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Colin Hinson
In the village of Blunham, Bedfordshire.

AIR PUBLICATION

4736A

VOLUME 1

H.F. SINGLE-SIDEBAND TRANSMITTER RECEIVER ARI.18179

GENERAL AND TECHNICAL INFORMATION

Prepared by direction of
the Minister of Aviation

Henry Hardman

Promulgated by Command
of their Lordships

[signature]

ADMIRALTY

P30834

NOTE TO READERS

The subject matter of this publication may be affected by Admiralty Fleet Orders, or by "General Orders and Modifications" leaflets in this A.P., or even in some others. If possible, Amendment Lists are issued to correct this publication accordingly, but it is not always practicable to do so. When an Order, or leaflet contradicts any portion of this publication, the Order, or leaflet is to be taken as the overriding authority.

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Each leaf, except the original issue of preliminaries, bears the date of issue and the number of the Amendment List with which it was issued. When this Volume is amended by the insertion of new or replacement leaves in an existing chapter, the new or amended technical information will be indicated by triangles, positioned in the text thus:— ◄——— ► to show the extent of amended text, and thus:— ► ◄ to show where text has been deleted. When a Part, Section, or Chapter is issued in a completely revised form, the triangles will not appear.

LAYOUT OF A.P.4736A

ARI.18179

The books issued under this A.P. number will be listed in A.P.113 and A.P.2463

VOLUME 1		**General and technical information**
	Part 1	**Leading particulars and general information**
	Part 2	**Servicing**
	Part 3	**Fault diagnosis**
	Part 4	**Circuit description**
VOLUME 2		**Application to be decided later**
VOLUME 3		**Application to be decided later**
VOLUME 4		**Application to be decided later**
VOLUME 5		(*Inapplicable*)
VOLUME 6	**Part 2**	**Repair and reconditioning instructions**

LETHAL WARNING

EJECTION SEATS AND CANOPY JETTISON MECHANISMS

1. Ejection seats and canopy jettison mechanisms are sources of potential danger to personnel and of damage to the aircraft. Serious injury (possibly fatal) may result if any firing mechanisms are inadvertently operated whilst the aircraft is on the ground.

2. The following instructions are to be obeyed:—

R.N. **Safety precautions contained in A.P.(N.)140—Naval Aircraft Maintenance Manual.**

R.A.F. **ALL PERSONNEL before entering the cockpit or cabin of an aircraft fitted with an ejection seat are to report to the N.C.O. immediately in charge of air-frame servicing who is to ensure that all safety pins (or other safety devices) are correctly positioned to render the seat and canopy jettison firing mechanisms safe. On completion of servicing, tradesmen are to report to the N.C.O.**

3. Full instructions for rendering the firing mechanisms safe are contained in the A.P.4288 and A.P.(N.)1023 series, in Aircraft Servicing Schedules and in the A.D.5037 series.

P30835 568721/4956 5/61 250 C & P Gp 375

CONTENTS OF VOLUME 1

P30835 568721/4956 5/61 250 C & P Gp 3:

LIST OF CONTENTS

PRELIMINARIES

PART 1

LEADING PARTICULARS AND GENERAL INFORMATION

PART 2

SERVICING

PART 3

FAULT DIAGNOSIS

PART 4

CIRCUIT DESCRIPTION

PART 1

LEADING PARTICULARS AND GENERAL INFORMATION

P30835 568721/4956 5/61 250 C & P Gp 375

LEADING PARTICULARS

TRANSMITTER-RECEIVER RADIO 5821-99-913-2249

Frequency	*Range* 1 2·5-5 *Mc/s* 2 5-10 *Mc/s* 3 10-20 *Mc/s*
Channel selection	*12 Preset-tuned channels, selected from remote control position*
Intermediate frequency	1·5 *Mc/s*
Sideband operation	*Upper sideband, over range* 2·5-20 *Mc/s* *Unwanted sideband suppression greater then* 40 *dB*
Audio frequency response	500 *c/s to* 3 *kc/s* ± 3 *dB*
Transmitter	
Output power	200-300 *W peak sideband power into* 50*-ohm load*
Type of emission	*Single sideband controlled carrier*
Harmonic output	*More than* 40 *dB below fundamental*
VOGAD	*Audio level to modulation, changes less than* 3 *dB with* 10 *dB change of input*
Receiver	
Signal/Noise ratio	*Greater than* 20 *dB for* 1 μ*V input signal*
◀*Sensitivity*	*Less than* 2 μ*V for* 50 *mW output into* 50 *ohms.*▶
Image rejection	2·5-10 *Mc/s* 60 *dB* 10-20 *Mc/s* 40 *dB*
I.F. rejection	80 *dB*
Automatic gain control	*Input* 1 μ*V to* 10 μ*V. Output variation* 4 *dB* *Input* 10 μ*V to* 1 *mV. Output variation* 3 *dB*
Audio output	300 *mV peak into* 50*-ohm output. Voltage constant within* ±2 *dB for load variation of* 50 *to* 150 *ohms*
Power requirements	28*V d.c. supply.* 200*V a.c.* 400 *c/s* 3*-phase supply*

Power consumption			
	Receive	270 *Watts*	190 *V.A.*
	Transmit	270 *Watts*	685 *V.A.*

Dimensions of units	*Height (in.)*	*Width (in.)*	*Depth (in.)*	*Weight (lb.)*
Generator, reference signal 5821-99-913-2244	8·0	14	11	35
Power supply 5821-99-999-2246	7·9	7·92	13	26½
Amplifier, radio frequency 5821-99-913-2232	7·9	7·92	13	13½
Transmitter-receiver sub-assembly	7·75	10·83	11·86	29½
Control radio set 5821-99-913-3108	5·0	5·75	3·25	
Interconnection box 5821-99-913-2245	4·75	8·625	1·51	2

SUPPRESSED AERIAL SYSTEM 5985-99-999-8559

The equipment is designed to tune and provide impedance-matching of the aerial cavity which is an integral part of the aircraft.

Input	50*-ohm coaxial*
Tuning range	*Capacitor unit* 3700*pF max, will tune cavity inductance of* 0·85μ*H from* 2·8 *to* 25 *Mc/s.* *With additional inductance in connector, radio frequency, range covered is* 2·5 *to* 25 *Mc/s.*

LEADING PARTICULARS — *contd.*

Impedance range ... 0·04 *to* 1·5 *ohms effective series resistance over the range* 2·8 *to* 25 *Mc/s*

Operational altitude ... ... 0 *to* 40,000 *ft.*

R.F. power handling capacity ... ... 400 *watts peak envelope (Atlantic City definition).*

Matching range ... *Matching better than* 1·5 *s.w.r. to* 50-*ohm source*

Frequency channels ... ... 12 *remotely controlled frequences in selected band in use.*

Power supplies ... (1) ... 28*V d.c.* 2·5*A (max.) normal* (11*A peak during channel change)*

(2) ... ... 200*V* 400 *c/s* 6 *V.A.*

Dimensions of units	*Height (in.)*	*Width (in.)*	*Depth (in.)*	*Weight (lb.)*
Tuner radio frequency 5950-99-999-8558	10·9	7·2 (*diameter*)	—	15·5
Network impedance matching 5915-99-999-8556	4·5	3·6	9	2·7
Selector unit 5985-99-999-8557 ...	8·8	5	9·5	10·7
Connector radio frequency 5995-99-999-8552	—	—	—	1·8
Mounting 5985-99-999-8546	6·9	5·2	11·3	2·1
Bracket and contact assembly ◀5915-99-950-7818	1	2·75	2·12	0·075▶

SECTION 1

INTRODUCTION TO SINGLE SIDEBAND EQUIPMENT ARI.18179

P30835 568721/4956 5/61 250 C & P Gp 375

Chapter 1

(Completely Revised)

PRINCIPLES OF OPERATION

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Long range aircraft communication in the h.f. band is usually on a manual telegraph system since the ranges and reliability obtainable with airborne R/T equipment are not always adequate for a satisfactory service. This inadequacy is due in the main to:—

(1) Restriction of power in airborne transmitters.

(2) Adjacent channel interference.

(3) Use of a double sideband amplitude-modulated system on radio circuits which are subject to the ill effects of multi-path propagation.

The application of single-sideband (s.s.b.) technique has shown, that over one particular series of flight trials the length of time for which reliable communications could be expected is increased from 30 per cent for a double-sideband (d.s.b.) transmission to 80 per cent for a single-sideband transmission, over the same path.

2. Single-sideband operation implies that one side-frequency component is transmitted for each modulator-frequency component applied to the transmitter audio input, as compared with d.s.b. operation where two side-frequency components are transmitted, the two components being symmetrically located relative to the carrier frequency. It is usual in s.s.b. operation to suppress the carrier and one sideband almost completely, or to reduce them to a low level.

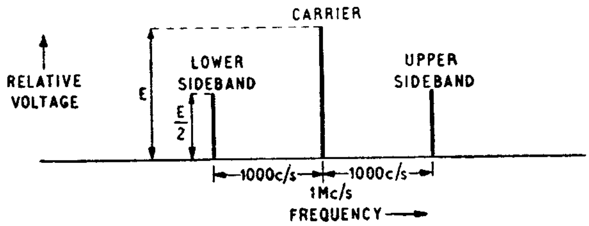


Fig. 1. Single-tone amplitude modulated transmission showing sideband components

GENERAL

Amplitude-modulated signals

3. When a carrier frequency is amplitude-modulated with an audio-frequency tone signal, two sideband frequencies are produced, one on either side of the original carrier. These two sideband frequencies are the means of conveying intelligence in a radio transmitter. This type of signal is referred to as an amplitude-modulated double-sideband transmission, and in fig. 1 is shown in diagram form. The frequencies shown are for the example only.

4. If now we remove, or suppress to a large extent the carrier and one of the sideband signals, the result is a single-sideband signal. Thus it can be seen that a single-sideband signal can be considered as the transposition of an audio frequency, or band of audio frequencies, into a suitable part of the r.f. spectrum (*fig.* 2).

Power gain

5. Considering the power of a d.s.b. transmission, where we have at least two-thirds of the output power produced in the carrier, there is a considerable saving in power by the partial or total elimination of the carrier (*para.* 4). This power gain is particularly important in the case of airborne transmitters where the output power is limited by the maximum voltage which may be applied to the aircraft aerial without corona discharge. For the same peak-voltage on the aerial, the peak-sideband power of an s.s.b. transmitter may be raised to the value obtained on the modulation crests of a d.s.b. transmission.

Peak-power

6. Transmitters which produce a type of emission employing a carrier (e.g. a.m., p.m. or f.m.) are rated in unmodulated carrier power output. The mean power output of an a.m. transmitter is 150 per cent of carrier power when 100 per cent sine-wave modulation is applied. The peak-power output is four times carrier power, since

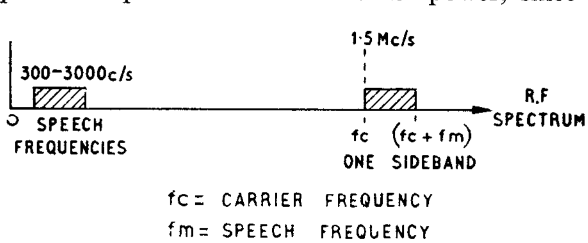


Fig. 2. Diagram showing transposition of a band of frequencies to a suitable part of the r.f. spectrum

both voltage and current are doubled at the modulation crest.

7. It is necessary when referring to s.s.b. power to refer to the peak-sideband power since we have no carrier reference in this type of transmission and a signal will appear at the output only whilst modulation signals are applied. Thus peak-sideband power is a useful reference in the same way that the carrier power is a useful reference for power in the case of d.s.b. transmission.

8. A comparison of an s.s.b. transmitter and an a.m. transmitter of equal performance under ideal conditions has shown that the peak-envelope voltage produced by the two transmitters to be in the ratio 2 for the a.m. unit and 0·7 for the s.s.b. unit. This indicates that, for equal performance under ideal conditions, the peak aerial voltage of the s.s.b. system is approximately one-third that of the a.m. system.

9. A comparison of the s.s.b. power and a.m. power which can be radiated from an aerial of given dimensions is even more significant. If an aerial is chosen which will radiate 400 watts of peak-envelope-power, the a.m. transmitter which may be used with this aerial must be rated at not more than 100 watts. This is so because the p.e.p. of the a.m. signal is four times the carrier power. An s.s.b. transmitter rated at 400 watts p.e.p. all of which is sideband power may be used with the same aerial, compared with the 50 watts of sideband power obtained from the a.m. transmitter with a 100-watt rating.

Note on definitions

Peak sideband power (p.s.p.) is the part of the peak power supplied by the sidebands. Peak envelope power (p.e.p.) is the average power in one r.f. cycle at the highest crest of the modulation envelope.

10. This is an important factor in view of the trend to reduce aircraft aerial dimensions and to employ suppressed aerials on high-speed aircraft.

11. Since the power of an s.s.b. signal is concentrated in one sideband only, the bandwidth of the receiver may be reduced to half that required for a d.s.b. signal, this producing an effective increase in gain in signal/noise ratio of 3dB.

Demodulation

12. The incoming signal will be at a frequency ($f_o + f_n$) at the instant at which we are examining it (assuming upper sideband operation). The information contained within the sideband must now be removed by the demodulation process.

13. In a typical normal a.m. receiver the incoming signal is applied to a diode detector and the a.f. signals appear as a component of the output. However, if an s.s.b. signal is applied to the diode detector, the output would be simply a d.c. level which corresponds to the amplitude of the input signal.

14. The essential difference between the two signals referred to in para. 13, is of course, that the a.m. signal has a carrier whose amplitude apparently varies at the a.f. rate. To extract the information from a single-sideband signal, it is first of all necessary to re-insert the carrier (*para.* 51). This may be accomplished in one of two ways either of which are well known, they are:—

(1) B.F.O. and diode detector method

(2) Heterodyne method.

Advantages and disadvantages of single sideband operation

15. An important advantage of using s.s.b. is the minimizing of the effects of non-linear distortion or selective fading which occurs with d.s.b. systems under conditions due to multi-path propagation. This advantage is of particular importance in aircraft communications where there is a wide range of propagation conditions due to the variation of range during a flight in addition to the diurnal variation.

16. As only one sideband and no carrier is transmitted, the received signal level does not rely upon the resultant amplitude between the two sideband signals and carrier as it does in a.m. Since the received signal does not depend upon a carrier level in s.s.b. no distortion can result from the loss of carrier power. The receiver signal does not depend upon the phase relationship between sideband and carrier hence no distortion can result from phase shift. Selective fading within the one sideband of a s.s.b. system changes only the amplitude and the frequency response of the signal, it very rarely produces enough distortion to cause the received signal or voice to be unintelligible.

17. It is difficult to assess the value of this advantage of using the s.s.b. technique but comparison tests over a long period of time have shown that it is a most important consideration.

18. The main advantage of s.s.b. transmission is apparent under limiting propagation conditions over a long-range path. An effective improvement of 9dB in signal/noise ratio should be realized under these conditions. No apparent improvement of s.s.b. over d.s.b. can be expected where the d.s.b. signal is already giving good communication.

19. Due to the absence of cross-modulation, a further effect obtained with an s.s.b. transmission is the improvement of readability when a wanted transmission is received in the presence of a strong interfering signal. Because the carrier is re-introduced at the receiver, it can have a large amplitude compared with that of the signal, so that demodulation is a linear frequency-changing process without cross-modulation between wanted and unwanted signals. The two signals appear together in the audio output and the ear can often interpret the wanted transmission in the presence of strong interference. This is especially true in the case of c.w. interference which is often experienced in the h.f. band. The performance of the beat detector does not fall off at low signal-to-noise ratios as it does with detectors employed for amplitude modulated signals.

20. The main disadvantages of using the single-sideband technique are:—

(1) The equipment is more complex

(2) It is necessary to reduce considerably the frequency tolerances usually permitted on d.s.b. systems.

21. This improvement in frequency accuracy necessitates a complex frequency generating unit in which, as the basis of frequency stability, is a specially developed form of crystal oscillator, exhibiting extremely small variations in frequency. Although the reduction of frequency tolerances is a disadvantage because it necessitates the use of complex equipment, the increase in frequency stability associated with it, brings about an increase in communication efficiency.

The effect of frequency errors

22. Assuming that a carrier component is supplied at the receiver demodulator from a local oscillator, and the carrier is completely eliminated at the transmitter; experiments show that the maximum permissible injected carrier error before speech becomes distorted is 30 to 50 c/s. The error is of course either added to or subtracted from the a.f. signal.

23. The carrier frequency error is made up of the errors of all the oscillators in the transmitter and the receiver; all must be very stable and the highest frequency oscillators normally contribute most of the errors in frequency. The frequency stability of suppressed carrier s.s.b. transmitters and receivers must be of the order of ± 20 c/s and at 20 Mc/s this represents an oscillator stability of 1 part in 10^6.

24. When an aircraft flies away from or towards a ground station, the frequency of the received signal is different from that transmitted, due to the Doppler effect. The Doppler effect in itself introduces only small errors, but in conjunction with the frequency errors produced by the oscillators in a transmitter and receiver could produce a large overall error. The Doppler frequency error is greatest as the speed of the aircraft increases, as the frequency in use becomes higher and when the aircraft is varying its range with respect to the ground station.

TRANSMISSION OF S.S.B. SIGNALS

Vector representation of amplitude-modulated waveform

25. Reference to fig. 3 (end of chapter) will be helpful during the following description. If we consider a carrier wave of frequency f_c an amplitude E, its waveform would be as shown in (a) of fig. 3, which also shows its vector representation. Thus the carrier vector as shown has a magnitude E and is rotating in a counter-clockwise direction at an angular velocity ω_c.

26. In (b) of fig. 3 is shown diagrammatically an amplitude-modulated waveform of a carrier frequency $f_c = \frac{\omega_m}{2\pi}$ modulated to 100 per cent by the modulating frequency $f_m = \frac{\omega_m}{2\pi}$. The carrier amplitude is not affected by modulation and it is important at this stage to appreciate that the waveform shown in fig. 3 is only an apparent variation in carrier amplitude. The output waveform shown in fig. 3 apparently varies between a value 2E and zero, and the reason for this is that the sidebands i.e. $(\omega_c - \omega_m)$ and $(\omega_c + \omega_m)$, add to or subtract from the carrier, depending on their relative phases.

27. The mean level of the modulated waveform obviously occurs at the points 1, 3 and 5 in (b) of fig. 3, and the mean value of the carrier at these points is E. As this is the mean level the sidebands are neither adding to the carrier or opposing it at the above mentioned points, hence they are effectively in opposition to each other and cancel out. However, at the points 2 and 4 the sidebands do not cancel each other as their vectors are in the same direction and add. The vector sum of the sideband signals at the point 2 can be seen to add to the carrier vector giving a total value of 2E, whilst at position 4 the two sideband vectors add together to oppose the carrier vector and thus produce zero resultant.

28. In (b) of fig. 3 a diagram is shown of carrier and sideband vectors, both the carrier vector and sidebands are of course rotating in the same direction, however, the lower sideband (l.s.b.) is rotating with angular velocity $(\omega_c - \omega_m)$ whilst the upper sideband (u.s.b.) is rotating with angular velocity $(\omega_c + \omega_m)$.

29. Therefore, if we consider the carrier as a reference vector and regard it as being stationary, the upper sideband vector will rotate about the carrier vector in a counter-clockwise direction and the lower sideband vector will rotate about the carrier vector in a clockwise direction, since the upper sideband is rotating faster than the carrier and the lower sideband rotating slower than the carrier. From (b) of fig. 3 it can be seen that a vector diagram showing the rotation of the sidebands can be drawn at any point on the modulated waveform and a typical series would be as shown in (c) of fig. 3. The sideband vectors are shown at the mean level of the carrier to demonstrate more easily the vector addition and subtraction.

Methods employed in generating s.s.b. signals

30. There are two methods in general use for obtaining a single-sideband signal, each method having its own advantages and disadvantages when employed for a particular use. The two methods are:—

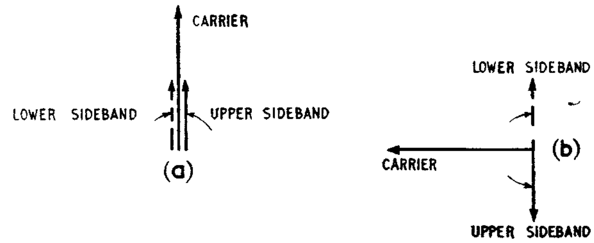


Fig. 4. Relationship between carrier and side bands produced during amplitude modulation—vector diagram

(1) Filter method

(2) Phasing method

The phasing method is used in ARI.18179 and is discussed further in the following paragraphs. Later versions of the equipment may use the filter method.

Filter method

31. A carrier is amplitude-modulated in the ordinary way to produce identical sidebands either side of the carrier. These sidebands and the carrier are fed into very sharp filter circuits which will attenuate the carrier and one of the sidebands. Alternatively, a balanced modulator may be used (this produces two sidebands and no carrier) and the unwanted sideband removed by filter circuits.

32. The types of filters in use are inductance-capacity filters (L-C), crystal filters and mechanical filters. They can all be designed to give good unwanted sideband suppression, but their selectivity is better as the design frequency is made lower.

Phasing method

33. This system consists fundamentally of removing the unwanted sidebands and carrier by means of a phasing and balancing process rather than by filtering. The principle employed may be explained by reference to fig. 4. This shows vector diagrams which illustrate the relationship between carrier and sidebands produced during amplitude modulation. The two diagrams show an amplitude-modulated signal at an interval of $\pi/2$ the carrier vector (i.e. the carrier vector has rotated through 90°).

34. The position of the sideband vectors in (a) of fig. 4 shows that peak-envelope conditions exist at the instant shown. The position of the sideband vectors in (b) of fig. 4 shows that the envelope has a value, at the instant shown, equal to the carrier amplitude (i.e. the amplitude modulating signal is displaced by 90° from that giving the conditions shown in (a) of fig. 4).

35. The carrier frequency shown in (b) of fig. 4 is the same as that shown in (a) but displaced 90° from it. If we now combine the two signals shown it can be seen that the upper sidebands will cancel (being equal in amplitude and also in phase opposition to each other) thus leaving the lower sidebands and vector sum of the two carriers only.

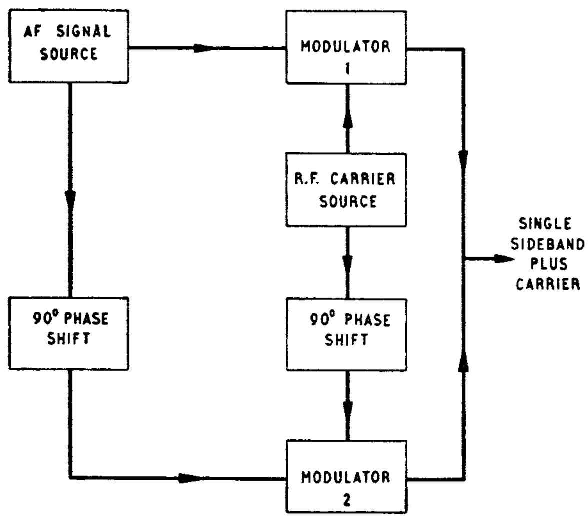


Fig. 5. Basic phasing method—block diagram

36. To achieve this result in practice we use a special form of modulator circuit. Reference to the block diagram shown in fig. 5 will show how this operates. A 90° phase shift is obtained between the r.f. carrier which is applied to modulator 1 and that applied to modulator 2 whilst at the same time a 90° phase shift is present between the a.f. signal input applied to the modulator 1 and that applied to modulator 2. The correct functioning of the system depends upon the phases of all the signals having the correct relationship.

37. The circuit shown in fig. 5 would function satisfactorily if the phase shift devices gave a constant 90° phase shift. The carrier phase-shift is easily accomplished as the carrier frequency can be made constant. In the case of the modulating signal, phase shifting is more difficult to produce since we have a band of audio frequencies to cover. The arrangement shown works well in principle but not in practice.

38. If, however, two phase-shift networks having a differential phase shift of 90° are inserted between the modulating signal source and the actual modulators, these networks will have a differential phase-shift of 90° over the desired range of modulating frequencies. This is illustrated in the block diagram (*fig.* 6).

39. This circuit will function in practice and it has several practical implications.

(1) A carrier of any desired fixed frequency can be used because the circuit design is only concerned with phase relationships, whereas the use of the filter system a carrier frequency below 500 kc/s must be used for sideband generation because of difficulty in filter design to obtain a suitable selectivity characteristic as the operating frequency is raised.

(2) Conventional parts can be used in all circuits, with consequent low cost.

(3) Any desired range of modulation frequencies may be chosen. The practical limits are set by the differential phase shift networks which can be designed to cover as much as seven octaves. This is far more than is necessary for speech communication.

(4) Simple switching may be incorporated for generating either upper or lower sideband.

40. In fig. 6 the output is shown as a single-sideband plus the carrier, when in fact we wish to obtain a single-sideband without the carrier. The carrier can be suppressed by inserting balanced modulators in the circuit in place of the conventional modulators shown.

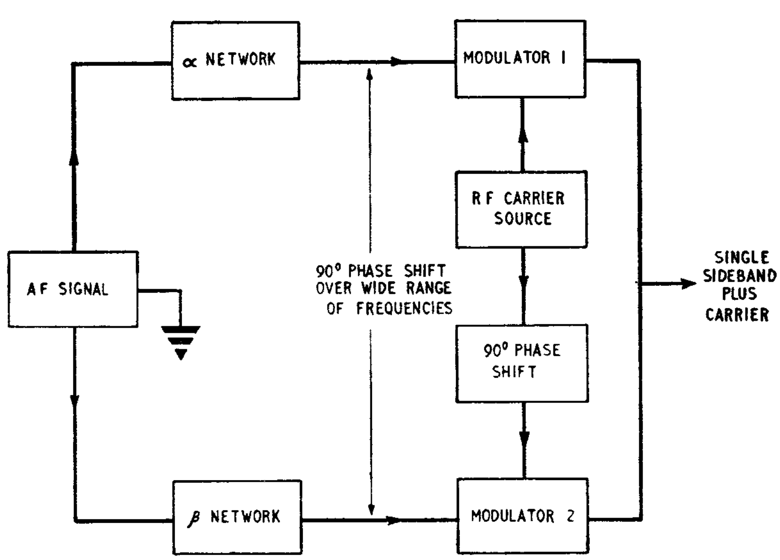


Fig. 6. Improved phasing method—block diagram

Balanced modulators—carrier suppression

41. The balanced modulator circuit is shown in simplified form in (a) of fig. 7 (end of chapter). The a.f. modulating voltage is applied to the valve grids in push-pull and the r.f. carrier signal is applied to the cathodes in push-pull. By considering the circuit shown it will be seen that the carrier components in the anode circuit will cancel since they will be in anti-phase.

42. Reference to vector diagrams (b) and (c) of fig. 7 show the vector representation at the anodes of the two balanced modulator valves V1 and V2. It will be seen that the carrier vector in (b) of fig. 7 is in anti-phase to that in (c) of fig. 7.

43. The output from V1 of the modulator rises from point 1 to a maximum at point 2. Meanwhile the output from V2 of the modulator goes less negative (i.e. more positive) from point 1 to a minimum at point 2.

44. Thus it can be seen that the outputs from the two valves V1 and V2 add in the common anode circuit and the resultant vector diagram (d) of fig. 7 shows the two sidebands with no carrier present.

Double-balanced modulator—carrier and sideband suppression

45. A block diagram of a double balanced modulator circuit is shown in (a) of fig. 8 (end of chapter). The carrier and a.f. input signals to the balanced modulators are in phase quadrature. The outputs from all four modulators will be combined in the output circuit and the resultant vector diagram is shown in (e) of fig. 8.

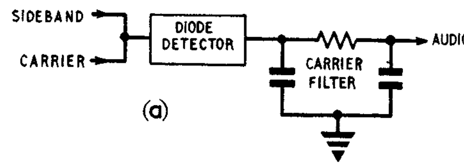
46. It can be seen that in this case the lower sidebands add and the upper sidebands cancel, so that the final output will contain the lower sideband only. The lower sideband obtained will have twice the amplitude it had in each modulator since the outputs of two balanced modulators are added.

47. To obtain the upper sideband, the relative "lead" or "lag" of either the carrier or the modulating voltage, but not both, must be changed, i.e. the modulating voltage to modulator V3 must lag that to modulator V2, instead of leading it; or the carrier voltage to modulator V3 must lead that to modulator V2 instead of lagging it. (The other two modulator inputs would naturally be correct).

48. Obviously, for the sidebands and carriers to cancel exactly, each modulator must be exactly balanced. The modulators must then be balanced in pairs in order to eliminate the unwanted sideband.

Use of linear amplifiers

49. Having generated an s.s.b. signal, all further application which is carried out must be a linear amplifying process. The class C high efficiency amplifiers and frequency-multipliers normally found in transmitting equipment employing the d.s.b. technique are not suitable for s.s.b. since



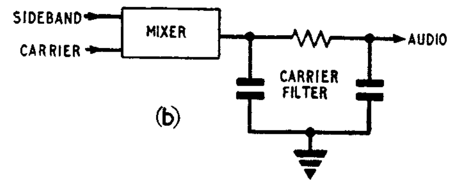


Fig. 9. Demodulation—block diagrams

they will produce severe intermodulation distortion; this is obvious from the way in which a class C amplifier operates.

50. This then prevents the use of high efficiency class C amplification and restricts s.s.b. amplifiers to class A or class B operation. However, the overall efficiency of an anode modulated class C amplifier as usually found in d.s.b. equipments, is very little higher than that of a linear-amplifier when the modulator power loss is taken into account. The use of linear-amplifiers for s.s.b. has certain compensations, e.g. a smaller amount of distortion is produced in the output than of an equivalent d.s.b. transmission. A linear power-amplifier also has a better overload performance than an anode-modulated stage.

RECEPTION OF S.S.B. SIGNALS

Demodulation

51. This may be accomplished in one of two ways, both of which are well known, they are:—

(1) B.F.O. and diode detector method

(2) Heterodyne method.

B.F.O. and diode detector method

52. The sideband signal and locally generated carrier signal are inserted into the detector input circuit (a) of fig. 9, the resultant signal applied to the diode being the carrier varying at the sideband signal frequency. (The carrier is not modulated). The detector output will contain the positive (or negative) half-cycles only, and will therefore contain the a.f. component which is required. It is necessary for the ratio of s.s.b. signal voltage to carrier injection voltage, to be of the order of 1 : 10 for this system to work satisfactorily without distortion.

Heterodyne method

53. The single-sideband signal and the injected carrier are applied to separate electrodes of a mixer valve (*fig.* 9). The output will be a heterodyne waveform (the process is identical to modulation). This output will contain the following components (assuming that the upper sideband is the input signal):—

(1) Injected carrier frequency f_o

(2) Input signal (f_c+f_m)

(3) Upper sideband $f_o+(f_c+f_m)=f_o+f_c+f_m$

(4) Lower sideband $f_o-(f_c+f_m)=f_o-f_o+f_m$

54. For correct operation the injected carrier frequency f_o will be equal to the transmitter carrier frequency f_c thus (3) becomes $2f_o+f_m$ and (4) becomes f . It will be noted that if f_o differs slightly in frequency from f_c the resultant audio in (4) will be f_m ± difference in frequency between f_o and f_c, "known" as carrier error. The output circuit is designed to remove all the components of frequency f_o or higher, the output will be then only the required a.f. signal.

MATHEMATICAL APPENDIX

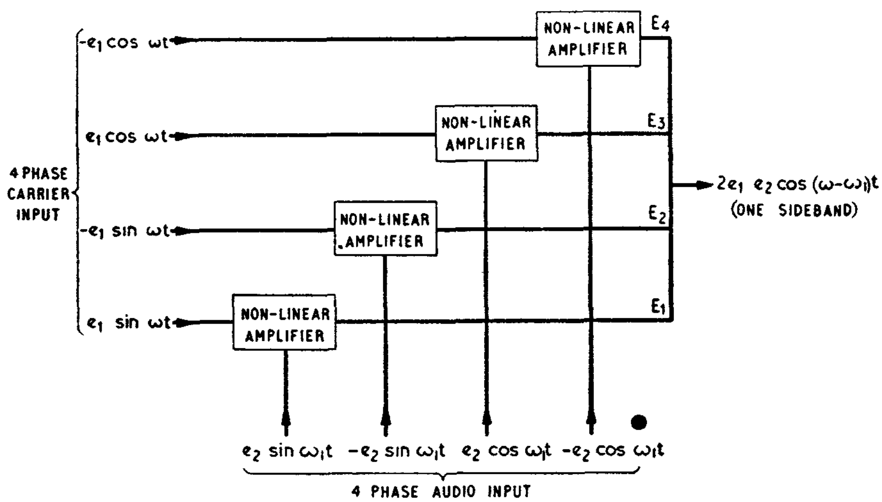


Fig. 10. Four-phase modulator—block diagram

The production of a single-sideband signal by a four-phase modulator

55. A four-phase modulator circuit can be considered as two balanced modulators with the carrier and audio inputs being in phase-quadrature. In fig. 10 is shown an operation diagram of a four-phase modulator. The carrier inputs and audio inputs are shown in phase-quadrature. The inputs and outputs are expressed as wave functions, modulation being considered in this instance as a single a.f. tone frequency.

$$E_1=e_1 \sin \omega t\ (1+e_2 \sin \omega_1 t)=e_1 \sin \omega t+\frac{e_1e_2}{2} \cos (\omega-\omega_1)\ t-\frac{e_1e_2}{2} \cos (\omega+\omega_1)\ t$$

$$E_2=-e_1 \sin \omega t\ (1-e_2 \sin \omega_1 t)=e_1 \sin t+\frac{e_1e_2}{2} \cos (\omega-\omega_1)\ t-\frac{e_1e_2}{2} \cos (\omega+\omega_1)\ t$$

$$E_3=e_1 \cos \omega t\ (1+e_2 \cos \omega_1 t)=e_1 \cos \omega t+\frac{e_1e_2}{2} \cos (\omega-\omega_1)\ t+\frac{e_1e_2}{2} \cos (\omega+\omega_1)\ t$$

$$E_4=-e_1 \cos \omega t\ (1-e_2 \cos \omega_1 t)=e_1 \cos \omega t+e_1e_2 \cos (\omega-\omega_1)\ t+e_1e_2 \cos (\omega+\omega_1)t.$$

Adding:—

$$E_1+E_2+E_3+E_4=2e_1e_2 \cos (\omega-\omega_1)t \text{ (one sideband)}$$

From the foregoing it can be seen that the four-phase modulator produces an s.s.b. signal, the carrier and one sideband being suppressed.

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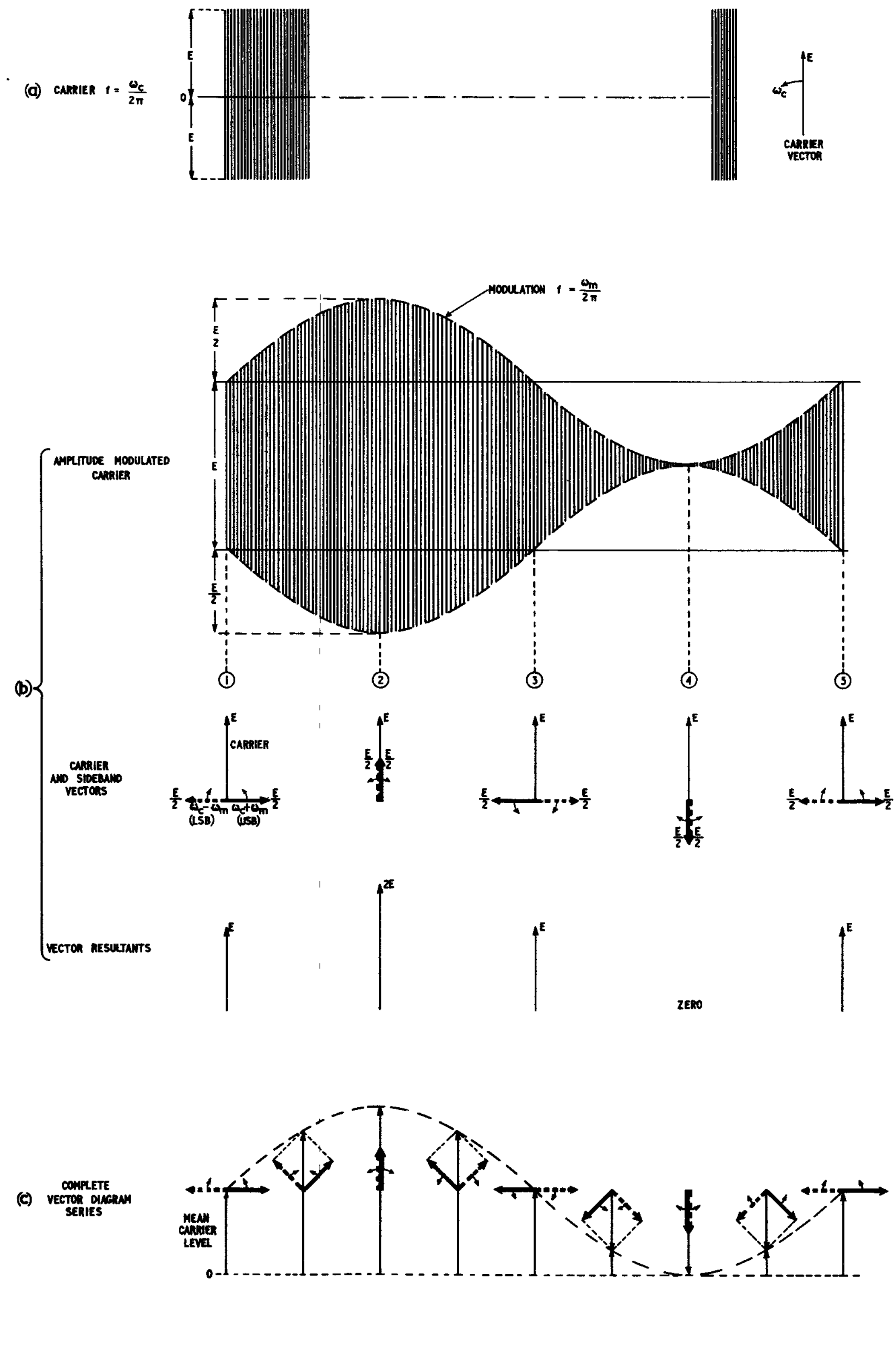

Fig.3 Vector representation of amplitude modulated waveforms Fig.3

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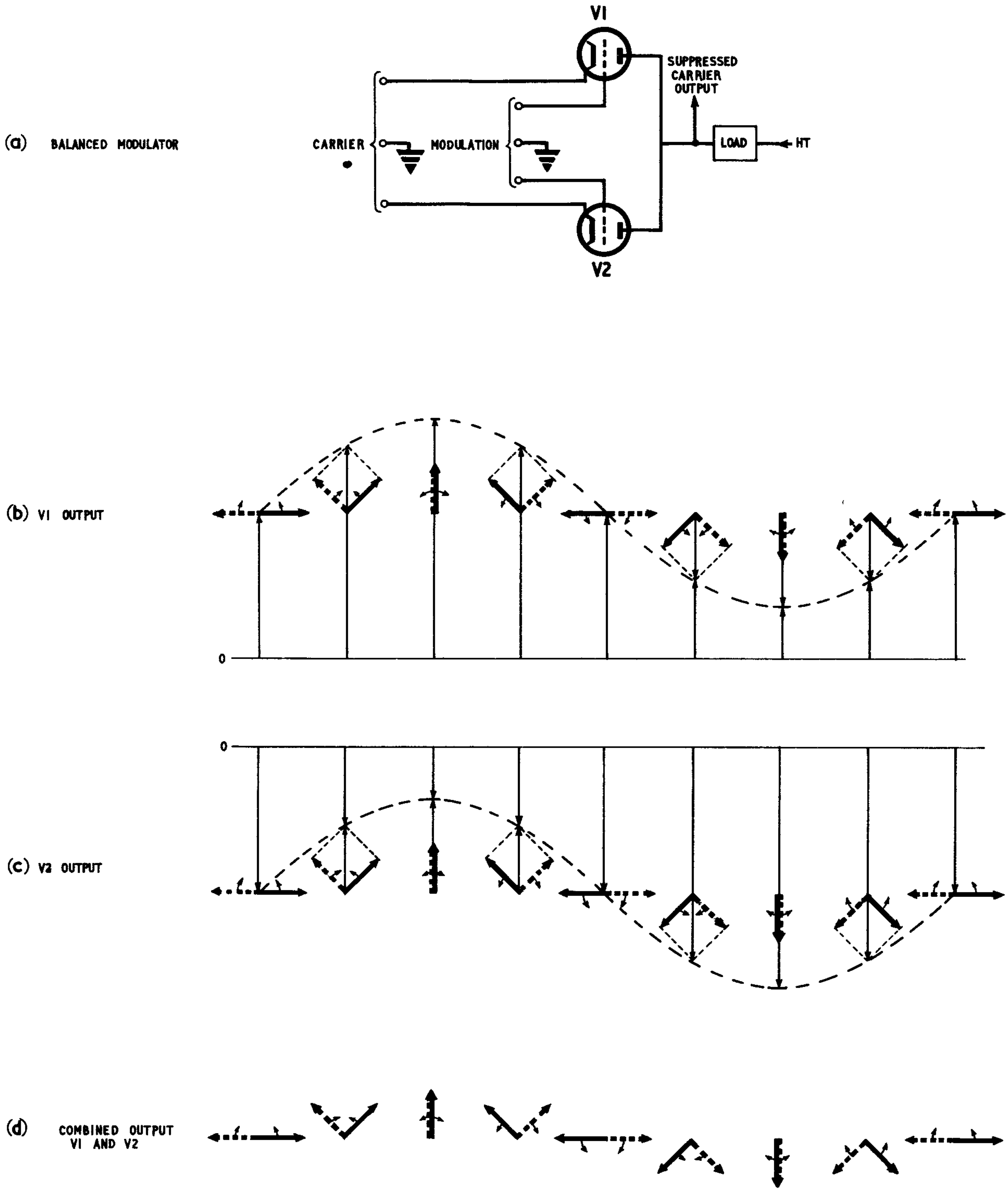

Fig. 7 Balanced modulator : circuit and vector diagrams Fig. 7

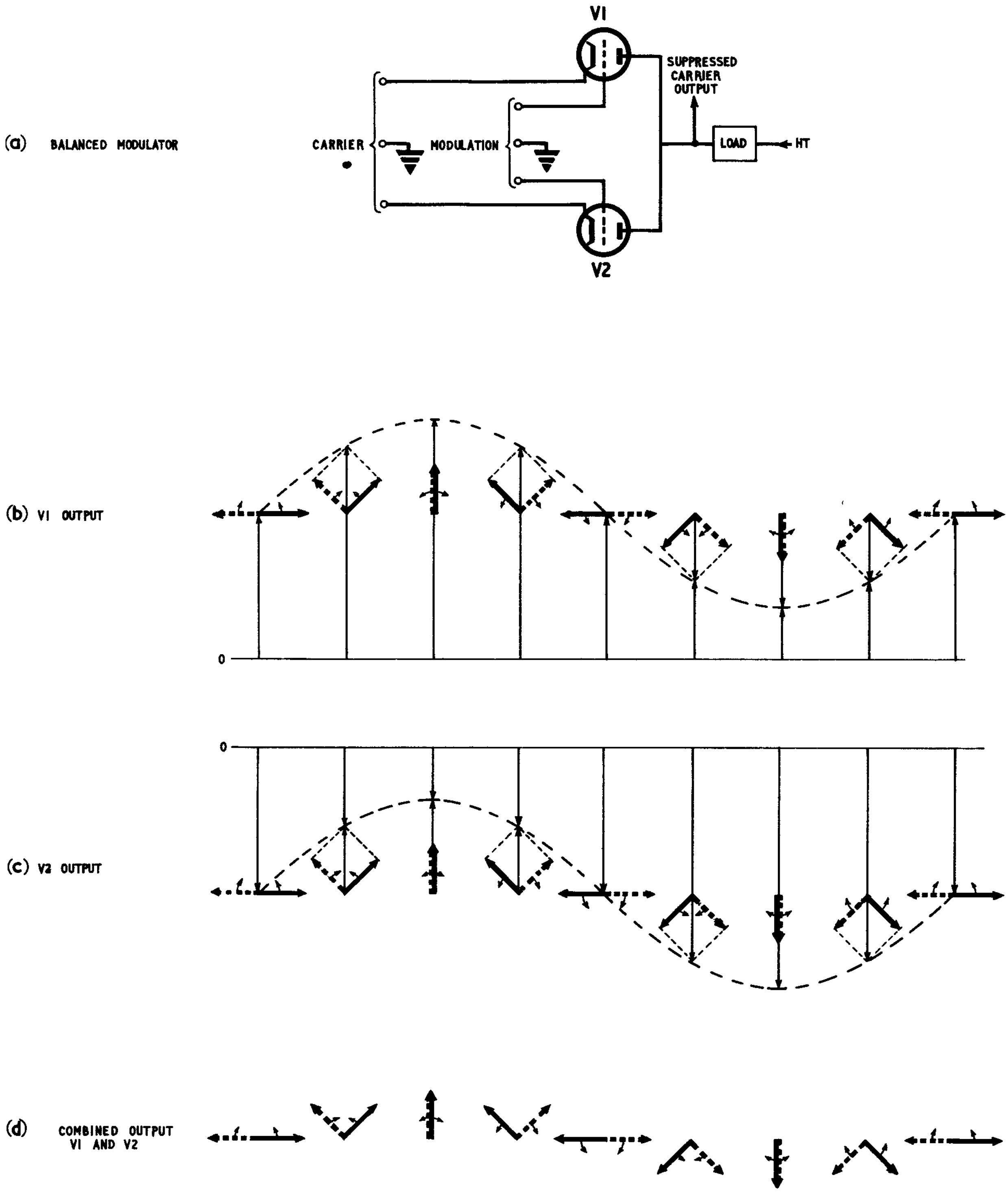

Fig. 7 Balanced modulator : circuit and vector diagrams Fig. 7

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SECTION 2

GENERAL DESCRIPTION OF TRANSMITTER-RECEIVER EQUIPMENT

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Chapter 1

GENERAL DESCRIPTION OF TRANSMITTER-RECEIVER

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The transmitter-receiver equipment associated with ARI.18179 is operated on a single sideband system in the h.f. band 2·5 to 20 Mc/s. It is used in the role of a long range R/T system for aircraft. By using a single sideband system it is possible to effectively increase the length of time for which reliable communications could be expected over a given path, since undesirable effects such as selective fading are minimized. However, the use of a s.s.b. system necessitates very high-stability frequency generation so that all stations in the network are intelligible.

2. A controlled carrier system using the upper side-band only is used in the equipment. Twelve preset channels are provided, each channel frequency being derived by the use of a frequency synthesizer known as the generator, reference signal (*Part* 4, *Sect.* 2, *Chap.* 1). This generator provides a choice of 17 500 channels in the frequency range 4 to 21·5 Mc/s in 1 kc/s steps for use in the transmitter-receiver. Final operating frequency is obtained by subtracting the intermediate frequency of 1·5 Mc/s from the frequency supplied by the generator.

3. Early versions of the s.s.b. transmitter-receiver equipment contain an automatic frequency control (a.f.c. system), this although included is inoperative. Due to the high degree of accuracy of the generator, reference signal later versions of the transmitter-receiver will not contain an a.f.c. system. Also in the later versions of the equipment provision is made for the use of either single-sideband or double-sideband transmission.

Fig. 1. General view of s.s.b. transmitter-receiver equipment

Construction

4. The following constructional details appertain to the transmitter-receiver equipment, the suppressed aerial 5895-99-999-8559 is described in Part 1, Sect. 3, Chap. 1 of this publication. The transmitter-receiver equipment consists of the following six units as shown in fig. 1.

(1) Generator, reference signal 5821-99-913-2244
(2) Transmitter-receiver radio 5821-99-913-2249
(3) Amplifier r.f. 5821-99-913-2232
(4) Interconnection box 5821-99-913-2245
(5) Control, radio set 5821-99-913-3108
(6) Power supply 5821-99-913-2246

Note . . .

In later equipments provision is made on the control, radio set 5821-99-913-3108 *to include selection of either single sideband transmission or double sideband transmission by means of a two-way switch.*

5. The generator reference signal, transmitter-receiver radio, amplifier r.f. and the power supply unit are designed for fitting into supports mounted in the radio bay of the aircraft; the control, radio set (remote control unit) is mounted in the cockpit of the aircraft, and is normally situated in a position facilitating manual control.

6. The generator, reference signal (*fig.* 2) contains eight detachable sub-units which are easily

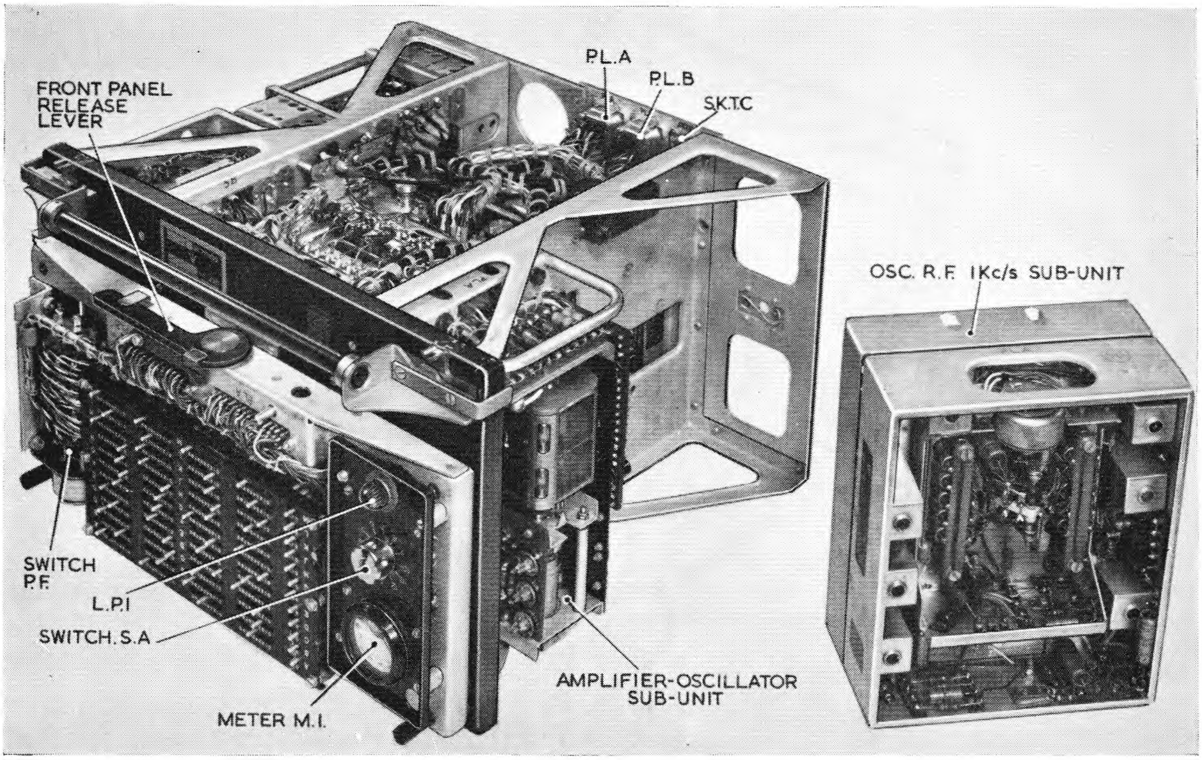

Fig. 2. Generator reference signal, showing sub-units

removed for adjustment or servicing, by loosening the associated green-painted retaining screws and then gently pushing the sub-unit on its opposite face or pulling on the handles, taking care that the sub-unit does not drop suddenly and become damaged. A check should also be made that the interconnecting plug is not twisted or wrenched. A hinged panel at the front of the generator can be opened to reveal the switch settings beneath; these are used for setting up the frequencies required from the generator for each channel.

7. Generatoı reference signal contains an accurate 5 Mc/s crystal oscillator, this provides the basic reference for the large number of frequencies obtainable. The frequency reference consists of a quartz crystal controlled, thermionic valve oscillator, capable of stability within plus or minus a few parts in 10^8 under vigorous operating conditions. The sub-units in the generator incorporate sub-dividers, multipliers and mixers in order to give a large number of available output frequencies, any twelve of which can be selected for operation in the transmitter-receiver.

8. Transmitter-receiver radio 5821-99-913-2249 is also built up mainly of removable sub-units (*fig*. 3) in a similar way to the generator, reference signal. The sub-units are easily removable for checking and servicing. On the left-hand side of the transmitter-receiver front panel is the control frequency selector, this is a sub-unit which is removable after withdrawal of four retaining screws. The control frequency selector contains a motor-driven selector switch which is capable of being rotated to any one of twelve preset channel positions over 180° rotation (depending on information received from the remote control unit) thus tuning the transmitter-receiver unit 5821-99-913-2249 to the required frequency channel. Detailed operation of the control, frequency selector (single-turn) is described in Part 4, Sect. 1, Chap. 10. The connections to the transmitter-receiver unit are via plugs and sockets at the rear.

9. The amplifier r.f. unit (*fig*. 4) contains the driver and power amplifier valves operating in a linear class AB condition, the latter valves providing the final s.s.b. output power to the suppressed aerial.

10. Located at the top of the front panel of the amplifier r.f. are an indicator meter and switch. Operation of the switch selects certain circuit functions e.g. voltages and currents which are indicated on the meter. Beneath the meter and switch is located a control, frequency selector (multi-turn), this is a removable sub-unit, used for channel selection and amplifier tuning. Tuning takes place over a maximum of 10 turns of the control frequency selector. At the lower left side of the amplifier front panel is a push-button switch used for tuning adjustment, also four sockets used for metering and checking. The potentiometer marked RV1 on the front panel of the unit is used for setting the cathode current of the power amplifier valves.

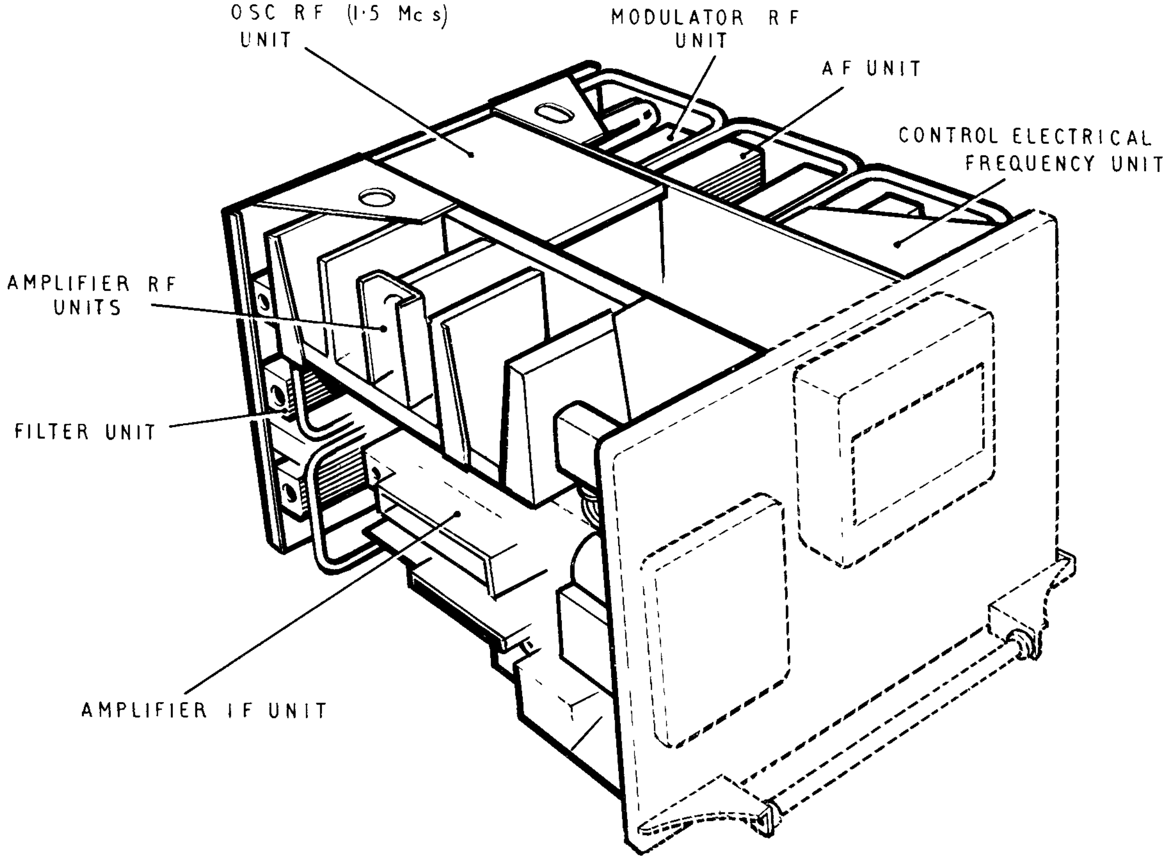

Fig. 3. Transmitter-receiver, sub-unit location

11. At the rear of the amplifier r.f. unit are mounted three valves (not shown in *fig.* 4) used as power amplifiers. In the front of these valves are located the range selection switch and output tuning coil, access to which is from the top of the unit after the cover has been removed.

12. The input and output coils for the power amplifier valves are wound on synthetic bonded fibre tube and are mounted at right-angles to each other, the coils are also situated on opposite sides of a metal screen, to reduce interaction between them.

13. The interconnection box (*fig.* 5) is a convenient system for connecting the various cables to individual units of the installation.

14. Channel selection and controlling arrangements are located on the control-radio set (remote control unit) (*fig.* 6) which is fitted in the cockpit of the aircraft. The remote control unit contains the means for selecting any one of twelve preset frequencies in the range 2-20 Mc/s. At the top left-hand side of the front panel is located the main ON/OFF, receive (R) and transmit/receive (T/R) switch. Also along the top of the front panel are the aerial fine tune switch and the 12-channel selector switch. Beneath these switches are three "dolls-eye" indicators, these indicate a.f.c. centre, crystal oven, and channel selected, respectively. The A.F.C./MANUAL control switch (*para.* 3), receiver (RX GAIN) and aerial fine tune potentiometer are located on the lower section of the remote control unit front panel.

15. The power supply unit is a separate item with input from the 200V three-phase 400 c/s and 28-volt d.c. systems of the aircraft. The power supply unit provides all the power requirements for the transmitter-receiver, and a d.c. supply for suppressed aerial system if required (*Chap.* 9).

16. On the front panel of the power supply unit (*fig.* 7) are eleven fuses (F1 to F11) which protect the various supplies to other items of the transmitter-receiver equipment. At the rear of the front panel, beneath the fuses are located switching relays (not shown in *fig.* 7), adjacent to which are mounted the regulator valves and smoothing capacitor. At the rear of the power supply unit chassis are mounted the three-phase 200V power transformers and associated rectifiers. The rectifiers are mounted on a special bracket which is hinged to facilitate servicing. Beneath the eleven fuses on the front panel is a detachable cover under which are located spare fuse links.

OPERATION OF TRANSMITTER-RECEIVER

17. The following is a brief description of the operation of the transmitter-receiver. The receiver section of the equipment operates as a superheterodyne receiver with an intermediate frequency of 1·5 Mc/s. The transmitter operates on a similar

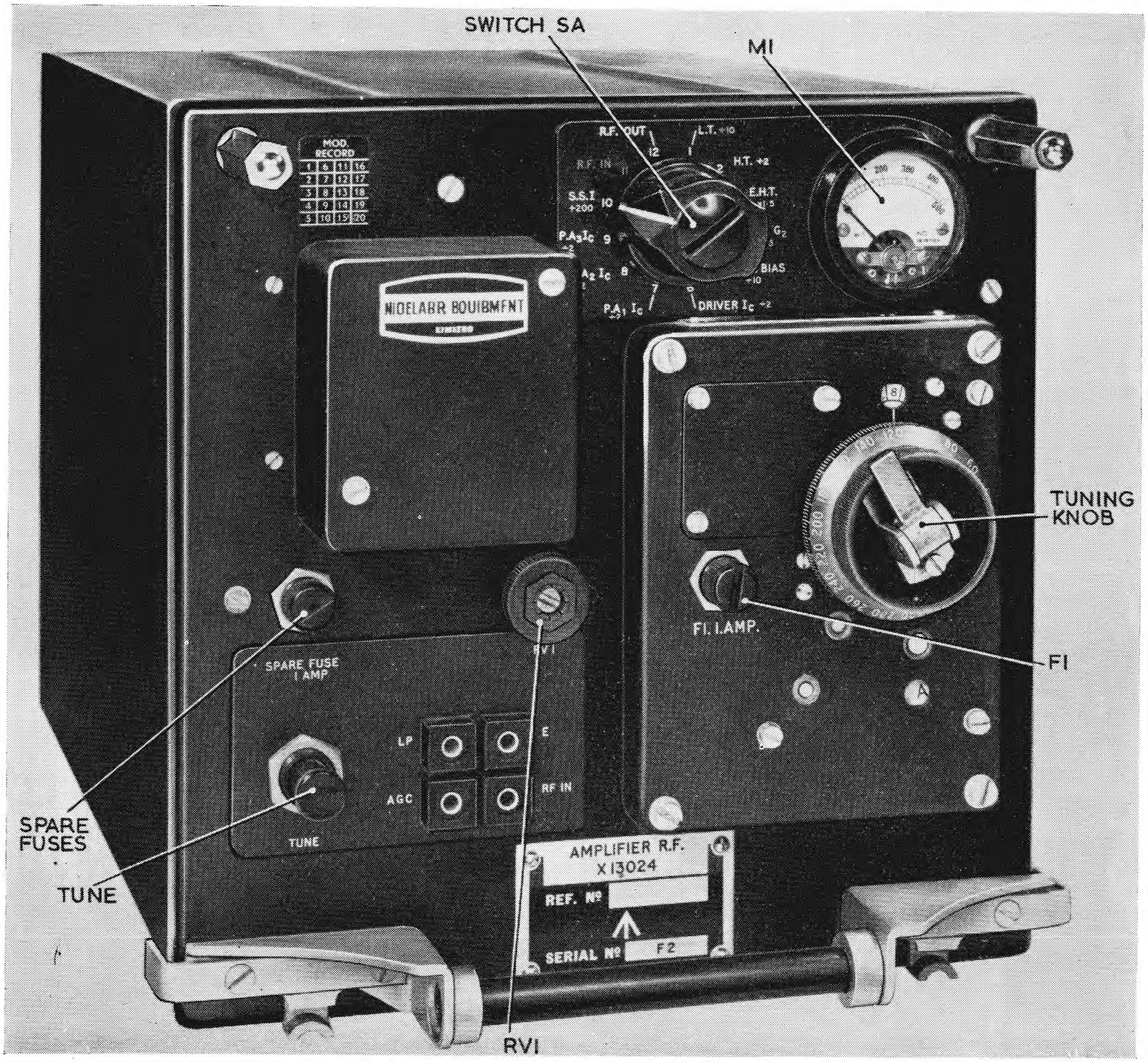

Fig. 4. Amplifier radio frequency—front view

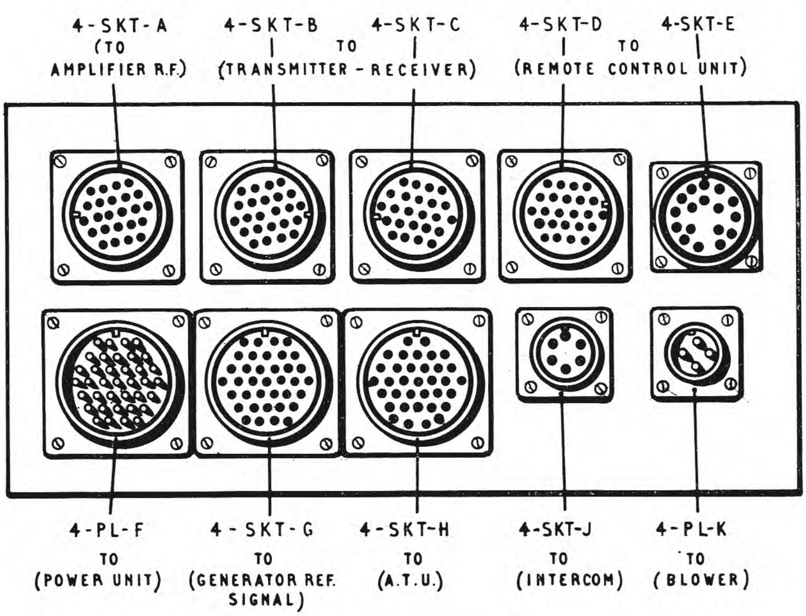

Fig. 5. Interconnection box

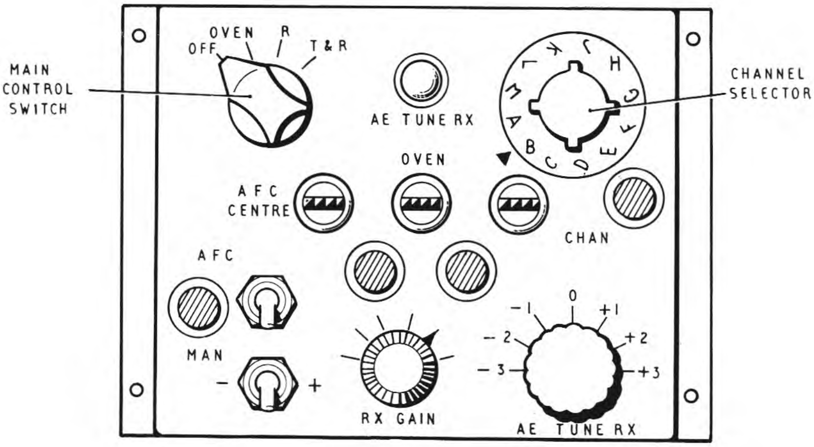

Fig. 6. Control, radio set

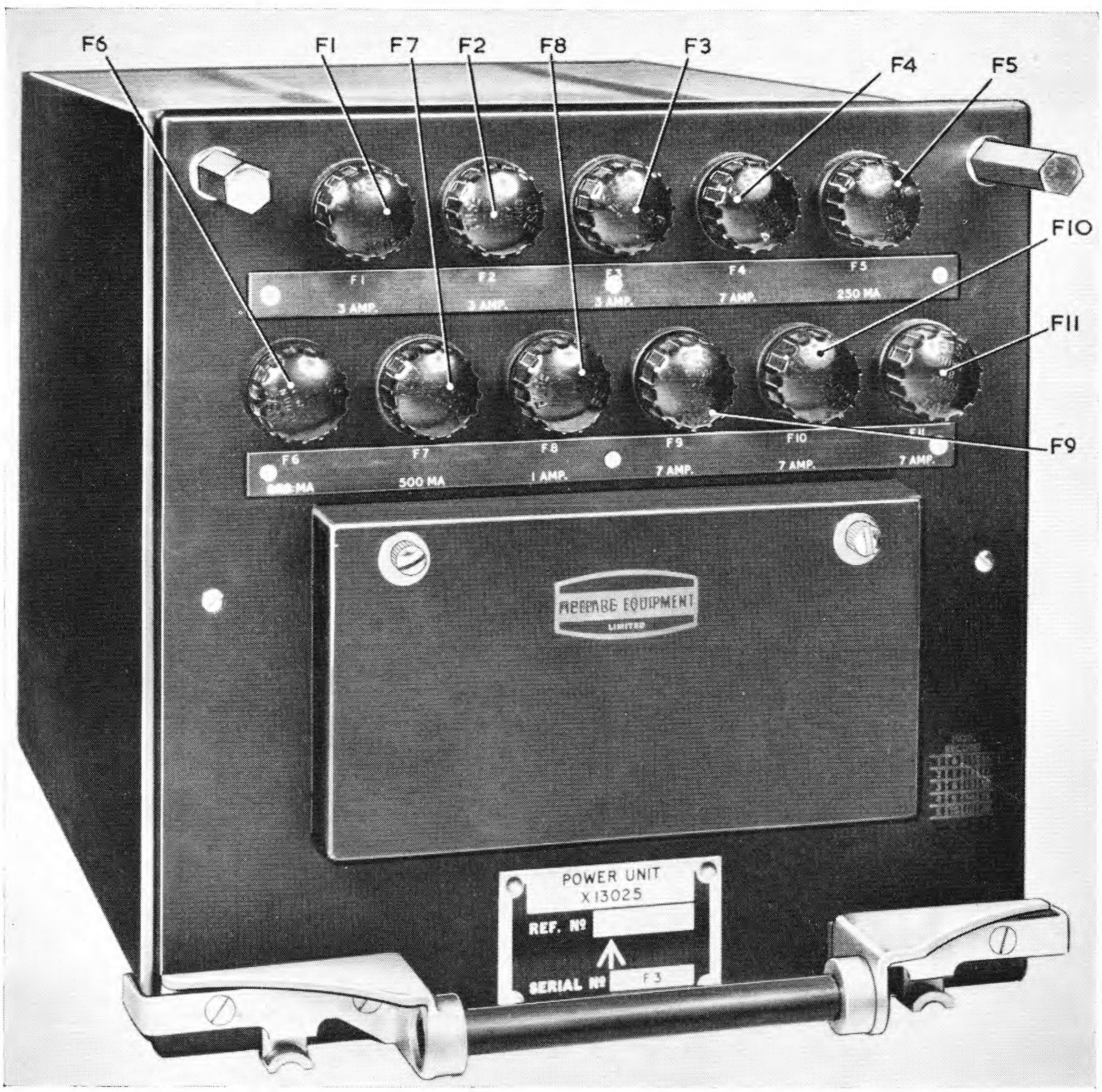

Fig. 7. Power supply—front view

principle to that of the receiver in that the single sideband signal is generated initially at a frequency of 1·5 Mc/s, this frequency is then changed to one suitable for transmission. The generator, reference signal is used as a common local oscillator for both the transmitter and receiver in the equipment.

Receiver

18. A block diagram of the transmitter-receiver is shown in fig. 8. A single-sideband signal is received on a particular frequency channel in the suppressed aerial system, it is then fed via a coaxial cable to the r.f. unit (power amplifier). Heıe the received signal passes through a pair of contacts on the transmit/receive relay and is then fed out again to the receiver r.f. amplifier.

19. In the receiver r.f. amplifier, the signal frequency is amplified before being applied to the receiver frequency-changer. The latter receives two signals at its input, one being the incoming s.s.b. signal from the r.f. stage and the other the local oscillator frequency obtained from the generator reference signal. The local oscillator frequency is 1·5 Mc/s higher than the signal frequency obtained from the r.f. stage, thus producing the intermediate frequency of 1·5 Mc/s which is the difference frequency between the received signal and the local oscillator signal injected into the frequency-changer stage.

20. The single sideband output from the frequency changer is fed to the i.f. amplifier which also contains the demodulators. In order to demodulate the s.s.b. signal a local oscillator signal is injected into the demodulators from the 1·5 Mc/s r.f. oscillator. The a.f. signals in phase-quadrature obtained from the demodulators are now applied to the control electrical frequency unit.

21. If a discrepancy exists between the original carrier frequency and the reinserted carrier from the 1·5 Mc/s r.f. oscillator, an error signal is obtained from the combining circuit, at the output of the control electrical frequency unit. This is a d.c. signal proportional to the difference in frequency between the original and reinserted carrier frequencies.

22. The required speech frequencies also appear at the output of the control electrical frequency unit, these are further amplified in the a.f. unit and are then applied to headphones.

Transmitter

23. In the transmitter, the audio or modulating frequencies are fed to the a.f. unit from the microphone. After amplification in this unit the a.f. is applied to the four-phase modulator in phase-quadrature. At the same time a 1·5 Mc/s r.f. signal also in phase-quadrature is fed to the modulator from the oscillator r.f. 1·5 Mc/s unit. The resultant output from the modulator being a single-sideband signal, at 1·5 Mc/s (*Part* 4, *Sect.* 1, *Chap.* 6). This single-sideband signal is applied to the transmitter frequency-changer, the output from the latter being a signal of suitable frequency for transmission.

24. The transmitter frequency-changer in the form of a Cowan diode modulator (*para.* 40) receives

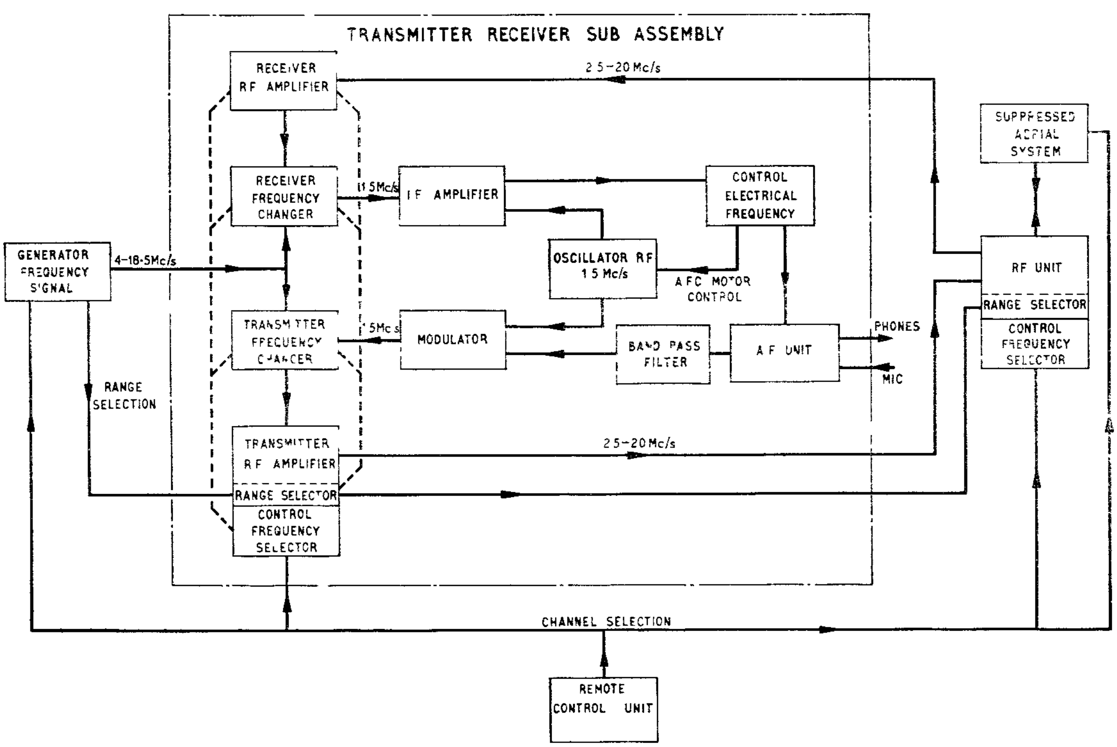

Fig. 8. Transmitter-receiver, block diagram

two signals, one the s.s.b. signal from the modulator, the second an r.f. signal from the generator reference signal. The resulting output frequency from the transmitter frequency-changer is within the range 2·5 to 20 Mc/s, and the particular frequency chosen is applied to the transmitter r.f. amplifier for further amplification. This r.f. amplifier is a "linear" amplifier operating under class A conditions, providing a minimum of distortion, as propounded in Part 1, Sect. 1, Chap. 1, para. 34.

25. Output at radio frequency from the r.f. amplifier is fed from the transmitter-receiver via a coaxial cable to the r.f. unit (power amplifier). This is a separate unit and contains the final power amplifier valves operating under "linear" class AB conditions to provide the necessary transmitter r.f. power output to be fed to the suppressed aerial system.

26. Channel selection information is provided by the remote control unit and is fed to:—

(1) the suppressed aerial system
(2) the control frequency selector in the r.f. unit (single-turn)
(3) transmitter r.f. power amplifier (multi-turn)
(4) the generator reference signal.

Each of these units is mechanically-operated to select the required predetermined channel frequency.

GENERAL DESCRIPTION

Audio frequency unit

27. Audio frequency signals from the microphone are amplified by a low-noise pentode stage which is in turn R-C coupled to one half of a double-triode valve. During transmission the a.f. output from this latter stage is passed through a filter network which has a passband of 500 c/s to 3 kc/s, giving a final balanced output of approximately 2V r.m.s. to the modulator.

28. The output from the low-noise pentode is also coupled to the triode section of a diode-triode valve. The diode section of this valve is used to rectify the a.f. output from the triode and the resulting d.c. voltage obtained is applied to both stages of the microphone amplifier so that the a.f. output from the unit is constant. This is known as VOGAD (voice operated gain control).

29. The output stages of the a.f. amplifier together with the low-noise pentode microphone amplifier act as the inter-communication amplifier, with the addition that in order to overcome receiver noise, a muting relay is incorporated. When this relay operates it allows a preset level of muting on receive. An audio output from the receiver is also amplified in two stages, by the a.f. unit, to the level required for the headphones.

30. Under receive conditions the band-pass filter mentioned in para. 27 is switched for use between the two receiver a.f. amplifying stages. The first stage amplifier gain is controlled by adjusting the negative feedback produced across the primary winding of a transformer connected in the cathode of the first a.f. stage.

Oscillator radio frequency (1·5 Mc/s)

31. An r.f. carrier is initiated from a 1·5 Mc/s crystal-controlled oscillator, this supplies outputs for producing s.s.b. operation of the transmitter and also demodulation of the s.s.b. signal in the receiver. The carrier oscillator uses a Pierce-Colpitts type of circuit having a stability of ± 5 parts in 10^6 maintained by an ovened crystal.

32. Since the a.f.c. system incorporated in the transmitter-receiver is inoperative, operation of the AFC/MANUAL switch on the remote control unit will have no effect. In later versions of the s.s.b. transmitter-receiver the a.f.c. switches on the remote control unit will be removed and a blanking plate fitted in place of these switches.

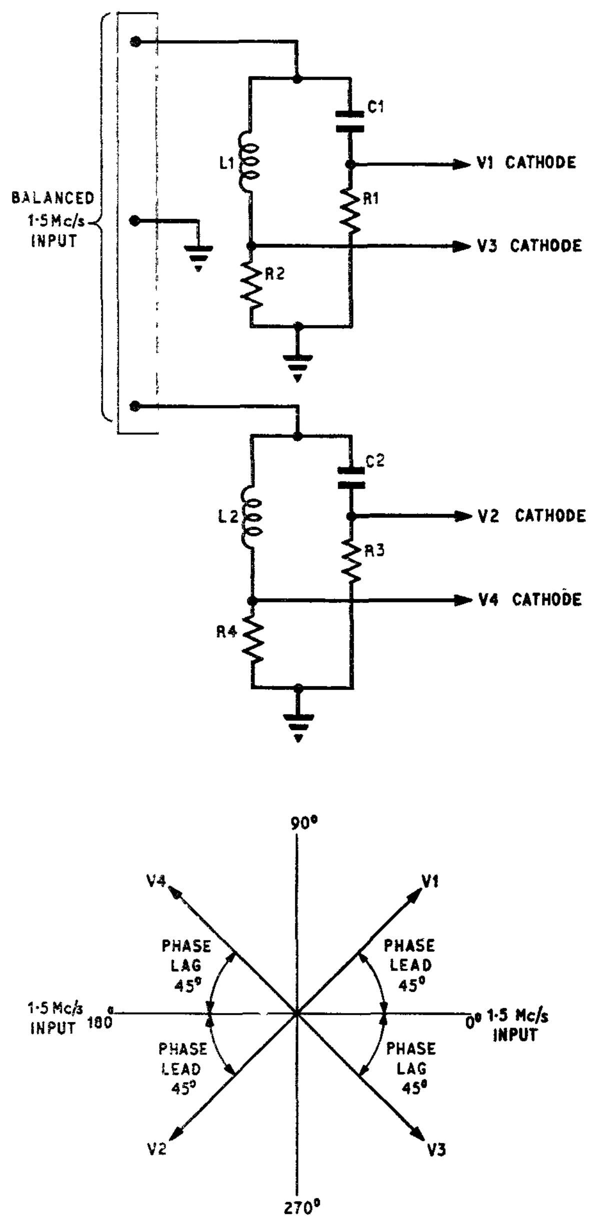

Fig. 9. 1·5 Mc/s four-phase input to modulator

Modulator

Production of phase shift at 1·5 Mc/s

33. To produce the necessary phase-shift of the r.f. signal use is made of L-R and C-R phase advance and retard circuits, operating from a balanced input, (*a*) of fig. 9.

34. The reactance of L1 at 1·5 Mc/s is arranged to equal the resistance of R2, thus providing a voltage across R2 whose phase lags behind that of the applied voltage. Similarly, the reactance of C1 is arranged to equal R1, thus producing a voltage across R1 whose phase leads that of the applied voltage. A similar arrangement of L2-R4 and C2-R3 produces two more voltages differing in phase by 90° as can be seen from (*a*) of fig. 9. These voltages are of the opposite 'sense' to the previous two voltages since they are obtained from the opposite phase of the balanced r.f. input. From (*b*) of fig. 9 it can be seen that the four cathodes of the modulator valves are fed in phase-quadrature, i.e. $\frac{\pi}{2}$ between them, but each pair of modulator valves i.e. V1, V2 and V3, V4, has a signal applied to the cathodes differing in phase by 180°. Hence there will be no carrier signal output from the modulator when the valves and circuits are balanced and no modulating signal applied.

Production of phase shift at audio frequencies

35. At audio frequencies the problem of phase shift is more difficult to obtain since it is necessary to produce a 90° phase shift over a band of frequencies, i.e. 300-3000 c/s. This is accomplished by the use of specially derived R-C networks; the resulting phase shift over the audio band being shown in fig. 10. The input to the audio phase-shifting network is again balanced, and four output signals in phase-quadrature are obtained from it. These four a.f. signals are applied to the grids of the modulator valves V1, V2, V3, V4. As it is necessary to produce a 90° phase shift over the band of frequencies 300 c/s-3000 c/s to within ±2°, a band-pass filter has been included in the a.f. unit which attenuates frequencies other than those in the pass-band. This filter is necessary to avoid undesirable effects caused by a phase-shift of other than 90° if frequencies outside this band (300 c/s to 3000 c/s) were allowed to enter the modulator. Frequencies below 300 c/s if transmitted could operate the a.f.c. circuits in the receiver giving false information to the a.f.c. system.

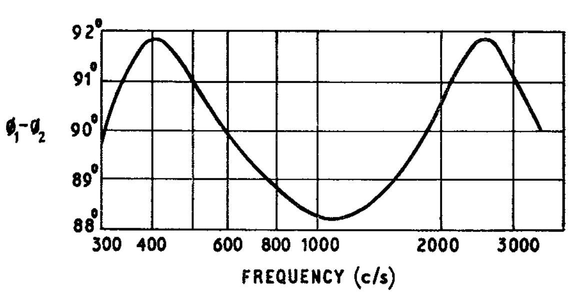

Fig. 10. Audio phase shift network—response curve

Generation of a single-sideband signal in the modulator

36. The s.s.b. signal is generated in the transmitter modulator sub-unit, this consists of a four-phase modulator with phase-shift circuits in the audio and r.f. signal circuits. A four-phase modulator is made up of two balanced modulator circuits. The resulting output from the four-phase modulator is a single-sideband signal, the carrier, and unwanted sideband being suppressed in the circuit. Operation of the four-phase modulator method of obtaining a single-sideband signal is described in Part 1, Sect. 1, Chap. 1 of this publication.

37. In the transmitter modulator the 1·5 Mc/s r.f. signal is applied to the cathodes of the four valves in the modulator, whilst the audio signals are applied to the grids. The r.f. signals are arranged in phase-quadrature such that with no a.f. signal applied, the r.f. carrier signals will cancel in the output (*para.* 34). When modulation is applied the carrier and one sideband are suppressed, thus giving the required single-sideband suppressed-carrier output signal (*Part* 4, *Sect.* 1, *Chap.* 6).

38. The single-sideband output signal derived from the modulator, is amplified and then passed to a crystal band-stop filter. The action of the filter is to reinforce the wanted sideband by further suppression of the unwanted sideband.

Controlled carrier system

39. A part of the 1·5 Mc/s r.f. signal which enters the modulator is applied to an amplifier valve via a gating circuit. The gating circuit is operated by an a.f. signal so that when voice frequencies are present the carrier is cut off. Under conditions when no voice frequencies enter the modulator the gate circuit opens allowing the 1·5 Mc/s carrier to appear in the output and hence provide drive to the r.f. power-amplifier; this is known as controlled-carrier operation. The r.f. power-amplifier provides an output carrier power of approximately 100W when no modulation input is applied to the transmitter-receiver.

Transmitter frequency-changer (Cowan modulator)

40. Having obtained an s.s.b. signal at 1·5 Mc/s, it is now necessary to change this frequency to a suitable one for transmission. This operation is carried out in the transmitter frequency-changer, the most important item of which is the Cowan modulator. The Cowan type of modulator is a ring modulator using four diodes. These diodes have two signals applied to them, one being the input frequency and the other the modulating frequency. The action of the circuit is such that the input signal is switched at the modulating signal frequency, this in effect being a frequency changing process.

41. The Cowan modulator frequency changer receives two signals one being the s.s.b. output signal from the modulator, and the other a r.f.

input from the generator, reference signal; these signals are applied to the Cowan modulator via wide-band transformer coupling. The output circuit of the Cowan modulator is tuned to the difference of the two applied frequencies, thus giving a signal within the range 2·5 to 20 Mc/s. The Cowan type of modulator circuit affords some 15 dB of suppression to both the original input signals at its output, even though the circuit is not of the balanced type.

Transmitter r.f. amplifier

42. The transmitter frequency-changer (described in *para.* 40, 41) is followed by two stages of linear r.f. amplification, with further tuned circuits to improve the selectivity and hence reduce any unwanted intermodulation products from the frequency-changing process. These linear r.f. amplifiers are operated as class A amplifiers tuned to the difference frequency (obtained from the transmitter frequency-changer) over the range 2·5 to 20 Mc/s. The output of the final stage is fed at low impedance (via a coaxial cable) to the amplifier r.f. (power amplifier).

Amplifier, radio frequency (power amplifier)

43. Final power amplification is carried out in the power amplifier. This is a linear amplifier as previously mentioned (*para.* 9). The single-sideband signal produced in earlier stages is fed to the control grids of a double-tetrode amplifier valve which functions as a drive valve operating under class AB1 conditions, the two halves of the valve being connected in parallel. Output r.f. voltages are used to drive the three parallel-connected double-tetrode power amplifiers. The valves used in this final section of the amplifier are also operated in class AB1 and have a small feedback capacitor, for neutralizing purposes. connected between the valve grids and the output of the pi-network tuning circuit. Both input and output tuned circuits of the "linear" amplifier circuit are π-section networks, which are mechanically tuned to the channel required. Range switching is provided by switching into circuit the required capacitors for the appropriate range Tuning is accomplished by means of variable inductors, which are adjusted to the required position by the "multi-turn" selector unit.

44. The final r.f. amplifier valves and their associated output circuit are matched into a 50-ohm impedance. Output r.f. power is taken to the suppressed-aerial tuning system via an aerial change-over relay in the r.f. power amplifier. The aerial change-over relay earths the receiver input when transmitting and switches the aerial to the receiver for reception. This relay is operated via the transmit/receive switching of the transmitter-receiver.

45. Contained in the transmitter r.f. unit is the automatic load control system (a.l.c.) whose function is to regulate the input drive level such that a constant output is maintained, thus it provides automatic compensation against overload and load variations with frequency changes.

Receiver r.f. amplifier and frequency changer

46. Amplifier r.f. 5821-99-913-2241, contains both the transmitter and receiver r.f. amplifier and frequency-changer stages. The receiver r.f. amplifier consists of a pentode r.f. stage which is inductively coupled to the aerial, followed by a further pentode valve used as the frequency-changer. Two signals are applied to the grid of the frequency-changer, one from the r.f. amplifier at the signal frequency, the other being local oscillations from the generator, reference signal. The intermediate frequency (1·5 Mc/s) produced is applied to the i.f. amplifier.

47. However, before the signal is fed to the i.f. amplifier valve it is passed through a crystal band-pass filter whose characteristics are selected to pass the upper sideband. This is necessary to reduce a.g.c. action from strong signals which may be present on the unwanted (lower) sideband. The a.g.c. voltage developed in the i.f. amplifier is applied to the receiver r.f. stage.

I.F. amplifier

48. In this sub-unit are contained the i.f. amplifier and demodulator stages of the receiver. The output from the i.f. crystal filter (*para.* 47) is amplified by three stages of amplification, using pentode valves and temperature compensated tuned circuits.

49. Demodulation is accomplished by beating the i.f. signal with a 1·5 Mc/s signal obtained from the oscillator r.f. (1·5 Mc/s) thus producing frequencies in the audio range (*Part* 1, *Sect.* 1, *Chap.* 1, *para.* 36).

50. The 1·5 Mc/s signal from the oscillator r.f. (1·5 Mc/s) is applied in phase-quadrature to both grids of the demodulator triodes. A s.s.b. signal from the final i.f. amplifier stage being applied in phase to the demodulator valve cathodes. The resulting audio signals are produced at the anodes in phase-quadrature. This demodulation process is very similar to the four-phase modulation process used in the transmitter.

51. The two audio signals obtained from demodulation (with upper and lower sidebands of both signals) are filtered to remove any r.f. component and then applied to an a.f. phase shifting stage consisting of two double-triodes with a.f. phase shift networks in the anode circuits. A differential phase shift of 90° is produced and the two a.f. signals (again upper and lower sideband on both signals with different phase relationships) are then applied to the combining stage contained on the control electrical frequency (a.f.c.) unit. Here the wanted sideband signals add and the unwanted sideband signals cancel in a similar way to that used in the transmitter modulator (*Part* 4, *Sect.* 1, *Chap.* 6).

Control electrical frequency unit (a.f.c.)

52. The a.f.c. unit contains the combining stage of the demodulator. The balanced demodulated a.f. output from the i.f. unit is amplified by a pair of d.c. amplifiers before being applied to the combining stage.

53. Output signals from the combining stage add when in phase and subtract when in opposition, thus the signal due to one sideband will be produced by one combiner and the alternative sideband signal by the other combiner. Either sideband may be selected for subsequent amplification in the a.f. unit by making appropriate connections on a link board. The combiner amplifiers are followed by low-pass filters these "cut-off" at a maximum of 300 c/s.

Channel and wave-change selection

54. The transmitter-receiver frequencies are pre-set, and are selected from the control, radio set (remote control unit). When a frequency is selected the range required is given automatically from the generator reference signal and this depends over which range the amplifier-oscillator unit in the generator is working. The five ranges are:—

(1) 2·5-5 Mc/s
(2) 5-10 Mc/s
(3) 10-15 Mc/s
(4) 15-20 Mc/s
(5) 20-25 Mc/s

55. The range changing is performed by means of 'Ledex' rotary solenoids. The circuit which operates the 'Ledex' switch in the transmitter-receiver unit is completed in the generator reference signal, this supplies an appropriate earth to the transmitter-receiver unit on one of three wires. The range information to the transmitter-receiver unit is taken from a separate switch, ranges 3, 4 and 5 being strapped together. A further wafer on the 'Ledex' rotary solenoid switch used in the transmitter-receiver unit completes the circuit to another similar switch in the amplifier r.f. (power amplifier) where the required capacitors appropriate to the waveband chosen are selected.

56. The setting of the tuning inductors in the amplifier r.f. (power amplifier) is set on each channel by means of the "multi-turn" selector unit. The transmitter and receiver common ganged capacitors which are situated on the r.f. sub-assembly in the transmitter-receiver, are preset on each channel by means of the single-turn selector unit.

Power supply unit

57. This unit provides all the h.t. power requirements for the s.s.b. transmitter-receiver; it operates from a three-phase 200V 400 c/s supply and 28V d.c. supply. The d.c. high tension supplies are obtained from a three-phase full-wave rectifying system employing silicon junction rectifiers. The transformers and rectifiers provide three h.t. supplies of 650, 200 volts positive and 200 volts negative to earth (the −200V supply being used for the −35V stabilized bias supply). The 650V line which is applied to the anodes of the PA valves is also used to provide input voltage for the stabilized screen supply. This supply is obtained by means of a stabilizing circuit and is used to provide a 300V supply for the PA screen. The 200-volt positive supply is used generally throughout the equipment and from this supply is obtained, via Zener diode stabilization, a 150V supply for use in the generator, reference signal.

58. A regulated −35V supply used for the power amplifier bias is obtained via a shunt regulator from a −200V supply.

59. The transmitter-receiver heater supply and also that of the generator, reference signal are provided from the 28V d.c. aircraft supply via the power supply unit. Relay supplies and interlocking systems are also supplied from the power supply unit.

Generator, reference signal

60. The generator, reference signal provides a very large number of stable frequencies for use in the transmitter-receiver by a process of frequency synthesis. The generator uses as a basis of frequency, a highly-accurate crystal oscillator operating at 5 Mc/s. By a suitable method of mixing and recombining sub-harmonics and multiples of this crystal oscillator, with other oscillators, a wide range of frequencies is available from the unit. Normally twelve frequencies are selected from the generator reference signal to allow the transmitter-receiver to function in the range 2 to 20 Mc/s. Each channel frequency is set up from the front panel of the generator by adjustment of special switches by means of which each channel frequency can be set to within 1 kc/s of any required frequency. The actual frequency obtained from the generator is 1·5 Mc/s higher than that indicated by the switches. All the frequencies obtainable from the generator reference signal have the same order of accuracy as the basic reference 5 Mc/s oscillator i.e. ± 4 in 10^8.

61. The generator is a highly complicated and specialized piece of equipment and the principles on which it operates are dealt with fully in a later chapter (*Part* 4, *Sect.* 2, *Chap.* 1).

62. It was found necessary to provide a frequency source of high stability because of the decreased tolerance range when using the single sideband technique. The introduction of the frequency generating unit with its associated highly stable frequency source has made the need for automatic frequency correction unnecessary; thus the a.f.c. circuits have been rendered inoperative as mentioned in para. 3.

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Chapter 2

INSTALLATION OF TRANSMITTER-RECEIVER EQUIPMENT

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The installation instructions given in this chapter are intended as a guide to the installation of the s.s.b. h.f. transmitter-receiver equipment, forming part of ARI.18179. Instructions regarding installation of the suppressed aerial system will be found in Part 1, Sect. 3, Chap. 2, of this publication.

2. Four items of the s.s.b. transmitter-receiver (para. 3) are intended for fitting into supports mounted in the radio bay of the aircraft. The control radio set (remote control unit) is however, fitted in the cockpit of the aircraft and is normally situated in a position facilitating manual control.

General installation

3. The transmitter-receiver equipment (fig. 1) consists of the following six units:—

(1) Transmitter-receiver radio 5821-99-913-2249

(2) Amplifier r.f. 5821-99-913-2232

(3) Power supply 5821-99-913-2246

(4) Generator reference signal 5821-99-913-2244

(5) Control radio set 5821-99-913-3108

(6) Interconnection box 5821-99-913-2245

4. The units in sub-paras. (1) to (4) are designed for easy removal from their supporting frames.

5. When the supporting frames for the units mentioned in para. 4 are installed, care must be taken to allow the front panel of each unit to be accessible for operation of the controls thereon for channel setting purposes, fuse changing and testing (fig. 1).

6. Sufficient clearance must also be left for the removal and refitting of units.

7. Fixing for the mountings is by ¼ in. UNC bolts into blind tapped holes in the anti-vibration mountings. These bolts should be suitably locked after installation.

8. Two wing nuts, located on each mounting are intended for pushing the associated unit into the back plugs on insertion of the unit in its mounting, the nuts are also used for pulling the unit out of the back plugs on withdrawal.

9. It is important that these nuts are tightened evenly until the plugs in the mounting and the unit are fully mated. Small holes are provided in the wing nuts for attaching a locking wire.

10. If a.c. blowers are used for cooling the equipment these must be fitted to the back plates of support electrical equipment 5821-99-913-3109, 3110 and 3112. The back plate of support electrical equipment 5821-99-913-3111 is also fitted with a special blower.

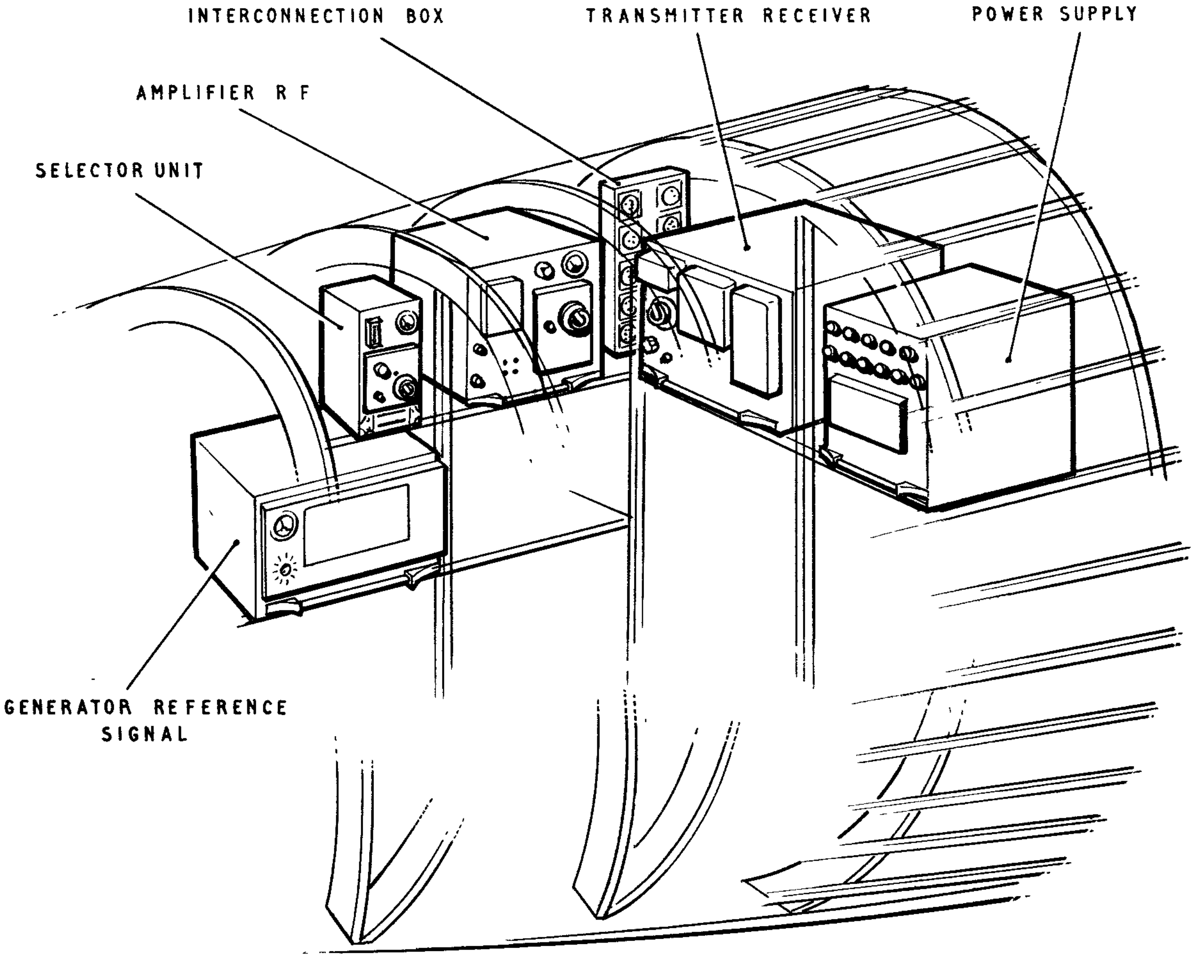

Fig. 1. Typical installation layout in radio bay

11. Alternatively a central cooling system can be provided using adaptor pipes.

Control radio set 5821-99-913-3108 (remote control unit)

12. The installation of this item should be arranged in the cockpit of the aircraft in such a position that the unit can be easily seen and operated.

13. Indirect illumination of the front panel engraving is provided. If dimming is required, the wire from pin N on plug 6PLB (fig. 2) should be taken via a variable-resistance dimmer. This dimmer may be common to control units of other equipments.

14. When glowing at full brilliance the panel lamps require 0·16A at 28 volts.

Interconnection box 5821-99-913-2245

15. The interconnecting box may be bolted directly to the airframe in any convenient position and attitude. In the installation of this item it is of course necessary to bear in mind that the plugs should be easily accessible for removal and refitting and that the unit is positioned as near as possible to the major units in the radio bay of the aircraft so that the resistance and weight of cables is kept to a minimum.

16. Two 0·5 μF capacitors are fitted in the interconnecting box. When Type 59 microphones are used; one capacitor is inserted in each microphone lead. The function of the capacitors is to limit the bass response of the microphone and hence enable a more intelligible voice signal to be provided to the equipment.

17. The label on the upper side of the interconnecting box should be marked to show whether these capacitors mentioned in para. 16 are in or out of circuit. The capacitors can be taken out of circuit by removing the lid of the interconnection box and soldering short-circuiting leads across each capacitor. This may be necessary when using some types of microphone. The inclusion of short-circuiting leads should be checked on installation since the capacitors mentioned are always short-circuited for bench testing.

Unit coding

18. Each unit in the installation has a circuit identification number given in Table 1. This number is marked on each unit adjacent to all unit plugs, including the back plates on the mounting.

19. Every plug or socket has a letter allocated to it, this letter is not duplicated on any one unit,

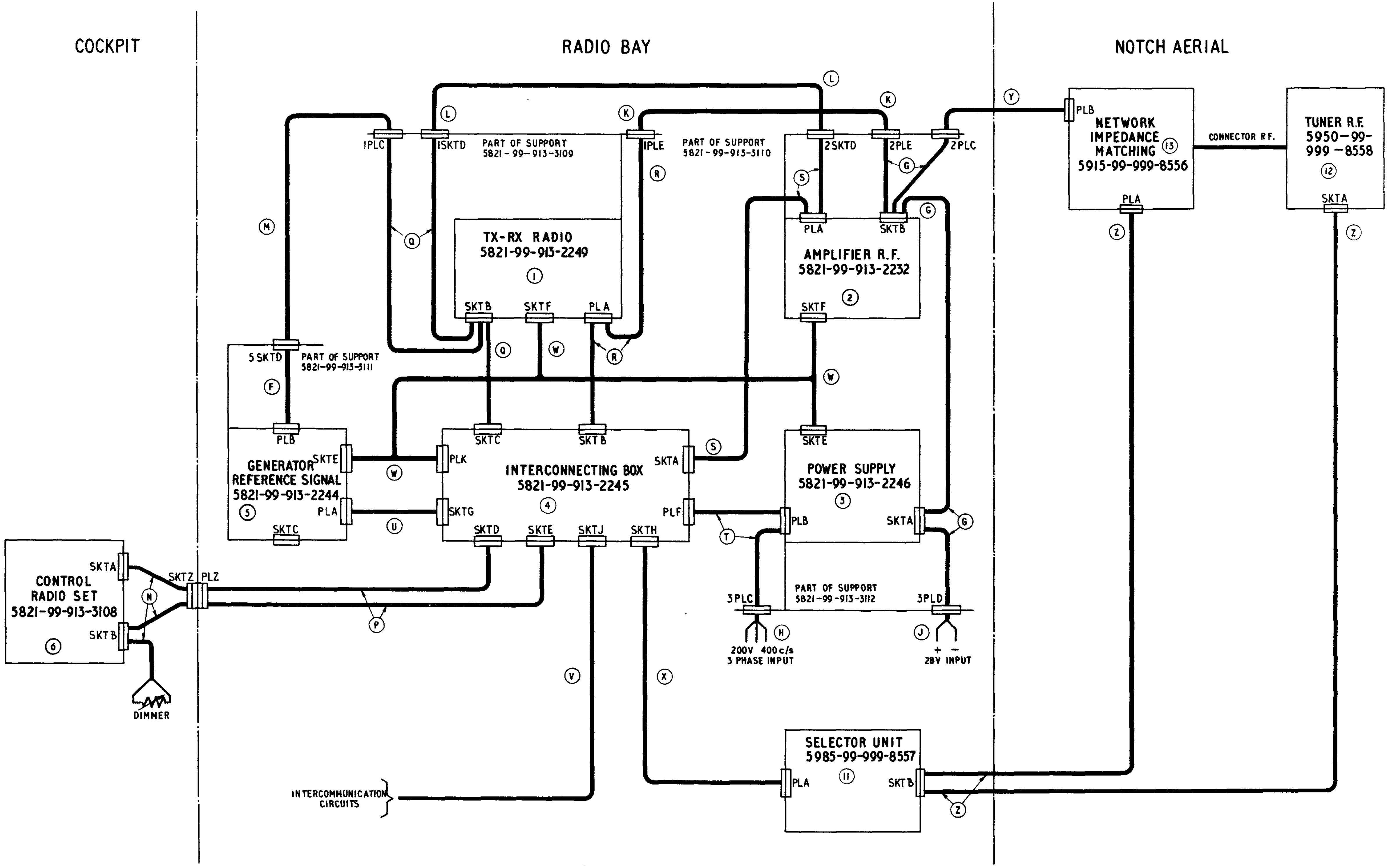

Fig. 2 A.R.I. 18179/1: cabling Fig. 2

Chapter 3

SETTING-UP AND OPERATION OF ARI 18179

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. This chapter is intended for guidance on the setting-up procedure for the main items of the transmitter-receiver and aerial system forming the complete ARI.18179. Further details regarding the setting-up of the suppressed aerial system are given in Part 1, Section 3, Chap. 2.

2. Access to the following items of the transmitter-receiver is required to set up the equipment:—

(1) Transmitter-receiver unit

(2) Amplifier r.f. 5821-99-2232 (P.A.)

(3) Generator reference signal 5821-99-913-2244 (F.G.U.)

(4) Control radio set 5821-99-913-3108

(5) Selector unit. 5895-99-999-8557

The setting-up can be done either in the maintenance bay or in the aircraft. When setting-up in an aircraft it is advantageous to have two persons available, one of these to operate functional switching in the cockpit.

3. Two procedures are given for setting up the transmitter-receiver, the first uses no test equipment, but this must NOT be carried out under radio silence conditions. The second setting up procedure assumes the use of test equipment and may be carried out even when radio silence conditions are in force.

SETTING-UP TO CHANNEL FREQUENCIES WITHOUT TEST EQUIPMENT

Note . . .

It is important to realize that the information given relating to setting up the ARI without the use of test equipment is a compromise and as such is intended only for use in an emergency where no approved test equipment is available.

4. First of all the suppressed aerial equipment 5985-99-999-8559 in the aircraft (or the test rig installation 5985-99-999-8547 when setting up in a maintenance bay) must be set up to the required frequency channels before attempting to adjust the transmitter-receiver. This may be accomplished as set out in para. 5-16.

Setting-up the suppressed aerial equipment

5. So that the required channel frequencies can be set-up on the aerial system, access to the selector unit 5985-99-999-8587 is necessary.

6. It is advantageous to record the settings required for the aerial system as shown in Table 1 The table is obtained from the information given in Sect. 3, Chap. 2, this holds for any one type of installation.

TABLE 1

Typical channel settings on the selector unit

Channel	Frequency (kc/s)	Tap	Dial readings
A	2868	11	29
B	2910	11	39
C	3081	11	106
D	3932	9	13
E	5626	7	16
F	5641	7	17
G	8913	1	81
H	9014	1	82
J	11299	1	109
K	13264	4	138
L	15051	5	155
M	17966	4	178

Setting the matching tap position

7. With the equipment in the aircraft switched off, the following adjustments are made on the front panel of the selector unit (Sect. 3, Chap. 2).

(1) Open the access door to the drum selector, this is located at the top right of the selector unit.

(2) Raise the catch at the base of the aperture, until the drum can be rotated by its slotted top edge; the catch will then remain raised and thus keep the access door open.

(3) Rotate the drum until the letter of the channel required is placed centrally in the aperture.

(4) Slide the contact stud, situated beneath the letter of the channel required to the click position required, e.g., No. 11 for channel A. Ensure that the contact stud is correctly located.

(5) Repeat for other channels.

(6) After all the required channels have been set up, rotate the drum selector slowly until the catch falls and the cover closes. The drum is now engaged at the channel whose letter is showing in the window of the channel selector.

Setting tuning information

8. With the equipment in the standby condition (power on) select the channel to be tuned on the control radio set located in the aircraft cockpit.

9. Unlock the tuning knob of the channel selector on the selector unit and using the slow motion drive provided, turn the tuning knob of the channel selector mechanism until the required dial reading appears in the SETTING window below the meter. The dial reading is obtained from graphs given in Sect. 3, Chap. 2.

10. Re-lock the tuning knob and remove the slow-motion drive. Setting-up the remaining channels is accomplished in an identical manner to the foregoing. The aerial system is now aligned for operation under reception conditions.

Setting-up under transmit conditions.

11. First of all the required tap position should be adjusted as described previously in para. 7. With the equipment under "transmit" conditions, select the required channel on the control set. The TUNE lamp will glow and remain glowing until the required channel has been selected, the TUNE lamp will then be extinguished.

12. Unlock the tuning knob on the selector unit and using the slow-motion drive previously mentioned, rotate the tuning knob until the required setting is shown in the SETTING window on the front panel of the selector unit.

13. Push the SET/TEST key, located on the top left-hand side of the front panel, upwards into the SET position; the TUNE lamp will now glow, and the "AE IN" meter show a reading. If the meter does not indicate a reading, adjust the setting of the tuning knob until a minimum dip is shown on the meter.

14. Remove the slow-motion drive from the tuning knob and lock the latter with the lever attached to it. Repeat the above procedure for other channels as necessary.

15. If a pronounced minimum reading cannot be obtained by the procedure given, the next band tap must be tried, e.g., if tuning is not possible using tap 11 (Band 1) select tap 10 (Band 2), or if tuning is not possible on tap 10 (Band 2) select tap 9 (Band 3).

Note . . .

On changing bands, the setting position of tuning will revert to the other end of the scale, i.e., a setting near 200 *on band* 1 *becomes a setting of approximately* 10 *on band* 2.

16. In cases where the tuning settings are under 6 or over 220, the "pull-in" check of Part 1, Sect.3, Chap. 2, para. 37 should be made. If the TUNE lamp glows rhythmically, the servo system has reached its end stop and the appropriate next band (tap) must be used.

Setting-up the transmitter-receiver unit

17. Release the two fasteners holding the cover on the front of the generator reference signal, this will expose the slider switches used to set up the output frequency from the generator reference signal (*fig.* 1).

18. Move the slider switches appropriate to the channel required until the switch position indicates the required channel frequency (*fig.* 1). This is repeated using different switches for each channel in turn. Replace the switch cover.

19. On the control radio set 5821-99-913-3108 select the receive (R) position on the main-control

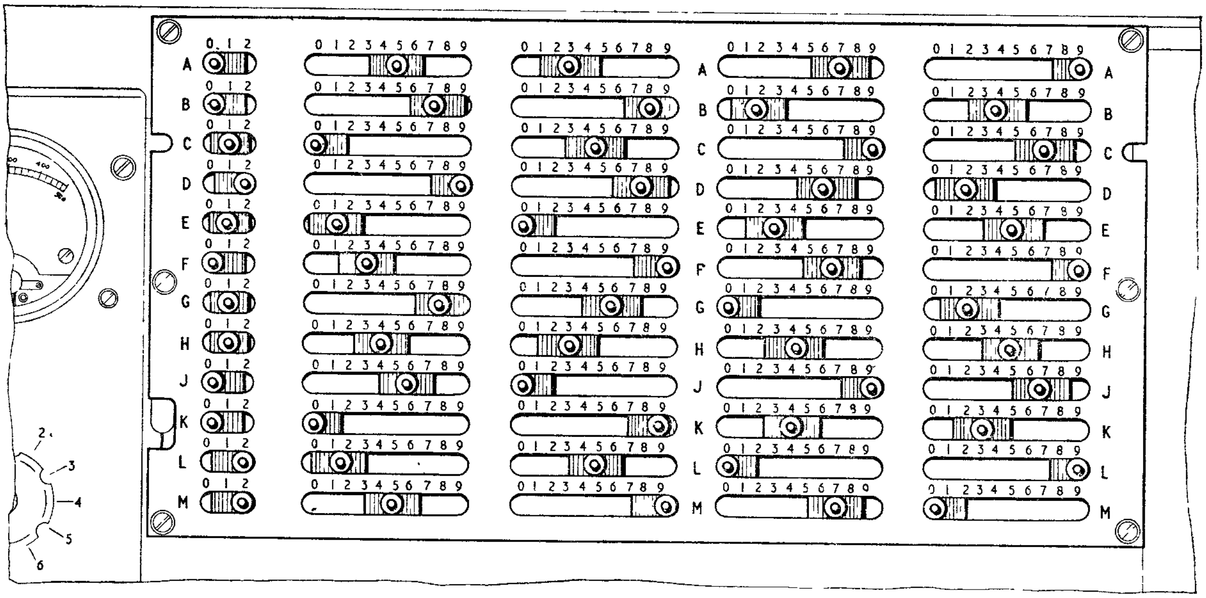

Fig. 1. Generator reference signal, frequency selection switch positions

switch (Sect. 4, Chap. 9) and wait for the oven heating "dolls eye" indicator to clear, now select the appropriate channel letter on the channel selector switch for the channel requiring setting-up.

20. Select position 10, S.S.I. on the meter switch located on the front panel of the amplifier r.f. 5821-99-913-2232 (Power Amplifier). Now unlock the tuning mechanism of the control frequency selector in the transmitter-receiver 5821-99-913-2249 and turn the tuning knob fully counter-clockwise.

21. With a headset connected to the mic tels socket, adjust the tuning mechanism mentioned in para. 20 until a peak on the S.S.I. meter is indicated at the same time as the receiver noise in the headset increases to a maximum. Re-lock the transmitter-receiver tuning mechanism.

Note . . .

It may happen that several positions are found where the receiver noise is a maximum when rotating the tuning mechanism. The correct position for this must be found by consideration of the channel position in the band being tuned. If the incorrect position has been chosen the amplifier r.f. will not tune-up.

Setting-up the amplifier r.f.

22. At this point the main control switch on the control radio set should be set to transmit (T & R) and position 11 (R.F. IN) selected on the meter switch of the amplifier r.f. unit.

23. Unlock the tuning mechanism of the multi-turn control frequency selector located on the front panel of the amplifier r.f. unit and have the press-to-talk button in the aircraft cockpit depressed, at the same time press the TUNE button on the front panel of the amplifier r.f.

24. Rotate the tuning mechanism until a minimum indication is shown on the front panel meter of the amplifier r.f. An approximate position for the tuning mechanism setting can be found by considering the frequency band in which the required channel lies and the relationship of the latter to the band limits.

25. Release the switches mentioned previously in para. 23 and adjust the meter switch on the amplifier r.f. to position 12 (R.F. OUT). Re-adjust the tuning mechanism to ensure that a peak reading is shown on the meter for transmitter power output. Finally lock the tuning mechanism with the lever provided on it.

26. The foregoing procedure is repeated for each channel to be used.

SETTING-UP TO CHANNEL FREQUENCIES USING APPROVED TEST EQUIPMENT

27. It is advantageous to set up the transmitter-receiver to the required channel frequencies using the approved test equipment. The items required to do this are as follows:—

(1) Generator signal 6625-99-913-2933.

(2) Test set radio 6625-99-913-2929.

(3) Test set r.f. power 6625-99-913-2931.

Setting-up the transmitter-receiver unit

28. Release the retaining screws and drop down the small cover on the front of the generator

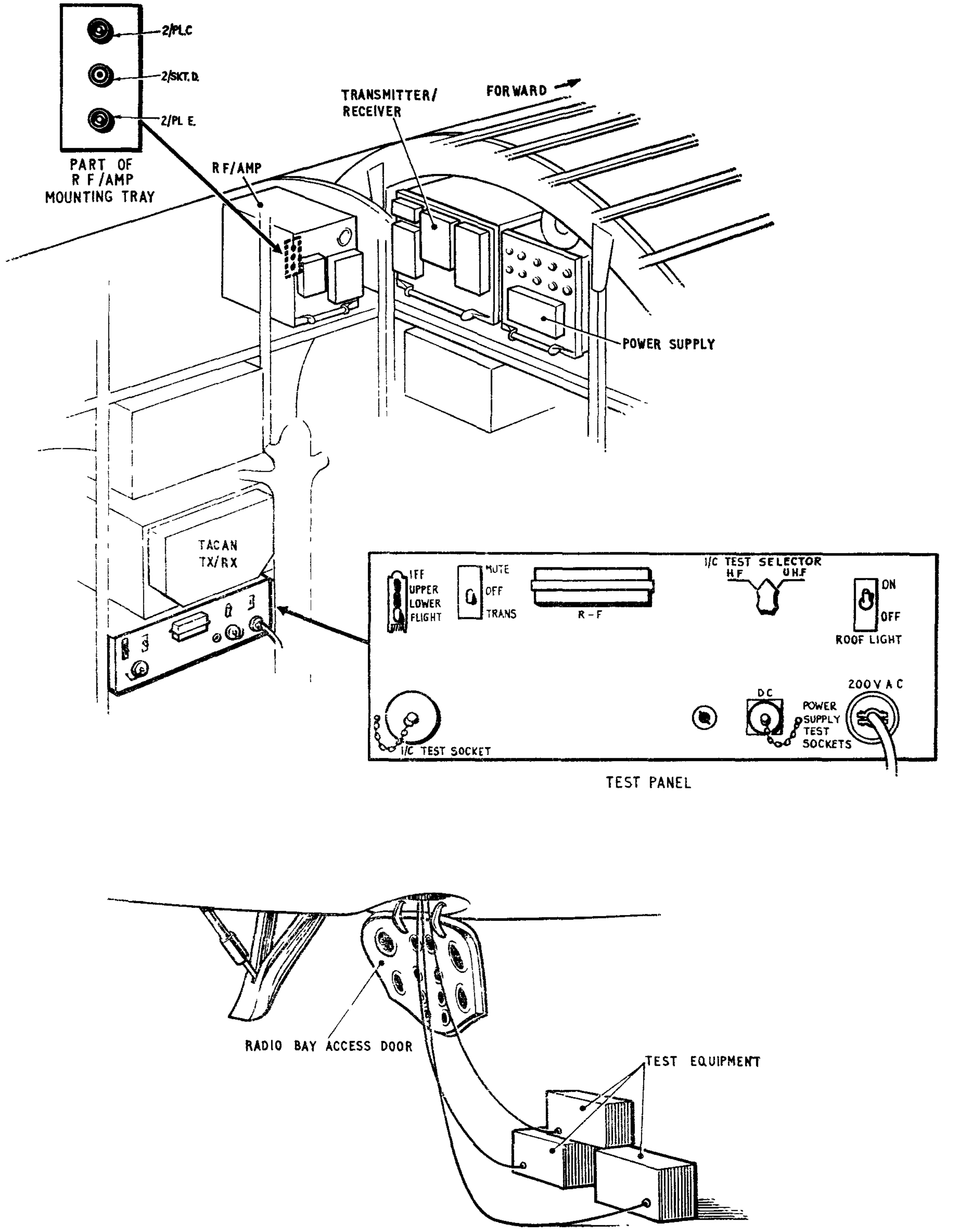

Fig. 2. Test equipment connections in the aircraft

reference signal 5821-99-913-2244 exposing the frequency selection switching sliders.

29. Move the slider switches appropriate to the required channel to obtain the desired channel frequency as described in para. 18. After this has been completed replace the switch cover.

30. Switch on the transmitter-receiver as described in para. 19 and select the first channel to be set up on the control radio set.

31. Set up the generator signal 6625-99-913-2933 to 1 kc/s above the frequency of the channel to be set up on the transmitter-receiver equipment.

32. Unlock the tuning control on the front panel of the transmitter-receiver radio 5821-99-913-2249 and connect the signal generator, using the appropriate connector to the input of the transmitter-receiver at plug PLE on the mounting tray, if setting up in the aircraft (*fig.* 2) or to the rear of the Tx/Rx if setting up on the test rig (*fig.* 3). Set the input level to the receiver at 2μV on the generator signal.

33. Attach the test set radio 6625-99-913-2929 to the inter-com system using the inter-comm test socket in the aircraft (*fig.* 2) or the inter-connection box when using the test rig installation in a maintenance workshop. Connect a headset to the mic/tel socket of the test set radio 6625-99-913-2929 or to a mic/tel socket in the aircraft installation whichever is more convenient and rotate the transmitter-receiver tuning control until a 1 kc/s note is heard in the headset.

34. Remove the headset and substitute output meter CT44 at the telephone terminals, or select position 2 on the TEST switch of the test set radio. Turn the tuning control for maximum reading on the CT44 (or test set radio) with the audio-gain control on the control radio set rotated fully clockwise.

35. After the maximum output has been obtained as in para. 34 lock the tuning control on the transmitter-receiver radio 5821-99-913-2249. If other channels are required to be set up the tuning procedure given in para. 28-35 must be repeated for each channel selected, after which the generator signal must be disconnected.

Note . . .

It is important to lock the tuning control of the channel selector mechanisms after each channel has been set-up. If this is not done the setting position for the channel may be lost and the channel will not then be retuned on reselection.

Setting-up the amplifier r.f.

36. Connect test set r.f. power 6625-99-913-2931 to the aerial plug PLC (*fig.* 2) and select T & R on the control radio set.

37. Select the channel to be set on the channel selector of the control radio set, this will of course have the same identification letter as that used previously when setting-up the receiver.

38. On the front panel of the amplifier r.f. (power amplifier) select position 6 on the meter switch, the meter will now indicate driver cathode current when the press-to-talk switch is depressed.

39. Depress the TUNE button on the front panel of the amplifier r.f. and the press-to-talk button on the pilots control column.

40. Unlock the multi-turn tuning mechanism on the amplifier r.f. and rotate this control until a dip is obtained in the front panel meter indication, this should also coincide with a peak indication on the test set r.f. power meter.

TABLE 2

Amplifier r.f. front panel meter readings

Switch position	Measurement	Scale Reading	Actual Reading	Remarks
1	L.T.	250	25V	
2	H.T.	400	200V	
3	E.H.T.*	430	650V	
4	H.T.	200	300V	
5	P.A. bias	320	32V	
6	Driver I_c	200	100mA	
7	P.A.$_1$ I_c	340	170mA	These currents should be approx. equal and not exceed 170mA
8	P.A.$_2$ I_c	340	170mA	
9	P.A.$_3$ I_c	340	170mA	
10	S.S.I.	400	—	Signal strength indication
11	R.F. in	40	2V	Minimum
12	R.F. out	340	70V	Minimum

Note . . .

*Readings marked * appear only under transmit conditions.*

41. Select positions 7, 8 and 9 (P.A. cathode current) on the front panel meter switch and check that the meter indication does not exceed 170mA on either of these positions (Table 2). If the current indicated is below 170mA, select the highest of the three readings and adjust RV1 on the front panel of the amplifier r.f. for a meter indication of 170mA.

42. This tuning procedure should be repeated for each channel to be set-up in turn and a final check made that the meter indications conform to the values given in Table 2.

43. Further stringent tests on the transmitter-receiver installation can be carried out by using the test set radio in accordance with the instructions given in Part 2, Sect. 3, Chap. 3.

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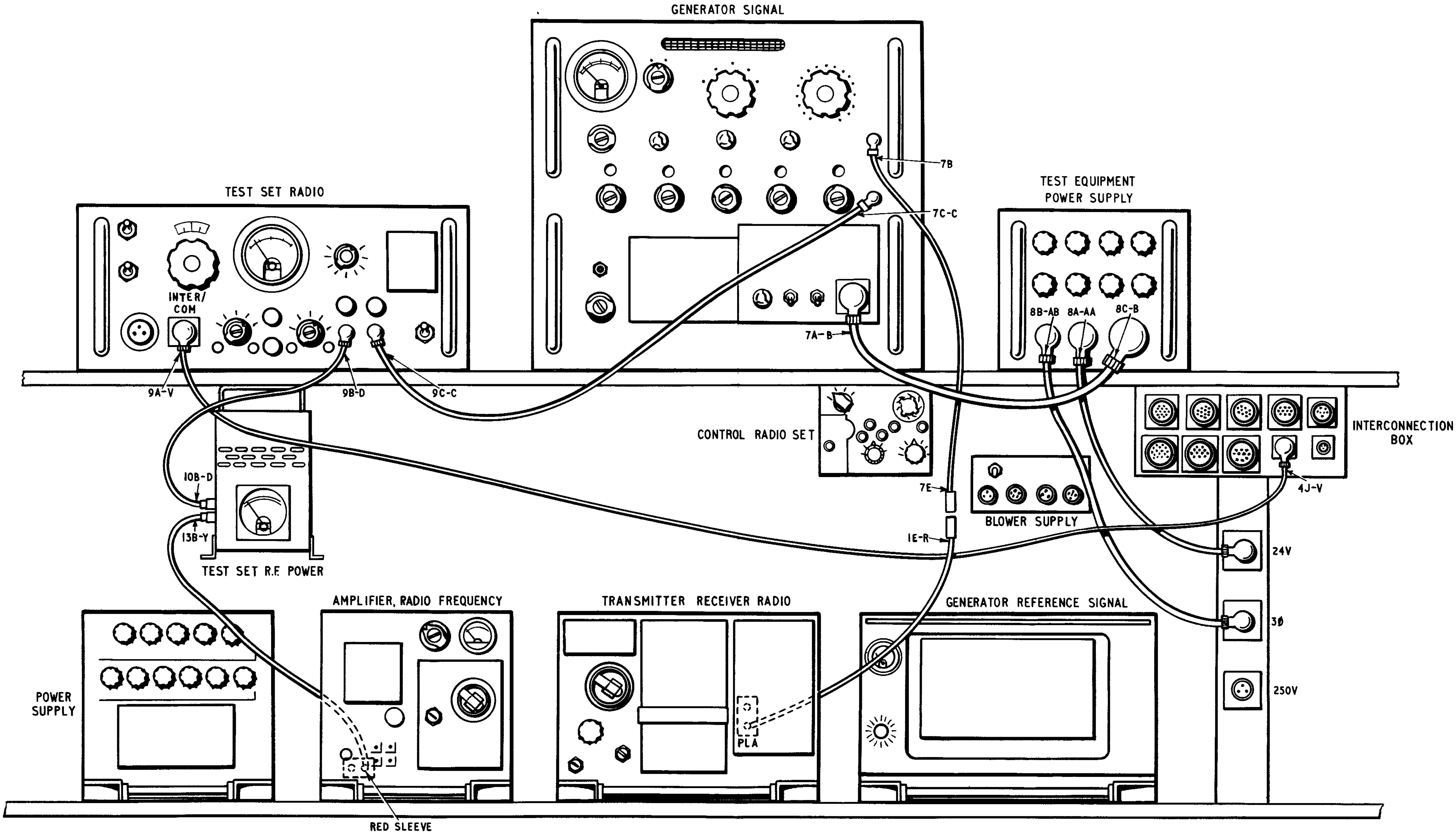

Fig. 3. Test equipment connections and test rig installation Fig. 3.

SECTION 3

SUPPRESSED AERIAL TUNING EQUIPMENT

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Chapter 1

GENERAL DESCRIPTION OF AERIAL SYSTEM 5985-99-999-8559

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

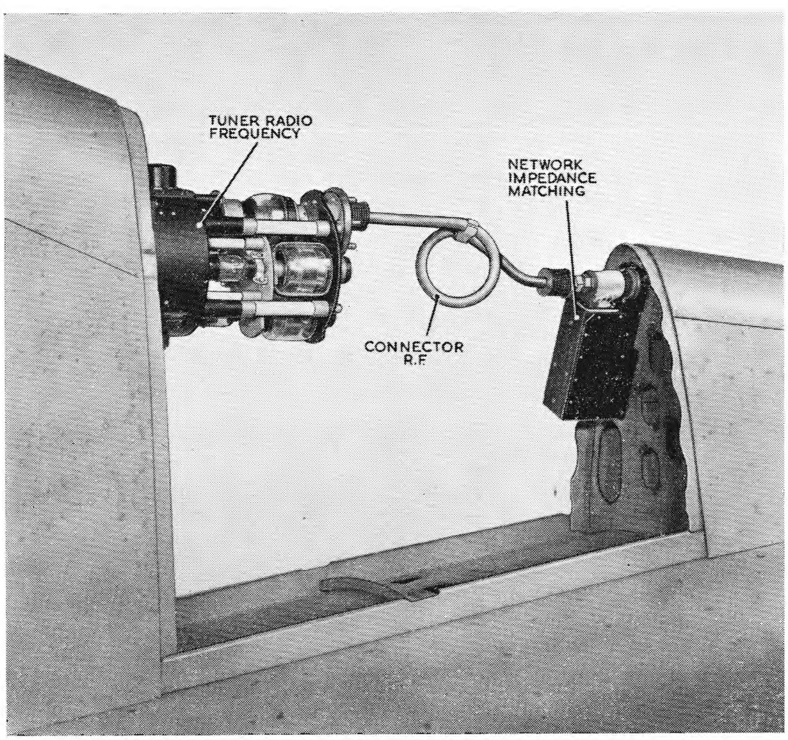


Fig. 1. Aerial system showing mounting arrangement in the aerial notch

Introduction

1. If a "notch" or "cavity" is cut into the dorsal fin of an aircraft it will form an inductance which can be turned by a variable capacitance to resonate at the desired frequency. When energized the notch causes r.f. currents to be set up in the fuselage and tail thus causing them to function as an aerial. The notch is made to a shape dependent on the structure of the aircraft and extra inductance if required can be obtained by adding a special r.f. connector to the aerial equipment used. This connector consists only of a tubular inductor which includes one or more loops.

2. High potentials of the order of several thousands of volts will appear across the aerial tuning capacitor at some operating frequencies with the normal transmitter peak sideband power of 300 watts. Special care has been taken in the design of the aerial system to ensure that operation may be safely undertaken at very high altitudes, for this reason, cleanliness and care must be observed when servicing or making repairs to the component parts in order to avoid any action which may impair the correct functioning of the aerial system.

GENERAL DESCRIPTION

3. Aerial system 5985-99-999-8559 is intended to be operated in conjunction with the s.s.b. transmitter-receiver to form the complete ARI.18179, it is, however, suitable for use with other h.f. transmitter-receiver equipments. The aerial system consists of three main units which are designed to match and tune the transmitter-receiver to the aerial notch. The three main units being: —

(1) Tuner radio frequency 5950-99-999-8558

(2) Network impedance matching 5915-99-999-8556

(3) Selector unit 5985-99-999-8557

The first two of the above units, i.e., the tuner, radio frequency and the network, impedance matching, are mounted directly in the aircraft aerial notch on opposite faces, and are connected together by the connector, radio frequency 5995-99-999-8552. A diagram showing the mounting arrangement in the aerial notch is shown in fig. 1.

4. The selector unit, which is a separate item, is mounted in a tray assembly in the radio bay of the aircraft directly under the notch aerial.

Tuner, radio frequency 5950-99-999-8558

5. The tuner, radio frequency (*fig.* 2) has a base consisting of a circular cast chassis, on the top surface of which are mounted four pillars of insulating material which support a circular top plate. Between these two faces are mounted three fixed and one variable capacitor, all of which are of the vacuum glass envelope type. A fibre-glass plate is used to support the lower end of each fixed capacitor and also to couple each capacitor to the vacuum switch mounted below it. Each of these three switches, one below each fixed capacitor, is actuated by a solenoid, the latter being mounted below the surface of the base casting.

6. The solenoid and switch form a complete mechanical assembly and can be withdrawn through the base of the tuner by the removal of three clamping screws.

7. A vacuum switch is normally operated by atmospheric pressure but in this assembly is held open 0·016 in. by means of a coil spring. When the solenoid is energized the spring pressure is removed and the switch closes due to atmospheric pressure.

8. Movement of the adjustable section of the variable-capacitor is restricted to 0·6 in. approxi-

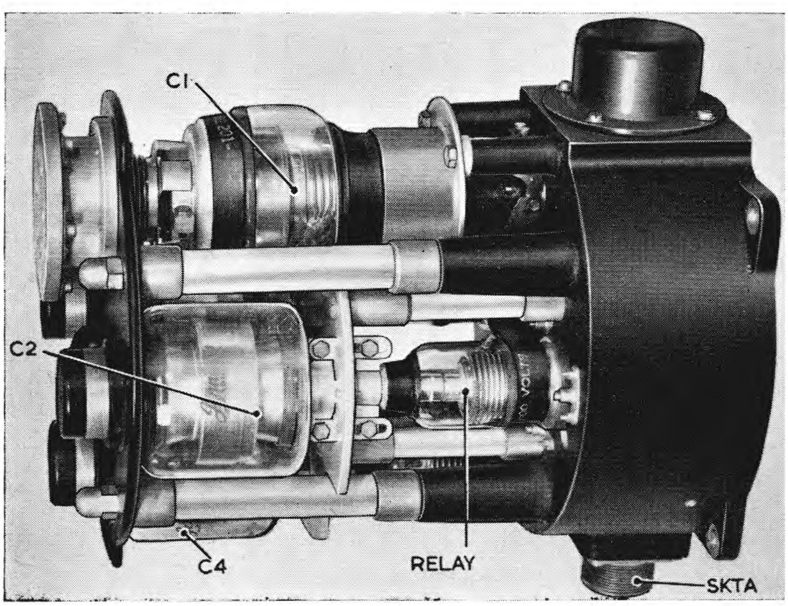


Fig. 2. Tuner radio frequency 5950-99-999-8558

mately. To reduce capacity the moving section is retracted by means of a forked crank; the return motion to increase capacity being due to atmospheric pressure, limited in effect by the crank itself.

9. Beneath the tuner chassis is a gear sector which is connected to the crank, the former being rotated by a reduction gear train from a small d.c. servo-motor. Mechanically coupled to this gearing mechanism is a variable-resistor, which forms part of a bridge network, providing positioning information for channel selection.

10. The movement arc of the actuating crank is limited by mechanical stops and two limit switches. The complete gear-crank assembly is removable from the underside of the casting. Access to the motor terminals can be obtained while the assembly is in position by the removal of a circular cover on the side of the base chassis.

11. Connection to the tuner, radio-frequency is made via the 19-way socket (SKTA) on the side of the chassis, and also by means of the connector, radio-frequency 5995-99-999-8552 which is attached to the circular flange on the top face.

12. To allow for the large dimensional tolerances needed on the glass-capacitor envelopes the top connections to these capacitors are adjustable. In the case of the variable-capacitor a bellows is used which is bolted to a circular flange and clamped to the top of the capacitor. The fixed capacitors have a conical cap fitted into a sliding spider spring, this is loaded in a cylindrical cap which is screwed into the top plate.

Network impedance matching 5915-99-999-8556

13. At the forward end of this unit and mounted vertically on the base is a 0·625 in. diameter rod (*fig.* 3) having a screwed thread at the top, this couples with the connector, radio-frequency. Hence it forms the conductor for the r.f. currents circulating in the notch. Around the base of the rod, is a screened transformer, the rod being the "single turn primary" winding. This forms the error transformer, and also provides the monitor indication.

◀**14.** Above the error transformer is a cylinder formed of ferrite rings; on this is wound a toroidal winding in two spaced layers, protected by a fibre glass cover. Connections to the tapping points on this transformer are taken through a dielectric window to the adjacent screened box. In this is a "Ledex" type switch which selects the correct tapping points and modifies the winding by switching out some turns at certain tap selections. Below the box, in the base and accessible when the base cover is removed, are the associated components of the error and monitoring circuits. The control connections are terminated on a 19-way plug (PLA) at the rear face of the base, PLB being the low-impedance r.f. connector. Around this plug on the inside of the box is a further transformer used to provide the matching (reflectometer) indication.▶

Selector unit 5985-99-999-8557

15. The selector unit front panel is shown in fig. 4. Above the carrying handle is the front panel of the control frequency selector (channel selector). The top space is taken up by the indicator meter M1, the spring-loaded access door to the selector drum switch (DS), and the SET/TEST key (KST). The tuning warning lamp (ILP) is set below this key, and the tuning position counter dial below the meter.

16. Behind the channel selector is a gear plate on which is mounted the setting potentiometer RV1 (not shown in *fig.* 4) and the step-up gear train which operates the counter dial. Above the control frequency selector is the selector drum switch which is rotated to each channel position by means of a plastic ball-chain drive from a sprocket wheel on the gear plate. This sprocket

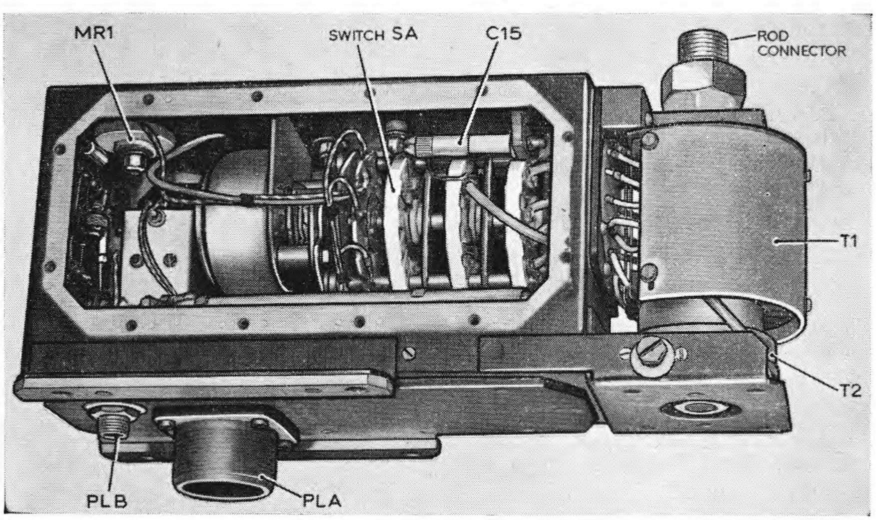


Fig. 3. Network impedance matching 5915-99-999-8556

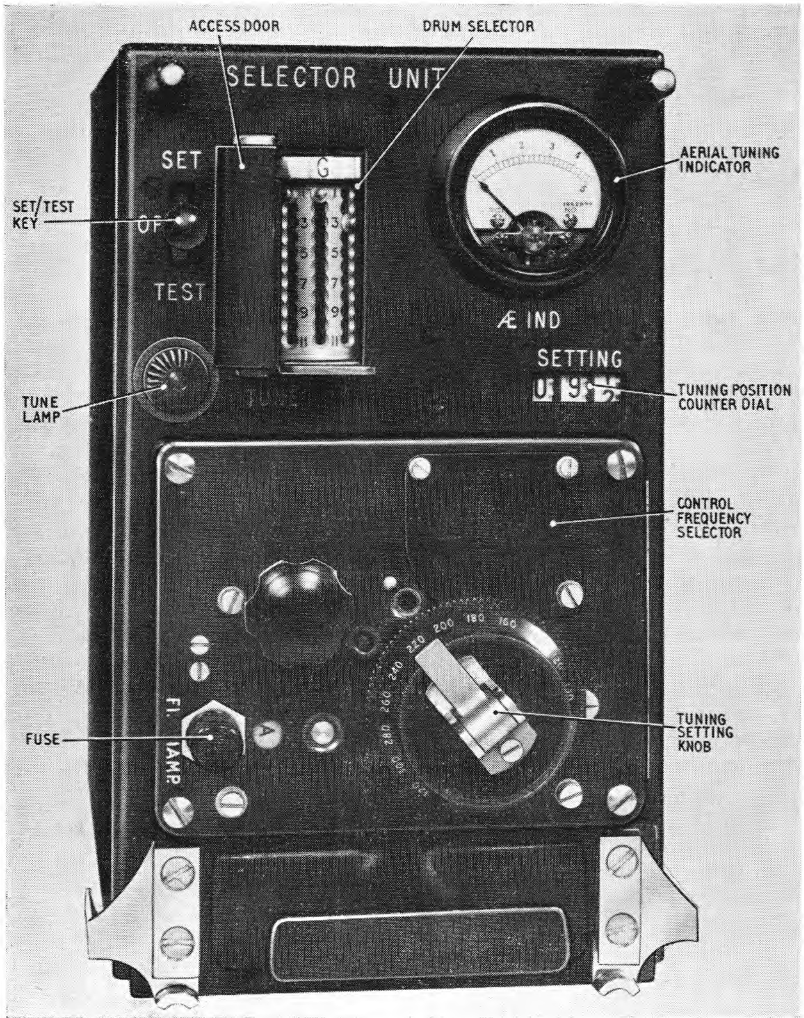


Fig. 4. Selector unit 5985-99-999-8557

engages with the channel selector shaft on the control frequency selector by a parallel sided coupling which mates up with the flats on the spindle.

17. The pin on the crank which is mounted on the tuning shaft of the control frequency selector engages in a slotted crank on the spindle of potentiometer RV1.

18. Electrical connections are made to the control frequency selector by plug PLA which is at the end of a free cable. This plug engages with socket SKTE which is mounted at the top of the main unit.

19. The selector unit has a plug and socket at the rear which engages with the back plate of the mounting 5985-99-999-8546 when the unit is in position in the radio bay.

20. A quick-release cover allows access to the top and sides of the unit, and a base cover, which is screw retained, exposes when removed, the underside of the shallow chassis which forms the base of the unit.

21. By removing the four retaining screws on the panel of the control frequency selector and the connecting plug, the former can be withdrawn completely through the front panel. Behind the gear plate are two vertical plug-in sub-unit panels, each of which align with sockets mounted in the chassis base. The forward panel contains the servo-amplifier, and the rear one the reduced speed unit. At the rear of the selector unit are the r.f. filter capacitors and the components of the surge limiter circuit. The two transistors of the surge limiting circuit are mounted on the rear outer face of the selector unit, they are covered by an air ducting system. This is done to form a "heat-sink" whilst the air duct assists the action of convection cooling.

22. Mounted vertically on the rear face of the gear plate in front of the servo-amplifier is a Ledex rotary solenoid switch, this switch is an important item in the selector unit and performs the following operations:—

(1) Switches into circuit relays for range switching of the tuner r.f.

(2) Selects the required tapping point on the

matching transformer, by operating a switch in the network impedance matching.

Mounting 5985-99-999-8546

23. The mounting is a conventional tray assembly and is mounted on four shock absorbing fixings. A back plate 5985-99-999-9548 is attached to the rear flanges, this carries the plug and socket for cables connecting the units mounted in the aerial cavity and junction box 5821-99-913-2245. The retaining catches fitted to the front of the tray allow the selector unit to be screwed home into its rear connections.

24. Spring dowel pins are fitted to the back plate, these locate with the selector unit during insertion but the spring dowel pins do not interefere with the plug/socket location when the latter are engaged.

Connector radio frequency 5995-99-999-8552

25. The connector consists of a 0·625 in. diameter metal tube in which a single turn of approx. 4 in. diameter is formed. Connecting flanges mounted on bellows coupling permit attachment to the tuner radio frequency, and the network impedance matching.

26. When in position in the notch this connector is supported by clamps on the dielectric cover of the notch. Bellows on the tuner radio frequency flange, allow relative movement of the two units joined by the conector radio frequency when in flight. In addition a metal braid is threaded down the centre of the connector r.f. to assist in electrical continuity.

Operation of the suppressed aerial 5985-99-999-8559

27. In fig. 5, the aerial system in shown in block diagram form. The tuner radio frequency includes a motor-controlled variable capacitor 12CV, the range of the latter may be increased by one of three parallel capacitors shown in the diagram as one capacitor 12Cp.

28. Channel information is supplied to the selector unit as an earth on one of 12 wires. This causes the 12-channel positioner in the control frequency selector to rotate until it is stopped mechanically by a cam and pawl system at the appropriate channel position (*Part* 4, *Sect.* 3, *Chap.* 4, *para.* 16).

29. There are two mechanical drives from this positioner, one rotates the matching selector drum switch to one of twelve, 30° spaced positions dependent on the channel selected. The other rotates a potentiometer 11RV1 to a definite position which can be varied during initial pre-setting of the system.

30. 11RV1 (*fig.* 5) is connected in a Wheatstone bridge to a second potentiometer 12RV1 mounted in the tuner radio frequency, the former being coupled mechanically to the variable capacitor 12CV.

31. If this bridge system is not balanced, an error signal flows in the primary winding of 11T2, the bridge being supplied from a 400 c/s source. The error signal decreases to zero, and changes phase 180° at balance.

32. A secondary winding of 11T2 connects any error signal via relay contact 11CTA1 to the 400 c/s servo amplifier which drives the phase relay 11CPR1. The phase relay has a centre zero position when there is no signal from the amplifier but closes on one of two contacts depending on the phase relationship when an error signal is present. These contacts actuate the transistor switches of the motor control circuit to drive motor 12MG1 and capacitor 12CV such that the bridge will balance. Capacitor 12CV is then set in a position determined by 11RV1 (and therefore as decided by the mechanical position of the channel positioner).

33. When all tuning operations have ceased, relay contact 11CTA1 changes to connect the servo amplifier to the chopper 11CX1.

34. During this sequence the preset contact chosen by the channel rotation of the matching selector drum switch supplies an earth to cause a Ledex solenoid-operated switch 11SB to rotate to one of 11 positions. Contacts on this solenoid-operated switch actuate a further similar type switch 13SA in the matching unit, which then connects the r.f. input lead from 13PLB to one of 11 taps on the matching transformer 13T1. By selecting connections on the capacitor selection panel other padding capacitors 12Cp are switched into circuit if required for a particular frequency. This selection is provided by pre-setting the required information determined for the particular aircraft type.

35. Thus suitable pre-adjustment of the position of 11RV1 and the matching selector drum switch will cause the tuner radio frequency and the net-work impedance matching to take up the correct positions to resonate the notch whenever a channel is selected. The notch may be tuned, without r.f. power being used, this allows reception of signals without prior radiation and allows change of frequency channel to be made for reception without breaking "radio silence".

36. Due to the high accuracy needed to resonate the cavity and also to allow for slight variations of equipment, a "fine tune" facility is fitted. This circuit, operated from the remote control unit allows a small voltage to be fed to a third winding on 11T2, this causes a slight variation about the setting position of variable capacitor 12CV. The facility is selected by a push button and self-locking contact, its effect is cancelled as soon as a channel is changed or transmission has com-menced.

37. When transmission commences, the r.f. power fed to the aerial from 13PLB causes r.f. currents to circulate in the aerial notch. These currents induce a r.f. voltage into a winding on transformer 13T2. The phases of the r.f. input current and the voltage induced into 13T2 by this current are compared in a discriminator. If there is an error in tuning the aerial cavity, a d.c. voltage will be fed from the discriminator to the vibrator (chopper) 11CX1. This vibrator, which is driven at 400 c/s from an external supply, converts the d.c. "error" signal to a 400 c/s square wave voltage. If the d.c. error signal changes in "sense" the converted 400 c/s signal will change 180° in phase. The error signal from the discriminator is connected, via the "chopper", to the servo amplifier, this amplifier provides power to control a motor which causes the tuning position of the variable capacitor 12CV to be corrected.

38. To ensure the stability of the servo-system, a monitor circuit is used which provides a speed reduction of the tuning motor 12MG1. The monitor signal obtained to provide speed reduction information is proportional to the current flow in the cavity, and thus the monitor signal is applied only when the cavity is in resonance; current flow being negligible when the cavity is off tune. Speed reduction is thus applied only when the cavity is close to the resonance position. The monitor signal is also taken to the meter 11M1 (*fig.* 5) which, when switch 11S1 is in the "TEST" position, allows a check of correct tuning to be made.

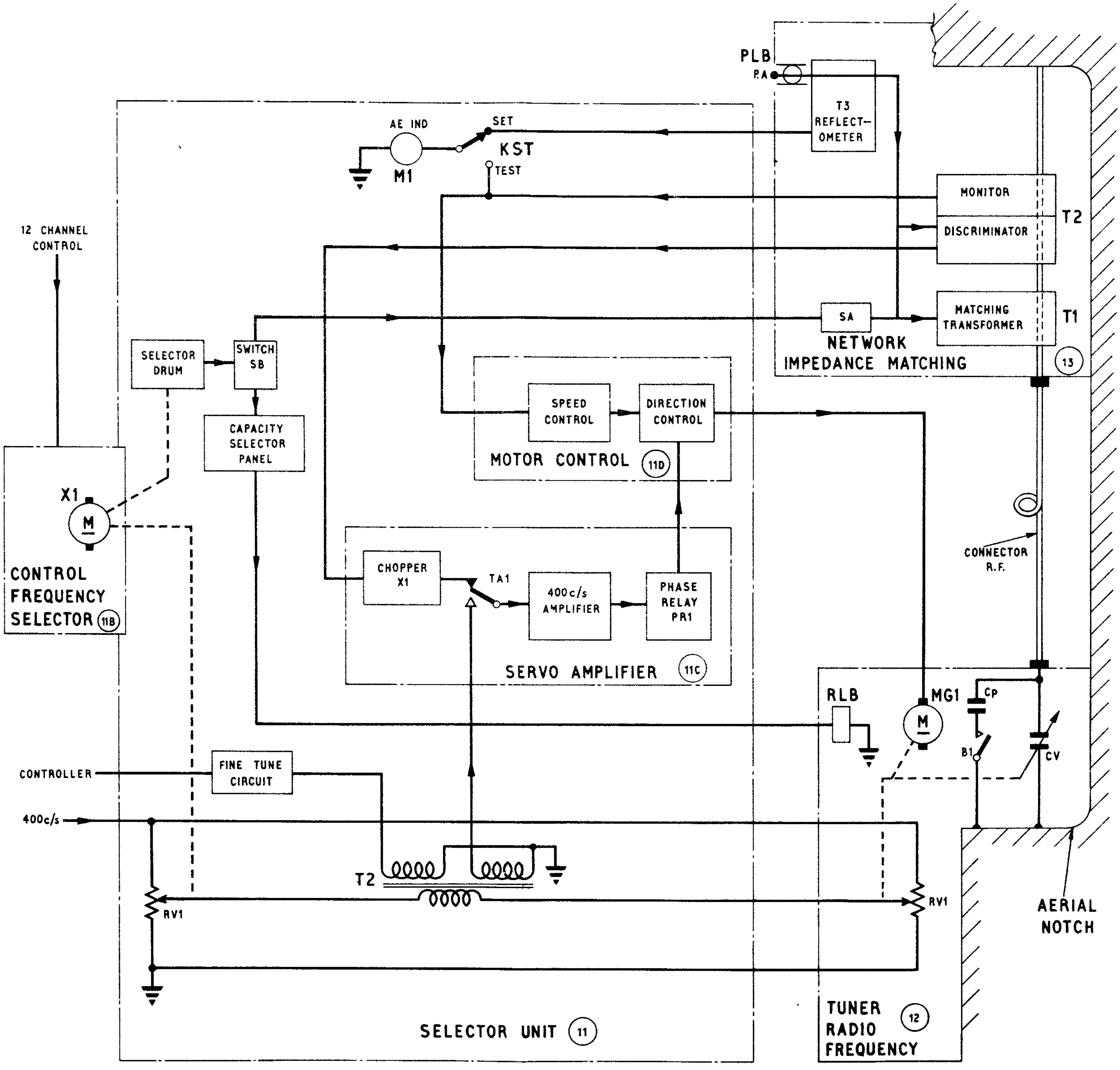
Reflectometer circuit

39. During the presetting of the matching taps it is desirable to be able to assess the degree of matching. For this purpose a reflectometer circuit 13T3 is provided. (The reflectometer gives zero reading on 11M1 when 50ohms input impedance to 13PLB is achieved and this is displayed on the meter when the SET/TEST key is placed in the "SET" position).

40. The reflectometer indicates reflected or backward power and when correct matching into 50-ohm load is achieved the reflectometer should indicate a 1: 1 s.w.r.

◀**Bracket and contact assembly 5915-99-950-7818**

41. This bracket is bolted direct to the airframe and serves to fix the coil end of the network impedance matching to the aircraft. Contact springs on this press against the underside of the network when this is secured.▶



Suppressed aerial system: 5985-99-999-8559 Fig. 5

block diagram

AIR DIAGRAM 6729H/MIN.	
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Chapter 2

INSTALLATION, SETTING UP AND OPERATION

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INSTALLATION

General

1. This chapter is intended for guidance on the installation, setting up and operation of the main items forming the suppressed aerial system. The aerial system is notch excited, and is specially suitable for use with high-speed aircraft. The system is designed so that the airframe itself becomes the radiator of radio frequency power. This is achieved by resonating the "notch" in the airframe to the particular frequency in use (2·8-20 Mc/s); this "notch" then couples the r.f. power to the airframe.

◄**2.** The main items which make up the aerial system are as follows:—

(1) Selector unit
(2) Tuner, radio frequency
(3) Network, impedance matching unit
(4) Connector, radio frequency
(5) Bracket and contact assembly►.

Selector unit

3. The selector unit contains the servo system for the suppressed aerial and also the preset information for pretuning the aerial.

4. It is important that reasonable access to the selector unit is provided, so that when the aircraft is on the ground it is comparatively easy to make the necessary adjustments for setting up channels and for testing the aerial. The selector unit front panel contains dials and a meter, thus the unit must be mounted so that these are readable. The location of the selector unit in the aircraft should be within 20 ft. of both the "notch" aerial and the interconnection box; connector cables from the selector unit are fed to both of these locations. The selector unit is usually mounted in the radio bay of the aircraft.

5. The selector unit is carried in mounting 5985-99-999-8546 which is a metal tray 5·3 in. × 9·5 in. mounted on four shock absorbing mounts of 5·81 in. × 2·40 in. fixing centres. A 6-inch gap should be left behind the mounting to allow clearance for the connectors. The spring dowels at the rear of the mounting project 2·1 in.

Units mounted in aerial cavity

6. The relative positions of the three items mounted in the aerial cavity are shown in fig. 1. After the dielectric cover of the aerial cavity has been removed the tuner, radio frequency and the network impedance matching unit should be mounted in position first, the connector, radio frequency forming a link between them.

Tuner radio frequency

7. This is a cylindrical shaped unit and is mounted directly on the rear bulkhead of the aerial notch by means of ¼ UNF bolts without shock mountings on 5·5 in. × 5·5 in. centres. The bolts must be of non-ferrous material and of adequate strength. The mounting surface, which is part of the notch bonding strip, must be clean before mounting the tuner, radio frequency. The unit must be mounted so that the plug is facing

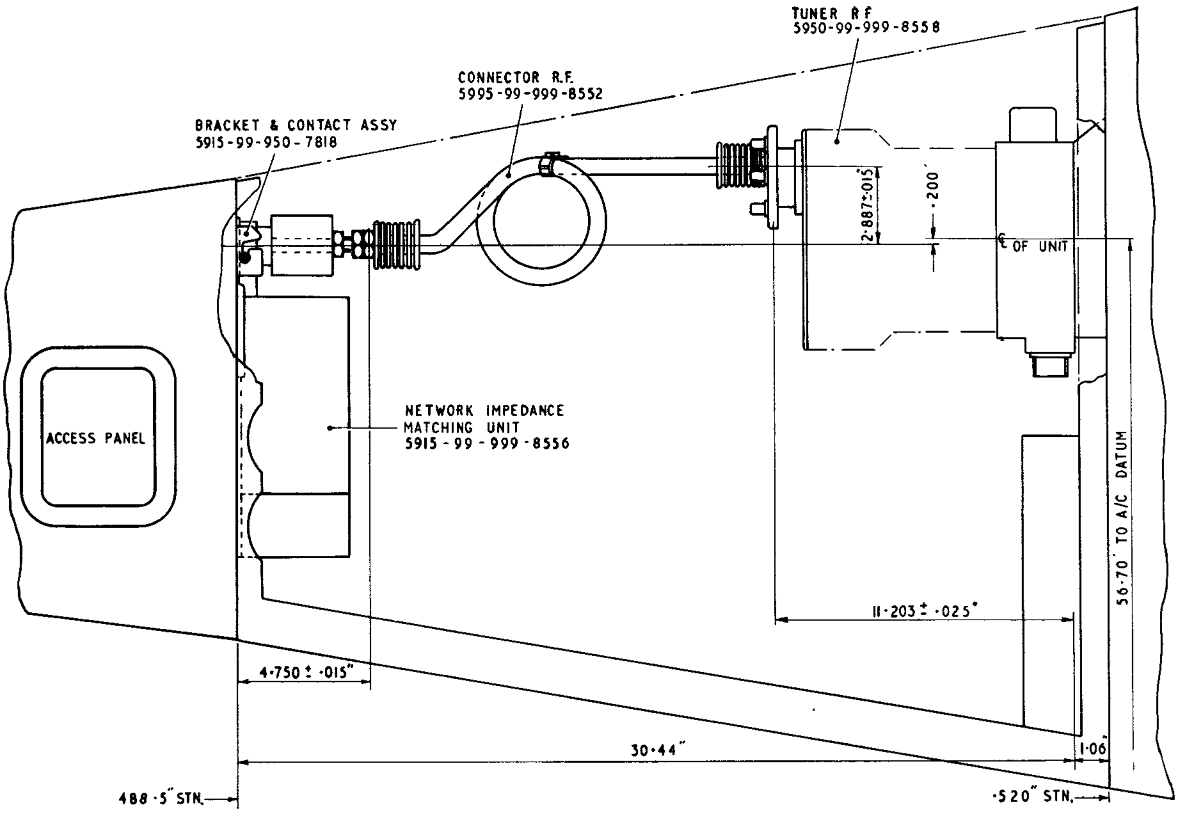


Fig. 1. Installation diagram showing aerial component positions in aircraft notch (typical)

downward. The unit fixing bolts engage in stiff clinch nuts in the aircraft structure.

Network impedance matching unit

◀8. The network, impedance matching unit is mounted directly on the forward bulkhead of the cavity without shock mountings. The coil end, which is uppermost, is held in position by means of the bracket and contact assembly which is fixed to the aircraft by four countersunk headed 10 UNF non-ferrous bolts fitted into stiff clinch nuts on the airframe. As stated in para. 7, the mounting surfaces must be clean. The bracket assembly is normally left in position on the aircraft.

9. The coil end of the network, impedance matching has two captive hexagon, slot headed 10 UNF bolts on each side of the base. These should be unscrewed 0·1 inch and engaged with the key slots of the side of the bracket assembly. The unit will then hang in position. The lower portion is now screwed to the airframe with four 10 UNF bolts (round-head or cheese-head) again fitting into stiff clinch nuts. The two bolts engaging the key slots are now tightened clamping the bracket assembly to the unit. The washers on these bolts must remain on the outside of the bracket.▶

Connector radio frequency

10. This item is terminated at both ends by ball and sliding joints which are bridged by phosphor-bronze bellows. Care should be taken to avoid bending these joints more than about plus or minus 10° from the straight position when fitting the connector, the following procedure is suggested:—

(1) Holding the connector, loop downwards, approximately in line with the network impedance matching and the tuner radio frequency, engage the end of the connector having a circular plate with the flange on the top of the tuner. Align the connector, with the loop vertical and the two top screws horizontal, then partially engage these screws, this end will now be held in position.

(2) Engage the $\frac{5}{8}$ in. UNF nut on the free end of the connector with the $\frac{5}{8}$ in. stud on the network impedance matching unit and screw up finger-tight.

(3) At the tuner radio frequency end of the connector, tighten up all six 4 B.A. screws, checking that the synthetic rubber "O" ring which forms a seal has remained in position.

(4) At the other (forward) end of the connector, hold the rear end of the bellows, which is hexagonal, in a spanner to stop rotation, and tighten the union nut. Tighten up the $\frac{5}{8}$ in. locking nut supplied on the network impedance matching unit and lock against the union nut; these can then be wire-locked after the system has been checked.

Note . . .

It is important that the bellows are not twisted during the installation of the connector, radio frequency.

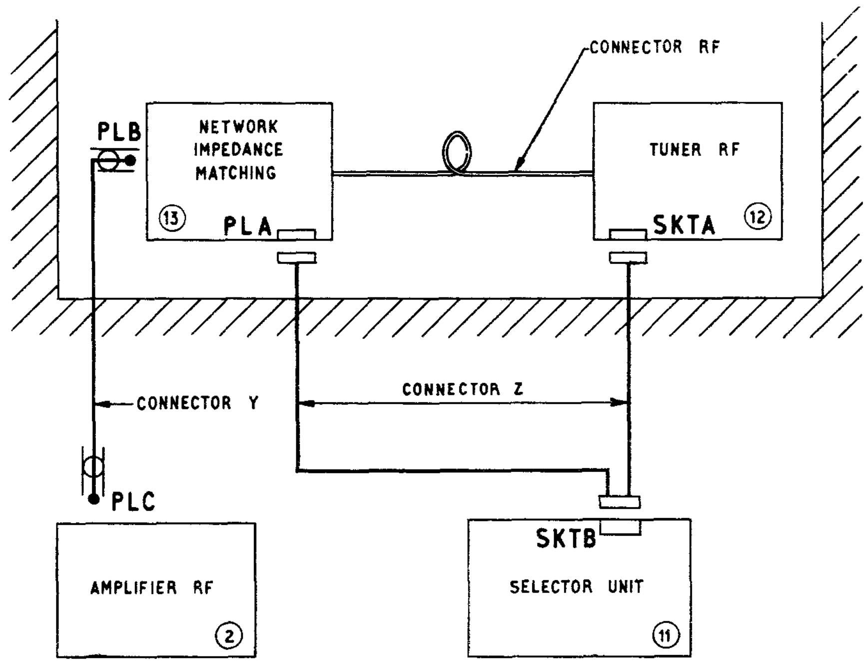


Fig. 2. Interconnecting cable, diagram

Facilities for indicator r.f.

11. An indicator r.f. 6625-99-999-8550 is used as a portable piece of test equipment for checking the aerial when the aircraft is on the ground. The indicator is suspended on the outside of the aerial notch cover during testing and it requires two countersunk UNF No. 10 screws for mounting. These screws are fixed at 4 in. centres, and at approximately the same vertical height when the aircraft is standing on the ground. They are approximately in the centre of the notch area on either the port or starboard side of the aircraft and are permanently included as part of the notch cover.

12. The UNF screws are made captive so that they may be screwed in to be flush with the notch cover when not in use and screwed out to project about $\frac{3}{8}$ in. when required.

Connectors

13. There are two connectors associated with the aerial equipment which are known as connector Z and connector Y (fig. 2).

14. Connector Z joins the selector unit with the units mounted in the aerial notch, this connector splits at a junction behind the units mounted in the notch, the cable end terminated by a plug is connected to the tuner radio frequency.

15. Similarly the socket end is taken to the network impedance matching unit and engaged via the access panel on the port side, just forward of the notch. This connector has an external metal braid which should be thoroughly bonded to the airframe at the point where the connector leaves the aerial notch beneath the tuner radio frequency. The braid of the connector feeding the network impedance matching unit should be bonded in a similar manner as close as possible to the latter. In addition the connector Z should be bonded at approximately 9-inch intervals along its length of run to the selector unit.

16. Connector Y is of the coaxial type and should take the shortest possible path from the network impedance matching unit to the mounting 5985-99-999-8546 of the r.f. (power) amplifier. Sufficient slack in this cable (uncleated) should be allowed adjacent to the r.f. amplifier to permit connection of this cable to the indicator s.w.r. 6625-99-999-8551, when this is used in the aircraft for checking purposes. A connecting cable which is part of the latter unit, is used to complete the connection to the r.f. amplifier in this case.

SETTING UP AND OPERATING INSTRUCTIONS

Setting up frequencies on the aerial system

17. Access to the selector unit 5985-99-999-8587 is needed only to set up channel frequencies or to change a channel already set up. This can be done either in the maintenance bay or in the aircraft.

18. It is advantageous to record the settings required for the aerial system as shown in Table 1. An example for twelve settings is given. The information is obtained from Table 2 and fig. 4 (end of Chapter), these hold for any one type of installation.

Table 1
Typical channel settings on selector unit

Channel	Frequency Kc/s	Tap	Dial readings
A	2868	11	29
B	2910	11	39
C	3081	11	106
D	3932	9	13
E	5626	7	16
F	5641	7	17
G	8913	1	81
H	9014	1	82
J	11299	1	109
K	13264	4	138
L	15051	5	155
M	17966	4	178

19. Table 2 lists the correct matching tap for various frequency ranges whilst fig. 4 is a set of graphs indicating the dial setting of the selector unit for the particular frequency required.

Setting matching tap information under radio silence conditions

20. With the selector unit removed from its rack, or with the equipment switched off, the following adjustments are made on the front panel of the unit. (The same procedure can be done with the equipment switched on, after the "TUNE lamp" has extinguished.)

(1) Open the access door (fig. 3) to gain access to the drum selector, which is situated on the left-hand side of the meter.

(2) Raise the catch at the base of the aperture, until the drum can be rotated by means of its slotted top edge; the catch will then remain raised and thus keep the access door open.

(3) Rotate the drum until the letter of the channel required is placed centrally in the aperture.

(4) Slide the contact stud, which is situtated beneath the letter of the channel required, to the click position required, e.g. No. 1 for channel A. Ensure that the contact stud is located.

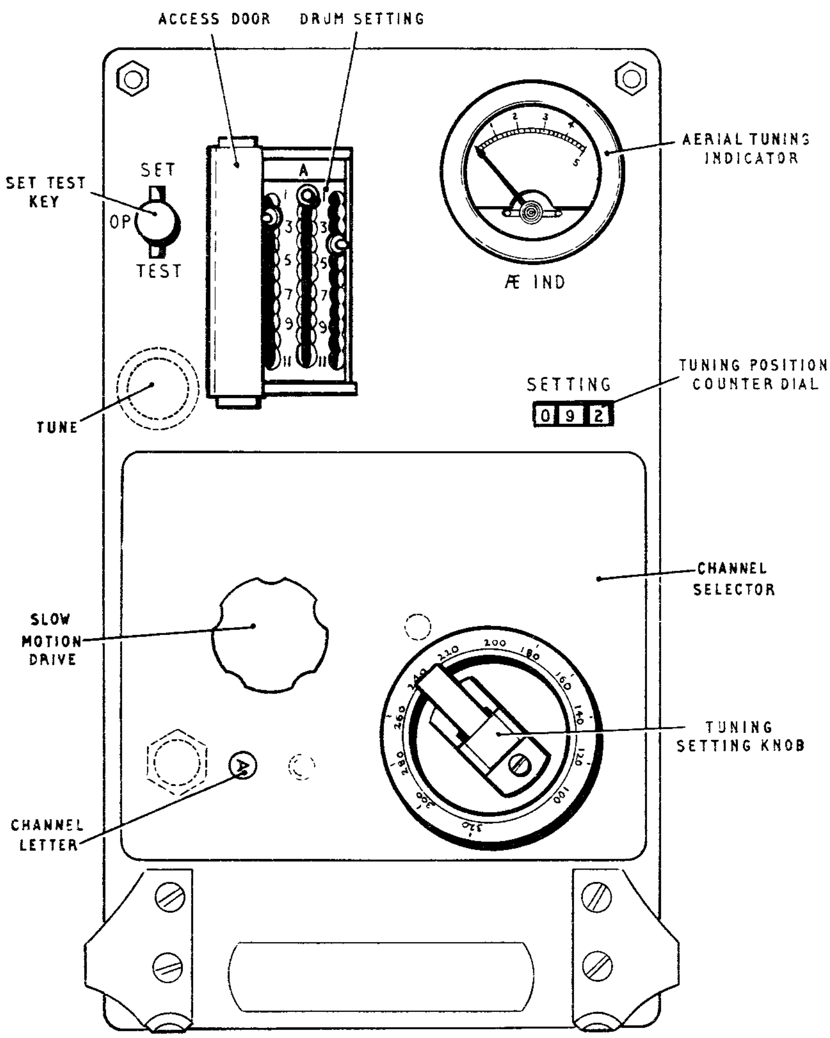


Fig. 3. Front panel of selector unit

(5) Repeat for other channels.

(6) After all the required channels have been set up, rotate the drum slowly until the catch falls and the cover closes. The drum is now engaged at the channel whose letter is indicated in the window of the channel selector.

Setting tuning information

21. With the equipment in the standby condition (power on) select the channel to be adjusted. Unlock the tuning knob of the channel selector and using the slow motion drive provided, turn the tuning knob of the channel selector until the dial reading required appears in the SETTING window below the meter.

22. Re-lock the tuning knob and remove the slow motion drive. Setting up the remaining channels is accomplished in an identical manner to the foregoing. The aerial system is now aligned for operation under radio silence reception conditions.

Method of matching tap selection and tuning setting

23. The aerial system is tuned in four bands using the tuner r.f. Difference in the tolerances of the components in the tuner r.f. and also those between different aircraft of the same type, make it difficult to define the limits of these bands accurately. Any one installation, may of course, be set to any frequency within the range of the equipment. Between the frequency bands there is a certain amount of overlap, therefore some frequencies may occur on adjacent bands; these may differ between various aircraft.

24. A set of six calibration curves (fig. 4 end of chapter) provides tuning information.

Band 1	2·8-3·16 Mc/s nominal—one curve
Band 2	3·16-3·85 Mc/s nominal—one curve
Band 3	3·85-5·2 Mc/s nominal—one curve
Band 4	5·2-20·0 Mc/s nominal—three curves

If a particular frequency occurs between the shaded lines on any of these curves, then the setting of the frequency selector can be taken directly from the curve and inserted in the setting record suggested in para. 18.

25. If a frequency occurs at either end of a curve covered by the shaded limit lines, then the tuning setting may occur on either of two bands e.g. 3170 kc/s may be at setting 200 on band 1, or at setting 6 on band 2.

26. Some experience of the particular installation is useful in deciding this point if complete radio-silence setting-up is required on a previously unused frequency.

27. When evidence exists from previous setting-up of the particular installation, it may be possible to decide which band to use, i.e. if 3190 kc/s has already been found to be on band 1, then 3170 kc/s will also occur on band 1.

28. Where possible a record of band coverage of each installation should be kept and checked when a change is made in the tuner r.f. in use. It is emphasized that setting-up by this method is only needed when complete radio silence is required on the ground or when a frequency selector unit or tuner r.f. is changed.

Selection of tap to use

29. The required tap used for a particular frequency is taken directly from Table 2. In the case of frequencies within the overlap range of the bands mentioned in para. 25, the correct tap to use is that for the band decided from the use of fig. 4, the tuning setting graphs.

Setting-up under transmit conditions

30. First of all the required tap position should be adjusted as described previously in para. 20. With the equipment under "transmit" conditions, select the required channel on the control radio set. The TUNE lamp will glow and remain glowing until the required channel has been selected, the TUNE lamp will then be extinguished.

31. Unlock the tuning knob (*fig.* 3) on the selector unit and using the slow-motion drive provided rotate the tuning knob until the required setting is shown in the SETTING window on the front panel of the selector unit.

32. Push the SET/TEST key located on the top left-hand side of the front panel, upwards into the SET position; the TUNE lamp will now glow, and the "AE IND" meter should show a reading. If the meter does not show an indication, adjust the SETTING until a maximum dip is shown on the meter. This is the correct tuning position.

33. Remove the slow motion drive from the tuning knob and lock the latter with the lever provided on it. Repeat the above procedure for other channels as necessary.

34. If a pronounced minimum reading cannot be reached, the next band must be tried, e.g. tuning not possible on tap 11 (Band 1) select tap 10 (Band 2) or tuning not possible on tap 10 (Band 2) select tap 9 (Band 3).

Note . . .

On changing bands, the setting position of tuning will revert to the other end of the scale, i.e. a setting near 200 *on band* 1 *becomes a setting of approximately* 10 *on band* 2.

35. In cases where the tuning settings are under 6 or over 220, the "pull-in" check of para. 37 should be made. If the TUNE lamp glows rhythmically the servo-system has reached its end stop and the appropriate next band (tap) must be used.

Routine checking of equipment

36. Move the SET/TEST key downwards into the TEST position, this should produce a reading of between 1 and 3 on the "AE IND" meter. The reading should be obtained in less than one second after operating the SET/TEST key. Typical figures for the meter reading to be expected between various frequencies are given in Table 3.

37. More complete checking can be carried out in the following manner:—

(1) Unlock the tuning knob on the selector unit and rotate the former by means of the slow-motion drive either plus or minus the following amounts from the setting indicated.

Frequency range	2·8 -5 Mc/s	40
	5·0-10 Mc/s	20
	10·0-20 Mc/s	10

(2) Place the SET/TEST key in the TEST position, the "AE IND" meter on the front panel of the selector unit should rise rapidly from zero to the normal test figures (Table 3).

(3) After checking a channel for "pull-in" in this way, restore the original channel setting by means of the tuning knob, after which the latter must be locked.

Wiring of plug PLC on selector unit 5985-99-999-8557

38. The links used in this plug determine the selection of the padding capacitors chosen for a particular channel selected. The plug is linked pole-to-pole in the following order:—

1 to 14, 2 to 15, 3 to 16, 4 to 17, 7 to 20, 8 to 21, 10 to 23.

TABLE 2

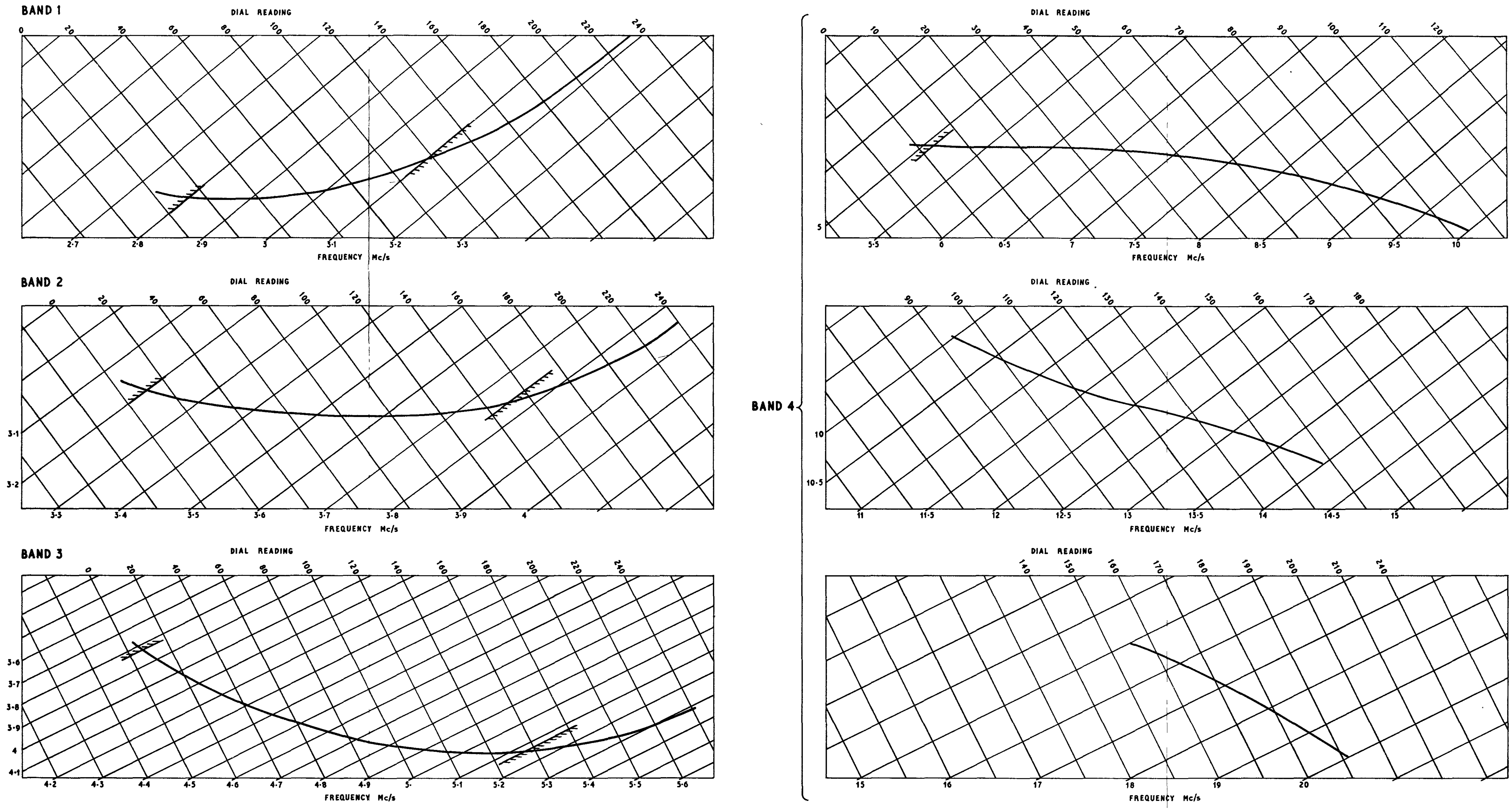
Suppressed aerial, tap selection

Freq. Mc/s	Use alternative tap shown if band is changed			
	1	2	3	4
2·8 - 3·1	11			
3·1 - 3·2	11	10		
3·2 - 3·75		10		
3·75- 3·83		10	9	
3·83- 5·14			9	
5·14- 5·31			8	7
5·31- 6·5				7
6·5 - 7·0				6
7·0 - 7·8				5
7·8 - 8·3				4
8·3 - 8·8				1
8·8 - 9·2				2
9·2 -11·0				3
11·0 -12·5				2
12·5 -14·5				1
14·5 -16·5				2
16·5 -20·0				3

TABLE 3

Typical AE/IND meter readings under test conditions

Freq. Mc/s	Test meter
2·8- 5·0	1·5
5·0- 5·5	2·3
5·5- 6·5	2·0
6·5- 8·0	1·4
8·0-10·0	0·5
10·0-12·0	1·0
12·0-15·0	1·2
15·0-20·0	0·8



Aerial system 5985-99-999-8559 Channel selector dial settings for aerial tuning

Fig. 4

AIR DIAGRAM
6729S/MIN.
ISSUE 1. PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY ADMIRALTY

PP9044 239577/5969 5/62 1130 C&P Gp. 924 (4)

PART 2

SERVICING

P31554 165257/7506 3/62 375 C & P Gp 37

SECTION 1

GENERAL SERVICING OF TRANSMITTER-RECEIVER EQUIPMENT

P31554 165257/7506 3/62 375 C & P Gp 37

Chapter 1

TEST EQUIPMENT REQUIREMENTS, DISMANTLING AND RE-ASSEMBLY

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. To satisfactorily test the h.f. s.s.b. transmitter-receiver it is necessary that the special-to-type test equipment be used. A list is given in Table 1.

2. Removal of the main items of the installation is described in the following paragraphs, these main items are made up of further sub-units in two cases. The dismantling instructions given illustrate how each sub-unit used may be removed from its associated parent unit.

General

3. A general description of the transmitter-receiver is given in Part 1, Sect. 2, Chap. 1. This present chapter provides information of the special test equipment to be used with the equipment together with dismantling and re-assembly instructions.

4. The main items in the transmitter-receiver installation are:—

(1) Amplifier r.f. 5821-99-913-2232
(2) Transmitter-receiver radio 5821-99-913-2249
(3) Power supply 5821-99-913-2246
(4) Generator reference signal 5821-99-913-2244

These are removable units which are installed in mounting trays in the radio bay of the aircraft. The suppressed aerial equipment is described elsewhere in this publication (*Part* 1, *Sect.* 3, *Chap.* 1).

5. To remove each unit from the aircraft racking all that is necessary is to unscrew the retaining screws at the front of the mounting tray. The retaining screws are of a special type allowing the unit to be partly withdrawn from its mounting by the action of unscrewing these retaining screws. The unit can then be simply withdrawn from the mounting. Locking wires may be fitted to the front retaining screws, these locking wires must be removed before the screws are loosened.

6. All rear connections are by plug and socket; this greatly facilitates easy and rapid withdrawal of the main units listed in para. 4.

List of test equipment

7. A complete list of test equipment for use with the transmitter-receiver is given in Table 1 although all of this may not be required at first and second line servicing levels.

Table 1

Test equipment for use with transmitter-receiver

Reference number	*Description*
6625-99-913-2929	Test set radio
6625-99-913-2933	Generator signal
6625-99-913-2932	Power supply (for generator signal)
6625-99-913-2931	Test set r.f. power
6625-99-913-3578	Test rig installation
6625-99-943-8384	Valve voltmeter CT429
6625-99-943-1524	Multimeter, panclimatic or Multimeter Type 1
6625-99-943-1523	Multimeter, panclimatic or Testmeter Type F
6625-99-949-0510	Wattmeter absorption CT44
FIC/5047	Megger, 250V
10S/831	Oscilloscope CT414
6625-99-943-2419	Test set electronic valve CT160
6625-99-932-4976	Signal generator 65B
6625-99-943-1911	Signal generator CT394 or signal generator CT394A
10S/16667	Trolley radio servicing
10K/17631	Matching transformer Type 3236

DISMANTLING

Transmitter-receiver radio 5821-99-913-2249

8. After removing the transmitter-receiver radio 5821-99-913-2249 from its mounting rack as described in para. 5, the cover can be withdrawn by loosening two snap-fasteners at the rear of the unit.

9. By holding the cover and pulling on the front handle of the unit the cover will easily slide off revealing the sub-unit construction as shown in fig. 1.

10. There are eight removable sub-units which are plugged into the main rack electrical equipment and retained by captive screws. The sub-units are as follows:—

(1) Amplifier radio frequency 5821-99-913-2241

(2) Oscillator radio frequency 5821-99-913-2236

(3) Amplifier intermediate frequency 5821-99-913-2251

(4) Control electrical frequency 5821-99-913-2234

(5) Amplifier audio frequency 5821-99-913-2237

(6) Modulator radio transmitter 5821-99-913-2235

(7) Control frequency selector (multi-turn) 5821-99-913-2248

(8) Filter bandpass 5915-99-913-2247

The removal of each sub-unit is described in the following paragraphs.

Amplifier radio frequency

11. Amplifier r.f. is the top left-hand sub-unit looking at the front of the transmitter-receiver. To remove this sub-unit the three green painted screws on the top of the sub-unit must first of all be slackened; the screws are located two at the rear and one at the front of the sub-unit and are made captive.

12. After slackening the retaining screws, the two miniature coaxial plugs which connect this sub-unit to the filter unit must be uncoupled, the sub-unit can now be withdrawn taking care not to strain the shaft coupler to the control frequency selector. It may be an advantage to rotate the selector mechanism to ease the disengagement of the coupler.

13. Having removed the sub-unit, all valves and associated components are readily accessible.

Oscillator radio frequency (1·5 Mc/s)

14. The oscillator is located in the central well of the transmitter-receiver rack electrical equipment (*fig.* 1).

15. To remove this sub-unit the two captive retaining screws at the top front must first of all be slackened off; inverting the transmitter-receiver and pushing on the underside will assist in detaching the 1·5 Mc/s oscillator sub-unit from its mating socket. Care must be taken however, to ensure that the sub-unit does not come completely free, fall and become damaged.

16. After removal of the sub-unit from the rack assembly it is necessary to remove the detachable lid and a metal cover to gain access to the main components.

17. This sub-unit chassis is constructed on a hinged system, this allows the sub-unit to be opened about the hinge, after slackening off two screws located on the top of the sub-unit visible after the metal cover has been removed. In this way the components mounted on the underside are easily accessible.

Amplifier intermediate-frequency

18. Location of the amplifier intermediate frequency is immediately below the amplifier r.f. sub-unit at the lower left-hand side of the main rack-assembly.

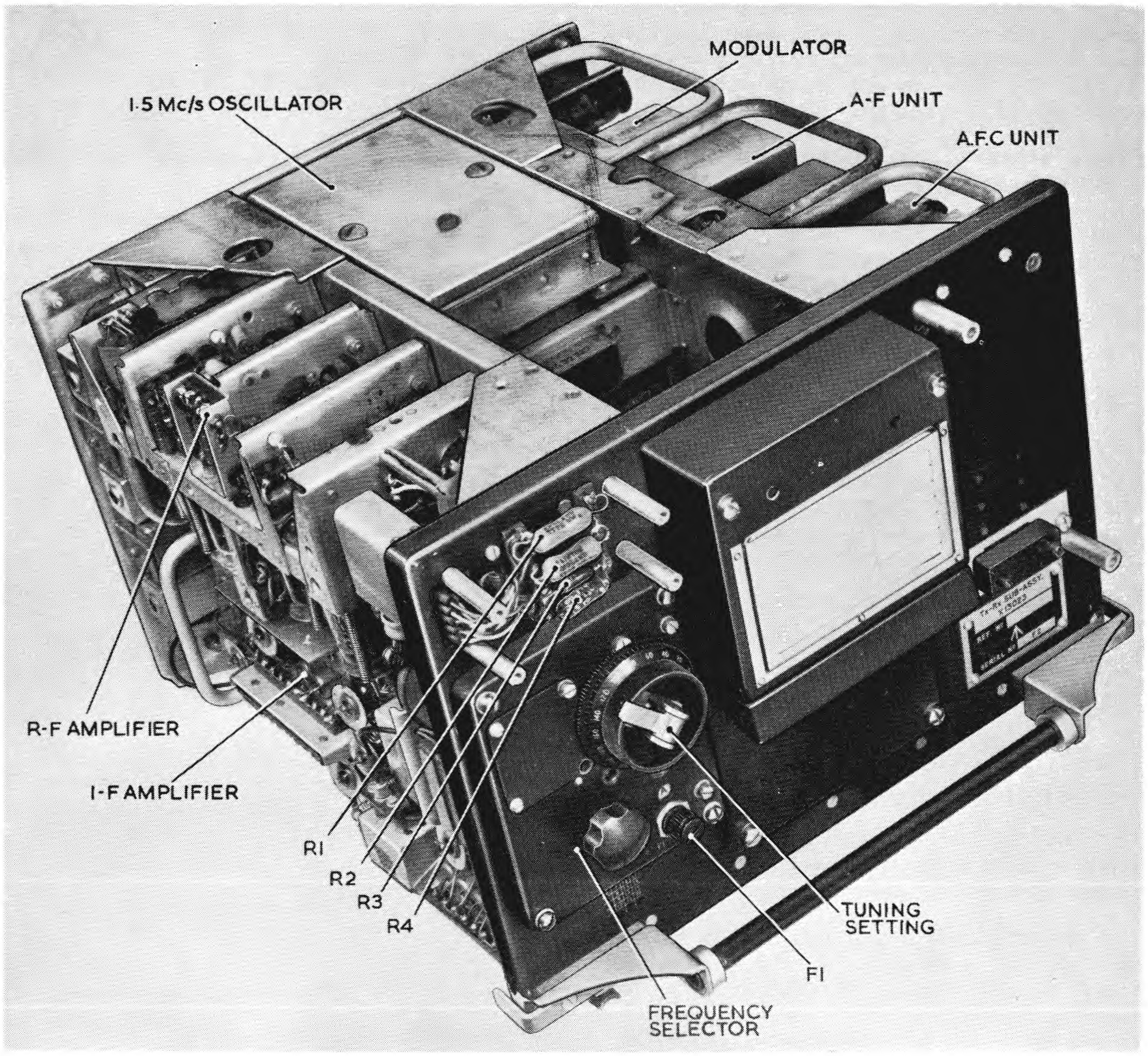


Fig. 1. Transmitter-receiver, sub-unit construction

19. Removal of the former sub-chassis is again by slackening off three captive retaining screws and removing two miniature coaxial free plugs, one of the latter feeds the signal from the crystal bandpass filter and the other links up with the 1·5 Mc/s oscillator unit.

Control electrical frequency and a.f. sub-units

20. To remove these sub-units slacken off the three green-painted retaining screws on each sub-unit and pull on the handles provided. The retaining screws are made captive in the sub-units to prevent loss or damage.

Modulator radio transmitter

21. After slackening off the three green-painted retaining screws accessible from the top of the sub-unit, it is necessary to disconnect a two-pin plug and socket arrangement; this is located at the right-hand side of the modulator sub-unit chassis when the latter is mounted in the transmitter-receiver rack electrical equipment.

22. A smart pull on the handles will now free the sub-unit from the rest of the assembly.

Control frequency selector and bandpass filter sub-units

23. The control frequency selector in the transmitter-receiver assembly is a front panel-mounted sub-unit. After removing four retaining screws in the front panel, the plug and socket located at the lower right of the transmitter-receiver assembly must be disconnected, the control frequency selector can then be carefully withdrawn.

24. To remove the bandpass filter assembly it is necessary to remove the green painted retaining screws, one at each end of the filter, and the associated coaxial plugs and sockets.

Generator reference signal, 5821-99-913-2244

25. The cover of the generator reference signal is removed by releasing the two snap fasteners at the rear of the unit. In the central well of the generator reference signal rack assembly are located three impulse governed oscillators (i.g.o.). Each i.g.o. is retained by two screws situated one on either side of the sub-unit.

26. To remove an impulse governed oscillator from the central well, firstly slacken off the retaining screws mentioned in para. 25. Since the i.g.o's are located very closely to each other provision has been made to assist the removal of the former by pushing on two protruding spring-loaded pins on the underside of the generator reference signal.

27. There are two pins for each impulse governed oscillator, these allow the sub-units to be partially removed from the rack assembly and complete removal is thereby made easier.

28. The following sub-units can easily be removed by slackening the associated number of retaining screws (shown in brackets) and pulling on the handles provided on each unit:—

(1) Amplifier oscillator (4 screws)
(2) Wadley oscillator (1 kc/s steps) (3 screws)
(3) Oscillator r.f. (5 Mc/s) (4 screws)
(4) Mixer-stage frequency (3 screws)

There are no coaxial cables to disconnect from any of the above sub-units before removing the sub-units from the rack electrical equipment.

29. A printed circuit board containing sixty selection switches forms a detachable sub-unit at the front of the generator reference signal.

30. Four retaining screws allow the cover of the switch assembly to be removed. After removing the cover, the screw holding the release lever should be slackened; operation of the release lever will now pull the switch assembly clear of its mating socket.

Power supply, 5821-99-913-2246

31. The cover of the power supply is removed by releasing the two snap fasteners at the rear of the unit and pulling on the handle at the front of the power supply.

32. A hinged chassis inside the power supply is retained by two 4 B.A. screws at the front. After these screws have been loosened the hinged chassis can be raised giving easy access to components on its underside.

33. Spare fuse links are provided under a cover at the front of the power supply unit. To remove this cover release the two knurled screws after which the cover can be pulled off.

Power amplifier (amplifier r.f. 5821-99-913-2232)

34. The cover of the power amplifier is removed in a similar way to that mentioned in para. 31; after removal of the cover all the components used are accessible.

35. Contained on the front panel of the power amplifier is a control frequency selector unit (multi-turn) this can be withdrawn from the front after:—

(1) Releasing the four retaining screws at the front

(2) Disconnecting plug and socket SKTC at the top left-hand side of the power amplifier.

Junction box and remote control unit (normally fixed in aircraft)

36. The junction box can be released by disconnecting the associated connecting cables and then releasing six retaining screws. The top of the junction box together with sockets and wiring will then become free from the cover, the latter being screwed to the aircraft. The remote control unit (control radio set) may be removed by disengaging two plugs from the rear and then releasing the retaining screws accessible through mounting brackets on the side of the remote control unit.

RE-ASSEMBLY

37. Re-assembly of the sub-units on the transmitter-receiver rack electrical equipment is the reverse procedure to that of dismantling, i.e. pushing the sub-units home into their respective sockets and connecting up any necessary coaxial cables. When replacing the control frequency selector in the r.f. unit, care should be taken that the coupler on the mechanism of the control frequency selector lines up with that on the r.f. unit.

38. Care should be exercised when replacing the sub-units in the rack assembly that the plugs and sockets do not become damaged by the use of excessive force.

39. After the sub-units are firmly re-seated and connected, the green-painted retaining screws must be firmly tightened down.

40. Re-assembly of the power supply unit involves re-fastening the hinged chassis assembly and replacing the cover previously removed.

41. When refitting the control frequency selector used in the r.f. power amplifier it will be found necessary to do this before the cover of the unit is in place, since the multi-way plug and socket connecting the power amplifier with the control frequency selector must be mated. Care should also be taken that the turns indicated on the mechanism line up with the brush position on the coil and that the coupler engages correctly.

42. The cover of the power amplifier is replaced by pushing the unit into the cover and re-fastening the quick-release screws at the rear.

Generator reference signal

43. Re-assembly of the sub-units on the generator reference signal rack electrical equipment is a reverse procedure to that of dismantling in a similar way to that of the transmitter-receiver itself. The retaining screws should be firmly screwed home after making sure that the sub-unit concerned is firmly seated.

P31553 165257/7506 3,62 375 C & P Gp 375

Chapter 2

GENERAL SERVICING

LIST OF CONTENTS

LIST OF TABLES

Introduction

1. The servicing instructions detailed in this chapter are concerned with the tests for each individual unit in the transmitter-receiver and the generator r.f. Overall tests for the equipment are given in Part 2, Sect. 3, Chap. 2.

2. The units are tested with the transmitter-receiver connected in the test rig installation as shown in fig. 3 of Part 1, Sect. 2, Chap. 3.

Note . . .

If the equipment is to be serviced with the air blowers disconnected the Unit dust cover must be removed. This will allow for more heat dissipation from high voltage points. Before switching the equipment on and when changing channels the tuning controls of the transmitter-receiver, the amplifier r.f. and the aerial selector switch should be locked. On the amplifier r.f. the motor switch should not not be left switched to position 11.

Duty cycle

3. The maximum duty cycle for the transmitter is 5 minutes in 15 minutes.

Preliminary procedure

General

4. Before proceeding with the servicing procedures examine the units for any of the following:

(1) Examine the interconnecting wires within the unit for any loose or broken wires, burst or split insulation.

(2) That components are securely soldered between connecting points; that there are no dry joints. Examine components for damaged insulation covering.

(3) Broken or corroded terminals or solder tags.

(4) Examine switches for loose or corroded contacts.

(5) Undue stiffness in any moving parts such as gears, shafts, motor driven potentiometers, spindles etc.

(6) Where motors are installed verify freedom of movement in rotating parts.

(7) Ensure the valves are firmly seated and transistor leads secure.

Power supply 5821-99-913-2246

5. Proceed as follows:

(1) Release the 'dzus' fasteners at the rear of the unit and remove the outer case.

(2) Inspect the case and fastenings for signs of damage or deterioration.

(3) Release the two knurled-headed nuts on the front panel and drop forward the spare fuse cover.

(4) Verify if there is a full complement of spare fuses. Replace any missing fuses, with the correct type and fuse rating.

(5) Replace the outer cover and secure.

Control radio set 5821-99-913-3108

6. Proceed as follows:

(1) Check the freedom of action of all switches. Ensure the control knobs are secured properly to the respective switch shafts.

(2) Examine the front of the controller for damage to switch and control knobs, and to the panel.

(3) Inspect the sockets at the rear of the unit and clean as necessary, using an approved cleaning agent. Lightly grease the threaded portions with grease XG275 (34B/9100512 or 13).

Interconnecting box

7. Inspect the plugs and sockets for signs of damage, bent pins. Clean as necessary, using an approved cleaning agent and lightly grease the threaded portions with grease XG275 (34B/9100512 or 13).

Transmitter-receiver radio 5821-99-913-2249

8. Proceed as follows:

(1) Remove the dust cover.

(2) Remove any excess dirt or dust with a dry air blower and soft brush.

(3) Ensure that the tuning control locking mechanism requires firm pressure to lock, and release.

(4) Inspect the plug and socket connectors. Clean as necessary using an approved cleaning fluid. Lightly grease any threaded portions with grease XG275 (34B/9100512/13).

Test equipment

9. The test equipment required to complete the test procedures is listed in Table 1 of Part 2, Sect. 1, Chap. 1.

TEST PROCEDURES

Amplifier intermediate frequency 5821-99-913-2251

Alignment

10. Proceed as follows:

(1) Disconnect co-axial lead plug PLB from the amplifier i.f.

(2) Connect the generator signal LOW LEVEL output to PLB.

(3) Short circuit the a.g.c. by connecting test point TP3 to earth.

(4) Connect the CT429, set to the 300mV a.c. range, between TP1 and earth.

(5) On the control radio, set, switch the control switch to position R.

(6) Tune the generator signal to 1·499 Mc/s with a LOW LEVEL 200μV output.

(7) The output indicated on the CT429 should be at least 60mV.

(8) If the output specified is not achieved set capacitor C19 to the mid-position.

(9) Adjust the cores of inductors L1, L2 and L3 for a maximum indication on the CT429, adjusting the generator signal output level to maintain the indication on the CT429 at approximately 60mV.

(10) Readjust capacitor C19 to give an indication of 60mV on the CT429 with an output level of 200μV from the generator signal.

(11) Repeat the procedure detailed in sub-para. (9) and (10) until no further improvement can be obtained.

(12) Remove the earth from test point TP2, remove the generator signal and the CT429.

(13) Calibrate the oscilloscope CT414 as follows:—

(a) Connect the generator signal HIGH LEVEL output to the Y1 and Y2 inputs of the CT414. Tune the generator signal to 1·5 Mc/s.

(14) Adjust the CT414 until both sine waves are displayed and approximately of equal amplitude.

Note . . .

The two sine waves should be exactly in phase. If they are not, any phase difference should be noted for use in subsequent measurements.

(15) Remove the generator signal from the CT414.

(16) Connect the generator signal LOW LEVEL output to plug PLB. Tune the generator signal to 1·499 Mc/s with an output of 350μV.

(17) Connect the Y1 and Y2 inputs of the CT414 to test points TP4 and TP3 respectively. Adjust the CT414 to display both sine waves for equal amplitude.

(18) Verify that the displayed waveforms are exactly in phase, after applying any corrections noted in sub-para. (14). Adjust C31 and L4 as necessary to achieve an in-phase condition. These controls have only slight effect.

(19) Adjust RV1 to obtain equal amplitude of the waveforms.

(20) Retune the generator signal to 1·502 Mc/s. Verify that the displayed waveforms are exactly anti-phase.

(21) Switch the equipment off and remove the test equipment. Reconnect plug PLB.

Amplifier audio frequency 5821-99-913-2237

Alignment

11. Proceed as follows:

(1) Remove the amplifier a.f. from the transmitter/receiver and reconnect the sub-unit to the main assembly by means of a suitable cable.

(2) On the control set radio, set the control switch to R, the channel selector CHAN to position A. Adjust the RX GAIN control fully clockwise.

(3) Tune the signal generator 65B to 1 Kc/s with an output voltage of 1V. Connect the signal generator to the end of capacitor C7 nearest the plug PLA.

(4) Connect the a.f. output meter CT44, set to 50 ohms impedance across the output terminals of transformer T4 (terminals 3 and 4) or alternatively across the EXT. PHONE terminals on the test set, radio.

(5) Adjust potentiometer RV2 until an output of 50mV is indicated on the CT44.

(6) Remove the signal generator 65B and the CT44.

(7) On the test set, radio, set the controls as follows:

(a) Set the BATTERY switch ON.

(b) Set the TX-RX switch to RX.

(c) Set the TEST switch to A.F.O.

(d) Set the AFO switch to 1 KC/S.

(e) Set the AFO LEVEL to NOISE.

(f) Adjust the SET 1 KC/S control until the needle of the dBm meter is on the red line.

(g) Set the A.F.O. LEVEL switch to I/C and S/T.

(8) Connect the valve voltmeter CT429, set to the 10V a.c. range, across the primary of transformer T3, (terminals 1 and 2). The meter connected between PLA B3 and earth is an alternative connection.

(9) Set the control radio set control switch to T and R.

(10) Key the transmitter and adjust RV3 for an indication of 3·3V a.c. on the CT429. Unkey the transmitter. Remove the CT429.

(11) On the test set radio set the controls as follows:

(a) Set the TEST switch to RX SENS.

(b) Set the A.F.O. LEVEL to L/C and S/T.

(12) Adjust RV4 until the needle of the dBm meter is on the blue line.

(13) Switch the control radio set to OFF. Remove the test equipment.

(14) Refit and reconnect the amplifier a.f. into the main assembly.

Modulator, radio transmitter 5821-99-913-2235

Setting-up

12. Proceed as follows:

(1) Remove the modulator from the main assembly and, using suitable extension cables, reconnect plugs PLA and PLB to the respective connections on the main assembly.

(2) On the control radio, set, switch the control switch to R, allow the equipment to warm up then set the selector switch to T and R.

Carrier and sideband rejection

13. Proceed as follows:

(1) On the test radio set the controls as follows:

(a) The BATTERY switch to ON.

(b) The TEST switch to AFO.

(c) The AFO LEVEL switch to NOISE LEVEL.

(d) Adjust the SET 1 KC/S control until the needle of the dBm meter is on the red line.

(2) Connect the Y1 terminal of oscilloscope CT414 between the R.F.IN and E test points on the amplifier radio frequency 5821-99-913-2232.

(3) Key the transmitter.

(4) Adjust the RV2, RV3 and RV4 for minimum of audio ripple on the r.f. signal displayed on the CT414. If necessary adjust inductors L1 and L2.

Adjustment of RV1

14. Proceed as follows:

(1) On the amplifier a.f. connect, in turn, the CT429, set to the 1V a.c. range, between earth and pins 3 and 4 of transformer T3.

(2) With the test set radio control set as detailed in para. 13, key the transmitter and adjust RV1 until the voltages are equal at approximately 0·6V.

(3) Unkey the transmitter and remove the CT429.

Modulator output adjustment

15. Proceed as follows:

(1) Key the transmitter.

(2) Adjust transformer T1 for maximum power output as indicated on the test set r.f. power.

(3) Unkey the transmitter. Remove the CT429.

Filter X2 alignment

16. Proceed as follows:

(1) Connect the signal generator 65B across the terminals 1 and 2 on the 1·5 Mc/s transmit filter sub-unit X2.

(2) Connect the CT429, set to the 3V a.c. range, between test point TP1 and earth.

(3) Key the transmitter.

(4) On the 1·5 Mc/s transmit filter sub-unit X2 adjust each transformer core for maximum indication on the CT429.

(5) Unkey the transmitter.

(6) Remove the signal generator.

Adjustment of RV5

17. Proceed as follows:

(1) Reset the CT429 to the 1V a.c. range.

(2) Key the transmitter.

(3) Adjust RV5 for an indication of 700 to 800mV on the CT429.

(4) Unkey the transmitter and remove the CT429.

(5) Switch the control radio, set OFF. Switch OFF and remove the test equipment.

(6) Disconnect the extension cables and refit the modulator to the main assembly.

Control electrical frequency 5821-99-913-2234

18. Proceed as follows:

(1) On the control radio, set switch the control switch to R. Set the CHAN switch to A.

(2) On the generator signal switch to LOW LEVEL. Connect the LOW LEVEL output to the RX input at the rear of the transmitter-receiver.

(3) Tune the generator signal to 1 Kc/s above the channel frequency.

(4) Connect the Y1 terminal of the oscilloscope CT414 to test point TP3. Adjust the CT414 to display a waveform.

(5) Adjust RV1 for a minimum waveform.

(6) Tune the generator signal to 1 Kc/s below the channel frequency. Connect the CT414 to test point TP4 or TP5.

(7) Adjust RV2 for a minimum waveform. Alternatively plug a suitable headset into the HEADSET socket on the test set, radio and adjust for a minimum note.

(8) Tune the generator signal to 1 Kc/s above the channel frequency. Adjust both the generator signal output and the RX GAIN control, on the control radio, set, until the needle in the dBm meter (test set, radio) is on the blue line.

(9) Tune the generator signal to 1 Kc/s below the channel frequency and increase the ATTENUATOR until the dBm meter again indicates on the blue line.

(10) The difference between the two meter indications is the sideband rejection figure and should be at least 15dB.

(11) Switch the equipment OFF and remove the test equipment.

Oscillator r.f. 5821-99-913-2236

Alignment

19. Proceed as follows:

(1) Release the 'dzus' fasteners and remove the cover from the sub-unit.

(2) On the control radio, set, switch the control switch to R and allow time for the equipment to warm-up.

(3) Connect the CT429, set to the 10V a.c. range, in turn between earth and plug PLA pins 19 and 20, and at each pin tune transformer T1 for a maximum indication on the CT429. This should be not less than 3V.

(4) Switch the control radio set to OFF and remove the test equipment.

(5) Refit the cover onto the oscillator r.f.

Filter bandpass-alignment

20. Proceed as follows:

Note . . .

Before commencing this test verify that the amplifier i.f. is correctly aligned.

(1) On the amplifier i.f. earth test point TP2.

(2) Disconnect the input to the transmitter-receiver from the generator reference signal. Connect the generator signal LOW LEVEL output to this point.

(3) On the amplifier r.f. (5820-99-913-2241) remove valve V1.

(4) Connect the wattmeter absorption CT44, set to 50 ohms impedance, to the HEAD SET output socket on the test set radio.

(5) On the control radio, set switch the control switch to R and allow time for the equipment to warm-up.

(6) Tune the generator signal to 1·499 Mc/s at 100μV, LOW LEVEL output and note the indication on the CT44.

(7) Retune the generator signal to 1·497 Mc/s and verify that the indication on the CT44 is within 3dB of the output noted in sub-para. (6).

(8) If necessary adjust transformer T1 and

T2 to obtain the flatest response over the frequency band.

(9) Retune the generator signal to 1·495 Mc/s and verify that the indication on the CT44 is at least 17dB below that noted in sub-para. (6).

(10) Switch the control radio, set to OFF. Switch test equipment OFF and remove.

(11) Reconnect the generator reference signal input to the transmitter/receiver. Refit valve V1 into the amplifier r.f.

Amplifier radio frequency 5820-99-913-2241

Alignment

21. The alignment of this sub-unit must be performed in-situ because any attempt to adjust the circuits with the unit attached to extension leads may result in misalignment.

22. If the sub-unit is removed for the purposes of repair, and it is intended to refit the same sub-unit note the relative positions of the tuning mechanism drive and the slotted cam.

23. Proceed as follows:

(1) On the generator reference, signal set the following frequencies.

Channel	Frequency (Mc/s
A	2·510
C	4·990
D	5·010
F	9·990
G	10·010
J	19·990

(2) Set these frequencies in accordance with the instructions given in Part 1, Sect. 2, Chap. 3.

(3) Remove the cam from the amplifier r.f. sub-unit by releasing the four securing screws.

(4) On the front of the transmitter-receiver unlock the control frequency selector and rotate the control until 'O' is indicated on the dial.

(5) Switch the control radio, set to R. Set the CHAN. switch to A.

(6) Unlock the control frequency selector and set to 5°. Relock the control.

Note . . .

In the following procedures ensure that the control frequency selector is locked before changing the channel settings.

(7) Select Channel D and C respectively, and set the control frequency selector to 5°.

(8) Select channels C, F and J, and at each channel setting set the control frequency selector to 175°.

(9) Disconnect the coaxial lead (yellow) between the amplifier r.f. and the transmitter-receiver plug PLA/D1.

(10) Connect the generator signal LOW LEVEL output to the receiver input plug PLA/D1.

(11) Connect the wattmeter absorption CT44, set to 50 ohms impedance, to the HEADSET socket on the test set, radio,

(12) On the control set radio, set the CHAN. switch to A.

(13) Tune the generator signal to 2·511 Mc/s and adjust the output level for an indication of approximately 50mW on the CT44.

(14) On the amplifier r.f. adjust the transformer T3 and T6 for a maximum indication on the CT44.

(15) Retune the generator signal to 4·991 Mc/s and set the CHAN. switch on the control set, radio to C.

(16) On the amplifier r.f. adjust capacitors C26 and C37 for a maximum indication on the CT44.

(17) Repeat the procedures detailed in sub-paras. (12) to (16) until no further improvement is obtained.

Note . . .

The CT44 indications noted in sub-para. (14) and (16) should be similar thus indicating a flat response across the frequency band.

(18) Repeat the procedure detailed in sub-para. (12) to (16) for Channel D and F (band 2), and Channels G and J (band 3). At each channel setting adjust the components of the amplifier r.f. 5821-99-913-2241 as detailed below.

Note . . .

In each case turn the generator signal 1 kc/s higher than the channel frequency.

Channel	Adjust
D	T2, T5
F	C27, C38
G	T1, T4
J	C28, C39

(19) Disconnect the generator signal from the receiver input and reconnect the lead removed in sub-para. (9).

(20) On the control radio set switch the control switch to T & R. Set the CHAN. switch to A.

(21) On the front panel of the amplifier r.f. 5820-99-913-2232 connect the CT429, set to the 30V a.c. range, between the RF IN and E sockets.

(22) Key the transmitter and on the amplifier r.f. under test tune transformers T9 and T10 for a maximum indication on the CT429. Unkey the transmitter.

(23) Set the CHAN. switch to C. Key the transmitter and adjust capacitors C5 and C22 for a maximum indication on the CT429. Unkey the transmitter.

(24) Repeat the procedures detailed in sub-paras. (20) to (23) until no further improvement can be obtained.

(25) Set the CHAN. switch, in turn, to channels D and F (band 2), and channels G and J (band 3). At each channel repeat the procedures detailed in sub-para. (20) to (23) adjusting the following components for each channel:

Channel	Adjust
D	T8, T11
F	C6, C23
G	T7, T10
J	C7, C24

(26) Switch the control radio set to OFF.

(27) Refit the amplifier r.f. cover.

Control frequency selector (single turn) 5821-99-913-2240

24. Proceed as follows:

(1) Release the dial locking lever and rotate the mechanism by hand. Verify that the mechanical end stops limit travel from 0° to, or below to 275°-280°.

(2) Adjust the two screws securing the locking lever for a positive locking and unlocking action.

(3) Switch the control radio set to R and select CHAN. A.

(4) Unlock the mechanism and rotate by hand to 5°, and relock.

(5) Select CHAN. B, unlock the mechanism and rotate by hand to 275°. Relock the mechanism.

(6) Reselect CHAN. A and verify that the mechanism completes its operation in not more than 4 seconds. Ensure that the letter A appears in the window below the mechanism.

(7) Repeat the procedures detailed in sub-para. (3) to (6) for the other channels. Note that the mechanism comes to rest within ±2° of each selected setting.

(8) Switch the control radio set to OFF.

Amplifier radio frequency 5821-99-913-2232

25. Note that the tuning of this amplifier r.f. is performed with the bench installation at TRANSMIT. Proceed as follows:—

(1) Set the generator reference signal to the following frequencies:—

Channel	Frequency (Mc/s)	Band
A	2·510	1
B	3·692	1
C	4·990	1
D	5·010	2
E	7·435	2
F	9·990	2
G	10·010	3
H	15·248	3
J	19·990	3

Set these frequencies in accordance with the instructions given in Part 1, Sect. 2, Chap. 3.

(2) Connect the amplifier r.f. output coaxial lead (red) to the test set r.f. power 6625-99-913-2931.

(3) Switch the control radio set to R and allow equipment to warm-up.

(4) Using a long-handled allen key loosen the two allen-screws holding the bevel gear to the shaft of coil L5. Slide the gear along the shaft, towards the coil, until it is uncoupled from coil L15 bevel gear. If necessary lightly grease the gears with grease XG275.

(5) On the front panel turn RV1 fully-clockwise, then turn the control back approximately $\frac{1}{8}$th of a turn.

Note . . .

When using the screwdriver during the following procedure care must be taken to avoid damage to the screwdriver slot on the shaft of L15.

(6) Locate the screwdriver slot on the end of L15 shaft. Insert the screwdriver through the chassis access hole and turn L15 to ensure smooth operation. Do not turn L15 so that the coil termination comes up hard against the coil brush.

(7) On the control radio, set select CHAN. A and set the selector switch to T & R.

(8) Set the meter switch to DRIVER IC (position 6) and key the transmitter. Adjust the tuning knob of the control frequency selector for a minimum indication on the meter. The tuning is very flat and a minimum reading should correspond to a maximum indication on the test set, r.f. power.

Note . . .

The test position for the contact of L5 should be between 0 and 1 turn.

(9) Using the screwdriver, turn coil L15 for a further minimum indication of the meter and note that the contact is positioned within 60° of the L5 contact.

(10) On the control radio, set select CHAN. C and repeat the procedure detailed in sub-para. (9) and (10). Verify that at minimum indication the meter indicates not more than 360 and that the test set r.f. power indicates at least 85W. If necessary adjust RV1 to achieve this output.

Note . . .

Should the output of 85W not be achieved check the drive from the transmitter-receiver by switching the meter switch to R.F.IN *(position 11). This should not be less than 40.*

(11) Unkey the transmitter and on the control radio, set switch the control switch to R.

(12) Remesh the bevel gears and tighten the two allen screws. Ensure that the gears are not binding.

(13) Switch the meter switch to PA_2IC (position 8). Key the transmitter and adjust RV1 for a meter indication of 340.

(14) Switch the meter to PA_1IC (position 7) and to PA_3IC (position 9). At each position of switch verify that the meter indication is between 320 and 360.

Note . . .

During the following procedures verify that on each channel the power output as indicated on the test set r.f. power is

Band 1 and 3 ... Not less than 85W
Band 2 Not less than 20W

(15) On the control radio, set switch to CHAN. F and adjust the tuning mechanism for a maximum indication on the test set r.f. power. Adjust capacitors C15 and C18 for a further increase in output power.

(16) Switch to CHAN. D and CHAN. E, in turn, and adjust the tuning mechanism for a maximum indication on the test set r.f. power.

(17) Switch to CHAN J and adjust the tuning mechanism for a maximum indication on the test set r.f. power. Adjust capacitor C12 for a further increase in output power.

(18) Switch to CHAN. G and CHAN. H, in turn, and adjust the tuning mechanism for a maximum indication on the test set r.f. power.

(19) Switch to CHAN. B and adjust the tuning mechanism for a maximum indication on the test set r.f. power.

(20) Set the meter switch, in turn, to positions 7, 8 and 9, and at each position verify that the meter indication is between 320 and 360. Re-adjust RV1 as necessary.

Note . . .

If the meter indications given are outside the limits quoted check the setting of RV2, the driver bias control.

(21) Switch the control radio, set to OFF.

Power supply 5821-99-913-2246

26. Proceed as follows:

WARNING . . .

The power supply unit produces lethal voltages and care must be taken when operating the power supply with the cover removed.

(1) Remove the power supply cover.

(2) On the control radio, set the control switch to OVEN and verify that the OVEN indicator shows a white stripe, then returns to the blank condition after approximately 5 minutes.

(3) Using the multimeter Type 1 measure the voltage at each fuse connection as detailed in Table 1.

TABLE 1

Power supply 5821-99-913-2246 — voltage data

Fuse	Nominal voltage	
F1, F2, F3	200V a.c.	±5% phase to phase
F4	28V	−4V+4·5V
F5	−35V d.c.	±1V
F6	200V d.c.	−0V+20V
F7	150V d.c.	−3V+7V
Switch the control radio set to R		
F8	650V d.c.	±20V
Switch the control radio set to T & R		
F9, F10, F11	28V	−4V+4·5V

(4) Place the power supply on its side to expose the base.

(5) On the left-side of the unit locate RV1 and RV2. Slacken the locknuts.

(6) On the control unit set the control switch to T & R.

(7) Connect the multimeter Type 1, set to the 500V d.c. range, between the cathode of V4 (pin 8) and earth. Rotate RV2 over the full voltage range and verify that the voltage varies from less than 290V to more than 310V. Adjust RV2 for an indication of 300V d.c. and lock the potentiometer control.

(8) Connect the multimeter Type 1, set to the 100V d.c. range, negative lead to the cathode of V1A (pin 8). Connect the positive lead to earth. Rotate RV1 over the full voltage range and verify that the voltage varies from less than −29V to more than −38V. Adjust RV1 for an indication of −35V and lock the potentiometer control.

(9) Locate rectifier MR31. Connect the multimeter, set to the 250V d.c. range, between the centre-part of MR31 and earth. Verify that the voltage indicated is 150V d.c. ±4V. Remove the multimeter.

(10) On the control set radio set the control switch to OFF.

(11) Replace the power supply cover.

Control set radio 5821-99-913-3108

27. To complete the following tests the unit should be removed from the installation. Use the multimeter Type 1 for resistance tests.

Receiver gain control

28. Proceed as follows:

(1) Connect the multimeter, set to the OHMS range, between SKTA, terminal N and terminal Z (earth).

(2) Rotate the RX GAIN control fully counter clockwise and verify that the resistance is greater than 1M ohm.

(3) From the fully counter-clockwise position switch to each position in turn and verify that the resistances are within the following limits.

Position	Resistances
1	100 ohms ±15%
2	30 ohms ±15%
3	15 ohms ±15%
4	4·7 ohms ±15%
Fully clockwise	Less than 0·5 ohm

Aerial tune/receive switch

29. To test the resistances associated with this switch proceed as follows:

(1) Connect one lead of the multimeter to SKTB, terminal R.

(2) Connect the other lead to terminal P.

(3) Set the AE TUNE RX switch to each position in turn and verify that the meter indications are within the limits given below.

Switch position	Resistance
+3	Less than 0·5 ohms
+2	1·5K±15%
+1	3·0K±15%
0	4·5K±15%
−1	6·0K±15%
−2	7·5K±15%
−3	9·0K±15%

(4) Reconnect one lead of the multimeter to terminal S of SKT.B.

(5) Repeat the procedure detailed in sub-para. (3) and verify that the resistances indicated are in the reverse order, starting with the −3 position.

(6) Remove the multimeter.

Generator reference signal 5821-99-913-2244 (F.G.U.)

30. Before commencing any servicing procedures ensure that all the modules are in place because if the unit is operated with any module removed damage could result to the parallel connected valve heaters.

31. The unit can be operated with the blowers disconnected provided the cover is removed.

Functional test

32. Proceed as follows:

(1) Release the two 'dzus' fasteners on the front of the unit and open the panel, to expose the frequency selector sliders.

(2) On the control radio, set switch the control switch to OVEN.

(3) On the generator reference signal observe the green OVEN LAMP and verify that the following takes place:—

(a) On first switching on, in an ambient temperature of 20°C, the lamp remains ON for about seven minutes before starting to cycle.

(b) When cycling starts the lamp should be ON approximately three seconds and OFF for seven seconds.

If this cycle of events takes place as detailed it indicates that the oven in the oscillator r.f. 5829-99-913-2238 is operating normally.

(4) On the control radio, set switch the control switch to R. Set the channel selector switch to B.

(5) Verify that the generator reference signal locks within 6 seconds of selecting channel B as indicated by the CHAN. indicator on the control radio, set.

(6) Switch the meter selector to each of the twelve positions in turn and check the meter indication against the limits detailed in Table 2.

TABLE 2

Generator reference signal 5821-99-913-2244 — monitoring data

Meter Switch position	Monitoring	Meter reading
1	Heaters	240 to 300
2	150V stabilised h.t.	300 to 340
3	150V h.t.	280 to 340
4	200V h.t.	360 to 440
5	1Mc/s i.g.o. signal	160 to 200
6	100kc/s i.g.o. signal	70 to 90
7	10kc/s i.g.o. signal	50 to 70
8	v.f.o. signal	50 to 250
9	Reference signal	250 to 350
10	Loop signal	220 to 280
11	2Mc/s output	220 to 280
12	Amplifier oscillator output	170 to 210

If at any position of the switch the meter indications are not within the limits given the unit is considered unserviceable.

(7) Repeat the procedure detailed in sub-para. (6) on frequency range 2 (5·0 to 9·999 Mc/s).

(8) Repeat the procedure detailed in sub-para. (6) on frequency range 3 (10·000 to 20·0 Mc/s).

Motor test

33. To verify the operation of the motor X1 at slow speed proceed as follows:—

(1) Run the motor for a period of 15 minutes.

(2) At the end of this time measure the voltage at the motor terminals, whilst the motor is running at slow speed. This should not exceed 5 volts in the forward and reverse directions of travel.

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SECTION 2

GENERAL SERVICING OF SUPPRESSED AERIAL TUNING EQUIPMENT

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Chapter 1

TEST EQUIPMENT REQUIREMENTS, DISMANTLING AND RE-ASSEMBLY

LIST OF CONTENTS

Introduction

1. A general description of the suppressed aerial system is given in Part 1, Sect. 3, Chap. 1. This chapter provides information of the special test equipment to be used with the system, together with the dismantling and re-assembly instructions for the main units. Where sub-assemblies are used the dismantling instructions given will enable the sub-assembly to be removed for repair or replacement.

2. The main units in the suppressed aerial system are as follows:—

(1)	Tuner radio frequency	5950–99–999–8558
(2)	Network impedance matching	5915–99–999–8556
(3)	Connector radio frequency	5995–99–999–8552
(4)	Selector unit	5985–99–999–8557
(5)	Mounting tray	5985–99–999–8546

Items 1, 2, and 3 are fitted in the aerial cavity, and items 4 and 5 are usually fitted in the radio bay within 20 ft. of both the notch aerial and the interconnecting box.

List of test equipment

3. The special test equipment used with the system is listed as follows:—

(1)	Indicator r.f.	6625–99–999–8550
(2)	Indicator s.w.r.	6625–99–999–8551
(3)	Test rig installation	5985–99–999–8547
(4)	Generator signal	6625–99–999–2933
(5)	Power supply (for generator signal)	6625–99–999–2922

Item 3 is used in bay servicing to simulate the notch parameters, the other items being used for tests with the units in situ.

DISMANTLING

Notch aerial units

4. When the notch aerial di-electric cover is removed all the units are accessible. Part 4, Sect. 3, Chap. 4, fig. 1 illustrates the units. It is important that the dismantling operations are carried out in the correct sequence. The procedure is as follows:—

(1) Disconnect the two sockets which are terminated on the network impedance matching (cable Y to PLB) and (cable Z to PLA).

(2) Disconnect the plug which is terminated on the tuner radio frequency (cable Z to SKTA).

(3) Ascertain whether wire locking has been used to secure the union nuts which retain the connector to the matching unit, and if so remove it.

(4) Unscrew the ⅝ in. UNF locknut on the matching unit.

(5) Retain the hexagonal end of the connector in a spanner (1·65 across flats—1 in.

UNC) to stop rotation and slacken the $\frac{5}{8}$ in. union nut which connects the stud on the matching unit to the connector. The nut should be left finger tight.

(6) Unscrew five of the 4 B.A. screws which connect the tuner unit to the connector, and slacken the remaining screw until it is finger tight only.

(7) Supporting the connector in one hand, unscrew the $\frac{5}{8}$ in. union nut and disconnect the connector from the matching unit.

(8) Unscrew the remaining 4 B.A. screw and disengage the connector from the two locating spigots on the tuner unit flange.

(9) Withdraw the connector from the notch aerial.

Note . . .

The connector radio frequency is terminated at both ends by ball and sliding joints which are bridged by phosphor-bronze bellows. It is important that these joints are not bent more than $\pm$ 10 *degrees from the straight, or the bellows subjected to any twisting action during the dismantling or re-assembly.*

5. The network impedance matching unit is mounted directly on the bulkhead and can be released by unscrewing the eight No. 10 UNF bolts. When removing the four bolts adjacent to the coil, a screwdriver with at least a 6 in. shank must be used, and care taken to avoid damage to the wires joining the coil.

6. The tuner radio frequency unit can be removed by unscrewing the four $\frac{1}{4}$ in. UNF bolts which secure the unit directly to the bulkhead.

Radio bay unit

7. The selector unit is retained in the mounting tray 5985–99–999–8546 by the usual type of quick release fastener. Interconnection is by a fixed plug (PLA) and socket (SKTB) mounted at the rear of the unit. On releasing the fasteners at the front the unit can be withdrawn with a straight pull forward.

8. When the unit has been withdrawn removal of the quick release cover gives access to the top and sides of the unit. The following sub-assemblies which form part of the selector unit are detachable.

(1) Control frequency selector

(2) Motor control

(3) Servo amplifier

Part 4, Sect. 3, Chap. 4, fig. 4 illustrates these sub-assemblies.

9. The control frequency selector is retained by four front panel screws and it can be withdrawn by releasing the four screws and disconnecting the plug PLA from the socket SKTE which is mounted at the top of the main unit.

10. The motor control and servo amplifier sub-assemblies are each secured by two fixing screws, one on each side of the top frame of the selector unit chassis. The units are terminated by a fixed plug and socket respectively, and dowel pins locate the sub-assemblies in the main chassis. When the retaining screws are removed, the sub-assemblies can be withdrawn through the top of the chassis.

RE-ASSEMBLY

Notch aerial units

11. The re-assembly of the units is the reverse process of the dismantling procedure, but care must be taken to ensure that where direct mounting of the units takes place, the contact surfaces are clean.

12. The termination of the connector radio frequency to the tuner unit is sealed by a synthetic rubber 'O' ring. It is important on re-assembly to ensure that the 'O' ring is undamaged and the seal effective.

Radio bay unit

13. The re-assembly of the sub-units and the refitting of the selector unit is the reverse process of the dismantling procedure. In all cases when the units are refitted care must be exercised to ensure that the sub-miniature plugs and sockets mate properly.

Chapter 2

GENERAL SERVICING

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

General

1. This chapter deals with general servicing of the aerial system 5985-99-999-8559 and is intended to cover the following maintenance aspects of the aerial: —

(1) Routine testing of the equipment when installed in an aircraft.

(2) Routine maintenance.

(3) Checking the aerial equipment, in the servicing bay using special test equipment (Sect. 2, Chap. 1).

ROUTINE TESTING OF EQUIPMENT INSTALLED IN THE AIRCRAFT

2. The equipment must be first of all set up according to instructions given in Sect. 3, Chap. 2, if this has not already been done. In this present chapter it will be assumed that the aerial equipment has been previously set up correctly to the frequencies required.

3. The form of routine testing to be carried out will depend on whether radiation from the aerial is permitted, i.e. if radio silence is in force.

4. Tests indicated in the following paragraphs should be carried out with the aircraft as free as possible from near metallic objects. The aircraft should not be on jacks, the wings should be in the flight position and the dive brake or brakes closed.

5. If routine testing is carried out under conditions which are different from those given, some difference in readings will result, these can only be estimated from experience.

Test frequencies

6. Testing of the aerial system can take place if desired on all the frequencies set up, up to a maximum of twelve; but if three frequencies are chosen, one in each of the following bands, the functioning of the equipment will be checked fully. The frequency bands are: —

(1) 2·8-3·0 Mc/s

(2) 8·0-10·0 Mc/s

(3) 15·0-20·0 Mc/s

Equipment check under receive conditions

7. From the cockpit position carry out the aerial fine tune check as follows:—

(1) Depress switch AE TUNE RX on the remote control unit (fig. 1) in the aircraft cockpit and release the switch (no pause is needed).

(2) Turn the fine tuning knob AE TUNE RX slowly from its central position until the required tuning position is found, this should be indicated in the following ways:—

(a) An increase in background noise.

(b) An increase in the strength of the wanted signal if this has already been detected.

(c) Recognition of the wanted signal.

Note . . .

The fine tune facility is only operative on reception, it is cancelled immediately any transmission is made.

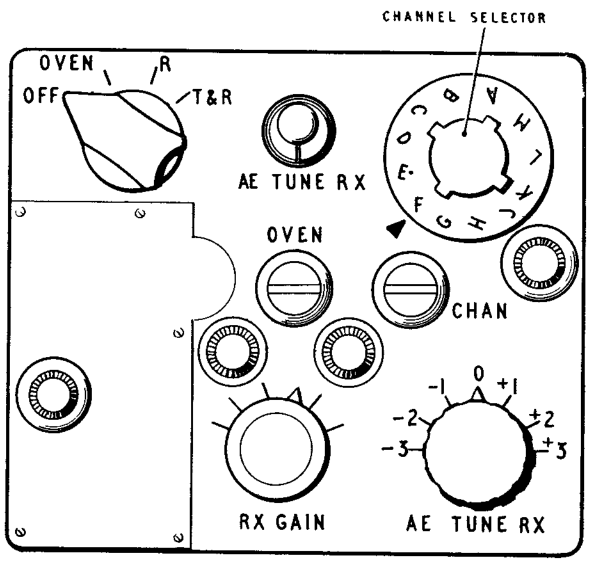

Fig. 1. Control radio set 5821-99-913-3108—front

Checking transmitter output and aerial tuning (full radiation)

8. Position the indicator r.f. 6625-99-999-8550 on the two captive screws which may be partly unscrewed on the lower edge of the air intakes on either side of the notch cover.

9. The carrying strap of the indicator should hang down and the switch on front of instrument should be in the TX. position. Now from the cockpit, select the channel to be tested on the remote control unit, select T and R on main control switch and close press-to-talk switch with microphone switched OFF.

10. With the indicator still in position on the captive screws the meter should now be read, from the ground if possible, or from a distance of not less than three feet. The notch must not be touched during the test and a metallic ladder should not be used.

11. When the press-to-talk switch is closed, the indicator will settle to a reading in less than 1 second. It may perhaps pass through a maximum before steadying. The meter reading should lie between 50 and 150 but will have a limited variation at any particular frequency.

Tuning check at selector unit

12. This check can be made in the radio bay of the aircraft. Place the SET/TEST key, on the front panel of the selector unit (fig. 2) to the TEST position. The aerial indicator meter on the front panel of the selector unit should rise in less than one second to a reading (not necessarily its maximum) of between 1 and 3 on the AE/IND meter scale. Typical figures are given in Table 1.

TABLE 1

Typical aerial indicator meter readings

Frequency Mc/s	Scale reading
2·8- 5·0	1.5
5·0- 5·5	2·3
5·5- 6·5	2·0
6·5- 8·0	1·4
8·0-10·0	0·5
10·0-12·0	1·0
12·0-15·0	1·2
◀15·0-20·0	0·8▶

Check of aerial system on overall reception

13. This check involves only very slight radiation from the aerial notch. The indicator r.f. 6625-99-999-8550 should be positioned as in para. 8.

14. Adjust the switch on indicator r.f. to the R.F. IN position. With the transmitter-receiver switched to the receive, "R", position connect generator signal 6625-99-913-2933, by means of an r.f. cable, to the plug marked R.F. IN on the left-hand side of the indicator r.f.

15. Apply a voltage from the generator signal of frequency 1 kc/s above the required channel frequency at an attenuator setting of approx. -114 dBm (2μV). The output selector switch on the front panel of the generator signal must be set to the LOW LEVEL position.

16. Using headphones in the cockpit check that a clear 1 kc/s note is heard and can be tuned using the AE TUNE RX control on the remote control unit.

Checking the operation of auto-tune circuits

17. Select the first channel to be checked, on the remote control unit in the cockpit of the aircraft. The main control switch on the remote control unit should be in the T & R position throughout this test.

18. The following operations can be carried out at the selector unit mounted in the radio bay of the aircraft.

19. Unlock the tuning knob of the control frequency selector on the front panel of the selector unit (fig. 2). Rotate the tuning knob until

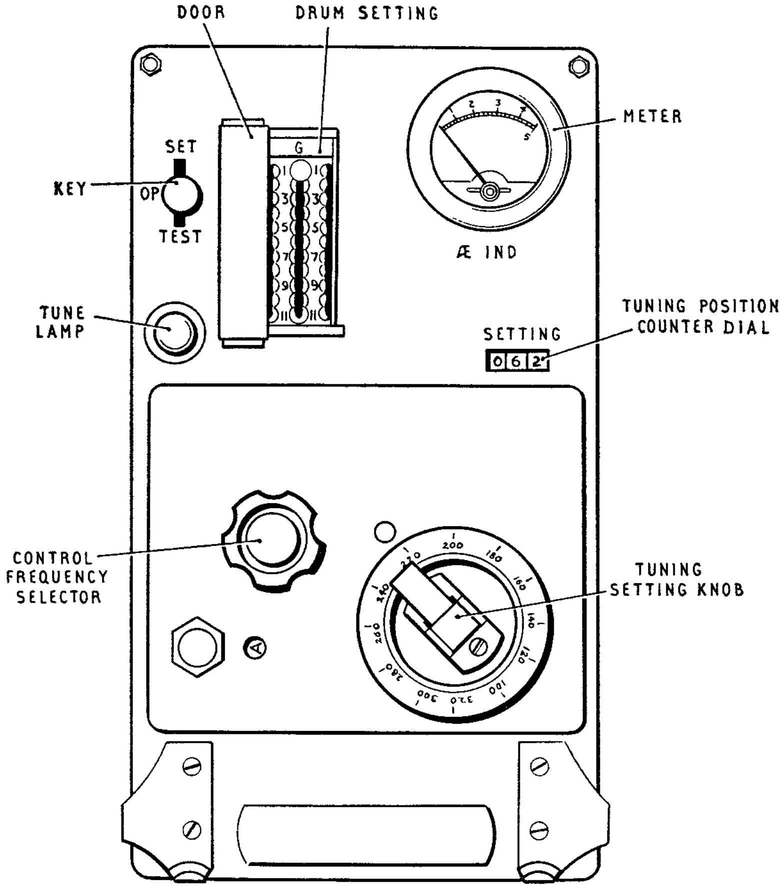

Fig. 2. Selector unit—front panel

the figure indicated in the SETTING counter window of the selector unit changes by the following figures.

(1)	2·8 Mc/s- 5·8 Mc/s ...	40
(2)	5·0 Mc/s–10·0 Mc/s ...	20
(3)	10·0 Mc/s–20·0 Mc/s ...	10

The tuning knob should be rotated so that the original setting is first of all increased and then decreased by the figures given.

20. After each displacement, place the SET/TEST key in the TEST position; the AE IND meter should rise rapidly to normal test figures (Table 1) from a low value.

21. After the two checks on each channel restore the channel setting to the original figure and lock the tuning knob. The next available channel may then be selected for checking.

Aerial matching circuits

22. To check the aerial matching circuits proceed as instructed in the following paragraphs.

23. Disconnect the coaxial cable (Y) joining the network impedance matching to the power amplifier, at the rack adjacent to the power amplifier. Place indicator s.w.r. 6625-99-999-8551 in a convenient position adjacent to the power amplifier. (The top of ARC 52 equipment is suggested).

24. Remove the coaxial cable (Y3) from the underside of the indicator s.w.r., and uncleat coaxial cable (Y) mentioned in para. 23, until the cable can be connected to plug PLB located on the right-hand side of the indicator s.w.r. Now connect coaxial cable (Y3) between the power amplifier at plug 2-PLC and SKTA at the left-hand side of the indicator s.w.r.

25. Select the first channel to be checked on the channel selector of the remote control unit in the cockpit. The main control switch should be set to T & R (fig. 1) and the microphone switched off.

26. Place the SET/TEST key on the selector unit to the TEST position, the left-hand meter of the indicator s.w.r. should indicate a reading of approximately 150 whilst the right-hand meter should indicate near zero. These readings should be noted and the s.w.r. may be obtained by dividing the sum of these readings by the difference.

27. After one channel has been checked the above procedure should be repeated on all channels. The standing wave ratio obtained should be better than 1·3 and not greater than 1·5 on any selected frequency channel. These figures apply to an aircraft in the condition stated earlier in para. 4 and standing on a surface relatively free from steel.

28. If the tests outlined in this chapter are carried out in a hangar, with aircraft wings folded, or with the aircraft standing on a steel surface, then the figures given will have to be modified by experience under such conditions.

29. At certain frequencies it may be found that the figures given for the standing wave ratio may be exceeded, this may be due to the setting given in the calibration being chosen from "flight" data, in such a case the "ground" figure may be slightly worse, these frequencies will be discovered by experience and the figures associated with them modified accordingly.

Power output

30. The reading given on the indicator s.w.r. allows a check on power output to be obtained. If the reading falls much below 120 on the left-hand meter, the transmitter output power should be checked using the 50-ohm, test set r.f. power 6625-99-913-2931.

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SECTION 3

SPECIAL TEST EQUIPMENT

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Chapter 1

SPECIAL TEST EQUIPMENT FOR USE WITH AERIAL SYSTEM 5985-99-999-8559

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

GENERAL

1. Three items of special test equipment are available for use with the aerial system 5985-99-999-8559, these are:—

(1) Indicator s.w.r. 6625-99-999-8551 used either in the aircraft or in conjunction with the test rig installation in bay servicing.

(2) Test rig installation 5985-99-999-8547. This is a rig used to simulate the parameters of the aircraft notch to allow testing of the aerial system in bay servicing.

(3) Indicator r.f. 6625-99-999-8550. This is a portable instrument for attachment to the aircraft to allow first line servicing and pre-flight checks on the aerial system to be carried out.

Indicator s.w.r. 6625-99-999-8551

2. This portable test instrument (fig. 1) is used in checking the voltage standing wave ratio (s.w.r.) of a coaxial feeder in the frequency range 2·0 to 20·0 Mc/s. It consists of a cast alloy case 8·5 in. × 4·25 in. × 4·3 in. with a removable rear panel, the case being fitted with a carrying handle. On the front sloping face are mounted two 0-200 micro-ammeters with stud guard protections to avoid meter damage.

3. Two coaxial plugs are mounted one at each end of the case, a calibration curve is affixed to the back. When the instrument is inserted in series with a 50-ohm coaxial feeder and r.f. power is present, the meters will indicate this.

4. If the feeder is correctly terminated, one meter will give a large deflection and the other will be near zero. These meter readings allow the s.w.r. on the line to be ascertained, and under certain conditions the power level can be read (para. 10). Connection to the r.f. generator (transmitter) may be made at either end of the indicator, the readings of the meters merely changing over.

Operation

5. The r.f. line to be checked, is broken at PLA and SKTB (fig. 2) and intercepted by a section of coaxial cable within the instrument. At each end, the inner conductor alone, passes through screened

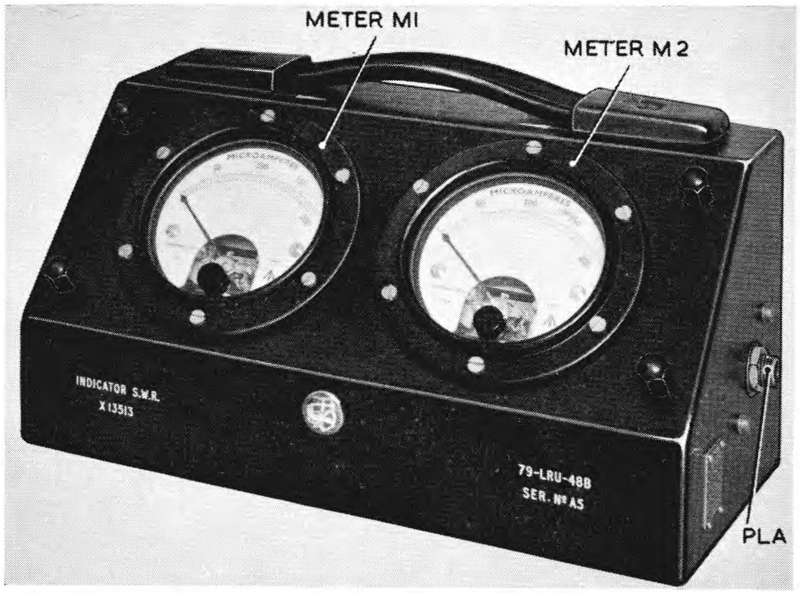

Fig. 1. Indicator s.w.r. 6625-99-999-8551

toroidal transformers T1 and T2 and forms the single turn primary winding. These transformers are wound on ferrite cores and the secondaries provide voltages proportional to the line current. The transformers being loaded by R3 and R4 respectively, are substantially independent of frequency. The windings of T1 and T2 are identical but are connected in phase opposition to each other.

6. A proportion of the voltage on the line is added in series with each transformer by means of the potential dividers formed by capacitors C3, C4 for T1 and C5, C6 for T2. This voltage is again substantially independent of frequency.

7. The trimmers C1 and C2 are adjusted so that the voltages mentioned in para. 6 are equal in magnitude to that induced in the corresponding transformer secondaries when the line is correctly terminated (i.e. with 50 ohms).

8. These two voltages are in phase and as the two transformer voltages are in antiphase, vector addition occurs due to the voltages at one transformer and vector subtraction at the other.

9. The resultant voltage at T1 develops between the junction of resistor R5 and rectifier MR1 to earth, it is rectified by MR1 (a semi-conductor diode). Thus an indication is obtained on meter M1.

10. When the line is correctly terminated, one meter indicates near zero (voltages in phase opposition) and the other a maximum (voltages in phase). Under these conditions it can be shown that the maximum reading is proportional to the power in the line. This power may be read from the calibration chart at the rear of the instrument.

Method of use

11. Connect the indicator s.w.r. in series with the line to be checked. Assume the right-hand connector is attached to a transmitter and the left-hand connector to a matching network via a short length of 50-ohm cable.

12. When power is applied both meters will read, and as the matching network is adjusted to correctly terminate the line, the left-hand meter indication will gradually reduce towards zero. The right-hand meter will remain at a varying high reading.

13. If B and F are the meter readings at a condition when the s.w.r. is to be estimated then:—

$$\text{s.w.r.} = \frac{\text{Sum of meter reading}}{\text{Difference of meter readings}} = \frac{F+B}{F-B}$$

This ratio is accurate at low values of s.w.r. but errors increase rapidly above a s.w.r. of 2.

14. At a s.w.r. of 1·3 or less, the power transmitted is approximately the difference of the "Forward" and the "Backward" power and is read off the calibration chart against meter readings.

15. It will be noted that the arrow above each meter indicates the direction of power transmission. Should the positions of the transmitter and load be interchanged, the indicator will still give a correct reading since it is electrically symmetrical. The arrow direction is still correct.

Meter readings

16. If the power can be adjusted at the time of reading, the following direct calibration can be used. The power should be adjusted such that the forward reading F is held at 150 (100 watts). Then the s.w.r. is given from the backward reading B in Table 1.

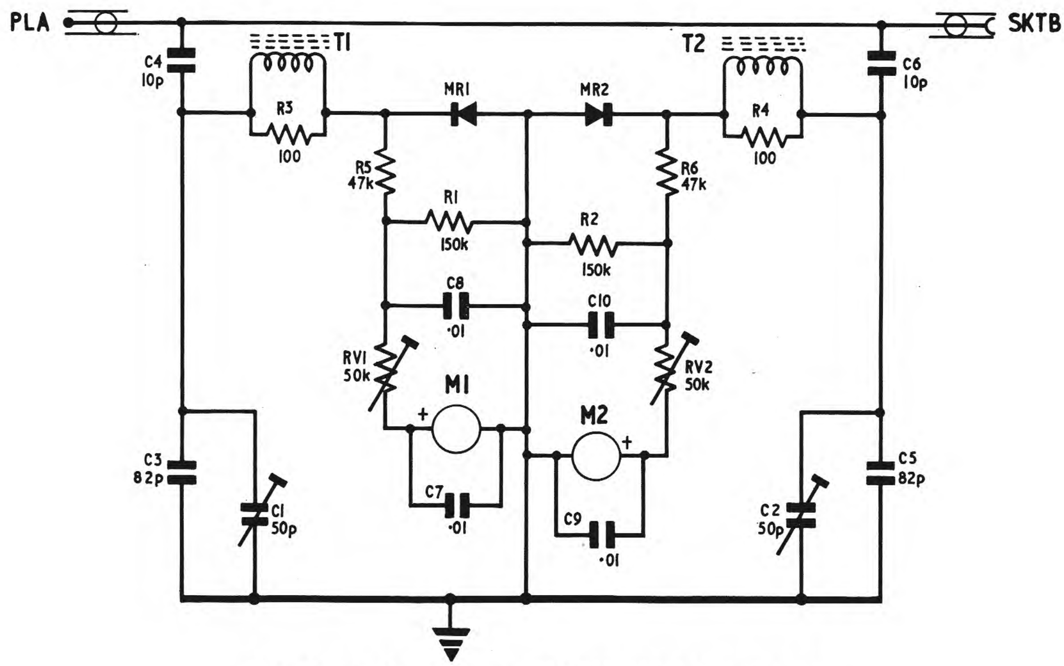

Fig. 2. Indicator s.w.r. 6625-99-999-8551: circuit

TABLE 1
Meter indications of s.w.r.

(B) Meter Reading	S.W.R.
7	1·1
14	1·2
20	1·3
25	1·4
30	1·5
35	1·6
39	1·7
43	1·8
47	1·9
50	2·0

Electrical characteristics

Accuracy of s.w.r. indication

17. When the indicator is terminated by a 50-ohm load of s.w.r. 1·01 to 1 or better, the s.w.r. indicated will not be greater than 1·06/1 at 100 watt level. When terminated by a 50-ohm load modified by a reactance to give a load of s.w.r. of 2·0 to 1, the indicator will read a s.w.r. of 2·0 $\pm$ 0·1 to 1.

Power rating

18. The indicator will read the mean power in the range 20 to 150 watts, at altitudes up to 10000 feet, and is continuously rated at 150 watts. An overload of 300 watts for 5 mins will cause no damage.

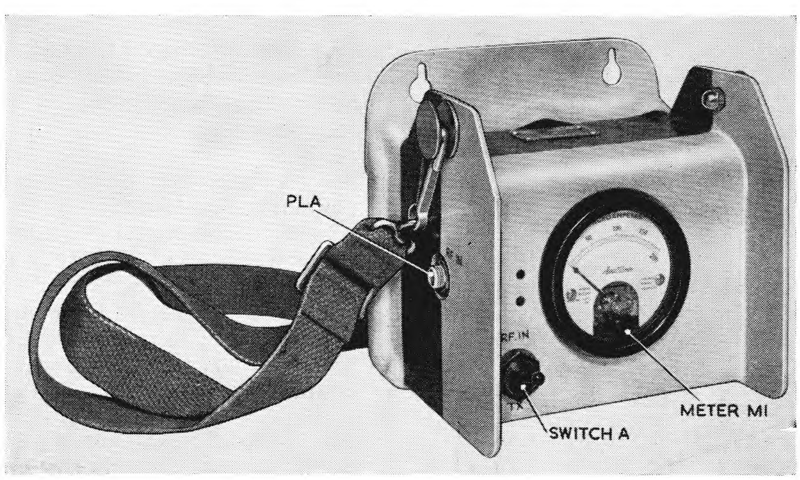

Fig. 3. Indicator r.f.

Power indication

19. When terminated by a load of s.w.r. 1·1/1 or better the power in the load will be indicated to ±5% using the calibration curve, and meter subtraction.

Insertion loss and s.w.r. error

20. At 100-watt level the insertion loss in a 50-ohm line is not greater than 0·12 dB. The s.w.r. introduced by the indicator in a 50-ohm line is not greater than 1·03.

Indicator r.f.

21. This item of test equipment consists of a rectangular shaped cast box with flanges at the top and at each end. The top flange carries two keyhole slots for hanging the instrument in position during tests (fig. 3) whilst the side flanges give some protection against meter damage.

22. The meter is centrally mounted in the front panel of the cast box and is a 2·5 in. microammeter instrument with a scale calibrated 0-200.

23. On the left-hand end of the indicator r.f. is a coaxial plug PLA marked R.F. IN to which the generator signal 6625-99-913-2933 is connected. When the switch A on the front panel of the unit is set to the R.F. IN position (fig. 3), the coaxial plug PLA is connected to a five-turn loop of wire mounted on the back panel of the housing, this loop coupled the signal from the generator signal 6625-99-913-2933 into the notch aerial.

24. When the switch is in the "TX" position, the plug PLA is disconnected, and one turn of the loop is connected to a detector circuit (fig. 4) consisting of a silicon rectifier MR1 (CV7050), a capacitor C1 and a variable resistor RV1. The signal detected in this way is passed to the meter.

Test rig installation, 5985-99-999-8547

25. This equipment is designed to allow complete testing of the aerial system 5985-99-999-8559 during bay servicing and in all repair echelons. It permits simulation of the notch aerial parameters

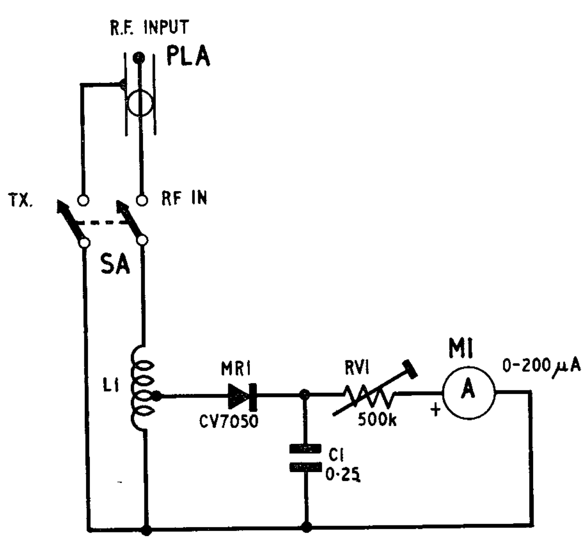

Fig. 4. Indicator r.f.: circuit

and thus allows the aerial system to be operated in close approximation to the conditions found in the aircraft. For this purpose indicator s.w.r. 6625-99-999-8551 and the units of A.R.I.18179 are required to work in conjunction with the test rig. This combination will also allow checking of the operation of indicator r.f., the same combination will allow complete testing of the aerial system.

Description of test rig

26. The test rig consists of a horizontal base, 18 in. wide, 12 in. back to front. Fixed at the rear of this is a vertical panel of full width and 14 in. high. These panels are braced by triangular gussets at each end. The whole is constructed of light alloy.

27. Looking from the front, on the left is a bracket on which the network impedance matching 5915-99-999-8556 can be mounted vertically by means of four screws (fig. 5). This allows front access to the base cover of this unit which may be removed for adjustment and servicing.

28. On the back panel, supported on ceramic insulators. is an inductor of 0·375 in. diameter tube. This coil is mounted with its axis vertical, on the right-hand side of the back panel and its lower end is terminated by a horizontal tube which has a flange to connect to the transformer rod of the network impedance matching.

29. The tuner r.f. 5950-99-999-8558 is placed in position vertically on the base at the left-hand side sliding between locating plates. Two hinged clamps can then be fastened by quick-release catches to hold the base of the tuner r.f. firmly on the test rig.

30. A horizontal tubular connection from the coil terminates in a plate, this is located immediately above the connector flange of the tuner r.f. when the latter is in position, and positive connection is made to this by two screws.

31. With the matching unit and tuner r.f. in position and connected to the coil, a tuned circuit is formed; the base acting as the closing link. The inductance of the coil simulates the effective inductive reactance of the aircraft notch, when power is applied.

32. The effective r.f. resistance of the aircraft notch varies considerably over the frequency band, and this is reproduced on the test rig in the following way.

33. A horizontal pivot is mounted beneath the coil, on the pivot rotates a cranked arm carrying a laminated silicon iron "C" core, this may be moved so that the arms of the core surround the horizontal connector to the inductance. The core is thus coupled by induction to the circulating current in the tuned circuit, and as the core material has a high loss at radio frequencies, r.f. resistance is coupled back into the tuned circuit.

34. This r.f. resistance is variable depending on the position of the core, the latter can be adjusted by a lever indicating against a scale, arbitrarily marked 1-10, alongside the matching unit bracket (fig. 5).

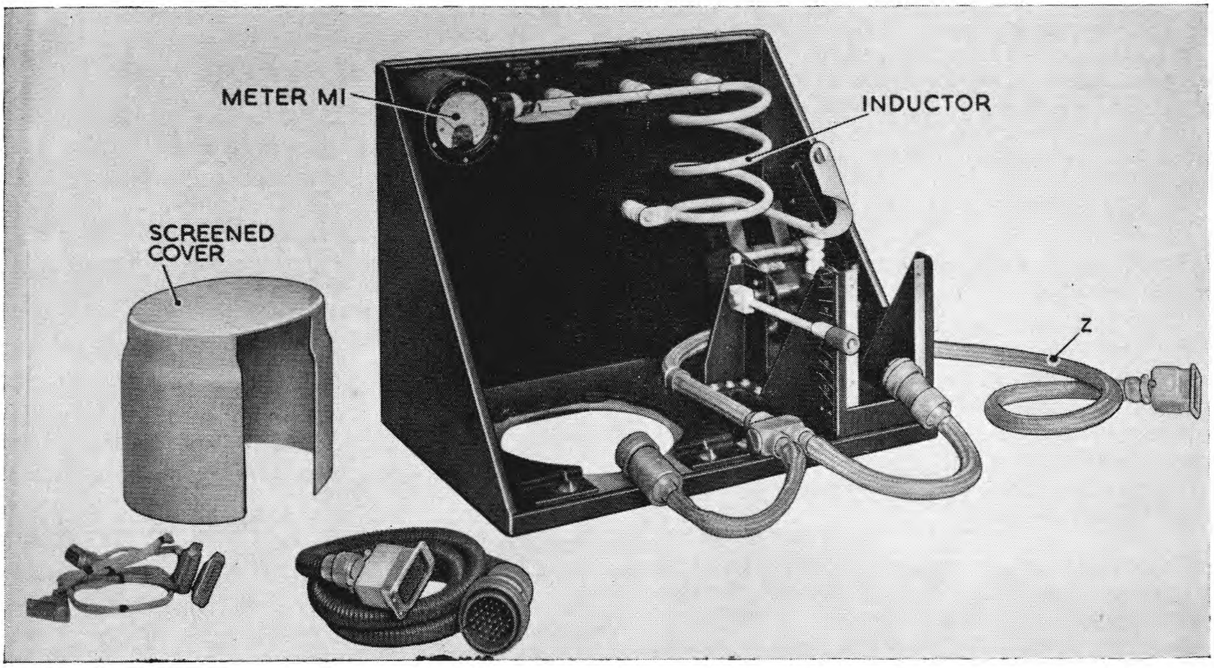

Fig. 5. Test rig installation

35. A knurled knob in a sector cut out on the right-hand side gusset allows the arm to stay in a chosen position during adjustment by means of a friction pad or enables it to be finally locked. The variation in resistance of the coil by this method, is obtained with the minimum change of its inductance.

Voltmeter r.f.

36. An r.f. voltmeter is fixed to the rear panel and connected to the coil lead at the point of connection to the tuner r.f. This voltmeter (voltmeter r.f. 6625-99-999-8529) is really a 2·5 in. microammeter, reading 0-200, mounted in a circular box. On one side of the box is a tube containing a capacitive voltage divider. The detecting circuit uses a conventional silicon diode rectifier and the voltmeter reads peak volts, 2000 volts full scale deflection. As positioned it reads the nominal voltage across the capacitor of the tuner r.f. and can indicate any excessive losses in the units under test.

Protective cover

37. A separate fibre glass cover is supplied and can be placed over the tuner r.f. during test, to protect operating personnel from the high r.f. potential on the top of the unit near the front of the test rig.

Cabling

38. The cable (Z) connecting the matching unit and tuner r.f. to the selector unit 5985-99-999-8557 has a screened outer sheath. It enters the test rig at the rear right-hand side and is cleated to the front midway between the two units. At this point it divides at a Y junction to each unit. The terminal connectors which engage with those on the appropriate units are of the quick connect type.

Access to underside of tuner r.f.

39. The test rig may be pulled forward and turned back-downwards so that the underside of the base is vertical. A large circular hole is provided to allow the gear train and switches of the tuner r.f. to be examined in operation.

Connectors and tools

40. A satchel is mounted on the left-hand side gusset and contains all the connectors needed for testing the items associated with the aerial system on this test rig. It also contains the necessary special tools needed for maintenance of the units of the aerial system. The tools are listed in Table 2.

TABLE 2
List of special tools

Tools	Ref. No.	Nomenclature
Spanner/wrench	5120-99-914-0775	Used in dismantling tuner r.f.
Special screwdriver	—	Used in adjustment of RV1 and C11 on the matching unit when on test rig.
Set of screws	—	B.A. size screws to fix matching unit in test rig, and to connect tuner r.f.

Testing of indicator r.f.

41. A small bracket at the top of the rear of the test rig projects over the coil. This bracket has two captive screws at the rear. The flat back of the indicator r.f. can be placed on this; the indicator then projects over the axis of the coil and is held by engaging its keyhole slots on the two screws. When the test rig is operated the indicator will function and its operation can be checked.

Operating the test rig installation 5985-99-999-8547

42. Operation of the test rig installation 5985-99-999-8547 consists of checking the network impedance matching and tuner radio frequency, at second line servicing levels. In addition it may be necessary to adjust the balancing controls used in the discriminator, this procedure can also be carried out using the test rig as detailed in the following paragraphs.

43. It is necessary to have a fully serviceable s.s.b. transmitter-receiver available for operating the test rig installation, a cable being provided with the test rig to connect the latter with the transmitter-receiver.

44. Connect up the cables shown in Table 4 to the test rig installation after having inserted a tuner r.f. and network impedance matching in their respective holders and a selector unit connected by cables. A connection must also be made, using the patching cable provided, between indicator s.w.r. and the test rig installation.

45. Switch the transmitter-receiver equipment main control switch to the R position on control radio set 5821-99-913-3108 and allow to warm up for at least ten minutes.

46. Select channel A on control radio set 5821-99-913-3108, set to frequency 2800 kc/s. Adjust the main control switch on the control radio set to the T & R position, check that the TUNE lamp on the front panel of the selector unit extinguishes.

47. Put the SET/TEST key (KST) on the selector unit to the TEST position and check that the auto-tune system operates by a dip on one meter of the indicator s.w.r. and a rise in the r.f. voltmeter reading on the test rig.

48. The loading can now be adjusted to give the best standing wave ratio by adjusting the pivot arm to bring the laminated C core either further into or out of the loading coil (fig. 5).

49. Readings obtained should be as shown in Table 3 and it is worthwhile keeping a note of these readings for future reference. The above should be repeated for the channels available A to L.

50. The test rig setting should be accurately adjusted on the graduated scale (fig. 5). On each channel select T & R and after the TUNE lamp has extinguished check that under autotune an s.w.r. is achieved of less than 1·5 on all frequencies (para. 12).

51. It is advisable at this stage to record the meter readings on the indicator s.w.r. and the r.f. volts from the voltmeter on the test rig installation.

TABLE 3 (Example only)
Typical readings obtained on test rig installation

Chan.	Freq. kc/s	Selector Tap	Unit Setting	Test rig Setting
A	2800	11	9	zero
B	3500	10	50	zero
C	4500	9	68	zero
D	5100	8	160	zero
E	6000	7	23	1
F	9000	2	81	6·7
G	11300	2	112	6·3
H	13200	1	140	5·5
J	15000	2	163	5·8
K	18100	3	186	7·9
L	20000	3	140	8·5

TABLE 4

List of cables used with the test rig

Cable identification	Nomenclature
Cable Z	Cable assembly, power electrical branched 5995-99-913-4769. Used to connect tuner r.f. and matching unit to selector unit.
Cable Y/Y2	Cable assembly radio frequency Ref. 5995-99-913-5101. Used to connect either the matching unit or indicator s.w.r. to amplifier r.f.
Cable Y1	Cable assembly radio frequency Ref. 5995-99-913-5102. Used to connect matching unit to indicator s.w.r.
Cable X	Cable assembly, power electrical Ref. 5995-99-913-4769. Used to connect the selector unit to the junction box.
Cable PZ	Cable assembly, power electrical Ref. 5995-99-913-6826. Used as patching leads in maintenance of selector unit. The leads are used to allow amplifier electronic control and the selector control sub-assembly to be operated when detached from their parent unit.

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Chapter 2

TEST SET RADIO 6625-99-913-2929

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

Introduction

1. Test set radio 6625-99-913-2929 is a small portable piece of test equipment used for routine testing on the s.s.b. transmitter-receiver, the latter forming part of ARI.18179. Test set radio may however be used with other single-sideband equipments although some adjustments may be necessary.

2. Together with the associated generator signal 6625-99-913-2933, and test set r.f. power 6625-99-913-2931, the test set radio will provide the following measurement facilities:—

(1) Receiver sensitivity, and signal-to-noise ratio.

(2) Receiver distortion.

(3) Receiver unwanted sideband rejection.

(4) Frequency error of the transmitter-receiver oscillators.

(5) Transmitter carrier rejection.

(6) Transmitter unwanted sideband rejection.

(7) Transmitter distortion.

3. In addition to the facilities given in para. 2 the test set radio will also provide standard microphone input levels suitable for testing s.s.b. systems.

Construction

4. Test set radio is constructed on a metal panel and chassis assembly, the latter being fitted into an instrument case which is retained by fourteen removable screws passing through the front panel.

5. Protective handles are fitted, one to each end of the front panel; these handles also assist in withdrawal of the test set from the case.

6. The major components are directly mounted on the front panel and chassis, the remaining components being wired across tag strips or suspended in the wiring. No sub-unit construction is used and the test set is completely transistorized.

7. A supply battery is mounted in a special holder attached to the front panel of the test set. By using this battery the test set needs no external power supply source.

Front panel controls

8. The front panel of the test set radio carries all the controls necessary for the setting-up and operation of the test set, an illustration of the front panel is given in fig. 1.

9. At the left-hand side of the front panel are located two toggle switches, the uppermost being the MUTE switch used for checking the receiver muting circuit; immediately below this is the transmit/receive (TX/RX) switch; this switch is useful for switching the transmitter on from the test set radio during testing.

10. Provision is made on the front panel of the test set radio for connection to a HEADSET by a jack socket and also to the intercommunication system by plug 9-PLA.

Frequency error interpolator

11. This control, situated at the top left-hand side of the front panel, consists of a control knob coupled to a potentiometer shaft and scale mechanism. Rotation of the knob produces a movement of the scale, the latter being calibrated directly in cycles per second.

TEST *switch*

12. Located on the top right-hand side of the front panel is the main TEST switch. The function of this switch is to select the required circuit in the test set when a particular test is to be carried out on the transmitter-receiver.

13. The TEST switch (fig. 1) has ten positions for checking the battery voltage and functioning of the transmitter-receiver; these are dealt with in greater detail in para. 79 to 93.

A.F.O. *switch*

14. Almost immediately below the FREQ ERROR control is the A.F.O. selector switch. Operation of this switch provides selection of either a single-tone or two-tones for testing purposes.

A.F.O. LEVEL *switch*

15. On the lower part of the front panel, beneath the TEST switch, is the A.F.O. LEVEL switch; this provides switching for the various microphone input levels selected.

Other controls

16. Also on the front panel are various controls used for setting up and calibrating the test set radio.

17. Beneath the front panel meter are the SET 1 kc/s and SET TWO-TONE controls; these controls enable variable resistors to be adjusted in the test set to produce the required audio frequency levels for test purposes as shown by the meter.

18. On the lower right-hand side of the front panel are the following controls:—

(1) SET R.F.

(2) FREQ. ZERO.

(3) BATTERY ON/OFF.

The first of these controls allows the r.f. input level to be set up to the corresponding marked portion of the front-panel meter scale. Adjustment of the FREQ ZERO control is used for zero setting of the interpolating oscillator in the test set radio, whilst the BATTERY ON/OFF switch provides main battery supply on/off switching.

19. Provision is also made on the front panel for use of an external microphone and headphones if desired, by means of spring-loaded terminals. An aircraft type headset may also be connected using the jack socket provided on the front pane.

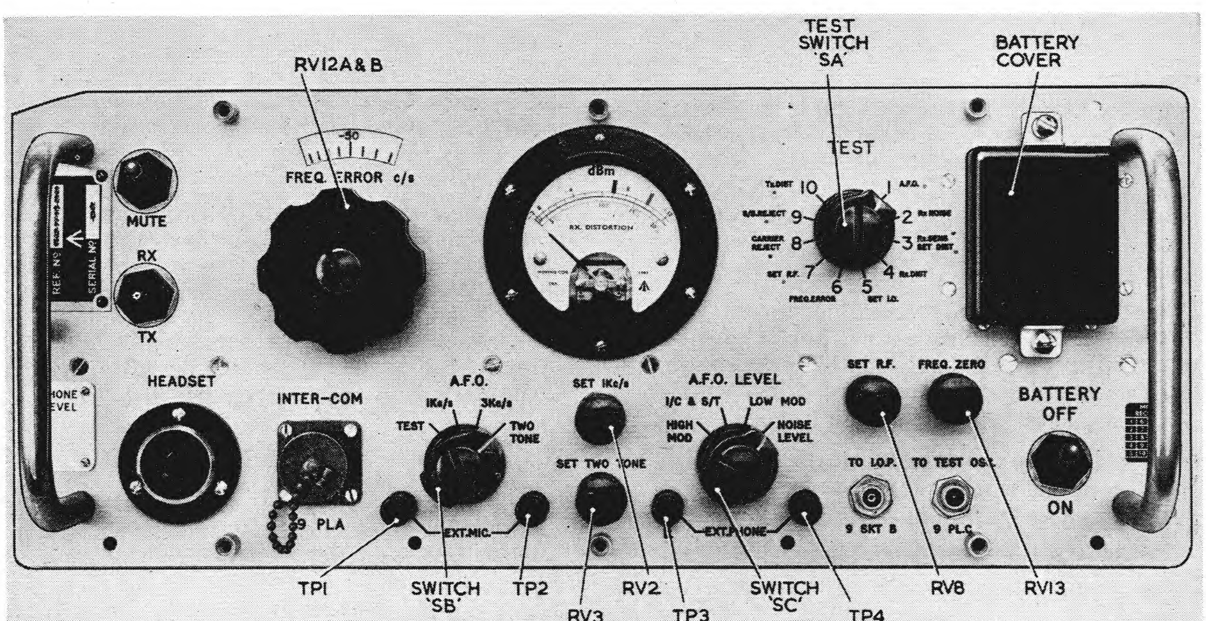

Fig. 1. Test set radio 6625–99–913–2929, front panel controls

CIRCUIT DESCRIPTION

A complete circuit diagram of test set radio 6625-99-913-2929 is given in fig. 5, end of chapter.

Audio frequency oscillators

20. Two audio oscillators in the test set radio provide a 1 kc/s or 3 kc/s and 800 c/s tones respectively for testing purposes. Provision is made by using the A.F.O. switch to bring either the first, or both oscillators into circuit.

21. The 1 kc/s oscillator consists of a transistor circuit using VT3 (CV7043), positive feedback occurs from the collector of transistor VT3 to the base via a coupling winding 4-5 on transformer T1 (fig. 5) with capacitor C10 acting as a d.c. blocking component.

22. Frequency of oscillation is determined by the inductance of the primary of T1 together with the parallel tuning capacitors C8 or C9. This oscillator can be switched to provide either a 1 kc/s or 3 kc/s tone by the A.F.O. switch SBb1 selecting either capacitors C8 or C9 for tuning.

23. Resistors R11, R12 and RV4 provide negative feedback for the oscillator circuit. Resistor R11 and RV4 are switched out of circuit for 1 kc/s operation of the oscillator and provide equalization of the a.f. output when the oscillator is operating in the 3 kc/s condition.

24. The biasing network of resistors R9 and R10 provide the correct operating conditions for transistor VT3. Variable resistor RV2 adjusts the output level by altering the supply voltage. Capacitor C7 functions as a decoupling component for RV2.

25. Diode MR2 (CV7040) is connected between the base of transistor VT3 and an overwinding on the primary of transformer T1, this diode in conjunction with negative feedback provided as in para. 23, controls the level and distortion of the audio output by adjusting the gain of the oscillator transistor VT3.

26. In the TWO-TONE position of the A.F.O. switch the second audio oscillator circuit consisting of transistor VT4 (CV7043) with transformer T2 and associated circuits is switched on through SBd2 to provide an additional 800 c/s tone, the circuit functions in a similar manner to the previous oscillator. Output level is controlled by RV3.

27. Audio frequency outputs from the secondary windings of transformers T1 and T2 are selected on positions 2, 3 and 4 of switch SBf1 and coupled through capacitor C3 to an emitter follower stage consisting of transistor VT1 (CV7043). Forming part of the emitter load of this transistor is the potentiometer RV1. the latter provides adjustment of tone level into a second transistor amplifier VT2 (CV7043). The audio tone is coupled to VT2 through capacitor C4.

28. Resistor R6 is the collector load for VT2, the amplified audio tone is coupled via C5 and switch SBf2 to the rectifiers and meter circuit to provide indication on the front panel meter M1 (para. 69).

29. The audio frequency tones are combined in the secondary windings of transformers T1 and T2, through the balance potentiometer RV5. The potentiometer equalizes the levels of the two individual tones of the two-tone signal. Selector switches SCb, SCa, connect the audio tones with 9-PLA pins C and D.

30. Between switches SCb and SCa are four attenuators formed by resistors R18, R19, R20, R21, R90, R91, R92. The output of the attenuator is matched to 200 ohms by the balancing and matching network R22, R23, R24, R25. Capacitors C14, C15, protect the matching network from r.f. pick-up via the microphone leads.

Receiver a.f. output tests

31. To measure receiver noise (test position 2) the telephone output of the transmitter-receiver is applied to the test set radio at 9-PLA pins A and B. When switch SAk2 is rotated to position 2 (fig. 5) the audio signal, at low-impedance, is amplified by the grounded-base transistor VT6 (CV7043)

32. Resistor R33 is the collector load of VT6, base biasing being provided by components R31, R32. Capacitor C17 effectively grounds the base of transistor VT6 to audio frequencies. The a.f. input signal to VT6 can be adjusted by the preset level control potentiometer RV6 (fig. 2) to enable the tester to be calibrated.

33. Audio signals are coupled through capacitor C18 to the metering network, for front panel meter indication.

34. Amplifier transistor VT6 (fig. 5) is also used when the switch SAk3 is rotated to positions 3, 4 and 6; in these cases, however, an attenuating network is switched in series with the input to transistor VT6.

35. The attenuating networks mentioned in para. 34 are 'T' resistive pads; in positions 3 and 6 of switch SAk2, resistors R35, R36, R37, R38 and R39 form the sections of one attenuator whilst R41, R42, R43, R93 constitute the second attenuator.

36. When the test set radio is used to measure receiver distortion the audio output from the receiver is amplified through transistor VT6 and then passed through a bandstop filter (fig. 2). The input audio level to the filter is adjusted by the pre-set potentiometer RV7 (fig. 2).

37. The audio frequencies obtained at the output of the bandstop filter are fed via switch SAb2 and coupling capacitor C24 to a further audio amplifier (fig. 5).

38. This amplifier consists of one emitter follower stage VT12 (CV7043) and two grounded emitter amplifier stages VT13 (CV7043), VT14 (OC202). Bias for the emitter follower is provided by R63 whilst R87 is the emitter load resistor.

39. The transistors VT12, VT13 are d.c. coupled and the audio output from the collector of VT13 is coupled through C33 to the base of transistor VT14. Biasing and thermal stabilization for the latter transistor is provided in the usual way by resistors R66, R67, R68 with C35 acting as a decoupling capacitor.

40. From the load resistor R69 the a.f. signal is fed to the metering circuit rectifiers MR4, MR5 through the coupling capacitor C34, for meter indication.

Interpolating oscillator

41. A Wien-bridge resistance-capacitance oscillator is used as the interpolating oscillator, this consists of transistors VT15, VT16 (CV7043) in conjunction with a normal R-C network. The frequency of the oscillator can be altered by variation of the two-ganged variable-resistor RV12 (fig. 2). A frequency range of 850 c/s to 1150 c/s is covered by the oscillator.

42. Transistors VT15 and VT16 (fig. 5) function as grounded emitter amplifiers producing the necessary zero degree phase-shift and amplification necessary for operation of the Wien-bridge oscillator circuit.

43. The audio frequency produced by the oscillator is coupled through C38 to an emitter-follower transistor VT17 (CV7043), the latter receives its d.c. supply voltage through variable resistor RV13 (fig. 4) which also feeds the supply voltage to the Wien-bridge oscillator transistors VT15, VT16.

44. As the frequency of the Wien-bridge oscillator varies to a small extent with any supply voltage change, variable resistor RV13 is used to calibrate the interpolating oscillator by adjusting the supply voltage to transistors VT15 and VT16.

45. The interpolating oscillator is calibrated by beating the audio frequency obtained from it against a 4 kc/s crystal oscillator (para. 46) in a beat detector (para. 50).

Crystal oscillator

46. A multivibrator circuit is used to produce the 4 kc/s crystal oscillator frequency. Two transistors VT9, VT10 (CV7043) are used in the multivibrator circuit (fig. 5). The crystal XL1 is located in one feedback path from transistor VT10 to VT9; the other feedback path consists of a series resonant circuit L3, C45 resonant at approximately 4 kc/s.

47. The small coupling capacitor C44 assists in starting the crystal oscillator by coupling a small amount of energy from the feedback path containing the crystal to the path containing the series tuned circuit L3, C45.

48. Diode rectifiers MR11, MR12 are connected between the bases of VT9 and VT10 to earth, respectively. These diodes protect the transistors by preventing large positive voltage transients on the bases. Protection of the crystal from excessive excitation is provided by resistor R89.

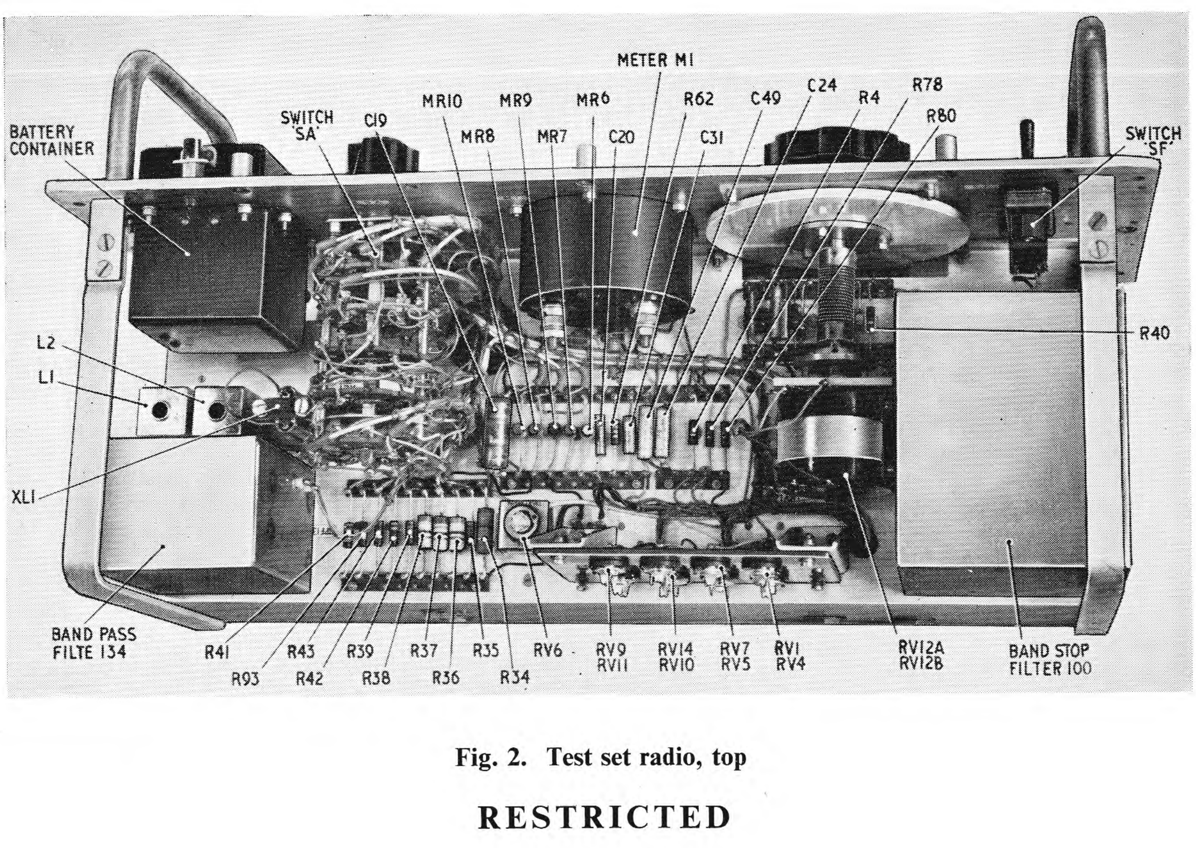

Fig. 2. Test set radio, top

49. An inductor L4, which is shunted by resistor R55 provides the collector load for transistor VT10. The 4 kc/s audio output is taken from the collector of VT10 and fed to the potential-divider network R53, R54. The a.f. obtained in this way is then coupled by capacitor C46 to position 5 of switch SAg (fig. 5).

Beat detector

50. When switch SAg is in position 5, the 4 kc/s crystal oscillator voltage is fed to the base of an emitter-follower transistor VT18 (CV7043). The audio frequency obtained at the emitter of VT18 across the emitter load resistor R85 is coupled by C42 to a further transistor amplifier VT19 (CV7043), grounded emitter in configuration.

51. The oscillator output from the Wien-bridge circuit is fed from the emitter of VT17 to the base of amplifier transistor VT20 (CV7043) via coupling capacitor C43 and diode MR14 (CV7040). MR14 increases the amount of 4th harmonic present by its non-linear action.

52. Variable resistor RV14 forms a common-collector load for both transistor VT20 and VT19 and the two signals which are present across this variable resistor beat together; and the 4th harmonic of the interpolating oscillator can be made to zero beat with the crystal frequency. The voltage obtained varies with the beat frequency of the two signals, this voltage is applied directly to the meter rectifier network.

Transmitter tests

Note . . .

For tests (6), (7) *and* (8) *para.* 88-92 *the transmitter is automatically modulated with* 1 *kc/s tone and for test* (9) *the two-tones.*

53. The r.f. output from the transmitter is fed into the test set r.f. power 6625-99-913-2931, a proportion of this output is also fed to 9-SKTB on the test set radio. By adjustment of the variable resistor RV8 (the SET R.F. control, fig. 3), a standard input voltage is obtained for use during the carrier reject, sideband reject, and transmitter distortion tests.

54. When switch SAa1 is set to position 7 (SET R.F.), radio frequencies from the transmitter are coupled via capacitor C20 (fig. 5) to the four diodes MR6, MR7, MR8, MR9. Only two diodes MR6, MR7 act as rectifiers to produce an indication on meter M1 by direct current being fed to the meter through the decoupling network R28, C48.

Carrier rejection

55. Carrier rejection is measured by demodulating the standard r.f. level obtained from RV8; diode MR10 (SX782) and C19 being included for this purpose. The carrier present is effectively a 1 kc/s modulation on the wanted sideband.

56. This 1 kc/s audio frequency is filtered by the low-pass filter C25, L1, C26, L2, C27. The output obtained from the filter is coupled through

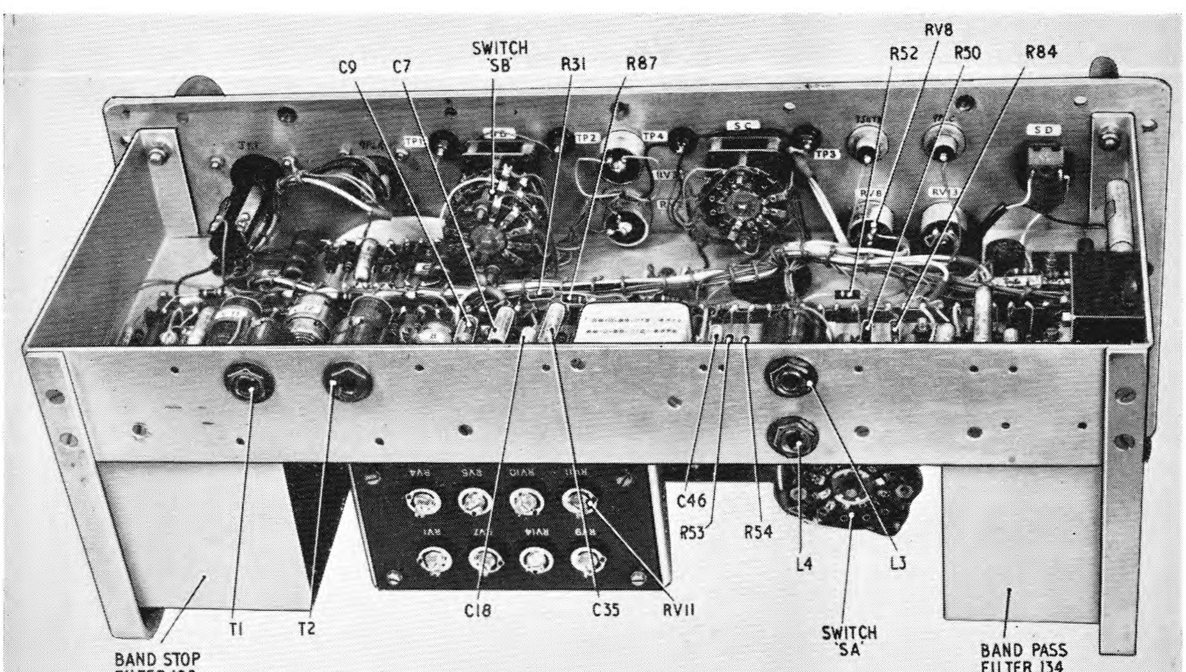

Fig. 3. Test set radio, rear

capacitor C28 to the amplifier transistor VT11 (OC202). After amplification in this transistor the output is taken from the load resistor R61, via coupling capacitor C30 and switch SAb1 to the potentiometer RV11 (fig. 3) the latter acting as a preset gain control.

57. Further amplification of the 1 kc/s audio frequency is provided by the transistor amplifier VT12, VT13, VT14 (para. 38). The audio output from transistor VT14 is fed via switch SAc (fig. 5) to the metering circuit (para. 69).

Unwanted sideband rejection

58. So that the transmitter unwanted sideband rejection can be measured the standard r.f. voltage obtained from the SET R.F. control RV8 is mixed with a high level switching signal from the test oscillator.

59. In position 9 (S/B REJECT) of switches SAa1, SAa2 and SAd1, the r.f. signal fed in from 9-SKTB is applied to the ring of diodes MR6, MR7, MR8, MR9 via coupling capacitor C20, the diodes in this case acting as an h.f. modulator.

60. A switching voltage from the generator signal 6625-99-913-2933 is applied to 9-PLC (fig. 4) on the test set radio. This switching voltage is then fed to the h.f. modulator through an unbalance to balance coupling transformer T3 and associated switches.

61. This switching voltage is set 2 kc/s away from the carrier frequency of the transmitter-receiver, in the wanted sideband. Thus at the output of the modulator appear the following frequencies:—

(1) 1 kc/s, audio tone at a high level, derived from the wanted sideband.

(2) 2 kc/s, audio tone at low level, derived from the carrier.

(3) 3 kc/s audio tone at low level, derived from the unwanted sideband.

62. The frequencies appearing in sub-paragraphs (1), (2) and (3) are fed to a low-pass filter and then amplified by transistor VT11, the action of which is mentioned in para. 56.

63. After amplification in transistor VT11, the frequencies given in sub-para. (1), (2) and (3) are applied to the bandstop and bandpass filters. The bandstop filter removes the 1 kc/s audio tone whilst the bandpass filter selects the 3 kc/s audio tone. This frequency of 3 kc/s is then amplified further by VT7, VT8, VT12, VT13 and VT14. The operation of transistors VT12, VT13 and VT14 is given in para. 38.

64. Amplifier transistors VT7 and VT8 (fig. 5) function in the grounded emitter mode. Transistor VT7 (CV4043) is an emitter follower, having a high input impedance. Base biasing for this transistor is provided in the usual way by resistors R45, R64. Resistor R46 acts as an emitter load for the transistor VT7.

65. The audio output from the emitter of transistor VT7 is directly coupled to the base of a further amplifier VT8. Transistor VT8 (OC202) is a grounded emitter amplifier, base bias being obtained by the potential divider formed by transistor VT7 with R46. The capacitor C21

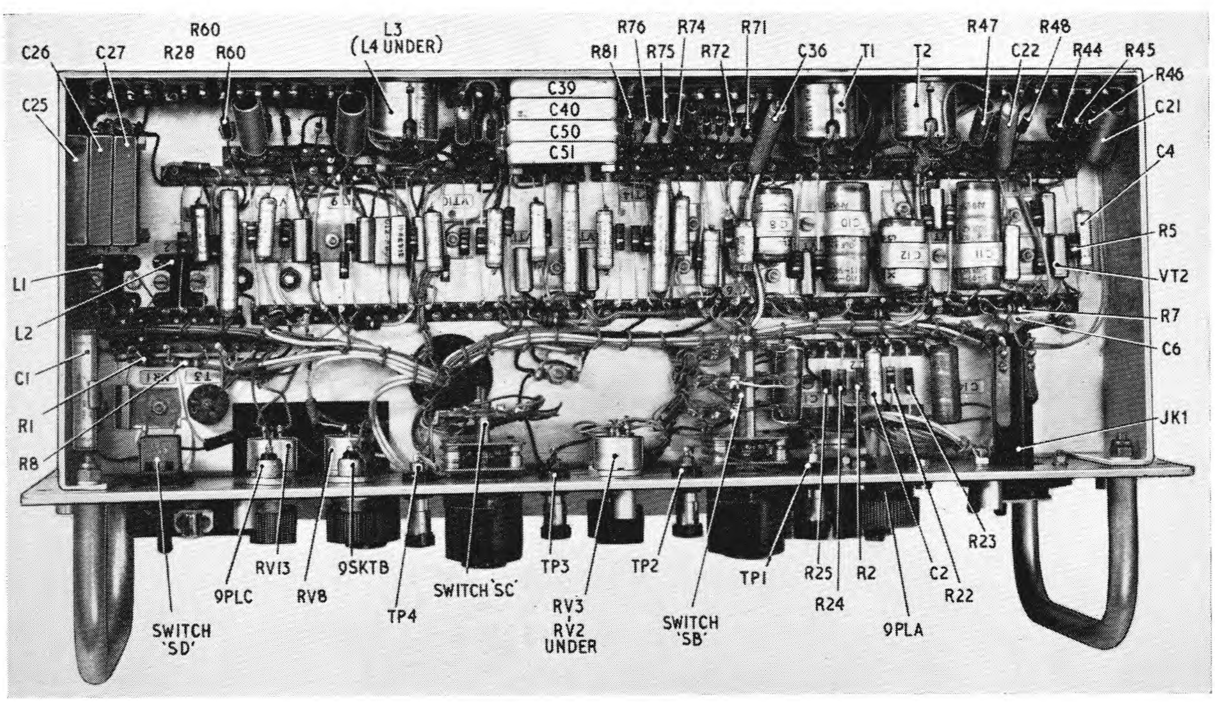

Fig. 4. Test set radio, underside

functions as a decoupling component for radio frequencies which may have leaked through up to this point.

66. Emitter resistor R47, which is decoupled by capacitor C22, functions to assist in the d.c. stabilization of the transistor in the normal way. The load resistor R48 for transistor VT8 provides an audio output which is fed to the transistor amplifier VT12, VT13, VT14 (para. 38).

Transmitter distortion

67. For transmitter distortion measurements, the inputs to the test set radio are as given in para. 59 and 60. The switching signal from the generator signal is, in this case, however, set at the carrier frequency of the transmitter-receiver. The frequencies present at the output of the demodulator diodes MR6, MR7, MR8, MR9 are:—

(1) 800 c/s and 1 kc/s, at higher level derived from the wanted two-tone signal.

(2) 600 c/s and 1200 c/s at a lower level derived from the third order intermodulation products in the transmitters.

Note . . .

There are of course other tones also present in the output representing other higher order intermodulation products in the transmitter.

68. In position 10 (TX. DIST.) of switch SA, the tones produced at the output of the diodes, as in para. 67, are fed to the bandstop filter, this rejects the 800 c/s and 1 kc/s tones but allows the 600 c/s and 1200 c/s third order products to pass to the transistor amplifier VT12, VT13, VT14. This amplifier then functions as in para. 38, the output being applied to a rectifier before operating the front panel meter M1 (para. 69).

Metering circuit

69. Selection of various a.c. inputs for metering purposes is obtained from switch SAc. Diode rectifiers MR4, MR5 (CV7040) together with capacitor C16 form a voltage-doubler circuit, the resulting d.c. output is applied to the base of emitter follower transistor VT5 (CV7043).

70. The meter M1 is connected in the emitter circuit of VT5 and the meter will give an indication proportional to the a.c. signal input to the rectifiers MR4, MR5, except at very low levels.

71. Resistors R29, R30 provide loading and current limitation for the transistor VT5, whilst base bias is provided in the usual way by the potential-divider network R26, R27.

Battery supply circuit

72. All the power for operation of the test set radio is supplied from a 9V battery, this connects at 9-PLD and 9-SKTF. A switch SD is provided to switch off the battery when the test set is not in use.

73. Supplies to the various transistor circuits are provided from a Zener diode stabilizer network MR1, R1, C1 (fig. 5) whilst a separate unstabilized supply is taken through R8 to the meter circuit to afford the facility of measuring battery voltage.

SETTING UP THE TEST SET RADIO

Note . . .

Throughout the following setting-up procedure for the test set radio it is important to note that a mic-tel plug must not be plugged into the mic-tel socket since this will cause inaccurate readings and results to be obtained.

Initial setting-up

74. Set the switch A.F.O. SWITCH on the front panel of the test set to the position marked TEST. If the reading on the front panel meter is below the orange calibration mark (i.e. 7 volts), the supply battery fitted into the test set should be changed.

75. Adjust the A.F.O. SWITCH to the position marked 1 kc/s, and switch A.F.O. LEVEL to the position marked NOISE LEVEL, now adjust the SET 1 kc/s control so that an indication on the orange calibration mark of the front panel meter is obtained.

76. Switch the A.F.O. SWITCH to the TWO TONE position and adjust the SET TWO-TONE control to give an indication on the orange calibration mark of the front panel meter.

77. Finally return the A.F.O. SWITCH to the TEST position and the A.F.O. LEVEL SWITCH to the LOW MOD position.

OPERATING INSTRUCTIONS FOR USE OF TEST SET RADIO WITH ARI.18179

Note . . .

It is important that the supply battery switch is returned to the OFF *position when the test set radio is not in use. Failure to observe this instruction will result in unnecessary waste of the battery power.*

78. There are nine rapid tests covered by the positions of the TEST switch which the test set radio can make on the s.s.b. transmitter-receiver used in the ARI.18179. These tests, together with the operation of the test set are given in the following paragraphs.

Receiver noise test (1)

79. The intercom socket on test set radio 6625-99-913-2929 must be connected to SKTJ on the interconnection box forming part of the radio installation. Connect SKTB of the test set radio to SKTB on the test set r.f. power 6625-99-913-2931; also connect the output of generator signal 6625-99-913-2933 to the receiver, via plug 1-PLE which is part of support 5821-99-913-3110.

80. On the control radio set 5821-99-913-3108 set the main control switch to the OVEN position and allow sufficient time (approx. 5 mins.) for the oven to warm up. This will be indicated by the appropriate "dolls-eye" indicator operating, now set the main control switch on control radio set to the receive position R. (*Receiver gain control must be turned to maximum.*)

81. With no input signal from the generator signal, and the TEST switch on the test set radio set to position 2 the receiver noise level can be read directly from the dBm scale on the front panel meter of the test set.

Receiver sensitivity test (2)

82. Feed a signal of 2μV, i.e. 114 dBm attenuation, from the generator signal 6625-99-913-2933 to the receiver (para. 79). The input from the generator should be set to a frequency 1 kc/s above that selected on the transmitter-receiver. This is to provide a 1 kc/s audio signal at the receiver output.

83. Set the TEST switch on the test set radio to position 3. The audio output power can now be read from the dBm scale on the test set radio front panel meter. The reading should be above the blue calibration mark, i.e. 50 mW. By increasing the input signal a maximum audio output of 100 mW should be attained, i.e. meter reading on orange calibration mark.

Receiver signal-to-noise ratio (3)

84. The signal-to-noise ratio for a 2μV input is given by the reading obtained in para. 83 plus 15 dBm, minus the reading obtained during the receiver noise test (para. 79).

Receiver distortion (4)

85. With the input set up as for the receiver sensitivity test, with meter reading on orange calibration mark, set the TEST switch on test set radio to position 4; the harmonic distortion of the audio output is read directly off the distortion scale on the front panel meter. The distortion should be less than 15%.

Frequency error test (5)

86. With the equipment connected as in the previous paragraphs switch the TEST switch on the test set radio to position 5. Adjust the FREQUENCY ERROR control, on the front panel of the test set radio, to zero. Now adjust the pre-set FREQ ZERO control, also on the test set radio front panel (fig. 1) to give a slow beat indication on the front panel meter. The interpolating oscillator is now set up.

87. To check the frequency error of the transmitter-receiver 1·5 Mc/s oscillator proceed as follows:—

(1) Set the TEST switch on test set radio to position 6.

(2) Apply 0·1-volt at a frequency of 1·499 Mc/s from the generator signal 6625-99-913-2933 to the receiver.

(3) Adjust the FREQUENCY ERROR control on the test set radio to zero beat. The frequency error of the 1·5 Mc/s oscillator in the transmitter-receiver is then measured directly from the scale reading of the FREQ ERROR control.

(4) Return the generator signal to a frequency 1 kc/s above the receiver input frequency (which will have been pre-set for a particular channel). Set the r.f. input level to 10μV and adjust the FREQUENCY ERROR control to give zero beat indication on the front panel meter of test set radio.

Note . . .

The frequency errors of the gen. ref. sig. and 1·5 Mc/s oscillator together are given on the scale of the freq. interpolator.

Set r.f. output (6)

88. The equipment remains set up as for the previous tests with the exception that the test set r.f. power 6625-99-913-2931 is connected to 9-SKTB in the test set radio via a coaxial cable.

89. Adjust the TEST switch on the test set radio to position 7 and switch the transmit/receive switch (TX/RX) on the test set radio to the TX position. Adjust the front panel control SET R.F. for a meter indication on the orange calibration mark of the meter scale. The transmitter power output is then read from the meter indication on the test set r.f. power. Return the TX/RX switch to the RX position.

Note . . .

The procedure given in para. 86 must be repeated before proceeding with tests on carrier rejection, sideband rejection and transmitter distortion, if the operating channel is changed.

Carrier rejection (7)

90. With the equipment connected as in para. 88, switch the TEST switch on the test set radio to position 8. Switch the transmit/receive switch (TX/RX) on the test set radio to the TX position. An indication will be shown by the meter of the test set radio on the dBm scale, and carrier rejection is measured having subtracted 33 dBm from the indicated value. The meter indication should be below the blue calibration mark (−26 dBm). Return TX/RX switch to the RX position.

Sideband rejection (8)

91. Adjust the TEST switch on the test set radio to position 9. Set the generator signal to give an output frequency which is 2 kc/s above the channel frequency required. Feed the high level output of the generator signal into 9-PLC on the test set radio. Switch the TX/RX switch to the TX position as for the carrier rejection rest.

92. The unwanted sideband rejection is read off the dBm scale by subtracting 47 dBm from the indicated value. This reading should be below the blue calibration mark, i.e. −40 dBm. Switch TX/RX switch to receive.

Transmitter distortion (9)

93. Set the frequency of the generator signal to that of the carrier of the channel selected on the transmitter-receiver. Feed the high level output to 9-PLC. Switch the TEST switch on the test set radio to position 10 and the TX/RX switch to transmit. An indication should be obtained on the front panel meter of test set radio, this indication is a measure of the transmitter inter-modulation products. The meter indication can be read off the dBm scale by subtracting 27 dBm from the observed value. The reading should be below the blue calibration mark, i.e. −20 dBm.

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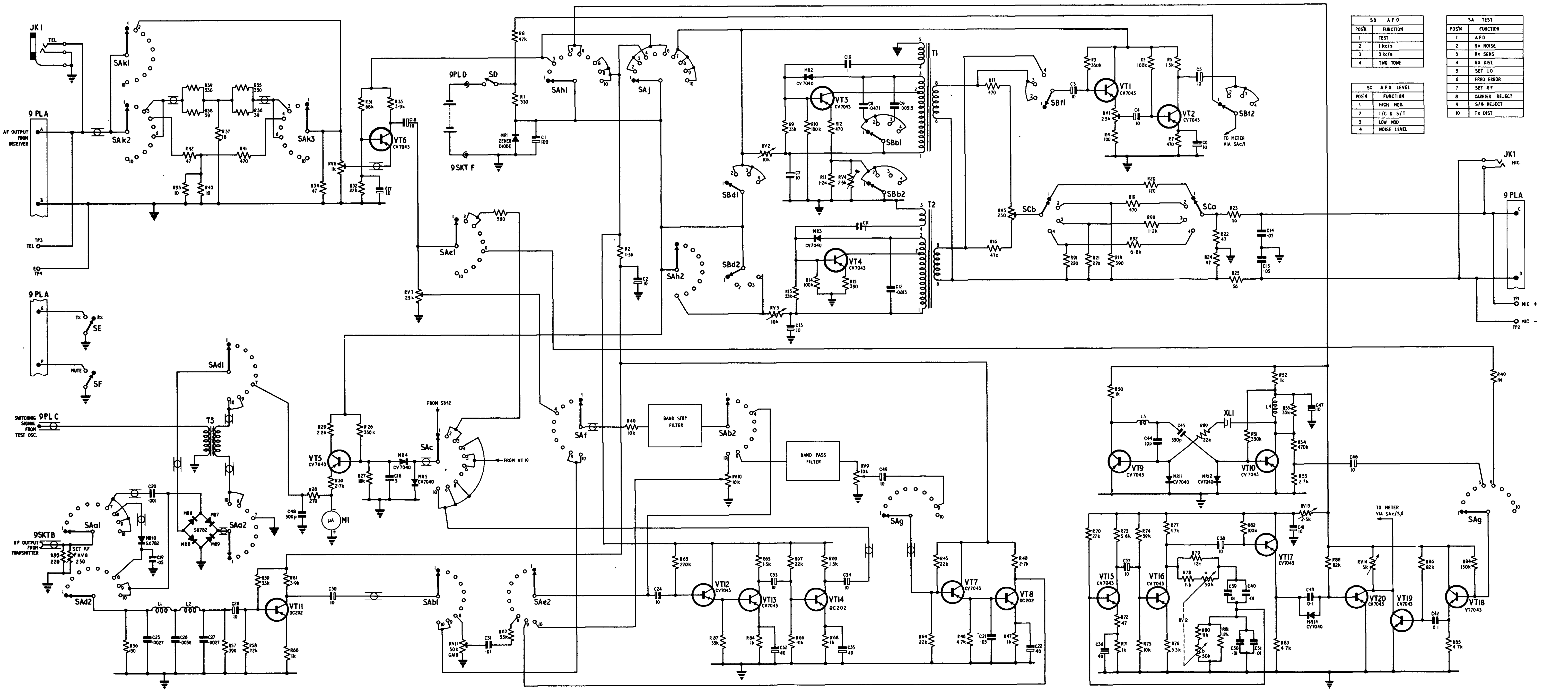

SB	AFO
POS'N	FUNCTION
1	TEST
2	1 kc/s
3	3 kc/s
4	TWO TONE

SC	AFO LEVEL
POS'N	FUNCTION
1	HIGH MOD.
2	I/C & S/T
3	LOW MOD
4	NOISE LEVEL

SA	TEST
POS'N	FUNCTION
1	AFO
2	Rx NOISE
3	Rx SENS
4	Rx DIST.
5	SET IO
6	FREQ. ERROR
7	SET RF
8	CARRIER REJECT
9	S/B REJECT
10	Tx DIST

Fig. 5 Test set radio 6625-99-913-2929 : circuit Fig. 5

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Appendix 1

SECOND LINE CALIBRATION PROCEDURE FOR TEST SET RADIO 6625-99-913-2929

LIST OF CONTENTS

LIST OF TABLES

Introduction

1. This calibration is introduced to fulfil two requirements:—

(1) To achieve higher accuracy when using the test set radio to test the ARI.18179 and thereby standardize the test figures being obtained.

(2) To enable the test set radio to be calibrated at second line for use with the ARI.18179. This procedure should be carried out on acceptance of new equipment and thereafter at six monthly intervals.

TABLE 1

Test equipment required

6625–99–913–2922	Generator signal	6625–99–913–2932	Power supply
6625–99–913–1420	Signal generator CT452	0557–99–949–0510	Wattmeter CT44
6625–99–943–8384	Multimeter electronic CT429	6625–99–913–8618 or	Oscilloscope CT436
6625–99–943–4059 or	Signal generator Advance J1	6625–99–943–1632	Oscilloscope CT414
6625–99–932–4976	Signal generator 65B		

Calibration procedure

Preparation

2. Remove the test set radio front and rear covers. Switch the test set radio battery to ON. Switch on all the test equipment to be used and allow a ten minute period before proceeding.

Test position 1

Voltage check

3. (1) Set the function switch to test position 1 and the A.F.O. switch to TEST. Check that the test set radio meter indication is above the red calibration mark.

(2) Connect the CT429 between the junction of C1, R1 and the chassis. Check that the voltage is between minus 4·8 and minus 5·8 volts and does not fall below minus 4·4 volts for any position of the function switch.

1 *kc/s and* TWO TONE *test*

4. (1) Set the function switch to test position 1 and the A.F.O. level switch to HIGH MOD. Connect the oscilloscope Y1 input to the test set radio EXT. MIC terminals. Set the oscilloscope CT436 controls as follows:—

Y1 controls:	200mV/cm.
	AC × 10 GAIN
	GAIN fully clockwise to CAL.
Timebase controls:	Time/cm 1 ms, X2
	FINE fully counter-clockwise to CAL.
	GAIN fully counter-clockwise to CAL.

(2) Set A.F.O. to 1 kc/s and adjust the SET 1 kc/s control for a red calibration mark indication in the test set radio meter. Accurately check and note the amplitude of the waveform.

(3) Unsolder one of the leads at R.V.2.

(4) Switch to TWO TONE and set the two tone control for a red calibration mark indication in the meter. Adjust RV5 until the waveform obtained is equal in amplitude to that obtained at 1 kc/s. The SET TWO TONE control must be used to keep the meter indication on the red calibration mark during this adjustment.

(5) Temporarily replace the connection at R.V.2 and repeat paras. (2) to (4) inclusive until equal amplitude waveforms are obtained.

(6) If a frequency counter is available, check that the frequencies obtained in paras. (2) and (4) are 1025 c/s $\pm$ 20 c/s and 780 c/s $\pm$ 10 c/s. Adjust T1 and T2 cores respectively.

(7) Resolder the connection at R.V.2.

(8) Set A.F.O. to 1 kc/s and adjust the SET 1 kc/s control for a peak-to-peak waveform amplitude of 80mV, i.e. with the oscilloscope controls set as in para. (1) the waveform should be 4cm. peak to peak.

(9) Set R.V.1 for a red calibration mark indication on the meter.

(10) Set A.F.O. level to LOW MOD. Oscilloscope to 100 mV/cm, A.C. $\times$ 10 GAIN. Check that the 1kc/s waveform is 1·5cm. peak-to-peak, i.e. 15mV.

(11) Disconnect the CT436. Set A.F.O. to the TEST position.

Test position 2 and 3

5. Connect the a.f. signal generator output to the wattmeter CT44. Set the wattmeter impedance to 50 ohms and the power range to 60mW. Set the signal generator frequency to 1kc/s and adjust the output attenuator to give a reading of 50mW in the CT44.

6. Leaving all settings as in para. 6 transfer the signal generator output to the test set radio phone input terminals. Set the function switch to test position 3 and adjust R.V.6 to give a meter indication on the blue calibration mark (i.e. 50mW).

7. Transfer the signal generator output to the wattmeter CT44. Set the wattmeter power range to 2mW. Reduce the signal generator output by 15dB, i.e. to give a wattmeter indication of 1·58mW.

8. Leaving all settings as in para. 3 return the signal generator output to the test set radio phone input terminals. Set the function switch to test position 2. The meter indication should be on the calibration mark $\pm$ 1dB.

9. There is no adjustment for this test position, if necessary repeat para. 1 and 2. Disconnect the signal generator from the test set radio.

Test position 4

10. Connect the a.f. signal generator output to the wattmeter CT44. Set the wattmeter impedance to 50 ohms and the power range to 2mW. Set the signal generator frequency to 1 kc/s and adjust the output attenuator to give a reading of 1mW in the CT44.

11. Leaving all settings as in para. 1 transfer the signal generator output to the test set radio phone input terminals. Set the function switch to test position 4. There should be no indication on the test set radio meter.

12. Tune the signal generator to 2 kc/s and adjust R.V.7 for a test set radio meter indication of 10%. Disconnect the signal generator from the test set radio.

Test position 6

13. Set the test set radio function switch to test position 5. Set FREQ. ERROR to zero and adjust FREQ. ZERO for a slow beat in the meter.

14. Set the function switch to test position 3. Connect the a.f. signal generator output to the test set radio phone input terminals. Adjust the signal generator output for a blue calibration mark indication in the test set radio meter.

15. Set the function switch to test position 6 and leaving the FREQ. ERROR set at zero, tune the signal generator about 1 kc/s for a slow beat in the test set radio meter. Check that the signal generator frequency is 1 kc/s $\pm$ 20 c/s. Disconnect the signal generator from the test set radio.

Test position 8

16. Connect the CT452 output to the test set radio 9 SKT B. Adjust the frequency to 2·100 Mc/s, c.w. and set the attenuator to 122dB.

17. Set the test set radio function switch to test position 7 and adjust the SET R.F. control for a meter indication on the red calibration mark.

18. Reduce the CT452 output to 116dB, modulated 53% at 1 kc/s.

19. Set the test radio function switch to test position 8 and adjust R.V.11 for a blue calibration mark indication on the test set radio meter. The blue calibration mark will now indicate a carrier level of —26dB on this position of the test switch. Disconnect the CT452 from the test set radio.

Test position 9

20. Connect the CT436 Y1 input to the test set radio at the junction of R69, C34.

21. Connect the CT452 output to the test set radio 9 SKT B. Adjust the frequency to 2·100 Mc/s, C.W. and set the attenuator to 122dB.

22. Connect the generator signal 7 SKT C to the test set radio 9 PL C. Switch HT–ON, set the function switch to HIGH LEVEL and frequency to 2·100 Mc/s.

23. Set the test set radio function switch to test position 7 and adjust the SET RF control for a meter indication on the red calibration mark.

24. Set the test set radio function switch to test position 9. Reduce the CT452 output to 82dB.

25. Tune the CT452 about 2·103 Mc/s for maximum amplitude waveform on the oscilloscope, check that the waveform is approximately 3 kc/s. Adjust the CT452 fine tuning for a peak in the test set radio meter.

26. Adjust RV9 for a blue calibration mark indication in the test set radio meter. The blue calibration mark will now indicate unwanted sideband at −40dB on this position of the test switch.

27. Disconnect the test equipment from the test set radio. Turn the generator signal H.T. switch to OFF.

Test position 10

28. Connect the CT436, Y1 input to the test set radio at the junction of R69, C34.

29. Connect the CT452 output to the test set radio 9 SKT B. Adjust the frequency to 2·100 Mc/s, CW and set the attenuator to 122dB.

30. Connect the generator signal 7 SKT C to the test set radio 9 PL C. Switch HT–ON. Set the function switch to HIGH LEVEL and the frequency to 2·100 Mc/s.

31. Set the test set radio function switch to test position 7 and adjust the SET RF control for a meter indication on the red calibration mark.

32. Set the test set radio function switch to test position 10. Reduce the CT452 output to 107dB.

33. Carefully tune the CT452 about 2·101 Mc/s for a test set radio meter dip, or minimum amplitude 1 kc/s waveform on the oscilloscope. Slowly offsetting the CT452 fine tuning control to one side of this dip should display a waveform rising in amplitude and reducing in frequency. Offsetting the other side should show a waveform increasing in amplitude and frequency.

34. Slightly offset the fine tuning from the dip position to obtain a waveform increasing in amplitude and in frequency and carefully tune for a test set radio meter, peak indication.

35. Adjust R.V.10 for a blue calibration mark indication in the test set radio meter. The blue calibration mark will now indicate third order harmonic distortion products, i.e. 600 c/s and 1200 c/s at −15dB.

36. Switch the test set radio battery—OFF. Switch off and disconnect the test equipment. Mark the test set radio phone label to indicate its calibration for use with ARI.18179. Replace and secure the test set radio covers.

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Chapter 3

GENERATOR SIGNAL 6625-99-913-2933

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. Generator signal 6625-99-913-2933 is an item of test equipment primarily intended for use with ARI.18179. The generator is capable of providing any frequency within the range 50 kc/s to 25 Mc/s in multiples of 1 kc/s.

2. The generator has a very high order of reset accuracy and stability, the latter being of the order of one part in 10^6. This high accuracy of the generator signal makes it suitable as an item of test equipment for use with single-sideband transmitting and receiving systems.

GENERAL DESCRIPTION

Construction

3. Generator signal 6625-99-913-2933 is constructed in a cabinet of dimensions $17\frac{3}{8}$ in. × 14 in. × 22 in. A framework consisting of sideplates, a chassis, and a rear strengthening frame is mounted off the rear of the front panel. This framework slides into the cabinet on two runners and is located by two spigots at the rear.

4. In addition to the generator reference signal 6625-99-913-2923 the following sub-units are included in the cabinet electrical equipment to make up the complete generator signal 6625-99-913-2933:—

(1) Mixer stage frequency 6625-99-913-2927.

(2) Filter assembly electrical 5915-99-913-2925.

(3) Modulator radio transmitter 6625-99-913-3578.

(4) Cabinet electrical equipment 6625-99-913-2928.

(5) Support electrical equipment 6625-99-913-2924.

5. The mixer stage frequency and filter assembly electrical, are mounted between the two side plates of the cabinet electrical equipment and the modulator radio transmitter, on the left-hand side plate. The generator reference signal is carried on a support electrical equipment, the latter being mounted on the chassis.

6. The support electrical equipment mentioned in para. 5 is a similar type to support electrical equipment 5821-99-913-3111, except that the antivibration mounts are replaced by 10 lb. shock absorbing mounts and a duct is added so that the cooling blower (para. 27) can be moved relative to the generator reference signal.

7. Forming the heart of the generator signal and fitting into the cabinet electrical equipment at the rear (fig. 1), is the generator reference signal 6625-99-913-2923. The latter can be easily inserted and withdrawn; it is retained by two special screw fixings which also provide facilities for the generator reference signal to be partly withdrawn from its mounting by the action of unscrewing these retaining screws.

8. Generator reference signal is used in its entirety with two exceptions. The main dust cover is not used, and the switch assembly 5930-99-913-2239 is replaced by a new switch assembly 5930-99-913-2922. The second switch assembly is similar to the first, except that it does not have frequency selector switches mounted on it, these have been transferred in a modified form to the front panel of generator signal 6625-99-913-2933 (para. 10).

9. For use in the generator signal, the second output connection of the generator reference signal 5821-99-913-2244 must be connected to the low level 5 Mc/s output instead of the 2 Mc/s output. These outputs are indicated on the unit and shown in fig. 2. A complete description of the generator reference signal appears in Part 4, Sect. 2 of this publication.

Front panel controls

Frequency switching

10. On the front panel of generator signal 6625-99-913-2933 are five selector switches (fig. 3) these can be adjusted to give the required output

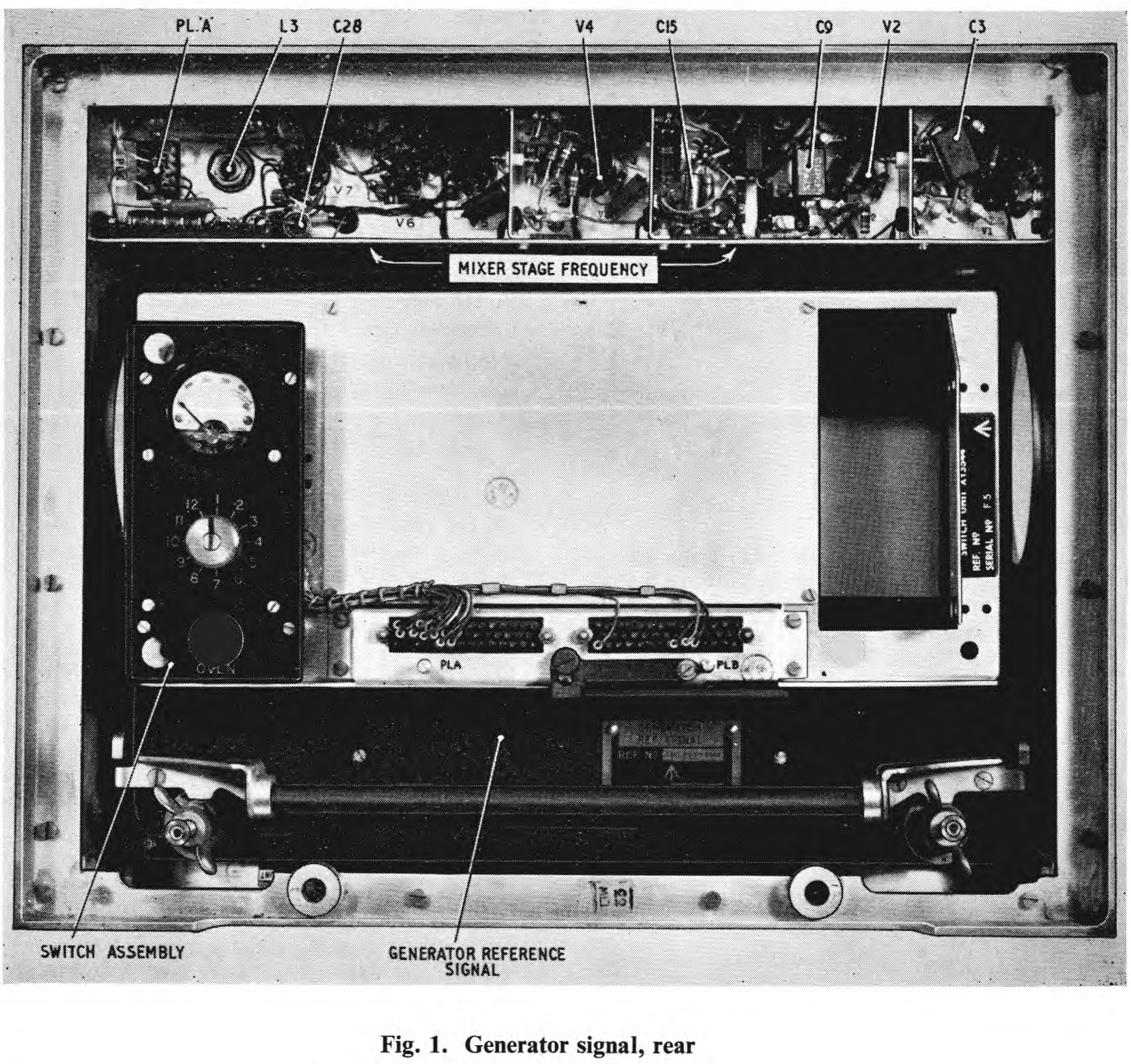


Fig. 1. Generator signal, rear

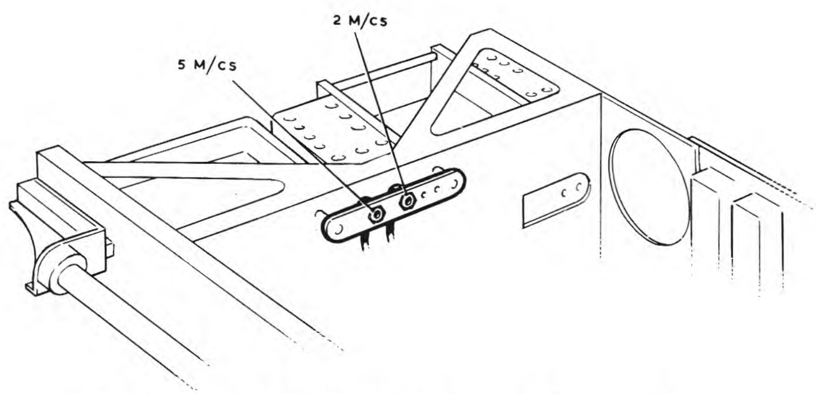


Fig. 2. Generator reference signal, output frequency sockets

frequency. The switches are arranged to give decade switching. A circuit diagram showing the switch connections is given in fig. 8 (end of chapter). The switches operate in a similar manner to that described in Part 4, Sect. 2, Chap. 2.

11. The generator reference signal 6625-99-913-2923, used in the generator signal, produces output frequencies which are 1·5 Mc/s higher than those selected by its own internal switching system (Part 4, Sect. 2). To obtain the same output frequency from the generator signal as that set up on the front panel switches, the latter are arranged to select frequency information from the generator

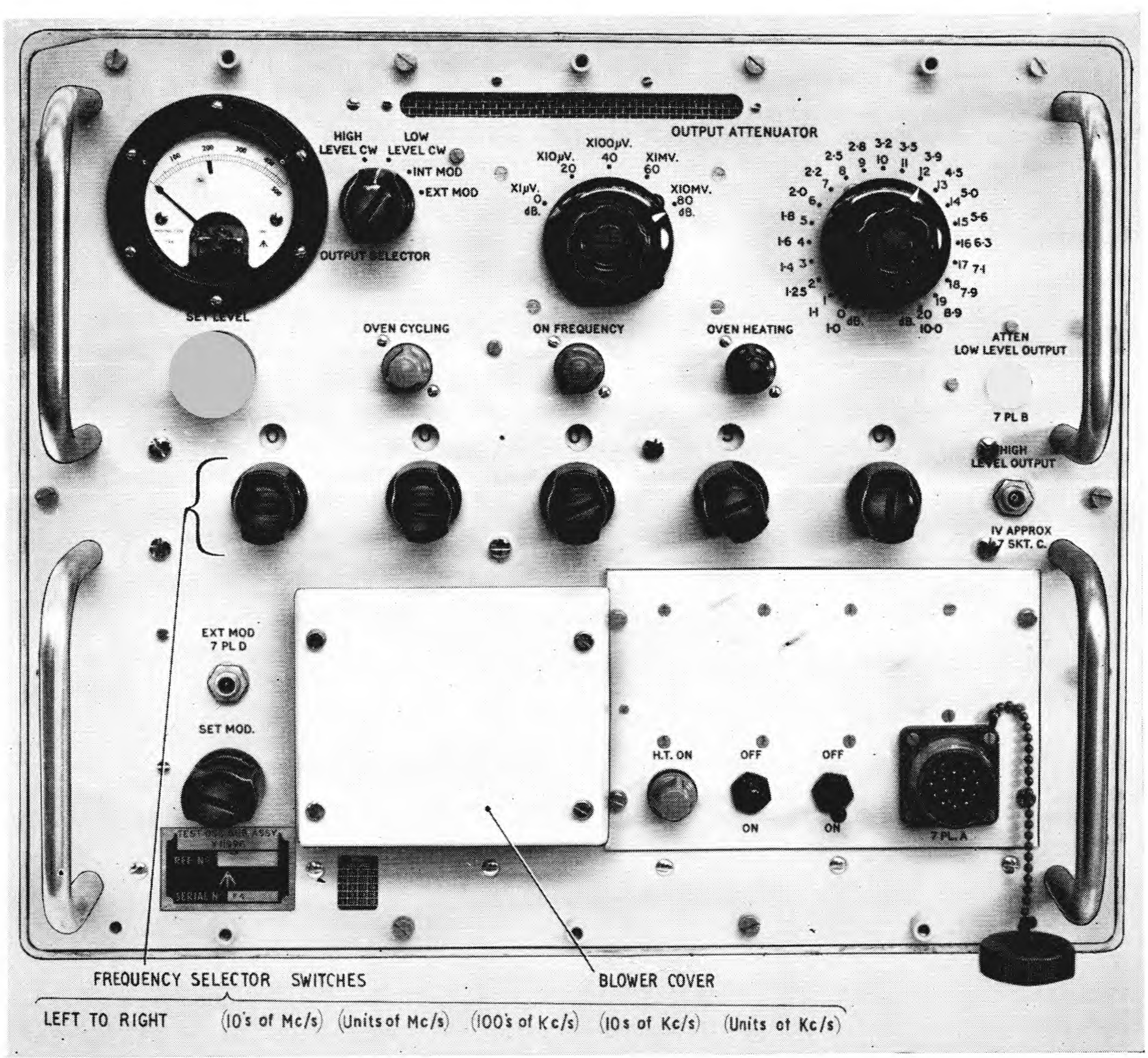


Fig. 3. Generator signal—front panel

reference signal 1·5 Mc/s below that indicated by these front panel switches.

12. When the frequency required is below 3·5 Mc/s, relays are actuated (contacts A1, A2, fig. 6) by contacts on the front panel switches, to select the correct filter to be used and bring into circuit the mixer stage frequency so that the required output frequency may be obtained.

13. The relays switch the mixer stage frequency into circuit, this allows the output frequency of the generator reference signal to be increased by 10 Mc/s (fig. 6).

14. A block diagram showing the operation of the generator signal is given in fig. 6.

Output selector switch (fig. 3)

15. The output selector switch has four positions:—

(1) HIGH LEVEL C.W.

(2) LOW LEVEL C.W.

(3) INT MOD

(4) EXT MOD

In the HIGH LEVEL C.W. position the output of the generator reference signal or mixer stage frequency (depending on the frequency selected on the front panel) is switched to the high level output socket where it is at high impedance with an output of approximately 4V r.m.s.

16. When switched to the LOW LEVEL C.W. position the output from the generator reference signal or mixer stage frequency is adjusted by the SET LEVEL potentiometer to a calibration mark on a meter M1 on the front panel; the output is connected to the modulator radio transmitter 6625-99-913-3578 (fig. 6). The output from this sub-unit is switched into the output attenuator (fig. 4).

17. In the INT MOD position the outputs mentioned in para. 15 and 16 are connected as in the LOW LEVEL C.W. position of the output selector switch. The audio oscillator is switched on and its output switched to the SET MOD potentiometer. The output of the potentiometer is fed to the mixer stage frequency and an indication of level is shown on a meter M1 on the front panel (fig. 3).

18. The same connections as in para. 17 are made in the EXT MOD position except that the audio oscillator is not switched on and the external modulation input plug is connected to the SET MOD control.

Output attenuator

19. Two screened attenuators (fig. 5) are mounted on the front panel of the generator signal, one consists of four 20dB steps and the other twenty 1dB steps. The output attenuator is thus capable of being adjusted in one hundred 1dB steps. The attenuators are connected in series and the output impedance is 50 ohms matched by a resistive pad, the attenuator characteristic impedance being 75 ohms.

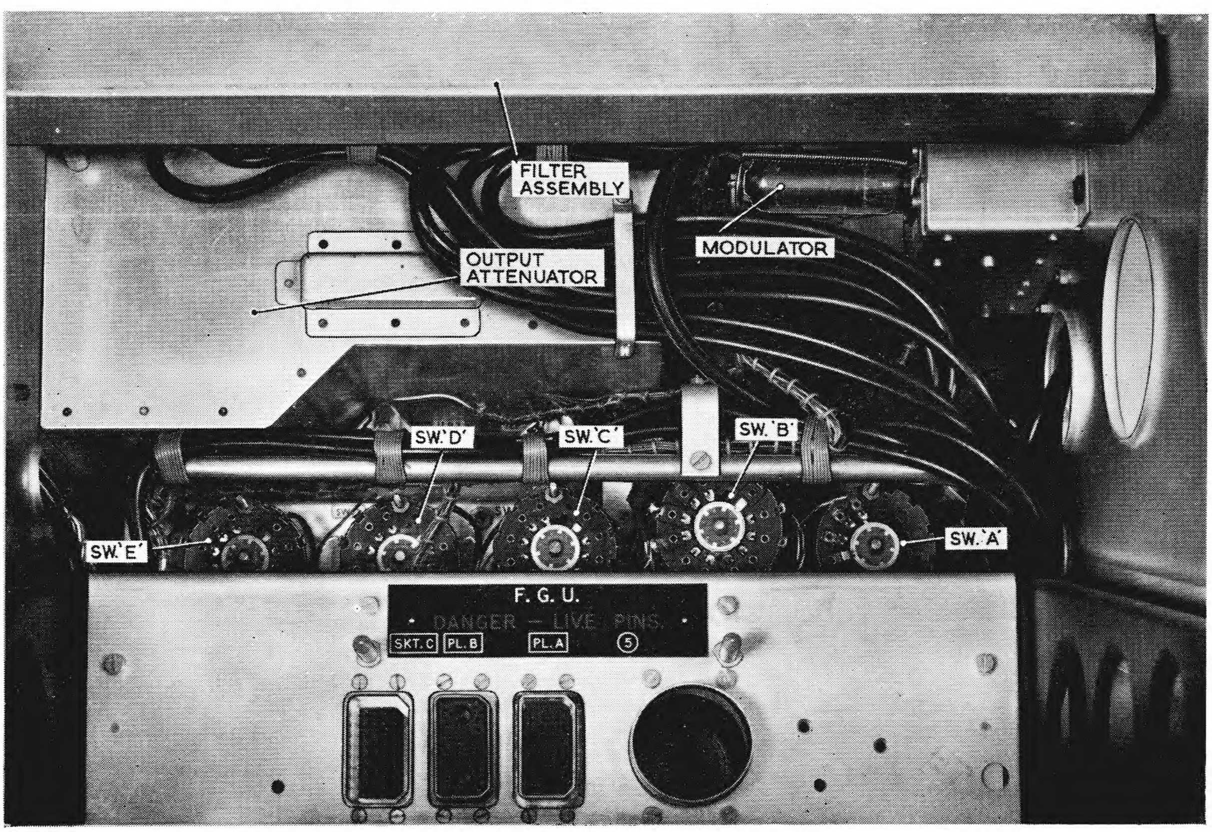


Fig. 4. Generator signal—interior

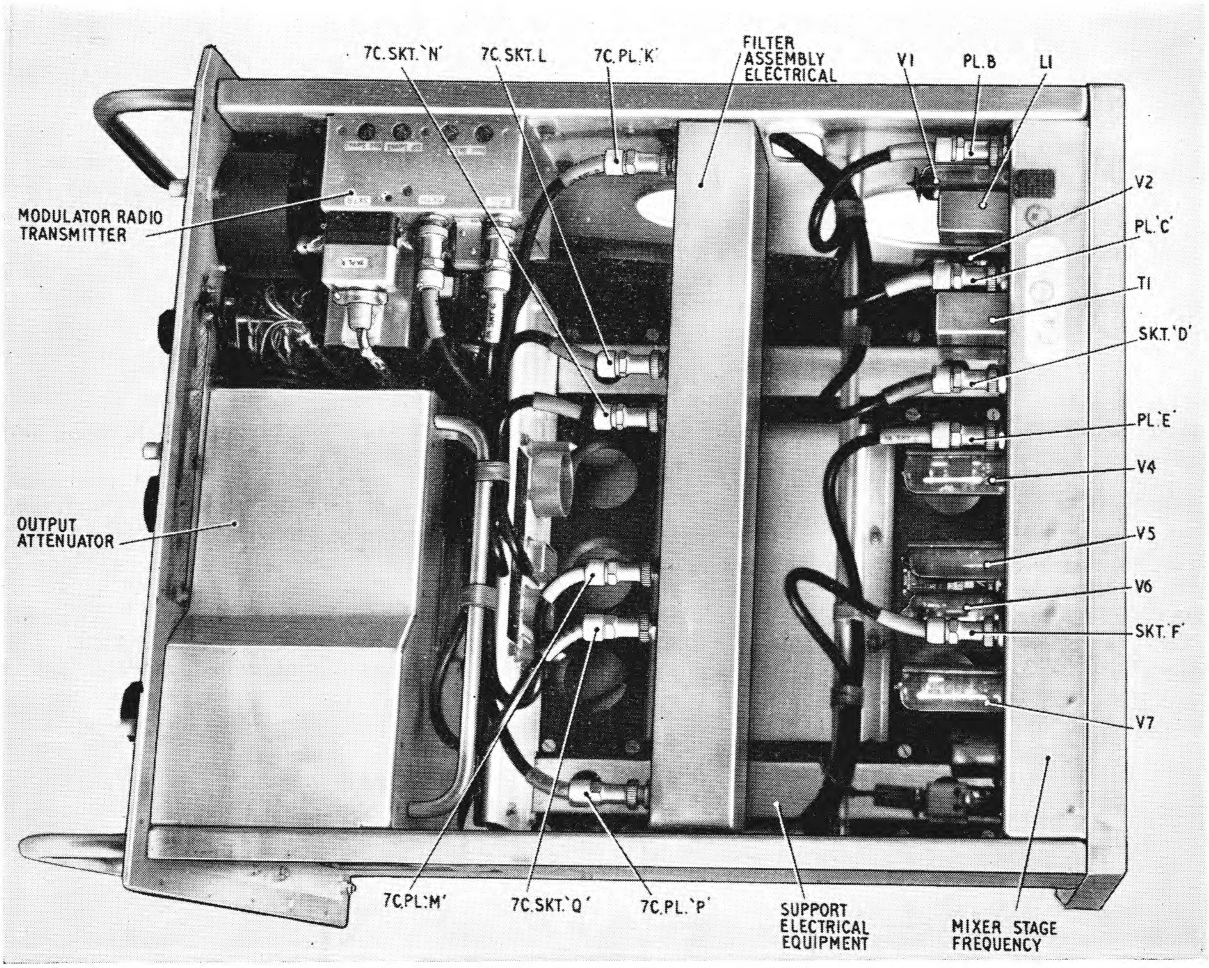


Fig. 5. Generator signal, showing sub-chassis

TABLE 1

Front panel indicator lamps

Colour	Identity	Indicates
Red	Oven heating	When the quick heating in the crystal oven of the generator reference signal is on.
Blue	Oven cycling	When the cycling heater in the crystal oven is on.
Green	On frequency	When the generator reference signal is locked to the selected frequency.
Clear	H.T. on	When the h.t. is switched on.

Indicator lamps

20. There are four indicator lamps on the front panel their colours and functions as shown in Table 1.

There are also dial lamps behind the frequency selection switches, these lamps indicate that the valve heater and crystal oven supplies are on.

21. The supply input plug, heater switches and h.t. indicator lamp are fitted to a separate sub-assembly, this is completely screened to prevent radiation occurring.

22. Each supply line is decoupled to minimize radiation at high frequencies; the red, blue and green indicator lamps are screened and decoupled for the same reason. All the indicator lamps can be dimmed if required.

Interconnecting cables

23. Housed in the cover of the generator signal are the cables used to connect the generator with its power supply. The interconnecting lead between generator signal and power supply is screened to prevent radiation.

24. The interconnecting cables are sufficiently long for the generator signal to be used up to 20 ft. away from the radio bay of the aircraft.

25. When used on the test bench at the higher frequencies, an attenuator pad providing 20 dB of attenuation may be connected at the end of the cable joining the generator signal with the transmitter-receiver.

26. This attenuator pad is supplied and stored in the cover panel of the generator signal and its use enables sensitivity measurements to be made satisfactorily at high frequencies.

Cooling

27. Generator signal 6625-99-913-2933 is cooled by a 28V d.c. blower mounted off the front panel. This blower is arranged to blow air through the generator reference signal 6625-99-913-2923, the latter forming the main part of the generator signal 6625-99-913-2933.

28. An air outlet is provided at the top of the front panel and both the air inlet and outlet are covered with gauze to prevent direct entry of rain or spray.

DETAILED CIRCUIT DESCRIPTION

Mixer stage frequency

29. The mixer stage frequency is a separate sub-unit mounted as mentioned in para. 5, the sub-unit is used to generate frequencies in the range 50 kc/s to 3·499 Mc/s.

30. A low-level input signal of 5 Mc/s obtained from the generator reference signal is amplified by buffer-amplifier valve V1 (CV4014 fig. 9). The tuned circuit L1, C4, is resonated at the input frequency of 5 Mc/s. Output r.f. voltage is coupled through capacitor C5 to the grid of V2 (CV4014); this latter valve functioning as a frequency doubler.

31. Decoupling to radio frequencies in the anode circuit is by resistor R7 and capacitor C6. A similar function for the screen grid is carried out by R6 and C7.

32. The primary of transformer T1 is resonated at twice the input frequency, i.e. 10 Mc/s. Transformer T1 has double-tuned circuits and the

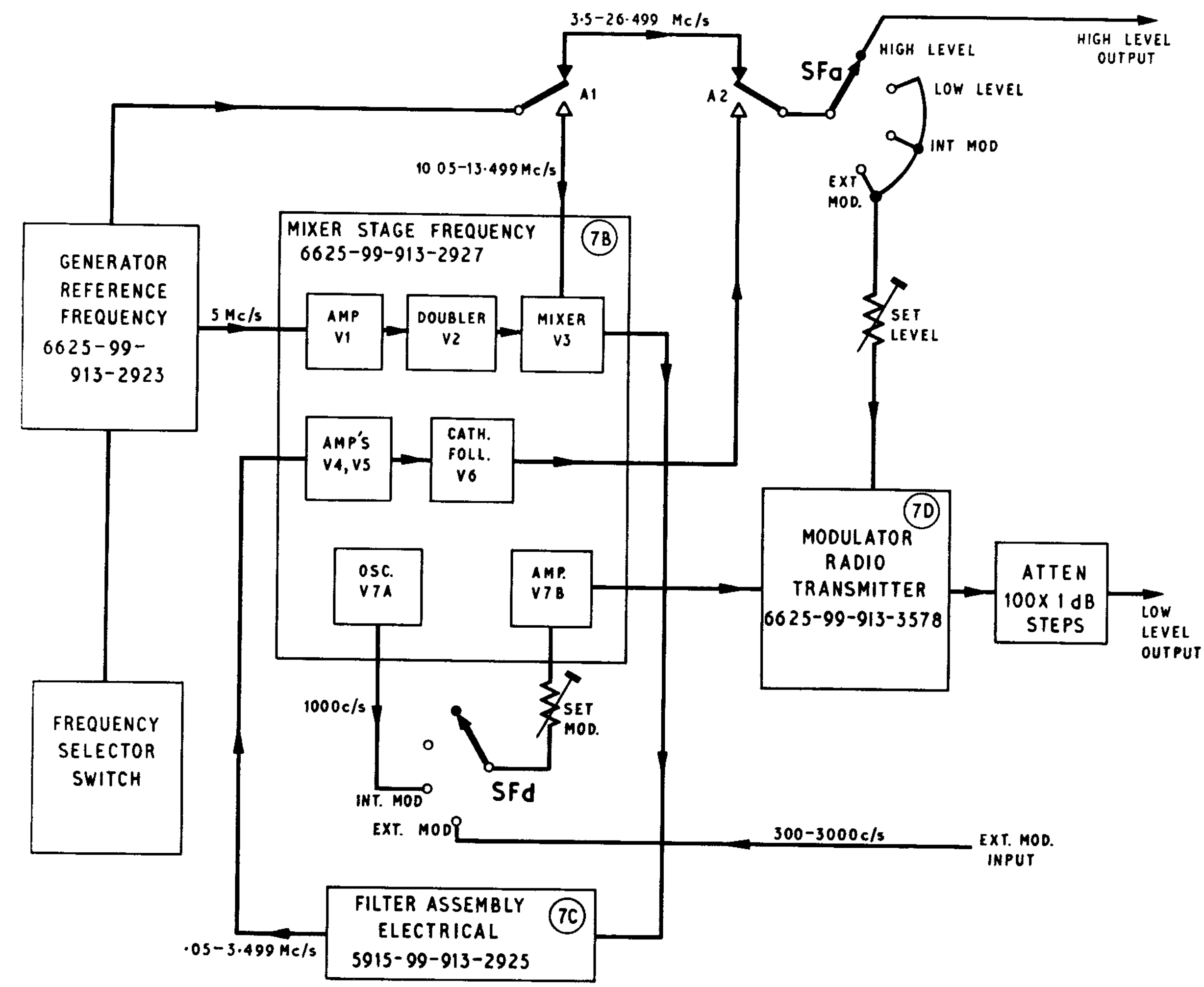


Fig. 6. Generator signal—block diagram

voltage obtained across the secondary winding is reduced by the potential-divider action of capacitors C10, C11, the resulting voltage is fed to the grid of valve V3 (CV3928) the latter functioning as a mixer.

33. Components C12 and L2 form an acceptor circuit, providing a low-impedance path to earth for 5 Mc/s signals at this point. It is necessary to reduce the 5 Mc/s signal as much as possible by this means since any 15 Mc/s signal, which may be produced if the 5 Mc/s signal were fed through the mixer valve V3, will cause spurious output frequencies to be produced.

34. In the mixer valve V3 the two r.f. voltages applied to it are combined. The two voltages being the 10 Mc/s one from V2 and the high level output from the generator reference signal 6625-99-913-2923 in the frequency range 10·050 Mc/s to 13·499 Mc/s, fed into the mixer at 7B-PLC.

35. After mixing, the resultant radio frequencies in the range 50 kc/s to 3·499 Mc/s are obtained at the cathode of the mixer valve V3. This output, at low impedance, is coupled through capacitor C15 and 7B-SKTD to the filter assembly electrical, where unwanted products are filtered out.

36. After passing through the filter assembly, the selected frequency in the range given in para. 35, is fed to the amplifier valve V4(CV4024), the stage being resistance-capacity coupled. The valve is a double-triode and both halves are used in cascade to amplify the selected radio frequency.

37. Output r.f. voltage from the anode of one half of valve V4, is coupled to a further amplifier through capacitor C21. This next stage of amplification employs a pentode valve (CV4014).

38. The amplified output voltage obtained at the anode of V5 is resistance-capacity coupled to the cathode-follower valve V6 (CV4040), by resistor R24 and capacitor C25; resistor R26 being the grid leak.

39. Valve V6 functions as a cathode-follower and the output r.f. voltage is taken from the cathode resistor R27 via coupling capacitor C26 to socket 7B-SKTF. The output at the cathode of V6 is at low-impedance because of the cathode-follower action of V6. The signal obtained is used as the input signal of the modulator radio transmitter 6625-99-913-3578 in the frequency range 50 kc/s to 3·499 Mc/s.

Audio oscillator

40. For internal modulation purposes in the generator signal, an audio oscillator is also contained on the mixer-stage frequency sub-unit. The oscillator consists of one-half of valve V7 (CV4024) and is a form of Hartley oscillator giving a high level output with low distortion.

41. Inductor L3 with capacitors C27, C28 (fig. 9) form the frequency determining network, feedback being provided in the usual way by a tap on the inductor L3.

42. Cathode bias is provided for V7a by resistor R30. A degree of automatic gain control is produced by C35, MR1, and R28, this is applied to the grid of valve V7A through R29.

43. Audio frequency output is taken from the cathode of V7a through coupling capacitor C30 to pin D2 of PLA, this output is then applied to the SET MOD potentiometer, via SWFd.

44. Using the other half of valve V7, the audio input from either internal or external sources supplied from pin C1 via resistor R31 and capacitor C31, is amplified to drive the modulator radio transmitter sub-unit. The anode load of valve V7b is situated in the modulator radio transmitter, connection being made via pin B3 of PLA.

45. A considerable amount of negative feedback is provided on valve V7b by components C32, R32 this ensures that the distortion of the audio-output voltage is as low as possible.

Filter assembly electrical

46. The filter assembly consists of three bandpass filters, these are automatically selected by the operation of the decade switches on the front panel of the generator signal 6625-99-913-2933. The pass-band of the filters is 1·2 to 2 Mc/s, 2 to 3 Mc/s, and 3 to 4 Mc/s respectively, each filter is designed to give a high degree of rejection to 5 Mc/s signals and the second harmonic of r.f. voltages within the bandwidth of the filter.

47. Considerable rejection of frequencies above 10 Mc/s is also provided in each filter and additional rejection of these frequencies is obtained by the wide-band amplifier V4 (para. 36) in the mixer stage frequency, since this amplifier has much less gain at these higher frequencies.

48. The three filter assemblies are aligned and tested during the manufacture of the generator signal, after which they are hermetically sealed to exclude moisture. The filters should need no adjustment during service.

Modulator radio transmitter

49. Modulator radio transmitter is a separate sub-unit forming part of the generator signal. The function of the modulator is to produce a modulated output signal from either the internal audio oscillator or from an external modulating source. The sub-unit also provides metering information for the levels of c.w. and modulated inputs.

50. In the low-level c.w. and modulated output conditions, the output r.f. voltage from the generator reference signal or the mixer stage frequency as the case may be, depending on the selected output frequency, is fed into a cathode follower stage, via plug 7D-PLG.

51. The cathode-follower stage using pentode V1 (CV2129) receives r.f. voltage from the generator reference signal on its signal grid as mentioned in para. 50. Components R15 and C10 decouple the anode circuit to radio frequencies.

52. Output voltages are taken from the cathode of valve V1 through coupling capacitor C5 and fed to an attenuating and matching unit consisting of resistors R17, R2, R3. This network provides the necessary matching to the 75-ohm input impedance of the output attenuator via socket 7D-SKTH.

53. Also in the cathode circuit resistor R5 and inductor L3 provide a d.c. connection to earth and bias for the valve.

54. When the output selector switch on the front panel of the generator signal is set to either INT MOD or EXT MOD, relay RLA/2 is operated. Contact RLA2 short-circuits resistor R17 and contact RLA1 introduces a shunt modulator across the resistors R2, R3.

55. This shunt modulator consists of four diodes MR1, 2, 3, 4 (SX782) arranged as a diode-ring modulator. The modulator is switched at audio frequency by the signal provided from the secondary of transformer T1, the a.f. voltage being in turn obtained from the a.f. buffer-amplifier in the mixer stage frequency (para. 44).

56. Inductors L1, L2 are radio frequency chokes to prevent r.f. feed-back through the connecting leads of the modulator radio transmitter to other sub-units.

57. The modulator is balanced by two preset potentiometers RV1 and RV2. These potentiometers also set the effective impedance of the modulator to give the same attenuation as resistor R17 provides when the output selector switch is set to the C.W. position.

58. Capacitors C1, C2, C3, C4 provide balancing compensation to earth for radio frequencies.

Meter indication

59. The signal at the junction of resistors R2 and R17 is coupled to a high impedance shunt detector MR6, through capacitor C6. The load for the detector consists of resistor R9 and capacitor C11, resistor R7 ensures current drive for the transistor VT1.

60. Transistor VT1 functions as an emitter follower, R10 forming the emitter load, in the case of a c.w. signal, being fed with d.c. from the shunt detector MR6. The meter M1 located on the front panel of the generator signal indicates the current in the emitter circuit of transistor VT1 and hence the relative level of the c.w. voltage. The preset variable resistor RV3 in series, allows the meter to be calibrated.

61. When modulated voltages are fed to diode MR6 an audio output is produced and fed to the base of VT1. Since VT1 functions as an emitter follower the output is at low impedance, the audio signal appearing at the emitter of VT1 is coupled to transistor VT2 via capacitor C7 and resistor R16 for further amplification.

62. Transistor VT2 functions as a grounded-emitter amplifier being suitably biased by the network R11, R12. The output a.f. signal at the collector of VT2 appears across the load resistor R14 and is coupled to the rectifier formed by diodes MR7, MR8, the load being R13.

63. A d.c. voltage is therefore fed from the output of the diodes MR7, MR8 to the meter M1 on the front panel of the generator signal, the meter indicates the relative level of modulated signal.

64. Calibration of the meter in this condition is obtained by adjustment of the preset variable resistor RV4 in the emitter circuit of VT2, this gives a variable amount of negative feedback over the stage thus varying the gain.

65. The metering circuits are supplied from a 12-volt d.c. supply which is derived from the 28V heater supply through resistor R8. This 12-volt supply is stabilized by the Zener diode MR5.

Checking circuit functions

66. Metering of various circuit functions inside the generator reference signal section of the generator signal is provided, the meter indications and circuit functions are given in Table 2, these are very similar to those given in Part 4, Sect. 2, Chap. 2, for the generator reference signal.

67. Referring to the circuit diagram (fig. 7) end of chapter. A part of the high tension and heater voltages appearing at PLA pins C9, B9, A9, B8 is applied to the generator reference signal metering circuit via the selector switch SA.

68. Resistors R11, R6, provide a potential-divider action for metering the 200V supply, whilst R10, R5, R9, R4, R8, and R3 serve a similar function for the other supplies.

69. The variable frequency oscillator output voltage is also divided down by the action of potential divider R13, R12, before being applied to the metering circuit.

TABLE 2

Test performance of generator reference signal

Plug PLA Pin No.	Switch (SA) Position	Meter Indication		Performance Test
		Min.	Max.	
B.8	1	240	300	25·2V heater supply
A.9	2	300	340	150V stabilized supply
B.9	3	280	340	150V unstabilized supply
C.9	4	360	440	200V h.t. supply
A.11	5	160	200	1 Mc/s i.g.o. signal
B.11	6	70	90	100 kc/s i.g.o. signal
C.7	7	50	70	10 kc/s i.g.o. signal
B.10	8	50	250	v.f.o. signal
A.12	9	250	350	reference signal
B.12	10	220	280	loop signal
C.10	11	220	280	2 Mc/s output
A.13	12	170	210	amp/osc output

Readings taken at channel frequency of 4000 kc/s

P31889 243029/6154 8/62 375 C & P Gp

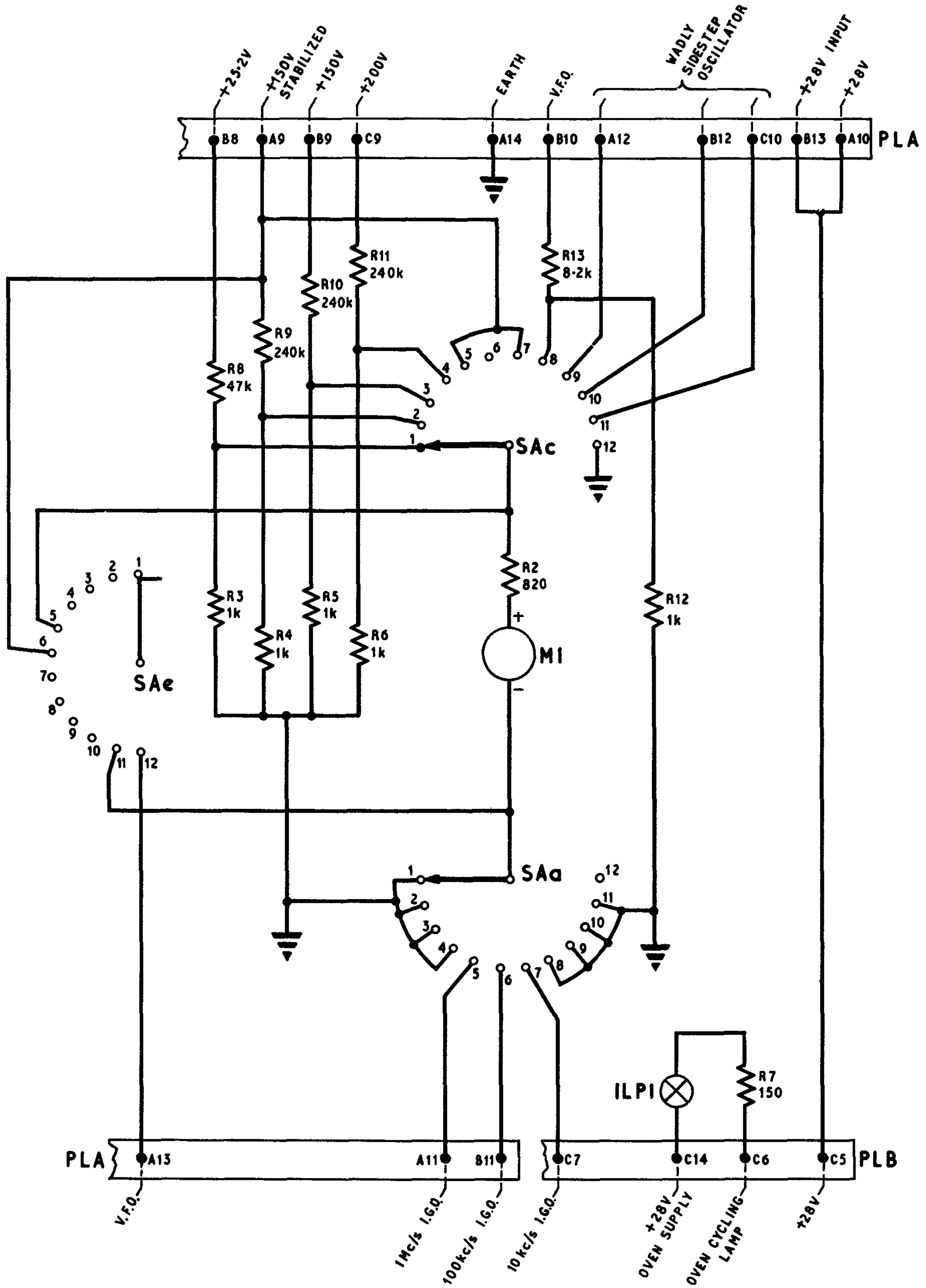
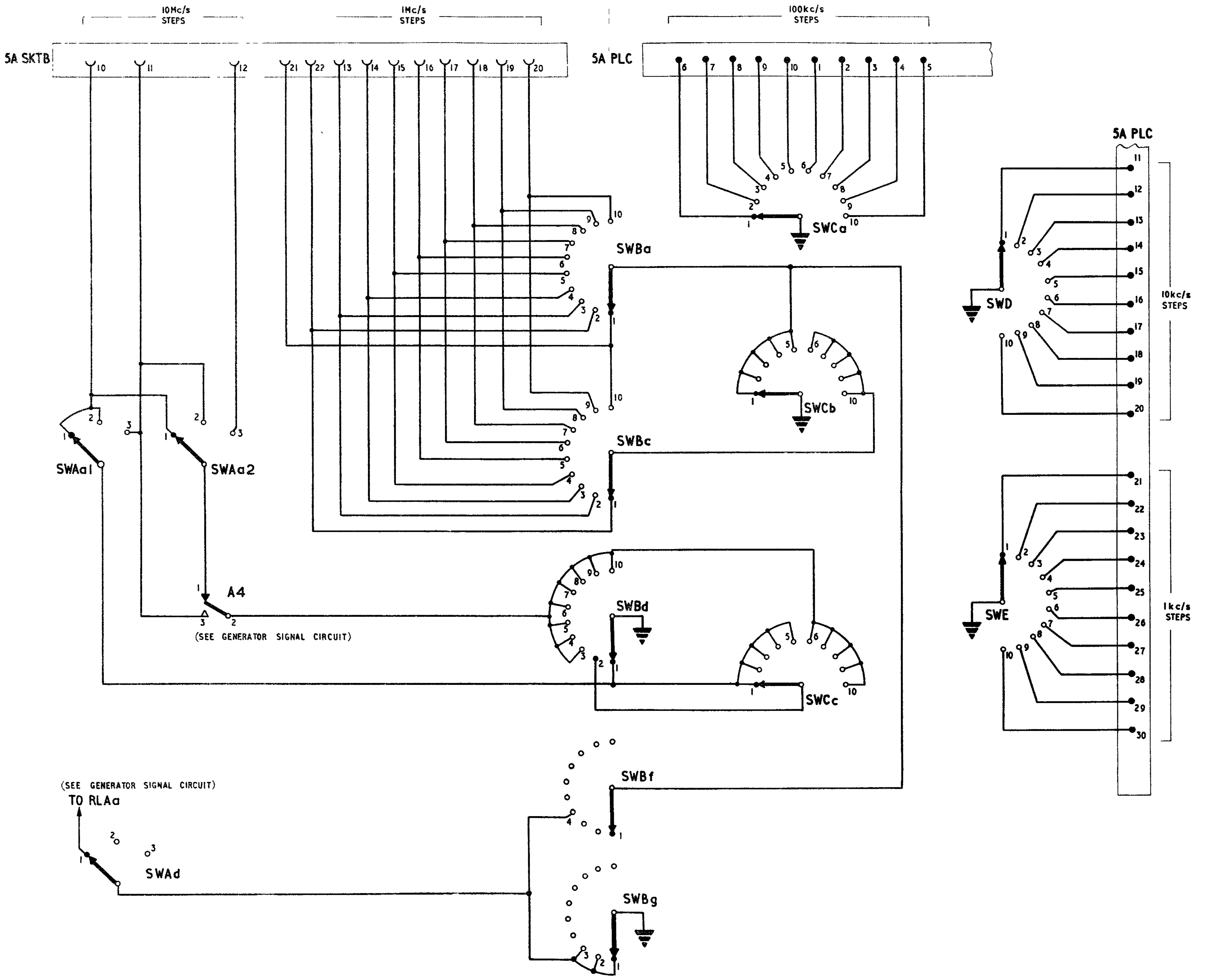


Fig. 7 Switch assembly 5930-99-913-2922: circuit Fig. 7

R D

PP9063 243030/6155 6/62 381 C & P Gp. 924 (4)



AIR DIAGRAM
6729 T/MIN.
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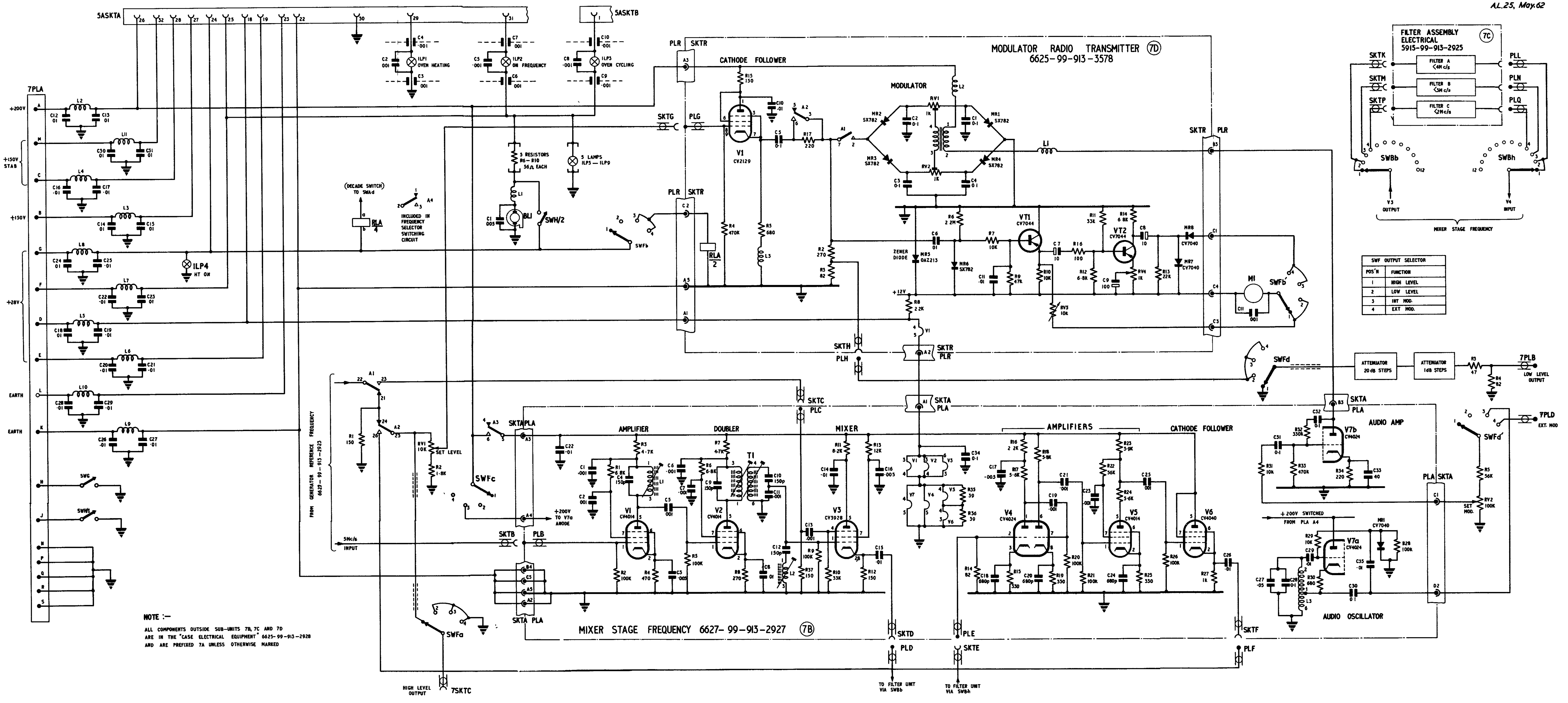
Generator signal 6625-99-913-2933, frequency selector switching: circuit.

Fig.8

PP9063 243030/6155 6/62 1131 C & P Gp. 924 (4)



AIR DIAGRAM
6729U/MIN.
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PP9063 243030/6155 6/62 1131 C & P Gp. 924 (4)

Generator signal 6625-99-913-2933: circuit

Fig. 9

Chapter 4

POWER SUPPLY 6625-99-913-2932

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. The power supply 6625–99–913–2932 is a small self-contained unit used to provide the power requirements for the generator signal 6625–99–913–2933, the latter being part of the test equipment used with ARI.18179.

2. Input to the power supply is from 200V, 400c/s, 3-phase and 28V d.c. sources. The use of a three-phase supply system in conjunction with silicon type rectifiers enables the physical dimensions of the power supply to be kept to a minimum.

Warning . . .

Power supply 6625–99–913–2932 produces voltages which can prove to be lethal, care should be exercised to avoid physical contact with components when operating the power supply chassis with the cover removed.

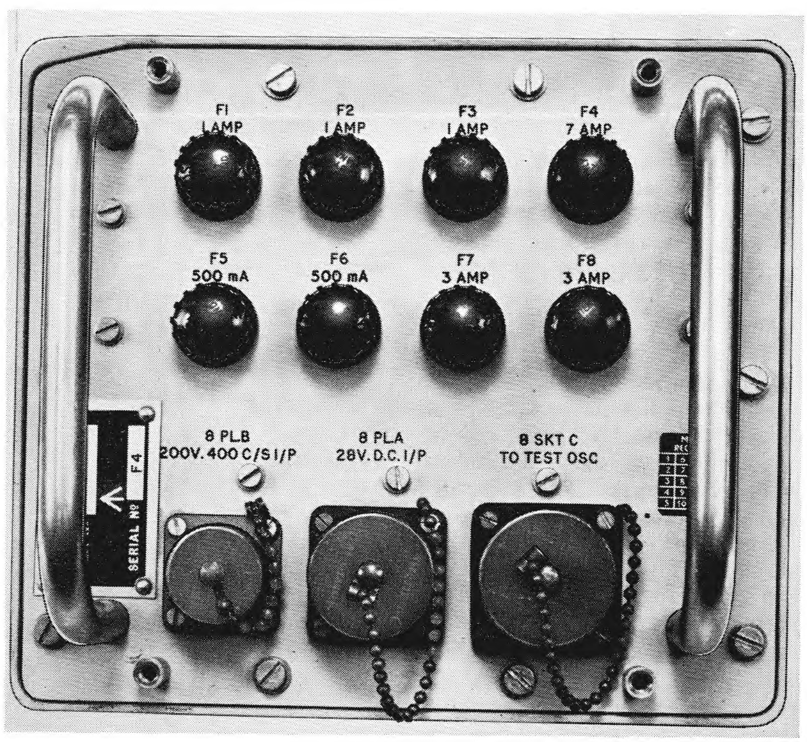

Fig. 1. Power supply—front panel

GENERAL DESCRIPTION

Front panel (fig. 1)

3. On the front panel of the power supply are eight fuses used to protect both the input supplies and the various power outputs from the power supply.

4. Located beneath the fuses are two plugs and one socket, these are used for connecting the power supply with the associated generator signal and the 200V, 400 c/s and 28V d.c. supplies.

5. Two handles are provided on the front panel to assist in the withdrawal of the front panel and chassis from the cover. These handles also afford some protection for the fuse covers and plugs and sockets.

Chassis

6. At the rear of the front panel are situated the major items used in the power supply. No sub-chassis construction is used and components are either directly attached to the chassis or to tag strips (fig. 2).

Supplies provided

7. The power supply provides the following output voltages for use in the generator signal:—

(1) 200-volt unstabilized supply

(2) 150-volt stabilized supply

(3) 150-volt unstabilized supply

(4) A 28-volt d.c. supply for operation of relays and valve heaters.

Circuit summary

8. As mentioned previously the power supply 6625–99–913–2932 operates from three-phase, 200V, 400 c/s and 28V d.c. supplies, usually obtained from the aircraft supply system, but may be obtained from the test bench for bay servicing.

9. A six-phase single-Y rectifying system is used for the d.c. high tension supply; the high voltage is obtained via silicon junction rectifiers from the secondary windings of the three-phase power transformers.

10. Both the 200V and 150V high tension supplies have choke input filters, this enables good voltage regulation to be obtained. General high tension for the generator signal is obtained from the 200V unstabilized supply. The 150V stabilized supply is obtained from the 200V supply by Zener diode stabilizers.

11. The valve heaters, oven, and relay supplies used in the generator signal, are controlled by contacts on relays RLA and RLB in the power supply.

DETAILED CIRCUIT DESCRIPTION

12. A circuit diagram of the power supply is shown at fig. 4. Alternating current is supplied to the primary windings of the three-phase transformer T1 from plug PLB, through the relay contacts RLB1, RLB2, RLB3 after the relay has operated.

13. There are six secondary windings on transformer T1 these are connected in two groups of three to provide two separate power outputs.

200V unstabilized supply

14. This supply is obtained from the six-phase single-Y rectifying system employing silicon diodes MR1, MR2, MR3, MR4, MR5, MR6. The d.c. output voltage obtained from the diodes is fed to a choke input filter, consisting of L1 with capacitor C1. Further smoothing of the 200V d.c. unstabilized supply is provided by resistor R4 and capacitor C3. The 200V d.c. output voltage appears at SKT–C for connection to the generator signal.

150V stabilized supply

15. A stabilized 150-volt h.t. supply is obtained from the 200V supply mentioned in para. 14, stabilization being by the use of Zener diodes MR13, MR14, MR15 (fig. 3).

16. Resistors R3 and R5 (fig. 4) together provide the necessary voltage drop to operate the Zener diodes at 150V; the connection between sockets M and C on SKT-C is provided in the generator signal.

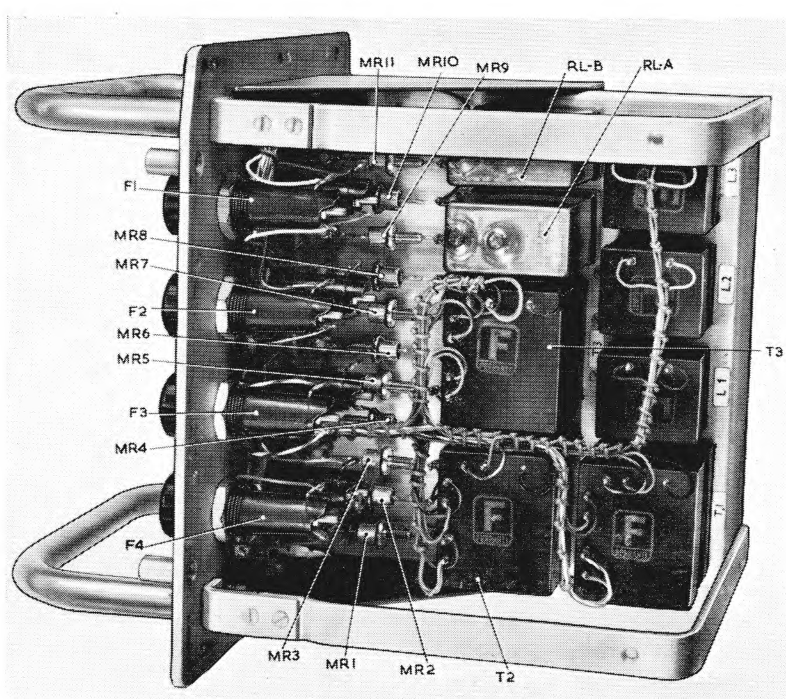

Fig. 2. Power supply—top

150V unstabilized supply

17. From further secondary windings on the power transformer T1 an a.c. supply is provided to a second set of silicon diode rectifiers arranged in a six-phase single-Y rectifying arrangement.

18. The d.c. output voltage obtained from the rectifiers MR7, MR8, MR9, MR10, MR11, MR12 is applied to a choke input filter formed by inductor L2 with capacitor C2. Further smoothing is accomplished by inductor L3 and capacitor C4; the 150V output appears at socket B of SKT-C.

28V d.c. supplies

19. A 28-volt input is applied to pins A and D of PLA (fig. 4) with capacitor C5 acting as a decoupling component. The 28-volt supply is used to operate the valve heaters, crystal oven, and relays used in the generator signal.

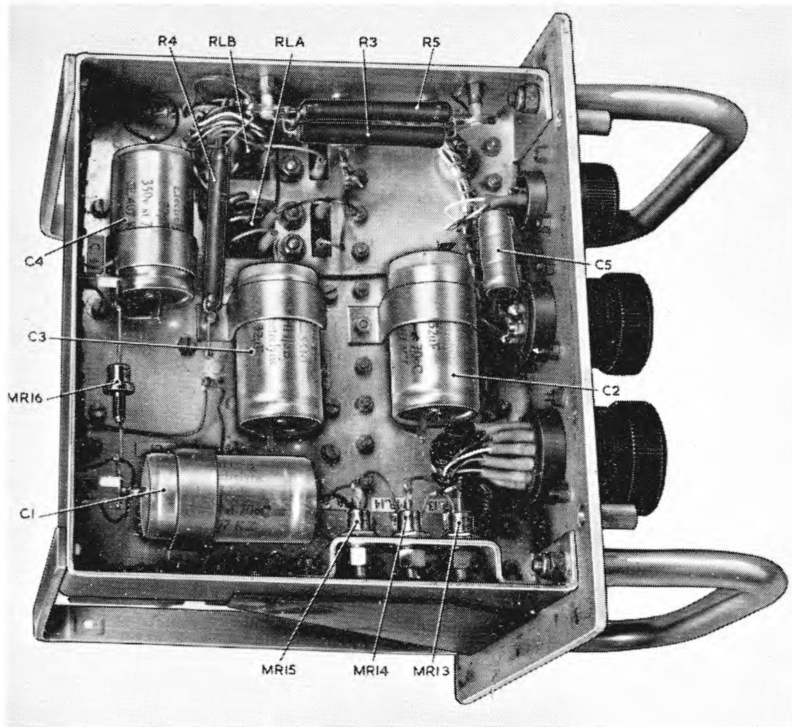

Fig. 3. Power supply—underside

20. The 28-volt supplies to these components are switched through relay contacts RLA1, RLA2, and RLA3 when coil RLA/3 is energized due to the heater switch on the generator signal being closed. Diode MR16 (Table 1) prevents large surges of current when the l.t. switch in the generator signal is closed.

TABLE 1

List of semi-conductors used in the power supply

Type	Circuit Reference	Function	Description
CV.7113	MR1–MR12	Rectifier	Silicon power diode
1S5051A	MR13,14,15	Voltage stabilizers	Silicon Zener voltage regulator
CV.7113	MR16	Safety diode	Silicon power diode

TABLE 2

Relay operation and functions in the power supply

Relay contacts	Control	Operation performed
RLA1	Heater switch	28-volt supply to valve heaters
RLA2	Heater switch	Oven heating
RLA3	Heater switch	28-volt relay supply switching
RLB1 RLB2 RLB3	H.T. switch	Power supply to the 200-volt 3-phase primary winding
RLB4	H.T. switch	28-volt relay supply switching

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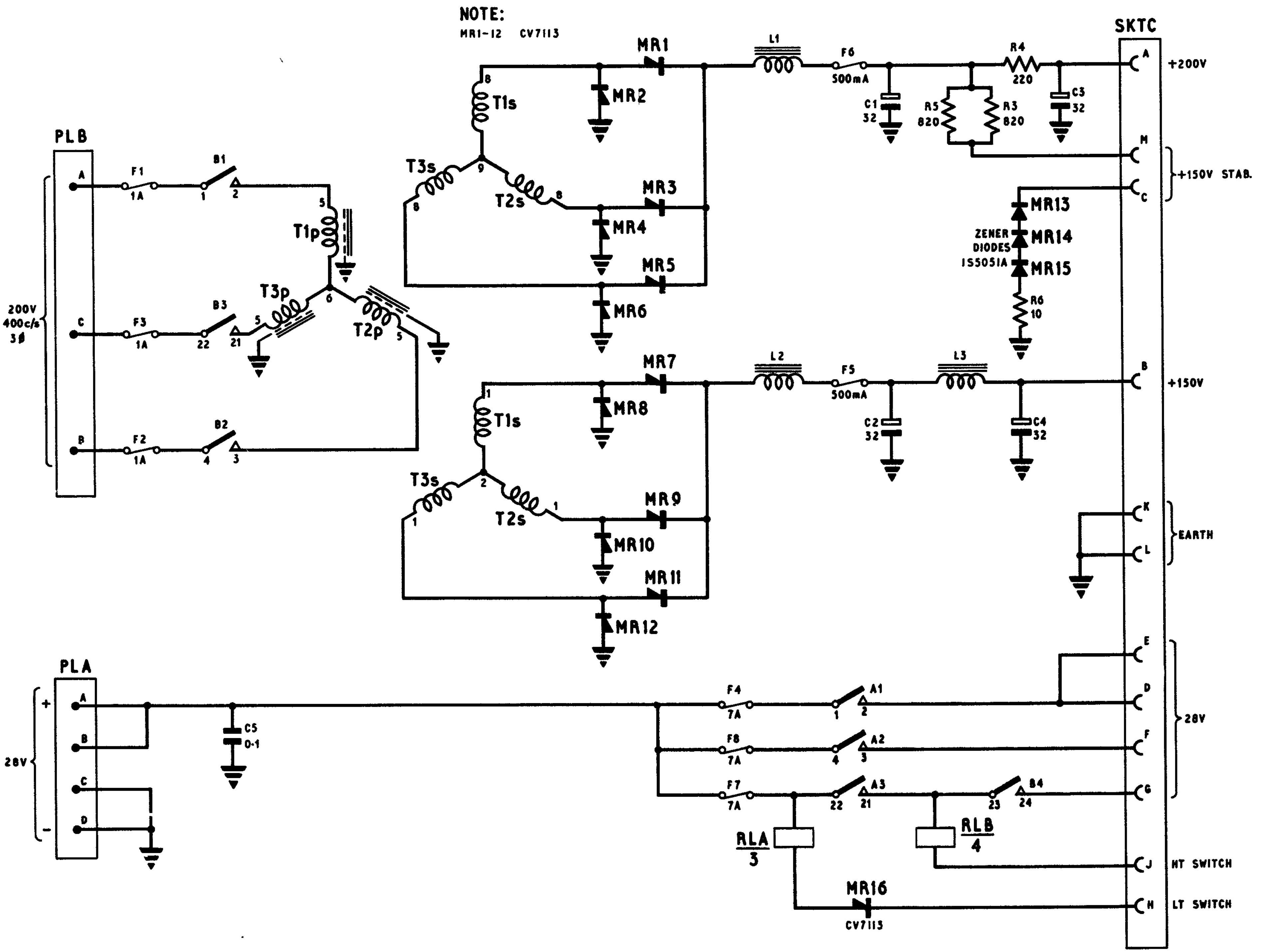

Fig. 4 Power supply 6625-99-913-2932: circuit Fig. 4

Chapter 5

TEST SET RADIO FREQUENCY POWER 6625-99-913-2931

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The test set r.f. power 6625–99–913–2931 is a compact portable instrument intended for measurement of r.f. ouput power up to 200 watts over the frequency range of the transmitter-receiver used in the ARI.18179, i.e. 2 Mc/s to 20 Mc/s. The input impedance of the test set is nominally 50 ohms.

Construction

2. A robust metal case is used to house the test set r.f. power, the former being well ventilated by louvres to allow free air flow through the instrument.

3. A thermocouple 0–2A meter is used as the r.f. current indicator, the meter being mounted low

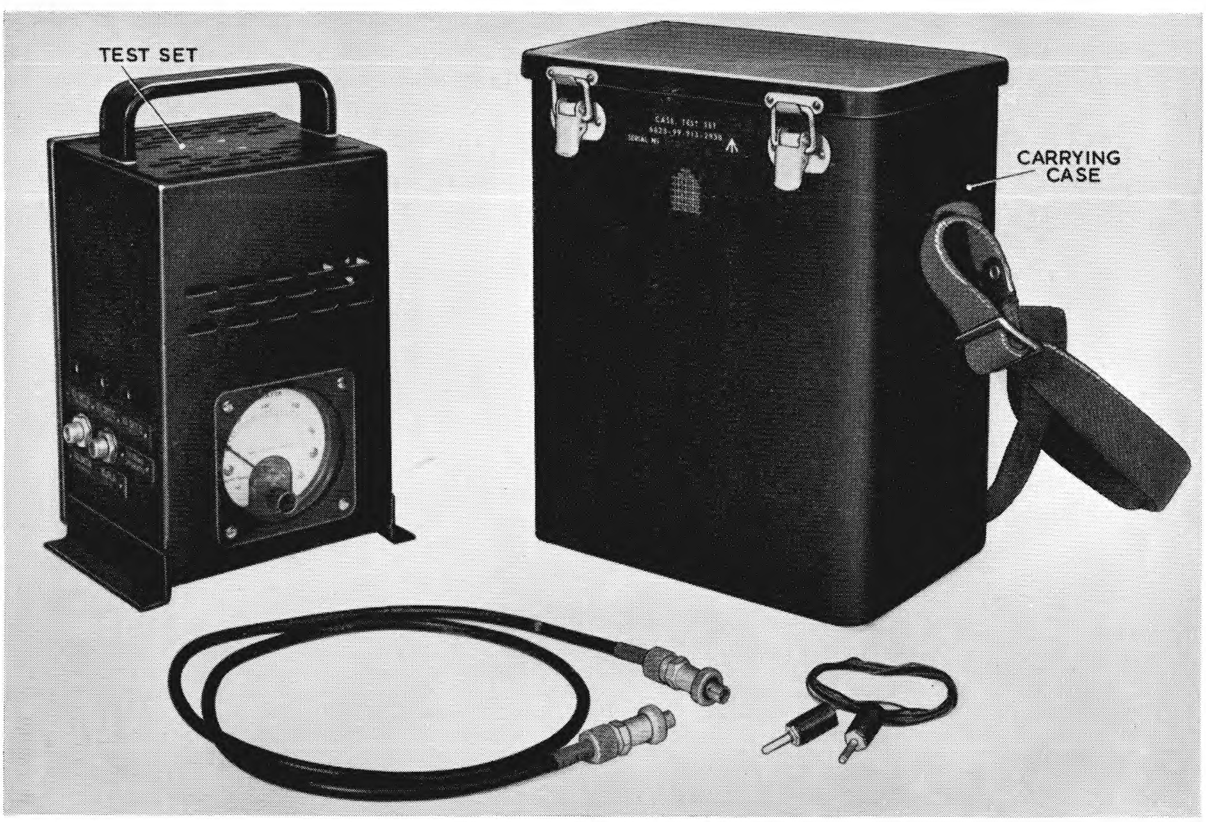

Fig. 1. Test set r.f. power and carrying case

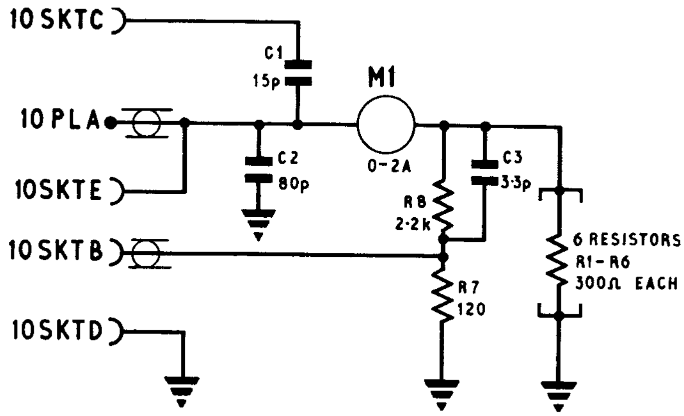

Fig. 2. Test set r.f. power 6625–99–913–2931: circuit

down on the front face of the case of the test-set. The front of the meter is protected by a perspex cover.

4. At the side of the test set r.f. power are three wander sockets and one coaxial plug and socket. The wander sockets are provided so that connection may be made to a valve voltmeter and cathode ray oscilloscope. The coaxial plug and socket are for connection to the transmitter and test set radio (Chap. 2) respectively.

5. A carrying handle is provided at the top of the instrument and angle brackets at the bottom act as feet for support on the bench.

6. Test set r.f. power is designed to be carried in the case provided for it (fig. 1). This case has a webbing carrying strap attached, for easy transportation and is provided with two clips at the front to retain the lid. All necessary coaxial and wander leads are accommodated in the carrying case

Circuit description

7. A circuit diagram of the test set r.f. power is given in fig. 2. The main resistance load is formed by six parallel non-inductive resistors R1–R6, capacitor C2 provides correction for the inductive component of the resistors at high frequencies. The thermo-couple meter indicates the r.m.s. value of r.f. current hence taking into account resistors R7, R8 the meter scale can be calibrated directly in r.f. watts.

8. Resistors R7, R8 form a potential divider network to provide an input voltage for the test set radio, this voltage appears on 10–SKTB. A small capacitor C3 is provided across R8 to correct the dividing action of resistors R7, R8 at the higher frequencies.

9. Radio frequency power is applied to the test set at coaxial plug 10–PLA, a r.f. voltage is available through coupling capacitor C1 for application to a cathode-ray oscilloscope if required. This appears at socket 10–SKTC.

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PART 3

FAULT DIAGNOSIS

Chapter 1

FAULT DIAGNOSIS OF TRANSMITTER-RECEIVER EQUIPMENT

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

WARNING . . .

This equipment uses comparatively high voltages and care must be taken to avoid physical contact with such voltage points when locating faults with the equipment withdrawn from its cover assembly and the power supplies switched on.

INTRODUCTION

1. The information contained in this chapter is intended as a guide to the location of simple faults. It should be used in conjunction with the servicing information contained in the appropriate chapters of Part 2 of this publication.

2. In the subsequent information given it will be assumed that the mains a.c. supply is present at the wall switch controlling the unserviceable equipment (for bench servicing) and that the equipment test rig installations are used. It is also assumed that the major unit is withdrawn from or pushed back into the cover assembly as required.

3. Fault diagnosis is given in this chapter in two parts namely:—

(1) Installation faults

(2) Diagnosing unit faults

The first case deals with faults which are apparent in the airborne installation and include faults which may occur on air testing of the transmitter-receiver. The second case provides the main diagnosis for simple faults in a repair workshop.

4. Prefix numbers for the various sub-units and appropriate references together with abbreviated titles which are used in the tabulated information which follows, are given in Table 1. An interconnection diagram for the transmitter-receiver appears in fig. 3 and for the complete ARI in fig. 4 at the end of this chapter.

TABLE 1

List of sub-units and references in s.s.b. transmitter-receiver

Sub-unit	Abbreviation	Circuit Prefix No.	Reference			
			Part	Sect.	Chap.	Fig.
Transmitter-receiver						
Amplifier r.f. 5821-99-913-2241	r.f. sub-unit	1B	4	1	1	4
Oscillator r.f. (1·5 Mc/s) 5821-99-913-2236	1·5 Mc/s crystal oscillator	1E	4	1	2	3
Amplifier intermediate frequency 5821-99-913-2251	i.f. sub-unit	1C	4	1	3	5
Control electrical frequency 5821-99-913-2234	c.e.f. sub-unit	1J	4	1	4	4
Amplifier audio frequency 5821-99-913-2237	a.f. sub-unit	1H	4	1	5	3
Modulator radio transmitter 5821-99-913-2235	Modulator sub-unit	1F	4	1	6	5
Control frequency selector 5821-99-913-2240	frequency selector (single-turn)	—	4	1	10	3
Generator reference signal						
Oscillator r.f. (5 Mc/s) 5821-99-913-	5 Mc/s standard oscillator	5	4	2	3	4
Oscillator r.f. (1 Mc/s) 5821-99-913-2230	1 Mc/s I.G.O.	5D	4	2	4	5
Oscillator r.f. (100 Kc/s) 5821-99-913-2228	100 Kc/s I.G.O.	5E	4	2	5	4
Oscillator r.f. (10 Kc/s) 5821-99-913-2229	10 Kc/s I.G.O.	5F	4	2	6	4
Oscillator r.f. (1 Kc/s) 5821-99-913-2231	1 Kc/s Wadley		4	2	7	5
Mixer stage frequency 5821-99-913-2227	—		4	2	8	4
Amplifier oscillator 5821-99-913-2233	—		4	2	9	5

INSTALLATION FAULTS

Misleading results

5. During ground testing of the airborne equipment it is possible for misleading results to be obtained if the aircraft is subject to the effects of local structures such as hangars, large metallic screens or even the steel deck of an aircraft carrier. Allowance for this form of "fault" must be made and if necessary tests should be conducted on a clear site.

6. Under the conditions mentioned the fault may appear as weak reception or no reception at all if the local screening is particularly effective. This is particularly true in the case of aerial parameter measurements such as voltage standing wave ratio (v.s.w.r.) also the polar diagram of the aerial will be changed due to proximity of metallic objects, or because the wings of the aircraft are folded as on an aircraft carrier.

7. Generally "faults" of this nature appear as incorrect readings on the test equipment used. In this connection it is important to eliminate the transmitter-receiver from the diagnosis by checking this separately with the suppressed aerial disconnected and the test set r.f. power substituted.

8. In Table 2 details of faults most likely to arise are given from experience with the equipment so far gained. Symptoms and probable causes are given for faults which can be checked in the aircraft.

Table 2

Location of installation faults

Symptom	Probable cause
Control radio set panel lights fail to operate	28V d.c. supply faulty. Check fuses F.S.9 and F.S.10 on front panel of power supply.
No receiver noise heard in headphones.	Faulty a.f. amplifier in transmitter-receiver.
Reception possible on one band but not others.	Channel tuning on control frequency selector requires adjustment.
Receiver will not tune correctly.	Clutch mechanism on control frequency selector not operating correctly. Check interlock system is working correctly.
Transmitter will not tune correctly.	Clutch mechanism of multi-turn control frequency selector. F.G.U. frequency setting incorrect.
No power output from transmitter	Press-to-talk button and associated circuit not functioning. Unserviceable valves in the power amplifier. Interconnecting coaxial cable between transmitter-receiver unit and power amplifier open circuit. Capacitors C33, C35, C36, C37, C38 or C39 burned out due to mismatch. Faulty switch wafer contacts in the transmitter-receiver unit.
Tuning system hunting.	Burrs on slow cams of multi-turn control frequency selector causing latch lever to jump and not locate.
Aerial system will not tune on any channel.	Variable capacitor in aerial tuner jammed against stop due to control frequency selector in the selector unit being set-up near the zero position too harshly.
Interlock inoperative control frequency selector motor runs continuously.	Most likely cause due to burrs on the slow cams of control frequency selector (multi-turn) causing the mechanism to stop just before selecting correct position on tuning drum. Faulty F.G.U. not in phase-lock.

DIAGNOSING UNIT FAULTS

General

9. A systematic method of fault location is given in the following paragraphs of this chapter, this is intended as a guide to the location of defective sub-units and valves in the transmitter-receiver equipment as a whole.

10. The information given is related to a "standard" arrangement of the test conditions (para. 17). The power supply requirements at the bench are:—

(1) 200V 400 c/s three-phase a.c.

(2) 28V d.c. supply

11. The transmitter-receiver equipment must not be switched on with any of the sub-units removed or disconnected as the series valve heater arrangement will cause the remaining valves to be overrun.

Test equipment

12. The test equipment required is as follows:—

(1) Generator signal 6625-99-913-2933

(2) Power supply 6625-99-913-2932

(3) Test set radio 6625-99-913-2929

(4) Test set r.f. power 6625-99-913-2931

(5) Test rig installation 6625-99-913-2926

(6) Headphones Type 9 (Ref. No. 10AH/141)

(7) Multimeter Type CT429

(8) Bench connector set, including extension leads for sub-units

(9) Oscilloscope CT414

13. A diagram of the arrangement of the test equipment and interconnecting cables is given in Part 1, Sect. 2, Chap. 3 of this publication. As the equipment may be running on the test rig installation without blower motors, it is imperative that the covers are first removed from all items of the ARI before switching on the power supplies.

WARNING . . .

High voltage points are exposed when equipment covers are removed and appropriate care must be taken to avoid physical contact with these points.

Fault location procedure

14. A number of quick checks concerning the functioning of the power supply circuits in the transmitter-receiver equipment may be made by direct observation of the following:—

(1) A.C. input. Observe that the valve heaters and dial lamps are glowing.

(2) D.C. input. Observe the operation of relays, electromechanical switches and motors.

(3) H.T. supply. Check the readings given on the front panel meters of the power amplifier and F.G.U. (*figs.* 1 *and* 2).

(4) Bias supply. Check the reading on the power amplifier front panel meter (switch position 5) after pressing the press-to-talk button.

FAULT LOCATION OF TRANSMITTER-RECEIVER UNIT (5821-99-913-2249)

15. Table 3 gives a number of possible defects in the operation of the transmitter-receiver unit and lists the probable sub-unit and/or valve which could cause the defect.

TABLE 3

Fault location transmitter-receiver 5821-99-913-2249

Observed effect	Defective circuit: Sub-unit	Defective circuit: Valve/circuit
Failure to select channel	Control frequency selector (single-turn)	Burrs on selector mechanism. Relay contacts and switches inoperative. Loose tensioning nut on slipping clutch mechanism.
Control frequency selector motor inoperative	Control frequency selector (single-turn).	Faulty relay RLA/4 Faulty selector motor X1. Faulty switch section SCa or b. Open circuit in wiring from plug PLA. Faulty switch contacts SA, SB, SD.
Distortion of audio signals on reception and transmission.	Modulator radio frequency.	Balanced modulator circuits out of alignment. Faulty valves V1-V4.
No i.f. output to amplifier r.f. sub-unit.	Modulator radio frequency.	Faulty valves V5-V7.
No receiver noise in headphones.	Control frequency selector. Amplifier—r.f.	Channel tuning setting out of adjustment. Resistors R12, R15 open circuit. Valves V1, V2 not functioning,
Reception possible on one band but not others.	Amplifier r.f.	Faulty wafer switch contacts PF5a, PF5b, PF6a, PF6b, PF6c.
No modulation when using microphone.	Amplifier a.f.	Faulty a.f. amplifier valves V1, V2, V3. Faulty relay switching circuits RLA/4.
Low or no carrier when speech is not applied to input.	Modulator r.f.	Faulty valves V5, V6. Faulty resistor RV5.
Distortion of speech under reception condition.	Control electrical frequency.	Faulty valves V1 or V2. Setting of potentiometers RV2, RV1 require adjustment.
Intermittent or faulty operation after channel switching is completed.	Amplifier r.f.	Dirty switch wafer contacts. Arcing of ledex switches and jamming of contacts.

Voltage measurements

16. When voltage measurements for fault diagnosis are to be taken in sub-units under operating conditions, it is necessary to use the approved extension connectors between the main-frame and the sub-unit, the transmitter-receiver remaining connected to the test rig installation.

17. The conditions under which the test voltages should be measured are:—

(1) Input voltages at nominal i.e. 28V d.c. and 200V a.c. at the supply terminals.

(2) Receiver gain control fully clockwise.

(3) Microphone input level −38dBm.

(4) Receiver input direct to the transmitter-receiver coaxial socket at rear of amplifier r.f.

(5) Microphone equalizing capacitors in the junction box short circuited.

18. As mentioned earlier (para. 16) the use of patching or extension cables may be used for fault-finding. It should be remembered however that this facility should only be used for simple fault finding and not for performance checking or alignment since the additional length of lead introduced by the patching cable will alter the performance of the sub-unit concerned at high frequencies.

19. All the readings given are with respect to the chassis and d.c. voltages are positive unless otherwise indicated.

TABLE 4

Valve pin voltages, transmitter-receiver 5821-99-913-2249

Valve				Multimeter type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
R.F. unit (amplifier r.f. 5821-99-913-2241)						
V1	CV4009	1	Control grid		—	Control radio set selector
		2	Suppressor		0	switch set to (R) Receive.
		3	Heater		—	
		4	Heater		—	
		5	Anode	300V	185	H.T. adjusted to 205V
		6	Screen grid	100V	96	with no r.f. or oscillator
		7	Cathode	3V	0·97	inputs.
V2	CV4014	1	Control grid		—	
		2	Cathode	3V	2·4	
		3	Heater		—	
		4	Heater		—	
		5	Anode	300V	197	
		6	Suppressor		0	
		7	Screen grid	300V	197	
V3	CV4014	1	Control grid		—	Control radio set selector
		2	Cathode	3V	1·8	switch to T & R and
		3	Heater		—	P.T.T. button depressed.
		4	Heater		—	
		5	Anode	300V	200	
		6	Suppressor	3V	1·8	
		7	Screen grid	300V	200	
V4	CV4055	1	i.c.			
		2	Control grid			
		3	Cathode	10V	7·0	
		4	Heater			
		5	Heater			
		6	—			
		7	Anode	300V	200	
		8	Screen grid	300V	200	
		9	Suppressor			

TABLE 4—*continued*

Vale				Multimeter type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
Oscillator r.f. (1·5 Mc/s) 5821-99-913-2236						
V1	CV4014	1	Control grid			Functions with control radio set switched to (R) or (T & R).
		2	Cathode	3V	2	
		3	Heater			
		4	Heater			
		5	Anode	300V	200	
		6	Suppressor		0	
		7	Screen grid	300V	195	
Amplifier i.f. 5821-99-913-2251						
V1	CV4015	1	Control grid			Functions with control radio set switched to R or T & R.
		2	Cathode	3V	2·2	
		3	Heater			
		4	Heater			
		5	Anode	300V	170	
		6	Suppressor grid	3V	2·2	
		7	Screen grid	300V	170	
V2	CV4015	1	Control grid			
		2	Cathode	3V	2·2	
		3	Heaters			
		4	Heaters			
		5	Anode	300V	170	
		6	Suppressor grid	3V	2·2	
		7	Screen grid	300V	170	
V4	CV4015	1	Control grid			
		2	Cathode	10V	3·3	
		3	Heaters			
		4	Heaters			
		5	Anode	300V	175	
		6	Suppressor grid	10V	3·3	
		7	Screen grid	300V	175	
V7, V8	CV4058	1	Anode	300V	175	
		2	i.c.			
		3	Heater			
		4	Heater			
		5	Anode	300V	175	
		6	Control grid			
		7	Cathode	30V	14	
V9, V10	CV4024	1	Anode 1	300V	165	
		2	Control grid			
		3	Cathode	3V	2·5	
		4	Heater			
		5	Heater			
		6	Anode	300V	165	
		7	Control grid			
		8	Cathode	3V	2·5	
		9	Heater c.t.			

TABLE 4—*continued*

Valve				Multimeter type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
Control electrical frequency 5821-99-913-2234						
V1	CV4024	1	Anode 1	100V	68	Functions when control radio set is at the (R) receive position.
		2	Control grid			
		3	Cathode	3V	1·5	
		4	Heater			
		5	Heater			
		6	Anode	100V	68	
		7	Control grid			
		8	Cathode	3V	1·5	
		9	Heater c.t.			
V2	CV4024	1	Anode 1	300V	115	
		2	Control grid			
		3	Cathode	100V	68	
		4	Heater			
		5	Heater			
		6	Anode	300V	115	
		7	Control grid			
		8	Cathode	100V	68	
		9	Heater c.t.			
Amplifier a.f. 5821-99-913-2237						
V1	CV4085	1	Screen grid	100V	30	
		2	—			
		3	Cathode	1V	0·65	
		4	Heater			
		5	Heater			
		6	Anode	30V	25	
		7				
		8	Suppressor			
		9	Control grid			
V2	CV4059	1	Anode			
		2	Cathode	30V	25V	
		3	Heater			
		4	Heater			
		5	Cathode	3V	1·9V	
		6	Control grid			
		7	Anode	300V	105	
V3	CV4024	1	Anode 1	300V	120	
		2	Control grid			
		3	Cathode	300V	113	
		4	Heater			
		5	Heater			
		6	Anode 2	300V	140	
		7	Control grid			
		8	Cathode	100V	40	
		9	Heater c.t.			

TABLE 4—*continued*

Valve				Multimeter type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
V4	CV4014	1	Control grid			
		2	Cathode	3V	1·7	
		3	Heaters			
		4	Heaters			
		5	Anode	300V	190	
		6	Suppressor	3V	1·7	
		7	Screen grid	300V	200	
Modulator radio transmitter 5821-99-913-2235						
V.1, V2 V3, V4	CV2432	1	Control grid			H.T. is applied when control radio set selector switch is in the R or T & R position.
		2	Cathode	10V	7·0	
		3	Heaters			
		4	Suppressor grid		0	
		5	Anode	300V	100	
		6	Heaters			
		7	Screen grid	300V	170	
		8	Cathode	10V	7·0	
V5	CV4014	1	Control grid			H.T. is applied when control radio set is switched to T. & R. and P.T.T. button depressed.
		2	Cathode	3V	1·4	
		3	Heater			
		4	Heater			
		5	Anode	300V	160	
		6	Suppressor	3V	1·4	
		7	Screen grid	300V	165	
V6	CV4024	1	Anode 1	100V	95	H.T. is applied when control radio set is switched to T. & R. and P.T.T. button depressed.
		2	Control grid			
		3	Cathode	3V	1·0	
		4	Heater			
		5	Heater			
		6	Anode 2	300V	195	
		7	Control grid			
		8	Cathode	3V	2·0	
		9	Heater c.t.			
V7	CV2432	1	Control grid			H.T. is applied when control radio set is switched to T. & R. and P.T.T. button depressed.
		2	Cathode	3V	2·0	
		3	Heater			
		4	Suppressor grid		0	
		5	Anode	100V	95	
		6	Heater			
		7	Screen grid	100V	97	
		8	Cathode	3V	2·0	

Control frequency selectors

20. Fault location on the control frequency selectors is mainly confined to d.c. point-to-point testing. It should be noted that when the units are in the "off" condition certain relay contacts are released compared with the normal stand-by condition of T & R; thus paths to earth (etc.) may not be complete. A listening rod applied to relays is a useful check of their operation.

Relay contacts

21. Any malfunctioning of relay RLA/4 contacts may cause the motor X1 not to run or fail to reverse.

Motor will not operate—tightness

22. This can be due to over-meshed gearing in the gear train but is more likely to be due to tightness and/or lack of oil in the shaft bearings. This symptom can also be caused by the motor clutch setting being too tight.

Selector motor runs continuously

23. This may be due to one or more of the following:—

(1) Burrs on the cams of the tuning shaft. When the notches on the cams are presented to the projections on the spring-loaded lever by rotation of the selector and tuning shafts, the lever is located by a latch spring and so stops the rotation of the tuning shaft. If burrs appear on these cams the latch lever will not locate and the motor will continue to run.

(2) Loose adjusting nut on the spring tension to the slipping clutch mechanism.

Selector motor will not start

24. If the drive motor X1 in either the single-turn or multi-turn selector will not start to run when the channel selector switch of the control radio set is changed, this may be due to one or more of the following faults:—

(1) Faulty action or contacts of RLA/4

(2) Faulty selector motor X1

(3) Faulty switch section SCa or SCb

(4) Open circuit in wiring from plug

(5) Faulty switch contacts SA, SB, SD

(6) Loss of 28V d.c. supply to RLA/4 and motor X1

Note . . .

When a fault is peculiar to one channel it can usually be traced from the appropriate circuit.

FAULT LOCATION IN AMPLIFIER R.F. 5821-99-913-2232

25. Some diagnosis of faults in the amplifier r.f. (power amplifier) can best be carried out by the use of the front panel mounted meter M1 in conjunction with the 12-position switch SA (*fig.* 1). For further diagnosis a multimeter Type CT429 for measuring valve electrode potentials is used.

26. A list of typical faults and an indication of suspected items appears in Table 5. Valve electrode r.f. potentials are given in Table 6.

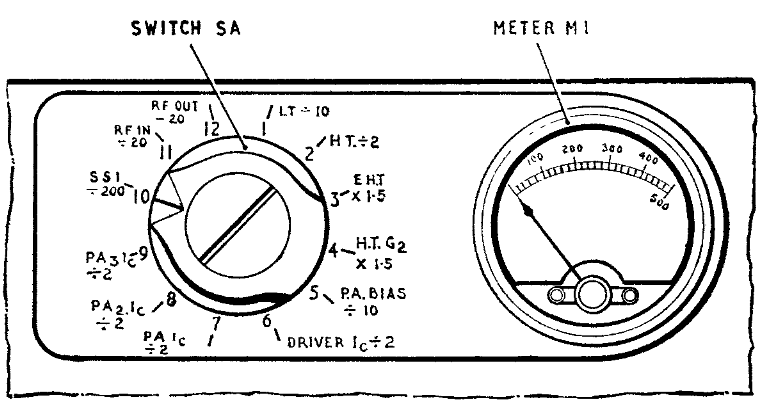

Fig. 1. Amplifier r.f. test switch selector and indicator

TABLE 5

Typical faults in amplifier r.f. 5821-99-913-2232

Observed effect	Defective circuit	
	Component	Valve
Low power output	Low drive from transmitter-receiver unit Power amplifier valve cathode current low. A.G.C. setting incorrect (RV.1).	V2, V3, V4
No output	Control frequency selector (multi-turn) causes coil runner of L5 or L15 to jump free from the coil turns. Setting of RV1 too high giving too much a.g.c.	
Power amplifier will not tune.	F.G.U. frequency setting incorrect. Control frequency selector (multi-turn) not functioning correctly (para. 20).	
Automatic load control circuit inoperative.	Faulty fuse F.S.5 in the power unit.	Transistor VT1 inoperative.
F.S.D. on front panel meter when switched to P.A. cathode current.		Valve V1 in power unit inoperative.
No power-amplifier cathode current.	Faulty or unserviceable power-amplifier valves Incorrect tuning point RV1 set incorrectly	V2, V3, V4

TABLE 6

Test r.f. potential readings for amplifier r.f.

Frequency		Voltage at "R.F. In" (ITP.1)		Voltage Grid V1		Voltage Grid V2-V4		Power output (P.E.P.)
		A.G.C. ON	A.G.C. S/C	A.G.C. ON	A.G.C. S/C	A.G.C. ON	A.G.C. S/C	A.G.C. ON
Band 1	2·5	7	8	17·5	19·5	32	36	240W
	3·75	7·6	13·5	18	32	36	46	220W
	5·0	11·5	13	28	32	35	37	180W
Band 2	5·0	6·6	8·3	16·2	20	34	38	240W
	7·5	7·5	8·2	21	23	34	36	250W
	10·0	4·2	7·1	15	23	36	41	240W
Band 3	10·0	4·5	4·7	16	16·5	31	32	240W
	15·0	2·3	3·4	11·5	14	32	36	220W
	20·0	4·6	5·4	8·2	9	37	37·5	200W

Note . . .

All readings measured with multimeter type CT429.

27. When using Table 6 the transmitter a.g.c. is set for a reading of 340 average P.A. cathode current on the front panel meter M1 (*fig.* 1). This reading must not in any case exceed 360.

28. The automatic gain control voltage S/C (short-circuit) measurements are made by momentarily short-circuiting ITP2 to earth (ITP3). This short circuit should be made just long enough to obtain a reading, since under these conditions the P.A. valves V2, V3, V4 can have a very high dissipation.

FAULT LOCATION IN POWER SUPPLY UNIT

29. Many of the relays associated with the supply line switching are housed in the power supply 5821-99-913-2246. A list of these relays and their functions appears in Part 4, Sect. 1, Chap. 9, of this publication and reference should be made to Tables 3 and 4 of Chap. 9 to assist in fault diagnosis.

30. Since the power supply unit controls the supplies to the suppressed aerial in addition to the transmitter-receiver and power amplifier, location of faults in the power supply unit becomes more complex since a fault in another item may appear as an apparent fault in the power supply.

31. In general the power supply should give little trouble and if the unit is suspected of being unserviceable it is a simple matter, first of all to check the fuses which are located on the front panel.

32. Apart from relay contacts and fuses the other most likely form of trouble to be encountered is the −35V stabilized bias supply. A break-down in diode MR28 (CV7040) could cause the bias voltage to be low or disappear completely with disastrous results for the power amplifier valves.

33. If the valve V1 is not functioning in whole or in part the −35V stabilizing circuit will not function and the transmitter bias voltage will vary with drive.

34. Other factors which can affect the −35V stabilized supply are faulty capacitors on the input and output sides of the stabilizer circuit. If C1 or C11, C12, developed a leak or open circuit this could also give rise to bad stabilizing action from the circuit.

35. The other stabilized voltages i.e. +300V, 150V and associated circuits are comparatively simple and little trouble should be realized.

36. Table 7 provides a guide for fault finding in the power supply unit the figures given are typical for an average equipment.

TABLE 7

Test potential readings for power supply unit

Valve	Type	Pin No.	Electrode	Voltage to earth
V1A		1	Anode	125
		2	Grid	−2·2
		3	Cathode	Earth
V1B		6	Anode	205
		7	Grid	− 39
		8	Cathode	− 35
V2		1, 2, 3	Anode	145
		4	Primer	145
		5, 6, 7	Cathode	Earth
V4		T.C.	Anode	630
		4	Screen grid	630
		5	Control grid	250
		8	Cathode	300
V5		1	Grid	125
		2	Cathode	130
		5	Anode	250
		6	Suppressor	130
		7	Screen grid	350
V6		1, 2, 3	Anode	130
		4	Primer	130
		5, 6, 7	Cathode	Earth

Note . . .

The voltage at pin 4 *of RLE/*2 *is* 208*V.*
*The voltages at the electrodes of valve V*1 *will vary with the setting of RV*1, *whilst those of V*4, *V*5 *will vary with the setting of RV*2. *The voltages given in Table* 7 *are taken with RV*1 *adjusted for* −35*V on the bias line and with RV*2 *adjusted for* 300*V on the stabilized line.*

FAULT DIAGNOSIS IN THE F.G.U.

37. Fault diagnosis in the F.G.U. as far as this chapter is concerned is limited to diagnosis of the location to the particular sub-unit which may be faulty and including some typical faults which are commonly found in those sub-units.

38. Since a large number of frequencies are involved in the functioning of the F.G.U. it is sometimes impracticable to remove a sub-unit on a patching cord for servicing, since the whole F.G.U. is affected by the alteration in performance of the sub-unit concerned at high frequencies due to the patching cord.

39. In the case of a sub-unit as mentioned in para. 38, only d.c. voltages can be measured when the sub-unit is connected to the F.G.U. via the patching cord hence the diagnosis is limited to simple fault finding for these sub-units. The particular sub-units involved are:—

(1) Mixer stage frequency

(2) Amplifier oscillator

Fault diagnosis using F.G.U. front panel meter (*fig.* 2)

40. By using the front panel meter M1 and 12-position switch SA on the F.G.U. it is possible to diagnose which sub-unit is at fault. The switch positions are numbered from one to twelve and give indications of certain circuit functions of sub-units in the F.G.U. as follows:—

Switch position indication	*Meter reading*
(1) 25·2V heater supply	240—300
(2) 150V stabilized supply	300—340
(3) 150V unstabilized supply	280—340
(4) 200V h.t. supply	360—440
(5) 1 Mc/s i.g.o. signal	160—200
(6) 100 Kc/s i.g.o. signal	70— 90
(7) 10 Kc/s i.g.o. signal	50—250
(8) V.F.O. signal	50—250
(9) Reference signal	250—350
(10) Loop signal	220—280
(11) 2 Mc/s output	220—280
(12) Amp/osc output	170—210

41. Positions 1 to 4 check various supply voltages and 5 to 9 the synthesized signal. Position 10 of the switch SA checks the loop signal. If on *any one* of positions 5, 6, 7, 9, 11, 12, the meter M1 shows a zero indication, there will be no reading on position 10 thus showing no loop signal present.

42. In position 8 of the 12-way switch a constant meter reading of 400 would indicate that the amplifier-oscillator has not locked in frequency with the synthesized signal.

43. If all the readings selected from positions 1-12 are correct but on position 12 the meter needle flicks upwards and then returns to zero, the fault is indicated in the alignment of the motor control circuits of the amplifier-oscillator.

44. When no reading at all occurs on position 12 the most likely fault is dirty contacts on the ledex mechanism or possible open circuit contacts of this item due to wear.

45. No output reading in positions 5, 6 and 7 of the switch SA indicate a faulty 1 Mc/s 100 Kc/s or 10 Kc/s i.g.o. sub-unit. Here again ledex switch contacts being dirty or open circuit are the most probable cause of trouble.

46. Additionally, if a short circuit occurs in the tuning capacitors of the i.g.o's used this may cause resistors R4, R5, to burn out and no reading to be obtained when the 12-way switch is rotated to positions 5, 6 or 7.

47. A fault in the mixer stage frequency giving no loop signal on position 10 of the 12-way switch SA could indicate tuned circuits out of alignment. The re-alignment check should be carried out in accordance with A.P.4736A, Vol. 5, Part 6.

48. A fault which sometimes is found in practice is the non-locking of the amplifier-oscillator

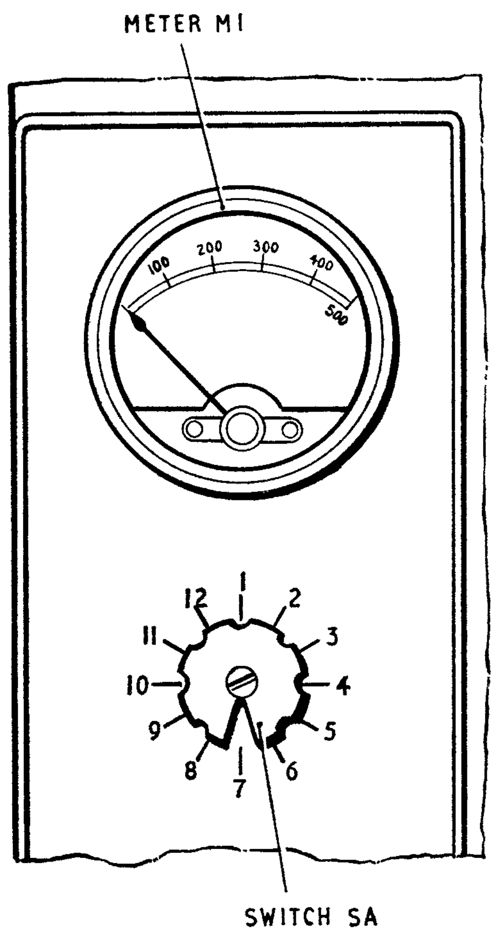

Fig. 2. F.G.U. test switch and indicator

frequency previously mentioned in para. 42, this may be due to the motor circuit potentiometer settings not being correct. A guide to this is the interlock "dolls-eye" not clearing on the CHAN position of the control radio set. This "dolls-eye" shows that the interlock system has not cleared.

49. Other faults commonly found with the amplifier-oscillator and the F.G.U. in general can be diagnosed to faulty ledex switch mechanisms due to wear. Cleaning the make-and-break contact usually provides a cure in these instances.

50. To asist in the location of faults in the F.G.U. a list of valve pin connections and associated d.c. voltages is given in Table 8.

TABLE 8

Valve pin voltages F.G.U. (Generator reference signal)

Valve				Multimeter type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
Oscillator r.f. (5 Mc/s)						
V1	CV2432	5	Anode	300V	112	Xtal inoperative
		7	Screen grid	100V	86	
		1	Control grid	10V	−6·9	
		2, 8	Cathode		0	
V1	CV2432	5	Anode	300V	106	Xtal operative
		7	Screen grid	100V	79	
		1	Control grid	10V	+6·0	
		2, 8	Cathode		0	
V2	CV2432	5	Anode	300V	120	Xtal inoperative
		7	Screen grid	100V	92	
		1	Control grid	10V	−4·1	
		2, 8	Cathode	3V	1·4	
V2	CV2432	5	Anode	300V	121	Xtal operative
		7	Screen grid	100V	90	
		1	Control grid	3V	2·7	
		2, 8	Cathode	3V	1·3	
Impulse governed oscillator 1 Mc/s steps						
V1	CV3929	5	Anode	300V	125	
		7	Screen grid	300V	115	
		2, 4, 8	Cathode	3V	1·8	
V2	E80T	T.C.	Anode	100V	70	
		1	Shield	300V	150	
		7	Beam plates	300V	100	
		9	Beam plates	300V	100	
V3	CV2492	1	Anode 1	300V	150	
		2	Grid 1	100V	75	
		3, 8	Cathode	100V	78	
		6	Anode 2	300V	150	
		7	Grid 2	100V	70	
V4	CV3929	5	Anode	300V	100	1 Mc/s at grid
		7	Screen grid	100V	70	1·6V±10%
		2, 4, 8	Cathode	1V	0·75	

TABLE 8—*continued*

Valve				Multimeter Type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
Impulse governed oscillator 100 Kc/s steps						
V1	CV3929	5	Anode	100V	70	
		7	Screen grid	100V	55	
		2, 4, 8	Cathode	1V	0·55	
V2	E80T	1	Shield	300V	150	
		7	Beam plates	100V	90	
		9	Beam plates	100V	90	
		T.C.	Anode	100V	71	
V3	CV2493	1	Anode 1	300V	150	
		2	Grid 1	100V	76	
		3, 8	Cathode	100V	79	
		6	Anode 2	300V	150	
		7	Grid 2	100V	71	
V4	CV5215	6	Anode-pen	100V	90	
		1	Anode-tri	100V	90	
		3	Screen grid	100V	80	
		2	Control grid pen.	10V	3·8	
		9	Control grid tri.	10V	3·0	
		—	R25, R26	10V	3·3	
		7, 8	Cathode	10V	7·5	
Impulse governed oscillator 10 Kc/s steps						
V1	CV3929	5	Anode	100V	75	
		7	Screen grid	100V	55	
		2, 4, 5	Cathode	1V	0·55	
V2	E80T	1	Shield	300V	150	
		7	Beam plates	100V	86	
		9	Beam plates	100V	86	
		T.C.	Anode	100V	70	
V3	CV2492	1	Anode 1	300V	150	
		2	Grid 1	100V	74	
		3, 8	Cathode	100V	78	
		6	Anode 2	300V	150	
		7	Grid 2	100V	70	
V4	CV5215	6	Anode-pen	100V	86	
		1	Anode-tri	100V	86	
		3	Screen grid	100V	75	
		2	Control grid pen	10V	3·8	
		9	Control grid tri.	10V	3·1	
		—	R25, R26	10V	3·2	
		7, 8	Cathode	10V	8·0	
Oscillator r.f. 1 Kc/s steps (Wadley)						
V1	CV3928	5	Anode	300V	150	
		7	Screen grid	—	—	
		2, 8	Cathode	3V	very low	

TABLE 8—*continued*

Valve				Multimeter Type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
V2	CV3929	5	Anode	300V	124	
		7	Screen grid	100V	72	
		2, 4, 8	Cathode	1V	0·8	
V3	CV3928	5	Anode	300V	135	
		7	Screen grid	100V	83	
		2, 8	Cathode	3V	1·0	
V4	CV3929	5	Anode	300V	140	
		7	Screen grid	100V	97	
		2, 4, 8	Cathode	1V	0·8	
V5	CV3928	5	Anode	300V	118	
		7	Screen grid	300V	104	
		2, 8	Cathode	3V	1·25	
V6	CV3928	5	Anode	300V	118	
		7	Screen grid	300V	104	
		2, 8	Cathode	3V	2·25	
V7	CV3929	5	Anode	300V	130	
		7	Screen grid	100V	84	
		2, 4, 8	Cathode	1V	0·9	
V8	CV3929	5	Anode	300V	110	
		7	Screen grid	300V	110	
		2, 4, 8	Cathode	3V	1·35	
V9	CV4029	5	Anode	300V	125	
		7	Screen grid	300V	128	
		2, 4, 8	Cathode	30V	14·7	
V10	CV477	5	Anode	300V	110	
		7	Screen grid	300V	110	
		2, 4, 8	Cathode	3V	1·85	
V11	CV2432	5	Anode	300V	100	
		7	Screen grid	300V	106	
		2, 8	Cathode	3V	very low	
Mixer stage frequency						
V1	CV3929	5	Anode	100V	85	
		7	Screen grid	300V	116	
		2, 4, 8	Cathode	3V	2·5	
V2	CV3929	5	Anode	100V	85	
		7	Screen grid	300V	116	
		2, 4, 8	Cathode	3V	2·5	
V3	CV3929	5	Anode	300V	113	
		7	Screen grid	300V	119	
		2, 4, 8	Cathode	3V	2·2	
V4	CV3928	5	Anode	300V	129	
		7	Screen grid	100V	99	
		2, 8	Cathode	3V	1·6	
V5	CV3929	5	Anode	300V	112	
		7	Screen grid	300V	117	
		2, 4, 8	Cathode	3V	2·3	

TABLE 8—*continued*

Valve				Multimeter Type CT429		
Circuit ref.	Type	Pin No.	Electrode	Range	Reading	Remarks
V6	CV3929	5	Anode	300V	111	
		7	Screen grid	300V	111	
		2, 4, 8	Cathode	3V	2·3	
V7	CV3928	5	Anode	300V	132	
		7	Screen grid	300V	99	
		2, 8	Cathode	3V	1·7	
V8	CV3929	5	Anode	300V	112	
		7	Screen grid	300V	118	
		2, 4, 8	Cathode	3V	2·2	
V9	CV3929	5	Anode	300V	116	
		7	Screen grid	300V	119	
		2, 4, 8	Cathode	3V	2·2	
V10	CV3928	5	Anode	100V	69	
		7	Screen grid	100V	54	
		2, 8	Cathode	1V	0·65	
V11	CV3929	5	Anode	300V	127	
		7	Screen grid	100V	98	
		2, 4, 8	Cathode	3V	1·9	
V12	CV3929	5	Anode	300V	136	
		7	Screen grid	100V	36	
		2, 4, 8	Cathode	—	—	
V13	CV3929	5	Anode	100V	36	
		7	Screen grid	100V	36	
		2, 4, 8	Cathode	—	—	
V14	CV3929	5	Anode	300V	145	
		7	Screen grid	300V	104	
		2, 4, 8	Cathode	3V	2·0	
V15	CV3929	5	Anode	300V	126	
		7	Screen grid	300V	103	
		2, 4, 8	Cathode	3V	2·1	
Amplifier-oscillator unit						
V1	CV4014	5	Anode	300V	195	
		7	Screen grid	300V	187	
		2	Cathode	10V	3·0	
		1	Grid	—	0	(R.M.S.)
V2	CV4010	5	Anode	300V	165	
		6	Screen grid	300V	170	
		2, 7	Cathode	30V	20	
		1	Grid	30V (a.c.)	16	(R.M.S.)
V3	CV2243	7	Anode	300V	195	
		8	Screen grid	300V	195	
		3	Cathode	10V	3·0	
		2	Grid	30V (a.c.)	13·0	(R.M.S.)
V4	CV4018	6	Anode	300V	180	
		5, 7	Screen grid	10V	8·0	
		2	Cathode	10V	8·0	
		1	Grid	—	0	
VT11 and VT12			Common emitter	3V	1·5	
VT13 and VT14			Common emitter	1V	0·5	
Collector voltages of VT11, 12, 13 and 14				3V	1·0	"OFF" state
				30V	25	"ON" state
Collector voltages of VT6 and VT7				30V	18·5V	In fast speed

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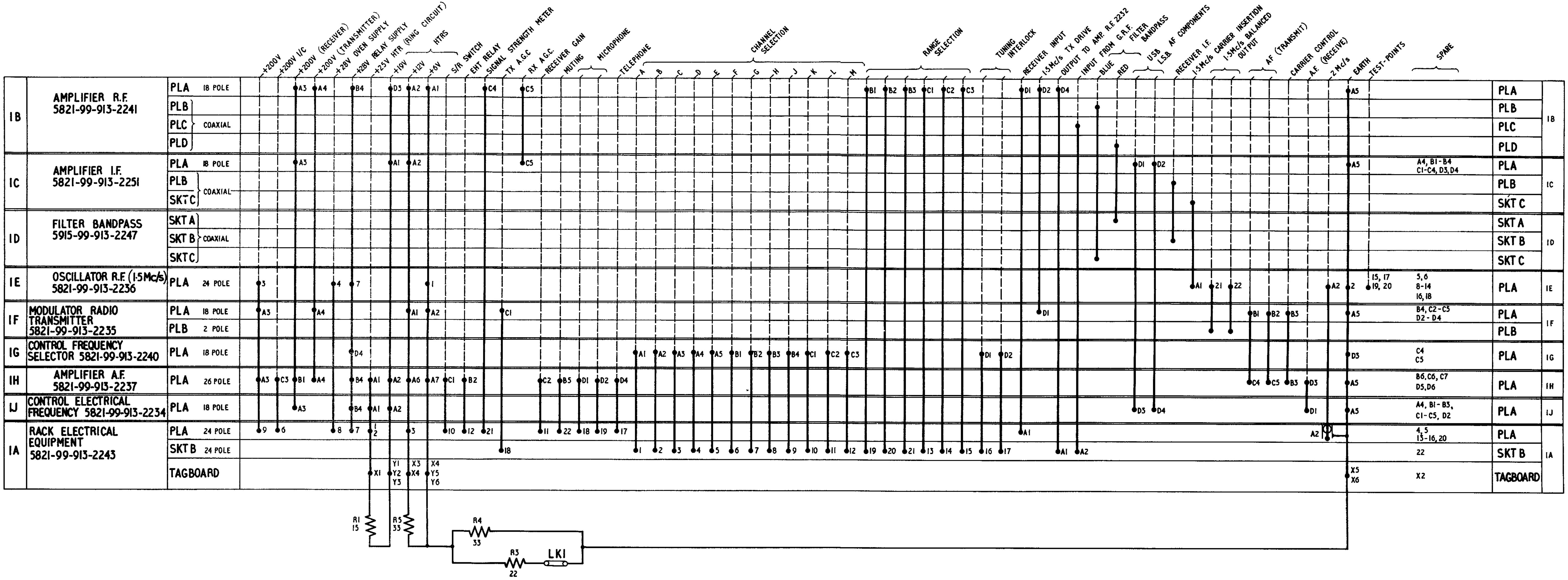

Transmitter-receiver radio 5821-99-913-2249: interconnections

Fig. 3

AIR DIAGRAM
6729AB/MIN.
ISSUE 1
PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY ADMIRALTY

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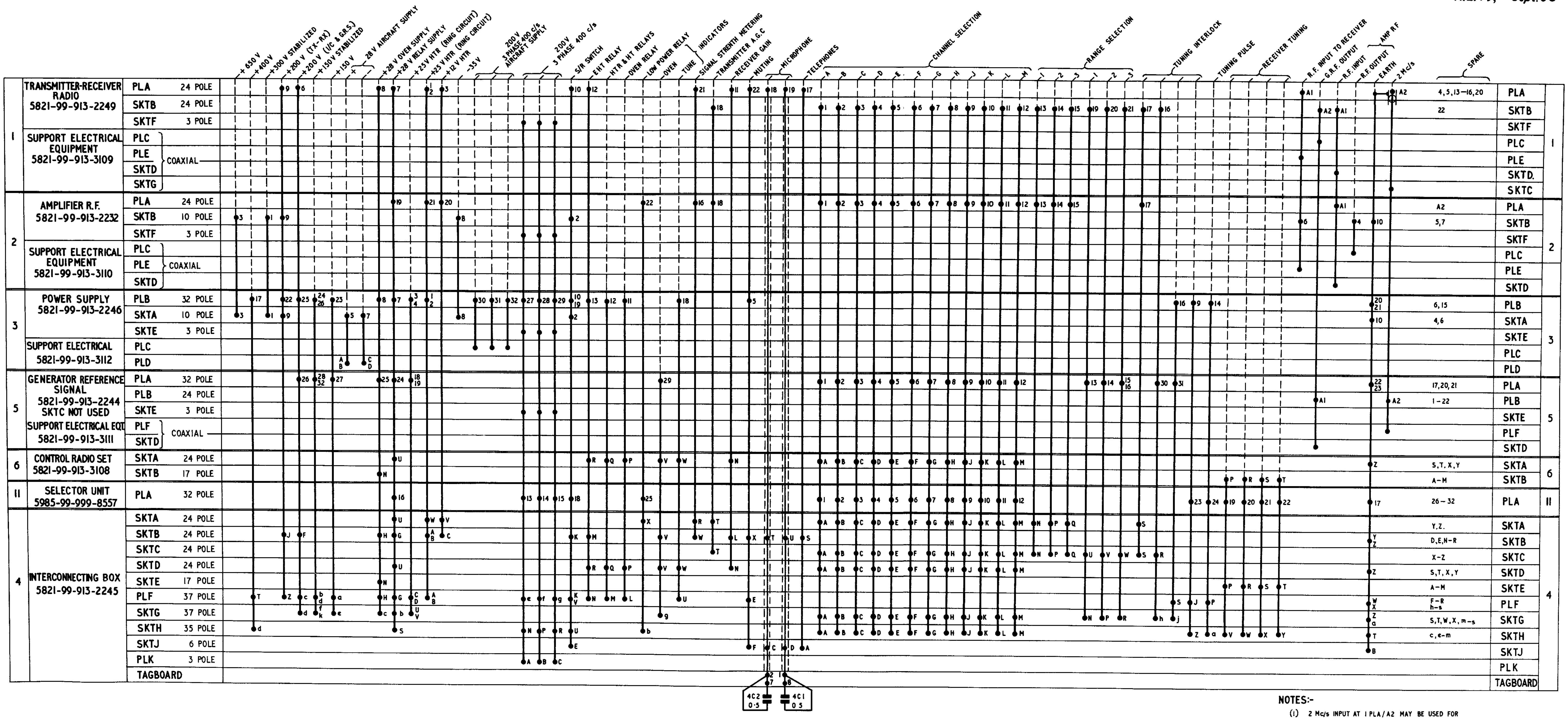

A.R.I. 18179/1 (excluding aerial system): interconnections.

NOTES:-

(1) 2 Mc/s INPUT AT 1 PLA/A2 MAY BE USED FOR D S B. WHEN INCORPORATED

(2) SHORTING LINKS ACROSS 4C1 AND 4C2 TO BE REMOVED WHEN TYPE 59 MICROPHONES ARE FITTED

AIR DIAGRAM
6729 AC/MIN.
ISSUE 2 — PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

Fig. 4

Chapter 2

FAULT DIAGNOSIS OF AERIAL TUNING EQUIPMENT

LIST OF CONTENTS

LIST OF TABLES

WARNING . . .

High r.f. potentials are developed in the suppressed aerial tuning equipment when it is operating, and consequently care must be taken when handling equipment in this condition. Protective covers should be used when these are available.

Introduction

1. The information contained in this chapter is intended as a guide to the location of simple faults. The chapter should be used in conjunction with that dealing with the servicing of the suppressed aerial tuning equipment in Part 2 of this publication.

2. In view of the nature of this equipment it will be assumed that it is connected in its test rig on a suitable bench and that the necessary supplies are available. It is also assumed that the covers of of the sub-units of the system are removed, preparatory to fault finding.

3. Fault diagnosis in this chapter will be divided into two parts, namely:—

(1) The diagnosis of certain possible faults.

(2) Information which will be of use in the location of faults which are not covered by the table of faults given.

4. Prefix numbers for the various sub-units, together with the chapter references of the circuit diagrams of these sub-units, is given in Table 1. The interconnection of these sub-units may be seen by consulting fig. 5 of Part 4, Sect. 3, Chap. 4 of this volume.

TABLE 1

List of sub-units, circuit prefixes and chapter references

Sub-unit	*Circuit prefix*	*Reference*			
		Part	*Section*	*Chapter*	*Fig.*
Selector unit 5985-99-999-8557	11	4	3	1	11
*Chassis electrical equipment 5985-99-999-8553	11A	4	3	1	11
*Control frequency selector 5821-99-913-2240	11B	4	3	1	4
*Amplifier electronic control 5895-99-999-8554	11C	4	3	1	7
*Selector control, sub-assembly 5985-99-999-8555	11D	4	3	1	11
Tuner, radio frequency 5950-99-999-8558	12	4	3	2	2
Network impedance matching 5915-99-999-8556	13	4	3	3	3

* Sub-units marked thus are sub-units of the Selector unit 5985-99-999-8557

FAULT DIAGNOSIS

Misleading results

5. If the suppressed aerial equipment is ground tested with the equipment mounted in the aircraft, then certain erroneous results may be obtained if testing takes place in the vicinity of hangars, large metallic objects or even on the steel deck of an aircraft carrier. These objects have a particular effect on the aerial system and it is therefore highly advisable to carry out fault finding with the equipment bench mounted.

Test equipment required

6. The test equipment required is as follows:—

(1) Indicator s.w.r. 6625-99-999-8551.

(2) Test rig installation, 5985-99-999-8547.

(3) Multimeter Type CT498.

(4) Transmitter-receiver of known serviceability.

7. When bench mounting the equipment, the network impedance matching 5915-99-999-8556 and the tuner, radio frequency 5950-99-999-8558 should be mounted in the test rig installation as specified in Part 2, Sect. 3, Chap. 1 of this volume. The transmitter/receiver is connected to the aerial equipment as shown in fig. 2 of Part 1, Sect. 2, Chap. 2.

Fault location table

8. The fault location table, given in Table 2, lists a number of possible faults and the probable fault source or sources.

TABLE 2

Fault location on the suppressed aerial equipment

Symptom	*Action*	*Probable fault*
1. Changes in channel at remote point do not cause change of of channel at aerial system.	1. Check fuse FS1 of the control frequency selector.	1. Faulty fuse.
	2. Check voltage at pin D4 of plug PLA of control frequency selector.	2. This should be +28 volts; if this is absent channel change cannot be instituted.
		3. If previously mentioned checks do not reveal fault source, then either RLA or the motor X1 are faulty.
2. Equipment will not set to a particular channel.		There is an open circuit in the connection to switch SE for that channel.
3. Control frequency selector functions correctly but tuner radio freqency does not retune or network impedance matching tapping point change.	1. Check voltage at junction of RLB/1 and SB6.	If the voltage at this point is not +28 volts then relay RLB is faulty.
4. Control frequency selector functions properly, and tuner, r.f. motor operates, but range relays of tuner r.f. and stepping motor of the network impedance matching do not function.	1. Check that the selector drum D.S. has adopted a new position.	1. If the drum does not move the fault probably lies in the drive to drum.
		2. If drum has moved fault lies in stepping motor SB.
5. When range is changed, the motor and relays of the tuner, radio frequency operate, but a new tapping point is not selected by the network impedance matching.		The stepping motor of the network impedance matching is probably at fault.
6. When range is changed, the tapping point changes in the network impedance matching, and the range relay of the tuner radio frequency operates, but tuner r.f. motor does not operate.	1. Check the a.c. voltage at contact 'b' of bridge potentiometer 11RV1. Initiate a frequency change and note this voltage. The voltage should have changed.	1. If there is no change of voltage with a channel change the drive to 11RV1 is faulty.
	2. If the previous test is correct, then again initiate the channel change and aurally check that the two phase motor (11C)PR/1 of the amplifier, electronic control operates.	2. If the motor does not operate the fault lies either in the motor or in the circuits of the amplifier electronic control which drive it.
	3. If the previous test does not reveal the fault then check the d.c. voltage appearing between pins 6 and 7 of plug PLB of the selector control sub-assembly. Initiate a frequency change and ensure that this voltage changes.	3. If the voltage noted is unchanged with a frequency change, or if no voltage is present, then the fault lies in the selector control sub-assembly. But if the voltages noted behave correctly, then the motor of the tuner r.f. is probably faulty.

Fault finding information

9. Information contained in the paragraphs which follow are intended to assist with the location of such faults as are not covered in the fault finding chart. The paragraphs should be read in conjunction with the relevant circuit diagrams.

Relay sequence

10. The equipment contains a number of relays, the action of which determines the action of the system as a whole. An examination of relay conditions will often help to localize a fault. In the table below the relay under consideration is, in each case, prefixed by the number of the sub-unit in which it is contained. The relays are mentioned, in most cases, in operational sequence, and the action of each set of contacts is given. The assumption is made that prior to the initiation of the sequence the equipment was operating at a particular frequency, i.e. only relays (11B) RLA/4, (11) RLB/1, (11) TC/1 and the appropriate range relay of the tuner, radio frequency were energized. The operating sequence is as follows: —

TABLE 3

Relay operating sequence

Relay	*Contact*	*Action*
(11B) RLA/4		De-energized due to a channel change.
	(11B) RLA1	Changes over and connects one side of motor (11B) XI to +28 volts.
	(11B) RLA2	Changes over and connects the opposite side of (11B) X1 to earth, causing motor to operate.
	(11B) RLA3	The contacts, which are hold on contacts for (11B) RLA/4, open.
	(11B) RLA4	Contacts open and break the earth path for coils of relays (11) RLB/1 and (11) TC/1.
(11) RLB/1		De-energizes.
	(11) RLB1	Contacts open and break path to +28 volts of ledex switch (11) SB/6 and relay (11) TA/2.
(11) TC/1		De-energizes.
	(11) TC1	Removes an earth from pin 23 of plug (11) PLA.
(11B) RLA/4		Energizes when motor (11B) X1 is driven to its zero position.
	(11B) RLA1	Changes over reversing the supply to (11B) X1.
	(11B) RLA2	Changes over and connects the opposite side of (11B) X1 to earth, reversing direction of rotation.
	(11B) RLA3	Contacts close and hold on (11B) RLA/4.
	(11B) RLA4	Contacts close and connect the coils of relays (11) RLB/1 and (11) TC/1 to switch (11B) SF which closes when the channel is selected.
(11) RLB/1		Energized when (11B) SF closes.
	(11B) RLB1	Contacts close, connecting the Ledex switch (11) SB6 and relay (11) TA/2 to −24 volts. The Ledex channel change switch operates and (11) TA/2 energizes.
(12) BA/1, BB/1 or BC/1		Energized as a result of channel selection and selects the appropriate tuning range of the tuner, radio frequency.
(11) TA/2		Energized.
	(11) TA1	Contacts close and connect the coil of relay (11) TB/2 between pins 6 and 7 of socket (11D) SKTA.

Table 3 — Relay operating sequence — *continued*

Relay	*Contact*	*Action*
	(11) TA2	Contacts change over and provide an earth path for the coil of relay (11C) TA1 and this relay is energized.
(11C) TA/1		Energized.
	(11C) TA1	Contacts change over and connect the error bridge transformer to the servo amplifier input.
(11) TB/2		Energizes due to the application of error voltage.
	(11) TB1	Contacts close and connect pin 23 of plug (11) PLA to earth.
	(11) TB2	Contacts close and connect the coil of (11) TA/2 to earth.
(11) TB/2		De-energizes when tuning is complete.
	(11) TB1	Contacts open and disconnect (11) PLA pin 23 from an earth connection.
	(11) TB2	Contacts open and disconnect coil of relay (11) TA/2 from earth.
(11) TA/2		De-energizes when transmitter tuning is complete.
	(11) TA1	Contacts open and break the path from (11) TB/2 coil to pin 7 of (11D) SKTA.
	(11) TA2	Contacts change over and break the path to earth of relay coil (11C) TA/1.
(11C) TA/1		De-energizes.
	(11C) TA1	Contacts change over and connect the input of the servo amplifier to the chopper for fine tuning.
(11) K/2		This relay is energized when the transmitter is keyed.
	(11) K1	Contacts open and break the path to earth of the coil of relay (11) FT/2.
	(11) K2	Contacts close and connect a 6V, 200 c/s supply to the coil of the chopper (11C) X1.
(11) FT/2		Energized when the fine tune switch of the remote control unit is depressed.
	(11) FT1	Contacts close and hold on (11) FT/2.
	(11) FT2	Contacts close and connect remote fine tune potentiometer across error bridge.

Set/operate/test switch

11. This key switch is located on the front panel of the selector unit 5985-99-999-8557. The switch has three positions and these positions and their functions are as follows: —

(1) SET — equipment operates on reduced power.

(2) OPERATE — normal operational setting of switch.

(3) TEST — full power is applied to the system with the switch is this position.

Fuses

12. The equipment contains two fuses, one in the control frequency selector 5821-99-913-1440, and the other in the amplifier, electronic control 5985-99-999-8554. The fuse in the frequency selector, if it blows will prevent a change of range or tuning. Whilst that in the servo amplifier will not prevent a change of range but will prevent a change of tuning.

Continuity

13. The source of fault in a system may be the inter-unit or inter sub-unit wiring. The continuity of this wiring may be checked with a suitable multimeter. Details of interconnections may be obtained by consulting fig. 5 of Part 4, Sect. 3, Chap. 4 of this handbook.

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PART 4

CIRCUIT DESCRIPTION

P31013 574947/5609 7/61 375 C & P Gp 375

SECTION 1

TRANSMITTER-RECEIVER EQUIPMENT

P31104 140381/6015 8/61 375 C & P Gp 375

Chapter 1

AMPLIFIER RADIO FREQUENCY 5821-99-913-2241

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The radio-frequency amplifier sub-unit contains both the r.f. amplifier and mixer stages for the transmitter and receiver sections of the s.s.b. equipment. These two sections, although contained on the same sub-unit, are entirely independent, of each other, with the exception of mechanical ganging of the tuning capacitors for both the transmitter and receiver sections. Range switching for both sections of the transmitter-receiver is carried out by a ' Ledex ' switching mechanism.

Receiver

2. Received signals from the aerial system are fed into the r.f. amplifier sub-unit on coaxial connectors. The input signal is inductively coupled to the receiver r.f. amplifier stage, the latter employing a variable-mu pentode valve. Automatic gain control is applied to this stage, the voltage being obtained from the i.f. sub-unit.

3. Following the receiver r.f. amplifier is a further pentode valve operating as a mixer. The mixer valve receives two signals one applied to the control grid, is the r.f. signal and the other, a local oscillator signal obtained from the generator, reference signal, is applied to the cathode.

4. Additive mixing takes place in the mixer valve V2 (*fig.* 1) due to non-linearity and a s.s.b.

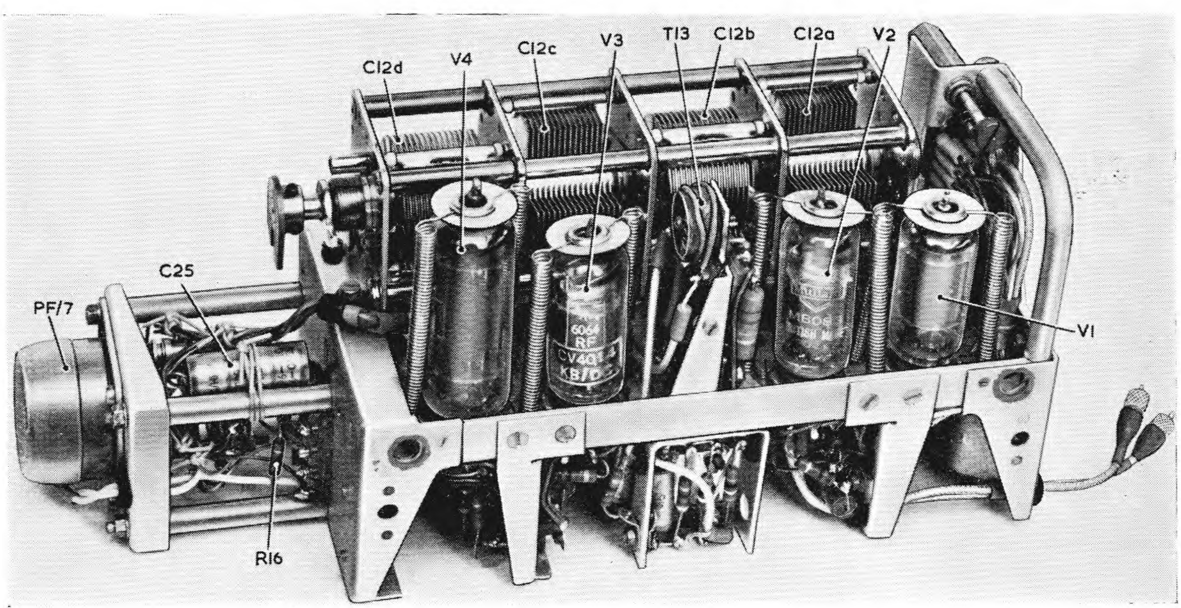


Fig. 1. Amplifier radio frequency—top

output at intermediate frequency (1·5 Mc/s) is fed via a crystal band-pass filter to the i.f. sub-unit for further amplification.

Transmitter

5. A single sideband signal produced in the modulator (*Chap.* 6) together with a local oscillator signal obtained from the generator, reference signal are applied to a form of Cowan modulator (*para.* 22), at the input to the transmitter section of the r.f. unit. The Cowan diode modulator operates as a mixer for the transmitter, converting the frequency of the s.s.b. signal generated in the modulator from 1·5 Mc/s to the required frequency for transmission.

6. The mixer is followed by two amplifier stages with tuned circuits to reject the unwanted frequencies produced in the mixing process.

7. These amplifiers provide sufficient output voltage from the r.f. sub-unit to operate the power amplifier.

8. The output obtained from the r.f. amplifiers is used as a drive signal to operate the " linear " power amplifier, the latter being contained in a separate unit and is fed from the r.f. amplifier by a coaxial cable.

DETAILED CIRCUIT DESCRIPTION

Receiver r.f. amplifier

9. A circuit diagram of the r.f. amplifier unit is given in fig. 4 (*end of Chapter*). An r.f. input at signal frequency from PLA/D1 is fed to the primary coils of the input transformers T1, T2, T3 (*fig.* 2) via the range selector switch PF5a. Secondaries of T1, T2, T3 are tuned by capacitor C12a with C30 acting as a fixed trimming capacitor (*fig.* 4). The three position switch PF5 selects the required secondary winding for each range. The wave band covered by the coils is 2·5-20 Mc/s in three ranges:—

(1) 2·5—5 Mc/s
(2) 5—10 Mc/s
(3) 10—20 Mc/s.

10. Trimming for alignment purposes of the input transformers on ranges 1, 2 and 3 is carried out by capacitors C26, C27, C28 respectively with C46 and C47 being extra fixed capacitors added to C27 and C28 on the two lower frequency ranges.

11. Switch PF5b (which is ganged to the other sections of switch PF and rotated by a ' Ledex ' rotary solenoid arrangement) short-circuits the tuned winding of both coils which are not in use on any one range. This measure effectively eliminates blind spots in the range being tuned caused by the absorption effects of the other coils. This procedure is adopted for both the receiver and transmitter coils throughout the sub-unit.

12. The r.f. signal is coupled to the grid of the amplifier valve V1 (CV.4009) via capacitor C29, resistor R9 is used as an anti-parasitic " stopper " The control grid of V1 receives a negative d.c. voltage via resistor R8, from the automatic gain control system of the equipment via PLA pin C5, the a.g.c. line being decoupled by capacitor C32.

13. Diode rectifier MR1 (CV1354) protects the

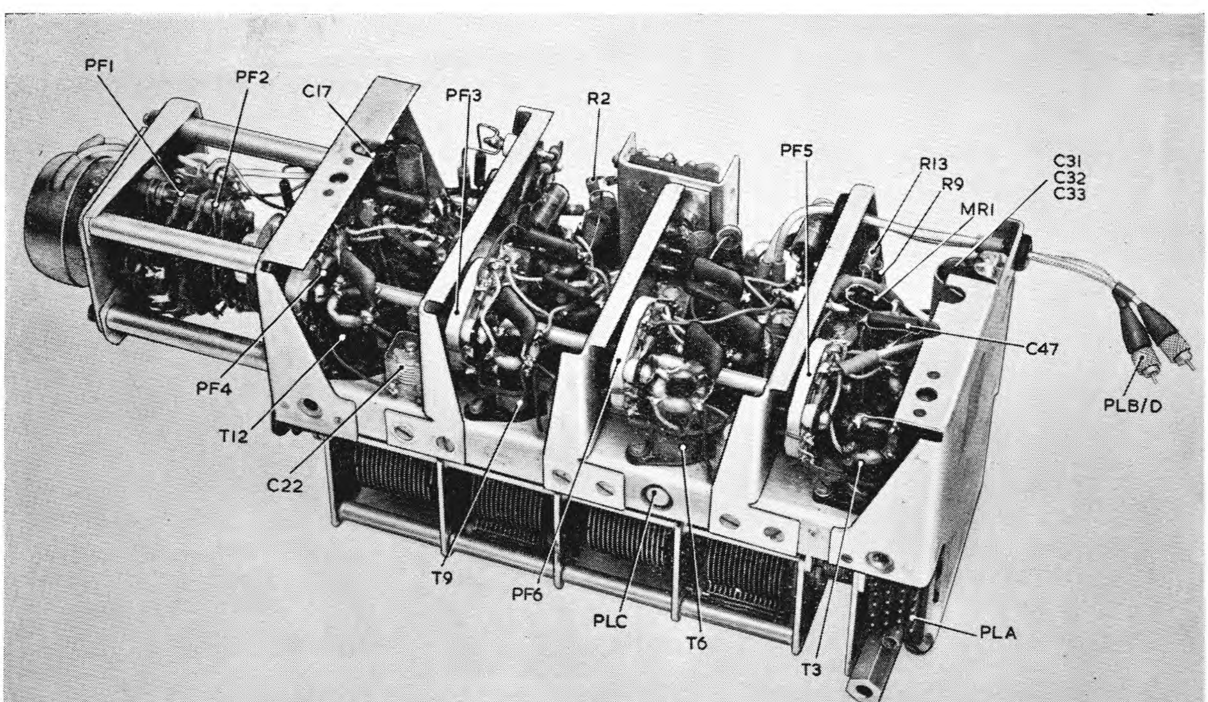


Fig. 2. Amplifier radio frequency—underside

input circuits in the event of a large r.f. voltage being fed into the r.f. amplifier from the aerial. When this r.f. voltage exceeds a few volts MR1 conducts and effectively short-circuits the input signal to valve V1.

14. Tuning meter indication is provided by a voltage appearing at PLA pin C4, this depends on the a.g.c. voltage applied to valve V1. As the a.g.c. voltage to the grid of V1 is increased, the cathode current of V1 is decreased; hence the voltage across R11 gives a lower tuning meter indication as the signal strength decreases.

15. The h.t. supplies for the screen grid of V1 are obtained by a potential divider R10, R20 from the 200V supply, r.f. decoupling is provided by capacitor C31. The anode supply for V1 is also provided from the 200V supply, decoupling components being R12 and C34.

16. An amplified signal appears at the anode of V1, where a similar tuning arrangement exists as for the input circuit (*para.* 9). Transformers T4, T5, T6 couple the signal appearing at the output from V1 to the mixer valve V2 (CV4014).

17. The secondary windings of T4, T5, T6 are tuned by a variable capacitor C12b, this being part of the four-ganged capacitor C12. Range switching is performed by switch PF6c, the unused coils being short-circuited by PF6b (*para.* 11). It should be noted however that there is no d.c. connection to earth in this case; the r.f. earth is provided by C40. (This blocking capacitor is necessary since it is possible to apply h.t. voltage across the coils T4, T5, T6, under certain circumstances).

Note . . .
The reason for this is that switch sections PF6a and b are part of the same switch wafer, with h.t. applied to contacts on PF6a. The switch rotates during operation through 360 *degrees and if C*40 *was not included, in certain switch positions the h.t. supply would be momentarily earthed causing arcing and burning of the switch contacts.*

18. Trimming adjustments for the secondary windings of the coils are available by variable trimmers C37, C38 and C39 respectively, for ranges 1, 2 and 3. Each of these trimmers has a fixed capacitor connected across it, these being C35, C36, C48 respectively.

Receiver mixer stage

19. The amplified r.f. signal is coupled into the receiver mixer stage via capacitor C41 and resistor R13. Cathode injection of the oscillator signal (obtained from the generator reference signal) is used. Both the signal frequency and the oscillator frequency appear across resistor R19 in the cathode circuit of V2. The oscillator signal is obtained from T13 via resistor R18, this together with R19 in series forms the correct load of 150-ohm to the generator, reference signal.

20. Owing to the non-linear characteristic of the mixer valve V2 the two signals mentioned in para. 19 are combined and the difference frequency (1·5 Mc/s) which appears at the anode of V2 is accepted by a crystal band-pass filter whose characteristics have been chosen to accept the lower sideband at this i.f. of 1·5 Mc/s (*Chap.* 11). The output to the crystal filter appears on coaxial plug PLB, the return feed to h.t. for the mixer anode being via coaxial plug PLD.

Note . . .
The received signal is upper sideband on all frequencies used. In the receiver mixer stage, however, since the frequency of the generator, reference signal is always set 1·5 *Mc/s higher in frequency to that of the incoming signal, sideband inversion takes place and the received u.s.b. signal is changed to a l.s.b. signal.*

21. Biasing for V2 is obtained by the voltage drop due to cathode current flowing through resistor R19 and R14, the latter is by-passed to radio frequencies by V43. A screen grid potential for mixer valve V2 is obtained from the h.t. supply via the combined anode and screen dropping resistor R15, the screen grid and anode being decoupled by capacitor C44.

Operation of the Cowan modulator

22. Before detailed description of the frequency-changer and r.f. amplifier in the transmitter section is given, the action of the Cowan diode modulator is described in the following paragraphs; a circuit is given in fig. 3.

23. During those half cycles of the carrier when point A is at a higher potential than B, all the rectifiers in the bridge arrangement are back-biased and the rectifier network presents a high impedance across the signal path from T1 to T2. However, during those half-cycles of carrier when B is at a higher potential than A, all the rectifiers are forward-biased, and the rectifier network presents a virtual short-circuit across the signal path, thus preventing the modulating signals from reaching the output. This switching action results in the output signals containing the modulation signal, upper and lower sidebands, and additional modulation products, but no carrier component. The output waveform is shown in (c) of fig. 3.

24. When the Cowan modulator in modified form is used as a frequency-changer for the transmitter the modulating signals shown in fig. 3, are replaced by the s.s.b. signal generated in the modulator radio transmitter (*Chap.* 6), whilst the carrier (or switching) frequency is replaced by the signal obtained from the generator reference signal (*para.* 25).

Transmitter mixer stage

25. The Cowan modulator frequency-changer MR2, MR3, MR4, MR5 (*fig.* 4) receives two signals, one being the s.s.b. modulated output

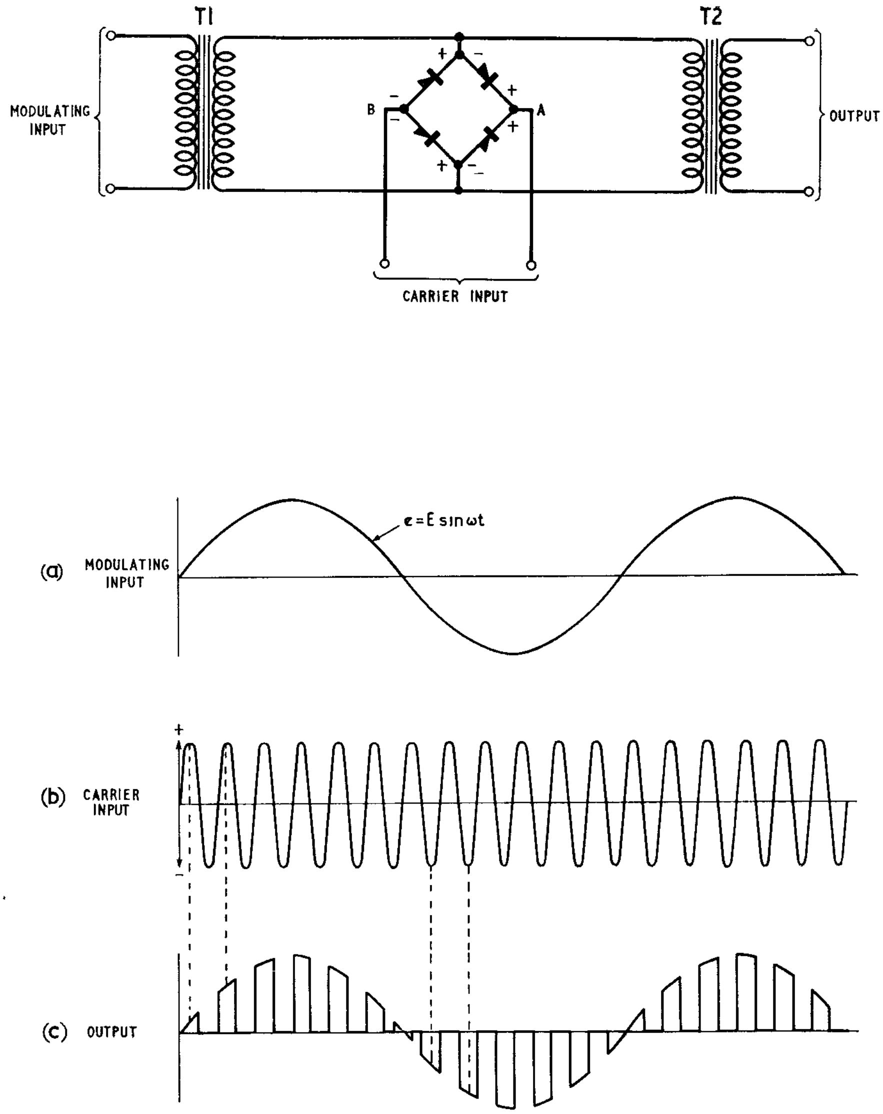


Fig. 3. Cowan modulator: circuit

signal from the modulator radio transmitter at 1·5 Mc/s and the other a r.f. input over the range 4 to 26·5 Mc/s from the generator, reference signal via PLC, these signals are applied to the Cowan modulator frequency-changer via the wide-band transformer T13 and coupling capacitor C2. The output circuit of the frequency-changer is effectively between the control grid of pentode V3 and earth with resistor R1 being the grid leak. Valve V3 (CV4014) operates as a straightforward amplifier. The Cowan modulator frequency-changer circuit affords some 15 dB of suppression to the signal injected from the generator reference signal, even though the circuit is not of the balanced type.

Transmitter r.f. amplifiers

26. The anode circuit of V3 (*fig.* 4) is tuned to the difference of the two applied frequencies mentioned in para. 24, thus giving an s.s.b. signal over the range 2·5-20 Mc/s. This band is divided into three ranges. Transformer T9 together with trimming capacitors C8, C5 and tuning capacitor C12c, forming the tuned circuit for range 1 (2·5-5 Mc/s). A similar arrangement of transformers T8 and T7, together with associated trimming capacitors C6, C9, C7, C10 covers ranges 2 and 3, 5-10 Mc/s and 10-20 Mc/s. Range switching is accomplished by switches PF3b, PF3c, switch PF3b short-circuits the two coils not in use on any one range this prevents r.f. absorption effects (*para.* 11). Capacitor C11 is included for the same reasons given in para. 17.

27. An h.t. supply for the anode and screen of amplifier valve V3 is obtained from PLA/A4 via decoupling components R3 and C4. Grid bias for the valve is provided in the usual way through resistor R2 and is decoupled by capacitor C3 in the cathode circuit.

28. The pentode V4 (CV4055) operates as a further r.f. amplifier for the s.s.b. signal, the latter being coupled from the anode circuit of V3 through capacitor C13. Resistors R4 and R5 function as an anti-parasitic " stopper " and grid leak respectively.

29, In the anode circuit of V4 are three coils L10, L11, L12 (one for each range). Each coil has its respective trimming capacitors. The coils are resonated to the required frequency by variable capacitor C12d, which is part of ganged capacitor C12. Capacitor C15 effectively blocks the d.c. path from the anode of V4 to the variable capacitor C12d, the inclusion of C15 is necessary to prevent the possibility of " arcing over " between the plates of the variable capacitor.

30. A tapping point on each of the coils T10, T11, T12 provides an output connection and impedance matching. Capacitor C17 couples the output signal to the connecting plug PLA/D4. As described in para. 26, coils not in use are short-circuited; section PF4b of the range selection switch PF provides this facility.

31. Anode and screen h.t. supplies for valve V4 are obtained from the main 200V h.t. supply via decoupling components R7, C18. Grid bias is obtained via cathode resistor R6, the latter is decoupled to radio frequencies by C14.

Range switching and tuning

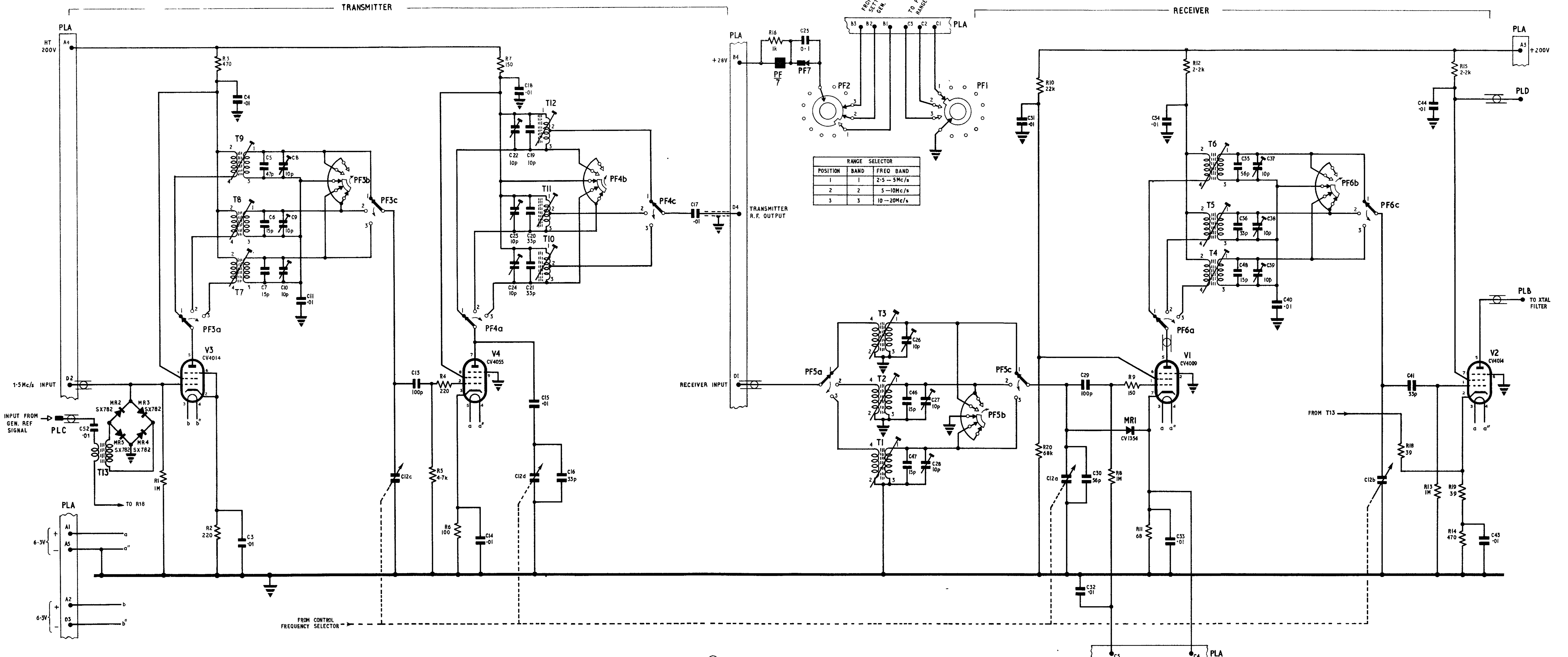
32. The r.f. amplifier sub-unit receives range switching information as an earth on either PLA pin B1, B2, B3, depending on the frequency range selected. This earth connection allows the 'Ledex' switch PF/7 to operate thus rotating the range selector switch PF until a cut-away segment in PF2 open circuits the earth connection from PLA, the selector switch has now selected the required frequency range.

33. Capacitor C25 and resistor R16 are suppressor components to minimize arcing during the operation of the ' Ledex ' switch.

34. A contact on switch PF1 provides an earth connection to either C1, C2 or C3 of PLA, this earth connection is used to actuate a further Ledex switch located in the r.f. power amplifier (amplifier r.f. 5821-99-913-2232) for range selection purposes in the latter unit.

Note . . .

Ledex switch units cannot be operated in parallel since unless they operate simultaneously the earth line is not broken and the switch units follow each other until the earth line is broken.



RANGE SELECTOR		
POSITION	BAND	FREQ BAND
1	1	2·5 — 5Mc/s
2	2	5 —10Mc/s
3	3	10 — 20Mc/s

NOTE: ALL COMPONENTS PREFIXED (1B)
VALUES OF FIXED CAPACITORS ACROSS THE TUNED CIRCUITS MAY VARY SLIGHTLY FROM VALUES SHOWN

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Amplifier radio frequency 5821-99-913-2241: circuit

Fig. 4

Chapter 2

OSCILLATOR RADIO FREQUENCY 5821-99-913-2236

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The initial carrier frequency to produce s.s.b operation of the transmitter and demodulation o the s.s.b. signal in the receiver is provided by a 1·5 Mc/s r.f. oscillator. Oscillation is controlled by an ovened crystal operating in a Pierce-Colpitts circuit. The crystal has a stability of the order of ± 5 parts in 10^6. By using a tuned circuit in series with the crystal the oscillator frequency can be adjusted or " pulled " slightly if required (*para.* 6).

2. The oscillator (*fig.* 1) is constructed on a removable sub-chassis and forms part of the transmitter-receiver assembly. Connection from this sub-chassis into the main transmitter-receiver is by plug and socket, not shown in fig. 1.

3. So that extraneous oscillations from the oscillator are not allowed to enter other sub-units mounted on the transmitter-receiver the oscillator r.f. has a metal cover fitted, this must be removed before access to the sub-unit can be made.

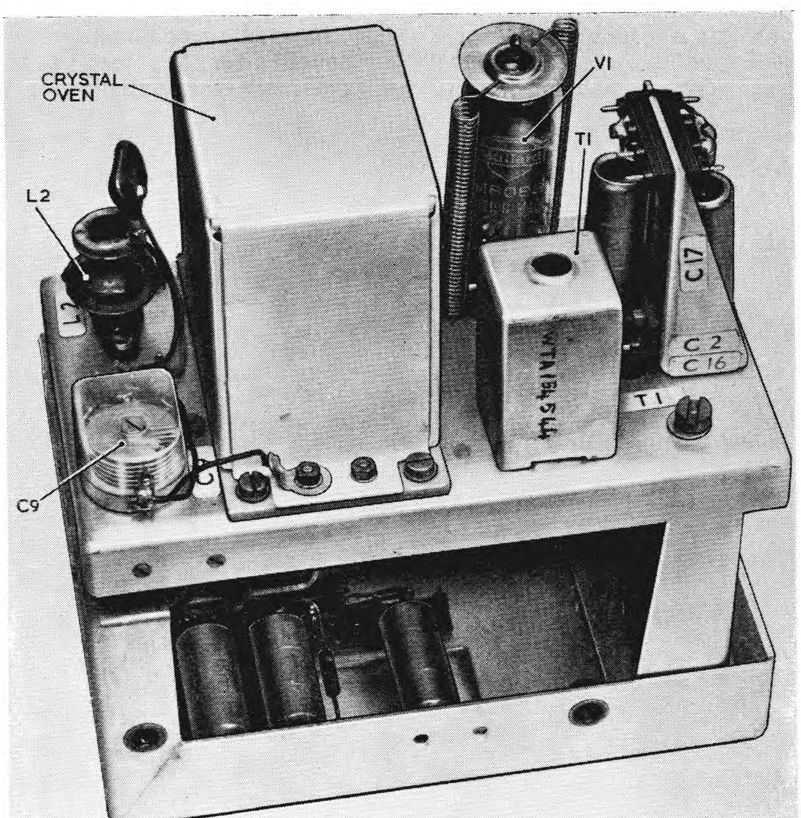

Fig. 1. 1·5 Mc/s oscillator, top

4. Two 1·5 Mc/s output signals are available from the oscillator. One output is balanced about earth and this provides the input signal to the balanced modulators in the modulator sub-unit (*Chap.* 6). The second 1·5 Mc/s output is not balanced and provides the r.f. signal for demodulation of the s.s.b. signal in the i.f. sub-unit.

DETAILED CIRCUIT DESCRIPTION

Crystal oven

5. The crystal oven used in this r.f. oscillator improves the frequency stability of the crystal. Using this method a sufficiently high order of frequency stability is obtained to satisfactorily operate the s.s.b. equipment.

6. Reference to the circuit diagram (*fig.* 3, *end of Chapter*) shows crystal XL1 connected in a series circuit with inductor L2, C8 and C9. The series tuned circuit allows the crystal frequency to be varied slightly about its nominal point.

7. A 28V oven heater supply is obtained from plug PLA/4, this supply is filtered by means of capacitors C1, C2 and inductor L1 and is used to heat the oven through heaters R1 and R2. A thermostat X1 controls the oven temperature to within fairly close limits at 75°C.

8. The oscillator valve V1 (CV4014) is a high slope r.f. pentode; use of a valve of this type enables an adequate output voltage to be obtained with a minimum of crystal heating which would otherwise give poor frequency control.

Oscillator

9. Valve V1 functions as a crystal oscillator, being a form of Colpitts oscillator operating at 1·5 Mc/s. The screen grid is held at earth potential to r.f. by capacitor C10 (*para.* 12). Since the crystal XL1 is connected effectively between control grid and earth, the crystal can be regarded as being connected between screen and control grid, with the screen grid performing the function of an anode. Regeneration is obtained by the cathode return to the junction of C11, C15 (*fig.* 2). A d.c. path to the cathode is provided by resistor R5. Resistor R4 is the grid leak, the current flowing through R4 provides grid bias for the valve.

10. Owing to the high gain provided by the oscillator valve V1 (CV4014) the output waveform contains a minimum of harmonics. A further advantage of the use of a high-gain valve is the reduced crystal heating obtained, with a complementary increase in frequency stability. As stated (*para.* 4) two 1·5 Mc/s output signals are available. Secondary winding 4, 6 on transformer T1 (*fig.* 3) provides balanced output signal. A centre tap at earth potential being obtained from the junction of resistors R6, R7. Capacitors C20, C21 are used for blocking purposes.

11. An unbalanced r.f. output is available at PLA/A1, this is obtained from the anode of V1 through coupling capacitor C14.

H.T. supplies

12. High tension supply to V1 is from PLA/3 through the r.f. filter consisting of R8, C17, C19. The screen grid receives its h.t. supply from the h.t. line via the dropping resistor R3. Capacitor C10 used in conjunction with R3 provides decoupling for the screen to radio frequencies, thus the screen is at earth potential to radio frequencies.

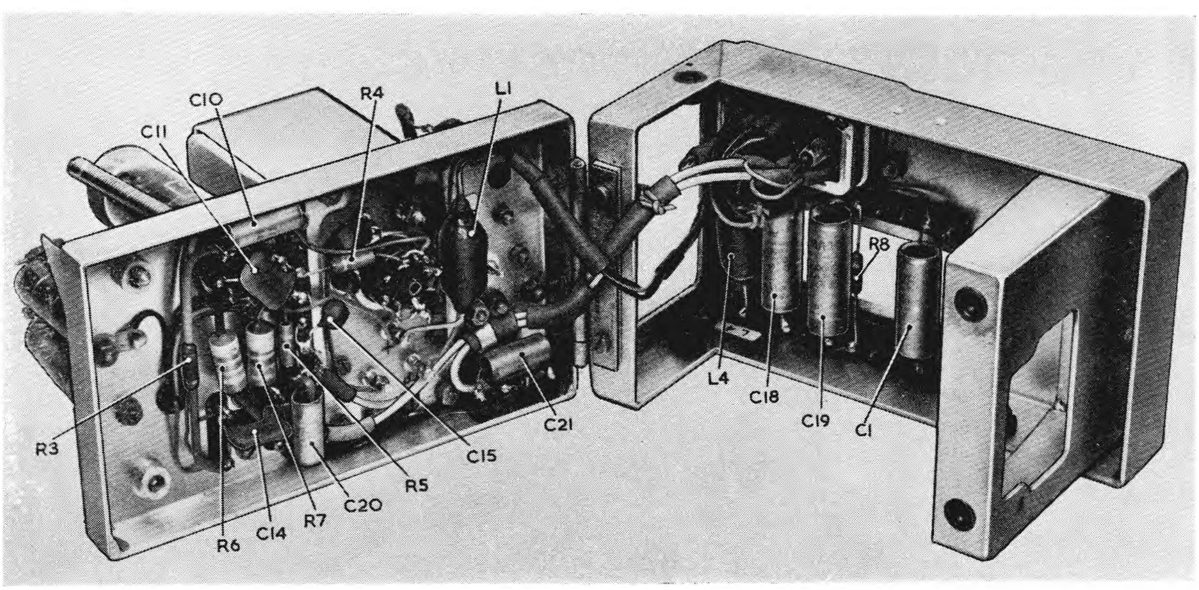

Fig. 2. 1·5 Mc/s oscillator, underside

Test points

13. Test points are available at PLA 19 and 20 for the balanced 1·5 Mc/s output signal and at PLA 15 for the unbalanced signal.

Heater supply

14. The 6·3V a.c. supply for the valve heater is brought into the sub-unit via PLA/1. This supply is filtered by C18, C16 and inductor L14.

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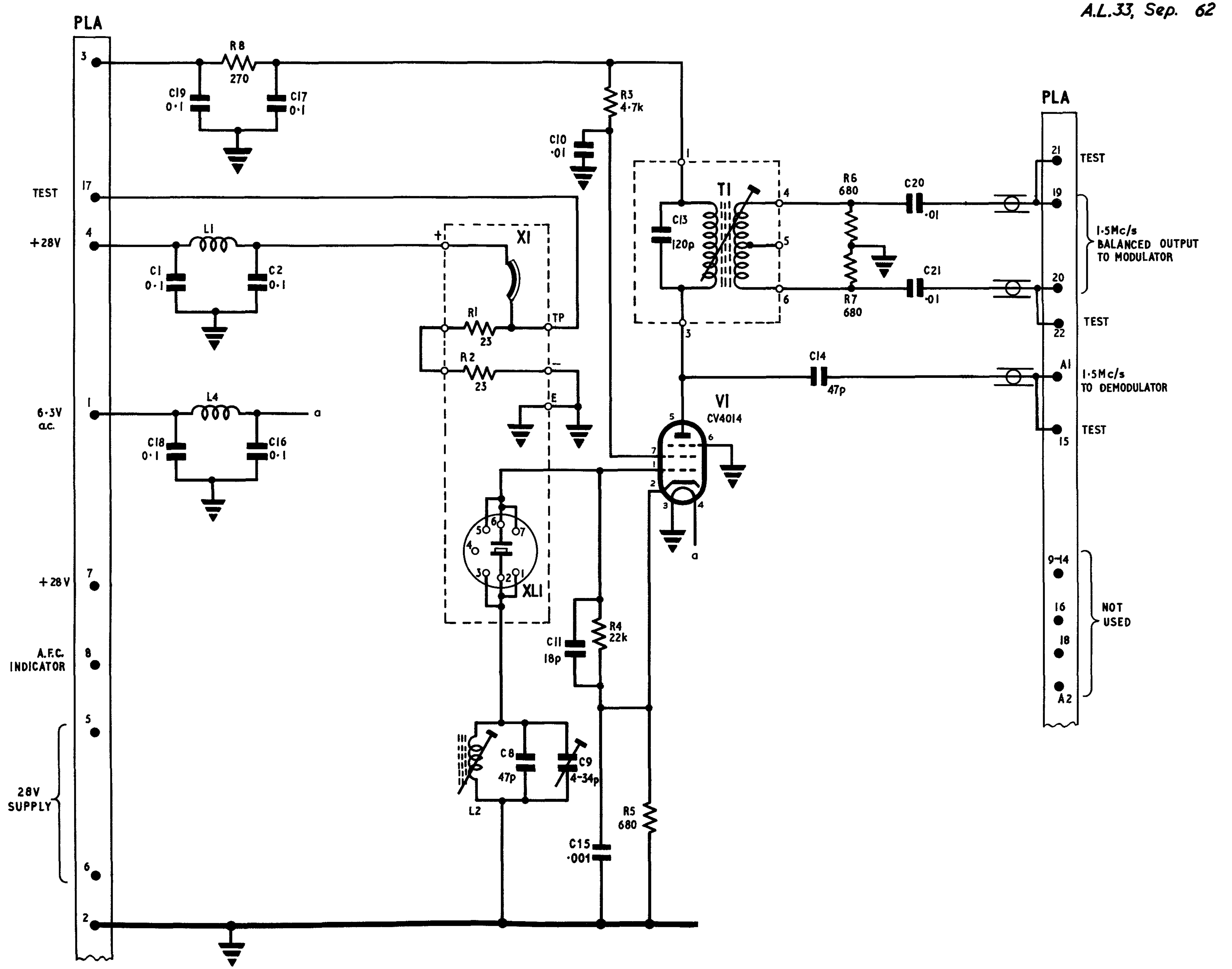

NOTE: ALL COMPONENTS PREFIXED (1E)

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Oscillator radio frequency (1·5 Mc/s) 5821-99-913-2236: circuit

Fig. 3

Chapter 3

AMPLIFIER, INTERMEDIATE FREQUENCY 5821-99-913-2251

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The amplifier, intermediate frequency 5821-99-913-2251 (*fig.* 1) contains the main i.f. amplifier and demodulator stages of the receiver. It is a removable sub-unit retained by three fixing screws.

2. A single-sideband signal at an i.f. of 1·5 Mc/s obtained from the output of a crystal bandpass filter is amplified by the three-stage i.f. amplifier. The tuned circuits used are temperature-compensated to provide each stage with the maximum stability.

3. A noise pulse limiter is connected in the output circuit of the final i.f. amplifier valve, the former limits pulse interference from airborne electrical equipment or external sources.

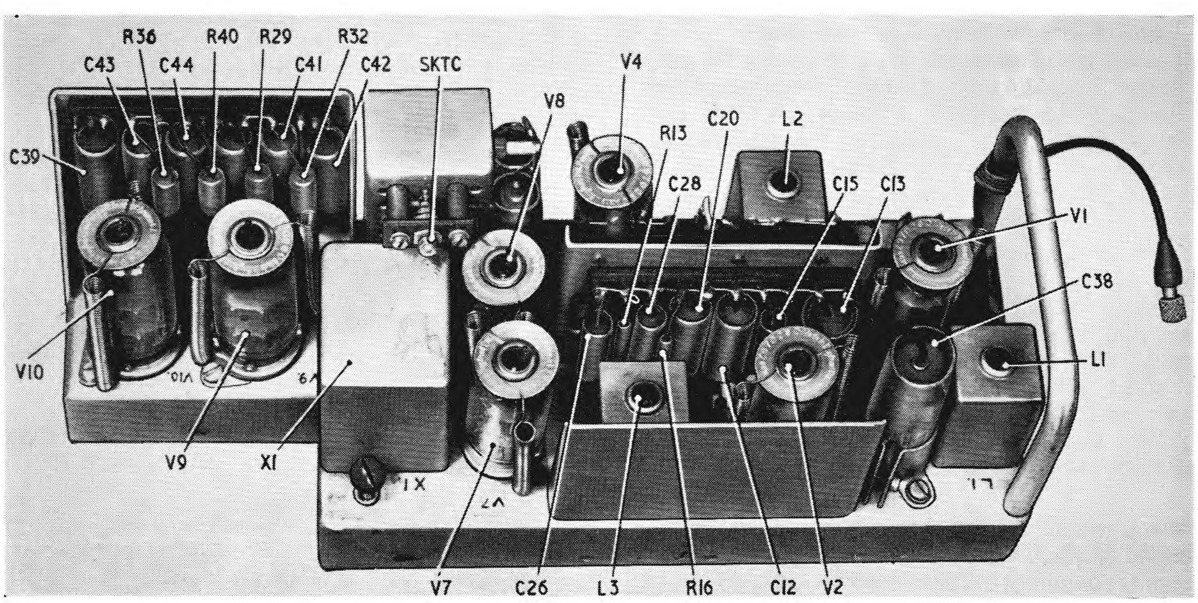

Fig. 1. Amplifier i.f. top—left

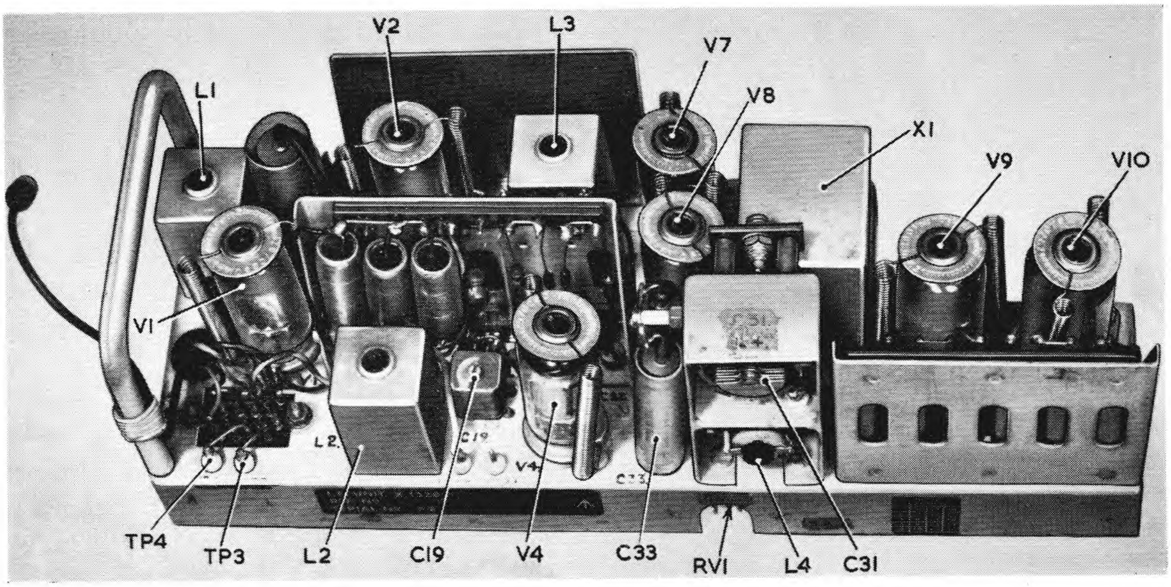

Fig. 2. Amplifier i.f. top—right

4. Automatic gain control voltage is developed from the output of the second i.f. amplifier stage; the d.c. voltage produced is applied to the receiver r.f. amplifier, the first two i.f. amplifier stages and a reduced amount is fed to the third i.f. amplifier. The overall gain of the i.f. amplifier is preset by a small variable capacitor used for coupling between the second and third i.f. stages.

5. Demodulation is produced by beating the received i.f. signal with a 1·5 Mc/s local carrier obtained from the oscillator r.f. (1·5 Mc/s) sub-unit known as the carrier insertion oscillator (c.i.o.), this process produces frequencies within the audio range (*Part* 1, *Sect.* 1, *Chap.* 1).

6. The 1·5 Mc/s c.i.o. voltage is applied in phase-quadrature to the grids of the demodulator triodes, the output from the final i.f. amplifier being applied to the cathodes. Audio frequency signals are produced at the valve anodes and are filtered to remove the r.f. component; they are then applied to the a.f. phase-shifting stage.

7. The a.f. phase-shifting stage consists of two double-triodes with audio phase-shift networks in the anode circuits, these networks produce a differential phase shift of 90° between the a.f. signals. The a.f. signals (with upper and lower sideband content on both signals) are fed to the combining stage contained in the control electrical frequency sub-unit (*Chap.* 4), where the wanted sidebands add and the unwanted sidebands cancel.

Note . . .

Inversion of the sidebands takes place in the mixer stage of the amplifier r.f. 5821-99-913-2241 (*Chap.* 1); *hence the transmitted sideband, i.e. the upper sideband, becomes the lower sideband following the receiver frequency changing process.*

DETAILED CIRCUIT DESCRIPTION

First i.f. amplifier

8. A circuit diagram of the i.f. amplifier 5821-99-913-2251 is given in fig. 5 at the end of this chapter. A single-sideband signal (lower sideband) at 1·5 Mc/s enters the amplifier from the crystal filter (*Chap.* 11) at coaxial plug PLB and is coupled to the control grid of the first i.f. amplifier valve, variable-mu pentode V1 (CV4015) (*fig.* 2) via capacitor C1 (*fig.* 5). An a.g.c. voltage is also fed to the control grid through R1 from the receiver a.g.c. line.

9. The amplified s.s.b. signal appears across the tuned circuit in the anode of V1. This tuned circuit provides a load for the valve but does not add much to the selectivity of the receiver, as this is obtained mainly by the crystal filter (*Chap.* 11).

10. Decoupling for anode and screen grid supplies is via components R3, C8. The heater of valve V1 is decoupled to radio frequencies by capacitors C3, C4, this is necessary to prevent undesirable effects due to back coupling at i.f. via the heater leads. Cathode bias is provided by R2 decoupled by C5.

Second i.f. amplifier

11. The second i.f. amplifier is similar to the first, i.f. signals being fed to the control grid of V2 (CV4015) through coupling capacitor C9. Automatic gain control voltage is also fed to the control grid of V2 through the high value resistor R5.

12. The amplified signal appears across the tuned circuit L2, C11, C14, C16, in the anode circuit as in the previous amplifier stage (*para.* 9).

13. Components R7 and C15 decouple the anode and screen grid of V2 to radio frequencies.

14. Cathode bias for the valve V2 (*fig.* 2) is provided by R6 which is decoupled by the by-pass capacitor C12.

Automatic gain control

15. Part of the output from the second i.f. amplifier V2 is used as the source of a.g.c. voltage. Diode MR1 (SX782) is reversed biased by the cathode potential of V2, this giving a small delay voltage to the a.g.c. system. When an r.f. signal of large enough magnitude to overcome the delay voltage, is fed from the anode of valve V2, via coupling capacitor C18, rectifier MR1 operates and a d.c. potential appears across the diode load resistors R9, R10, R11. This d.c. potential is proportional to the received signal strength and the voltage at the junction of R9, R10 is fed back to the first and second i.f. amplifier valves effectively reducing the gain as the voltage increases. A decoupling network is provided for the a.g.c. connections to the i.f. amplifier valves, the former consists of R8, R4 with C10, C13, C17; this network prevents undesirable coupling between the i.f. stages via the a.g.c. line.

16. A reduced amount of a.g.c. bias is applied to the third i.f. amplifier since a.g.c. action is not so effective at this point in the circuit. The a.g.c. bias for V4 is applied through grid resistor R12 decoupling being provided by capacitor C20.

17. A test point TP2 is provided at the junction of R9 and R10. This test point can be earthed to short circuit the a.g.c. action during certain tests, e.g. re-alignment of the amplifier.

Third i.f. amplifier

18. This stage has a somewhat lower gain than the previous two i.f. amplifier stages. The input signals to the valve V4 are fed from the previous stage via coupling capacitor C19. The two capacitors C19, C21 together form a capacitor-divider network the input s.s.b. signal being applied to the grid of valve V4, a variable-mu pentode (CV4015), across capacitor C21 (*fig.* 3).

19. Since capacitors C19, C21 form a r.f. capacitive potential divider, adjustment of trimmer C19 gives control of overall amplifier gain (*para.* 4) by altering the potential divider ratio. To set a limit on the minimum gain of the amplifier capacitor, C46 is included across C19.

20. The amplified s.s.b. signal appears across the tuned circuit L3, C22, C25 in the anode of V4, the tuned circuit again forming the load as in the previous amplifiers.

21. Anode and screen grid decoupling to the h.t. supply is provided by R14 and C26, whilst cathode bias for the valve V4 is obtained by the volts drop across resistor R13. It will be noticed that no decoupling capacitor is shown across this resistor, this is done to provide a degree of negative current feedback over this stage, thus increasing stability also tending to broaden the tuning, the latter improves the action of the impulse noise limiter (*para.* 22).

Noise limiter

22. The purpose of the noise limiter is to assist in the reduction of aircraft electrical noise pulses, so that their effects may be minimized at the receiver output.

23. Two diode rectifiers MR2 and MR3 (CV7040) are used in the noise limiter circuit and are arranged so that both diodes are back biased from the h.t. supply. This back bias is provided from the potential divider network R15, R16 and is of the order of 30 volts d.c. across the two diodes.

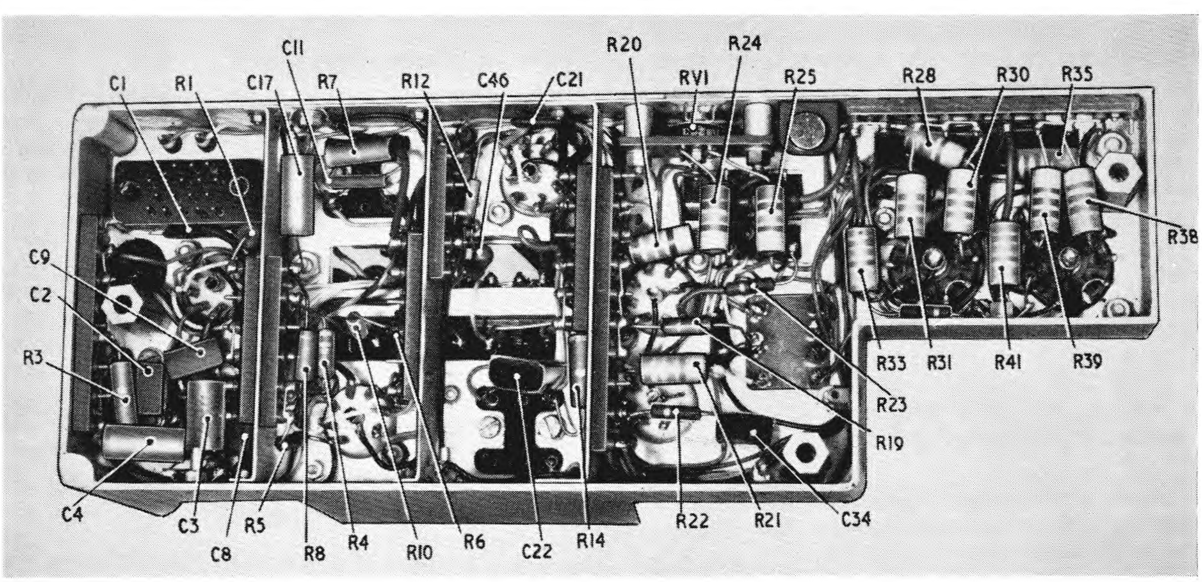

Fig. 3. Amplifier i.f. underside

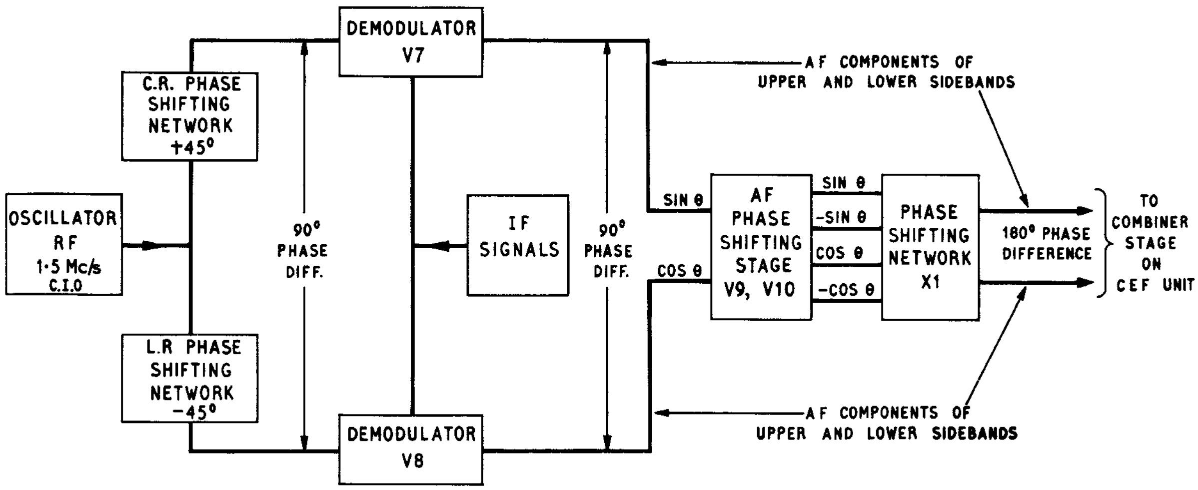

Fig. 4. Double demodulators and phase shifting networks, block diagram

24. Resistors R43, R44, across each of the diodes ensure that an equal d.c. potential appears across each diode. A short noise impulse voltage having a positive polarity will cause the diodes to conduct, when this occurs the diodes act as a virtual short circuit and there is practically no output from the third i.f. amplifier stage. The R-C network, consisting of resistor R16, C28, has a time constant suitable to give good operation of the noise limiter with negligible distortion.

Heterodyne demodulator

25. Demodulation of the single-sideband signal is accomplished by heterodyning the i.f. signal with a 1·5 Mc/s local carrier obtained from the 1·5 Mc/s carrier insertion oscillator (c.i.o.) thus producing frequencies in the audio range (*Part* 1, *Sect.* 1, *Chap.* 1).

26. The 1·5 Mc/s c.i.o. voltage is applied in phase-quadrature to the control grids of the square-law demodulator triode valves V7, V8 (CV4058) (*fig.* 4), whilst the received s.s.b. signal at i.f. is fed in-phase at low impedance to the cathodes. The resulting audio signals containing upper and lower sideband signals are then produced at the anodes with a 90 deg. phase relationship between them.

27. To produce the necessary phase shift of the 1·5 Mc/s inserted carrier, use is made of L-R and C-R phase advance and retard circuits. The inserted carrier is fed in via SKTC; inductor L4 (*fig.* 2) with R17 providing phase lag whilst C30, C31, with R18 provide a phase lead, the two signals across R17, R18 being in phase-quadrature are applied to the control grids of V7, V8 (*fig.* 5).

28. An s.s.b. signal input at intermediate frequency is applied across resistor R19 in the cathode circuit of the demodulator valves V7, V8 (*para.* 27). Bottom bend biasing arrangements are provided by resistors R20, R21 with capacitors C32, C33, acting as decoupling components.

29. The single-sideband signal is demodulated by the heterodyne process (*para.* 26) within valves V7, V8; the output from the latter valves will then contain four component frequencies viz:—

(1) Injected carrier frequency at 1·5 Mc/s
(2) The input s.s.b. signal
(3) An s.s.b. signal at twice the i.f. frequency
(4) The required a.f. signals

The first three signals indicated by sub-paragraphs (1), (2) and (3), are removed by means of r.f. filters; the R-C filters being formed by R22 and R23 together with C34, C36 and C35, C37 respectively. Resistor R24 forms the anode load for valve V7 with the balancing potentiometer RV1. A similar function for V8 is carried out by R25 and RV1 (*fig.* 3).

30. Audio frequency output signals from the demodulator are coupled to the a.f. phase-shifting stage by capacitors C39, C40.

The a.f. phase-shifting stage

31. This stage consists of two double-triode valves (CV4024) which operate as phase inverters. From the two signals applied to them four signals in phase-quadrature are obtained, these are fed to the phase shift network X1 (*fig.* 2).

Note . . .

Although only the upper sideband is used in the equipment for communication, it is possible for a very strong interfering signal on the lower sideband to produce sufficient signal voltage at a simple heterodyne demodulator to cause the wanted signal to become unintelligible; hence in addition to a crystal filter, a double demodulator and outphasing system of demodulation is used to eliminate any interfering signal (*Chap.* 4).

32. Two a.f. signals from the demodulators, with 90 deg. phase shift between them, contain the a.f. content of the upper and lower sidebands of the received signal. The output from valve V8 is fed to the grid of V10a (CV4024) with R37 functioning as a grid leak. A 180 deg. phase shift occurs in V10a and the a.f. signal appears at the anode where R35 forms the load resistor. Bias for the valve is obtained from the volts drop across resistor R38 in the cathode lead to the valve. No by-pass capacitor is fitted to resistor R38 thus providing a degree of negative feedback. This method of providing bias is common to all four sections of the CV4024 valves used.

33. A part of the output from V10a is coupled via R36 and C43 to the grid of V10b with R42 being the grid leak. The a.f. signal at the anode is again 180 deg. out of phase with that at the grid, the signal appearing across the load resistor R41. Resistors R36 provide a negative feedback loop so that the signal appearing at the anode of V10b tends towards being equal in magnitude and opposite in phase from that at the anode of V10a. These a.f. signals are fed to pins D and C of the phase-shift network X1, capacitor C44 functions as a d.c. blocking capacitor.

34. An identical arrangement is provided for the other two a.f. signals obtained from the anode circuit of V7 (*para.* 29)—capacitor C39 couples these signals to the grid of V9a (CV4024), R27 is the grid leak for valve V9a. The amplified a.f. signals, 180 deg. out of phase, appear at the anode where resistor R28 forms the load. Both a.f. signals are coupled to the grid of V9b via R29 and C41. Resistor R34 is again a grid leak. A negative feedback loop R29, R32, functions as mentioned in para. 33.

35. The output signals from valves V9a and V9b are fed to terminals A and B respectively of the phase-shift network X1. At the output terminals G and F of phase-shift network X1 there are two a.f. signals each containing audio frequencies of both upper and lower sidebands of the received signal. These audio signals have a relative phase difference of 180 deg. and by combining the signals in a combining stage (*Chap.* 4) the unwanted sideband a.f. signals subtract being out of phase, whilst the wanted sideband signals add in phase.

36. The combining stage in the control electrical frequency sub-unit is fed with the a.f. signals mentioned in para. 35 from PLA pin D1 and D2 (*fig.* 5).

Heater supply

37. Valve heater supply enters the sub-unit on PLA pin A1, A2, this heater supply is decoupled to earth by capacitors C3, C4, C45. The action of decoupling the heater supply assists in preventing unwanted feedback troubles via the heater chain.

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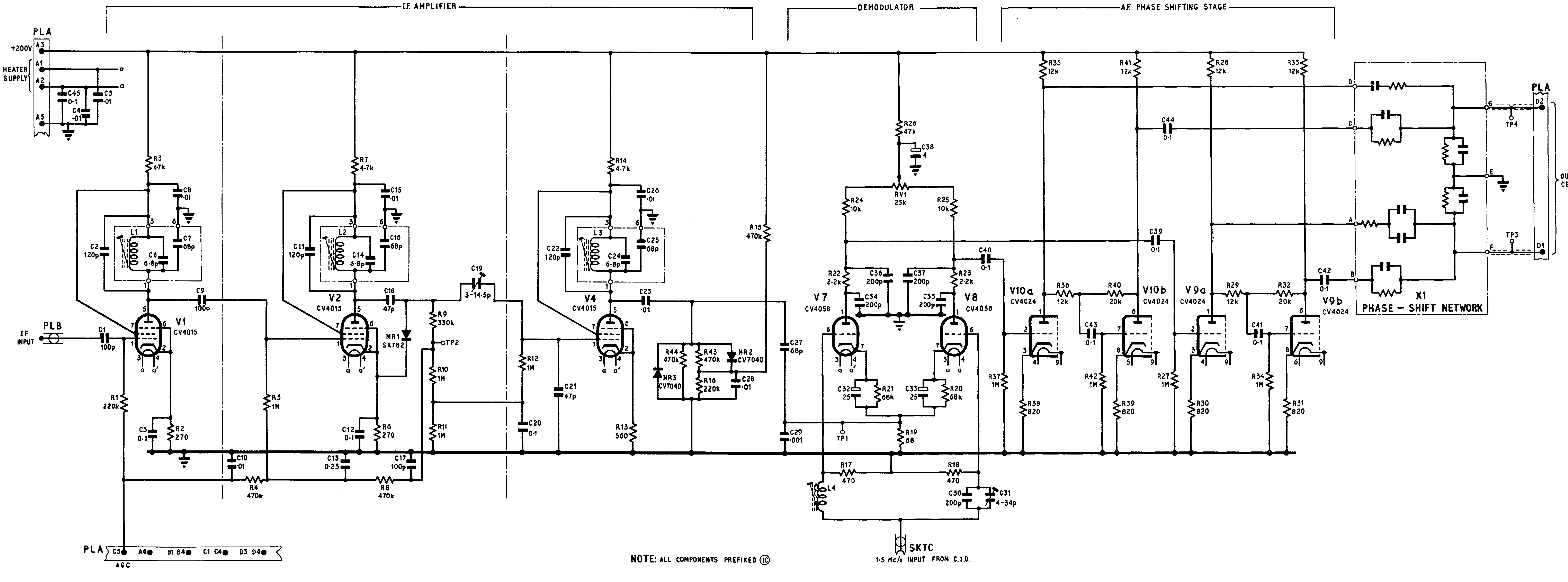

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Amplifier intermediate frequency 5821-99-913-2251: circuit

Fig. 5

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Chapter 4

CONTROL ELECTRICAL FREQUENCY 5821-99-913-2234

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The single-sideband signals which have been demodulated in the amplifier i.f. sub-unit (*Chap.* 3) are amplified and combined in the control electrical frequency 5821-99-913-2234. This sub-unit (*fig.* 1) provides an audio output of either upper or lower sideband intelligence, normally only the information contained in the upper sideband is chosen.

2. A balanced demodulated output signal from the amplifier i.f. is amplified by a pair of d.c. amplifiers before being applied to the combining stage. The a.f. output signals from the combining stages add when in phase and subtract when in opposition, thus the a.f. signal due to one sideband will be produced at the output of one combiner and the alternative sideband signal at the output of the other combiner.

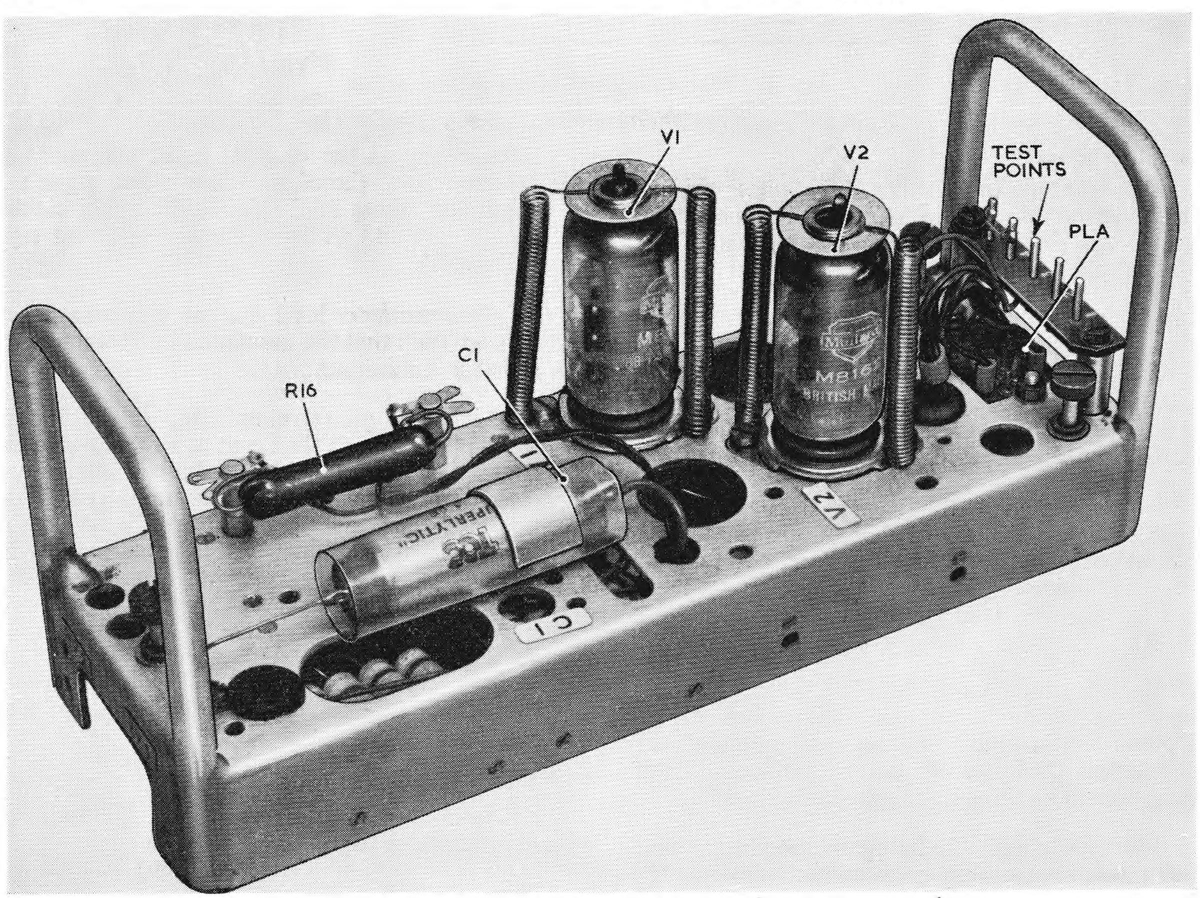


Fig. 1. Control electrical frequency—top

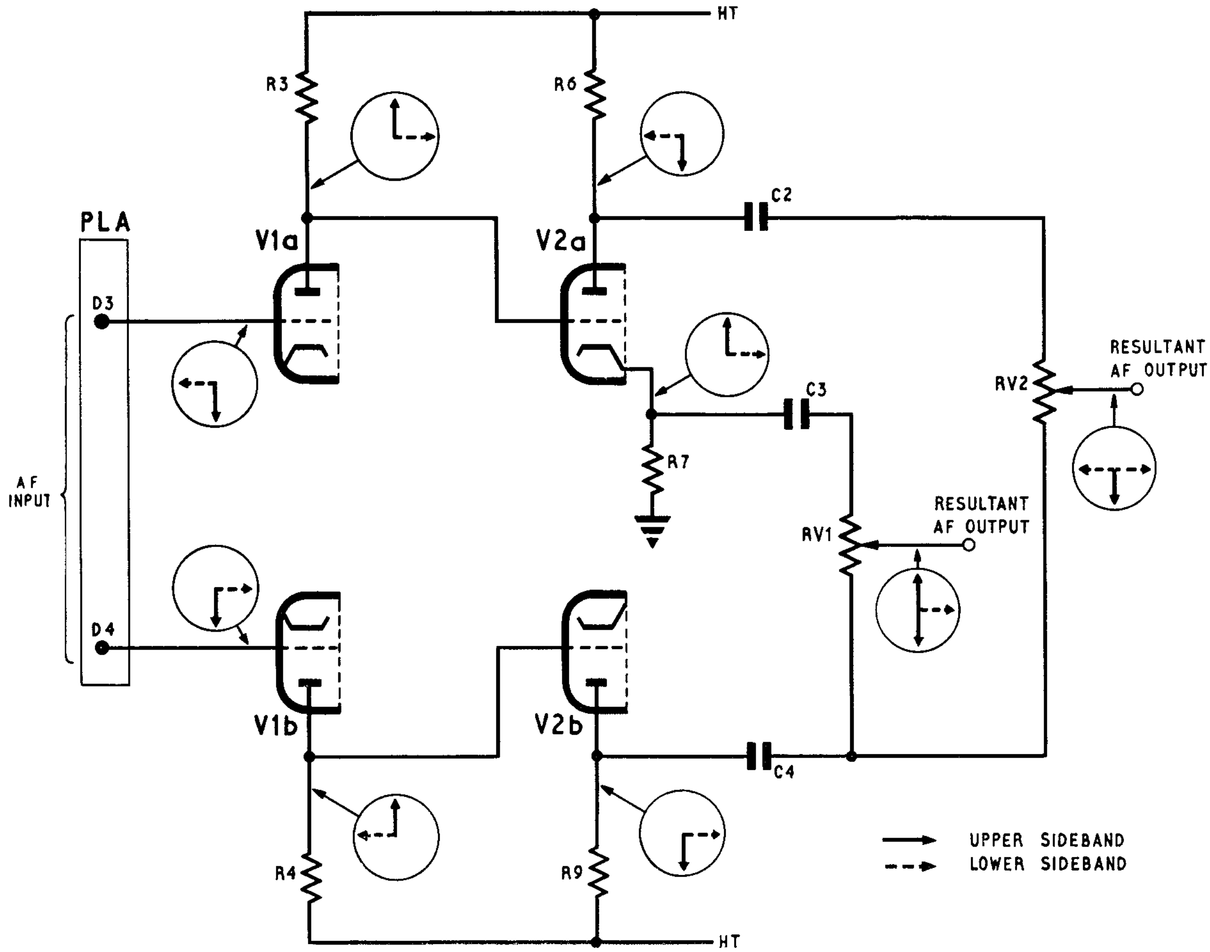


Fig. 2. Vector diagram of combining action

Circuit summary

3. The demodulator valves and phase-shifting circuits in the amplifier i.f. (*Chap.* 3) produce audio signals containing the component signals of the received upper and lower sidebands.

Note . . .

It is possible for a signal to be received which contains both upper and lower sideband signals even though only one sideband is actually transmitted. This can be due to an interfering transmission being present on the alternative sideband.

4. Components of the upper sideband which appear on pins D3, D4 of PLA are in phase with each other whilst the lower sideband components are in antiphase (*fig.* 2). The upper sideband signals, however, lead the lower sideband signals by 90°.

5. Double-triode valves V1a and V1b (CV4024) form a pair of d.c. amplifiers, therefore no change in phase relationship to the input signals will take place before the latter arrive at the control grids of phase-splitting valves double-triode V2a, V2b.

6. Valves V2a and V2b being phase-splitters have 180° phase relationship between the signals at the anode and cathode of each valve. The signals at the anodes of V2a and V2b bear the same phase relationship as the original input signals at pins D3 and D4, therefore when these signals are combined across RV2 (*fig.* 2) the upper sideband signals will add whilst the lower sideband signals will cancel.

7. Potentiometer RV2 is set to give an amplitude balance such that the unwanted i.e. lower sideband signal is a minimum.

8. Since the phase relationship at the anode of V2b is the same as the input at PLA/D4 and there is a phase shift of 180° between the signals at the cathode of valve V2a and the input at D3, these two signals i.e. at the anode of V2b and cathode of V2a can be combined across potentiometer RV1 to cancel the upper sideband signals whilst the lower sideband signals add in phase.

9. Potentiometer RV1 is used as an amplitude balance control in the same way as RV2 (*para.* 7). In this case RV1 is set for minimum upper sideband signal.

10. The required sideband signal is fed to the a.f. unit by connecting test point 4, TP4 (*fig.* 4) to either test point 3 or 5.

Note . . .

Selection of the alternative sideband at the test *points also requires a change in the i.f. sideband filter* (*Chap.* 11).

DETAILED CIRCUIT DESCRIPTION

D.C. amplifiers

11. Audio frequency signals are directly coupled via PLA pins D3 and D4 (*fig.* 4) from the amplifier i.f. to the control grids of the d.c. amplifier valves V1a, V1b; the latter being a double-triode valve CV4024.

12. The a.f. signals fed to the grid of V1a contain the components of both upper and lower sideband signals, these are amplified by V1a and appear at the anode where resistor R3 forms the anode load. Decoupling to audio frequencies for both V1a and V1b is provided by resistor R2 and capacitor C1 which are connected in the anode h.t. supply lead to these valves.

13. Similarly the a.f. signal applied to the grid of V1b contains components of both upper and lower sideband signals but with different phase relationships to those at V1a. These signals are amplified by V1b and appear at the anode of the valve, the anode load being in this case resistor R4.

14. Grid bias for each valve is provided by a cathode resistor; resistor R1 performs this function for V1a whilst R5 has a similar action for V1b. The positive voltage on the cathodes is made slightly higher than the h.t. potential from anode to earth of the previous stage so that the grid is in effect slightly negative with respect to the cathode so giving a small negative bias (*para.* 18).

15. The amplified output signals from valves V1a and V1b are directly coupled to the control grids of the combiner stages.

Combining stages

16. A double-triode valve CV4024 is used in the combining stages to produce the required phase relationships which allow the unwanted audio components to cancel and the wanted signals to add in phase.

17. Valve V2a (*fig.* 4) one half of double-triode functions as a phase-splitter. The total load is split between anode and cathode, the anode load resistor being R6 whilst R7 is the cathode load resistor. Resistor R7 also functions as part of the potential divider network R33, R7.

18. This potential divider provides a positive potential for the cathode of V2a thereby providing grid bias. A high positive potential is provided for the cathode from the h.t. supply because the grid of V2a is directly coupled to the anode of V1a hence the grid of V2a is at a high potential above earth, the grid to cathode potential, i.e. the grid bias, is the difference between the potential of the grid and that of the cathode. The audio signals at the cathode of V2a are in phase with those at the grid and 180° out of phase with signals at the anode of this valve.

19. The second half of V2 i.e. V2b also functions as a phase-splitter, however only the signal appearing at the anode is used in this application. The total load for the valve is formed by R8 and R9, resistors R34 and R8 function in a similar manner to R33 and R7 mentioned in para. 17. Audio signals appear at the anode of V2b where R9 forms the anode load.

20. To obtain the audio content of the upper sideband the audio signal appearing at the anodes of V2a and V2b are combined across the resistor chain R12, RV2, R13, coupling from V2a being provided by capacitor C2 and that from V2b by capacitor C4.

21. The output signals from the cathode of V2a are coupled to a further resistor network R10, RV1, R11, by capacitor C3. Also coupled to this network are the audio signals obtained from the anode of valve V2b, from fig. 4 it can be seen that the upper sideband audio components cancel in this case and the lower sideband audio components are obtained by being added in phase.

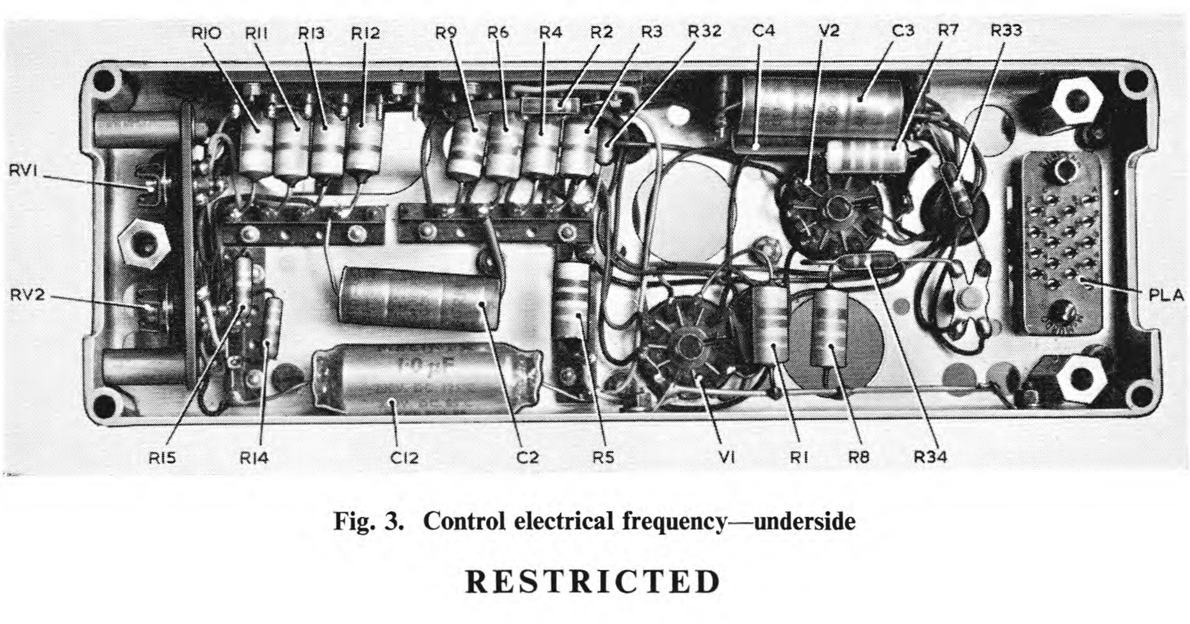


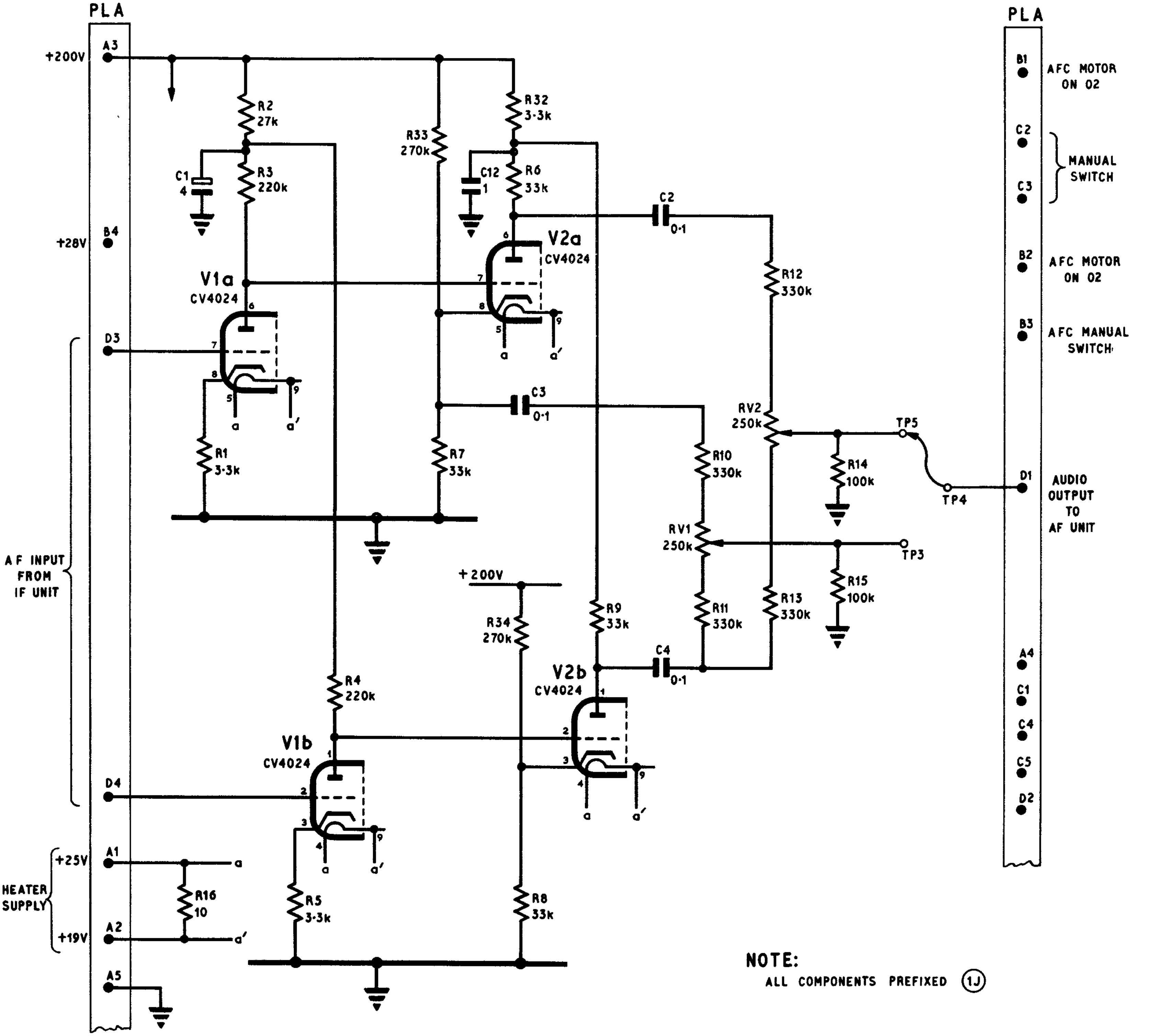
Fig. 3. Control electrical frequency—underside

22. Potentiometer RV2 acts as an amplitude balancing device for the upper sideband with resistor R14 forming a load across the output.

23. A similar action is obtained from potentiometer RV1 for the lower sideband with R15 acting as the load resistor. Both potentiometers are adjusted for minimum unwanted sideband signal amplitude.

24. The combining stage phase splitter valve V2a and V2b anode circuits are decoupled by resistor R32 and capacitor C12.

25. The upper or lower sideband signals obtained from the combiner stages are fed to the a.f. unit by connecting test point 4 to either test point 3 or 5 (*para.* 10).



Control electrical frequency 5821-99-913-2234: circuit — Fig 4

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Chapter 5

AMPLIFIER AUDIO FREQUENCY 5821-99-913-2237

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. Amplifier a.f. 5821–99–913–2237 is a detachable sub-unit of the s.s.b. transmitter-receiver equipment, the former providing amplification both for the audio signals received and voice signals from the microphone.

2. In the a.f. amplifier sub-unit (*fig.* 1) the level of the voice signals is raised sufficiently to satisfactorily operate the headphones in the case of sidetone and provides an a.f. output signal to the modulator of approximately 2V for the transmitter. The received signal after demodulation is also amplified in the a.f. sub-unit. In addition the sub-unit provides a d.c. signal to the carrier control system in the modulator.

Circuit summary

3. An audio signal appearing at the input of the sub-unit from the microphone is amplified by a

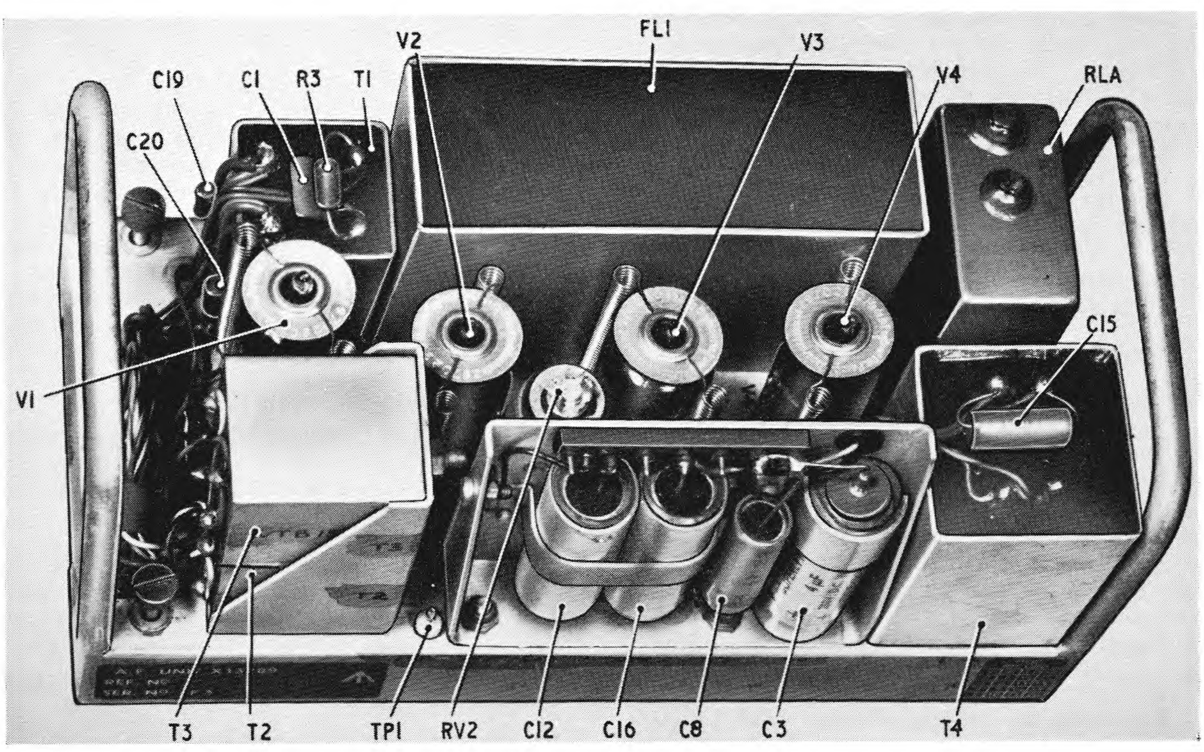

Fig. 1. Amplifier audio frequency—top

low-noise pentode amplifier stage, this is in turn resistance-capacity coupled to one half of a double-triode valve. The output from the double-triode valve is fed through an L-C audio bandpass filter having a pass band of 500 c/s–3 kc/s. The filter supplies an a.f. output to the modulator radio transmitter sub-unit (*Chap.* 6) when the s.s.b equipment is switched to the transmit condition.

4. Voice operated gain control (VOGAD) is applied to both stages of the microphone amplifier to keep the a.f. output constant with varying input speech levels.

5. A sidetone signal is taken from the anode circuit of the triode section of the diode-triode VOGAD amplifier, via a pre-set volume control potentiometer and relay contacts, to the telephones output stage. This sidetone amplifier acts as an intercommunication system when the equipment is operating in the receive condition.

6. Muting is provided by a relay contact, this when open allows a preset level of muting on receive by connecting a high value resistor in series with the grid of the receiver first audio amplifier valve (*para.* 40).

7. The receiver audio amplifier consists of a pre-amplifier stage, bandpass filter circuit and telephone output amplifier. The output amplifier producing approximately 300 mW into an impedance of 50 ohms.

8. Receiver audio gain control is obtained by adjusting the negative feedback produced across the primary winding of a transformer connected in the cathode of the first stage.

9. Audio gain is adjusted by a remote switch in the control radio set 5821–99–913–3108, (remote control unit). The switch has six positions these effectively insert shunts across the secondary of the transformer (*para.* 8) changing the gain in approximately three decibel steps.

10. The a.f. unit contains three relays, two of which are operated by the action of the transmit/receive switch and are shown in fig. 2, whilst the third is operated by the muting switch situated on the remote control unit.

DETAILED CIRCUIT DESCRIPTION

Microphone amplifier

11. Input audio signals from the microphone enter the a.f. sub-unit via pins D1, D2 of plug PLA (*fig.* 3 *end of Chapter*). This a.f. input is balanced with respect to earth by resistors R1, R2 and capacitors C19, C20, this network effectively putting a centre tap on the primary winding of input transformer T1. Capacitors C19, C20 also have additional use for decoupling to radio frequencies which may be present on the input signal, due to pick-up in the wiring.

12. The secondary winding of transformer T1 has resistor R3 connected in parallel to form a load, with C1 connected as a further r.f. decoupling capacitor. Speech signals produced across the secondary of transformer T1 are applied to the control grid of the microphone amplifier, pentode valve V1 (CV4085), via the grid "stopper" resistor R5. Valve V1 is a special low-noise high-gain pentode to provide maximum gain with a minimum of hum and distortion.

13. An amplified version of the speech signals appear at the anode of V1 where resistor R8 forms the load. Decoupling in the anode circuit is performed by resistor R7 in conjunction with capacitor C3. A similar function for the screen grid is carried out by components R4, C2; in addition resistor R4 provides the necessary volts drop to give the correct operating voltage for the screen grid.

14. Grid bias for valve V1 is provided by connecting the cathode to a positive potential from the h.t. supply, this is done so that the grid bias does not vary with the cathode current of V1. Resistors R9, R6 for a potential divider network, the voltage across R6 is applied to the cathode of the valve. The cathode of V1 is decoupled to a.f. by capacitor C4.

15. Audio signals are coupled from the anode of V1 to a further amplifier valve V3b through capacitor C11. Resistors R23 and RV3 form a potential divider network, a portion of the a.f. signal, depending on the setting of RV3, is fed to the grid of V3b.

16. Bias for the grid of V3b is obtained from biasing the cathode to a positive potential from the h.t. supply in a similar way to that mentioned in para. 14. Resistors R27, R25 form a potential divider network, the cathode voltage being obtained across R25.

17. A resistor R26 in the anode circuit of V3b forms a load for the valve and an amplified audio signal is obtained across this load.

18. The audio output signal from the anode of V3b is applied to the audio bandpass filter FL1 (under transmit conditions) the signal is then coupled to the primary of T3 via correction network R32, C17 (*para.* 33). The voltage induced in the secondary winding of T3 is fed to pins C4, C5 of PLA for connection to the modulator, radio transmitter sub-unit (*Chap.* 6), the latter is also fed with an a.f. signal from the primary winding of T3, this signal operates the carrier control system in the modulator.

Voice operated gain control (VOGAD)

19. The object of VOGAD is to provide a constant audio level to the modulator sub-unit irrespective of the level of the voice frequencies fed to the a.f. amplifier from the microphone.

20. Audio frequencies are fed to valve V2a (CV4059) via capacitor C5 from valve V1. Valve V2a is the triode section of the diode-triode valve used for VOGAD control. The grid of V2a is connected to earth through resistor R11 the latter operating as a grid leak.

21. Speech frequencies are amplified in V2a and appear at the anode where resistor R13 forms the anode load.

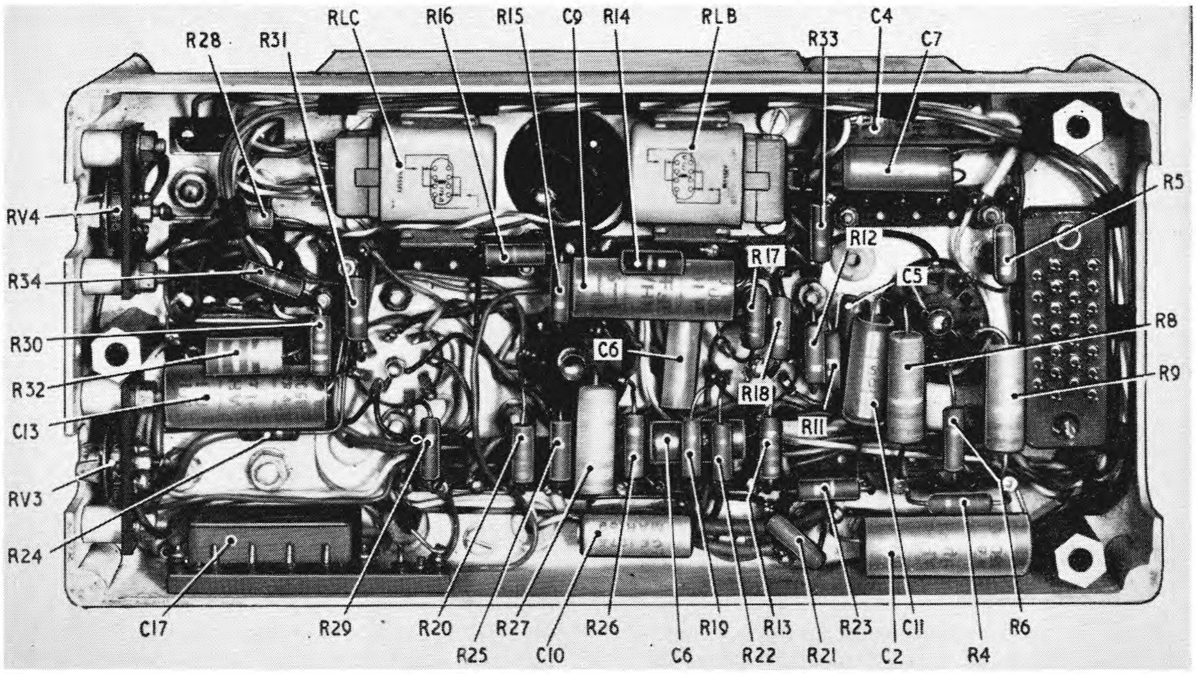

Fig. 2. Amplifier audio frequency—underside

22. Grid bias for V2a is provided by resistor R12 in the cathode lead. This resistor is not bypassed, in this way giving some degree of negative current feedback over this stage.

23. Audio signals are coupled from the anode of valve V2a through capacitor C6 to the cathode of the diode section of the valve V2b. The cathode of V2b is held at a positive potential with respect to the anode by the potential divider chain R14, R18 fed from the h.t. supply. Capacitor C9 acts as a decoupling capacitor for resistor R18, whilst R17 provides the d.c. connection to earth for the diode V2b.

24. The anode of the diode V2b is earthed via resistor R21. When an a.f. signal is present of sufficient level to overcome the bias applied to the diode, the diode will conduct, thereby producing a negative d.c. voltage across resistor R21.

25. This d.c. voltage obtained from the diode is applied to the control grid of valve V1 (CV4085) via a.f. filter network C12, R19, C8, to reduce the gain of this stage.

26. Approximately half the d.c. voltage obtained from the diode V2b is also fed to the grid of triode valve V3b (CV4024), via the potential divider network R22, R24, capacitor C13 acts as an a.f. decoupling component.

27. The action of the circuit is as follows, as the audio level from the microphone increases, the d.c. negative bias voltage obtained from the diode also increases thereby reducing the gain of audio amplifiers V1 and V3b. This action provides an almost constant audio signal level at the output of the a.f. sub-unit on pins B3, C4, C5 of PLA.

Receiver pre-amplifier

28. The audio signal from the combining stage of the control electrical frequency is fed into the receiver pre-amplifier stage via PLA/D3. Valve V3a one half of a double-triode (CV4024) operates as a pre-amplifier. Audio signals are coupled to the grid via capacitor C7, with potentiometer RV2 functioning as a pre-set gain control.

29. A resistor R33 (*fig.* 2) in series with the signal path acts as a muting resistor, relay contact RLB1 short circuiting the latter under receive conditions. Resistor RV2 has a potentiometer action on the audio signal giving suitable fixed attentuation to avoid over-loading and distortion.

30. Included in the cathode circuit of V3a is transformer T2, this transformer provides negative feedback over the amplifier stage and coupling for the remote gain control fitted to the remote control unit.

31. The gain of amplifier V3a is controlled by adjusting the negative feedback produced across the primary winding of transformer T2. Feedback is provided by resistors R15, R16. Capacitor C10 provides an earth connection for audio frequencies, at the same time blocking the path to earth for the d.c. bias. Grid bias is produced by resistor R15.

32. An amplified audio signal appears at the anode of valve V3a where the load resistor is R20. This audio signal is coupled to the a.f. output stage through the audio bandpass filter FL1 and relay contacts RLA1, RLA2.

Receiver output stage

33. The receiver output stage is capable of producing 300 mW of audio signal into a 150-ohm load. Amplifier valve V4, a high-slope pentode (CV4014) is used in this position. Signals received are fed from the filter via capacitor C17 and resistor R32 to the grid of the amplifier V4. The capacitor C17 with resistor R32 provide an audio "top lift" circuit, this has the effect of providing a rising characteristic curve over the band of a.f. signals used giving improved clarity of voice frequencies. Resistors R28, R30 and RV4 together form the grid leak of the output stage under these conditions.

34. Cathode bias for amplifier valve V4 is produced across the resistor R31 which is decoupled by capacitor C16. By connecting the bias circuit into the secondary of the output transformer circuit, negative-voltage feedback is produced over the output stage, thus providing reduced noise level with improved frequency response.

35. Transformer T4 functions as an output transformer for the stage. Capacitor C15 connected across the primary of this transformer provides a shunt path for the higher audio frequencies. Output audio signals are connected to PLA/D4 for application to headphones.

36. The h.t. supply for the screen grid of V4 is taken from the main 200V supply via an anti-parasitic "stopper" resistor R29.

Intercommunciation system

37. A sidetone signal is taken from the output of the a.f. amplifier valve V2a through coupling capacitor C14 to the grid of the output valve V4. Variable resistor RV4 functions as a gain control for the intercomm. system; the a.f. sidetone signal then reaches the grid via isolating resistor R28 and relay contacts RLA3 and RLC1.

38. When the s.s.b. equipment is switched to transmit conditions, relay contacts RLA3 and RLC1 change over; these contacts then connect resistor R34 between the control grid of V4 and earth, at the same time the sidetone signal is still applied to the output valve V4.

39. The reason for this change in grid leak value for the valve V4 is that the input loading of the a.f. bandpass filter FL1 on the output valve V4 requires the grid leak value to be changed so that the sidetone level is maintained approximately the same in both transmit and receive conditions.

Receiver muting

40. In order to overcome receiver noise being heard in the headphones during periods of intercommunication, a muting relay RLB/1 is fitted. Relay contacts RLB1 short circuits resistor R33 in the grid circuit of V3a (*para.* 29) under normal receive conditions allowing full receiver sensitivity. When RLB/2 is de-energized by opening the muting switch contact to PLA/B5, the short circuit across R33 is removed by relay contact RLB1 in this way reducing receiver noise in the headphones.

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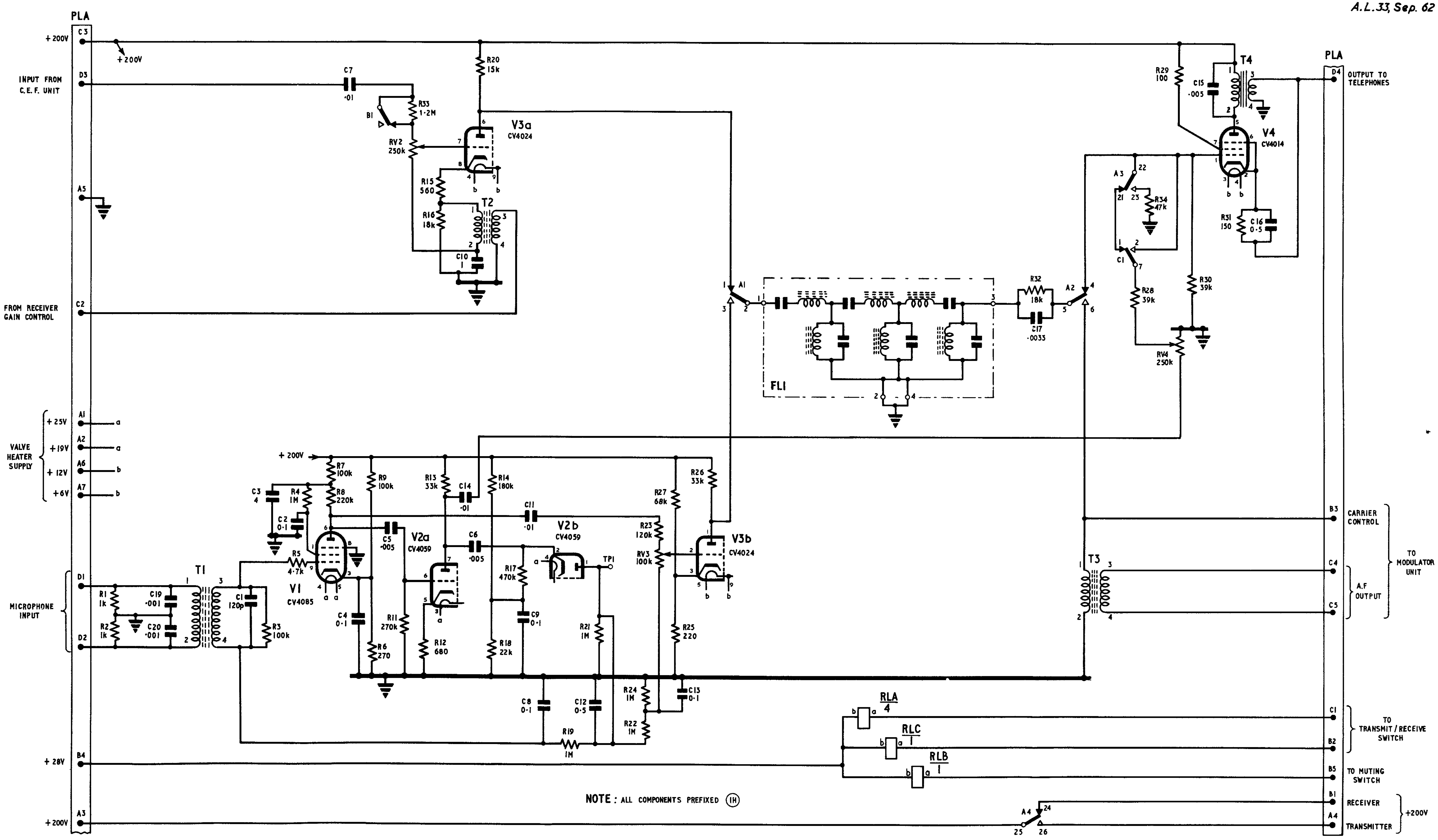

Amplifier A.F. 5821-99-913-2237: circuit

Fig. 3

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Chapter 6

MODULATOR RADIO TRANSMITTER, 5821-99-913-2235

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

1. The function of the modulator radio transmitter is to produce a single-sideband signal which after frequency conversion, is suitable to provide a drive signal for the transmitter, power amplifier. This is accomplished by combining two inputs, namely an r.f. input of 1·5 Mc/s and a.f. speech frequencies obtained from the microphone. The modulator uses a four-phase modulator circuit arrangement to obtain the single-sideband signal. A four-phase modulator can be considered as being two balanced modulators with the r.f. and a.f. inputs in phase-quadrature, (*Part* 1, *Sect.* 1, *Chap.* 1, *para.* 31). In the normal balanced-modulator arrangement the carrier is suppressed, and two sidebands appear in the output. With the four-phase modulator this is extended further so that not only is the carrier suppressed, but also the lower sideband is cancelled leaving the upper sideband to appear at the output of the modulator, thus giving the required s.s.b. signal at 1·5 Mc/s. This is also known as the "phasing" method of sideband generation.

Circuit summary

2. In the four-phase modulator to be described, four pentodes are used, the high input impedance characteristics of the valves avoiding reaction on the relative phases of the audio inputs to the control grids. In addition the outputs of the modulators are combined conveniently by the parallel connection of the four anodes to a common anode circuit. The modulators are followed by a crystal filter to further reject the unwanted sideband and a buffer stage is interposed to correctly match the filter input to the modulators.

3. The modulator (*fig.* 1), is constructed on a removable sub-chassis and forms part of the transmitter-receiver assembly. The two input signals to the modulator are obtained:—

(1) from the oscillator r.f. 1·5 Mc/s sub-unit.

(2) from the a.f. unit.

Variable potentiometers RV1, RV2, RV3, RV4 (*fig.* 2) are used for modulator and sideband balancing and are accessible from the side of the sub-unit. Above these potentiometers and also accessible from the side of the sub-unit are the radio frequency phasing capacitors and inductors. The modulator valves are held in small metal screens; these valves have flexible leads and are directly wired into the circuit.

4. The 1·5 Mc/s r.f. signal applied to the cathodes of the modulator valves is a four-phase signal obtained from a balanced source via phase-shifting networks in the cathode circuits. The balanced a.f. input obtained from the audio-amplifier is also passed through a phase-shift network, and the four-phase signal thus obtained is applied to the grids of the modulator valves.

5. The s.s.b. signal obtained from the modulator valves in the common anode circuit is applied to a

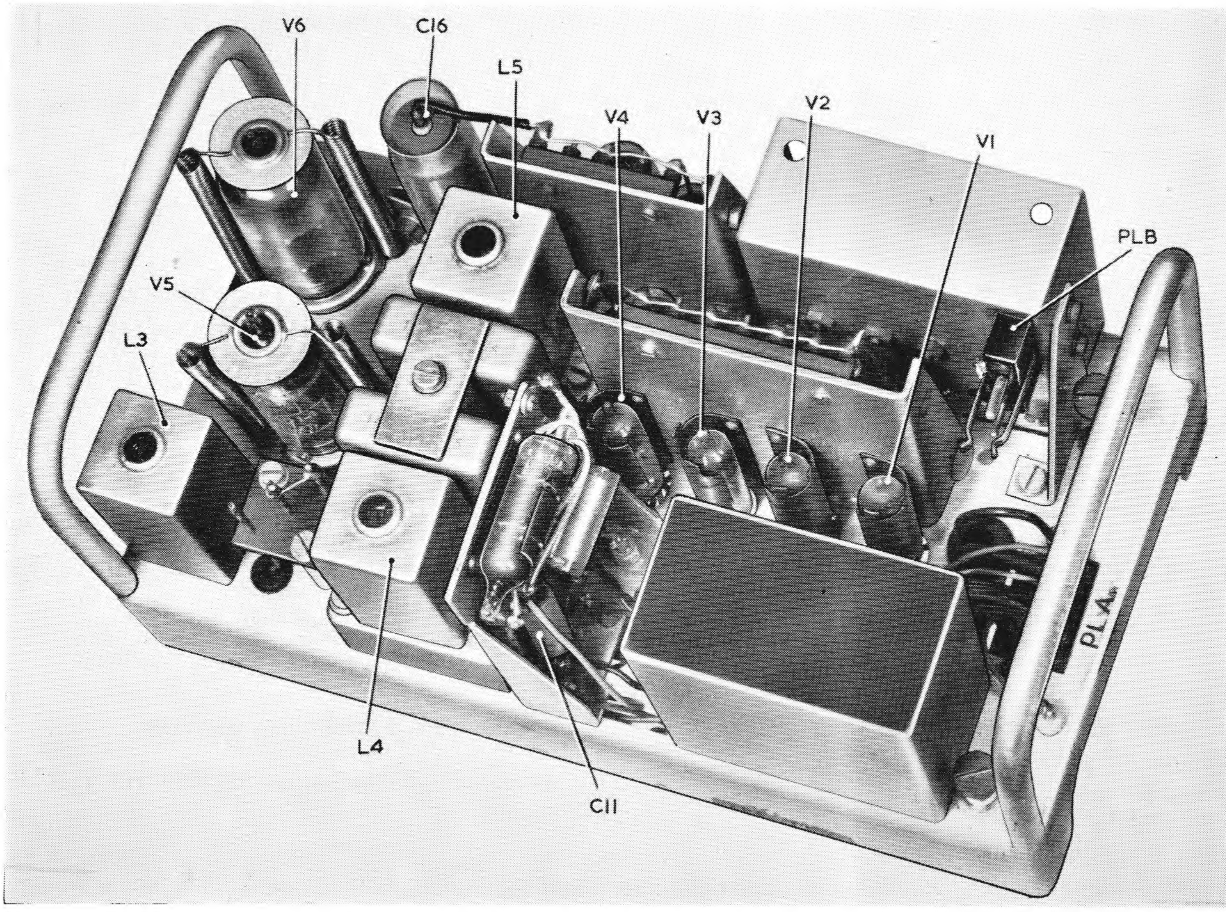

Fig. 1. Modulator radio transmitter, top view

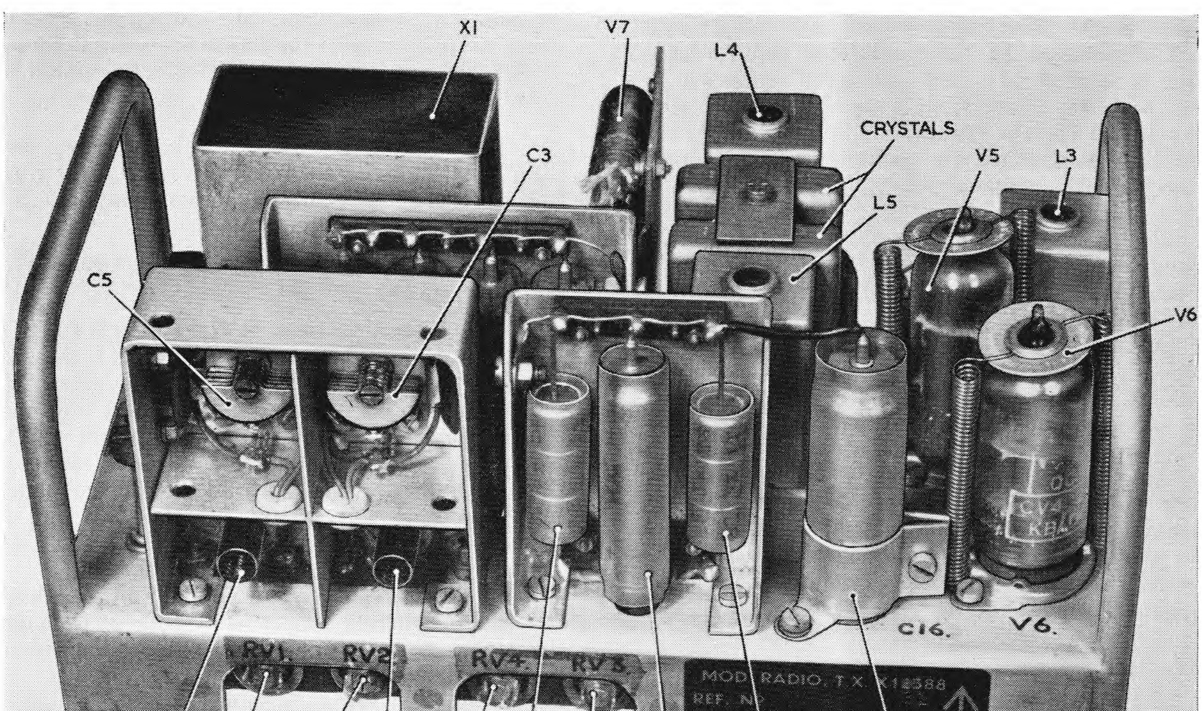

Fig. 2. Modulator radio transmitter, side view

buffer-amplifier valve V7 before being fed to a crystal band-pass filter. After passing through the crystal band-pass filter, which is designed to reject frequencies of the lower sideband, the s.s.b. signal is again amplified by a further buffer-amplifier stage V5 before being applied to the r.f. amplifier sub-unit.

6. An automatic load correction voltage is developed in the r.f. power amplifier, this is a negative d.c. voltage and is fed back onto the control grid of the second buffer-amplifier in the modulator, to vary the output of the modulator so that constant output from the r.f. power amplifier is obtained over the frequency range covered.

7. The transmitter is designed to transmit a low-power carrier during periods when no a.f. modulation is applied to the four-phase modulator (*see Note*). This carrier signal is obtained by using a gating valve which, in the absence of an audio signal, applies some of the 1·5 Mc/s r.f. to the last amplifier stage in the modulator, thus producing a carrier signal of half the s.s.b. peak signal amplitude. When an audio signal enters the modulator from the a.f. unit, the audio frequencies are rectified and used to bias the carrier control valve to cut-off. This carrier level amplitude is set by RV5 which is accessible from the end of the sub-chassis.

Note . . .

The original design of the equipment necessitated the use of an a.f.c. unit for frequency correction. This unit was operated in other receivers by the transmission of a low-power carrier the deviation of which caused a correction to be applied by the a.f.c. motor. Since the development of the generator reference signal, the a.f.c. unit has become redundant and no longer has any effect on the transmitted frequency. The lower-power carrier is, however, still transmitted as originally arranged and may serve a purpose in future applications.

DETAILED CIRCUIT DESCRIPTION

Note . . .

A list of valve functions is given in Table 1 at the end of this chapter.

Four-phase modulator

8. Reference to the circuit diagram (*fig.* 5, *end of chapter*) shows that a balanced input from the oscillator r.f. (1·5 Mc/s) is brought into the modulator sub-unit via plug PLB, thus the r.f. signals at the points C2, C3, L1 and C4, C5, L2, are in anti-phase. The components C2, C3 and R2 form a phase-advance network such that the voltage appearing across R2 is advanced 45° in phase from the voltage applied from pin 1 of PLB. Similarly, components L1, and R6. form a phase-retard network such that the voltage appearing across R6 is retarded 45° in phase from the voltage applied from pin 1 of PLB.

9. Thus we have between the cathodes of V1 and V3 two signals differing in phase by 90°. A similar phase-shift but of opposite sense (i.e. 180° out of phase with the first) is applied from pin 2 of PLB to the cathodes of V2, V4; the phase shifting components being in this case C4, C5, R5, L2 and R9. Trimmers C3 and C5 permit accurate adjustment of the carrier phases. The r.f. signals thus applied to the cathodes of V1, V2, V3 and V4 are in phase-quadrature (*fig.* 3).

10. Signals from the a.f. unit enter the modulator via pins B1, B2 on PLA (*fig.* 5) and are applied across RV1, the a.f. balance potentiometer. The a.f. signals appearing at pins F and G on the phase-shift network X1, are in anti-phase. These two voltages are equal and are balanced to earth, the necessary adjustment being obtained by operation of RV1. After passing through the R–C phase shift network X1 which is a "potted" unit, the a.f. signals appear on pins D, C, B and A of X1 in phase-quadrature and are applied to the grids of the four-phase modulator valves V1, V2, V3, V4.

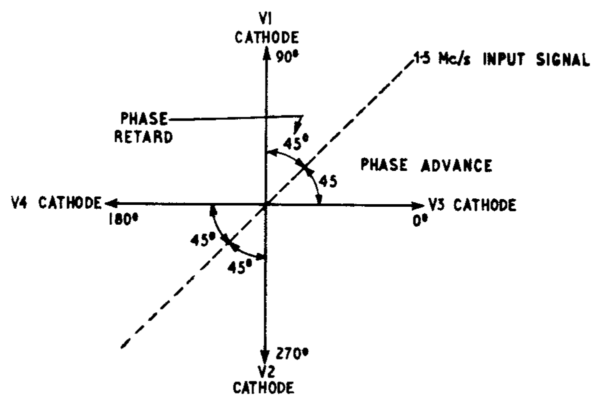

Fig. 3. Modulator radio frequency 1·5 Mc/s phase relationship

11. Thus we have r.f. and audio signals (in phase quadrature) applied to the valves in the four-phase modulator. Due to the alteration in the relative phases of the outputs of the two balanced modulators V1, V2 and V3, V4, four sideband signals are produced in the anode circuit. However one pair of signals will add being in phase, whilst the other pair will cancel, being out of phase, the final result is a single sideband signal in the anode load resistor R26.

12. It can be seen from the foregoing that the four-phase modulator produces a s.s.b. signal, the carrier being suppressed. By exchanging the audio inputs of the phase shifting networks, it is possible to cancel the alternative sideband, but filter X2 would also have to be changed. A simplified vector diagram representation of the action of the modulator is given in Part 1, Sect. 1, Chap. 1, fig. 8, of this publication.

13. Anode voltage is supplied to the modulator valves from the h.t. supply line via R26 the common anode load, R11 being a decoupling resistor used in conjunction with C11. The screen-grid supply to the valves is decoupled via R10 and C10. The anode voltage to the modulators is maintained in both the transmit and receive conditions to keep the modulator balance stable during operation.

14. The purpose of RV2 and RV3 is to obtain modulator carrier balance, whilst RV4 is used for sideband balance. RV2 equalizes the gain of V1 and V2 thus making the carrier gain equal in both valves and therefore being in anti-phase the carrier signal cancels at the anode. RV3 performs the same function for V3 and V4. RV4 equalizes the gain of the combination V1, V2 as set by RV2, and V3, V4 as set by RV3. Thus the unwanted sideband components now being equal in amplitude but opposite in phase will cancel out.

Sideband amplifier and filter

15. The signal generated in the four-phase modulator is applied to a buffer-amplifier valve V7 via coupling components C31 and R4, R3 being a grid-stopper resistor. An underside view of the modulator is given in fig. 4. The load in the anode circuit of V7 consists of a tuned circuit which forms the input to a half-lattice crystal band-pass filter X2, this is a 1·5 Mc/s transmit filter adjusted to reject the lower sideband. The resonant frequencies of the two crystals are at the lower and upper edges of the pass-band respectively, while the input and output circuits are tuned to the mid-band frequency. At frequencies below the lower edge of the pass-band, both crystals present a capacitive impedance due to the "push-pull" input and parallel output connections, the outputs from the two crystals are in anti-phase, so that the resultant output is less than that from one crystal alone. Between the resonant frequencies of the two crystals, the outputs, owing to the method of connections, are additive, so that their combined output is greater than that obtained from one crystal alone. Above the higher edge of the pass-band, both crystals present an inductive impedance, but their outputs being in anti-phase, tend to cancel out. Thus a low attenuation is obtained between the resonant frequencies of the two crystals and a high attenuation outside this band.

16. Output from the crystal band-pass filter is fed to a further amplifier valve V5 via C17, C23, with R25, R24, acting as grid resistors. The junction of R25, R24, is taken to pin C1 on PLA where the a.l.c. voltage is obtained which controls the output of the valve V5 to provide a constant carrier-amplitude output. The amplified intermediate-frequency signal at 1·5 Mc/s appears across the tuned primary of transformer T1, the secondary of which provides the output coupling to pin D1 of plug PLA. A link is provided to by-pass the transmit crystal filter during alignment, coupling between valves V7 and V5 is then provided by R12 and C13.

Carrier control ciruit

17. This circuit is arranged so that a carrier is produced from the modulator radio transmitter unit between speech signals during a transmission.

18. Valve V6, a double-triode, is used as an amplifier and gating valve to control the carrier signal. A speech frequency signal from the microphone via the a.f. unit is brought into the modulator radio transmitter via pin B3 of PLA. This signal is applied to the grid of V6a which operates as an a.f. amplifier, decoupling to r.f. frequencies, which may be present due to stray pick-up, is provided by R13, C14. The valve V6a is biased in

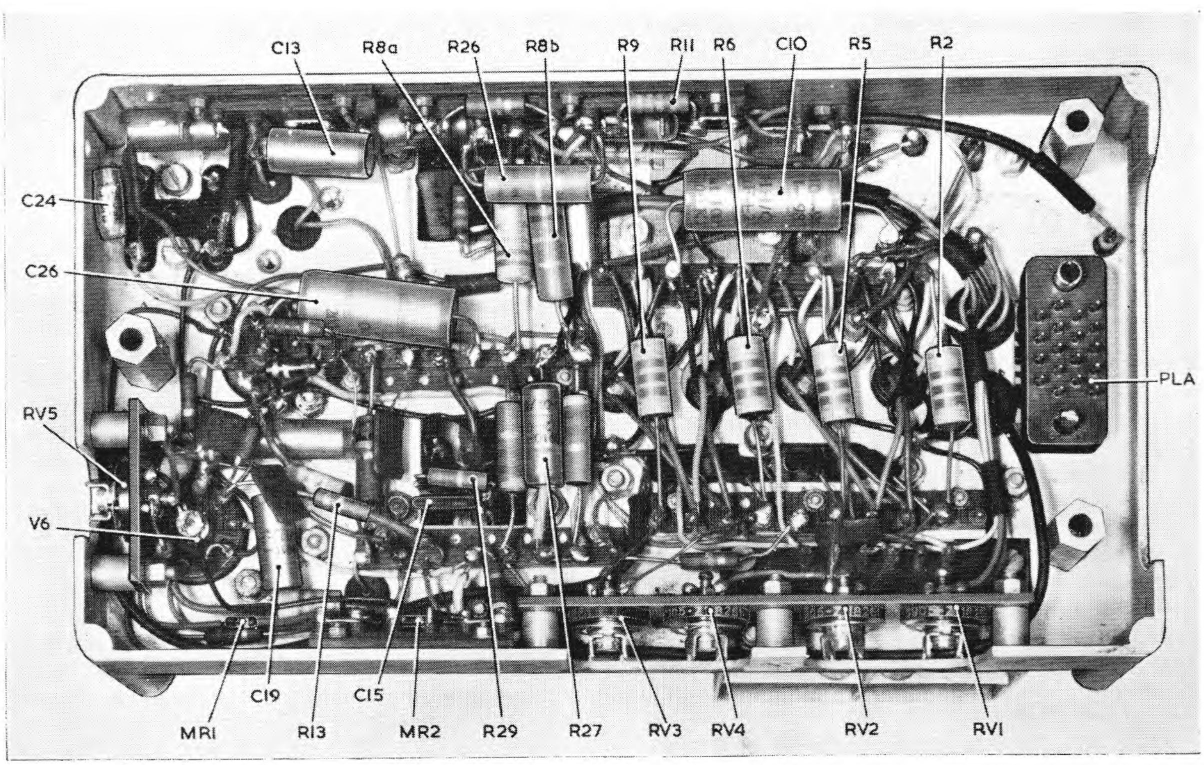

Fig. 4. Modulator radio transmitter, underside

the normal way by C18 and R16. An amplified a.f. signal appears at the anode of V6a, where R18 forms the anode load resistor. From the anode of V6a the a.f. signal is fed via C19 to a voltage-doubler circuit consisting of two rectifiers MR1, MR2 and the capacitor C20. The rectifiers MR1, MR2, provide a large additional negative d.c. bias to the grid of the valve V6b when an audio signal is present. Thus when speech is being transmitted V6b is "cut off" and no carrier signal is fed to the amplifier valve V5.

19. A connection from pin 2 of PLB via C1 and R1, to the potentiometer RV5 supplies a small amount of 1·5 Mc/s r.f. signal which is injected into the cathode of V6b. An amplified version of this r.f. signal appears at the anode of V6b in the absence of an a.f. signal. The amplitude of the r.f. signal can be adjusted by the setting of RV5. The r.f. carrier signal thus obtained is now applied to the grid of V5 via coupling capacitor C23. The r.f. output from this amplifier valve V5 constitutes a signal at 1·5 Mc/s, this is suitable for transmission after its frequency has been changed to that of the signal frequency in use.

Table 1

Valve types and functions in the modulator, transmitter radio

Valve Type	*Function*	*Valve No.*	*Description*
CV2432	Modulator	V1	Pentode (wire ends)
CV2432	Modulator	V2	Pentode (wire ends)
CV2432	Modulator	V3	Pentode (wire ends)
CV2432	Modulator	V4	Pentode (wire ends)
CV4014	Amplifier-output	V5	Pentode
CV4024	Amplifier and gating	V6	Double-triode
CV4014	Sideband amplifier	V7	Pentode

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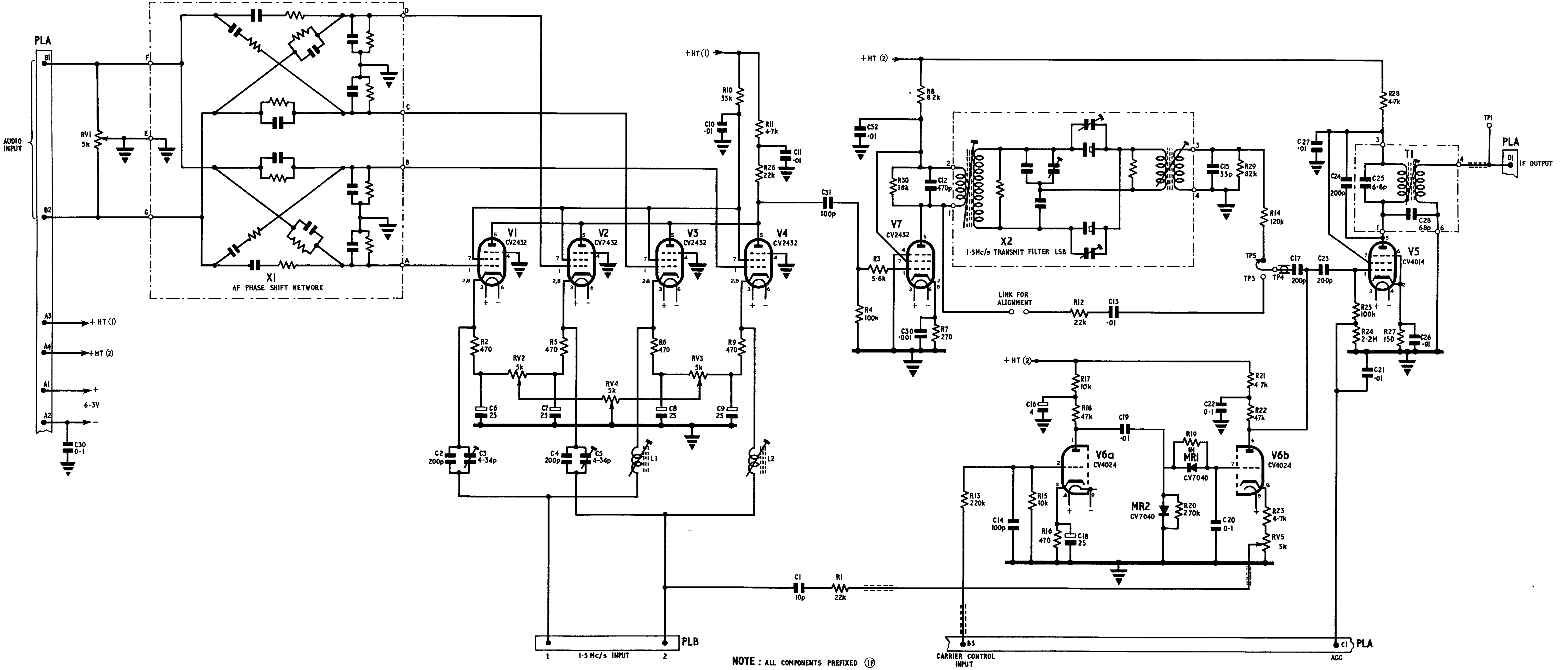

AIR DIAGRAM 6729D/MIN.	
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Modulator radio transmitter 5821-99-913-2235: circuit

Fig. 5

Chapter 7

CONTROL RADIO SET 5821-99-913-3108

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

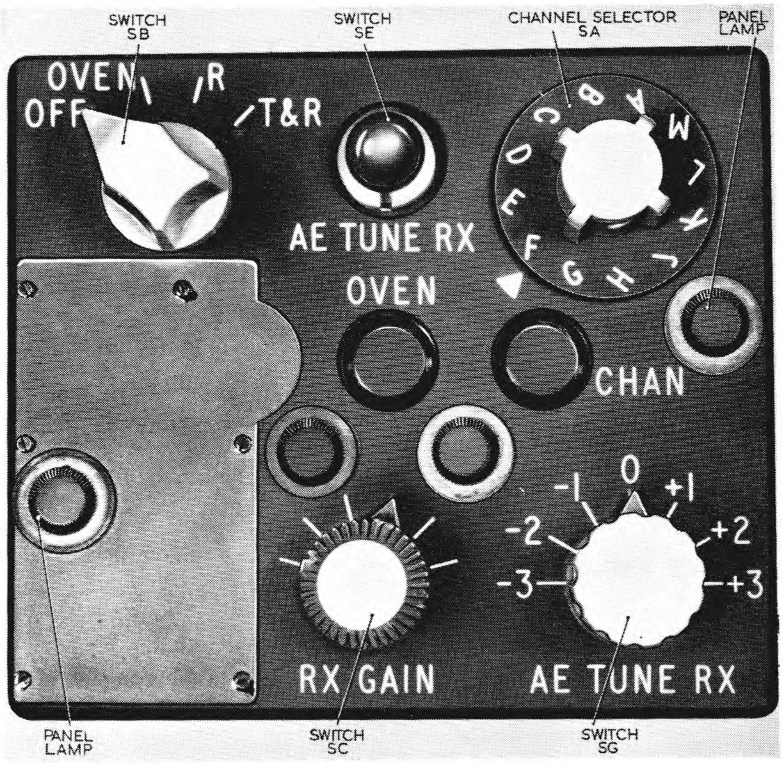

Fig. 1. Control, radio set—front

INTRODUCTION

1. Channel selection and controlling facilities are provided by control radio set 5821-99-913-3108 (remote control unit). This is a separate unit and can be fitted in the cockpit of the aircraft to give manual control and visual indication to the operator.

2. The remote control unit contains facilities for selecting any one of twelve pre-set frequency channels in the range 2 to 20 Mc/s, by rotation of a manual control engraved A to K.

Construction

3. Control radio set 5821-99-913-3108 (*fig.* 1) is contained in a rectangular metal housing 5 in. × $5\frac{3}{4}$ in. × $3\frac{1}{4}$ in. The controls on the front panel and their function are indicated in the table below.

4. The original positions taken up by the AFC/MANUAL control switches are now covered by a blanking plate since the a.f.c. system has been removed.

5. At the rear of the remote control unit are two sockets, these connect with cables to the interconnection box joining the remote control unit to the equipment.

DETAILED CIRCUIT DESCRIPTION

Channel selection

6. A circuit of the control unit is given in fig. 3. Selection of a particular channel is initiated by the operator in rotating the switch sections SA a, b, c, d, in the remote control unit. This switch is a double-bank 12-position switch, the moving contacts of which are earthed.

7. Rotation of this switch places an earth on one of twelve connections, the latter being taken to sockets SKTA and SKTB respectively. The earth connection is applied via the interconnection box to the control frequency selectors used in the s.s.b. transmitter-receiver and aerial equipment.

Audio gain control circuit

8. By means of switch SC, located on the front panel of the remote control unit, resistors R1, R2, R3, R4, are individually selected, the selected resistor is connected via pin N of SKTA across the primary winding of a transformer in the a.f. unit (*Chap.* 5). This switch provides manual audio gain control depending on the value of resistor selected by switch SC (in the minimum position pin N is connected to earth and in the maximum position pin N is unconnected).

Indicator circuits

9. The OVEN and TUNE "dolls-eye" indicators are electromagnetically operated. When the OVEN

Table 1

Front panel controls and functions

Item	Circuit Ref.	Description
Power switch ON/OFF Receive (R) Transmit/Receive (T/R)	SB	Main switch, selects oven, heater, h.t. and e.h.t. relays—these operate due to earth on SB.
Channel selector switch	SA	Selects one of 12 pre-set channel positions A to M.
Aerial fine tune button	SE	Energizes relay FT/2 located in selector unit 5985-99-999-8557 to provide aerial fine tune facility.
"Dolls eye" indicators	X1, X2	Indicate OVEN and TUNE respectively.
RX GAIN	SC	Receiver gain control.
AE. TUNE. RX	SG	Aerial fine tuning potentiometer.

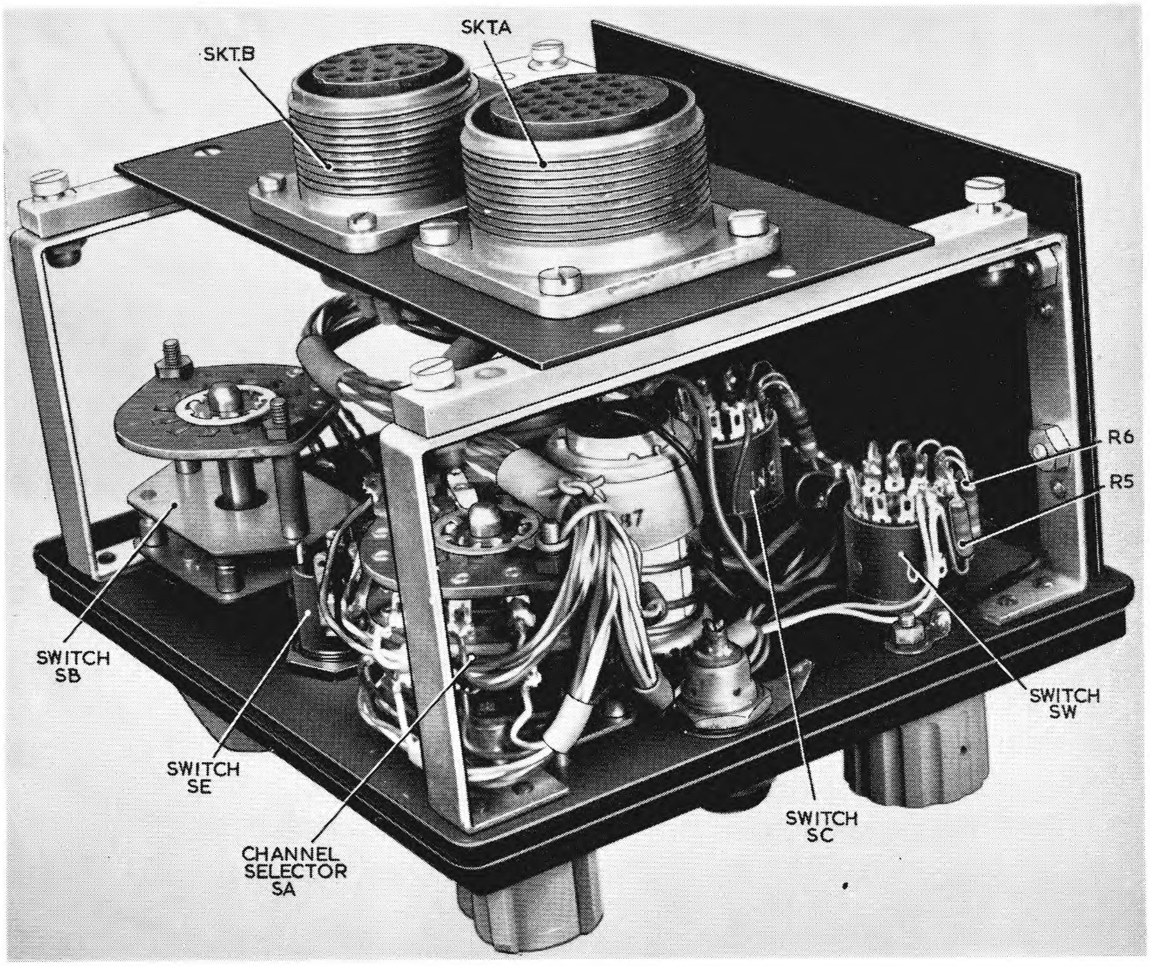

Fig. 2. Control, radio set—interior

indicator receives a 28V d.c. supply from the transmitter-receiver via SKTA/V, the solenoid X1 (*fig.* 3) operates the "dolls-eye" indicator on the front panel of the remote control unit. Resistor R11 functions as a damping resistor for the solenoid coil.

10. In a similar way to that described in para. 9 the TUNE indicator receives a 28V d.c. supply from the transmitter-receiver (SKT/U). The solenoid operates as in para. 9, R12 being the damping resistor for solenoid X2.

Aerial fine tune circuit

11. This circuit is connected to the selector unit which forms part of the suppressed aerial system. When the mechanically-biased switch SE (*fig.* 3) is closed the potentiometer network formed by resistors R5-R10 comes into action. By selecting any one of seven tapping positions on switch SG, the aerial system can be tuned a small amount about the position selected by the channel-change bridge circuit in the selector unit during reception. (*Sect.* 3, *Chap.* 1).

12. The aerial fine tune information is fed out to the selector unit via SKTB/P, R, S.

Main control switch action

13. When the main control switch SB is rotated, an earth on the common contact is placed on pins P, Q, R of SKTA depending on the facility desired, i.e. OVEN, receive (R) or transmit/receive (T/R).

14. The earth appearing on SKTA pins P, Q, and R, energize the oven relay, heater and h.t. relay and e.h.t. relay, respectively. These relays are located in the power supply unit.

Lamp circuit

15. A 28V supply enters the remote control unit via SKTB/N, this supply operates lamps ILP1, ILP2, ILP3, ILP4, which are connected in parallel. These lamps are screwed into the perspex face of the front panel to give "edge" illumination. The panel is sprayed black and only the white engraving is illuminated. The 28V supply is obtained from the cockpit dimmer control which controls the illumination of all control units in the cockpit.

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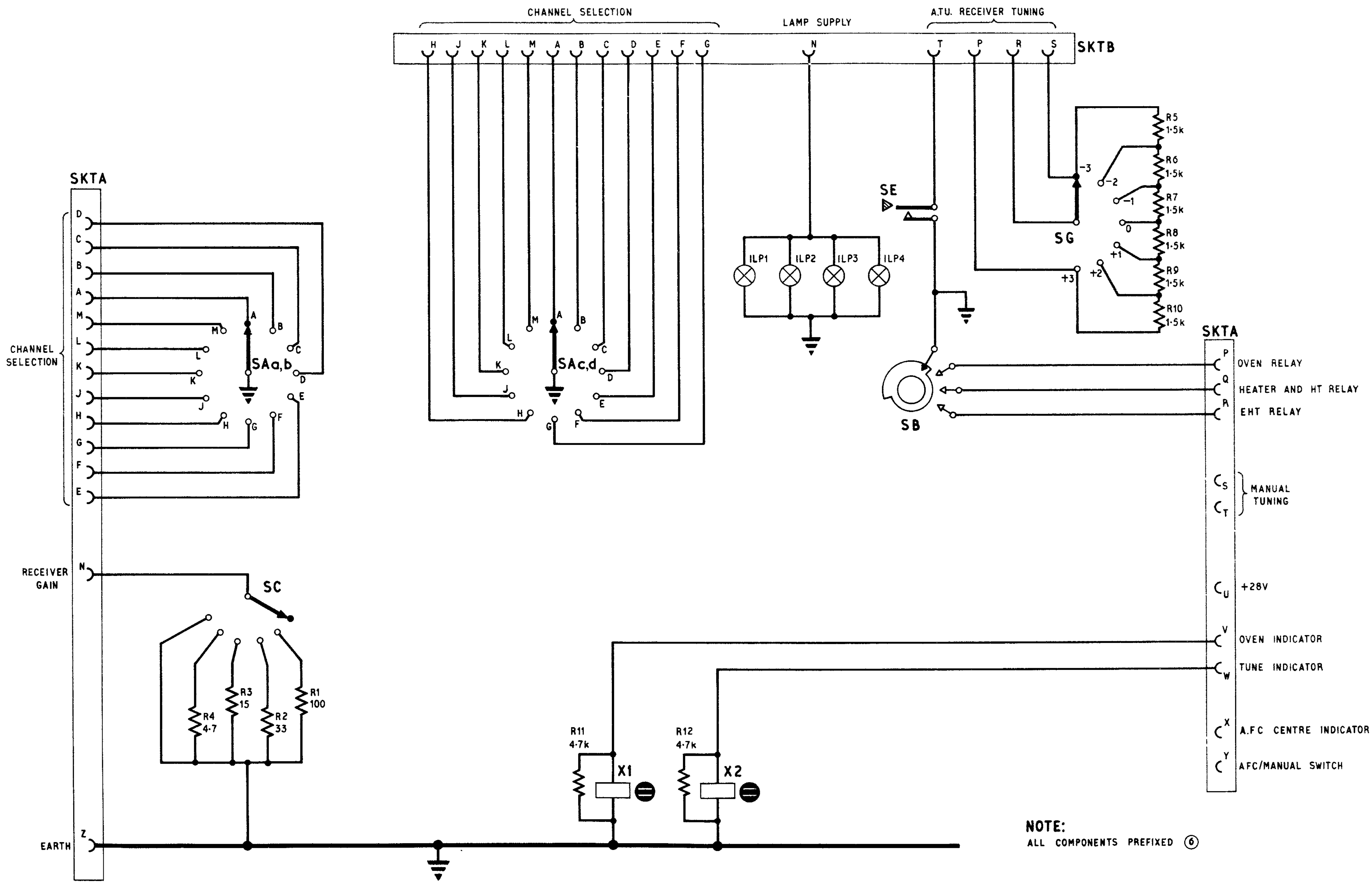

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Control radio set 5821-99-913-3108: circuit

Fig. 3

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Chapter 8

AMPLIFIER, RADIO FREQUENCY 5821-99-913-2232

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Introduction

1. Amplifier r.f. 5821-99-913-2232 (power amplifier) is operated under "linear" class AB1 conditions. A "linear" amplifier is one in which the output voltage is proportional to the input voltage. Linear amplification is necessary in the case of s.s.b. r.f. power amplifiers because it is required to amplify a modulated voltage (*Part* 1, *Sect.* 1, *Chap.* 1). If the amplification is not linear, severe distortion of the waveform will be obtained. When the envelope of a modulated signal is distorted a great many new frequencies are generated, consequently the signal received from the transmitter will tend to be unintelligible. The linear amplifier will provide a peak s.s.b. output signal of approximately 300 watts on any preset frequency within the range 2·5–20 Mc/s.

Circuit summary

2. The power amplifier (*fig.* 1) is constructed on a removable chassis which is attached to anti-vibration mountings in the radio bay of the aircraft. The output r.f. signal is fed via a coaxial cable from the output socket of the amplifier to the aerial tuning unit, the latter resonates the aerial system to the frequency being transmitted.

3. The tuning range of 2·5—20 Mc/s is covered by the power amplifier in three bands:—

(1) 2·5—5 Mc/s

(2) 5—10 Mc/s

(3) 10—20 Mc/s

Power amplifier tuning over these three ranges is carried out by a variable inductor in association with switched fixed capacitors in the form of a π network. The variable inductor is operated mechanically from a control, frequency selector (*Part* 4, *Sect.* 1, *Chap.* 10). Band selection takes place by means of switching into, or out of, circuit extra capacitors in the π networks. Two networks are used, one in the anode of the driver valve and the other in the anode circuit of the power output valves, the two inductors being mechanically coupled.

4. As a single-sideband signal is fed to the power amplifier all amplification which is carried out must be linear. To accomplish this the driver and output valves are operated under class AB1 conditions, three double-tetrode valves being used in parallel for the final amplifier (*fig.* 2).

5. Provision is made in the amplifier circuit for metering the various voltages and currents used, in addition the r.f. input and output levels are also indicated on the front panel meter M1.

6. In order to keep the output power obtained from the final stage constant with frequency and load changes, an automatic load control (a.l.c.) voltage is obtained from a transistor circuit connected across the cathode resistor of one of the power amplifier valves. This circuit provides a negative d.c. voltage which controls the 1·5 Mc/s single-sideband output from the modulator in the transmitter-receiver (*Chap.* 6).

7. The single-sideband signal produced in the transmitter-receiver is fed to the grids of the driver-amplifier stage via a low-impedance coaxial cable. This driver-amplifier valve is of the low-loss double-tetrode type operated under class AB1 conditions, the output from this valve is used to drive the three parallel-connected double-tetrode power amplifiers. The power output section, valves V2, V3, V4 is operated under class AB1 conditions, and has a small feedback capacitor (for neutralizing) connected between the grid of the power amplifier valves and the output end of the π network.

8. A π-network coupling is used in the s.s.b. driver amplifier in order to overcome non-linearity caused by power amplifier grid circuit loading due to the latter valves drawing a small grid current on signal peaks. If the power amplifier is operated under such conditions where a small grid current is drawn, non-linearity distortion is avoided by operating the valve from a low impedance r.f. drive source; hence the use of a π-network coupling ensures that the final power amplifier is operated from a low impedance source and the drive valve is operating into its correct anode load. The use of a π-section network in the anode circuit of the final

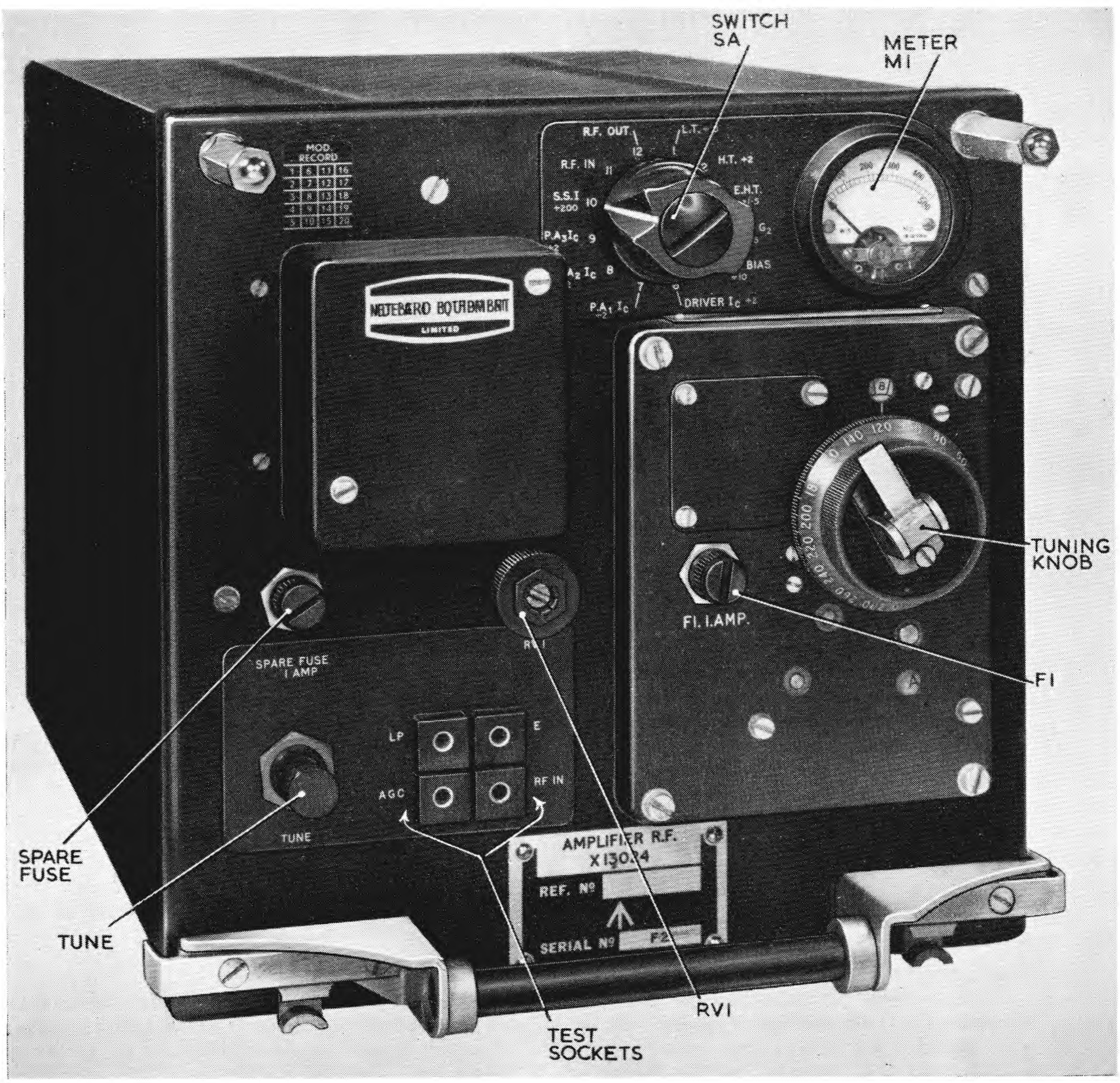

Fig. 1. Amplifier radio frequency 5821-99-913-2232-front

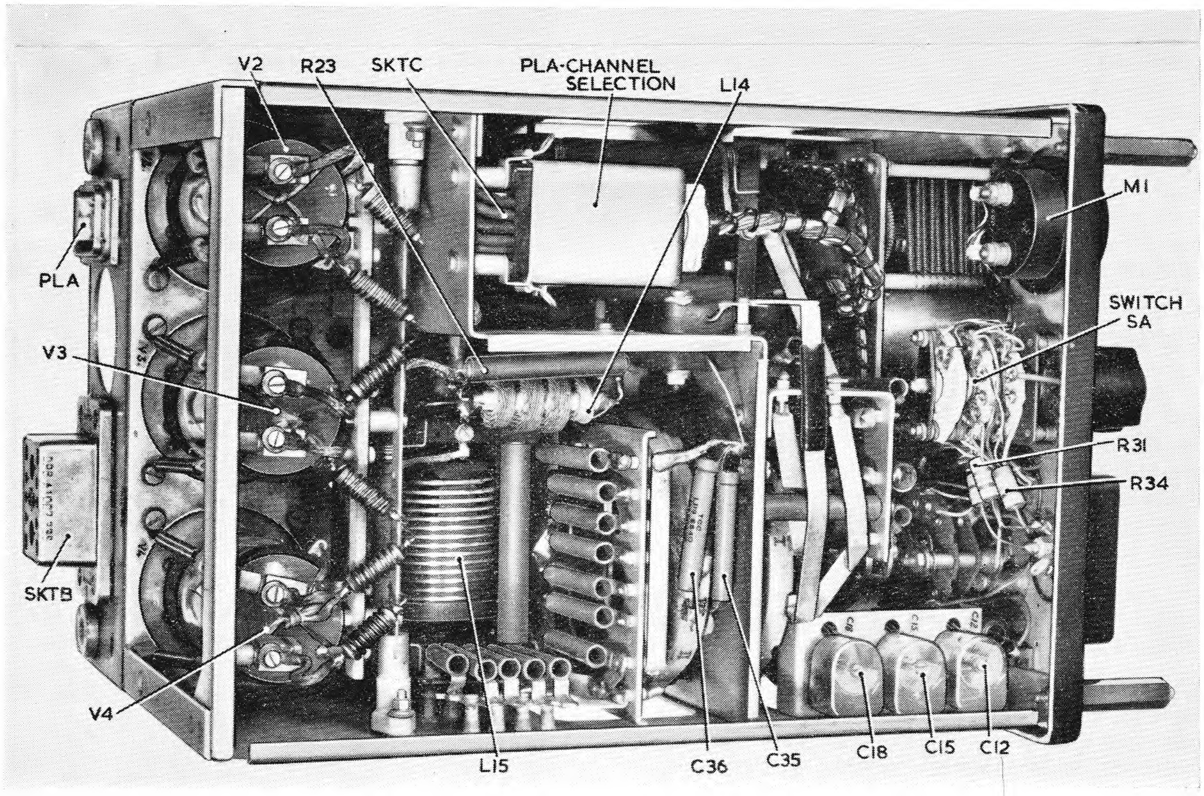

Fig. 2. Amplifier radio frequency, 5821-99-913-2232—top

amplifier ensures that the anodes of V2, V3, V4 are presented with the correct impedance when the output circuit of the power amplifier is terminated with a 50-ohm load.

9. The π-sections are tuned by means of a variable inductor, this consists of a rotatable coil and a fixed spring loaded contact which connects with the coil turns. The coil is rotated by a mechanical coupling from the control frequency selector, multi-turn (*Chap.* 10), thus effectively altering the tapping position.

DETAILED CIRCUIT DESCRIPTION

Driver stage

10. The driver stage is operated under class AB1 conditions as a voltage amplifier, producing the required r.f. drive voltage for the power amplifier. A single-sideband signal at the required frequency is fed from PLA/A1 the input coaxial connector (*fig.* 6—end of Chapter), to pin 3 on the wideband input transformer T1 (*fig.* 3). Coupling for the signal from the input transformer T1 to the grid of the driver valve V1 (CV2797) is via capacitor C1 and inductor L1 (*fig.* 5).

11. Between the control grid and earth of V1 are connected L2, R3 and capacitor C13, which together with L1, are included for correct impedance matching. Connected to the grid of V1 is rectifier MR1, the latter, in conjunction with resistor R5 and capacitors C4, C5, provides a d.c. voltage to operate meter M1 to indicate the r.f. input signal level.

12. Negative bias for the drive valve V1 is obtained from the —35V supply available at socket SKT/8. Potentiometer RV2 and resistor R1 form a potential divider across the bias supply. Connection from the moving contact of RV2 via resistor R4 to the grid of V1, allows adjustment of the bias voltage applied to the driver valve, this supply is decoupled to earth for radio frequencies by capacitor C2. A screen supply voltage for the driver valve is obtained from the 300V supply via SKTB/1, this supply is decoupled by C3.

13. R.F. voltages appearing at the anode of V1 are fed to the power amplifier valves via capacitor C7, the anode load for V1 being the π network, C11, L5, C22. The components L4 and R9 in the anode circuit act as suppressors against parasitic oscillations. Decoupling of the anode supply line from the h.t. supply of 650V is obtained via resistor R10, capacitor C6, and inductor L3.

Power amplifier

14. Valves V2, V3 and V4 (CV2797) are operated in parallel as the final power amplifier stage. These valves are of the low-loss double-tetrode type and together produce approximately 300W peak effective power output.

15. The input circuit of V2, V3, V4, consists of a π network; r.f. voltage being fed from the driver valve via capacitor C7. The π-network is made up of a variable inductor L5 tuned by fixed capacitors C11 and C22. Additional capacitance to resonate the coupler for each particular band, is switched into circuit by the three position switch SB2. Switch SB2 is ganged mechanically to switch SB3 in the output π-network and both are operated by the range 'Ledex' mechanism. The Ledex switch circuit consists of a rotary solenoid arrangement SB/4 permitting range selection in three positions. Suppression of sparking is obtained by resistor R53 and capacitor C29.

16. The coupling C11, L5, C22 (*fig*. 6) performs the combined functions of an anode tuned circuit for the driver valve V1 (*para*. 13) and grid tuning and matching over a wide frequency range for the input to the power amplifier valves. The circuit does this with the use of the minimum number of component elements. A circuit of this type provides in general more harmonic attenuation than other forms of coupling with the added advantage of having less circuit loss.

17. Tuning and matching is set for each band by switching fixed capacitors across the input and output of the π-network coupling.

18. For band 1 (2·5–5 Mc/s) operation, capacitors C16, C17, C18 are switched into circuit by position 1 of switch SB2 to tune the input of the π-network; the output being similarly matched and tuned by switching capacitor C20 into circuit.

19. Tuning and matching capacitors used for band 2 (5-10 Mc/s) are C54, C14, C15 at the network input, with C16, C17, C18 at the output of the network. For band 3 (10-20 Mc/s) the corresponding capacitors are C12 and C19. Matching and tuning capacitors for the latter two frequency bands are switched into circuit by positions 2 and 3 of the range selector switch SB2, this switch being coupled to and operated by the range 'Ledex' mechanism.

20. When the required capacitors have been selected for each band by switch SB2, final tuning for a particular frequency channel in the band selected is carried out by the variable inductor L5, the adjustable section of which is operated mechanically from the control frequency selector (multi-turn) as previously mentioned (*para*. 9).

21. The r.f. output signal from the driver valve V1 is fed through capacitor C25 to the control grids of V2, V3 and V4. Grid bias of −35V is supplied from SKTB/8 via L7, R54 to the grids of the power amplifier valves.

22. Cathode current for the power amplifier valves is metered separately via R13, R14, for V2, with C26 operating as a r.f. by-pass capacitor, the complementary cathode metering components for V3 and V4 being R17, R18, C27 and R21, R22, C28.

23. The screen grid supply for V2, V3, V4 is obtained from the 300V stabilized supply, with

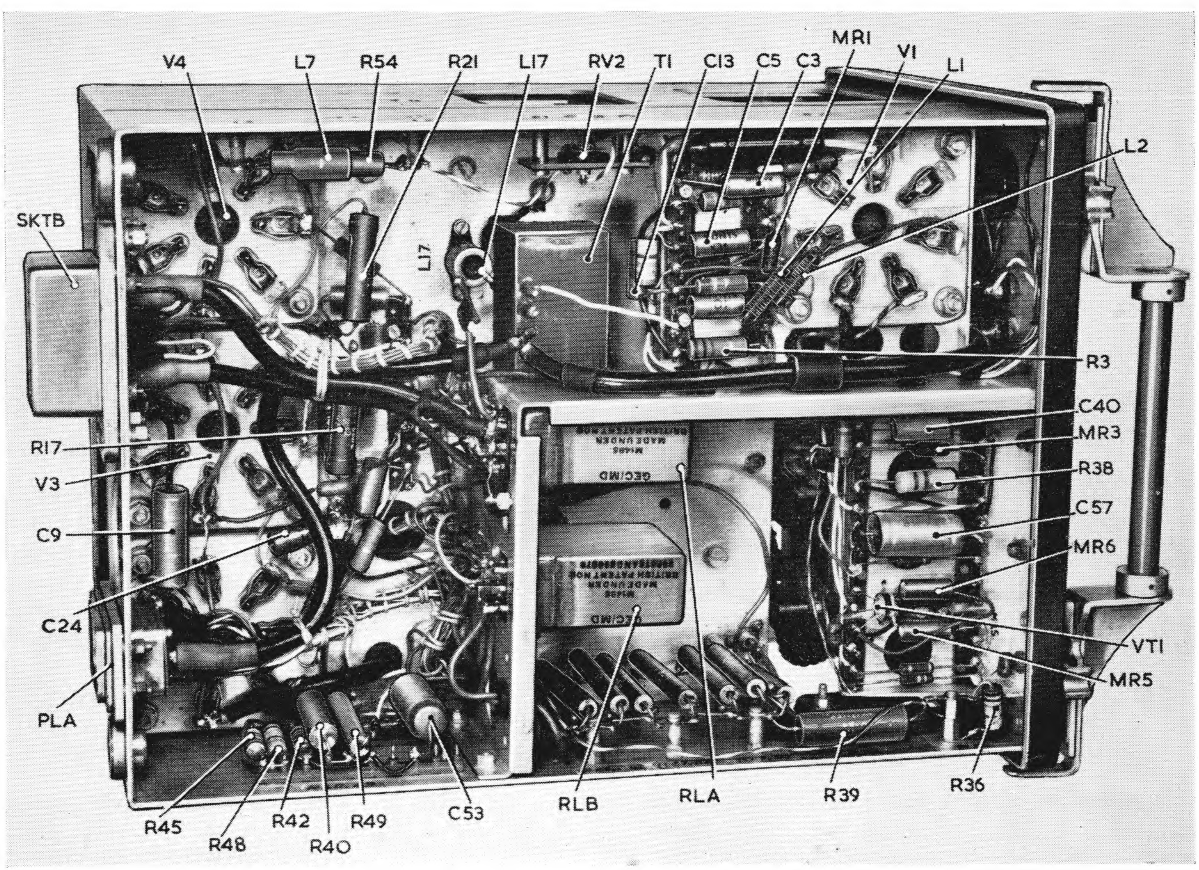

Fig. 3. Amplifier radio frequency, 5821-99-913-2232—underside

C24 effectively decoupling the valve screen grids to radio frequencies.

24. In the anode circuit of each half-section of the p.a. valves are small r.f. chokes L8, L9, L10, L11, L12, L13 shunted by resistors R12, R15, R16, R19, R20, R24 respectively. These components act as suppressors against parasitic operation. The common anode circuit of the three valves V2, V3, V4, is connected to r.f. decoupling inductor L14, which has a damping resistor R23 in parallel. The anode load is presented by the input of the π-network connected via C31.

25. A facility is provided whereby on operation of relay RLB/2 by the spring-loaded switch SC (mounted on the front panel), resistors R49 and R25–R30 are brought into circuit by the opening of relay contacts B1 and B2, this allows low power operation of the power amplifier by reason of the reduced anode and screen grid voltage.

26. The h.t. supply for the anodes of the power amplifier valves is obtained from the 650V supply at SKTB/3, decoupling to r.f. is by capacitor C30 and inductor L14.

27. Output coupling and matching for the anode circuit of V2, V3, V4 to the aerial tuning equipment is performed by a similar π-network to that used previously in the power amplifier grid circuit. The tuning and matching is set for each band by the selected fixed capacitors, i.e. for band 1, C58 and C37-C39 at the input and C42, C46-C49 at the output. Corresponding capacitors for bands 2 and 3 are, C35, C36 at the input with C58, C37-C39 at the output. These capacitors are selected by a three-position switch SB3 which is mechanically ganged to switch SB2 used in the first π-network at the input to the power amplifier valves. Both of these switches are operated by the rotary solenoid SB/4 which is situated at the rear of the front panel of the power amplifier unit behind a removable cover.

28. Final tuning of the output π-network for the preset channel required is performed by adjustment of the variable inductor L15 (*fig.* 2). There is also mechanical ganging of inductor L15 to L5, both linkages being controlled from the control frequency selector, (multi-turn) this positions the coil turns suitably for the channel selected. The inductor L16 (*fig.* 6) provides a d.c. path to earth for the aerial, without appreciably shunting the signal.

29. A low-impedance (50-ohm) output is provided and radio frequency power is taken via relay contact A1 to coaxial socket SKTB/4 for connection to the aerial tuning equipment. The r.f. output is indicated in position 12 of the metering switch SA; diode MR3 in conjunction with R32, C43, C40 provides a d.c. voltage proportional to r.f. power output.

Transmit/receive switching

30. In the circuit diagram (*fig.* 6) the transmitter-receiver is shown in the "receive" condition; when the transmitter-receiver is operated in the "transmit" condition, relay RLA/3 is energized by an earth appearing on SKTB/2 from the send/receive switch in the cockpit of the aircraft. Relay contacts A1 and A3 are closed, contact A2 opens. The r.f. power generated in the power amplifier is now allowed to energize the aerial tuning system via contact A1.

31. At the same time the receiver is disconnected from the aerial tuning system by relay contact A2, and the input circuit to the receiver is grounded via relay contact A3 closing, thus short-circuiting the receiver input. Inductor L17 is included in the connection to the receiver and is adjusted to shunt signals of 1·5 Mc/s to earth. This is known as an "i.f. trap".

Automatic load control

32. An automatic load control system is a device for keeping the transmitter signal level adjusted so that the power amplifier operates as close as possible to its maximum capability without being overdriven on signal peaks.

33. The control system adopted (*fig.* 4) receives its input from the potential developed across the cathode resistor of one of the power amplifier valves (V3), the d.c. output is used to control the gain of one of the valves in the modulator (*Chap.* 6).

34. The stabilized supply of −35V is used as the supply for the transistor in the a.l.c. system; the operating point of the transistor being adjusted so that no reduction in transmitter power output is obtained until the signal level is nearly up to the full power capability of the power amplifier.

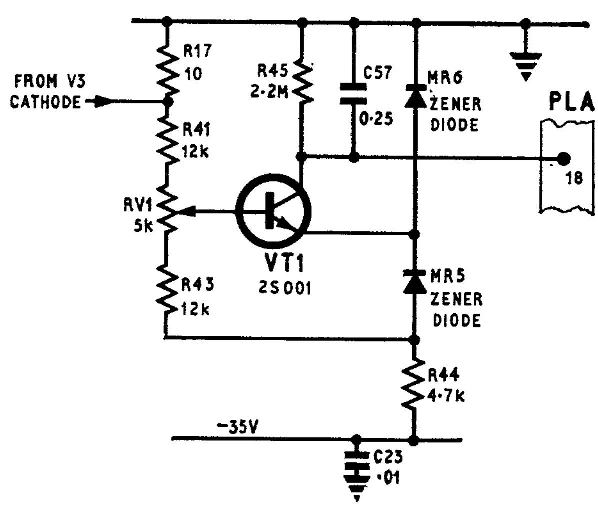

Fig. 4. Automatic load control—simplified circuit

35. It is necessary for the a.l.c. response to have a fast attack time-constant for use with voice signals in order that the drive signal may be reduced rapidly to remove the overload from the power amplifier. After the signal peak has passed, a longer release time-constant for the circuit returns the drive to normal.

36. Transistor VT1 operates as a d.c. amplifier, the emitter/earth d.c. potential being stabilized by the Zener diodes MR5, MR6 (*fig.* 4). Resistors R44, R43, RV1, R41 and R17 form a potential-divider network across the bias supply voltage of —35V, with capacitor C23 providing decoupling to r.f. Resistor R45 forms the collector load, C57 connected in parallel with this resistor acts as a decoupling capacitor, the combination of R45, C57 has a long time-constant thus giving a long release time for the a.l.c. voltage.

37. A voltage is produced across R17 which is proportional to the d.c. current flowing through the valve V3. If there is an increase of the voltage across R17, because of current changes due to the amplifier operating near maximum power capability, causing load changes, then this change of voltage across R17 is applied to the base of transistor VT1 via R41, C51, C53, this network having a short time-constant. An amplified version of this d.c. voltage will appear at the collector of VT1 across the load resistor R45. Any r.f. voltages which may have been passed by the transistor are decoupled by capacitor C57.

38. The d.c. potential produced by the transistor VT1 is used as the a.l.c. bias supply to an amplifier valve in the modulator radio (*para.* 33). The setting of the potentiometer RV1 determines the r.f. output level about which the a.l.c. circuit operates (*para.* 34).

Circuit metering

39. Circuit metering is carried out by meter M1 in conjunction with switch SA, the latter having twelve positions to select certain circuit functions. In the first four positions of the metering switch SA the various l.t. and h.t. supplies to the power amplifier are indicated on the meter M1, it is necessary to divide the meter scale reading by various factors given in Table 1, depending on the facility required.

40. The cathode current for the valves V1, V2, V3 and V4 is measured indirectly by measuring the voltage dropped across low value resistors inserted in their cathode return to earth (*para.* 22).

41. Position 10 of switch SA permits measurement of received signal strength, whilst r.f. input and output indications are obtained via rectifiers and shown on the meter M1 when switch SA is in positions 11 and 12.

Table 1

Switch positions and circuit functions of switch SA

Position	Measurement	M1 scale reading
1	L.T. voltage	Divide by 10
2	H.T. 200V	Divide by 2
3	H.T. 650V	Multiply by 1·5
4	H.T. 300V	Multiply by 1·5
5	P.A. bias volts	Divide by 10
6	V1 cathode current	Divide by 2
7	V2 cathode current	Divide by 2
8	V3 cathode current	Divide by 2
9	V4 cathode current	Divide by 2
10	Signal strength indication	Divide by 200
11	R.F. input	Divide by 20
12	R.F. output	Divide by 20

Valve heater supply

42. Both the driver and power output valves are of a type in which the heaters used in each half of each valve may be connected in a series or parallel arrangement, depending on the supply available. In the application considered here the valves are operated with each half of each valve in series with the other, hence 12·6V is required for each valve heater. The four valves V1, V2, V3, V4, are operated in a series parallel arrangement in order that power for the heater supply may be obtained from the 25·2V supply available in the installation.

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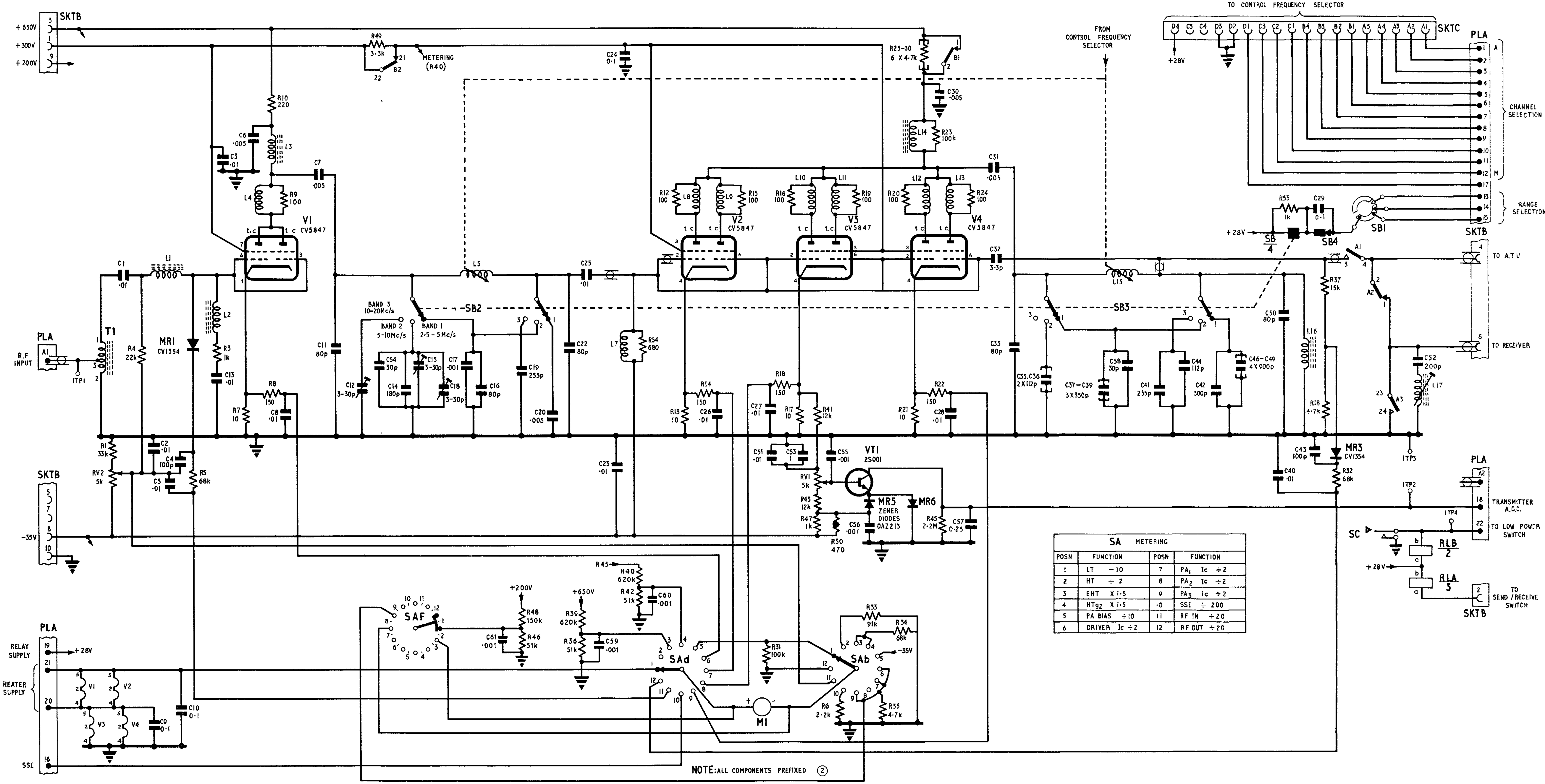

SA METERING

POSN	FUNCTION	POSN	FUNCTION
1	LT ÷10	7	PA_1 Ic ÷2
2	HT ÷2	8	PA_2 Ic ÷2
3	EHT X1·5	9	PA_3 Ic ÷2
4	HT_{92} X1·5	10	SSI ÷200
5	PA BIAS ÷10	11	RF IN ÷20
6	DRIVER Ic ÷2	12	RF OUT ÷20

AIR DIAGRAM
6729E/MIN.
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Amplifier radio frequency 5821-99-913-2232: circuit

Fig. 6

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Chapter 9

POWER SUPPLY 5821-99-913-2246

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. The power supply 5821–99–913–2246 is a separate self-contained unit used to provide all the power requirements for the single-sideband transmitter-receiver equipment. It also controls the supplies to the suppressed aerial tuning unit. There are no removable sub-units contained in the power supply unit, all the components are mounted on the chassis.

2. Input to the power supply chassis is from the 200V 400 c/s 3-phase and 28V d.c. aircraft supplies. The use of a three-phase supply system in conjunction with silicon type rectifiers has enabled a comparatively large capacity power supply to be produced within a small physical size.

WARNING . . .

Power supply 5812–99–913–2246 produces voltages of a lethal nature, great care should be exercised to avoid physical contact with components when operating the power supply chassis with the cover removed.

GENERAL DESCRIPTION

Front panel

3. On the front panel of the power supply (*fig.* 1) are eleven fuses, these are used to protect the input supplies to the unit and also the various power requirements provided by the unit for other items in the installation.

Fig. 1. Power supply, front view

4. Beneath the eleven fuses on the front panel is a detachable cover, under this are located spare fuse links.

Chassis

5. At the rear of the front panel, beneath the fuses, are situated the switching relays (not shown in *fig.* 1). Adjacent to the latter are the regulator valves and smoothing capacitor. Towards the rear of the power supply chassis are mounted the supply transformers and smoothing inductors.

6. A hinged plate, which is retained by fixing screws, is supported on small metal pillars above the rear of the power supply chassis. This plate carries some of the silicon power rectifiers used in the power supply. These silicon rectifiers (*fig.* 2) are isolated from the hinged plate by means of small stand-off insulators.

Mounting

7. The power supply is mounted in a supporting rack in the radio bay of the aircraft. At the rear of the power supply are plugs and sockets PLB, SKTA, (*fig.* 3) which mate with a similar arrangement in the mounting support. To remove the power supply from the supporting rack it is only necessary to release the two retaining screws on the mounting, after which the power supply can be withdrawn.

Supplies provided

8. The power supply unit provides the following voltages for use in the various items of equipment:

(1) 650V e.h.t. (unstabilized) for the power amplifier valves.

(2) 300V stabilized supply for the power amplifier valves.

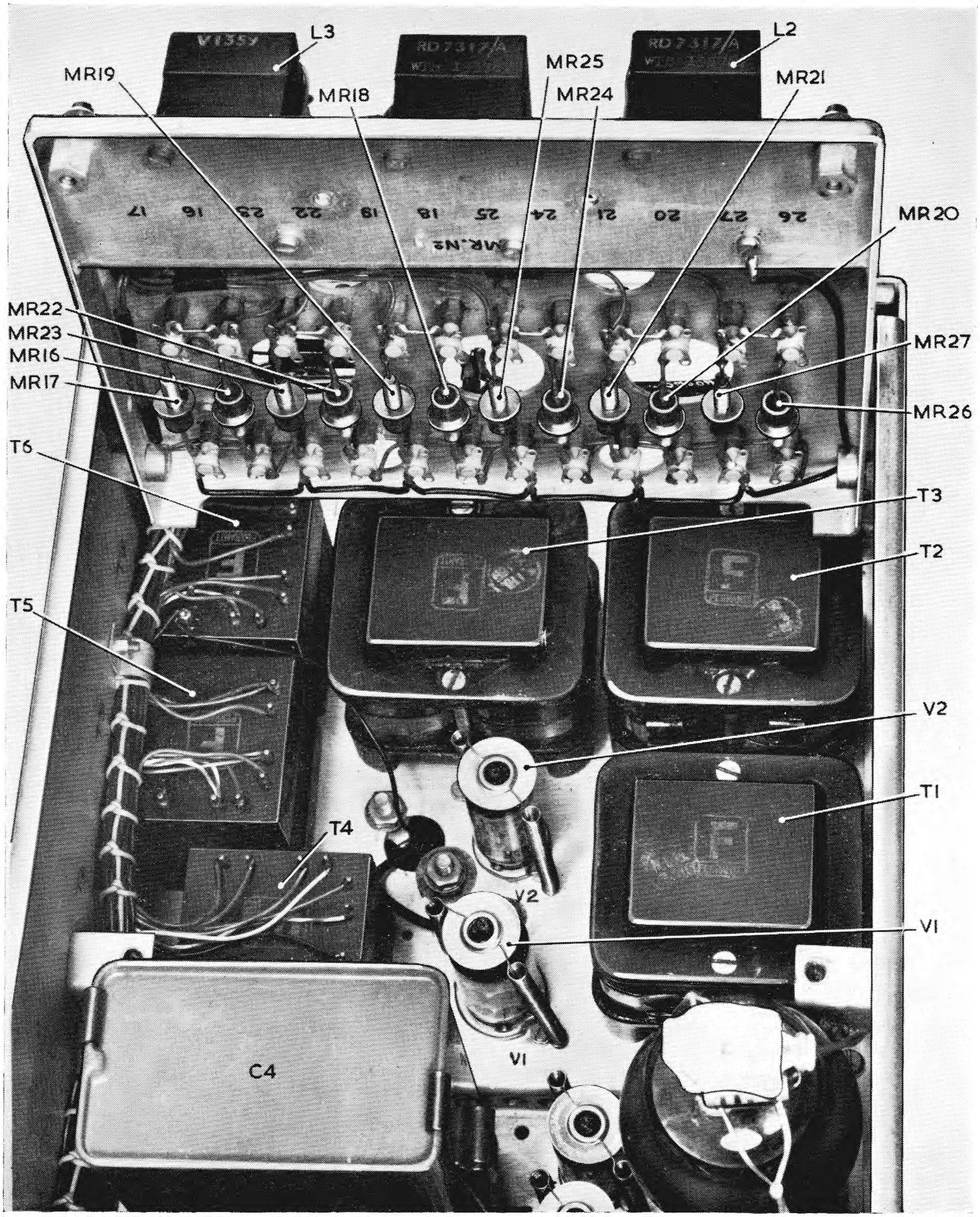

Fig. 2. Power supply showing hinged plate assembly

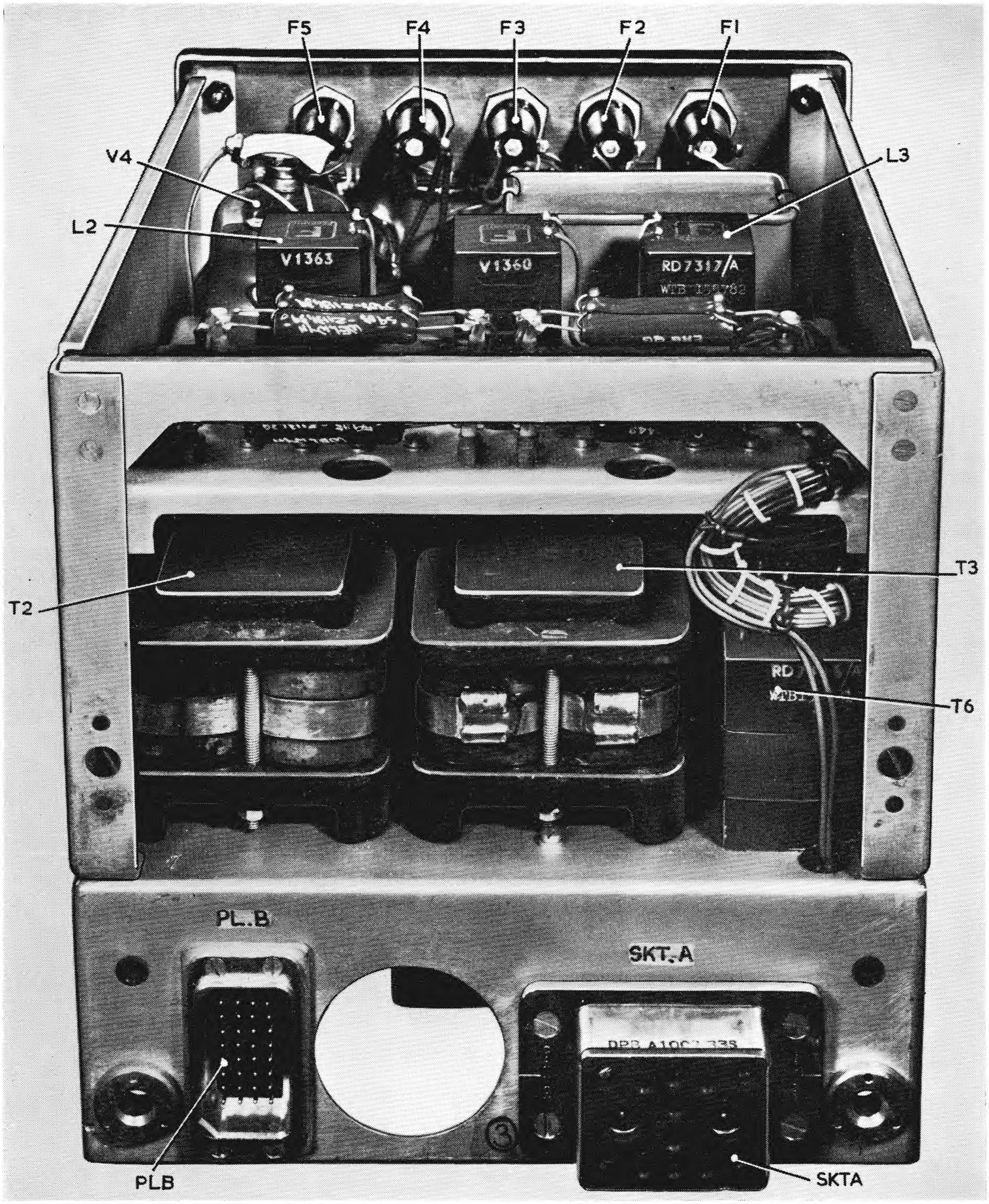

Fig. 3. Power supply, rear

(3) Aerial tuning unit power supplies, 200V, 3-phase 400 c/s a.c. supply and 28V d.c. supply.

(4) −35V d.c. stabilized bias supply, obtained from −200V d.c. and +200V d.c. supplies.

(5) 200V d.c. unstabilized supply for general h.t. supply to transmitter-receiver and generator reference signal.

(6) Two 150V d.c. supplies, one stabilized by Zener diodes, the other an unstabilized supply.

(7) A 28V supply for operation of relays and valve heaters.

Circuit summary

9. As mentioned previously (*para.* 2) the power supply unit operates from the three-phase 200V, 400 c/s and 28V d.c. supplies available from the aircraft supply system. The d.c. high tension supplies provided by the power supply are obtained from the secondary windings of the two three-phase transformers via a full-wave rectifying system employing silicon rectifiers. For the high voltage supply (650V) two silicon rectifiers are connected in series from each secondary winding of the supply transformer, this is necessary because of the high peak-inverse-voltages obtained and the limitations of the peak-inverse-voltage of the silicon rectifiers.

10. The transformers and rectifiers provide four supplies, i.e. 650V, −200V and −200V, and a separate 150V supply. An anode supply for the drive and three power amplifier valves is obtained from the 650V e.h.t. supply. A 300V supply is obtained from this 650V line via a series stabilizing circuit and used for the driver and power amplifier valves screen supply.

11. General high tension voltage used throughout the equipment is obtained from the 200V positive supply; also from this supply is obtained, via Zener diode stabilization, a 150V supply for the generator, reference signal.

12. A regulated −35V supply used as the power amplifier bias is obtained from the −200V supply via a shunt stabilizer circuit.

DETAILED CIRCUIT DESCRIPTION

650V e.h.t. supply

13. A circuit diagram of power supply 5821-99-913-2246 is given in fig. 6 at the end of this chapter. The 650V e.h.t. supply voltage is obtained from the three-phase secondary windings S1 of the supply transformer T1, T2, T3, via the three-phase full-wave rectifying system of silicon rectifiers MR4–15 (*Table* 1). Primary windings of transformers T1, T2, T3 (*fig.* 2) are fed from the 200V, 400 c/s 3-phase aircraft supply. Each pair of silicon rectifiers is shunted by a potential divider network of two resistors, e.g. MR4, MR5 shunted by R35, R36 (*fig.* 6), these resistors ensure that the reverse voltage developed across each diode is equal, this avoids possible breakdown of the diodes due to excess voltage being applied across one alone.

14. A d.c. voltage, obtained from the rectifiers is fed to a choke input filter which consists of choke L4 and capacitor C4. The output e.h.t. voltage of 650V approx. is fed to pin 3 of SKTA. This e.h.t. supply is unstabilized, although some regulation is provided by the use of a choke input filter.

300V h.t. stabilized supply

15. A conventional series stabilizer circuit working from the 650-volt e.h.t. supply is used to provide a 300V stabilized supply for the screen grids of the drive and power amplifier valves. Valve V4 is used as the series control element, with resistors R21, R22 acting as anti-parasitic 'stoppers'. Valve V5 (*fig.* 4) operates as the control amplifier, the control grid potential of this valve is determined by the potential divider network (*fig.* 6) R32, RV2, R31, with R48 acting as a grid 'stopper'.

16. The stabilizer valve V6 is used to provide a voltage reference for the cathode of V5. The anode potential of V5 and hence the control grid potential of V4 is determined by the anode current which flows through the anode load resistor R25 of valve V5. This in turn is dependent upon the grid-to-cathode potential of V5. If the output voltage from cathode of V4 should change due to a change in load current, the potential of the control grid of valve V5 will be changed in such a sense as to oppose the original alteration of output voltage, i.e. the change of potential at the control grid of V5 will cause the potential appearing at the anode to change. Thus the variation of the potential at the control grid of V4 is in such a sense as to restore the voltage change at the cathode of V4. Potentiometer RV2 is adjusted so that an output of 300V is obtained under load conditions.

17. Capacitor C7 provides additional smoothing for the d.c. output voltage which is fed to pin 1 on SKTA, via relay contacts E1, F2. These contacts are closed when the relay coils RLE/3 and RLF/4 are energized by the send/receive switch and interlock circuit action.

Table 1

List of semi-conductors used in the power supply

Type	Ref. No.	Circuit function	Description
OA211	MR1–15	a.c. power rectifiers	silicon junction rectifier
OA210	MR16–27	a.c. power rectifiers	silicon junction rectifier
CV7040	MR28	safety diode	silicon rectifier
1S5075A	MR29	voltage stabilizer	zener diode
1S5075A	MR30	voltage stabilizer	zener diode

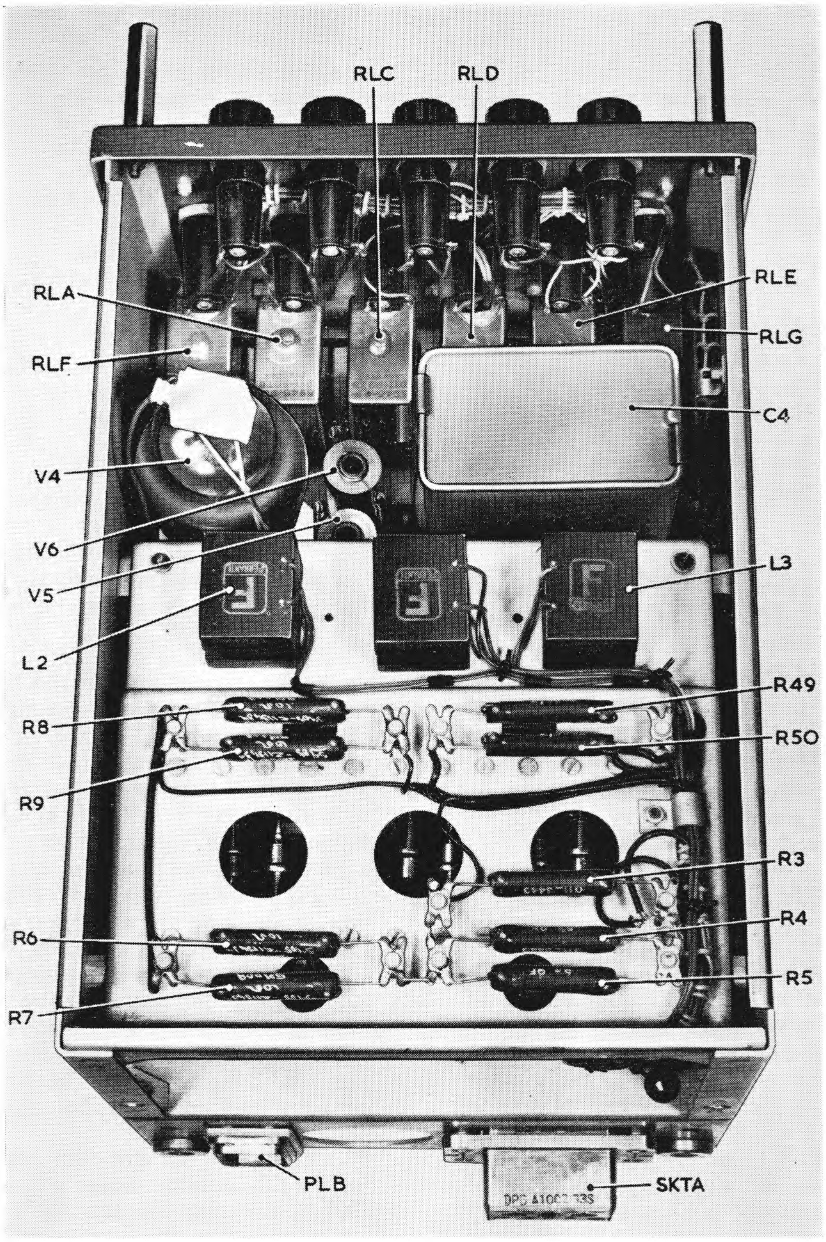

Fig. 4. Power supply, top

Aerial tuning unit power supplies

18. The suppressed aerial tuning unit obtains a 200V, 400 c/s 3-phase supply from the power supply unit. The 200V, 3-phase supply to the aerial tuning unit is taken from the supply to the primary windings of T1, T2, T3 and fed to PLB pins 27, 28, 29, via relay contacts RLC1, RLC2, RLC3.

19. The 28V d.c. supply for the aerial tuning unit is obtained from the power supply through contacts on RLC/4 and plug PLB/7.

20. Facilities are provided whereby an h.t. supply for certain types of aerial tuning unit is available. This supply is obtained from the 650V e.h.t. supply and is fed via PLB/17 if required.

—35V stabilized bias supply

21. This supply is obtained from a —200V supply via a form of shunt regulator. The +200V line in the power supply unit is used to obtain a 150V reference potential for the regulating system and also as h.t. for the regulator valve.

22. A 200-volt three-phase supply is provided from secondaries S2 of transformers T1, T2, T3 (*fig.* 5). This supply is half-wave rectified by silicon rectifiers MR1, MR2, MR3 to give a positive earthed supply. The d.c. voltage obtained is applied to the low-pass filter formed by C5, R47 and C1 (*fig.* 6), the smoothed output obtained from the filter is applied between control grid and earth of V1a (*Table* 2) the valve operating as a shunt regulator.

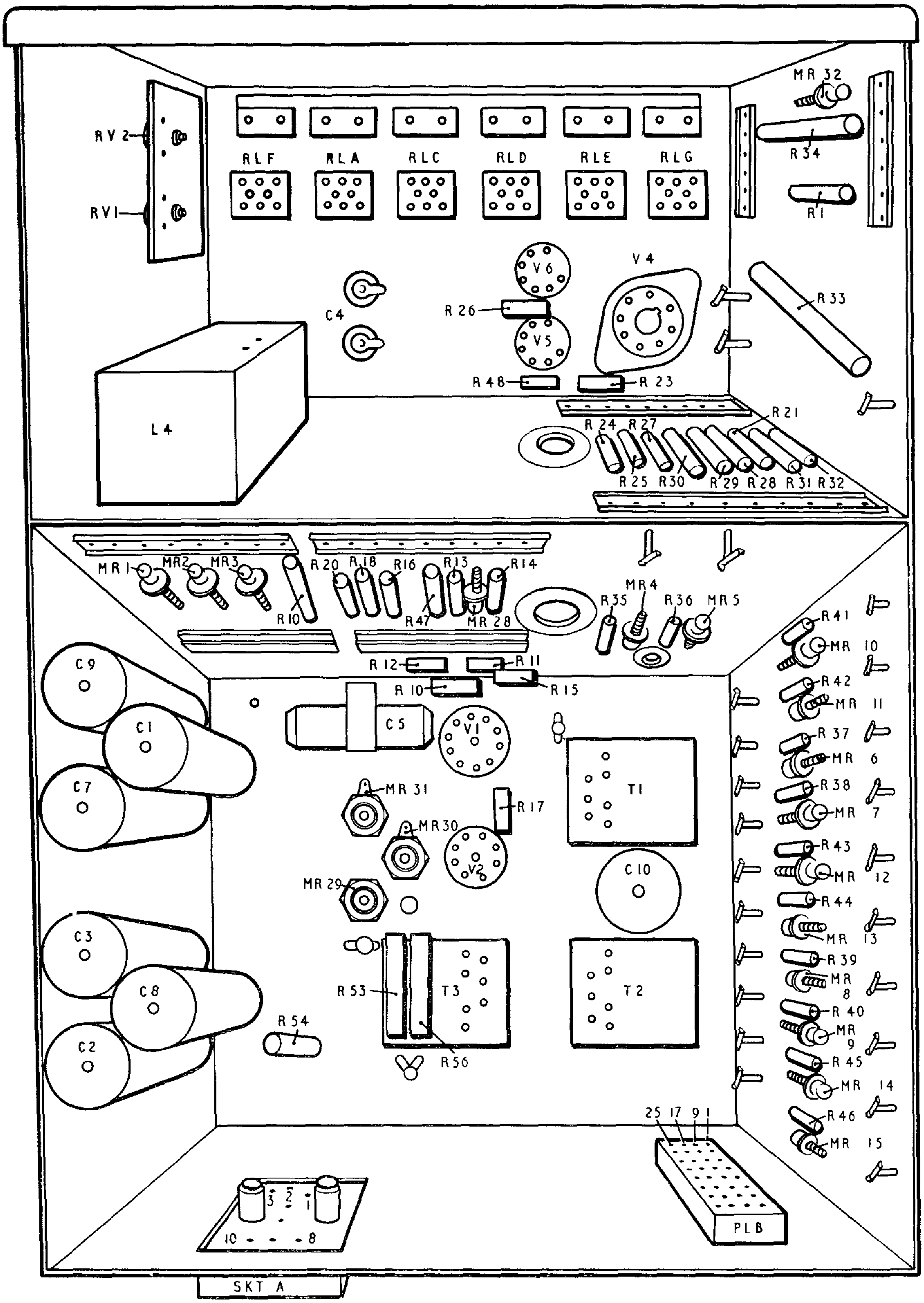

Fig. 5 Power supply, underside

Table 2

List of valves used in the power supply.

Type	Ref. No.	Circuit function	Description
V1	CV4024	Amplifier-regulator	Double-triode
V2	CV287	Voltage reference source	Gas-filled stabilizer
V4	CV345	Series voltage regulator	Beam tetrode
V5	CV4014	Control amplifier	Pentode
V6	CV287	Voltage reference source	Gas-filled stabilizer

23. Bias for V1a is obtained in the following manner; resistors R10 and R15 form a potential divider across the −200V supply thus the junction of R10, R15 is held at a negative potential with respect to earth, from the −200V supply. At the same time due to current being drawn through cathode resistor R15 the cathode of V1a becomes positive with respect to the earth line and hence the true potential between grid and cathode is the sum of the two voltages appearing across R15. The reason for the inclusion of R12 (a comparatively high resistance value) is to limit grid current surges which could damage valve V1a.

24. Stabilizer valve V2 operates as a voltage reference source, the priming electrode being connected to the h.t. supply via resistor R20. The control grid of V1b is connected to the junction of R17, R16 these resistors being part of the potential divider network across V2, the other resistors being RV1 and R15. Since R15 is also the cathode resistor of valve V1a, any change in the voltage across this resistor will also change the control grip potential of V1b, this in turn changes the anode potential of valve V1b, due to voltage drop across the anode load resistor R14. Since the anode of valve V1b is connected to the control grid of V1a via resistor R11 any change in the anode potential of V1b is fed back to the grid of V1a in such a way that it will oppose the original change in potential; thus the circuit operates as a voltage stabilizing circuit.

25. Adjustment of variable resistor RV1 will allow a regulated output voltage of −35V to be adjusted within certain limits. The regulated output voltage is fed to SKTA/8. Diode MR28 prevents the bias line from becoming positive when relay contact E2 is open (i.e. under receive conditions).

200V h.t. supply

26. A three-phase, full-wave rectifying system is used to obtain the +200V h.t. supply from windings S1 of power transformer T4, T5, T6, using silicon junction rectifiers MR16-21 for this purpose

27. A choke input filter is used for smoothing, the components being inductor L2 and capacitor C2. This 200V supply is fed to PLB/22 and PLB/9 to provide the power supply for the transmitter-receiver unit of the equipment.

28. In addition to the supplies referred to in para. 26 and 27, a part of the +200V supply from the power supply unit in decoupled via resistor R54 with capacitor C8 and provides a 200-volt supply for the generator, reference signal and intercomm system: this 200V supply appears on SKTA/25.

150V d.c. supplies.

29. There are two separate +150V d.c. supplies provided by the power supply unit for the generator reference signal, one of which is stabilized.

30. The d.c. voltage obtained across capacitor C2 in the 200V supply is applied to a voltage stabilizer circuit employing Zener diodes (*Table* 1) Resistors R53, and R53b (*fig.* 6) are used as voltage dropping and limiting resistors for Zener diodes MR29, MR30, MR31 to provide the stabilized +150V supply which is fed to the generator reference signal via SKTA/24 and 26; the circuit being completed in the generator.

31. The output from secondary winding S2 of three-phase transformer T4, T5 T6, is also full-wave rectified by silicon junction rectifiers in a similar circuit to that mentioned previously (*para.* 26). The six silicon rectifiers used for providing the 150-volt unstabilized d.c. supply are MR22-27.

32. A choke input filter consisting of L3 and C3 provides some regulation of the output voltages, further smoothing of the d.c. supply is accomplished by inductor L5 and capacitor C9. The 150V d.c. output is fed to SKTA/23. Both 150-volt supplies are fused using FS6 and FS7 respectively for stabilized and unstabilized supplies.

28V d.c. heater and relay supplies

33. Power for operation of valve heaters and relays is obtained directly from the 28-volt d.c. aircraft supply, via ◀SKTA/5▶ and 7. A list of relays and their functions is given in Table 3. Resistor R49 with R50 in parallel, functions to reduce the 28V d.c. supply voltage to approximately 25V required by the heater circuits of the transmitter-receiver section. This voltage is provided at PLB/1 and 2 after relay contact G1 has operated; the heater supply is fused by FS11.

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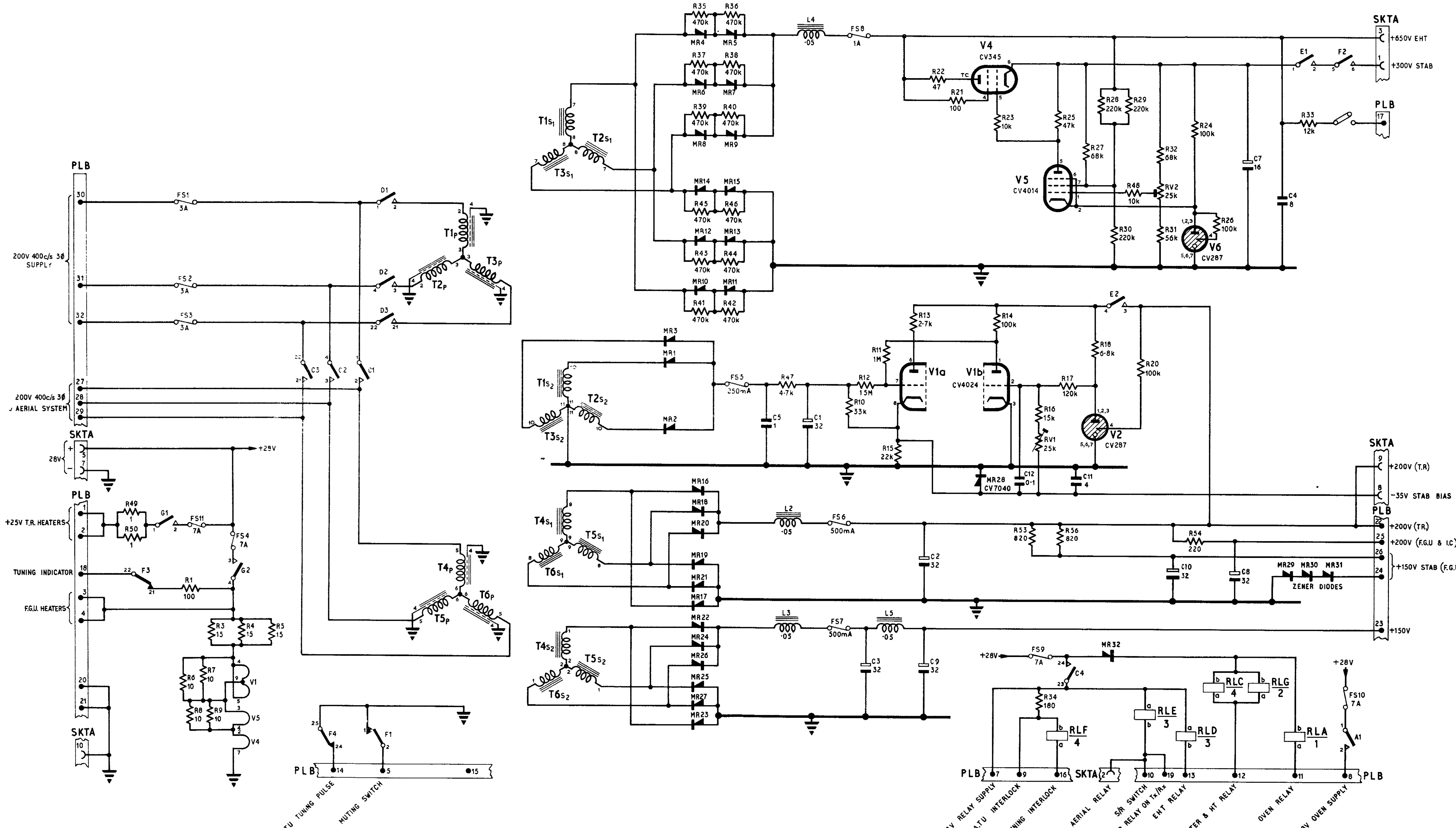

Power supply 5821-99-913-2246: circuit

Fig. 6

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Table 3

List of relays and functions in power supply

Relay No.	Control function
RLA/1	28-volt crystal oven supply
RLC/4	H.T. supplies to transmitter-receiver and frequency generator unit, also −35V bias supply to power amplifier.
RLD/3	E.H.T. 650V supply and 300V stabilized supply to power amplifier.
RLE/3	Send/receive switching relay
RLF/4	Tuning interlock and indicator supply.
RLG/2	Transmitter-receiver and generator reference signal heater supplies.

34. Heater supply for the generator reference signal is obtained from the 28-volt supply, via fuse FS4 and relay contact G2. This supply is fed out to the generator on PLB/3 and 4. The valves used in the power supply unit also obtain their heater supplies from the 28-volt aircraft supply via fuse FS4 and contact G2. Resistors R3, R4 and R5 together form a low resistance series dropping resistor to obtain 25·5V heater supply whilst R6, R7, R8 and R9 are shunt resistors for the valve heaters to equalize the current flowing through each valve heater.

35. A d.c. supply for operating the various relays used in the equipment is also obtained from the 28-volt aircraft supply via SKTA/6 and 7, the relay supply is fused by FS9. Various relay operations are given in Table 4 which should be read in conjunction with the following paragraphs.

36. Immediately after the equipment is switched on relays RLA/1, RLC/4 and RLG/2 (*fig.* 4) are energized from the 28-volt d.c. supply. When the respective contacts on these relays operate, the internal heater supplies and h.t. supplies are switched on after contact C4 has operated e.h.t. relay RLD/3 (*fig.* 6). Relay contact A1 allows a 28-volt supply to reach the crystal-oven heater via PLB/8 (*Table* 4).

37. Operation of relay contact C4 also allows the 28-volt supply to reach the coils of relays RLE/3 and RLF/4, these are operated by the send/receive switching and interlocking system.

38. Contact C4, when closed, also allows the 28-volt d.c. supply to energize the 12V coil of relay RLF/4 via the dropping resistor R34. Operation of RLF/4 is from the tuning interlock system via PLB/16. A 28-volt supply for operating the other relays in the installation is available from PLB/7, whilst power for the aerial tuning unit interlocking system is provided at PLB/9.

Table 4

Operations performed by relay contacts located in the power supply 5821-99-913-2246

Remote control unit main switch position	Relay contacts	Operation performed
OVEN	RLA1	28V supply to crystal oven heater
	RLC1 RLC2 RLC3	200V 3-phase supply to transformer T4, T5, T6 and aerial tuning system
	RLC4	28V supply for 12V relay RLF/4. 28V supply to other relays in the transmitter-receiver and A.T.U. interlock
	RLG1	25V supply to transmitter-receiver heaters
	RLG2	Valve heater supply for generator reference signal and transmitter receiver unit.
RECEIVE(R)	RLD1 RLD2 RLD3	200V 3-phase supply to the primary windings of T1, T2, T3. This provides 650V e.h.t. supply and −200V supply for the transmitter bias stabilizing circuit
TRANSMIT/RECEIVE (T/R)	RLF1	Provides an earth for muting switch via plug PLB/5
	RLF2	Connects 300V stabilized h.t. supply in readiness for send/receive switch operation
	RLF3	Breaks tuning indicator supply from 28V
	RLF4	Removes earth from A.T.U. tuning pulse line via PLB/14
SEND/RECEIVE (This switch is located on the operators control)	RLE1	Completes 300V stabilized supply to transmitter section
	RLE2	Brings into operation transmitter −35V bias supply
	RLE3	Earth connection on AFC/Manual switch via PLB/6

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Chapter 10

CONTROL FREQUENCY SELECTORS

(Single-turn and Multi-turn)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The control frequency selectors (single-turn and multi-turn) are used in the s.s.b. transmitter-receiver and suppressed aerial equipment to provide remote-channel changing and tuning facilities.

2. Control frequency selector 5821-99-913-2240 (single-turn) is used in the transmitter-receiver unit, where it selects a preset channel and at the same time tunes the transmitter and receiver sections of the unit to the required frequency of this channel. The selector is also used in the suppressed aerial equipment for remote selection of a pre-determined channel.

3. Contained in the amplifier r.f. 5821-99-913-2232 (power amplifier) is a control frequency selector 5821-99-913-2248 (multi-turn), this selector is used for driving the variable-inductances in the amplifier r.f. and selecting capacitors for tuning on the three ranges provided.

4. The control frequency selectors used in the s.s.b. transmitter-receiver equipment are mounted on the front panel of the units mentioned in para. 2 and 3, and the former are easily detached by the removal of four retaining screws and a free socket.

Mechanical construction (control frequency selector, single-turn)

5. A d.c. motor is coupled through a gear train to a friction clutch to provide primary drive to the mechanism. There are two functional shafts in the unit, these shafts being the tuning shaft and the selector shaft (*fig.* 1). The tuning shaft is driven through a slipping clutch whilst the selector shaft receives its drive through a free-wheel mechanism.

6. Both the selector shaft and the tuning shaft have mounted on them twelve notched cams or discs; associated with each pair of the latter is a pivoted spring-loaded lever containing projections which correspond to the notches on the cams or discs.

7. When the notches are presented to the projections on the spring-loaded lever by rotation of the tuning and selector shafts, the lever is located by a latch spring and so stops the rotation of the tuning shaft.

8. The cams around the selector shaft are spaced and keyed at 30° intervals, in this way ensuring that one lever only can be selected at a time.

9. A free-wheel close-wound coil spring is wrapped round the boss of a driving gear and is attached to the selector shaft. Tightening of the

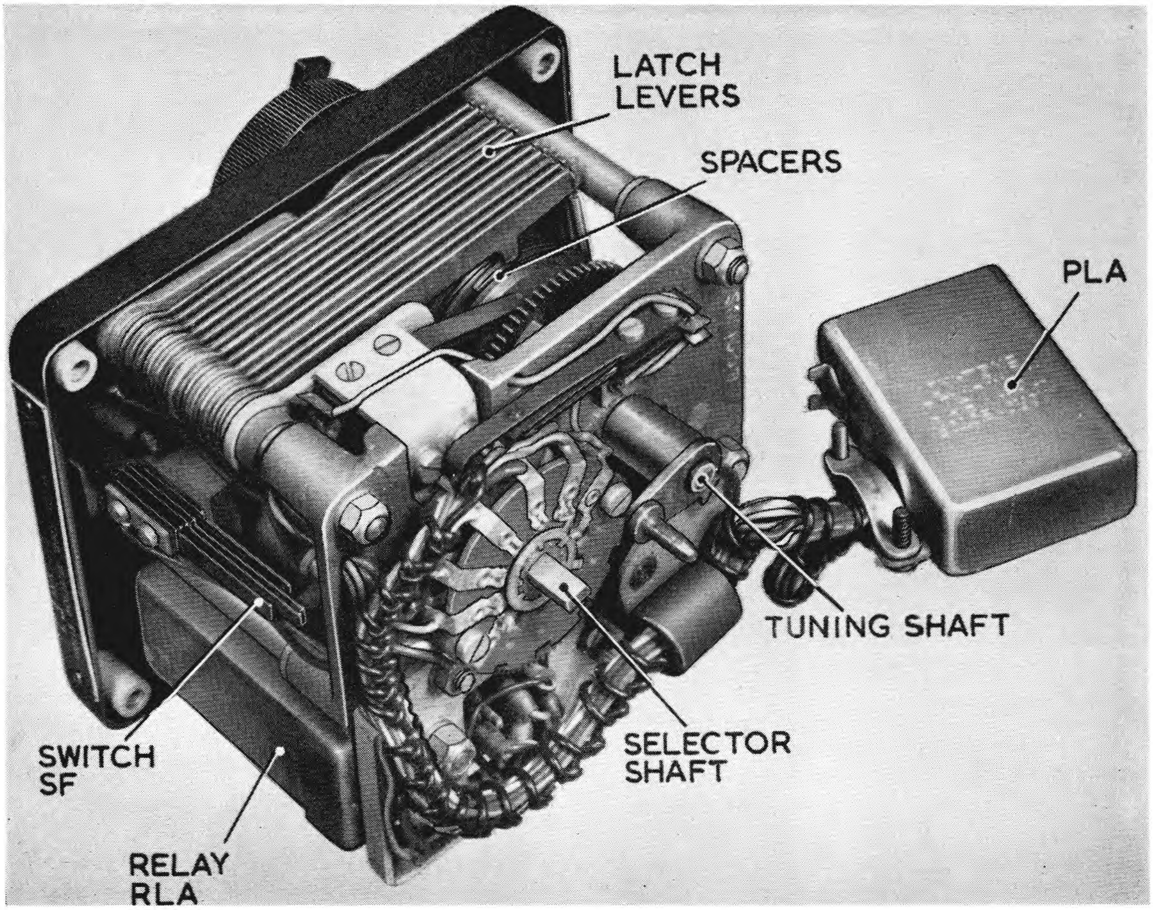

Fig. 1. Control frequency selector (single-turn)

spring in one direction by rotation of the gear imparts motion to the shaft, whilst rotation of the gear in the opposite direction allows the shaft to slip. In this way the selector shaft is driven in counter-clockwise direction only.

10. So that the selector shaft is accurately positioned with each of the latch levers as required, a single-pole twelve-way switch is mounted on the selector shaft. The orientation of this switch must be an accurate one and to accomplish this a fine-location interrupter contact (*fig.* 1) is incorporated with the twelve-way switch.

11. For automatic tuning, the twelve notched discs on the tuning shaft are locked to the latter by a cam-lever which can be operated from the front of the control frequency selector. To release the cams for manual tuning and setting up, the notched discs are released by operating the cam-lever, this unlocks the cams on the tuning shaft. Manual tuning can be obtained by the insertion of a special slow-motion key into the tuning knob.

Mechanical construction (control frequency selector, multi-turn)

12. The multi-turn selector is similar to the single turn unit with the exception of the tuning shaft and stop gears.

13. The tuning shaft consists of two concentric shafts (*fig.* 2), the inner shaft carries the tuning discs, spacers, setting knob and other components. The outer shaft acts as the turns counter and consists of slow cams with toothed spacers which rotate between thrust races. This latter shaft rotates in the same direction and at one seventeenth the speed of the centre shaft.

14. There are four flat surfaces provided on the tuning shaft; mounted on the latter are thirteen spacers capable of axial movement but prevented from rotating by the flats.

15. Between each of the spacers are twelve tuning discs, these are capable of rotation on the shaft. Both spacers and discs are unlocked for manual tuning and locked by a cam and associated items as in the single turn unit for automatic tuning (*para.* 11).

16. On the rim of each spacer is mounted a toothed driving gear the latter meshing with a pinion which runs the length of the stack of discs.

17. Mounted on each tuning disc and between the toothed spacers are twelve slow cams, these together with the spacers are rotated at one-seventeenth of the speed of the centre portion of the tuning shaft, by a gear train.

18. The slow cams are of annular form and "U" shaped cross-section, they have a small part of the base of the "U" section cut away to allow entry of the projection on each associated lever into the notch of the fast tuning disc.

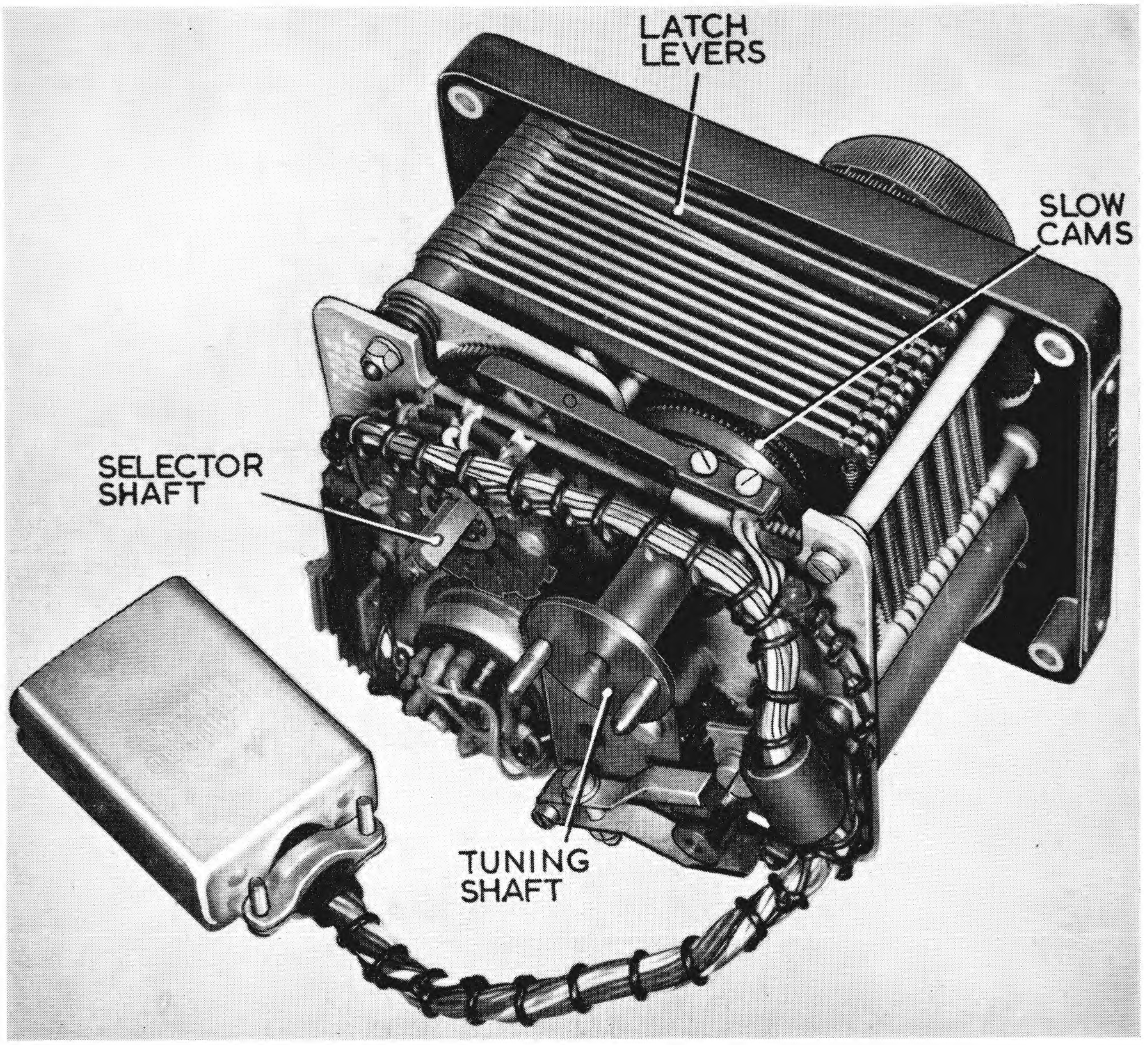

Fig. 2. Control frequency selector (multi-turn)

DETAILED CIRCUIT DESCRIPTION

Control frequency selector (multi-turn)

19. This control frequency selector 5821-99-913-2248 consists basically of an electric 28V motor driving two shafts through separate clutch mechanisms.

20. One shaft carries the selector discs and is ganged to the selector switches SE (*fig.* 2); there are indentations in the selector discs which correspond to the positions of the selector switch contacts. The other shaft carries the tuning discs.

21. The shaft carrying the tuning discs (*fig.* 2) is coupled to a "zero-stop", this shaft is used to drive the rotatable coil in the amplifier r.f. unit (power amplifier). Around each tuning disc is a slow cam, the slow cam having a slot in it which is slightly wider than the indentation in the tuning disc itself. These slow cams are driven at one-seventeenth the speed of the tuning discs.

Operation

22. When the 28V d.c. supply is switched on, the motor X1 (*fig.* 3) rotates the selector discs and tuning discs in a counter-clockwise direction. This operation continues until the tuning discs reach their limit of rotation against the end stop. The "zero-stop" also reaches the end of its traverse and closes contacts SB.

23. By operation of the slipping clutch, the tuning discs and "zero-stop" remains stationary, whilst the selector discs continue to rotate in the same direction until the position of switch SE coincides with the required position of the selector switch in the remote control unit (control radio set 5821-99-913-3108). Switch SC is kept open throughout the foregoing by the selector (fine setting) until switch SE has made full contact.

24. When the relay (RLA/4) circuit is completed through switches SB, SC, SD, SE and the switch in the remote control unit, relay contact RLA3

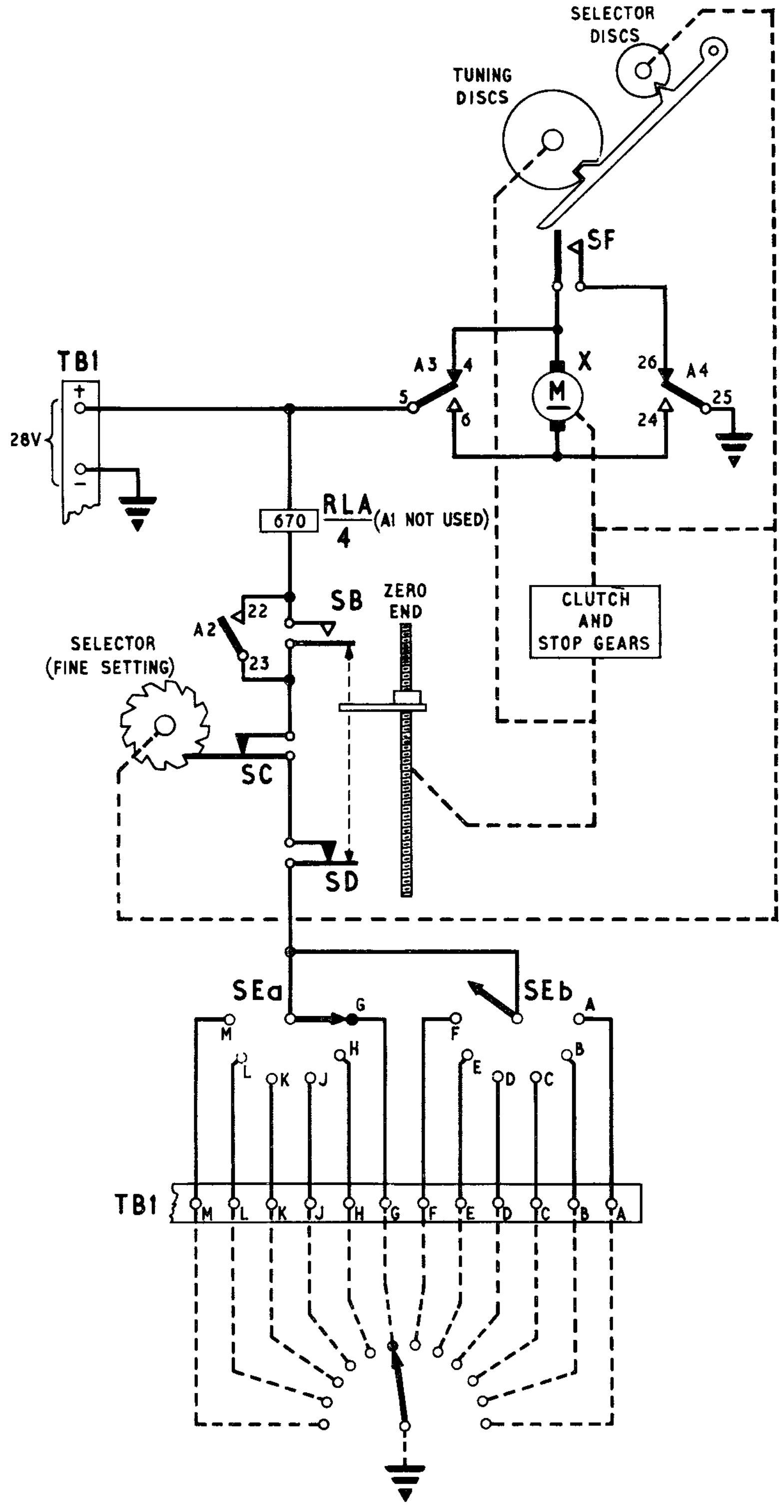

Fig. 3. Control frequency selector (multi-turn): circuit

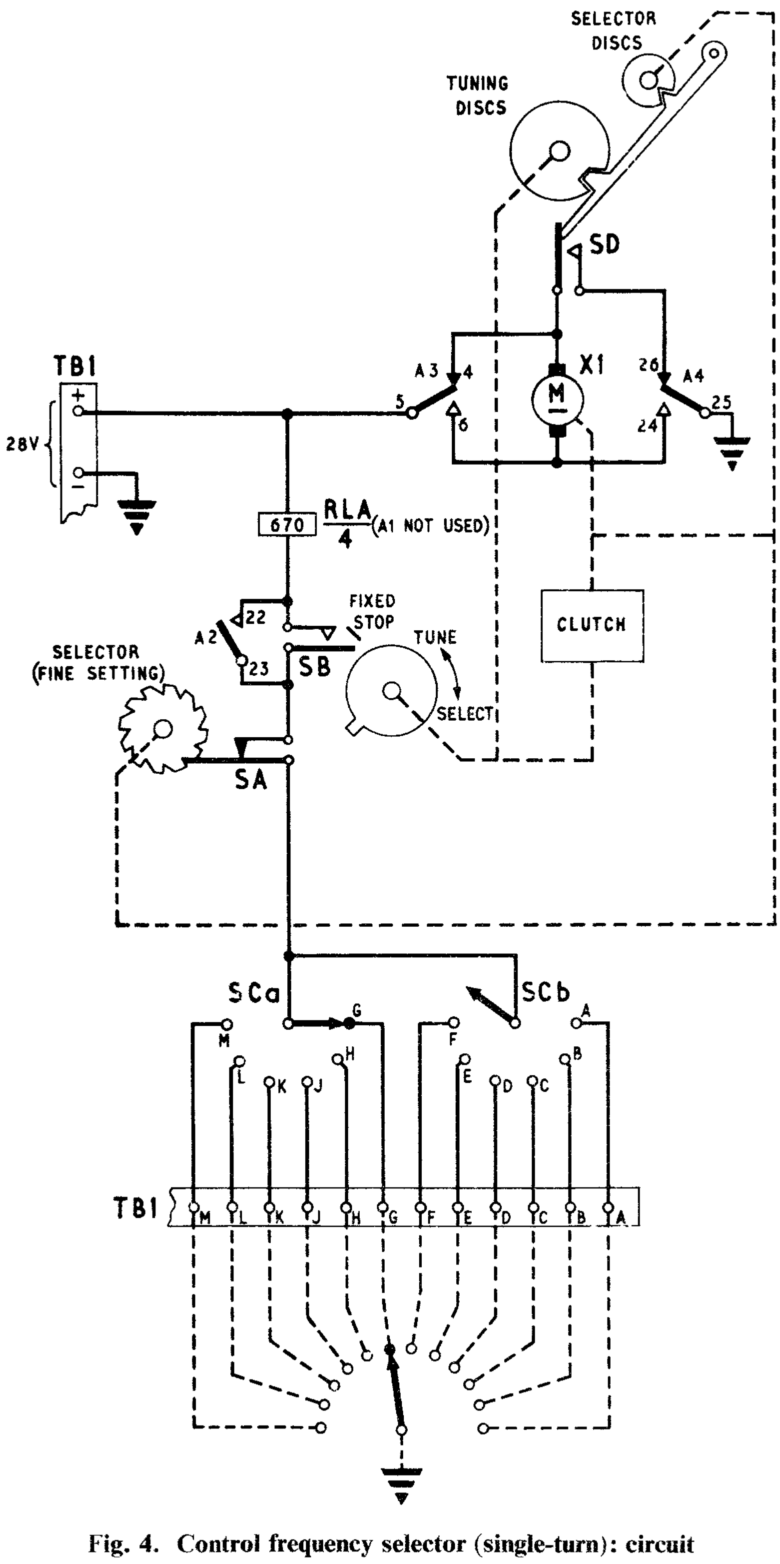

Fig. 4. Control frequency selector (single-turn): circuit

closes thus holding in the relay RLA/4. At the same time the polarity of the d.c. supply to the motor X1 is reversed via relay contacts RLA1 and RLA2.

25. The tuning discs now rotate in a clockwise direction, the selector discs remaining stationary (since the selector shaft which drives them is only capable of driving in an anti-clockwise direction, through a free wheel).

26. When the latch arm drops through the slot in the slow cam into the indentation in the tuning disc corresponding to the recess in the selector disc of the required channel, the tuning shaft is arrested and the motor is switched off by the switch contacts SF. The slow cam in this way selects the number of turns, and the tuning disc selects the angular rotation for each channel.

27. Switch SF breaks the supply circuit to the motor X1, also completing the circuit of the interlock relay. The equipment is now ready for operation.

Note . . .

If the latch arm does not locate in a recess of the tuning disc, the motor X1 will continue to drive the mechanism until the zero-stop reaches the end of its traverse and opens switch SD. Relay RLA/4 is thus de-energized and the direction of rotation of the motor is reversed. The whole process described will repeat itself until the latch arm does locate and switch SF is opened.

Control frequency selector (single turn)

28. The control frequency selector 5821-99-913-2240 (single turn) operates in a similar way to that shown in para. 22 to 27, except that the turn selecting slow cams are not fitted. The control frequency selector (single-turn) drives the variable capacitors used for tuning in the transmitter-receiver amplifier r.f. sub-unit, and is also used in the selector unit of the suppressed aerial system.

29. A circuit diagram of the control frequency selector 5821-99-913-2240 is given in fig. 4.

P31437 161552/7255 1/62 375 C & P Gp 375

Chapter 11

FILTER BANDPASS 5915-99-913-2247

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

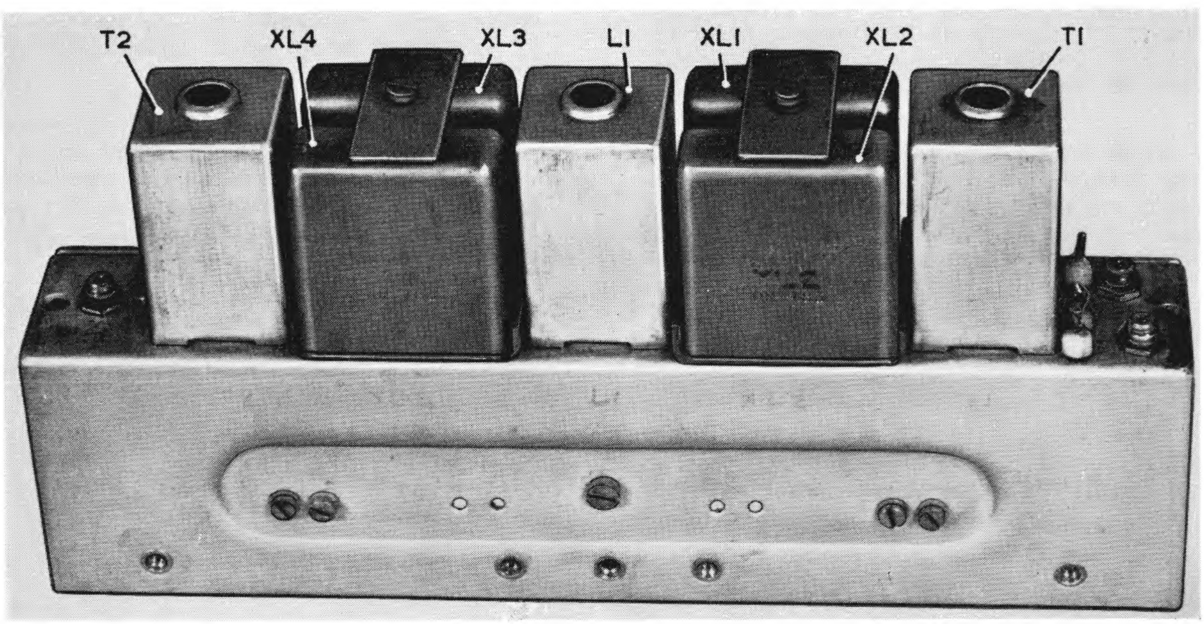

Fig. 1. Filter bandpass sub-unit—top

INTRODUCTION

1. Filter bandpass 5915-99-913-2247 is a separate sub-unit forming part of the s.s.b. transmitter-receiver assembly. This bandpass filter is included to provide suitable acceptance of the upper sideband.

2. The crystal bandpass filter (*fig.* 1) assists reception of transmitted signals on the upper sideband and carrier frequency of 1·5 Mc/s, at the same time attenuating signals of the lower sideband frequencies.

3. A double section half-lattice type of crystal filter is employed, this giving a good response curve for the filter with a minimum of critical adjustments.

Operation

4. Each section of the filter is adjusted so that there is a passband from 1499·5 to 1503 kc/s, with a stopband of 40 dB attenuation from 1505·5 to 1525 kc/s and from 1497 to 1475 kc/s.

5. As mentioned in Chap. 4, an alternative crystal filter with a passband accepting the lower sideband may be substituted in the s.s.b. transmitter-receiver when it is required to receive the alternative sideband.

6. Each section of the filter contains two crystals, the resonant frequencies of the latter being at the lower and upper edges of the pass-band respectively. The input and output circuits are tuned to the midband frequency.

7. At frequencies below the lower edge of the passband, both crystals present a capacitive impedance due to the "push-pull" input and parallel output connections. The outputs from the two crystals are in anti-phase however and the resulting output is less than that from one crystal alone.

8. The output signals, owing to the method of connections, are additive between the resonant frequencies of the two crystals, here their combined output is greater than that obtained from one crystal alone.

9. Above the higher edge of the passband, both crystals present an inductive impedance, but their outputs being in anti-phase tend to cancel out.

CIRCUIT DESCRIPTION

10. The primary winding of input transformer T1 (*fig.* 3) forms the anode load for the mixer valve in the receiver section of amplifier r.f. 5821-99-913-2241 (*Chap.* 1). Signals at the intermediate frequency of 1·5 Mc/s are fed from the anode of this mixer valve through transformer T1 to the two crystals XL1 and XL2.

11. These two crystals form a half-section crystal lattice network (*para.* 3). Resistor R1 is an impedance matching resistor for the input of the crystal filter (*fig.* 2). Capacitors C1 and C2 (*fig.* 3) effectively provide a centre tap on the secondary winding of transformer T1, the junction of C1 and C2 being earthed. The trimmer C3 connected across capacitor C2 assists in the balancing of the centre tap position.

12. Crystals XL1 and XL2 have a low value capacitor connected across each, these capacitors being C9 and C4 respectively. Capacitor C4 is a small trimmer capacitor, adjustment of this provides control of the rejection notches obtained of the crystal filter.

13. Radio frequencies are coupled from the first section half-lattice filter to the second section via common coupling inductor L1. Inductor L1 provides a common coupling impedance and is provided with an adjustable iron dust core.

14. The second section half-lattice network is identical to the first. The crystals in this section being XL3, XL4 with capacitors C5 and C8 having the same operation as C9 and C4 in the previous section (*para.* 12).

15. A centre tap for the primary of output transformer T2 is provided by capacitors C6, C7, C10 with the latter providing adjustment of the centre tap position as before.

16. Resistor R2 is the output matching resistor, connected across the primary winding of transformer T1. The secondary winding of transformer T2 provides a single sideband output signal which is fed to the i.f. amplifier sub-unit (*Chap.* 3) for further amplification.

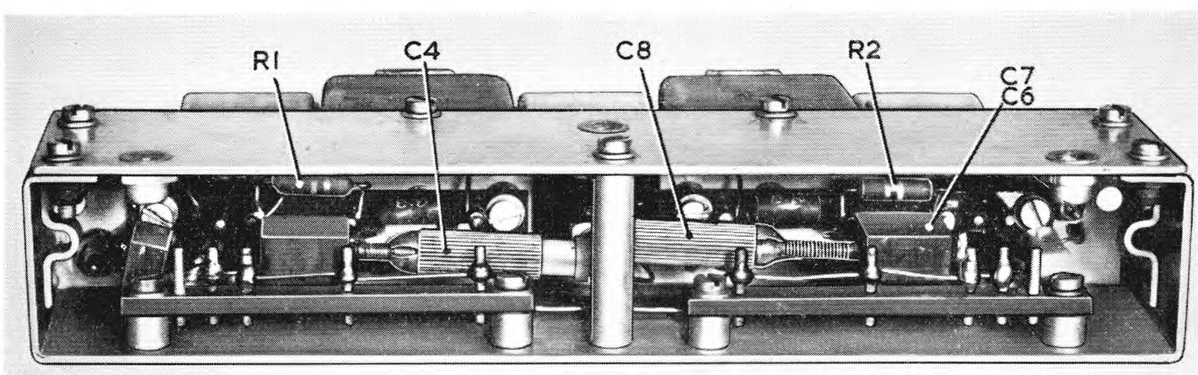

Fig. 2. Filter bandpass sub-unit—underside

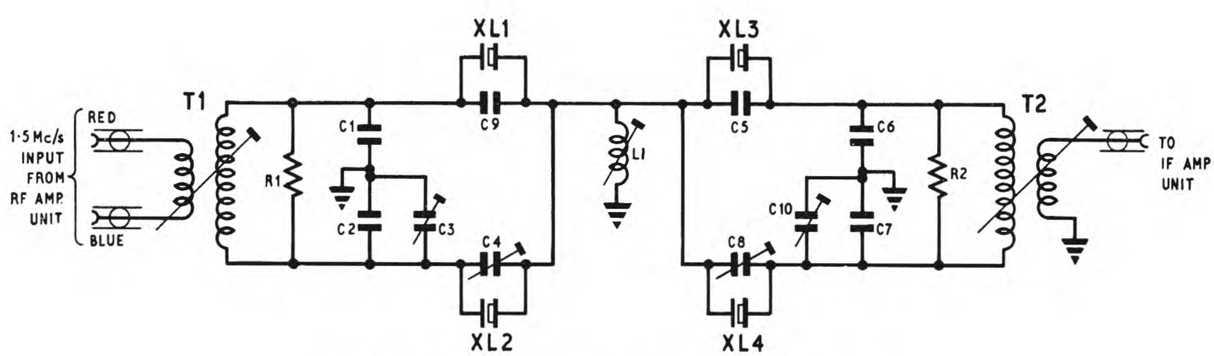

Fig. 3. Filter, bandpass 5915-99-913-2247: circuit

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SECTION 2

GENERATOR REFERENCE SIGNAL
5821-99-913-2244

P31467 161933/7359 2/62 375 C & P Gp 37

Chapter 1

GENERATOR REFERENCE SIGNAL, THEORY OF OPERATION

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

1. Because of the congested state of the high frequency communications bands (2-30 Mc/s), it is becoming increasingly important that the drive frequencies for transmitters and receivers used on these bands should be obtained from variable frequency oscillators having a very high order of stability instead of from the more usual quartz crystal control system.

2. In airborne single-sideband communications equipment it is necessary not only to have a high order of frequency stability in an oscillator but also that the oscillator must be capable of being reset to new frequencies very rapidly. Both these requirements have been met in the generator, reference signal to be described in this chapter.

3. The generator, reference signal has been produced as a separate unit so that it can be used in the s.s.b. equipment and separately as a signal generator having very high orders of stability and reset accuracies. Used in this latter role the calibration is, of course, directly in output frequency.

Frequency synthesis

4. A system in which harmonics and sub-multiples of a standard oscillator frequency are combined to provide a large number of output frequencies, is known as frequency synthesis.

5. This system has the advantage that the accuracy and stability of the output signal is equal to that of the standard oscillator. One difficulty in any frequency synthesizer is the presence of spurious signals generated in the combining mixers during the synthesizing process. It is necessary to use extensive filtering and careful selection of the working frequencies to avoid spurious outputs occurring in the final signal.

6. The generator, reference signal retains the advantage of the frequency synthesizer and also avoids many of the spurious frequency problems. This is because the synthesizer is used to provide a reference signal which controls the frequency of a variable-frequency master oscillator, the latter actually providing the final output frequency.

System used in the generator, reference signal

7. Although it is possible to obtain by synthesis methods a frequency spectrum of 23000 channels spaced at intervals of 1 kc/s in the h.f. band, directly from a number of standard decades, this method produces considerable problems of filtering to achieve a high purity of the output waveform. An alternative, used in the generator, reference signal, is a system whereby a variable-frequency oscillator is phase-locked to the synthesized product of the reference frequencies supplied to a servo-loop system.

8. The final output frequency is provided by this servo-controlled variable frequency oscillator. The oscillator tuning over the required range is obtained in five sub-bands. Initial tuning is carried out by a motor-driven variable capacitor, after which for final tuning, the oscillator is phase-locked to the desired frequency by comparison with four selectable reference frequencies generated from a 5 Mc/s frequency standard.

9. The control loop (*para.* 54) contains the necessary mixers, filters, phase discriminator and reactance device, for phase-locking the oscillator and also the means of controlling the motor.

Construction of the generator, reference signal

10. Generator, reference signal 5821-99-913-2244 (*fig.* 1) is designed for mounting in a standard aircraft rack which is normally fitted in the radio bay of the aircraft.

11. The generator consists of eight sub-units and a supporting rack, the latter carrying the internal wiring and sockets for the sub-units.

12. One of the sub-units contains a printed circuit board which provides 60 separate switches (*fig.* 2), from these switches pre-selection of twelve channels each of five digits can be obtained. The multiple switch panel, covered by a lid, is mounted on the front panel of the generator.

13. A supporting frame for the multiple switch carries a meter, which used in conjunction with a switch, enables the performance of various key points in the system to be monitored.

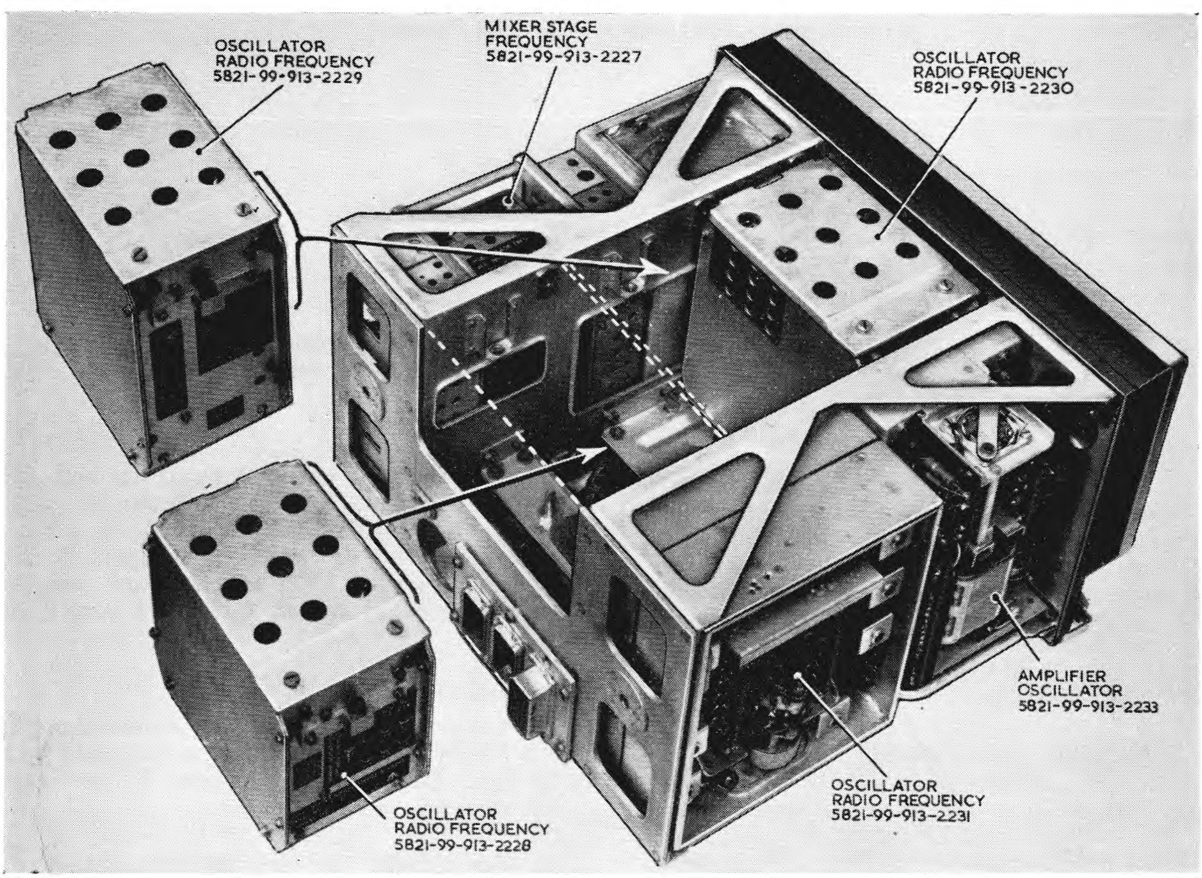


Fig. 1. Generator reference signal, sub-unit construction

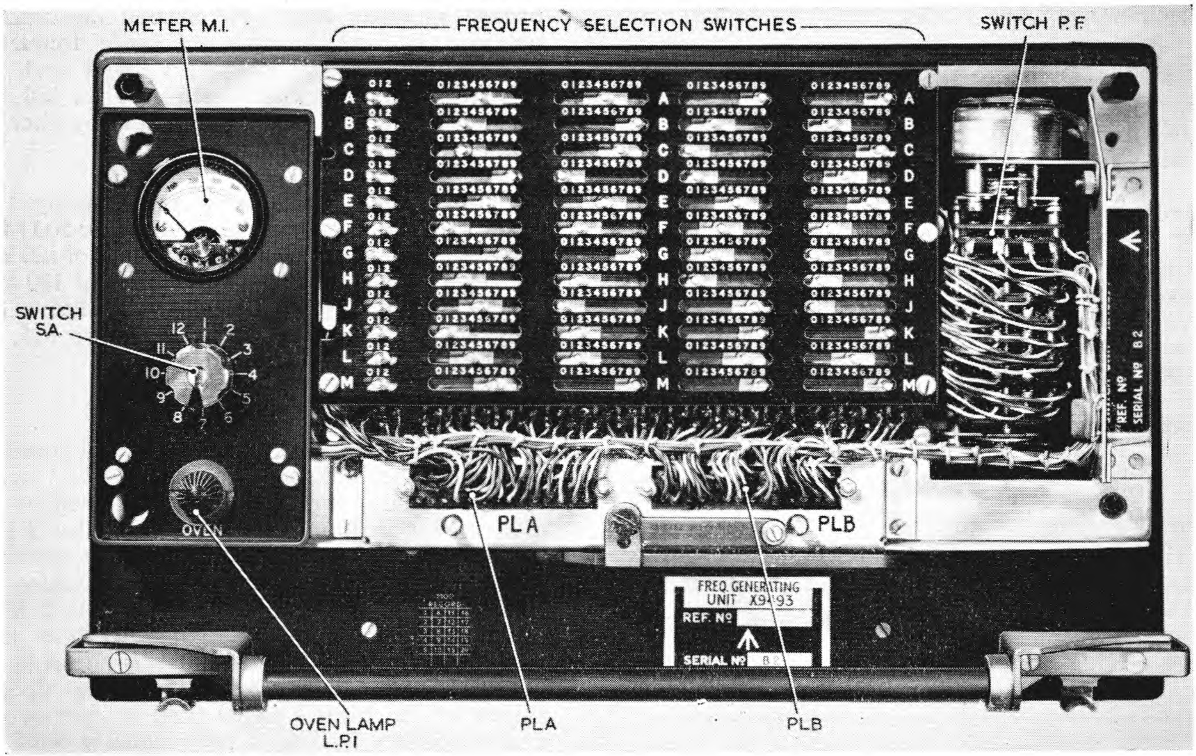


Fig. 2. Generator reference signal showing switching

14. The remaining seven sub-units are contained in a supporting framework (rack, electrical equipment). This is constructed with two vertical members forming a central well, into which the three impulse-governed oscillators are mounted. Outside the well are mounted the 5 Mc/s frequency-standard oscillator and mixer-filter unit on one side, with the variable-frequency oscillator and sidestep oscillator with discriminator unit on the other. This form of construction provides a strong and compact assembly. An adequate air supply is provided by a blower mounted on the aircraft racking at the rear of the generator, reference signal.

Switching

15. All switching operations involved in obtaining a preset frequency are performed by electro-magnetic 'Ledex' type switches from information supplied by the switches on the front panel of the unit. The frequency channels used are selected on the remote control unit in the cockpit of the aircraft. In addition the generator makes available externally the band switching information used in its own variable frequency oscillator, i.e. one of five connections is earthed depending on the range over which the variable frequency oscillator is operating.

GENERAL CIRCUIT DESCRIPTION

16. A block diagram of the system used in the generator, reference signal is given in fig. 9. The variable frequency oscillator which generates the required final r.f. output is included in a main control loop. A portion of the output of this v.f.o. is fed via mixers M1, M2 and M3 and band-pass filters F1, F2 and F3 to a phase discriminator D. The discriminator provides a d.c. control signal to the reactance device R; the latter maintaining the v.f.o. in phase-lock with the selected multiple of the reference standard. (5 Mc/s).

17. The overall output frequency range of the generator (3·500 to 26·499 Mc/s) is divided into 23 bands each 1 Mc/s wide by providing 23 spot frequencies at 1 Mc/s intervals into the first mixer M1. The 23 spot frequency intervals range from 159 to 181 Mc/s inclusive, so that for each 1 Mc/s band of the v.f.o. coverage, one, and only one, of these frequencies can produce the first i.f. band of 154·501 to 155·500 Mc/s in the filter F1 (*see Table* 1).

18. For example the difference between 159 Mc/s and the output frequency band of 3·500 to 4·499 Mc/s gives the i.f. band in Table 1, while 160 Mc/s combines with 4·500 to 5·499 Mc/s to give the same i.f. band. Thus there is a direct relation between the spot-frequency introduced into M1 and the particular megacycle band of the output frequency in use.

19. The 23 steps of 1 Mc/s referred to in para. 17 ranging from 159 Mc/s to 181 Mc/s are obtained by mixing a fixed 125 Mc/s signal (obtained by two times–five multipliers from the 5 Mc/s standard oscillator) with the output of generator Oscillator 1 (23 steps from 34 Mc/s to 56 Mc/s), in mixer M4. The sum of the two frequencies is selected by the filter F4.

Generator (Oscillator 1)

20. Generator Oscillator 1, is an impulse governed oscillator (i.g.o.) which produces harmonics of 1 Mc/s from a 1 Mc/s source obtained from the 5 Mc/s frequency standard through a frequency divider. The 23 harmonics required between 34 and 56 Mc/s inclusive are selected by means of switches. Thus generator Oscillator 1 is phase-locked to the 5 Mc/s frequency-standard oscillator, and therefore has the same order of stability as the latter. The frequencies produced in this i.g.o. can be selected by the two switches corresponding to the tens and units Mc/s digits of the required channel frequency (*fig.* 3).

Table 1

Oscillator-amplifier coverage and i.g.o. frequency relationship

V.F.O. coverage	Spot frequency (Mc/s)	I.F. band
3·500 to 4·499 (Mc/s)	159 Mc/s	
4·500 to 5·499	160	
5·500 to 6·499	161	
6·500 to 7·499	162	
7·500 to 8·499	163	
8·500 to 9·499	164	
9·500 to 10·499	165	
10·500 to 11·499	166	
11·500 to 12·499	167	
12·500 to 13·499	168	
13·500 to 14·499	169	
14·500 to 15·499	170	154·501 to 155·500 Mc/s
15·500 to 16·499	171	
16·500 to 17·499	172	
17·500 to 18·499	173	
18·500 to 19·499	174	
19·500 to 20·499	175	
20·500 to 21·499	176	
21·500 to 22·499	177	
22·500 to 23·499	178	
23·500 to 24·499	179	
24·500 to 25·499	180	
25·500 to 26·499	181	

21. The first intermediate frequency band (154·501 to 155·500 Mc/s) is changed to a second i.f. band of 29·501 to 30·500 Mc/s by the frequency changing process in mixer M2. The second i.f. band is obtained by selecting the difference frequency between the first i.f. frequency band and the 125 Mc/s signal previously used in mixer M4, the resultant frequency band being passed by filter F2 (29·501 Mc/s to 30·500 Mc/s).

22. By a similar process to that employed in mixer M1 (*para.* 17) the band 29·501 to 30·500 Mc/s is now further sub-divided into ten bands of 100 kc/s bandwidth each. Ten spot-frequencies at 100 kc/s intervals from 27·2 to 28·1 Mc/s inclusive are provided through filter F5 from mixer M5, to mixer M3.

Generator (Oscillator 2)

23. The 100 kc/s step frequencies are obtained at the filter F5, as the sum of a fixed 25 Mc/s signal and the output of the (i.g.o.) generator Oscillator 2, after mixing in M5. Generator Oscillator 2 is a second impulse governed oscillator which provides ten harmonics of 100 kc/s between 2·2 and 3·1 Mc/s inclusive. The i.g.o. is phase-locked to the 5 Mc/s standard oscillator in a similar way to that mentioned in para. 20, the 100 kc/s signal being obtained from a divide by ten frequency divider driven by the 1 Mc/s signal used to operate the i.g.o. Oscillator 1. The 25 Mc/s signal is obtained via a multiplier from the 5 Mc/s standard Oscillator. A ten-position switch selects the frequencies which correspond to the 100 kc/s digit of the required channel frequency.

24. The third i.f. band of 2·301 to 2·400 Mc/s is produced by mixing the output from filter F5 (27·2–28·1 Mc/s) in steps of 100 kc/s, with the output frequency 29·501–30·500 Mc/s from filter F2 in mixer M3. Referring to para. 18. the spot frequency actually obtained between 29·501 and 30·500 Mc/s through filter F2 is dependent on the frequency of the v.f.o. Thus any frequency between 3·500 and 4·499 Mc/s will be changed to a frequency between 29·501 and 30·500 Mc/s as will any frequency between 4·500 and 5·499 Mc/s and so on up the frequency range. Therefore the change in frequency of the v.f.o. will bear a definite relationship to the frequencies between 29·501 and 30·500 Mc/s.

25. The particular spot frequency in 100 kc/s steps between 27·2 and 28·1 Mc/s selected as the input to mixer M3 can only produce a frequency at the

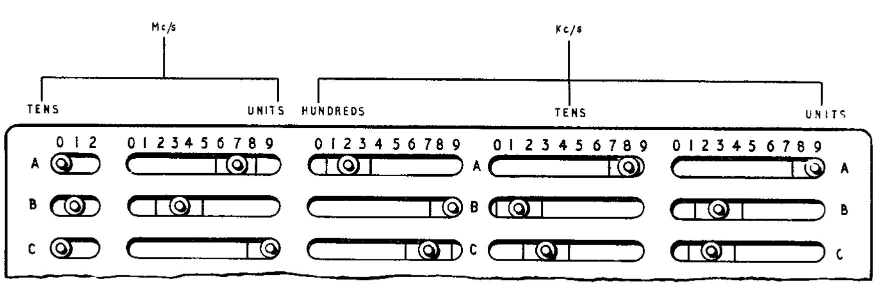


Fig. 3. Frequency selection setting switches

output of M3 between 2·301 and 2·400 Mc/s when the v.f.o. produces through filter F2 a frequency band corresponding to the spot frequency plus 2·301 to 2·400 Mc/s, e.g. a v.f.o. frequency of 4·780 Mc/s will appear at filter F2 as 30·220 Mc/s. The only selectable frequency at filter F5 which will produce a signal inside the passband of filter F3 is 27·9 Mc/s, i.e. 30·220—27·9=2·320 Mc/s. This will apply to any frequency having a figure 7 as the 100 kc/s digit, therefore 27·9 Mc/s is selected by the figure 7 on the frequency selection switches (*fig.* 3) corresponding to the hundreds of kilocycles.

26. At the output of filter F3 the v.f.o. output has been compressed by a ratio of 230 : 1 in such a way that an output can only appear when the v.f.o. frequency is equivalent to two settings corresponding to ratios of 23 : 1 and 10 : 1. Therefore any frequency band of 100 kc/s from the 3·5 to 26·499 Mc/s v.f.o. output can be selected. The next step is to further subdivide these 100 kc/s bands into steps of 1 kc/s separation.

Phase discriminator

27. Phase discriminator D is fed with a signal from filter F3 called the loop signal, a second input to the phase discriminator consists of 100 spot-frequencies at 1 kc/s intervals over an identical band of 2·301 to 2·400 Mc/s. These spot-frequencies are obtained by the direct addition of the outputs of the generators Oscillator 3 and Oscillator 4, in the mixer-filter system M6, F6; the required frequencies being selected by the fourth and fifth of the five ten-position switches previously indicated in fig. 3 (i.e. tens of kc/s and kilocycles).

Generator (Oscillator 3)

28. Generator Oscillator 3 (*fig.* 9) is a third impulse governed oscillator which produces ten harmonics of 10 kc/s from 290 kc/s to 380 kc/s inclusive. The 10 kc/s signal is obtained from a divide-by-ten frequency divider driven by the 100 kc/s signal produced for i.g.o. Oscillator 2. Generator Oscillator 4 makes use of a drift-cancelling sidestep technique (described later, *para.* 42) to produce ten harmonics of 1 kc/s from 2·011 to 2·020 Mc/s. Both generators are driven by reference signals derived from the 5 Mc/s crystal standard, as are the other i.g.o. generators previously mentioned.

29. The operation of the system is to compare the frequency obtained from the v.f.o. through the filter at F3 and that obtained from mixer M6. Having already established that the output from the v.f.o. can be reduced to a specific bandwidth of 100 kc/s by selection of the tens and units of Mc/s switches and hundreds of kc/s switch; the correction to 1 kc/s spacing can now be applied.

30. The output frequency from i.g.o. Oscillator 3 is controlled by the tens of kilocycles switch and the output frequency from Oscillator 4 is controlled by the units of kilocycles switch. As the two outputs are added in mixer M6 a hundred steps of 1 kc/s are selectable between 2·301 and 2·400 Mc/s. This frequency band is the same as that supplied by filter F3 and can therefore be used to control the v.f.o. frequency down to the last kilocycle. If the two frequencies differ there will be an output from the discriminator; the output voltage will depend on the difference between the frequencies and whether the v.f.o. frequency is higher or lower. This voltage can be made to control the tuning of the v.f.o. in such a way that a correction is made to return and keep the v.f.o. on frequency to the same order of stability as the 5 Mc/s standard. A more detailed description of the operation of the discriminator and motor control assembly is given in para. 53 to 63.

5 Mc/s standard oscillator

31. The accuracy of the final output frequency depends only on the 5 Mc/s standard oscillator; this is made to have the highest possible order of stability compatible with the limitations of airborne equipment. The crystal oscillator circuit consists basically of a form of Colpitts oscillator and an amplifier with an automatic level control device to ensure constant amplitude output. A special 5 Mc/s quartz crystal is used which is operated in the fundamental series mode. This configuration has the advantage that a higher permissible drive level is obtained, thus allowing the required output voltage to be achieved with fewer stages.

32. The crystal itself is enclosed in a cylindrical oven block of hard anodized aluminium; this oven block has the heating elements wound directly onto its surface. The anodic film produced during the anodizing process provides the necessary electrical insulation for the heating element with good heat conductivity into the block. The thermal insulation for the oven is provided by interleaved layers of glass wool and aluminium foil, with an outer jacket of expanded polythene.

33. The temperature of the oven block is raised rapidly from cold, by electrical heating, using a coarse heater which is switched off at 60°C approximately by a small bi-metallic thermostat switch. Fine control of temperature is effected by a further heating element controlled by a special mercury capillary-contact thermometer which also incorporates a heater winding in order to make the oven cycling time very short. By this means the working temperature in the crystal space is held within 0·01°C, thus the stability of the crystal frequency exceeds 1 part of 10^6 over six months in its working range of —40°C to +55°C.

Impulse governed oscillators (I.G.O.)

34. The production of any desired output frequency from the generator, reference signal, necessitates the provision of four selectable reference frequencies:—

(1) within the range 34 to 56 Mc/s
(2) within the range 2·2 to 3·1 Mc/s
(3) within the range 290 to 380 kc/s
(4) within the range 2·011 to 2·020 Mc/s

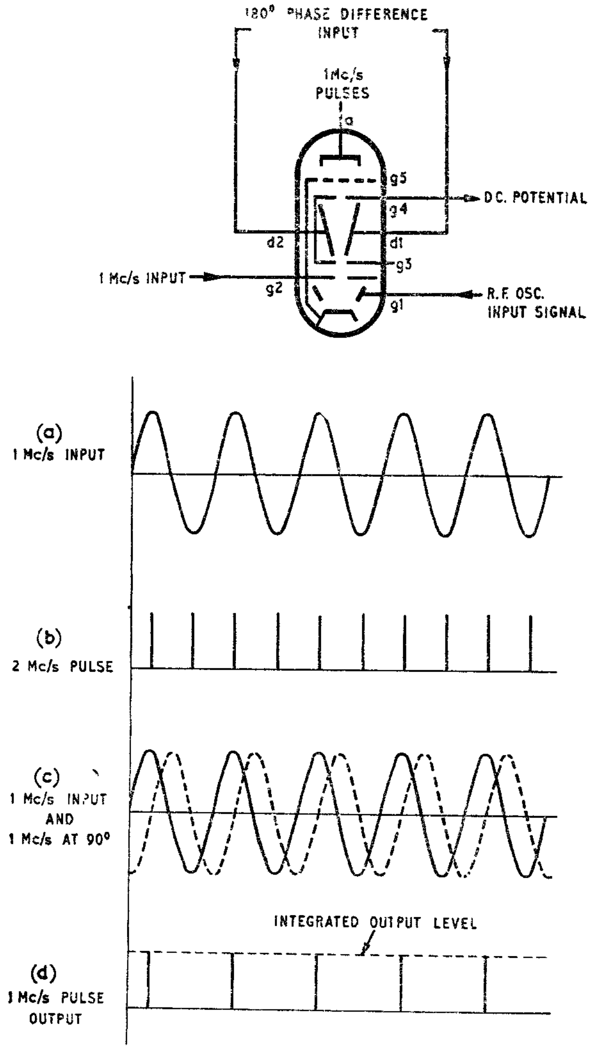


Fig. 4. The beam deflection tube, operation diagram

For the first three mentioned, use is made of a technique of synchronizing an oscillator to the appropriate harmonic of the reference frequency; the reference frequency having been converted to a pulse sufficiently short to include all the harmonics up to the highest required.

35. Beam deflection tube Type E80T performs two functions, namely, discrimination and pulse generation; the tube is illustrated in diagram form in fig. 4 and operates as a small oscilloscope without the fluorescent screen. When the tube is switched on an electron beam is formed between anode and cathode. If a r.f. voltage is applied between the deflector plates d1, d2 the electron beam will be deflected alternately from d1 to d2 at this frequency. Grids g3, g4, consist of a plate with slots cut in it such that anode current can only flow when the beam is central. Thus when the beam is being deflected by plates d1 and d2, anode current can only flow in short duration pulses at twice the frequency applied to the deflector plates.

36. The anode pulses are halved in frequency by stopping the beam every other pulse. This is done by shifting the phase of the deflecting signal by 90° and applying this to g2 which will have a potential alternatively positive and negative during every pulse of anode current ((*c*) of *fig.* 4). This sweep frequency is obtained from the basic 5 Mc/s standard suitably divided down in frequency. The frequency to be governed by or locked to the standard is applied to g1 and will therefore modulate the electron beam and consequently the pulses. These pulses are integrated in the anode circuit to form a d.c. control signal which is fed to a reactance device R, which in turn controls the frequency being governed. A block diagram (*fig.* 5) shows a complete impulse governed oscillator unit.

37. Each i.g.o. includes an oscillator with a controlled frequency; the circuit takes the form of a decade oscillator, the frequencies being selected in ten steps equivalent to multiples of the sweep frequency by switched capacitors, e.g. in Oscillator 3 the sweep frequency is 10 kc/s and the oscillator is switched between 290 and 380 kc/s inclusive in ten steps, each step being a harmonic of 10 kc/s. The decade oscillator is also provided with a reactance control device which accepts the slowly varying d.c. from the integrated anode pulses as its input. This reactance control completes a control loop through the E80T and therefore any change in the relative phase of the decade oscillator and the sweep frequency will cause a variation in the input to the reactance device in such a sense as to oppose this phase change. The decade oscillator is thus locked to the sweep frequency which is obtained from the 5 Mc/s standard.

38. A feature of the type of circuit used for the impulse governed oscillator (*para.* 37) is that the capture range of frequency is less than the holding range. This means that if the oscillator frequency drifts out of the capture range, but still remains within the holding range, the reactance device can now exert no control over the frequency to return this within the capture range. Thus it is necessary to vary the oscillator frequency (if it is outside the capture range) so that it passes through the capture range; in this way the oscillator frequency becomes, once more, locked to one of the harmonics of the reference signal. The effect of this search circuit is to make the capture range of the reactance device almost equal to the holding range; thus it is possible

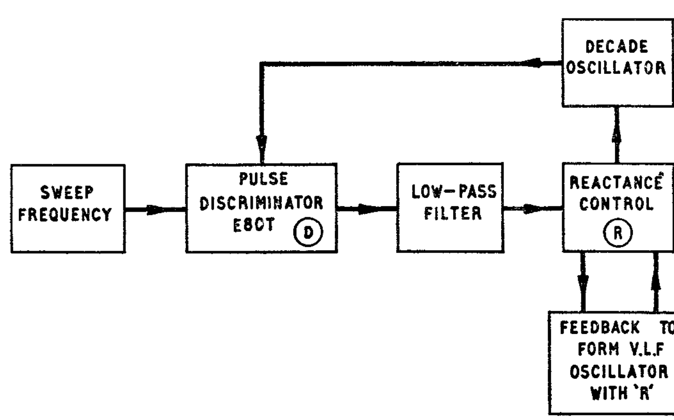


Fig. 5. Impulse governed oscillator—block diagram

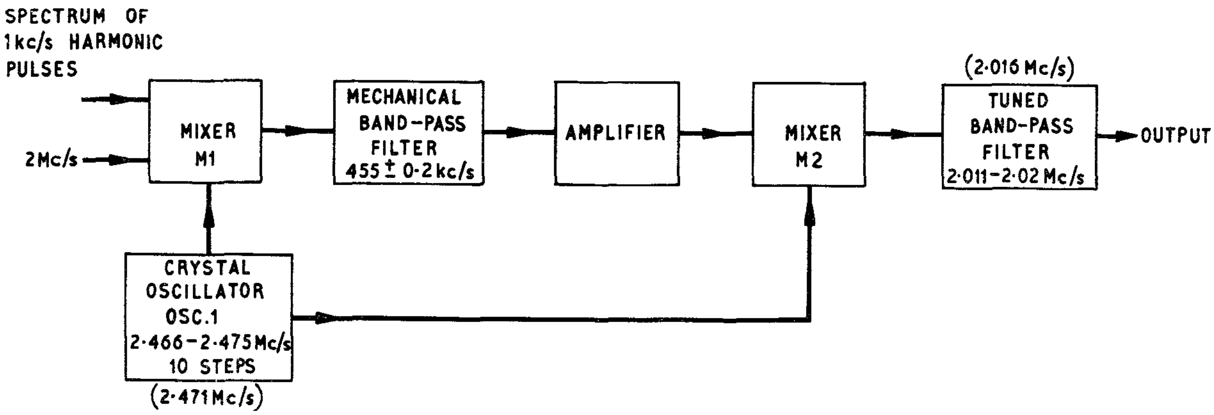


Fig. 6. Sidestep oscillator—block diagram

to arrange the tuning of the i.g.o. oscillator (on any pulse) so that it will never drift out of the capture range.

39. This variation of decade oscillator frequency is obtained by making the d.c. control valve (in the reactance control R) form part of two loops; one as described in para. 37 having a high loop gain, the other forming part of a very low-frequency oscillator having low loop gain.

40. If the system is not exactly in phase-lock this latter loop causes the d.c. control valve to oscillate at about 5 c/s (depending upon the particular i.g.o.) thus varying the decade oscillator frequency at the same rate. There will be a point in some part of this frequency excursion where the decade oscillator frequency will be the necessary integral multiple of the sweep frequency or exactly in phase. When this occurs the main control loop (the one with the higher gain) locks the decade oscillator to the sweep frequency and the high loop gain of the main control loop stops the v.l.f. oscillation of the d.c. control valve. This in effect gives a coarse and then a fine control of frequency.

41. All three impulse governed oscillators used in the generator, reference signal operate on the same basic principles to those previously described. Each decade oscillator has a Colpitts form of circuit in which the preset tuning capacitors for each of the required output frequencies are selected by electro-mechanical switches operated by the frequency selecting digit switches on the front panel.

Sidestep oscillator (Wadly)

42. The impulse governed oscillator (i.g.o.) has not been used to produce 1 kc/s steps because of its susceptibility to microphony, the low-pass filter being more narrow in frequency increases this tendency. This is especially important in an air-borne equipment where the valve electrodes are subjected to vibration. The effect of vibration is to noise-modulate the output; the circuit being unable to correct quickly enough and in the extreme case to unlock the control loop. For this reason the sidestep technique is used to produce the required frequency spectrum.

43. In the sidestep technique a group of ten auxiliary crystals are used to select the appropriate harmonics of a 1 kc/s spectrum. The frequency stability of these crystals is only required to be adequate to make the selection (performed by a mechanical filter, *para.* 49) of the appropriate harmonic unambiguous. The crystal frequency does not appear in the final output of the generator, reference signal.

44. A block diagram of the sidestep oscillator is shown in fig. 6, from this it can be seen that the first mixer M1 has applied to it a signal at 2·0 Mc/s and a series of pulses at 1 kc/s intervals both of these being derived from the 5 Mc/s crystal standard oscillator. In the mixer M1 these signals produce a spectrum of frequencies spaced at 1 kc/s intervals, the particular frequencies required being 2·011 to 2·020 Mc/s.

45. To select the signal corresponding to the desired final digit in the generator output from the frequency band 2·011 to 2·020 Mc/s the mixer M1 (*fig.* 6) has a third input from the auxiliary crystal oscillator (Oscillator 1) applied to it at a frequency chosen to produce 455 kc/s when mixed with the appropriate signal in the range 2·011 to 2·020 Mc/s (e.g. 2·016 Mc/s would require 2·471 Mc/s).

46. The particular frequency chosen will be accepted by the mechanical filter which has a bandwidth limited to 0·2 kc/s on either side of its nominal frequency of 455 kc/s. Thus although the crystal frequency of 2·471 kc/s will mix with all the pulses in the 1 kc/s spectrum giving outputs every kilocycle from 475 kc/s down to zero frequency, only the 455 kc/s signal is passed by the filter.

47. After passing through the mechanical filter the required signal is amplified and mixed in a second mixer stage M2 with the original signal obtained from the auxiliary crystal oscillator (Oscillator 1) to produce the required output frequency. The frequency from the auxiliary crystal oscillator (Oscillator 1) having been intro-duced into and subsequently extracted from the mixing process, does not affect the accuracy of the resulting output frequency. Hence it is not necessary to fit ovens to either the crystals or mechanical filter in the sidestep oscillator, since the drift of both the crystals and mechanical filter do not cause the nominal 455 kc/s signal from the first mixer to fall outside the pass-band of the mechanical filter, e.g.

(1) Crystal Oscillator 1
= 2·471 Mc/s ... ... (1)

(2) Spectrum frequency = 2·016 Mc/s
(2 Mc/s plus 16th pulse) (2)

(3) Output from M1
= 455 kc/s (1)–(2) ... ... (3)

(4) Output from M2 = 2·016 Mc/s (1)–(3)

Suppose the crystal oscillator (Oscillator 1) frequency drifts 100 c/s high then

(*a*) Crystal Oscillator 1 = 2·471 Mc/s ... (1)

(*b*) Spectrum frequency = 2·016 Mc/s ... (2)

(*c*) Output from M1
= 455·1 kc/s ... (3) ... (1)–(2)

(*d*) Output from M2
= 2·016 Mc/s ... (4) ... (1)–(3)

If the crystal oscillator (Oscillator 1) frequency drifts by more than 200 c/s the mechanical band-pass filter will not pass the difference frequency and the output will be zero. Thus the oscillator must not drift by more than plus or minus 200 c/s, i.e. the bandwidth of the filter which at 2·470 Mc/s is 0·016%, this is easily maintained by the crystal oscillator.

48. The output signal from the sidestep oscillator in ten, one kilocycle steps is mixed with the signal from the i.g.o. oscillator (Oscillator 3) (*fig.* 9) in ten 10 kc/s steps at mixer M6 to produce a frequency between 2·301 Mc/s and 2·400 Mc/s. This latter frequency is applied to the phase discriminator D (*fig.* 9) of the main loop, where it is compared with the main loop signal.

Mechanical filter

49. A mechanical filter (*fig.* 7) is included in the circuit of the sidestep oscillator, this type of filter is not at present in common use, hence a brief description of its operation is given in the following paragraphs.

50. The mechanical filter can be designed to have excellent rejection characteristics, be extremely rugged and it is small enough in physical size to be used in miniaturized equipment. A "Q" factor of the order of 10 000 can be obtained from a mechanical filter.

51. The filter is a magneto-striction or mechanically resonant device which receives electrical energy at its input, converts this into mechanical vibration and then re-converts the vibration back into electrical energy at the output of the filter.

52. Basically four elements (indicated in *fig.* 7) make up the construction of a mechanical filter, they are:—

(1) An input transducer which converts electrical input to mechanical oscillations.

(2) Metal discs which are mechanically resonant by means of their physical dimensions.

(3) Coupling rods which couple the mechanical discs.

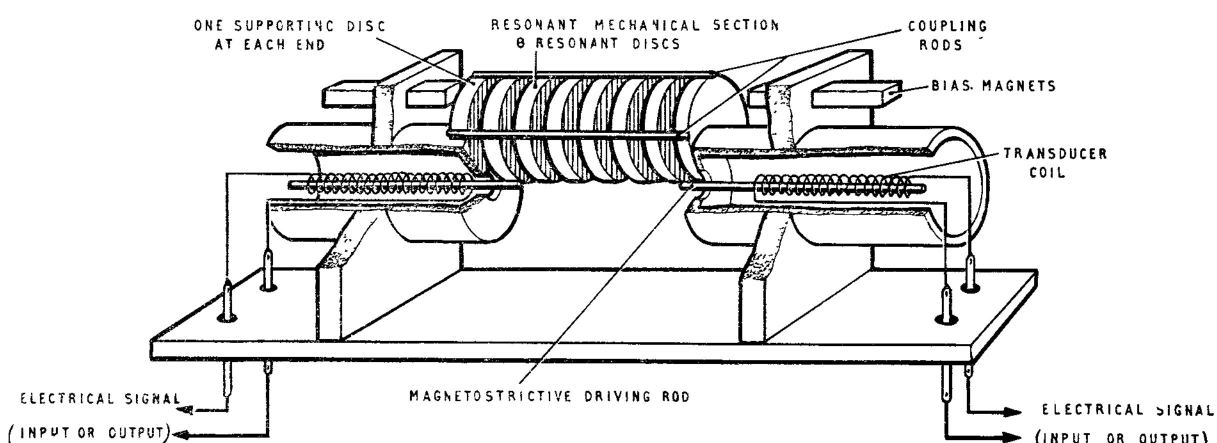
(4) An output transducer to convert mechanical vibrations back into electrical oscillations.

53. The mechanical filter used in the generator, reference signal, uses transducers which convert electrical energy into mechanical energy and vice versa these are the magneto-strictive type; the transducer also provides proper termination and matching for the mechanical network. The operating frequency of this filter is 455 kc/s and its bandwidth is plus and minus 200 c/s.

Mixer and filter assembly

54. A mixer and filter sub-assembly contains all the mixers in the main control loop (i.e. M1 to M3 inclusive) and also the mixers M4 and M5 together with their associated filters. Output from the mixer and filter sub-assembly feeds the main loop signal to the sub-unit containing the phase-discriminator D. Several types of mixer circuit are used in the sub-assembly these circuits employ sub-miniature type pentode valves.

55. The filters used in the generator are mainly of the L-C band-pass type; an exception to this is



(Reproduced by permission—Collins Radio Company)

Fig. 7. Mechanical filter

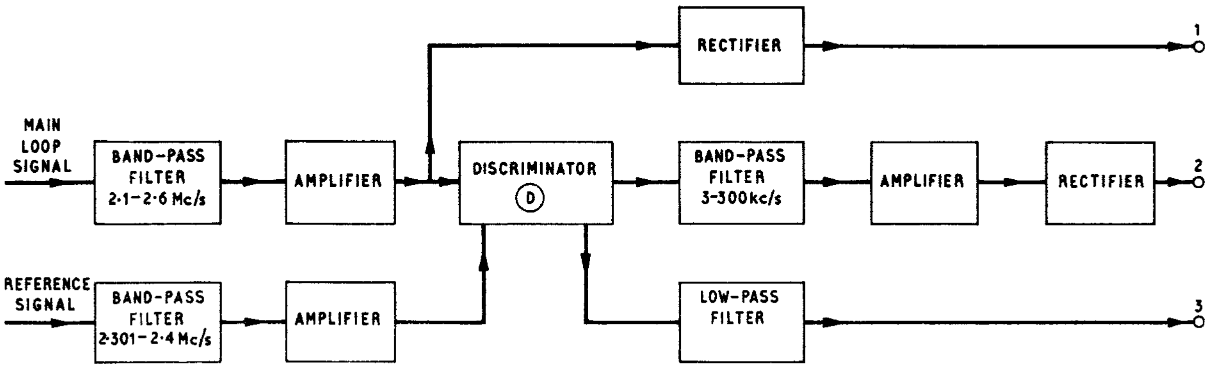


Fig. 8. Main loop discriminator—block diagram

the u.h.f. filter F4, where owing to the high frequency and wide bandwidths used top capacitance coupling is added to the normal L-C filter arrangement. For this purpose a special miniature trimmer is used.

Discriminator unit

56. The generator, reference signal, operates so that the comparison of the signal obtained from the main variable frequency oscillator through mixer M3 (*fig.* 9) is always made between the frequencies 2·301 Mc/s and 2·400 Mc/s inclusive. This comparison is carried out by the discriminator unit D (*fig.* 8).

57. Three output signals are produced by the discriminator for the purpose of controlling the tuning of the variable frequency oscillator:—

(1) Shows that the main loop signal frequency is approaching the desired setting, i.e. the v.f.o. is within 200-300 kc/s.

(2) Shows that the main loop signal frequency is now within the capture range of the v.f.o. reactance device, i.e. the v.f.o. is within 3 kc/s.

(3) The control signal which maintains the loop in phase-lock.

58. A signal is fed from the band-pass filter to the amplifier in the main loop, a portion of the output produced by the main loop signal amplifier (which feeds the discriminator) is rectified (*fig.* 8) this rectified signal constitutes the required signal showing that the main loop signal is approaching the desired setting to within 200-300 kc/s signal (1) in fig. 8. An output at this band of frequencies will not appear until the v.f.o. frequency is within 300 kc/s or so of that selected from the reference standard (see *para.* 57).

59. When the two signals become very close in frequency a beat frequency will be produced in the discriminator, the beat will become zero when the two frequencies are equal, this fact is used to produce the signal (2) in fig. 8 showing that the main loop signal frequency is now within the capture range of the main oscillator reactance device.

60. The third control signal (3) in fig. 8 is produced by a normal phase discriminator circuit. After integration, the resulting d.c. output from this circuit is fed to the control grid of the reactance device controlling the v.f.o. The signals produced at (1) and (2) are used to control the motor tuning operation of the v.f.o. and the signal at (3) is used to finally control the v.f.o. drift electronically via the reactance valve.

V.F.O. and motor control circuit

61. The output signal from the generator, reference signal, is obtained from a main variable-frequency oscillator via a buffer-amplifier stage. The variable capacitor tuning the oscillator section and a similar section variable capacitor which tunes the buffer-amplifier, are ganged; this double-ganged capacitor is driven by a small servo-motor via a 600 : 1 reduction gear train. When the motor has rotated the gang capacitor into the required position, the oscillator is phase-locked to the reference frequency by a reactance valve. The r.f. output level from the buffer amplifier is held constant by means of an a.g.c. system.

62. Speed control of the servo-motor is provided by transistor switching circuits. In the absence of the near frequency signal, obtained from the main loop phase-discriminator, at (1) fig. 8 the servo-motor runs at a fast speed in the forward direction. When the frequency of the v.f.o. is such that a near frequency signal is produced at the discriminator the motor speed is rapidly slowed down to approach the "on frequency" condition. This is done to speed up the overall operating time and to prevent over-shooting and hunting which would occur at this speed of operation.

63. The "on frequency" signal is obtained from the output of the beat detector (2) in fig. 8 and the condition of null output, produced at (3) in fig. 8 when the v.f.o. is in phase-lock with the synthesized signal. When the output frequency of the v.f.o. is within the capture range of the reactance device, control of the motor is obtained from the reactance valve cathode current.

64. If the reactance valve cathode current is near its mid-range no action is required from the motor;

should the valve current approach either the upper or lower limit, the motor shaft rotates in such a direction that the reactance valve current is restored to mid-range. This ensures that if the v.f.o. drifts outside of the range of reactance control the oscillator would not come out of lock and re-select frequency. Thus at all times the range of control of the reactance valve is optimum.

65. The direction of rotation of the motor is controlled by two bi-stable transistor multivibrator circuits operating at different levels. One circuit is triggered "on" with low reactance valve current, whilst the other circuit triggers "on" when the reactance valve current reaches its upper limit.

66. From para. 65 it can be seen that neither multivibrator switching circuit will be "on" if the reactance valve current does not vary beyond either its upper or lower limits and thus the motor will be stationary.

Setting up a frequency

67. The tuning capacitors operated by the motor are capable of 360° rotation but 180° of this is made inoperative by a cam operated micro-switch so that the frequency always increases with forward motion of the motor.

68. The frequency range of the v.f.o. is from 3·5 to 26·499 Mc/s and is covered in five ranges:—

(1) 3·5–6·499 Mc/s
(2) 6·5–11·499 Mc/s
(3) 11·5–16·499 Mc/s
(4) 16·5–21·499 Mc/s
(5) 21·5–26·499 Mc/s

These ranges are arranged so that the oscillator cannot be tuned to a harmonic over any one range and the rate of tuning in degrees per megacycle is kept as constant as possible.

69. The generator, reference signal produces a signal 1·5 Mc/s above that indicated by the setting switches on the front panel (*fig.* 2) this is necessary because the generator is in fact used as a local oscillator for the mixing process in the transmitter-receiver. For example if the required frequency from the transmitter-receiver is 9·425 Mc/s, the generator output signal is actually 10·925 Mc/s. As mentioned in para. 3, when the generator, reference signal is used as a signal generator, the calibration of the selection switches on the front panel is, of course, directly in output frequency.

70. Switching information is provided in the form of five connections, the wire corresponding to the range in use having an earth on it. Ranges 1 and 2 correspond to ranges 1 and 2, i.e. 2·5-5 Mc/s and 5-10 Mc/s on the main equipment. The wires corresponding to ranges 3 and 4 are joined to provide range 3, i.e. 10-20 Mc/s information to the main equipment. Range 5 information is not used, the upper frequency limit of the main transmitter-receiver equipment being 20 Mc/s.

71. All switching operations involved in setting up a required frequency from the generator reference signal are performed by electro-magnetic "Ledex" switches; the channel selection is provided by a remote control unit (control radio set) fitted in a position in the cockpit of the aircraft so that the remote control can be performed manually.

72. To set up the system on a particular channel frequency therefore it is necessary to select the corresponding output from each of the four generators, Oscillator 1 to Oscillator 4 (*fig.* 9) by setting up the five switches shown in fig. 2 to the digits required, the output frequency being obtained automatically from the variable frequency oscillator by the system which has been described. Channel changing takes approximately five seconds to be complete.

73. Oscillators 1 to 4 are connected to produce frequencies in the following order when any frequency in the band 3·5–25 Mc/s is set up on the switch bank on the front panel of the generator, reference signal.

Oscillator 1—34 to 56 Mc/s corresponding to 4 to 26 Mc/s, the megacycle bands changing at 4·5, 5·5, 6·5 Mc/s, etc.

Oscillator 2—2·2 to 3·1 Mc/s corresponding to 400 kc/s to 500 kc/s the zero digit being equivalent to 2·6 Mc/s.

Oscillator 3—290 to 380 kc/s corresponding to 90 kc/s down to 0 kc/s.

Oscillator 4—2·011 to 2·020 Mc/s corresponding to 9 kc/s down to 0 kc/s.

In setting up a frequency of 11·381 Mc/s on the switches (*fig.* 2) the following frequencies are produced by the oscillators:—

Oscillator 1—41 Mc/s

Mixer M4—166 Mc/s

Mixer M1—155·5 to 154·501 Mc/s }
Mixer M2—30·5 to 29·501 Mc/s } When the v.f.o. is varied from 10·499 to 11·499 Mc/s

Oscillator 2—2·3 Mc/s

Mixer M5—27·3 Mc/s

Mixer M3—2·301 to 2·400 Mc/s—When the v.f.o. is varied from 11·300 to 11·399 Mc/s

Oscillator 3—300 kc/s

Oscillator 4—2·019 Mc/s

Mixer M6—2·319 Mc/s

Mixer M3 can only produce 2·319 Mc/s when the v.f.o. passes through 11·381 Mc/s

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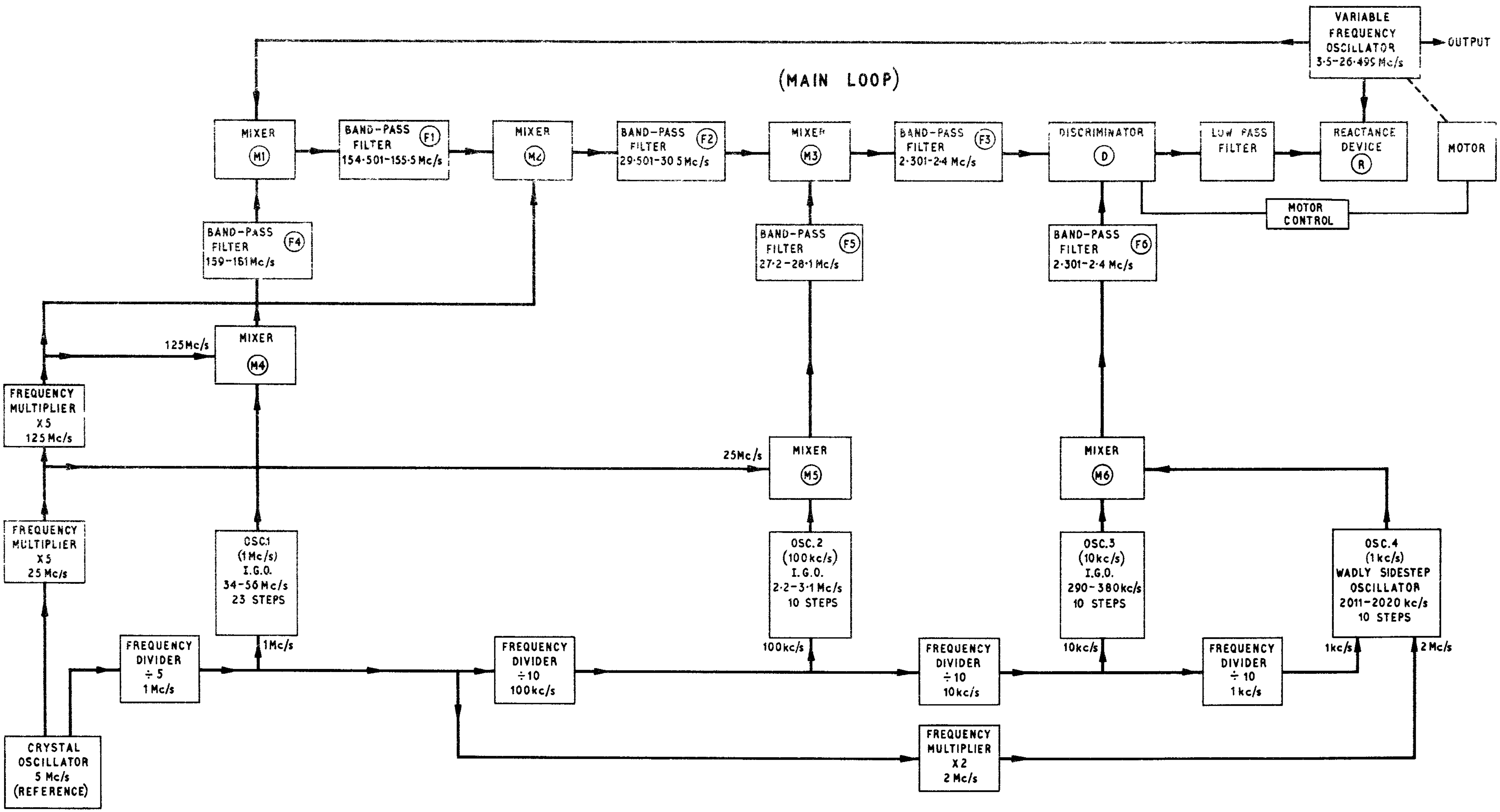

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Generator reference signal 5821-99-913-2244: simplified block diagram Fig. 9

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Chapter 2

RACK ELECTRICAL EQUIPMENT 5821-99-913-2250 AND SWITCH ASSEMBLY 5930-99-913-2239

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The rack electrical equipment 5821–99–913–2250 forms the basic housing for all the sub-units used in the generator reference signal. The rack contains all the interconnecting wiring, together with plugs and sockets to make up a completely self-contained unit.

2. Switch assembly 5930–99–913–2239 forms a detachable front panel of the rack electrical equipment, the switch unit contains sixty separate switches which allow any twelve channels in the range 2·5–20 Mc/s to be preset for use in the main transmitter-receiver equipment.

Construction

3. Rack electrical equipment 5821–99–913–2250 is designed to fit a standard aircraft racking system and its dimensions are 13 in. × 13 in. × 8 in. As mentioned in para. 1 the rack carries the interconnecting wiring and sockets for the eight sub-units used (*fig.* 1).

4. Seven sub-units are supported in the rack which is constructed with two vertical members thus forming a central well into which the three impulse-governed oscillators are plugged.

5. The three i.g.o.'s are positioned so close together that there is insufficient room to grip the

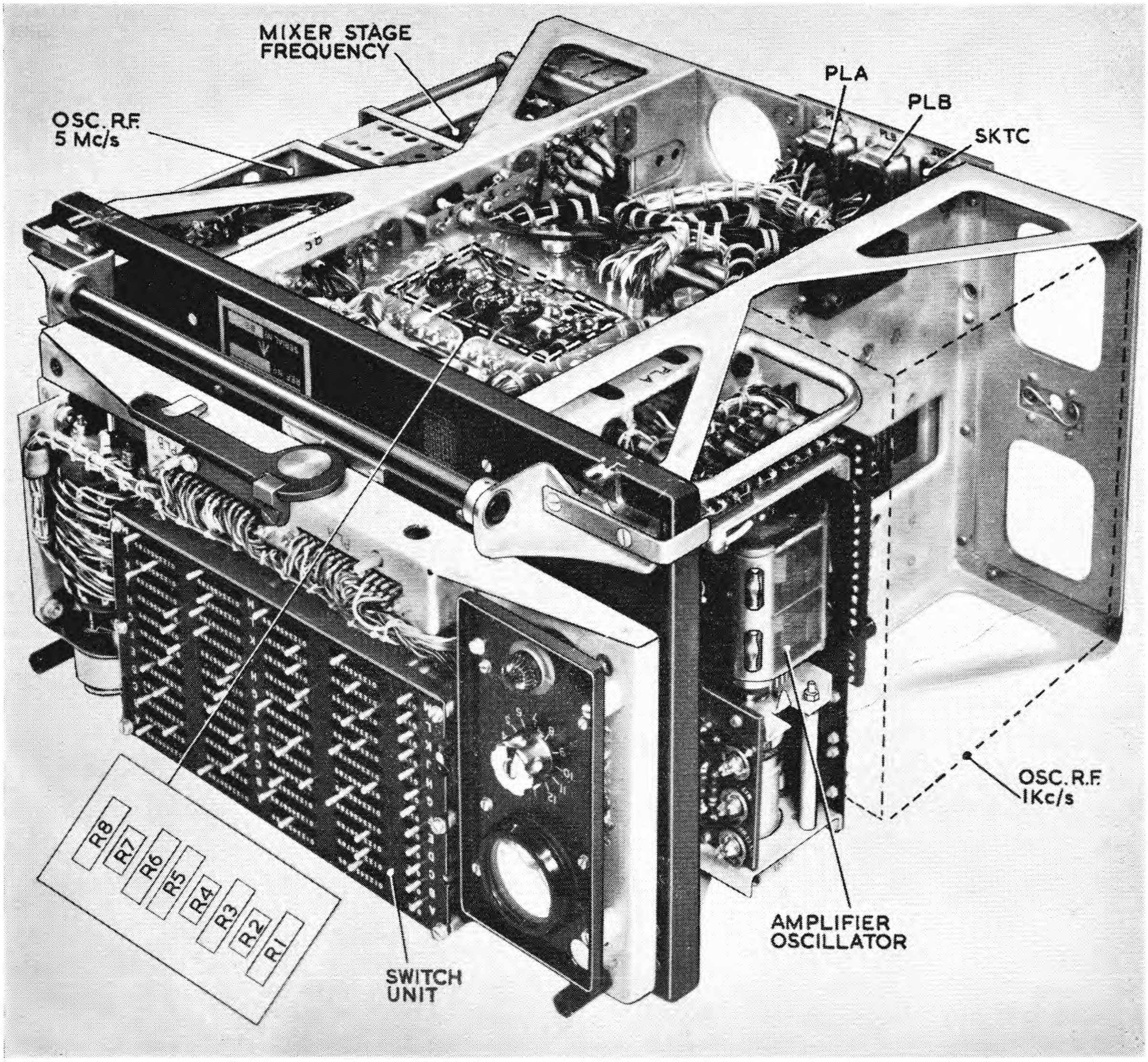

Fig. 1. Rack electrical equipment showing sub-units

top of the units to disconnect them from their plugs when the retaining screws have been loosened off.

6. Under the well adjacent to the plugs beneath each i.g.o. are two studs. When the retaining screws have been loosened these studs can be pressed against the base of the i.g.o. in this way disengaging the plug from the socket and partially withdrawing the unit.

7. The outside of the well carries the 5 Mc/s reference oscillator and mixer/filter unit on one side, with the variable frequency oscillator, sidestep oscillator and discriminator unit on the other.

8. This form of well construction produces a rigid and compact assembly whilst at the same time providing adequate freedom of passage for cooling air flow forced in by a blower arrangement fitted on the aircraft racking at the rear of the generator reference signal.

Interconnections

9. Reference to fig. 4 (end of chapter) shows the interconnections between sub-units on the rack electrical equipment. From the diagram, interconnections can easily be traced from sub-unit to sub-unit since plug and socket identification letters are given at the left-hand side of the diagram and facilities available at the top of the diagram.

10. Attached to component mounting brackets on the underside of the rack electrical equipment are eight resistors R1 to R8, (*fig.* 1) these resistors are used for dropping the voltage from the supply to that required for various valve heaters used in the generator reference signal.

11. There are two co-axial sockets on the rack electrical equipment (*fig.* 1) these provide an output for the 5 Mc/s reference frequency and 2 Mc/s

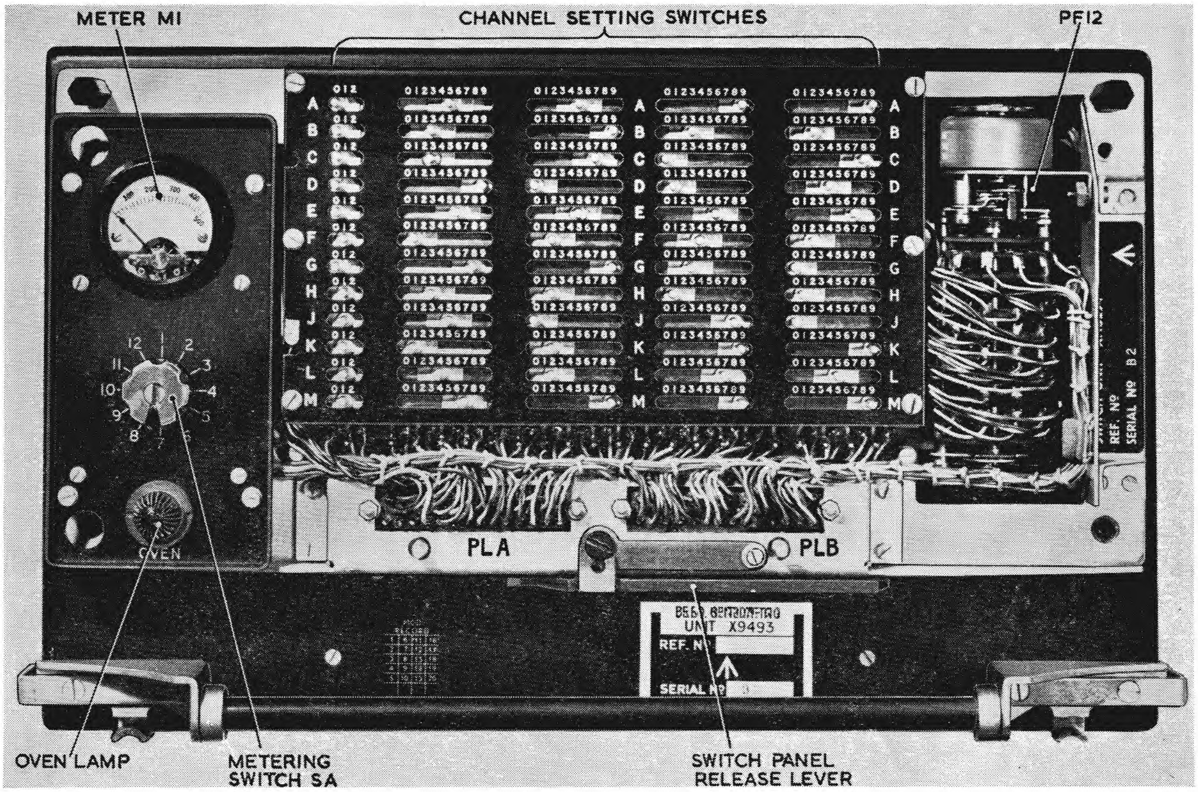

Fig. 2. Switch assembly—front

frequency which will be used in later equipments to provide a 1·5 Mc/s frequency to operate the transmitter-receiver instead of the crystal oscillator at present employed.

SWITCH ASSEMBLY 5930–99–913–2239

12. The switch assembly is a removable sub-unit and consists of a printed circuit board (*fig.* 2). On the printed circuit board are provided sixty separate switches which can be adjusted to produce pre-selection of 12 frequency channels each of five digits (e.g. 13286 kc/s).

13. This multiple switch panel is attached to the front face of the rack electrical equipment. The panel is covered by a lid and its supporting frame ◀ carries a meter and switch (*fig.* 2). Adjustment of ▶ the switch allows the performance of various key points in the system to be monitored by meter indication (*Table* 1).

14. Four screws, one in each corner of the lid, when loosened off enable the lid to be withdrawn together with the screws which are captive. The switch assembly is then only held by its plug and socket.

15. In order to remove the switch assembly the green captive screw in the centre of the arm marked 'RELEASE GREEN SCREW BEFORE OPERATING LEVER' must be loosened off and the green arm ◀ raised to allow forward movement of the release ▶ lever.

16. As this lever is pulled outwards the plugs will be pulled away from the sockets. When the switch assembly is replaced the reverse procedure must be adopted.

17. All switching operations involved in setting-up a frequency at the generator reference signal are carried out by electro-magnetic 'Ledex' type switches from the pre-set information supplied by the settings on the switch assembly 5930–99–913–2239.

Metering

18. Metering of various circuit functions are shown in Table 1.

19. A circuit diagram of the switch assembly is given in fig. 3 at the end of this chapter. A part of the high tension and heater voltages appearing at PLA pins C9, B9, A9, B8 are applied to the metering circuit via the selector switch SA. The resistors R11, R6 provide a potential-divider action for metering the 200V supply whilst R10, R5, R9, R4, R8 and R3 have a similar use for the other supplies.

◀ **20.** The variable frequency oscillator output ▶ voltage level is also divided down by the potential divider R13, R12 before being applied to the metering circuit.

Channel setting and selection

21. To pre-set a frequency for operation the setting switches shown in fig. 2 are adjusted for the particular frequency required on a certain channel.

22. If reference is made to fig. 3 it will be seen that adjustment of the setting switches will allow an earth connection to appear at the output terminations of the switch assembly when a channel is selected thus providing information to the various impulse governed oscillators used in the equipment. These oscillators in turn provide the reference signal to control the variable frequency oscillator in the generator reference signal.

23. An example is given for one particular channel and frequency; in this instance channel D has been chosen and a frequency of 18815 kc/s is required to be preset.

24. Referring to fig. 3, setting up channel D involves adjustment of switches as given in Table 2.

25. The procedure given in Table 2 is followed for the other frequency channels to be set up on the generator reference signal.

26. When a particular channel is selected from the control radio set 5821–99–913–3108 (remote control unit), an earth connection appears on one of twelve wires of PLB (*fig.* 3). Ledex switch PF12/9 will operate, rotating switch wafer PF1 until the earth connection to PF1 is removed by the alignment of the 'cut-out' of the switch motor with the fixed contact carrying the earth connection.

27. At the same time switches PF3 to PF9 are rotated by the 'Ledex' switch mechanism to the same relative angular positions since all the switches PF1 to PF9 are ganged on the same shaft.

28. The switches PF3 to PF9 are thus set to select the frequency set up as shown in the example (*Table* 2).

Output frequency

29. It should be noted that the actual frequency delivered by the generator reference signal is 1·5 Mc/s higher than that set for a particular channel on the switch assembly. This is due to the fact that the generator reference signal is used as a source of local oscillations in the s.s.b. transmitter-receiver.

Table 1

Test performance of generator reference signal

Plug PLA Pin No.	Switch (SA) Position	Meter Indication Min.	Meter Indication Max.	Performance Test
B.8	1	◄ 240	300	25·2V heater supply
A.9	2	300	340	150V stabilized supply
B.9	3	280	340	150V unstabilized supply
C.9	4	360	440	200V h.t. supply
A.11	5	160	200	1 Mc/s i.g.o. signal
B.11	6	70	90	100 kc/s i.g.o. signal
C.7	7	50	250 ►	10 kc/s i.g.o. signal
B.10	8	50	250	v.f.o. signal
A.12	9	250	350	Reference signal
B.12	10	220	280	Loop signal
C.10	11	220	280	2 Mc/s output
A.13	12	170	210	Amp/osc. output

Readings taken at channel frequency of 4000 *kc/s*

Table 2

Channel setting and selection

Switch identification	Position	Action on selection of Channel D
SE SS	1 8 }	Earth connections on PLA/B7, C5, allowing 'Ledex' switches in 1 Mc/s i.g.o. to select required reference harmonic.
SAE	8	Earth connection on PLA/A1 allows 'Ledex' switch in 100 kc/s i.g.o. to select required reference harmonic.
SAS	1	Earth connection on PLB/B13 allows 'Ledex' switch in 10 kc/s i.g.o. to select required reference harmonic.
SBE	5	Earth connection on PLB/A8 allows 'Ledex' switch in 1 kc/s Wadly oscillator to select required reference harmonic.

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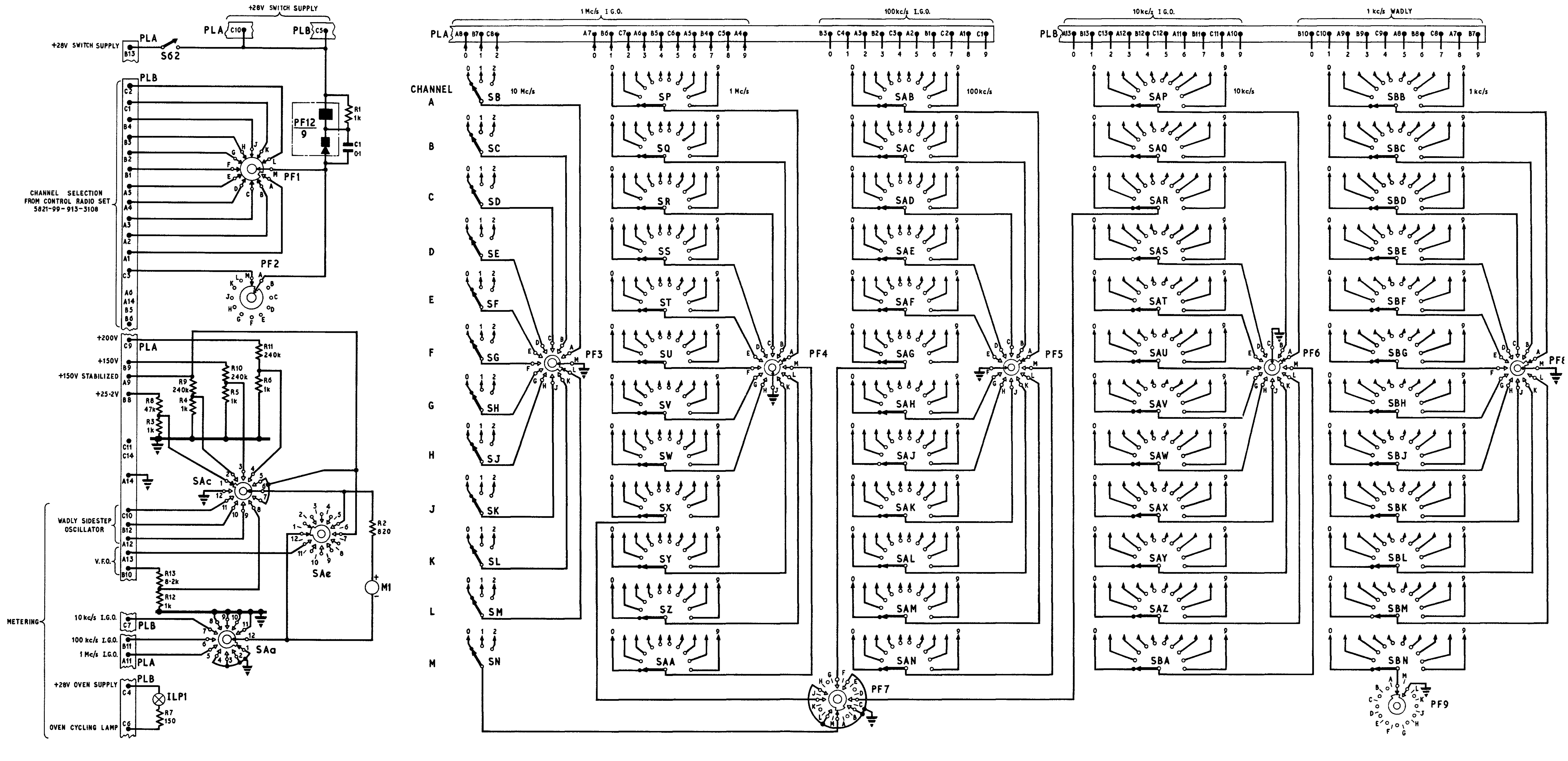

Switch assembly 5930-99-913-2239: circuit

Fig.3

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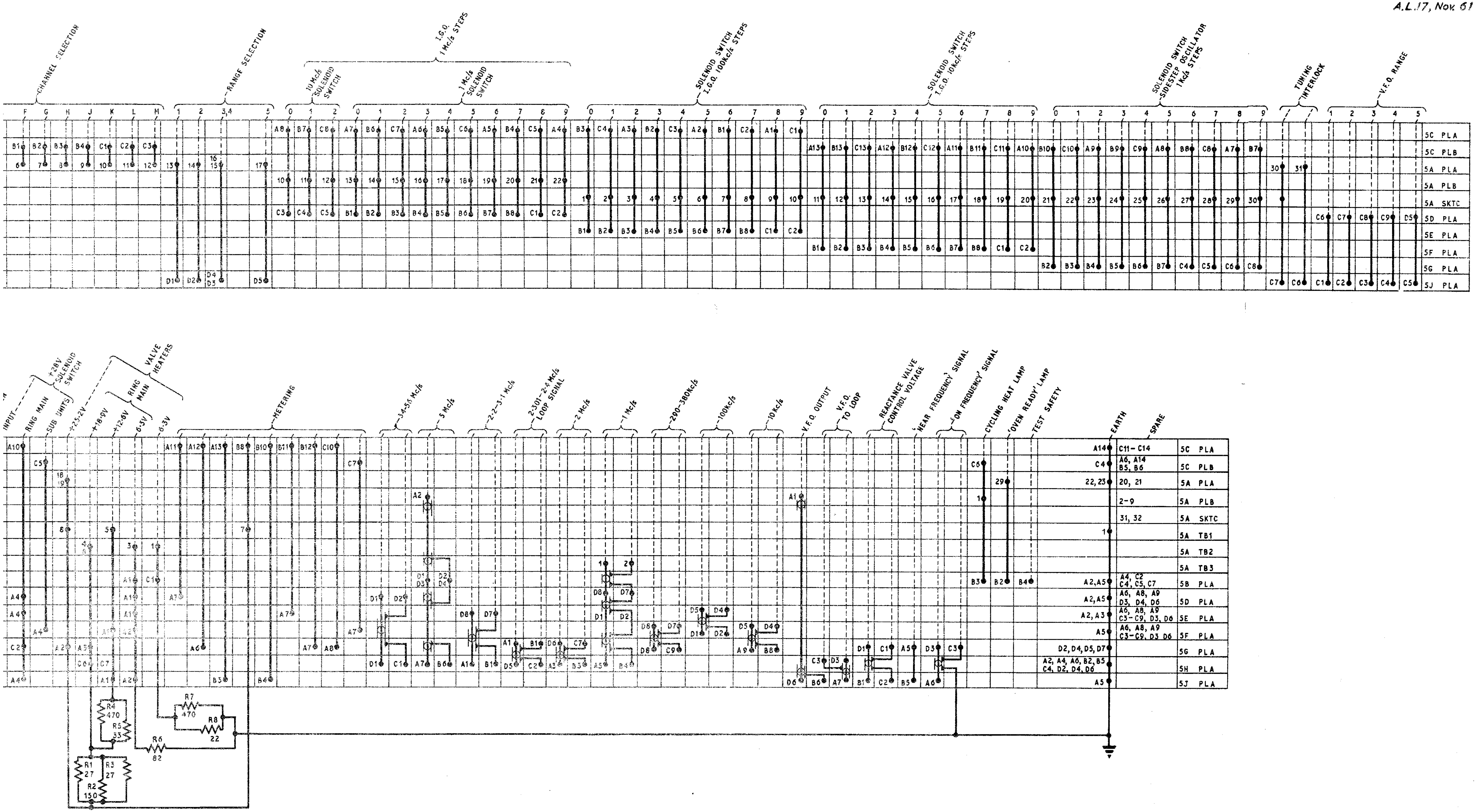


Rack electrical equipment 5821-99-913-2250: interconnections

Fig. 4

Chapter 3

OSCILLATOR RADIO FREQUENCY (5 MC/S), ◄5821-99-913-2238►

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The accuracy of the final output frequency from the generator reference signal depends only on the accuracy of the 5 Mc/s standard oscillator, since the latter provides the reference signal used in the servo-loop.

2. Oscillator r.f. (5 Mc/s) is constructed so that it has the highest possible order of frequency stability compatible with the limitations of airborne equipment. The crystal used is enclosed in a temperature controlled oven, in this way the crystal operating temperature can be controlled to within 0·01°C. By this close control of temperature the stability of crystal frequency can be made greater than 1 part in 10^6 over six months in its working range of $-40°C$ to $+55°C$.

Construction

3. The crystal oscillator circuit consists of a Pierce-Colpitts oscillator followed by a buffer amplifier. The valves used are of the miniature type and are wired directly into the circuit (*fig.* 1). An automatic level control device ensures a constant amplitude output from the crystal oscillator.

4. Construction of the oven block allows the crystal itself to be inserted in one end of the block whilst the thermometer control is inserted at the other (*fig.* 2) there is thus the shortest possible distance between the controlling thermometer and the crystal when both are mounted in the oven block.

5. Hard anodized aluminium is used for the construction of the oven block itself, the latter having the heating elements wound directly onto its surface.

6. A main heater winding is centrally placed on the oven block with one half of the cycling heater bifilar wound at either end. This winding method allows uniform heating of the oven block.

7. The anodic film produced during anodizing provides the necessary electrical insulation for the heating elements whilst at the same time providing good thermal conductivity into the oven block.

8. Thermal insulation for the oven is provided by interleaved layers of glass wool and aluminium foil, with an outer jacket of expanded polyethene.

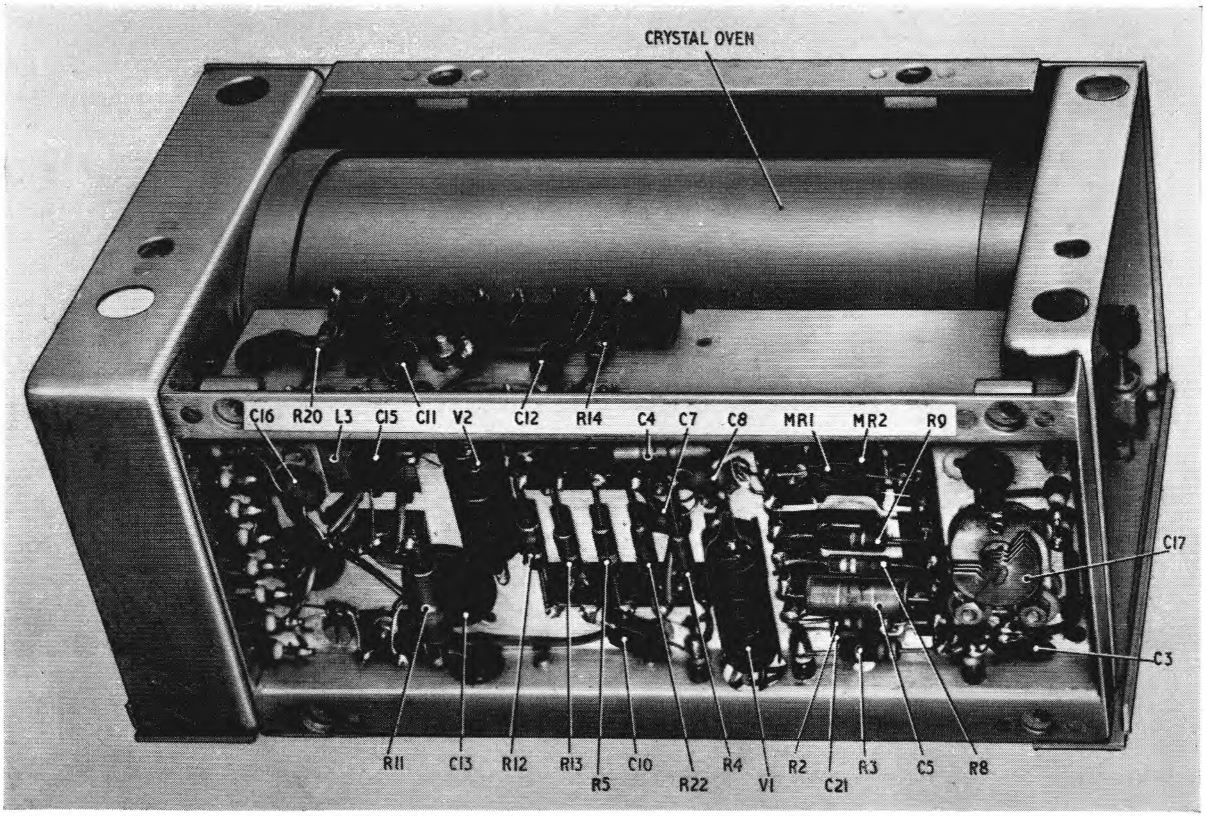


Fig. 1. Oscillator r.f. ◀5821-99-913-2238▶: top

9. The components used for the oscillator circuit and temperature control of the oven are mounted on paxolin board on either side of the oven itself, the assembly being covered by a metal screen to form a completely self-contained unit.

DETAILED CIRCUIT DESCRIPTION

Crystal oscillator

10. Valve V1 (CV2432) functions as a form of Pierce-Colpitts oscillator in conjunction with the associated circuit (*fig.* 3). Valve V1 provides high gain thus ensuring low loading on the 5 Mc/s crystal XL1 and giving high output.

11. Crystal XL1 is operated in its fundamental series mode. In this mode the crystal series resistance is extremely low, in fact almost zero, hence resistor R1 has negligible effect on this crystal resistance, however resistor R1 does provide sufficient damping of the circuit to prevent the crystal functioning in the anti-resonance mode which of course is undesirable in the circuit used.

12. The tuned circuit formed by inductor L1 and C1, C2, C17, C18, C19 and C24 resonates at or near the crystal frequency and is essentially a pulling circuit locked by the crystal. By the use of trimmers C17 and C24 this tuned circuit frequency can be adjusted until the output frequency is exactly 5 Mc/s. This allows adjustment for drift of frequency with time such as is produced by crystal ageing.

13. Coupling into the grid of valve V1 is through capacitor C3 with resistor R2 providing the d.c. return to chassis. The purpose of R3 is to stop the valve V1 producing parasitic oscillations since the gain involved is high.

14. The screen grid of V1 is held at earth potential to r.f. by the capacitor C7. Since the crystal oscillator circuit is connected effectively between control grid and earth, the circuit can be regarded as being connected between screen and control grid, with the screen grid performing the function of an anode.

15. Regeneration is obtained by the cathode return to the junction of capacitor C1 with C2 and C18. A d.c. path to earth from the cathode is provided by the choke L2.

16. The h.t. supply for the screen of V1 is provided from the + 150V supply via the potential divider R6, R7.

17. Two resistors R4 and R22 together form the anode load of the oscillator valve V1. The 5 Mc/s output signal is fed from V1 anode through the coupling capacitor C10 to the buffer-amplifier valve.

18. A part of the 5 Mc/s output is fed to the diode rectifiers MR1, MR2 via coupling capacitor C8, this voltage is used after rectification as the automatic level control (*para.* 26).

19. Components R5 together with C4 and C25 provide decoupling for the anode supply to the oscillator valve V1.

Buffer amplifier

20. The 5 Mc/s standard oscillator frequency is coupled to the buffer amplifier valve by the resistance-capacitance coupling formed by C10 and R13. Resistor R12 is a "stopper" resistor, performing the same function as R3 in the oscillator valve circuit.

21. Valve V2 is operated as a class A amplifier and biased accordingly by components R14, C12.

22. Screen grid h.t. supplies are obtained from the 150V h.t. supply through the series resistor R10, the screen grid being decoupled by capacitor C11.

23. A tuned circuit L3, C15 forms the anode load of the buffer-amplifier valve V2, this tuned circuit resonates at the crystal frequency of 5 Mc/s and is adjusted by the dust iron core in the coil L3.

24. Resistor R11 completes the valve anode supply connection to the + 150V h.t. supply line, with capacitor C13 acting as a decoupling component.

25. The 5 Mc/s output signal is fed to pins D3 and D5 on PLA via coupling capacitors C16 and C24 through a short length of coaxial cable, the braiding of the latter is connected to pins D2 and D4. An earth connection is provided only at the far end of this connecting cable.

Automatic level control

26. As mentioned in para. 18 a voltage obtained from V1 through coupling capacitor C8 is fed to the diodes MR1, MR2. These diodes form with R9 and C9 a voltage-doubler circuit, to increase the voltage control on the grid of V1.

27. The d.c. voltage obtained from the voltage-doubler appearing across capacitor C9 is filtered by resistor R8 and capacitors C5, C21 to remove radio frequencies. This d.c. voltage is negative with respect to earth and is fed to the grid of V1 through the grid leak R2.

28. As the amplitude of the r.f. voltage output from V1 rises, this produces an increase in the d.c. voltage produced by the diodes MR1, MR2, the negative voltage increases and being applied to

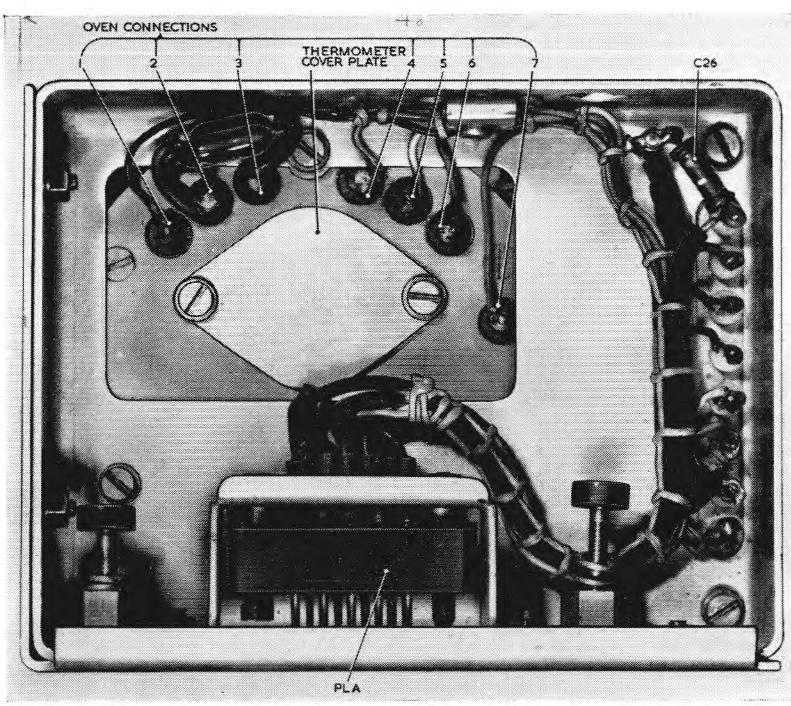


Fig. 2. Oscillator R.F. 5821-99-913-2238: side

the grid of V1 reduces the output level. A similar action but reversed takes place if the output of V1 falls. In this way automatic control of output level is obtained.

Oven temperature control

29. There are four heaters in the oven block as follows: —

(1) Quick heater.
(2) Thermometer heater.
(3) Cycling heater.
(4) Compensating heater.

Quick heater

30. The quick heater R19 heats up the oven block from cold and provides the main source of heat for this purpose, this heater is switched off at 62°C by the thermostat X3, when this occurs the 28V supply to the "oven indicator" in the control radio set, is removed and the "dolls-eye" operates, this shows the oven is ready for use.

Thermometer heater

31. So that the time-lag between heat being applied to the oven block by the heater (*para.* 30) and heat received by the thermometer is kept to a minimum, a special heating winding X1/R1 is provided. This is wound around a mercury reservoir on the thermometer itself, thus as soon as heat is applied to the oven block a proportional quantity of heat is also supplied to the thermometer heater.

32. The resistors R21a and R21b allow fine adjustment of the current through the thermometer heater X1/R1 during setting up and should need no re-adjustment during service.

Cycling heater

33. This is formed by the bifilar winding on the oven block; the supply current for this heater R18 is controlled by the switching transistor VT2 (CV7061).

Compensating heater

34. As there is some heat lost from the oven through the lead out wires, the latter are made of fine gauge wire to reduce this heat loss; however even further compensation is applied by winding the oven lead out wires over resistor R20. The latter resistor gives some heat to the lead out wires, in this way reducing the heat differential and almost completely compensating for loss of heat from the lead out wires.

Operation of the circuit

35. Current flow through the heaters R20,X1/R1 and R18 (*fig.* 3) is switched on or off by the switching transistor VT2 (CV7061), the latter being in turn switched by transistor VT1 (CV7062) functioning as an emitter follower.

36. If the oven temperature rises, the mercury capillary in thermometer X1 also rises and a short circuit appears from the base of VT1 to earth. Transistor VT1 then is cut-off and the base of VT2 being directly connected to the emitter VT1 is also at earth potential or very close to it.

37. Transistor VT2 is thus cut off and presents a high impedance in the path of current flow from the 28V supply through the heaters R20, R18, and X1/R1 to earth.

38. When the oven temperature falls, XI removes the earth connection from the base of transistor VT1, this transistor now conducts being suitably biased by resistor R16 (resistor R17 is a voltage limiting resistor for the collector of VT1). The base of VT2 is directly connected to the emitter of VT1, hence the potential of the former will rise and VT2 will conduct allowing the oven to be heated.

39. This cyclic heating continues throughout the period when the equipment is in use and is indicated by the green cycling lamp on the front panel of the generator reference signal flashing. This occurs since when the transistor VT2 is bottomed, the supply to the cycling lamp is removed by the effect of VT2 short-circuiting the lamp.

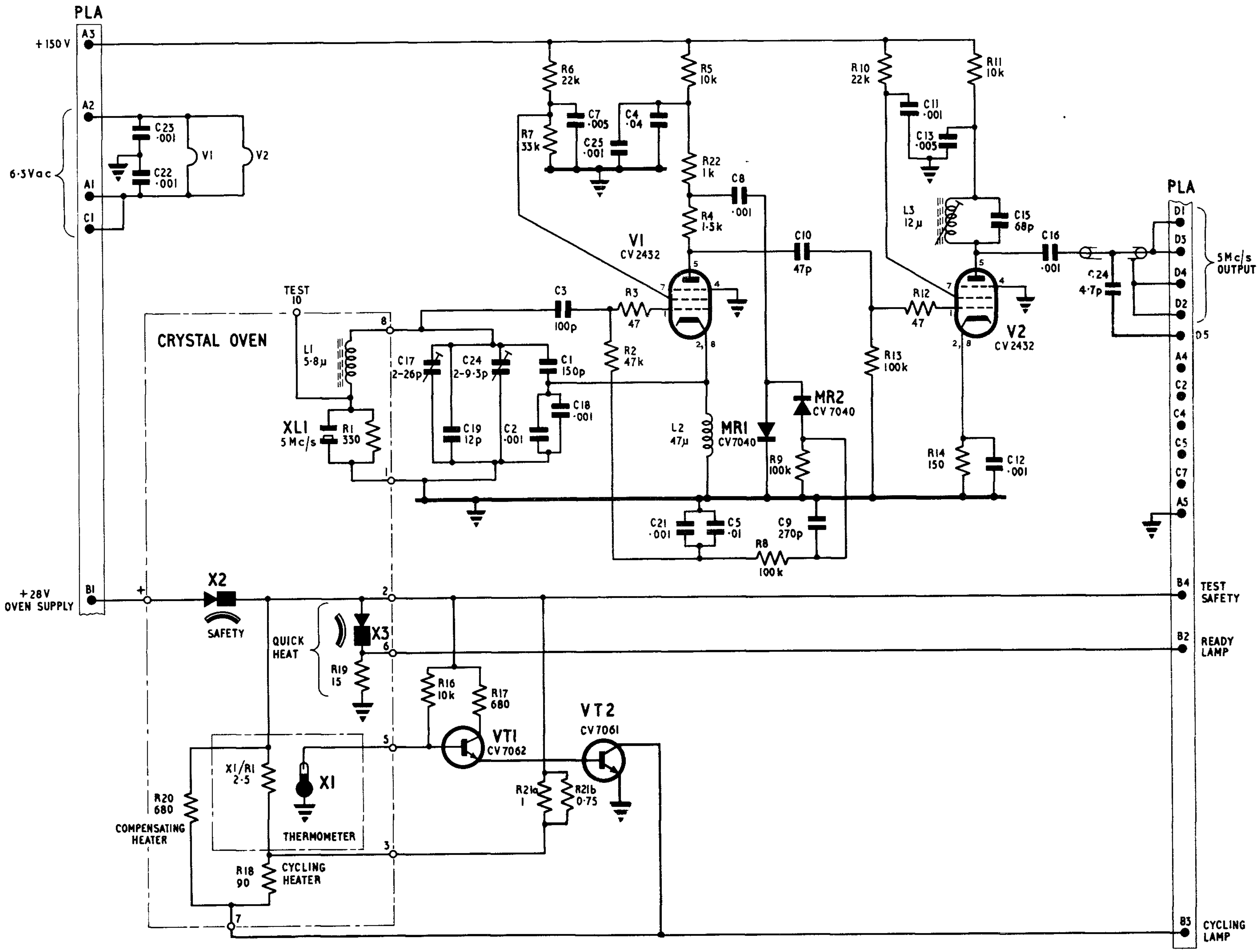
Safety cut-out

40. A safety cut-out thermal switch X2 is provided to open circuit the 28V heater supply to the oven if the oven temperature rises above 110°C due to a fault developing in the oven heating circuits.

41. When the oven temperature falls to normal again the cut-out reconnects the 28V oven supply automatically. The safety cut-out is adjusted during the manufacture of the oven-block and normally needs no readjustment.

Heater supply

42. The heaters of valves V1 and V2 are operated in parallel from the 6·3V a.c. supply available at PLA/A1, A2. This supply is de-coupled to radio frequencies by capacitors C22, C23, the junction of these components being earthed.



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Oscillator radio frequency 5821-99-913-2238: circuit

Fig. 3

Chapter 4

OSCILLATOR RADIO FREQUENCY (1 MC/S, I.G.O.)

5821-99-913-2230

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Oscillator radio frequency 5821-99-913-2230 is an impulse-governed oscillator (i.g.o.) which is fundamentally a sine-wave oscillator in which use is made of a technique of synchronizing the sine-wave oscillator to an appropriate harmonic of a reference frequency.

2. The oscillator produces frequencies between 34 and 56 Mc/s in 1 Mc/s steps, whilst the synchronizing voltage is controlled by a servo-loop system, this is in turn operated by a 1 Mc/s voltage obtained from the 5 Mc/s frequency standard (Chap. 3) through a frequency divider.

3. In this way the oscillator r.f. 5821-99-913-2230 is phase-locked to the 5 Mc/s frequency-standard oscillator (Chap. 3) and therefore has the same order of stability as the latter.

Construction

4. The oscillator r.f. 5821-99-913-2230 is constructed on a self-contained sub-unit. Screening is provided by metal plates which are attached to the top and sides of the sub-unit by screws.

5. Miniaturized technique is used, the smaller components being attached to tag strips or suspended in the wiring.

6. The sub-unit is divided into a number of sections by metal screens, the latter are not removable since they are rivetted to the sub-unit chassis.

OPERATION

Beam deflection tube

7. Beam deflection tube E80T performs two

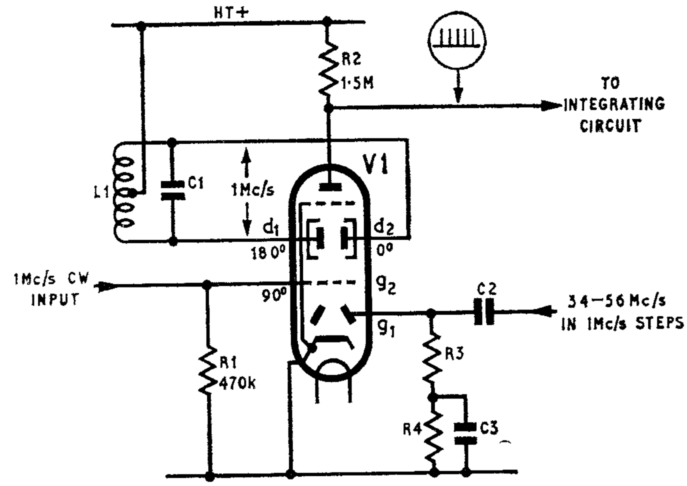

Fig. 1. Beam deflection tube simplified circuit

functions, namely, discrimination and pulse generation, the tube is illustrated in diagram form in fig. 1.

8. The tube operates as a small cathode ray tube without the fluorescent screen. When the tube is operating an electron beam is formed between anode and cathode.

9. If an alternating voltage is applied between the deflector plates d_1, d_2 (*fig.* 1), the electron beam will be deflected alternately from d_1 to d_2 at this frequency. Grids g_3 anf g_4, consist of a plate with slots cut in it so that anode current can only flow when the beam is central.

10. When the electron beam is being deflected by the plates d_1 and d_2, anode current can only flow in short duration pulses at twice the frequency applied to the deflector plates.

11. The anode pulses are halved in frequency by stopping the beam every other pulse. This is accomplished by shifting the phase of the deflecting signal by 90° and applying this to the gating grid g_2, which will have a potential alternatively positive and negative during every pulse of anode current.

12. The frequency produced by the Colpitts oscillator (para. 17) is applied to g_1 of the beam deflection tube and this frequency will therefore intensity-modulate the electron beam and consequently the amplitude of the pulses will depend on the phase relationship between the reference signal and the oscillator signal.

Circuit summary

13. The 1 Mc/s impulse governed oscillator (i.g.o.) consists basically of a series fed Colpitts oscillator, and a frequency controlling device (fig. 2).

Note . . .

The circuit of the r.f. oscillator uses a tapped inductor in conjunction with selected capacitors for tuning, and although from the circuit the layout may appear to be that of a Hartley oscillator, due to the frequencies involved the feedback is completed through the inter-electrode capacitances (para. 28) *and the circuit functions as a form of Colpitts oscillator.*

14. By using a number of preset capacitors and combining two electro-magnetic switches the Colpitts oscillator frequency can be set up to produce twenty-three spot frequencies in multiples of 1 Mc/s between 34 and 56 Mc/s inclusive. The frequency range being covered in three bands; 34-41 Mc/s, 42-51 Mc/s, 52-56 Mc/s by switching three values of capacitance across the tank circuit. These spot frequencies can be phase-locked to the frequency controlling device forming the second section of the i.g.o.

15. A 1 Mc/s c.w. voltage (fig. 2) is fed as the reference to the frequency controlling circuit from a frequency-divider, the latter in turn obtaining its imput from the 5 Mc/s reference crystal oscillator.

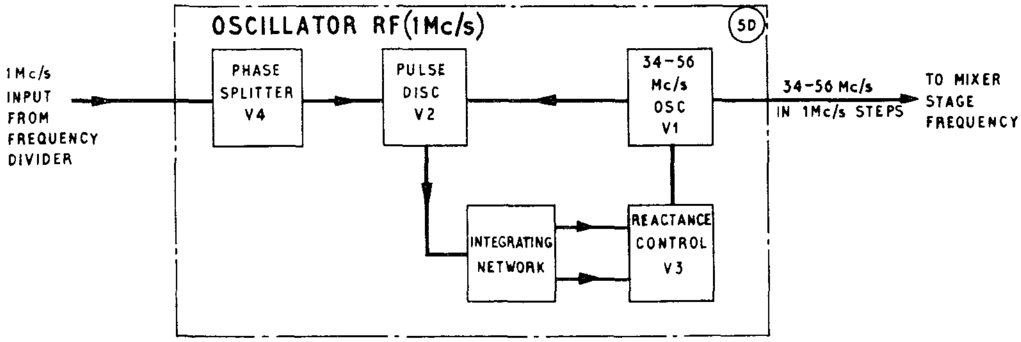

Fig. 2. Oscillator r.f. 5821-99-913-2239, block diagram

16. After amplification by a valve the original 1 Mc/s voltage is split into three parts with different phase relationships and applied to a special valve known as a beam deflection tube (fig. 1). This beam deflection tube produces an output voltage consisting of sharp pulses at a pule repetition frequency (p.r.f.) of 1 Mc/s.

17. The Colpitts oscillator is phase-locked to the 5 Mc/s reference oscillator by feeding some of the output of the Colpitts c.w. oscillator at the required spot frequency between 34-56 Mc/s to the control grid g_2 of the beam deflection tube. Any change in the relative phase of the Colpitts oscillator and reference signal frequencies will amplitude-modulate the pulses which after integration are fed as a d.c. control voltage to the reactance device in such a way as to oppose this phase change and thus keeping the system in lock.

18. If, however, the frequency generated by the Colpitts oscillator drifts from phase-lock with the reference signal, the loop gain round the deflection-tube resistance-control circuit falls and the system unlocks.

19. From the output of the beam deflection tube the pulses at a p.r.f. of 1 Mc/s are fed to an integrating network to produce a d.c. voltage proportional to the amplitude of the pulses.

20. The d.c. voltage produced as described in para. 17 controls a reactance device, this allows a small capacitance to be introduced in parallel with the Colpitts-oscillator tank-circuit by switching diodes, across the tuned circuit, thus effectively correcting the frequency produced by the oscillator.

21. When the Colpitts oscillator frequency drifts from phase-lock with the reference frequency (1 Mc/s) the loop gain round the deflection-tube reactance-device falls, since the control valve forms part of two loops, at this point the Wien bridge oscillator begins to oscillate at 5 c/s.

22. The v.l.f. oscillator then switches the diodes at this frequency to include more capacitance and provide a sweep of the Colpitts oscillator frequency of the order ± 220 kc/s.

23. This sweep occurs until the frequency of the Colpitts oscillator becomes the required integral multiple of the reference signal.

24. At this point the main control loop locks the Colpitts oscillator to the reference (1 Mc/s) signal, the higher gain damping the v.l.f. oscillation.

DETAILED CIRCUIT DESCRIPTION

Colpitts r.f. oscillator (34-56 Mc/s)

25. The r.f. oscillator consists of a series fed Colpitts oscillator circuit (fig. 5) using valve V1 (CV3929). The tuned circuit consists of transformer T1 and a number of fixed tuning capacitors which can be connected in parallel with this inductor by the switch wafers 2PF/C, 2PF/D (range selector) 1PF/E, 1PF/H; 1PF/I, 1PF/L; 1PF/M, 1PF/N. Fine adjustment of the tuned circuit is provided by trimmers C4-C11, C13-C22, C24-C28.

26. The 23 one megacycle steps produced by the oscillator can be selected by the switch wafers mentioned in para. 25.

27. The primary of transformer T1 (fig. 4) is centre tapped and connected to the + 150V h.t. supply through resistors R4, R5 (fig. 5) the latter resistor acting as a decoupling component to r.f., in conjunction with capacitor C30. The centre tap is left floating with respect to alternating current.

28. Feedback is provided from anode to grid of the oscillator valve V1, via the interelectrode capacitances Cak, Cgk. Capacitor C3 acts as a grid blocking component. The grid leak for the oscillator is resistor R3, whilst resistor R29 functions as a grid "stopper" to prevent parasitic oscillation occurring.

29. Cathode bias is provided for valve V1 by components R2 with C2, the valve functions as a Class A oscillator having a good output waveform.

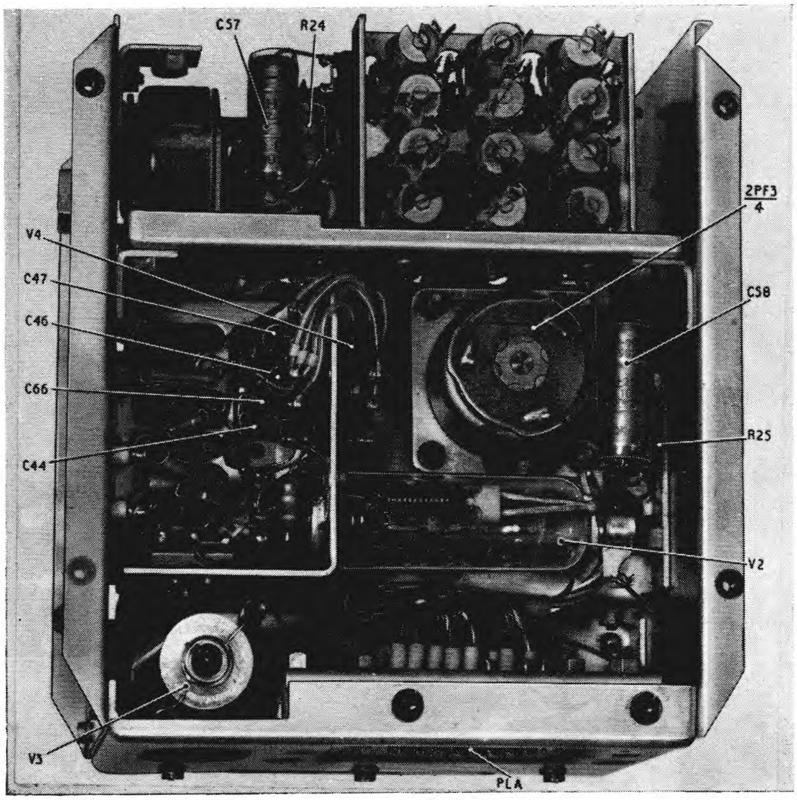

Fig. 3. Oscillator r.f. 5821-99-913-2230, side

30. The secondary of transformer T1 consists of a coupling winding, this provides output frequencies in the range 34-56 Mc/s in 23 one megacycle steps. The purpose of resistors R27, R28 is to match the output impedance of the oscillator to that of the input of the mixer stage frequency (Chap. 8). The output appears at PLA pin D1.

31. The reactance control-current of the system is metered at pin A7 of PLA by measuring the voltage developed across R6 due to current flow through the bridge switching circuit. The meter indication is provided on the front panel switch unit (Chap. 2).

1 Mc/s Amplifier

32. Input to the amplifier and phase-splitter circuit is at a frequency of 1 Mc/s derived from a frequency-divider which in turn obtains its input from the 5 Mc/s reference oscillator. The input is applied at PLA D7, D8, and fed via the capacity divider C44, C66 (fig. 5) to the control grid of an amplifier, pentode valve V4 (CV3929), the grid leak component is resistor R20.

33. The valve V4 is biased to function as a class A amplifier by the cathode bias components R21, C46. An amplified r.f. voltage at 1 Mc/s appearing in the anode circuit.

34. A tuned circuit formed by L3 and C45 is resonant at 1 Mc/s, the inductor L3 is centre tapped, in this way at each end of the inductor appears the 1 Mc/s voltages with a relative phase difference of 180° between them.

35. An output is also taken from the anode of V4 through capacitor C35 to a further tuned circuit L4, C37, resonant at 1 Mc/s, the coupling capacitor C35 and tuned circuit components being chosen to produce a 90° phase-shift of the 1 Mc/s voltage before this is applied to the grating grid g_2 of V2 (E80T). ▶◀ Capacitors C59, C60 provide test points for aligning the amplifier V4.

Pulse generation and discrimination

36. The beam deflection tube V2 (fig. 5) functions as a discriminator and pulse generator (para. 7) with the two 1 Mc/s voltages in antiphase mentioned in para. 34 being applied to the beam deflection plates. The grid V(g3+g4) of the beam deflection plates is held at a high potential by connection to the +150V supply, and decoupled by R8 and C36 to radio frequencies (fig. 5).

37. Short duration 1 Mc/s pulses are produced at the anode of V2 where resistor R10 acts as a combined anode load and part of an integrating network in conjunction with the stray capacity from anode to earth. Components C40, R15 act

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as a compensating network for the integrator. (Allowing maximum holding range for lock and keeping transients well damped).

38. The frequency produced by the Colpitts oscillator is applied to valve V2 on the control grid electrode g_2 through the coupling capacitor C39 to intensity modulate the electron beam. Resistors R26 and R14 function as a form of grid leak to the control-grid focusing-electrode g_2 whilst R14 and capacitor C61 provide bias for the latter electrode.

Control valve circuit

39. A d.c. voltage is produced by integrating the 1 Mc/s pulses in the integrating network mentioned in para. 37, this d.c. voltage, which is proportional to the amount of error in the Colpitts oscillator frequency is fed to the control grid of one half of valve V3 (CV2492), the latter valve functioning as a control valve to a reactance device.

40. Valve V3 has a common-cathode resistor R16 for both sections of the valve, the d.c. voltage drop across this resistor is so arranged that together with the positive potential supplied by the the d.c. connection of V2 to the grid of the control valve, a working bias is applied to the control grid of the valve V3.

41. When a change in the voltage produced by the integrating network occurs, a corresponding change will appear in the current through the control valve V3; this current in turn flows through diodes MR1, MR2, allowing capacitors C32, C31 to be brought into circuit across the Colpitts oscillator tuned circuit in proportion to the current flowing through the diodes.

42. By the action of the capacitors C31, C32, the frequency produced by the Colpitts oscillator is corrected over a small range; if, however, the frequency should drift out of this holding range, the circuit described in the following paragraphs functions to once again restore the Colpitts oscillator frequency to phase-lock with a harmonic of the reference frequency.

Wien bridge oscillator

43. The second half of valve V3 functions as a Wien bridge oscillator the frequency of oscillation is determined by the components R18, C41, C42, R19, at approximately 5 c/s.

44. Working bias for the oscillator is provided by the potential divider network R11, RV1, R12 in conjunction with the voltage developed across R16.

45. When the Wien bridge oscillator begins to function a sweep voltage at approximately 5 c/s is applied to the diode switching circuit consisting of MR1, MR2, L1 and L2; this allows the fre-

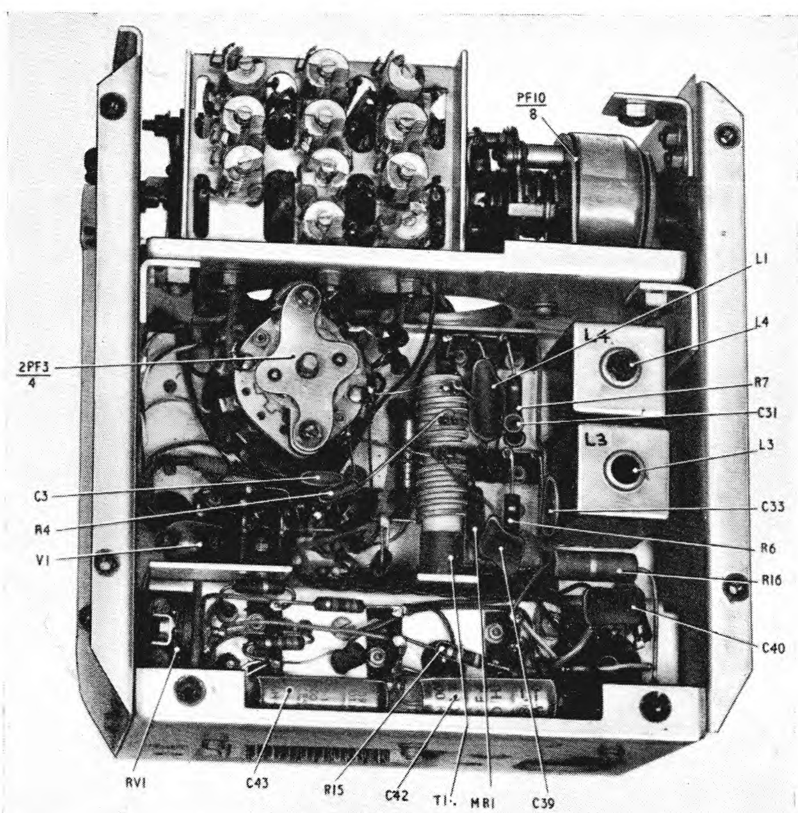

Fig. 4. Oscillator r.f. 5821–99–913–2230, underside

quency of the Colpitts oscillator to be swept through the range $\pm$ 220 kc/s approximately.

46. At some point in this frequency excursion the Colpitts oscillator frequency will become an integral multiple of the reference frequency in the beam deflection tube circuit. When this occurs, a d.c. voltage is fed to the grid of the control valve V3. The loop gain of the reactance circuit then becomes higher than the loop gain of the Wien bridge circuit and the latter ceases to oscillate. The output frequency of the Colpitts oscillator is again under the control of the reactance circuit.

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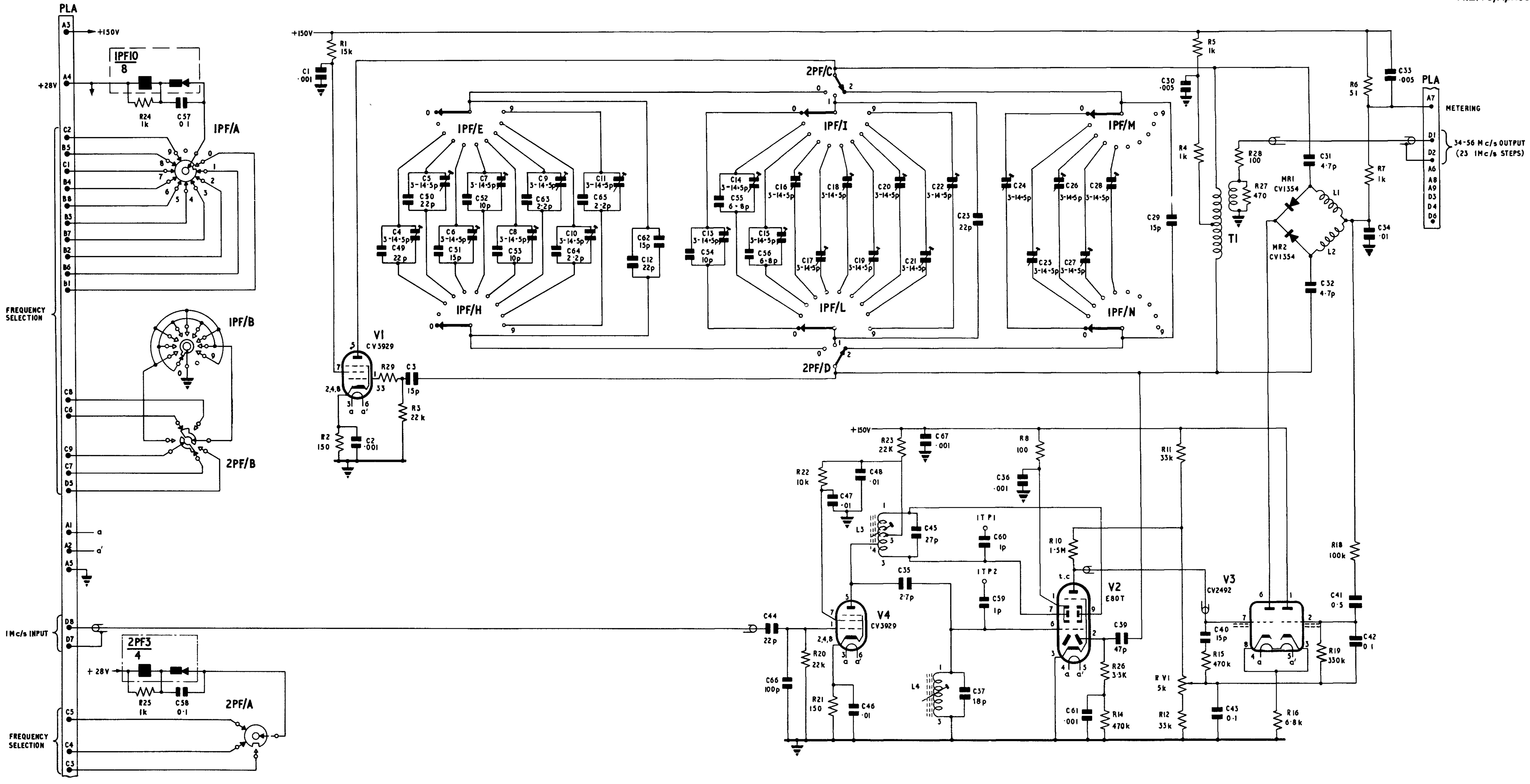

Oscillator radio frequency 5821-99-913-2230: circuit

Fig 5

AIR DIAGRAM
6729V/MIN.

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Chapter 5

OSCILLATOR RADIO FREQUENCY (100 KC/S, I.G.O.) 5821-99-913-2228

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Oscillator radio frequency 5821-99-913-2228 is an impulse-governed oscillator, i.e., an oscillator whose frequency is controlled by a technique of synchronization with an appropriate harmonic of a reference frequency. The oscillator is similar to that described in Chap. 4.

2. The oscillator produces ten harmonic frequencies between 2·2 Mc/s and 3·1 Mc/s in 100 kc/s steps, whilst the synchronizing voltage is controlled by a servo-loop system, which is in turn operated by a 100 kc/s voltage obtained from the 5 Mc/s frequency standard (Chap. 3) through frequency-dividers.

3. In this way the oscillator r.f. 5821-99-913-2228 is phase-locked to the 5 Mc/s frequency-standard oscillator (*Chap.* 3) and therefore has the same order of stability as the latter.

Construction

4. The oscillator r.f. 5821-99-913-2228 (*fig.* 1) is constructed in a self contained sub-unit. Screening is provided by metal plates which are attached to the top and sides of the sub-unit by screws.

5. Miniaturized technique is used, the smaller components being attached to tag strips or suspended in the wiring.

6. The sub-unit is divided into a number of sections by metal screens, the latter are not removable since they are rivetted to the sub-unit chassis.

OPERATION

Beam deflection tube

7. Beam deflection tube E80T performs two functions, namely, discrimination and pulse

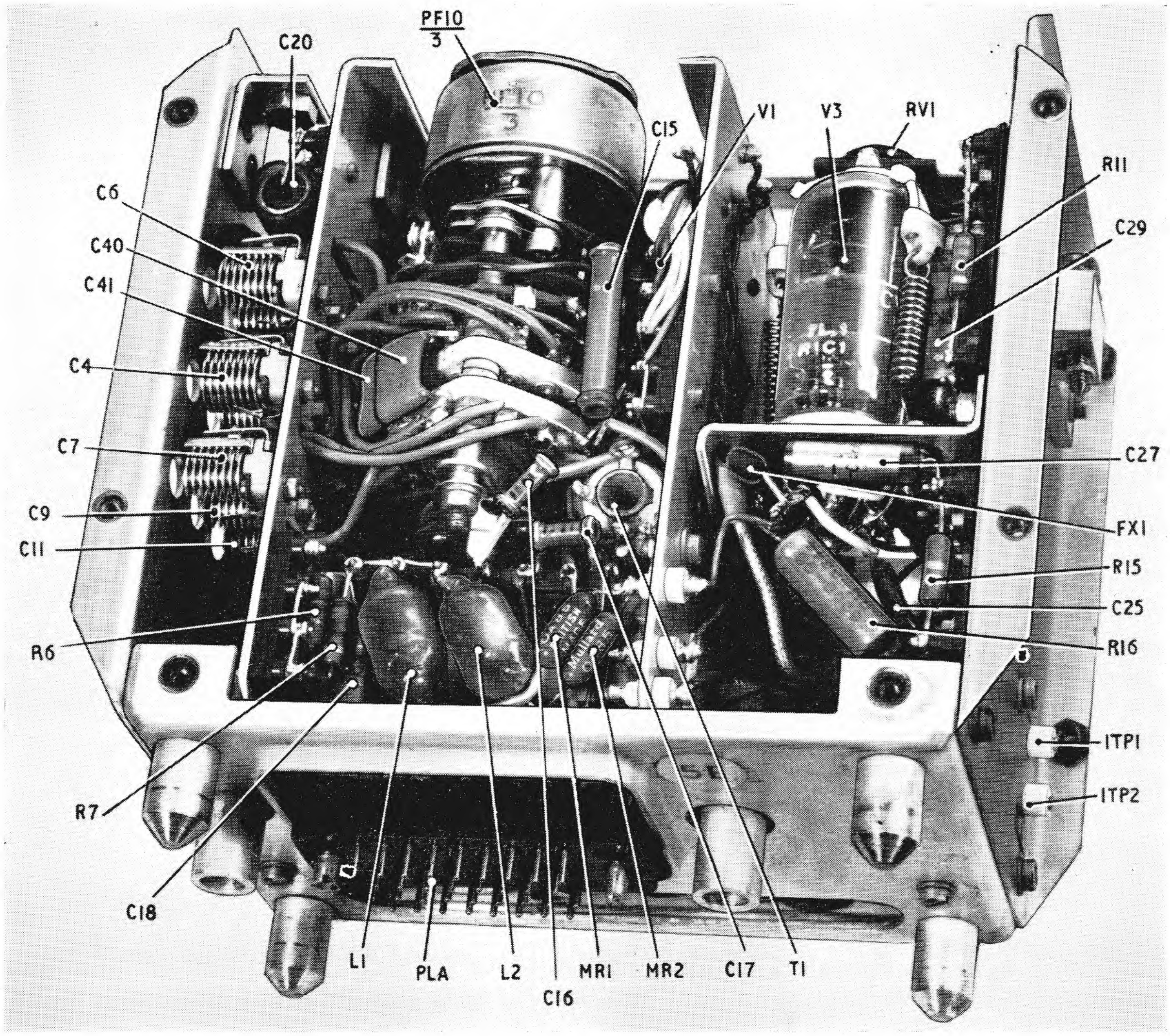

Fig. 1. Oscillator r.f. 5821-99-913-2228, underside

generation. The tube is described in some detail in Chap. 4 of Section 2, to this publication. The electron gun is similar to that of a cathode ray tube but the function is quite different since discrimination and pulse generation takes place within the tube.

Circuit summary

8. The 100 kc/s impulse governed oscillator (i.g.o.) consists basically of a series fed Colpitts oscillator, and a frequency controlling device.

9. By using a number of preset capacitors selected by a ten-position switch PF10/3 (*fig.* 1) the Colpitts oscillatoı frequency can be set up to produce ten spot frequencies in multiples of 100 kc/s between 2·2 Mc/s and 3·1 Mc/s inclusive. The frequency range is covered by switching the various values of capacitance across the tank circuit. These spot frequencies can be phase-locked to the frequency-controlling device forming the second section of the i.g.o.

10. A 100 kc/s c.w. voltage is fed as the reference to the frequency controlling loop from a times ten frequency-divider (*fig.* 2), the latter in turn obtaining its input from the 1 Mc/s reference voltage, obtained from the reference (5 Mc/s) oscillator.

11. From the output of the locked-oscillator frequency-divider the 100 kc/s voltage is split into three parts with different phase relationships and applied to a special valve (E80T) known as a beam deflection tube (Sect. 2, Chap. 4). This beam deflection tube produces an output voltage consisting of sharp pulses at a pulse repetition frequency (p.r.f.) of 100 kc/s.

12. The Colpitts oscillator is phase-locked to the 100 kc/s reference voltage by feeding some of the output of the Colpitts c.w. oscillator at the required spot frequency between 2·2 Mc/s and 3·1 Mc/s to the control grid g_1 of the beam deflection tube. Any change in the relative phase of the Colpitts oscillator and reference signal will amplitude-modulate the pulses which, after integration, are fed as a d.c. control voltage to the reactance device in such a way as to oppose this phase change and thus keep the system in lock.

13. If however the frequency generated by the Colpitts oscillator drifts from phase-lock with the reference signal, the loop gain round the deflection-tube resistance-control circuit falls and the system unlocks.

14. From the output of the beam deflection tube the pulses at a p.r.f. of 100 kc/s are fed to an integrating network to produce a d.c. voltage proportional to the amplitude of the pulses.

15. The d.c. voltage produced as described in para. 12 controls a reactance device that allows a small capacitance to be introduced in parallel with the Colpitts oscillator tank circuit by switching diodes, thus effectively correcting the frequency produced by the oscillator.

16. When the Colpitts oscillator frequency drifts away from phase-lock with the reference frequency 100 kc/s the loop gain round the deflection tube reactance-device falls, since the control valve forms part of two loops. At this point the Wien bridge (v.l.f.) oscillator begins to oscillate at 3 c/s approximately.

17. The v.l.f. oscillator then switches the diodes of this frequency to include more capacitance and provide a sweep of the Colpitts oscillator frequency of the order ± 25 kc/s.

18. This sweep occurs until the frequency of the Colpitts oscillator becomes the required integral multiple of the reference signal.

19. At this point the main control loop locks the Colpitts oscillator to a harmonic of the reference 100 kc/s signal, the higher gain damping the v.l.f. oscillation.

DETAILED CIRCUIT DESCRIPTION

Colpitts r.f. oscillator (2·2 Mc/s to 3·1 Mc/s)

20. The r.f. oscillator consists of a series fed Colpitts oscillator circuit (*fig.* 4) using valve V1 (CV3929). The tuned circuit consists of transformer T1 (*fig.* 1) and a number of fixed tuning capacitors which can be connected in parallel with this inductor by the switch wafers PF/C and PF/F (*fig.* 4). Fine adjustment of the tuned circuit is provided by trimmers C4-C13.

21. The primary of transformer T1 is centre tapped and connected to the + 150V h.t. supply through resistors R4, R5, the former resistor acting as a decoupling component to r.f., in conjunction with capacitor C14. The centre tap is left floating from a r.f. viewpoint.

22. Feedback is provided from anode to grid of the oscillator valve V1, via capacitors C15, C50. Capacitor C3 acts as a grid blocking component. The grid leak for the oscillator is resistor R3, whilst capacitor C49 functions to reduce the r.f. voltage on the grid of V1, in this way preventing overdrive.

23. Cathode bias is provided for valve V1 by components R2 with C2, the valve thus functions as a Class A oscillator having a good output wave-form.

24. The secondary of transformer T1 consists of a coupling winding, this provides output frequencies in the range 2·2 to 3·1 Mc/s in ten

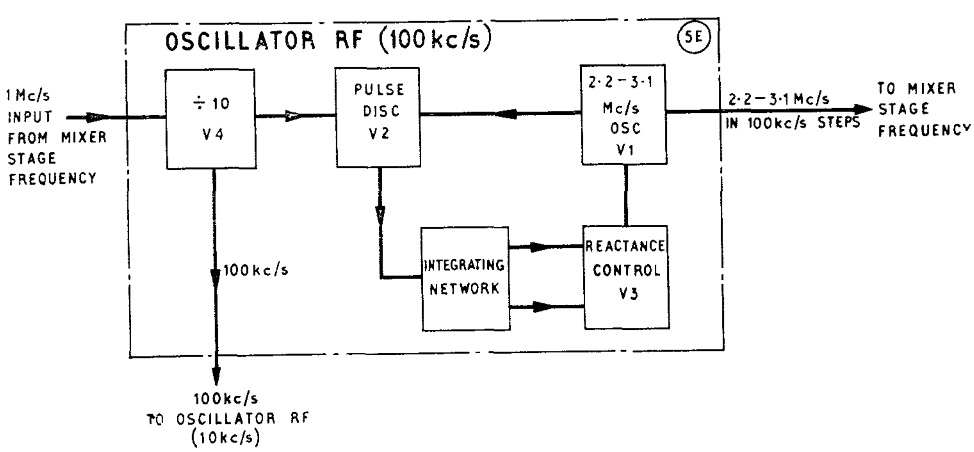

Fig. 2. Oscillator r.f. 5821-99-913-2228; block diagram

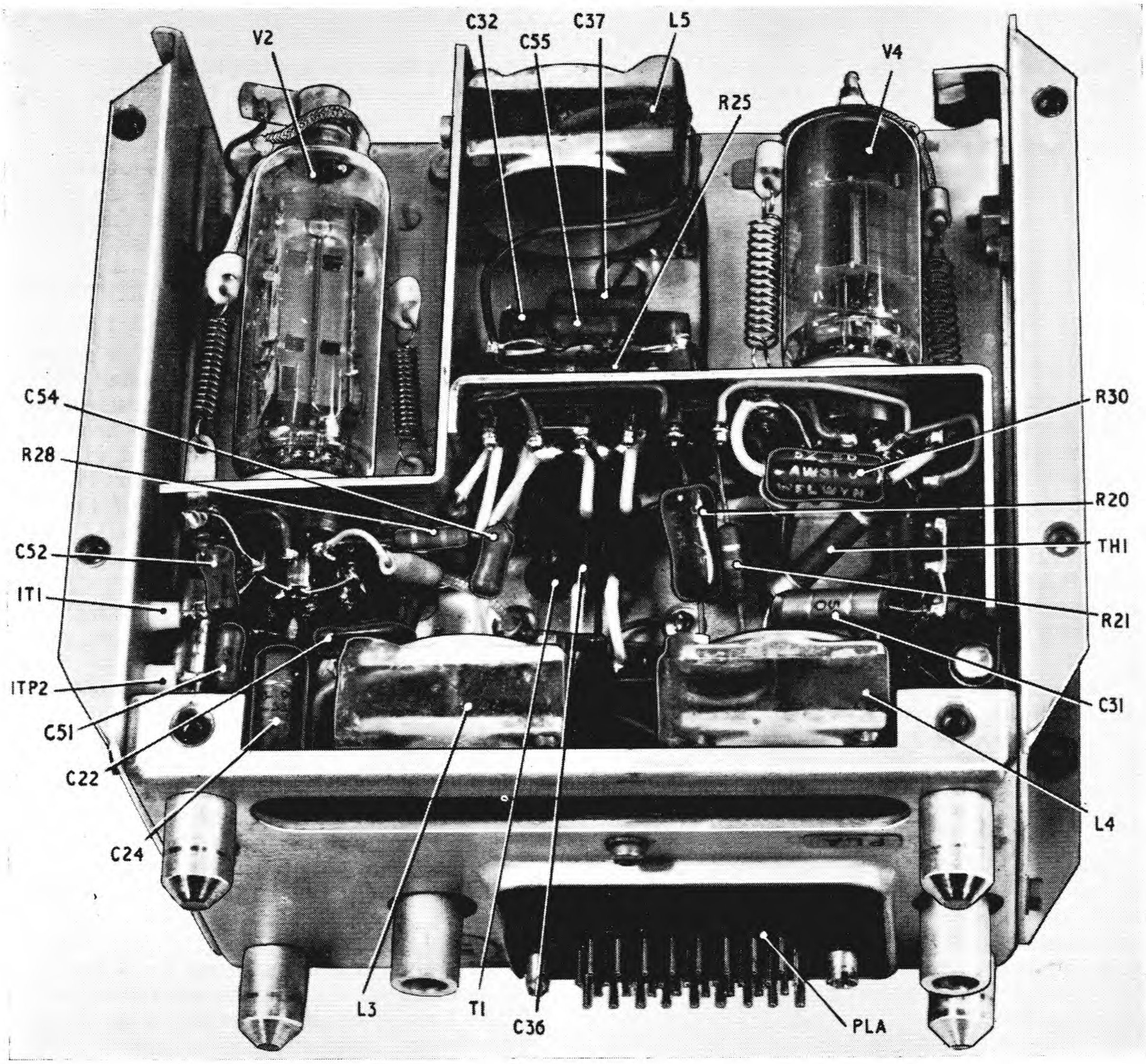

Fig. 3. Oscillator r.f. 5821-99-913-2228, side

one hundred kilocycle steps. The output appears at PLA pin D8, D7.

25. The reactance-control current of the system is metered at pin A7 of PLA by measuring the voltage developed across R6 due to current flow through the bridge switching circuit. The meter indication is provided on the front-panel switch-unit (Chap. 2).

Frequency divider

26. Valve V4 (CV5215) functions as a divide-by-ten frequency-divider, a one megacycle r.f. input is applied to PLA/D1, D2 from a times five frequency-dividing circuit; this 1 Mc/s frequency is indirectly obtained from the 5 Mc/s reference oscillator (Chap. 3). The coupling capacitor C31 couples the r.f. voltage to a network consisting of diode rectifier MR3 and resistor R22. This network in conjunction with cathode resistors R25 and R26 provide a voltage to cut-off the pentode section of valve V4 (CV5215) under reference frequency failure conditions, thus preventing V4 from operating.

27. The d.c. voltage on the grid of valve V4 is stabilized by the action of the Zener diode MR4, this constant voltage on the grid of the pentode section of V4 prevents the divider action from going out of lock with the reference frequency for increased input voltage. The operating potential for this diode is provided by the divider network R14, R23.

28. It is important that the correct ratio of r.f./d.c. voltage is provided at the grid of the pentode section of valve V4 to give a good locking range for the frequency-divider. The r.f. ratio is provided by the capacity-divider C33, C34.

29. The two halves of valve V4 (*fig.* 3) may be considered as a locked oscillator with the tuned circuit C37, C55, L5 (*fig.* 4) resonant to 100 kc/s coupling being taken via capacitor C35. The

L-C circuit mentioned oscillates at 100 kc/s and is held in lock by the triggering action of every tenth cycle of the input frequency. Also the pentode section of V4 isolates the anode tuned circuit from the grid circuit through the buffering action of the pentode.

30. A steady d.c. potential is provided on the screen-grid of the pentode section and the anode of the triode section of V4, by resistors R20, R21, the decoupling to radio frequencies is by capacitor C32.

31. A tuned circuit in the anode of the pentode section of V4, is formed by L4 and C54, C36, this is resonant at 100 kc/s, the inductor L4 is centre tapped, thus at each end of the inductor appears a 100 kc/s voltage with a relative phase-difference of 180° between them.

32. An output is also taken from the anode of V4 through capacitor C21 to a further tuned circuit L3, C53, C22, resonant at 100 kc/s, the coupling capacitor C21 and tuned circuit components being chosen to produce a 90° phase-shift of the 100 kc/s voltage before this is applied to the gating grid, g2, of valve V2 (E80T) through the coupling components C23, R9. Capacitors C51, C52 are test points used for peaking up L4 and L3 for maximum output.

Pulse generation and discrimination

33. The beam deflection tube V2 (*fig.* 3), functions as a discriminator and pulse generator (*para.* 7) with the two 100 kc/s voltages in anti-phase mentioned in para. 31 being applied to the beam deflection plates. The grid V(g3 + g4) of the beam deflection plates is held at a high potential by connection to the +150V supply (*fig.* 4) and decoupled by R8 and C24 to radio frequencies.

34. Short duration 100 kc/s pulses are produced at the anode of V2 where resistor R10 acts as a combined anode load and part of an integrating network in conjunction with the stray capacity from anode to earth. Capacitors C27, C25, with resistor R15 act as an integral compensating network. (Allowing maximum holding range for lock, keeping transients well damped).

35. The frequency produced by the Colpitts oscillator is applied to V2 on the control grid electrode g_1, through the coupling capacitor C26 to intensity-modulate the electron beam. Resistors R28 and R12 function as a form of grid leak to the control-grid focusing-electrode g_1, whilst R12 and capacitor C48, provide bias for the latter electrode.

Control valve circuit

36. A d.c. voltage is produced by integrating the 100 kc/s pulses in integrating network mentioned in para. 34. This d.c. voltage (proportional to the amount of error in the Colpitts oscillator frequency) is fed to the control-grid of one half of valve V3 (CV2492), this section functioning as a control valve to a reactance device.

37. Valve V3 has a common-cathode resistor R16 for both sections of the valve, the d.c. voltage drop across this is so arranged that together with the positive potential supplied by the d.c. connection of V2 to the grid of the control valve V3, a working bias is applied to the control grid of the latter.

38. When a change in the voltage produced by the integrating network occurs, a corresponding change will appear in the current through the control valve V3; this current in turn flows through diodes MR1, MR2, allowing capacitors C16, C17 to be brought into circuit across the Colpitts-oscillator tuned-circuit in proportion to the current flowing through the diodes.

39. By the action of these capacitors C16, C17 (*fig.* 4) the frequency produced by the Colpitts oscillator is corrected over a small range; if however the frequency should drift out of this holding range the circuit described in the following paragraphs functions to once again restore the Colpitts oscillator frequency to phase-lock with a harmonic of the reference frequency.

Wien bridge oscillator

40. The second half of valve V3 functions as a Wien-bridge oscillator, the frequency of oscillation is determined by the components R18, C28, C29, R19, at approximately 3 c/s.

41. Working bias for the oscillator is provided by the potential-divider network R11, RV1, R13 in conjunction with the voltage developed across R16.

42. When the Wien bridge oscillator begins to function a sweep voltage at approximate 3 c/s is applied to the diode-switching circuit consisting of MR1, MR2, L1 and L2; this allows the frequency of the Colpitts oscillator to be swept through the range ± 25 kc/s approx.

43. At some point in this frequency excursion the Colpitts oscillator frequency will become an integral-multiple of the reference frequency in the beam deflection tube circuit. When this occurs, a d.c. voltage is fed to the grid of the control valve V3. The loop gain of the reactance circuit then becomes higher than the loop gain of the Wien bridge circuit and the latter ceases to oscillate. The output frequency of the Colpitts oscillator is again under the control of the reactance circuit.

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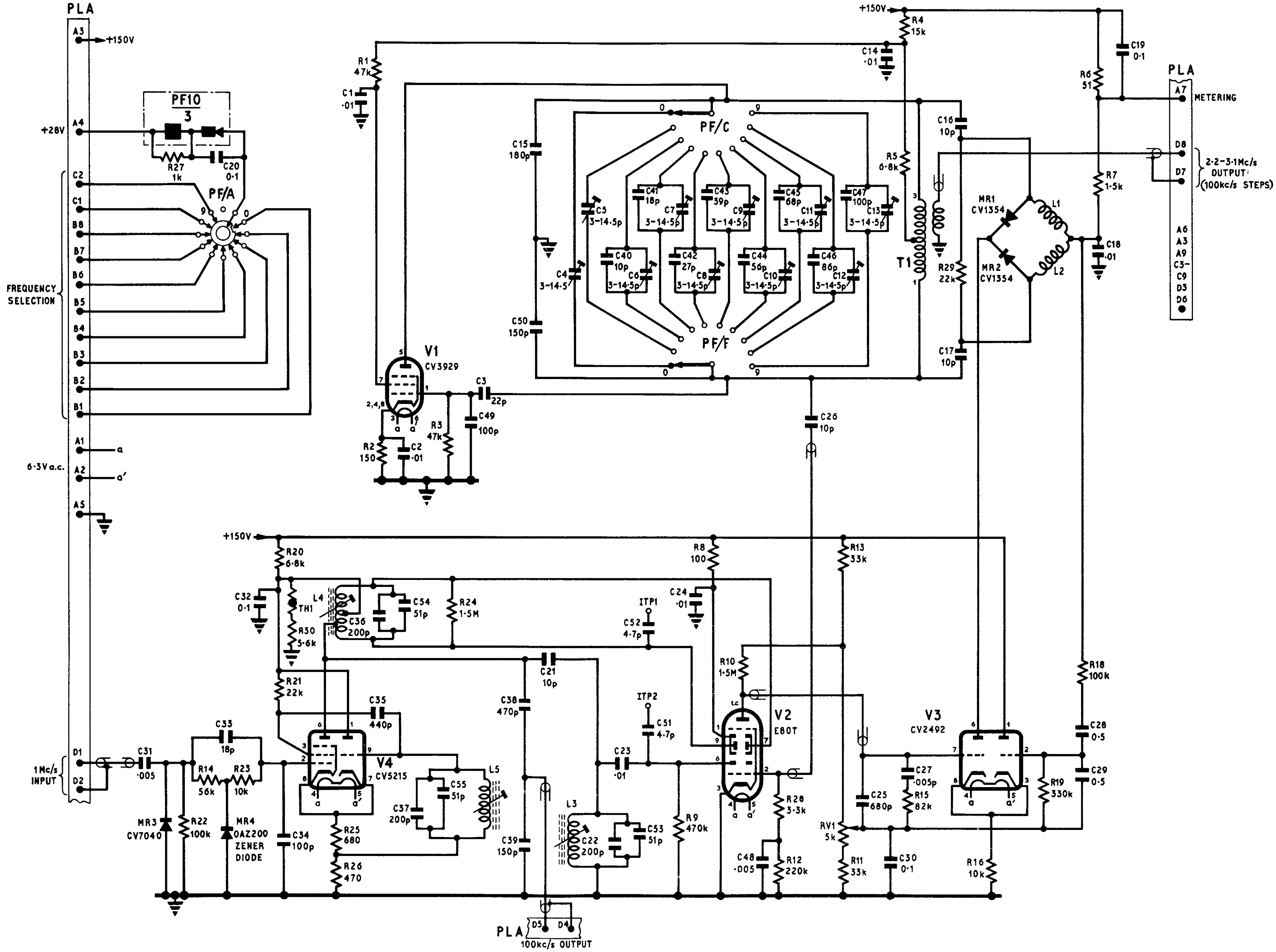

Oscillator radio frequency 5821-99-913-2228: circuit

Fig. 4

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Chapter 6

OSCILLATOR RADIO FREQUENCY (10 KC/S, I.G.O.)

5821-99-913-2229

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Oscillator radio frequency 5821-99-913-2229 is an impulse-governed oscillator, i.e. an oscillator whose frequency is controlled by a technique of synchronization with an appropriate harmonic of a reference frequency. The oscillator is similar to that described in Chapter 5.

2. The oscillator produces ten harmonic-frequencies between 290 kc/s and 380 kc/s in 10 kc/s steps, whilst the synchronizing voltage is controlled by a servo-loop system, which is in turn operated by a 10 kc/s voltage obtained from the 1 Mc/s frequency standard (Chap. 4) through frequency dividers.

3. In this way the oscillator r.f. 5821-99-913-2229 is phase-locked to the 5 Mc/s frequency-standard oscillator (Chap. 3) and therefore has the same order of stability as the latter.

Construction

4. The oscillator r.f. 5821-99-913-2229 (*fig.* 1) is constructed in a self-contained sub-unit. Screening is provided by metal plates which are attached to the top and sides of the sub-unit by screws.

5. Miniaturized technique is used, the smaller components being attached to tag strips or suspended in the wiring.

6. The sub-unit is divided into a number of sections by metal screens, the latter are not removable since they are rivetted to the sub-unit chassis.

OPERATION

Beam-deflection tube

7. Beam-deflection tube E80T performs two functions, namely, discrimination and pulse generation. The tube is described in some detail in Chap. 4 of Sect. 2, to this publication. The electron-gun is similar to that of a cathode-ray tube, but the function is quite different since discrimination and pulse generation takes place within the tube.

Circuit summary

8. The 10 kc/s impulse governed oscillator (i.g.o.) consists basically of a series fed Colpitts oscillator, and a frequency-controlling device.

9. By using a number of preset capacitors selected by a ten-position switch, the Colpitts oscillator frequency can be set up to produce ten spot frequencies in multiples of 10 kc/s between 290 kc/s and 380 kc/s inclusive. The frequency range is covered by switching the various values of capacitance across the tank circuit. These spot frequencies can be phase-locked to the frequency controlling device forming the second section of the i.g.o.

10. A 10 kc/s c.w. voltage is fed as the reference to the frequency controlling loop from a times-ten frequency divider (*fig.* 2) the latter in turn obtaining its input from the 100 kc/s reference voltage, obtained indirectly from the reference (5 Mc/s) oscillator.

11. From the output of the locked-oscillator

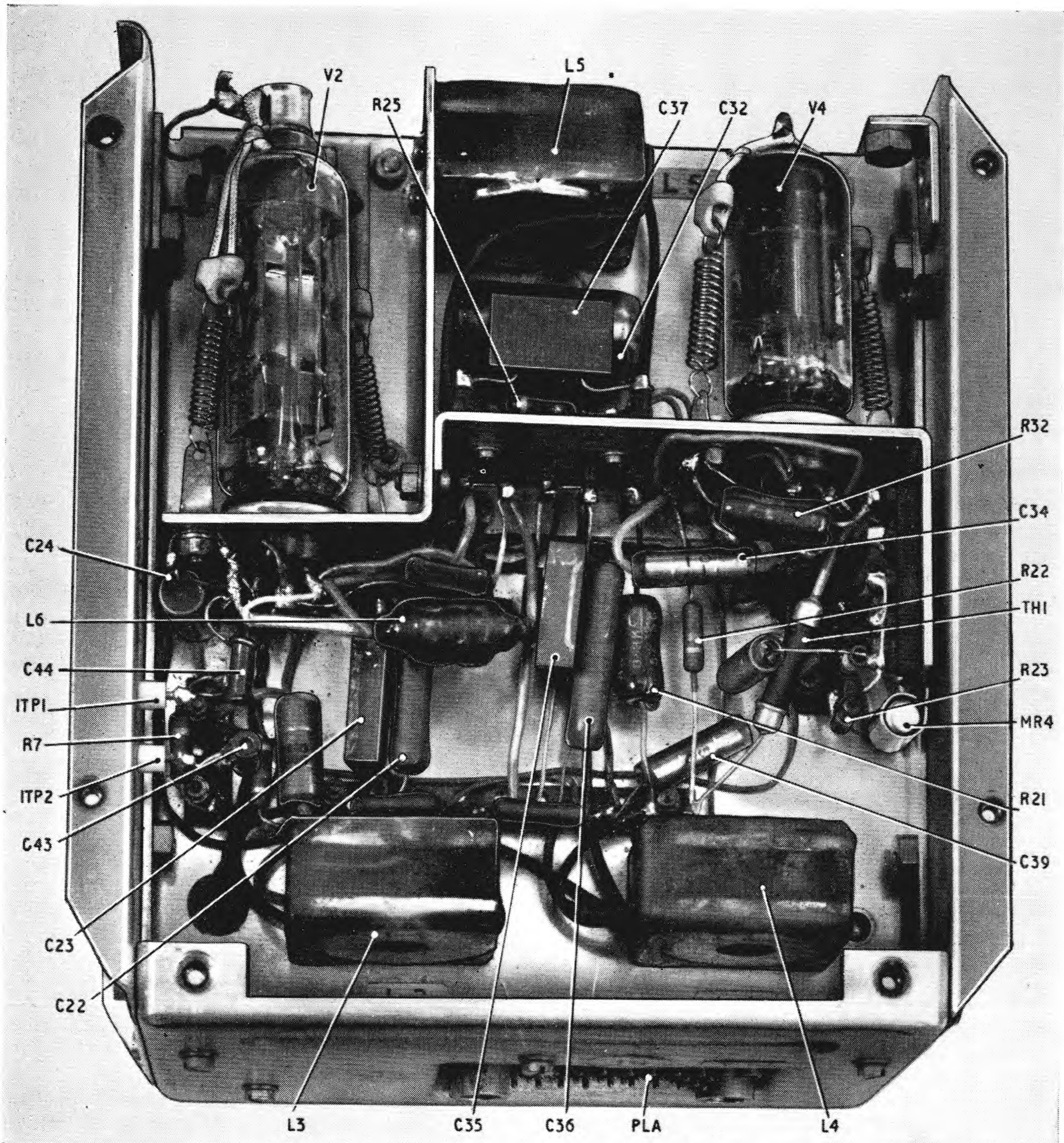

Fig. 1. Oscillator r.f. 5821-99-913-2229, front

frequency-divider (*fig*. 2) the 10 kc/s voltage is split into three parts with different phase relationships and applied to a special valve (E80T) known as a beamdeflection tube (Sect. 2, Chap. 4). This beamdeflection tube produces an output voltage consisting of sharp pulses at a pulse repetition frequency (p.r.f.) of 10 kc/s.

12. The Colpitts oscillator is phase-locked to the 10 kc/s reference voltage by feeding some of the output of the Colpitts c.w. oscillator, at the required spot frequency between 290 kc/s and 380 kc/s, to the control grid g_1 of the beam-deflection tube. Any change in the relative phase of the Colpitts oscillator and reference signal, will amplitude-modulate the pulses, the latter after integration are fed as a d.c. control voltage to the reactance device in such a way as to oppose the original phase-change and thus keep the system in lock.

13. If, however, the frequency generated by the Colpitts oscillator drifts from phase-lock with the reference signal, the loop gain round the deflection-tube resistance-control circuit falls and the system un-locks.

14. From the output of the beam-deflection tube, the pulses at a p.r.f. of 10 kc/s are fed to an integrating network to produce a d.c. voltage

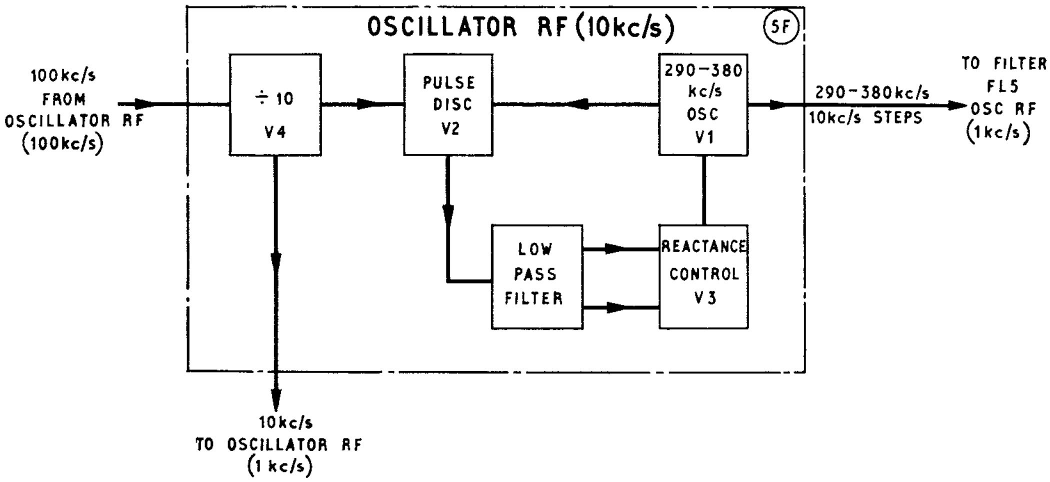

Fig. 2. Oscillator r.f. 5821-99-913-2229; block diagram

proportional to the amplitude of the pulses.

15. The d.c. voltage produced as described in para. 12 controls a reactance device that allows a small capacitance to be introduced in parallel with the Colpitts oscillator tank circuit by switching diodes, thus effectively correcting the frequency produced by the oscillator.

16. When the Colpitts oscillator frequency drifts away from phase-lock with a harmonic of the reference frequency (10 kc/s) the loop gain round the deflection-tube reactance device falls since the control valve forms part of two loops. At this point the Wien bridge (v.l.f.) oscillator begins to oscillate at 3 c/s approximately.

17. The v.l.f. oscillator then switches the diodes at this frequency to include more capacitance and provide a sweep of the Colpitts oscillator frequency of the order ± 2 kc/s.

18. This sweep occurs until the frequency of the Colpitts oscillator becomes the required integral-multiple of the reference signal.

19. At this point the main-control loop locks the Colpitts oscillator to a harmonic of the reference 10 kc/s signal, the higher gain damping the v.l.f. oscillation.

DETAILED CIRCUIT DESCRIPTION

Colpitts r.f. oscillator (290 kc/s to 380 kc/s)

20. The r.f. oscillator consists of a series fed Colpitts oscillator circuit (*fig.* 4) using valve V1 (CV3929). The tuned circuit consists of transformer T1 and a number of fixed tuning capacitors which can be connected in parallel with this inductor by the switch wafers PF/3 and PF/2. Fine adjustment of the tuned circuit is provided by trimmers C4-C12 (*fig.* 3).

21. The primary of transformer T1 (*fig.* 4) is centre-tapped and connected to the + 150V h.t. supply through resistors R4, R5, the former resistor acting as a decoupling component to r.f., in conjunction with capacitor C14. The centre tap is left floating from a r.f. viewpoint.

22. Feedback is provided from anode to grid of the oscillator valve V1 (*fig.* 3) via capacitors C14, C55 (*fig.* 4). Capacitor C13 acts as a grid-blocking component. The grid leak for the oscillator is resistor R3, whilst capacitor C54 functions to reduce the r.f. voltage on the grid of V1, in this way preventing overdrive.

23. Cathode bias is provided for valve V1 by components R2 with C2, the valve thus functions as a Class A oscillator having a good output waveform.

24. The secondary of transformer T1 consists of a coupling winding, this provides output frequencies in the range 290 kc/s to 380 kc/s in ten 10 kc/s steps. The output appears at PLA pin D7, D8.

25. The reactance-control current of the system is metered at pin A7 of PLA by measuring the voltage developed across R6 due to current flow through the bridge switching circuit. The meter indication is provided on the front-panel switch unit (Chap. 2).

Frequency-divider

26. Valve V4 (CV5215) functions as a divide-by-ten frequency-divider, a 100 kc/s r.f. input is applied to PLA/D1, D2, from the i.g.o. 2 (Chap. 5). This 100 kc/s frequency is indirectly obtained from the 5 Mc/s reference oscillator (Chap. 3). The coupling capacitor C31 couples the r.f. voltage to a network consisting of diode rectifier MR3 and resistor R20. This network in conjunction with cathode resistors R25 and R26 provide a voltage to cut-off the pentode section

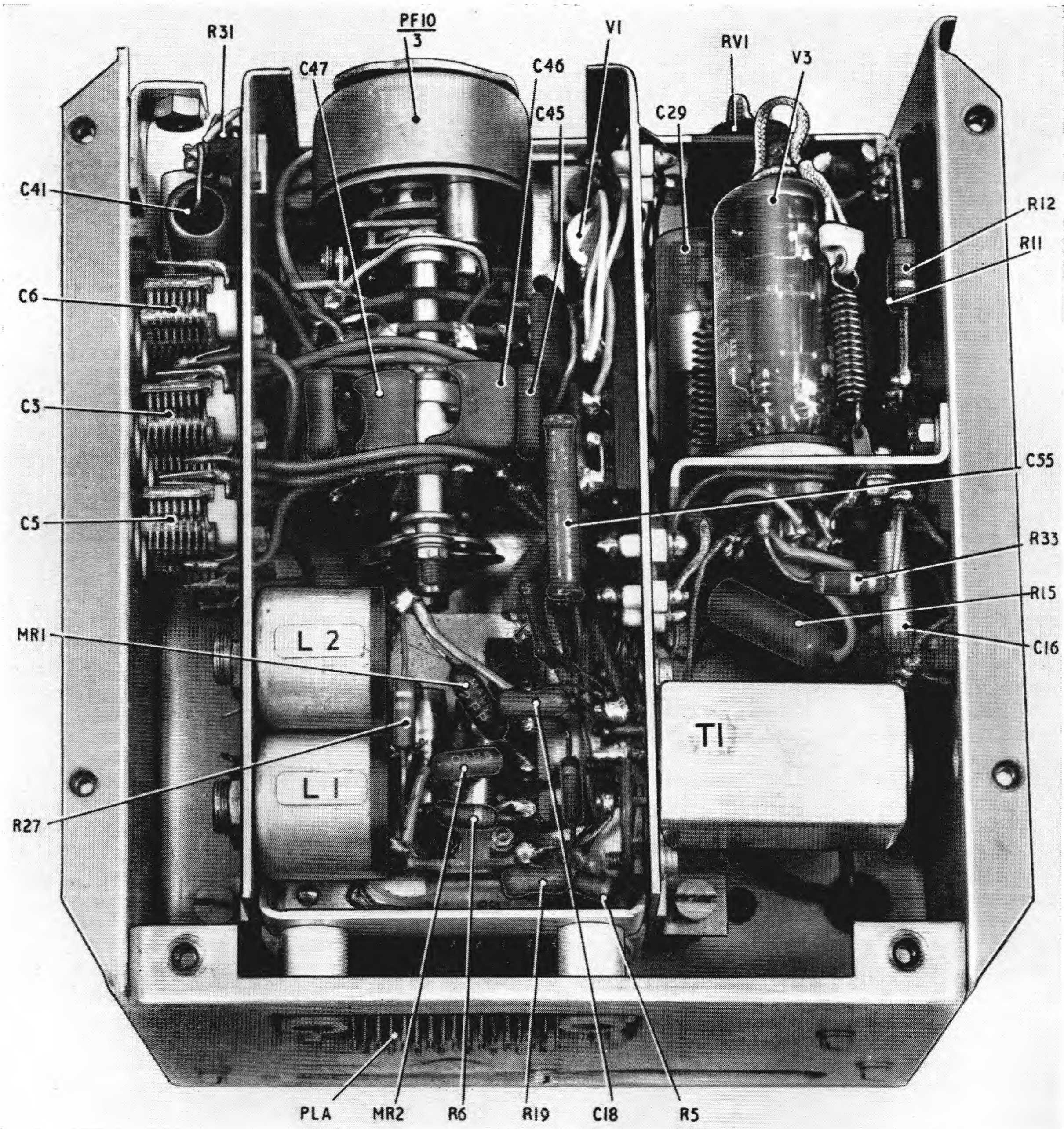

Fig. 3. Oscillator r.f. 5821-99-913-2229; rear

of valve V4 (CV5215) under reference frequency failure conditions, thus preventing V4 from operating.

27. The d.c. voltage on the grid of valve V4 is stabilized by the action of the Zener diode MR4, this constant voltage on the grid of the pentode section of V4 prevents the divider action from going out of lock with the reference frequency for increased input voltage. The operating potential for this diode is provided by the divider network R19, R23.

28. It is important that the correct ratio of r.f./d.c. voltage is provided at the grid of the pentode section of valve V4 to give a good locking range for the frequency-divider. The r.f. ratio is provided by the capacity-divider C33, C56.

29. The two halves of valve V4 may be considered as a locked-oscillator with the tuned circuit C37, C38, L5 resonant to 10 kc/s, coupling being taken via capacitor C34. The L-C circuit mentioned oscillates at 10 kc/s and is held in lock by the triggering action of every tenth cycle of the input frequency. Also the pentode section of V4 isolates the anode tuned circuit from the grid circuit through the buffering action of the pentode.

30. A steady d.c. potential is provided on the screen-grid of the pentode section and the anode of the triode section of V4, by resistors R21, R22, the decoupling to radio frequencies is by capacitor C32.

31. A tuned circuit in the anode of the pentode section of V4, is formed by L4 and C35, C36, this is resonant at 10 kc/s, the inductor L4 is centre-tapped, thus at each end of the inductor appears a 10 kc/s voltage with a relative phase-difference of 180° between them.

32. An output is also taken from the anode of V4 through capacitor C21 to a further tuned circuit L3, C22, C23, resonant at 10 kc/s, the coupling capacitor C21 and tuned circuit components being chosen to produce a 90° phase-shift of the 10 kc/s voltage before this is applied to the gating grid g_2 of valve V2 (E80T) through the coupling components C23, R8. Capacitors C43, C44 are test points for peaking up L4 and L3 for maximum output during alignment.

Pulse generation and discrimination

33. The beam-deflection tube V2, functions as a discriminator and pulse generator (para. 7) with the two 10 kc/s voltages in antiphase mentioned in para. 31 being applied to the beam deflection plates. The grid V ($g_3 + g_4$) of the beam deflection plates is held at a high potential by connection to the +150V supply, and decoupled by R7 and C24 to radio frequencies.

34. Short duration 10 kc/s pulses are produced at the anode of V2 where resistor R9 acts as a combined anode load and part of an integrating network in conjunction with the stray capacity from anode to earth. Capacitors C27, C16, with resistor R14 act as an integral compensating network. (Allowing maximum holding range for lock, keeping transients well damped).

35. The frequency produced by the Colpitts oscillator is applied to V2 on the control-grid electrode g_1, through the coupling capacitor C26 to intensity-modulate the electron beam. Resistors R10 and R13 function as a form of grid leak to the control-grid focusing-electrode g_2, whilst R10 and capacitor C17, provide bias for the latter electrode.

Control valve circuit

36. A d.c. voltage is produced by integrating the 10 kc/s pulses in integrating network mentioned in para. 34. This d.c. voltage (proportional to the amount of error in the Colpitts oscillator frequency) is fed to the control-grid of one half of valve V3 (CV2492), this section functioning as a control valve to a reactance device.

37. Valve V3 has a common-cathode resistor R15 for both sections of the valve, the d.c. voltage drop across this is so arranged that together with the positive potential supplied by the d.c. connection of V2 to the grid of the control valve V3 a working bias is applied to the control grid of the latter.

38. When a change in the voltage produced by the integrating network occurs, a corresponding change will appear in the current through the control valve V3; this current in turn flows through diodes MR1, MR2, allowing capacitors C18, C19 to be brought into circuit across the Colpitts oscillator tuned circuit in proportion to the current flowing through the diodes.

39. By the action of these capacitors C18, C19, the frequency produced by the Colpitts oscillator is corrected over a small range; if, however, the frequency should drift out of this holding range the circuit described in the following paragraphs functions to once again restore the Colpitts oscillator frequency to phase-lock with a harmonic of the reference frequency.

Wien bridge oscillator

40. The second half of valve V3 functions as a Wien-bridge oscillator, the frequency of oscillation is determined by the components R17, C29, C30, R18, at approximately 3 c/s.

41. Working bias for the oscillator is provided by the potential-divider network R11, RV1, R12 in conjunction with the voltage developed across R15.

42. When the Wien bridge oscillator begins to function a sweep voltage at approximately 3c/s is applied to the diode-switching circuit consisting of MR1, MR2, L1 and L2; this allows the frequency of the Colpitts oscillator to be swept through the range ± 2 kc/s approximately.

43. At some point in this frequency excursion the Colpitts oscillator frequency will become an integral-multiple of the reference frequency in the beam-deflection tube circuit. When this occurs, a d.c. voltage is fed to the grid of the control valve V3. The loop gain of the reactance circuit then becomes higher than the loop gain of the Wien bridge circuit and the latter ceases to oscillate. The output frequency of the Colpitts oscillator is again under the control of the reactance circuit.

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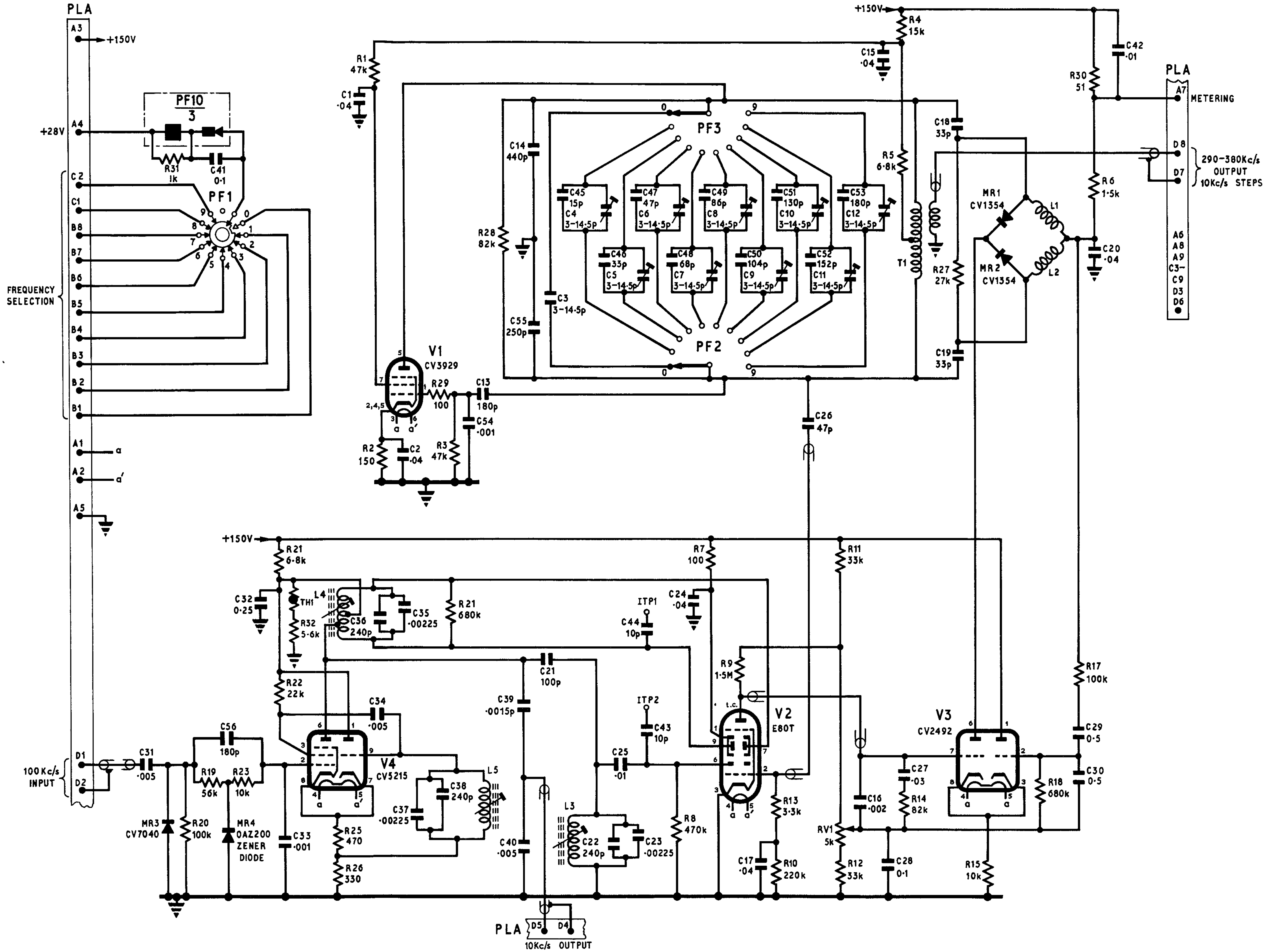

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Oscillator radio frequency 5821-99-913-2229: circuit

Fig. 4

Chapter 7

OSCILLATOR, RADIO FREQUENCY (1kc/s WADLEY) 5821-99-913-2231

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Oscillator radio frequency 5821-99-913-2231 is an oscillator producing the reference signal in the frequency range 2·301 Mc/s to 2·400 Mc/s in 1 kc/s steps.

2. An impulse governed oscillator as previously described in Chap. 4, 5, 6 has not been used because of its susceptibility to microphony; the band-pass filter used having a narrow frequency response increases this tendency. This is especially

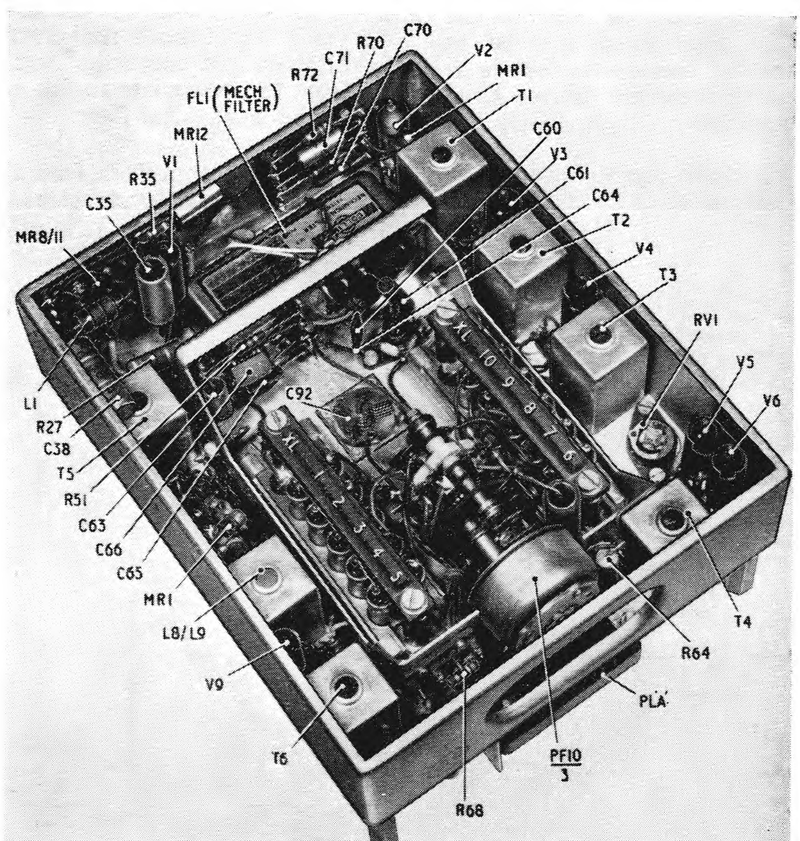

Fig. 1. Oscillator r.f. 5821-99-913-2231, top

important in an airborne equipment where the valve electrodes are subjected to vibration.

3. The effect of vibration is to noise-modulate the output; the circuit being unable to correct quickly enough and in the extreme case to unlock the control loop. For this reason the sidestep technique (Part 4, Sect. 2, Chap. 1) is used to produce the required frequency spectrum mentioned in para. 1.

Construction

4. The oscillator (*fig.* 1) is constructed on a self-contained, plug-in sub-unit. Screening is provided by the sides of the chassis and a metal base cover, the latter is attached to the chassis by screws.

5. Miniaturized technique is used throughout, the smaller components being attached to tag strips or suspended in the wiring. The larger components however are bolted directly to the chassis.

Circuit summary

6. The sidestep technique uses a group of ten auxiliary crystals to select the appropriate harmonics of a 1 kc/s spectrum. The frequency stability of these crystals is only required to be adequate to make the selection (performed by a mechanical filter) of the appropriate harmonic unambiguous. The crystal frequency does not appear in the final output of the generator, reference signal.

7. A block diagram of the sidestep oscillator is shown in fig. 2, from this it can be seen that the first mixer V1 has an input signal applied at 2·0 Mc/s and a series of rectangular pulses at 1 kc/s intervals, both of these are derived from the 5 Mc/s crystal-standard oscillator (Chap. 3).

8. In the mixer V1 these signals produce a spectrum of frequencies spaced at 1 kc/s intervals, the particular frequencies required being 2·011 Mc/s to 2·020 Mc/s.

9. To select the signal corresponding to the desired final digit in the generator reference signal output, from the frequency band 2·011 Mc/s to 2·020 Mc/s, the mixer V1 has a third input from the auxiliary crystal oscillator (mentioned in para. 6) applied to it at a frequency chosen to produce 455 kc/s when mixed with the appropriate signal in the range 2·011 Mc/s to 2·020 Mc/s (e.g. 2·016 Mc/s would require 2·471 Mc/s).

10. The particular frequency chosen will be accepted by the mechanical filter (para. 32) which has a bandwidth limited to $\pm$ 0·2 kc/s of the nominal frequency. Thus although the crystal frequency will mix with all the pulses in the 1 kc/s spectrum, giving outputs every kilocycle from 475 kc/s down to zero frequency, only the 455 kc/s signal component will be passed by the filter.

11. After passing through the mechanical filter, the required signal is amplified and mixed in a second mixer stage V2, with the original crystal-oscillator frequency to produce the output frequency in the range 2·011 Mc/s to 2·020 Mc/s.

12. The crystal-oscillator frequency having been introduced into and subsequently extracted from the mixing process, does not affect the accuracy of the resulting frequency. From the foregoing it is unnecessary to fit ovens to either the crystals or mechanical filter in the sidestep oscillator, since the drift of both the crystals and mechanical filter do not cause the nominal 455 kc/s signal from the first mixer to fall outside the pass-band of the mechanical filter.

13. The output signal from the sidestep oscillator, in ten, one-kilocycle steps is mixed with the

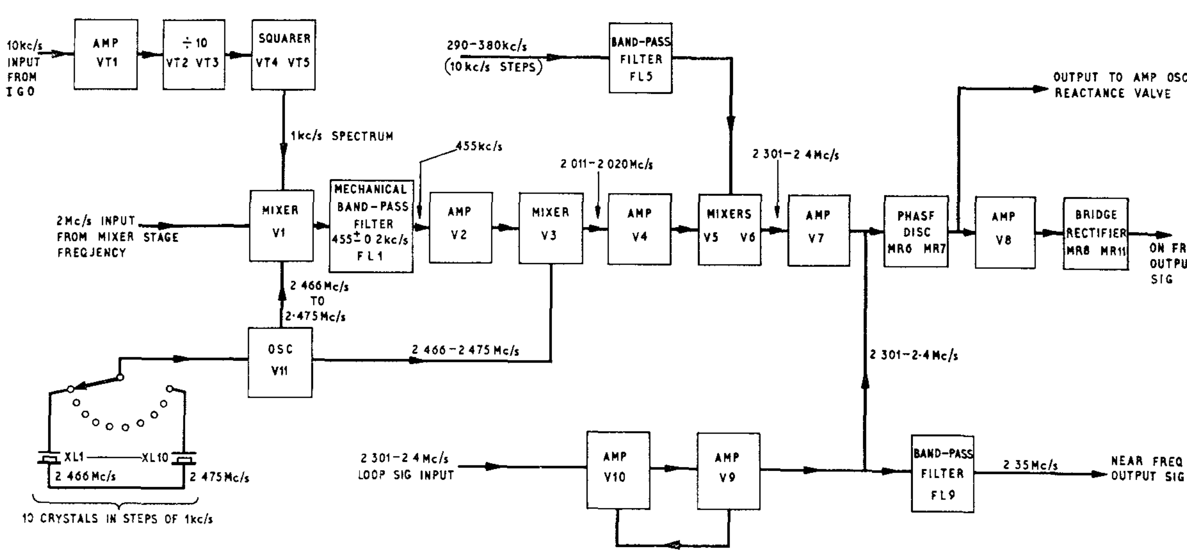

Fig. 2. Oscillator r.f. 5821-99-913-2231, block diagram

signal from the 10 kc/s i.g.o. at mixer V5, V6 (*fig.* 2) to produce the signal applied to the phase discriminator of the main loop, where it is compared with the main loop signal.

14. There are two outputs from the oscillator r.f. 5821-99-913-2231 these are used for:—

(1) Controlling the motor in the amplifier-oscillator.

(2) The control potential to the control grid of the reactance valve used in the amplifier-oscillator.

15. Motor-control voltages are supplied in three forms:—

(1) By rectification of a signal supplied by the amplifier stages and bandpass filters.

(2) By rectification of amplified beat-frequency produced by the difference between the voltage used in (1) and the reference voltage.

Note . . .

When the two voltages in (2) *are at the same frequency there will be no output voltage produced.*

(3) By the control potential to the reactance-valve control grid, when the reference and input frequencies are equal this is a function of the phase difference between the two frequencies.

DETAILED CIRCUIT DESCRIPTION

Transistorized divider circuit

16. The function of transistor VT1 (*fig.* 5) is to produce square waves from the 10 kc/s sinusoidal input. This input signal is sufficiently large to switch VT1 hard on thus producing square waves at the collector across the load resistor R42.

17. Consider a train of pulses at the junction of

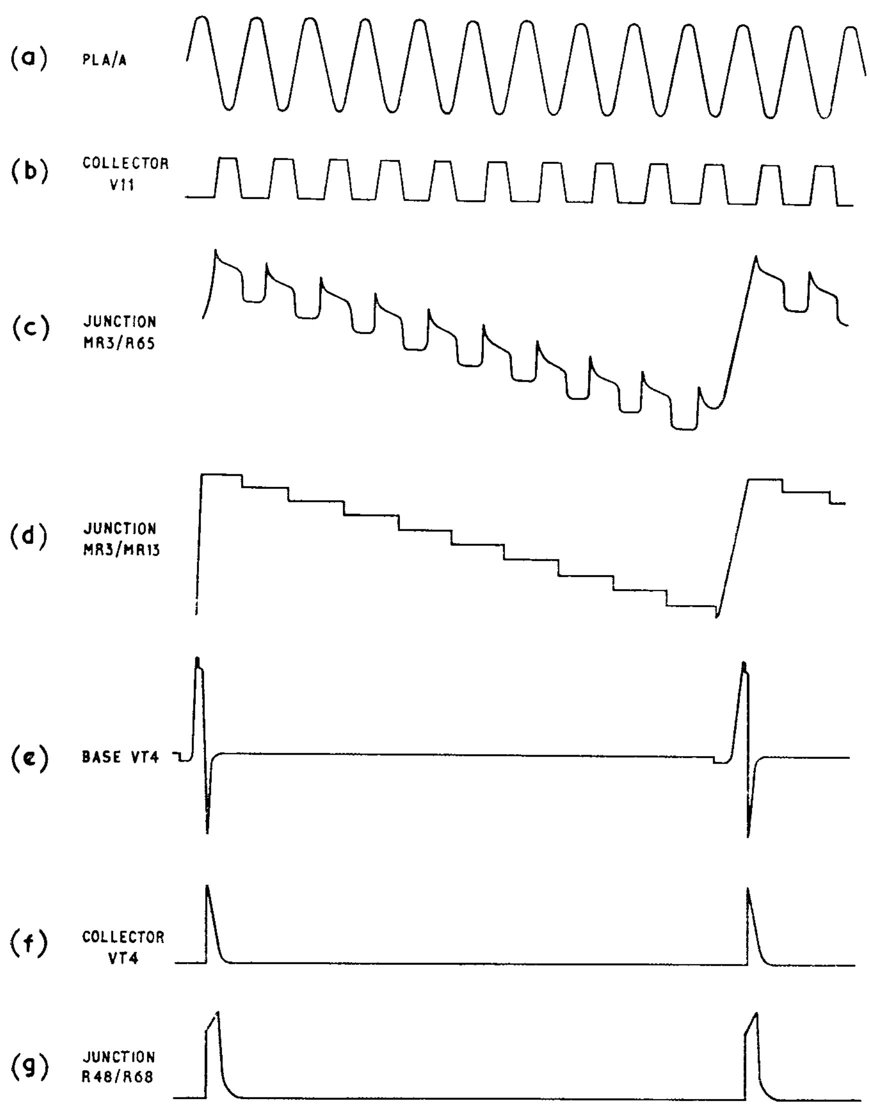

Fig. 3. Frequency-divider waveforms

capacitor C1 and resistor R42 (*fig.* 3). On arrival of the first negative going edge a charging current will flow into the capacitor network C1, C55 and C57. The distribution of charge in the network, assuming the diode MR3 perfect, will be such that capacitor C57 will acquire a potential which will be a fraction of the input pulse potential.

18. On arrival of the positive edge of the pulse, the switching action of diode MR3 (CV7053) leaves C57 charged, whereas C1 and C55 must attempt to follow the input waveform. There is thus a large difference of potential across MR3.

19. The emitter-follower transistor VT2 will therefore have a large input signal applied to it which will cause a current to flow through V2. This current will be charging current flowing into C1 and C55 which will tend to prevent the potential at the junction or resistor R65 and diode MR3 from changing.

20. When the potential across diode MR3 falls to zero, there will be no input signal to transistor VT2, no charging current will flow and the circuit will remain stable until the arrival of the next pulse.

21. On arrival of the second negative going edge diode MR3 will again allow a charging current very nearly equal to that of the first pulse to flow into the capacitor network. This will give rise to the second step of the stair case (*fig.* 3) which will be almost equal in amplitude to the first step.

22. This cycle of operation will continue until the charge in capacitor C57 has a potential equal to the potential at the junction of resistors R43, RV3. In the times-ten divider the first ten pulses only are required and can be considered to be of equal amplitude, hence the term " linear staircase generator ".

23. It can be seen from the circuit diagram (*fig.* 5) that the base of transistor VT5 is returned to a relatively higher potential point in the potential chain compared with the base of transistor VT4. This ensures that under no signal input conditions transistor VT5 will be conducting while VT4 will be non-conducting. It is arranged that the tenth "stair step" will cause the potential at capacitor C57 to charge to a level such that diode MR13 will conduct. The current due to this conduction is sufficient to start the switch over action between VT4 and VT5 the latter transistors forming the Schmitt trigger. The circuit time constant associated with C59 is of sufficient length to ensure the complete discharge of C57. At the same time VT3 is switched on sufficiently hard to completely discharge C57 before the first pulse of the next series arrives.

24. The discharge of capacitor C67 commences when transistor VT5 is switched off. The negative going excursion of the VT5 collector potential is supplied via C58 to the base of transistor VT3. The magnitude of this current is limited by resistor R74 to prevent damage to VT3 either by switching current or the discharge current of C57.

25. The supply voltage to the collector of transistor VT1 is taken from the potential divider chain R43, RV3, R28, R69 so that, after initial setting up, the change in pulse amplitude due to variations in supply will be such that it will require the same number of pulses to turn over the trigger. This is because the reference voltage for the trigger is taken from the same potential divider.

Crystal oscillator

26. The crystal oscillator circuit is of the Colpitts type using valve V11 (CV2432), the crystals XL1—XL10 (*fig.* 1) are selected by the ten position switch PF2, the wafer PF3 short circuits the crystals not in use. Feedback for radio frequencies is provided in the usual way by the capacitor divider C65, C66, the d.c. path to earth being completed by choke L4.

27. A small trimmer capacitor C92 is provided across the crystals to allow incremental adjustment to within $\pm$ 50 c/s of the nominal frequency.

28. The anode load for the oscillator valve V11 is formed by L3 and capacitors C60, C61, this circuit is effectively in parallel with components R50, C64 through the coupling capacitance C62.

29. Capacitors C60, C61 form a capacitive-divider circuit and part of the total available r.f. voltage produced by the oscillator is fed from the junction of these two capacitors to the first mixer valve V1 (CV3928). A further portion of the crystal oscillator voltage is fed to the second mixer valve V3 (CV3928) from a tap on the inductor L3.

Mixer circuits

30. There are three mixer circuits used in the side-step oscillator to provide the necessary changes in frequency to give the required output.

First mixer

31. The first mixer stage valve V1 (CV3928) produced a 455 kc/s signal accurate to five parts in 10^5 irrespective of the crystal frequency input from V11 (para. 29). Considering first of all the 2 Mc/s signal from PLA pin 6 modulated by the 1 kc/s pulses applied to the screen grid of the valve V1 (CV3928). Depending upon the shape of the pulse, there will be a symmetrical-sideband spectrum about 2 Mc/s. If now a third signal (from the crystal oscillator) is introduced, a further modulation will take place and it has been so arranged that the crystals used will beat with the signal in the spectrum 2011 to 2020 kc/s to produce a 455 kc/s signal.

32. Only a 455 kc/s signal is accepted by the mechanical filter FL1 (*fig.* 5) all other signals present in the anode circuit of the mixer stage V1 are rejected to a level of at least 55 db down on the wanted nominal 455 kc/s signal.

33. The mechanical filter FL1 is followed by an amplifier valve V2 (CV3929) and bandpass filter T1, the latter being necessary to ensure that no spurii produced in the mechanical filter reach the second mixer valve V3 (CV3928). Fixed capacitors C6, C8 in conjunction with trimmers C5, C9 allow compensation adjustment for stray capacitance together with anode-to-earth and grid-to-earth capacitance variations of the valve V1 and V2.

Second mixer

34. The second mixer stage V3 produces a signal in the range 2011-2020 kc/s at selected intervals of 1 kc/s steps with a stability of one part in 10^7. This is achieved by mixing the selected crystal frequency obtained from V11 with the 455 kc/s produced in the first mixer. Both of these signals will be accurate to five parts in 10^5, but as the selected output frequency is the difference frequency between these two input signals, the errors will be self-cancelling.

35. The bandpass filter T2 is followed by an amplifier V4 and bandpass filter T3. A secondary winding on T3 is centre tapped and provides 180° out-of-phase voltages to the supressor grids of the two valves used in the balanced mixer V5, V6, (CV3928). The r.f. voltages at this point are in the frequency range 2·011 to 2·020 Mc/s.

Balanced mixer

36. The third mixer stage is of the balanced type and produces a signal in the range 2301 to 2400 kc/s at selected intervals of 1 kc/s steps with a stability of one part in 10^7. This is achieved by mixing the signal produced in para. 34 with a signal in the range 290 to 380 kc/s in 10 kc/s steps which is derived from the same standard as the 2 Mc/s and the 1 kc/s signals.

37. This loop signal is fed in at PLA/D8 through two tuned circuits C30, L8 and L7, C29, these are necessary to provide the comparatively wide bandwidth. Transformer T7 (*fig.* 4) is an unbalance-to-balance component and supplies two out-of-phase signals to the control grids of the balanced mixer valves V5, V6 (*fig.* 4). Balance adjustment is provided by RV1 in the potentiometer chain R15, RV1, R16, between the cathodes of V5, V6.

38. A balanced mixer is used for this stage to cancel the 2 Mc/s carrier which, with such a wide band filter following would not have been sufficiently attenuated. The sum frequency of the two input signals previously mentioned is selected by the bandpass filter T4, this is followed by the

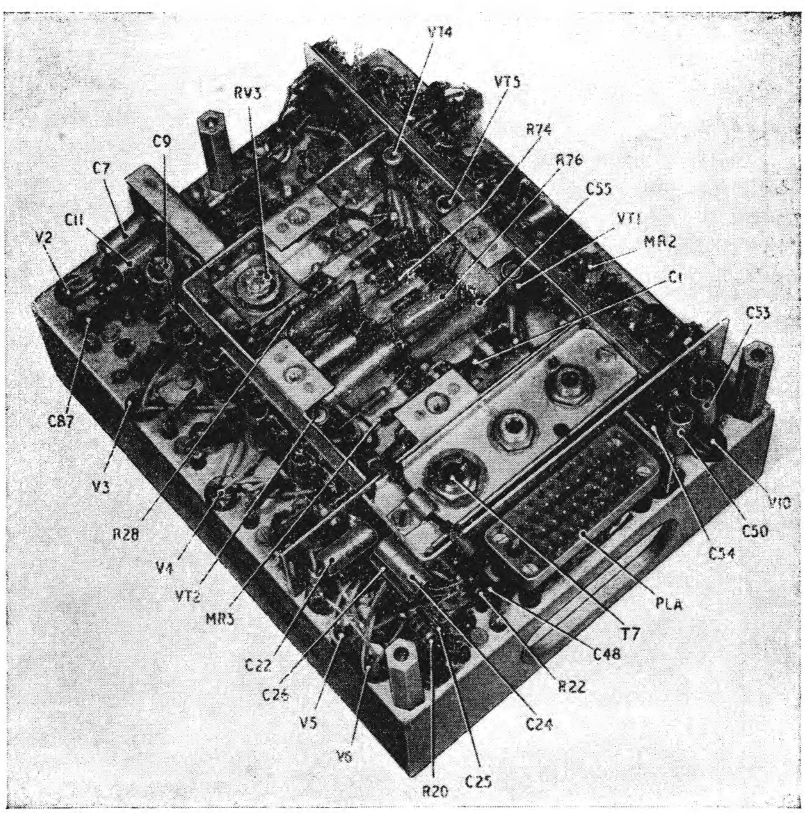

Fig. 4. Oscillator r.f. 5821-99-913-2231, underside

amplifier valve V7 and the bandpass filter T5. Valve V7 is biased in the normal way by resistor R25 and capacitor C34.

Loop signal amplifiers

39. Amplifiers V9 and V10 (*fig.* 5) are two pentode valves CV4029 and CV477. The loop signal input appears at PLA/A2 and is coupled to V10 via capacitor C54.

40. The loop signal is amplified by valve V10 and is coupled to the second amplifier stage V9 by the band-pass filter T6. After further amplification in the valve the loop signal is coupled from the tuned circuit C72, L8 through capacitor C69 and L9 to the diode rectifier MR2 (CV7053).

41. Diode MR2 functions to produce a positive d.c. output voltage after passing through the r.f. filter formed by L2 with C42, C36. This positive voltage is arranged to place a reverse pulse on the switching transistors of the motor control circuit in the amplifier oscillator sub-unit (Chap. 9).

42. A part of the output-loop signal is coupled via capacitor C45 to a delayed a.g.c. circuit formed by the components R32 MR5, C39 and R31. The delay voltage is provided for the diode by the potential-divider R30, R31.

43. Delayed a.g.c. has been incorporated in the loop-signal amplifier to commence operating when the input level at PLA/A2 exceeds 150mV. The d.c. voltage is fed back to the control grid of V10 via R59 and R40, decoupling being provided by capacitor C33.

Phase discriminator

44. The phase-discriminator stage is of the switching diode type. The reference signal supplied by transformer T5 will cause the two diodes MR6, MR7 to conduct once per cycle. The period of conduction will mainly depend on the time constants of the R-C networks C79, R54 and C80, R55. The loop signal input is effectively applied in parallel to the two diodes across the 1KΩ resistor R57. This will mean that the whole of the phase-discriminator current flow will be relative to this input.

45. When the system is in lock, the output control voltage from the wiper of RV2 to PLA/D1 will be the mean of the instantaneous voltage of the loop signal during the condition period of the diodes. When there is a loop signal present but it is not phase locked to the reference signal, a beat frequency will be produced across resistors R54 and R55. This beat frequency is then a.c. coupled via capacitor C81 to the amplifier stage V8 (CV3929) after passing through the filter R80, R81 and C82. The beat frequency is amplified by the valve V8 and coupled through transformer T8 to the bridge-rectifier network MR8, 9, 10, 11.

46. From the foregoing it is seen that there will be no measurable output from this bridge network when the loop signal is identical to the reference signal or when there is no loop signal present. The output voltage is prevented from rising beyond a predetermined level by the action of the Zener diode MR 12 and components C35, R35.

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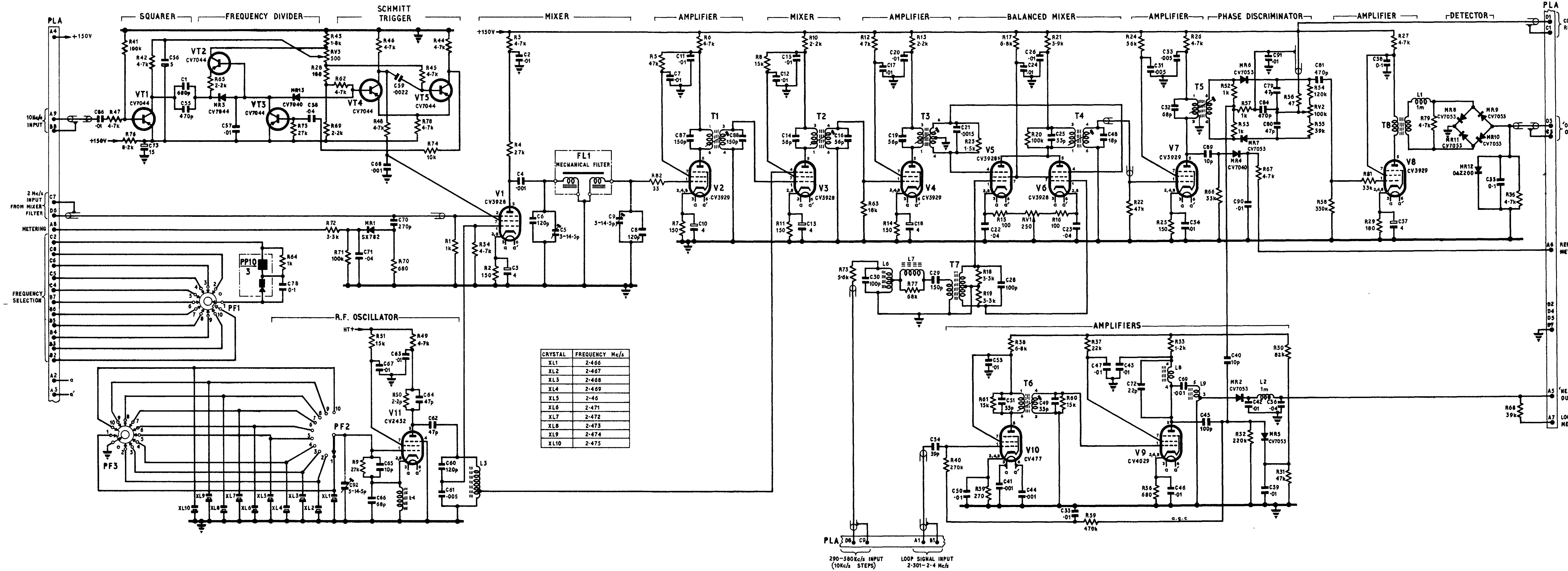

CRYSTAL	FREQUENCY Mc/s
XL1	2·466
XL2	2·467
XL3	2·468
XL4	2·469
XL5	2·46
XL6	2·471
XL7	2·472
XL8	2·473
XL9	2·474
XL10	2·475

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Oscillator radio frequency 5821-99-913-2231: circuit

Fig. 5

Chapter 8

MIXER STAGE, FREQUENCY 5821-99-913-2227

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. The mixer stage frequency sub-assembly, described in this chapter, contains all the mixers in the main control loop of the generator reference signal together with mixers and associated filters used in generating the necessary v.h.f. (159-181 Mc/s) and h.f. (27·2-28·1 Mc/s) signals which are fed to these main loop mixers to produce the loop signal.

2. A reference signal from the mixer stage frequency at 2 Mc/s is fed to the 1 kc/s (Waldy) oscillator (Chap. 7) together with the loop output signal; whilst in addition a 1 Mc/s reference frequency is provided to the 1 Mc/s I.G.O. and the 100 kc/s I.G.O. (Chaps. 4, 5).

Construction

3. Mixer stage frequency 5821-99-913-2227 (*fig.* 1) is constructed on a rectangular metal chassis the sides and top being used as screens to reduce stray radiation from the sub-unit to a minimum. These screens may easily be removed for servicing by unfastening a number of small retaining screws.

4. The assembly of the mixer stage uses miniaturized techniques and components. Many of the coils and larger components are mounted directly on the chassis, the smaller ones being attached to tagboards or suspended in the wiring. A considerable amount of inter-stage screening has been included in the mixer stage frequency to prevent interaction between the various mixer and amplifier stages used.

CIRCUIT SUMMARY

5. To understand the functioning of the mixer stage frequency a block diagram is shown in fig. 2, this diagram has been sub-divided into sub-chassis A, B, C, D each performing particular functions. The action of each sub-chassis will be described separately.

Sub-chassis D

6. This sub-chassis is known as the divider multiplier, frequency 5821-99-913-3774. This sub-chassis provides the 1 Mc/s and 2 Mc/s reference signals for the 1 Mc/s and 100 kc/s I.G.O. stepped oscillators, also for the 1 kc/s (Wadly) stepped

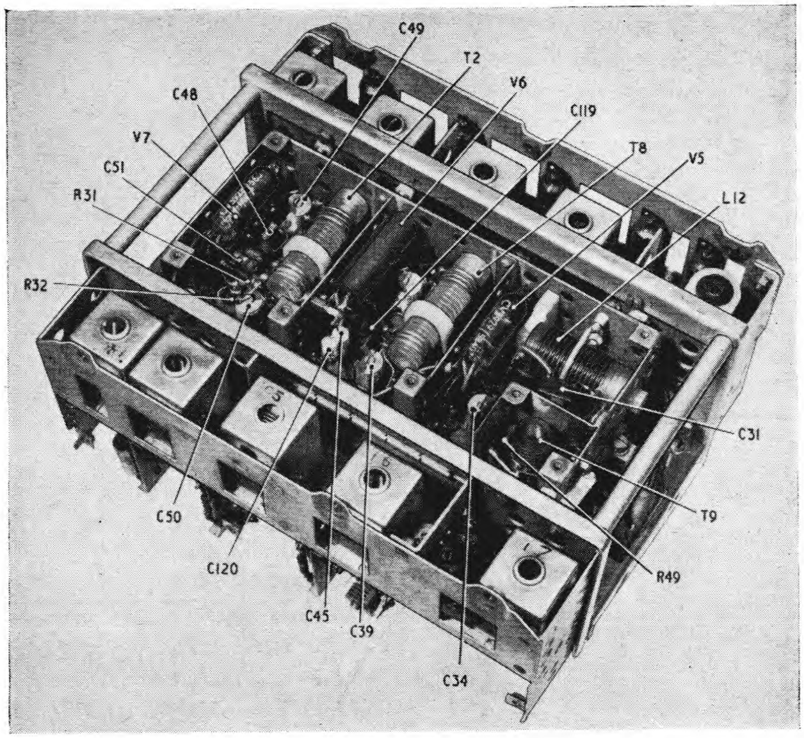

Fig. 1. Mixer stage frequency—top

oscillator from the 5 Mc/s input supplied by the crystal oscillator. The sub-chassis also provides a 25 Mc/s signal, the latter being fed to sub-chassis C, via a times-five multiplier stage.

Sub-chassis C

7. The sub-chassis filter assembly, electrical 5915-99-913-3773 consists of a high-frequency mixer V8 (*fig.* 2) this converts the output from the 1 Mc/s I.G.O. stepped oscillator in the range 34 Mc/s to 56 Mc/s to frequencies within the range 159-181 Mc/s. The following stage V9, functions as a wide-band amplifier, the gain being approximately constant over the range 159-181 Mc/s.

8. After passing through a further wide-band filter FL7B the selected frequency within the range 159 Mc/s-181 Mc/s is applied to a further mixer V10. The difference frequency between that obtained in the range 159 Mc/s-181 Mc/s from the filter FL7B and the signal from the master oscillator (Chap. 9) in the range 3·5 Mc/s—26·499 Mc/s, is obtained at the output of mixer V10.

Sub-chassis B

9. This sub-chassis amplifier, frequency-multiplier 5821-99-913-3775, provides the 25 Mc/s balanced high level frequency to the balanced mixers V1, V2 in sub-chassis A; the 125 Mc/s high level inputs to the mixer V7 in sub-chassis B and mixer V8 in sub-chassis C.

10. The 125 Mc/s signal is obtained from the 25 Mc/s signal, fed from sub-chassis D, via a times-five multiplier stage. After amplification in V6 the 125 Mc/s signal is fed to the mixer V7 where it is mixed with the output from sub-chassis C in the range 154·501-155·5 Mc/s, the resultant output signal is within the range 29·501-30·5 Mc/s and fed to the sub-chassis A via the band-pass filter FL3 (*fig.* 2).

Sub-chassis A

11. The fourth sub-chassis, filter assembly, electrical 5915-99-913-3772 contains the balanced mixer V1, V2, amplifier V3 and the final mixer in the loop chain, V4.

12. Balanced mixer V1, V2 is fed with two signals, one being a frequency in the range 2·2-3·1 Mc/s from the oscillator r.f. (100 kc/s steps) and the other a 25 Mc/s frequency obtained from sub-chassis B (para. 9). The addition of these frequencies produces an output in the range 27·2 Mc/s-28·1 Mc/s this being fed to the bandpass filter FL6A.

13. After amplification in V3 and further filtering in FL6B the signal is fed to the mixer V4 and mixed with a signal in the range 29·501-30·5 Mc/s obtained from sub-chassis B (para. 10). The difference frequency obtained from mixer V4 constitutes the loop-signal to the oscillator r.f. 1 kc/s (Wadly) described in Chap. 7 this loop-signal lies within the frequency range of 2·301 Mc/s-2·4 Mc/s.

DETAILED CIRCUIT DESCRIPTION

Divider-multiplier, frequency (Sub-chassis D)

Multiplier-amplifier

14. An input voltage at a frequency of 5 Mc/s from the crystal standard oscillator is fed at a high level to the amplifier-multiplier valve V11 (CV3929) via coupling components C83 and R53 (*fig.* 5) resistor R73 functions as a grid "stopper".

15. Bias for the amplifier is provided in the normal way by components R55 and C85 connected in the cathode of V11. The tuned circuit formed by L3 with capacitors C86, C88, C89 is resonated at 25 Mc/s. In addition the capacitors previously mentioned form a capacitive divider producing a low impedance for feeding the 25 Mc/s voltage to V5 on sub-chassis B (*fig.* 5).

Frequency divider

16. The 5 Mc/s input voltage from PLA/A7 is also coupled via the capacitive divider C90, C111 to the frequency divider formed by valves V12, V13 (CV3992).

17. The frequency divider is of the simple regenerative type and produces an output frequency of 1 Mc/s from the 5 Mc/s input. If the input voltage from the 5 Mc/s standard crystal oscillator should fail or depart from the nominal frequency there will be no output from the frequency divider.

18. Briefly the divider functions in the following way. A 5 Mc/s voltage is fed to the control grid of pentode V12; in the anode circuit of this valve

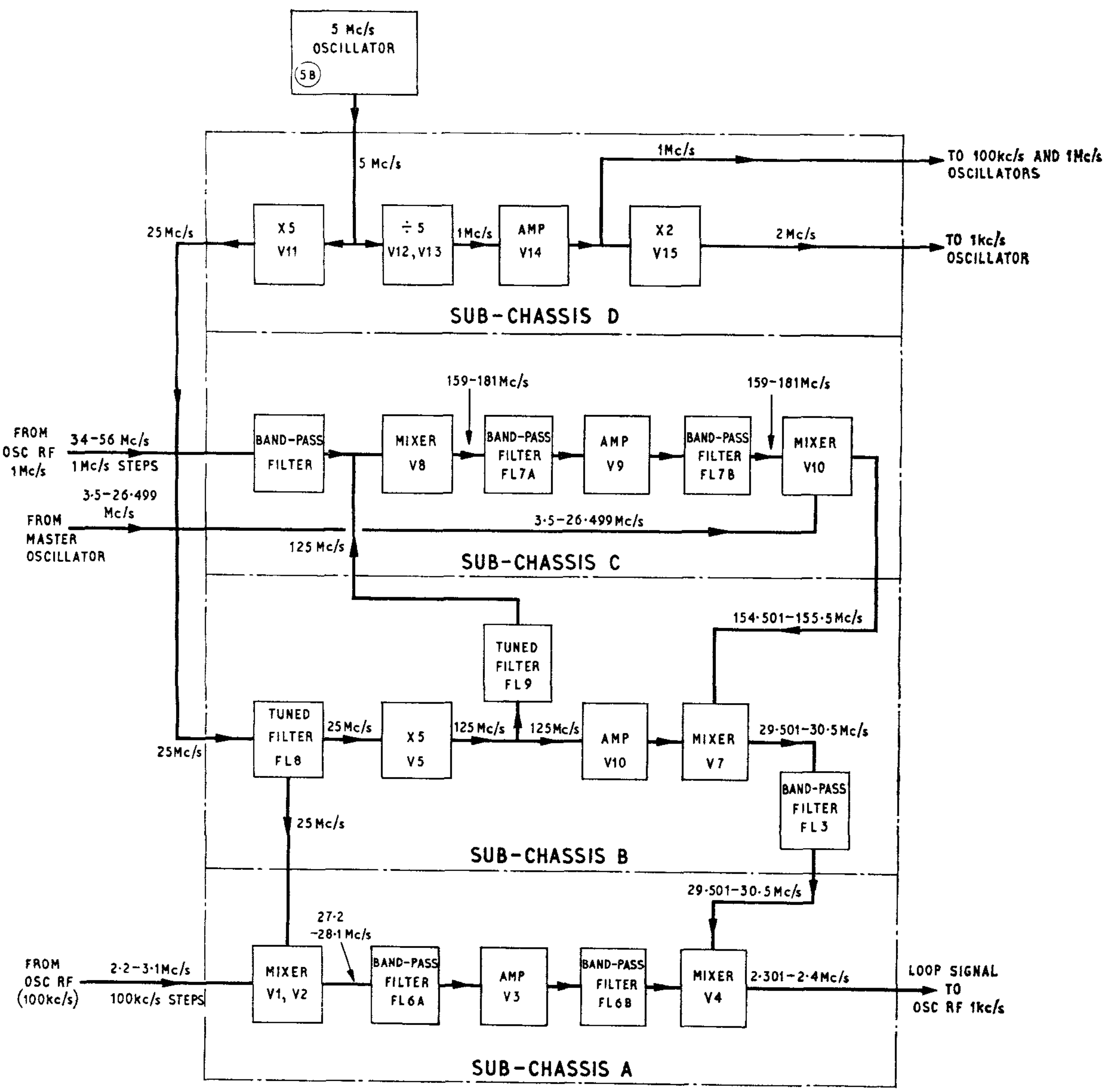

Fig. 2. Mixer stage frequency; block diagram

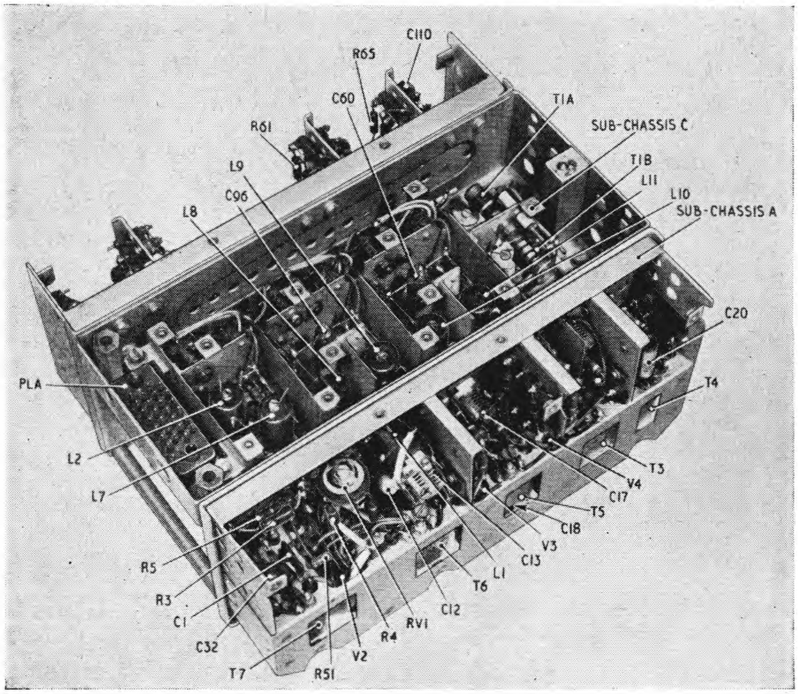

Fig. 3. Mixer stage frequency underside, 1

is a tuned circuit L4, C92 C93 tuned to 1 Mc/s. Capacitors C92, C93 form a capacitive-divider and the 1 Mc/s voltage present across C92 is fed to the control grid of V13, resistor R59 being the grid-leak.

19. Valve V13 functions as a frequency-multiplier, the tuned circuit in the anode L5, C95, is tuned to 4 Mc/s. By connecting the anode of V13 directly to the screen of grid V12 the 4 Mc/s frequency is mixed with the incoming 5 Mc/s frequency (para. 18) to produce a difference frequency of 1 Mc/s in the anode of V12.

Amplifier

20. The 1 Mc/s frequency is fed from R59 via the capacitive divider C98, C94 to the amplifier valve V14 (CV3929) the anode tuned circuit L6, C101, C102 being resonated at 1 Mc/s. From the junction of C101, C102 a stepped down voltage at 1 Mc/s is fed to the chassis coaxial plug PLA/A5 also to the control grid of V15 (CV3929) through coupling capacitor C104 and grid leak R65.

Multiplier

21. Valve V15 functions as a frequency multiplier stage the tuned circuit formed by the primary winding of transformer T10 with C106 selecting the second harmonic of the 1 Mc/s input. The secondary winding of T10 and capacitor C112 in conjunction with C108, C109, C27 is also resonant at 2 Mc/s the latter capacitors function as a divider to feed the 2 Mc/s frequency at low impedance to the chassis plug PLA/A3/B3 via a short length of coaxial cable.

Filter assembly electrical (sub-chassis C)

22. The 125 Mc/s signal from sub-chassis B (*fig.* 5) is fed via coupling capacitor C43 to the control grid of the first mixer valve V8 (CV3929). This valve functions as an additive mixer, the 125 Mc/s frequency being mixed with low-level signals in the range 34 to 56 Mc/s in 1 Mc/s steps, fed in at PLA/D1.

23. Tuned circuits formed by L2, C54 and L7 (*fig.* 3), with the grid-to-cathode capacitance of V8, are resonant at 125 Mc/s. The former tuned circuit prevents the 125 Mc/s voltage from getting back to the 1 Mc/s I.G.O.

24. Capacitor C82 tunes the effective inductance of L2 and L7 in series, to approximately the midband frequency (45 Mc/s) of the 1 Mc/s I.G.O. output. This is a very low Q circuit, since it is shunted by the 47-ohm resistor R35. The combination of L2 with L7 also serves to halve the low-level input voltages from the 1 Mc/s I.G.O.

25. In the anode circuit of the mixer valve V8 is a top-capacitance coupled double-tuned-circuit filter, this consists of inductor L8 plus the stray capacitances of the anode circuit of V8 and L9 plus the stray capacitances of the grid circuit of V9. The coupling capacitor C96 functions as the top-coupling capacitor for L8 and L9.

26. Valve V9 (*fig.* 4) functions as a wideband amplifier the anode circuit consisting of L10 and the stray capacitances form part of a double-tuned circuit filter, the latter being completed by L11, R45, plus the stray grid-cathode capacitance. The top-coupling capacitor in this case being C60.

27. The overall response of the double-tuned circuit filter from the anode of V8 to the grid of V10 is from 159 Mc/s to 181 Mc/s, level to within 1dB. The high level direct breakthrough of 125 Mc/s from V8 anode receives more than 40dB attenuation over the two filters described in para. 37-39, reducing the 125 Mc/s voltage to a negligible amount.

28. At the mixer V10 (CV3928) the frequency in the v.h.f. range 159-181 Mc/s fed from the wide-band amplifier valve V9, is mixed with the output from the master oscillator (Amplifier-oscillator 5821-99-913-2233).

29. The v.h.f. voltage is fed to the control grid of V10 whilst the input supplied by the master-oscillator in the range 3·5 to 26·499 Mc/s is injected onto the suppressor grid. A direct connection to earth for the suppressor grid of mixer valve V10 is provided by R50 and bias obtained from R46, C64 in the normal manner.

30. So that the operating system of the frequency generating unit can function the output of mixer V10 must produce a narrow-band of frequencies in the range 154·501 to 155·500 Mc/s. The mixer valve V10 has therefore in its anode circuit a narrow-band filter, T1a, T1b (*fig.* 3) covering this range.

31. This filter, mentioned in para. 44 has a pass-band which is level to within 0·5dB over its working range and is a link-coupled, double-tuned circuit component. Trimmer capacitors are used for resonating the primary and secondary windings, these are C66 and C69 respectively (*fig.* 4).

32. The output voltage obtained across the secondary winding T1b of the filter is stepped down by the capacitive-divider C68 and C114. This voltage is then fed directly to the control grid of mixer valve V7 located in sub-chassis B.

Filter assembly electrical (sub-chassis B)

33. The 25 Mc/s input voltage from sub-chassis D (para. 15) is injected into the control grid circuit of the quintupler valve V5 (CV3929) by transformer T9a. A stepped-up voltage appears across capacitor C34 and is fed to the control grid of V5 by C35 and R23. Bias for the multiplier V5 is obtained from resistor R24 and capacitor C36.

34. In the anode circuit of V5 is a loosely-coupled double-tuned circuit filter, T8, this is tuned to the fifth harmonic (125 Mc/s) of the input circuit. In parallel with the primary inductance of T8 are two capacitive potentiometers consisting of C120 plus C119, and C45 plus the grid-to-cathode capacitance of the next valve V6. The secondary of T8 (*fig.* 5) is connected through the capacitive-divider C41, C42 and coupling capacitor C43 to the input circuits of the sub-

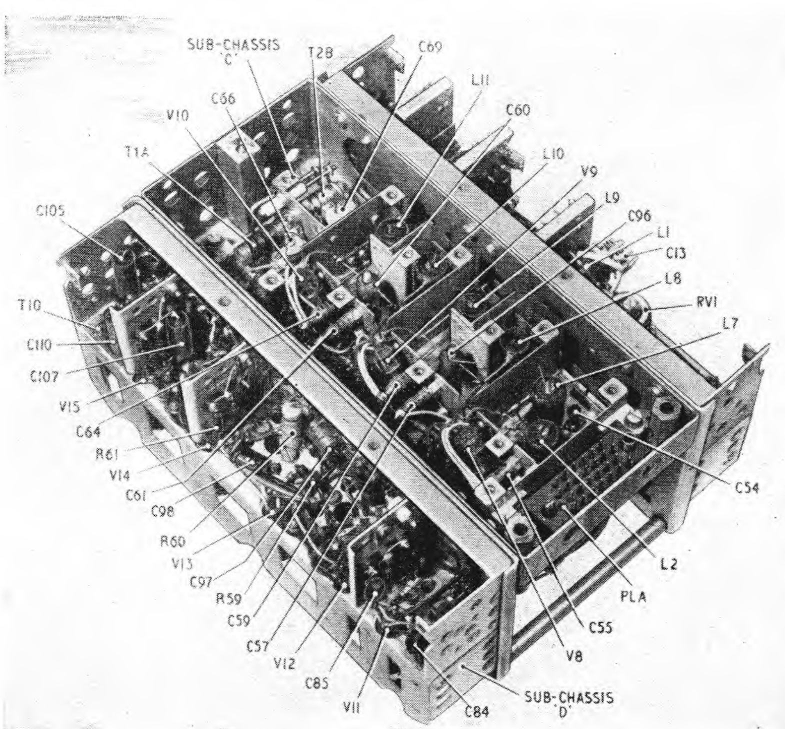

Fig. 4. Mixer stage frequency underside, 2

chassis C, this 125 Mc/s frequency constitutes the high-level signal output from sub-chassis B.

35. Following the frequency-multiplier stage is a 125 Mc/s amplifier V6 (CV3929) contained in a special screen to minimize radiation. In the anode circuit of this valve is a loosely coupled double-tuned transformer T2 tuned to 125 Mc/s. The secondary of this transformer supplies a high level signal to the suppressor grid of the mixer valve V7. Transformers T8 and T2 previously mentioned are high-Q circuits to reduce the possibility of 100 Mc/s or 130 Mc/s voltages getting through to V7 where these frequencies could beat with the 125 Mc/s frequency to produce 25 Mc/s which is undesirable.

36. Valve V7 (CV3928) functions as a multiplicative mixer; a frequency in the range 154·501 to 155·5 Mc/s is fed to the control grid of V7 from sub-chassis C and the 125 Mc/s signal from V6 is fed to the suppressor of V7. The anode tuned circuit of V7 is in sub-chassis A (*fig.* 5) and consists of the band-pass tuned transformer T3, the latter passing frequencies in the range 29.501 to 30·500 Mc/s.

Filter assembly electrical, sub-chassis A

37. This sub-chassis contains a balanced mixer (valves V1, V2), amplifier V3 and the final mixer in the loop chain, V4.

38. Valves V1, V2, receive a 25 Mc/s high level r.f. voltage on their control grids from the secondary winding of transformer T9b (*fig.* 5) this secondary is balanced about earth and resonated at 25 Mc/s by capacitors C116, C117, C118, C100. Resistors R51 and R52 are anti-parasitic "stoppers".

39. A second r.f. voltage, in the frequency range 3·100 to 2·200 Mc/s, is fed to the cathodes of V1 and V2 via transformer T7 and the coupling and balancing network C4, C5, R2, RV1, R4. Mixing occurs in the balanced valves V1, V2 and a resultant frequency in the range 28·1 to 27·2 Mc/s is produced across the primary winding of the double tuned transformer T6.

40. The balanced mixer is required to decrease the level of the 25 Mc/s direct breakthrough as much as possible since the presence of a voltage at this frequency at the mixer V4 would cause beating with the wanted signal producing frequencies within the pass-band of subsequent filters.

41. Transformer T6, in the anode circuit of valves V1, V2 is mutually coupled and damped by resistor R6 to produce the required pass-band of 27·2 to 28·1 Mc/s. The secondary of transformer T6 is loosely coupled through capacitor C12 to a 25 Mc/s absorption circuit L1, C11, C13 connected effectively between the control grid V3 and the earth return, this further attenuates any 25 Mc/s voltage which may still be present.

42. Valve V3 functions as an amplifier, bias being provided by components R9, C15, with resistor R8 acting as a grid leak. In the anode circuit of V2 is a tuned circuit consisting of the primary winding of transformer T5, this circuit is resonated at 27·65 Mc/s and is loosely coupled by mutual inductance to a 25 Mc/s absorption circuit formed by the secondary winding of T5 with capacitors C19, C18. This absorption circuit functions in a similar way to that described in para. 30.

43. The single tuned circuit, mentioned previously, which is the primary of transformer T5, fills in the midband dip of the previous double tuned transformer T6 in the anode circuit of the balanced mixer valves (para. 41).

44. An output voltage from the anode of the amplifier V3 is coupled via C21 and suppressor grid resistor 13 to the suppressor grid of the mixer valve V4, the latter valve being suitably biased by components R17, C115, C23, to function in this manner.

45. At the mixer V4 the high level 100 kc/s stepped frequency in the range 27·2 to 28·1 Mc/s obtained from V3 is mixed with a frequency in the 29·5 to 30·5 Mc/s band from the mixer V7 in sub-chassis B (para. 36). This is fed to the control grid of mixer V4 via the double-tuned transformer T3 and coupling components C26 and R18.

46. A double-tuned transformer T4 in the anode of mixer valve V4 (CV3928) passes frequencies in the band 2·301 to 2·400 Mc/s obtained from the mixing process in V4. The signal obtained in this band is the "loop-output" voltage, this is then fed to the 1 kc/s steps Wadly oscillator (Chap. 7) via PLA/D5/C5.

Note . . .

In practice, the bandwidth of the transformer T4 is approximately 200 *kc/s greater than the frequency range* 2·301 *to* 2·400 *Mc/s, this is necessary to provide a motor "slow" voltage in ample time to the motor control unit in the amplifier-oscillator* 5821-99-913-2231 (*Chap.* 9).

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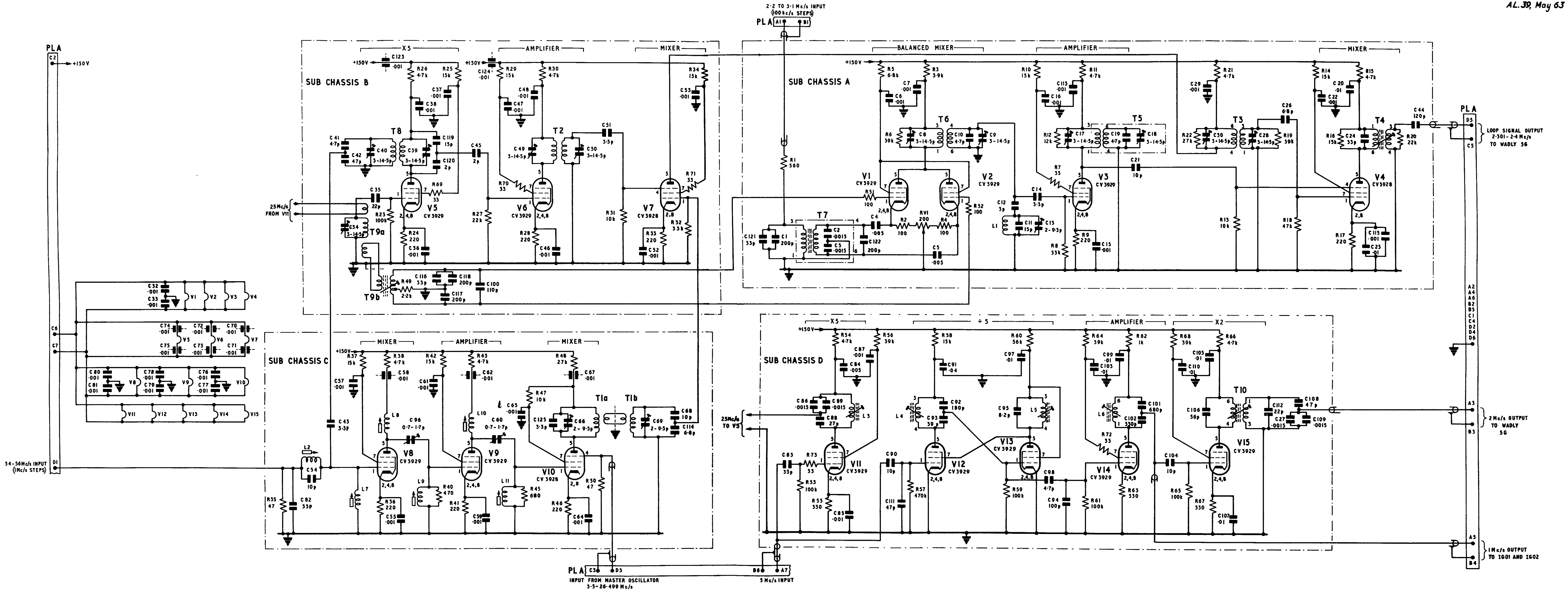

Mixer stage frequency 5821-99-913-2227: circuit

Fig. 5

AIR DIAGRAM 6729Z/MIN.
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Chapter 9

AMPLIFIER-OSCILLATOR, 5821-99-913-2233

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. The sub-unit amplifier-oscillator 5821-99-913-2233 contains the variable-frequency master oscillator used in the frequency generating system of ARI.18179 in the generator reference frequency.

2. The final output frequency is provided by this v.f.o., the oscillator frequency being obtained over the required range in five sub-bands.

3. Initial tuning is carried out by a servo-operated motor-driven variable capacitor, after which for final tuning, the oscillator is phase-locked to the desired frequency by comparison with four selectable reference frequencies obtained as described in earlier chapters of this section of the publication.

Construction

4. Components associated with the valve circuits used are mounted, in the main, within a shallow box chassis, the valves are situated on the top of of this chassis (*fig.* 1).

5. The drive motor, gear head and ganged variable-capacitor are mounted in a similar manner above the chassis with the transistors and their associated components disposed on two boards mounted vertically, on edge, alongside the variable-capacitor and motor.

6. A removable bottom screen-cover gives access to the valve circuit components and the transistor component boards have leads of sufficient length to allow them to swing away, clear of the chassis, for servicing.

CIRCUIT SUMMARY

General

7. A block diagram of the amplifier-oscillator sub-unit is shown in fig. 2.

8. The amplifier-oscillator sub-unit provides the variable-frequency r.f. output from the generator

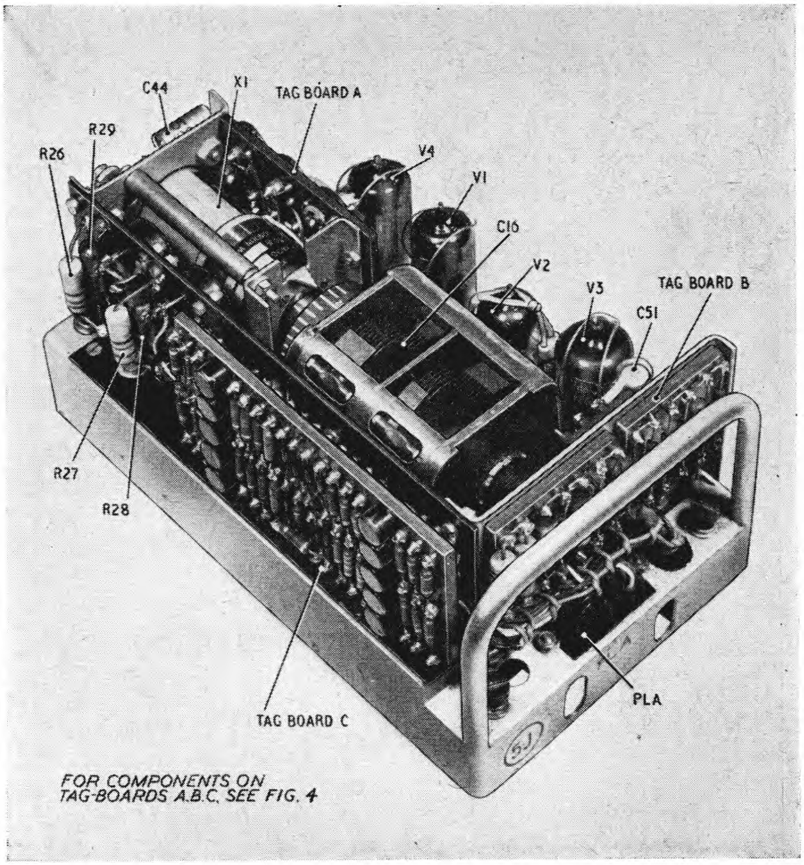

Fig. 1. Amplifier-oscillator, top

reference signal, as mentioned in para. 1. To do this a motor driving a two-gang split-stator capacitor via a reduction gearbox is used. This capacitor adjusts the frequency of the v.f.o. and associated amplifier (*fig.* 2) sufficiently closely to a predetermined reference frequency, to enable a reactance valve V1 (*fig.* 2) to lock the v.f.o. frequency to that of the reference.

9. If the frequency produced by the v.f.o. should drift such that it is approaching the limit of the control range of the reactance valve, small adjustments are made by the motor, to the variable-capacitor to bring the v.f.o. frequency once again into the centre of the control range of the reactance valve.

10. Both the variable frequency oscillator V2 and amplifier V3 (*fig.* 2) each have five operating bands selected by an electro-magnetically operated range switch.

11. The electro-magnetic switch is provided with electrical switching voltage information, from the sub-unit oscillator, radio frequency 5821-99-913-2230 (1 Mc/s I.G.O. Chap. 4).

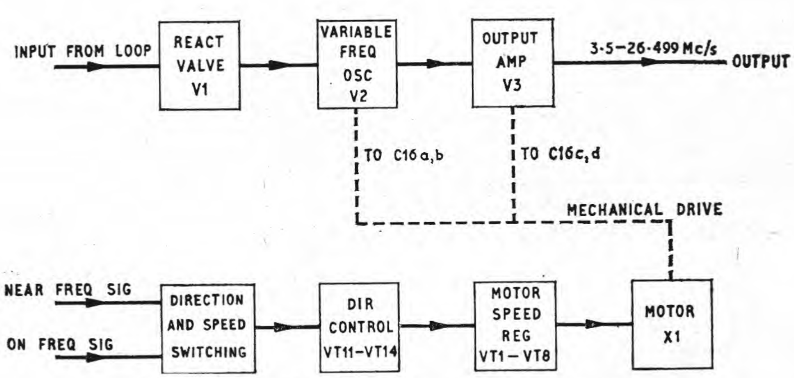

Fig. 2. Amplifier-oscillator, block diagram

Motor speed-and-directional control

12. Motor speed and regulation is provided by transistor switching circuits. Transistors VT9 and VT10 are included in the logic system and VT1-VT8 provide speed control. In the absence of the near frequency signal, the servo-motor runs at a fast speed in the forward direction.

13. When the frequency of the v.f.o. is approaching the desired frequency, a "near-frequency" signal is produced at the discriminator (Chap. 7). This "near-frequency" signal is fed to the transsistor switching circuit VT9 (*fig.* 2) the latter transistor functioning to rapidly reduce the speed of the motor as it approaches the "on-frequency" condition. This is done to speed-up the overall operating time and prevent over-shooting and hunting which would occur if the servo-motor was not slowed down in this way.

14. The "on-frequency" signal is obtained from the oscillator v.f. 5821-99-913-2231 (1 Kc/s Wadly) when the v.f.o. is in phase-lock with the synthesized signal. When the output frequency of the v.f.o. is within the capture range of the reactance device V1 (*fig.* 2) control of the motor is obtained from the reactance valve cathode current.

15. If the reactance valve cathode current is near its mid-range point, no action is required from the motor; should the valve current approach either the upper or lower limit, the motor shaft will rotate in such a direction that the reactance valve current is restored to mid-range.

16. This ensures that if the v.f.o. drifts towards the limits of the range of reactance control, the v.f.o. would not come out of phase-lock and re-select frequency.

17. Directional control of the motor is controlled by two bi-stable transistor multivibrator circuits VT11-VT14 (*fig.* 2) operating at different levels.

18. One circuit is triggered "on" with low reactance valve current whilst the other triggers "on" when the reactance valve reaches its upper limit.

19. From para. 15, it can be seen that neither multivibrator switching circuit will be "on" if the reactance valve current does not vary beyond either its upper or lower limits, hence the motor will be stationary.

DETAILED CIRCUIT DESCRIPTION

Valve circuits

20. Two valves V2 and V3 shown in the circuit diagram (*fig.* 5) are used in the amplifier-oscillator sub-unit for generation of the output frequency and its subsequent amplification. A Colpitt's type of oscillator circuit is used for the v.f.o. and this is capable of being controlled by a reactance valve V1.

21. The output amplifier V3 has an automatic gain control voltage applied to it to hold the output amplitude constant at about 4V r.m.s. The output frequency range of 3·5 - 26·499 Mc/s is divided into five sub-ranges as follows:—

(1) 3·5 Mc/s to 6·499 Mc/s

(2) 6·5 Mc/s to 11·499 Mc/s

(3) 11·5 Mc/s to 16·499 Mc/s

(4) 16·5 Mc/s to 21·499 Mc/s

(5) 21·5 Mc/s to 26·499 Mc/s.

Master oscillator and amplifier

22. The ranges mentioned in para. 21 are selected by the electro-mechanical switch PF5/10, the latter being set by electrical information fed in from the 1 Mc/s I.G.O. (Chap. 4). The use of a two gang split-stator capacitor C16a-d (*fig.* 5) suitably tracked by the fixed capacitors C13, 14, 15, 23, 24, 25 in conjunction with the coils L2-L6 and L7, to L11 enables each range except (1) in para. 21 to be 5 Mc/s wide.

23. Valve V2 (CV4010) functions as a Colpitt's oscillator, the feedback of radio frequencies to maintain oscillation being provided by capacitors C17, C19, the junction of these capacitors is connected to the cathode of V2. The oscillator frequency is determined by inductors L2-L6 (*fig.* 3) tuned by capacitor C16.

24. The anode load of the oscillator valve V2 is formed by resistor R8 and the output voltage obtained is coupled via C22 to the control grid of the amplifier valve V3 (CV2243). The grid resistor R11 functions as a parsitic "stopper" resistance.

25. Normal bias for V3 is provided by the cathode components R13, C26; in addition to this automatic gain control is provided over the output valve by the diode MR8 (SX782). The d.c. voltage obtained across R16 is filtered to r.f. by R15, C38, C54 and fed back as a control voltage to the grid of V3 via R12.

26. The point at which the a.g.c. diode MR8 begins to function is determined by the positive potential applied to the cathode from the h.t. potentiometer network R18, R19, R17. Inductors L7-L11 form the tuned anode load for V3 in conjunction with part of the two-gang split-stator capacitor C16 and fixed capacitors C23, C24, C25. The small capacitors shown across the inductors L7-L11 (*fig.* 5) are used for initial setting up and alignment.

27. Output r.f. voltage from the amplifier V3 is coupled via a capacitive voltage-divider consisting of C40, C41, to the output socket PLA/D6. In addition, output (attenuated by R20) is taken for the control loop from pin A7 and unattenuated via C52 to the rectifier circuit of diode MR13.

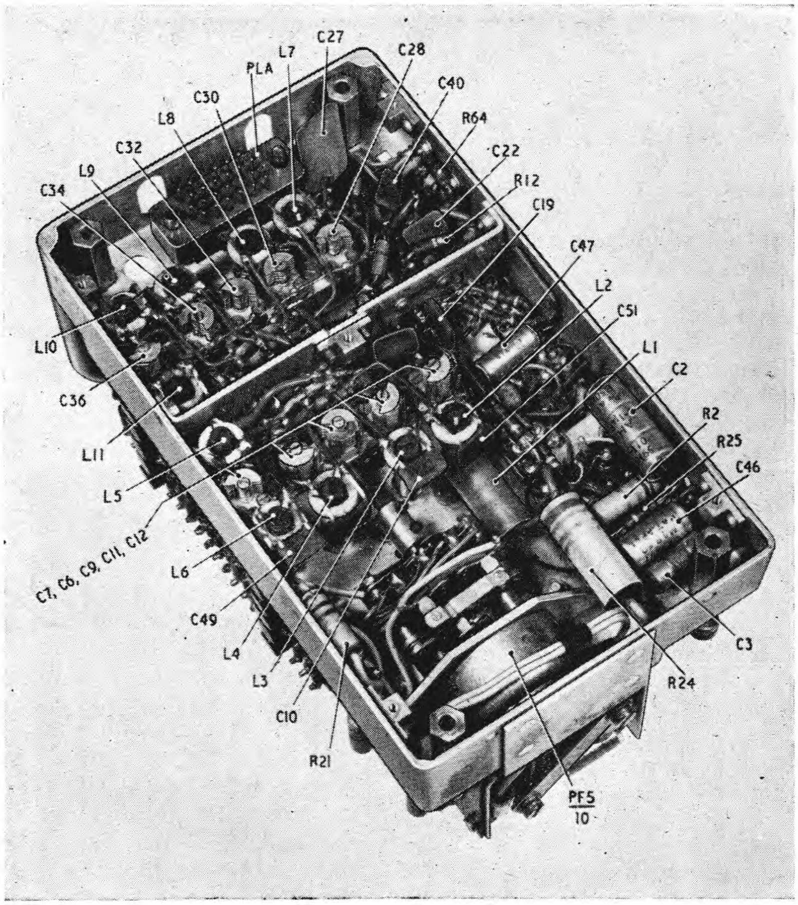

Fig. 3. Amplifier-oscillator underside

28. This diode provides a d.c. level across its load resistor R66 in conjunction with C52 to operate the meter provided for monitoring on the front panel switch assembly of the generator reference signal (*Chap.* 2).

Reactance valve

29. A d.c. voltage from the phase discriminator of control-loop is applied between the control grid and R4/R58 of the reactance valve V1 (CV4014) via pins B1 and B2 of plug PLA. This d.c. voltage will vary the anode current of V1 and hence the apparent reactance produced by V1 across the oscillator tuned circuit coupled to it by C5. Components R1 and C1 decouple the control grid to radio frequencies.

30. When the reactance valve is functioning the potential at the junction of resistors R4/R58 (*fig.* 5) varies with respect to earth proportionally to the cathode current of V1. This voltage is fed to the transistor circuits and metering connection pin B4 via the diode MR12 (CV7040), this diode disconnects resistor R58 from the control line (pin B4) when this goes positive.

31. The thyratron valve V4 is normally biased so that it is non-conducting. If the grid potential of V4 is raised above the cathode bias level, set by the potentiometer RV1, by a positive voltage on pin B1, the thyratron will conduct discharging capacitor C2 and momentarily remove the screen voltage of V1 hence reducing the potential across resistor R58. A large positive going transient on pin B1, is thus caused to produce a negative going pulse across resistor R58.

Transistor circuits

32. These can conveniently be divided into three groups; logic circuits, bistable switches and motor drive circuits.

Logic

33. The gate formed by the diodes MR3 and MR4 (CV7040) supplies current into the base circuits of transistors VT12 and VT13 (*fig.* 4) so long as either or both of transistors VT9 and VT10 are in the " off " condition. Transistor VT9 is switched " on " to bottoming by the positive going near-frequency signal which appears as soon as there is an output from the control loop.

34. Transistor VT10 is normally biased " on " by current from the 28V supply via resistor R40, but switches to " off " when a negative going signal appears on pin A6 of PLA due to the difference between the frequency produced by the motor-driven oscillator and that of the reference signal. There are thus three states to be considered:—

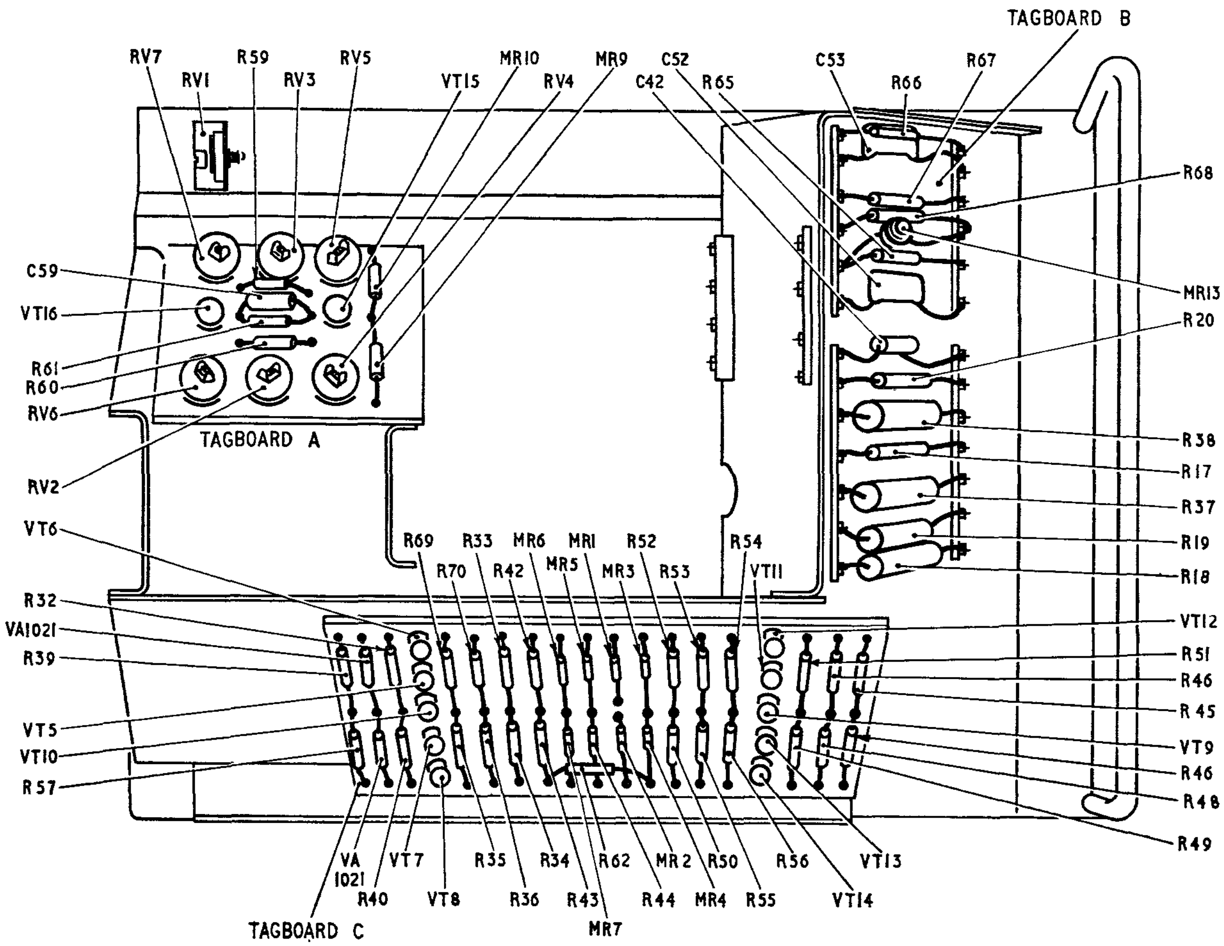

Fig. 4. Amplifier-oscillator, tagboard connections

(1) Oscillator frequency far from the desired frequency:
Transistor VT9 " off "—diode MR4 conducting
Transistor VT10 " on "—diode MR3 non-conducting

(2) Oscillator frequency close to the desired frequency and beating with the reference signal:
Transistor VT9 " on "—diode MR4 non-conducting
Transistor V10 " off "—diode MR3 conducting

(3) Oscillator frequency so close to the desired frequency that the beat between them falls to zero. Transistors VT9 and VT10 both switched to the " on " condition, neither of the diodes MR3 or MR4 conducting.

35. The last is the only case in which there is no output from the gate. For similar reasons the gate formed by diodes MR9, MR10 function in like manner, hence transistor VT16 is only allowed to be " on " in state (3) para. 34.

36. When transistor VT16 is " on " this closes the interlock and the ARI is then in the " ready " condition (*Sect.* 1, *Chap.* 7). Since state (2) is reached rapidly as the motor is at this time running at a fast speed, transistor VT9 bottoms rapidly and a negative going pulse is derived from its collector via capacitor C51. This pulse is used to decelerate the motor by momentarily switching it to reverse.

Bistable switches

37. The transistors VT11 and VT12 form one bistable switch associated with the forward direction of rotation of the motor, while VT13 and VT14 (*fig.* 4) form the bistable switch for the reverse direction. In the latter case the emitters are held at a small positive potential by a current through resistor RV7 and additional feedback is provided from the collector to base by R55 and R56.

38. The control voltage, i.e. the potential between the control line (B4) and earth, is applied to both switches in parallel via resistors R51 and R52. When the base potential of transistor VT13 is higher than the emitter potential set by potentiometer RV7 transistor VT13 switches to " on " taking its collector potential down close to earth, thereby clamping diode MR2 at a low potential.

39. When the base potential of transistor VT13 falls below the emitter potential the transistor VT13 will switch to " off ". Backlash between the " off " and " on " points is provided by the feedback resistors R55 and R56.

40. In a similar manner, transistor VT11 and VT12 operate for the forward direction of the motor. In this case RV6 (*fig.* 4) is set to give a slightly higher value of common-emitter potential so that the action of the circuit takes place at higher levels of base voltage on transistor VT12.

41. It will be seen from fig. 5 that the diode MR2 is connected to VT13, the control signal being applied to the base of the latter transistor, whereas the diode MR1 is connected to VT11, this is the opposite half of the corresponding bistable circuit. These circuits therefore switch " on " and " off " the reverse bistable at low values of base potential (i.e. low voltage between the control line and earth) and the forward bistable at high values of base potential.

42. The bistable circuits operate in opposite directions so that when the potential is near its mid-range value transistor VT13 will be conducting (MR2 clamped to low potential) and VT11 will be also conducting (MR1 clamped to low potential). If the base potential falls below the mid-range value transistor VT13 will unclamp the diode MR2, permitting reverse rotation of the motor. If the potential rises towards the upper limit determined by RV6, VT11 will switch off, thereby unclamping MR1 and allowing forward rotation.

Motor-drive circuits

43. To make the permanent-magnet field motor reversible it is connected between the transistors VT1, VT2, VT3 and VT4 (*fig.* 5). When VT1 and VT4 are conducting, the motor rotates in the forward direction and when transistors VT2 and VT3 are conducting the motor rotates in the reverse direction.

44. The speed of rotation of the motor will depend on the voltage applied across it (VT1 is an emitter-follower fed by the emitter-follower VT5) so that the motor voltage ultimately depends on the potential at the collector of transistor VT6. This potential in turn depends on the current drawn by VT6 through resistor R33. The transistor VT6 is controlled by its base and emitter potentials.

45. The base potential is set by the potentiometer RV4, R37 and R35. In parallel with resistor R35 is resistor R39 which is in series with diode MR6, the latter reduces R35 to a low value sufficient to reduce the current through transistor VT6 to a very small amount. If, however, the positive going d.c. near-frequency signal appears on PLA/B5, current will flow through diode MR5 into R39 and when the potential across R39 rises sufficiently, diode MR6 will cut off, leaving the base potential of VT6 to be determined by RV4, R37 and R35 alone.

46. In this condition, the base potential of VT6 is adjusted by potentiometer RV4 so that the voltage resulting at the collector of VT6 is of a level required to give slow speed operation of the motor.

47. In the condition where resistor R39 is in parallel with R35 the collector potential of transistor VT6 will be much higher and thus give the fast speed of the motor.

48. A small resistance R26 in series with the emitter of transistor VT4 develops a voltage proportional to the motor current and this voltage is applied to the emitter of transistor VT6.

49. When the motor is running in the slow condition, the motor will draw additional current and the voltage across R26 will increase if an increase of torque is experienced. This voltage is fed to the emitter of transistor VT6 via RV2, thereby reducing the current through transistor VT6, increasing its collector potential and so increasing the voltage applied to the motor.

50. This increase in voltage can be made equal to the " IR " drop of the motor so that the full torque of the motor remains available at reduced speeds. Should the supply voltage change, for example, towards a lower potential, the voltage at the collector of VT6 will tend to decrease and so also will the base voltage. However, the effect of the reduction in base voltage is to increase the collector voltage and due to the ratio of resistors RV4 plus R37 and R33, in conjunction with the gain provided by transistor VT6, the motor slow speed voltage remains virtually constant.

51. Finally, to offset changes in speed setting caused by temperature effects, the temperature sensitive network R69, TH1 is inserted in the base of VT6. The motor slow speed is in this way protected against variations due to change of torque, change of supply voltage, and change of temperature, and the speed can be changed from fast to slow by the potential across the resistor R39. The reverse half of the circuit is identical, resistor R39 being common to both. The " IR " drop compensation is adjusted by RV2 and the slow speed is set by RV4.

52. Since the motor X1 is running at a fast speed at the moment when the near frequency signal appears at PLA/B5, there is a possibility that although the motor voltage at once falls to the slow speed value due to the action of R39, the inertia of the armature may cause the motor to overrun the position at which it should have stopped.

53. To ensure that this does not happen the negative going pulse derived from the collector of transistor VT9, as mentioned in para. 36. is applied to the bases of VT12 and VT13 across MR11. The action of this is to drive the base potential of

VT12 in a negative direction so the forward bistable switch goes into the " off " position (VT11 conducting) while the reverse switch goes into the " on " condition (VT13 non-conducting).

54. The reverse voltage is thus applied to the motor X1, bringing the armature to rest very rapidly. At the end of the pulse the circuits revert to normal and as the near frequency signal is now present, the motor runs at a slow speed. At this point the logic is in stage (2) described in para. 34, and there is, therefore, an output from the gate MR3/MR4 supplying current to the bases of transistors VT12 and VT13 keeping these transistors switched to the " on " condition. This permits the motor to run in the forward direction.

55. When the logic experiences state (3) para. 34, there will be no output from the gate MR3/MR4 and the base potential of transistors VT12 and VT13 will be determined only by the potential across resistor R58. The potentials set by the variable resistors RV6 and RV7 (*fig.* 4) are chosen so that with the backlash produced by the action of resistors R47, R48 and R55, R56 both forward and reverse switches clamp their respective diodes MR1 and MR2 to a low potential when the voltage across resistor R58 shows that the reactance valve current is at approximately mid-range.

56. In this condition the motor remains stationary since the bases of transistors VT5 and VT7 are held near earth potential. If the cathode current of V1 changes so that the potential across R58 decreases, the potential will, at a level determined by RV7, cause transistor VT3 to switch off, hence allowing the motor X1 to rotate in the reverse direction.

57. Conversely, should the potential across resistor R58 rise to bring the base potential of VT12 above the level determined by variable resistor RV6, transistor VT11 will be switched to the " off " condition, thereby allowing motor X1 to run forward.

58. A large positive going transient applied to the control grid of V1 (*fig.* 5) would have the effect of switching the motor forward for the duration of the transient and when the conditions reverted to normal, the system would only be able recover its locked condition after the motor had rotated the gang capacitor through a complete rotation forward.

59. To prevent such an occurence, the thyratron V4 is arranged to cause large positive going transients appearing on PLA/B1 to give negative going transients across resistor R58 as described in para. 31. A negative going transient at resistor R58 momentarily switches the motor into the reverse direction from which it can rapidly recover by its normal action of going forward while there is a negative signal (due to beat frequency) present on PLA/A6.

TABLE 1
List of valves used in the amplifier-oscillator

Type	Ref. No	Circuit function	Description
V1	CV4014	Reactance valve	Pentode
V2	CV4010	Oscillator	Pentode
V3	CV2243	Amplifier	Pentode
V4	CV4018	Clamp valve	Thyratron

TABLE 2
List of semi-conductors used in the amplified-oscillator

Type	Ref. No.	Circuit function	Description
VT1	CV7061	Motor drive	NPN Silicon junction transistor
VT2	CV7061		
VT3	CV7061		
VT4	CV7061		
VT5	CV7062	Motor control	NPN Silicon junction transistor
VT6	CV7062		
VT7	CV7062		
VT8	CV7062		
VT9	CV7062	Active elements of logic	
VT10	CV7062		
VT11	CV7062	Forward bistable switch	NPN Silicon junction transistor
VT12	CV7062		
VT13	CV7062	Reverse bistable switch	NPN Silicon junction transistor
VT14	CV7062		
VT15	CV7062	Interlock circuit	NPN Silicon junction transistor
VT16	CV7062		

TABLE 3

List of diodes used in the amplifier oscillator

Type	Ref. No.	Circuit function	Description
MR1 }	CV7040	Clamp diode	Silicon general purpose diode
MR2 }			
MR3 }		Gating diodes	Silicon general purpose diode
MR4 }			
MR5		"Steering" diode	
MR6 }	CV7040	Gating diodes	Silicon general purpose diode
MR7 }			
MR8	CV7053	a.g.c. diode	High speed switching diode
MR9 }	CV7040	Gating diodes	High speed switching diode
MR10 }			
MR11		Clamping diode	High speed switching diode
MR12		Blocking diode	High speed switching diode
MR13	CV7053	Rectifying diode Oscillator monitoring circuit	

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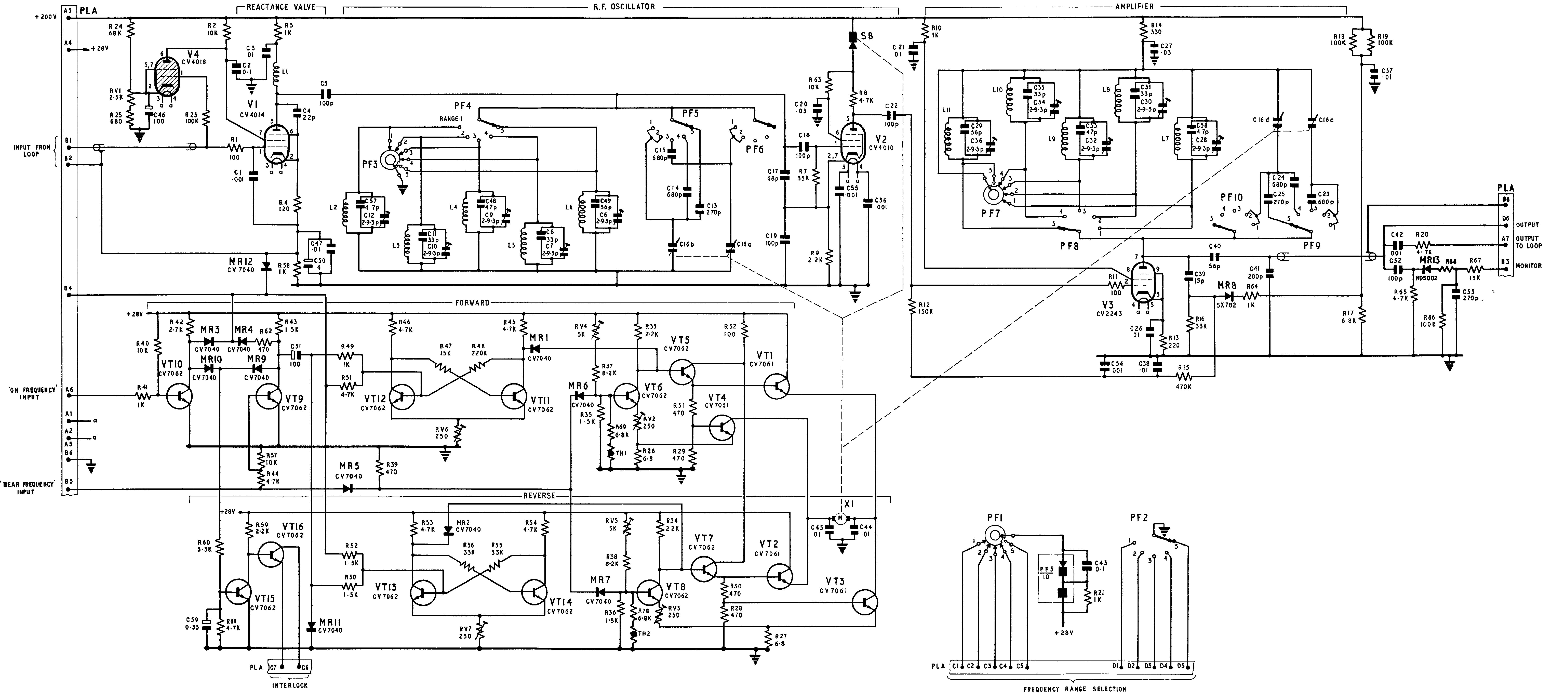

Amplifier-oscillator 5821-99-913-2233: circuit

Fig. 5

AIR DIAGRAM
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SECTION 3

SUPPRESSED AERIAL TUNING EQUIPMENT

P31013574947/5609 7/61 375 C & P Gp 375

Chapter 1

(*Completely revised*)

SELECTOR UNIT 5985-99-999-8557

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The selector unit 5985-99-999-8557 contains the control elements for the channel selection, matching and tuning systems used in the suppressed aerial system. Within the selector unit is the control frequency selector (channel selector), the latter being a common item to the s.s.b. transmitter-receiver (Sect. 2, Chap. 1).

General description

2. The selector unit (*fig.* 1) is designed for rack mounting. A plug and socket, fitted at the rear, engage with corresponding fittings on the back plate of mounting 5985-99-999-8546 when the unit is in position in the radio bay of the aircraft.

3. A quick-release cover allows access to the top and sides of the unit; a base cover, which is screw retained, closes the underside of the shallow chassis which forms the base of the unit.

4. The channel selector (*fig.* 3) is contained in the front lower half of the selector unit (*fig.* 1). The area above the channel selector panel is occupied by the indicator meter M1, the spring loaded access door to the drum selector, and the SET/TEST key. A tuning warning lamp is set below this key, and the tuning position counter dial is beneath the meter.

5. Behind the channel selector is a step-up gear assembly (*fig.* 2) which operates the counter dial. The drum selector (mounted above the channel selector) is rotated to each channel position by a plastic chain driven by a sprocket wheel on the gear assembly. This sprocket engages with the channel position shaft on the channel selector.

6. The setting potentiometer RV1 is mounted on the back plate of the gear assembly. A slotted crank on the potentiometer spindle engages with a crank (*fig.* 2) mounted on the tuning shaft of the channel selector.

7. The electrical connections to the channel selector are made through a plug PLA which is at the end of a free cable. This plug engages with a socket SKTE which is mounted at the top of the main unit. By removing four retaining screws on the front panel the channel selector can be removed completely from the selector unit.

8. At the rear of the gear assembly on the selector unit are two vertical panels, each of these connects with corresponding sockets mounted in the chassis base. The foremost panel contains the servo-amplifier, and the rear one the reduced speed unit. At the rear of the selector unit are located the r.f. filter capacitors (*fig.* 2) and the

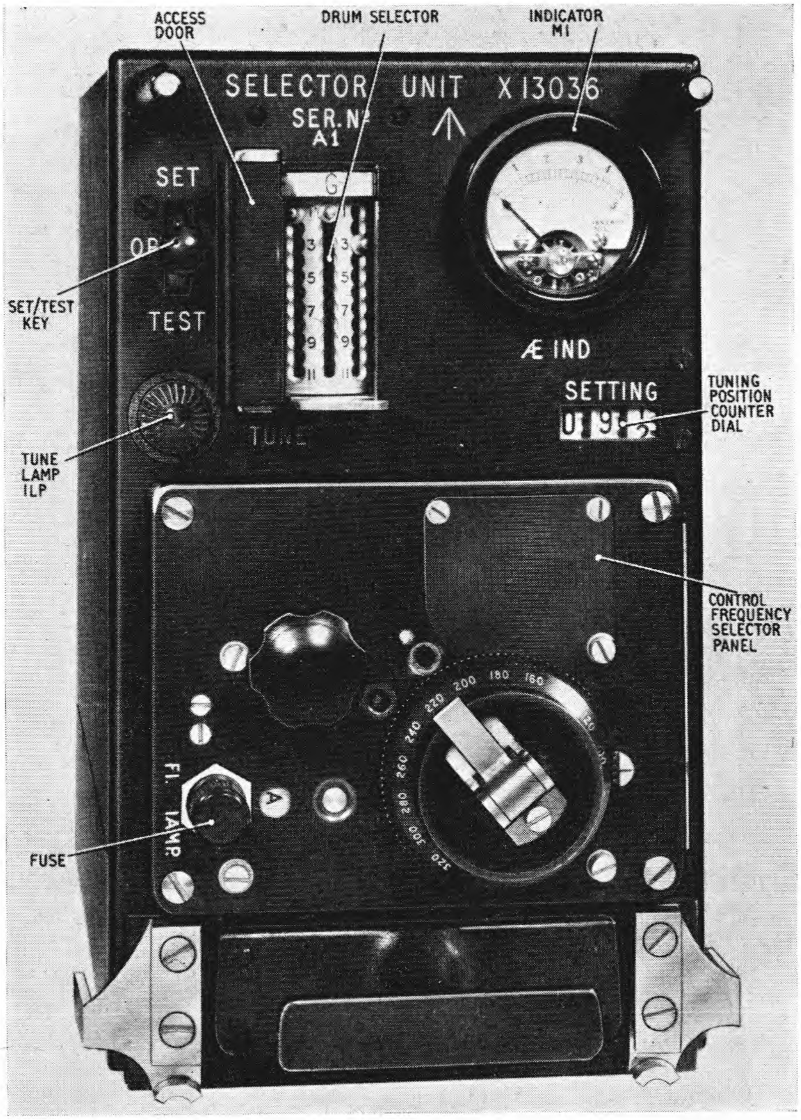


Fig. 1. Selector unit, front

surge limiter circuit components. The two transistors of the surge limiting circuit are mounted on the rear outer face of the selector unit they are covered by an air ducting system (*fig.* 2) which assists the "heat sink" for cooling purposes.

9. An important item of the selector unit is a solenoid-operated switch SB this is mounted vertically on the rear face of the gear assembly, in front of the servo-amplifier. This switch selects the required matching tap via the Network Impedance Matching (Sect. 3, Chap. 3), and also the required padding capacitors in the tuner radio frequency, unit (Sect. 3, Chap. 2). At the top of the selector unit is a 25-way socket SKTD which connects with the capacitor selector plug PLC.

DETAILED DESCRIPTION OF SELECTOR UNIT

Note . . .

For ease of component location of the selector unit the circuit references are given the following prefixes:—

(11*A*) *Main chassis*
(11*B*) *Control frequency selector*
(11*C*) *Amplifier electronic control*
(11*D*) *Selector control sub-assembly*

For simplicity the prefix (11*A*) *will not be used in the following description. It should therefore be assumed that circuit references without a prefix refer to components on the main chassis. A complete circuit diagram of the selector unit is given in fig.* 11.

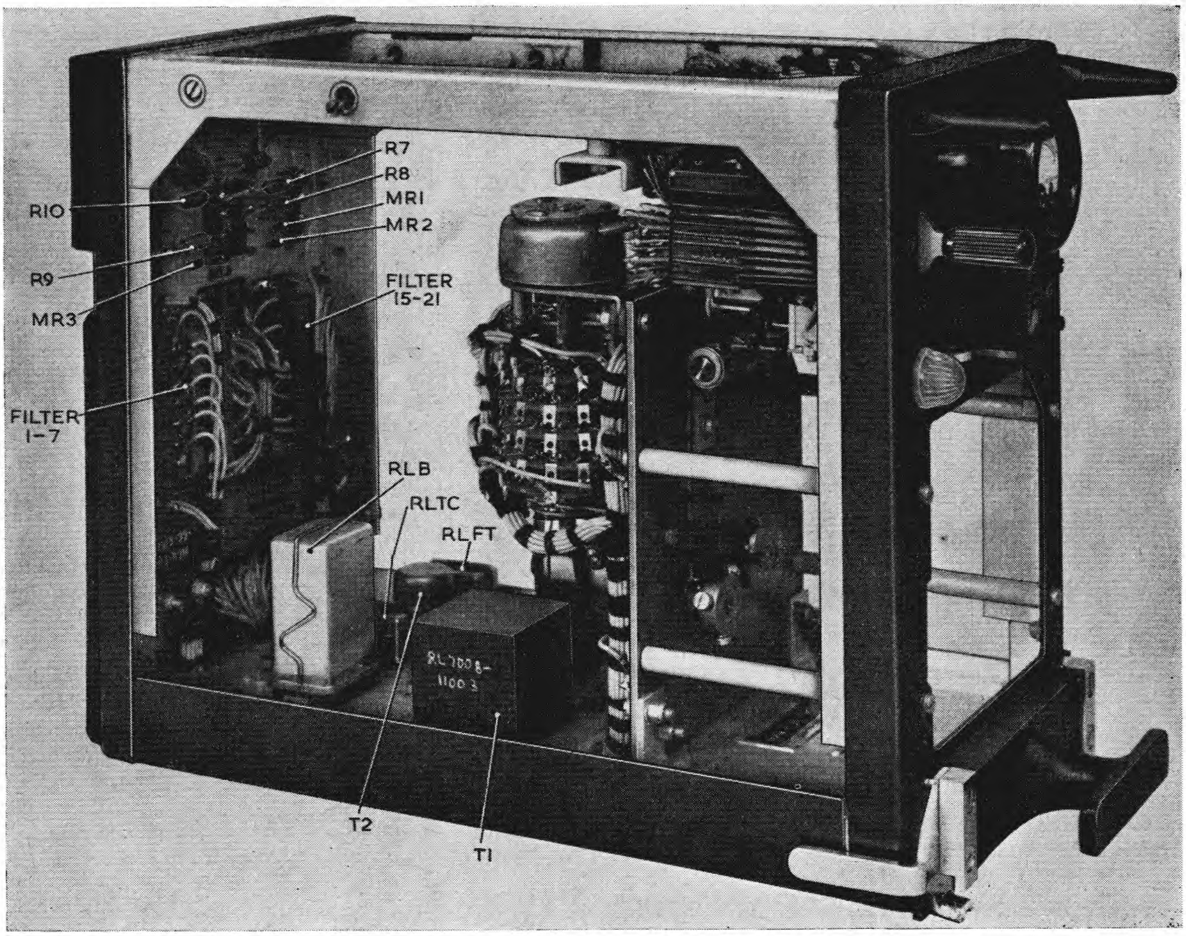


Fig. 2. Selector unit, side

Channel selection

10. When a channel is selected, an earth is placed on one of the wires PLA1-12 from the transmitter-receiver junction box; the control frequency selector operates, the tuning shaft (*fig*. 3) turning the moving arm of potentiometer RV1 (*fig*. 2) to a pre-determined setting and the channel shaft rotating the matching selector drum (DS) to the chosen channel position. Detailed operation of the channel selector is described in the following paragraphs.

11. An illustration of the channel selector is shown in fig. 3, and reference to the simplified circuit (*fig*. 4), will show how the selector operates. The circuit shows a channel selected and power connected to the unit.

12. If another channel is required, the channel selector switch on the remote control unit is turned to select this channel, whereupon relay RLA/4 is de-energized and a voltage applied across the motor X1 with a polarity such that the rotation of the motor will drive the tuning

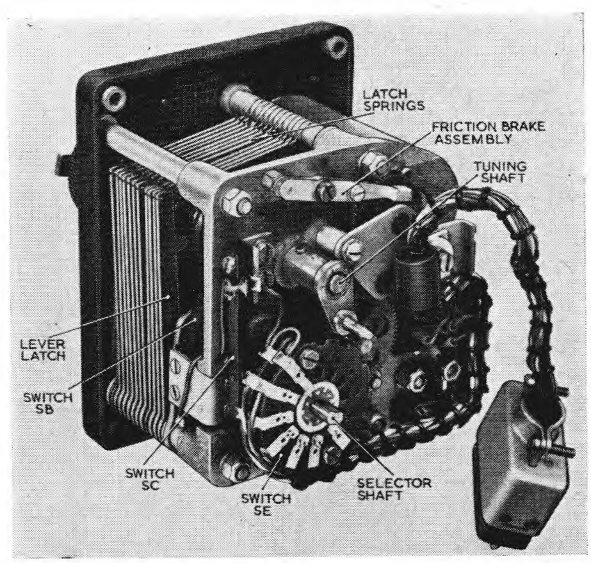


Fig. 3. Control frequency selector

shaft in the return-to-zero direction, whilst at the same time driving the selector shaft. Both these shafts are rotated in the counter-clockwise direction. To allow the profile of the latch lever (*fig.* 3) to lift from engagement with the disc, the slipping clutch permits the tuning shaft to remain stationary whilst the cam on the selector shaft lifts the latch lever. Movement of the latch lever operates a connecting arm which closes contact SF. After the latch lever has lifted, the tuning shaft is able to rotate towards the zero position.

13. When the tuning shaft has reached the zero position, contact SB is closed. The drive to the tuning shaft is then allowed to slip by means of the slipping clutch, the selector shaft continuing to rotate until the mechanically driven selector switch (SE) coincides with the selected segment of the remote control switch, thus putting an earth connection on to relay RLA/4, the fine location interrupter spring set contact is also closed.

14. When this occurs relay RLA/4 is energized and is held in by its self-locking contact RLA3. The motor is then made to reverse by the action of the change-over contacts RLA1 and RLA2 (*fig.* 4) thus the direction of rotation of the shafts is reversed. A free-wheel arrangement disconnects the motor drive to the selector shaft, the location for the profile of the selected lever having now been provided.

15. The tuning shaft continues to rotate until the second profile of the selected lever enters the notch of the disc required, here the tuning shaft is mechanically arrested and the contact SF is opened by the operation of the selected latch lever dropping into position, thus breaking the current supply to the motor. The motor is allowed to run down against the slipping clutch. At this point the required channel has been selected by the frequency selector mechanism.

Tune circuit

Note . . .

All components prefixed (12) *refer to the Tuner Radio Frequency.*

16. Selector unit 5985-99-999-8557 circuit diagram (*fig.* 11) should be referred to whilst reading the following description of the operation of the selector unit. During the channel-selection phase, switch (11B) SF opens across D2 and D1 of (11B) PLA and thus de-energizes guard relay B/1 which operated when power was first supplied to the equipment. The guard relay contact B1 opens to interrupt the supply to switch SB and so prevents multiple operations of the network impedance matching, during channel selection, due to rotation of the drum selector (DS).

17. At the same time, the channel selection

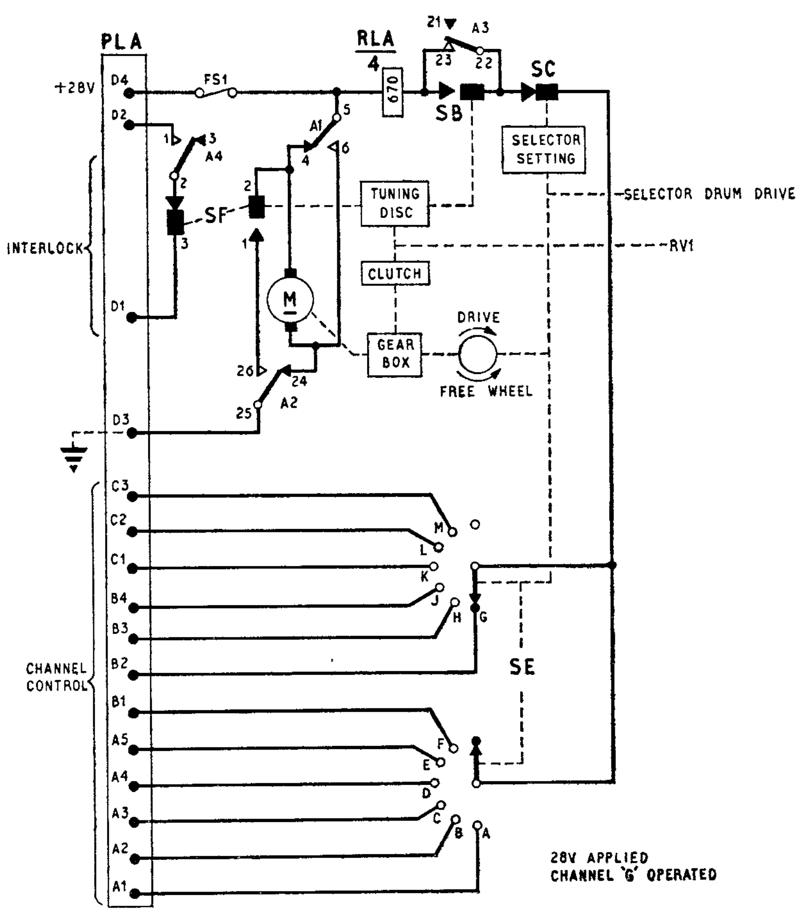


Fig. 4. Operating conditions, control frequency selector circuit

mechanisms on the transmitter-receiver equipment place an earth on PLA/24, the tune line, for as long as channel selection of the transmitter-receiver continues. The TUNE lamp ILP indicates via SKTB/23 and as soon as contact B1 closes, tune relay TA/2 also operates. Contact TA1 connects the tune relay TB/2 in circuit across the motor (12) MG1 located in the tuner radio frequency (Sect. 3,Chap. 2). Contact TA2 earths relay coil (11C) TA/1 which closes contact (11C) TA1 and thus connects the input of the servo-amplifier to the bridge-error transformer T2.

18. Normally, the bridge will now be unbalanced, and motor (12) MG1 will be energized at 28-volts from the selector control sub-assembly. Relay TB/2 will operate and earth the tune line through relay contact TB2. This guards against tuning operations on the transmitter-receiver ceasing before the aerial tuning is complete. Relay contact TB1 places an earth on the "interlock out" line to the transmitter-receiver to prevent r.f. power being applied before the aerial is fully tuned.

19. The condition described in para. 18 continues until the tuning capacitor (12) C1 also located in the tuner has reached its chosen position at the balance point of the bridge circuit. At this point relay TB/2 is de-energized and when the earth is removed from PLA/24, all earths are removed from the tune line; relay coil TA/2 is also de-energized. The TUNE lamp ILP extinguishes, and relay contact (11C) TA1 connects the servo-amplifier to the synchroverter (chopper) (11C) X1, via resistor (11C) R4, ready for the auto-tune cycle.

The a.c. bridge circuit

20. The bridge circuit is used to select the required approximate tuning position (pre-set) of the tuning capacitor (12) C1. This enables the auto-tune circuit to carry out the final tuning correction quickly on transmission, whilst also permitting the aerial to be used for reception.

21. When a channel is selected, potentiometer RV1 is rotated to a pre-selected position by the channel selector.

22. Potentiometer RV1 forms, with (12) RV1 located in the tuner radio frequency, a wheatstone bridge circuit earthed at RV1c, to which point an independent earth is brought via SKTB/21 from (12) RV1. Power is supplied to the bridge at 12V r.m.s. 400 c/s at RV1a from the secondary of T1 connections 6 and 7. The bridge "detector" is connected from the moving contact of RV1b to that on (12) RV1 via SKTB/20 and consists of the winding 1-2 of T2, the detector transformer.

23. When the bridge is balanced by movement of (12) RV1, the current through the winding 1-2 of transformer T2 falls to a minimum. Potentiometer (12) RV1 is geared to the motor (12) MG1 which rotates the variable capacitor (12) C1. The voltage to ground across the secondary winding 5-6 of T2 falls to a minimum and reverses in phase as the bridge passes through the balance point.

24. Any error signal from the secondary of T2 is connected to the servo-amplifier at (11C) PLA/8 and so operates the tuning motor (12) MG1 when (11C) TA1 has operated. When balance is reached (11C) TA1 releases, and the bridge circuit is disconnected from the amplifier, it then has no further control until the tune line is again earthed by a channel change, or key operation of the fine-tune circuit.

25. Mechanical stops on the potentiometer RV1 effectively place fixed resistors of 7 ohms (approx.) at each end of the potentiometer track at "a" and "c". These resistors effectively limit the travel of potentiometer (12) RV1 and thus provide "electrical" stops inside the mechanical stops of the capacitor drive gearing in the tuner radio frequency.

Fine-tune circuit

26. This circuit allows the aerial to be tuned a small amount about the position selected by the channel-change bridge circuit during reception. This facility is intended for signal searching, or correction of the tuning under radio silence operation. (The aerial automatically becomes accurately tuned as soon as any short transmission occurs).

27. The fine-tune circuit comes into operation as soon as the mechanically-biased switch (6) SE on the remote control unit is closed (*fig.* 11). Thus an earth on PLA/22 energizes the fine tune relay FT/2 through contacts TA2 and K1. Relay contact FT1 closes, holding in relay FT/2 whilst at the same time energizing relay (11C) TA/1; the biased switch on the remote control unit then no longer has any control. Relay contact FT2 has closed thus connecting the 400 c/s supply from the moving contact of RV1 to an auxiliary bridge formed by R1 and R2 and the fine tuning potentiometer on the remote control unit mounted in the aircraft cockpit. Normally the potentiometer is set in its centre position and as R1 = R2, the bridge is balanced. If the fine tuning potentiometer is moved away from its centre, an out-of-balance current flows through winding 3-4 on T2. This induces a small error signal into winding 5-6 on T2 this signal is fed into the servo-amplifier to cause a shift of the tuning motor (12) MG1. Hence variation of the fine tuning control about its centre position will cause a variation of capacitor (12) C1 about the selected channel position.

28. Ideally, the full variation of the fine tuning control potentiometer should produce a constant percentage change in the resonant frequency tuned by variable capacitor (12) C1, no matter what centre frequency has been selected. Some attempt is made to achieve this in altering the supply voltage to the auxiliary bridge by taking it from the moving contact of RV1. Thus, when the variable capacitor (12) C1 is at its maximum, full voltage is applied to the drive motor giving a corresponding large shift of the capacitor. At the capacitor minimum position i.e. at the h.f. end of the band, the supply voltage and capacitor shift are correspondingly reduced. The actual amount of fine tuning shift obtained will depend on the setting of the fine tuning control.

29. As soon as r.f. power is supplied, the aerial will be accurately tuned by the auto-tune action and for that particular channel, fine tuning will no longer be required.

30. Thus the fine-tune action is cancelled as soon as the key line is earthed. Relay coil K/2 then energizes operating contact K1 to de-energize the fine tune relay FT/2. Contact FT1 then allows relay (11C) TA/1 to energize, thus operating contact (11C) TA1 to accept the auto-tune error signal. The fine tuning action is also cancelled every time a channel is changed, when contact TA2 releases relay FT/2.

Keying circuit

31. When the key line from the transmitter-receiver is earthed, relay coil K/2 is energized and contact K1 cancels the fine tune circuit (para. 30), whilst contact K2 connects the 400 c/s supply to the chopper (11C) X1. This operation only allows the latter to operate during transmission, when it is needed for the auto-tune cycle, and greatly extends its expectation of life.

Servo-amplifier operation on a bridge error signal

Note . . .

The components contained in the amplifier, electronic control (servo-amplifier) all have the prefix (11*C*).

32. Operation of the a.c. bridge occurs during channel change and fine tuning, when relay TA/1 has operated.

33. A circuit diagram of the servo-amplifier is given in fig. 7. The 400 c/s error signal obtained from the a.c. bridge is connected at PLA/8 and hence through to the input capacitor C6 via relay contact TA1. Components C1 and R1 provide a phase-shift which, with that through the amplifier, totals 90 degree at the control winding of motor PR/1. Capacitor C2 functions as an r.f. bypass capacitor.

34. The transistor amplifier is conventional, the input transistor VT1 being operated in the grounded-emitter mode. The error signal at the output of VT1 is coupled via C9 to the base of VT2 which is also operating as a grounded-emitter amplifier. The error signal is further amplified in transistor VT3, which forms the driver stage for the output push-pull pair of transistors; transformer T1 is the driver transformer. Transistors VT4 and VT5 (*fig.* 5) are operated as a push-pull power amplifier, the output from this is used to control the direction of rotation of a 400 c/s two-phase motor PR/1 (*fig.* 5). A centre-tapped control winding L4 on the motor PR/1 forms the load for the output transistors.

35. To provide improved operation at low temperatures, negative feed-back is applied to the first three transistor amplifier stages by the omission of the decoupling capacitors normally found across emitter resistors.

36. The reference winding L3 of the motor PR/1 is supplied directly at 28V r.m.s. from transformer T1 via PLA/4 and as explained previously (para. 33), this has a 90° phase difference from the control winding L4, due to the amplifier.

37. When the error signal is zero at the amplifier input, the motor shaft will not rotate. When the error increases the rotor will turn in one direction or the other, depending on the phase of the input signal. The rotor shaft of the motor PR/1 carries a disc with a cut-out which engages with the centre spring of a change-over contact set. These contacts are arranged to short circuit socket (11D) SKTA pins 3 and 4, or 4 and 5, on the reduced

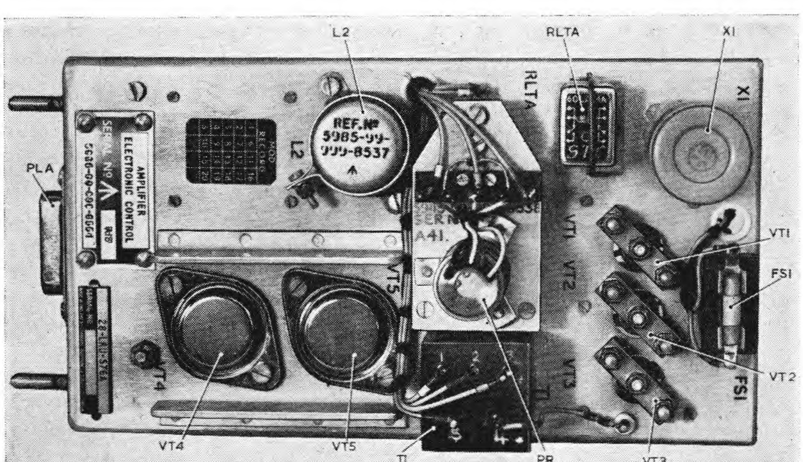


Fig. 5. Amplifier electronic control—top

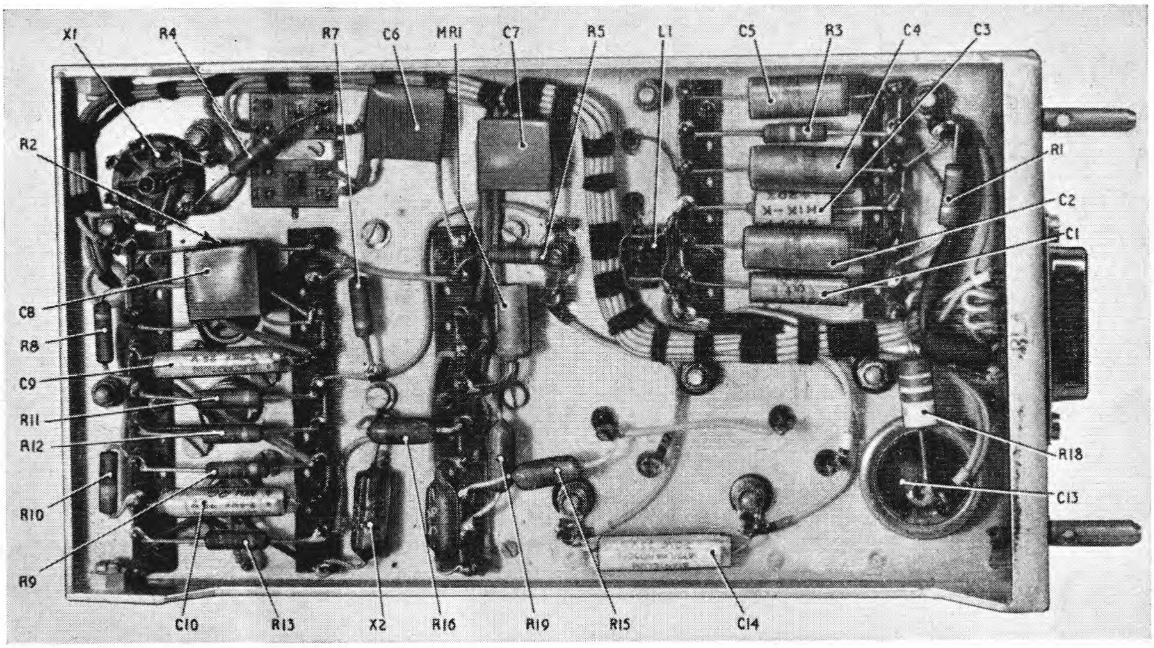


Fig. 6. Amplifier electronic control—underside

speed unit (*fig.* 11). When the error signal passes through zero a 180° phase change is obtained and applied to the motor PR/1 via the amplifier, this reverses the direction of the motor; hence the motor PR/1 effectively acts as a phase relay.

38. Fuse FS1 is included to protect the control winding of the motor in the event of a fault developing in the output stage.

39. The combination of the disc cut-out together with the stiffness of the centre spring of motor PR/1 allows a "dead zone", this prevents chatter of the tuning motor (12) MG1 located in the tuner radio frequency.

Servo-amplifier operation on an auto-tune error signal

40. Under auto-tune conditions contact TA1 is in the rest position (normally closed). The error signal, which is positive or negative relative to earth, appears on PLA/13 and is obtained from the network impedance matching. Inductor L1 (*fig.* 6) and capacitor C3 provide r.f. filtering on the error line, whilst L2 and C4 operate as an a.f. filter to remove modulation and 400 c/s stray pick-up. The signal via these filters is applied to contact 1 of the chopper X1 (*fig.* 6) and through the relay contact TA1 to the base of transistor VT1.

41. The chopper X1 is energized only when the error signal is present, i.e. when the key line is earthed. When this occurs relay contact K2 closes and connects the 400 c/s supply from transformer (11A) T1, reduced to 6 volts by R3 (on the main chassis, fig. 11), to the coil of X1. The chopper contact 1 is then cyclically earthed at 400 c/s, thus the potential between contact 1 and earth falls from full error signal to zero at 400 c/s. This produces a 400 c/s square wave signal at the base of transistor VT1. Components R3 and C5 introduce a phase-lead and are connected via the

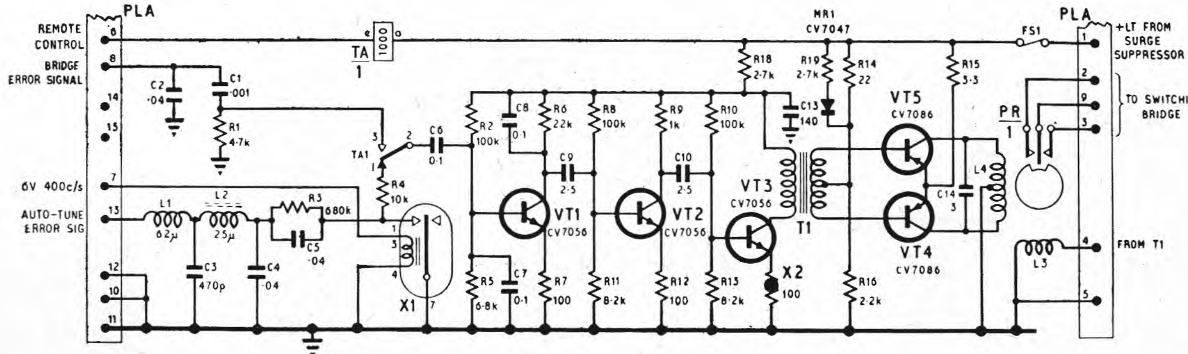


Fig. 7. Amplifier electronic control—circuit

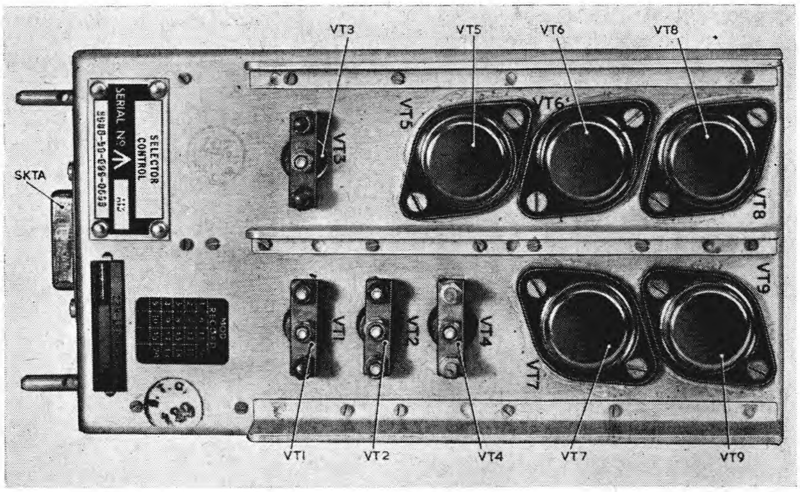


Fig. 8. Selector control sub-assembly, top

moving contact of X1 to ground; the phase-lead obtained aids the overall servo stability.

42. Thus the amplifier is now provided with an a.c. error signal equal in amplitude to the d.c. error signal and which reverses in phase when the polarity of the d.c. error signal changes. The amplifier then operates exactly as explained in para. 33 and 34.

Selector control sub-assembly 5985-99-999-8555 (*fig.* 8 *and* 9)

43. This selector control sub-assembly (reduced speed unit) has two functions, one to act as a reversal switch to the servo motor (12) MG1, and the second to reduce the speed of this motor, when the equipment is approximately on tune, to increase the servo stability. All components in this sub-assembly have the prefix (11D).

Motor switching function

44. Motor switching is carried out by the four transistors VT6-9 (*fig.* 8) arranged in a bridge circuit (*fig.* 11). The emitters of transistors VT8 and VT9 are connected to +28 volts at the r.f. filter C4-L2. The common collectors of transistors VT6 and VT7 can be considered as approximately at −28 volts (earth) through transistor VT5.

45. With the phase relay (11C) PR/1 in the centre position, all four transistors have their respective bases and emitters at the same potential, the connecting resistors being of a low value. Thus all four transistors are in a high impedance (cut-off) condition, and the motor terminals at SKTA/6-7 are at a common potential, leaving the motor (12) MG1 at rest (Sect. 3, Chap. 2).

46. If (11C) PR/1 now operates to make connection between SKTA pins 4 and 5, the base of transistor VT7 is connected to the collector, the transistor thus becomes of low impedance (conducts) and SKTA/7 is effectively at −28 volts d.c. Current passes through resistors R15 and R13 making the base of transistor VT8 negative, causing it to conduct, which opens up this transistor to the 28-volt line thus connecting SKTA/6 to +28 volts. The motor will then run

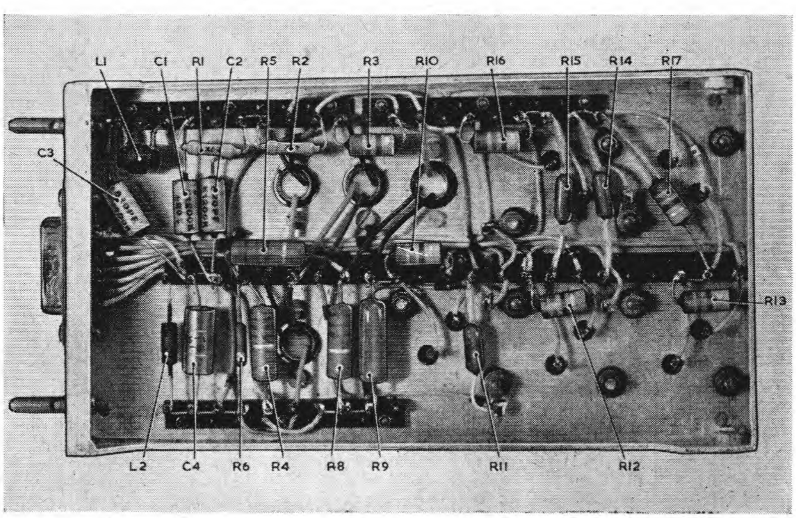


Fig. 9. Selector control sub-assembly, underside

because it is in series with the two transistors VT7 and VT8. When (11C) PR/1 reverses, a similar action causes transistors VT6 and VT9 to conduct, thus reversing the polarity of the current applied to the motor and also its direction.

Reduced speed operation

47. Fast operation occurs when the variable capacitor (12) C1 (in the tuner radio frequency) is moving in a position well off the final tuning setting. Reduced speed occurs only when (12) C1 is close to the final setting point.

48. All the current for the transistors in the switching bridge and thus the motor current, is drawn through the regulator transistor VT5. In the fast condition, as soon as the switching bridge has opened, transistor VT5 will conduct, as its base current is only limited by R9 (180 ohms). This condition continues throughout the fast tuning phase.

49. However, as the aerial cavity is tuned to near resonance, a negative potential to earth of —2 volts approximately is produced by the impedance matching network at SKTB/6 (Sect. 3, Chap. 3, para. 13). This potential is applied to the base of transistor VT1 via SKTA/2 (*fig.* 11); capacitors C1, C2, C3 and inductor L1, forming an r.f. filter. The potential thus applied reduces the base current of VT1, and hence the collector current. This in turn increases the current through the emitter-followers VT3, VT4 and finally reduces that of transistor VT5, which carries the full motor current, switched by the transistor bridge. This reduced motor current in the permanent magnet motor reduces its speed to about one fifth of its full speed.

50. Such a form of speed control will reduce the motor torque available and this could be serious when the motor is to work at low temperatures with a variable mechanical load. To compensate for this to some extent a positive feed back circuit is used. If the mechancial load on the motor tends to increase, its speed will drop and thus the back e.m.f. across the armature will also decrease. The emitter potential of transistor VT5 will rise relative to earth and the collector current increase slightly, causing the potential across resistor R11 to rise. This potential is fed back to the base of transistor VT2, causing it to pass more current hence reducing the potential of the base of transistor VT3 and so decreasing the emitter current of the latter.

51. This effect operating through transistor VT4 allows more current to flow in transistor VT5 and effectively increases the potential applied to the motor, increasing its torque and allowing it to overcome the increased mechanical loading. In the event of the mechanical load now decreasing, the reverse sequence occurs.

52. The effect of this positive feedback circuit is to compensate for mechanical load variations in the reduced speed condition, whilst at the same time keeping the motor at approximately the same reduced speed.

Surge suppression of 28-volt d.c. supply

Note . . .

All components used in the surge suppression circuit have prefix 11A.

53. The 28V d.c. aircraft supply can provide high-voltage short-duration transients, which could break down the transistors used in this equipment or decrease their performance with life. The surge suppression circuit (*fig.* 10) using transistors VT1 and VT2 (CV7086) functions to provide protection against this. Normally the base and emitter of VT1 are of a similar potential, because the value of R7 is low, and thus VT1 does not conduct. The supply current to the servo-amplifier and reduced-speed unit passes from the 28-volt supply through diode MR4 and transistor VT2. When the supply voltage rises transiently above 33 volts (approx.), the three Zener diodes MR1, MR2, MR3, start to conduct and hold the potential between MR1 and earth constant at 33 volts. The base of transistor VT1 then falls in potential (becomes more negative) VT1 conducts and by effectively connecting the base of transistor VT2 to the emitter of VT1, this causes VT2 to cut off, thus interrupting the d.c. supply to the equipment from terminal strip TS7, except through R10 which has a comparatively high resistance.

54. The connection from terminal strip TS7 supplies the necessary power to both the reduced speed unit and the servo-amplifier.

Drum selector circuits

55. As described in para. 10 selection of a particular channel on the remote control unit will turn the drum selector DS to that channel position. This drum carries twelve vertical slots each of which locates with a contact stud in one of eleven positions. The contact stud can be adjusted, on setting up, from the front of the unit to a chosen "tap". The stud, which is earthed, makes contact with one of eleven contact strips connected to SB1.

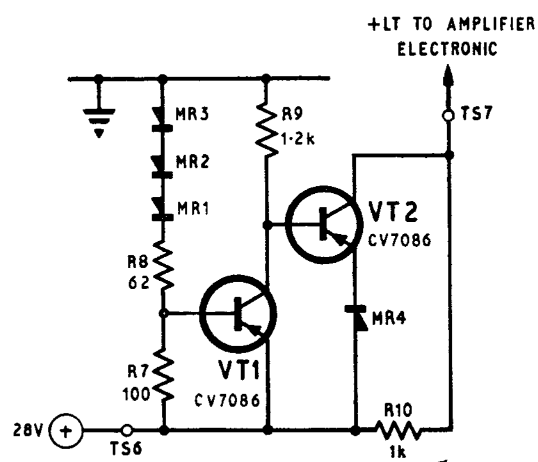


Fig. 10. Surge suppressor 28-volt d.c. supply

56. The drum has a dual function for each channel.

(1) To select the appropriate matching tap on the network impedance matching.

(2) To select one or more parallel capacitors in the tuner radio frequency if needed, for the particular channel frequency selected.

An earth applied to one contact of switch SB1 allows the stepping solenoid SB/6 to rotate switch SB (relay contact B1 is closed) until this earth is removed by the alignment of a "cut-out" segment of switch SB1 with the chosen switch position. Switch SB5 has then taken up its selected position, since it is mechanically connected to SB1, being part of switch SB. Switch SB5 is connected via a six-wire circuit to the network impedance matching; the position of which SB5 determines the tap position selected.

57. In certain positions, SB2, SB3 and SB4 connect a 28-volt supply to pins on SKTD. Plug PLC, which mates with this, can be linked so that this supply is connected through to the relays for capacitor selection in the tuning unit. Plug PLC is prewired and is unchanged for any one type of aircraft and so forms part of the calibration of the equipment.

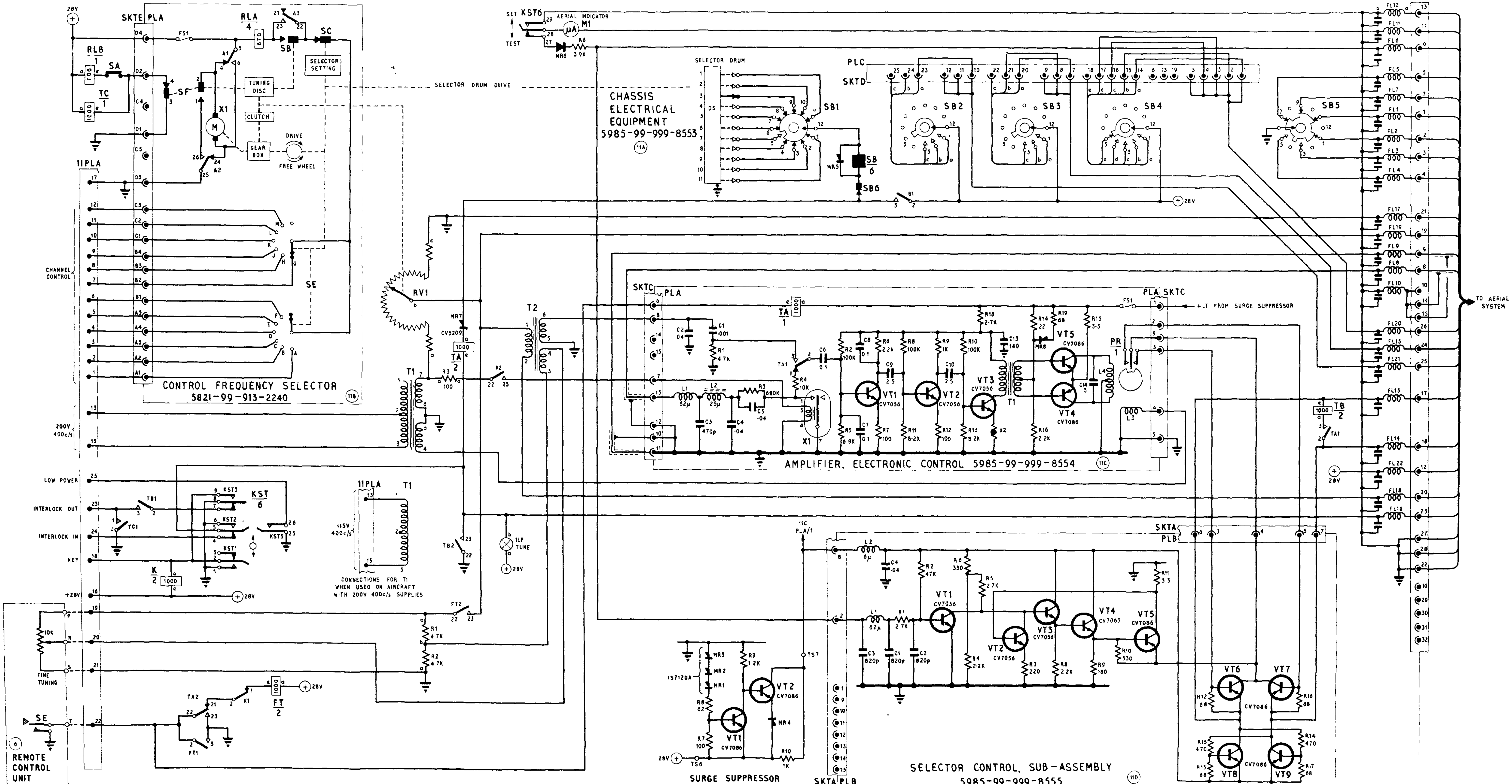
58. While the access door to the drum selector is open, microswitch SA is broken, thus preventing the stepping solenoid SB/6 from following taps selected when the drum is being rotated manually during setting up or calibration.

59. Rectifier MR7 prevents lamp ILP (TUNE) from glowing due to the "false" earth obtained via the resistance of relay TA/2 and a contact on the selector drum.

Setting up the bridge circuit

60. Under radio silence conditions it is necessary to set the bridge potentiometer RV1 (*fig.* 11) so that the notch will be tuned to resonance at a particular channel frequency; this will then allow reception.

61. Setting the bridge circuit requires that the cams of the control frequency selector are set accurately to the calibration provided. As the scale of the setting knob is limited in clarity by its dimensions, a gear train of 10 : 1 step up ratio is provided from the shaft of RV1. This gear train drives a SETTING counter which is displayed on the front panel of the selector unit (*fig.* 1), this counter shows the angular setting of potentiometer RV1 in degrees. The calibration setting is then made on the counter to the nearest whole number.



Selector unit 5985-99-999-8557: circuit

Fig. 10

Chapter 2

(*Completely revised*)

TUNER RADIO FREQUENCY 5950-99-999-8558

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The function of the tuner radio frequency is to resonate the total inductance of the aerial cavity plus the connector radio frequency to form a tuned circuit to the particular frequency in use. The tuner radio frequency is simply a variable tuning capacitor arranged to operate via remote control in conjunction with other component parts forming the suppressed aerial.

2. The unit has for its base a circular cast chassis (*fig.* 1) on the top surface of this are mounted four insulating pillars which support a circular top plate. Between these two faces are mounted three fixed and one variable capacitor, all of these are of the glass envelope vacuum type. An intermediate fibre-glass plate is used to support the lower end of each fixed capacitor which is coupled to a vacuum switch mounted below it.

3. Each of the three vacuum switches is actuated by a d.c. solenoid, the latter being mounted below the surface of the base casting.

4. The concentric plate type variable capacitor is retracted by a forked crank through a bellows coupling seal to decrease capacity, the return motion to increase capacity being due to atmospheric pressure limited in effect by the crank. A return spring is fitted to assist the return action of the crank at high altitudes.

5. The crank has a gear sector attached to it, the latter is located beneath the chassis; this gear sector is rotated by a reduction gear train from a small d.c. servo motor. Coupled to the gear train is the moving arm of a variable-resistance this provides the position information of the variable capacitor to the selecting mechanism.

6. Connection to the tuner radio frequency is by the 19-way socket SKTA (*fig.* 1) on the side of the chassis; r.f. connection is also made by means of the connector radio frequency which is attached to the circular flange on the top face.

Circuit description

Note . . .

The prefix (12) *which applies to all references in this section is omitted in the text.*

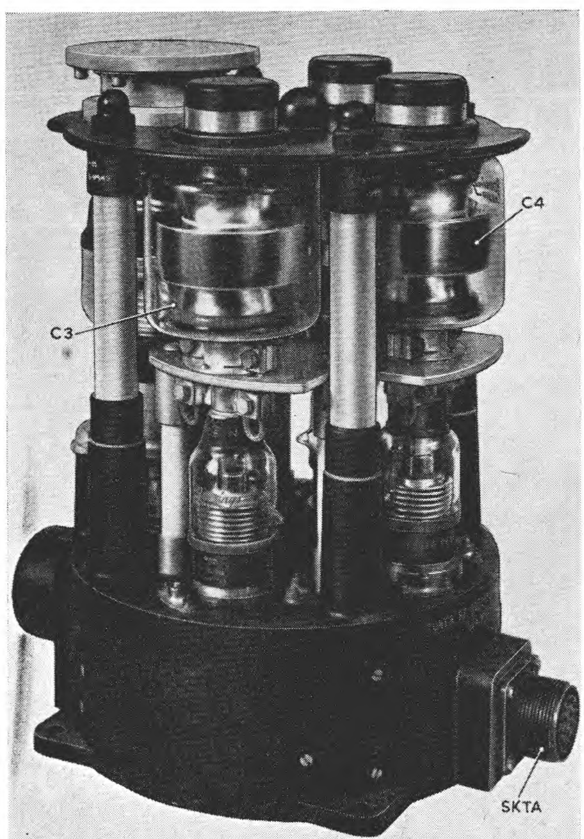


Fig. 1. Tuner radio frequency, top

WARNING . . .

This unit is operating in a tuned circuit; the whole of the metal top plate and surrounding area is at a high potential point in this circuit. As potentials of several thousand volts are present great care should be exercised in the vicinity of this unit when it is operating.

7. The connector, radio frequency is attached to the variable-capacitor C1, one side of which is earthed. This variable capacitor C1 is driven through a gear train by motor MG1 (*fig.* 2); the speed of the motor is controlled by the reduced speed unit (selector control sub-assembly, Chap. 1, para. 47). Potentiometer RV1 (*fig.* 3) is also geared to the same gear train such that the full movement of RV1 is obtained over the whole of the capacitor travel. The potentiometer RV1 is used to control the setting of the capacitor C1 under the bridge condition described in Chap. 1, para. 20.

8. Three fixed capacitors C2, C3, C4 may be switched in parallel with C1 by vacuum switches BA1, BB1, BC1 these being actuated by relays BA/1, BB/1 and BC/1 (*fig.* 2). The filter FL1 is a motor-hash filter.

9. When power is fed to the servo-motor MG1 (*fig.* 3) from the reduced speed unit (selector control sub-assembly), this indicates that the aerial cavity is not at the desired resonance. The motor MG1 will rotate thus driving variable capacitor C1 in such a direction that the aerial cavity is brought into resonance. This decreases the error signal fed to the servo-amplifier and hence the power applied to the motor MG1, under auto-tune conditions.

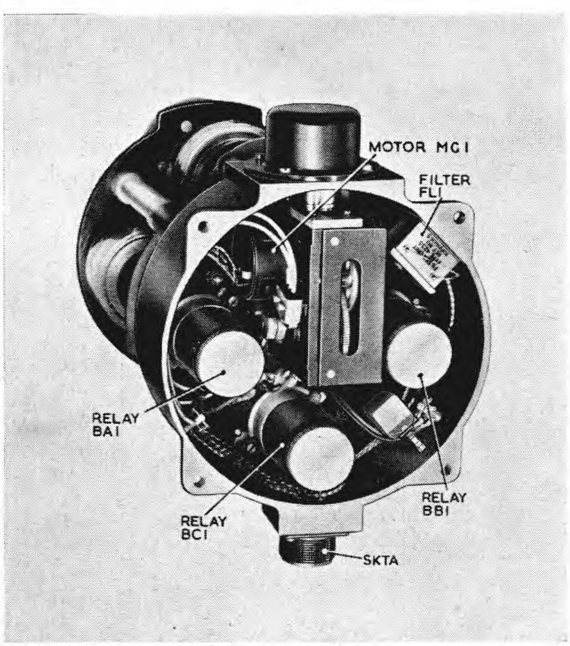


Fig. 2. Tuner radio frequency, underside

10. If the aerial is being used under receive conditions then the motor MG1 receives power from the reduced speed unit via the a.c. bridge and drives the variable capacitor C1 so that the aerial cavity is brought into resonance. This time, however, due to the moving arm of RV1 being mechanically attached to the motor via a gearbox, potentiometer is driven back to a balance position where no power is supplied to the motor MG1 from the servo-amplifier.

Limits of movement of tuning capacitor

11. Limit switches SA and SB in the tuner radio frequency are operated when capacitor C1 reaches either end of its travel. This component is limited in its travel in three ways, by:—

(1) mechanical stops
(2) electrical stops
(3) electrical limit stops

Mechanical stops

12. These stops are fitted on the gear train of the tuner radio frequency and are intended only to come into operation under extreme conditions, e.g. due to broken control wires. Because of the very high torque applied to the variable capacitor actuating arm, the mechanical stops are operated by cams on the final drive pinion shaft of the motor. The cams allow cranked pawls to operate at the stop position and thus apply the stop to the worm wheel shaft at the low torque end of the gear train. The mechanical stops are placed at the extreme limits of the safe limit of travel of the variable capacitor C1.

Electrical stops

13. While the bridge circuit is in operation the electrical stops are provided by the end resistances on (11) RV1 which result from the mechanical limitation of the travel of the moving arm of (11) RV1 located on the cam assembly of the control frequency selector (11B). These end resistances would limit the travel of RV1 (*fig.* 3) such that its end resistances equalled those of (11) RV1 (not shown on fig. 3), assuming that the connection between RV1 and (11) RV1 are of negligible resistance.

Electrical limit stops

14. When the suppressed aerial equipment is working under auto-tune conditions the electrical stops described above in para. 13 become inoperative, because the bridge circuit is no longer in use.

15. In this case if the variable capacitor C1 should move to its limits, a cam on the shaft of RV1 operates either switch SA or SB which earths the tune line via SKTA pin G on the tuner radio frequency.

16. Thus earthing the tune line immediately returns the circuit to the bridge position and the varaible capacitor C1 driven by the motor MG1 will home to this position. Power will be cut off as TB1 will earth the "interlock out" line at 11 PLA pin 23. The tune lamp ILP will glow until the bridge balance is obtained.

17. It is possible that the "fault" will now cause the auto-tune circuit to again drive the variable capacitor C1 to the end stop and the process will repeat giving slow flashing of lamp ILP; this indicates a fault condition.

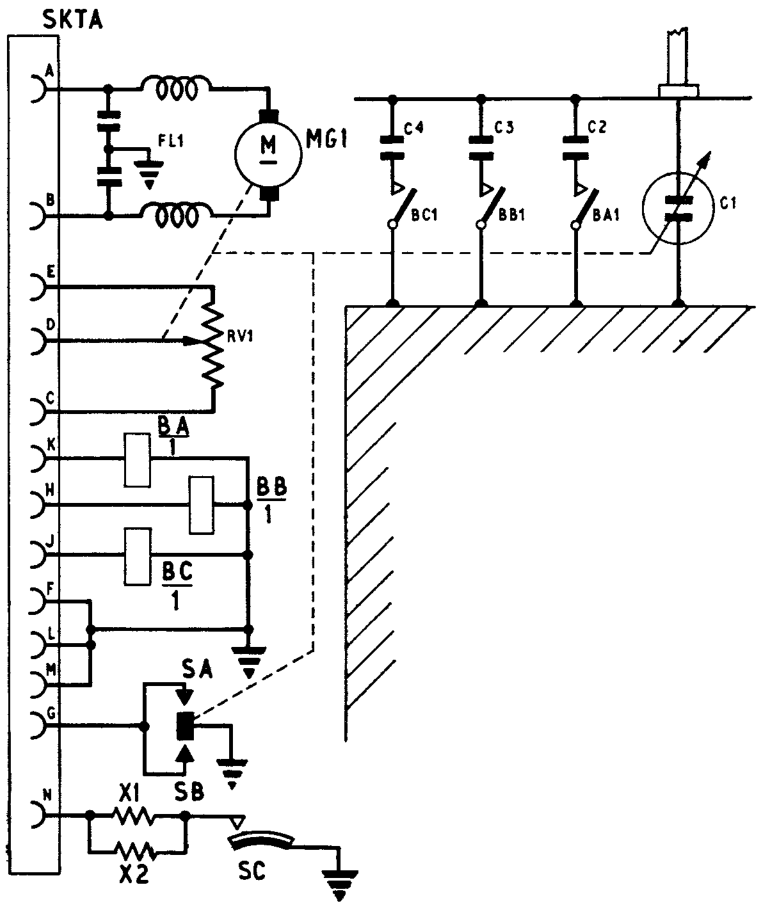


Fig. 3. Tuner radio frequency 5950-99-999-8558, circuit

Chapter 3

NETWORK IMPEDANCE MATCHING 5915-99-999-8556

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. For maximum transfer of r.f. power from the transmitter-receiver to the aerial it is necessary for good matching to be obtained between these two items. The network impedance matching used in the suppressed aerial system provides the required matching facility between transmitter-receiver and aerial, thus ensuring that maximum r.f. power is being transferred to the aerial under all operating conditions. Matching indication is also provided.

2. The network impedance matching 5915-99-999-8556 (matching unit fig. 1) is a separate unit which is mounted inside the aerial cavity of the aircraft. At the forward end of the matching unit, a rod is mounted, to this is attached the connector radio frequency 5995-99-999-8552. The connector radio frequency is attached at its other end to the tuner radio frequency 5950-99-999-8558 and thus forms a conductor for the r.f. currents which circulate around the cavity.

3. Around the rod, which is part of the matching unit is a screened transformer, the rod forming a "single turn" primary winding. This screened transformer is used as the error transformer in the matching unit; it also provides the monitor indication.

◀**4.** Above the screened transformer is a ferrite cylinder on which is wound (toroidally) the matching transformer in two air-spaced layers; the rod again forming the "single turn" secondary winding. The winding has ten tapping points. Leads from these tapping points are taken through a dielectric window to the screened box adjacent (fig. 1).▶

5. The screened box contains a solenoid-operated switch which selects the required taps on the matching transformer. Below the screened box and accessible when the base cover is removed are the associated components of the error and monitor circuit (*fig.* 2).

6. At the rear face of the base is a further transformer which is used to provide the matching (reflectometer) indication.

CIRCUIT DESCRIPTION

Note . . .
The prefix (13) *which applies to all circuit references in this section is omitted in the text.*

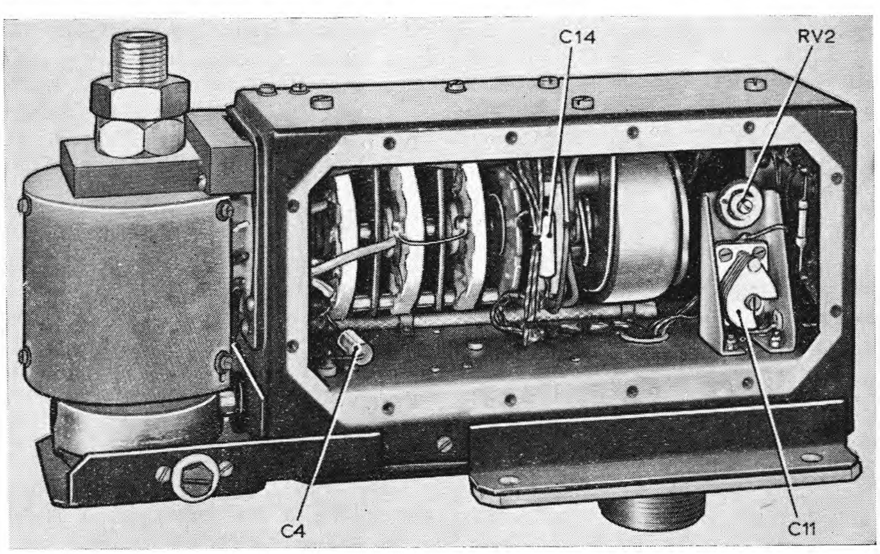


Fig. 1. Network impedance matching, front

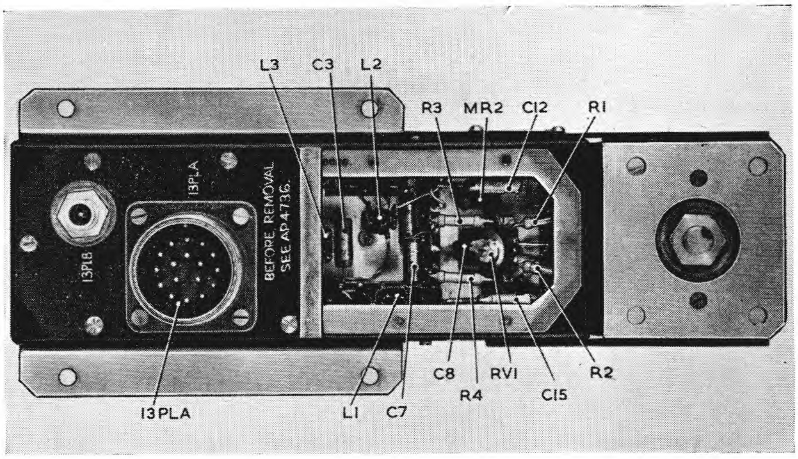


Fig. 2. Network impedance matching, rear

Matching transformer

7. Output power from the transmitter enters the network, impedance matching at PLB (fig. 2) and is transferred by co-axial cable to contact 1 of switch SA4 from where it is connected to one of ten taps on the matching transformer, depending on the selected position of S.A. Transformer T1 is a toroidal transformer wound with a two-layer primary winding on a ferrite core, the secondary being formed by a 0·625 diameter rod reduced in diameter slightly through the core. This is attached to the connector radio frequency when the equipment is installed and is thus part of the notch circuit. On certain tap selections the primary winding of T1 is open-circuited into two or three sections by switches SA2 and SA3. This is to prevent unwanted resonances in unused turns when a low turns-ratio is chosen. Trimmer condenser C15 is used to adjust stray capacity across SA3 and the associated windings to a known value. The stepping solenoid is used to position the three switch banks SA2, SA3, and SA4 depending on the earth position on switch bank SA1. The air-spaced winding of T1 is protected against handling by a cylindrical fibre glass cover.

8. The stepping solenoid SA4 positions switch wafer SA depending on the "earth" position on SA1.

Reflectometer indication

9. A toriodally wound transformer with a ferrite core T3 has the 50-ohm r.f. input connector from PLB as a "single turn" primary. The secondary voltage of this transformer developed across the diode MR5 (*fig.* 3) is proportional to the r.f. line current. A capacity potential-divider C10, C11 connected between the r.f. connector and earth provides a potential at R6 proportional to the voltage on the line.

10. These two voltages are effectively added across diode MR5, which by rectification of the r.f. voltages produces a d.c. potential at PLA pin N. The secondary of T3 is connected in such a way that when the line voltage and current are in phase the two potentials across MR5 are in opposition.

11. When the line is correctly terminated by 50 ohms, the line voltage and current are in phase and C11 is adjusted so that their effects are equal, thus a minimum (nominally zero) d.c. potential is produced at PLA pin N. This minimum near zero, indicated on a meter connected between PLA/N and L4 is used to indicate when the matching transformer T1 tapping point is correctly selected.

Monitor indication and reduced speed signal

12. A second toroidal transformer T2 with a shielded dust iron core is mounted concentrically with T1, the transformer T2 also has the connecting rod as its primary. The full aerial circulating current induces a voltage proportional to this current in each of two independent windings of the transformer T2.

13. The winding connected to MR4 acts as a current detector and its rectified output, negative to earth, is used as the monitor indication and as the reduced speed signal in the selector unit (Chap. 1, para. 37).

Servo-error signal

14. The remaining winding of transformer T2 supplies a balanced phase-discriminator. A voltage proportional to the current circulating in the aerial cavity is induced in the winding. The phase of this voltage is compared with that of the voltage produced by the potential divider network C4, C8, obtained directly from the r.f. input. When the two voltages obtained as described above are in phase the d.c. output of the diodes MR3 and MR2 is zero. Capacitors C12, C13 are small trimmers; these allow some adjustment of balance of the discriminator.

15. As the voltage induced in the aerial cavity is substantially in-phase with the input voltage to the transformer T1, the discriminator effectively compares the phase of the induced current and voltage in the aerial cavity. Zero output from the discriminator indicates the notch is at resonance; and any output signal due to non-resonance of the aerial cavity is used to operate the servo system tuning the aerial cavity (Chap. 1, para. 43).

16. Filtering at r.f. is provided by L1, L2, C3 and C7 in the error lines at PLA/J and H. When a phase difference is present the error signal appears as a +ve or −ve potential on PLA/H relative to PLA/J.

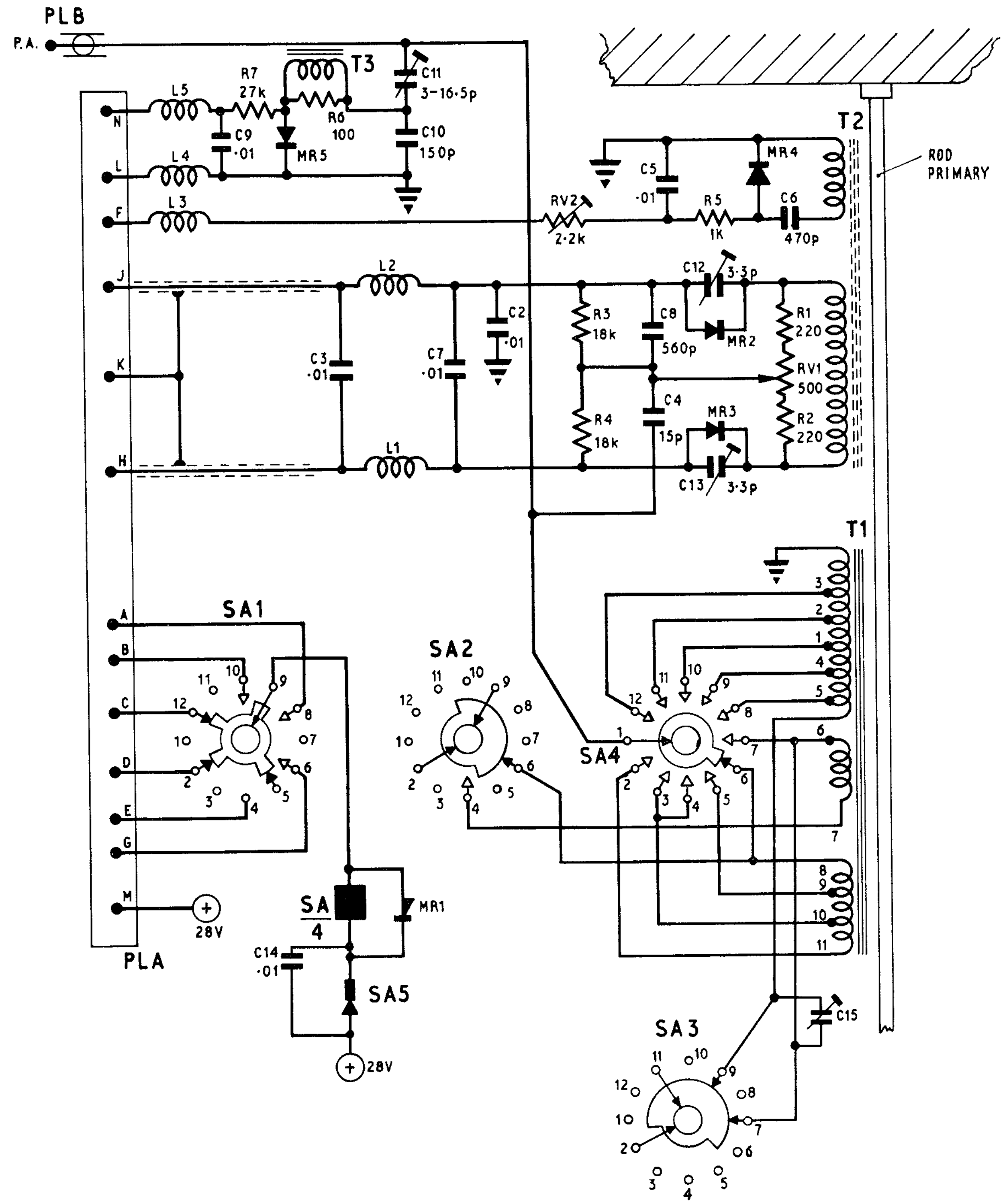


Fig. 3. Network impedance matching 5915-99-999-8556; circuit

Chapter 4

AERIAL SYSTEM 5985-99-999-8559

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

1. Aerial system 5985-99-999-8559 has been designed for use with the airborne single-sideband transmitter-receiver together forming ARI.18179.

2. Notch excitation of the aerial system is used, the inductive component being formed by the boundary walls of the notch in the airframe. The aerial tuning capacitor (tuner radio frequency) can be mounted within the notch and greatly increases the radiated power at some frequencies in the operating band. Tuning is effected by means of a variable capacitor which, with the inductance of the notch, forms a tuned circuit.

3. The aerial system consists of four main items:—

(1) Network impedance matching 5915-99-999-8556
(2) Selector unit 5985-99-999-8557
(3) Tuner radio frequency 5950-99-999-8558
(4) Connector radio frequency 5995-99-999-8552

With the suppressed aerial used (*fig.* 1), the notch is automatically brought into resonance at the required pre-set operating frequency of the transmitter-receiver.

4. At the same time the network impedance matching 5915-99-999-8556 makes the necessary change in the tapping point of the impedance matching transformer to preserve an adequate match between the dynamic impedance of the loaded tuned circuit of the cavity and the 50-ohm aerial feeder carrying r.f. power from the r.f. power amplifier.

Frequency coverage

5. The frequency band covered by the aerial system is the same as that for the transmitter-receiver equipment, i.e. 2·8 to 20 Mc/s. This band is too great to be covered easily by a single variable capacitor, which if used would tend to give a cramped frequency scale and make accurate tuning very difficult. For this reason the tuning capacitor is sub-divided into one variable and three fixed capacitors, the variable capacitor being permanently in circuit and the fixed capacitors being brought in by a relay switching device according to the frequency in use.

Note . . .

A detailed physical description of each of the three main items used in the suppressed aerial system appears in Part 1, *Sect.* 3, *Chap.* 1, 2 *and* 3, *respectively.*

Network impedance matching

◀**6.** In order to simplify the matching arrangements, continuously variable tapping is not used on the aerial system and eleven preset tapping selections are provided by the network impedance matching. The network impedance matching unit also contains a discriminator circuit to provide an error signal; this is fed back to the servo-amplifier which in turn operates the motor drive to the tuner radio frequency thus ensuring the correct tuning of the aerial system.▶

7. A reflectometer matching device is also included as part of the network impedance matching. This device gives an indication of the degree of matching obtained between the transmitter r.f. power amplifier and the notch aerial, the degree of mismatch is shown on a meter (1M1) which is mounted on the front panel of the selector unit (*fig*. 2).

8. At the forward end of the network impedance matching is a circular rod which, having a screwed thread at the top, connects with the connector radio frequency to form a conducting path for the r.f. currents circulating around the notch. Around this rod at its base is a screened current transformer, this provides the error signal (*para*. 44).

9. Above the error transformer is mounted the impedance matching transformer (T1), the tapping points on which are taken through a dielectric window to the adjacent screened box. In this box is a solenoid-operated "Ledex" switch which selects the required tapping points. Below the screened box in the base of the unit are the associated components of the error monitoring circuits. On the inside of the box and around the r.f. connector plug is a further current transformer (T3) which is used to provide the matching (reflectometer) indication.

Selector unit

10. The selector unit is a rack mounted unit fitted in position in the radio bay of the aircraft. A quick-release cover allows access to the top and sides of the unit, whilst a similar cover, when removed, exposes the underside of the shallow chassis of the selector unit.

11. The selector unit contains the servo-elements for selecting a particular channel in the aerial system. It also (*fig*. 2) contains the control electrical frequency (channel selector) as a removable unit behind which is a gear plate; on this is mounted the setting potentiometer RV1 which forms part of a bridge network for channel selection. Above the channel selector is the selector drum switch which is rotated to each channel selected by a plastic-ball chain drive from a sprocket wheel on the gear plate. The sprocket also engages with the channel selecting shaft on the channel selector.

12. Behind the gear plate (*para*. 11), are two vertical panel sub-units each of which connects into sockets mounted in the chassis base. The forward panel contains the servo-amplifier, and the rear one the reduced speed unit. At the rear of the selector unit are the r.f. filter capacitors and the components which make up the surge suppressor circuit. There are two power transistors in the surge limiting circuit and these are mounted on the rear outer face of the selector unit, they are covered by an air ducting system. This is done to obtain the maximum cooling effect for these items.

Tuner radio frequency

13. The tuner radio frequency consists basically of three fixed vacuum capacitors and one vacuum variable-capacitor. The former are selected by relay switching for the frequency band in use, whilst the latter is operated by an electric motor. Outward movement of the adjustable section of the vacuum variable-capacitor is effected through the bellows seal by means of a forked crank; the return motion (increase in capacity) being due to atmospheric pressure.

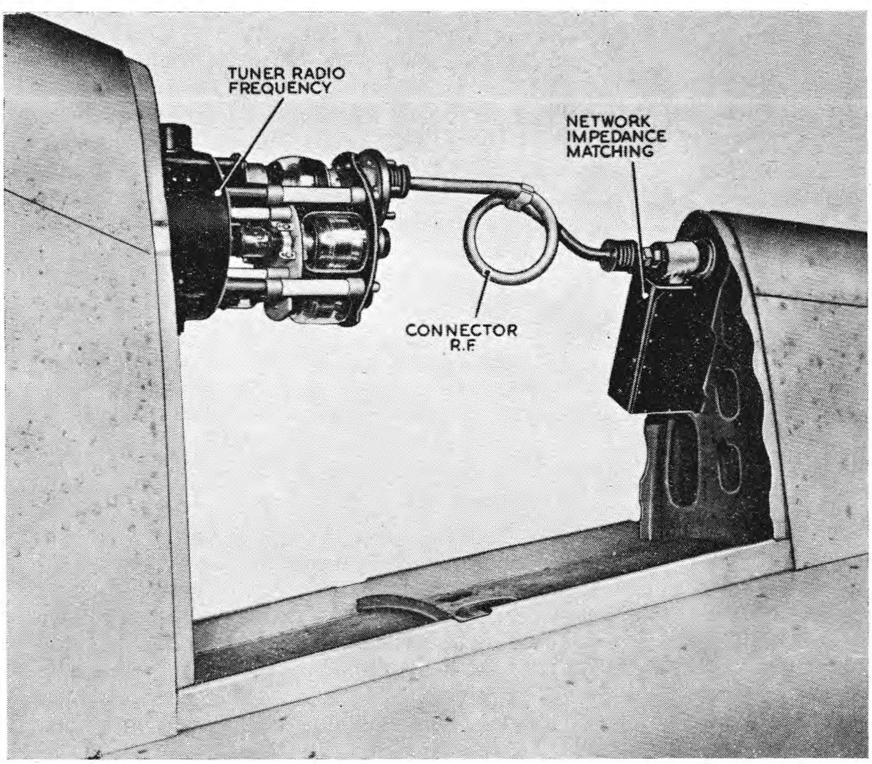


Fig. 1. Suppressed aerial — typical installation in a high speed aircraft

14. The shaft of the variable capacitor and motor, are ganged mechanically to a potentiometer which forms part of the bridge network previously mentioned in para. 11. This provides positioning information for channel selection.

15. Connection to the tuner radio-frequency is made via the 19-way socket (SKTA) on the side of the chassis, and also by means of the connector, radio-frequency which is attached to the circular flange on the top face.

CIRCUIT DESCRIPTION

Note . . .

The following prefix numbers relate to components which are mounted on main chassis and sub-units as follows:—

11*A*. *Main chassis*
11*B*. *Control frequency selector*
11*C*. *Servo amplifier*
11*D*. *Motor speed-control*
12. *Tuner radio frequency*
13. *Network impedance matching*

Channel selection

16. When a channel is selected, an earth is placed on one of the twelve wires from the transmitter-receiver junction box. The channel selector (control frequency selector) operates the tune shaft of potentiometer RV1 rotating it to a pre-determined setting, whilst the select shaft of the channel selector rotates the matching selector drum switch (DS) to the chosen channel position. A circuit diagram of the complete aerial system is given in fig. 5.

17. Dealing with the operation of the channel selector itself. When a channel is selected an earth is removed from relay coil (11A) RLA/4 which is thus de-energized. Contacts RLA1 and RLA2 operate so that a voltage from the supply is applied across the motor X1, with a polarity so that the rotation of the motor will drive the tuning shaft in the return-to-zero direction, whilst at the same time driving the selector shaft. Both these shafts are rotated in a counter-clockwise direction. In order to allow the profile of the latch lever (which is preset to operate on a certain channel) to lift from engagement with the disc (*fig.* 3), the slipping clutch permits the tuning shaft to remain stationary whilst the cam on the selector shaft lifts the latch lever, at the same time the lever closes contact SF. After the latch lever has lifted, the tuning shaft rotates toward the zero position.

18. When the tuning shaft has reached the zero position, contact SB is closed by the travelling nut on the lead screw. The drive to the tuning shaft is then allowed to slip by means of a slipping clutch, the selector shaft continuing to rotate until the mechanically driven switch (SE) coincides with the selected segment of the remote control switch, thus connecting an earth to relay RLA/4 (*fig.* 5). The fine location interrupter spring set contact is also closed.

19. When this occurs relay RLA/4 (*fig.* 5) is energized and is permanently held in by its self-locking contact RLA3. The motor is then made to reverse by the action of the change-over contacts RLA1 and RLA2, thus the direction of rotation of the shafts is reversed into the clockwise direction. A free-wheel clutch disconnects the motor drive to the selector shaft thus providing a location for the small profile of the latch lever.

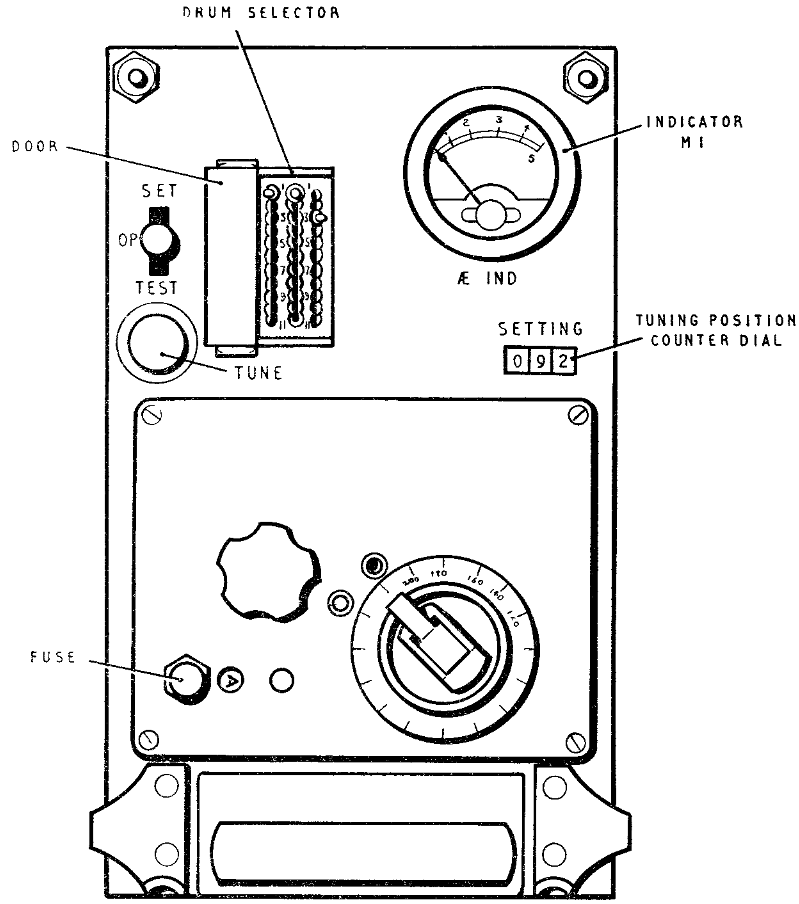


Fig. 2. Selector unit, front panel

20. The tuning shaft continues to rotate until the larger square profile of the latch lever enters the notch of the disc required, here the tuning shaft is mechanically arrested and the contact (11B) SF is opened by the action of the latch lever falling down into the selected notches. When contact (11B) SF opens the current supply to the motor is broken, and the motor is allowed to run down against the slipping clutch. At this point the required channel has been selected.

21. During this channel selection phase, switch (11B) SF opens across (11B) PLA D2 and D1, and thus releases guard relay (11A) B/1 (*fig.* 5) which operated when power was first applied to the equipment. The relay contact B1 opens to interrupt the supply to Ledex switch (11A) SB (on the main chassis) and so prevents multiple operations of the matching unit switch (13) SA during channel selection, due to rotation of the selector drum switch selecting the different contacts as it passes through each channel.

22. At the same time the channel selection mechanism on the transmitter-receiver equipment places an earth on PLA/24, the tune line, for as long as channel selection on that equipment continues. Tune lamp ILP glowing indicates tuning via pins SKTB 17 and 18. The relay contact TA2 earths relay coil (11C) TA/1, which operates and thus closes contact (11C) TA1 effectively connecting the input of the servo-amplifier at (11C) C6 to the bridge error transformer T2.

The a.c. bridge circuit

23. When a channel is selected, (11A) RV1 is turned to a pre-selected position by the channel selector. With (12) RV1 this forms a wheatstone bridge earthed at RV1c, to which point an independent earth is brought via pin SKTB/21 from (12) RV1. Power is supplied to the bridge at 12V r.m.s. 400 c.p.s. at the point RV1a and is obtained from the secondary winding of T1 (6-7). The bridge "detector" is connected from the moving contact RV1b to the moving contact on (12) RV1 via pin (12) SKTA/20 and the "detector" consists of the winding 1-2 of transformer T2.

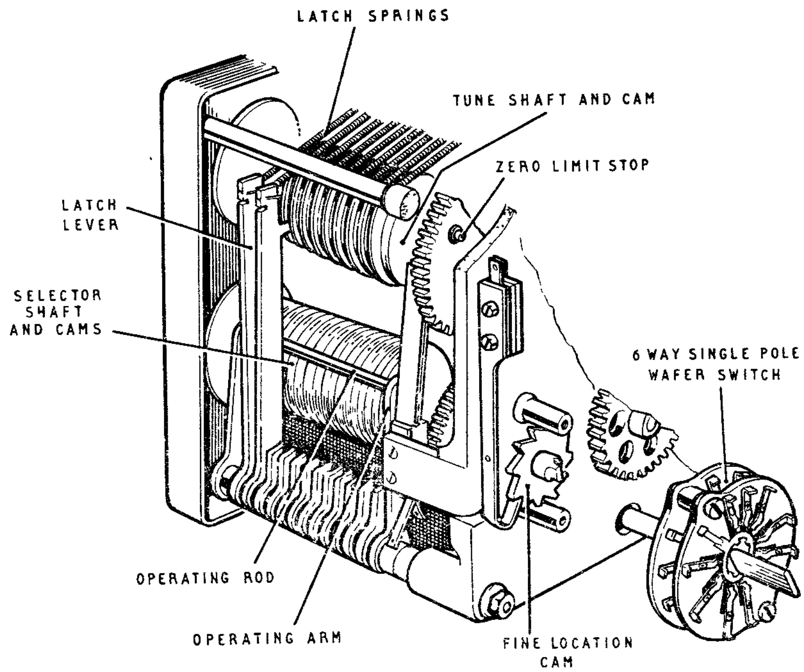


Fig. 3. Channel selector, showing select levers and discs

24. Initially on selecting a channel the a.c. bridge is unbalanced because of the conditions set up by rotating the moving contact of (11) RV1. This unbalance will cause a 400 c/s error signal to be developed in the "detector" winding 1-2 of transformer T2. Any such error signal will thus induce a signal in the secondary winding 5-6 of T2, this signal will fall to a minimum and reverse in phase as the bridge passes through the balance point as described in para. 25 to 31. The error signal thus induced in secondary winding 5-6 of T2 is applied to the servo-amplifier at pin (11C) PLA/8 and so operates the tuning motor (12) MG1 via the selector control sub-assembly.

The servo-amplifier (Amplifier, electronic control)

25. The 400 c/s error signal obtained as described in para. 24, is connected from pin (11C) PLA/8 through to the input capacitor C6. The combination C1 and R1 provide a phase shift which, with that through the amplifier totals 90° at the control winding of motor (11C) PR/1. Capacitor C2 functions as an r.f. bypass.

26. The servo-amplifier (*fig.* 4) is a conventional transistor l.f. amplifier. The input transistor being operated in the grounded-emitter mode. A signal appearing at the output of transistor VT1 (*fig.* 5) is coupled via C9 to the base of VT2 which is also operated as a grounded-emitter amplifier. The error signal coupled from VT2 is further amplified in transistor VT3. A thermistor X2 stabilizes the d.c. current flowing in VT3 with changes in temperature, the transistor forming the driver stage for the output push-pull pair of transistors. Transistors VT4 and VT5 are operated as a class B power amplifier, T1 being the driver transformer. A small amount of forward bias is provided by potentiometer R16, R14. The resistor R19 with diode MR8 provide d.c. stabilization against thermal runaway of the output transistors VT4 and VT5.

27. To enable more reliable operation at low temperatures, negative feedback is allowed on the first three transistor amplifier stages by the omission of the decoupling capacitors normally found across emitter resistors. Capacitors of the electrolytic type normally used tend to fail when cold in low impedance circuits.

28. The reference winding of the two-phase motor (11C) PR/1 is supplied directly at 26V r.m.s. from T1 via (11C) PLA/4 and as explained in para. 25 this has a 90° phase difference from the control winding owing to a phase-shift in the amplifier.

29. When the error signal is zero at the amplifier input, the motor shaft will not rotate. If the error increases the motor shaft will move in one direction. The motor shaft carries a disc-shaped cam with a cut-out sector in it, the edges of this sector engage the centre spring of a change-over contact set the contacts of which either short-circuit the connections to pins (11D) SKTA/3 and 4, or 4 and 5 on the selector control sub-assembly. When the signal applied to the amplifier passes through zero, there is 180° phase change which is applied via the servo-amplifier to the motor (11C) PR/1 which reverses its direction, thus the motor effectively acts as a phase relay.

30. Fuse (11C) FS1 is included to protect the control winding of the motor in the event of a fault developing on the output stage.

31. The combination of the disc cut-out sector and the stiffness of the centre spring of (11C) PR/1 allow a "dead zone" which prevents chatter of the final tuning motor (12) MG1 located in the tuner radio frequency.

Motor switching

32. It is shown that the error signal obtained from the out-of-balance condition of the a.c. bridge, is

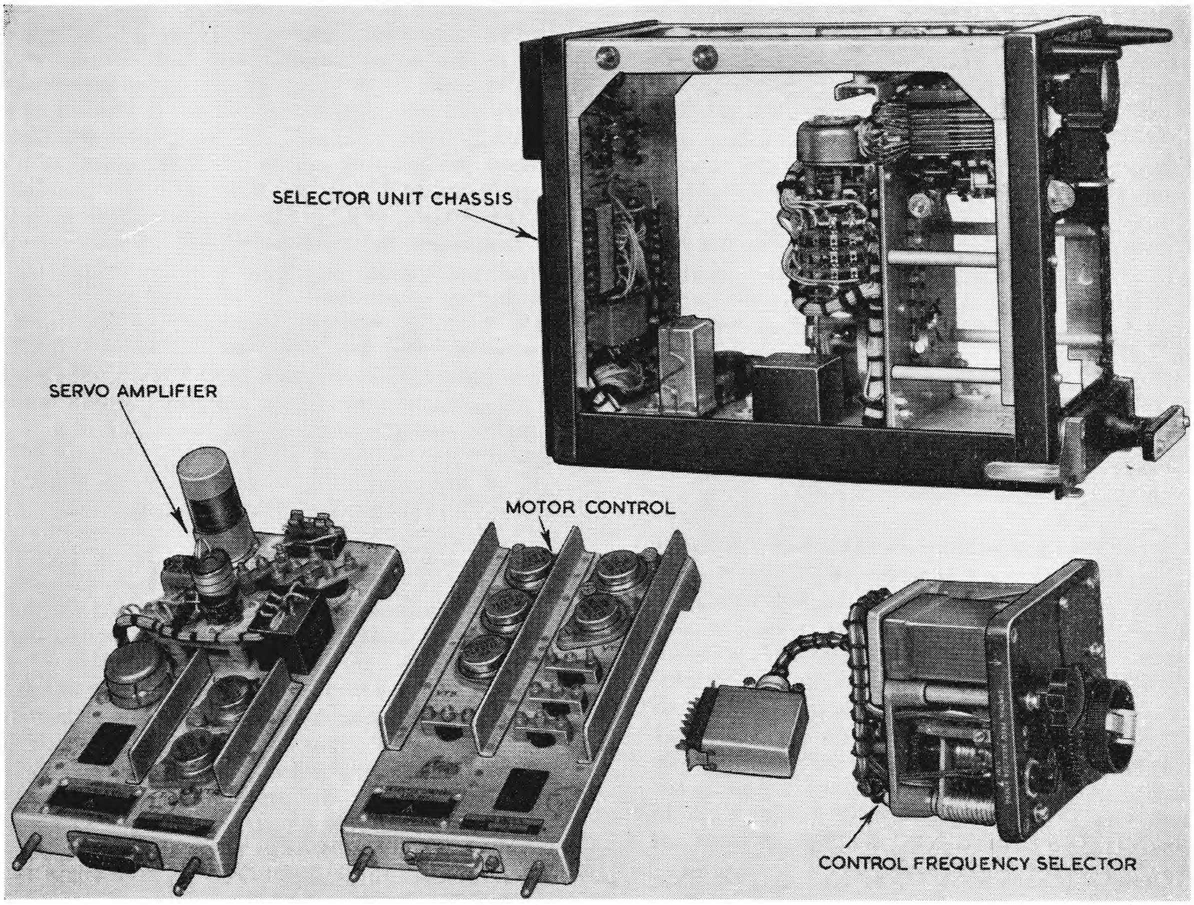


Fig. 4. Selector unit, showing sub-units

used to control the direction of motor (11C) PR/1, this motor controls the action of the switching bridge in the selector control sub-assembly 5985-99-999-8559 (*fig.* 4). The selector control sub-assembly has two functions:—

(1) To act as a reversal switch to the servo-motor 12-MG1, located in the tuner radio frequency.

(2) To reduce the speed of this motor when the equipment is approximately on tune, thus increasing the servo stability.

33. If now the error signal operates motor (11C) PR/1 (*fig.* 5) such that the switch contacts short-circuit pins (11D) SKTA/4 and 5, then the base of transistor (11D) VT7 is joined to the collector, the transistor offers a low impedance (conducts) and pin SKTA/7 is effectively at −28 volts d.c. (through VT5—*para.* 36). Current passing through (11D) R15 and R13 making the base of (11D) VT8 negative, causing it to conduct thus opening this transistor to the +28V line (11D) SKTA/8 and connecting pin (11D) SKTA/6 to the 28-volt supply.

34. The motor (12)MG1 will now run, being in series with the two transistors VT7 and VT8. When phase relay (11C) PR/1 reverses, a similar action to that in para. 33 causes (11D) VT6 and VT9 to conduct thus reversing the polarity of the supply to the motor (12)MG1 and, of course, its direction. The motor (12)MG1 will now drive the variable-capacitor (12) C1 and also the moving contact on (12) RV1 such that the a.c. bridge is restored to a balance condition. The 400 c/s signal in the winding 1-2 of T2 thus falls to a minimum, and the signal induced in the secondary winding 5-6 of T2 also falls to a minimum. Thus the motor (12)MG1 will stop, placing (12) C1 in the required position, since there is no output from the servo-amplifier.

Reduced speed operation

35. Fast operation of the tuning motor (12)MG1 occurs when the capacitor is moving in a position well off the final setting, but as the setting approaches the desired position the motor speed is reduced; this occurs in the following manner.

36. All the current for the transistors in the switching bridge and thus the motor current, is drawn through the regulator transistor (11D) VT5. In the fast condition, as soon as the switching bridge conducts (11D) VT5 will conduct since its base current is limited only by (11D) R9 (180 ohms). This condition continues throughout the fast tuning phase.

37. However, as soon as the notch is tuned to near resonance, a negative potential to earth of 2 volts approx. is produced by the network impedance matching (13) at SKTB/6 (*Chap.* 3, *para.* 12) this potential is applied to the base of transistor (11D) VT1 via pin (11D) SKTA/21, with capacitors (11D) C1, C2, C3 and inductor L1 forming an r.f. filter. The potential thus applied reduces the base current of VT1, and hence the collector current. This in turn increases the current through the emitter followers (11D) VT3, (11D) VT4 and finally reduces that of (11D) VT5, which as mentioned previously (*para.* 36) carries the full motor current switched by the transistor bridge. This reduced motor current in the permanent-magnet motor reduces its speed to about one-fifth of its full speed.

38. Such a form of speed control will reduce the motor torque and this could be a serious disadvantage if the motor is to work at low temperatures with a variable mechanical load.

39. The reduction in torque of the motor is partly compensated by a positive feedback circuit. Should the motor load tend to increase, its speed will drop, thus the back e.m.f. across the armature will decrease. The emitter potential of transistor (11D) VT5 will rise relative to earth and its collector current increase slightly, causing the potential across (11D) R11 to rise. This potential across (11D) R11 is fed back to the base of (11D) VT2 causing the transistor to pass more current thus lowering the potential of the base of transistor (11D) VT3, in doing so it decreases the emitter current of (11D) VT3.

40. This effect, operating through (11D) VT4 allows more current to flow in transistor (11D) VT5 and effectively increases the potential applied to the motor, increasing its torque and allowing it to overcome the increased load. Should the mechanical load now decrease, the reverse sequence occurs.

41. The effect of this positive feedback circuit is to compensate for mechanical load variations in the reduced speed condition, while at the same time keeping at approximately this reduced speed.

42. When the variable capacitor (12) C1 has been driven to its chosen position and the a.c. bridge is balanced, relay TB/2 releases and when the earth is removed from PLA/24, all earths are removed from the tune line and TA/2 also releases. Tune lamp ILP is extinguished and relay (11C) TA1 connects the servo-amplifier to the chopper (11C) X1, via (11C) R4 ready for the auto-tune cycle.

Automatic aerial tuning under transmit conditions

43. When transmission commences, r.f. power is fed from the transmitter radio frequency power amplifier to the network impedance matching via plug PLB, this is connected by a coaxial cable to the contact 1 of (13) SA3. From this switch, r.f. is connected to one of eleven taps on the matching transformer T1 depending on the selected position of SA.

44. A toroidally wound current transformer T2 with a shielded dust iron core has the connector rod inside the network impedance matching as a single turn primary winding. The r.f. currents circulating in the aerial notch induce a voltage in the winding a-b of T2 proportional to the circulating current in the aerial. The phase of this induced voltage is compared with that of the voltage produced by the capacity divider (13) C4, C8 from the input signal. When the induced voltage and the direct voltage signals are in phase, the d.c. output of the diodes (13) MR3 and MR2 in the discriminator is zero this indicates that the aerial cavity is tuned to resonance. Phase adjustments and balancing are performed by setting up capacitors C12, C13 and potentiometer (13) RV1. If, however, the cavity is not tuned to resonance, the two voltages applied to the discriminator circuit will not be in phase and hence a d.c. output signal will be obtained which is proportional to the error in tuning. This d.c. error signal is used to operate the servo-motor (12) MG1, via an amplifier. This motor rotates capacitor (12) C1 so that the aerial notch is tuned.

45. In the auto-tune condition i.e. on transmit, contact (11C) TA1 is in the rest position. The error signal obtained from the network impedance matching is positive or negative relative to earth, this appears on pin (11C) PLA/13. Pin (11C) PLA/11 provides an independent earth from the network impedance matching 13. Inductor (11C) L1 and capacitor (11C) C3 provide r.f. filtering on the error signal line, whilst (11C) L2 and (11C) C4 operate at audio frequency to remove modulation and 400 c/s stray pick-up. The signal from these filters is applied to contact 1 of the synchroverter (chopper) (11C) X1 and from there via the relay contact TA1 to the base of (11C) VT1.

46. The chopper is energized only when the error signal is present. i.e. when the key line is earthed. Relay contact K2 closes and connects the 400 c/s supply of T1, reduced to 6 volts by R3, to the coil of (11C) X1. The chopper contact 1 is then cyclically earthed at 400 c/s, thus its potential falls from full error signal to zero at this frequency. This produces a 400 c/s square wave signal at the base of transistor (11C) VT1. Resistor (11C) R3 and (11C) C5 introduce a phase lead in conjunction with the effective resistance of (11C) X1 to ground and aids the overall servo stability.

47. Thus the servo-amplifier is now provided with an a.c. error signal equal in amplitude to the d.c. error signal and which reverses in phase when the polarity of the d.c. error signal changes. The servo-amplifier motor switching and speed control operate exactly as in para. 32 above, this time, of course, driving the capacitor (12) C1 to resonate the notch and produce zero error signal for the input to the servo-amplifier.

48. Thus the notch is tuned quickly, accurately, and entirely automatically for the period of transmission.

Aerial impedance matching

49. When a channel is selected, control frequency selection 11B (channel selector) operates as described in para. 16. The select shaft of the channel selector rotates the matching selector drum switch DS to the chosen channel position. This selector drum switch carries twelve vertical slots each of which locates with a contact stud in one of eleven positions. The contact stud can be adjusted, on setting up, from the front of the unit to a chosen "tap". The stud being earthed makes contact with one of the eleven contact strips connected to switch (11A) SB1.

50. The drum switch has a dual function for each channel.

(1) To select the appropriate matching tap on the matching unit (13).

(2) To select one or more parallel capacitors if needed, for the channel frequency required, the capacitors being located in the tuner radio frequency (12).

51. An earth on one contact of switch SB1 allows the stepping solenoid SB/6 to rotate switch SB until a "cut-out" segment on the switch coincides with the earthed contact of SB1, this occurs when relay contact B1 is closed. Switch SB5 then assumes its selected position, since it is mechanically coupled to switch SB1. Switch SB5 places an earth, via the six wire circuit, in one position of the locating bank of switch 13-SA in the matching unit, and therefore selects the chosen tap on transformer 13-T1.

52. Again in certain matching positions, SB2, SB3 and SB4 connect +28V to pins on SKTD. Plug PLC which mates with SKTD can be linked in such a manner that this supply is connected through to the relays which switch in the necessary tuning capacitors in the tuner radio frequency.

53. Normally taps 7-11 on the selector drum are used for the lower frequencies. As an example, if tap 11 is used for a 2·8 Mc/s channel:—

SB2 position 1 will with PLC/10-23 linked, operate relay 12-BC/1

SB3 position 1 will with PLC/7-20 linked, operate relay 12-BB/1

SB4 position 1 will with PLC/1-14 linked, operate relay 12-BA/1

All three fixed tuning capacitors 12-C2, C3, C4 are then selected on tap 11.

◀**54.** Plug PLC is prewired for any one type of aircraft and so forms part of the initial calibration of the installation. The construction of the primary of 13T1 is designed in three sections. On taps 11-7 inclusive all three sections are in use. On taps 6 and 5 two sections are used and on taps 4, 3, 2 and 1 only one section is in use. The removal of the unused sections of the winding on the lower taps used on the higher frequencies, prevents self-resonance in these due to inter-turn capacities. This is also reduced by the two layer construction of the primary winding. In this way resonances affecting, the matching performance are reduced to an acceptable level at the higher frequencies.▶

55. While the access door to the selector drum switch is opened, micro-switch SA is broken and so prevents the stepping solenoid SB/6 following taps selected when the drum switch is being rotated manually during setting up or calibration.

56. Rectifier MR7 prevents partial illumination of lamp ILP (TUNE) due to the "false" earth obtained via the resistance of relay TA/2 and a contact on the selector drum switch.

Fine tune facility

57. This circuit allows the aerial to be tuned a small amount about the position selected by the channel change a.c. bridge circuit, it only operates under reception conditions. The facility is intended for correction of the tuning under radio silence operation. The aerial becomes accurately tuned as soon as any short transmission occurs.

58. The fine tune circuit is put into operation as soon as the biased switch 6-SE on the remote control unit is closed. The earth placed on PLA/22 operates the fine tune relay FT/2 through contacts TA2 and K1. Relay contact FT1 operates, holding in relay FT/2 and at the same time operating (11C)TA1; the biased switch on the remote control unit then no longer has any control. Relay contact FT2 has closed thus connecting a 400 c/s supply from the moving contact of 11RV1 to an auxiliary bridge formed by R1 and R2 and the fine tuning potentiometer on the remote control unit. Normally the potentiometer is set in its centre position and because R1 = R2 the bridge is balanced. If the fine tuning potentiometer moving contact is moved away from its centre position, an out-of-balance current flows through winding 3-4 on T2. This induces a small error signal into winding 5-6 and thence into the servo-amplifier to cause a shift of the tuning motor 12MG1. Thus variation of the fine tuning control about its centre position will cause a change of capacitor 12-C1 about the set channel position.

59. Ideally, the full variation of the fine tuning control potentiometer should produce a constant percentage change in the resonant frequency tuned by capacitor 12C1, irrespective of frequency. In an attempt to approximate to the desired result, the supply voltage to the auxiliary bridge is taken from the moving contact of 11RV1. Under the conditions where 12C1 is at maximum capacity, full voltage is applied to the servo-motor 12MG1 giving a corresponding large shift of the capacitor. At the h.f. end of the frequency band, where the capacitor will be near its minimum value the supply voltage to the motor and subsequent shift of the capacitor are correspondingly reduced. The actual amount of fine tuning shift will depend on the setting of the fine tuning control.

60. As soon as transmission commences and r.f. power is supplied to the aerial, the latter will become accurately tuned by the auto-tune action, and for that particular channel fine tuning will no longer be required.

61. Thus the fine tune action is cancelled as soon as the key line is earthed. Relay K/2 then operates, contact K1 opening to release the fine tune relay FT/2, at the same time contact FT1 closes, earthing one side of relay (11C) TA/1 which then operates, changing over contact TA1 to accept the auto-tune error signal from the discriminator circuit in the network impedance matching.

62. The fine tuning circuit is also cancelled every time a channel is changed, when contact TA2 releases relay FT/2.

28-volt supply surge suppressor

63. Aircraft power supplies are prone to fluctuation and they can often give short duration transient voltages which could break down the transistors used in this aerial equipment or at any rate decrease their performance and life. The surge suppressor circuit using transistors VT1 and VT2 is used to provide protection against this.

64. Normally, the base and emitter of VT1 are of a similar potential because the value of R7 is low and thus VT1 does not conduct. The supply current passes through diode MR4 and VT2. When the supply voltage rises transiently above 33 volts (approx.), the three Zener diodes MR1-3 start to conduct and hold the potential from MR1 to earth constant at 33 volts. The base of transistor VT1 then falls in potential (i.e. becomes more negative), transistor VT1 conducts and by effectively connecting base of VT2 to the emitter of VT1 causes transistor VT2 to cut off, thus interrupting the d.c. supply to the equipment except through R10 which is a high resistance.

65. The connection from TS7 supplies power to both the reduced speed unit (selector control sub-assembly) and the servo-amplifier (amplifier, electronic control).

Operation of the SET/TEST key and meter circuit

66. On the front panel of the selector unit is mounted a key KST, this is used to check operation of the aerial equipment, and to assist in the initial setting-up operations.

67. The key has three positions:—

(1) Key in the up position is spring biased, this is the "SET" position.

(2) Key in the centre and normal position, this is the position used for "OPERATE".

(3) Key in the down position, again spring biasing is used, this is the "TEST" position.

68. When the key is in the "SET" position contacts KST2/5 and 6 close, placing an earth on the tune line, thus putting the a.c. bridge into operation and so allowing the aerial "notch" to be tuned. The earth on "Interlock in" is removed from pin 24 of PLA.

69. Contacts KST3, 8 and 9 close, earthing the key line at pin 18 of PLA thus applying r.f. power to the aerial system; any earth on "Interlock out" is removed. Contacts KST5 earth PLA pin 25 thus allowing the equipment to operate at low power for tuning purposes.

70. Key contacts KST6, 28 and 29 close to connect the meter M1 to the reflectometer circuit on the matching unit 13 at pin 13 of SKTB.

71. When the key is in the "OPERATE" or normal position, KST2 connects the tune line to the "Interlock in" line at PLA24. Key contact KST3 connects an earth to TB1 to provide an "Interlock out" signal at pin 23 of PLA. Contacts 27 and 28 of KST6 are closed to connect meter M1 to the monitor winding of the network impedance matching at pin 6 of SKTB. The rectifier MR6 is inserted in order to prevent the positive bias from (11D) R1 causing the meter M1 to indicate when no potential is present at the monitor output.

72. In the "TEST" position the key contacts 1 and 2 of SKT1 close and apply r.f. power to the aerial system by earthing the key line. Under these conditions the remaining sections of the SET/TEST key KST are unaltered from the "OPERATE" position.

73. The equipment is allowed to operate on full power when the SET/TEST key is placed in either the OPERATE or TEST positions.

Reflectometer circuit

74. A toroidally wound transformer 13T3, with a ferrite core has as its primary the 50-ohm r.f. input connector from 13 PLB. The voltage induced in the secondary winding is applied across the diode 13-MR5, this voltage being proportional to the r.f. line current. A capacity potential divider 13-C10, C11 connected between the r.f. line and earth provides a potential at R6 proportional to the voltage on the line.

75. These two voltages are added across diode MR5, this produces a d.c. potential at PLA pin N. The secondary winding of 13-T3 is connected so that when the line voltage and current are in phase the two potentials across MR5 are in opposition.

76. If the line is correctly terminated by 50-ohm non-inductive loading a s.w.r. of 1: 1 is achieved. To set the reflectometer, a 50-ohm non-inductive load is used and capacitor C11 adjusted until the meter M1 on the selector unit front panel reads zero.

77. On connection of the aerial load, the s.w.r. obtained should be better than 1·5: 1, a large deviation from this value indicates that aerial matching is incorrect.

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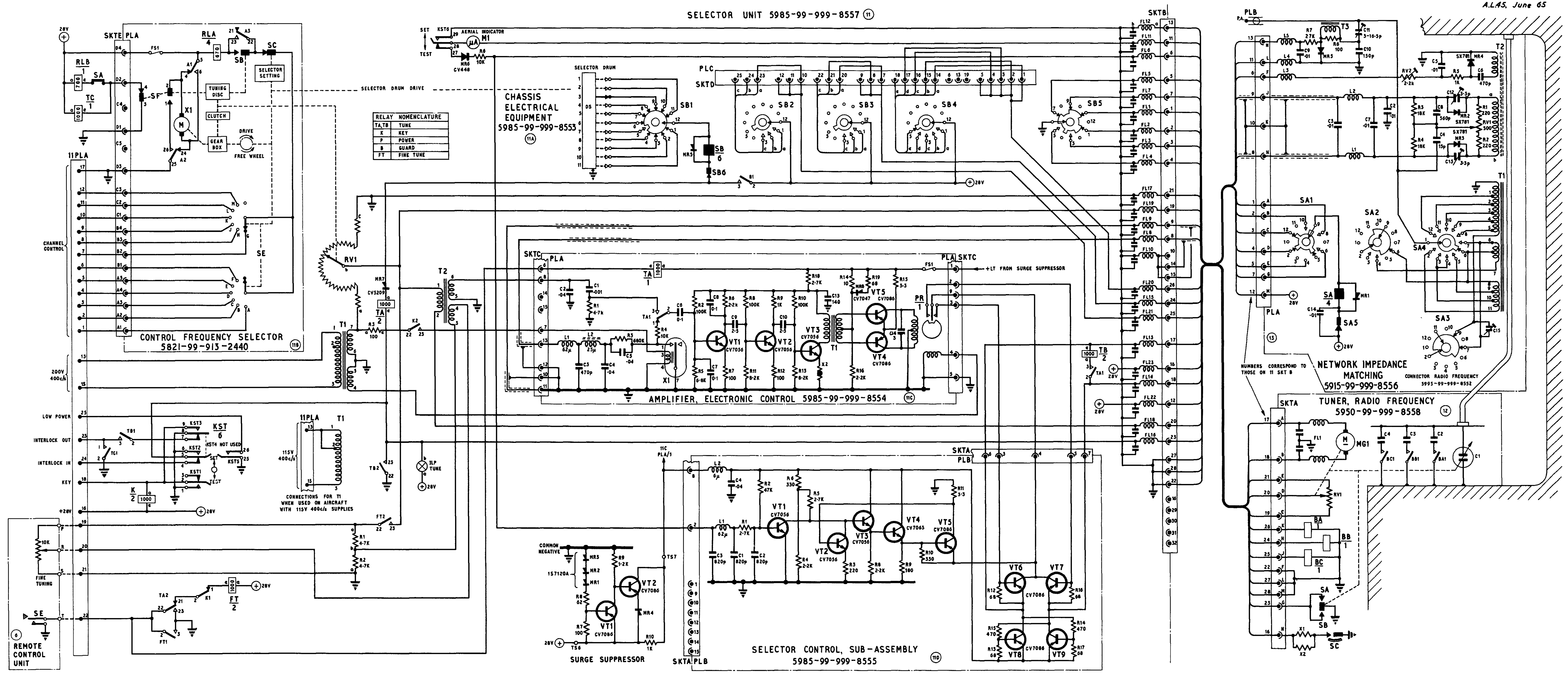

AIR DIAGRAM 6729G/MIN.
ISSUE 2.

Aerial system 5985-99-999-8559: circuit

Fig. 5