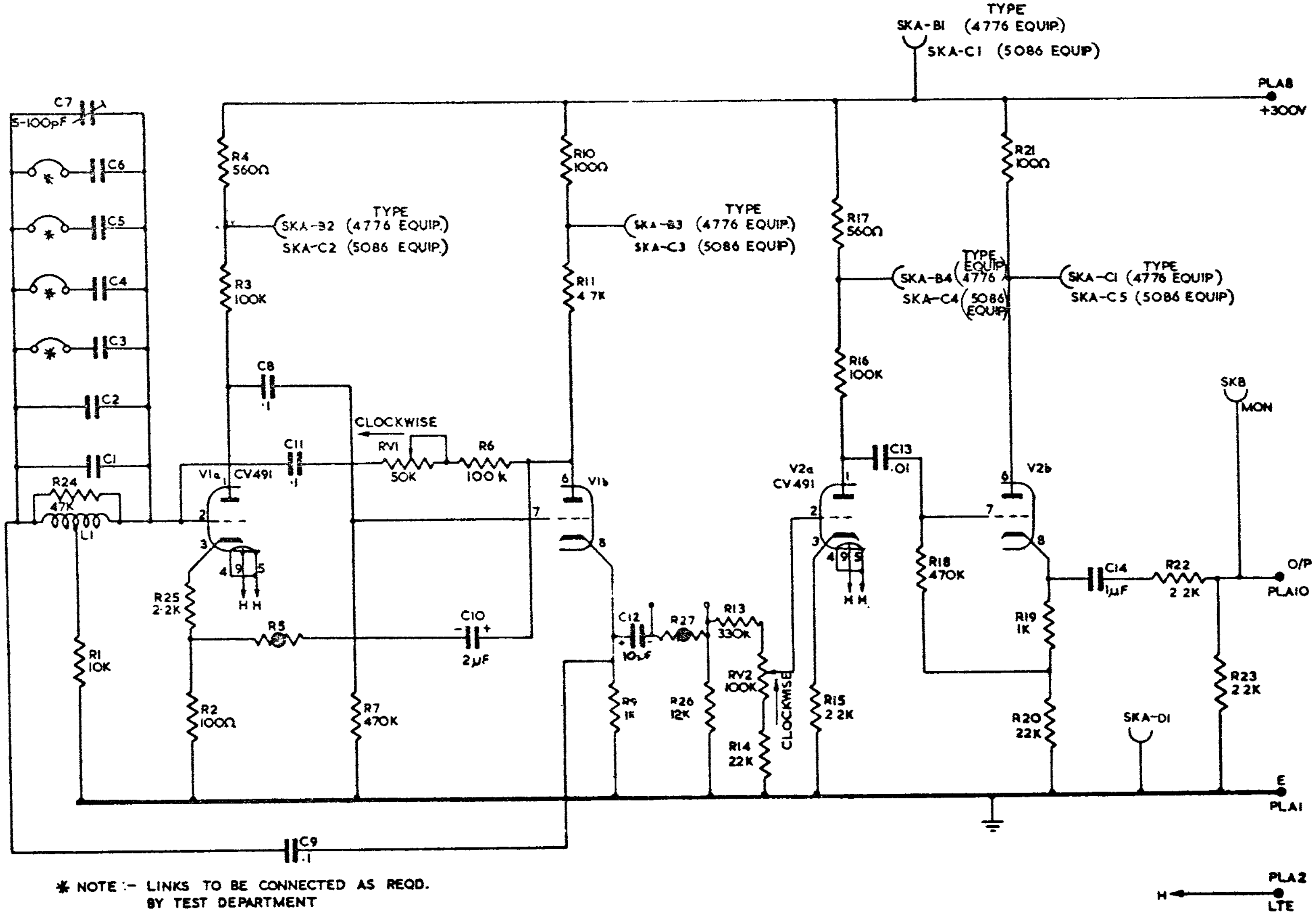


Fig. 4: Tone Oscillator - circuit

8. V2 is a limiter and squarer stage, and a square wave of given amplitude is produced at the anode of V2B. RV2 is the SIGNAL BIAS control and the capacitor C1 shapes the waveform; variation of RV2 moves the waveform about the zero level so that different MARK/SPACE ratios may be obtained. Thus with 1 : 1 reversals applied as a test signal to the input of this unit, a 1 : 1 MARK/SPACE ratio may be obtained at the output. The total bias variation of RV2 is ± 15%. The square wave output of V2B is passed via R25 to the grid of V3A.

9. The diodes MR1 and MR2 are in shunt across the grid circuit of V3A; they act as d.c. limiters, so that the output of the unit is limited to the predetermined level of ± 8 volts at PLA 10. The potential divider R27, R28 between earth and - 150 V h.t. arranges a fixed negative potential so that MR1 is "back-biased". The value of this bias sets a limit to the amplitude of negative signals from R25; if the signal swings in excess of the bias, MR1 conducts and clamps the signal to bias level. MR2 operates in a similar manner for the positive excursions of the signal, being also "back-biased" by the potential divider R29 and RV3 between + 150 V h.t. and earth. This bias is variable by alteration of RV3, the setting of which may be adjusted to give the same "clipping" effect as MR1.

10. V3A is a cathode follower and is included as a matching device to drive the low-pass filter L1, C2, C3. The filter has a cut-off frequency of 250 c/s which, at a keying speed of 100 bauds, curbs the signal elements (all odd harmonics above the 5th will not be passed). The output of the filter is applied to V3B which is also connected as a cathode follower circuit. The low impedance output of this stage matches the low impedance input to the next unit (Modulator). The output waveform at V3B cathode is almost trapezoidal, which prevents transients in the modulators when an oscillator is switched on.

11. The output is in the order of + 8 volts for MARK and - 8 volts for SPACE. SKC is a monitor point for the d.c. input to this unit, SKB is a monitor point for the ± 8 V output of the unit. SKA is used in conjunction with the VALVE FEEDS METER UNIT, which is a common unit in the equipment, enabling valve feeds and supplies to be metered throughout, using the connecting lead supplied.

Tone Oscillators (fig. 4)

12. All twelve tone oscillators are identical in circuitry, the difference between editions being the values of the frequency determining elements L and C.

13. The oscillator itself is of the Franklin type, where positive feedback to maintain oscillation is derived from the anode of an amplifier following the oscillator valve proper. The oscillator tuned circuit comprises L1 and C1 to C7 in the grid circuit of V1A. C3 to C6 inclusive give a coarse frequency adjustment and C7 a fine frequency adjustment. Negative (degenerative) feedback is applied to V1A via C9 and L1; positive feedback is via R6, RV1 (FEEDBACK CONTROL), and C11. The overall feedback is developed across R1, and the amount so obtained can be adjusted by RV1. The thermistor R5 is, from an a.c. point of view, in parallel with the anode load of V1B (R11) and as the thermistor heats, the gain of the valve falls due to the negative temperature co-efficient of R5. The second thermistor R27 keeps the output of the oscillator unit constant for variations in ambient temperature.

14. V1B is a low impedance cathode follower and the output is taken via the gain control RV2 to the grid of V2A. The latter is a conventional amplifier with negative feedback. The output impedance of V2A is increased by virtue of this feedback, which is current feedback derived from the unbypassed cathode resistor R15; the increased output impedance enables matching to the cathode follower output stage V2B.

15. The output of the unit is taken from V2B cathode, the amplitude of the tone being of the order of 2 volts at PLA 10. SKB is a monitor point on the front panel of the unit. SKA is also on the front panel and is provided for the connection of a lead to the VALVE FEEDS METER UNIT.

16. It should be noted that, in common with other units of this equipment, negative feedback has been liberally employed in the various circuits. Although the merits of negative feedback are well-known, it might be convenient to repeat them at this point. The application of negative feedback (voltage, current, or composite):

(a) Makes the gain of a stage practically independent of supply voltage changes, ageing of valves, etc.

(b) Enables input and/or output impedances to be adjusted to conform with design requirements.

(c) Reduces all forms of distortion (i.e., harmonic, attenuation, phase, etc.).

(d) Reduced noise generated in the feedback loop.

Modulators (fig. 5)

17. The upper half of the circuit diagram (TR3, TR4, and associated circuitry) is the SPACE tone modulator, and the lower half (TR1, TR2, etc.) is the MARK tone modulator. The purpose of the modulators is to key the output (ON or OFF) of the two tone oscillators associated with the particular channel in accordance with the ± 8 volts d.c. output of the Transmitter Input Unit.

18. Action. The output of the MARK oscillator is applied to PLA 15, and that of the SPACE oscillator to PLA 14, PLA 1 being earth, The keying waveform from the Transmitter Input Unit (± 8 V) is applied to PLA 12.

(a) Mark Input. When PLA 12 is at a potential of + 8 V, diodes D1 and D2 are forward-biased and therefore conduct via R3, D1, R1 to earth, for D1, and via R4, D2, R2 to earth, for D2. At the same time, diodes D3 and D4 are back-biased. As D1 and D2 are conducting in their forward direction, they offer a low impedance path for the tone appearing across the secondary winding of TR1 which therefore appears at the output across the secondary winding of TR2 virtually unattenuated; this is the MARK tone. Conversely, D3 and D4 are offering their back impedance so the SPACE tone will not appear across TR4 secondary. Thus, MARK is keyed ON and SPACE is keyed OFF (as far as modulator output is concerned) under these conditions.

(b) Space Input. When PLA 12 is at a potential of - 8 V, the above action is reversed, D1 and D2 being back-biased and D3 and D4 forward-biased. This results in the MARK tone being suppressed at the modulator output and the SPACE tone being passed to TR4.

19. Mark and Space outputs from TR2 and TR4 respectively are taken from the unit via PLA 11 and PLA 10 via the level controls RV1 and RV2. They are then passed to the next units which are bandpass filters. SKA and SKB are front panel monitoring points for the SPACE and MARK tones respectively.

Bandpass Filters (figs 6 and 7)

20. There are three types of filter units. Earlier editions of the HL13/HL14 (up to Serial No. 68) employed a filter using series-tuned circuits, and this filter type will not be discussed here. Information can be obtained by reference to the maker's Technical Handbook.

21. The second and third types of filter unit use series and shunt parallel tuned circuits, but differ in the positions of the two halves of the twin triode amplifier included in them. Serial Nos. 69 - 98 of the HL13/HL14 employ both types of unit, the type being dependent on the frequency of the associated tone, i.e. :-

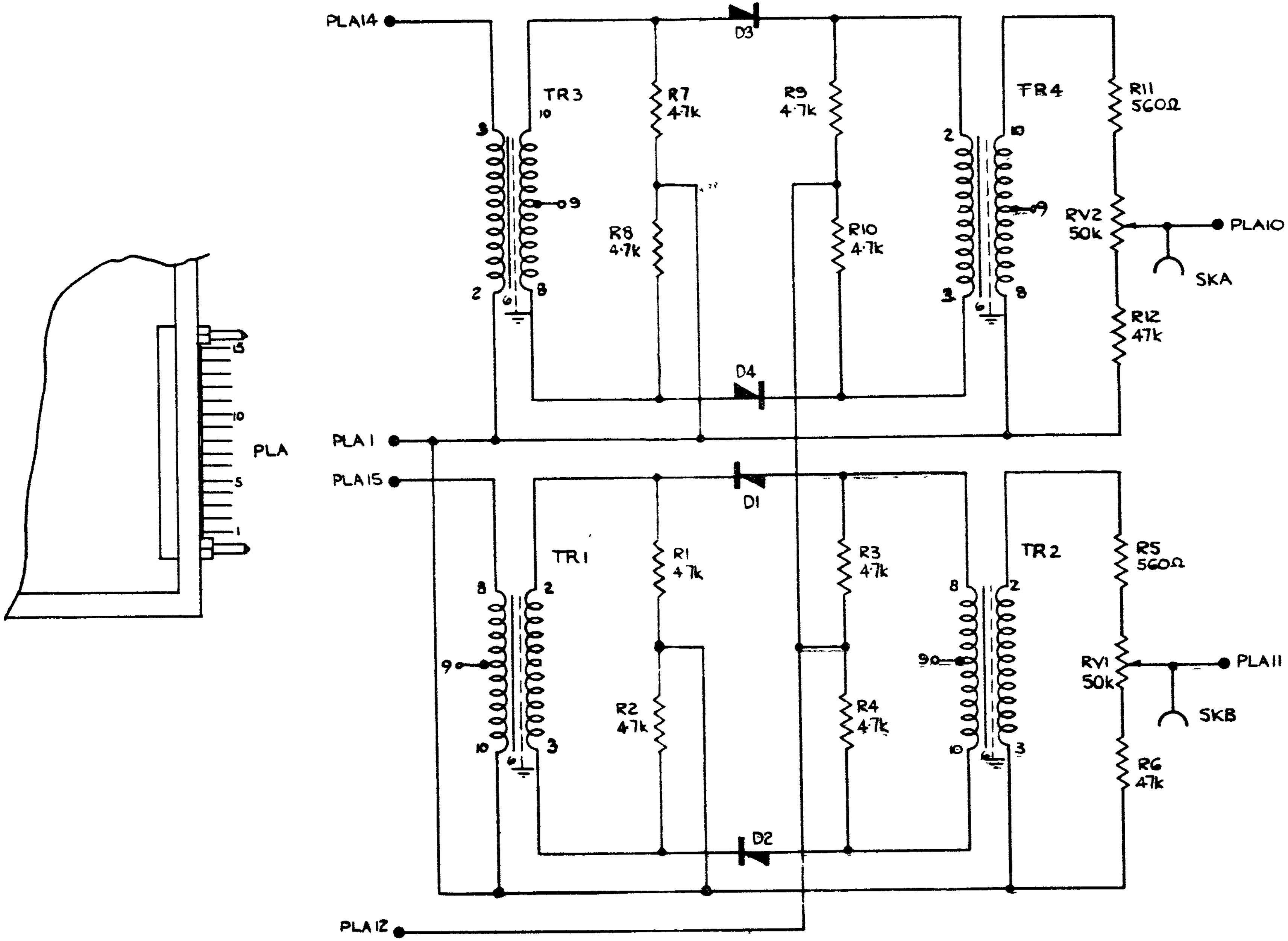
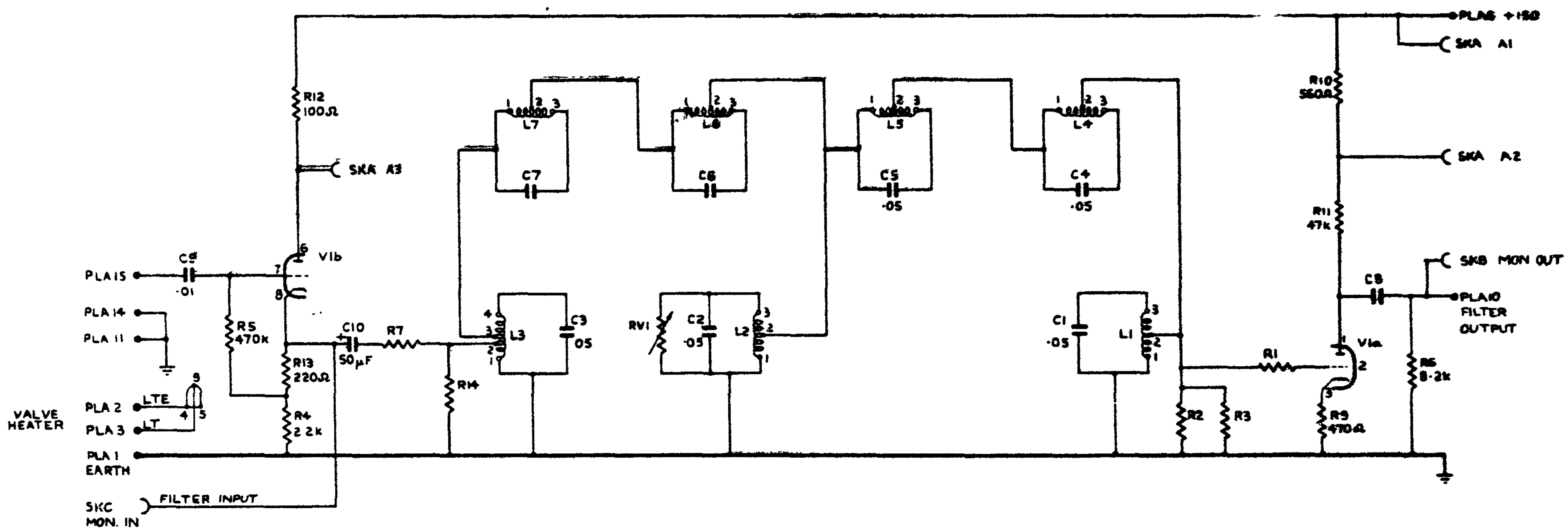


Fig. 5: Modulators - circuit



FOR COMPONENT LAYOUT SEE WZ.25912/D. SH. *FREQUENCIES 1785 C.S. TO 2975 C.S.*

NOTE:
R7 & R14 ARE NOMINAL VALUES ONLY AND ARE SELECTED ON TEST.

CIRCUIT REF	FREQUENCY 425 c/s	595 c/s	765 c/s	935 c/s	1105 c/s	1275 c/s	1445 c/s	1615 c/s	1785 c/s	1955 c/s	2125 c/s	2295 c/s	2465 c/s	2635 c/s	2805 c/s	2975 c/s
C6	·02	·02	·02	·02	·02	·02	·02	·02	·05	·05	·05	·05	·05	·05	·05	·05
C7	·02	·02	·02	·02	·02	·02	·02	·02	05	·05	05	05	05	·05	·05	·05
C8	·25	·25	·25	25	·25	·25	·25	·25	·04	·04	·04	·04	04	·04	·04	·04
R1	NOT FITTED					2 2k	2·2k	2 2k	3 9k	3·9k	3 9k	4 7k	4 7k	4·7k	4 7k	4·7k
R2	12k	12k	12k	12k	12k	3 9k	3·9k	3·9k	3·9k	3·9k	3·9k	2 2k	2·2k	2·2k	2·2k	2·2k
R3	12k	12k	12k	12k	12k	–	–	–	3·9k	3·9k	3·9k	2 2k	2·2k	2·2k	2·2k	2·2k
R7 (SEE NOTE)	11k	11k	11k	11k	11k	7·5k	7·5k	6·8k	3·9k	3·9k	3 3k	2·0k	2·0k	2·0k	2 0k	2·0k
R14 (SEE NOTE)	1 8k	1·8k	1·8k	1·8k	1 8k	1 2k	1 2k	1 1k	620	620	560	330	330	330	330	330
RV1	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M

TITLE

Fig. 6: BANDPASS FILTER CIRCUIT DIAGRAM

(a) 1785 c/s to 2295 c/s inclusive where one half of the triode is at the input and the other half at the output of the filter.

(b) 425 c/s to 1615 c/s inclusive where both halves of the twin triode are connected at the input of the filter.

From Serial No. 99 onwards, the type referred to in subpara (a) is used for all frequencies; it will therefore be discussed first.

22. <u>1785 c/s to 2295 c/s Filter Unit (fig. 6).</u> In this filter arrangement, the amplifier V1A is placed at the output end of the unit. The input from the associated modulator is fed via PLA 15 direct to the grid of V1B, the cathode follower. The low impedance output of this valve, developed across R13, R4 is matched to the input to the filter circuits, to which it is applied via C10 and part of L3. SKC is a socket located at this point in the circuit to enable monitoring of the filter input to be carried out.

23. The filter units are identical in construction, differing only in their component values (see the "Frequency - Components" Table of fig. 6). Each filter has seven parallel resonant circuits, each circuit consisting of a Ferroxcube variable inductance and a close tolerance capacitor. RV1 is for adjusting the "overshoot" of the filter. The resonant circuits consist of series arms and shunt arms, as follows:

(a) The series arms of the filter are:

(i) L4, C4; L6, C6 - both tuned to the upper rejection frequency.

(ii) L5, C5; L7, C7 - both tuned to the lower rejection frequency.

(b) The shunt arms of the filter are:

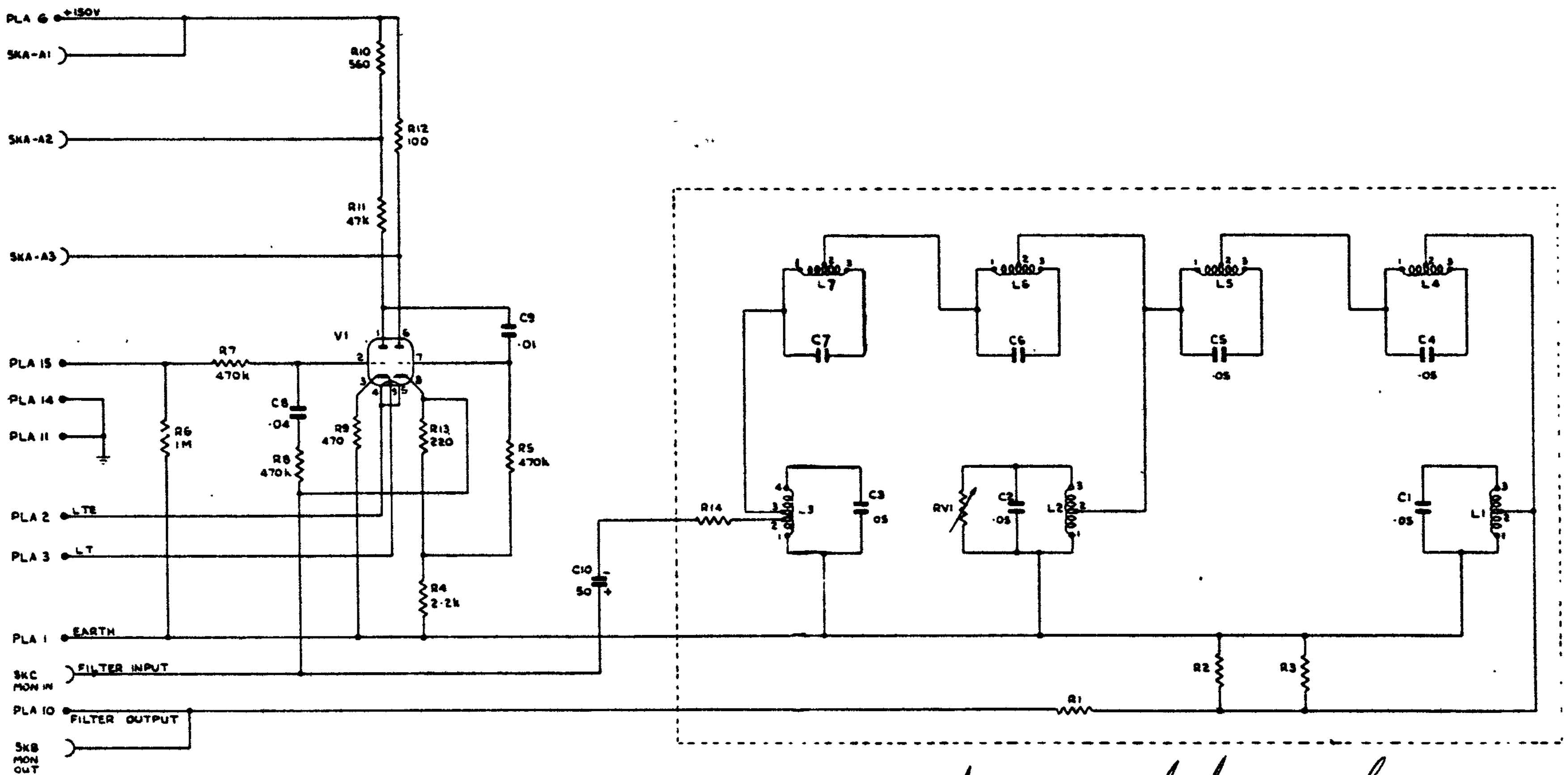
(i) L1, C1; L2, C2; C3, C3 - all tuned to a frequency slightly lower than the nominal centre frequency of the filter.

The output impedance of the filter varies slightly according to its nominal centre frequency.

24. The output of the filter circuit is applied via R1 to the triode V1A. This is a straight-forward amplifier with current feedback derived from the unbypassed cathode resistor R9. From the anode of V1A, the output is taken via C8 to PLA 10, and the input-to-output gain of the entire unit is 0.9. SKB is a monitoring point for the output, located on the front panel of the unit, and SKA is for measurement of h.t. and valve feeds in conjunction with the VALVE FEEDS METER UNIT.

25. <u>425 c/s to 1615 c/s Filter Unit (fig. 7).</u> The second type of filter arrangement will only be found on certain installations, as shown in para 21. This filter unit includes the entire twin triode at the input end. The amplifier V1A is located before the cathode follower V1B, so that the input from the associated modulator is applied to the amplifier grid via R7. The triode is again a straight-forward amplifier with current negative feedback derived from R9, the unbypassed cathode resistor. The output of V1A is applied direct to V1B via C9, and the cathode follower output is passed to the filter circuits in a similar manner to the previous type of unit; the filter circuits are also identical, the "Frequency - Components" Table of fig. 7 showing once again the different values to satisfy frequency requirements.

26. The gain of V1A (approx. 20) is too great for the input-to-output requirements (which will, of course, still be 0.9 as in the other type). Voltage negative feedback is employed across both triodes, being taken from the cathode follower output via R8 and C8 back to the amplifier grid. As this negative feedback factor is 0.5, the resultant gain of V1 is reduced to 2.



gain of ·9. which is a loss

FOR COMPONENT LAYOUT SEE WZ 26316/D SH1

TITLE

Fig. 7: BANDPASS FILTER CIRCUIT DIAGRAM

CIRCUIT REF	FREQUENCY															
	425c/s	595c/s	765c/s	935c/s	1105c/s	1275c/s	1445c/s	1615c/s	785c/s	1955c/s	2125c/s	2295c/s	2465c/s	2635c/s	2805c/s	2975c/s
C6	02	·02	02	·02	02	02	02	·02	·05	·05	·05	·05	·05	·05	05	·05
C7	·02	·02	02	·02	02	·02	·02	02	05	05	·05	05	·05	·05	·05	·05
R1	← NOT FITTED →						2·2k	2 2k	3·9k	3·9k	3·9k	3·9k	3·9k	3·9k	3 9k	3 9k
R2	12k	12k	12k	12k	12k	12k	3·9k	3·9k	3 9k	3·9k	3·9k	2·2k	2·2k	2 2k	2 2k	2·2k
R3	12k	12k	12k	12k	12k	12k	← NOT FITTED →		3 9k	3·9k	3 9k	← NOT FITTED →				
R14	1·5k	1·5k	1·5k	1·5k	1 5k	1k	1k	900	500	500	450	270	360	360	330	430
RV1	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M

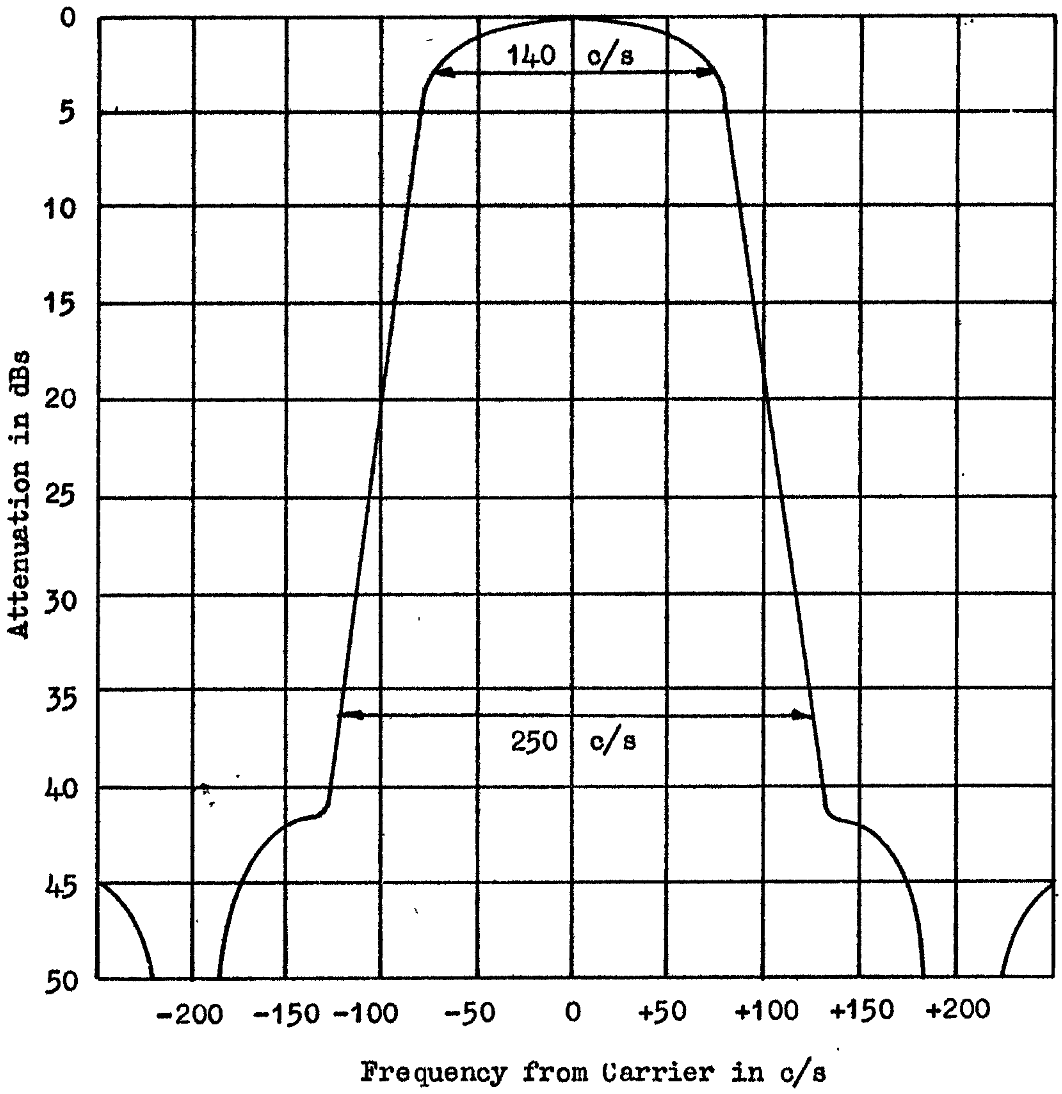


Fig. 8: Typical Bandpass Filter Response Curve

27. SKA, SKB, and SKC have the same function on this unit as on the other type of unit, and the contacts of PLA feed the same points.

Channel Amplifier (fig. 10)

28. The purpose of this unit is to amplify the outputs of the MARK and SPACE bandpass filters; there is one amplifier per channel.

29. Action. The outputs from the MARK and SPACE filters of the associated channel are applied to PLA 14 and PLA 13 respectively. The tone frequency present is applied to the grid of V1 via the CHANNEL GAIN control RV1 (remember that only one of the tones - MARK or SPACE - will be present at any one time). V1 is a pentode amplifier with negative feedback derived from the unbypassed cathode resistor R4, thus reducing any distortion that may be developed in the amplifier. The simplified circuit diagram (fig.9) shows that with the CHANNEL switch (SWA) in the OFF position, the output from the anode (via C3) is earthed and does not pass to the following stage (the Single Channel Attenuator), the latter being common to all channels.

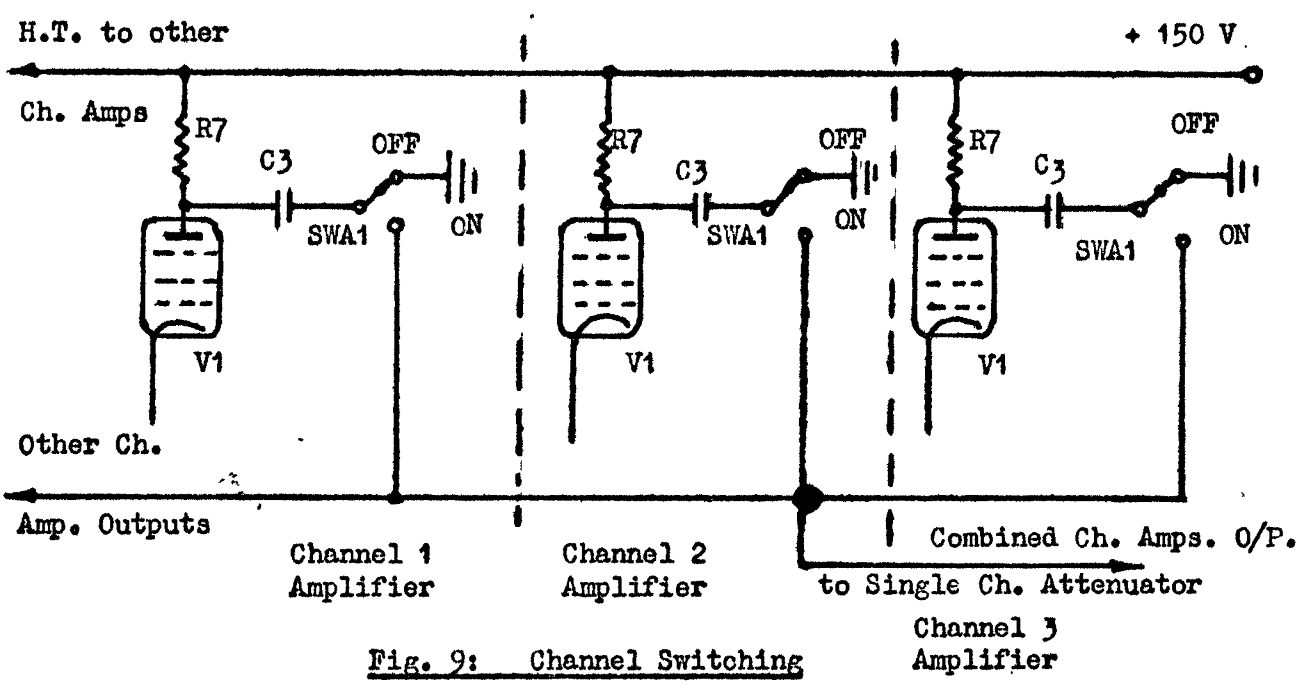
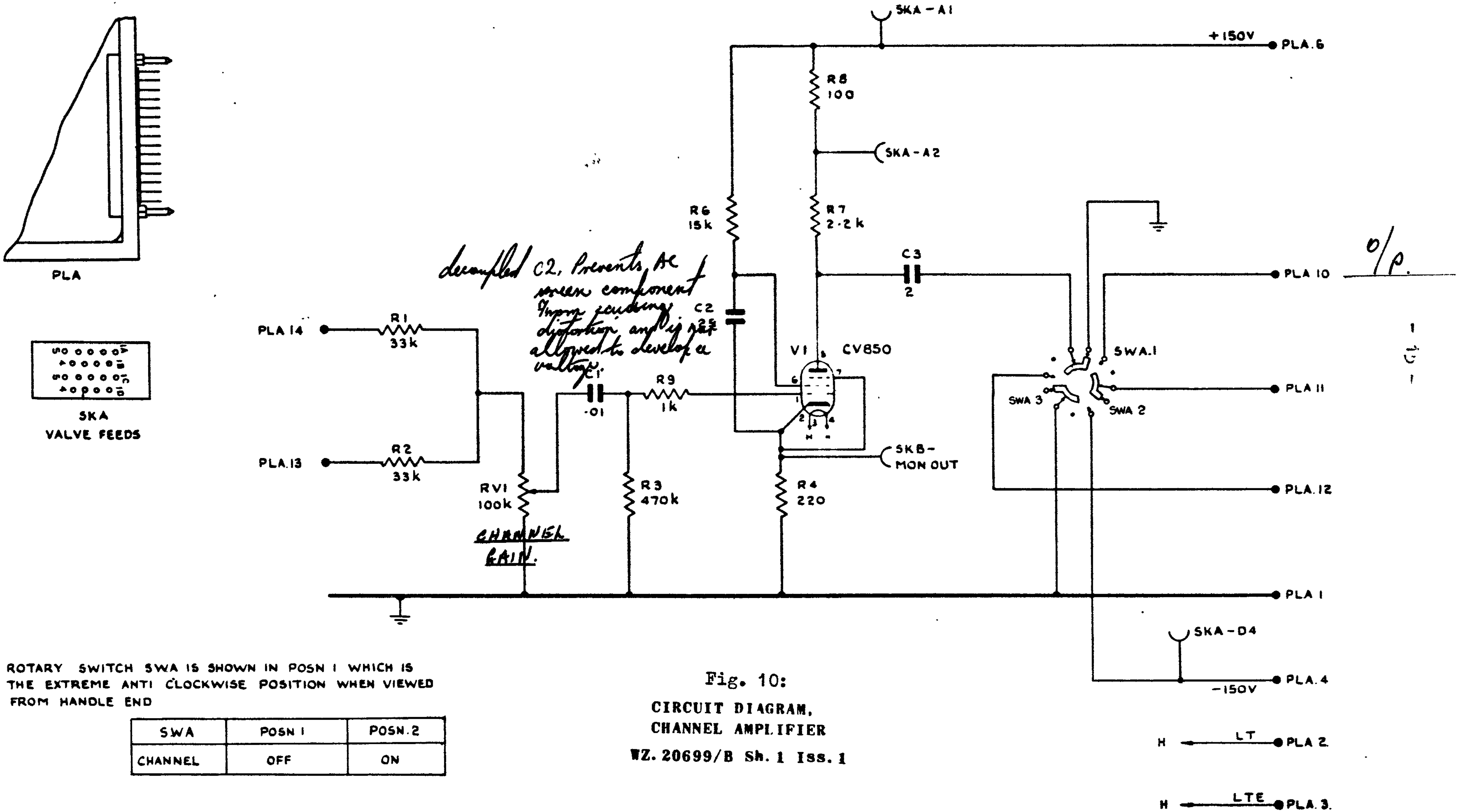


Fig. 9: Channel Switching

30. SWA1 switches the output, SWA2 (see fig. 8) breaks the - 150 V supply line from PLA 4 (incoming) to PLA 11 (outgoing). This - 150 V supply is for the next stage (the Single Channel Attenuator) and it will be realised that it is applied via SWA 2 of any channel amplifier provided that channel is switched to the ON position. The switching of the - 150 V supply is an integral function of the Attenuator, and this will be described in Section F below.

31. With SWA in the ON position, PLA 4 and PLA 11 are linked, and the output of the amplifier is also applied to PLA 10. It should be noted that in this position, the anode loads of each Channel Amplifier are parallelled (see Fig. 9); thus their effective resistance is lowered and, consequently, as more channels are switched ON, their individual gains are further reduced. By careful selection of the values of R7, it is arranged that the peak power output of the combined channels is kept constant regardless of the number of channels in use.

32. SKB is a monitoring point on the front panel (MONITOR OUTPUT), and SKA, also on the front panel, is used for making checks of valve feeds and supply voltages. These checks are, as in the other units, made in conjunction with the common VALVE FEEDS METER UNIT and the connecting lead supplied.



ROTARY SWITCH SWA IS SHOWN IN POSN 1 WHICH IS THE EXTREME ANTI CLOCKWISE POSITION WHEN VIEWED FROM HANDLE END

SWA	POSN 1	POSN.2
CHANNEL	OFF	ON

Fig. 10:

CIRCUIT DIAGRAM,
CHANNEL AMPLIFIER

WZ. 20699/B Sh. 1 Iss. 1

Single Channel Attenuator (fig. 11)

33. The purpose of this unit is to reduce the peak output level when there is only one channel in use. The normal peak level can be reduced by 0 to 6 dBm, by means of a switched ATTENUATOR (SWA) on the front panel of the unit.

34. The combined outputs of the channel amplifiers (in this case, the tone present in each amplifier is combined) are fed into the unit at PLB 15 which is the input to V1A, an amplifier with the usual form of negative feedback. The output of V1A is fed to the grid of V1B, a similar amplifier. Additional voltage negative feedback is applied across the complete amplifier stage from the anode of V1B via R10 to the cathode circuit of V1A. The amplified tones appear across the transformer TR1 via the potential divider R11, R12.

35. The cathode of V2 is connected to the junction of R34 and a resistor network consisting of R16, R24, R22 in parallel with R27, R25, R23. The other side of the network is connected to earth via the centre-tapped secondary of TR1, whilst the other end of R34 is connected to - 150 V; thus a bias voltage of - 23 V is applied to the cathode. As stated in para 30, SWA2 of the Channel Amplifier, switches the - 150 V supply to the Single Channel Attenuator. As each channel is switched ON, this - 150 V is applied to each of the terminals PLB 7 to PLB 14. Thus with all channels switched ON, R14 to R21 are in parallel. These resistors in series with R13 (to + 150 V) form a potential divider between positive and negative supplies and under the above (ON) conditions, the potential applied to the grid of V2 is negative with respect to the cathode. As each channel is switched OFF, the equivalent resistance in series with R13 is increased until, with only one channel operative it reaches 390 ohms (i.e. only one resistor in circuit) and the potential of V2 grid is positive with respect to the cathode.

36. Thus the current through V2 will be changed from minimum to maximum and due to the cathode resistor R34, the potential at the cathode will rise accordingly. In the single channel condition, the cathode will be above earth potential and, as the secondary of TR1 is centre-tapped to earth, the diodes MR1, MR2 will conduct. The resistor network R22 to R32 now becomes a load across the secondary, the effect being to shunt the tone output across R12, the degree of shunting being controlled by SWA which switches the resistor network. There is a corresponding reduction in the amplitude of the output of the two stage amplifier V1, which is applied to PLA 10.

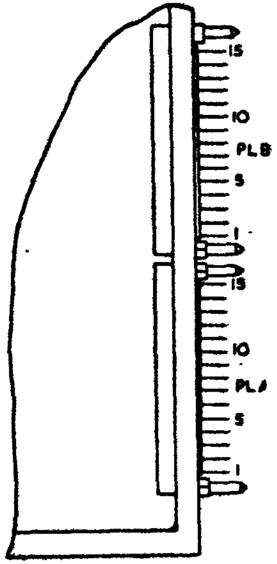
37. The rectifiers MR3 and MR4 act as limiters, ensuring that the voltage at V2 grid does not exceed approximately $\pm$ 29 volts. SKB is a monitor point on the front panel, and SKA (also on the front panel) is for connecting a lead to the VALVE FEEDS METER UNIT.

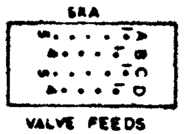
Common Amplifier (fig. 12)

38. The Common Amplifier is a three-stage amplifier with negative feedback. Its purpose is to amplify the combined v.f. tones and its overall gain is sufficient to give an output of + 10 dBm in 600 ohms.

39. The input to this unit is at PLA 15. The inputs at PLA 13 and PLA 14 are for another application of this unit (use with a Single Channel V.F. Equipment) and are not considered in this Trainee Note. Service requirements call for a Multi-channel V.F. Equipment, and the MULTI/SINGLE links must be connected in the "MULTI" position at all times (positions 2 - 3 in the input circuit and positions 1 - 2 in the feedback circuit). The attenuator switch SWA is also for use with single channel equipment and in multi-channel working it should always be left in the fully clockwise (10 dBm) position (this attenuator is calibrated - 10 to + 10 dBm in 2 dBm steps).

40. V1A and V1B comprise a two-stage amplifier. Both stages have current negative feedback derived from their unbypassed cathode resistors. Additional voltage negative feedback is obtained over the whole amplifier via R37 in the output of V2 and fed back to the cathode circuits of V1A.





SWA ROTARY SWITCH IS SHOWN IN POSN I WHICH IS EXTREME ANTICLOCKWISE POSITION WHEN VIEWED FROM HANDLE END

SWA	POSN.I	2	3	4	5	6	7
ATTEN	0db	1db	2db	3db	4db	5db	6db

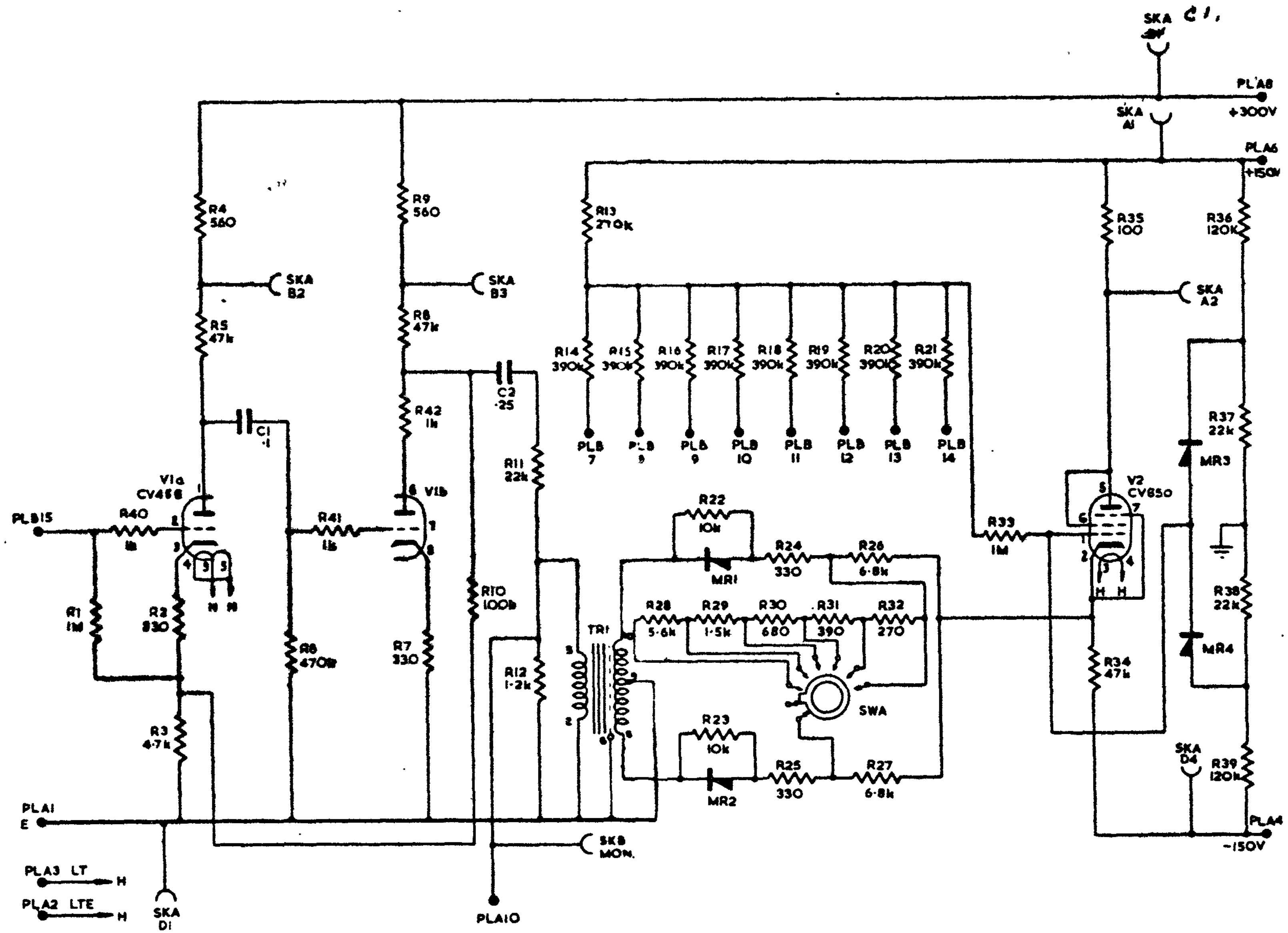
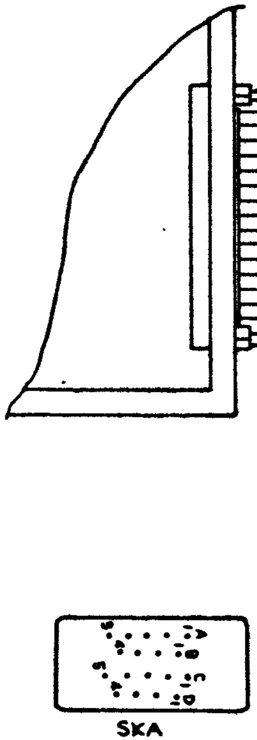


Fig. 11: Single Channel Attenuator - circuit



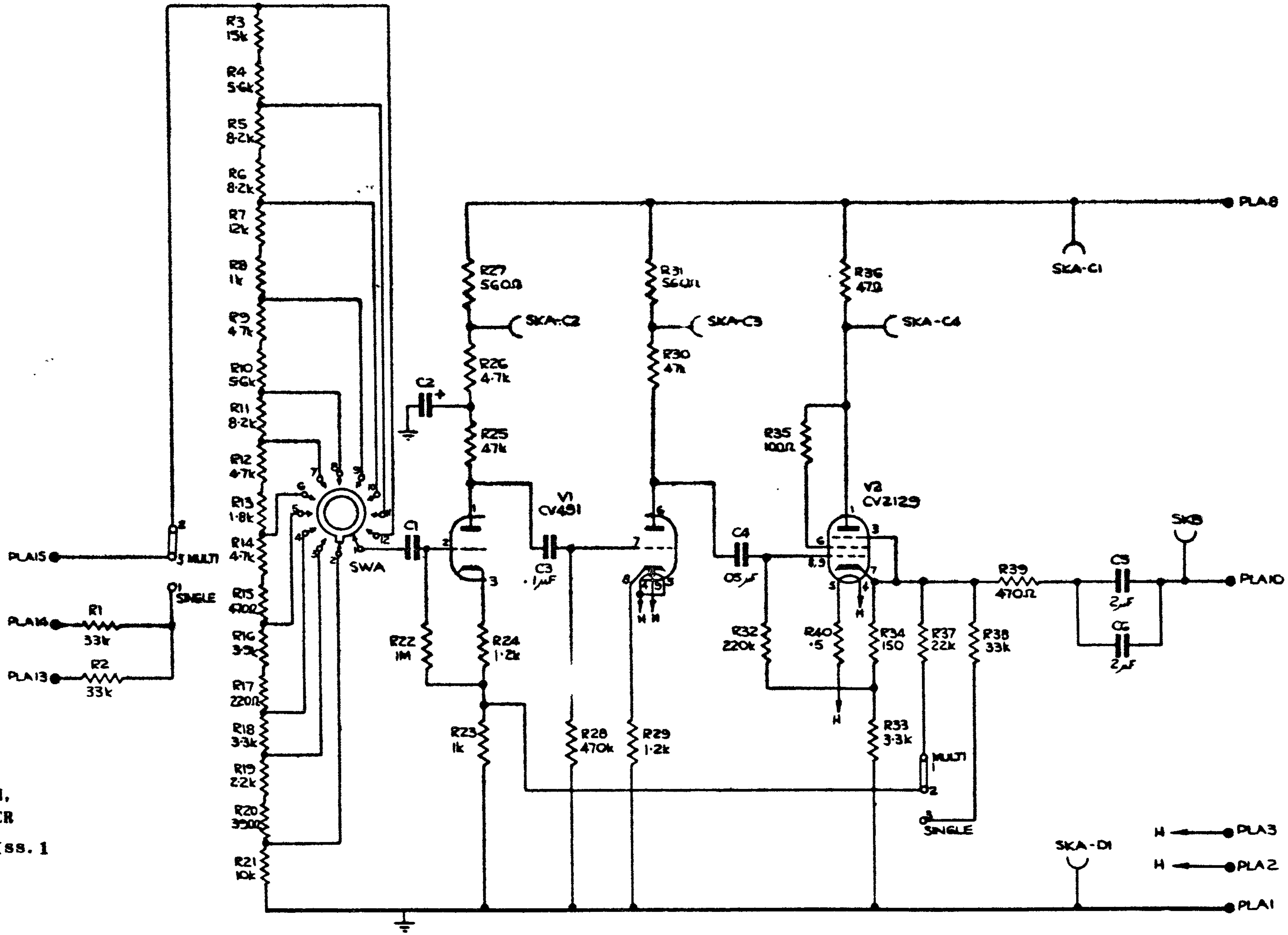
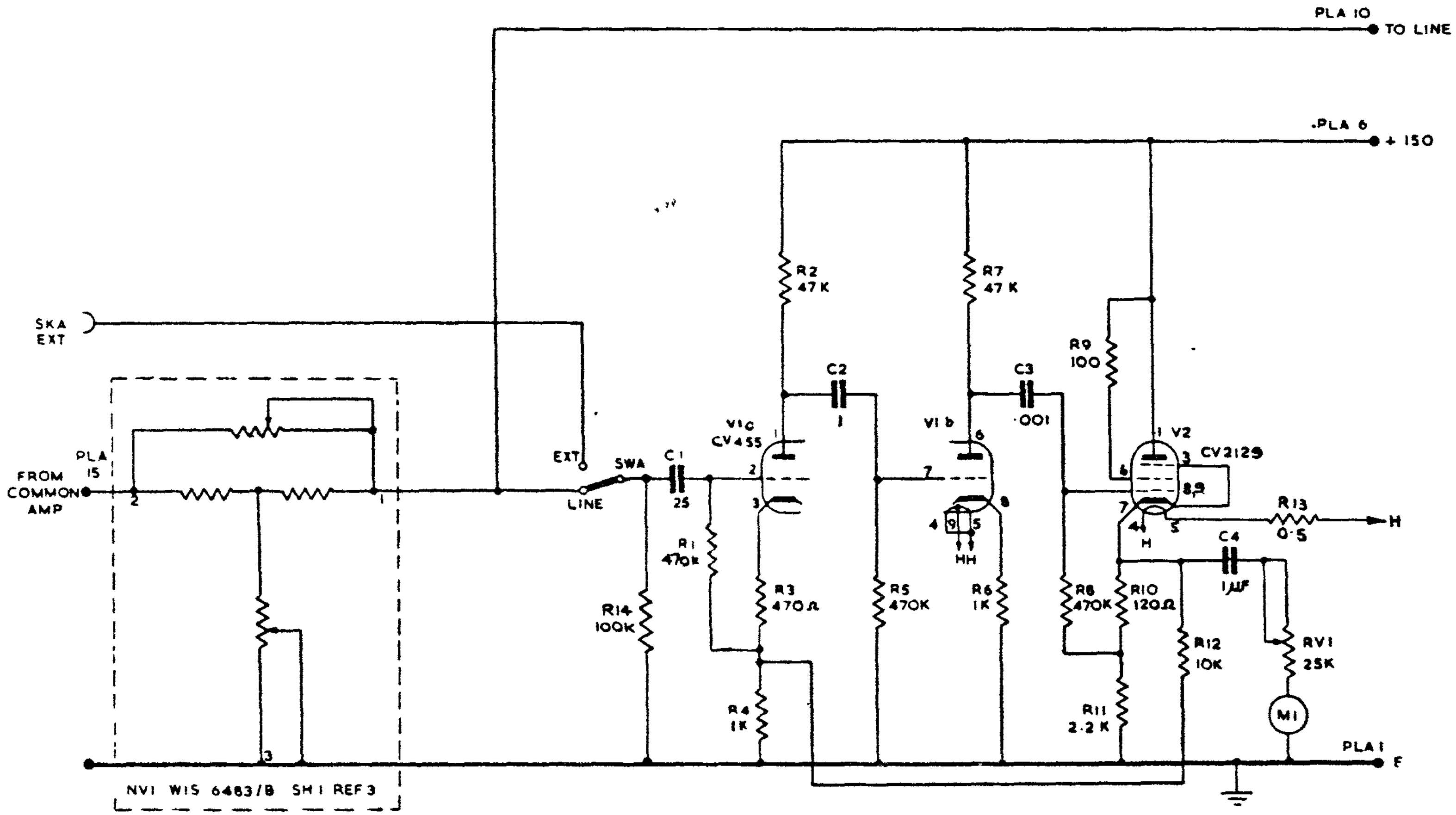


Fig. 12:

CIRCUIT DIAGRAM,
COMMON AMPLIFIER

WZ. 20700/B Sh. 1 Iss. 1



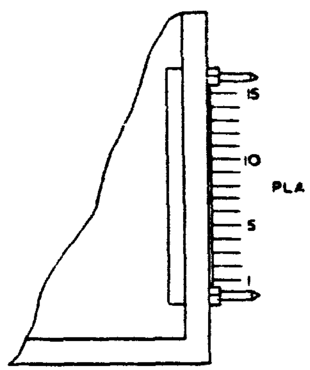
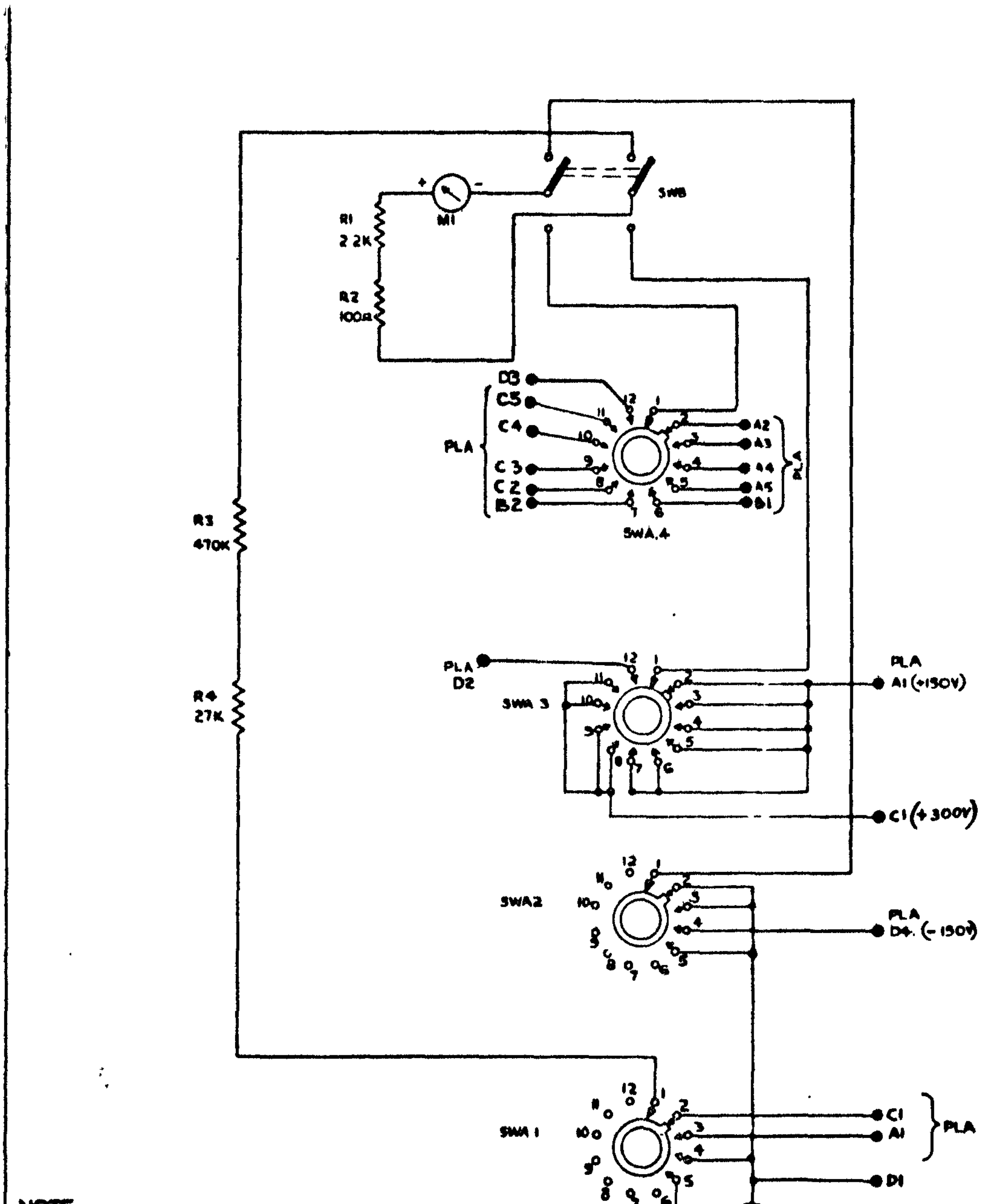


Fig. 13: Level Indicator - circuit



NOTE.
ALL SWITCHES SHOWN IN POSN 1 WHICH IS EXTREME ANTI-CLOCKWISE POSN WHEN VIEWED FROM HANDLE END

SWITCH No	POSN 1	POSN 2	POSN 3	POSN 4	POSN 5	POSN 6	POSN 7	POSN 8	POSN 9	POSN 10	POSN 11
SWA	1	2	3	4	5	6	7	8	9	10	11
SWB	SUPPLIES	VALVES									

FRONT VIEW OF PLUG. PLA

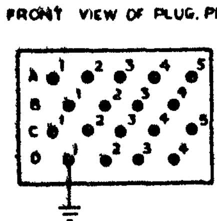


Fig. 14: Valve Feeds Meter Unit - circuit

41. V2 is a cathode follower stage included to provide matching to the next stage (Level Indicator and Output Attenuator) which requires a low impedance input. H.T. to the Common Amplifier unit is at 300 volts supplied at PLA 8. SKB is a monitor point on the front panel, and SKA also on the front panel, is for connecting a lead to the VALVE FEEDS METER UNIT for measurement of supply voltage and valve feed currents.

Level Indicator and Output Attenuator (fig. 13)

42. The output of the Common Amplifier is fed in at PLA 15, then through a "bridged-T" attenuator, and out again to line at PLA 10. The attenuator is switched in 1 dB steps from - 15 dB to + 10 dB.

43. The EXT/LINE switch (SWA) enables measurement to be made of either:

(a) The output signal (LINE).

(b) Signal levels throughout the equipment (EXT) using a patching cord in conjunction with the SKA (EXT) socket on this unit and the SKB (MONITOR) sockets on the various other units.

44. The three-stage level indicator employs the usual current negative feedback for individual stages as well as the overall voltage negative feedback (via R12). V1A and V1B comprise a two-stage amplifier; V2 is a cathode follower stage and the output to be measured is taken via C4 and RV1 to the meter M1. RV1 is for calibration pruposes and M1 has a "built-in" rectifier. The meter is calibrated 0 - 1 volt r.m.s. and also in dB relative to 1 mW in 600 ohms.

45. If a balanced output is used (i.e. a 1 : 1 transformer is interposed between the output attenuator and the lines), it should be noted that the actual output level will be approximately 1 dB less than that shown on the meter. This is due to the insertion loss of the transformer.

Valve Feeds Meter Unit (fig. 14)

46. In conjunction with the patching lead and sockets SKA (on the front panels of all units), measurement of supplies and feed currents is facilitated.

47. There are two switches:

(a) Switch SWB is a d.p.d.t. switch enabling the meter to indicate h.t. voltages (SUPPLIES) or feed currents (VALVES).

(b) Switch SWA is an eleven-position rotary switch which, in positions 1, 2, 3 and 4 (with SWB at SUPPLIES) enables measurement of the + 300 V, + 150 V, - 150 V, and + 50 V h.t. supplies to the unit concerned to be carried out. If the unit does not have a particular supply connected to it, then no reading is obtained in the appropriate position 1 to 4. In positions 1 to 6 (with SWB at VALVES), measurement can be made of the current of valves with + 150 V h.t. In positions 7 to 10 (again with SWB at VALVES), measurement can be made of the current of valves with + 300 V h.t. and in position 11, the only valve with + 50 V h.t. can be checked (this is the Check Oscillator V1).

48. Examples of the use of this Meter Unit are as follows:-

(a) Tone Oscillator Unit. H.T. to this unit is + 300 volts. Therefore when the supplies are measured, there will be a reading on position 1 (+ 300 V) and no reading on positions 2 to 4. When the valve currents are measured, there will be:-

(i) A reading on position 7 = V1A (mA)

(ii) A reading on position 8 = V1B (mA)

(iii) A reading on position 9 = V2A (mA)

(iv) A reading on position 10 = V2B (mA)

(v) No readings on positions 1 to 6 or position 11, as there are no + 150 V or + 50 V supply voltages to this unit.

(b) Single Channel Attenuator Unit. H.T. supplies to this unit are both + 300 volts and + 150 volts. Therefore, when the supplies are measured, there will be:-

(i) A reading on position 1 = + 300 V.

(ii) A reading on position 2 = + 150 V.

(iii) A reading on position 3 = - 150 V.

(iv) No reading on position 4 (no + 50 V supply).

When the valve currents are measured, there will be:-

(v) A reading on position 1 = V2 (mA) (+ 150 V h.t. supplied) (remember that this valve is only conducting during single channel operation of the equipment).

(vi) A reading on position 7 = V1A (mA).) } + 300 V h.t. supplied)

(vii) A reading on position 8 = V1B (mA)) }

(viii) No readings on the remaining positions as there are no other valves or supplies.

Check Oscillator (Units A and B - figs. 15 and 16)

49. The purpose of the check oscillator is to enable a frequency check to be carried out on any of the tone oscillators. The basic frequency of the check oscillator is 1530 c/s; this frequency is then divided by multivibrator circuits down to an 85 c/s output, which is used to provide a circular timebase on an oscilloscope. To check any one tone oscillator, its output is patched to the oscilloscope, where it modulates the brightness of the circular trace in the form of "bright-ups" which appear as segments of the circle. The number of these "bright-ups" is related to the frequency of the tone under test i.e., the lowest tone of 425 c/s, being the fifth harmonic of 85 c/s, will show as five "bright-ups" on the circular trace. There will be seven for the next tone of 595 c/s, nine for 765 c/s, and so on. Thus, if any tone frequency is correct, it will be recognised both by the number of segments and the fact that they are stationary. If, however, a tone is high or low, it will not be an exact harmonic of 85 c/s and this will show on the oscilloscope as a rotation of the bright segments, i.e., if it is high, the rotation will be anticlockwise if it is low, clockwise. The output of Unit A is at 170 c/s, which is the basic oscillation frequency of 1530 c/s divided by 9. This output is fed into Unit B, where a further frequency division of 2 takes place, giving the final required output of 85 c/s.

50. Unit A (fig. 15). XL1 is a crystal cut to 1530 c/s with V1 as the maintai ing valve. V1 also acts in an electron-coupled oscillator circuit, with the screen of the valve operating as the oscillator anode. Feedback is from the screen via the blocking capacitor C2 and the crystal XL1 to the grid. Valve h.t. is + 50 volts obtained from the potential divider R8, R9 between + 150 vol and earth. The crystal operates in the XY flexure mode, and crystals operatin in this manner are of relatively large physical size compared to other cuts. The large physical size and the low operating frequency introduce the danger of complete disintegration of the crystal due to large mechanical movement. Precautions are taken to obviate this danger with the result that the voltage across the crystal is kept low. These precautions are:-

(a) Keeping the h.t. low (approximately 50 volts).

(b) Including R30 as a safety bias.

(c) Applying negative feedback derived from the unbypassed R30.

(d) Applying a.g.c. action.

51. The a.g.c. is obtained from the valve output as follows. The output from C5 at 1530 c/s is fed via the rectifier (MR1) and filter circuit R6, C4;

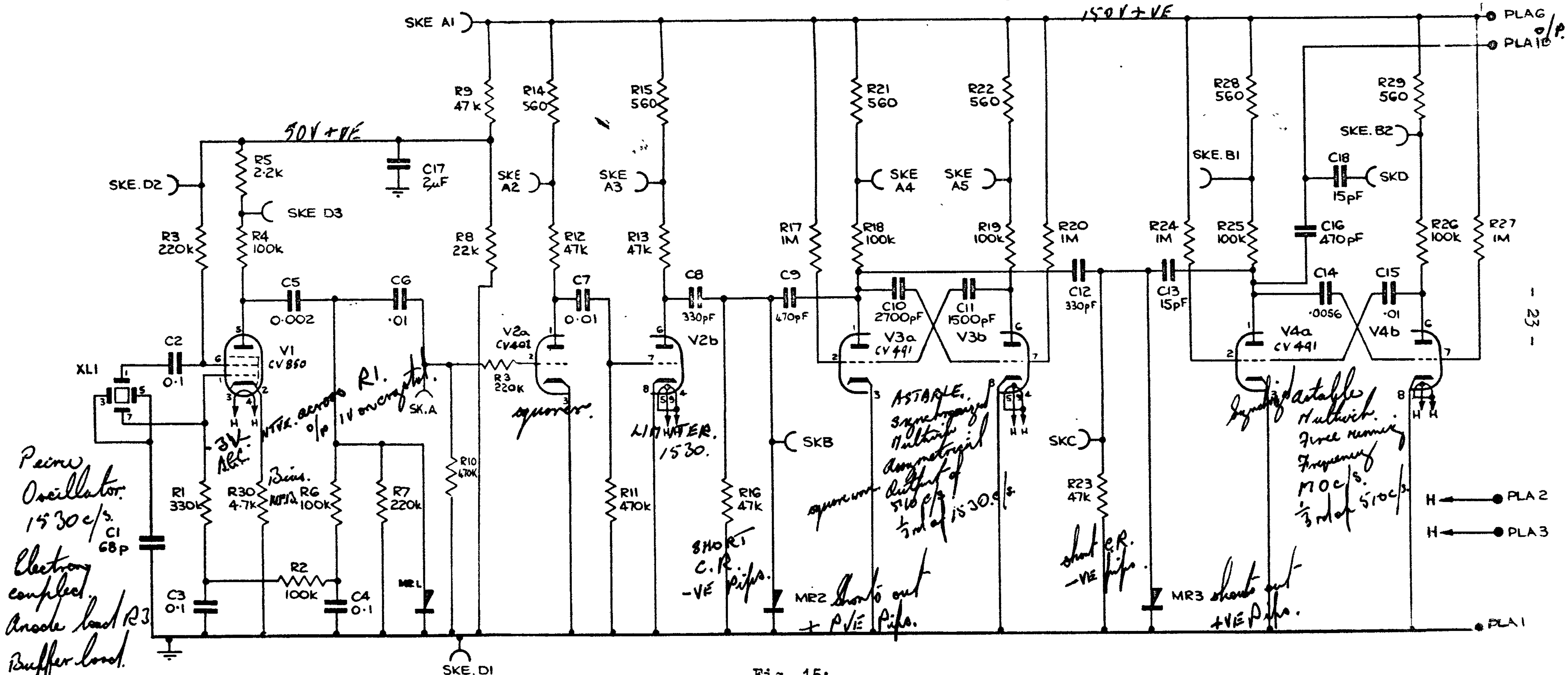
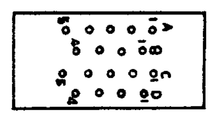


Fig. 15:

CIRCUIT DIAGRAM
CHECK OSCILLATOR UNIT A
WZ.20707/D Sh.1 Iss.3



VALVE FEEDS
SKE

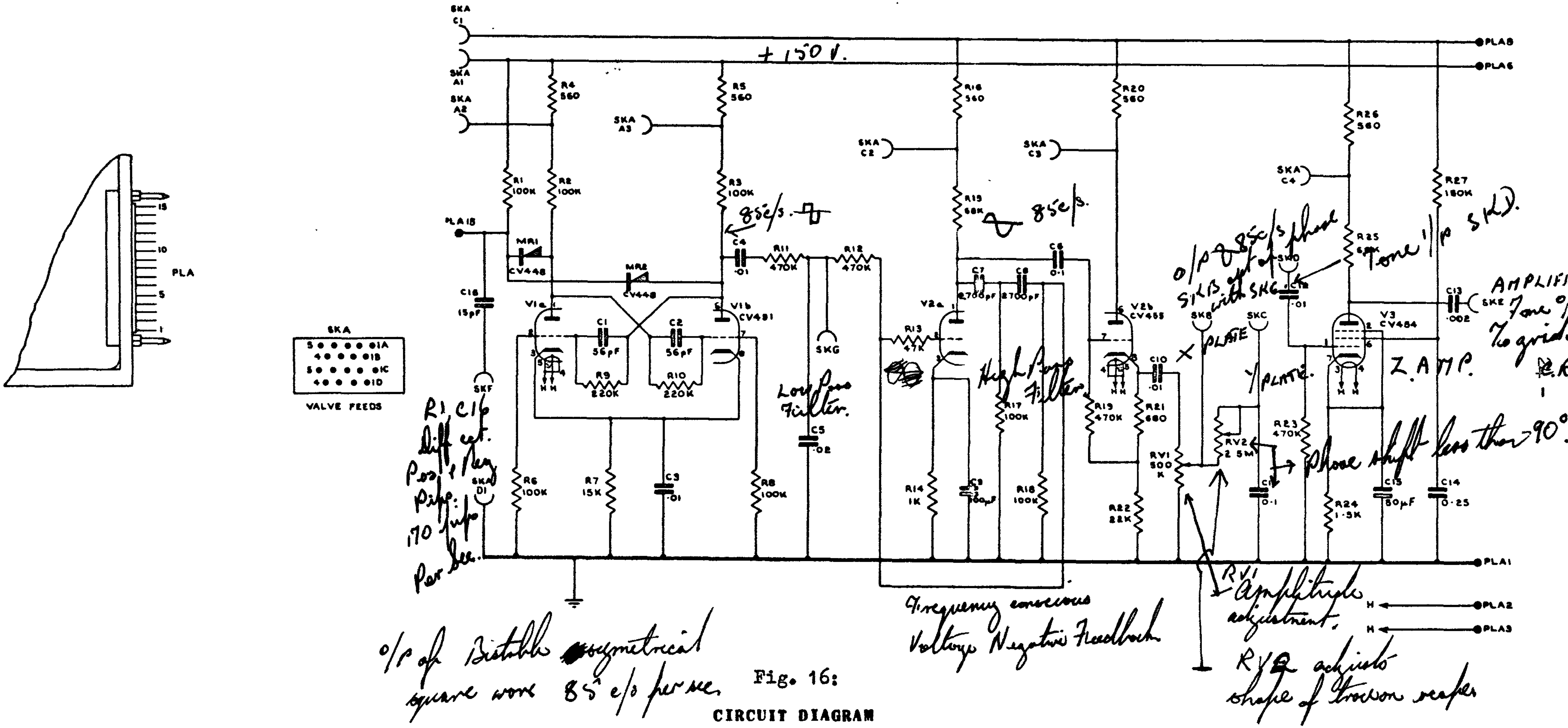


Fig. 16:

CIRCUIT DIAGRAM
CHECK OSCILLATOR UNIT B
WZ.20708/B Sh.1 Iss.3

R2, C3 to the grid of V1. Positive half cycles are removed by the shunting effect of MR1, with the result that only the negative half cycles appear across R7, which is the load resistor. This unidirectional output, after filtering, is fed as a bias voltage of approximately 3 volts to the valve grid. Thus with all the conditions of para 50 (a) to (d) above being met, the voltage across the crystal are kept below 1 volt.

52. Amplification is effected at the anode of V1 and by virture of the electron-coupled oscillator arrangement, changes in loading do not (by reflection) affect the frequency of the oscillator itself.

53. V2A and V2B form a two-stage squarer giving an output of 70 volts peak-to-peak. This is differentiated by C8 and R16 and the positive pulses are removed by the rectifier MR2, leaving negative pulses at 0.655 millisecond intervals (i.e., one pulse for each complete cycle of oscillator frequency). V3A and V3B form a free-running or astable multivibrator circuit. C10 and C11 give 100 % feedback to the grids from the opposing anodes, and R17, R20 are the grid leaks. The frequency of the multivibrator is one third of the oscillator frequency (i.e., 510 c/s), and this output also is differentiated and its positive pulses removed; the negative pulses applied to the following multivibrator stage are now at 1.965 millisecond intervals. These pulses trigger the second astable multivibrator stage V4, which gives a square wave output at one third of its input frequency (i.e., 170 c/s). This output is applied to PLA 10 from which it is fed to PLA 15 of Unit B. The action of the multivibrators and the "counting down" principle may best be followed by reference to the circuit diagram (fig. 15) and the waveform diagram (fig.17).

54. Monitoring points, all on the front panel, are as follows:

(a) MON 1 (SKA) - Output from oscillator.

(b) MON 2 (SKB) - Differentiated output of V2 (triggering pulses for V3).

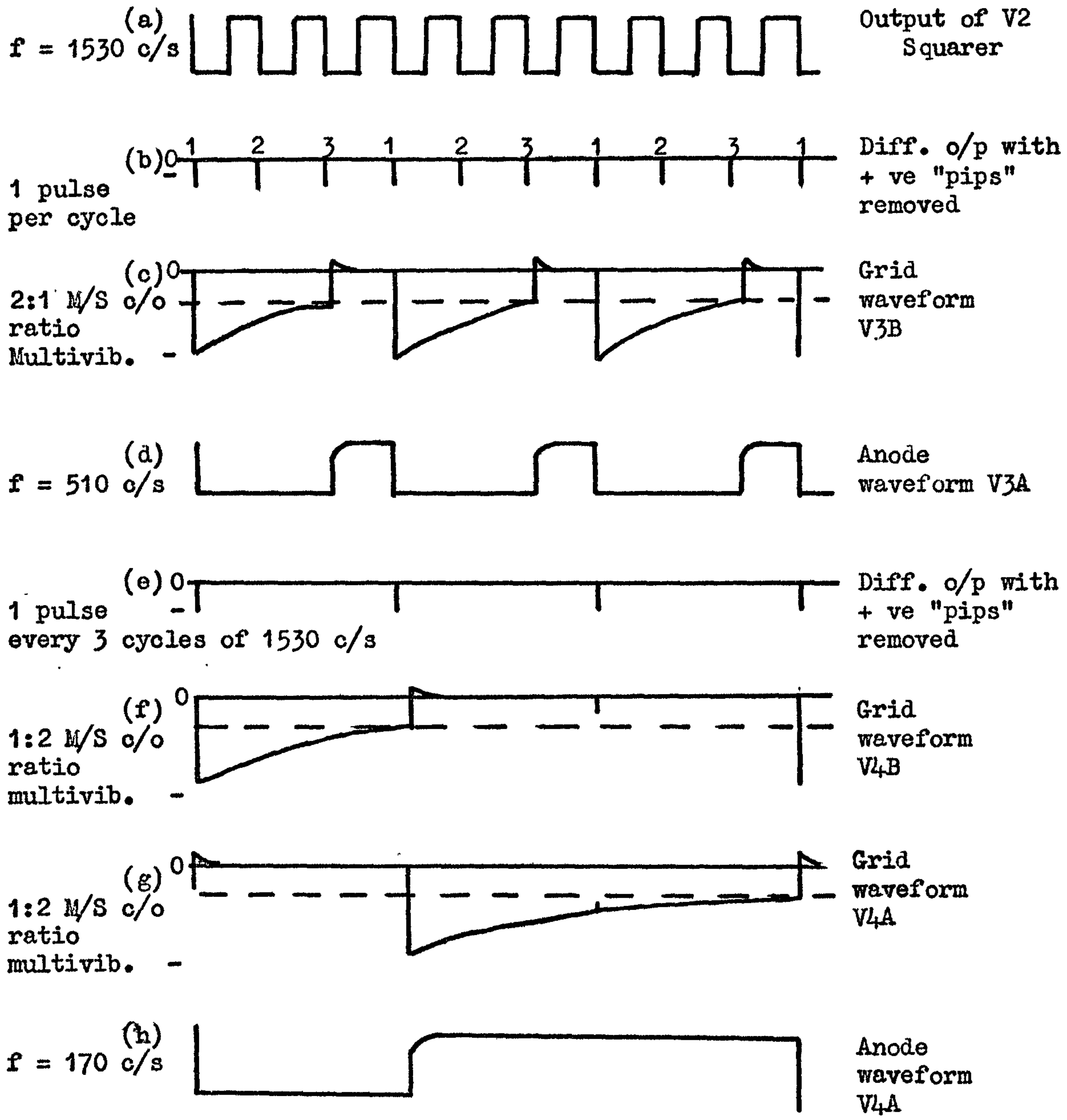
(c) MON 3 (SKC) - Differentiated output of V3 (triggering pulses for V4).

(d) MON 4 (SKD) - Output of V4 (triggering pulses for V1 in Unit B).

55. Unit B (fig. 16). The purpose of this unit is to give a final division by two to give an output of 85 c/s. After shaping, this output is split to give two outputs in phase quadrature, the outputs being used as a timebase to provide a circular trace on the oscilloscope.

56. Referring to fig. 16, the input from Unit A (normally a square-wave, as explained in para 53) is now modified by the effect of C16 in Unit A being connected to R1 of Unit B. This now forms a differentiating circuit, and the resultant pulse signals are applied to the bistable multivibrator V1; as the positive pulses do not have any effect on the multivibrator, they can be ignored. The negative pulses trigger the multivibrator, which will therefore give a square-wave output at one half of the input frequency (i.e., 85 c/s).

57. The action is as follows. Assuming V1 to be in one of its stable states, where V1A is conducting and V1B is non-conducting, the anode of V1A is at some relatively low positive potential and V1B anode is high (at + h.t. potential). MR1 and MR2 are connected "back-to-back" between the anodes. The potential applied to MR1 under these conditions is such that it is back-biased; MR2 has zero bias. Application of a negative trigger pulse to the junction of the rectifiers (from Unit A via PLA15) will have little effect on MR1, but will result in a pulse of current through MR2 and R3. This pulse of current through R3 will cause a drop in the anode potential of V1B, the fall being communicated via C1, R9 to the grid of V1A which is conducting. V1A commences to cut-off. As the anode current falls in V1A, the anode potential rises, and this rise is communicated to the grid of V1B via C2, R10, causing V1B to conduct. The anode potential of V1B therefore falls further and the fall assists cut-off of V1A.



NOTES

1. The squarewave output of V2 is somewhat idealised at V2 is a triode squarer. However, the sides of the waveform are sufficiently fast to give the short-time duration negative pips for triggering the first multivibrator in a satisfactory manner.

2. The negative pips are shown as lines for convenience. They are of course very narrow pulses.

3. It will be seen that while there are NINE cycles in (a), there is only ONE cycle at (h). Division by 9 has thus taken place in Unit A.

4. It will also be noticed that the multivibrators have a 2:1 or 1:2 MARK/SPACE ratio. This is accomplished by the choice of grid capacitor values. 2700 pF and 1500 pF in V3 circuit; 0.0056 μF and 0.01 μF in V4 circuit.

Fig. 17: Check Oscillator Unit A - Frequency Division Principle

The action is violently cumulative and the result is to change the state of the circuit to conditions where V1A is cut-off and V1B cut-on. The circuit is stable in this state and no further action takes place until the next trigger pulse arrives. The effect of MR1, MR2 now being reversed, change-over to the original state is initiated. Two negative pulses are necessary to take the action of V1 through one complete cycle; division by two is therefore accomplished, and the output is a 85 c/s square waveform.

58. The 85 c/s square wave is applied to the integrating circuit R11, C5, a saw-tooth waveform appearing across C5. C4 is a blocking capacitor and R11, R12, C5 form a low-pass filter section. The input is applied to the grid of V2A, an amplifier with voltage negative feedback derived from the output of the high-pass filter section C7, C8 and R17. High frequency components are thus fed back to the grid in anti-phase so that the output from V2A anode consists of the fundamental 85 c/s only.

59. The final 85 c/s waveform is fed to V2B, a cathode follower stage with a sine wave output. This output is passed to RV1 via the blocking capacitor C10, providing control of the output amplitude at this point. There is a direct output to SKB from the slider of RV1, SKB being a socket on the front panel enabling connection of V2B output to the X-plate of a cathode ray oscilloscope. A second output is taken via a phase shift network (RV2, C11) to SKC, another socket on the front panel. This output is phase shifted by 90° and is applied to the Y-plate of the oscilloscope.

60. V3 and its associated circuit form an a.f. amplifier, its purpose being for amplification of the tone under test (i.e., from the appropriate channel oscillator). This tone is applied via socket SKD to the grid of V3, the output of the valve (approximately 67 V) being taken to socket SKE where it may be connected to the grid of the oscilloscope to provide modulation of the electron beam. This connection is necessary to produce the required "bright-up" display on the c.r.t. for checking the frequency.

61. Additional sockets on the unit are as follows:

(a) MON 1 (SKF) - As MON 4, Unit A.

(b) MON 2 (SKG) - Integrated square wave output of V1.

(c) SKA - a multi-way socket on the front panel for connecting a lead to the VALVE FEEDS METER UNIT when making valve feed or supply voltage checks.

Power Supplies

62. L.T. supplies are obtained from the two transformers in the Distribution Unit (see paras. 63 - 65). H.T. supplies of + 300 volts, + 150 volts, and - 150 volts are obtained from the three power units mounted at the rear of the cabinet. All supplies are switched and fused on the Distribution Unit.

Distribution Unit (fig. 25)

63. This unit contains the l.t. transformers TR1 and TR2, and switches and fuses for both l.t. and h.t. supplies. SWA is the MAINS switch, with poles in the line and neutral inputs from the supply. LP1 is the MAINS ON neon indicator lamp, connected between line and earth to ensure correct connection of the a.c. supply line to the input terminals at the base or roof of the cabinet. This lamp is the only one which is ON when the equipment is operational. Note that the mains supply may be connected to the three h.t. supply units (- 150 V, + 150 V and + 300 V) by switches SWB, SWC, and SWD respectively. These switches must be operated in that order. Each line is fused (FS2, FS3, FS4) and each fuse has a neon indicator lamp and limiting resistor in parallel with it (PL3, PL4, PL5). Should a fuse blow due to a fault condition on a h.t. power unit, the neon will strike and therefore give

a visual indication of the fault condition.

64. As soon as mains is switched on by SWA, a.c. is applied to TR1 and TR2 via fuse FS1 (with alarm lamp LP2 in parallel). Four "Brimistors" (surge limiting resistors) are available and any one can be connected in the "line" leg to the transformer TR1. Selection of Brimistor and tapping for the primary of TR1 is dependent on the mains voltage and loading on the secondary. TR1 has two secondary windings; the first supplies l.t. to channels 1, 2, and 3 via fuses FS8, FS9 and FS10 (with associated alarm lamps); the second winding supplies l.t. to channels 4, 5 and 6 via fuses FS11, FS12 and FS13 (also with associated alarm lamps). TR2 is of similar arrangement to TR1; the first secondary winding supplies l.t. to the common units of the equipment, via FS16 (with associated alarm lamp), the circuits via FS14 and FS15 not being used in the present equipment); the second winding also is not used.

65. The Distribution Unit also accepts the h.t. supplies - 150 V, + 150 V and + 300 V from the power units and distributes these supplies via fuses and alarm lamps FS5, LP6; FS6, LP7; FS7, LP8 respectively.

+ 300 Volts Power Unit (fig. 26)

66. Mains voltage from the Distribution Unit (via SWD, fig. 25) is applied to the primary winding of TR1. This transformer has three secondary windings, giving the following outputs:

(a) 300 volts (with various tappings) at 400 mA.

(b) 164 volts at 8 mA.

(c) 6.3 volts at 4 amps.

The 164 volts is a bias supply (when rectified by MR5, MR10) and is stabilised by V1 at 85 V. The 6.3 volts supply the heaters of the valves in this unit.

67. The main 300 V h.t. is derived from MR3, MR4, MR6, and MR7 in a bridge-type circuit. The Brimistor R44 has a high resistance when cold and prevents surges when switching on. R60 in parallel with the Brimistor prevents it from heating too rapidly (note that surges must be prevented when switching on as they will result in excess voltage being applied to the load before the stabilising circuits start to operate; "Brimistor" is a trade name for this type of thermistor). Switching off and on again while the Brimistor is still hot will not damage the power unit, but at least three minutes cooling time should normally be allowed. C20 across the secondary of the transformer and MR2 with C1 and R68 prevent damage to the rectifiers by switching transients and transient mains voltage surges.

68. Two stabilising circuits are employed; a slow regulator, using a transductor (or saturable reactor), and a fast regulator, using valves. The overall stability is such that a mains variation of $\pm$ 10% will give rise to an output voltage change of less than 1 % and the ripple output does not exceed 5 mV peak-to-peak.

69. Fast Regulator. Sudden changes in loading (such as those occurring through switching transients) would be reflected into the power supply from this unit and the fast regulator circuit has been designed to combat the resultant quick change (rise or fall) in output voltage. The action is as follows:

(a) The cathodes of V6 are at earth potential and the grid of V6A (pin 7) is held at + 85 volts by the reference valve V2 (a stabiliser). If the output voltage is correct, due to the potential divider (consisting of R41, R45, R46 to R55 inclusive, RV3 and R42), the grid of V6B (pin 2) is at the same potential as V6A grid.

(b) The two halves of V4 operate in class B, passing a quiescent current of 25 mA, the potential at V4A cathode (pin 3) being approximately half of the potential between V4A anode (pin 2) and V4B cathode (pin 6); V4A and V4B, with R56, R57 and R12 thus form a potential divider network.

(c) If the output falls, the potential at V5A anode (pin 6) also falls causing the grid of V4B to fall and thus V4B conducts less heavily. The chain of events leading to this begins with the balance of V6 being destroyed, i.e. as the output voltage falls, V6B grid (pin 2) drops in potential, resulting in a rise in the potential of V6B anode (pin 1). This sharp rise is communicated to V5A grid (pin 7) via R23, R25, resulting in a fall in V5A anode potential (pin 6), as referred to above.

(d) Similarly the potential at V5B anode (pin 1) rises. This is again due to the off-balance condition of V6; as the output falls and V6B grid (pin 2) drops, as in sub-para (c) above, the current through the common resistor R38 falls, causing the cathode to go less positive. In effect, the bias at V6A grid (pin 7) is decreased. and therefore V6A anode (pin 6) will fall in potential, this fall now being communicated to the grid of V5B (pin 2) via R32, R31. V5B anode (pin 1) will rise in potential, and this rise is communicated to V4A grid (pin 1) causing V4A to conduct more heavily.

(e) The final result of all these changes is to decrease the d.c. resistance of V4A and increase that of V4B so that the potential at V4A cathode (pin 3) rises sharply. This sharp rise is now passed via C3 to the h.t. positive line, tending to oppose the original fall in voltage.

(f) If the output rises, the converse of all the above action will take place, causing opposition to the rise by a drop in potential at V4A cathode.

70. Slow Regulator. This circuit caters for relatively slow changes in the circuit conditions. The previous paragraph considered rapid changes, such as switching transients; allowance must also be made for slower voltage changes from the mains and d.c. changes due to the fact that, in the case of switching off or on a channel, after the switching transients have died away, there is a permanent load change due to the altered channel conditions. These slower changes are stabilised by the action of the transductor (saturable reactor) X1 in conjunction with the control valve V3. The action is as follows:

(a) When the rectifier conduction commences at each half cycle of the supply frequency, the back e.m.f. produced across X1 allows only a small amount of current to flow; this is due to the inductive reactance of X1, as with a normal smoothing choke. However, the core material of the transductor is of high permeability (such as mumetal) which saturates sharply for small changes in the magnetising force.

(b) Since the magnetising force is proportional to the rectified current, when the current reaches a certain value, saturation of X1 takes place. Under these conditions, the back e.m.f. across X1 disappears and normal rectifier conduction takes place.

(c) During the period when the rectifier output voltage is below that on C1, current flows through X1 in the reverse direction and the core flux moves towards negative saturation.

(d) The length of the conduction period (and therefore the output voltage) thus depends on the current allowed to flow through X1 in the reverse direction, and this can be controlled by varying the grid potential of V3. This potential is derived from pin 6 of V5, which provides feedback (via R20, RV2, R9, and R6) in the correct sense to oppose changes in output voltage. The level of stabilisation may be preset by the potentiometer RV2.

+ 150 Volt and - 150 Volt Power Units (fig. 27)

71. To all intents and purposes these units are identical, so only one circuit is shown. This diagram is mistitled "- 150 V"; the only distinction between the two units is R1, across the Brimistor R2. This is inserted in the + 150 V Power Unit, but since the current drain is less, the parallel resistor is not required in the - 150 V Power Unit.

72. Comparison of fig. 26 (+ 300 V Power Unit) and fig. 27 (-150 V Power Units) will show numerous similarities. The principle of operation of all the power units in the HL13/HL14 equipment is the same apart from a few minor differences. These are as follows:-

(a) In the + 300 V Power Units, the cathode of V6 is connected to h.t. negative via R38 and V2 holds the grid of V6A at + 85 V. In the + 150 V and - 150 V Power Units, the grid of V6A is at h.t. negative potential and the cathodes are held at - 85 V by V2. The latter's supply is derived from the 256 V bias winding and associated rectifier (MR5, MR6), smoothing (C12, R18, C13, R3), and stabiliser (V1).

(b) The bleeder drain between h.t. negative and h.t. positive in the + 300 V Power Unit consists of R41, R45, R46 to R55 inclusive, RV3 and R42 (R46 to R55 consisting of 10 x 12 k resistors in series). In both 150 V Power Units, the network is R41, R43 to R52 inclusive, RV3, and R42 (R43 to R52 consisting of 10 x 15 k resistors in series).

73. The two 150 V Power Units are almost identical, but it should be noticed that the only earth line shown is on the mains transformer. This makes the polarity of the output a comparitively easy matter to decide.

RECEIVER (VFT) TYPE 15150 (Marconi HL 14)

Purpose

74. The two-tone voice frequency (v.f.) telegraph equipment described in the following paragraphs is designed to convert the multi-channel tone output of a radio receiver (such as the HR 24), into double-current telegraph signals. These signals are then used to operate some form of 5 - unit apparatus, such as a teleprinter or receiving reperforator. The equipment is intended to be operated in conjunction with the Transmitter Type 15149 (Marconi HL 13) already described.

75. The equipment is in "dual diversity" and being so, minimises the effects of selective fading experienced on the radio link. Both this equipment and the HL 13 previously discussed, are intended for use as a multi-channel voice frequency transmitting/receiving equipment in conjunction with the techniques of single sideband transmission and reception.

Concise Details

76. The specifications given below are not rigid, the figures given are only typical examples.

(a) Bandwidth: 300 - 2420 c/s.

(b) Tone Frequencies: The lowest and highest frequencies are 425 c/s and 2295 c/s respectively, the tone separation being 170 c/s.

(c) Input Level: - 10 dBm in 600 ohms balanced, medium signal input. The circuits are designed to allow short term signal level variations between 0 dBm and - 35 dBm.

(d) Keying Speed: 50 - 100 bauds, synchronous or non-synchronous. Optimum performance is within the range 80 - 100 bauds.

(e) Demodulation: A slide-back system is used, the time constant being approximately 170 milliseconds.

(f) Outputs: There are two outputs:

- (i) 30-0-30 V with a source impedance of 4700 ohms - this being a direct output from the equipment.
- (ii) 80-0-80 V using a relay unit and an external signalling supply.

(g) Filters: The passband of the filters is as narrow as possible, consistent with a keying speed of 100 bauds.

(h) Power Supply: 110 V or 200-250 V, 40 - 60 c/s single phase a.c. Consumption 850 watts at 0.95 power factor.

General Description

77. Mechanical. The entire equipment is mounted in a 7 ft. cabinet which is divided into shelves front and rear. The various units are (as with the HL 13) narrow etched-wiring boards with their associated valves, switches, etc., mounted on the front panel. Units such as demodulators, recording bridge, or filters of one channel may be removed without affecting the remaining channels.

78. Electrical. The block schematic diagram (fig. 18) gives an overall picture of the operation of the HL 14. The operation of each of the six channels is identical. The composite tone signal from each of the diversity paths is applied through a gain control to an amplifier, one for each path. The output of the path amplifiers is applied to all the filters in that particular path, each filter passing only one tone. From the filters, the tones are applied to mark and space demodulators (detectors employing full-wave rectification). A "slide-back" system is also incorporated to ensure that the signal is always sampled at half amplitude. Thus, for one channel there are four detector outputs, two for mark (one from each diversity path) and two for space (again, one from each diversity path), and these outputs are combined in a linear manner, each contribution to the resultant in proportion to its amplitude. The combined output is limited and applied to a recording bridge, which is a d.c. amplifier chain delivering an output of 30-0-30 V either to line direct, or to a relay unit which gives an output at 80-0-80 V to line.

DETAILED DESCRIPTION

Input Amplifier (fig. 19)

79. This unit contains two identical amplifiers, one for each path. The description that follows will be for the Path A amplifier, the equivalent components for Path B being shown in brackets.

80. Input from line is at PLA 15 (PLA 14) and is fed to V1A (V2A) via the gain control RV1 (RV2); this control is a preset brought out to the front panel and marked "PATH A (B) LEVEL". Current negative feedback is applied in series with the input signal, being derived from the cathode resistors R5, R6 (R26, R27). R5 (R26), in conjunction with R4 (R25) arranges the normal self-bias for the valve.

81. The amplified tones appear across the anode load of the valve and are passed via C2 (C6) to the resistance chain R9 to R16 inclusive (R30 to R37 inclusive). This resistor chain is used in conjunction with the switch SWA1 (SWA2), located on the front panel and marked "CHANNELS OPERATIONAL". The eight positions of the switch are to compensate for the gain reduction in the HL 13, where the gain of each channel is reduced in proportion to the number of channels in use. For ONE channel, the output of V1A (V2A) is taken from the junction of R15, R16 (R36, R37); for TWO channels, the output is taken from the junction of R14, R15 (R35, R36); and so on up the chain, to the maximum of EIGHT channels, where the output is taken direct to V1B (V2B). Thus, the gain of the amplifier is increased with the number of channels in use. (It should be noted that both the HL 13 and HL 14 have provision for eight channel working, but it will be remembered from paragraph 64 that channels 7 and 8 are not used in this equipment - FS14 and FS15 in the Distribution Unit, fig. 25).

82. V1B (V2B) is a cathode follower, the output of which is taken via C4 (C8) to PLA 13 (PLA 12), where it is split to feed both the Path A (B) tone filters and the level indicator unit.

Level Indicator Unit (fig. 20)

83. The function of this unit is to facilitate measurement of the incoming signal, and it is permanently connected to the output of the Input Amplifier. There are two similar circuits in the unit and levels of both A and B Paths may be monitored simultaneously. The circuitry of the two meter amplifiers in this unit is identical with that of the Level Indicator in the HL 13 transmitting equipment, and the description given in paras 44 and 45 will apply here.

Bandpass Filters

84. The function of the filters is to separate the combined tone frequencies of the input and to route each individual tone to its correct demodulator.

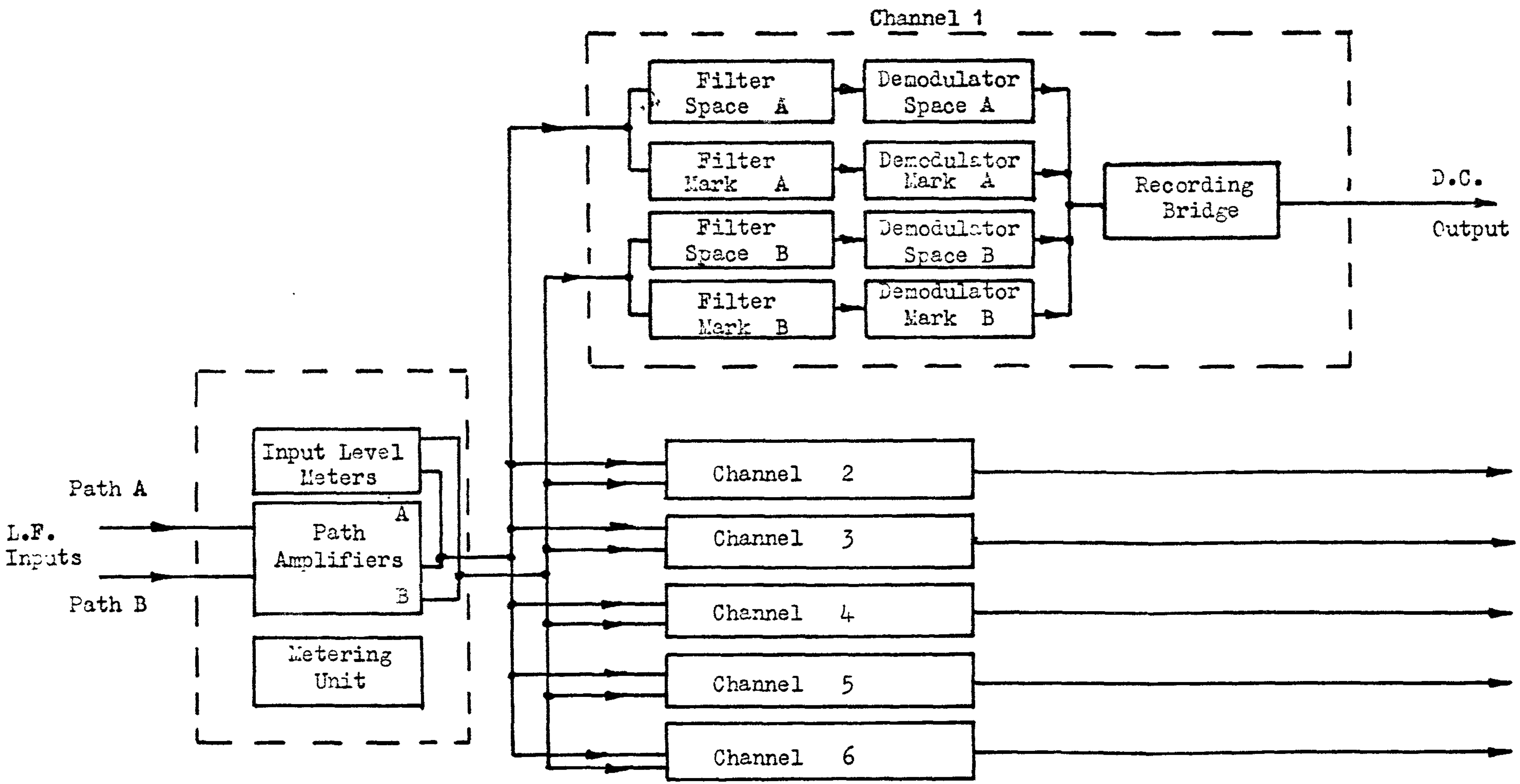
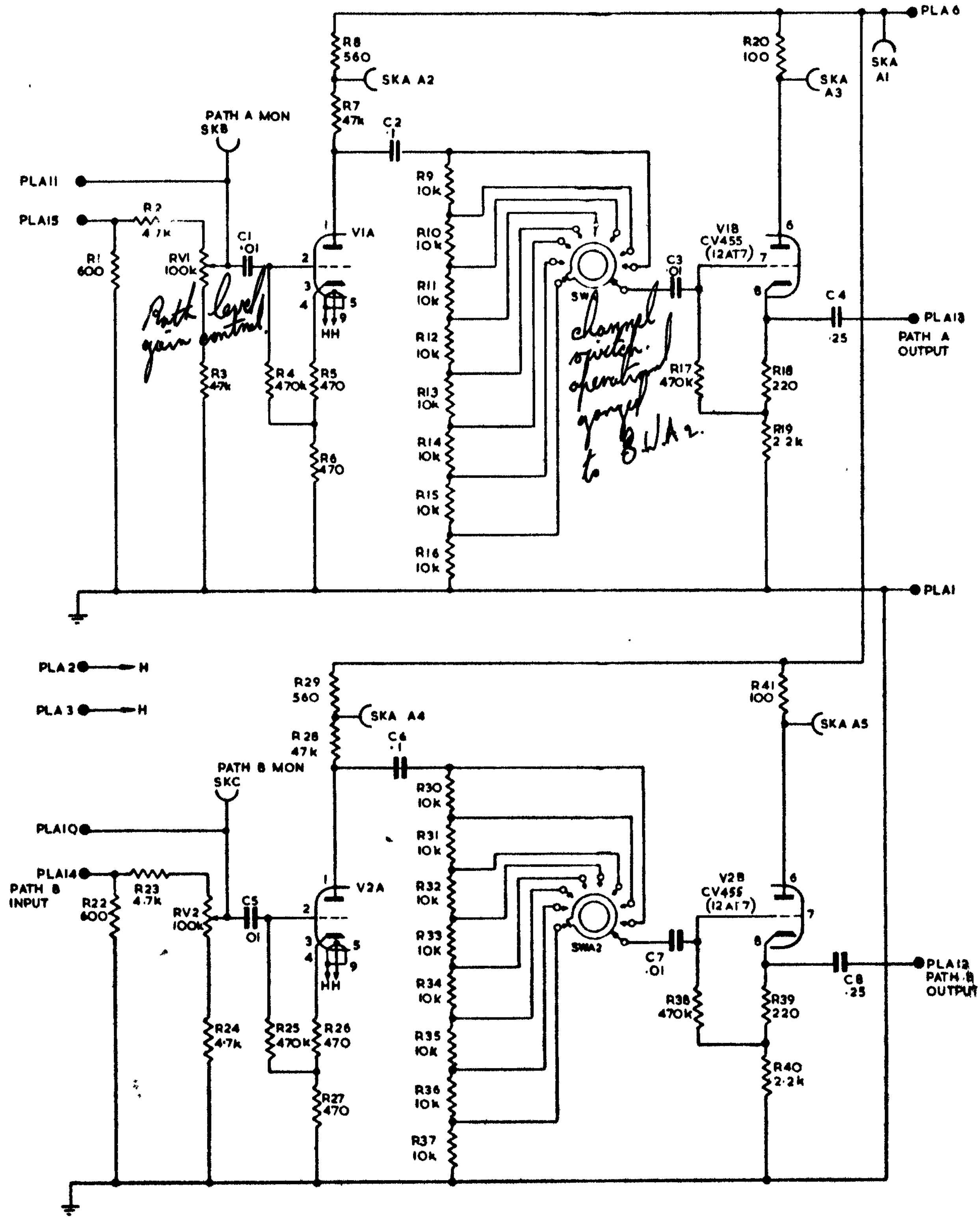


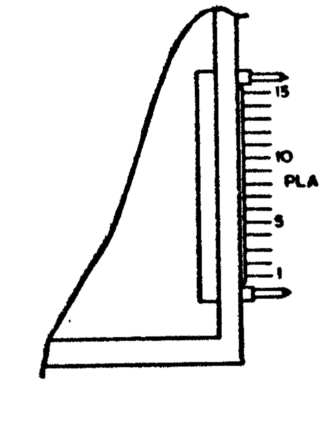
Fig. 18: Six-Channel V.F.T. Terminal (HL14) - block diagram



NOTE

ROTARY SWITCH SWA IS SHOWN IN POSN. 1 WHICH IS EXTREME ANTICLOCKWISE POSITION WHEN VIEWED FROM HANDLE END.

SWA 1 & 2	POSN 1	2	3	4	5	6	7	8
CHANNELS OPERATIONAL	1	2	3	4	5	6	7	8



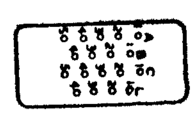

SKA

Fig. 19:

CIRCUIT DIAGRAM
INPUT AMPLIFIER
WZ.20703/B Sh.1 Iss.3

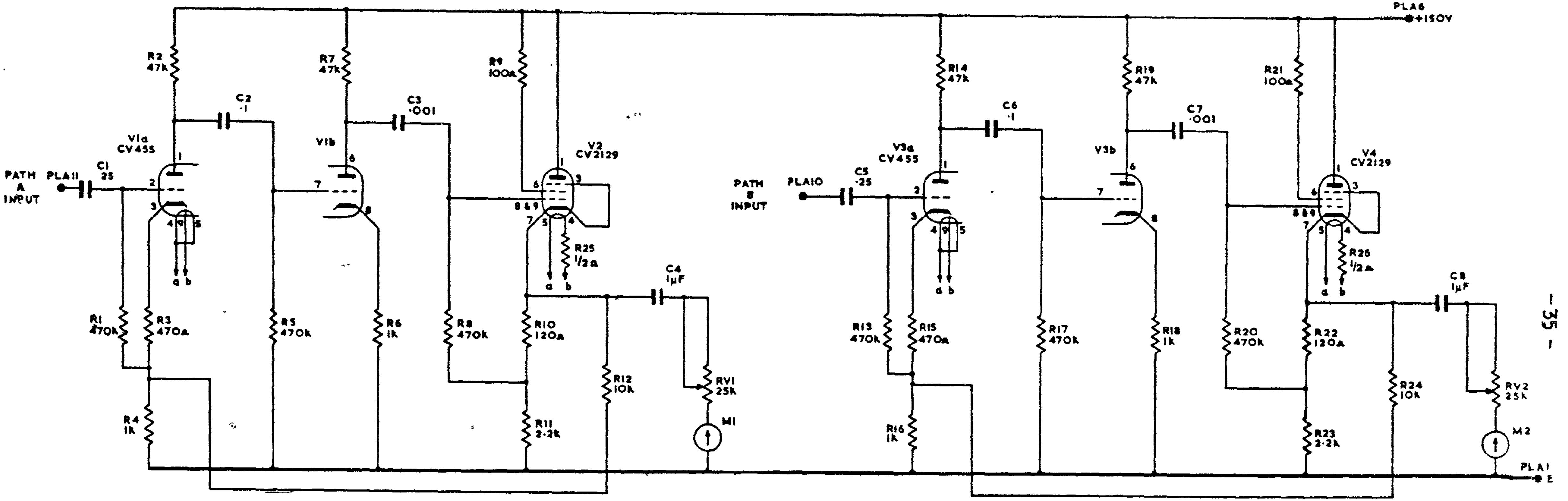
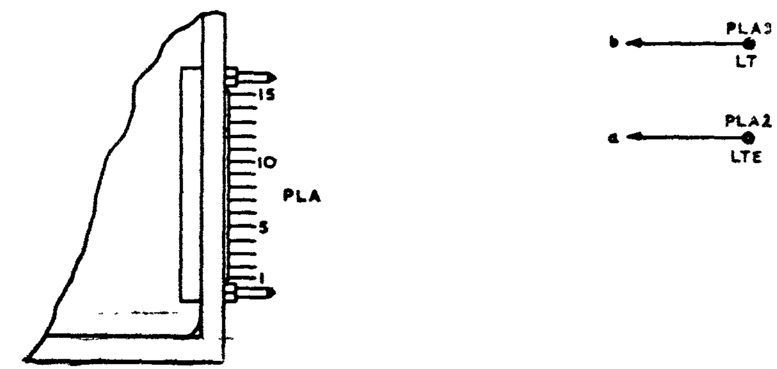


Fig. 20:

CIRCUIT DIAGRAM
PATH LEVEL METER UNIT
WZ.20705/D Sh.1 Iss.2



With six two-tone channels in dual diversity, there will be 24 filters; they are the same as those described for the HL13 and reference should be made to the section of the HL13 notes (paras 20 to 27), as well as fig. 6 and 7.

Demodulators (Mark and Space) (figs. 21 and 22)

85. The purpose of the demodulators (or detectors) is to convert the tones from the receive filters into positive and negative going pulses of d.c.; notice that this process is now the reverse of that carried out in the transmit side. All the demodulator units are identical, except for the direction of the output diodes; in this case, all MARK demodulators are identical and all SPACE demodulators are identical. As the equipment is in dual diversity, there will be two MARK units and two SPACE units for each channel, i.e. there are as many demodulator units as there are receive filters.

86. Demodulator (Mark) (fig. 21). The output from the appropriate MARK filter is fed into the unit at PLB 15. RV1 is a gain control potentiometer, R1 ensuring that, even with RV1 in the "fully out" position, there is always an input to the grid of V1A. V1A and B1B, with the associated circuitry, form a self-balancing phase splitter. R2 is a grid stopper and, with C8 between anode and earth, ensures elimination of high frequency pick up at this stage. The full output of V1A is developed across R4 and therefore appears across R10 via C1. This output is fed via the grid stopper R11 to the grid of V2A.

87. In parallel with R10, there is the resistor chain R6, R7, and R14; these latter resistors being in series, the voltage input to V1B will therefore be that portion of V1A output developed across R7 and R14. This will be approximately 0.75 of the output. It will be seen, therefore, that should the gain of V1A alter for any reason, or the input to V1A vary, the input to V1B will be adjusted in proportion.

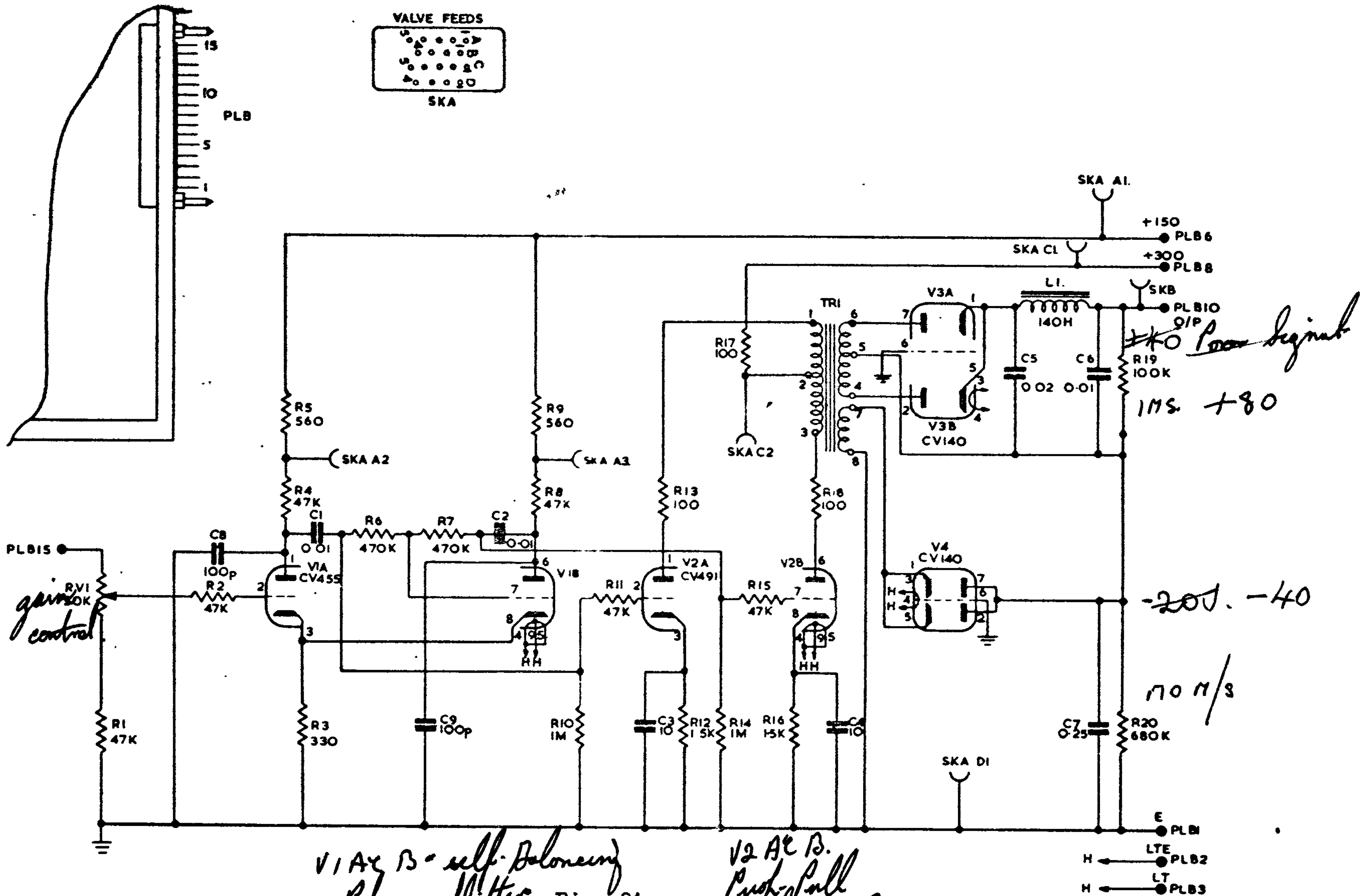
88. Due to the application of negative feedback, the gain of V1B is approximately 1.33, and the output of this stage is developed across R8; it will therefore appear across R14 via C2 from where it is fed via the grid stopper R15 to the grid of V2B.

89. Reconsidering the resistor chain referred to in para 87, it can now be said that R7, R6 and R10 are a series chain in parallel with R14. The voltage developed across R6 and R10 (approximately 0.75) is the negative feedback that determines the gain referred to in para 88. Therefore, the output of V1B will be 1.33 (the gain) times 0.75 (the applied proportion of V1A output) of the V1A output, i.e. V1B output will approximately equal V1A output, and will also be in anti-phase.

90. The antiphase outputs of V1A and V1B drive the push-pull amplifier V2, which operates under Class AB1 conditions. The anode load of the valve consists of the transformer TR1, which has two secondaries. V3 and its associated circuitry is connected to one secondary.

91. V3 is a detector circuit which will be recognised as a full-wave rectifier. When a tone frequency, modulated at the keying frequency, is present at TR1, detection takes place and the cathodes of V3 move in a positive direction. The capacitor input filter (C5, L1, C6) eliminates unwanted frequency components, leaving only the low frequency intelligence. This is in the form of a positive pulse at the output PLB 10.

92. At the same time, the other secondary of TR1, in conjunction with the half-wave rectifier (i.e., detector) V4, will produce a "slide-back" voltage. The output from V4 is in opposition to that of V3, by virture of the former's output being taken from its anode. The proportion of voltages applied as inputs to the two circuits is such that half the total signal voltage appears



V1A & B - self-balancing Phase splitter.

V2 A & B. Push-Pull in class AB1.

Fig. 21:

CIRCUIT DIAGRAM

DEMODULATOR (MARK)

WZ.20105/3 Sh.1 Iss.3

across winding 7 - 8 of TR1 (for the slide-back detector circuit), whereas the full signal voltage appears across windings 4 - 5, 5-6. Thus, the output of V4 is half of the V3 output and of opposite polarity.

93. The purpose of the slide-back detector is to ensure that the signal is always "sampled" at half amplitude and the output of the unit is the algebraic sum of signal and slideback outputs across R19 and R20. The time constant of discharge of C7, R20 is approximately 170 milliseconds, and the slideback voltage will therefore be unable to follow the modulation envelope of the received signal (i.e., the keying frequency). It will however follow the variations in amplitude of the signal over a relatively long period (such as variations caused by fading). Variations in amplitude would result in a varying bias condition in the telegraph circuits were it not for the presence of the slide-back voltage. Sampling at half amplitude is sampling at a point where this variation in bias is at a minimum.

94. RV1 provides a means of adjusting the output of the demodulator unit, so that it can be equalised to the outputs of others of the same channel. As in the case of the HL13 units, SKB is a monitor point and SKA a socket for connection of a lead to the VALVE FEEDS METER UNIT.

95. Demodulator (Space) (fig. 22). All the units are the same, and there are two for each channel (one for each diversity path). The circuitry is the same as that of the MARK demodulator except, as mentioned in para. 85, the diodes V3 and V4 are reversed. Consequently, the outputs are negative from V3 and positive from V4, and the output at PLB 10 is thus a negative SPACE voltage.

Recording Bridge (fig. 23)

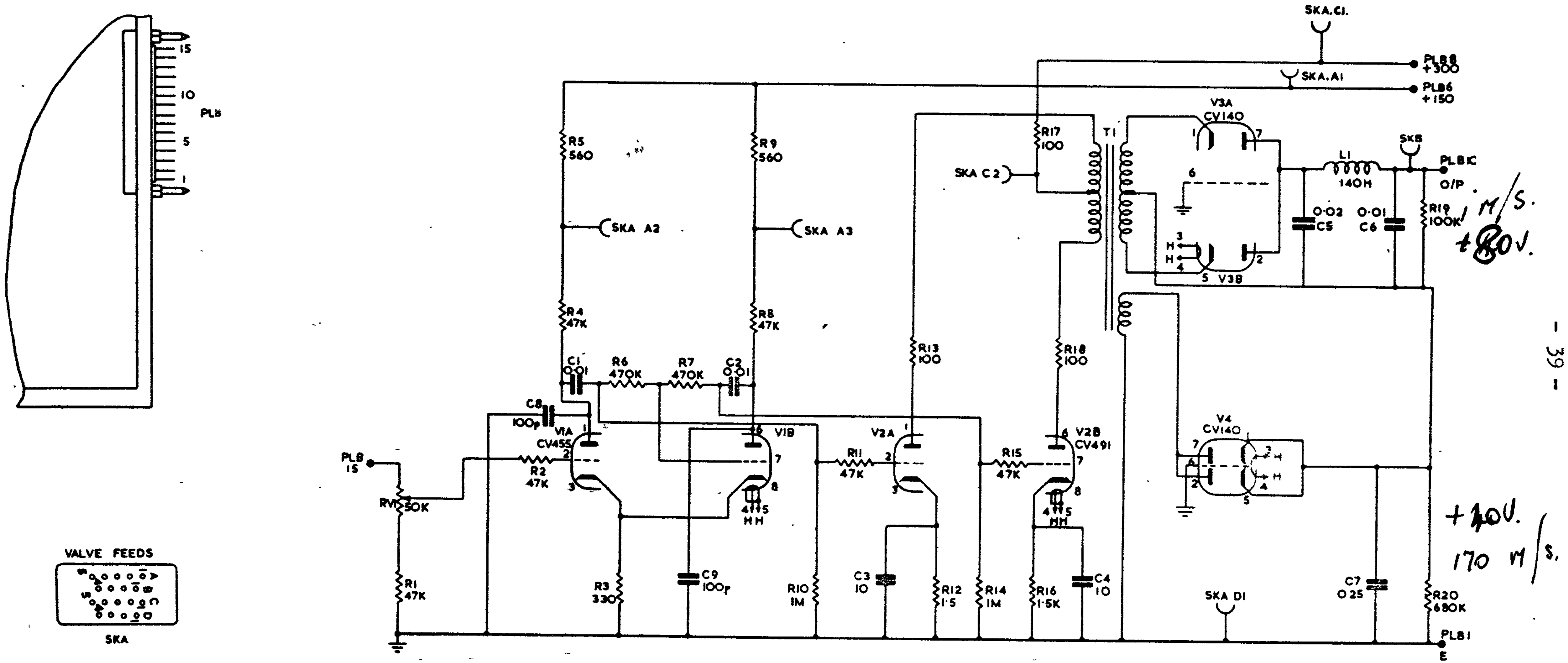
96. This unit is a d.c. amplifier chain delivering an output of 30 - 0 - 30 volts either to line direct, or to a relay unit which gives an output of 80 - 0 - 80 volts to line. There are four inputs - a MARK and a SPACE input from each diversity path.

97. The four demodulator outputs are fed into the unit via terminals PLA 12, PLA 13, PLA 14, and PLA 15, and are combined in a linear manner (resistors R1, R2, R3, and R4). From the common connection, the MARK or SPACE signal is applied to the grid of V1A via SWA1 (in the "TRAFFIC" position) and grid resistor R5.

98. SWA1 has four positions. On position one (MARK), a positive voltage is applied to V1A grid and on position two (SPACE), a negative voltage is applied. The positions are provided for test purposes only and during operation, SWA1 will be in position three (TRAFFIC). Position four (REVS) connects 50 cycles a.c. supply from a point on the potential divider network R30, R31 and R32 between the l.t. heater supply and earth, thus giving a "reversals" input, again for test purposes.

99. V1A operates either as an amplifier or clipper, dependent on whether the input is of low or high level. If the input is of low level, the positive and negative excursions of the grid swing do not give rise to grid current (positive limiting) or go beyond cut-off (negative limiting). With a high level input the effects of grid current and cut-off result in clipping of the signal. The output of V1A is therefore limited in amplitude.

100. V1B, which shares the cathode resistor R6, largely compensates for any change in heater voltage. Variations in this voltage would cause the anode current of V1A to alter and this would tend to alter the cathode potential (and therefore the bias) of V1A. An increase in current through R6 would raise the cathode potential and therefore increase the negative bias to V1A. However, the same increase in cathode potential causes the bias to V1B to increase, reducing the current taken by this valve. The combination of increase of current (due to heater voltage) and decrease of current (taken by V1B) results in a stabilisation of cathode and therefore bias potential. The potential at the cathode is approximately + 5.5 V with respect to earth.



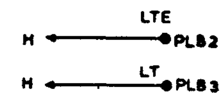
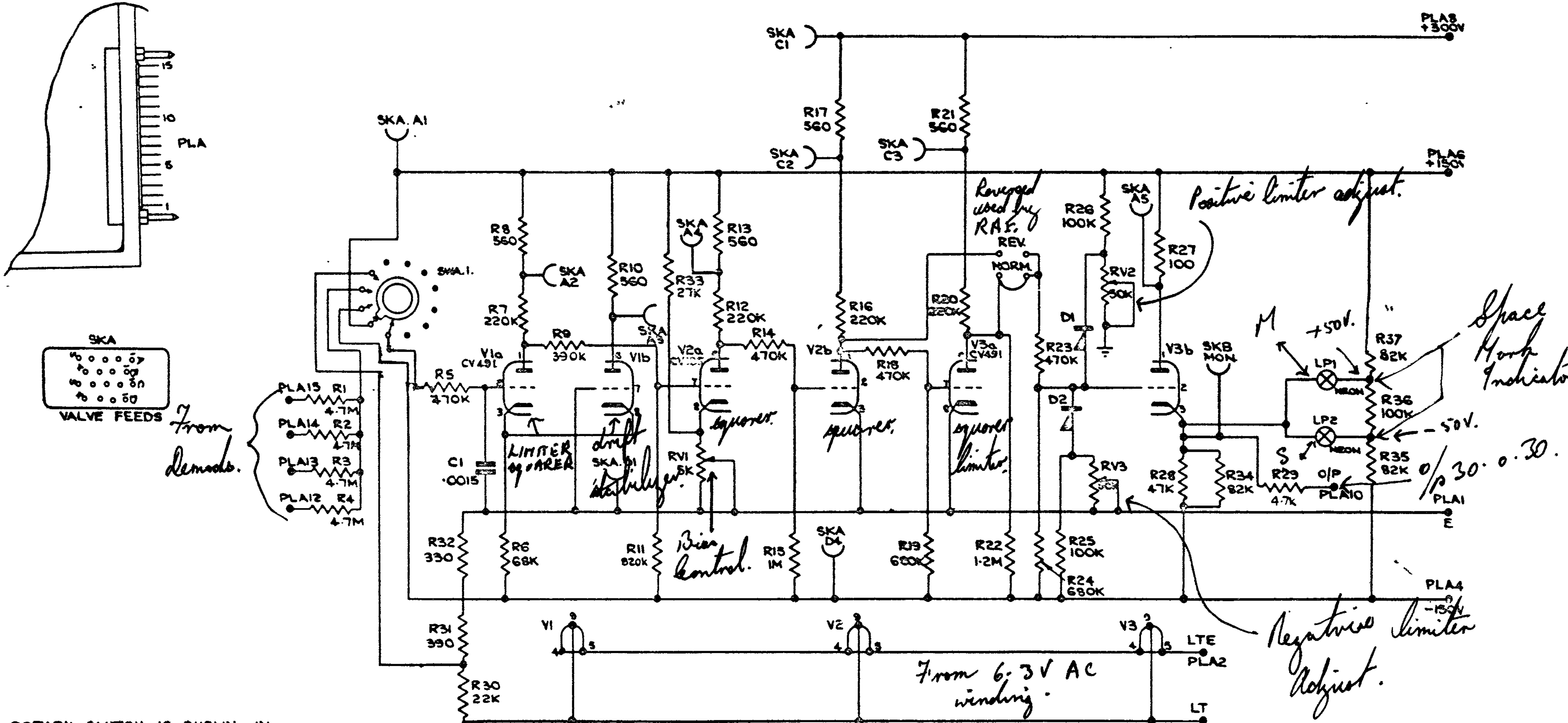


Fig. 22:

CIRCUIT DIAGRAM
DEMODULATOR (SPACE)
WZ.20106/B Sh.1 Iss.5



ROTARY SWITCH IS SHOWN IN POSN 1 WHICH IS EXTREME ANTI-CLOCKWISE POSN. WHEN VIEWED FROM HANDLE END

SWA1	POSN.1	2	3	4
	MARK	SPACE	TRAFFIC	REVS

Fig. 23:

CIRCUIT DIAGRAM
RECORDING BRIDGE

101. V2 is a d.c. amplifier. V2A is fed from the anode of V1A, via the potential divider R9, R11 between V1A anode and - 150 V h.t. RV1 in the cathode (located on the front panel and marked ZERO ADJUST) alters the bias to V2A and is adjusted to compensate for signal bias introduced in the unit. This is achieved by applying sine wave reversals (from SWA, position 4) to the input of the unit and connecting an oscilloscope to the output of the unit (SKB MON). A mains frequency square wave is displayed and RV1 is adjusted for equal length of MARK and SPACE elements.

102. V2B is a further d.c. amplifier stage and has two outputs, one from the junction of the potential divider R18, R19 to drive V3A, and the other from the anode direct to the REVERSE/NORMAL link (in the REVERSE position). V3A is a d.c. amplifier stage and the output is passed to V3B via the REVERSE/NORMAL link (in the NORMAL position). However, under the latter condition, the polarity of the MARK output will be positive and the SPACE will be negative. This is the opposite of Service requirements and the link is therefore connected in the REVERSE position, so that V2B is connected to V3B and V3A (with its 180° phase reversal) is bypassed; thus, a negative MARK and a positive SPACE appear at the output.

103. The signal from the anode of V2B is now passed to the grid of V3B via the potential divider R23, R24. D1 and D2 are clamping diodes and the action of these components is similar to the diodes in the HL13 Input Unit (see para. 9). Both diodes are back-biased and the rheostats RV2 and RV3 are used to adjust the bias to give the required MARK and SPACE voltages at the unit output. Again, this is achieved by the use of SWA (this time in the test positions 1 - MARK - and 2 - SPACE), whereby a test voltage is applied to the unit input and the output voltage measured at monitor point SKB. The voltage should be 30, polarity depending on whether MARK or SPACE, and RV2, RV3 are adjusted to obtain this figure.

104. V3B is connected as a cathode follower output stage and no phase reversal of signal is introduced. The output is at PLA 10 and will be a 30 - 0 - 30 V low current output.

105. Two neon lamps, LP1 and LP2, provide visual indication of the output, the action being as follows:

(a) Between + 150 V h.t. and - 150 V h.t., there is a chain of resistors, R35, R36, and R37. LP1 and LP2 are in series across the centre resistor R36. The junction of the two neons is connected to the cathode of V3B, which is operating above and below earth potential, according to the polarity of the signal output.

(b) LP1 is connected to the positive end of R36, which is at a potential of + 50 V and LP2 to the negative end, which is at - 50 V.

(c) When the cathode of V3B swings to + 30 V, the potential across LP2 is sufficient to cause it to strike. When the cathode swings to - 30 V, the potential across LP2 increases in a similar manner and that in turn will strike. Visual indication of output polarity is thus given.

Relay Unit (fig. 24)

106. This unit provides a means of converting the 30 - 0 - 30 V low current output of the recording unit to an 80 - 0 - 80 V output, using an external supply. The input from the recording unit is fed in at PLA 10 and via R4, to the coils of the polarised relay RLA/1. The coils of the relay are series aiding and R4 presents the correct impedance to the recording unit. The ± 80 V signalling supply is applied to the M/S contacts of RLA1 via PLA 14, LPR1, SWA, L1c, and via PLA4, LPR2, L1b. SWA is the REVERSE OUTPUT switch and operation of this switch enables reversal of the line output polarity. L1b, C1, R1; L1c, C2, R2; and L1a, C3, R3 form spark suppression circuits. LPR1 and LPR2 are "guard" lamps.

107. The output is fed from the tongue of the relay via L1a and PLA 15 to line. PLA 15 is taken to terminal strips in the roof and the base of the cabinet and the output may be connected as convenient. SKA is a front panel monitoring point for checking the line output.

Power Distribution Panel (fig. 28)

108. This unit is similar to that of the HL13, except that an extra transformer (TR3) is added. The loading by the heater circuits on the HL14 has its own l.t. winding from a transformer. The supply for the common units is obtained from the second winding of TR1, which also supplies Channel 2 heaters.

109. It will be remembered that the Distribution Unit of the HL13 was fitted with windings for Channels 7 and 8, although these are not in use in six-channel working. The Distribution Unit of the HL14 has no windings for the extra channels, but should they be required, circuitry is available, except that connection would have to be made to a fourth transformer (TR4) which would be fitted in the base of the cabinet.

Valve Feeds Motor Unit

110. This unit is identical with that used in the HL13. Details will be found in the section on the Transmitter Type 15149 (paras. 46 to 48 above).

Power Units

111. There are three power units, providing + 300 V, + 150 V and - 150 V. This is the same arrangement as for the HL13, and (except that the output current loading is different), the units are identical to those already described. A description of the units will be found in the section on the Transmitter Type 15149 (paras. 66 to 73) and figs. 26 and 27.

112. Whilst on the subject of the power units, it may be noted here that the construction of silicon rectifiers is similar to that of other semi-conductor devices, such as germanium or selenium. The silicon type has advantages over the others, three of which are:

(a) Silicon rectifiers have a long "ageing" characteristic, i.e. the non-linear characteristic of the device does not alter with time to the same extent as other types of rectifiers.

(b) They can operate at a temperature of 2000° C without an excessive voltage drop across them.

(c) They are physically small.

Appendices

113. A number of appendices follow these notes, dealing with current and voltage checks, level checks, setting up instructions, etc.

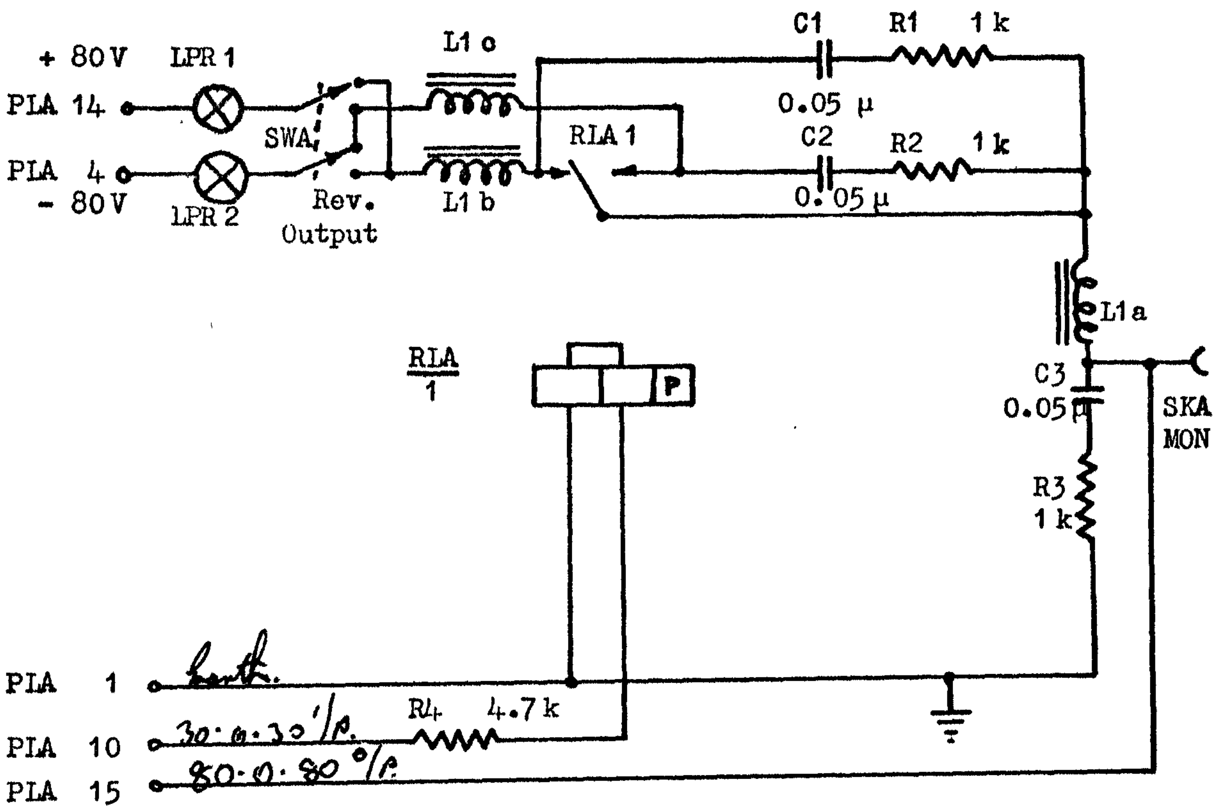


Fig. 24: Circuit Diagram of Relay Unit

APPENDIX A

VALVE CURRENTS AND H.T. VOLTAGE CHECKS

1. Transmitter (VFT) Type 15149 (HL13). Check valve currents and h.t. as follows:-

(a) Connect internal meter lead between socket SKA on the unit under test and plug PLA on the Valve Feeds Meter Unit.

(b) Set the meter and selector switches as indicated in Table 1 and check readings.

TABLE 1

UNIT	VALVE OR SUPPLY	METER SWITCH POSITION	SELECTOR SWITCH POSITION	READING		METER F.S.D.
				MARK	SPACE	
Transmitter Input	V1A	VALVES	1*	2.1	0.4	5 mA
	V1B	"	2*	0.4	2.1	"
	V2A	"	3	2.2	0.7	"
	V2B	"	4	0.2	0.65	"
	V3A	"	5	4.1	1.7	"
	V3B	"	6	4.8	1.6	25 mA
	+150V	SUPPLIES	2	150		500 V
	-150V	SUPPLIES	3	150		500 V
Tone Oscillators	V1A	VALVES	7	2.2		5 mA
	V1B	"	8	10		25 mA
	V2A	"	9	2.2		5 mA
	V2B	"	10	6.25		25 mA
	+300V	SUPPLIES	1	300		500 V
Bandpass Filters	V1A	VALVES	1	1.3		5 mA
	V1B	"	2	4.5		25 mA
	+150V	SUPPLIES	2	150		500 V
Channel Amplifiers	V1	VALVES	1	7.5		25 mA
	+150V	SUPPLIES	2	150		500 V
Single Channel Attenuator	V1A	VALVES	7	3.2		5 mA
	V1B	"	8	3.7		"
	V2	"	1	12 ≠		25 mA
	+300V	SUPPLIES	1	300		500 V
	+150V	"	2	150		"
	-150V	"	3	150		"
Common Amplifier	V1A	VALVES	7	3.3		5 mA
	V1B	"	8	3.7		"
	V2	"	9	36		50 mA
	+300V	SUPPLIES	1	300		500 V

TABLE 1 (CONT'D)

UNIT	VALVE OR SUPPLY	METER SWITCH POSITION	SELECTOR SWITCH POSITION	READING		METER F.S.D.
				MARK	SPACE	
	V1	VALVES	11	0.04		1 mA
	V2A	"	1	0.8		5 mA
	V2B	"	2	0.8		"
Check	V3A	"	3	0.8		"
Oscillator	V3B	"	4	0.8		"
Unit A	V4A	"	5	0.8		"
	V4B	"	6	0.8		"
	+150V	SUPPLIES	2	150		500 V
	+ 50 V	"	4	50		"
	V1A	VALVES	1	0.8		5 mA
	V1B	"	2	0.8		"
Check	V2A	"	7	2		"
Oscillator	V2B	"	8	4.5		"
Unit B	V3	"	9	2.5		"
	+300V	SUPPLIES	1	300		500 V
	+150V	"	2	150		"

NOTE: On no account should the metering unit be used for making adjustments to the supply voltage.

≠ Maximum feed with one channel in use.

* Note that these readings are for "Positive Mark" inputs. They will be reversed if the switch SWA is modified as per para. 6 of these notes.

2. Receiver (VFT) Type 15150 (HL14)

Measure the valve currents and h.t. voltages as follows:

(a) Connect the internal meter lead between socket SKA on the unit under test and plug PLA on the valve feeds metering unit.

(b) Set the meter and selector switches as indicated in Table 2 and compare readings.

TABLE 2

UNIT	VALVE OR SUPPLY	METER SWITCH POSITION	SELECTOR SWITCH POSITION	READING		METER F.S.D.
Input Amplifier	V1A	VALVES	1	1.5		5 mA
	V1B	"	2	5.0		25 mA
	V2A	"	3	1.5		5 mA
	V2B	"	4	5.0		25 mA
	+150V	SUPPLIES	2	150		500 V
Bandpass Filters	V1A	VALVES	1	1.3		5 mA
	V1B	"	2	4.5		25 mA
	+150V	SUPPLIES	2	150		500 V
Demodulators	V1A	VALVES	1	1.5		5 mA
	V1B	"	2	1.5		"
	V2	"	7	15		25 mA
	+300V	SUPPLIES	1	300		500 V
	+150V	"	2	150		"
Recording Bridges				MARK	SPACE	
	V1A	VALVES	1	0.7	0.3	5 mA
	V1B	"	2	1.6	2.2	"
	V2A	"	3	0.3	0.7	"
	V2B	"	7	1.25	0.5	"
	V3A	"	8	0.5	1.2	"
	V3B	"	4	10.0	1.0	25 mA
	+500V	SUPPLIES	1	300		500 V
	+150V	"	2	150		"
	-150V	"	3	150		"

NOTE: On no account should the metering unit be used for making adjustments to the supply voltages.

APPENDIX B

INITIAL LEVEL CHECKS TO TRANSMITTER (VFT) TYPE 15149 (HL13)

Test Equipment

1. The following items of test equipment are required for initial level checks:

(a) 10S/16373 Valve Voltmeter Type CT54.

(b) 10W/18318 Resistor 600-ohm 1/2 watt.

2. Perform preliminary adjustments as follows:

(a) Connect a 600-ohm 1/2 watt close tolerance resistor across the V.F. OUTPUT and remove the lines.

(b) Set the attenuator on the Common Amplifier to + 10 dB.

(c) Set the Single Channel Attenuator to 0 dB.

(d) Set the Channel Amplifier switch to ON for the channel under test and set the switches on the other five channels to OFF.

Space Adjustments

3. Perform SPACE condition adjustments as follows:

(a) Set the TEST switch on the transmitter input unit to SPACE.

(b) Connect the valve voltmeter type CT54 between monitor point SKB and earth on the SPACE oscillator.

(c) Adjust the SPACE oscillator AMPLITUDE control for a reading of 2 volts on the valve voltmeter.

(d) Transfer the valve voltmeter to monitor point SKB on the SPACE filter.

(e) Adjust the SPACE modulator AMPLITUDE control to give 600 mV on the valve voltmeter

(f) Disconnect the valve voltmeter.

Mark Adjustments

4. Perform MARK condition adjustments as follows:

(a) Set the TEST switch on the transmitter input unit to MARK.

(b) Connect the valve voltmeter type CT54 between monitor point SKB and earth on the MARK oscillator.

(c) Adjust the oscillator AMPLITUDE control for a reading of 2 volts on the valve voltmeter.

(d) Transfer the valve voltmeter to monitor point SKB on the MARK filter.

(e) Adjust the MARK modulator AMPLITUDE control to give 600 mV on the valve voltmeter.

(f) Disconnect the valve voltmeter.

5. Repeat paragraphs 2 to 4 for the other five channels.

Final Adjustments

6. Adjust GAIN control on the Channel Amplifier to give zero dBm to line as indicated on the level meter.

NOTE: There may be a slight discrepancy between readings on the level meter for MARK and SPACE on any one channel. The mark or space AMPLITUDE control on the Modulator should be re-adjusted so that the outputs are equal.

7. Complete the level checks as follows:

(a) Set the output attenuator on the LEVEL INDICATOR to 0 dB.

(b) Remove the 600-ohm resistor from the V.F. OUTPUT terminals and reconnect the lines.

(c) Make the equipment operational by setting the required channel TEST switch to TRAFFIC and the ON/OFF switch to ON.

NOTE: If only one channel is to be used, the Single Channel Attenuator switch should be set accordingly.

APPENDIX C

USE OF TEST FRAME

1. Any unit under test is extended for ready accessibility by use of the Test Frame as follows:

(a) Slacken the retaining screws of the unit to be extended,

(b) Remove the unit and insert the test frame in its place.

(c) Tighten the retaining screws.

(d) Insert the unit into the test frame.

(e) Tighten the retaining screws.

NOTE: Special test leads with long prods for inserting into monitor points are supplied with the equipment and these should be used.

WARNING!!!

Dangerous voltages exist on the units when they are operated in the extended position and care should be taken when connecting test equipment or making adjustments.

APPENDIX D

SETTING UP THE TRANSMITTER (VFT) TYPE 15149 (HL13) INPUT UNITS

Test Equipment

1. The following items of test equipment are required to set up the input units:

(a) Test Frame (supplied with the equipment).

(b) 10S/6625-9437177 Oscilloscope Type CT 386A.

(c) 10S/17447 Multimeter Type 12889.

(d) 10S/17124 Test Set Telegraph Type 14013.

(e) 10S/16373 Valve Voltmeter Type CT54.

(f) Voltage Supply Unit.

Sensitivity

2. Check the sensitivity of the transmitter input unit as follows:

(a) Extend the unit in the test frame as detailed in Appendix C.

(b) Make up test voltage supply unit.

(c) Set TEST switch to TRAFFIC.

(d) Apply 20 volts positive to monitor point SKC, thereby setting the trigger in the positive position.

(e) Connect the oscilloscope between monitor point SKB and earth.

(f) Adjust the test voltage supply unit for 5 volts negative and slowly increase the voltage until the trigger flips over to the negative condition as indicated in the oscilloscope.

(g) Note the applied voltage.

(h) Adjust the test voltage supply unit for 5 volts positive and slowly increase the voltage until the trigger flips over to the positive direction.

(j) Note the applied voltage.

(k) Compare the voltage readings noted in paras (g) and (j). They should be approximately 15 volts and equal to each other within 0.5 volt. If this condition is not met, RV1 should be adjusted by small amounts and the procedure repeated until a satisfactory balance is obtained.

(l) Disconnect the oscilloscope and voltage supply unit.

Mark and Space Balance

3. Check MARK and SPACE balance as follows:

(a) Connect the test telegraph sender to the appropriate VF INPUT terminals.

(b) Connect the valve voltmeter between monitor point SKB (OUTPUT) and earth.

(c) Switch the telegraph sender to SPACE and note the reading on valve voltmeter, it should be between 5.25 volts and 8.75 volts.

(d) Switch the telegraph sender to MARK and adjust RV3 to obtain a meter reading equal to that taken in para (c)(SPACE condition).

(e) Restore the input unit to its normal position (i.e., remove the test frame).

4. Repeat paras 2 and 3 for the other five channels.

Input Unit Keying

5. Check the transmitter input keying as follows:

(a) Switch the telegraph sender to 100 Baud reversals and apply to the appropriate VF INPUT terminals.

(b) Connect the oscilloscope between monitor points SKB and earth; adjust RV5 (SIGNAL BIAS) for equal lengths of the MARK and SPACE elements portrayed on the oscilloscope.
NOTE: The total bias variation obtainable should be at least 15%.

(c) Refer to the TIM/CM control and the X EXPANSION control on the oscilloscope; having obtained a stationary picture, measure the curbing of the trapezoidal waveform. It should be within the limits of 1 to 3 milliseconds (see fig. 1).

(d) Repeat subparas (a) to (c) for the other five channels.

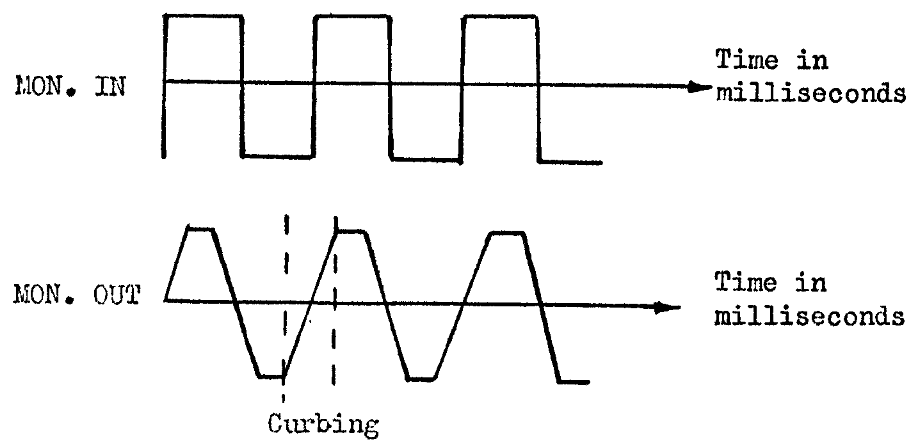


Fig. 1: Waveforms for Transmitter Input Units

APPENDIX E

SETTING UP THE TONE OSCILLATOR FREQUENCIES AND VOLTAGES

Test Equipment

1. The following items of test equipment are required for setting up the tone oscillator frequencies and voltages:-

(a) Test Frame (supplied with the equipment).

(b) 10V/16498 Test Oscillator Type M26.

(c) 10S/6625-9437177 Oscilloscope Type CT 386A.

(d) 10S/16710 Valve Voltmeter Type 8187.

(e) 10S/16373 Valve Voltmeter Type CT54.

Frequency Checks

2. Check the frequency of the tone oscillators as follows:-

(a) Connect monitor point SKB of the tone oscillator to monitor point SKD on the check oscillator Unit B.

(b) Connect monitor point SKB on the check oscillator Unit B to the X-plate of the oscilloscope.

(c) Connect monitor point SKC on the check oscillator Unit B to the Y amplifier of the oscilloscope.

(d) Ensure that the oscilloscope has been switched OFF for at least 30 seconds and connect monitor point SKE on the check oscillator Unit B to the grid of the socilloscope. Switch the oscilloscope to ON.

WARNING!!!

The grid of the oscilloscope, when switched on, is at a very high negative potential with respect to earth.

(e) Adjust RV1 on the check oscillator Unit B to give a trace of suitable diameter and adjust RV2 for a circular trace.

(f) Count the number of sections ("bright ups") on the trace and check against Table 1.

FREQUENCY	SECTIONS	FREQUENCY	SECTIONS
425 c/s	5	1445 c/s	17
595 "	7	1615 "	19
765 "	9	1785 "	21
935 "	11	1955 "	23
1105 "	13	2125 "	25
1275 "	15	2295 "	27

NOTE: If the trace appears to be rotating, the frequency of the oscillator is incorrect and the direction of rotation indicates whether the frequency is high or low.

Tuning

3. Adjust the tone oscillator frequency as follows:-

(a) Release lock nut on C7.

(b) Adjust C7 to give a stationary trace with correct number of sections.

(c) Tighten lock nut.

Frequency Adjustment

4. If C7 fails to give stationary trace, proceed as follows:-

(a) Extend the unit in the test frame (see Appendix C).

(b) Set RV1 and RV2 to mid-position.

(c) Release lock nut on C7 and set the capacitor to mid-position.

(d) Connect point SKB of Tone Oscillator under test to SKD on test oscillator Unit B.

(e) Connect the valve voltmeter across R2.

(f) Unsolder or solder-in capacitors C3, C4, C5 and/or C6 as necessary to bring the frequency as near as possible to give a stationary trace with the correct number of sections, making final adjustment to C7.

(g) Tighten lock nut on C7.

(h) Adjust RV1 for a valve voltmeter reading of 0.35 volts; this reading is not critical, but adjustment of RV1 will necessitate re-adjustment of C7.

(j) Transfer the valve voltmeter to monitor point SKB and earth, and adjust RV2 for a reading of 2 volts.

(k) Disconnect the oscilloscope, valve voltmeter and test oscillator Unit B.

(l) Remove test frame and restore the unit to its normal position.

APPENDIX F

SETTING UP THE MODULATOR VOLTAGES IN TRANSMITTER TYPE 15149 (HL13)

Test Equipment

1. The following item of test equipment is required for setting up the modulator stages:-

10S/16710 Valve Voltmeter Type 8187

2. Adjust the modulator voltages as follows:-

(a) Connect the valve voltmeter between monitor point SKB (MARK OUTPUT) and earth.

(b) Set the appropriate channel test switch to MARK.

(c) Adjust AMPLITUDE control RV1 for a reading of 1 volt on the valve voltmeter.

(d) Set the appropriate channel test switch to SPACE and ensure that the valve voltmeter reads less than 10 mV.

(e) Transfer the valve voltmeter to monitor point SKA (SPACE OUTPUT) and earth.

(f) Adjust AMPLITUDE control RV2 for a reading of 1 volt on the valve voltmeter.

(g) Set the appropriate channel test switch to MARK and ensure that the valve voltmeter reads less than 10 mV.

(h) Disconnect the valve voltmeter.

APPENDIX G

CHANNEL AMPLIFIER VOLTAGE ADJUSTMENTS IN TRANSMITTER TYPE 15149

Test Equipment

1. The following items of test equipment are required to check the channel amplifier voltages:-

(a) Test Frame.

(b) 10S/16710 Valve Voltmeter Type 8187.

(c) 10C/5356 Capacitor 0.1 μF 350 volt working.

2. Adjust the channel amplifier voltages as follows:-

(a) Extend the unit in the test frame and switch all other channels OFF.

(b) Connect the valve voltmeter between pin 1 of V1 and earth.

(c) Set the appropriate channel test switch to MARK and adjust CHANNEL GAIN control for a reading of 0.1 volt on the valve voltmeter.

(d) Transfer the valve voltmeter to pin 5 of V1 in series with a 0.1 μF capacitor of 350 volts rating and ensure that the reading is 0.6 volts plus or minus 15%.

(e) Disconnect the valve voltmeter.

(f) Remove test frame and restore unit to its normal position.

APPENDIX H

SINGLE CHANNEL ATTENUATOR VOLTAGE AND FUNCTION CHECKS IN TRANSMITTER TYPE 15149

Test Equipment

1. The following items of test equipment are required to check the voltages of the single channel attenuator:-

(a) Test Frame.

(b) 10S/16170 Valve Voltmeter Type 8187.

Preliminary Adjustments

2. Check the voltage of the single channel attenuator as follows:-

(a) Extend the unit in the test frame (see Appendix C).

(b) Set the attenuator switch SWA to 0 dB.

(c) Connect the Valve Voltmeter between monitor point SKB and earth.

(d) Set Channel 3 Test Switch to SPACE and the ON/OFF switch to ON.

(e) Set Channels 1, 2, 4, 5 and 6 ON/OFF switches to OFF.

Voltage Readings

3. Ensure that the voltage reading is 0.5 volts plus or minus 20% .

4. Repeat the above procedure for Channel 1 SPACE and Channel 6 MARK. The voltage readings should not vary from each other by more than 5%.

Setting the Output Levels

5. Set the output levels as follows:-

(a) Set Channel 1 Test Switch to MARK and ON/OFF switch to ON.

(b) Switch remaining Channels OFF.

(c) Adjust Channel 1 CHANNEL GAIN control for a reading of 0.1 V on the valve voltmeter.

(d) Repeat (a), (b), and (c) for the other five channels.

Attenuator Switch

6. Check the function of the attenuator switch as follows:-

(a) Set Channel 1 Test Switch to MARK and ON/OFF switch to ON.

(b) Switch the remaining Channels OFF.

(c) Leaving the valve voltmeter connected between monitor point SKB and earth, ensure that the voltage reading is progressively reduced when the attenuator switch SWA is moved from 0 dB to 6 dB, and that the cumulative error does not exceed 0.5 dB.

(d) Ensure that with any two channels switched on, the attenuator switch SWA is inoperative, and has no effect on the voltage reading between SKB and earth.

7. Disconnect the valve voltmeter, remove the test frame and restore the attenuator to its normal position.

APPENDIX J

COMMON AMPLIFIER VOLTAGE CHECKS IN TRANSMITTER TYPE 15149

Test Equipment

1. The following items of test equipment are required to check the common amplifier voltages:-

(a) Test Frame.

(b) 10S/16373 Valve Voltmeter Type CT54.

(c) 10W/18381 Resistor 600-ohms 1/2 watt, close tolerance.

Preliminary Adjustments

2. Perform preliminary adjustments as follows:

(a) Extend the common amplifier in the test frame (see Appendix C).

(b) Remove the level indicator unit.

(c) Connect a 600-ohm 1/2 watt close tolerance resistor between monitor point SKB and earth. Disconnect external lines.

(d) Set switch SWA fully clockwise.

(e) Set Channel 3 ON/OFF switch to ON.

(f) Set Channel 3 Test Switch to SPACE.

(g) Switch remaining channels OFF.

(h) Set valve voltmeter to a.c. 2.5 volt range.

Voltage Measurements

3. Measure voltages as follows:-

(A) Connect the valve voltmeter between V2 pin 7 and earth, and ensure that the voltage is 5 volts plus or minus 20 %.

(b) Transfer the valve voltmeter between SKB and earth and ensure that the voltage is 2.5 volts ± 20 %.

(c) Repeat the above operations on Channel 1 SPACE and Channel 6 MARK respectively.

(d) Disconnect the valve voltmeter, 600-ohm resistor, remove test frame and restore the amplifier and level indicator units to their normal position.

(e) Reconnect external lines.

APPENDIX K

BANDPASS FILTER UNIT LEVEL CHECKS IN TRANSMITTER TYPE 15149

Test Equipment

1. The following item of test equipment is required to check the levels of the bandpass filters:-

10S/16710 Valve Voltmeter Type 8187.

Level Checks

2. Perform level checks as follows:-

(a) Set the appropriate channel MARK/SPACE/TRAFFIC switch to MARK or SPACE to give the signal or condition for the tone of the required frequency under test.

(b) Connect the valve voltmeter between point SKC (FILTER IN) and earth. The voltage should be between 0.8 volts and 1 volt.

(c) Transfer the valve voltmeter between point SKB (FILTER OUT) and earth. The voltage should now be between 0.5 volts and 0.8 volts.

(d) Measure the level at monitor point SKB on the corresponding modulator unit. Note the reading.

(e) Measure the level at monitor point SKB on the filter unit. NOTE the reading.

(f) The difference between the readings taken in sub-para (d) and sub-para (e) is the total loss of the filter unit and should not be more than 6 dB down for any channel.

APPENDIX L

INITIAL LEVEL VOLTAGE ADJUSTMENTS IN RECEIVER TYPE 15150 (HL14)

Test Equipment

1. The following items of test equipment are required for initial level voltage adjustments:

(a) 10S/16170 Valve Voltmeter Type 8187.

(b) 10V/16498 Test Oscillator Type M26.

(c) 10S/6625-9437177 Oscilloscope Type CT 386A.

Path A

2. Perform the Path A level voltage adjustments as follows:

(a) Connect the test oscillator between the Path A VF INPUT terminals and disconnect the lines.

(b) Connect the valve voltmeter between PLA 11 and earth on the Path Level Meter Unit.

(c) Set the test oscillator frequency to 425 c/s (Channel 1 SPACE) and adjust its LEVEL control for a reading of 2.5 volts ($\pm$10 dBm) in its internal meter.

(d) Set the CHANNELS OPERATIONAL switch on the input amplifier to position 1.

(e) Adjust the Path A GAIN control on the input amplifier for a reading of 0.8 volts in the valve voltmeter.

(f) Disconnect the test oscillator and valve voltmeter and reconnect the lines.

Path B

3. Perform the Path B level voltage adjustments as follows:

Repeat the operations detailed in sub-paras 2 (a) to 2 (f), this time connecting the test oscillator between Path B VF INPUT terminals, the valve voltmeter to PLA 10, and adjusting the Path B GAIN control.

Mark/Space Equality

4. Check the equality of MARK/SPACE elements as follows:

(a) Connect the oscilloscope between socket SKB and earth on the Channel 1 Recording Bridge.

(b) Set the Recording Bridge TEST switch to REVS and adjust SET ZERO control (RV1) for equal lengths of MARK and SPACE elements displayed on the oscilloscope.

(c) If a relay unit is being used, transfer the oscilloscope to monitor point SKA on this unit and check for equal lengths of MARK and SPACE elements displayed.

(d) If the two displays differ appreciably one from the other, adjust the relay (see Appendix P).

(e) Repeat the operations detailed in sub-paras (a) to (d) for each of the remaining five channels.

(f) Restore the units to operational use by setting the Recording Bridge TEST switches to TRAFFIC and the CHANNELS OPERATIONAL switch on the input amplifier to the number of channels in use.

APPENDIX M

SETTING UP THE INPUT UNITS IN RECEIVER TYPE 15150 (HL14)

Test Equipment

1. The following items of test equipment are required to set up the input amplifier:-

(a) 10S/16710 Valve Voltmeter Type 8187.

(b) 10V/16498 Test Oscillator Type M26.

(c) Test Frame.

Path A

2. Set up the Path A input amplifier as follows:-

(a) Extend the unit in the test frame (see Appendix C).

(b) Set the CHANNELS OPERATIONAL switch to position 8.

(c) Connect the test oscillator to the Path A INPUT terminals and disconnect the lines.

(d) Set the test oscillator frequency to 1500 c/s and adjust its LEVEL control for an output of + 4 dBm in its internal meter.

(e) Connect the valve voltmeter between PLA 13 and earth.

(f) Adjust the Path A GAIN CONTROL for a reading of 0.8 volts.

(g) Vary the test oscillator frequency from 350 c/s to 3050 c/s, keeping its output constant at 4 dBm and ensure that the valve voltmeter reading does not vary by more than 0.5 volts either way.

(h) Reset the test oscillator frequency to 1500 c/s and ensure its LEVEL control is adjusted for an output of 4 dBm in its internal meter, and that the readings in the valve voltmeter are within 5 % as shown in Table 1 for the indicated positions of the CHANNELS OPERATIONAL switch.

TABLE 1

SWITCH POSITION	VOLTAGE	SWITCH POSITION	VOLTAGE
1	0.1	5	0.5
2	0.2	6	0.6
3	0.3	7	0.7
4	0.4	8	0.8

(j) Set the oscillator output for a reading of + 10 dBm and re-adjust the Path A GAIN control for a reading of 0.8 volts on the valve voltmeter with the CHANNELS OPERATIONAL switch set to position 1.

Path B

3. Set up the Path B input amplifier as follows:

(a) Repeat the operations detailed in paras 2(b) to 2(j), this time connecting the test oscillator between Path B VF INPUT terminals, the valve voltmeter between PLA 12 and earth and adjusting the Path B GAIN control.

4. Disconnect the test oscillator and the valve voltmeter, remove the test frame and restore the unit to its normal position in the cabinet. Reconnect Path A and Path B lines.

APPENDIX N

DEMODULATOR VOLTAGE AND KEYING ADJUSTMENTS IN RECEIVER TYPE 15150

Test Equipment

1. The following items of test equipment are required to adjust the voltages and the keying sensitivity of the demodulators:-

(a) Test Frame.

(b) 10V/16498 Test Oscillator Type M26.

(c) 10S/16710 Valve Voltmeter Type 8187.

(d) 10S/16373 Valve Voltmeter Type CT54.

(e) 10L/16062 Attenuator Type T.F.338B.

(f) 10S/17124 Test Set Telegraph Type 14013.

(g) 10S/6625-9437177 Oscilloscope Type CT386A.

(h) 5QP/17447 Multimeter Type 12889.

Levels

2. Adjust the level of the Path A demodulators as follows:-

(a) Extend the unit in the test frame (see Appendix C).

(b) Connect the test oscillator to the Path A VF INPUT terminals and disconnect the lines.

(c) Set the oscillator to the appropriate frequency for the demodulator under test and adjust the LEVEL control for an output of + 4 dBm in its internal meter.

Signal Voltage

3. Measure the signal voltage as follows:-

(a) Transfer the valve voltmeter CT54 to connect it across resistor R19 and ensure that the voltage is between 190 volts and 220 volts.

(b) Set the CHANNELS OPERATIONAL switch on the input amplifier to 1 and adjust the appropriate path gain for a reading of 0.4 volts on the path level meter.

(c) Connect the valve voltmeter to the appropriate filter unit monitor point SKB and ensure that the voltage reading is between 0.2 and 0.3 volts.

(d) Connect the multimeter, set to the 250 V d.c. range, to monitor point SKB on the demodulator and adjust RV1 for a reading of 65 volts.

(e) Transfer the multimeter to connect it across R19 and check that the reading is between 125 volts and 128 volts. Note the reading.

(f) Transfer the multimeter to connect it across R20 and ensure that the reading is approximately half of that noted in subpara (e), e.g. between 70 volts and 100 volts.

(g) Repeat the operations detailed in sub-paras (a) to (f) for the Path B demodulators.

(h) Disconnect the oscilloscope and multimeter.

APPENDIX O

RECORDING BRIDGE VOLTAGE AND SENSITIVITY ADJUSTMENTS IN RECEIVER TYPE 15150

Test Equipment

1. The following items of test equipment are required to adjust the voltage and sensitivity of the recording bridges:-

(a) Test Frame.

(b) 10S/16373 Valve Voltmeter CT54.

(c) 10S/16710 Valve Voltmeter Type 8187.

(d) 10S/6625-9437177 Oscilloscope Type CT386A.

Output Voltage

2. Adjust the output voltage as follows:-

(a) Extend the unit in the test frame (see Appendix C).

(b) Set RV2 fully clockwise, RV3 fully counter clockwise and RV1 to the mid-position.

(c) Connect the valve voltmeter CT54 between monitor point SKB and earth, setting it for balanced working (120 - 0 - 120 V range).

(d) Set the Test Switch to MARK, ensure that the voltage is at least 30 volts positive and that the MARK indicator neon strikes.

(e) Adjust RV2 for a reading of 28 volts for relay output or 30 volts when using direct output.

(f) Set the test switch to SPACE, ensure that the voltage is at least 30 volts negative and that the SPACE neon indicator strikes.

(g) Adjust RV3 for a reading of 28 volts negative for relay output or 30 volts when using direct output.

NOTE: The voltage polarity indicated in subparas 2(c) and 2(e) applies only when the reversing link is in the NORMAL position, the polarity will be of opposite sign.

(h) Transfer the valve voltmeter to between the junction of R30/R31 and earth.

(j) Connect the oscilloscope between monitor point SKB and earth.

(k) Set the Test Switch to REVS and ensure that the reading on the valve voltmeter is 200 mV plus or minus 20 %.

(l) Adjust RV1 for equal lengths of MARK and SPACE elements displayed on the oscilloscope.

(m) Transfer the oscilloscope to monitor point SKA on the corresponding relay unit.

(n) Connect a 3.9 kilohm resistor across the corresponding RELAY OUTPUT terminals and connect an 80 - 0 - 80 volt signalling supply to terminals 28 to 30.

(o) Ensure that the waveform displayed on the oscilloscope is similar to that shown in Appendix F2 of Vol. 5 of the A.P. 2922 ZA (this is a square waveform). If the bias is in excess of 20 %, the relay is to be adjusted (see Appendix P).

(p) Disconnect the 3.9 kilohm resistor, valve voltmeter, and oscilloscope and restore the unit to its normal operating position.

APPENDIX P

RELAY CLEANING AND ADJUSTMENTS CARPENTER 4H7 (Z) MK.2 POLARISED RELAY

1. Cleaning. Normal cleaning may be carried out by passing a feeler gauge, of 0.002" to 0.005" thickness, a number of times between the contact side spring and the friction plate on which it bears, care being taken to hold the gauge parallel with the rubbing surface of the spring. The contacts themselves should be burnished by passing the same feeler gauge a few times over the contact surfaces. In order to clean badly pitted contacts, it is necessary to remove the side contact assemblies.

2. Adjustments. After cleaning, the following procedure is to be carried out to set the relay up for operational use:

(a) Insert relay in Relay Test Set and remove cover of relay.

(b) Slacken the contact locking screws and turn both contact adjusting screws anti-clockwise, one or two of the calibrated divisions on the screw-heads, to increase the contact gap. Check that, with light finger pressure, the armature can be made to rest on either contact with similar pressures, the condition being indicated on the meter (% BIAS). Adjust d.c. control for 100 % Contact Time on the meter.

(c) Connect a.c. to the relay winding and set for 3.2 mA through the winding (0-10 mA).

(d) Advance both contacts slowly until the relay begins to vibrate and adjust both contacts for a contact time of 79% ± 1 % and zero bias. Tighten locking screws and, if possible, an oscilloscope should be attached to the relay output (tongue) to check for contact bounce. If contact bounce is present, then the relay has not been properly cleaned.

NOTE: On some relays it may not be possible to make the relay vibrate immediately with 3.2 mA coil current. In this case, the relay may be set initially with 8 mA current and a contact time of 90%.

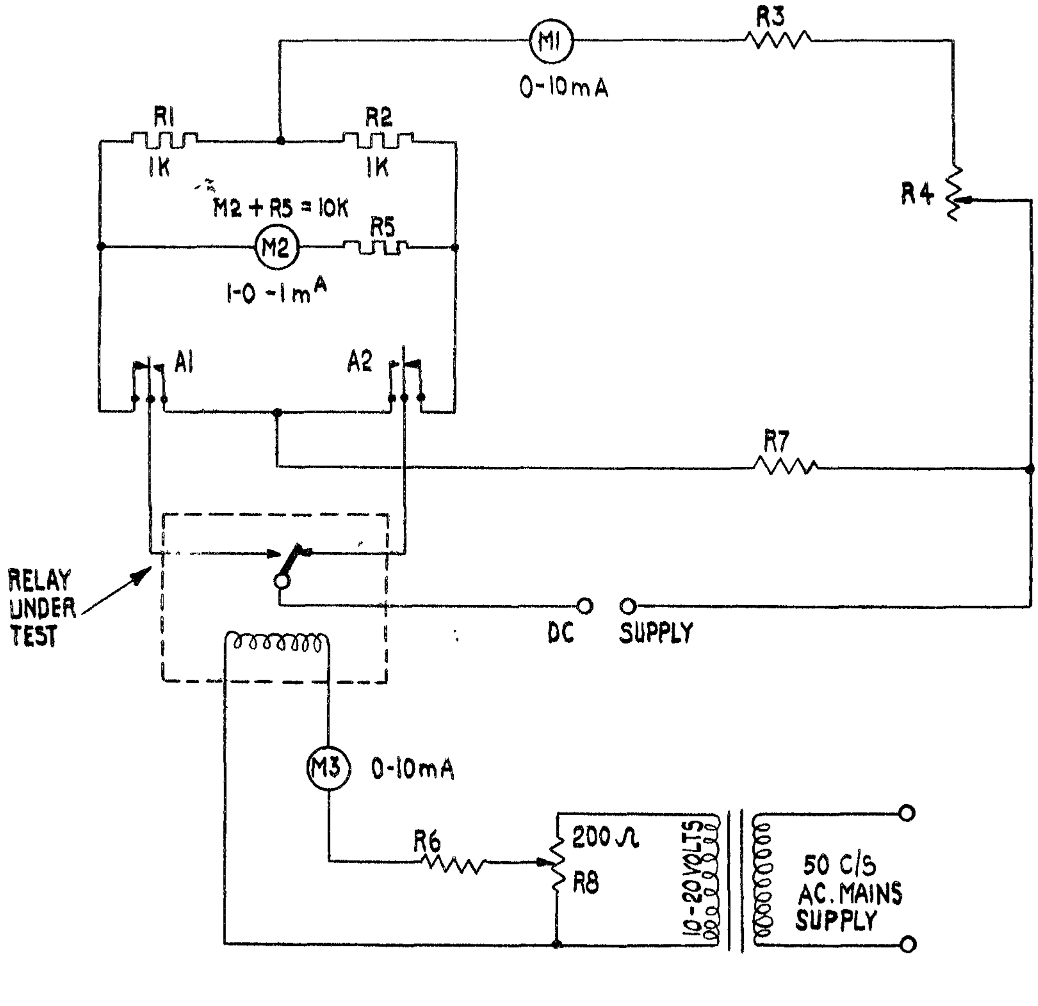


Fig. 1: Test Circuit Carpenter Relay Type 4

APPENDIX Q

RECOMMENDED METHODS OF SERVICING PRINTED WIRING BOARDS

1. Printed wiring boards are made of a laminated material with a thin sheet of copper bonded to one side. The conductor pattern is formed by an etching process. Component leads are threaded through holes punched in the boards and the ends of the leads are normally bent over against 'pads' on the copper conductors. The completed assembly is then soldered and a protective coating applied.

Tools and Materials Required for Servicing

2. A small soldering iron with a bit diameter of approximately 3/16" and a working temperature rather above the normal 250° C. A suitable tool is the Precision Iron, Model C240, 230-240 volts, 15 watts, with the No. 4 standard bit, made by A.N.T.E.X. Ltd., 3 Tower Hill, London, E.C.3.

3. 22 SWG resin cored 60/40 solder, such as multicore Type PC35. Additional flux must not be used.

4. A pair of small side-cutters, such as the 5 1/2 inch Pointed Nose Diagonal Cutting Nipper, Cat. No. 21123, made by Wilkinsons Tools Ltd., Kerfoot Street, Warrington, England.

5. A pair of small snipe-nosed instrument pliers, such as the 5 1/2 inch or 6 inch Long Snipe Nosed Pliers, Cat. No. 23107, made by Wilkinsons Tools Ltd.

6. A small stiff-bristled brush such as the Post Office Type Brush, fitch, Paint, No. 7, round.

7. A small-bladed knife, e.g. a penknife.

8. An epoxy resin repair kit, e.g. the Araldite Two-tube Pack.

Repair Procedure

9. It is recommended that the board be removed from the equipment before servicing, in order to facilitate inspection of the underside after repair.

10. Care should be taken to avoid mechanical damage to the board. Where the protective coating has been applied to both the component and the copper side of the board, it will be necessary to apply a sideways force to the component, after freeing the leads, in order to release it from the coating lacquer.

11. Avoid excessive heating of the joint, as this will reduce the strength of the bonding adhesive and damage more than the necessary minimum area of protective varnish.

12. Mechanical damage to the copper foil is most likely to be caused by stress on the component leads from the component side of the board.

13. In those methods where the soldering iron is applied to the copper 'pad', the following points should be noted:-

(a) It is not necessary to remove the protective varnish beforehand.

(b) The iron should only be applied to the pad for the absolute minimum of time necessary to melt the solder.

(c) Local repair of the damaged protective coating must be carried out immediately after the final soldering and cleaning operations, to prevent the ingress of moisture.

14. There are three recommended methods for the replacement of defective components, the suitability of each being determined by the circumstances.

Method 1

15. This is the recommended method for axial lead components, and certain others, when it is possible to leave a sufficient length of wire attached to the board.

(a) Clip off the leads close to the component (Fig. 1). In the case of certain non-axial lead components it may be necessary to break the component in the middle (Figs. 2 and 3). Remove the component.

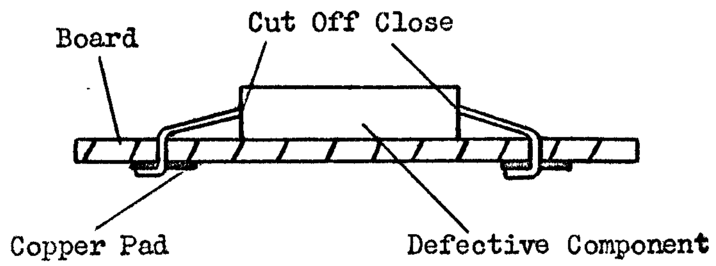


Fig. 1:

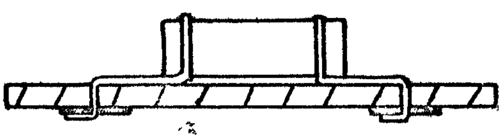


Fig. 2:

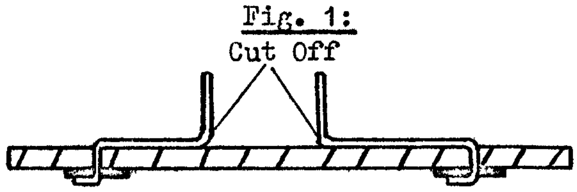


Fig. 3:

(b) Straighten the wires left on the board, by bending away from the board, until they are perpendicular to it (Fig. 4).

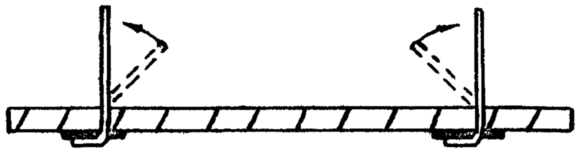


Fig. 4:

(c) Bend simicircular hooks on the replacement component leads, to correspond with the spacing of the old component wires, slide on to the old leads and solder into position, ensuring that the component lies flat on the board.

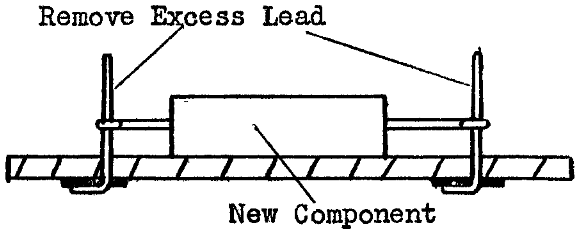
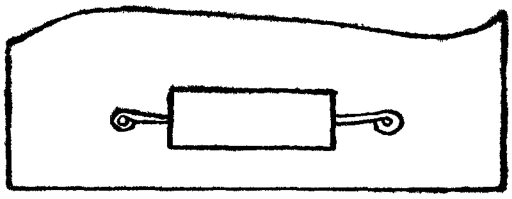


Fig. 5:



Plan View

Fig.6:

(Figs. 5 and 6). For radial lead components, form the leads as Fig. 7 and attach as shown in Fig. 8.

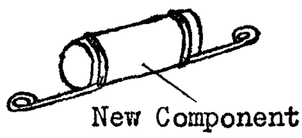


Fig. 7:

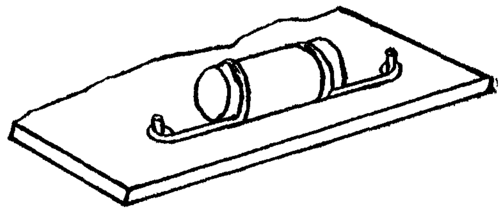


Fig. 8:

NOTE: Where insulating spacers have been used to keep a component, such as a wirewound resistor, raised from the board, they should be retained as shown in Fig. 9 to maintain adequate ventilation.

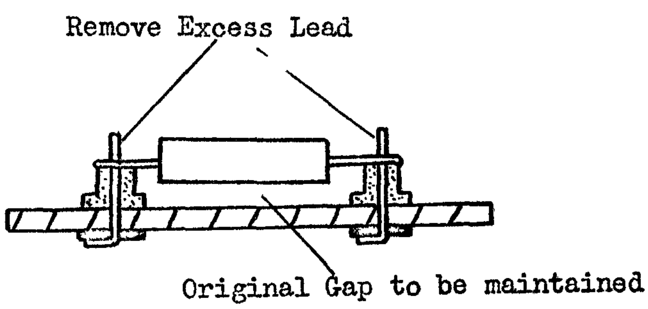


Fig. 9:

Method 2

16. This is the recommended procedure when it is desired to retain, as far as possible, the original appearance of the board. It is preferable however that it should not be used unless the importance of appearance overrides the obvious advantage of avoiding application of heat direct to the copper pads.

(a) Proceed as in Method 1 until the old component leads are perpendicular to the boards.

(b) Clip off the leads close to the component side of the board.

(c) Melt the soldered connection by the brief application of a hot iron and flick the board rapidly so that the lead stub is ejected, together with the solder in the hole. Check that no solder remains in the hole. Care should be taken to avoid physical damage to the board when flicking.

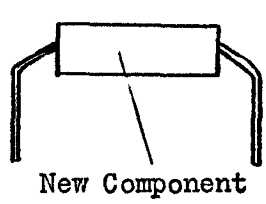


Fig. 10:

(d) Form the leads of the replacement components to the required shape. (Fig. 10).

(e) Fit the component and, after ensuring that it is lying flat on the board, clench the lead ends by gripping with the pliers, $\frac{1}{8}$ inch from the board, and pressing sideways, not allowing the pliers to twist, so that the sides of both jaws remain parallel to the board throughout the movement (Fig. 11).

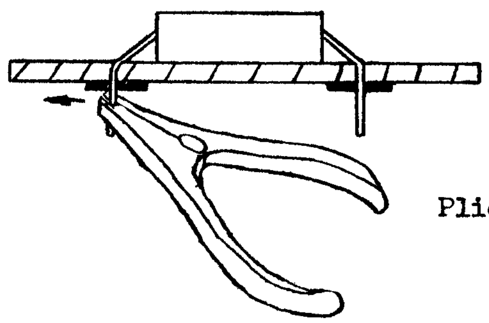


Fig. 11:

(f) Cut off leads at the edge of the pad between the two right-angle bends (Fig. 12).

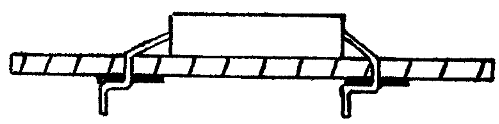


Fig. 12:

(g) Resolder the joint using only resin-cored solder and a hot iron. The iron should be applied for the least possible time consistent with obtaining a good soldered joint.

(h) Remove the excess resin and any contaminant from around the joints by wiping with a degreasing solvent, e.g. trichlorethylene. Allow excess solvent to evaporate.

(i) Mix the components of the epoxy resin, according to the makers instructions and apply to the areas from which varnish has been removed during soldering, taking care to overlap the old varnish. The new resin will cure at room temperature but, if it is desired to achieve a 'tack free' state rapidly, the cure may be accelerated by raising the temperature of the board to 50° C.

NOTE: Operations (h) and (i) should follow (g) as rapidly as possible. If resealing is appreciably delayed, it is strongly recommended that the board be heated to 50° C and maintained at this temperature for one hour before resealing.

Method 3

17. This method is recommended where access to the leads on the component side of the board is denied and where destruction of the component to gain access is impracticable.

(a) Apply a hot iron to the soldered connections, one at a time, and as soon as the solder has melted, remove as much excess as possible with the stiff brush.

(b) With the excess solder removed, supply the soldering iron to the clenched component lead end and as the solder melts, introduce the blade of the small pen-knife under the clenched end, removing the soldering iron immediately this is achieved. Straighten the clenched end by twisting the knife in such a manner that the thin edge remains both on the board and touching the lead where it leaves the hole (Fig. 13).

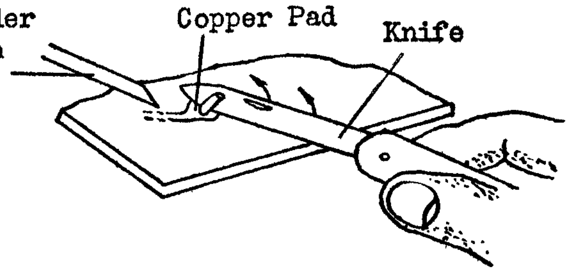


Fig. 13:

(c) After repeating operation (b) on all the leads of the component, carefully examine the leads where they enter the board, to ensure that they are not still attached to the pads. In those cases where they are attached they must be freed by re-applying the iron to the wire and after the solder has melted, moving the wire to and fro in the hole until the solder has set.

(d) When all the leads are freed the component may be withdrawn and a new one inserted, pre-forming the leads where necessary.

(e) After insertion the ends are clenched, trimmed and soldered and the board resealed as in Method 2 (h) and (i).

NOTE 1: Certain components, such as valve bases, may be fitted with tags which it is impracticable to clench over because of risk of damage to the board. Where these components have to be replaced, operation (b) is omitted during the removal and, correspondingly, the re-clenching operation is not carried out when fitting the new component.

NOTE 2: In operation (b) the knife must not be inserted without first melting the solder, or damage to the copper pad may result. Similarly in (d) the component must not be withdrawn until all the leads are freed as in (e).

Test and Inspection

NOTE: At no time, either while locating a faulty component or while testing following a repair, should any lead be attached to the copper side of the board.

18. Repairs should be inspected for dry joints. When Methods 2 or 3 have been used the amount and shape of solder should be similar to the original connections on the board and it should be possible to see the outline of the component leads.

19. Repairs should be inspected to ensure that all varnish displaced during the servicing operations has been made good and that a sufficient overlap of varnish has been allowed to effect a complete seal.

APPENDIX R

POWER UNIT ADJUSTMENTS - VOLTAGE

Test Equipment

1. The following item of test equipment is required:

Multimeter Type 12889 - 10S/17447.

Transmitter Type 15149

2. Adjust the power unit voltages as follows:

(a) Connect the multimeter between pin C1 of socket SKA on the single channel attenuator unit and earth.

(b) Adjust RV3 on the 300 volt power unit for a reading of 300 volts in the multimeter.

(c) Transfer the multimeter to between pin A1 of socket SKA on the single channel attenuator unit and earth.

(d) Adjust RV3 on the 150 volt positive power unit for a reading of 150 volts in the multimeter.

(e) Disconnect the multimeter and reversing the leads, reconnect between pin D4 of socket SKA on the single channel attenuator unit and earth.

(f) Adjust RV3 on the 150 volt negative power unit for a reading of 150 volts in the multimeter.

Receiver Type R.15150

3. Adjustment for the receiver is identical to that of the transmitter (see para 2 above), except that any Recording Bridge is used in lieu of the single channel attenuator.

DW 19918/1/710 250 9/63 XL